

ZANDY & GREG

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Zandy in particular, you're quoted throughout;
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FIVE YEAR STATUS REVIEWS OF SEA TURTLES LISTED UNDER
THE ENDANGERED SPECIES ACT OF 1973:

Leatherback Sea Turtle (*Dermochelys coriacea*)

is most welcome → in particular, see p. 10.
It's real easy reading, shouldn't be too
much of a burden. Not looking for comment,
just want to make sure your agendas are

Prepared by:

Karen L. Eckert

Executive Director, WIDECAST

covered ☺

♡ Karen

Submitted to: Jack Woody
National Sea Turtle Coordinator
U. S. Fish and Wildlife Service
500 Gold Avenue, S. W.
Albuquerque, New Mexico 87103

USFWS P.O. No. 20181-1-0060

FINAL DRAFT / APRIL 1992

FIVE YEAR STATUS REVIEWS OF SEA TURTLES LISTED UNDER
THE ENDANGERED SPECIES ACT OF 1973:

Leatherback Sea Turtle (*Dermochelys coriacea*)

Biological Background

The leatherback is the largest living turtle and is so distinctive that it is placed in a separate taxonomic family, the Dermochelyidae. Whereas other sea turtles have bony plates covered with horny scutes on the carapace, the slightly flexible carapace of the leatherback is distinguished by a rubber-like texture. The carapace is about four cm thick and is largely constituted of tough, oil-saturated connective tissue raised into seven prominent ridges and tapered to a blunt point posteriorly. A nearly continuous layer of small dermal bones lies just below the leathery outer skin of the carapace. The narrow ribs lack pleural flanges and remain widely separated throughout life. No sharp angle is formed between the carapace and the plastron, resulting in the animal being somewhat barrel-shaped. Adult males are distinguished by a long, thick tail that extends well beyond the posterior carapace margin.

The epidermis is black, with varying degrees of pale spotting, and is scaleless. The underside is mottled pinkish-white and black; the proportion of light to dark pigment is variable. The front flippers are proportionally longer than in other sea turtles and may span 270 cm in an adult. Hatchlings are likewise predominately black with mottled undersides, but differ in being covered with tiny polygonal or bead-like scales. The flippers have white margins, and rows of white scales appear as stripes along the length of the back. Front and rear flippers lack claws. In both adults and hatchlings, the upper jaw bears two tooth-like projections, each flanked by deep cusps, at the premaxillary-maxillary sutures. For a detailed discussion of anatomy, including embryonic development, see Deraniyagala (1932, 1936), Dunlap (1955), Pritchard (1971), Pritchard and Trebbau (1984), and Renous et al. (1989).

The population of leatherback turtles nesting at the Sandy Point National Wildlife Refuge (NWR) on St. Croix, U. S. Virgin Islands (USVI), has been intensively studied since 1981 under the auspices of the USVI Division of Fish and Wildlife. A similar project was initiated on Playas Resaca and Brava (Culebra Island, Puerto Rico) in 1984 by the U. S. Fish and

Wildlife Service. The average curved carapace length (CCL) of nesting females on these beaches is 155 cm (range 137-176 cm) and weights of 262-506 kg have been recorded (Eckert and Eckert 1983, 1985; Basford et al. 1986, 1988; Brandner et al. 1987, 1990; Tucker 1988; Tallevast et al. 1990). Hatchlings average 61.3 mm (n=398) straightline carapace length and 45.8 g (n=282) in weight (Eckert et al. 1984). Similar data are reported from Australia (Limpus and McLachlan 1979), French Guiana (Fretey and Girondot 1989), Costa Rica (Hirth and Ogren 1987), and Trinidad (Bacon 1970). Nesting females are larger and smaller, respectively, in South Africa (averaging 164 cm CCL; Hughes et al. 1967) and Pacific Mexico (averaging 144 cm CCL; Sarti et al. 1987). The largest leatherback on record is a male that stranded on the coast of Wales in 1988 and weighed 916 kg (Morgan 1989).

Leatherbacks have the most extensive range of any reptile (71°N to 47°S; Pritchard and Trebbau 1984) and exhibit broad thermal tolerances. The species is commonly reported in New England waters and northward into eastern Canada, as well as occasionally sighted in British Columbia and northward into Alaska. In Trinity Bay, Newfoundland, an adult was observed by fishermen throughout an entire day swimming in open water amongst ice (Goff and Lien 1988). The core body temperature for adults in cold water has been shown to be several degrees C above ambient (Frair et al. 1972). This may be due to several features, including the thermal inertia of a large body mass, an insulating layer of subepidermal fat, counter-current heat exchangers in the flippers, and potentially heat-generating brown adipose tissue (Mrosovsky and Pritchard 1971; Frair et al. 1972; Greer et al. 1973; Neill and Stevens 1974; Goff and Stenson 1988). The skeleton remains extensively cartilaginous, even in adult animals, and the species is unique among turtles in showing an extensive cartilage canal vascular system in the long bones (Rhodin et al. 1981).

With the exception of very preliminary data on growth in mature females (nesting females returning to Sandy Point NWR gain, on average, about 0.5 cm CCL per year; R. Boulon, unpubl. data), information concerning the growth rate of wild individuals is entirely lacking. Based on the unusual features of the leatherback skeletal system, as well as evidence that some individuals have grown quite rapidly in captivity, Rhodin (1985) has speculated that leatherbacks may reach sexual maturity in 2-3 years. Bels et al. (1988) challenge this hypothesis in their report of a healthy captive leatherback 1200 days (3.28 yrs) old with a carapace length of 82 cm and a weight of 28.5 kg, dimensions which are an order of magnitude smaller than mature leatherbacks measured in the wild. Leatherbacks may indeed reach sexual

maturity at an earlier age than other sea turtles; however, information on the growth of juveniles in the wild is necessary before growth rates can be accurately predicted.

Analysis of stomach contents has shown that leatherbacks feed primarily on cnidarians (medusae, siphonophores) and tunicates (salps, pyrosomas) in temperate and boreal latitudes (Bleakney 1965; Brongersma 1969; Den Hartog and Van Nierop 1984; Davenport and Balazs 1991). The turtles are sometimes observed in association with jellyfish, such as *Stomolophus* (Leary 1957; Lohofener et al. 1988), *Aurelia* or *Chrysaora* (Musick 1988; Collard 1990), but actual feeding behavior has only occasionally been documented. Foraging has been observed at the surface (e.g., on *Aurelia*, as reported by Eisenberg and Frazier 1983), but is also likely to occur at depth. Based on offshore studies of diving by adult females nesting on St. Croix, Eckert et al. (1989a) proposed that the observed inter-nesting dive behavior reflected nocturnal feeding on vertically migrating zooplankton, chiefly siphonophore and salp colonies. Den Hartog (1980) speculated that foraging may occur at depth after finding nematocysts from deep water siphonophores in leatherback stomach samples.

The evidence currently available from tag returns and strandings in the western Atlantic suggests that adults engage in routine migrations between temperate and tropical waters, presumably to optimize both foraging and nesting opportunities. Leatherbacks tagged while nesting in the Caribbean sometimes strand on New England shores (Pritchard 1973, 1976; Lambie 1983; Boulon et al. 1988). Rhodin and Schoelkopf (1982) reported a gravid female stranded in August on the shores of New Jersey, the eggs possibly residual from her last clutch of the season in more southerly latitudes. Conversely, an adult female tagged in Chesapeake Bay in May 1985 was killed in the Gulf of Guacanayabo, Cuba, in July 1986 (Keinath and Musick 1990). The species composition of epibiotic barnacle communities on Caribbean-nesting leatherback provides indirect evidence that gravid females embark from and subsequently return to temperate latitudes (Eckert and Eckert 1988). The longest documented movement is that of an adult female who traveled 5,900 km to Ghana, West Africa, after nesting in Surinam (Pritchard 1973). Long distance (> 100 km) intra-seasonal movement sometimes occurs among nesting beaches; for example, between French Guiana and Surinam (Pritchard 1973) and between St. Croix and Puerto Rico (Eckert et al. 1989b).

A mating in Puerto Rican waters was described by Carr and Carr (1986), but there is some evidence that mating typically occurs prior to (or during) migration to the nesting ground

(Eckert and Eckert 1988). Nesting is generally nocturnal. Preferred nesting beaches have deep and unobstructed offshore access (Hirth 1980; Mrosovsky 1983). When nesting occurs on high energy, spatially unpredictable beaches, it is not uncommon for large numbers of eggs to be lost to erosion (see Mrosovsky 1983; Eckert 1987 for review). The most detailed reproductive data available for entire nesting colonies have been collected at Sandy Point NWR, St. Croix, and on Culebra Island, Puerto Rico. In these areas, nesting commences in March (rarely in February) and continues into July. Females renest on average every 9-10 days, deposit an average of 5-7 nests per annum (observed range 1-11), and remigrate at 2-3 year intervals. Annual project reports record that clutch size averages 116 eggs, including 80 yolked eggs, on Sandy Point (1982-1989) and 103 eggs, including 70 yolked eggs, on Culebra Island (1984-1989). Similar data have recently been reported elsewhere in the Western Atlantic; for example, in French Guiana (Fretey and Girondot 1989) and Costa Rica (Hirth and Ogren 1987). Data from Culebra Island suggest that remigrants (returning turtles tagged during a previous nesting year) lay more clutches per annum than do turtles recorded nesting at this rookery for the first time (Tucker and Frazer 1991).^② Nesting is typically nocturnal.

The temperature in the nest during the 55-75 days of incubation influences the sex of hatchlings. The "pivotal temperature" (=1:1 sex ratio) for leatherback eggs is estimated to be 29.25°C-29.50°C in Surinam and French Guiana (Mrosovsky et al. 1984; Rimblot-Baly et al. 1986-1987). Pivotal temperatures have not been defined elsewhere for this species. Several authors have cautioned against artificial incubation techniques which potentially bias sex ratios (e.g., Mrosovsky and Yntema 1980; Morreale et al. 1982; Dutton et al. 1985). Under natural circumstances hatchlings emerge from the nest in the early evening and, to the best of our knowledge, orient toward the ocean using light; that is, using the brightness of the seaward horizon as their primary cue. Once in the water there is some evidence that hatchlings maintain their orientation by swimming at a fixed angle relative to waves (Lohmann et al. 1990). Locomotion is described by Davenport (1987). Nothing is known of the behavior or survivorship of post-hatchlings. In his review of the pelagic stage of post-hatchling sea turtle development, Carr (1987) found no evidence that young leatherbacks associate with *Sargassum* or epipelagic debris. On 19 May 1989, an injured juvenile (29 cm CCL) was found in the surf off Playa Humacao, Puerto Rico. It was transferred to Coral World, St. Thomas, for rehabilitation and subsequently died there (Johnson 1989). Beyond a few such chance encounters, there are no data on immature leatherbacks under U. S. jurisdiction.

Population Size

Nesting grounds are distributed circumglobally (ca. 40°N to 35°S), with the Pacific coast of Mexico supporting the world's largest known colony of nesting females. The only available estimates of the world population of leatherback turtles are confined to breeding females. From seasonal nest counts, and a knowledge of intra- and inter-annual nesting periodicities, the number of breeding females can be approximated. The latest published estimate is 115,000 adult females worldwide (Pritchard 1982), with about half of them nesting along the Pacific coast of Mexico. During the 1986-1987 breeding season, an estimated 4796 nests were laid on 4.5 km of beach at Mexiquillo, Michoacan, Mexico (Sarti et al. 1989). Nesting at this site has been steadily dropping, however. An estimated 1200 nests were laid in 1990-1991, slightly up from a low of ca. 1074 in 1989-1990 (Laura Sarti M., UNAM, unpubl. data). It is not clear whether the decline reflects natural fluctuation, a geographic shift in nesting (most likely northward), or is a warning that the population is in serious jeopardy. The other large colony in the western hemisphere is Yalimapo-Les Hattes, French Guiana, where the total number of adult females is estimated at 14,700-15,300 (Fretey and Girondot 1989). As erosion has degraded nesting beaches in French Guiana, the large colony there has spilled over into Surinam. There were fewer than 100 leatherback nests laid in Surinam in 1967, but annual numbers have risen steadily to 5565 nests in 1977 and 9816 nests in 1987 (Fretey 1989).

Until recently, large colonies also flourished in the eastern hemisphere. At least 13,000 leatherback nests were reported in 1984 on 17.8 km of coast extending eastward from Tanjung Jamursba on the Bird's Head Peninsula, Irian Jaya, making this Indonesian site one of the most important in the world (Bhaskar 1985). In 1991, Betz and Welch (1992) visited the Jamursba-Medi rookery and reported that nesting levels had declined to a mere 25% of those reported by Bhaskar (1985); the near total collection of eggs has most certainly contributed to the population's demise. Similarly, Terengganu, Malaysia, once considered a major nesting ground, has declined dramatically, largely as a result of intensive egg collection. The data show a steady drop in nesting activity from 6721 landings in 1968 to 372 in 1988 (Chua 1988) to 207 in 1991 (Sukarno Wagiman, Marine Fisheries Resource Research Center, Terengganu, *in litt.*, December 1991). Population declines have also been reported in India, Sri Lanka, and Thailand (see Ross 1982).

Pritchard (1971), Bjørndal (1982), Groombridge (1982), Carr et al. (1982), Bacon et al. (1984a), and Pritchard and Trebbau (1984) offer the most complete discussions of the present distribution of leatherback nesting grounds. Based on summaries presented by these authors, nesting in the western Atlantic occurs in Brazil, the Guianas (French Guiana, Surinam, Guyana), Venezuela, Central America (notably Panama and Costa Rica), and Mexico. In the West Indies, Trinidad and the Dominican Republic are relatively important (supporting perhaps 200-300 leatherbacks per annum), while nesting elsewhere in the eastern Caribbean is predictable but occurs nowhere in large numbers. There is considerable anecdotal information to suggest that nesting has declined at many Caribbean rookeries over the last several decades. However, with few exceptions (see Cambers and Lima 1990; Eckert 1992) documentation is lacking. Information concerning the historical status of western Atlantic populations is currently being compiled by the Wider Caribbean Sea Turtle Recovery Team and Conservation Network (WIDECAST), as part of an effort to draft sea turtle recovery action plans for each of 39 Caribbean governments.

In the eastern Atlantic, direct and/or indirect evidence of nesting is available from Angola, Sénégal, Liberia, Côte d'Ivoire, Ghana, Gabon, Togo, and Zaire. Fretey and Girardin (1988) report nesting between Pongara Point and Ndindi in Gabon, near the Congo border, and suggest a population size of 1276-2553 breeding females. In the Mediterranean, rare nestings are reported from Israel and the southern coast of Sicily. In the Indian Ocean, the best known nesting grounds are in Sri Lanka and in Tongaland, South Africa. Small-scale nesting occurs in India, and larger aggregations are known in the Union territories of the Andaman and Nicobar Islands. In Indonesia, Sumatra and Java reportedly receive some nesting; Irian Jaya may still be important (see discussion above). Thailand (especially Phuket) is important, Burma less so, and there is still some nesting in Malaysia. In the western Pacific, Papua New Guinea, the Solomon Islands, and Australia have nesting. The largest nesting colonies in the eastern Pacific are located in Mexico. Nesting occurs on a smaller scale along the Central American coastline, Colombia, Ecuador and, possibly, Peru.

In U. S. jurisdiction, St. Croix and Culebra islands support the largest nesting colonies of leatherback turtles. Between 1982-1991, the total number of nests laid per annum at Sandy Point NWR ranged from 82 (1986) to 260 (1991), or 18 to 48 females (Dutton et al. 1992). On Culebra Island between 1984-1990, 88-184 nests (=12-27 females) were laid per annum (Tallevast et al. 1990). Sandy Point NWR receives 50-70% of all leatherback nests in the

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USVI. Playas Resaca and Brava receive 91-100% of the nesting on Culebra (Tucker 1988); < nesting occurs elsewhere in Puerto Rico, but nowhere in large numbers (Cintron and Cintron 1987). In 1991, 18 nests were reported at Playa Añasco, three nests at Mayagüez, and one nest at Cabo Rojo; between 1986-1991, 149 nests were reported at Luquillo (B. Pinto, pers. comm.). // Playa Humacao ?? // An April-June 1991 survey of Vieques Island revealed 30 leatherback nests (Benito Pinto, PR NDR, pers. comm.). Kontos (1986) documented 11 nests on Mona Island between 17 April-19 June 1985; there were no nests in 1986, five crawls in 1987, and none in 1988 or 1989 (Richardson 1990). Nesting on the Atlantic coast of Florida may sometimes approach that reported in the U. S. Caribbean, but nest density is considerably lower. According to Barbara Schroeder (Florida Department of Natural Resources), 38-188 leatherback nests were reported to State authorities per annum between 1981 and 1991. Nesting north of Florida is very rare (see Schwartz 1977; Ruckdeschel et al. 1982). No nesting is reported from the U. S. Pacific.

While estimates of foraging population sizes are not available, sightings and incidental catch data indicate that leatherbacks (adult or near adult size) are found in Alaska as far north as 60.34°N, 145.38°W and as far west as the Aleutian Islands (Hodge 1979; Stinson 1984). Documented encounters extend southward through the waters of British Columbia (Logier and Toner 1961; MacAskie and Forrester 1962), Washington and Oregon (Eisenberg and Frazier 1983; Brueggeman 1991), and California (Stinson 1984; Starbird et al. 1992). After analyzing some 363 records of sea turtles sighted along the Pacific coast of North America (from 29°45'N northward), Stinson (1984) concluded that the leatherback was the most common sea turtle in U. S. eastern Pacific waters. The species is also present in U. S. temperate Atlantic waters; however, recent efforts to calculate sea turtle population size in east coast waters using aerial survey techniques have been largely unsuccessful with regard to leatherbacks (Thompson 1988; Epperly et al. 1990), presumably because of a statistically inadequate number of sightings. In the one published study that made an attempt to quantify density, Lohofener et al. (1988) reported 0.027 leatherbacks per 100 km² during periods of peak density offshore of Louisiana in October 1987.

A survey of the Cape Canaveral area conducted during March 1982-August 1984 reported that 94.5% of all leatherback sightings (n=128 total) occurred east of the 20 m isobath and 90.6% occurred during the summer (Schroeder and Thompson 1987). An earlier (1979) aerial survey of the mid- and north-Atlantic areas of the U. S. Outer Continental Shelf between

North Carolina and Nova Scotia showed leatherbacks to be present April to November throughout the study area (but most likely to be observed from the Gulf of Maine south to Long Island); peak estimates of relative abundances during the summer were in the hundreds (Shoop et al. 1981). The same study concluded that leatherbacks were observed more frequently in colder waters at higher latitudes during the summer than were other sea turtle species. In Cape Cod Bay, Massachusetts, sightings peak in August and September (Prescott 1988). There have been noticeably more leatherbacks observed at sea off South Carolina since 1989 than in any other years since record-keeping began, and this increase is corroborated by a significant increase in the numbers of stranded leatherbacks in the state since 1989. Causal factors (e.g., shift in currents, prey abundance) have not been determined and systematic pelagic surveys have not been undertaken (Sally Murphy, SC Wildl. Mar. Res. Dept., pers. comm.).

It is not known at the present time whether leatherback populations under U. S. jurisdiction are stable, increasing, or declining, but there can be no doubt that some nesting populations (e.g., St. John and St. Thomas, USVI) have been virtually extirpated (Eckert 1992). Historical levels of nesting are not known, but continuing studies at Sandy Point NWR and Culebra Island show annual fluctuations which do not appear abnormal, and do not project a long-term decline. Even as important nesting beaches are protected, however, egg poaching remains a very serious concern in Puerto Rico. Furthermore, incidental catch and entanglement at sea are unquantified and potentially important sources of mortality. Strandings reported from U. S. Atlantic, Gulf of Mexico, and Caribbean coasts increased 123% in 1987 (n=134) over 1986 (n=60) (Schroeder 1988). Strandings declined in 1988 (n=79), but have since risen again (n=104 in 1989, n=102 in 1990, n=118 in 1991) (Wendy Teas, NMFS, pers. comm.). In April 1991, 30 leatherbacks stranded on the Georgia coast, nearly equal to the total of 39 leatherbacks stranded in that state during the preceding 11 years. Unusually high mortality levels of other sea turtle species during this time were blamed on record levels of shrimp trawling offshore, and the fact that turtle excluder devices (TEDs) were not required in April (Shoop 1991). It is noteworthy, however, that even when a TED is properly installed it is not designed to liberate a turtle (or any object) as large as an adult leatherback.

Listing Factors

1. Present or Threatened Destruction, Modification or Curtailment of Habitat or Range

Sea turtles of all species are threatened by the present and planned destruction or modification of nesting and foraging habitats. Nesting beaches around the world have been degraded by residential and commercial coastal construction (particularly high density development), beach-front lighting, sand mining, beach armoring (including stabilization structures such as seawalls, groins, and erosion barriers), mechanized beach cleaning, vehicle traffic on the beach, litter, and the removal of stabilizing native plants or the introduction of exotic vegetation. The recent construction of a pipeline at Playa Humacao (Puerto Rico), a beach regularly visited by leatherbacks, involved bright lights maintained on the beach while construction proceeded during the nesting season; not a single leatherback ventured ashore during this time (B. Pinto, pers. comm.). Oceanic foraging grounds are chronically degraded as huge amounts of anthropogenic waste continue to be disposed of at sea (e.g., UNEP 1984; CEE 1987). General overviews of habitat alteration and its observed consequences are provided by Bjørndal (1982), Groombridge (1982), Coston-Clements and Hoss (1983), Bacon et al. (1984b), Hopkins and Richardson (1984), Raymond (1984), and the National Research Council (1990).

Oil spills are a continuing source of concern. In September 1989, following Hurricane Hugo, a 42,000 gallon spill of #6 fuel oil (heavy crude oil) at the Water and Power Authority facility in Christiansted, St. Croix, left south coast beaches heavily oiled. Between March 1991 and March 1992, two more spills, both outside of U. S. waters, threatened U. S. nesting beaches. The first occurred on 6 March 1991, 13 nm north of Nevis, when the Trinidad-registered barge Vestabella, loaded with about 560,000 gallons of #6 fuel oil, sank in 600 m of water after a towing cable snapped; the initial oil slick was more than 30 miles long (Simmonds 1991). According to *The Daily News* (30 March 1991), a USVI newspaper, tar balls began appearing on St. John on 21 March and soon thereafter were reported from St. Thomas, St. Croix, Culebra, Vieques, and the main island of Puerto Rico. One year later, on 15 March 1992, a pipe ruptured during ship-to-shore pumping of #6 fuel oil to a transfer station at St. Eustatius Terminal, Netherlands Antilles. One hundred barrels of crude oil were released to the sea in a slick that headed northwest out across the rich fishing grounds of the Saba Bank. Heavy seas broke up the slick before it entered U. S. waters, but tar balls eventually fouled the coast of Puerto Rico (Zandy Hillis, USNPS, pers. comm.).

Specific examples of important leatherback nesting beaches that have been lost to beach sand mining can be found in the British Virgin Islands (Cambers and Lima 1990), Grenada (Eckert and Eckert 1990a), and elsewhere in the eastern Caribbean. Beach armoring and other

nearshore stabilization structures can also threaten nesting habitat. A breakwater constructed for Green Cay Marina, St. Croix, resulted in the loss to erosion of a leatherback nesting beach immediately to the east (Eckert 1992). At Sandy Point NWR, St. Croix, nesting turtles are disoriented by coastal lighting and are often attracted, particularly on moonless nights, to the intense glare of elevated baseball field lighting in Frederiksted several km to the northwest (K. Eckert, pers. observ.). On neighboring Anegada, British Virgin Islands, a post-nesting female died recently after crawling tens of meters inland to the site of an elevated security light (Cambers and Lima 1990). At Sandy Point NWR, litter, including discarded glass and metal, can cause nesting attempts to be aborted (K. Eckert, pers. observ.) and vehicle traffic can result in death to 20%-25% of hatchlings in nests which have been driven over (Eckert et al. 1984).

// T. Tallevast -- upland development threatens Culebra beaches ?? // G. Hughes -- sewage on > @
Sandy Point NWR ?? //

At sea, there is mounting evidence that the ingestion of plastic bags, presumably mistaken for jellyfish, is commonplace for leatherback turtles. Eleven of 15 leatherbacks that washed ashore on Long Island during the summer of 1982 had plastic bags "totally blocking their stomach openings" (Anon. 1983). Plastic bags and film were "common" in the intestinal tracts of leatherback carcasses discarded by fishermen in Peru (Fritts 1982). Mrosovsky (1981) reviewed stomach content data and found that in seven of 16 cases (44%), the leatherbacks examined had ingested plastic. Hughes (1974) reported that an adult female stranded in Natal, South Africa, "had its duodenal tract completely filled by a sheet of heavy plastic" measuring 3 m x 4 m. Near Rochelle, France, seven of eight leatherbacks examined had swallowed plastic (Duron and Duron 1980). These are not isolated data, and suggest that the ability of leatherback populations to recover depends not only on protection from direct harvest and the conservation of important nesting habitat, but also on the general health and cleanliness of the oceans. The damaging effects of chemical pollutants, such as oil and pesticides, on leatherbacks have yet to be determined.

2. Over-utilization for Commercial, Recreational, Scientific, and Educational Purposes

There is virtually no international commerce in leatherback sea turtle products. Nonetheless, local commercial and subsistence exploitation is heavy in many parts of the world. The literature is replete with accounts of the harvest of eggs and/or adults in all major breeding areas. In the Western Atlantic, leatherbacks are widely taken for both meat and oil, the latter

consumed for general vitality or employed medicinally for respiratory congestion. Tag returns indicate that this take occurs at least in part in populations that migrate between foraging grounds under U. S. jurisdiction and tropical nesting beaches outside U. S. jurisdiction. Prior to recent conservation programs involving indigenous peoples (Tambiah 1992), an estimated 80% of nesting females were slaughtered during their attempts to nest on beaches in Guyana (Pritchard 1986). Ross and Ottenwalder (1983) reported that nearly 100% of gravid females were harvested by local people for food in the Dominican Republic. The harvest of adults continues in the BVI (Cambers and Lima 1990), Grenada (Eckert and Eckert 1990a), St. Lucia (d'Auvergne 1992), Trinidad (Chu Cheong 1990), and elsewhere. In addition to harvest on tropical nesting beaches, there are several reports of leatherbacks having been shot or harpooned in temperate Atlantic (Brongersma 1972) and Pacific (Stinson 1984) latitudes.

The harvest of eggs also continues throughout the turtle's breeding range, including much of the Western Atlantic. Hirth and Ogren (1987) estimated that the "vast majority" of eggs laid between Parismina and Pacuare, Costa Rica, were harvested. In Puerto Rico, where the collection of sea turtle eggs has been illegal for many years, Matos (1986) reported a "flourishing black market offering high prices for meat and eggs" and concluded that the illegal hunting of nesting females and eggs was a threat to population recovery. In the eastern tropical Pacific, where leatherbacks feeding off the west coast of the U. S. go to reproduce, Pritchard (1989) notes that the collection of eggs by local people for food or sale is so intensive that few nests laid from Costa Rica to Colombia survive. Egg collection is also widespread in Pacific Mexico, despite laws prohibiting it (L. Sarti M., pers. comm.). In Irian Jaya, egg collectors "remove clutches by the boatload" (Bhaskar 1985). In Malaysia, a predominantly Islamic nation where the consumption of sea turtle meat is forbidden by religious custom, virtually 100% of the eggs were collected (Chan et al. 1985) prior to a 1989 moratorium on egg harvest. This exploitation is implicated in the steady decline of that population. Between 1967-1976 and 1984-1988, based on mean values, there was an 86% drop in the number of turtles visiting the well-studied Terengganu rookery (Chua 1988).

The effects of utilizing leatherback turtles for scientific purposes are not likely to negatively affect remaining populations. Leatherback research consists primarily of population surveys, hatchery programs, and other activities which do not involve the death or debilitation of individuals. In the United States, the use or take of leatherbacks for scientific purposes (e.g., captive diet studies, blood sampling, deploying remote equipment) is controlled by a permit

system designed to protect endangered and threatened species. Live leatherbacks are difficult to maintain in captivity and are not intentionally captured for recreational or educational purposes.

3. Disease or Predation

The extent to which disease or parasites influence the survival prospects of wild leatherback turtles is unknown, but these are not considered serious threats. Wolke (1981) reported a case of enteritis. Ogden et al. (1981) diagnosed hematogenous septic arthritis and osteomyelitis involving the elbow, distal humerus, and proximal radius and ulna in a 135 cm adult stranded on the New England coast after being struck in the head by a boat propeller. Rothschild (1987) documented avascular necrosis of bone in Oligocene and Eocene members of the Dermochelyidae; the extent to which the phenomenon debilitates modern dermochelids is unknown. Analysis of adipose tissue, as well as samples of liver and pectoral muscle, from an adult male leatherback stranded in Wales in 1988 indicated that heavy metal values were not elevated above 'normal' background levels seen in other organisms (Davenport et al. 1990; Davenport and Wrench 1990).

Internal parasites include intestinal nematodes (species unidentified) and trematodes (*Pyelosomum* [= *Astrorchis*] *renicapite*, *Calycodes anthos*), amoebae (cf. *Entamoeba histolytica*), and gall bladder flukes (*Cymatocarpus* sp.) (Dunlap 1955; Yerger 1965; Brongersma 1972; Threlfall 1979). An external parasitic isopod (*Excorallana antillensis*) was reported on gravid leatherback nesting on St. Croix by Eckert and Eckert (1988). Several barnacle species appear to colonize leatherback turtles, including *Stomatolepas dermochelys* [= *elegans*], *Platylepas hexastylus*, *Balanus trigonus*, *Conchoderma auritum*, *C. virgatum*, and *Lepas anatifera* (see Eckert and Eckert 1988 for review).

Ghost crabs (*Ocypode quadratus*), vultures (*Coragyps atratus*), monitor lizards (*Varanus* sp.), genet cats (*Genetta* sp.), water mongooses (*Ictonyx* sp.), night herons (*Nyctanassa violacea*), gray foxes (*Urocyon* sp.), raccoons (*Procyon lotor*, *P. cancrivorus*), coatis (*Nasua nasua*), fly larvae (*Megaselia scalaris*), locust larvae (family Acrididae), ants, and a variety of bacteria and fungi prey on eggs and hatchlings in the nest (e.g., Pritchard 1971; Fretey 1981; Whitmore and Dutton 1985). Exotic species, such as the wild pig (*Sus scrofa sulawensis*) in New Guinea (Bhaskar 1985) and the mongoose (*Herpestes auropunctatus*) in the Caribbean (Eckert et al. 1984), also consume eggs and hatchlings. Rates of depredation do not appear to

pose an important threat to U. S.-nesting populations. Losses to non-human predators at Sandy Point NWR are estimated to be <0.5% of annual productivity (Eckert et al. 1984). In contrast, at Les Hattes, French Guiana, the loss to domestic dogs of nearly 1000 hatchlings per night has been documented (Fretey 1981).

Crocodiles periodically consume nesting adults in Papua New Guinea (Lockhart 1989). Jaguars and tigers may have been historical predators on nesting adults, but are less important today (Pritchard 1971; Henri Reichart, WWF, pers. comm.). At sea leatherback hatchlings are consumed by fishes, having been found in the stomachs of carnivorous fishes in the waters of French Guiana (Fretey 1981). Juveniles and adults are preyed upon by killer whales (*Orcinus orca*) (Caldwell and Caldwell 1969), crocodiles (Pritchard 1981), and, presumably, sharks. Rates of depredation on any life stage in the open ocean are unknown.

4. Inadequacy of Existing Regulatory Mechanisms

In the United States, both national and international laws protect leatherback turtles from harassment, harvest, and commerce. According to the Code of Federal Regulations (50 CFR 17.11), the leatherback sea turtle is listed as Endangered throughout its entire range under the U. S. Endangered Species Act (ESA) of 1973, as amended (35 FR 8495; June 2, 1970). Similarly, the species is classified as Endangered in the International Union for Conservation of Nature and Natural Resources' (IUCN) *Red Data Book*, where taxa so classified are considered to be "in danger of extinction and whose survival is unlikely if the causal factors continue operating" (Groombridge 1982). Leatherbacks are included on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The U. S. ratified CITES in 1974.

All federal agencies must ensure that actions authorized, funded, or carried out by them do not result in the destruction or adverse modification of habitat designated as Critical Habitat for marine turtles pursuant to Section 7 of the ESA. Critical Habitat has been designated by both the U. S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS). The beach at Sandy Point, St. Croix, became the first nesting beach for any marine turtle to be proposed as Critical Habitat (Federal Register, 23 March 1978; 43 FR 12050-12051) (Dodd 1978). In September 1978, FWS determined the perimeter of the Sandy Point peninsula (3.06 km in length and 0.32 km wide from MHT inland) to be Critical Habitat for leatherback

turtles. In March 1979, NMFS designated the surrounding waters, following the 100 fathom contour from 17°42'12"N around the peninsula to 64°50'00"W, as Critical Habitat (see USFWS 1981). In September 1984, FWS purchased 2.4 km of this nesting beach, establishing Sandy Point NWR. The most important leatherback nesting beaches in Puerto Rico, Playas Resaca and Brava on Culebra Island, were designated Critical Habitat in 1982 (effective 26 July), but the designation was for the protection of hawksbill, not leatherback, turtles (Dodd 1978).

The broad protection afforded the species has been effective in eliminating harvest in the continental USA, but less so in Puerto Rico and the USVI. On the island of Puerto Rico, the theft of eggs for local consumption is nearly ubiquitous (Matos 1986; Cintron and Cintron 1987). Inadequate law enforcement is a widely recognized problem. In contrast, egg poaching on Puerto Rico's Culebra Island, once described as "extensive and unrelenting" (Carr 1978), has been brought under control by nightly patrol and nest protection programs initiated in 1984 (Tucker 1988). Egg theft continues at a very low level in the USVI, principally on St. Croix, but an ongoing egg protection program at Sandy Point NWR has resulted in substantial increases in annual population productivity (Eckert and Eckert 1990b). It is clear that regulations for the protection of leatherbacks and their eggs are adequate, but vigilant enforcement and more visible > (6) public awareness campaigns are needed.

At sea leatherbacks are vulnerable to incidental catch and pollution. In addition to a well documented take of sea turtles, including a relatively low number of leatherbacks, by the shrimp trawling industry (Henwood and Stuntz 1987), NMFS has limited information that leatherbacks are incidentally taken in other types of commercial fishing gear in U. S. waters, particularly pelagic longlines and possibly drift/gillnets. The agency has issued a Biological Opinion on this subject, evaluating a variety of fisheries with regard to the incidental catch problem (NMFS 1989). NMFS, under the auspices of the Marine Mammal Exemption Program, is now beginning to establish observer programs to more clearly document the take of sea turtles and marine mammals in these commercial fisheries (Charles Oravetz, NMFS, pers. comm.). Efforts are now underway to mandate the use of TEDs in U. S. waters by most shrimping vessels (inshore and offshore) at all times (NMFS 1991). TEDs are not designed to release leatherbacks, however, so this regulatory improvement is not likely to reduce the number of leatherbacks killed each year in shrimp trawls.

Recent progress has been made on the issue of incidental catch on the high seas. On 20 December 1991, the United Nations General Assembly passed a driftnet resolution co-sponsored by the United States and Japan that called upon all nations to reduce fishing effort in existing large-scale pelagic driftnet fisheries by 50% by 30 June 1992 and to fully implement a global moratorium on all such driftnets by 31 December 1992. The resolution passed by consensus. A variety of legal regimes exist to address the problem of ocean dumping both regionally and internationally (see Bean 1987; Lentz 1987). These include the Law of the Sea Convention, The London Dumping Convention, the International Convention for the Prevention of Pollution from Ships (MARPOL), and a host of regional agreements, such as those sponsored by the UNEP Regional Seas Programme. Despite achievements in these areas, the problems persist on a grand scale. International support for stringent regulations governing indiscriminate fishing and ocean dumping is needed, as is a mechanism for effective enforcement.

5. Other Natural or Manmade Factors

Incidental capture and entanglement at sea in active and abandoned fishing gear present serious problems for leatherback turtles worldwide (Brongersma 1972; Balazs 1985). Summarizing a decade (1977-1987) of data, Prescott (1988) implicated entanglement (mainly in lobster pot lines) in 51 of 57 (89%) adult leatherback strandings in Cape Cod Bay, Massachusetts. Goff and Lien (1988) reported that of 20 leatherbacks encountered off the coasts of Newfoundland and Labrador (1976-1985), 14 (70%) were entangled in fishing gear, including salmon nets, herring nets, gill nets, trawl lines, and crab pot lines. Gill net entanglement is also suspected in the waters of New England, based on observations of leatherbacks with cuts, severed limbs, or chafing marks (National Research Council 1990). Further south the species is a rare but regular casualty of shrimp trawls, and some individuals become "entangled in the gangion or caught on the hook" when attracted to lights associated with longlining for tuna in the northern Gulf of Mexico (Hildebrand 1987). They are ensnared in longlines set in the southeastern U. S. (Witzell 1984) and northern Caribbean (Cambers and Lima 1990; Tobias 1991). On 21-22 March 1992, five 300-foot gill nets were legally set as close as 10 m from shore in Critical Habitat off Sandy Point NWR. There is no evidence to indicate that gravid females were caught during this incident, but the fishermen involved readily admitted that leatherbacks had been ensnared in the past and killed in order to save the net (Greg Hughes, USFWS, pers. comm.). Leatherbacks are also incidentally captured in the water intakes of industrial facilities, such as power plants. Three were trapped in the St. Lucie,

Florida, Power Plant in 1978 and two more in 1981 (Roithmayr and Henwood 1982); a total of eight were reported between 1976 and 1988 (Ernest et al. 1989).

In the eastern North Pacific leatherbacks become entangled in gill nets off the coasts of California, Oregon, and Washington (Stick and Hreha 1989; Scott Eckert, NMFS, pers. comm.). Eleven leatherbacks were captured in gill nets by a single fisherman from Bahia de la Paz, Baja California, between 1985 and May 1987 (Alvarado and Figueroa 1990). Both adults and juveniles are occasionally caught in tuna purse-seines operating in the eastern tropical Pacific (S. Eckert, pers. comm.). A very young individual (about 15 cm carapace length) was captured in a purse-seine in April 1976 about 180 nm west of San José, Guatemala (Robert Pitman, NMFS, pers. comm.). Balazs (1982) documented the death of leatherbacks in pelagic drift nets. Frazier and Brito Montero (1990) reported that "at least several hundreds" are captured per annum incidental to the swordfish industry in Chile. In Australian waters, leatherbacks are ensnared and drowned in shark nets, prawn trawls, buoy lines, shark lines, and lobster pot lines (Limpus and McLachlan 1979). In the South China Sea about 400 leatherbacks are caught annually off the coast of Terengganu (Brahim bin Salleh et al. 1987); trawl nets are responsible for some 60% of the total number of turtles caught, with the balance attributed to drift nets (Chan et al. 1988). Finally, leatherbacks are struck, sometimes fatally, by propellers (Brongersma 1972; Stinson 1984).

On the nesting beach, storm events and seasonal erosion degrade or destroy nesting beaches and can result in egg losses ranging from <2.5% in Malaysia to 50% or more in the Guianas and the U. S. Virgin Islands (Mrosovsky 1983; Eckert 1987). Eggs may also be destroyed by females digging into nests constructed earlier in the season (Fretey 1986). Shimmering inland lagoons, or debris that blocks the ocean's bright horizon, can disorient hatchlings and preclude their passage to the sea (Mrosovsky 1983). Adult females in French Guiana are sometimes unable to reach the sea after nesting, having become trapped behind accumulations of dead trees, impaled against a root or branch, or held prisoner between stumps deeply embedded in the sand (Pritchard 1971; Fretey 1977, 1981). Females disoriented by an inland lagoon or swamp may mistake its reflection for that of the sea and orient toward it after nesting. Turtles mired in the soft mud of a mangrove swamp or river delta can die from exposure, exertion or asphyxiation.

Conclusion

While the leatherback sea turtle enjoys complete protection in the U. S., the species is often inadequately protected elsewhere. The direct and/or indirect harvest of adults continues in all major and most minor breeding grounds. This despite the fact that the IUCN considers the species Endangered throughout its global range; that is, "in danger of extinction and whose survival is unlikely if the causal factors continue operating" (Groombridge 1982). In Mexico, the largest breeding colony of leatherback turtles in the western hemisphere has suffered enormous losses of both adults and eggs in recent decades (Pritchard 1982). The extent to which the recent ban on sea turtle harvest in Mexico (Aridjis 1990) will mitigate this situation remains unknown. Referring to Irian Jaya, host to the largest breeding colony of leatherback turtles in the eastern hemisphere, Bhaskar (1985) wrote, "The proliferation of outboard engines in the area in the last decade has made the once remote nesting beaches easily accessible to egg collectors who remove clutches by the boatload. On less favored beaches ... to the southeast, nesting leatherbacks are killed for food by inhabitants newly settled on the coast. In years to come, the turtle population will undoubtedly be under even greater human pressure as transmigration of Indonesian families into Irian Jaya continues." This prediction appears to have come to pass. Recent reports indicate an alarming decline in the nesting population at the Jamursba-Medi site; the persistent and nearly complete harvest of eggs has been implicated (Betz and Welch 1992).

Pritchard (1981) reviewed the status of leatherback turtles in the Solomon Islands and concluded that there had been a gradual decline over the years, ominous but difficult to document. While not all leatherback populations are declining, Pritchard's words accurately describe the situation throughout much of the species' range. Perhaps it is fortunate in a backhanded way that in some areas these seemingly innocuous gradual declines have matured into population collapse. By examining these disasters, by evaluating cause and effect, we may be able to avert similar catastrophes elsewhere. One case in point is Terengganu, Malaysia, where nesters arrived by the low thousands per annum 25 years ago and now arrive in the tens. The collapse was precipitated not by the harvest of turtles, but of eggs. As a generation of breeders has died out, there has been no significant recruitment. Another illustrative example is the British Virgin Islands, where the persistent harvest of gravid females for meat and oil has extirpated a once thriving local population. The nature of sea turtle life history allows nesting turtles and/or eggs to be over-harvested for decades from large populations, seemingly without

consequence. By the time declining trends are statistically perceived amid the background noise of normal annual fluctuations, a population may be committed to a downward spiral from which it is not capable of recovering. Malaysia recently implemented a moratorium on the harvest of leatherbacks and their eggs and the BVI is attempting to do the same. In both cases it is likely that the decision has come too late. Many leatherback populations have been seriously over-harvested in past decades and will need wise stewardship into the next century if they are to avoid potentially irreversible declines.

Causal factors operative in the marine environment have not been satisfactorily quantified but appear serious. Thompson et al. (1990) concluded that intensifying human utilization of deeper offshore waters is placing all life history stages of the leatherback turtle at "increasing risk". All indications are that debilitation, particularly of large juveniles and breeding age adults, due to entanglement in and ingestion of persistent marine debris is high. In addition, this status review has summarized incidental catch and drowning in a wide variety of fishing gear. On the basis of these data it would not be unreasonable to conclude that the status of foraging populations occurring in U. S. jurisdiction has worsened since protection was first afforded the species under the Endangered Species Act nearly 20 years ago. It is noteworthy that animals foraging in the U. S. include juveniles which will eventually recruit into the breeding aggregations of the western Atlantic and eastern Pacific, where they will (should present circumstances prevail) face considerable threat at the nesting grounds. The best available commercial and scientific data indicate that the leatherback sea turtle (*Dermochelys coriacea*) should remain listed as Endangered throughout its range pursuant to Section 4 of the Endangered Species Act of 1973, as amended.