Appendix C Sea Turtles

Leatherback Turtle (*Dermochelys coriacea)*

The leatherback turtle is listed as endangered under the ESA throughout its global range. Furthermore, the Red List 2000 of the IUCN has classified the leatherback as "critically endangered"[32] due to "an observed, estimated, inferred or suspected reduction of at least 80% over three generations" based on: (a) direct observation; (b) an index of abundance appropriate for the taxon; and (c) actual or potential levels of exploitation.

Leatherback turtles are the largest of the marine turtles, with a CCL (curved carapace length) often exceeding 150 cm and sometimes spanning 270 cm in an adult (NMFS and USFWS, 1998c). Befitting its unusual ecology, the leatherback is morphologically and physiologically distinct from other sea turtles. Its streamlined body, with a smooth, dermis-sheathed carapace and dorso-longitudinal ridges may improve laminar flow of this highly pelagic species. Its front flippers are proportionately larger than in other sea turtles.

Leatherback turtles are widely distributed throughout the oceans of the world. The species is often divided into four main populations in the Pacific, Atlantic, and Indian Oceans, and the Caribbean Sea. Leatherbacks also occur in the Mediterranean Sea, although they are not known to nest there.

Population Status

Leatherback populations have been severely reduced world-wide. In 1980, the leatherback population was estimated at approximately 115,000 (adult females) globally (Pritchard, 1982). A 1996 publication estimated the global population of nesting female leatherbacks at 26,200 to 42,900 (Spotila et al., 1996).

The four main populations are further divided into nesting aggregations. Leatherback turtles are found on the western and eastern coasts of the Pacific Ocean, with nesting aggregations in Mexico and Costa Rica (eastern Pacific) and Malaysia, Indonesia, Australia, the Solomon Islands, Papua New Guinea, Thailand, and Fiji (western Pacific). In the Atlantic Ocean, leatherback nesting aggregations have been documented in Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida. In the Caribbean, leatherbacks nest in the U.S. Virgin Islands and Puerto Rico. In the Indian Ocean, leatherback nesting aggregations are reported in India, Sri Lanka, and the Andaman and Nicobar Islands.

Increases in the number of nesting females have been noted at some sites in the Atlantic, but these are far outweighed by local extirpations, especially of island populations, and the demise of once large populations throughout the Pacific, such as in Malaysia and Mexico. In the Pacific,

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[32] Taxa are categorized as critically endangered when they are facing an extremely high risk of extinction in the wild in the immediate future.

leatherback turtle populations are in severe decline (NMFS and FWS, 1998a; Sarti et al., 1996b; Spotila et al., 2000). The dramatic decline over the last decade in the number of leatherbacks nesting annually may indicate that the leatherback turtle is now on the verge of extinction in the Pacific Ocean, although new nesting beaches were discovered in PNG and other Melanesian islands by NMFS aerial surveys in 2003 (WPRFMC, pers. comm.).

Primary threats to the species are the incidental killing of turtles by coastal and high seas fishing and to a lesser extent the killing of nesting females, collection of eggs at the nesting beaches (Eckert and Sarti, 1997; NMFS and FWS, 1998d; Spotila et al., 2000; Wetherall et al., 1993) and degradation of habitat. On some beaches, nearly 100% of the eggs are harvested.

There are no nesting populations of the leatherback turtle in areas under U.S. jurisdiction in the Pacific; however, there are important foraging areas off the west coast of the continental United States and on the high seas near the Hawaiian islands.

Eastern Pacific

The eastern Pacific population has been monitored since the 1980s and the data indicate declining population trends based on the number of nesting females per year (Sarti, 2000; Sarti, 2002). Recent estimates indicate that the rate of decrease in number of leatherbacks nesting annually is between 20-22 percent (Sarti et al., 1996b; Spotila et al., 2000). During the 2001/02 nesting season, preliminary data revealed only 75 leatherbacks nested in Costa Rica and approximately 109 to 120 leatherback turtles nested in Mexico (NMFS 2002). Three principal nesting beaches in Mexico and the main nesting beach in Costa Rica represent approximately 80 percent of all nesting activity in the region.

Conservation efforts during the last few years at nesting beaches in Mexico and Costa Rica have led to increased survival of eggs, and therefore greater hatchling production per nesting female. This has the potential for increasing future recruitment if post-hatchling survival is not further reduced; however, since numbers of nests are so low, and post-hatchling and juvenile natural mortality are assumed to be high, this increase in hatchling production may only result in the addition of a few adults annually.

Western Pacific

The major nesting colonies in the western Pacific are located along the coasts of New Guinea and particularly in the Bird's Head region of Papua (formerly Irian Jaya), Indonesia. In 2001, data indicated that between 456-601 leatherback turtles nested in Jamursba-medi, Papua and approximately 128 to 169 turtles nested at War-mon beach, Papua in 1993 (the last available monitoring information) (Hitipeuw, 2002). Preliminary data for the 2003 summer nesting season in Papua (Jamusba-medi) indicates that nesting numbers were a bit lower than last year, but well within normal variability (P. Dutton, pers. comm.). The second major nesting area in the western Pacific occurs in Papua New Guinea where it is estimated that approximately 350 females nest per year (Philips, 2002). Nesting also occurs in western Australia (and to a lesser extent eastern Australia). Small nesting colonies also exist along the east peninsular coast of Malaysia and in the Solomon Islands. The status of the Solomon Islands' population is also unclear, however the population at the once major leatherback nesting beaches along the coast of Terengganu, Malaysia, is less than two percent of the levels recorded in the 1950s, and the decline has continued. The number of nests at this beach had dropped from over 10,000 per year in 1956 to less than 100 by 1995 (Chan and Liew, 1996). The primary cause of the decline was many years of excessive egg harvest, and later the incidental capture of leatherbacks by coastal fisheries in Terangganu beginning in the early 1970s and high seas large scale driftnet fisheries in the 1980s (Chan and Liew, 1996).

Overall, both eastern and western Pacific populations appear to have low female abundance as a result of legal harvest of eggs and nesting females, poaching, and incidental take in fisheries. Representation in the various age classes of female leatherback turtles is most likely unbalanced as a result of losses of adult females, juveniles and eggs and sub-adults and adults as a result of on-going fisheries and the now-defunct high seas driftnet fisheries. Gaps in age structure may cause sudden collapse of nesting populations when age classes with few individuals recruit into the reproductive population as older individuals die or are removed.

Reproduction, Maturity and Life Span

Reproduction is seasonal with females returning to breeding grounds (= remigration interval) every two or three years. Spotila et al. (2000), found the mean remigration interval of females on Playa Grande, Costa Rica, the fourth largest nesting colony in the world, to be 3.7 years, while in Mexico L. Sarti (pers. comm.) reports three years as the typical interval. In Mexico, the nesting season extends from November to February, although some females arrive as early as August (Sarti et al., 1989). In the western Pacific, nesting peaks in May and June (Chu-Chien, 1982), in peninsular Malaysia in June and July (Chan and Liew, 1989) and in Queensland, Australia in December and January (Limpus et al., 1984).

On the Pacific coast of Mexico, females lay one to eleven clutches per year, with clutch size averaging 64 yolked eggs (each clutch also contains a complement of yolkless eggs of various sizes). Clutch sizes in Terengganu, Malaysia, and in Pacific Australia are larger, averaging around 85-95 yolked eggs and 83 yolked eggs, respectively (*in* Eckert, 1993).

Though still controversial among sea turtle biologists, using skeletochronological analysis of a small sample size of leatherback sclerotic ossicles, Zug and Parham (1996) suggested that mean age at sexual maturity for leatherbacks is around 13 to 14 years of age. There are a few records of leatherback females nesting for more than 20 years (S. Eckert, pers. comm.), but longevity has not been determined (NMFS and FWS, 1998b). Pritchard (1996) suggests that the characteristics of the leatherbacks life history make it more flexible than chelonid turtles enabling it to respond better to protection measures (e.g., potentially rapid maturation and the ability to quickly shift nesting sites within a season).

Foraging

The diet of the leatherback turtle generally consists of cnidarians (i.e., medusae and siphonophores) in the pelagic environment (for a review see Bjorndal, 1997). Surface jellyfish feeding is reported in waters under U.S. jurisdiction, especially off the western coast of the continental United States (Eisenberg and Frazier, 1983; Starbird et al., 1993). While Monterey Bay and the Farallon islands in California (Starbird et al., 1993) and the southwest Pacific off Chile and Peru (Eckert, 1999b; Eckert, unpub. data) appear to be important seasonal foraging areas for the leatherback, there has been no systematic study of leatherback turtle foraging grounds in the Pacific (NMFS and FWS, 1998a).

Based on offshore studies of diving by adult females nesting on St. Croix, U.S. Virgin Islands, Eckert et al. (1989) proposed that observed internesting[33] dive behavior reflected nocturnal feeding within the deep scattering layer (strata comprised primarily of vertically migrating zooplankton, chiefly siphonophore and salp colonies, as well as medusae). Hartog (1980) also speculated that foraging may occur at depth, when nematocysts from deep water siphonophores were found in leatherback stomach samples. Leatherbacks also appear to spend almost the entire portion of each dive traveling to and from maximum depth, suggesting that maximum exploitation of the water column is of paramount importance to the leatherback (Eckert et al., 1989). Maximum dive depths for post-nesting females have been recorded at over 1,000 meters, with routine dives recorded at between 50 and 84 m while in tropical waters. The maximum dive length recorded for such female leatherbacks was 37.4 minutes, while routine dives range from 8-14.5 minutes (Eckert, 1999b; Eckert et al., 1989, 1996).

There is currently no rigorous scientific information available on the daily nutritional needs nor daily energy consumption requirements of the leatherback. However, a few researchers have attempted to calculate how much food a leatherback would need to consume per day. Duron (1978) proposed that leatherbacks would consume 200 pounds per day of jellyfish based on observations of feeding turtles and some assumptions about energy requirements, and Lutcavage (Lutcavage and Lutz, 1986) proposed that leatherback hatchlings would need to consume their own weight in jellyfish per day. It is clear by most accounts that the volume of jellylike animals that must be consumed by a leatherback on a daily basis would be quite high.

Migration and Movements

Leatherback turtles have the most extensive range of any living reptile and have been reported circumglobally from 71°N to 47°S latitude in the pelagic Pacific and in all other major pelagic ocean habitats (NMFS and USFWS, 1998c). For this reason, studies of their abundance, life history and ecology, and pelagic distribution are exceedingly difficult. Leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Males are rarely observed near nesting areas, and it has been proposed that mating most likely takes place outside of the tropical waters, before females move to their nesting beaches (Eckert and Eckert, 1988). Leatherbacks are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Morreale, et al., 1994; Eckert, 1998; Eckert, 1999a). In a single year, a leatherback may swim more than 10,000 kilometers (Eckert, 1998).

Migratory routes of leatherback turtles originating from eastern and western Pacific nesting beaches are not entirely known. Satellite tracking of post-nesting females and genetic analyses of

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[33] Internesting - time spent between laying clutches of eggs.

leatherback turtles caught in U.S. Pacific fisheries or stranded on the west coast of the U.S. present some strong insight into at least a portion of their routes and the importance of particular foraging areas. Current data from genetic research suggest that Pacific leatherback stock structure (natal origins) may vary by region.

Migratory corridors of leatherback turtles originating from western Pacific nesting beaches most likely exist along the eastern seaboards of Australia and Asia, including the former Soviet Union (NMFS and USFWS, 1998c). Recent information on leatherbacks tagged off the west coast of the United States has also revealed an important migratory corridor from central California, to south of the Hawaiian Islands, leading to western Pacific nesting beaches. Leatherback turtles originating from western Pacific beaches have been found along the U.S. mainland. There, leatherback turtles have been sighted and reported stranded as far north as Alaska (60°N) and as far south as San Diego, California (NMFS and USFWS, 1998c). Of the stranded leatherback turtles that have been sampled to date from the U.S. mainland, all have been of western Pacific nesting stock origin (P. Dutton, NMFS, personal communication, 2000).

NMFS and FWS (1998b) and Eckert (1999) speculate that the high density of leatherback sightings in and around Monterey Bay and the Farallon Islands, peaking in August, may represent a migration of turtles southward along the U.S. coastline to Mexican nesting beaches where they arrive in time for the initiation of nesting in October. However, genetic analyses on leatherbacks captured by the Hawaii-based longline fishery indicate this may not be the case because most are from western Pacific stocks. Of the 14 leatherbacks sampled in the fishery one was from Eastern Pacific origins and 13 from western Pacific origins (P. Dutton et al., in press; P. Dutton, NMFS, pers. comm., February 2001). Of leatherbacks sampled on the U.S. West coast, all six (two stranded, two captured by the coastal driftnet fleet and two captured for satellite tracking) were of western Pacific origin (Dutton et al., in press; P. Dutton, NMFS, pers. comm., February 2001). Further, two of these turtles (both female) were captured and satellite transmitters attached to the turtles in Monterey Bay. Eckert (pers. comm.) speculated that they were heading toward nesting areas in the western Pacific, but two of the actual tracks indicated a movement back toward the West Coast. Their eventual destination should lend valuable insight into the migratory routes of leatherback sea turtles in the Pacific (S. Eckert, pers. comm.).

In the offshore waters of Hawaii fishers commonly see leatherback turtles, generally beyond the 100 fm curve but within sight of land. Two areas where sightings often take place are off the north coast of Oahu and the West coast of the Island of Hawaii. The pelagic zone surrounding the Hawaiian Islands is apparently regularly used as foraging habitat and migratory pathways for this species. Further to the north of the Hawaiian islands, a high seas aggregation of leatherback turtles is known to occur at 35° N. latitude, between 175° and 180° W longitudes (NMFS, 1991).

Little is known about the distribution of juvenile leatherbacks. However, a recent analysis of sighting and stranding data for the species has yielded some interesting insight into the developmental habitats of this species. It appears that young leatherbacks < 100 cm in carapace length reside only in waters warmer than 26° C, which should put them out of areas in which longline swordfish fleets operate (Eckert, 1999a; S. Eckert, submitted ms.). Thus the net impact of such fishing on leatherback populations is likely to be focused only on larger size classes of turtles - a situation analogous to that of the sea turtle incidental mortality issues addressed in the shrimp fisheries of the southeastern United States in the 1970s and 1980s (Crowder et al., 1994).

Loggerhead Turtle (*Caretta caretta*)

The loggerhead turtle is listed as threatened under the ESA throughout its range, primarily due to direct take, incidental capture in various fisheries, and the alteration and destruction of its habitat. The loggerhead is categorized as endangered by the International Union for Conservation of Nature and Natural Resources (IUCN), where taxa so classified are considered to be facing a very high risk of extinction in the wild in the near future. Loggerhead turtles are a cosmopolitan species inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters.

The loggerhead is characterized by a reddish brown, bony carapace, with a comparatively large head, up to 25 cm wide in some adults. Adults typically weigh between 80 and 150 kg, with average curved carapace length (CCL) measurements for adult females worldwide between 95-100 cm CCL (*in* Dodd, 1988) and adult males in Australia averaging around 97 cm CCL (Limpus, 1985, *in* Eckert, 1993). Juveniles found off California and Mexico measured between 20 and 80 cm (average 60 cm) in length (Bartlett, 1989, *in* Eckert, 1993).

Population Status

Loggerhead Turtles are considered to be divided into five populations: the Atlantic Ocean, Pacific Ocean, Indian Ocean, Caribbean Sea and Mediterranean Sea. These populations are further divided into nesting aggregations. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics (*in* NMFS and USFWS, 1998d).

In the western Pacific the only major nesting beaches are in the southern part of Japan (Dodd, 1988). There are approximately 42 nesting beaches in Japan, of which nine are considered primary nesting beaches (Kamezaki et al., 2003). Approximately 1,000 females nest in Japan every year (Suganuma ,2002; Kamezaki et al., 2003).

Table C-1 Loggerhead Nesting Activity in Japan

Nesting Season	Number of Nests
2000	2589
1999	2255
1998	2479

Sources: Suganuma, 2002; Kamezaki et al., 2003

Although population data indicate a declining trend in loggerhead nesting numbers compared to historic numbers, a recent presentation given by the Fisheries Research Agency of Japan reveals a slight upswing in nesting population numbers at five loggerhead nesting sites in Japan (Kiyota et al., 2003).

In the south Pacific, approximately 300 to 500 loggerhead females nest in eastern Australia every year (Dodd, 2002; Limpus, 2002). In southern Great Barrier Reef waters, nesting loggerheads have declined approximately 8% per year since the mid-1980s (Heron Island), while the foraging ground population has declined 3% and were comprised of less than 40 adults by 1992. Researchers attribute the declines to perhaps recruitment failure due to fox predation of eggs in the 1960s and mortality of pelagic juveniles from incidental capture in longline fisheries since the 1970s (Chaloupka and Limpus, 2001).

Aggregations of juvenile loggerheads off Baja California Mexico have been reported, although their status with regard to increasing or declining abundance has not been determined. NMFS and USFWS (1998c) report "foraging populations ... range from 'thousands, if not tens of thousands' (Pitman, 1990) to 'at least 300,000 turtles' (Bartlett, 1989). Extrapolating from 1988 offshore census data, Ramirez-Cruz et al. (1991) estimated approximately 4,000 turtles in March, with a maximum in July of nearly 10,000 turtles."

There are no records of nesting loggerhead turtles in the Hawaiian Islands (Balazs, 1982a), or in any of the islands of Guam, Palau, the Northern Mariana Islands, Marshall Islands (Thomas, 1989), the Federated States of Micronesia (Pritchard, 1982a), or American Samoa (Tuato'o-Bartley et al., 1993). There are very few records of loggerheads nesting on any of the many islands of the central Pacific, and the species is considered rare or vagrant on islands in this region (NMFS and FWS, 1998d). Pacific populations of loggerhead turtles found in U.S. jurisdictions are thought to originate from Japanese nesting areas (NMFS and FWS, 1998d).

Reproduction, Maturity and Lifespan

Upon reaching maturity, adult females migrate long distances from resident foraging grounds to their preferred nesting beaches. The average re-migration interval is between 2.6 and 3.5 years in Queensland, Australia (*in* NMFS and USFWS, 1998c). Nesting is preceded by offshore courting, and individuals return faithfully to the same nesting area over many years. Clutch size averages 110 to 130 eggs, and one to six clutches of eggs are deposited during the nesting season (Dodd, 1988).

Based on skeletochronological and mark-recapture studies, mean age at sexual maturity for loggerheads ranges between 25 and 35 years of age, depending on the stock (*in* Chaloupka and Musick, 1997), although Frazer *et al*. (1994 *in* NMFS and USFWS, 1998d) determined that maturity of loggerheads in Australia occurs between 34.3 and 37.4 years of age. Skeletochronological age estimates and growth rates were derived from small loggerheads caught in the Pacific high-seas driftnet fishery. Loggerheads less than 20 cm were estimated to be three years or less, while those greater than 36 cm were estimated to be six years or more. Age specific growth rates for the first 10 years were estimated to be 4.2 cm/year (Zug, et al., 1995).

Foraging

For their first years of life, loggerheads forage in open ocean pelagic habitats. Both juvenile and subadult loggerheads feed on pelagic crustaceans, mollusks, fish, and algae. The large aggregations of juveniles off Baja California have been observed foraging on dense concentrations of the pelagic red crab, *Pleuronocodes planipes* (Pitman, 1990; Nichols, et al., 2000b). Data collected from stomach samples of turtles captured in North Pacific driftnets indicate a diet of heteropods (*Carinaria* sp.), gooseneck barnacles (*Lepas* sp.), pelagic purple snails (*Janthina* sp.), medusae (*Vellela* sp.), and pyrosomas (tunicate zooids). Other common components include fish eggs, amphipods, and plastics (Parker, et al., in press). These loggerheads in the north Pacific are opportunistic feeders that target items floating at or near the surface, and if high densities of prey are present, they will actively forage at depth (Parker, et al., in press). As they age, some loggerheads begin to move into shallower waters, where, as adults, they forage over a variety of benthic hard- and soft-bottom habitats (reviewed *in* Dodd, 1988). Subadults and adults are found in nearshore benthic habitats around southern Japan, in the East China Sea and the South China Sea (e.g., Philippines, Taiwan, and Viet Nam).

Studies of loggerhead diving behavior indicate varying mean depths and surface intervals, depending on whether they were located in shallow coastal areas (short surface intervals) or in deeper, offshore areas (longer surface intervals). Loggerheads appear to spend a longer portion of their dive time on the bottom (or suspended at depth), which may be related to foraging and refuge. Unlike the leatherback, bottom time may be more important than absolute depth to the loggerhead foraging in the benthos (Eckert, et al., 1989). The maximum recorded dive depth for a post-nesting female was 211-233 m, while mean dive depths for both a post-nesting female and a subadult were 9-22 m. Routine dive times for a post-nesting female were between 15 and 30 minutes, and for a subadult, between 19 and 30 minutes (Sakamoto, et al., 1990 *in* Lutcavage and Lutz, 1997).

Adult loggerheads in Queensland, Australia, are primarily benthic feeders, preferring benthic invertebrates like gastropods, cephalopods, pelycepods, decapods, echinoderms and the occasional fish (Moody, 1979; Dodd, 1988; Yamaguchi et al., 1993).

Migration and Movements

The transition from hatchling to young juvenile occurs in the open sea, and evidence is accumulating that this part of the loggerhead life cycle may involve trans-Pacific developmental migration (Bowen et al.,1995). This is supported by the fact that the high seas driftnet fishery, which operated in the Central North Pacific in the 1980s and early 1990s, incidentally caught juvenile loggerheads (mostly 40-70 cm in length) (Wetherall et al., 1993). In addition, large aggregations (numbering in the thousands) of mainly juveniles and subadult loggerheads are found off the southwestern coast of Baja California, over 10,000 km from the nearest significant nesting beaches (Pitman, 1990; Nichols, et al., 2000). Genetic studies have shown these animals originate from Japanese nesting subpopulation (Bowen et al., 1995), and their presence reflects a migration pattern probably related to their feeding habits (Cruz, et al., 1991, *in* Eckert, 1993). These loggerheads are primarily juveniles, although carapace length measurements indicate that some of them are 10 years old or older. Loggerheads tagged in Mexico and California with flipper and/or satellite transmitters have been monitored returning to Japanese waters (Resendiz, et al., 1998a-b). In addition, genetic analyses of 135 loggerheads caught and sampled in the Hawaii-based longline fishery indicated that all originated from Japanese nesting stock (P. Dutton, NMFS, personal communication, October 2002). Satellite telemetry studies show that loggerhead turtles tend to follow 17° and 20°C sea surface isotherms north of the Hawaiian Islands (Polovina et al., 2000; Eckert, unpublished data).

Green Turtle (*Chelonia mydas*)

Green turtles are listed as threatened under the ESA, except for breeding populations found in Florida and the Pacific coast of Mexico, which are listed as endangered. The IUCN has classified the green turtle as endangered due to an "observed, estimated, inferred or suspected reduction of at least 50% over the last 10 years or three generations, whichever is longer," based on: (a) direct observation; (b) an index of abundance appropriate for the species; and (c) actual or potential levels of exploitation. Using a conservative approach, Seminoff (2002) estimates that the global green turtle population has declined by 34% to 58% over the last three generations (approximately 150 years) although actual declines may be closer to 70% to 80%. Causes for this decline include harvest of eggs, subadults and adults, incidental capture by fisheries, loss of habitat, and disease.

Green turtles are distinguished from other sea turtles by their smooth carapace with four pairs of lateral scutes, a single pair of prefrontal scutes, and a lower jaw-edge that is coarsely serrated. Adult green turtles have a light to dark brown carapace, sometimes shaded with olive, and can exceed one meter in carapace length and 100 kilograms (kg) in body mass.

Population Status

Green turtles are found throughout the world, occurring primarily in tropical, and to a lesser extent, subtropical waters. The species is considered to consist of five main populations: the Pacific Ocean, Atlantic Ocean, Indian Ocean, Carribean Sea, and Mediterranean Sea. These populations can be further divided into nesting aggregations, within the eastern, central, and western Pacific Ocean; the western, northern, and eastern Indian Ocean; Mediterranean Sea; and eastern, southern, and western Atlantic Ocean, including the Carribean Sea. Primary nesting aggregations of green turtles (i.e., sites with greater than 500 nesting females per year) include: Ascension Island (south Atlantic Ocean), Australia, Brazil, Comoros Islands, Costa Rica, Ecuador (Galapagos Archipelago), Equatorial Guinea (Bioko Island), Guinea-Bissau (Bijagos Archipelago), Iles Eparses Islands (Tromelin Island, Europa Island), Indonesia, Malaysia, Myanmar, Oman, Philippines, Saudi Arabia, Seychelles Islands, Suriname, and United States (Florida) (Seminoff, 2002).

The genus *Chelonia* is composed of two taxonomic units at the population level, the eastern Pacific green turtle (referred to by some as "black turtle," *C. mydas agassizii*), which ranges (including nesting) from Baja California south to Peru and west to the Galapagos Islands, and the nominate *C. m. mydas* in the rest of the range (insular tropical Pacific, including Hawaii).

Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawaii, as a direct consequence of a historical combination of overexploitation and habitat loss (Eckert, 1993; Seminoff, 2002).

In the western Pacific, the only major (> 2,000 nesting females) populations of green turtles occur in Australia and Malaysia. In Queensland, Australia there are three distinct genetic breeding stocks of green turtles; although they occupy the same foraging habitats, very little interbreeding exists. The southern Great Barrier Reef subpopulation (located at the Capricorn/ Bunker group of islands and in the Coral Sea Islands Territory) has an average annual nesting population of 8,000 females; the northern Great Barrier Reef subpopulation (Raine Island and Moulter Cay) consists of an average of 30,000 nesting females; and the Gulf of Carpenteria (nesting concentrated around Wellesley) averages 5,000 nesting females. Threats to green turtles in this area include boat strikes, indigenous harvest of adults and eggs, increased incidence of disease, ingestion of synthetic materials, incidental catch in shark control programs and by commercial fisheries, predation of eggs at nesting beaches, and tourism (*in* Dobbs, 2001). In a study conducted between 1985 and 1992 on foraging greens near southern Great Barrier Reef waters, researchers documented an 11% per year increase in the resident green turtle population, while the female nesting population increased at 3% per year. In 1992, the resident green turtle population was estimated to be comprised of 1,300 individuals (Chaloupka and Limpus, 2001).

Smaller colonies of green turtles occur in the islands of Polynesia, Micronesia, and Malaysia (Wetherall et al., 1993). Although green turtles used to nest in large numbers at Scilly, Motu-one, and Mopelia, located in the western limits of French Polynesia, their populations have declined in recent decades due mainly to commercial exploitation for markets in Tahiti (Balazs, et al., 1995). Currently, Scilly is the only known sea turtle nesting site of any magnitude throughout the 130 islands and atolls that comprise French Polynesia. Although residents of Scilly are allowed to harvest 50 adult turtles annually, Balazs et al. (1995) estimate that the number of green turtles nesting annually in 1991 is approximately 300-400 turtles, similar to what Lebeau (1985 *in* Balazs et al., 1995) estimated several years earlier.

Based on limited data, green turtle populations in the Pacific islands have declined dramatically, due foremost to harvest of eggs and adults by humans. In the green turtle recovery plan (ref), directed take of eggs and turtles was identified as a “major problem” in American Samoa, Guam, Palau, CNMI, Federated States of Micronesia, Republic of the Marshall Islands, Wake, Jarvis, Howland, Baker, and Midway Islands, Kingman Reef, Johnston and Palmyra Atoll. Severe overharvests have resulted in modern times from a number of factors: 1) the loss of traditional restrictions limiting the number of turtles taken by island residents; 2) modernized hunting gear; 3) easier boat access to remote islands; 4) extensive commercial exploitation for turtle products in both domestic markets and international trade; 5) loss of the spiritual significance of turtles; 6) inadequate regulations; and 7) lack of enforcement (NMFS and USFWS, 1998a).

In Hawaii, green turtles nest on six small sand islands at French Frigate Shoals, a crescent-shaped atoll situated in the middle of the Hawaiian Archipelago (Balazs, 1995). Green turtles in Hawaii are considered genetically distinct and geographically isolated although recently a nesting population at Islas Revillagigedos in Mexico has been discovered to have some animals with the same mtDNA haplotype that commonly occurs in Hawaii. Ninety percent of the nesting and breeding activity of the Hawaiian green turtle occurs at French Frigate Shoals, where 200-700 females are estimated to nest annually (NMFS and USFWS, 1998a). Important resident areas have been identified and are being monitored along the coastlines of Oahu, Molokai, Maui, Lanai, Hawaii, and at large nesting areas in the reefs surrounding French Frigate Shoals, Lisianski Island, and Pearl and Hermes Reef (Balazs, 1982; Balazs et al., 1987). Since the establishment of the ESA in 1973, and following years of exploitation, the nesting population of Hawaiian green turtles has shown a gradual, but definite increase (Balazs, 1996). For example, the number of green turtles nesting at an index study site at East Island has tripled since systematic monitoring began in 1973 (NMFS and USFWS, 1998a).

Unfortunately, the green turtle population in the Hawaiian Islands area is afflicted with a tumor disease, fibropapilloma, which is of an unknown etiology and often fatal, as well as spirochidiasis, both of which are the major causes of strandings of this species (G. Balazs, NMFS, personal communication, 2000). The presence of fibropapillomatosis among stranded turtles has increased significantly over the past 17 years, ranging from 47-69 percent during the past decade (Murakawa et al., 2000). Green turtles captured off Molokai from 1982-96 showed a massive increase in the disease over this period, peaking at 61% prevalence in 1995 (Balazs et al., 1998). Preliminary evidence suggests that there is an association between the distribution of fibropapillomatosis in the Hawaiian Islands and the distribution of toxic benthic dinoflagellates (*Prorocentrum* spp.) known to produce a tumor promoter, okadaic acid (Landsberg et al., 1999). Other studies have discovered growing evidence that fibropapilloma tumors are caused by a virus spread by ozobranchus leeches (Hurley, 2004). Fibropapillomatosis has been considered an inhibiting factor to the full recovery of the Hawaiian green turtle populations, and the incidence of decreased growth rates in afflicted turtles a minimum estimate of the impact of the disease (Balazs et al., 1998). More recent modeling work, however, indicates that the disease is not a major factor in the recovery of the species (Balaz and Chaloupa, in press.) Stranding reports from the Hawaiian Islands from 1982-1999 indicate that the green turtle is the most commonly stranded sea turtle (96.5 percent, compared to other species), averaging around 150 per year (2,689 total/18 years).

The primary green turtle nesting grounds in the eastern Pacific are located in Michoacán, Mexico, and the Galapagos Islands, Ecuador (NMFS and USFWS, 1998a). There, green turtles were widespread and abundant prior to commercial exploitation and uncontrolled subsistence harvest of nesters and eggs. More than 165,000 turtles were harvested from 1965 to 1977 in the Mexican Pacific. In the early 1970s nearly 100,000 eggs per night were collected from these nesting beaches (*in* NMFS and USFWS, 1998a). The nesting population at the two main nesting beaches in Michoacán (Colola, responsible for 70% of total green turtle nesting in Michoacán (Delgado and Alverado, 1999), and Maruata) decreased from 5,585 females in 1982 to 940 in 1984. Despite long-term protection of females and their eggs at these sites since 1990, the population continues to decline, and it is believed that adverse impacts (including incidental take in various coastal fisheries as well as illegal directed take at forage areas) continue to prevent recovery of endangered populations (P. Dutton, NMFS, personal communication, 1999; Nichols, 2002). In addition, the black market for sea turtle eggs in Mexico has remained as brisk as before the ban (Delgado and Alvarado, 1999). On Colola, an estimated 500-1,000 females nested nightly in the late 1960s. In the 1990s, that number dropped to 60-100 per night, or about 800-1,000 turtles per year (Eckert, 1993). During the 1998-99 season, based on a comparison of nest counts and egg collection data, an estimated 600 greens nested at Colola. Although only about 5% of the nests were poached at Colola during this season, approximately 50% of the nests at Maruata were poached, primarily because of difficulties in providing protections as a result of political infighting (Delgado and Alvarado, 1999).

Reproduction, Maturity, and Lifespan

Compared to all other sea turtles, green turtles exhibit a particularly slow growth rate, and age to maturity appears to be the longest. Based on age-specific growth rates, green turtles are estimated to attain sexual maturity beginning at age 25 to 50 years (Limpus and Chaloupka, 1997; Bjorndal et al., 2000; Chaloupka et al., in press; *all in* Seminoff, 2002; Zug *et al*., 2002). The length of reproductivity has been estimated to range from 17 to 23 years (Carr et al., 1978; Fitzsimmons et al., 1995 *in* Seminoff, 2002). In Hawaii, green turtles lay up to six clutches of eggs per year (mean of 3.7), and clutches consist of about 100 eggs each. Females migrate to breed only once every two or possibly many more years. Eastern Pacific green turtles have reported nesting between two and six times during a season, laying a mean of between 65 and 86 eggs per clutch, depending on the area studied (Michoacán, Mexico and Playa Naranjo, Costa Rica) (*in* Eckert, 1993 and NMFS and USFWS, 1998a).

Females nesting in Hawaii averaged 92 cm in straight carapace length (SCL), while at the Olimarao Atoll in Yap, females averaged 104 cm in curved carapace length (CCL) and approximately 140 kg. In the rookeries of Michoacán, Mexico, females averaged 82 cm in CCL, while males averaged 77 cm CCL (*in* NMFS and USFWS, 1998a).

Foraging

Most green turtles appear to have a nearly exclusive herbivorous diet, consisting primarily of sea grass and algae (Wetherall et al., 1993; Hirth, 1997), those along the east Pacific coast seem to have a more carnivorous diet. Analysis of stomach contents of green turtles found off Peru revealed a large percentage of mollusks and polychaetes, while fish and fish eggs, and jellyfish and commensal amphipods comprised a lesser percentage (Bjorndal, 1997). In the Hawaiian Islands, green turtles are site-specific and consistently feed in the same areas on preferred substrates, which vary by location and between islands (Landsberg et al., 1999).

Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, it is presumed that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (NMFS and USFWS, 1998a). The maximum recorded dive depth for an adult green turtle was 110 meters (Berkson, 1967; Lutcavage and Lutz, 1997), while subadults routinely dive 20 meters for 9-23 minutes, with a maximum recorded dive of 66 minutes (Brill et al., 1995; Lutcavage and Lutz, 1997). Additionally, it is presumed that drift lines or surface current convergences are preferential zones due to increased densities of likely food items. In the western Atlantic, drift lines commonly contain floating *Sargassum* capable of providing small turtles with shelter and sufficient buoyancy to raft upon (NMFS and USFWS, 1998a). Underwater resting sites include coral recesses, the undersides of ledges, and sand bottom areas that are relatively free of strong currents and disturbance from natural predators and humans. In the MHI these foraging and resting areas for adults usually occur at depths greater than 10 meters, but probably not normally exceeding 40 meters. Available information indicates that green turtle resting areas are in proximity to their feeding pastures (NMFS, 2000e). Immature Hawaiian green turtles have been found in increasing numbers residing in "foraging pastures" around the eight main Hawaiian Islands. These pastures consist of a narrow band of shallow water around these islands which "accounts for 96% of the benthic habitat potentially available for recruitment by post-pelagic green turtles" (Balazs, 1996).

Migration and Movements

The nonbreeding range of green turtles is generally tropical, and can extend thousands of miles from shore in certain regions. Hawaiian green turtles monitored through satellite transmitters were found to travel more than 1,100 km from their nesting beach at French Frigate Shoals, south and southwest against prevailing currents to numerous distant foraging grounds within the 2,400 kilometer span of the archipelago (Balazs, 1994; Balazs et al., 1994; Balazs and Ellis, 1996). Three green turtles outfitted with satellite tags on Rose Atoll (the easternmost island at the Samoan Archipelago) traveled on a southwesterly course to Fiji, approximately 1,500 km distance (Balazs et al., 1994). Tag returns of eastern Pacific green turtles establish that these turtles travel long distances between foraging and nesting grounds. In fact, 75 percent of tag recoveries from 1982-90 were from turtles that had traveled more than 1,000 kilometers from Michoacán, Mexico. Even though these turtles were found in coastal waters, the species is not confined to these areas, as indicated by 1990 sightings records from a NOAA research ship. Observers documented green turtles 1,000-2,000 statute miles from shore (Eckert, 1993). The east Pacific green is also the second-most sighted turtle in the east Pacific during tuna fishing cruises; they are frequent along a north-south band from 15°N to 5°S along 90°W, and between the Galapagos Islands and Central American Coast (NMFS and USFWS, 1998a). In a review of sea turtle sighting records from northern Baja California to Alaska, Stinson (1984) determined that the green turtle was the most commonly observed sea turtle on the U.S. Pacific Coast, with 62% reported in a band from southern California and southward. The northernmost reported resident population of green turtles occurs in San Diego Bay, where about 50-60 mature and immature turtles concentrate in the warm water effluent discharged by a power plant (McDonald et al., 1994). These turtles appear to have originated from east Pacific nesting beaches and the Revillagigedo Islands (west of Baja California), based on morphology, genetic analyses, and tagging data (*in* NMFS and USFWS, 1998a; P. Dutton, NMFS, personal communication, March 2002); however, the possibility exists that some are from Hawaii (P. Dutton, NMFS, personal communication, January, 2001). Green turtles appear to prefer waters that usually remain around 20°C in the coldest month; for example, during warm spells (e.g., El Niño), green turtles may be found considerably north of their normal distribution. Stinson (1984) found green turtles to appear most frequently in U.S. coastal waters with temperatures exceeding 18°C.

Olive Ridley Turtle (*Lepidochelys olivacea*)

The olive ridley is listed as threatened under the ESA throughout the Pacific, except for the Mexican nesting population, which is listed as endangered, primarily because of over-harvesting of females and eggs. The olive ridley is categorized as endangered by the IUCN, where taxa so classified are considered to be facing a very high risk of extinction in the wild in the near future (IUCN Red List, 2000).

The olive ridley is one of the smallest living sea turtles (carapace length usually between 60 and 70 cm and rarely weighing over 50 kg) and is regarded as the most abundant sea turtle in the world. They are olive or grayish green, with a greenish white underpart, and adults are moderately sexually dimorphic (NMFS and USFWS, 1998e).

Population Status

Olive ridley turtles occur throughout the world, primarily in tropical and sub-tropical waters. The species is divided into three main populations in the Pacific Ocean, Indian Ocean, and Atlantic Ocean. Nesting aggregations in the Pacific Ocean are found in the Marianas Islands, Australia, Indonesia, Malaysia, and Japan (western Pacific) and Mexico, Costa Rica, Guatemala, and South America (eastern Pacific). In the Indian Ocean, nesting aggregations have been documented in Sri Lanka, east Africa, Madagascar, and very large aggregations in India at Orissa. In the Atlantic Ocean, nesting aggregations occur from Senegal to Zaire, Brazil, French Guiana, Suriname, Guyana, Trinidad, and Venezuela.

In the eastern Pacific, nesting occurs all along the Mexico and Central American coast, with large nesting aggregations occurring at a few select beaches located in Mexico and Costa Rica. Few turtles nest as far north as southern Baja California, Mexico (Fritts et al., 1982) or as far south as Peru (Brown and Brown, 1982). A single olive ridley nested in 1985 on the island of Maui, Hawaii, but the eggs did not hatch (Balazs and Hau, 1986 *in* NMFS and USFWS, 1998e), and the event was most likely an anomaly. Where population densities are high enough, nesting takes place in synchronized aggregations known as *arribadas*. The largest known *arribadas* in the eastern Pacific are off the coast of Costa Rica (~475,000 - 650,000 females estimated nesting annually) and in southern Mexico (~800,000+ nests/year at La Escobilla, in Oaxaca (Millán, 2000).

Declines in olive ridley populations have been documented in Playa Nancite, Costa Rica; however, other nesting populations along the Pacific coast of Mexico and Costa Rica appear to be stable or increasing, after an initial large decline due to harvesting of adults. Historically, an estimated 10 million olive ridleys inhabited the waters in the eastern Pacific off Mexico (Cliffton et al., 1982 *in* NMFS and USFWS, 1998e). However, human-induced mortality led to declines in this population. Beginning in the 1960s, and lasting over the next 15 years, several million adult olive ridleys were harvested by Mexico for commercial trade with Europe and Japan (NMFS and USFWS, 1998e). Although olive ridley meat is palatable, it was not widely sought after; its eggs, however, are considered a delicacy, and egg harvest can certainly be considered one of the major causes for its decline. Fisheries for olive ridley turtles were also established in Ecuador during the 1960s and 1970s to supply Europe with leather (Green and Ortiz-Crespo, 1982).

The nationwide ban on commercial harvest of sea turtles in Mexico, enacted in 1990, has improved the situation for the olive ridley. Surveys of important olive ridley nesting beaches in Mexico indicate increasing numbers of nesting females in recent years (Marquez et al., 1995;

Arenas et al., 2000). Annual nesting at the principal beach, Escobilla Beach, Oaxaca, Mexico, averaged 138,000 nests prior to the ban, and since the ban on harvest in 1990, annual nesting has increased to an average of 525,000 nests (Salazar et al., in press). At a smaller olive ridley nesting beach in central Mexico, Playon de Mismalayo, nest and egg protection efforts have resulted in more hatchlings, but the population is still "seriously decremented and is threatened with extinction" (Silva-Batiz et al., 1996). Still, there is some discussion in Mexico that the species should be considered recovered (Arenas et al., 2000).

In the western Pacific, olive ridleys are not as well documented as in the eastern Pacific, nor do they appear to be recovering as well. There are a few sightings of olive ridleys from Japan, but no report of egg-laying. Similarly, there are no nesting records from China, Korea, the Philippines, or Taiwan. No information is available from Viet Nam or Kampuchea (Eckert, 1993). In Thailand, olive ridleys occur along the southwest coast, on the Surin and Similan islands, and in the Andaman Sea. On Phra Thong Island, on the west coast of Thailand, the number of nesting turtles declined markedly from 1979 to 1990. During a 1996-97 survey, only six olive ridley nests were recorded, and of these, half were poached, and one was predated by feral dogs. During the 1997-98 survey, only three nests were recorded. The main threats to turtles in Thailand include egg poaching, harvest and subsequent consumption or trade of adults or their parts (i.e., carapace), indirect capture in fishing gear, and loss of nesting beaches through development (Aureggi et al., 1999)

Olive ridleys nest on the eastern and western coasts of peninsular Malaysia; however, nesting has declined rapidly in the past decade. The highest density of nesting was reported to be in Terengganu, Malaysia, and at one time yielded 240,000 *eggs* (2,400 nests, with approximately 100 eggs per nest) (Siow and Moll, 1982, *in* Eckert, 1993), while only 187 *nests* were reported from the area in 1990 (Eckert, 1993). In eastern Malaysia, olive ridleys nest very rarely in Sabah and only a few records are available from Sarak (*in* Eckert, 1993).

There are no records of nesting on the unincorporated U.S. territories in the North Pacific. In the central Pacific, a single nesting was reported in September, 1985 on the island of Maui, Hawaii (*in* Eckert, 1993). In October 2002, an olive ridley turtle was reported to have nested on the shores of Hilo Bay, on the Island of Hawaii.

Reproduction, Maturity and Lifespan

Olive ridleys are considered to reach sexual maturity between 8 and 10 years of age, and approximately 3 percent of the number of hatchlings recruit to the reproductive population (Marquez, 1982 and Marquez, 1992, *in* Salazar et al., 1998). The mean clutch size for females nesting on Mexican beaches is 105.3 eggs, in Costa Rica, clutch size averages between 100 and 107 eggs (*in* NMFS and USFWS, 1998d). Females generally lay 1.6 clutches of eggs per season by Mexico (Salazar et al., 1998) and two clutches of eggs per season in Costa Rica (Eckert, 1993). Olive ridley turtles begin to aggregate near the nesting beach two months before the nesting season, and most mating is generally assumed to occur in the vicinity of the nesting beaches, although copulating pairs have been reported over 100 km from the nearest nesting beach. Data on the remigration intervals of olive ridleys in the eastern Pacific are scarce; however, in the western Pacific (Orissa, India), females showed an annual mean remigration interval of 1.1 years. Reproductive span in females of this area was shown to be up to 21 years (Pandav and Kar, 2000).

The primary nesting areas for the olive ridley occur in the Indian Ocean along the northeast coast of India (Mrosovsky, 1993), and in the Pacific Ocean along the West coast of Mexico and Central America (Eckert, 1993). In the eastern Pacific, the largest nesting concentrations occur in southern Mexico and northern Costa Rica, with very few turtles nesting as far north as southern Baja California (Fritts et al., 1982) or as far south as Peru (Brown and Brown, 1982).

Foraging

The olive ridley turtle is omnivorous and identified prey include a variety of benthic and pelagic prey items such as shrimp, jellyfish, crabs, snails, and fish, as well as algae and sea grass (Marquez, 1990). Olive ridley turtles appear to forage throughout the eastern tropical Pacific Ocean, often in large groups, or flotillas. It is not unusual for olive ridley turtles in reasonably good health to be found entangled in scraps of net or other floating synthetic debris. Small crabs, barnacles and other marine life often reside on debris and are likely to attract the turtles. In a three year study of communities associated with floating objects in the eastern tropical Pacific, Arenas et al. (1992) found that 75 percent of sea turtles encountered were olive ridleys and were present in 15 percent of the observations implying that flotsam may provide the turtles with food, shelter, and/or orientation cues in an otherwise featureless environment. Thus, it is possible that young turtles move offshore and occupy areas of surface current convergences to find food and shelter among aggregated floating objects until they are large enough to recruit to benthic feeding grounds of the adults. Although they are generally thought to be surface feeders, olive ridleys have been caught in trawls at depths of 80-110 m (NMFS and USFWS, 1998d), and an olive ridley turtle was sighted foraging for crabs at a depth of 300 m (Landis, 1965 *in* Eckert et al., 1986). The average dive lengths for adult females and males are reported to be 54.3 and 28.5 minutes, respectively (Plotkin, 1994, *in* Lutcavage and Lutz, 1997). The maximum depth recorded was 238 meters. The range of water temperatures recorded was between 23° and 28°C (Polovina et al., in press).

Migration and Movements

Olive ridley turtles lead a primarily pelagic existence (Plotkin et al., 1993), migrating throughout the Pacific, from their nesting grounds in Mexico and Central America to the north Pacific. While olive ridleys generally have a tropical range, with a distribution from Baja California, Mexico to Chile (Silva-Batiz et al., 1996), individuals do occasionally venture north, some as far as the Gulf of Alaska (Hodge and Wing, 2000). Surprisingly little is known of their oceanic distribution and critical foraging areas, despite being the most populous of north Pacific sea turtles. The post-nesting migration routes of olive ridleys tracked via satellite from Costa Rica traversed thousands of kilometers of deep oceanic waters, ranging from Mexico to Peru, and more than 3,000 kilometers out into the central Pacific (Plotkin et al., 1993). The turtles appeared to occupy a series of foraging areas geographically distributed over a very broad range within their oceanic habitat (Plotkin et al., 1994). Stranding records since 1982 indicate that the olive ridley is the third most often stranded sea turtle in the Hawaiian Islands, averaging 2 per year (20 strandings from 1982-99) (G. Balazs, NMFS, personal communication, 2000); stranding records from 1990-1999 indicate that olive ridleys are rarely found off the coast of California, averaging 1.3 strandings annually (J. Cordaro, NMFS, pers. comm., April 2000).

Recent genetic information analyzed from 39 olive ridleys taken in the Hawaii-based longline fishery indicate that 74% of the turtles (n=29) originated from the eastern Pacific (Mexico and Costa Rica) and 26% of the turtles (n=10) were from the Indian and western Pacific rookeries (P. Dutton, NMFS, personal communication, January 2001), indicating the animals from both sides of the Pacific converge in the north Pacific pelagic environment. An olive ridley taken in the CA/OR drift gillnet fishery originated from an eastern Pacific stock (i.e., Costa Rica or Mexico) (P. Dutton, NMFS, personal communication, October 2002).

Hawksbill (*Eretmochelys imbricata)*

The hawksbill turtle is listed as endangered under the ESA and in the International Union for the Conservation of Nature (IUCN) Red Data Book. Under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the hawksbill is identified as “most endangered.” Anecdotal reports throughout the Pacific indicate that the current population is well below historical levels. In the Pacific, this species is rapidly approaching extinction primarily due to the harvesting of the species for its meat, eggs, and shell, as well as the destruction of nesting habitat by human occupation and disruption (Meylan and Donnelly, 1999; NMFS, 2001)

Hawksbill turtles are circumtropical in distribution, generally occurring from latitudes 30°N to 30°S within the Atlantic, Pacific and Indian Oceans and associated bodies of water (NMFS and FWS, 1998c). Adult and immature hawksbill turtles are found in Hawaiian waters, but they are uncommon. There are no reports of interactions between this species and the Hawaii-based longline fishery, although the potential for interaction exists.

Hawksbills are recognized by their relatively small size (carapace length less than 95 cm), narrow head with tapering “beak,” overlapping scutes, and strongly serrated posterior margin of the carapace. Hawksbills may be distinguished from green turtles by the transverse division of the prefrontal scales into two pairs (these scales are elongate and undivided in greens) (Pritchard and Trebbau, 1984, *in* NMFS and USFWS, 1998c). The carapace of adult turtles is dark brown with faint yellow streaks and blotches; the scales on the dorsal side of the flippers and head are dark brown to black with yellow margins; the ventral side of the flippers and the plastron are pale yellow, with scattered dark scales on the flippers (Witzell and Banner, 1980 *in* NMFS and USFWS, 1998c). The epidermal scutes that overlay the bones of the shell are the tortiseshell of commerce. They are unusually thick, and overlap posteriorly on the carapace in all but hatchlings and very old individuals. The soft skin on the ventral side is cream or yellow, and may be pinkish-orange in mature individuals. In the U.S. Caribbean, nesting females average about 62-94 cm in straight carapace length. Weight is typically to 80 kg in the wider Caribbean, with a record weight of 127 kg. Hatchlings average about 42 mm straight carapace length and range in weight from 13.5-19.5 g.

Population Status

The hawksbill occurs in tropical and subtropical seas of the Atlantic, Pacific and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean, with representatives of at least some life history stages regularly occurring in southern Florida and the northern Gulf of Mexico (especially Texas); in the Greater and Lesser Antilles; and along the Central American mainland south to Brazil. Within the United States, hawksbills are most common in Puerto Rico and its associated islands, and in the U.S. Virgin Islands. In the continental U.S., hawksbill turtles have been recorded from all the gulf states and from along the eastern seaboard as far north as Massachusetts, with the exception of Connecticut, but sightings north of Florida are rare (Meylan and Donnelly, 1999).

In the U.S. Pacific Ocean, there have been no hawksbill sightings off the west coast (Meylan and Donnelly, 1999). Hawksbills have been observed in the Gulf of California as far as 29°N, throughout the northwestern states of Mexico, and south along the Central and South American coasts to Columbia and Ecuador (Meylan and Donnelly, 1999). In the Hawaiian Islands, hawksbill turtles nest in the main islands, primarily on several small sand beaches on the Islands of Hawaii and Molokai. Two of these sites are at a remote location in the Hawaii Volcanos National Park.

Along the far western and southeastern Pacific, hawksbill turtles nest on the islands and mainland of southeast Asia, from China to Japan, and throughout the Philippines, Malaysia, Indonesia, Papua New Guinea, the Solomon Islands (McKeown, 1977) and Australia (Limpus, 1982).

Along the eastern Pacific rim, hawksbills were apparently common to abundant as recently as 50 years ago in nearshore waters from Mexico to Ecuador, particularly the east coast of Baja California Sur in the vicinity of Concepción Bay and Paz Bay, Mexico (Cliffton et al., 1982). Today, the hawksbill is rare to nonexistent in most localities; there are no known nesting beaches remaining on the Pacific coast of Mexico (Cliffton et al., 1982). Hawksbills may still represent a rare nesting species along Pacific Central America, but there has been no documented nesting in recent years (Cornelius, 1982). Within the Central Pacific, nesting is widely distributed but scattered and in very low numbers. Foraging hawksbills have been reported from virtually all of the island groups of Oceania, from the Galapagos Islands in the eastern Pacific to the Republic of Palau in the western Pacific (Witzell, 1983; Pritchard, 1982a,b).

Hawksbills appear to be declining throughout their range. By far the most serious problem hawksbill turtles face is the harvest by humans, while a less significant threat, but no less important, is loss of habitat due to expansion of resident human populations and/or increased tourism development. Dramatic reductions in the numbers of nesting and foraging hawksbills have occurred in Micronesia and the Mexican Pacific coast, probably due largely to technological advances in fishing gear, which facilitate legal and illegal harvest. In addition, the hawksbill tortoiseshell trade probably remains an important contributing factor in the decline of the hawksbill. Although the Japanese market was closed in 1994, southeast Asia and Indonesia markets remain lucrative (NMFS and USFWS, 1998b). In addition to the demand for the hawksbill's shell, there is a demand for other products including leather, oil, perfume, and cosmetics. Prior to being certified under the Pelly Amendment, Japan had been importing about 20 metric tons of hawksbill shell per year, representing approximately 19,000 turtles. A negotiated settlement was reached regarding this trade on June 19, 1992. The hawksbill shell commands high prices (currently $225/kilogram), a major factor preventing effective protection[34].

Hawksbill turtles are widely distributed throughout the Pacific, yet nest in low abundance. The following table is a summary of major nesting sites. Additional nesting may also occur in the Seychelles, Papua New Guinea, Palau, Vietnam and Thailand (NMFS, 2002).

Table C-2 Annual Hawksbill Turtle Population Estimates at Major Nesting Sites

Location	Avg. No. per year (unless specified)
Queensland, Australia (Dobbs 2002)	4,000 females
Terengganu, Malaysia (Liew 2002)	20 nests (2000)
Sabah, Malaysia (Bastinal 2002)	337 females (2000)
Jamursba-medi, Papua (Hitipeuw 2002)	40 nests (2001)
Solomon Islands (Mortimer 2002)	600 nests
Hawaii (L. Katehira pers. comm.)	18 nests
Mexico (Marquez 2002)	6,000 nests (2000)

Reproduction, Maturity and Life Span

The best estimate of sexual maturity for hawksbill turtles is about 20 to 40 years (Chaloupka and Limpus, 1997; Crouse, 1999a). Boulon (1994) estimated that juvenile hawksbills from the U.S. Virgin Islands would require between 16.5 and 19.3 additional years to reach maturity after entering nearshore habitats at several years of age at 21.4 cm straight carapace length. Growth rates within benthic stage (juvenile turtles which have returned from pelagic developmental habitats) Australian hawksbill turtles are sex dependent, with the female growing faster. Maximal growth rates for both males and females occurred at 60 cm curved carapace length (CCL) and then declined to minimal rates of growth as the turtles neared maturity at 80 cm CCL (Chaloupka and Limpus, 1997).

Posthatchling hawksbills occupy the pelagic environment, taking shelter in weedlines that accumulate at convergence points. Hawksbills reenter coastal waters when they reach approximately 20-25 cm carapace length. Hawksbills utilize different habitats at different stages of their life cycle. Hawksbills are also known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore of continents where coral reefs are absent.

Hawksbills nest throughout the insular tropical Pacific, though only in low density colonies. In the Campbell Island colony of northeastern Australia, nesting females average 83.2 cm CCL,

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[34] Http://www.nmfs.noaa.gov/prot_res/species/turtles/hawksbill.html

weigh 51.6 kg and lay three clutches of eggs 14 days apart. Average clutch size was 132 eggs (Limpus et al., 1983). In Independent Samoa, hawksbill nesting occurs from September-July. Nests averaged 149.5 eggs. In the eastern Pacific a single hawksbill female nesting at Ostional National Wildlife Refuge, measured 82 cm CCL and laid 120 eggs (Almengor et al., 1994).

There is much variation in clutch size from site to site and among sizes of turtles, with the larger turtles laying the largest clutches. Known clutch size in the Pacific averages 130 eggs per clutch, for about three clutches per year, and anecdotal reports indicate that hawksbill remigration intervals average around two years (Eckert, 1993; NMFS and USFWS, 1998b). Mrosovsky et al. (1995) evaluated the effect of incubation temperature on sex determination in hawksbill hatchlings. Incubation temperatures warmer than approximately 29.2°C produced females, while cooler temperatures produced males (Mrosovsky et al., 1995).

Foraging

There is limited information on the biology of hawksbills, probably because they are sparsely distributed throughout their range and they nest in very isolated locations (Eckert, 1993). Hawksbills have a relatively unique diet of sponges (Meylan, 1985; 1988). While data are somewhat limited on diet in the Pacific, it is well documented in the Caribbean where hawksbill turtles are selective spongivores, preferring particular sponge species over others (Dam and Diez, 1997b). Foraging dive durations are often a function of turtle size with larger turtles diving deeper and longer. At a study site also in the northern Caribbean, foraging dives were made only during the day and dive durations ranged from 19-26 minutes at depths of 8-10 m. At night, resting dives ranged from 35-47 minutes in duration (Dam and Diez, 1997a).

As a hawksbill turtle grows from a juvenile to an adult, data suggest that the turtle switches foraging behaviors from pelagic surface feeding to benthic reef feeding (Limpus, 1992). Within the Great Barrier Reef of Australia hawksbills move from a pelagic existence to a neritic life on the reef at a minimum CCL of 35 cm. The maturing turtle establishes foraging territory and will remain in this territory until it is displaced (Limpus, 1992). As with other sea turtles, hawksbills will make long reproductive migrations between foraging and nesting areas (Meylan, 1999), but otherwise they remain within coastal reef habitats. In Australia, juvenile turtles outnumber adults 100:1. These populations are also sex biased with females outnumbering males 2.57:1 (Limpus, 1992).

Coral reefs are widely recognized as the resident foraging habitat of juveniles, subadults and adults. This habitat association is undoubtedly related to their diet of sponges, which need solid substrate for attachment. The ledges and caves of the reef provide shelter for resting both during the day and night. Hawksbills are also found around rocky outcrops and high energy shoals, which are also optimum sites for sponge growth. Hawksbills utilize both low- and high-energy nesting beaches in tropical oceans of the world. Both insular and mainland nesting sites are known. Hawksbill turtles appear to prefer nesting sites with steep beaches and coarse sand.

Migration and Movements

Like other sea turtles, hawksbills are highly migratory, although they are less of a long-distant migrant. An adult female tagged in its foraging ground in the Torres Strait was observed nesting 322 days later in the Solomon Islands, a distance of over 1,650 km (Pritchard and Trebbau, 1984). Another female traveled 1,400 km from the Solomon Islands to its foraging grounds in Papua New Guinea (Parmenter, 1983). Tag return data (Pritchard and Trebbau, 1984) and recent genetic studies (Bowen et al., 1996) suggest that individual foraging areas support hawksbills from distant breeding populations rather than just from nearby rookeries.

Clearly, the hawksbill has the potential to be a long range migrant. It is likely that adult hawksbill movements will prove to be similar to that of Australian loggerhead turtles (C. Limpus, pers. comm.), whereby individual adults perform regular migratory movements among a preferred nesting beach, a breeding ground and a persistent foraging territory. The distances between these territorial foci (boundary markers of a home range) vary greatly and appear to be of random length among individuals.

Hawksbills are known to leave the area of the nesting beach after the final nest of the season is laid; three of seven turtles radio-tagged at Buck Island, St. Croix (northeastern Caribbean) left the vicinity after their final nest (the disposition of the other four turtles is unknown, because they were no longer carrying transmitters) (Starbird, 1993). It is likely that the nesting females return directly to their preferred foraging habitat, wherever that may be. The geographic proximity of an adult's foraging habitat in relation to its natal beach is not known, and the same must be said for juveniles as well. Once a foraging or nesting site is chosen, hawksbills tend to be persistent in the continuing use of that site. However, hawksbills can move long distances. Thus, it must be assumed that the nesting and foraging animals observed in such localities as the Republic of Palau or Saipan have potential home ranges extending throughout the islands of Micronesia and Melanesia and even the waters of the Philippines, Indonesia and Australia. The existing ambiguity concerning movements and migrations of Pacific hawksbills can only be clarified with extensive tagging programs.