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EDGE

EVOLUTIONARILLY DISTINCT & GLOBALLY ENDANGERED

Survival Blueprint

Green turtle, *Chelonia mydas*

Mantanani, Sabah

Photo credit: Nicolas J. Pilcher

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1. STATUS REVIEW

Green sea turtles are one of the charismatic and iconic marine species globally. They are found in tropical waters and are listed as 'endangered' under the IUCN Red List. The primary threats to this species are bycatch, intentional killing of the turtles and egg harvesting, boat strikes, and loss of habitats. Protection of sea turtles from their human-induced threats differs between regions.

1.1 Taxonomy:

Kingdom: Animalia

Phylum: Chordata

Class: Reptilia

Order: Testudines

Family: Cheloniidae

Genus: Chelonia

Species: *Chelonia mydas*

Common name: Green turtle

Local name: Penyu hijau / Penyu agar (Malay)

The green sea turtle, *Chelonia mydas* (Linnaeus 1758) is one of the six extant species of hard-shelled marine turtles within the *Cheloniidae* family. Its common name is derived from the green colour of the turtles' fat tissues (Hirth 1997). The green turtle's snout is very short, and, unlike the hawksbill turtle, its beak is unhooked. The carapace colour and pattern changes with age, from dark brown to olive at juvenile stage, while mature adults are either entirely brown, spotted or marbled with variegated rays (Wyneken 2001).

In the eastern Pacific Ocean, a subspecies, commonly referred to as the black turtles *Chelonia mydas agassizii* (Bocourt, 1868), has been proposed with a range extending from Baja California south to the Republic of Peru and west to the Revillagigedos Islands and Galápagos Archipelago (Márquez-Millán, 1990; Pritchard, 1997). However, genetic analyses do not support such taxonomic distinctiveness (Bowen et al., 1992; Karl et al., 1992) and the subspecies status is currently unaccepted (see WoRMS - World Register of Marine Species).

1.2 Distribution and population status:

Green turtles are distributed world-wide (circumglobally) in tropical and sub-tropical waters (Fig. 1; Seminoff et al. 2015; Groombridge & Luxmoore, 1989). In general, there are no true estimates of population size for the species due to the complex ecological niche of the animal migrating across ocean basins, encompassing a large geographical extent, and occupying several marine habitats throughout their life cycle (Limpus et al. 1992). Many of the published studies focusing on sea turtle have estimated population sizes for a single ontogenic stage, (e.g., adult nesting turtles by tagging nesting turtles and identify rates of reoccurrence and recruitment; nesting track counts during peak and non-peak nesting seasons; and nest counts Bjorndal et al. 1999; Bjorndal et al. 2005).

Genetically, green sea turtles show distinctive mitochondrial DNA (mtDNA) properties for each nesting region (Bowen et al., 1992). The geographical scale of genetic population structure varies among regions and genetic differentiation is usually detected between rookeries separated by more than 500km (Dethmers et al., 2006; Jensen et al., 2013). Studies have suggested that the global matriarchal phylogeny of green turtles has been shaped by ocean basin separations (Bowen et al., 1992; Encalada et al., 1996) and by natal homing behaviour (Meylan et al., 1990).

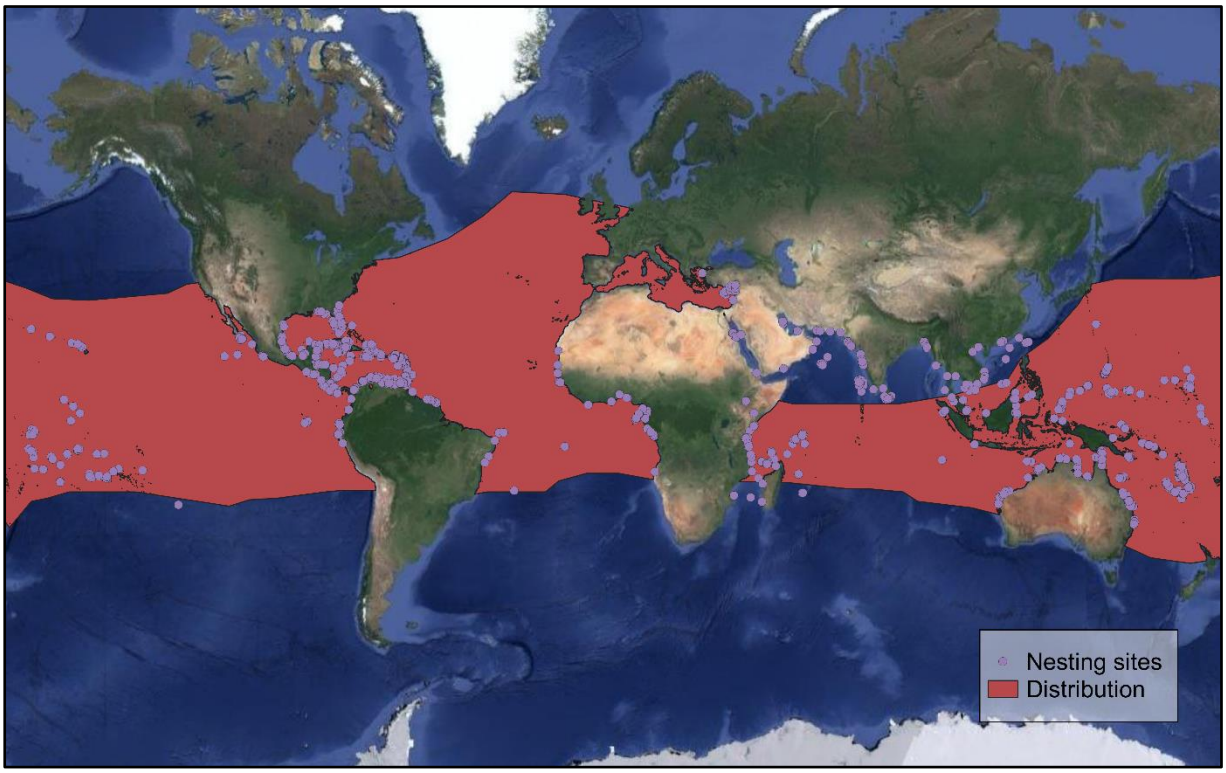

Figure 1: Global distribution (Seminoff 2004) and nesting sites (SWOT, 2021) of green turtle *Chelonia mydas*.

1.2.1 Global distribution:

Country	Population estimate	Distribution	Population trend	Notes
British Oversea Territory	23,724 annual turtle nests in 2010-2013 (Weber et al. 2014).	Ascension Island.	Increased nesting females from 1976 to 2013 (Mortimer & Carr 1987; Godley et al. 2001; Broderick et al. 2006; Weber et al. 2014).	Nesting populations
Australia	Coast of Queensland: High density seasons with more than 10,000 nesting females at once (1950s, 1965-1966, and 1974-1975) (Limpus et al. 2003). Northwest Cape: More than 800 tagged nesting females in 1994 (Prince 2000). Raine Island: Nesting female of more than 1,000 individuals within a nesting season (Limpus et al. 2003).	Coast of Queensland; Northwest Cape; & Raine Island.	Coasts of Queensland: An upward trend from 1976 to 1996 followed by a downward trend from 1996 to 2004 (Limpus 2009). Northwest Cape: Insufficient data to estimate population trend (Prince 2000).	Nesting populations
Comoro Islands	Beaches of Itsamia: Annual nesting females of more than 3,000 individuals (Innocenzi et al. 2010). Grande Saziley beach of Mayotte: average of 1,545 (± 439) nesting females per year from 1998 to 200 (Bourjea et al. 2007).	Beaches of Itsamia, Moheli; & Grande Saziley beach of Mayotte.	Population trend is stable from 1998 to 2005. Lack of data to estimate long-term trend.	Nesting populations
Eparses Islands	Tromelin Island: Average nesting tracks of 7,178 (± 3,053) annually for 20 years since mid-1980 (Laurent-Stepler et al. 2007).	Tromelin Island; Grande Glorieuse Island &	No data on long-term population trend.	Nesting populations

	Grande Glorieuse Island: 16% coverage of nesting beach with an average nesting tracks of 1,480 (± 666) annually for 20 years since mid-1980 (Laurent-Stepler et al. 2007). Europa Island: 26% coverage of nesting beach with an average nesting tracks of 1,361 (± 903) annually for 20 years since mid-1980 (Laurent-Stepler et al. 2007).	Europa Island.		
Brazil	Trindade Island: Annual average of 3,600 nests from 1991 to 2008, which is approximately equivalent to 600 female nesters (Almeida et al. 2011). Atol das Rocas and Fernando de Noronha islands: Turtle nesting monitoring program exist, but no published data to estimate population size (Moreira et al. 1995; Bellini et al. 1996; Bellini & Sanches 1996; Marcovaldi & Marcovaldi 1999).	Trindade Island; Atol das Rocas Island; & Fernando de Noronha Island.	Trindade Island: Population size for nesting turtles is stable between 1991 and 2008 (Almeida et al. 2011). Atol das Rocas and Fernando de Noronha islands: No published data to estimate population trend of nesting turtles (Moreira et al. 1995; Bellini et al. 1996; Bellini & Sanches 1996; Marcovaldi & Marcovaldi 1999).	Nesting populations
Saudi Arabia	Karan and Jana Islands: Less than 100 nesting turtles annually (Miller 1989; Al-Merghani et al. 2000; Phillott & Rees 2019). Ras Baridi and Farasan Islands: Annual nesting turtles of 150 individuals (Miller 1989; Pilcher 1999; Al-Merghani et al. 2000;	Karan Island; Jana Island; Ras Baridi; & Farasan Island.	Insufficient data to estimate population trend	Nesting populations

	Pilcher & Al-Mansi 2000; Pilcher & Al-Merghani 2000).			
Oman	Masirah Island and Ras al-Hadd: More than 10,000 nesting turtles (Ross & Barwani 1982; Reece et al. 2016).	Masirah Island; & Ras al-Hadd.	Insufficient data to estimate population trend	Nesting population
Djibouti	Iles Moucha & Maskali, Ras Siyyan, and Iles des Sept Fréres: Estimated nesting population of approximately 100 individuals (PERSGA 2003; PERSGA/GEF 2004).	Iles Moucha & Maskali; Ras Siyyan; & Iles des Sept Fréres.	Insufficient data to estimate population trend	Nesting population
Egypt	Wadi Al-Gimal, Ras Banas, Sarenka, Siyal, Zabrgad and Rowabil Islands: Estimated nesting population of approximately 200 individuals (Frazier & Salas 1984; PERSGA 2003; PERSGA/GEF 2004). Zabargad Island: Important nesting sites for green turtles, with 438 nests in 2001 and 1,527 nests in 2008 (Hanafy 2012). Ras Begdadi: 29 nests in 2001 and 2 nests in 2006. No nest was found in 2007 and 2008 (Hanafy 2012). Umm Abas: 33 nests in 2001 and 1 nest in 2007. No nest was found in 2008 (Hanafy 2012).	Wadi Al-Gimal Island; Ras Banas Island; Sarenka Island; Siyal, Zabrgad Island; Rowabil Island; Zabargad Island; Ras Begdadi; & Umm Abas.	Wadi Al-Gimal, Ras Banas, Sarenka, Siyal, Zabrgad and Rowabil Islands: Insufficient data to estimate long-term trend of nesting population size. Zabargad Island: Increasing nesting females from 200 individuals in 2001 to 611 individuals in 2008 (Hanafy 2012). Ras Begdadi: Decreasing nesting trend from 29 nests in 2001 to 0 nest in 2008 (Hanafy 2012). Umm Abas: Decreasing nesting trend from 33 nests in 2001 to 0 nest in 2008 (Hanafy 2012).	Nesting population Hanafy (2012) reported nesting turtles in Tiran Island, but no quantified data available.

Costa Rica	Tortuguero: Average annual nesting turtles of between 17,402 and 37,290 in 1999-2003 (Troéng & Rankin 2005). San José Island: A total of 1,232 nesting females identified over 4 nesting seasons from 2012 to 2016 (Fonseca et al. 2018).	Tortuguero; & San José Island	Tortuguero: 417% increase in nesting trend from 1971 to 2003 (Bjorndal et al. 1999; Troéng & Rankin 2005). San José Island: Insufficient data to estimate population trend (Fonseca et al. 2018).	Nesting population
Ecuador	Isabela (Quinta Playa & Barahona beaches), Santa Cruz (Las Bachas beach), and Baltras Islands (Las Salinas beach): Approximately 1,400 nesting females annually in 1979-1982 (Hurtado 1984), 1,657 nesting females annually in 2001-2005 (Zárate et al. 2006). Quinta Playa: Between 1,381 and 3,418 nesting females annually in 2009-2011. Between 160 and 570 nesting females annually in 2016-2018 (IAC 2019).	Galapagos Archipelago (Zárate et al. 2006)	Quinta Playa: Decreasing nesting trend in 2016-2018 (IAC 2019). Las Bachas: Decreasing nesting trend in 2013-2017 (IAC 2019).	Nesting population
Guinea-Bissau	Beaches of the Orango National Park: 200-300 nests annually (Barbosa et al. 1998). Poilão Island: 314 and 1,651 nesting females tagged from July to September in 1994 and July to October in 1995 respectively (nesting seasons) (Fortes et al. 1998).	Beaches of the Orango National Park Poilão Island	Insufficient data to estimate population trend	Nesting population

Indonesia	Sangalaki Island: Total monthly emergences and protected nests fluctuated between 160 - 1,166 (mean = 584 ± 234.5) and 93 - 812 (mean = 354 ± 153) respectively (Adnyana et al. 2008). Derawan Island: Total monthly emergences and protected nests fluctuated between 4-65 (mean = 21 ± 13) and 4-33 (mean = 13 ± 6) respectively (Adnyana et al. 2008).	Sangalaki Island; & Derawan Island.	Sangalaki Island: Estimated average daily emergences in the 1950s and 1970s were 200 and 150 turtles respectively (Lindsay & Watson 1995). The average monthly nest was 616 in 1995-2000 (Adnyana 2003). The monthly average number of nests during the period of 2002-2006 was 354 nests (Adnyana et al. 2008). In general, turtle nesting trend is decreasing. Derawan Island: Monthly average nests were 51 in 1985-1990 (Adnyana 2003), compared to the current value of 13 monthly average nests (Adnyana et al. 2008).	Nesting population Salm et al. (1982), Gikes & Adipati (1987), and WWF Indonesia (1997) reported nesting turtles in Yapen Island; Dethmers et al. (2006) reported nesting turtles in Aru Islands; Tapilatu et al. (2017) reported nesting turtles in Wondama, Manokwari, and Kaimana, but no quantified data available.
Philippines	Tan-awan: 82 individual turtles encountered from May 2012 to October 2018, with 28% (n = 23) encountered once throughout study period (Arajo et al. 2019). Turtle Islands, Tawi-Tawi: Most of the tagged 10,172 nesting turtles from 1982 to 2002 (Sagun 2002 & 2004). Baguan Island: From July 1984 to December 1989, a total of 27,458 nests were recorded (Trono 1991). In 1995 and 2011, ~2,466 and ~2,844 individual	Tan-awan; Turtle Islands, Tawi-Tawi; & Baguan island (part of the Turtle Islands Protected Heritage Area - TIHPA).	TIHPA: Nesting turtle population has increased	Tan-awan: In-water sea turtle study. Turtle Islands: Nesting population

	nesting females were recorded (Burton 2012).			
Seychelles	Aldabra Atoll: Annual nest of 2,000-3,000 in late 1960s to an annual nest of 15,669 in 2004-2008 (~3,100-5,225 nesting females) (Mortimer et al. 2011).	Aldabra Atoll	Aldabra Atoll: Increasing nesting population trend from late 1960s to 2008 (Mortimer et al. 2011).	Nesting population
Suriname	An estimated number of 1,500 to 2,000 turtles nested across all beaches in 1968-1974 annually (Schulz 1975). Krofajapasi: A total of 204 nests in 1982 (Mrosovsky et al. 1984). Matapica: Number of nests are more than 500 in 1993 (Godfrey et al. 1996). Galibi: Estimation of 4,150 nesting turtles in 1995 (Weijerman et al. 1998).	Krofajapasi; Matapica; & Galibi	Increasing nesting trend from 1968 to 1995 (Schulz 1975; Mrosovsky et al. 1984; Godfrey et al. 1996; Weijerman et al. 1998).	Nesting population
Mexico	Michoacán (Colola beach): Average of 229 annual nesting females from 1983 to 1986; average of 7,618 annual nesting females from 2014 to 2017 (IAC 2019). Yucatan Peninsula (El Cuyo): 390 nests in 2002; 157 nests in 2003; 172 nests in 2004 (Xavier et al. 2006). Veracruz: 617 nests in 2005, 501 nests in 2006, 536 nests in 2007 ( ).	Michoacán (Colola beach); Yucatán; & Veracruz.	Colola beach: Increasing nesting trend from 2014 to 2017 (IAC 2019). Campeche: Decreasing nesting trend from 2000 to 2003 (Hernandez-Guzmán 2003).	Nesting population

United States of America	Florida (central east coast in Brevard County): Annual nesting turtles of ~608 individuals in 1989-1999 (Witherington & Koeppel 2000). Florida (central east coast at the Canaveral National Seashore): An annual average of 185 (± 55) nests 1985 to 2003 (range: 5–857) (Antworth et al. 2006). Hawaii (French Frigate Shoals): More than 1,100 female nesters tagged from 1988 to 1992 (Balazs & Chaloupka 2004).	Florida; & Hawaii.	Florida: Increasing nesting trend (Witherington & Koeppel 2000; Antworth et al. 2006). Hawaii: Increasing nesting trend (Balazs & Chaloupka 2004).	Nesting population
Bahamas	Union Creek Reserve and Conception Island: Annual estimates of abundance (Horvitz-Thompson method) ranged from 41 to 257 individual in-water turtles from 1978 to 2001, with an average immigration rate of 42.4% (range = 23.2 - 89.8%) (Bjorndal et al. 2005).	Union Creek; & Conception Creek	Union Creek Reserve: Turtle abundance increase at an annual rate of 38.8% (1979-1985), followed by a period of significant decrease (1985-1994) at an annual rate of 213.1%. Turtle abundance did not change significantly in 1994-2001. The upward shift in 2001, which was followed by a higher year in 2002 (data not included) suggests that the abundance of the turtles has increased (Bjorndal et al. 2005). Conception Island: A constant trend in abundance from 1990 to 2001 (Bjorndal et al. 2005).	In-water turtle population

A variety of published research articles (referenced from Seminoff et al. 2015) revealed other lesser nesting areas of green turtles around the world:

Cook Islands: Scilly Atoll (Lebeau 1985); Palmerston Atoll (White 2012); Venezuela (Prieto et al. 2012; Vera & Buitrago 2012) Guyana (Pritchard 1969); Australia: Gulf of Carpentaria (Limpus 2009); Yemen (PERGSA/GEF 2004); Sri Lanka (Dattatri & Samarajiva 1983; Kapurusinghe 2006; Ekanayake et al. 2011); Dominican Republic (Ottenwalder 1981); d'Entrecasteaux Islands (Pritchard 1994); Brazil: Atoll da Rocas (Bellini et al. 2012); Somalia (Goodwin 1971); French Guiana (Fretey 1984); Papua New Guinea (Kinch 2003; Wangunu et al. 2004); Iran (Mobaraki 2004); Pakistan (Kabraji & Firdous 1984); Japan (Kamezaki et al. 2004); Thailand (Groombridge & Luxmoore 1989); Mayotte Archipelago (Bourjea et al. 2007); Micronesia (Wetherall et al. 1993); Natuna Islands (Limpus 2009); New Caledonia (Limpus 1985, 2009); Bangladesh (Khan 1982); China (Groombridge & Luxmoore 1989); Primieras Islands (Hughes 1974); Angola (Carr & Carr, 1991); Equatorial Guniea (Bioko Island: Tomás et al. 1999); Ghana (Fretey 2001); Cuba (Blanco et al. 2009); Cyprus (Kasparek et al. 2001); India (Kar & Bhaskar 1982); Kenya (Wamukoya et al. 1996); Madagascar (Rakotonirina & Cooke 1994); Maldives (Frazier, 1990); Marshall Islands: Bikar Atoll (McCoy 2004); Mauritius (Groombridge & Luxmoore 1989); Palau (Bureau of Marine Resources 2008; Maison et al. 2010); Sierra Leone (Fretey & Malaussena 1991); Taiwan (Chen & Cheng 1995); Turkey (Kasparek et al. 2001); Myanmar (Lwin 2009); Sao Tome é Principe (Brongersma 1982); Vietnam (Hien 2002); Solomon Islands (Leary & Laumani 1989); Tanzania (Howell & Mbindo 1996); Mexico: Revillagigedos Islands (Holroyd & Telfry 2010). Sporadic nesting occurs in at least 30 additional countries (Groombridge & Luxmoore 1989).

1.2.2 Local distribution: Malaysia

Region / province	Site	Level of Protection	Population size	Reference(s)	Notes
Peninsular: Penang	Coasts of Penang Island	Low: Although nesting habitat is not actively protected, turtle nesting activities are low.	A total of 165 nests from 2001 to 2009.	Salleh et al. (2012).	
Labuan Island		Medium: Low turtle nesting activities within established Marine Park Centre	A total of 29 nests from 2011 to 2017.	Ghazali & Jamil (2019).	Pulau Rusukan Besar Marine Park Centre.
Peninsular: Terengganu		High: Highest nesting population in Peninsular Malaysia within established turtle sanctuaries.	4,000-5,000 nests in 1984 and 1986; >5,000 nests in 1991. 2,000-3,000 nests annually from 1996 to 2000. Average of 85 (range: 44-140) nesting turtles annually from 1993 to 2008. 1,000-3,000 nests annually in the past five years of 2017.	Chan (2006); Chan (2013); Jolis et al. (2015); Joseph et al. (2017).	Turtle sanctuaries: Rantau Abang, Ma' Daerah, Redang Island, and Perhentian Island.
Borneo: Sarawak	Pulau Talang-Talang Besar Pulau Talang-Talang Kecil Pulau Satang Besar Pulau Satang Kecil	High: Nesting habitats are part of the gazetted national park,	Between 2,000 and 3,000 nests annually from 1970 to 2000.	Chan (2006).	Talang Satang National Park.

Borneo: Sabah	Pulau Selingaan Pulau Gulisaan Pulau Bakkungan Kecil	High: Highest nesting population in the nation, which is within the gazetted Turtle Islands Park.	From 1991 to 2000, nesting abundance was more than 8,000 annually. Annual nesting abundance is between 10,000 and 15,000 for the past five years of 2017.	Chan (2006); Sabah Parks: unpublished data – cited in Joseph et al. (2017).	Turtle Islands Park.

1.3 Protection status:

Conservation of green turtles, along with other marine turtle species, aims to promote the survival of populations by recovering depleted stocks, protecting habitats considering the dynamics of interactions with human communities (Eckert, 1999). Protection of green turtles from their anthropogenic threats is approached in a variety of ways in different regions. Globally, green turtles are protected under Appendix I of the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) from international trading. Green turtles in the Indo-Pacific region are also protected under the Convention on the Conservation of Migratory Species of Wild Animals (CMS).

Green turtles are found in most tropical regions and these animals are protected under respective national legislations and laws. In the Western and Central Pacific Ocean (or Oceania), green turtles are under the jurisdiction of the National Marine Fisheries Service (NMFS). In the United States Federal Government, green turtles are protected under the Endangered Species Act (ESA) which prohibits unauthorised 'take' of green turtles defined as to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct". The Environment Protection and Biodiversity Conservation

Act 1999 under the Australian government is enforced to conserve sea turtle populations in Australia. In the Philippines, Task Force Pawikan in 1979 was mandated to protect and conserve sea turtles, which is now under the Pawikan Conservation Project of the Department of Environment and Natural Resources (Trono, 1991; Cruz, 2004; Bagarinao, 2011).

In Malaysia, sea turtles' protection and conservation are regulated by their respective states (Fisheries Act, 1985). Sea turtles are not listed as a protected animal in the state of Perlis and Selangor of Peninsular Malaysia as there were no records of sea turtle nesting in these states (Ahmad et al., 2004). In Sabah, there are several legislations that list sea turtles as protected animals. The Wildlife Conservation Enactment 1997 listed green and hawksbill turtles as fully protected animals; the Fauna Conservation Ordinance 1963 of Act No. 11, and the Custom Act 1967, prohibited trading of sea turtles in Sabah; and the Fauna Conservation (Turtle Farms) Regulations, 1964 regulates the collection of green and hawksbill turtle eggs for hatchery purposes. Sea turtles are also protected within gazetted Parks and Natural Reserves under the Parks Enactment 1984, Part VIII, No. 48 (1) d.

1.4 Ecology, behaviour and habitat requirements:

Green turtles are herbivorous during most of their life (Arthur and Balazs 2008; Santos et al. 2011). They occupy different marine habitats at specific life stages. The nesting and foraging grounds of sea turtles are different, therefore the sea turtles sighted underwater at a given location may be of different populations: foraging turtles that reside around the area most of the time over a long period, and nesting turtles that visit the area during nesting season (Senko et al. 2010; Teh et al. 2018). The life history of green turtles is characterized by oceanic dispersal of post hatchling turtles that are transported by ocean currents for several years (Bolten 2003). During this stage, they are omnivorous and feed on any pelagic debris that comes across.

When they grow and increase their body size, they become less vulnerable to predators and eventually (after ~5-10 years) recruit into neritic feeding habitats (Musick and Limpus 1997, Bolten 2003) and feed on either seagrass or algae (Hirth 1971). Juvenile turtles often move through a succession of developmental habitats over a period of 20 years or more before settling into one area upon reaching sexual maturity (Musick and Limpus 1997, Jensen et al. 2013). Once turtles have settled into feeding grounds, they generally show strong fidelity to specific areas (López-Castro et al. 2010). They are recruited to neritic developmental habitats with an abundance of seagrass and/or marine algae, where they feed and grow until they reach sexual maturity (Musick and Limpus 1997). After reaching sexual maturity both females and males tend to migrate back to their natal rookery to mate and breed (Fitz-Simmons et al. 1997, López-Castro et al. 2010). In Sabah for instance, Mabul (Palaniappan and Haziq, 2017) and Mantanani (Pilcher 2010) Islands are some of the most documented foraging grounds for green turtles, with preferences towards shallow coral reef habitats and seagrass meadows.

The ecological behaviour of these turtles results in demographic isolation and significant genetic structuring among rookeries or nesting populations (Jensen et al. 2013). Nuclear gene flow may occur if turtles from different nesting stocks interbreed on foraging grounds or along migration corridors (Bowen et al. 2005), but the extent to which this male-mediated gene flow occurs remains unclear (Dutton et al. 2013, Roden et al. 2013). Population isolation means that they are not likely to be recolonized in the case of local population decline or local extinction, highlighting the importance of identifying rookeries in most need of protection (Bowen et al. 2005).

1.5 Threat analysis:

Threat	**Description of how this threat impacts the species**	**Intensity of threat** *(low, medium, high, critical, or unknown)*	**IUCN Red List threats classification**
Chemical and debris ingestion	Inhalations and indiscriminate feeding cause green turtles to consume contaminated water (oil spills and heavy metals) and debris, resulting in reduced food assimilation, gastro-intestinal tract obstruction, and potential damage to the tissues of their digestive tract (Camacho et al. 2013; Yaghmour 2019).	Medium	9.4: Garbage & solid waste
Debris entanglement	Green turtles are reported to get entangled in discarded fishing gears made of non-biodegradable synthetic materials (Wilcox et al. 2013; Duncan et al. 2017). Plastic debris in the water also causes entanglement of green turtles and may eventually lead to death (Vegter et al. 2014).	Critical	9.4: Garbage & solid waste
Intentional harvest of turtles	Green turtles are harvested intentionally for their meat and eggs for consumption (Bjorndal & Jackson 2002; Allen 2007).	Critical	5.4: Fishing & harvesting aquatic resources
Climate change/ global warming	Like any other marine turtles, green turtles exhibit temperature-dependent sexual determination (TSD; Mitchell et al. 2009; Telemeco et al. 2009). Successful incubation of eggs occurs between 25 and 33°C (Miller 1985). A major proportion of female hatchlings are observed at the upper thermal range during incubation phase and vice versa (Spotila & Standora 1985). Increased temperature due to climate change could lower hatchling success rate (Hawkes et al 2007), causing imbalances in population's sex ratios (Hawkes et al. 2007, 2009).	Medium	11.5: Climate change & severe weather: Other impacts
Vessel collisions	Vessel collision is a common threat for many marine megafauna, especially those that breath air. Green turtles forage at shallow waters and often these areas are hotspots for commercial and recreational vessels (Marsh et al. 2012; Schofield et al. 2015)	Critical	6.1: Recreational activities

Habitat destruction	Nesting turtles travel to natal sandy beach areas to lay eggs (Hirth 1980). These areas may be altered or lost due to human activities (Lutcavage et al. 1997) and rising sea temperature as a result of climate change (Baker et al. 2006; Fish et al. 2008). Green turtle foraging grounds are located primarily in shallow waters with presence of seagrass. These areas are being severely altered by anthropogenic activities (Christianen et al. 2014; Unsworth et al. 2018).	Medium	1: Residential & commercial development; 6.1 Recreational activities; and 11.1 Habitat shifting & alteration.

1.6 Stakeholder analysis:

Stakeholder	**Stakeholder's interest in the species' conservation**	**Current activities**	**Impact** *(positive, negative or both)*	**Intensity of impact** *(low, medium, high or critical)*
The Board of Trustees of the Sabah Parks.	It is established for the conservation of heritage sites of Sabah state of Malaysia.	Active monitoring and management on Sabah's Turtle Islands Heritage Protected Area (TIHPA), one of the largest nesting grounds of green turtles. In progress of gazetting Mantanani waters as part of the proposed marine protected area.	Positive: The gazettement will further enhance conservation efforts towards the protection of green turtles in the surrounding waters.	Critical
Mantanani Police authority	Green turtles are registered as a protected animal species by the state and is enforced through the police department.	Law and legislation enforcement on the protection and conservation of green sea turtle species.	Positive: Any party members that directly harm or threaten the survival of the species will be charged under the law. Violations of the law also include fish bombing, which was reported to be practiced by a small portion of the community.	Medium.
Local non-government organisation (Reef Check Malaysia – Mantanani)	Marine conservation and protection of threatened species (as listed in the IUCN red list of threatened species), aligned with the welfare of local communities involved, is their long-term goal.	Reef Check Malaysia team stationed in Mantanani has been focusing on promoting sustainable lifestyle and improving the quality of life of the local community. Some ongoing projects include solid waste management and	Positive: Improving community livelihoods helps to shift destructive fishing practice (fish bombing) to sustainable methods. Upskilling the community members allows them to acquire financial resources through other means (crafts, tourism & hospitality, and	High

		community upskilling programmes.	consumable products) as alternatives.	
Tourism sector (Resort and tour agencies)	Green turtles are charismatic key marine species. The reefs of Mantanani attract a vast variety of tourists from around the world. Having an abundance of foraging green turtles will add further value in terms of tour attraction to this hotspot.	Regular tourism activities include motorised boat operations for logistics (in and out between the island and mainland, around the island), recreational water activities (SCUBA diving, snorkelling, banana boating, etc.). Note: Due to the pandemic, most agencies are in retreat from business operation, which means there are very limited tour activities in Mantanani. This leads to the reduced motorised boat operations around the waters of Mantanani.	Positive. Low numbers of motorised boat operations are expected to reduce potential boat strikes to green turtles. A reduction in disturbance and harassment to foraging turtles is possible when SCUBA diving activities (one of the common water-based tour activities in Mantanani) are reduced. Negative. Unregulated boat traffic and operations could potentially collide with and harm sea turtles. Reduced tourism impact community financial income and can create economical shift towards a more marine resources-dependent livelihood practice.	Critical

1.7 Context and background information that will affect the success of any conservation action for this species:

	Description	Barriers to conservation	Opportunities for conservation
Socio-cultural effects and cultural attitudes	Local communities currently rely on small scale fishing to sustain their livelihood with a complimentary financial income from tourism activities. Fishermen practiced fish bombing in the past. However, this fishing method has reduced due to enforcement by the state authority, though not completely absent. Unpublished reports mentioned rare occurrence of green turtle nesting, but the eggs were collected by the community as a food source.	The inability for stakeholders to be aware of the long-term negative impacts towards the marine environment by the lack of management on fishing and tour activities. These impacts will cause habitat degradation, which will in turn affect their livelihood. The lack of awareness and knowledge in the community about the impact of using bombing methods to harvest seafood, added to the ease of harvesting fish compared to the traditional hook and line method, is causing the persistence of such destructive practice.	The long-term dependence on local fishery resources allows the opportunity to develop alternative livelihoods that are sustainable. A positive change must be adopted by local fishers in order to ensure marine resources are sustainable.

Economic implications	Green turtles can economically affect the tourism sector and the livelihood of the community indirectly. Green turtles are charismatic animals and are always an attraction for tourists and visitors. They are a key marine species because they play crucial ecological role in coral reef and seagrass habitats mainly as nutrient transporters. The community has founded the Mantanani Homestay, a program by which they offer accommodation and hospitality services to tourists and visitors on the island. Some are even trained and offers PADI SCUBA diving courses, who were previously working as fishers.	Increased tourism and fishing activities without proper regulations and managements could threaten the local green turtle local population and the marine ecosystem in general. Currently, engagement of the local community in conservation or environmentally friendly activities is low, due to a lack of awareness and education programs	Expansion of the local tourism industry and the need for the community to harvest marine resources for their livelihood gives opportunity to develop nature-based tourism. This form of economy allows communities to sustain their livelihood while ensuring their marine resources are well-protected. 'Sea turtle rangers' initiative can be spear-headed train local fishermen to observe and protect nesting adult green sea turtles to keep their eggs protected and increase hatchling success rate.
Existing conservation measures	Green turtles are listed as fully protected animals. Fines and imprisonment will be imposed to individuals caught guilty of harassing, harvesting,	Most people from the local community have a negative perception about the marine protected area proposal. There is an unwillingness to adopt sustainable fishing practices and respect proposed	upskilling programmes to increase alternative income for the community could serve as good incentive to reduce illegal fishing practices. This will reduce

	and killing the animal, part of the animal, and/or product of the animal. There is a proposed gazettement of Mantanani waters as part of a marine protected area by the state government sector.	zoning to protect important sea turtle foraging areas. Lack of studies on and understanding of how the welfare of the community will be maintained if the gazettement is enforced.	their dependency on harvesting marine resources, which make possible the implementation of the marine protected area.
Administrative/ political set-up	Mantanani Island is under the jurisdiction of the district of Kota Belud. A village chief, usually a man, is enacted every several years (though not consistent) for decision making on local welfare, including land management and cultural affairs. Waste management, electricity supplies, and tourism are regulated and taxed by the district administrations. The gazettement and enforcement of the proposed marine protection area by the Sabah Parks is under the state's authority.	Due to logistical difficulty of accessing the island, essential supplies and services (waste management and electricity) are provided to the community at a higher cost. A lack of involvement and investments by NGOs and various government sectors, primarily due to the accessibility to the islands. This is among the factors that slows down progress for the proposed action plan. Government representatives are less welcomed by the Mantanani community due to the fear of the enforcement of the 'no-take' zones at their fishing grounds.	Community members are keen to participate and contribute toward efforts to improve their livelihood. Sustainable development and local fishery practices should aim at improving livelihood for the community.

Local expertise and interest	Sabah Parks, in collaboration with the Borneo Marine Research Institute of Universiti Malaysia Sabah will provide essential expertise to evaluate conservation action plans suited for enforcement in the case of Mantanani waters.	Limited funding and financial resources by the stakeholders cause difficulty in establishing collaborative programmes. Although the proposed gazettement of Mantanani as an MPA still stands, there is a lack of extensive research to gather baseline data for decision making.	Through decades of working alongside with the community of Mantanani by local NGOs, the community is slowly becoming aware of the importance of sustainable practices and of preserving their marine assets. This allows them to be more receptive to conservation interventions, as long as their income and livelihood is not compromised.
Resources	Conservation resources are majorly provided by local and international NGOs. Government investments are channelled towards completion of the proposed marine protected area.	Conservation and research projects are initiated through grant applications. There is a need for plans to acquire long-term funds for the continuation of conservation works. Sea turtles are long-lived animals and conservation results can only be seen after years of consistent efforts.	Results from a survey in the community showed that many members are willing to engage with conservation activities as a livelihood alternative, to reduce, but not quit fishing. This will create opportunity for capacity building as a step forward to expand conservation effort.

2. ACTION PROGRAMME

Vision (30-50 years)	
A sustainable population of green turtles in the waters of Mantanani through community-driven conservation efforts.	
Goal(s) (5-10 years)	
Identify and minimise the threats to green turtles that are recruited to the foraging grounds of Mantanani.	
Objectives	**Prioritisation** *(low, medium, high, or critical)*
Identify and quantify main threats to foraging green turtles in the waters of Mantanani by the end of 2023.	Medium
Extend ongoing aerial monitoring program to understand changes over time of the distribution and abundance of green turtles in the shallow waters of Mantanani.	High
Estimate the home range of green sea turtles in the coral reefs of Mantanani by 2025.	High
Upskilling at least 20 local fishing community members to transition into ecotourism jobs by 2025.	High
Facilitate a participatory drafting process of the management plan for the proposed MPA to be created in Mantanani, ensuring local communities are included appropriately in the process.	Critical

Activities	Country / region	Priority *(low, medium, high, or critical)*	Associated costs (currency)	Time scale	Responsible stakeholders	Indicators	Risks	Activity type
Objective 1: **Identify and quantify main threats to foraging green turtles in the waters of Mantanani by the end of 2023**								
Interview surveys on bycatch of green turtles through artisanal fishery.	Mantanani, Sabah	High	~ £ 800 per survey for hire marine biologist to conduct interview. ~ £ 500 per survey to cover field expenses.	Annually for 5 years	NGOs	Reports on annual green turtle bycatch through local fishing activities.	Lack of cooperation by the fishermen. Fishermen provide inappropriate information, resulting in false interpretation of bycatch numbers.	Research and scientific data collection.
Initiate monitoring program to document	Mantanani, Sabah	High	~ £ 5,000 per year to hire a wildlife ranger.	10 to 20 years minimum	NGOs & community members.	Reports on annual green turtle stranding numbers and causes.	Stranding cases not reported and documented. Lack of interest by the monitoring team.	Conservation action program.

stranded green turtles.			~ £ 200 for training expenses.					
Objective 2: **Extend ongoing aerial monitoring program to understand changes over time of the distribution and abundance of green turtles in the shallow waters of Mantanani.**								
Workshop training for other NGOs and the community on unmanned aerial vehicles for green turtle aerial monitoring applications.	Mantanani, Sabah (and probably other potential green turtle foraging shallow waters)	High	~ £ 1,000 expenses per workshop. ~ £ 200 per field survey, including logistics, accommodation, and other expenses.	Monthly data collection for at least 3 years period	NGOs, community, and government authority.	Secure interests from the community members and local NGO to support the program. Community / NGO-led aerial monitoring program for long-term data collection.	Lack of interest and commitment by the stakeholders.	Capacity building.
Acquire aerial monitoring	Mantanani, Sabah	High	~ £ 2,000 to purchase	1 to 2 years period	NGOs, community, and	Acquire all necessary	Insufficient funding resources to purchase equipment.	Equipment purchase.

equipment and tools.			equipment (a full set drone equipment). ~ £ 4,000 to subscribe to computer applications for data analyses and aerial photogrammetry, and cloud computing.		government & non-government associations with grants and funding opportunities.	equipment and desktop application to initiate aerial mapping procedures.	Lack of maintenance on aerial equipment could cause malfunctioning.	
Initiation of long-term aerial monitoring program.	Mantanani, Sabah	High	~ £ 2,400 annual overhead cost for aerial mapping. ~ £ 2,000 on reporting and publication expanses.	5 years period or more.	NGOs, community, scientific peer reviewers and conservation advisory services from leading	Data visualisation and mapping long-term distributions of foraging green turtles. Annual reports and 5-year report on	Inconsistency of aerial planning for the long-term aerial monitoring program. Zoning plan causes conflict of interests among the various stakeholders.	Reporting and conservation action implementation.

					international sea turtle conservation organisations.	sea turtle distribution incorporating possible marine conservation zoning plan at targeting areas.		
Objective 3: **Determine the site fidelity of at least 10 green turtles foraging in the coral reefs of Mantanani by 2025 through acoustic telemetry application.**								
Obtain acoustic receivers and transmitters.	Mantanani, Sabah	Medium	~ £ 5,000 to purchase 15 telemetry equipment and necessary tools.	Within first 2 years	Local SCUBA diving agencies.	Received acoustic receivers and transmitters.	Inappropriate acoustic receivers and transmitters being purchased for the project.	Purchase of tools, equipment, and facility.
Organise turtle capture and tagging field trips	Mantanani, Sabah	High	~ £ 3,000 for program expenses.	5 to 10 years		Acoustic transmitters appropriately attached to the captured turtles	Personnel safety being compromised while on the field to capture green turtles.	Conservation action program.

Deploy receivers at selected established SCUBA dive sites.	Mantanani, Sabah	High	~ £ 500 to deploy 15 receivers through SCUBA diving method, at selected coral reef dive sites. ~ £ 2,000 for data collection and devices maintenance. ~ £ 1,000 for data analyses and publication fees.	5 to 10 years		Acoustic receivers deployed at 15 selected sites and acquire data on green turtle site fidelity.	Receivers not appropriately placed, causing damage or loss of the equipment.	Research and scientific data collection.
Objective 4: **Upskilling at least 20 local fishing community members to transition into ecotourism jobs by 2025.**								
Plan and organise training workshops and awareness program on	Mantanani, Sabah	High	~ £ 1,000 expense per workshop session.	2 years	NGOs and local community, corporate trainers	Planned workshops and community members attended the workshops.	Lack of interest and participations by the community members, especially local fishermen.	Capacity building, sustainable development.

sustainable fishery practices, eco-friendly tourism and promoting alternative income sources for the local community.			~ £ 1,000 to hire trainer per workshop session. ~ £ 3,000 to fund and start up community-led economy development.			Establish community-led corporate start-ups.		
Plan and organise training sessions (identification of threatened marine species; eco-friendly practices for SCUBA diving; and boat speed limits) for local tour guide and	Mantanani, Sabah	High	~ £ 1,000 expense per workshop session. ~ £ 1,000 to hire trainer per workshop session.	2 years	NGOs and local tour operators	Planned training sessions and tour operators invited for the programs.	Lack of interest and participations by the tour operators.	Capacity building

SCUBA diving instructors.								
Setup of promotion media and tour facilities in collaboration with local tour operators and community members involved in tourism sector to boost eco-tourism in Mantanani.	Mantanani, Sabah	High	~ £ 1,000 media production and webpage design. ~ £ 10,000 allocation for facility building. ~ £ 2,000 yearly for facility maintenance.	2 to 5 years.	NGOs, tour operators and community members	Promotion webpages being setup (with highlights on on-going conservation projects) to promote and receive tour bookings from clients. Appropriate and eco-friendly facilities setup for tour activities operation.	Lack of interests by established tour operators to incorporate eco-tourism as their marketing strategy to promote tour business. Insufficient funds and monetary investment into setting up eco-friendly facilities.	Eco-friendly development program.

Objective 5: **Facilitate a participatory drafting process of the management plan for the proposed MPA to be created in Mantanani, ensuring local communities are included appropriately in the process.**								
Organise discussion sessions to present acquired scientific results to compliment and discuss action plans for the conservation of marine resources in the waters of Mantanani	Mantanani and in the district of Kota Belud, Sabah.	High	~ £ 1,000 logistic expenses. ~ £ 1,000 for results publishing expenses.	5 years	NGOs, local and federal authorities	Discussion sessions held with the government authorities and the community leaders of Mantanani community. Compilated results of the in-water monitoring programs submitted and reviewed by the panels of the Sabah Parks Board of Trustees.	Interrupted events that hinder data collection in the local monitoring programs, causing incomplete data used for analyses. This will result to inaccurate outcomes being submitted for the review process. Risk of the submitted reports not reviewed by the panels in the decision-making process.	Conservation action program.

Policy drafting to highlight and protect marine turtle foraging hotspots and zoning of boat restriction areas for reduce boat strike as a threat to marine turtles.	Mantanani, Sabah	Critical	~ £ 2,000 field expenses for logistic and accommodation, boat rental, etc.	1 year	NGOs, local and federal authorities, community members	Community-led conservation initiatives focusing on the marine turtle hotspot areas. Policy draft and enforcement action plan for the conservation of marine turtles.	Zoning areas conflict with the local fishing grounds and common boat areas. Insufficient results from the varies aspects of the actual context for the implementation of zoning sensitive areas for the conservation of marine turtles.	Regulations, and enforcement of legislations.

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