HAWKSBILL SEA TURTLE
(ERETMOCHELYS IMBRICATA)

5-YEAR REVIEW:
SUMMARY AND EVALUATION

NATIONAL MARINE FISHERIES SERVICE
OFFICE OF PROTECTED RESOURCES
SILVER SPRING, MARYLAND
AND
U.S. FISH AND WILDLIFE SERVICE
SOUTHEAST REGION
JACKSONVILLE ECOLOGICAL SERVICES OFFICE
JACKSONVILLE, FLORIDA

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U.S. Department of Commerce
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NATIONAL MARINE FISHERIES SERVICE

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U.S. FISH AND WILDLIFE SERVICE

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1.0 GENERAL INFORMATION

1.1 Reviewers

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1.2. Methodology used to complete the review

The National Marine Fisheries Service (NMFS) Office of Protected Resources led the 5-year review with input from the U.S. Fish and Wildlife Service (FWS). The draft document was distributed to NMFS regional offices and FWS regional and field offices for their review, and edits were incorporated where appropriate. Information sources include the final rule listing of this species under the Endangered Species Act (ESA); recovery plans for the U.S. Pacific and for the U.S. Caribbean, Atlantic and Gulf of Mexico; peer reviewed publications; unpublished field observations by the NMFS and FWS (Services), States; unpublished survey reports; and notes and communications from other qualified biologists. The public notice for this review was published on October 10, 2012, with a 60-day comment period (77 FR 61573). Two comments were received relevant to the hawksbill sea turtle. The commenters provided information on the continued threat of fisheries bycatch and adverse impacts of climate change. The information was incorporated as appropriate into the 5-year review.

1.3 Background

1.3.1 FR notice citation announcing initiation of this review

October 10, 2012 (77 FR 61573)

1.3.2 Listing history

Original Listing
FR notice: 35 FR 8491
Date listed: June 2, 1970
Entity listed: Species
Classification: Endangered

1.3.3 Associated rulemakings

Critical Habitat Designation: 47 FR 27295, June 24, 1982. The purpose of this rule was to designate terrestrial critical habitat for the hawksbill turtle as follows: Puerto Rico: (1) Isla Mona. All areas of beachfront on the west, south, and east sides of the island from mean high tide inland to a point 150 meters from shore. This includes all 7.2 kilometers of beaches on Isla Mona. (2) Culebra Island. The following areas of beachfront on the north shore of the island from mean high tide to a point 150 meters from shore: Playa Resaca, Playa Brava, and Playa Larga. (3) Cayo Norte. South beach, from mean high tide inland to a point 150 meters from shore. (4) Island Culebrita. All beachfront areas on the southwest facing shore, east facing shore, and northwest facing shore of the island from mean high tide inland to a point 150 meters from shore.

Critical Habitat Designation: 63 FR 46693, September 2, 1998. The purpose of this rule was to designate marine critical habitat for the hawksbill turtle as follows: Mona and Monito Islands, Puerto Rico – Waters surrounding the islands of Mona and Monito, from the mean high water line seaward to 3 nautical miles (5.6 km).

Regulations Consolidation Final Rule: 64 FR 14052, March 23, 1999. The purpose of this rule was to make the regulations regarding implementation of the Endangered Species Act of 1973 by NMFS for marine species more concise, better organized, and therefore easier for the public to use.

1.3.4 Review history

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007. Hawksbill Sea Turtle (*Eretmochelys imbricata*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Silver Spring, Maryland, and U.S. Fish and Wildlife Service Jacksonville, Florida. 90 pages.

> Conclusion: Retain the listing as an endangered species. However, a review and analysis of the species listing relative to the Distinct Population Segment policy was recommended.

Plotkin, P.T. (Editor). 1995. National Marine Fisheries Service and U.S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland. 139 pages.

> Conclusion: Retain the listing as an endangered species.

Mager, A.M., Jr. 1985. Five-year status reviews of sea turtles listed under the Endangered Species Act of 1973. U.S. Department of Commerce, NOAA, National Marine Fisheries Service, St. Petersburg, Florida. 90 pages.

> Conclusion: Retain the listing as an endangered species.

FWS also conducted 5-year reviews for the hawksbill in 1985 (50 FR 29901) and in 1991 (56 FR 56882). In these reviews, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors or threats as they pertain to the individual species. The

notices stated that FWS was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notices indicated that if significant data were available warranting a change in a species classification, the Service would propose a rule to modify the species status.

Conclusions: Retain listing as endangered throughout its range.

1.3.5 Species' recovery priority number at start of review

National Marine Fisheries Service = 1 (this represents a high magnitude of threat, a high recovery potential, and the presence of conflict with economic activities).
U.S. Fish and Wildlife Service (48 FR 43098) = 1C (this represents a monotypic genus with a high degree of threat, a high recovery potential, and the potential for conflict with construction or other development projects or other forms of economic activity).

1.3.6 Recovery plans

Name of plan: Recovery Plan for the Hawksbill Turtle (*Eretmochelys imbricata*) in the U.S. Caribbean, Atlantic and Gulf of Mexico (NMFS and FWS 1993)
Date issued: December 15, 1993

Name of plan: Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*) (NMFS and FWS 1998)
Date issued: January 12, 1998

Dates of previous plans: Original plan date - September 19, 1984

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate? Yes.

2.1.2 Is the species under review listed as a DPS? No.

2.1.3 Is there relevant new information for this species regarding the application of the DPS policy?

Yes. In the 2007 5-year review, we noted information indicating an analysis and review of the species should be conducted in the future to determine the application of the DPS policy to the hawksbill. Since the species' listing, a substantial amount of information has become available on population structure (through genetic studies) and distribution (through telemetry, tagging, and genetic studies). The Services have not yet fully assembled or analyzed this new information; however, at a minimum, these data appear to indicate a possible separation of populations by ocean basins.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

No. The existing recovery plans are based on population and management units within ocean basins and do not represent the species' listing. The Recovery Plan for the Hawksbill Turtle (*Eretmochelys imbricata*) in the U.S. Caribbean, Atlantic and Gulf of Mexico was signed in 1993, and the Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*) was signed in 1998. The recovery criteria, in these plans, do not strictly adhere to all elements of the 2006 NMFS Interim Recovery Planning Guidance, but may provide a useful benchmark for measuring progress toward recovery. Thus, we consider progress toward recovery objectives in this section.

Recovery Objectives as written in the U.S. Caribbean, Atlantic, and Gulf of Mexico Recovery Plan

The U.S. populations of hawksbill turtles can be considered for delisting if, over a period of 25 years, the following conditions are met:

1. The adult female population is increasing, as evidenced by a statistically significant trend in the annual number of nests on at least five index beaches, including Mona Island, Puerto Rico, and Buck Island Reef National Monument, U.S. Virgin Islands.

   Status: Two nesting populations are increasing: Puerto Rico (Mona Island) and U.S. Virgin Islands (Buck Island Reef National Monument). Also in the U.S. Caribbean, additional nesting beaches are now being more systematically monitored to allow for future population trend assessments. Elsewhere in the Caribbean outside U.S. jurisdiction, nesting populations in Antigua/Barbuda and Barbados are increasing; however, other important nesting concentrations in the insular Caribbean are decreasing or their status is unknown, including Antiqua/Barbuda (except Jumby Bay), Bahamas, Cuba (Doce Leguas Cays), Jamaica, and Trinidad and Tobago. The Turks and Caicos Islands host a remnant population, and the Cayman Islands nesting population is thought to be extirpated.

2. Habitat for at least 50 percent of the nesting activity that occurs in the U.S. Virgin Islands and Puerto Rico is protected in perpetuity.

   Status: Major nesting areas for hawksbills have been identified and are being protected; however, information on the extent of nesting activity occurring on protected lands is currently insufficient to make a determination of progress toward meeting this recovery objective.

3. Numbers of adults, subadults, and juveniles are increasing, as evidenced by a statistically significant trend on at least five key foraging areas within Puerto Rico, U.S.Virgin Islands, and Florida.

   Status: This task is partially complete. An in-water research project at Mona Island, Puerto Rico, has been ongoing for 15 years. Although the project has provided excellent information on habitat use, abundance indices have not yet been incorporated into a rigorous analysis or a published trends assessment. In addition, standardized in-water surveys have been initiated within the wider Caribbean (e.g., Pearl Cays, Nicaragua), but the time series is not long enough to detect a trend. In Florida, two in-water projects have been ongoing in Key West and Marquesas Keys conducted by the In-Water Research Group and Palm Beach County.

4. All priority one tasks have been successfully implemented.

- Identify important nesting beaches (Task 111).

  Status: This task is partially complete. Expanded nesting surveys in some areas have helped to identify beaches used by hawksbills. Florida has an extensive nesting beach survey program, and a small amount of hawksbill nesting has been documented, primarily in South Florida. In Puerto Rico, monitoring of nesting beaches has identified hawksbill nesting on the main island, and on the islands of Culebra and Vieques, as well as Mona Island. In the U.S. Virgin Islands, hawksbill nesting has been documented on several beaches on St. Croix, St. John, and St. Thomas, as well as at Buck Island Reef National Monument.

- Ensure long-term protection of important nesting beaches (Task 112).

  Status: This task is ongoing. Key beaches are protected in Florida, Puerto Rico, and the U.S. Virgin Islands. However, as other beaches are identified, they should be acquired or otherwise managed to ensure long-term protection.

- Prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties and breakwaters (Task 114).

  Status: This task is ongoing. FWS and NMFS work with the U.S. Army Corps of Engineers (USACE) to review projects and minimize the impacts of shoreline stabilization practices. However, with increasing storms and sea-level rise expected from climate change, there will likely be more frequent use of erosion-control measures.

- Identify important marine habitats (Task 121).

  Status: This task is partially complete. Several in-water foraging ground monitoring sites have been established and numerous satellite telemetry studies have been conducted to elucidate migration patterns and habitat use in the Caribbean Sea and Gulf of Mexico.

- Prevent the degradation or destruction of important [marine] habitats caused by upland and coastal erosion and siltation (Task 126).

  Status: This task is ongoing. The Puerto Rico Environmental Quality Board requires developers to use sediment fences to reduce upland erosion impacts on surface waters. FWS has worked with local governments and private entities in Puerto Rico and Florida to develop habitat conservation plans that include measures to minimize and/or mitigate impacts to hawksbill sea turtles from beach driving, beach armoring, and coastal construction activities.

- Prevent the degradation of reef habitat caused by sewage and other pollutants (Task 127).

  Status: This task is ongoing. NMFS consults with the Environmental Protection Agency on projects that may affect water quality. Although water quality has improved, significant impairment remains, especially in Puerto Rico where urban runoff, agriculture, and municipal discharge have impacted estuaries, bays, and coastal waters (http://www.epa.gov/waters/ir/index.html).

- Monitor nesting activity on important nesting beaches with standardized index surveys (Task 211).

  Status: This task is ongoing. Monitoring programs have been established and are ongoing at key nesting beaches in Florida, Puerto Rico (Mona Island), and U.S. Virgin Islands (Buck Island Reef National Monument).

- Evaluate nest success and implement appropriate nest-protection measures on important nesting beaches (Task 212).

  Status: This task is ongoing. Efforts are ongoing to evaluate nest success and implement nest protection measures. Studies are ongoing on how to predict and prevent egg depredation by mongoose, a major issue in the Caribbean.

- Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles (Task 214) and increase law-enforcement efforts to reduce illegal exploitation (Task 225).

  Status: This task is ongoing. Efforts are ongoing to prevent poaching on nesting beaches and illegal fishing of turtles. Illegal poaching is rare in the United States and jurisdictional territories.

- Determine nesting beach origins for juvenile and subadult populations (Task 217)

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Status: This task is partially complete. Population genetic structure of nesting and foraging turtles has been elucidated for populations in the U.S. Virgin Islands, Costa Rica, Mexico, Barbados, Antiqua, Nicaragua, Puerto Rico, Cuba, and Guadeloupe.

Recovery Objectives as written in the U.S. Pacific Recovery Plan

The hawksbill recovery criteria for delisting identified for the Pacific Ocean are:

1. All regional stocks[1] that use U.S. waters have been identified to source beaches based on reasonable geographic parameters.

   Status: Substantial efforts have been made to determine the nesting population origins of hawksbills on foraging grounds, and genetic research has shown that hawksbills of multiple nesting beach origins commonly mix in these areas. Over 550 hawksbill tissue samples have been archived in the NMFS Southwest Fisheries Science Center Molecular Research Sample Collection, intended for use in a variety of eastern and western Pacific population structure and trophic studies. Genetic analysis has been completed for nesting populations in the Pacific Ocean where samples have been obtained. However, additional sampling of nesting populations is needed to obtain a more complete understanding of connectivity and population structure in the Pacific.

2. Each stock must average 1,000 females estimated to nest annually (FENA) (or a biologically reasonable estimate based on the goal of maintaining a stable population in perpetuity) over six years.

   Status: In the Pacific areas under U.S. jurisdiction or U.S. affiliation, about 20 females nest annually in Hawaii. Nesting data have not been analyzed for trend information, although historic nesting density may have been significantly higher. In the Republic of Palau, 15-25 females nest annually, but the population trend is unknown. American Samoa has less than 30 females, and anecdotal information suggests the population has declined. In the Mariana Archipelago of Guam and the Commonwealth of the Northern Mariana Islands, less than 10 females nest annually, which likely represents a significant decrease from historic levels. Information on nesting activity is lacking for the Federated States of Micronesia, and the Republic of the Marshall Islands. However, Micronesia, with its thousands of islands and atolls, probably supports about 300 females annually. The populations in Micronesia, Melanesia and Polynesia (with exception of Hawaii) are exploited for shell, meat and eggs for local consumption, and are considered overall depleted and declining.

[1] The U.S. Pacific Recovery Plan does not explicitly define the term 'stocks.' However, the Plan specifies sea turtle populations under U.S. jurisdiction in terms of the recovery criteria and, in terms of taxonomy, cites D. Broderick (pers. comm.)—"suggests using the term 'stocks' rather than separate subspecies, especially at the management level, because this is where population changes will be detected."

3. All females estimated to nest annually (FENA) at source beaches are either stable or increasing for 25 years.

   Status: Nesting beach monitoring has been supported at several source beaches, but the time series, in most cases, is not sufficient to determine the progress towards this recovery objective. In Hawaii, nesting activity has been monitored since 1989 on the Big Island where 3 to 18 females nest per year. A few turtles nest on Maui and Molokai. Capacity building in American Samoa, Guam, Commonwealth of the Northern Mariana Islands, and Palau for nesting beach monitoring has been supported. Nesting beach monitoring occurs in American Samoa, whereas Guam and the Commonwealth of the Northern Mariana Islands programs monitor for green turtles and opportunistically record data on hawksbills. Nesting beach monitoring and tagging of nesting females on the outer islands of Yap State, Federated States of Micronesia has also been supported.

4. Existing foraging areas are maintained as healthy environments.

   Status: Efforts to attain this goal are ongoing. In-water assessments of threats to habitat have been supported in America Samoa, Guam, Commonwealth of the Northern Mariana Islands, and Palmyra Atoll.

5. Foraging populations are exhibiting statistically significant increases at several key foraging grounds within each stock region.

   Status: Capacity building in American Samoa and Palau for in-water monitoring has been supported. Capture-mark-recapture studies of sea turtles in the Pacific islands under U.S. jurisdiction occur in the Commonwealth of the Northern Mariana Islands, Palmyra Atoll, and Hawaii. However, the duration of these in-water monitoring programs have not been sufficient for trend analysis.

6. All priority #1 tasks have been implemented.

- Protect and manage turtles on nesting beaches (Tasks 1.1.1.1, 1.1.1.2, 1.1.2, 1.1.3, 1.1.5.1, 1.1.5.2, and 1.1.5.3.1 through 1.1.5.3.3).

   Status: These tasks are ongoing or partially complete. Public education efforts to reduce directed and incidental take are ongoing in Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Marina Islands. For example, NMFS facilitated the design and production of signs informing the public of the laws against poaching in Guam and the Commonwealth of the Northern Mariana Islands. Enforcement has been increased to prevent illegal exploitation and harassment on nesting beaches and in the marine environment. In Hawaii, an invasive species removal program has been implemented on the Big Island and Maui. Other threats being addressed include artificial lights, hatchling stranding, vehicular traffic, and incompatible recreational use of nesting beaches. In Hawaii, an outreach program has been implemented to reduce recreational fisheries interactions with sea turtles, including hawksbills. Nest monitoring programs also are supported and ongoing on Ofu and Olosega Islands in American Samoa, the

Commonwealth of Northern Mariana Islands, Guam, the outer islands of Yap State, Federated States of Micronesia, and the Republic of Palau.

- Protect and manage nesting habitat (Tasks 1.2.1, 1.2.2).

Status: These tasks are ongoing. In areas under U.S. jurisdiction, NMFS and FWS consult with the USACE on projects to control beach erosion. Measures to minimize the impacts of erosion control structures such as jetties and breakwaters are considered in the consultation process. NMFS provided comments on numerous draft Environmental Impact Statements for the construction of jetties or breakwaters in Hawaii outlining the potential impacts to sea turtles and suggesting mitigating activities such as measures to reduce light pollution and seasonal restrictions on construction activities.

- Protect and manage populations in marine habitat (Tasks 2.1.1.1, 2.1.1.2, 2.1.2.1 through 2.1.2.4, and 2.1.8).

Status: These tasks are ongoing, partially complete, or complete. Public education efforts to reduce directed and incidental take are ongoing in Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands. NMFS supports or has supported in-water surveys and studies in American Samoa, Guam, Commonwealth of the Northern Mariana Islands, Hawaii, and Palmyra Atoll. A capture-mark-recapture program in the Commonwealth of the Northern Mariana Islands was conducted for the period between August 2006 and March 2013. The results of this study will increase our understanding of recruitment, habitat use, ecology, and growth rates of neritic foraging populations in the western Pacific Ocean (Summers *et al.* 2013 unpublished). Satellite and radio telemetry studies of post-nesting females in the main Hawaiian Islands and American Samoa have been conducted. A skeletochronological study was completed in Hawaii to determine growth rates, survivorship, and age to sexual maturity. A centralized tagging program and tag-series database were completed (Turtle Research Database System) in collaboration with six international agencies. An in-water population assessment that includes genetic analyses and a threat assessment study is ongoing at Palmyra Atoll. Genetic studies were also supported in the Marshall Islands and Hawaii.

- Protect and manage marine habitat (Tasks 2.2.1 through 2.2.7).

Status: These tasks are ongoing or partially complete. In areas under U.S. jurisdiction, NMFS consults with the USACE on dredging and harbor construction and maintenance to minimize the impacts from siltation, blasting, and direct destruction or modification of marine habitat. NMFS also consults with the USACE and Environmental Protection Agency on actions that affect water quality.

- International Cooperation (Tasks 4.1 through 4.3).

Status: The United States is a party to the Secretariat of the Pacific Regional Environment Program (SPREP), which has goals to promote cooperation in the Pacific Islands region and to provide assistance to ensure sustainable development for present

and future generations. Sea turtles are among the focal animal groups within this program through SPREP's Marine Turtle Action Plan. The United States is a party to the Inter-American Convention for the Protection and Conservation of Sea Turtles, a binding agreement that has the potential to enhance the conservation of hawksbills in the U.S. Pacific and adjoining western hemisphere nations. The United States participated in the Indian Ocean Southeast Asian Marine Turtle Memorandum of Understanding (IOSEA) to provide a similar comprehensive framework for the conservation and protection of sea turtles and their habitats in the Indo-Pacific region. See section 2.3.2.4 for a complete list of international efforts.

2.3 Updated Information and Current Species Status

The review is current with information available through early 2013. Recent research has added to our knowledge of how hawksbill sea turtles interact with their environment and how they contribute to a healthy marine ecosystem. We know more now about their migration patterns and fine scale movements within local habitats. We have a better understanding of the biological and environmental factors that drive individual choices for where a hawksbill forages and what it eats. The results of long-term studies have filled gaps in our understanding of hawksbill demography and population structure. Advances in genetic and stable isotope analyses, tagging techniques, especially satellite, radio, and sonic telemetry, and time depth recorders have vastly improved our knowledge of the biology and ecology of hawksbill sea turtles. Understanding the ecological role of hawksbills and predicting where they are in space and time are important for developing management strategies to meet recovery goals and objectives.

2.3.1 Biology and Habitat

Distribution

Hawksbills nest on insular and mainland sandy beaches throughout the tropics and subtropics (Figure 1; for additional maps see State of the Worlds Sea Turtles OBIS-SEAMAP: http://seaturtlestatus.org/). Once considered to be naturally rare and to have a more dispersed nesting pattern than other sea turtle species (Groombridge and Luxmoore 1989), it is now believed that the dispersed nesting observed today is the result of overexploitation of previously large colonies (Limpus 1995; Meylan and Donnelly 1999). Sites where aggregated nesting occurs may typify pre-exploitation levels of hawksbill nesting density. These sites include Dimaniyat Islands of Oman (Salm *et al.* 1993), Milman Island in Australia (Dobbs *et al.* 1999), the Yucatan Peninsula in Mexico (Meylan and Donnelly 1999), and at certain protected sites in the Seychelles (see Allen *et al.* 2010; Meylan and Donnelly 1999). Several sites that formerly held large breeding colonies are known to have been lost once inhabited by humans, including the Cayman Islands (Bell *et al*. 2006, 2007) and extensive sections of the Brazilian coastline (Frazier 1980; Mangar and Chapman 1996; Marcovaldi *et al.* 2007). Several nesting aggregations have been nearly extirpated (i.e., less than 10 nesting females per year), including Turks and Caicos Islands, British Oversees Territory, Bonaire, Costa Rica (Tortuguero National Park), Equatorial Guinea (Bioko), Honduras (Bay Islands), Kenya, Mozambique, Myanmar, Sri Lanka, and Thailand (Andaman Sea coast), Japan, and Malaysia and areas throughout Micronesia, Melanesia, and Polynesia in the Pacific.

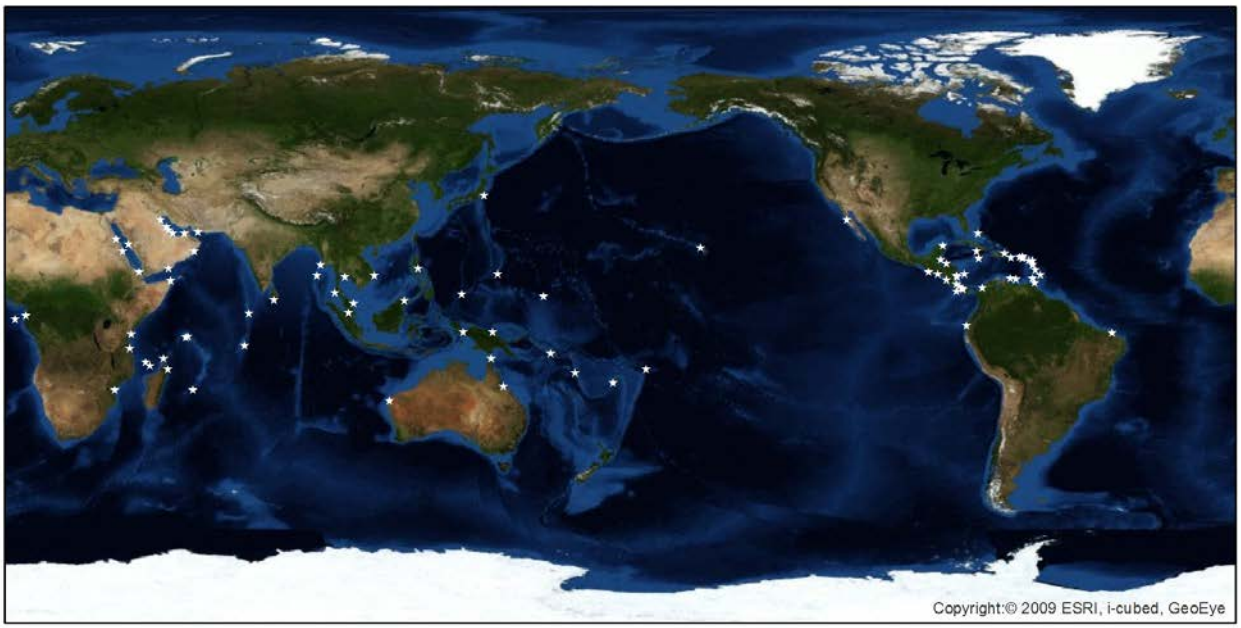

Figure 1. Global Nesting Distribution—Hawksbill Sea Turtle (see Tables 1-3 for source information).

Migration and Reproduction

Hawksbill movement within the marine environment is not fully understood, but it is believed hawksbills inhabit coastal waters of more than 108 countries (Groombridge and Luxmoore 1989). Adult hawksbills were once considered to be relatively non-migratory, but are now thought to use a mixed migration strategy. Post-reproductive tagging, telemetry, and genetic studies have revealed that some turtles remain close to their rookery and others are highly mobile, traveling hundreds to thousands of kilometers between nesting beaches and foraging areas (Hawkes *et al.* 2012; Horrocks *et al.* 2011; Moncada *et al*. 2012; Musick and Limpus 1997; reviewed by Plotkin 2003; Tagarino and Saili in press*;* van Dam *et al.* 2008). Some post-nesting females travel less than 200 km (Ellis *et al.* 2000; Horrocks *et al.* 2011; Marcovaldi *et al.* 2012; Moncada *et al*. 2012; Mortimer and Balazs 2000; Parker *et al.* 2009; van Dam *et al*. 2012) while others migrate distances exceeding 2,000 km (Cuevas *et al.* 2008; Ellis *et al.* 2000; Gaos *et al.* 2012b; Hawkes *et al.* 2012; Hillis-Starr *et al.* 2000; Horrocks *et al.* 2001, 2011; Marcovaldi *et al.* 2012; Miller *et al.* 1998; Moncada *et al.* 2012; Mortimer 2002; Parker *et al.* 2009; Tagarino and Saili in press; Troëng *et al.* 2005; van Dam *et al*. 2008). The distance an individual will travel after the nesting season varies within the same rookery. For example, post-nesting travel of females from Mona Island, Puerto Rico, ranged from 84 km to reach foraging grounds within waters of Puerto Rico to 2,051 km to forage in waters of Nicaragua and Honduras (van Dam *et al.* 2008). Moncada *et al.* (2012) found similar movement in post-nesting females tracked from Cuba, where some stayed within Cuban waters (< 578 km) and others traveled in excess of 2,000 km to foraging areas off Nicaragua and Honduras. A post-nesting hawksbill satellite tagged in Samoa by SPREP in 2006 traveled through the waters of seven nations for a distance of 4,500 km before transmission expired (SPREP 2007). Shorter overall migration distances were documented for hawksbills nesting on isolated islands. Post-nesting distance ranged 90 to 345 km in Hawaii (Parker *et al.* 2009) and 35 to 175 km in the Seychelles (Mortimer and Balazs 2000). Hawksbills nesting in isolated areas likely stay within proximity to those areas after the

nesting season because they would need to travel extreme distances to reach foraging grounds associated with a major land mass (Marcovaldi *et al.* 2012).

During the internesting period, females tend to remain near their nesting beaches within core areas as small as 0.01 km^2 (Walcott *et al.* 2012), 2.03 km^2 (Gaos *et al.* 2012b), and 43.1 km^2 (Marcovaldi *et al*. 2012). These relatively small core areas may allow females to conserve energy stores during the breeding season when they are thought to not feed.

Females exhibit strong fidelity in their choice of nesting sites (Witzell 1983). Genetic studies have demonstrated natal homing for female hawksbills in both Atlantic (Bass 1999; Bass *et al*. 1996; Bowen *et al*. 2007) and Pacific (Broderick *et al.* 1994) populations. However, homing is not exactly precise, some females select different beaches up to 38 km apart both within and between breeding seasons (Allen *et al.* 2010; Bell *et al*. 2000; Miller *et al*. 2008). Upon arriving on the nesting beach, the female will select a nest site usually associated with vegetation (Cuevas *et al*. 2010; Ficetola 2007; Horrocks and Scott 1991; Kamel and Mrosovsky 2005; Mortimer 1982); however, many physical factors such as beach slope, nearshore habitat features and oceanographic conditions, temperature, and sand compaction likely influence where a female will lay her eggs (Garcon *et al*. 2010; Glen and Mrosovsky 2004; Horrocks and Scott 1991; Kamel and Mrosovsky 2006; Walcott *et al*. 2012).

Hawksbills reach sexual maturity after several decades, have a long reproductive lifespan, and are fecund. Age-to-maturity has been estimated as 20 or more years in the Caribbean, and a minimum of 30-35 years in the Indo-Pacific. In northeastern Australia, first breeding is estimated to occur at 31-36 years for females and 38 years for males (Limpus and Miller 2008). Bell and Pike (2012) estimated similar age to sexual maturity (30 to 40 years) for males and females foraging on the Great Barrier Reef in northeastern Australia. In Hawaii, estimated age to maturity occurs between 17 and 22 years (Snover *et al.* 2013). During the last decade, individual Caribbean hawksbills have been recorded actively nesting over a period of 14-24 years (C.E. Diez, Chelonia Inc., unpublished data; Parrish and Goodman 2006; Tilley *et al.* 2012). In the Indo-Pacific, Mortimer and Bresson (1999) and Limpus (1992) have reported nesting over 17-20 years, comparable to other chelonid turtles that range from 20 to 30 years (Carr *et al*. 1978; FitzSimmons *et al*. 1995).

Numerous studies have addressed periodicity of nesting both within (internesting interval) and between nesting seasons (remigration interval). Females at most sites typically lay clutches at approximately 2-week intervals (Witzell 1983). At sites where tagging has approached saturation, females lay, on average, between 3 and 5 egg clutches during a single nesting season (Beggs *et al*. 2007; Mortimer and Bresson 1999; Richardson *et al.* 1999). Hawksbills do not nest each year likely due to the energy demands of migration (Miller *et al.* 1998). Remigration intervals vary from one nesting site to another, averaging 1.84 years in Sabah, Malaysia (Pilcher and Ali 1999); 2.8 years at Jumby Bay, Antigua (Tilley *et al.* 2012); 2.47 years in Barbados (Beggs *et al*. 2007); 2 to 3 years in Yucatán, Mexico (Garduño-Andrade 1999); 2 to 3 years on Mona Island, Puerto Rico (see Velez-Zuazo *et al.* 2008); 2 to 3 years at Cousin Island, Seychelles (Mortimer and Bresson 1999); 2 to 3 years at Pulau Redang, Terengganu, Malaysia (Chan and Liew 1999); 5 years at Milman Island, Australia (Limpus 2009); 3 to 4 years in Hawaii (Seitz *et al.* 2012); and 5 to 7 years at Arnavon Islands Marine Conservation Area in the

Solomon Islands (Pita and Broderick 2005). Variation in the remigration interval is likely due to multiple factors including the distance between the nesting beaches and foraging grounds, individual body condition, and food quality and availability in the non-breeding years (see Beggs *et al*. 2007).

Considering that mean remigration intervals range from 2 to 5 years, a female may nest 3 to 12 seasons over the course of her life. Based on the reasonable means of 3-5 nests/season (Mortimer and Bresson 1999; Richardson *et al.* 1999) and 130 eggs/nest (Witzell 1983), a female may lay 9 to 60 egg clutches, or about 1,170-7,800 eggs, during her lifetime. These are rough estimates, but they nonetheless provide a basis for characterizing reproductive effort in hawksbill turtles.

Growth and Survival

Most hawksbills exhibit slow growth rates, which vary substantially within and among populations. The variation in growth rates is due to many factors such as prey quality and abundance, quality of foraging habitat, duration of foraging season, population density, and competition for resources (see Bell and Pike 2012; Bjorndal *et al*. 2000; Chaloupka *et al*. 2004). Growth rates in the Indo-Pacific averaged between 1 and 3 cm/year (Chaloupka and Limpus 1997; Mortimer *et al*. 2002; Mortimer *et al*. 2003; Whiting 2000). In the Caribbean, rates were higher with 2 to 4 cm/year being typical (Blumenthal *et al.* 2009a; Boulon 1994; Diez and van Dam 2002; León and Diez 1999), but averaging more than 5 cm/year at certain other sites (Diez and van Dam 2002; León and Diez 1999). Growth rates in sea turtles vary with size and age. Chaloupka and Limpus (1997) recorded immature female hawksbills growing at about 0.5 cm/year faster than immature males at all recorded sizes. At most sites, hawksbill growth rates tended to be non-monotonic, rising rapidly from recruitment to a maximum growth rate before declining to negligible growth approaching sexual maturity (Bell and Pike 2012; Bjorndal and Bolten 2010; Chaloupka and Limpus 1997; Diez and van Dam 2002; Mortimer *et al*. 2003). Bjorndal and Bolten (2010) used growth rate data from a 30-year mark-recapture study in the Bahamas and compared it to other studies in the Caribbean, Indian Ocean, and Pacific Ocean. They found differing growth patterns and slower growth rates for hawksbills in the Pacific and Indian Oceans compared to those in the Caribbean. The reason for the overall ocean basin difference is unknown, but may be related to diet and habitat quality.

Survival probabilities for nesting females from Varanus Island, Western Australia, were constant over 20 years at 0.947 (Prince and Chaloupka 2012). Similar survival probabilities (0.95) were documented for nesting females at Long Island near Antigua (Kendall and Bjorkland 2001). Bell *et al.* (2012) found high survivorship likelihoods in the foraging aggregation in the Great Barrier Reef — adult females (0.92), adult males (0.72), juvenile females (0.93), and juvenile males (0.78). Coupled with the recent studies of demography and survivorship, these data are critical for developing accurate population models (Chaloupka and Musick 1997; Prince and Chaloupka 2012).

Sex Ratios

Hawksbills exhibit temperature-dependent sex determination, and warmer incubation temperatures produce more females (reviewed by Wibbels 2003). The temperature at which a nest will produce 50% males/females is 29.2 °C (Antiqua) and 29.6 °C (Brazil) (reviewed by

Wibbels 2003). Recent studies of sex ratios in foraging aggregations in Florida, Dominican Republic, U.S. Virgin Islands, British Virgin Islands, Chagos Archipelago (Indian Ocean), Japan, and Australia, have found a significant female bias (see Hawkes *et al*. 2013). However, a slight male bias (0.8:1) was found in juveniles foraging at Mona Island, Puerto Rico (Diez and van Dam 2003).

Taxonomy, Phylogeny, and Genetics

The hawksbill taxonomic classification (below) is unchanged since the last 5-year review (NMFS and FWS 2007).

Kingdom: Animalia
Phylum: Chordata
Class: Reptilia
Order: Testudines
Family: Cheloniidae
Genus: *Eretmochelys*
Species: *imbricata*
Common name: Hawksbill sea turtle

Based on mitochondrial DNA analyses, hawksbills have significant population structure (Bass *et al.* 1996; Broderick *et al.* 1994; Browne *et al.* 2010; LeRoux *et al.* 2012; Velez-Zuazo *et al.* 2008; Zolgharnein *et al.* 2011). The analyses support a natal homing model for recruitment of breeding females. Natal homing was also documented in breeding males from Mona Island, Puerto Rico (Velez-Zuazo *et al.* 2008). These studies indicate reproductive populations are effectively isolated over ecological time scales (Bass *et al*. 1996; reviewed by Bowen and Karl 2007; LeRoux *et al.* 2012). If subpopulations become extirpated they may not be replenished by the recruitment of turtles from other nesting rookeries over ecological time frames, given the tendency toward site fidelity. Because each nesting subpopulation is genetically discrete, the loss of even one rookery represents a decline in genetic diversity and resilience of the species (Bass *et al*. 1996).

Substantial efforts have been made to determine the nesting population origins of hawksbills on their foraging grounds, and genetic research has shown that hawksbills of multiple nesting beach origins commonly mix in these areas (Bowen *et al*. 1996; Broderick and Moritz 1996; Mortimer and Broderick 1999). Bowen *et al*. (2007) demonstrated that the origin of juveniles found on foraging areas correlates with both nesting population size and distance from the nesting areas. Ocean currents likely influence juvenile dispersal (Blumenthal *et al* 2009c; Bowen *et al*. 2007), and they disperse across ocean basins (Bellini *et al*. 2000; Bowen *et al*. 2007; Grossman *et al.* 2007; Monzón-Argüello *et al*. 2011; Whiting *et al*. 2010), which contributes to the genetic diversity found on foraging grounds.

Habitat Use and Ecosystem Conditions

Throughout their range, hawksbills feed on sponges (reviewed by Bjorndal 1997), but their primary diet differs depending on the region occupied. In the Caribbean, hawksbills mainly eat sponges (Berube *et al.* 2012; León and Bjorndal 2002; Meylan 1988; Rincon-Diaz *et al.* 2011b; van Dam and Diez 1997b), but the species is more omnivorous in the Indo-Pacific (King 2012).

In the northeastern Australia Great Barrier Reef, the primary food item was algae (72.7%) followed by sponges, soft corals, invertebrate species (total 23%), and inorganic material (5.4%) (Bell 2012). In the Seychelles at Cosmoledo Atoll and D'Arros Island, spongivory predominates (reviewed by Bjorndal 1997), but to a lesser extent in the lagoons of Aldabra Atoll, Seychelles, where hawksbills feed primarily on algae (J. Mortimer, Island Conservation Society, unpublished data) and have been observed to feed on hard coral (Obdura *et al*. 2010). Algae are also a major diet item for hawksbills foraging in Diego Garcia, British Indian Ocean Territory (Mortimer and Day 1999).

Recent studies provide a clearer picture of fine scale movement within local habitats and the size of the area used for daily activities, such as foraging and resting. Where hawksbills aggregate in local habitats is not entirely related to food availability, but rather is influenced by multiple factors including shelter and predator avoidance. In the Caribbean, areas with a high cover of gorgonians and stony corals (used as refuge and resting sites) have a greater abundance of hawksbills (Rincon-Diaz *et al.* 2011a). Hawksbills also aggregate within established protected areas in Belize, which may reflect a combination of reduced exposure to fisheries bycatch and high quality habitat (Scales *et al.* 2011). Although home range areas may not be compared among all studies due to the various analytical methods used, generally these studies show that home ranges depend on many factors, including habitat and prey quality, life stage, availability of resting sites, and local population abundance. Home range size varies from less than 2 km^2 (Berube *et al.* 2012; Blumenthal 2009a; Cuevas *et al.* 2007; Gaos *et al.* 2012b; Parker *et al.* 2009; Scales *et al.* 2011; van Dam and Diez 1998; Walcott *et al.* 2012) to greater than 2,000 km^2 (Hawkes *et al*. 2012; Marcovaldi *et al*. 2012). Generally, adults establish larger home ranges (Cuevas *et al.* 2008; Hawkes *et al*. 2012; Horrocks *et al*. 2001; Marcovaldi *et al*. 2012) than juveniles (Berube *et al.* 2012; Cuevas *et al.* 2007; van Dam and Diez 1998). In Belize, larger juveniles tend to range farther than smaller individuals (Scales *et al.* 2011), but other studies found no such relationship (Blumenthal *et al*. 2009a; Gaos *et al.* 2012; Hawkes *et al*. 2012).

Hawksbill diving behavior has been studied at several sites (van Dam and Diez 1997a, 1997c, 1998; Houghton *et al.* 2003; von Brandis 2010). Dive patterns are influenced by complex biological and environmental factors (Blumenthal *et al.* 2009b; Gaos *et al.* 2012c), thus factors such as benthic topography, oceanic characteristics, prey availability, diel period, and life stage would likely affect diving behavior. Unlike other marine turtles, hawksbills are not generally deep divers, which may be a reflection of the shallow depths of their primary food— sponges and macroalgae. Hawksbills actively forage during the day and tend to rest at night (Blumenthal *et al.* 2009b; Hart *et al.* 2012; Okuyama *et al.* 2010; Witt *et al.* 2010). However, Gaos *et al.* (2012c) documented foraging activity at night as well as during the day and thought it might be due to possible overlap of foraging and resting areas.

Less is known about the hawksbill's oceanic stage, but it is thought that neonates live in the oceanic zone where water depths are greater than 200 m. Distribution in the oceanic zone may be influenced by surface gyres. During the oceanic phase, hawksbills are thought to ingest a combination of plant and animal material associated with surface zones (reviewed by Bjorndal 1997). Newly hatched hawksbills have been observed drifting motionless in *Sargassum*, a pelagic brown algae often associated with surface convergence zones, off nesting beaches in Honduras (Hasbun 2002). Juvenile hawksbills have also been found associated with *Sargassum*

in both the Atlantic and Pacific Oceans (Musick and Limpus 1997; Witherington *et al.* 2012). The attraction to floating objects has been observed in the laboratory where hawksbill hatchlings were attracted to artificial weeds (Mellgren and Mann 1996; Mellgren *et al.* 1994) or floating objects (typically dead leaves) that fell into the test tanks (Chung *et al.* 2009). Hawksbills remain in the oceanic environment until reaching a carapace length of approximately 20 to 30 cm, interpreted as 7-10 years (Bell and Pike 2012). At that point, they recruit into neritic habitats. Studies in the Caribbean documented that small juveniles newly recruited to the neritic foraging grounds feed on goose barnacles and algae (Berube *et al.* 2012; Rincon-Diaz 2011b) and exhibit slower growth rates (Bjorndal and Bolten 2010), suggesting a transition from a pelagic to a benthic diet (Berube *et al.* 2012; Bjorndal and Bolten 2010; Rincon-Diaz 2011b).

Since the last 5-year review (NMFS and FWS 2007), knowledge of the ecological role of hawksbills has increased. Similar to other sea turtle species, hawksbills contribute to marine and coastal food webs and transport nutrients within the oceans (Bouchard and Bjorndal 2000). Hawksbills are no longer thought to be obligate reef dwellers and may occupy a range of habitats that include coral reefs or other hard bottom habitats, seagrass, algal beds, mangrove bays and creeks (reviewed by Musick and Limpus 1997). Hawksbills support healthy reefs by controlling sponges and macroalgae, which would otherwise outcompete reef-building corals for space (Bjorndal and Jackson 2003; Goatley *et al*. 2012; Hill 1998; León and Bjorndal 2002). Hawksbills in the eastern Pacific forage in mangrove saltwater forests and man-made shrimp ponds, an association not reported previously (Gaos *et al*. 2012a, 2012b). The reason for this novel habitat use is unknown, but appears to be limited to adults, as juveniles tend to forage in nearshore, open-coast habitats in the region (Gaos *et al.* 2012b). In the Caribbean, seagrass beds, which are thought to be peripheral habitat for hawksbills, sustain hawksbill foraging aggregations comparable to reef habitat (Bjorndal and Bolten 2010). Although not as common as coral reef or hard-bottom habitat, Bjorndal and Bolten (2010) state that hawksbills historically may have used seagrass habitat but abandoned it as green turtle populations collapsed and the pastures went ungrazed decreasing the value of the habitat for hawksbills. Nonetheless, seagrass pastures may become more important as coral reefs decline (Bjorndal and Bolten 2010).

Abundance and Trends

In this section, the current nesting abundance is provided for 88 nesting assemblages among 10 ocean regions (Tables 1-3), followed by a narrative of issues affecting trends in each region. The regions are: Atlantic Ocean—Insular Caribbean, Western Caribbean Mainland, South Western (Figure 2) and Eastern (Figure 3); Indian Ocean—South Western, North Western, Central and Eastern (Figures 4); and Pacific Ocean—Western, Central (Figure 5) and Eastern (Figure 6).

The information is updated from the last 5-year review (NMFS and FWS 2007) and, in many instances, is from Mortimer and Donnelly (2008). The abundance analysis provides a summary of the empirical data available for each nesting assemblage and is not a robust modeling exercise. The analysis is limited as it relies on nesting beach data. There is a near total lack of long-term trend data at foraging sites, primarily because these data are logistically difficult and relatively expensive to obtain. Therefore, the primary information source for evaluating trends in global hawksbill populations is nesting beach data.

Figures for current and historic abundance are largely based on estimated annual reproductive effort (i.e., numbers of nesting females, egg clutches laid, or nesting emergences recorded at each site); and in some cases evidence of historic abundance are based on tortoiseshell export statistics (Mortimer and Donnelly 2008). Data were recorded during beach monitoring programs in which reproductive effort was quantified on a fixed length of beach over the course of a nesting season (Schroeder and Murphy 1999). Because hawksbill nesting activity at a given beach can vary from year to year (Miller 1997), estimates of abundance are based on mean nesting activity over the course of multiple nesting seasons for which data are comparable. In some cases where data are poor, we rely on professional judgment for an estimate (e.g., Micronesia—see NMFS and FWS 1998).

In addition to current abundance at each site, an estimate of total combined annual reproductive effort (i.e., total number of nesting females) for all sites is presented. To convert from number of nests to number of nesting females, a bracketed figure of 3-5 nests per female was used. Where the estimate is derived from total number of tracks (crawls), a conversion factor of 1.8 tracks per nest is used (based on Mortimer and Bresson 1999). All estimates were rounded up to whole numbers where there was a fraction. The application of these conversion factors is based on the assumptions that the mean number of egg clutches/female/season differ insignificantly through time, and that efforts to monitor nesting activity are consistent through time. Where data are reported from the State of the World's Sea Turtles OBIS-SEAMAP (Halpin *et al.* 2009), their conversion factors were used.

As with any assessment based on long-term data, there is a level of uncertainty relating to the final results. Using the annual number of nesting females to assess population trends only provides information for the proportion of the adult females that nest in any given year, not the total adult female population. This limitation is heightened by the inter-annual variability in magnitude of nesting, and the potential that the proportion of a population's adult female cohort nesting each year may oscillate over decadal or longer time frames (Limpus and Nichols 1988, Miller 1997).

Population trends are assessed over two time frames: 'Recent' trends apparent within the past 20 years and 'Historic' trends apparent over a period of > 20 to 100 years. Where known, historic trends were applied to rookeries (El Salvador, Guatemala, Ecuador, Nicaragua, and Pacific coast of Costa Rica) that were not reported in the last 5-year review (NMFS and FWS 2007). However, historic trends are unchanged for sites reported in the last 5-year review and are what was reported in the IUCN report (Mortimer and Donnelly 2008). For each of the two time frames, each site was assigned one of the following four categories: increasing▲, stable ▬, decreasing ▼, or trend unknown ? (Tables 1-4). To characterize the quality of data used to estimate current abundance, this report uses a letter grading system (A, B; Tables 1-3). An 'A' is given to those data sources that are either in peer-reviewed published literature or are based on unpublished data collected by highly dependable experts and a 'B' is used when data come from personal communications or other sources for which the data precision is not fully verifiable, or when the estimate is imprecise. It should be noted that the grade given for confidence in data is independent of the time duration for which the estimate is based. In other words, a letter grade of 'A' is given for peer-reviewed data, even if it represents only a single nesting season.

Table 1. Estimates of current (or most recent) abundance for hawksbill nesting rookeries in the Atlantic Ocean with data confidence grades (G). See page 16 for explanation of data confidence grades. See Figures 2-3 for location of rookeries. Population trends, both recent (Rec T) within the past 20 years and historic (His T) comparing current nesting female abundance with that during a period > 20 to 100 years ago are indicated. Data types include: AF = annual nesting females; AN = annual nests; AT = annual tracks; ▲ = increasing population; ▼= decreasing population; ▬ = stable population; ? = unknown trend. Additional information about trend data is presented in the text for each geographic location. Information derived largely from review by Mortimer and Donnelly (2008).

Location	Data	Years	Number of nesting ♀ /season	G	Rec T	His T	Reference
ATLANTIC: INSULAR CARIBBEAN							
1. Antigua (Jumby Bay)	AF	2011	63	A	▲	?	Tilley *et al.* 2012
2. Antigua/ Barbuda (outside Jumby Bay)	AN	2011-2012	17-27	B	▼	▼	Levasseur *et al.* in press.
3. Bahamas	AN	2001-2005	100-333	B	?	▼	Bolten 2008; Mortimer and Donnelly 2008
4. Barbados	AF	2008-2009	458-493	A	▲	?	Horrocks 2010
5. Bonaire	AT	2006-2011	5-18	B	?	▼	Sea Turtle Conservation Bonaire 2007, 2008, 2009, 2010. 2011, 2012
6. British Virgin Islands	AN	2003-2005	< 10	B	▼	▼	McGowan *et al.* 2008
7. Cuba (Doce Leguas Cays)	AN	2002	400-833	B	?	▼	Mortimer and Donnelly 2008
8. Dominican Republic	AN	2006-2010	~ 30	B	▼	▼	Revuelta *et al.* 2012
9. French West Indies (Guadeloupean Archipelago)	AF	2000-2007	17-98	A	?	▼	Kamel and Delcroix 2009
10. French West Indies (Martinique)	AN	2006	50-100	B	?	▼	La Gazette de Karets 2006
11. Jamaica	AN	1991-1996	200-275	B	?	▼	Mortimer and Donnelly 2008
12. Grenada	AT	2010	27	B	?	▼	State of the World's Sea Turtles OBIS-SEAMAP (http://seaturtlestatus.org/): Dow *et al.* 2007; Fastigi 2010; Carl Lloyd, Ocean Spirits, personal communication
13. Puerto Rico (Culebra, Caja de Muertos, Humacao, Manuabo)	AN	2011-2012	61-169	A	▲	?	Carlos Diez, Puerto Rico Department of Natural and Environmental Resources, personal communication
14. Puerto Rico (Mona Island)	AN	2011-2012	280-467	A	▲	?	van Dam *et al.* in press
15. St. Kitts	AT	2006	25-56	B	▼	▼	Mortimer and Donnelly 2008
16. Trinidad and Tobago (N. coast Trinidad)	AN	2000-2004	150	A	?	?	Livingstone 2006
17. U.S. Virgin Islands (Buck Island Reef NM)	AF	2010-2012	46-65	A	▲	?	Ian Lundgren, National Park Service, personal communication
18. U.S. Virgin Islands (sites outside Buck Island Reef NM)	AT	2006	30-222	B	?	▼	Mortimer and Donnelly 2008
ATLANTIC: WESTERN CARIBBEAN MAINLAND							
19. Belize (Manatee Bar, Sapodilla Cays, South Water Cay)	AT	2006	8-56	B	▼	▼	Mortimer and Donnelly 2008

Location	Data	Years	Number of nesting ♀ /season	G	Rec T	His T	Reference
20. Colombia (Isla Fuerte)	AT	2006	19-93	B	▼	▼	Mortimer and Donnelly 2008
21. Colombia (outside of Isla Fuerte)	AT	2002	266	B	▼	▼	State of the World's Sea Turtle database (http://seaturtlestatus.org/); Amarasooriya and Jayathilaka 2002; Moreno 2002
22. Costa Rica (Tortuguero National Park)	AF	2005-2008	~ 14	A	▼	▼	de Haro and Harrison 2007; Debade and Harrison 2009
23. Costa Rica (Cahuita and Erlin)	AT	2010	27-45	B	?	?	Didiher Chacon, WIDECAST, personal communication
24. Honduras	AT	2006	~ 30	B	?	▼	State of the World's Sea Turtle database (http://seaturtlestatus.org/); Macias 2006
25. Mexico (Entire Yucatan Peninsula: Campeche, Yucatan, and Quitana Roo)	AN	2001-2006	534-891	A	▲	?	Mortimer and Donnelly 2008
26. Nicaragua (El Cocal)	AN	2008-2011	18-43	A	?	▼	Lagueux *et al.* 2012; Cynthia Lagueux and Cathi Campbell, Wildlife Conservation Society, personal communication
27. Nicaragua (Pearl Cays)	AN	2010-2012	60-104	A	▲	▼	Lagueux *et al.* 2013
28. Panama (Bastimentos Island National Marine Park)	AN	2011	116-192	A	▲	▼	Meylan *et al.* 2012
29. Panama (Chiriqui Beach)	AN	2011	174-290	A	▲	▼	Meylan *et al.* 2012
30. Venezuela (Los Roques and Paria region)	AN	2006	32-53	A	?	▼	Mortimer and Donnelly 2008
ATLANTIC: SOUTH WESTERN							
31. Brazil	AN	2005	335-558	A	▲	▼	Marcovaldi *et al.* 2007
ATLANTIC: EASTERN							
32. Equatorial Guinea (Bioko)	AF	1996-2005	< 10	A	▼	▼	Rader *et al.* 2008; Tomás *et al.* 2010;
33. Sao Tomé and Principe	AN	1998-2001	14-27	A	▼	▼	Mortimer and Donnelly 2008
TOTAL			**3,626-6,108**				

Table 2. Estimates of current abundance for hawksbill nesting rookeries in the Indian Ocean with data confidence grades (G). See page 16 for explanation of data confidence grades. See Figure 4 for location of rookeries. Population trends, both recent (Rec T) within the past 20 years and historic (Hist T) comparing current nesting female abundance with that during a period > 20 to 100 years ago are indicated. Data types include: AF = annual nesting females; AN = annual nests; AT = annual tracks; ▲ = increasing population; ▼= decreasing population; ▬ = stable population; ? = unknown trend. Additional information about trend data is presented in the text for each geographic location. Information derived largely from Mortimer and Donnelly (2008).

Location	Data	Years	Number of nesting ♀ /season	G	Rec T	His T	Reference
INDIAN OCEAN: SOUTH WESTERN							
34. Comoro Islands	AF	1996	25-50	A	?	▼	Ben Mojadji *et al.* 1996
35. France Iles Eparses (Europa, Tromelin, Juan de Nova, Glorieuses)	AN	2006	20-45	A	?	?	Gravier-Bonnet *et al.* 2006; Mortimer and Donnelly 2008
36. Kenya	AN	2004	< 10	A	?	▼	Okemwa *et al.* 2004
37. Madagascar	AF	2001	~ 1,000	B	▼	▼	Mortimer and Donnelly 2008
38. Mauritius (including St. Brandon)	AF	1996	< 50	A	?	▼	Mangar and Chapman 1996
39. Mayotte	AF	2006	10-50	B	?	▼	Mortimer and Donnelly 2008
40. Mozambique	AF	2006	< 10	A	?	▼	Mortimer and Donnelly 2008
41. Seychelles (all 22 Inner Islands)	AF	2000-2003	625	A	▼	▼	Mortimer 2004, 2006; Mortimer and Donnelly 2008
42. Seychelles (Outer Islands)	AN	2000-2006	800	A	?	▼	Mortimer and Donnelly 2008
43. Tanzania	AF	1996	< 50	B	▼	▼	Howell and Mbindo 1996
INDIAN OCEAN: NORTH WESTERN							
44. Bahrain		2006	no estimate		?	?	
45. Egypt	AF	2006	50-100	A	?	▼	Mortimer and Donnelly 2008
46. Eritrea		1996	no estimate	B	?	?	Hillman and Gebremariam 1996
47. Iran	AF	1970s	500-1,000	B	?	?	Ross and Barwani 1982
48. Kuwait	AF	2009	10-20	B	?	?	Papathanasopoulou 2010
49. Oman	AF	1990s	600-800	A	▬	?	Salm *et al.* 1993, Baldwin and Al-Kiyumi 1997
50. Qatar	AN	2005	> 100	A	▬	?	Pilcher 2006
51. Saudi Arabia (Arabian Gulf)	AF	1990s	175-265	A	?	?	Mortimer and Donnelly 2008; Pilcher 1999
52. Saudi Arabia (Red Sea)	AN	2005	100-200	A	?	?	Mortimer and Donnelly 2008
53. Somalia		2006	no estimate		?	?	Mortimer and Donnelly 2008
54. Sudan	AN	1970s	300-350	B	?	?	Moore and Balzarotti 1977, Hirth and Abdel Latif 1980

Location	Data	Years	Number of nesting ♀ /season	G	Rec T	His T	Reference
55. United Arab Emirates	AF	2006	100-200	B	?	?	Mortimer and Donnelly 2008
56. Yemen	AF	1960s-1970s	~ 500?	B	?	?	Ross and Barwani 1982
INDIAN OCEAN: CENTRAL and EASTERN							
57. Australia (Western Australia)	AF	2002	~ 2,000	B	?	?	Limpus 1997, 2002
58. British Indian Ocean Territory (Chagos Islands)	AF	1996	300-700	A	?	▼	Mortimer and Day 1999
59. India (Andaman and Nicobar)	AF	1990s	~ 250	B	?	▼	Andrews *et al.* 2006
60. Malaysia (Melaka)	AN	2011	114-190	B	?	▼	World Wildlife Fund for Nature 2012
61. Maldives	AN	1988-1995	460-767	B	▼	▼	Zahir and Hafiz 1997
62. Myanmar	AF	1989	< 5	B	?	▼	Groombridge and Luxmoore 1989
63. Sri Lanka (south coast)	AN	2006	~ 10	A	?	▼	Mortimer and Donnelly 2008
64. Thailand (Andaman Sea)	AF	2006	< 10	A	▼	▼	Mortimer and Donnelly 2008
TOTAL			**<8,184 - 10,157**				

Table 3. Estimates of current abundance for hawksbill nesting rookeries in the Pacific Ocean with data confidence grades (G). See page 16 for explanation of data confidence grades. See Figures 5-6 for location of rookeries. Population trends, both recent (Rec T) within the past 20 years and historic (His T) comparing current nesting female abundance with that during a period > 20 to 100 years ago are indicated. Data types include: AF = annual nesting females; AN = annual nests; AT = annual tracks; ▲ = increasing population; ▼ = decreasing population; ▬ = stable population; ? = unknown trend. Additional information about trend data is presented in the text for each geographic location. Information derived largely from Mortimer and Donnelly (2008).

Location	Data	Years	Number of nesting ♀ /season	G	Rec T	His T	Reference
PACIFIC OCEAN: WESTERN							
65. Australia (Torres Strait-Northern Great Barrier Reef)	AF	2004	~ 4,000	A	▼	?	Limpus 2009
66. Australia (Northeastern Arnhem Land)	AF	2004	~ 2,500	A	?	?	Limpus 2009
67. Indonesia (entire country)	AN	2006	1,362-3,026	A B	▼	▼	Mortimer and Donnelly 2008; Suganuma *et al.* 1999
68. Japan		1980s	rare	B	▼	▼	Groombridge and Luxmoore 1989
69. Malaysia (East) Sabah Turtle Islands	AN	2006	90-150	A	▬	?	Chan 2006
70. Malaysia (West): Terengganu	AN	1992-2000	4-6	A	▼	▼	Liew 2002
71. Papua New Guinea	AF	2004	~ 500-1000	B	▼	▼	Mortimer and Donnelly 2008; Wilson *et al.* 2004
72. Philippines	AF	1980s	< 500	B	▼	▼	Groombridge and Luxmoore 1989
73. Thailand (Gulf of Thailand)	AN	1990-2005	~20	A	▼	▼	Mortimer and Donnelly 2008
74. Vietnam	AF	1980s	100	B	▼	▼	Groombridge and Luxmoore 1989
PACIFIC OCEAN: CENTRAL							
75. American Samoa and Western Samoa	AF	1991	< 10-30	B	▼	▼	Grant *et al.* 1997; Mortimer and Donnelly 2008; Tuato'o-Bartley *et al.* 1993
76. Fiji	AN	2006	100-200	A	▼	▼	Batibasaga 2002
77. Mariana Archipelago (Guam and CNMI)	AF	2003	< 5-10	B	▼	▼	Mortimer and Donnelly 2008
78. Hawaii	AF	1989-2009	< 20	B	?	▼	Seitz *et al.* 2012; Kyle Van Houtan, National Marine Fisheries Service, personal communication
79. Micronesia	AF	1998	~ 300	B	▼	▼	NMFS and FWS 1998
80. Palau Republic	AF	2004-2006	15-25	B	?	▼	Eberdong and Klain 2008
81. Solomon Islands	AN	2004	200-300	B	▼	▼	Ramohia and Pita 1996; Wilson *et al.* 2004
82. Vanuatu	AF	2004	> 300	B	?	▼	Mortimer and Donnelly 2008; Wilson *et al.* 2004
PACIFIC OCEAN: EASTERN							
83. Mexico (Baja California)	AF	2007-2009	< 10	A	?	▼	Gaos *et al.* 2010
84. Guatemala	AF	2007-2009	< 10	A	?	▼	Gaos *et al.* 2010
85. El Salvador	AN	2007-	100-215	A	?	▼	Gaos *et al.* 2010; Liles *et al.* 2011

Location	Data	Years	Number of nesting ♀ /season	G	Rec T	His T	Reference
		2009					
86. Nicaragua	AF	2007-2009	~ 15	A	?	▼	Gaos *et al*. 2010
87. Costa Rica	AF	2007-2009	~ 18	A	?	▼	Gaos *et al*. 2010
88. Ecuador	AF	2007-2009	~ 15	A	?	▼	Gaos *et al*. 2010
TOTAL			**10,194 - 12,770**				

Table 4. Summary of recent trends (within the past 20 years) and historic trends during a period of > 20 to 100 years (Mortimer and Donnelly 2008; NMFS and FWS 2007) for each of the 88 sites for which data are available. Key to trend symbols: ▲ = increasing population; ▼= decreasing population; ▬ = stable population; ? = unknown trend.

Ocean Basin	Number of Sites								
	Total Sites	Recent Trends (within past 20 years)				Historic Trends (during a period of >20 to 100 years)			
		▲	▬	▼	?	▲	▬	▼	?
Atlantic	33	10	0	10	13	0	0	25	8
Indian	31	0	2	5	24	0	0	17	14
Pacific	24	0	1	13	10	0	0	21	3
Total	**88**	**10**	**3**	**28**	**47**	**0**	**0**	**63**	**25**

Based on the mean annual reproductive effort reported in Tables 1-3, an estimated total of 22,004 to 29,035 hawksbills nest each year among the 88 sites included in this evaluation. This is a rough estimate of total annual reproductive effort since not all nesting sites have been surveyed and included in the evaluation, some data are for single years, and some represent a professional judgment of the estimate of annual reproductive output (e.g., Micronesia—see NMFS and FWS 1998). Nevertheless, it provides a good baseline to estimate annual global nesting effort since most of the major nesting assemblages are included in this analysis.

Nesting trend summary data are provided in Table 4. Among the 63 sites for which historic trends could be assessed, all 63 (100%) showed a decline during the long-term period of > 20 to 100 years. Among the 41 sites for which recent trend data are available, the picture is somewhat more optimistic with 10 (24%) increasing, 3 (7%) stable, and 28 (68%) decreasing. Although greatly depleted from historic levels, nesting populations in the Atlantic Ocean in general are doing better than in the Indo-Pacific. In the Atlantic Ocean, more population increases have been recorded in the Insular Caribbean than along the Western Caribbean Mainland or the Eastern Atlantic. In general, hawksbills are doing better in the Indian Ocean (especially the South Western and North Western Indian Ocean) than in the Pacific Ocean. In fact, the situation for hawksbills in the Pacific Ocean is particularly dire; despite the fact that it still has more nesting hawksbills than in either the Atlantic or Indian Oceans, a greater proportion of the nesting sites are declining.

Quantitative continuous data over periods of approximately 20 or more years are available for only 11 sites in the world. In the Atlantic Ocean, these are Antigua (Jumby Bay), Barbados, Puerto Rico (Mona Island), U.S. Virgin Islands (Buck Island Reef National Monument), Mexico (Yucatan Peninsula), and Costa Rica (Tortuguero National Park). In the Indo-Pacific, these are Seychelles (four nature reserves in the inner islands), Australia (Milman Island), Malaysia

(Sabah Turtle Islands), Malaysia (Terengganu), and Thailand (Ko Khram). Among these 11 sites, five are increasing (Antigua, Barbados, Puerto Rico, U.S. Virgin Islands, and Mexico), five are decreasing (Costa Rica, Australia, Malaysia-Terengganu, Thailand, Seychelles), and one is stable (Malaysia-Sabah Turtle Islands). Unfortunately, these data are not representative of the global picture. The fact that turtles are legally protected at most of these 11 sites and/or are monitored continuously provides a degree of protection to both turtles and their habitats that is not enjoyed by most nesting populations worldwide (Mortimer and Donnelly 2008).

Atlantic Ocean: Insular Caribbean

There are eight nesting concentrations of particular interest in the Insular Caribbean, including Antigua/Barbuda (especially Jumby Bay), Bahamas, Barbados, Cuba (Doce Leguas Cays), Jamaica, Puerto Rico (especially Mona Island), Trinidad and Tobago, and U.S. Virgin Islands (especially Buck Island Reef National Monument) (Figure 2). Of these, the rookeries that are being regularly monitored (Jumby Bay, Barbados, Mona Island, and Buck Island Reef National Monument) are increasing; while at the other sites the few recent data that exist indicate a less optimistic status (especially Bahamas, Jamaica, Trinidad (east coast) and Tobago, and U.S. Virgin Islands (outside of Buck Island Reef National Monument). There are remnant rookeries in the Turks and Caicos Islands (Richardson *et al.* 2009). Once abundant, the nesting population in the Cayman Islands is thought to be extirpated (Bell *et al*. 2006, 2007).

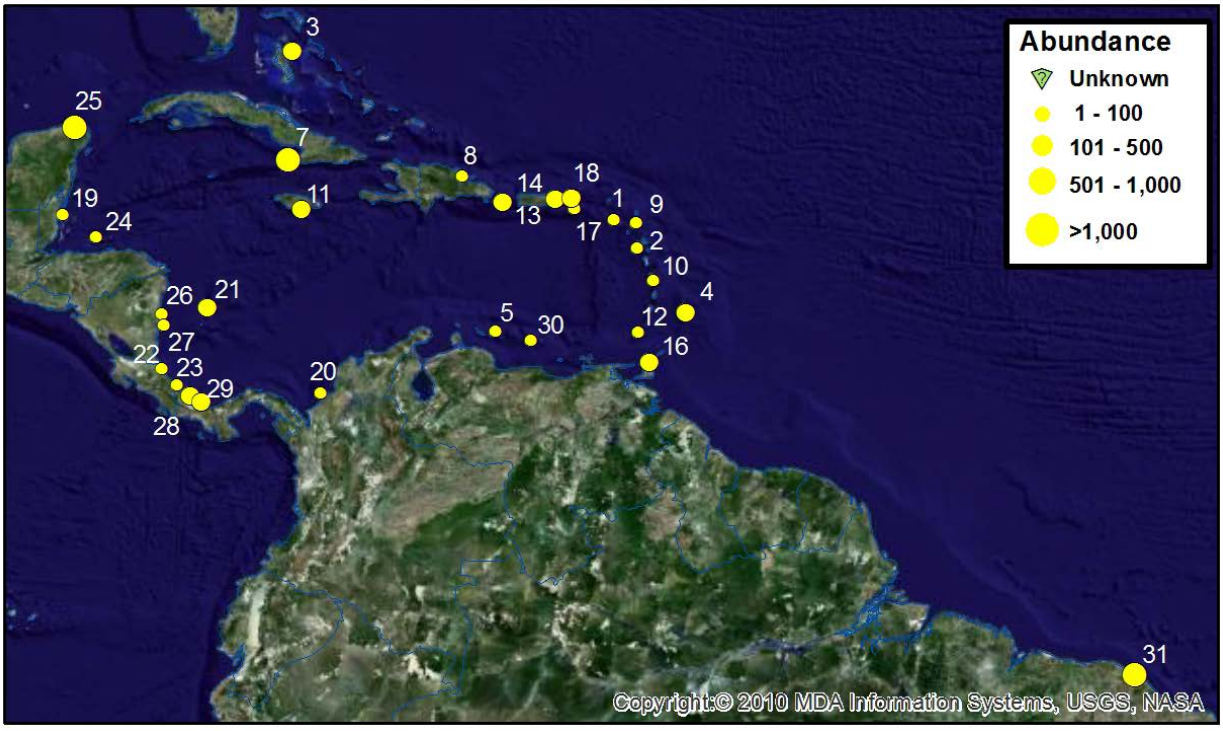

Figure 2. Hawksbill nesting distribution and relative abundance (estimated females nesting annually) in the western Atlantic Ocean, Caribbean Sea, and Gulf of Mexico (see Table 1 for site location information).

At Antigua/Barbuda, some 36 nesting beaches have been documented (Fuller *et al*. 1992) of which only one (Jumby Bay) has been monitored (Richardson *et al*. 2006). Although the population at Jumby Bay has increased 79% during the past 19 years (McIntosh *et al.* 2003; Parish and Goodman 2006; Richardson *et al.* 2006; Stapleton and Stapleton 2004, 2006), there is no evidence of similar increases anywhere else in Antigua (Mortimer and Donnelly 2008).

The Bahamas was historically a major source of tortoiseshell for the European market, and by the 1890s some 4,186 kg were exported annually. Despite high Japanese demand for shell, exports declined by 82% from the 1890s to 1979 (see Mortimer and Donnelly 2008). In addition, in 2009, the Bahamas instituted a ban on the harvest of sea turtles. Today an estimated 100-333 females nest annually on the 700 islands and cays that comprise the Bahamas (Bolten 2008; Mortimer and Donnelly 2008).

In Barbados, hawksbills have been monitored since the mid-1980s and a moratorium on take has been in place since 1998. Estimated numbers of nesting females have increased by more than 700%. For the 2008 and 2009 nesting seasons, 493 and 458 females were observed nesting (Horrocks 2010). Nesting habitat is largely unprotected, however, and coincides with areas that are heavily developed for tourism or are designated for tourism development.

For Cuba (Doce Leguas Cays), historical records indicate that thousands of nesting females were captured annually during the 19th and 20th centuries (Ballou 1888 as cited in McClenachan *et al.* 2006; McClenachan *et al.* 2006). In 1936, a closed season was introduced, and in 1961 the government prohibited egg collection and disturbance of nesting females, suggesting concern about sustainability (Carrillo *et al.* 1999). Annual legal exploitation of 5,000 turtles on foraging grounds was reduced to 500 in 1995 (Carrillo *et al.* 1999), and suspended in 2008 (Mortimer and Donnelly 2008). The number of nesting females is suspected to be declining in some areas (Carrillo *et al.* 1999; Moncada *et al.* 1999), with small increases at other sites (Mortimer and Donnelly 2008).

In Jamaica, nesting surveys conducted from 1991-1996 indicated 200-275 females nesting per year (Mortimer and Donnelly 2008). No recent information is available.

The most significant hawksbill nesting in Puerto Rico occurs on Mona Island, which is located in the middle of the Mona Passage between Hispaniola and the mainland of Puerto Rico. Nesting also occurs on Culebra Island, Vieques Island, and some mainland beaches. Nesting populations of Puerto Rico appeared to be in decline until the early 1990s, but all have increased during the periods they were surveyed: Mona Island (1974-2005), +539%; Caja de Muertos (1995-2003), +23%; Culebra Island (1993-2005), +190%; and Humacao (1987-2004), +930% (NMFS and FWS 2007). Mona Island now hosts some 280-467 nesting females annually (van Dam *et al.* in press).

Trinidad and Tobago support important hawksbill rookeries, but from 2000 to 2004 only the north coast of Trinidad was surveyed and some 150 females were reported nesting annually (Livingstone 2006). Similarly significant nesting is reported for the east coast of Trinidad and nearby Tobago, but annual nesting numbers have not yet been determined (Livingstone 2006).

The most significant nesting in the U.S. Virgin Islands occurs at Buck Island Reef National Monument, a small, uninhabited island about 2.4 km north of the northeast coast of St. Croix. Nesting also occurs on other beaches in St. Croix and on St. John and St. Thomas. The U.S. Virgin Islands have a long history of tortoiseshell trade (Schmidt 1916). At Buck Island Reef National Monument, protection of nesting females and nests has been in force since 1988, and during the period from 1988 to 2006 hawksbill nesting increased by +143% to 56 nesting females annually, with apparent spill over to beaches on adjacent St. Croix (Mortimer and Donnelly 2008). However, similar increases have not been recorded at St. John, perhaps due to the proximity of the legal turtle harvest in the British Virgin Islands (Mortimer and Donnelly 2008).

Other nesting populations, for which estimates are available, occur at Bonaire (Sea Turtle Conservation Bonaire 2007, 2008, 2009, 2010, 2011, 2012; Wider Caribbean Sea Turtle Conservation Network (WIDECAST), unpublished data), British Virgin Islands (McGowan *et al.* 2008), Dominican Republic (Revuelta *et al.* 2012; Ottenwalder 1981, 1987, as cited in Meylan 1999), French West Indies including the Guadaloupean Archipelago (Chevalier *et al.* 2003, 2005) and Martinique (La Gazette des Karets 2006), Grenada (Dow *et al.* 2007; Fastigi 2010), and St. Kitts (Mortimer and Donnelly 2008).

The centuries-old historic trade in tortoiseshell greatly impacted hawksbill populations in the Insular Caribbean. During 1950-1992 alone, Cuba exported the equivalent of 106,948 turtles (170,047 kg shell) to Japan (Mortimer and Donnelly 2008). Increases in nesting hawksbills in the region coincide with the decline of international trade in hawksbill shell (Milliken and Tokunaga 1987; Japanese Trade Statistics), and in particular with the 90% reduction in the annual take of large hawksbills from Cuban waters during the same period (i.e., down from 5,000 large hawksbills annually during 1970-1992 to fewer than 500 annually since 1995) (Carrillo *et al.* 1999).

Atlantic Ocean: Western Caribbean Mainland

The most important hawksbill rookery in the Western Caribbean mainland region is along the coastline of the Mexican Yucatan Peninsula (Figure 2). That population was in decline until 1978 when local and regional protection was implemented; and during 1985 to 1999 numbers of nesting hawksbills increased dramatically (Garduno-Andrade *et al.* 1999). But, during 1999-2004 nesting numbers declined by 63% in 5 years, reaching its lowest point in 2004 (Abreu-Grobois *et al.* 2005). Since 2004, nesting numbers have increased (Mortimer and Donnelly 2008).

Playa Chiriqui, Panama, may once have been the most significant rookery in the region, but from the early 1950s to 1981 it has declined by more than 95% and is now considered severely depleted (Carr 1956; Carr *et al.* 1982; Meylan and Donnelly 1999). In 2004, it gained a degree of protected status as a Damani-Guariviara Wetland, but threats from poaching and predators (especially dogs) are difficult to address on this mainland beach where some 174-290 females nest annually (Meylan *et al.* 2012). The nesting population has increased substantially (to 116-192 females/year in 2011) (Meylan *et al.* 2012) in Bastimentos Island Marine National Park where nesting females and their nests have been protected since 1988.

Other historically significant, but now much reduced, hawksbill rookeries include those at Belize, Colombia (San Andres Archipelago), and Honduras. Belize supported a significant tortoiseshell industry in the early 1900s (Smith *et al.* 1992 cited in Meylan 1999), but now has less than 50 nesting females (Mortimer and Donnelly 2008). The rookeries of Colombia's San Andres Archipelago were an important source of tortoiseshell in the 1930s (Parsons 1972), but by 1981 were almost extirpated (Carr *et al.* 1982). Approximately 350 females nest annually in Colombia (Dow *et al.* 2007; Mortimer and Donnelly 2008). The Honduran Bay Islands were a major hawksbill rookery in the 16th and 17th centuries (McClenachan *et al.* 2006), but 20th century declines have been significant (Carr *et al.* 1982; Meylan 1999). In 2006, fewer than 40 females per year were estimated to nest (Dow *et al.* 2007).

In Costa Rica, hawksbills nest in the Tortuguero National Park and at Cahuita and Erlin in small numbers, where, respectively, fewer than 15 females and an estimated 6-37 females now nest annually. Despite decades of protection in the Tortuguero National Park, nesting numbers have declined by 80% since the 1950s (Troëng *et al.* 2005).

In Nicaragua, the hawksbill nesting population of El Cocal in the late 1990s had declined by more than 75% since the 1970s (Lagueux and Campbell 2005). The current population trend is unknown, but nesting activity appears to have slightly increased from 72 nests reported in 2000 (Lagueux and Campbell 2005) to an average of 112 nests counted from 2008 to 2011 (Lagueux *et al.* 2012). At the Pearl Cays rookery (60-104 females/year), the average number of nest has increased 6.4% each year since 2000 (Lagueux *et al.* 2013). Efforts to protect nesting females and eggs have been successful through community awareness programs and increased law enforcement; however, illegal harvest of eggs continues (Abarca *et al.* in press; Campbell *et al.* 2012) and coastal development poses an extreme threat to nesting habitat (Campbell *et al.* 2012; Lagueux *et al.* 2003, 2013).

In Venezuela (Los Roques and Paria region), hawksbill populations (now approximately 32-53 females/year) are much reduced, primarily due to massive exploitation for shell in the 1960s and 1970s, and more recently to illegal take, destruction of foraging and nesting habitats, and incidental capture in fishing gear (see Mortimer and Donnelly 2008).

The centuries-old historic trade in tortoiseshell greatly impacted hawksbill populations in the Western Caribbean Mainland. During 1950-1992, Panama alone exported the equivalent of 152,070 turtles (203,774 kg shell) to Japan (Mortimer and Donnelly 2008). Mexican researchers suspect the more recent declines in the Yucatan population may be due to extraction at low levels and/or impacts on marine habitats (Abreu-Grobois *et al.* 2005). Throughout the region, hawksbills are still killed for meat, eggs, and shell; and their foraging and nesting habitats are being destroyed by unregulated coastal development.

Atlantic Ocean: South Western

In Brazil, an estimated 335-558 hawksbills now nest annually (Marcovaldi *et al.* 2007). This represents a decline of about 80% during the past 100+ years due to a combination of directed take of females and eggs, manufacture of shell ornaments, incidental capture in fishing gear, and habitat destruction before 1982. Nesting once extended from north Rio de Janeiro State to the Ceará State (Marcovaldi and Marcovaldi 1999), but is today restricted primarily to northern

Bahia and Sergipe (approximately 1,300 nests annually), Rio Grande do Norte near Pipa (approximately 450 nests in 2002-2003), and only scattered nesting elsewhere (Marcovaldi 2005). Since protection began in 1982, the decline in the nesting population has stopped; studies from 1990 to 2003 on the remnant population in Northern Bahia show increasing trends in nest numbers although the numbers fluctuate from year to year (Marcovaldi 2005). Hybridization of hawksbills with other sea turtle species may be a threat (Lara-Ruiz *et al.* 2006).

Hawksbills nest in other coastal areas of South America, but in low numbers. For example, Guyana supports a small nesting population (< 7 females nest annually) at Shell Beach, which has been protected since 2000 (Saheed 2008).

Atlantic Ocean: Eastern

Two areas of interest in the eastern Atlantic Ocean include Bioko Island (Equatorial Guinea) and São Tomé and Principe (Figure 3).

Figure 3. Hawksbill nesting distribution and relative abundance (estimated females nesting annually) in the eastern Atlantic Ocean (see Table 1 for site location information).

Hawksbill populations along the west coast of Africa have suffered significant declines due to intense exploitation for eggs and shell. Hawksbills were once common in the Republic of Ghana, but have been absent for the last 15 years (Tanner 2013). At Bioko, Equatorial Guinea, fewer than 10 females nest annually, and the population is declining (Mortimer and Donnelly 2008; Rader *et al.* 2008; Tomás *et al.* 2010). In São Tomé and Principe, only about 14-27 females nest annually, and exploitation of about 80% of the females and eggs occurs (Mortimer and Donnelly 2008).

Surveys in Liberia have also documented low numbers of hawksbills nesting. Between July 2005 and July 2006, a community-based project organized by Save My Future Foundation (SAMFU) recorded 37 hawksbill nests along 15 km of coastline in Borgor Point, Rivercess County, Liberia. Much of the remaining 579 km of Liberian coastline remains unsurveyed, suggesting the potential for greater numbers of undocumented hawksbill nesting, although any nests located outside the Borgor Point survey areas are likely collected for local consumption (SAMFU 2006).

Indian Ocean: South Western

In the South Western Indian Ocean, the most important hawksbill nesting populations remaining occur in the Seychelles and Madagascar (Figure 4).

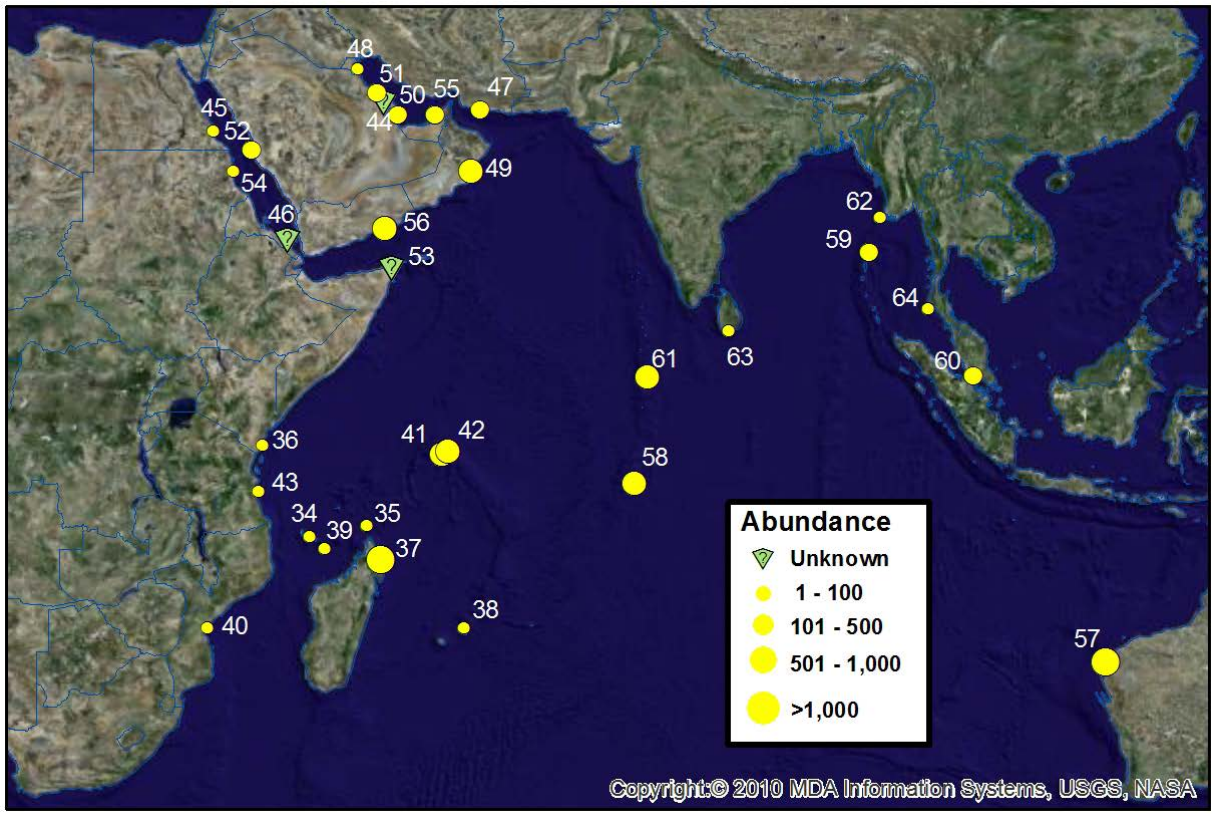

Figure 4. Hawksbill nesting distribution and relative abundance (estimated females nesting annually) in the Indian Ocean (see Table 2 for site location information).

In the Seychelles, hawksbills nest throughout the entire country, but predominantly on the 22 inner islands (including the granitic islands) and in the Amirantes group (Mortimer 1984). Shell export intensified in the 19th and 20th centuries, and prior to the 1960s most of it was exported to Europe (Mortimer 1984). From the mid-1960s through the mid-1990s, most shell was exported to Japan, with the remainder used for the local curio trade. During that same period, except at protected sites, most females were killed prior to laying eggs (Mortimer 1984; Mortimer and Collie 1998). In 1994, Seychelles passed legislation protecting all turtles and prohibiting all trade in turtle products (Mortimer 2000; Mortimer and Collie 1998); that same year, all domestic

tortoiseshell trade ceased (Mortimer 1999). Surveys at key nesting beaches clearly show a relationship between the level of protection and the nesting population trends (Mortimer 2006). At seven islands with intermediate levels of protection since 1979, hawksbill numbers declined by 21% (from 240 to 190 females); and at 13 islands that had no protection prior to 1994, hawksbill numbers declined by 59% (from 536 to 220 females) (Mortimer 2006). Cousin Island Reserve has experienced a 1013% increase in annual nesting activity from 23 females in 1973 to 256 females during the 2007-2008 season (Allen *et al.* 2010). At D'Arros Island in the Amirantes Group, nesting activity increased from the early 1970s through the mid-1990s when harvest of females and eggs was intense to the period from 2004 through 2009 when poaching virtually ceased (Mortimer *et al.* 2011), likely due to the presence of an active monitoring program. Turtle conservation programs are continually expanding in the Seychelles, so future increases in the nesting populations can be expected. Currently, the most serious threat to hawksbills is destruction of nesting habitat from inadequate regulation of coastal development (Mortimer 2004). In the outer islands of the Seychelles, an estimated 800 females nest annually. Unpublished data suggest a similar pattern as in the inner islands, with increases at protected sites and declines at unprotected sites (Mortimer 2006; see Mortimer and Donnelly 2008).

Madagascar exported hawksbill shell as early as the 15th century (Frazier 1980). From the mid-19th century to 1920, exports were equivalent to about 4,054 to 5,405 turtles (see Mortimer and Donnelly 2008). By the mid-20th century, exports dropped to an estimated 1,351 turtles and to an estimated 270 turtles by 1973 (see Mortimer and Donnelly 2008). Sale of worked shell to tourists continues (Meylan and Donnelly 1999). Nesting turtles in surveyed areas appear to be in decline with exploitation for meat, eggs, and shell (Metcalf *et al.* 2007; Rakotonirina and Cooke 1994). Turtles are often entangled in nets (Metcalf *et al.* 2007), and trawling along the northwest and west coasts of Madagascar is believed to be a threat (Randrianmiarana *et al.* 1998).

At some sites in the South Western Indian Ocean, nesting hawksbills occur only in small numbers and no evidence exists that they were ever abundant: Comoro Islands, 25-50 females/year and France (Iles Eparses), 20-45 females/year (see Mortimer and Donnelly 2008). Other sites in the region have probably suffered significant declines, due in large part to the historic trade in tortoiseshell, but also to destruction of nesting habitat, exploitation for meat and eggs, and entanglement in fishing gear: Mauritius, now <50 female/year; Mayotte, now estimated at 10-50 females/year, but inadequately surveyed; Kenya, now <10 females/year; Tanzania, now <50 females/year; and Mozambique, now <10 females/year (see Mortimer and Donnelly 2008).

Indian Ocean: North Western

Important hawksbill populations in the region are found in Iran (mostly along the Arabian/Persian Gulf coast) and in Oman (Figure 4). Saudi Arabia hosts important hawksbill rookeries on two coasts, along the Arabian/Persian Gulf and along the Red Sea. Elsewhere along the Gulf, relatively recent data are available for Kuwait, Qatar, and United Arab Emirates, but data are lacking for Bahrain. Along the Red Sea, recent data are available for Egypt, but only old data (1960s-1970s) are available for Sudan. Almost no data exist for Eritrea and Somalia. The most recent data available for Yemen is from the 1960s and 1970s.

Iran was estimated to host as many as 500 to 1,000 females/year in the early 1970s (Ross and Barwani 1982). In 2006 and 2007, the islands of Shidvar, Qeshm, Hendourabi, Lavan, and Hormuz were surveyed (Devin *et al.* 2008; Mobaraki 2006; Nabavi *et al.* 2012), indicating fewer than 115 females may be nesting on these islands each year. However, survey effort was not consistent across months and may not represent a good estimate of annual nesting activity (Nabavi *et al.* 2012). Hormoz Island, Iran, was surveyed in 2006 where 46 nests were recorded of which half were destroyed by mongoose predation (Devin *et al.* 2008). Populations are threatened by egg harvest, especially on the mainland (Nabavi *et al.* 2012); incidental capture in fishing gear (Mobaraki and Elmi 2005; Nabavi *et al.* 2012); foraging habitat degradation due to coral bleaching events (Sheppard 2006; Sheppard and Loughland 2002), and oil spills (Miller 1989; Nabavi *et al.* 2012). Current population trends are unknown.

In Oman, approximately 600-800 females nest annually, primarily on the coast of the Gulf of Oman, including 250-350 at the protected Dimaniyat Islands and 100 at Masirah Island (see Mortimer and Donnelly 2008). Monitoring at Dimaniyat Islands indicates stable nesting numbers, and egg harvest is believed to be minor at both Dimaniyat and Masirah Islands (see Mortimer and Donnelly 2008). On mainland beaches, foxes destroy over 60% of the eggs, and others are destroyed by tidal inundation. Vehicular traffic, rainwater runoff, gill nets, and tourist activities also impact the nests (see Mortimer and Donnelly 2008).

In Saudi Arabia, approximately 175-265 females nest annually along the Arabian Gulf (see Mortimer and Donnelly 2008). Population trends are unknown. Threats include entanglement in gill nets and debris, and destruction of nesting and foraging habitats. Coral bleaching events have occurred resulting in destruction of coral reefs in the Arabian Gulf (see Mortimer and Donnelly 2008). Along the Red Sea coastline, 100-200 females nest annually (see Mortimer and Donnelly 2008). Low density nesting occurs at numerous sites from the islands of the Farasan Archipelago to Tiran Island at the Gulf of Aqaba. Population trends are unknown. Major threats include egg harvest, fisheries related mortality, and habitat destruction caused by cement dust that lands on the beach and solidifies (see Mortimer and Donnelly 2008).

Kuwait reportedly hosts fewer than 20 females/year (Papathanasopoulou 2010), while both Qatar and the United Arab Emirates host significant numbers of nesting females, more than 100 females/year in Qatar and 100-200 females/year in the United Arab Emirates (see Mortimer and Donnelly 2008). Several countries in the immediate area have banned trawling, including Bahrain, Kuwait, and Qatar (see Mortimer and Donnelly 2008).

For Egypt on the Red Sea, the recent estimate is 50-100 females annually (see Mortimer and Donnelly 2008). Egypt is a historically important source and consumer of shell. Threats include destruction of habitat (see Mortimer and Donnelly 2008).

Neighboring Sudan has not been surveyed since the 1970s when a total of 300-350 females/year nested on the islands of the Suakin Archipelago and islands off Mohammed Qol (see Mortimer and Donnelly). In Sudan, hawksbills were intensively exploited for the tortoiseshell trade and killed for meat in the late 19th century at the opening of the Suez Canal (see Mortimer and Donnelly 2008). Subsistence harvest was reported in the 1970s (Frazier 1980). The current situation is unknown (see Mortimer and Donnelly 2008).

Eritrea has never been properly surveyed (Okibagiorgis 2008). Although subsistence harvest occurs (Okibagiorgis 2008), the sparse coastal human population indicates that neither directed harvest nor coastal development is likely to pose a major threat (Hillman and Gebremariam 1996). However, fisheries related mortality (especially from trawlers and shark nets) may be a serious problem with an estimated 0.61 turtles (47% are hawksbills) caught per hour trawled in Eritrean waters (Gebremariam *et al.* 1998).

For Somalia, nesting is reported in the northeast and southwest regions, but no nesting estimates are available (see Mortimer and Donnelly 2008). Bajun on the south coast harvested tortoiseshell for generations, which they sold to Europe in the 1970s, and formerly to Zanzibar at approximately 100 kg/year, except for 5,099 kg exported in 1976 (Frazier 1980).

For Yemen, approximately 500 nesting females/year are estimated based on data from the 1960s and 1970s. Nesting is reported for Socotra, Abd al Kuri, Jabal Aziz, and Perim, and at low coral islands 3-30 km offshore (see Mortimer and Donnelly 2008). Meat and eggs were eaten by fishermen (Frazier 1980).

The tortoiseshell trade in the North Western Indian Ocean has been insignificant since at least 1950, which may explain the current relative abundance of hawksbills in the region. Regardless, the species faces significant threats from entanglement in fishing gear, habitat degradation associated with oil production, exploitation for meat and eggs, and coastal development.

Indian Ocean: Central and Eastern

Currently, the most important hawksbill nesting populations in the Central and Eastern Indian Ocean are those that occur in Australia (Western Australia), Maldives, British Indian Ocean Territory (Chagos Islands), and India (Andaman and Nicobar Islands) (Figure 4). Except for those of Australia, all the hawksbill rookeries of the Central and Eastern Indian Ocean have declined significantly. Populations in Malaysia (Melaka), Myanmar, Sri Lanka, and Thailand (Andaman Sea) are considered remnant populations.

The Western Australian hawksbill population is the largest in the Indian Ocean (Limpus 1997, 2002). Regionally significant rookeries occur within the Dampier Archipelago and the Montebello Islands (Limpus 2009). Much of the nesting occurs within areas of the greatest industrial development, including brightly lit oil/gas facilities on islands and at sea. Altered light horizons may reduce nesting activity and increase hatchling predation at sea. Habitat destruction from coastal development occurs, but impacts to sea turtles are not monitored (Limpus 2009).

Maldives hosts an estimated 460-767 females/year based on data collected in the 1980s and during 1988-1995 (see Mortimer and Donnelly 2008). The long history of tortoiseshell export combined with hunting for eggs and meat has had a significant negative impact (Frazier 1980). In the early 1980s, Maldives was considered one of the most important areas for hawksbills in the Indian Ocean, but exploitation has been identified as the probable cause for depletion (Groombridge 1982).

The British Indian Ocean Territory (BIOT; Chagos Islands) hosts an estimated 300-700 females/year. Historical records show a significant tortoiseshell industry, but by 1929 the annual

harvest was 200 animals/year (see Mortimer and Donnelly 2008). BIOT turtles are now protected by law, but enforcement is difficult in the outer islands. Threats include erosion of nesting beaches, especially in the outer islands, and coral reef mortality (see Mortimer and Donnelly 2008). Hawksbill numbers have declined significantly since the late 18th century, but current population trends are unknown.

India (Andaman and Nicobar Islands) has an estimated 250 females/year based on incomplete surveys conducted in 1992 (Andrews *et al.* 2006). The historical trade in tortoiseshells decimated the hawksbill population in India (Mortimer ad Donnelly 2008; Tripathy and Choudhury 2007). Current threats include sand mining, egg predation by dogs and pigs, incidental capture in active and discarded gill nets, and poaching of nesting females and foraging turtles by settlers (Andrews *et al.* 2006).

Malaysia (Melaka State) hosts the most important hawksbill rookery remaining in Peninsular Malaysia. In 2011, 568 nests (approximately 114-190 females) were recorded along the Melaka coast (World Wide Fund for Nature 2012). Egg harvest is the major cause of the hawksbill population decline. The government established hatcheries in the mid-1900s, which led to a decrease in egg harvest but not enough to sustain the natural population (Chan 2006). Bycatch in coastal fisheries and loss of nesting habitat due to coastal development have contributed to the overall decline.

Myanmar hosts a remnant population of fewer than 5 females/year (based on data from Maxwell 1911 as cited in Groombridge and Luxmoore 1989). Hawksbills are more common in the Thanintharyi Region situated in the southern part of Myanmar in the Andaman Sea where seagrass beds and coral reefs are abundant (Thant and Lwin 2012). No recent data are available on population trends.

Sri Lanka is believed to host only about 10 females/year (see Mortimer and Donnelly 2008). In the 1840s, hawksbills were and and a flourishing local artisanal trade developed. Legislation protecting turtles and eggs was enacted in 1972, but not adhered to or enforced. Heavy exploitation continues (see Mortimer and Donnelly 2008). Virtually no eggs survive outside hatcheries, but many hatcheries are poorly managed, and the Sri Lanka Department of Wildlife Conservation has failed to regulate them (Kapurusinghe *in press*). In addition to egg exploitation, fisheries bycatch and coastal development remain significant threats to the hawksbill population in Sri Lanka (Kapurusinghe *in press*; Kapurusinghe and Ekanayeka 2008). This is a remnant population, but recent trends are unknown.

Thailand (Andaman Sea coast) hosts fewer than 10 hawksbill females/year (see Mortimer and Donnelly 2008). In Thailand, exploitation for turtle meat and eggs was unregulated until the 1947 Fisheries Act, which prohibited killing of turtles and required concessions of 10-15% of eggs. By the 1980s, massive coastal development and tourism were a major threat, but several National Parks were established. In the 1980s, small numbers of hawksbills nested at Sulin and Similan islands, Phang Nga Province, and at Tarutao National Park in Satun Province. Nesting is now reported only at Ko Surin National Park. Major threats include poaching of eggs, turtles, and fisheries related mortality (see Mortimer and Donnelly 2008). This is a depleted population in decline.

Pacific Ocean: Western

The most important extant populations in the Western Pacific Ocean are found in Australia, Indonesia, and Melanesia (Figure 5).

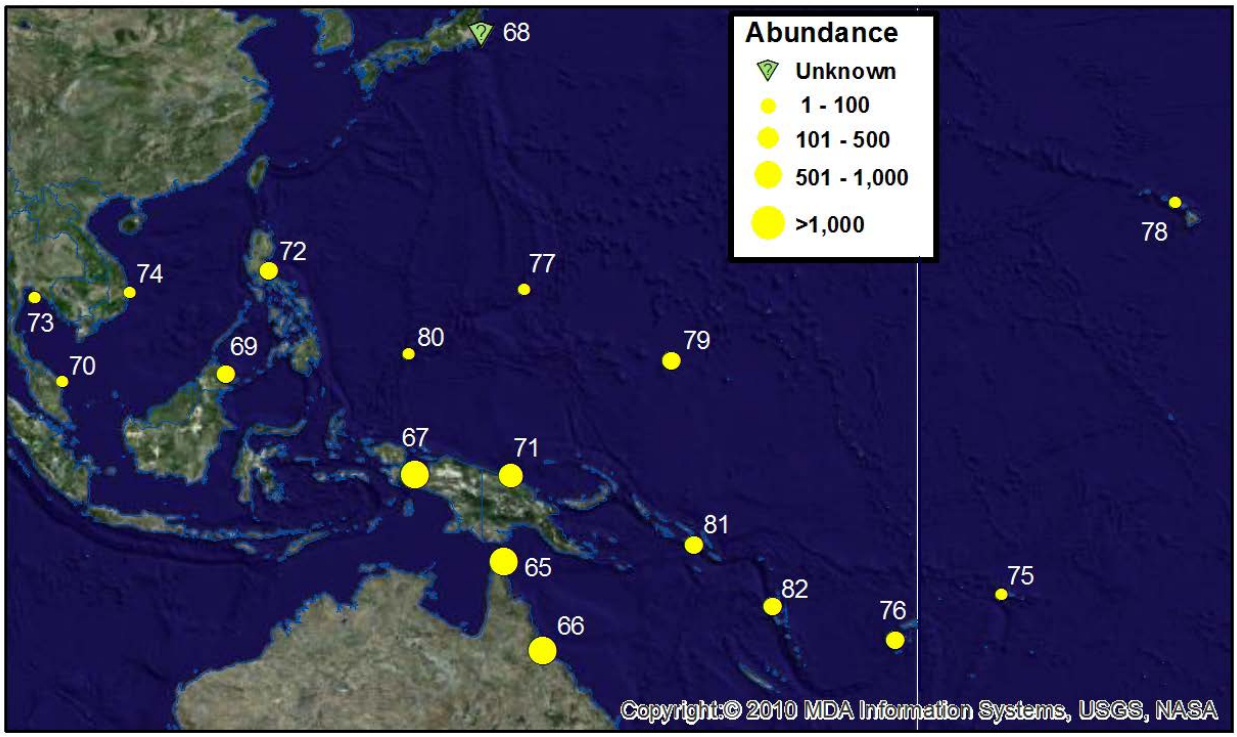

Figure 5. Hawksbill nesting distribution and relative abundance (estimated females nesting annually) in the western and central Pacific Ocean (see Table 3 for site location information).

Hawksbill populations throughout most of the Western Pacific (with the exception of Australia) plummeted during the 20th century. The decline was enhanced by both past and current exploitation of hawksbills for the tortoiseshell trade, continued take for meat, incidental capture in fisheries, and destruction of nesting habitat by unregulated coastal development. This region was historically a significant breeding and foraging area for the hawksbill, and population declines here represent a significant global loss.

The Australian Torres Strait-Northern Great Barrier Reef (GBR) population comprises an estimated 4,000 females/year (Limpus 2009; Limpus and Miller 2008). Within Torres Strait and western Cape York Peninsula, half of all nesting is outside protected habitat (Limpus 2009; Limpus and Miller 2008). On the inner shelf of the Northern GBR, most rookeries are within National Parks, but these nesting females are harvested on foraging grounds in adjacent countries, particularly Solomon Islands (Limpus 1997, 2009; Limpus and Miller 2008). From about 1850 into the 1930s, a ton of tortoiseshell (representing an annual harvest of more than 1,000 adult hawksbills) was exported each year from Torres Strait (Limpus 2009); however, since 1968 hawksbills have been protected in Queensland. The Milman Island index population, surveyed since 1990, is declining at a rate of 3-4% annually (Limpus 1997, 2009; Limpus and Miller 2008). If trends continue, the projected overall decline for the Torres Strait-Northern Great Barrier Reef population would be greater than 90% by the year 2020 (i.e., in less than one

hawksbill generation) (Limpus 2009; Limpus and Miller 2008). Foraging populations within the Great Barrier Reef Marine Park also declined overall, but appear to have been stable between 2004 and 2008, which may be due to conservation measures implemented within the park (Bell *et al*. 2012). Furthermore, the Milman populations showed a decline in the number of experienced nesting females and an increase in first time nesters, which indicates a population subjected to excessive mortality (Limpus and Miller 2008).

The Australian Northeastern Arnhem Land population comprises an estimated 2,500 females/year (Limpus 2009; Limpus and Miller 2008). Most hawksbill rookeries of Arnhem Land are outside National Parks or other habitat managed for conservation purposes (Limpus 2009; Limpus and Miller 2008). Populations are not regularly surveyed, and population trends are not known.

Indonesia may at one time have hosted more nesting hawksbills than any other country in the world. By the mid-1980s, the hawksbill populations were depleted. The shoal waters of the East Indian archipelago were once the most productive source of tortoiseshell in the world. The majority of the tortoiseshell was exported to Japan, Singapore, and the Netherlands during 1918-1927 (see Mortimer and Donnelly 2008). However, even in those early years intensive egg collection was ongoing, and heavy egg exploitation continues and the population continues to decline (see Mortimer and Donnelly 2008).

Papua New Guinea has not been surveyed recently, but low density nesting occurs throughout the country, suggesting a possible nesting population of approximately 500-1,000 females/year (see Mortimer and Donnelly 2008). Nesting has been reported for the East Sepik Province on the mainland and islands, in West Sepik Province on islands, on Long Island and mainland beaches of Madang Province, and on islands of Central Province (see Mortimer and Donnelly). A monitoring program was initiated in the Calvados Chain of the Milne Bay Province where 22 hawksbills were encountered during a three-week nesting beach survey in December 2003 (Kinch 2007). The only relatively recent surveys conducted were at Long Island in Madang Province (Wilson *et al*. 2004). A significant tortoiseshell industry occurred historically and a low level of trade continues (Kinch and Burgess 2009). The current level of trade probably accounts for less than 250 hawksbill turtles annually, a small fraction of the overall subsistence and semi-commercial take (Kinch 2007). The population is thought to be declining.

In the Philippines, the nesting population was reported to be less than 500 females in the 1980s (Groombridge and Luxmoore 1989), but more recent estimates are not available. Mindanao coast and the Sulu district of southern Philippines are historic sources of shell. Outlying islands of the Sulu Archipelago exported shell to Japan; in 1917, almost all of the 8,000 kg of shell collected each year were exported to Japan (see Mortimer and Donnelly 2008). Populations have declined due to exploitation for shell, meat, and eggs. In 1980, virtually every nesting turtle was killed in the Central Visayas, and it was believed the same occurred throughout the Philippines (see Mortimer and Donnelly 2008). However, nesting was documented as recently as 2009 on Guimaras Island, Philippines (Bagarinao 2011). Direct harvest and incidental capture in local fisheries are a continuing threat (Bagarinao 2011; Lucero *et al*. 2011).

East Malaysia hosts the Sabah Turtle Islands where an estimated 90-150 females nest annually (Chan 2006). Eggs were overexploited prior to 1965 when protection began at Turtle Islands Park (de Silva 1982). There is concern that incubation of all eggs in hatcheries since 1965 has feminized offspring (Chan 2006; Mortimer 1991c). The population is believed to be stable.

On the east coast of Peninsular Malaysia, hawksbills nest primarily in the states of Terengganu, Pahang, and Johor. In the late 1970s, several hundred hawksbill nests were produced annually in Terengganu at Pulau Redang (island), Tanjung Galiga on the mainland, and Tioman Island off the Pahang-Johor border. By the early 2000s, only 4-6 females were estimated to nest annually (Liew 2002). Eggs have been harvested since the early 20th century (Chan 2006; Siow and Moll 1982), and overexploitation has caused a significant decline (Chan 2006; Liew 2002). Surveys conducted in 1990 estimated 100-200 egg clutches laid annually in Johor (Mortimer 1991b), and fewer than 100 in Pahang (Mortimer 1991a), with nesting levels at both sites reported by local inhabitants to be much lower than in previous years. Local informants attributed declines to overexploitation of eggs, capture of turtles in commercial fishing gear (especially trawl nets), and destruction of nesting beach habitat by coastal development (Chan 2006; Mortimer 1991a, 1991b). No recent data are available from Johor and Pahang.

The west coast of Thailand (Gulf of Thailand) now hosts about 20 nesting females/year (see Mortimer and Donnelly 2008). Ko Khram, Thailand, is an important hawksbill nesting site, controlled and protected by the Royal Thai Navy since the 1950s. During the 1980s, most of the eggs laid at Ko Khram and nearby islands that were not sold to Navy Officers, were incubated in a hatchery, and all hatchlings were headstarted at Ko Man Nai (Aureggi 2006; Mortimer 1988). Other threats include mortality from heavy trawl activity and poaching of nesting females (reviewed by Aureggi 2006), and disturbance from bright lights and noise from a jetty built in the 1970s (reviewed by Aureggi 2006). There has been a serious decline in nesting activity since the 1950s, including a recorded decline of 43% during 1973-2005 and an estimated decline of 75% during 1956-2005. Nesting at other sites in the Gulf of Thailand is now insignificant (see Mortimer and Donnelly 2008).

Vietnam hosts approximately 100 nesting females/year (Groombridge and Luxmoore 1989). In the 1930-1940s, hawksbills were common along the coast of Vietnam. In 1995, Vietnam was described to have a strong local tortoiseshell industry (Le Dien and Broad 1995); however, the overall market in turtle products has declined (Stiles 2008). The population is considered depleted and probably in decline.

Japan is the northern extreme of the hawksbill's distribution in the Pacific Ocean and hosts a remnant population of nesting hawksbills off the southern main islands in Ryukyu Archipelago and Ogasawara Islands. In this area, hawksbills only occur in small numbers with low nest counts (Kikukawa *et al.* 1999). It has been considered in danger of extirpation since 1985 (Groombridge and Luxmoore 1989). Hawksbills are harvested on the foraging grounds in Japan (TRAFFIC East Asia-Japan 2000).

In China, hawksbills can be found in the Yellow, East China, and South China Seas and nest in the Dongsha and Nansha Archipelagos (see Chan *et al.* 2007). The hawksbill population was estimated to be 1,680 to 4,630, based on harvest data from 1959 through 1988 (Chan *et al.* 2007).

The population has plummeted due to overexploitation, and although directed harvest is no longer allowed, illegal and incidental capture in gillnet, trawl, and set-net fisheries still occurs (Chan *et al.* 2007).

In 2011, TRAFFIC released a report summarizing that marine turtle trade persists and that the number of seizures in the region has been increasing; hawksbill turtles continue to be a heavily exploited and sought-after commodity (Lam *et al.* 2011). Evidence from current seizure records between 2000 and 2008 and market surveys highlight a consistent illegal trade route to mainland China from the Coral Triangle region of South-east Asia (mainly the Philippines, Malaysia, and Indonesia). Of seizures, 128 involved East Asian countries (China, Taiwan, Hong Kong, and Japan) with a trade volume of over 9,180 marine turtle products including whole specimens (2,062 turtles), crafted products (n = 6,161 pieces) and raw shell (789 scutes and 919 kg), with Hainan Province of China being the major market for illegal trade (Lam *et al.* 2011).

Pacific Ocean: Central

In the Central Pacific Ocean, the Solomon Islands have an estimated 200-300 nesting females/year. Nesting declined in the second half of the 20th century, and declined by more than 50% from 1988 to 1997 due to directed harvest (see Moritmer and Donnelly 2008).

Vanuatu is believed to have more than 300 females nesting annually (see Mortimer and Donnelly 2008). Nesting is scattered throughout the country, especially at: a) Banks/Torres; b) Malekula; c) Epi, Green; and d) Aneityum (Petro *et al.* 2007; Wilson *et al*. 2004). Hawksbills have been subject to heavy exploitation at some sites (i.e., Malekula) while elsewhere there has been little or no pressure (Wilson *et al*. 2004); more recently exploitation has lessened in many areas (especially on foraging populations) due to public awareness programs. There are a number of unsurveyed nesting beaches, but surveys in 2006-2007 identified two beaches: Moso Island (Efate) with over 100 nests, and Bamboo Bay (Malakula) with over 200 nests (see Mortimer and Donnelly 2008). Since 1995, there have been efforts to revive traditional management systems to regulate (or sustainably mange) community-based harvest of turtles (Hickey 2007). This includes the Wan Smolbag turtle conservation program that began in 1995 to raise community awareness to address overharvest of turtles through plays, workshops, and a monitoring program with over 262 villages (on 40 islands) and 400 turtle monitors (Vanua-Tai network) participating in monitoring and conservation efforts (Petro 2002). The network has identified direct harvest by villagers (turtles and eggs), nest predation by dogs, and wave inundation (erosion) to be primary threats in Vanuatu (Mortimer and Donnelly 2008; Petro *et al.* 2007).

Fiji has about 100-200 nesting females/year, but hawksbills have been heavily exploited for more than 100 years. In the latter half of the 20th century, there was intense local exploitation of eggs and adults for food and a major shell carving industry. A decline of 50% in 20 years was reported at Namena Lai Lai, a major hawksbill rookery hosting 30-40 females/year (see Mortimer and Donnelly 2008). Domestic subsistence and traditional use continues as well as an underground export trade (Laveti and MacKay 2009).

In the Cook Islands, hawksbills have not been observed to nest, but juveniles have been reported from the area (White 2012).

Micronesia with its thousands of islands and atolls probably supports about 300 females annually (NMFS and FWS 1998). The Republic of Palau has the largest nesting population remaining in Micronesia with about 15-25 females/year (Eberdong and Klain 2008). However, the population in Micronesia is exploited for shell, as well as meat and eggs for local consumption (Meylan and Donnelly 1999), and is considered depleted and declining. In Palau, although a 5 year moratorium on hawksbill turtles is effective from 29 December 2010 to 29 December 2015, turtle take likely still occurs and extensive poaching of eggs has been documented in the Rock Islands Southern Lagoon World Heritage site. Trend data for hawksbills in Palau are unavailable (Yalap 2013). In the Federated States of Micronesia, monitoring of nesting beaches in the Turtle Islands has occurred since 2005, but hawksbills are rarely encountered (Cruce 2007).

In American Samoa and Western Samoa, fewer than 30 females are estimated to nest annually (see Mortimer and Donnelly 2008). On Ofu Island, American Samoa, regular monitoring of nesting beaches is occurring. Between October 1, 2011 and March 31, 2012, a total of six hawksbill nests were documented on two Ofu beaches (Tagarino 2012).

In the Mariana Archipelago of Guam and the Commonwealth of the Northern Mariana Islands, only about 5-10 females are estimated to nest annually (see Mortimer and Donnelly 2008). In 2009, four hawksbill nests and in 2010 three hawksbill nests were documented on Guam (DAWR 2011). These populations are thought to be declining.

In Hawaii, fewer than 20 females nest annually, and although the population trend is unknown, historically the population was significantly more abundant (Van Houtan *et al.* 2012). There are also indications that the Big Island nesting population may be stable (Seitz *et al.* 2012). Nesting activity in the U.S. Pacific Remote Island Areas (Wake, Johnston and Palmyra Atolls, Kingman Reef, and Jarvis, Howland, and Baker Islands) is rare with no hawksbill nests documented, although turtles do occur foraging throughout the area.

Pacific: Eastern

Important nesting populations in the eastern Pacific include Mexico and El Salvador (Figure 6).

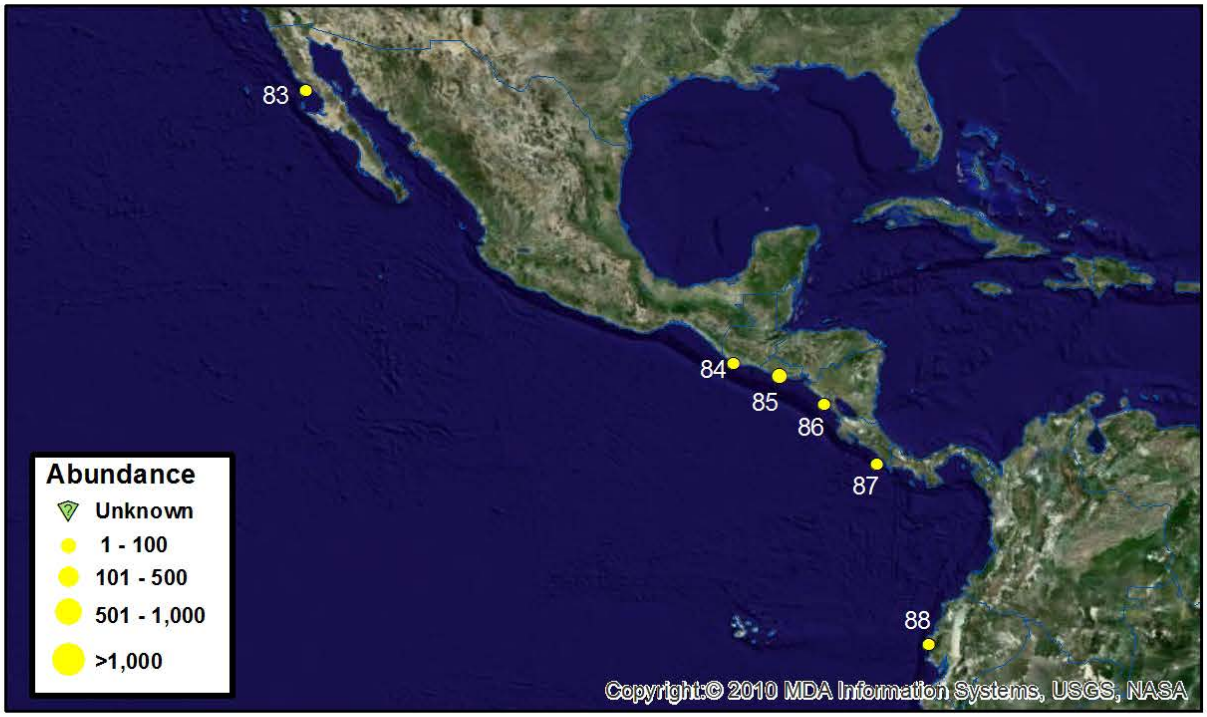

Figure 6. Hawksbill nesting distribution and relative abundance (estimated females nesting annually) in the eastern Pacific Ocean (see Table 3 for site location information).

Once abundant, hawksbills are now rare in the eastern Pacific (Cliffton *et al*. 1982; Gaos *et al.* 2010; Seminoff *et al*. 2003b). Within the eastern Pacific, approximately 300 females are estimated to nest each year along the coast from Mexico south to Peru (Gaos *et al*. 2010). Most of the nesting within the region occurs in El Salvador (Gaos *et al*. 2010; Liles *et al.* 2011). Mexico hosts remnant populations of hawksbills with fewer than 15 females estimated to nest each year. There are low nesting numbers in Jalisco, Nayarit, and Tres Marias Islands (Seminoff *et al*. 2003b). Most of the nesting in Ecuador is reported from Machalilla National Park and in Costa Rica from Corcovado National Park (Gaos *et al.* 2010). The decline of the hawksbill population in the eastern Pacific is due to heavy egg harvest, trade in tortoiseshells, and fisheries bycatch (Gaos *et al.* 2010).

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

The determination to list a species under the ESA is based on the best scientific and commercial data regarding the five listing factors (see below). Subsequent 5-year reviews must also make determinations about the listing status based, in part, on these same factors.

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

Since the last 5-year review (NMFS and FWS 2007), impacts to the nesting and marine environments that affect hawksbills have increased. Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard *et al*. 1998; Lutcavage *et al*. 1997). These factors may directly, through loss of beach habitat, or indirectly, through changing thermal profiles and increasing erosion, serve to decrease the amount of nesting area available to nesting females, and may evoke a change in the natural behaviors of adults and hatchlings (Ackerman 1997; Witherington *et al*. 2003, 2007). Sea-level rise resulting from climate change may increase practices to fortify the coast, further exacerbating the problem (Hawkes *et al.* 2009). In addition, coastal development is usually accompanied by artificial lighting. The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults (Witherington 1992) and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991) or may even cause them to change course offshore (Harewood and Horrocks 2008). In many countries, coastal development and artificial lighting are responsible for substantial hatchling mortality. Although legislation controlling these impacts does exist (Lutcavage *et al*. 1997), a majority of countries do not have regulations in place.

Tropical coastlines are rapidly being developed for tourism, which often leads to destruction of hawksbill nesting habitat (Mortimer and Donnelly 2008). Because hawksbills prefer to nest under vegetation (Horrocks and Scott 1991; Mortimer 1982), they are particularly impacted by beachfront development and clearing of dune vegetation (Mortimer and Donnelly 2008). The loss of native vegetation cover on nesting beaches will increase the number of nests exposed to elevated temperatures due to climate and may impact natural sex ratios (Kamel 2013). Daytime nesting hawksbills in the Western Indian Ocean are especially sensitive to disturbance from human activity on the coast and in internesting habitat (Mortimer 2004). In other parts of the world, such as the Middle East and Western Australia, gas and oil refineries seriously disrupt nesting habitat (Limpus 2002; Miller 1989; Mortimer and Donnelly 2008).

Considering that coastal development and beach armoring are detrimental to hawksbill nesting behavior (Lutcavage *et al*. 1997), the pending human population expansion is reason for major concern. This concern is underscored by the fact that over the next few decades the human population is expected to grow by more than 3 billion people (about 50%). By the year 2025, the United Nations Educational, Scientific and Cultural Organization (UNESCO) (2001) forecasts that population growth and migration will result in 75% of the world human population living within 60 km of the sea. Such a migration undoubtedly will change the coastal landscape that, in many areas, is already suffering from human impacts. The problems associated with development in these zones will progressively become a greater challenge for conservation efforts, particularly in the developing world where wildlife conservation is often secondary to other national needs.

In addition to impacting the terrestrial zone, anthropogenic disturbances also threaten coastal marine habitats. These impacts include removal of mangroves, contamination from herbicides, pesticides, oil spills, and other chemicals, as well as destruction of benthic habitat from excessive

boat anchoring, dredging, and fishing gear (Francour *et al*. 1999; Gaos *et al.* 2012b; Lee Long *et al*. 2000; Shester and Micheli 2011; Waycott *et al*. 2005). Hawksbills often associate with coral reefs, which are among the world's most endangered marine ecosystems (Wilkinson 2000). Warmer water temperatures cause corals to expel algae (zooxanthellae) living in their tissue. The coral turns white (called 'bleaching') and may survive the event, but is more susceptible to mortality. Climate change has led to massive coral bleaching events with permanent consequences for local habitats (Donner *et al.* 2005; National Oceanic and Atmospheric Administration 2013). Depending on the geographic area, hawksbills also associate with macroalgae, seagrass pastures, and mangroves. Climate change is anticipated to impact these marine habitats by, for example, alterating growth rates, increasing mortality from heat stress and frequency and severity of storms, severely reducing or redistributing existing habitats due to changes to water depth and tides (Harley *et al.* 2006; Short and Neckles 1999).

The Services believe that hawksbills remain in danger of extinction because of ongoing and threatened destruction, modification, and curtailment of their habitat.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Hawksbills, like all sea turtle species, are vulnerable to anthropogenic impacts during all life-stages: from eggs to adults. The greatest threats to hawksbills result from harvest for commercial and subsistence use. These include directed take of eggs and females on nesting beaches and juvenile and adults in foraging areas. Hawksbills are harvested largely for their shell, but also for subsistence, medicine, and oil.

Recent and historical tortoiseshell trade statistics are key to understanding the enormous and enduring effect that trade has had on hawksbill populations around the world (Mortimer and Donnelly 2008). Within the last 100 years, millions of hawksbills have been killed for the tortoiseshell markets of Europe, the United States, and Asia. The global plight of the hawksbill in the latter half of the 20th century has been recognized by the inclusion of the species in the most threatened category of the IUCN's Red List since its creation in 1968 and the listing of all hawksbill populations on Appendix I of CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, since 1977. Nevertheless, trade continued, and nearly 400,000 adult female hawksbills were killed for the Japanese market from 1950 through 1992 (Mortimer and Donnelly 2008). Although Cuba implemented a moratorium on its sea turtle fisheries in 2008, the country retains the right to dispose of its tortoiseshell stockpile and significant domestic trade in hawksbill products continues to be a major problem in many other countries (Bräutigam and Eckert 2006; Chacón 2002; Fleming 2001; Lam *et al.* 2011; Mortimer and Donnelly 2008; Reuter and Allan 2006; TRAFFIC Southeast Asia 2004; van Dijk and Shepherd 2004).

One of the most detrimental human threats to hawksbill turtles is the intentional and intensive exploitation of eggs from nesting beaches. Egg exploitation has impacted hawksbill populations throughout the world, but has been especially detrimental in Asia. In some countries, very few eggs hatch outside protected hatcheries (Mortimer and Donnelly 2008), particularly in Indonesia, Thailand, Malaysia, and Sri Lanka. As each nesting season passes and populations continue to suffer from egg harvest, they will progressively lose the juvenile cohorts that would have

recruited from the post-hatchling phase (Mortimer 1995). In some instances, present nesting populations may appear hardy, but without recruitment into the juvenile population and a well-balanced distribution of turtles among all cohorts, populations are more vulnerable to decline (Crouse *et al*. 1987; Frazer 1992).

Notwithstanding recent measures to protect hawksbills, harvest of adults and juveniles in foraging areas remains a major concern in many countries. Although adult mortality in foraging habitats results in more quickly observable abundance changes on the nesting beach, the mortality of immature turtles in marine habitats may be as great a threat to the population stability. This life-stage is the most valuable in terms of recovery and stabilization of sea turtle populations due to the fact that not only have large juveniles already survived many mortality factors, thus having a high reproductive value, but also there are typically more juveniles than adults in a population (Crouse *et al*. 1987; Ogren 1989). Therefore, relatively small changes in the survival rate of this life-stage impact a large segment of the population (Crouse 1999). As with the delayed feedback from egg harvest, the hawksbill's slow maturation delays the observable effects of juvenile harvests, and this threat may not be observed as a decline in nesting females for decades. Once there is a crash in the adult nesting population as a result of non-recruitment, it is substantially more difficult to achieve population recovery with an equally (or more so) depleted juvenile population (Mortimer 1991d).

Genetic research has shown that hawksbills of multiple nesting beach origins commonly mix in foraging areas (Bowen *et al*. 1996; Broderick and Moritz 1996; Mortimer and Broderick 1999). Thus, a significant harvest of hawksbills at one site can impact multiple other sites (e.g., harvest at a nesting beach can impact multiple feeding grounds, and harvest at a feeding ground can impact multiple nesting sites) (Broderick 1998; Kinch 2007; Limpus and Miller 2008; Mortimer *et al*. 2007; however see Campbell and Godfrey 2010), thus reinforcing the need for regional cooperation.

The Services believe that hawksbills remain in danger of extinction because of overutilization for commercial purposes.

2.3.2.3 Disease or predation:

Fibropapillomatosis has been reported in all sea turtle species, including the hawksbill. This disease is characterized by the presence of internal and external tumors (fibropapillomas) that may grow large enough to hamper swimming, vision, feeding, and potential escape from predators (Herbst 1994). The frequency of fibropapillomatosis in hawksbills is relatively low and is not presently a major source of concern for this species.

Predators of hawksbill eggs include feral pigs (Diez *et al*. 1998), mongoose (Leighton *et al*. 2008; Nellis and Small 1983), raccoons and coatimundis (Smith 1991), dogs (Lagueux *et al*. 2003; Meylan *et al*. 2006), fox and feral cats (Ficetola 2008), ghost crabs (Hitchins *et al*. 2004; Wood 1986), and monitor lizards, ants, and fly larvae (Chan and Liew 1999). Natural predation on hatchling hawksbills by birds and fish is also undoubtedly high, although documented cases are scarce (Witzell 1983). Juvenile and adult hawksbills are also taken by carnivorous fish (Witzell 1983).

At Playa Chiriqui, Panama, the most significant hawksbill nesting beach in the region, threats from predators (especially dogs) have proven difficult to address (Meylan *et al.* 2006). In the Andaman and Nicobar Islands in India, egg predation by feral dogs and pigs is a major concern at several beaches (Andrews *et al.* 2006). Within the U.S. Caribbean, feral pig predation was formerly a major threat to the survival of hawksbill nests laid on Mona Island, Puerto Rico, with 44 to 100% of all hawksbill nests deposited outside fenced areas from 1985 to 1987 destroyed (Kontos 1985, 1987, 1988). However, the installation of protective fencing to exclude feral pigs from Mona Island nesting beaches has significantly reduced this threat (Mona Island Research Group 2012). In northeastern Brazil, an eradication program for brown rats was implemented to prevent depredation of hawksbill eggs and hatchlings (Zeppelini *et al.* 2007). In the U.S. Virgin Islands, mongooses were destroying up to 55% of all nests on Buck Island Reef National Monument until they were eradicated in 1987 (Small 1982). In Qatar, Arabian Gulf, the sand fox (*Vulpes rueppelli*) and feral cats are a significant problem at beaches adjacent to cities, but netting placed over nests was shown to stop predation (Ficetola 2008).

Although disease and predation may cause significant impacts at specific sites, they are believed to be relatively minor in terms of overall threats to the hawksbill.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

The conservation and recovery of sea turtles is enhanced by a number of regulatory instruments at international, regional, national, and local levels. Since the 2007 5-year review (NMFS and FWS 2007), the Papahanaumokuakea Marine National Monument in the northwestern Hawaiian Islands was established prohibiting oil and gas exploration and vessel anchoring on live or dead coral, which will likely protect hawksbill habitat. In 2012, NMFS proposed to list 66 corals (7 in the Caribbean and 59 in the Pacific; 77 FR 73219 December 7, 2012) for protection under the ESA. If listed, actions to protect and conserve corals may result in beneficial effects to hawksbills, especially in the Caribbean where hawksbills are closely associated with coral reefs. Also several conservation actions to reduce directed take have been implemented. The following countries banned the harvest of hawksbills: Cuba in 2008, Cayman Islands in 2008 (Blumenthal *et al.* 2009a), and the Bahamas in 2009. Community conservation programs to decrease or eliminate poaching of nesting female and eggs have been implemented in many areas. For example, poaching decreased to approximately 1% of total nests in Tanzania since the establishment of the Tanzania Turtle & Dugong Conservation Programme (Muir and Abdallah 2008). In 2008, the Eastern Pacific Hawksbill Initiative (http://hawksbill.org) was established to promote recovery, and programs to protect nests and nesting females have been supported in Mexico and Central America. In 2009, the United States established the Mariana Trench, Rose Atoll, and Pacific Remote Islands National Monuments, which prohibited commercial and recreational fisheries in an area encompassing over 95,000 square miles.

As a result of these designations, agreements, and legal actions, many of the anthropogenic threats have been lessened: harvest of eggs and adults has been slowed at several nesting areas through nesting beach conservation efforts and an increasing number of community-based initiatives are in place to slow the capture and killing of turtles in foraging areas. Moreover,

there is now a more concerted effort to reduce global sea turtle interactions and mortality in artisanal and industrial fishing practices.

Despite these advances, human impacts continue throughout the world. The lack of comprehensive and effective monitoring and bycatch reduction efforts in many pelagic and near-shore fisheries operations still allows substantial direct and indirect mortality, and the uncontrolled development of coastal and marine habitats threatens to destroy the supporting ecosystems of hawksbill turtles. Although several international agreements provide legal protection for sea turtles, additional multi-lateral efforts are needed to ensure they are sufficiently implemented and/or strengthened, and key non-signatory parties need to be encouraged to accede.

Considering the worldwide distribution of hawksbills, virtually every legal instrument that targets or impacts sea turtles is almost certain to cover hawksbills. A summary of the main regulatory instruments from throughout the world that relate to the conservation and recovery of hawksbills is provided below.

United States Magnuson-Stevens Conservation and Management Act
The United States Magnuson-Stevens Fishery Conservation and Management Act (MSA), implemented by NMFS, mandates environmentally responsible fishing practices within federally managed U.S. fisheries. Section 301 of the MSA establishes National Standards to be addressed in management plans. Any regulations promulgated to implement such plans, including conservation and management measures, shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch. Section 301 by itself does not require specific measures. However, mandatory bycatch reduction measures can be incorporated into management plans for specific fisheries, as has happened with the U.S. pelagic longline fisheries in the Atlantic and Pacific Oceans. Section 316 requires the establishment of a bycatch reduction engineering program to develop "technological devices and other conservation engineering changes designed to minimize bycatch, seabird interactions, bycatch mortality, and post-release mortality in federally managed fisheries."

FAO Technical Consultation on Sea Turtle-Fishery Interactions
The 2004 Food and Agriculture Organization of the United Nations' (FAO) technical consultation on sea turtle-fishery interactions was groundbreaking in that it solidified the commitment of the lead United Nations agency for fisheries to reduce sea turtle bycatch in marine fisheries operations. Recommendations from the technical consultation were endorsed by the FAO Committee on Fisheries (COFI) and called for the immediate implementation by member nations and Regional Fishery Management Organizations (RFMOs) of guidelines to reduce sea turtle mortality in fishing operations, developed as part of the technical consultation.

Currently, all five of the tuna RFMOs call on their members and cooperating non-members to adhere to the 2009 FAO "Guidelines to Reduce Sea Turtle Mortality in Fishing Operations," which describes all the gears sea turtles could interact with and the latest mitigation options. The Western and Central Pacific Fisheries Commission (http://www.wcpfc.int) has the most protective measures (CMM 2008-03), which follow the FAO guidelines and ensure safe handling of all captured sea turtles. Fisheries deploying purse seines, to the extent practicable, must avoid

encircling sea turtles and release entangled turtles from fish aggregating devices. Longline fishermen must carry line cutters and use dehookers to release sea turtles caught on a line. Longliners must either use large circle hooks, whole finfish bait, or mitigation measures approved by the Scientific Committee and the Technical and Compliance Committee. The InterAmerican Tropical Tuna Convention (http://www.iattc.org) has a sea turtle resolution, which encompasses the elements in the Western and Central Pacific Fisheries Commission, but does not require the use of a specific mitigation device or bait type in longline fisheries. The InterAmerican Tropical Tuna Convention has also developed a memorandum of understanding with the InterAmerican Convention for the Protection and Conservation of Sea Turtles. The International Commission for the Conservation of Atlantic Tunas (http://www.iccat.int) has a recommendation on sea turtles, which calls for implementing the FAO Guidelines for sea turtles, avoiding encirclement of sea turtles by purse seiners, safely handling and releasing sea turtles, and reporting on interactions. The Commission does not have any specific gear requirements in longline fisheries. The International Commission for the Conservation of Atlantic Tunas is currently undertaking an ecological risk assessment to better understand the impact of its fisheries on sea turtle populations. The Indian Ocean Tuna Commission (http://www.iotc.org/) is also in the process of carrying out an ecological risk assessment for sea turtles. Their turtle measures encompass similar elements of the other organizations but do not require the use of certain gear or bait in longline fisheries. Finally, the Commission for the Conservation of Southern Bluefin Tuna (http://www.ccsbt.org) supports the measures called for in the Western and Central Pacific Fisheries Commission and the Indian Ocean Tuna Commission (http://www.wcpfc.int/node/591).

Other international fisheries organizations that may influence hawksbill recovery include the Southeast Atlantic Fisheries Organization (http://www.seafo.org) and the North Atlantic Fisheries Organization (http://nafo.int). These organizations regulate trawl fisheries in their respective Convention areas. Given that sea turtles can be incidentally captured in these fisheries, both organizations have sea turtle resolutions calling on their Parties to implement the FAO Guidelines on sea turtles as well as to report data on sea turtle interactions.

Indian Ocean – South-East Asian Marine Turtle Memorandum of Understanding (IOSEA)
Under the auspices of the Convention of Migratory Species, the IOSEA memorandum of understanding provides a mechanism for States of the Indian Ocean and South-East Asian region, as well as other concerned States, to work together to conserve and replenish depleted marine turtle populations. This collaboration is achieved through the collective implementation of an associated Conservation and Management Plan. Currently, there are 33 Signatory States. The United States became a signatory in 2001. The IOSEA has an active sub-regional group for the Western Indian Ocean, which has improved collaboration amongst sea turtle conservationists in the region. Further, the IOSEA website provides reference materials, satellite tracks, on-line reporting of compliance with the Convention, and information on all international mechanisms currently in place for the conservation of sea turtles. Finally, at the 2012 Sixth Signatory of States meeting in Bangkok, Thailand, the Signatory States agreed to procedures to establish a network of sites of importance for sea turtles in the IOSEA region (http://www.isoeaturtles.org).

Memorandum of Understanding on Association of South East Asian Nations (ASEAN) Sea Turtle Conservation and Protection

The objectives of this Memorandum of Understanding, initiated by the ASEAN, are to promote the protection, conservation, replenishing, and recovery of sea turtles and their habitats based on the best available scientific evidence, taking into account the environmental, socio-economic and cultural characteristics of the Parties. It currently has nine signatory states in the South East Asian Region. As the technical arm of ASEAN, the Southeast Asia Fisheries Development Center (SEAFDEC) supports the work of this Memorandum of Understanding. Further, the Japanese Trust Fund in collaboration with the Malaysian government is supporting a project on the research and management of sea turtles in foraging habitats in Southeast Asian waters (http://document.seafdec.or.th/projects/2012/seaturtles.php).

Memorandum of Agreement between the Government of the Republic of the Philippines and the Government of Malaysia on the Establishment of the Turtle Island Heritage Protected Area

Signed in 1996, this bilateral Memorandum of Agreement paved the way for the Turtle Islands Heritage Protected Area, which protects very important concentrations of nesting green turtles and hawksbills. In 2004, a Tri-national regional action plan and marine protected area for marine turtles was established as part of the Sulu Sulawesi Marine Ecoregion. More information on this agreement can be found at http://www.fishdept.sabah.gov.my/ssme.asp.

Memorandum of Understanding Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa

This Memorandum of Understanding was concluded under the auspices of the Convention on the Conservation of Migratory Species of Wild Animals and became effective in 1999. It aims at safeguarding six marine turtle species - including the hawksbill - that are estimated to have rapidly declined in numbers during recent years due to excessive exploitation (both direct and incidental) and the degradation of essential habitats. However, despite this agreement, killing of adult turtles, harvesting of eggs, and turtle bycatch remain widely prevalent along the Atlantic African coast. Additional information is available at http://www.cms.int/species/africa_turtle/AFRICAturtle_bkgd.htm.

Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC)

This Convention is the only binding international treaty dedicated exclusively to sea turtles and sets standards for the conservation of these endangered animals and their habitats with an emphasis on bycatch reduction. The Convention area is the Pacific and the Atlantic waters of the Americas. Currently, there are 15 Parties. The United States became a Party in 1999. The IAC has worked to adopt fisheries bycatch resolutions, carried out workshops on Caribbean hawksbill conservation, and established collaboration with other agreements such as the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region and the International Commission for the Conservation of Atlantic Tunas. Additional information is available at http://www.iacseaturtle.org.

Convention on the Conservation of Migratory Species of Wild Animals

This Convention, also known as the Bonn Convention or CMS, is an international treaty that focuses on the conservation of migratory species and their habitats. As of January 2007, the

Convention had 118 Parties, including Parties from Africa, Central and South America, Asia, Europe, and Oceania. While the Convention has successfully brought together about half the countries of the world with a direct interest in sea turtles, it has yet to realize its full potential (Hykle 2002). Its membership does not include a number of key countries, including Brazil, Canada, China, Indonesia, Japan, Mexico, Oman, and the United States. Additional information is available at http://www.cms.int.

Convention on Biological Diversity (CBD)

The primary objectives of this international treaty are: 1) the conservation of biological diversity, 2) the sustainable use of its components, and 3) the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. This Convention has been in force since 1993 and had 193 Parties as of March 2013. While the Convention provides a framework within which broad conservation objectives may be pursued, it does not specifically address sea turtle conservation (Hykle 2002). Additional information is available at http://www.cbd.int.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

Known as CITES, this Convention was designed to regulate international trade in a wide range of wild animals and plants. CITES was implemented in 1975 and had 177 Parties as of March 2013. CITES has been of critical importance in ending the legal international trade in hawksbill shell. Nevertheless, it does not limit legal and illegal harvest within countries, nor does it regulate intra-country commerce of sea turtle products (Hykle 2002).

In 1975, in recognition of its endangered status, the hawksbill was included on Appendices I (Atlantic population) and II (Pacific population) of CITES when the Convention came into force. By 1977, the entire species was moved to Appendix I to prohibit all international trade. Nevertheless, the global trade continued for a number of years, in large part driven by Japanese demand. At the end of 1992, Japanese imports ceased, but the industry continues to operate with stockpiled material (Mortimer and Donnelly 2008). Although the tortoiseshell trade continues to threaten hawksbills in numerous places, overall volume is substantially reduced. Thirty years after CITES came into force, the ban on international trade demonstrates its value over time in protecting hawksbills. Above all, nesting increases in the Caribbean coincide with the enormous reduction in hawksbill fishing in Cuban waters (Mortimer and Donnelly 2008). Additional information is available at http://www.cites.org.

Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean

This Protocol is under the auspices of the Barcelona Convention for the Protection of the Mediterranean Sea against Pollution. It has been in force since 1999 and includes general provisions to protect sea turtles and their habitats within the Mediterranean Sea. The Protocol requires Parties to protect, preserve, and manage threatened or endangered species, establish protected areas, and coordinate bilateral or multilateral conservation efforts (Hykle 2002). In the framework of this Convention, to which all Mediterranean countries are parties, the Action Plan for the Conservation of Mediterranean Marine Turtles has been in effect since 1989. Additional information is available at http://www.rac-spa.org.

Convention on the Conservation of European Wildlife and Natural Habitats
Also known as the Bern Convention, the goals of this instrument are to conserve wild flora and fauna and their natural habitats, especially those species and habitats whose conservation requires the cooperation of several States, and to promote such cooperation. The Convention was enacted in 1982 and includes 51 European and African States and the European Union as of March 2013. Additional information is available at: http://www.coe.int/t/dg4/cultureheritage/nature/bern/marineturtles/default_en.asp.

Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region
Also called the Cartagena Convention, this instrument has been in place since 1986 and has 23 Signatory States as of March 2013. Under this Convention, the component that may relate to hawksbill turtles is the Protocol Concerning Specially Protected Areas and Wildlife (SPAW) that has been in place since 2000. The goals are to encourage Parties "to take all appropriate measures to protect and preserve rare or fragile ecosystems, as well as the habitat of depleted, threatened or endangered species, in the Convention area." All six sea turtle species in the Wider Caribbean are listed in Annex II of the protocol, which prohibits (a) the taking, possession or killing (including, to the extent possible, the incidental taking, possession or killing) or commercial trade in such species, their eggs, parts or products, and (b) to the extent possible, the disturbance of such species, particularly during breeding, incubation, estivation, migration, and other periods of biological stress. The SPAW protocol has partnered with WIDECAST to develop a program of work on sea turtle conservation, which has helped many of the Caribbean nations to identify and prioritize their conservation actions through Sea Turtle Recovery Action Plans. Hykle (2002) believes that in view of the limited participation of Caribbean States in the aforementioned Convention on the Conservation of Migratory Species of Wild Animals, the provisions of the SPAW Protocol provide the legal support for domestic conservation measures that might otherwise not have been afforded. Additional information is available at http://www.cep.unep.org/about-cep/spaw.

Convention for the Protection of the Natural Resources and Environment of the South Pacific Region
This Convention, also known as the Noumea Convention, has been in force since 1990 and includes 26 Parties as of March 2013. The purpose of the Convention is to protect the marine environment and coastal zones of the South-East Pacific within the 200-mile area of maritime sovereignty and jurisdiction of the Parties, and beyond that area, the high seas up to a distance within which pollution of the high seas may affect that area. Additional information is available at http://www.unep.org/regionalseas/programmes/nonunep/pacific/instruments/default.asp.

Secretariat of the Pacific Regional Environment Programme (SPREP)
SPREP's turtle conservation program seeks to improve knowledge about sea turtles in the Pacific through an active tagging program, as well as maintaining a database to collate information about sea turtle tags in the Pacific. SPREP supports capacity building throughout the central and southwest Pacific. SPREP established a marine turtle action plan for the Pacific Islands in 2007 and revised the plan in 2012 (http://www.sprep.org).

Notwithstanding the growing number of domestic and intergovernmental authorities, the Services believe that hawksbills remain in danger of extinction because of inadequacy of existing regulatory mechanisms for their protection.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Hybridization has been documented between hawksbills and loggerheads, and hawksbills and olive ridleys in Brazil (Lara-Ruiz *et al*. 2006; Vilaca *et al.* 2012), loggerheads in Florida (Meylan and Redlow 2006), and greens in the Eastern Pacific (Seminoff *et al*. 2003a). Hybridization of hawksbills with other species of sea turtles is especially problematic at certain sites where hawksbill numbers are particularly low (Mortimer and Donnelly 2008).

There are also several manmade factors that affect hawksbill turtles in foraging areas and on nesting beaches. Two of these are truly global phenomena: climate change and fisheries bycatch.

Impacts from climate change, especially due to global warming, are likely to become more apparent in future years (IPCC 2007a). The global mean temperature has risen 0.76 ºC over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007a). There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. These changes include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007b) and damage to coral reefs (Sheppard 2006).

Climate change will impact sea turtles through increased temperatures, sea-level rise, ocean acidification, changes in circulation patterns, and increased cyclonic activity. As global temperatures continue to increase, so will sand temperatures, which in turn will alter the thermal regime of incubating nests and alter natural sex ratios within hatchling cohorts (e.g., Glen and Mrosovsky 2004). Because hawksbill turtles exhibit temperature-dependent sex determination (reviewed by Wibbels 2003), there may be a skewing of future hawksbill cohorts toward strong female bias (since warmer temperatures produce more female embryos). The effects of global warming are difficult to predict, but changes in reproductive behavior (e.g., remigration intervals, timing and length of nesting season) may occur (reviewed by Hawkes *et al.* 2009). In the southern Gulf of Mexico, hawksbill nesting data from 1980 to 2010 were analyzed in relation to sea surface temperatures associated with the Atlantic Multidecadal Oscillation (del Monte-Luna *et al.* 2011). In the past 30 years, overall temperatures have increased in the North Atlantic, and in years of anomalously warm temperatures, there were proportionately fewer hawksbill nests. Although the causal relationship is unclear, it highlights the complexity of basin-wide decadal environmental processes and long-term hawksbill population trends (del Monte-Luna *et al.* 2011). The sea-level rise from global warming is also a potential problem for areas with low-lying beaches where sand depth is a limiting factor. For these areas, the sea will inundate nesting sites and decrease available nesting habitat (Daniels *et al*. 1993; Fish *et al*. 2005; Fuentes *et al.* 2010). Sea-level rise is likely to increase the use of shoreline stabilization practices (e.g., sea walls), which may accelerate the loss of suitable nesting habitat (reviewed by Hawkes *et al.* 2009). The loss of habitat as a result of climate change could be accelerated due to

a combination of other environmental and oceanographic changes such as the frequency and timing of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Fuentes and Abbs 2010; Van Houtan and Bass 2007). At sea, hatchling dispersal, adult migration, and prey availability may be affected by changes in surface current and thermohaline circulation patterns (reviewed by Hawkes *et al.* 2009). Climate change has increased water temperatures and acidity, which cause corals to bleach and lose their ability to calcify. Damage to coral reefs caused by global warming (Sheppard 2006) threatens to impact hawksbill foraging populations at the global level. However, the impact may be beneficial in certain areas where sponge abundance is predicted to increase (reviewed by Hawkes *et al.* 2009).

Fisheries bycatch in artisanal and industrial fishing gear is also a major impact. Although other species such as leatherback turtles and loggerhead turtles have received most of the attention relative to sea turtle bycatch, hawksbill turtles are also susceptible, particularly in nearshore artisanal fisheries gear. These fisheries practices include drift-netting, long-lining, set-netting, and trawl fisheries, and their adverse impacts on sea turtles have been documented in marine environments throughout the world (Epperly 2003; Lutcavage *et al*. 1997; National Research Council 1990; Wallace *et al.* 2010). In Malaysia, gill nets, hook and line fishing, purse seiners and trawl fishing boats had the greatest impacts to sea turtles with mortality of some 4,490 marine turtles and an average of 10 turtles caught by fishermen / vessel each year, a proportion of which are likely hawksbills (Pilcher *et al.* 2008). Hawksbills are particularly susceptible to entanglement in gill nets and to capture on fishing hooks of artisanal fishers (Mortimer 1998). Several fisheries in the eastern Pacific use explosives, which have killed adult hawksbills (Gaos *et al.* 2010). The majority of the world's 17 major fisheries zones are either considered depleted or are in early stages of collapse (Pauly *et al*. 2005). Unfortunately, rather than elicit a closure of fisheries, declines in catch rate are often greeted with new fisheries and expanding fleets (Pauly *et al*. 2005). Without effective management practices, such expansion likely will result in increased mortality of all sea turtle species.

In addition to climate change and fisheries, natural impacts on hawksbill turtles may include the effects of aperiodic hurricanes and catastrophic environmental events such as tsunamis. In general, these events are episodic and, although they may affect hawksbill hatchling production, the results are generally localized to a small area (but see Hamann *et al*. 2006) and they rarely result in whole-scale losses over multiple nesting seasons (Hamann *et al.* 2006). The negative effects of hurricanes on low-lying and/or developed shorelines may be longer-lasting and a greater threat overall.

Additional factors affecting hawksbill turtles, albeit perhaps not as globally significant as those mentioned above, include increasing incidence of exposure to heavy metals and other contaminants in the marine environment. Contaminants such as organochlorine pesticides, polychlorinated biphelyls, flame retardants, emulsifiers to make plastics, mercury, copper, and other metals have been found in sea turtle tissue and eggs from numerous areas (Al Rawahy *et al*. 2006; Hermanussen *et al*. 2008; Keller *et al.* 2012; Lewis 2006; Malarvannan *et al.* 2011; Miao *et al*. 2001, Presti *et al*. 1999; van de Merwe *et al.* 2008). Although their explicit effects on hawksbills have yet to be determined, such exposure may lead to immunosuppression, enlarged livers, thyroid disruption, and neuro-behavioral changes (Keller *et al.* 2012). Heavy metals have been detected in corals (Huang *et al.* 2003), which diminish the health of coastal marine

ecosystems and, in turn, adversely affect hawksbills. Arsenic is also found in hawksbills, but this compound may be accumulated from dietary sources (Agusa *et al*. 2008; Fujihara *et al.* 2003; Saeki *et al*. 2000). In fact, the hawksbill may be unsuitable for human consumption due to bioaccumulation and magnification of toxic compounds from its diet (Aguirre *et al.* 2006; Meylan and Whiting 2008; Warwick *et al.* 2013). For instance, several Micronesians died and approximately 90 others became sick after they ingested hawksbill meat (Buden 2011).

In the southeast United States., boat strikes are a concern. For example in Florida, over 560 hawksbills stranded dead on coastal beaches from 1980 to 2007 (Foley *et al.* 2009). Of these stranded turtles, 9% had definitive propeller wounds indicating the turtle collided with a motorized boat (Foley *et al.* 2009).

Oil spills may be a concern. There is evidence that oil pollution has a greater impact on hawksbills than on other species of turtle (Meylan and Redlow 2006; Yender and Mearns 2003). In 2010, a major oil spill occurred in the north central U.S. Gulf of Mexico, affecting multiple habitats used by hawksbills of various life stages. Assessment of the harm is ongoing as part of the Natural Resources Damage Assessment. In some parts of the world, especially in the Middle East, oil pollution poses a major problem for hawksbills (Mortimer and Donnelly 2008). In addition, sea turtle interaction with oils spills may lead to immunosuppression and other chronic health issues (Sindermann *et al*. 1982). Ingestion of and entanglement in marine debris is also a concern as it can reduce food intake and digestive capacity (Bugoni *et al*. 2001, Meylan and Redlow 2006).

For the reasons described above, the Services conclude that hawksbills remain in danger of extinction because of other natural or manmade factors affecting their continued existence.

2.4 Synthesis

Recent research has added to our knowledge of how hawksbill sea turtles interact with their environment and how they contribute to a healthy marine ecosystem. We know more now about their migration patterns and fine scale movements within local habitats (see section 2.3.1). We have a better understanding of the biological and environmental factors that influence where hawksbills forage and what they forage on. The results of long-term studies have filled gaps in our understanding of hawksbill demography and population structure. Advances in genetic and stable isotope analyses, tagging techniques, especially satellite, radio, and sonic telemetry, and time depth recorders have vastly improved our knowledge of the biology and ecology of hawksbill sea turtles. Understanding the ecological role hawksbills hold in their environment and predicting where they are in space and time are important for developing management strategies to meet recovery goals and objectives.

Since the 2007 5-year review, we have new information on nesting populations in the eastern Pacific, and the Nicaragua nesting population in the western Caribbean appears to have improved. However, the trends and distribution of the species throughout the globe largely is unchanged (see section 2.3.1). The hawksbill turtle was once abundant in tropical and subtropical regions throughout the world. Over the last century, this species has declined in most areas and stands at only a fraction of its historical abundance. Hawksbill populations were

examined by ocean basin at 88 nesting sites among 10 regions around the world. Historic trends for 25 sites are unknown and the remaining 63 sites have declined during the long-term period of > 20 to 100 years. Among the 41 sites for which recent trend data are available, the picture is somewhat more optimistic with 10 (24%) increasing, 3 (7%) stable, and 28 (68%) decreasing. Although greatly depleted from historical levels, nesting populations in the Atlantic in general are doing better than in the Indian and Pacific Oceans. In the Atlantic, more population increases have been recorded in the insular Caribbean than along the western Caribbean mainland or the eastern Atlantic. In general, hawksbills are doing better in the Indian Ocean (especially the southwestern and northwestern Indian Ocean) than in the Pacific Ocean. The situation for hawksbills in the Pacific Ocean is particularly dire, despite the fact that it still has more nesting hawksbills than in either the Atlantic or Indian Oceans.

Substantial international cooperation and community-based programs to conserve and protect hawksbills exist (e.g., South Pacific Regional Environment Programme, East Pacific Hawksbill Initiative, Inter-American Convention for the Protection and Conservation of Sea Turtles). However, threats from manmade and natural sources remain, including the tortoiseshell trade, poaching, incidental capture in commercial and artisanal fisheries, climate change, and coastal development.

Recent and historic tortoiseshell trade statistics are fundamental to understanding the enormous and enduring effect that trade has had on hawksbill populations around the world. Within the last 100 years, millions of hawksbills have been killed for the tortoiseshell markets of Europe, the United States, and Asia. Intensive exploitation of eggs from nesting beaches has impacted hawksbill populations throughout the world, but has been especially detrimental in Asia. Harvest of adults and juveniles in foraging areas is a major concern in many countries. While the recent national bans on hawksbill harvest in Cuba (2008), the Bahamas (2009), and the Cayman Islands (2008) are positive recovery actions, these bans are insufficient to recover hawksbills given other existing threats. Fisheries bycatch in artisanal and industrial fishing gear (e.g., driftnets, longlines, trawls) is also a major impact. Climate change is an emerging and major threat to the conservation and recovery of hawksbills. The sea level is expected to rise resulting in the loss of nesting habitat. The ocean is expected to become warmer impacting coral reefs, which are important foraging habitat. Average air temperatures are expected to be warmer, thus exposing hawksbill eggs to hotter temperatures and skewing natural sex ratios. Loss of suitable nesting habitat is anticipated to continue due to climate change and other human-related activities as coastal areas are developed. In addition to impacting the terrestrial zone, anthropogenic disturbances also threaten coastal marine habitats, including contamination of waters and degradation of coral reefs. Hybridization of hawksbills with other species of sea turtles is problematic at certain sites where hawksbill numbers are particularly low. Additional factors affecting hawksbill turtles include the ingestion of and entanglement in marine debris that can reduce food intake and digestive capacity and injure or kill. Interactions with oil spills are a concern as evidenced by the 2010 oil spill in the north central U.S. Gulf of Mexico.

Recovery objectives specified in the U.S. Atlantic, Caribbean, and Gulf of Mexico Recovery Plan and the U.S. Pacific Recovery Plan have not all been met (see section 2.2). In the U.S. Atlantic, Caribbean, and Gulf of Mexico, significant progress has been made resulting in increases in the nesting population on index beaches in the U.S. Atlantic and Caribbean. The

two most important nesting populations in the United States are increasing: Puerto Rico (Mona Island) and Buck Island Reef National Monument, U.S. Virgin Islands. Progress towards other high priority recovery actions is unknown (percent of habitat protected in perpetuity) or only partially complete (analysis of in-water population trends). In the U.S. Pacific, substantial efforts have been made to identify populations to source beaches, but none have reached the recovery objective of 1,000 females estimated to nest annually (or a biologically reasonable estimate based on the goal of maintaining a stable population in perpetuity) over 6 years.

For the foregoing reasons, and based on a review of the best available information since the 2007 5-year, we conclude that the hawksbill sea turtle remains in danger of extinction throughout all or a significant portion of its range and should not be reclassified or delisted (see section 3.0).

3.0 RESULTS

3.1 Recommended Classification:

Based on the best available information, we conclude the hawksbill sea turtle should not be delisted or reclassified.

3.2 New Recovery Priority Number:

No change. The recovery priority number should remain at 1 and 1C (see section 1.3.5 for definition).

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

The current Recovery Plan for the Hawksbill Turtle (*Eretmochelys imbricata*) in the U.S. Caribbean, Atlantic and Gulf of Mexico was signed in 1993 and the Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*) was signed in 1998. The recovery plans are dated and do not address a major, emerging threat—climate change. Actions to protect nesting beaches and foraging habitat and to preserve natural sex ratios should be comprehensively examined in the context of the threat of climate change. These plans should also conform to current Services' recovery planning guidance. Thus, the existing recovery plans should be updated.

In addition to impacts from climate change, additional information and data are particularly needed on long-term population trends based on both nesting and in-water population monitoring (National Research Council 2010). Numerous gaps remain in our understanding of hawksbill biology. Sufficient information is lacking on basic demography such as growth and age-to-maturity for the vast majority of global populations. Information on annual reproductive output is similarly scant for many sites. In the marine environment, the oceanic juvenile phase remains one of the most poorly understood aspects of hawksbill life history, both in terms of where turtles occur and how long they remain oceanic. At-sea mortality in fisheries is also an area for which few data are available. The paucity of information regarding these aspects continues to inhibit effective modeling of populations, development and assessment of conservation recovery

actions and prevents a full understanding of which populations are most at risk. The Services should consider and support, where appropriate, research that would address these data gaps.

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NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW of *Hawksbill Sea Turtle*

Current Classification: Endangered

Recommendation resulting from the 5-Year Review: No change

Review Conducted By:

Therese Conant, Angela Somma (National Marine Fisheries Service)
Sandy MacPherson, Kelly Bibb (U.S. Fish and Wildlife Service)

REGIONAL OFFICE APPROVAL: The draft document was reviewed by the appropriate Regional Offices.

HEADQUARTERS APPROVAL:
Director, Office of Protected Resources, NOAA Fisheries

Approve: Donna S. Wieting Date: _____
Donna S. Wieting

Assistant Administrator, NOAA Fisheries

X Concur _____ Do Not Concur

Signature _____ Date 5/29/13

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FIELD OFFICE APPROVAL:

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Cooperating Regional Director, Fish and Wildlife Service

✓ Concur ____ Do Not Concur

Signature _____ Date 6/19/13