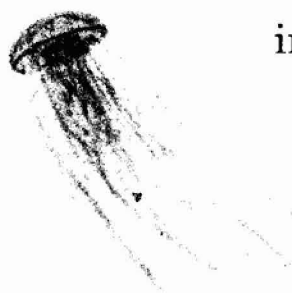
Recovery Plan for

LEATHERBACK TURTLES
Dermochelys coriacea

in the U.S. Caribbean, Atlantic, and

Gulf of Mexico



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Literature citations should read as follows:

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1992. Recovery Plan for Leatherback Turtles in the U.S. Caribbean, Atlantic and Gulf of Mexico. National Marine Fisheries Service, Washington, D.C.

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PART 1. INTRODUCTION

Geographic Scope: This plan is directed at recovery of leatherback populations occurring within the U.S. Caribbean, Atlantic and Gulf of Mexico. The team recognizes the importance of U.S. coastal and pelagic waters to leatherbacks from nesting populations outside the United States. It is not within the scope of this plan to develop recovery criteria for these populations at their nesting beaches. Recovery measures delineated in this plan are, however, intended to include all leatherbacks within U.S. Caribbean, Atlantic and Gulf of Mexico waters regardless of nesting beach affiliations.

Taxonomy: The generic name *Dermochelys* was introduced by Blainville (1816). The binomial refers to the distinctive leathery, scaleless skin of the adult turtle. The specific name *coriacea* was first used by Vandelli (1761) and adopted by Linneaus (1766) (see Rhodin and Smith, 1982). For the most recent detailed discussion of taxonomy and synonymy, see Pritchard and Trebbau (1984).

Description: The leatherback is the largest living turtle and is so distinctive that it is placed in a separate family, Dermochelyidae. *Dermochelys* possesses a skeletal morphology unique among turtles (Rhodin et al., 1981) and recent karyological studies with *Dermochelys* (Medrano et al., 1987) support classifications which segregate extant sea turtle species into two distinct families (Gaffney, 1975, 1984; Bickham and Carr, 1983). All other extant sea turtles are in the family Cheloniidae.

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 4 cm thick and is made primarily of tough, oil-saturated connective tissue raised into seven prominent longitudinal 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. No sharp angle is formed between the carapace and the plastron, resulting in the animal being somewhat barrel-shaped. The front flippers are proportionally longer than in other sea turtles and may span 270 cm in an adult. The mean curved carapace length for adult females nesting in the U. S. Caribbean is 155 cm (range 137 to 176). On Sandy Point NWR, weights of 262 kg to 506 kg (n=46) have been recorded (Eckert and Eckert, 1985; Basford et al., 1986; Brandner et al., 1987). Adults and near adults captured in Virginia waters over the last decade range from 137 to 183 cm curved carapace length (J. Keinath, pers. comm.). Size and weight relationships calculated from adult females in St. Croix, suggest the Virginia leatherbacks range in weight from 204 to 696 kg. The largest leatherback on record (a male) stranded on the coast of Wales in 1988 and weighed 916 kg (Morgan, 1989).

Dermochelys hatchlings are dorsally mostly black and covered with tiny polygonal or bead-like scales; the flippers are margined in white and rows of white scales appear as stripes along the length of the back. In the USVI hatchlings average 61.3 mm (n=398) in straightline carapace length and 45.8 g (n=282) in weight (Eckert et al., 1984). Both front and rear flippers lack claws. In the adult the epidermis is black (with varying degrees of pale spotting) and scaleless. This scaleless condition is unique among sea turtles. The undersurface is mottled, pinkish-white and black, the proportion of light to dark pigment being highly variable. In both adults and hatchlings, the upper jaw bears two tooth-like projections, each flanked by deep cusps, at the premaxillary-maxillary sutures (Pritchard, 1971).

The internal anatomy and physiology are also distinctive. The core body temperature, at least for adults in cold water, has been shown to be several °C above the 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, countercurrent heat exchangers in the flippers, potentially heat-generating brown adipose tissue, and a relatively low freezing point for lipids (Mrosovsky and Pritchard, 1971; Friar et al., 1972; Greer et al., 1973; Neill and Stevens, 1974; Goff and Stenson, 1988; Davenport et al., 1990; Paladino et al., 1990). The skeleton of *Dermochelys* remains extensively cartilaginous, even in adult animals, and the species is unique among turtles in showing an extensive cartilage canal vascular system in the epiphyseal regions (Rhodin et al., 1981).

Population Distribution and Size

Nesting: Nesting grounds are distributed circumglobally (ca. 40°N to 35°S; Sternberg, 1981), with the Pacific coast of Mexico supporting the world's largest known concentration of nesting leatherbacks. Pritchard (1982) estimates that 115,000 adult female leatherbacks remain worldwide and that some 50% of them may nest in western Mexico. The largest nesting colony in the wider Caribbean region is found at Ya:lima:po-Les Hattes, French Guiana, where the total number of adult females is estimated to be 14,700 to 15,300 (Fretey and Girondot, 1989). Lower density Caribbean nesting is also reported from Surinam (Pritchard, 1973; Schulz, 1975), Guyana (Pritchard, 1988a,b), Colombia and Venezuela (Pritchard and Trebbau, 1984), Panama (Meylan et al., 1985; García, 1987), and Costa Rica (e.g., Carr and Ogren, 1959; Hirth and Ogren, 1987).

On the islands of the eastern Caribbean, Bacon (1970) estimated that 150 to 200 leatherbacks nested annually in Trinidad, primarily at Matura and Paria Bays. Shortly thereafter, Bacon and Maliphant (1971) indicated that perhaps 200 to 250 leatherbacks nested annually in Trinidad; recent population estimates are not available. Nesting north of Trinidad in the Lesser and Greater Antilles is predictable, but occurs nowhere in large numbers (Caldwell and Rathjen, 1969; Carr et al., 1982; Meylan, 1983). The largest sub-regional nesting colony is in the Dominican Republic, where an estimated 300 leatherbacks nest annually (Ross and Ottenwalder, 1983). The U. S. Caribbean supports relatively minor nesting colonies (probably 150-200 adult females per annum, combined) but represents the most significant nesting activity within the United States.

Leatherback nesting in the U. S. Caribbean is reported from the Virgin Islands (St. Croix, St. Thomas, St. John) and Puerto Rico, including Islas Culebra, Vieques, and Mona. Tables 1 and 2 in Appendix I summarize nesting records or reports in the U.S. Caribbean. Sandy Point NWR (2.4 km nesting beach) on St. Croix and Playas Resaca and Brava (2.2

km nesting beach) on Isla Culebra support the largest nesting colonies of leatherback turtles in the United States and its territories. The total number of nests deposited annually on Sandy Point NWR has ranged from 82 (1986) to 260 (1991) (Eckert and Eckert, 1985; Basford et al., 1986, 1988; McDonald, et al., 1991). On Isla Culebra, the colony is smaller (88 to 184 nests per year 1984 to 1989; Tallevast et al., 1990). Playas Resaca and Brava receive 91 to 100 percent of all leatherback nesting on Culebra (Tucker, 1988).

Following up on earlier reports of *Dermochelys* nesting on Isla Vieques (e.g., Rainey, 1979), Pritchard and Stubbs (1982) reported 26 nests from aerial surveys conducted between October 1980 and October 1981. On Isla Mona, no leatherback nesting was reported in 1974 or 1975 (Thurston, 1975; Thurston and Wiewandt, 1975). Later surveys reported 0-11 nests per annum (1983 to 1988; Gonzáles, 1984; Kontos, 1985, 1987, 1988). On the main island of Puerto Rico, leatherback nesting occurs on several beaches but nowhere does the species occur in large numbers (Cintron and Cintron, 1987). Recent surveys have recorded 10 or fewer nests each annually on Playas Humacao, Paulinas and Piñones (Matos, 1986, 1987). Slightly higher levels of activity were reported during earlier WATS surveys.

In the USVI, fewer than ten leatherback nests per anum are recorded on the islands of St. John and St. Thomas (Zullo, 1986; Boulon, 1987; Eckert, 1989). About 50 to 70 percent of the total nesting on St. Croix occurs on Sandy Point NWR (O. Tranberg pers. comm.). The second most important nesting beach for the species on St. Croix is Manchenil Bay (11 to 52 nests per annum 1983 to 1988; Adams, 1988); low levels of nesting (<10 nests per year) are reported from a dozen other beaches (Boulon, 1987; Eckert, 1989). The National Park Service recorded 0 to 18 leatherback crawls annually during 1982 to 1989 on Buck Island Reef National Monument, a small island situated off the northeast coast of St. Croix (Z. Hillis, pers. comm.).

Leatherback nesting in Florida was once considered extremely rare (Carr, 1952; Caldwell et al., 1956; Allen and Neill, 1957). Later, when new data became available, including a record 11 nests reported in 1957, Caldwell (1959) suggested that the species "emerges regularly to nest on the beaches of the south Atlantic coast of Florida." Today most beaches in Florida are monitored for sea turtle nesting and 38 to 125 leatherback nests were reported to State authorities annually during the period 1981 to 1990 (Conley and Hoffman, 1987; B. Schroeder, FDNR, pers. comm.). Table 3 in Appendix 1 summarizes nesting in Florida by county during the period 1979 to 1990. Florida Atlantic coast nest numbers may approach those reported for Sandy Point NWR or Culebra, but nest density is considerably lower. For example, in 1987, a high year in Florida, 125 nests were reported from some 271 kms of Florida beach as compared to 184 nests on 2.2 km at Culebra (Playas Resaca and Brava) and 171 nests on 2.4 km at Sandy Point NWR.

No nesting has been reported on the west coast of Florida since the year the State began keeping records in 1979 (B. Schroeder, pers. comm.), but in 1974 a nest was reported on St. Vincent Island NWR off the northwest coast of Florida (LeBuff, 1976).

More recently, a leatherback false crawl was observed on Sanibel in July 1988 (LeBuff, 1990). A single nesting record from each of Cumberland Island and Blackbeard Island, Georgia (Ruckdeschel et al., 1982), and an unconfirmed report of hatchlings emerging at Cape Lookout, North Carolina (Schwartz, 1977), provide the only documentation of the species nesting north of Florida. Hildebrand (1963) was informed by a resident of Padre Island, Texas that a few nesting individuals had been seen on the island in the 1930's, but none in recent years.

Throughout the southeastern United States the geography of beach coverage is more or less complete, but the timing is often inadequate to gain a complete picture of leatherback nesting. Beach patrols are designed to maximize observations of loggerhead sea turtle nests and generally commence in May, whereas leatherbacks start nesting as early as late February or March. Thus, current data slightly underestimate actual nesting activity. Leatherback nests reported from Florida and Georgia are probably deposited by 10 to 25 females annually.

Pelagic: Virtually nothing is known of the pelagic distribution of hatchling or juvenile leatherback turtles. The paths taken by hatchlings leaving their natal beaches are uncharted. Discussions of the "lost year" (the early pelagic stage of sea turtle development) which include tabulated summaries of neonate and juvenile sea turtles associated with *Sargassum* weed or taken from pelagic habitats (e.g., Carr, 1987) have not mentioned sightings of young *Dermochelys*. Our knowledge of juvenile "distribution" rests on a handful of chance observations, and includes sightings in waters within (Caldwell, 1959; Johnson, 1989; J. Webster, pers. comm. to A. Kontos) and outside (e.g., Brongersma, 1970; Hughes, 1974; Pritchard, 1977; Horrocks, 1987) the United States.

Leatherbacks stranding on United States shores are generally of adult or near adult size, demonstrating the importance of pelagic habitat under U. S. jurisdiction to turtles breeding in tropical and subtropical latitudes. Direct evidence of this is available from Caribbean and South American tagged turtles stranding on U. S. shores. Nesters tagged in French Guiana subsequently stranded in Georgia (S. Eckert, pers. comm.), as well as in New York (S. Morreale; pers.comm.), New Jersey, South Carolina, and Texas (Pritchard, 1976). Nesters tagged in Trinidad and St. Croix subsequently stranded in New York (Lambie, 1983) and New Jersey (Boulon et al., 1988), respectively. Conversely, an individual tagged in Virginia waters in 1985 was killed a year later in Cuba (Barnard et al., 1989). Additional evidence of the importance of U.S. coastal waters for leatherbacks is provided by the Sea Turtle Stranding and Salvage Network. During the period 1980 to 1991, 816 leatherback strandings were recorded along the continental U.S. coastline. During this same period, 161 leatherbacks were recovered dead along Florida's coast. Curved carapace lengths for the Florida strandings ranged from 110.0 cm to 195.0 cm. Eighty-four percent of all leatherback strandings in Florida occurred between January to April and October to December. Strandings were lowest (16%) during summer months, May-September.

Efforts to determine leatherback distribution and numbers in the marine environment have met with varying degrees of success. A 1987 aerial survey of shallow Gulf of Mexico waters (Perdido Bay, AL to Cape San Blas, FL) described leatherbacks as "uncommon" in all study areas (though relatively more common in autumn than in spring), the highest density being 0.027 leatherbacks/ 100 km^2 offshore Louisiana in October (Lohoefener, et al., 1988). Earlier surveys (April 1982-February 1983) in the Atlantic revealed leatherbacks in the study area (Key West, FL to Cape Hatteras, NC, out to the western boundary of the Gulf Stream) year around, but no density estimates were given (Thompson, 1984). Thompson (1984) reported a significant negative correlation between leatherbacks and water temperature in the spring, fall and winter, suggesting that the species is not dependent upon warm temperatures and is likely to be associated with cooler, perhaps more productive waters. The same study reported that leatherbacks appeared to prefer water about 20°C (±5°) and were rarely sighted in the Gulf Stream sampling areas. Summarizing incidental catch and interview data (1897-1980), as well as at-sea observations recorded during shore to Gulf Stream summer transects, Lee and Palmer (1981) also concluded that (at least off North Carolina) leatherbacks were rarely seen in the Gulf Stream and were most often seen in waters <500 fathoms in depth.

A survey conducted during March 1982-August 1984, but restricted to the Cape Canaveral area, reported that 94.5 percent of all leatherback sightings (n=128 total) occurred east of the 20 m isobath and 90.6 percent occurred during the summer (Schroeder and Thompson, 1987). In contrast, New England Aquarium surveys of Florida and Georgia (1984-1988) reported few leatherbacks prior to 1988, but in mid February of that year 168 leatherbacks were sighted along the northeast coast of Florida, with peak densities reported along 50 miles of coastline between Daytona Beach and Cape Canaveral (Knowlton and Weigle, 1989). The impetus for this sudden winter abundance in Florida nearshore waters is unknown; by the following survey (16 March) the animals had disappeared (Knowlton and Weigle, 1989). The extent to which distribution and abundance are defined by transient phenomena is presently unclear.

A 1979 aerial survey of the mid- and north-Atlantic areas of the U. S. Outer Continental Shelf (shoreline to the surface projection of the 2000 m isobath) between Cape Hatteras, NC and Cape Sable, 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. Small boaters fishing within 10 miles of the south shore of Long Island, New York and within Cape Cod Bay, Massachusetts frequently report leatherback sightings (S. Morreale, pers. comm.; R. Prescott, pers. comm). Leatherbacks are frequently sighted during aerial surveys of Chesapeake Bay, especially at the mouth (and during the summer months) where they appear to be foraging (Keinath and Musick, in press). In Cape Cod Bay, Massachusetts, sightings peak in August and September (Prescott, 1988). Between 1977 and 1987, no live sightings were reported before June or after October and 82 percent of all stranded turtles were observed in September, October and November (Prescott, 1988).

Status

The leatherback sea turtle is considered endangered throughout its global range (Groombridge, 1982). It was listed as Endangered under the authority of the Endangered Species Act by the United States Department of the Interior on June 2, 1970 and is included on Appendix I of CITES, which the United States ratified in 1974. The nesting beach at Sandy Point NWR, St. Croix, became the first nesting beach of any marine turtle to be proposed as critical habitat (Federal Register, 23 March 1978; 43 FR 12050-12051) (Dodd, 1978). In September 1978, the FWS designated the nesting beach on Sandy Point, St. Croix, as critical habitat; in March 1979, the NMFS determined the surrounding waters as critical habitat.

Declines in the number of nesting females have been documented in Malaysia (Brahim et al., 1987), India (Cameron, 1923; Kar and Bhaskar, 1982), Thailand (Polunin, 1977), and the West Indies (Bacon, 1970; Eckert and Lettsome, 1988; Eckert, 1989). It is not known at the present time whether leatherback populations within the United States are stable, increasing or declining, but there is no question that some nesting populations (e.g., St. John, St. Thomas) have been virtually exterminated. The number of leatherbacks nesting in the past at what is now Sandy Point NWR is unknown, but studies of the population since 1981 show annual fluctuations which do not project a long-term decline.

Biological Characteristics

Habitat: Adult leatherbacks are highly migratory and believed to be the most pelagic of all sea turtles. Habitat requirements for juvenile and post-hatchling leatherbacks however, are virtually unknown. Nesting females prefer high-energy beaches with deep, unobstructed access (Hirth, 1980; Mrosovsky, 1983) which occur most frequently along continental shorelines (Hendrickson, 1980).

Diet: Food habits are known primarily from the stomach samples of slaughtered animals (Brongersma, 1969; Hartog, 1980; Hartog and Van Nierop, 1984). Leatherbacks feed on pelagic medusae (jellyfish), siphonophores, and salpae in temperate and boreal latitudes (e.g., Bleakney, 1965; Brongersma, 1969; Duron, 1978; Eisenberg and Frazier, 1983; Musick, 1988). Keinath and Musick (in press) note that "many" leatherbacks are observed off the mouth of Chesapeake Bay, "presumably feeding on the abundant jellyfish [there]." Aerial surveys document leatherbacks in Virginia waters, especially May to July during peak jellyfish (*Chrysaora, Aurelia*) abundance (Musick, 1988; J. Keinath, pers. comm.). Further south, foraging on the cabbage head jellyfish (*Stomolophus meleagris*) has been observed in waters off North Carolina (F. Schwartz, pers. comm.). In February 1989, an adult female leatherback (originally tagged in French Guiana) stranded on the Georgia coast and stomach contents revealed unidentified medusae and *Libinia* sp., a small crab commensal on *Stomolophus* (S. Eckert, pers. comm.). Captain Joe Webster has observed leatherbacks feeding on "jellyballs" (*Stomolophus*) in Georgia waters and notes that the turtles are seen in water as shallow as 15 feet where jellyballs are abundant (A. Kontos, pers. comm.). In the Gulf of Mexico, aerial survey data often show leatherbacks associated with *Stomolophus* (e.g., Leary, 1957; Lohoefener et al., 1988). Other observers have also reported a "co-incidence" of leatherbacks and maximum jellyfish abundance, especially *Aurelia*, in the Gulf (S. Collard, pers. comm.)

Foraging has most often been observed at the surface, but Hartog (1980) speculated that foraging may occur at depth after finding nematocysts from deep water siphonophores in leatherback stomach samples. Limpus (1984) reported a leatherback feeding on octopus bait on a handline at 50 m depth off western Australia. Based on offshore studies of diving by adult females nesting on St. Croix, Eckert et al. (1989) proposed that the observed internesting dive behavior reflected nocturnal feeding within the deep scattering layer (strata comprised primarily of vertically migrating zooplankters, chiefly siphonophore and salp colonies in the Caribbean; Michel and Foyo, 1976). Eckert et al. (1989) calculate a maximum dive depth of 1300 m, but report that 95 percent of all dives are <20 minutes in length and 95 percent are <200 m in depth.

Growth: No data on the growth rate of juvenile leatherback turtles in the wild are available. This situation arises from the unfortunate fact that the distribution of juvenile leatherback turtles is unknown, and thus specimens are unavailable for capture-recapture methodologies designed to measure growth. The problem is exacerbated by poor survivability in captivity, which further limits opportunities for study. Nonetheless, some investigators have been successful in raising leatherbacks and publishing data on captive growth rates (Deraniyagala, 1936; Glusing, 1967; Birkenmeier, 1970; Frair, 1970; Spoczynska, 1970; Foster and Chapman, 1975; Phillips, 1977; Witham, 1977; Bels et al., 1988). With the exception of Bels et al. (1988), turtles did not survive beyond two years.

Captive growth data are widely disparate, but the very rapid growth reported by some investigators (coupled with evidence of chondro-osseous development conducive to rapid growth) has led to speculations that leatherbacks may reach sexual maturity in 2 to 3 years (Rhodin, 1985). Bels et al. (1988) challenge this hypothesis in their report of a healthy captive leatherback 1200 days of age weighing 28.5 kg, with a carapace 82 cm in length. While leatherbacks may well grow to sexual maturity at an earlier age than other sea turtles, it is clear that more data are needed before growth rates can be accurately calculated.

Reproduction: Mating behavior is described by Carr and Carr (1986) in waters off Puerto Rico, though there is some indirect evidence that mating typically occurs prior to (or during) migration to the nesting ground (Eckert and Eckert, 1988). Nesting behavior (i.e., the basic sequence entailing beaching, ascent, selection of a suitable site, 'body pitting', egg chamber excavation, oviposition, nest filling and camouflage, departure) is similar to that of other marine turtle species (detailed descriptions in Deraniyagala, 1936; Carr and Ogren, 1959). Gravid females emerge from the sea nocturnally; diurnal nesting occurs only occasionally. Because of a proclivity for nesting in high energy and thus frequently unpredictable environments, it is not uncommon that large numbers of eggs are lost to erosion (Bacon, 1970; Pritchard, 1971; Hughes, 1974; Mrosovsky, 1983; Eckert, 1987), though this is not always the case (Tucker, 1989). While the majority of females return to the same nesting beach repeatedly throughout the nesting season, some females are known to nest on separate beaches >100 km apart within a season.

In the United States and wider Caribbean, nesting commences in March (a very few nests are laid in February) and continues into July. The most systematic data available on reproductive output has been gathered at Sandy Point NWR and Isla Culebra. Data from these projects reveal that females arrive at the nesting beach asynchronously, renest an average of every 9-10 days, deposit 5-7 nests per annum (observed maximum = 11), and remigrate predominantly at 2-3 year intervals. The annual nest:false crawl ratio on Culebra (all beaches) is 4:1 to 6.2:1 (1984-1987; Tucker, 1988); 1.2:1 to 3:1 on Sandy Point (1982-1988; USVI Div. Fish Wildl., unpubl. data). Clutch size averages 116 eggs, including 80 yolked eggs, on Sandy Point NWR, 103 eggs, including 70 yolked, on Culebra. Clutch size average 101 eggs, including 76 yolked, on Hutchinson Island, Florida (E. Martin, pers. comm.). Similar clutch sizes are reported elsewhere on St. Croix (Adams, 1988) and Puerto Rico (Matos, 1986, 1987), as well as in Florida (Carr, 1952; Caldwell, 1959; Broward County EPD/EQCB, 1987) and Georgia (Ruckdeschel et al. 1982). 'Eggs incubate for 55 to 75 days, consistently averaging 63 days on both Sandy Point and Culebra and 64 days on Hutchinson Island, Florida. *In situ* hatch success for nests surviving to term is ca. 55 percent on Manchenil Bay, St. Croix (Adams, 1988) ca., 65 percent on Sandy Point NWR (Eckert and Eckert, 1985; Brandner et al., 1987, 1990) and ca. 66 percent on Hutchison Island, Florida (E. Martin, pers. comm.). Higher success (ca. 75 percent) is reported on Culebra (Tucker, 1988, 1989).

The temperature of nest incubation influences the sex of hatchlings and several authors have cautioned against artificial incubation techniques which potentially bias sex ratios (e.g., Mrosovsky and Yntema, 1980; Morreale et al., 1982; Mrosovsky, 1983; Dutton et al., 1985; Rimblot et al., 1985). For sea turtles, high temperatures result in female hatchlings and low temperatures result in male hatchlings. The "pivotal temperature" (ca. 1:1 sex ratio, Mrosovsky and Yntema, 1980) may differ with species and locale. For example, in Surinam, leatherbacks require slightly higher (ca. 0.5°C) temperature for female differentiation than green turtles, and leatherbacks nest in relatively greater numbers during the warmer parts of the season (Mrosovsky et al., 1984). The pivotal temperature for leatherback eggs is estimated to be 29.25 to 29.50°C in Surinam (Mrosovsky et al., 1984; Dutton et al., 1985) and French Guiana (Lescure et al., 1985; Rimblot-Baly et al., 1986-1987) and may be lower in higher latitudes (such as the U. S. Caribbean territories).

Some work has been done to define temperature regimes on Sandy Point NWR beach with the objective of assessing the effects of egg relocation on natural sex ratios. No statistically significant temperature differences were recorded spatially along the 2.4 km nesting beach, suggesting that "egg relocation [from zones of high erosion risk to zones of low risk] has no effect on the natural sex ratio of the hatchlings" (Basford and Brandner, 1989). Pivotal temperatures have yet to be determined on Sandy Point NWR, but based on pivotal temperatures reported from Surinam and broad correlations between incubation duration and sex ratio (from Mrosovsky et al., 1984), Basford (1988) predicted that males were more likely to be produced early in the season (March-April nests), while later nests (June) may produce nearly 100% females. Estimates of the proportion of females produced over the course of the season (based on incubation duration) were 75.4% in 1985, 65.8% in 1986 and 92.2% in 1987, the latter an unusually hot year (Basford, 1988).

Migration/Movements: The leatherback migrates farther (Pritchard, 1976) and ventures into colder water more than does any other marine reptile (e.g., Threlfall, 1978; Goff and Lien, 1988). The evidence currently available from tag returns and strandings in the western Atlantic suggests that adults engage in routine migrations between boreal, temperate and tropical waters, presumably to optimize both foraging and nesting opportunities (Bleakney, 1965; Pritchard, 1976; Lazell, 1980; Rhodin and Schoelkopf, 1982; Boulon et al., 1988;). The composition of epibiotic barnacle communities on Caribbean-nesting leatherbacks provides indirect evidence that gravid females embark from and subsequently return to temperate latitudes (Eckert and Eckert, 1988).

Direct evidence of long-distance movement is scarce, but is available from leatherbacks tagged while nesting in the Caribbean and subsequently stranding in northern latitudes (Pritchard, 1973, 1976; Lambie, 1983; Boulon et al., 1988; see Population Distribution and Size-Pelagic) and also from a turtle tagged in Chesapeake Bay in 1985 and killed in Cuba in 1986 (Barnard et al., 1989). In addition, a nester tagged at Jupiter Beach, Florida, was recaptured near cayo Arcas, Gulf of Campeche (Hildebrand, 1987), and a nester tagged at Sandy Point NWR, St. Croix, was recaptured near cayos Triangulos, also in the Gulf of Campeche, two years later and some 3,000 km from the tagging site (Boulon, 1989). The longest known movement is that of an adult female who traveled 5,900 km to Ghana, West Africa, after nesting in Surinam (Pritchard, 1973). An adult female tagged with a satellite transmitter while nesting in French Guiana in 1986 traveled 820 km in three weeks (an average speed of 40 km/day, Duron-DuFrenne, 1987). A nester tagged with a satellite transmitter on Sandy Point NWR, St. Croix in 1989 travelled 515 km (and ventured some 200 km south of St. Croix) before the transmitter was removed 18 days later when the turtle emerged to nest on Isla Culebra (J. Keinath, pers. comm.).

Threats - Nesting Environment

Poaching: The leatherback was never harvested to any great extent along the southeastern United States, though Caldwell (1959) reports a subadult shot in 1954 in the Indian River, Florida and a nester flipped over (presumably in preparation for slaughter) on Jupiter Island, Florida in 1957. Leatherback turtles historically were taken only rarely for their meat in the USVI where it was occasionally available salted or cured in local markets (O. Tranberg, pers. comm.). Very few leatherbacks are known to have been killed in recent years in the USVI. Otto Tranberg, a former USVI Environmental Enforcement Officer, reported a slaughtered leatherback on Sandy Point, St. Croix, in 1979 and FWS (1981) reported three slaughtered leatherbacks on Sandy Point during the 1980 nesting season. In March, 1988, a turtle was found slaughtered on St. Croix at Judith's Fancy.

In Puerto Rico adults are still occasionally taken for meat and oil (B. Cintron, pers. comm.) Stranding data include two killings since 1985; one in July 1986 on the nesting beach at Las Paulinas and a second in April 1987 from Piñones, both on the northeast coast (K. Hall, pers. comm.). In addition, in April 1985 an adult was killed and left tied to a rock on a Vieques beach east of Punta Salinas (M. Weitzel, pers. comm. to T. Tucker).

The theft of eggs for local consumption is not currently a problem in Florida (P. Raymond, pers. comm.), but continues at low levels in the USVI (Adams, 1988; Eckert, 1989; O. Tranberg, pers. comm.) and is widespread in Puerto Rico (e.g., Cintron and Cintron, 1987). Even though the harvest of sea turtle eggs is illegal in Puerto Rico, law enforcement efforts have been unsuccessful in deterring it. Historically the situation was no better on Puerto Rico's smaller islands; e.g., egg poaching has been described as "extensive and unrelenting" (Carr, 1978a) and a "major problem" (Tucker, 1988) on Culebra. Today poaching has been all but eliminated on Culebra as a result of nightly patrol and nest protection programs initiated by FWS on important nesting beaches in 1984 (Tucker, 1988).

Beach Erosion: Leatherbacks prefer open access beaches presumably to avoid damage to their soft plastron and flippers. However, beaches with little shoreline protection tend to be very dynamic, often displaying severe beach erosion during seasonal changes in wind and wave direction. Eggs that are laid in beach areas that erode before hatching are lost. In the U.S. Caribbean, most leatherback nesting beaches are relative stable with little egg loss due to erosion, but on Sandy Point, approximately 40 to 60 percent of all eggs laid each year would be lost without human intervention (Basford et al., 1988). Many nests laid on Manchenil beach St. Croix are lost to wave inundation (Adams, 1988). Many nests laid on Buck Island, St. Croix, Mona Island, and the north coast of Puerto Rico are lost to early winter swells. Given the current low number of leatherbacks nesting in the United States this egg loss could be a significant threat to the recovery of leatherbacks that nest in the United States.

Because leatherbacks nest in the tropics during hurricane season, there is also potential for storm generated waves and wind to erode nesting beaches and result in nest loss. On Sandy Point NWR, where eggs are continuously moved out of erosion zones, most of the nests now lost to erosion are the result of tropical storms or hurricanes (Basford, et al., 1988). Twelve nests were lost to Hurricane Dean in 1989 on Culebra (T. Tallevast, pers. comm.). In 1980, only four out of approximately 80 nests laid on Sandy Point NWR survived to hatch following the catastrophic effects of Hurricane Allen in mid-July (O. Tranberg, pers. comm.).

Beach Armoring: Where beachfront development occurs, the site is often fortified to protect the property from erosion. Virtually all shoreline engineering is carried out to save structures, not dry sandy beaches, and ultimately results in environmental damage. Beach armoring includes sea walls, rock revetments, riprap, sandbag installations, groins and jetties. Approximately 21 percent (234 km) of Florida's beaches are armored (FDNR, unpubl. data;). Beach armoring can result in permanent loss of a dry nesting beach through accelerated erosion and prevention of natural beach/dune accretion and can prevent or hamper nesting females from accessing suitable nesting sites. Clutches deposited seaward of these structures may be inundated at high tide or washed out entirely by increased wave action near the base of these structures. As these structures fail and break apart they spread debris on the beach which may further impede access to suitable nesting sites (resulting in higher incidence of false crawls) and trap hatchlings and nesting turtles. Sandbags are particularly susceptible to rapid failure and result in extensive debris on nesting beaches. Rock revetments, riprap and sand bags can cause nesting turtles to abandon nesting attempts or to construct improperly sized and shaped egg cavities when inadequate amounts of sand cover these structures.

Groins and jetties are designed to trap sand during transport in longshore currents or to keep sand from flowing into channels in the case of the latter. These structures prevent normal sand transport and accrete beaches on one side of the structure while starving neighboring beaches on the other side thereby resulting in severe beach erosion (Pilkey et al., 1984) and corresponding degradation of suitable nesting habitat. Drift fences, also commonly called sand fences, are erected to build and stabilize dunes by trapping sand moving along the beach and preventing excessive sand loss. Additionally, these fences can serve to protect dune systems by deterring public access. Constructed of narrowly spaced vertical wooden or plastic slats or plastic fabric, improperly placed drift fences can impede nesting attempts and/or trap emergent hatchlings and nesting females.

Beach Nourishment: Beach nourishment is a common practice in Florida and consists of pumping, trucking or scraping sand onto the beach to rebuild what has been lost to erosion. Beach nourishment can impact turtles through direct burial of nests and by disturbance to nesting turtles if conducted during the nesting season. Sand sources may be dissimilar from native beach sediments and can affect nest site selection, digging behavior, incubation temperature (and hence sex ratios), gas exchange within incubating nests, hydric environment of the nest, hatching success and hatchling emergence success (Mann, 1977; Ackerman, 1980; Mortimer, 1982; Raymond, 1984a). Beach nourishment can result in severe compaction or concretion of the beach. Trucking of sand onto project beaches may increase the level of compaction.

Significant reductions in loggerhead nesting success have been documented on severely compacted nourished beaches (Raymond, 1984a). Nelson and Dickerson (1988) evaluated compaction levels at ten renourished east coast Florida beaches and concluded that 50 percent were hard enough to inhibit nest digging, 30 percent were questionable as to whether hardness affected nest digging and 20 percent were probably not hard enough to affect nest digging. They further concluded that, in general, beaches nourished from offshore borrow sites are harder than natural beaches, and, while some may soften over time through erosion and accretion of sand, others may remain hard for 10 years or more. Nourished beaches often result in severe escarpments along the mid-beach and can hamper or prevent access to nesting sites.

Nourishment projects result in heavy machinery, pipelines, increased human activity and artificial lighting on the project beach. These activities are normally conducted on a 24-hour basis and can create barriers to nesting females emerging from the surf and crawling up the beach, causing a higher incidence of false crawls (non-nesting emergences). Increased human activity on the project beach at night may cause further disturbance to nesting females. Artificial lights along the project beach and in the nearshore area of the borrow site may deter nesting females and disorient or misorient emergent hatchlings from adjacent non-project beaches.

Beach nourishment projects require continual maintenance (subsequent nourishment) as beaches erode and hence their negative impacts to turtles are repeated on a regular basis. Beach nourishment projects conducted during the nesting season can result in the loss of some nests which may be inadvertently missed or misidentified as false crawls during daily patrols conducted to identify and relocate nests deposited on the project beach (Lund, 1973; R. Wolf, pers. comm.). Nourishment of highly eroded beaches (especially those with a complete absence of dry beach) can be beneficial to nesting turtles if conducted properly. Careful consideration and advance planning and coordination must be carried out to ensure timing, methodology and sand sources are compatible with nesting and hatching requirements.

Artificial Lighting: Extensive research has demonstrated that the principal component of the sea finding behavior of emergent hatchlings is a visual response to light (Daniel and Smith, 1947; Hendrickson, 1958; Carr and Ogren, 1960; Ehrenfeld and Carr, 1967; Mrosovsky, 1978; Dickerson and Nelson, 1989; Witherington and Bjorndal, 1991). Artificial beachfront lighting from buildings, streetlights, dune crossovers, vehicles and other types of beachfront lights have been documented in the disorientation (loss of bearings) and misorientation (incorrect orientation) of hatchling turtles (McFarlane, 1963; Philibosian, 1976; Mann, 1977; Ehrhart, 1983). On Sandy Point NWR, hatchlings are strongly attracted, especially on moonless nights, to the lights of Frederiksted several km to the northeast.

The results of disorientation or misorientation are often fatal. As hatchlings head toward lights or meander along the beach their exposure to predators and likelihood of desiccation are greatly increased. Misoriented hatchlings can become entrapped in vegetation or debris, and in Florida loggerhead hatchlings are frequently found dead on nearby roadways and in parking lots after being struck by vehicles. Hatchlings that successfully find the water may be misoriented after entering the surf zone or while in nearshore waters. Intense artificial lighting can even draw hatchlings back out of the surf (Daniel and Smith, 1947; Carr and Ogren, 1960).

The problem of artificial beachfront lighting is not restricted to hatchlings. A post-nesting leatherback died recently after traveling inland toward a security light on Anegada, British Virgin Islands (Eckert and Lettsome, 1988). Raymond (1984b) indicated that adult loggerhead emergence patterns were correlated with variations in beachfront lighting in south Brevard County, Florida, and that nesting females avoided areas where beachfront lights were the most intense. Witherington (1986) noted that loggerheads aborted nesting attempts at a greater frequency in lighted areas. More recently, Witherington (in press) determined broad spectrum artificial lights significantly reduced loggerhead and green turtle nesting activity within a Melbourne Beach, Florida study area. Problem lights may not be restricted to those placed directly on or in close proximity to nesting beaches. The background glow associated with intensive inland lighting, such as that emanating from nearby large metropolitan areas, may deter nesting females and disorient or misorient hatchlings navigating the nearshore waters. Cumulatively, along the heavily developed beaches of the southeastern continental United States and Puerto Rico, the negative effects of artificial lights may be profound.

Beach Cleaning: Beach cleaning refers to the removal of both abiotic and biotic debris from developed beaches. There are several methods employed including mechanical raking, hand raking and picking up debris by hand. Mechanical raking can result in heavy machinery repeatedly traversing nests and potentially compacting sand above nests and also results in tire ruts along the beach which may hinder or trap emergent hatchlings. Mann (1977) suggested that mortality within nests may increase when externally applied pressure from beach cleaning machinery is common on soft beaches with large-grain sand. Mechanically pulled rakes and hand rakes can penetrate the surface and disturb the sealed nest or may actually uncover pre-emergent hatchlings near the surface of the nest. In some areas collected debris is buried directly on the beach, and this can lead to excavation and destruction of incubating egg clutches. Disposal of debris near the dune line or on the high beach can cover incubating egg clutches and subsequently hinder and entrap emergent hatchlings and may alter natural nest temperatures. Mechanical beach cleaning is the sole reason for extensive nest relocation on Florida beaches.

Increased Human Presence: Residential and tourist use of developed (and developing) nesting beaches can result in negative impacts to nesting turtles, incubating egg clutches and hatchlings. The most serious threat caused by increased human presence on the beach is the disturbance to nesting females. Night-time human activity can cause nesting females to abort nesting attempts at all stages of the behavioral process. Murphy (1985) reported that disturbance can cause loggerhead turtles to shift their nesting beaches, delay egg laying, and select poor nesting sites. Heavy utilization of nesting beaches by humans (pedestrian traffic) may result in lowered hatchling emergence success rates due to compaction of sand above nests (Mann, 1977), and pedestrian tracks can interfere with the ability of hatchlings to reach the ocean (Hosier et al., 1981). Campfires and the use of flashlights on nesting beaches misorient hatchlings and can deter nesting females (Mortimer, 1979).

Recreational Beach Equipment: The placement of physical obstacles (e.g., lounge chairs, cabanas, umbrella, hobie cats, canoes, small boats and beach cycles) on nesting beaches can hamper or deter nesting attempts and interfere with incubating egg clutches and the sea approach of hatchlings. The documentation of false crawls at these obstacles is becoming increasingly common as more recreational beach equipment is left in place nightly on nesting beaches. In addition, the placement of recreational beach equipment directly above incubating egg clutches may hamper hatchlings during emergence and can destroy eggs through direct invasion of the nest.

Hatchling Mortality: A considerable number of leatherback eggs survive the incubation period, develop to full-term and then fail to successfully emerge (Eckert and Eckert, 1990). A portion of this mortality is due to entanglement in beachvine roots that have grown into or over the nest cavity since egg deposition. On beaches with regular nest monitoring, many of these may be saved by excavation following the main hatchling emergence. A second, larger portion of pre-emergence mortality remains unexplained. On Sandy Point NWR in 1988, 27.5 percent of all embryos that developed to term were found dead in the nest, either in the shell, pipped or emerged from the shell (Basford et al., 1988). On Manchenil Beach this mortality was 23.3 percent (Adams, 1988). Stress and/or lack of oxygen at this critical time may be very important factors in this mortality.

Ghost crabs (*Ocypode quadratus*) and yellow crown night herons (*Nyctanassa violacea*) are common hatchling predators on the beach at night, but probably do not account for a significant amount of hatchling mortality. Other predators include dogs, mongooses and ants. Annual loss of productivity due to beach predators was estimated at <0.5 percent on Sandy Point NWR (Eckert and Eckert, 1985). Abiotic beach threats include debris entanglement and vehicle tracks (see below). Hatchlings have been fatally ensnared by beach vines and discarded fishing line on Sandy Point NWR. Once they leave the beach the hatchlings are preyed upon by sharks, fish and seabirds (R. Boulon, pers. obs.). This may be the most important hatchling mortality factor, but is one which is difficult to quantify.

Beach Vehicular Driving: Beaches are often times viewed as a playground for off-road vehicles (ATV's, 4x4's, motorcycles). This may decrease hatchling success due to sand compaction (Mann, 1977) or directly kill pre-emergent hatchlings as happened on Sandy Point NWR in 1984 with at least one nest. Vehicles can also strike and kill hatchlings while they are crawling to the ocean. Vehicle tire ruts also interfere with the ability of hatchlings to traverse the beach to the ocean (Hosier, et al., 1981). On some beaches this is a serious problem. Beaches with limited access (eg. Culebra, Buck Island) have little or no problem of this sort. On other beaches however, this may be a serious problem (e.g. Sandy Point NWR, Basford et al., 1988; Mandahl and Caret Bays, St. Thomas; Bureau of Environmental Enforcement Officers, pers. comm.; Manchenil Bay, St. Croix, Adams, 1988; and northeastern Puerto Rico, P.J.R. Lugo, H.C. Horta, pers. comm.) In both the USVI and Puerto Rico this activity is illegal, yet it persists. In Florida beach driving is permitted in portions of Nassau, St. John's, Flagler and Volusia Counties along the east coast. Night driving is permitted within some of these areas. This can disturb nesting turtles and result in aborted nesting attempts.

Threats - Marine Environment

Entanglement at Sea: Leatherbacks become entangled fairly often in longlines, fish trap warps, buoy anchor lines and other ropes and cables. This can lead to serious injuries and/or death by drowning. Many nesting females on Sandy Point NWR exhibit various degrees of rope or cable cuts on their shoulders and front flippers (R. Boulon, pers. observ.). During the 1988 nesting season two different Culebra, Puerto Rico, fishermen reported finding drowned leatherbacks entangled in their fish trap ropes. The setting of "large mesh nets suitable for turtling" is common in Puerto Rican waters, with as many as 37 of them recorded during a single over-flight of Puerto Rico (including the islands of Culebra and Vieques) in 1984 (T. Carr in Rathbun et al., 1985). This practice continues, despite the 1984 amendment of the Puerto Rico Fisheries Act prohibiting the use of turtle nets in Puerto Rico's territorial waters. Though the nets are intended for hawksbills and green turtles, leatherbacks also occasionally become entangled.

Summarizing a decade of data (1977-1987), Prescott (1988) implicated entanglement (primarily in lobster pot lines) in 51 of 57 (89%) adult leatherback strandings in Cape Cod Bay, Massachusetts. Fretey (1982) published an extensive inventory of flipper injuries among leatherbacks in the large French Guiana nesting colony, some of these animals are known to come from feeding grounds in the northeastern United States. Goff and Lien (1988) reported that of 20 leatherbacks encountered off the coasts of Newfoundland and Labrador (1976 to 1985), 14 (70%) were entangled in fishing gear (including salmon net, herring net, gillnet, trawl line and crab pot line). Leatherbacks are attracted to lights associated with longlining for tuna in the northern Gulf of Mexico and become "entangled in the ganglion or caught on the hook" (Hildebrand, 1987).

Ingestion of Marine Debris: Marine turtles have been found to ingest a wide variety of abiotic debris items such as plastic bags, raw plastic pellets, plastic and styrofoam pieces, tar balls and balloons. Effects of debris ingestion can include direct obstruction of the gut, absorption of toxic byproducts and reduced absorption of nutrients across the gut wall (Balazs, 1985). Studies conducted by Lutz (in press) revealed that both loggerhead and green turtles actively ingested small pieces of latex and plastic sheeting. Physiological data indicated a possible interference in energy metabolism or gut function, even at low levels of ingestion. Persistence of the material in the gut lasted from a few days to 4 months (Lutz, in press).

Leatherbacks apparently mistake floating plastic (bags, sheets) for jellyfish and consume it. Ten of 33 dead leatherbacks washed ashore on Long Island between 1979 and 1988 had ingested plastic bags, plastic sheets or monofilament (Sadove and Morreale, 1989). Mrosovsky (1981) reviewed data from leatherback stomach content examinations conducted worldwide (N= 16) and concluded that approximately 44 percent of the adult leatherbacks examined had plastic in their stomachs. In 1981 a leatherback tagged on St. Croix stranded in New Jersey with a clay-like enterolith blocking the ileocecal valve (Boulon et. al., 1988). The origin of this obstruction is unknown.

Commercial Fisheries: Henwood and Stuntz (1987) estimated the offshore commercial shrimp fleet captures about 640 leatherbacks annually in the southeastern United States. Approximately 25 percent (160) of the captured animals die from drowning and many other animals are undoubtedly injured unintentionally as a consequence of the difficulty of handling such a large and cumbersome animal on the deck of a shrimp boat. The use of TEDs by the shrimp industry is not expected to reduce leatherback captures and mortality significantly because TEDs are generally incapable of passing adult leatherbacks through the TED exit opening. Other commercial fisheries, particularly long line fisheries, are known to capture leatherbacks but quantitative data on capture, mortality and injury rates are not available.

Boat Collisions: Leatherbacks, are vulnerable to boat collisions and strikes particularly when inhabiting near shore waters. Over the years at Sandy Point NWR and other monitored nesting beaches, turtles have frequently shown up with what resemble propeller scars. In Florida, 17.4 percent of all stranded leatherbacks had evidence of propeller or boat collision damage. It is unknown whether the injuries occurred ante- or post-mortem or to what degree any ante-mortem injuries may have contributed to an individuals turtle's death. Open ocean collisions by large ships are most likely not noticed if they occur.

Oil and Gas Exploration, Development Transportation and Storage: Experimental and field results reported by Vargo et al. (1986) indicate that marine turtles would be at substantial risk if they encountered an oil spill or large amounts of tar in the environment. Physiological experiments indicate that the respiration, skin, some aspects of blood chemistry and composition, and salt gland function of marine turtles are significantly affected (Vargo et al., 1986). Spills in the vicinity of nesting beaches are of special concern and could place nesting adults, incubating egg clutches (Fritts and McGehee, 1989) and hatchlings at significant risk. Anywhere that shipping or petroleum processing occurs upwind or upcurrent of a nesting beach, the potential exists for an oil spill or discharge to foul the beach. Hess Oil is directly upwind from Sandy Point NWR. While tar balls periodically appear on the beach, there have not been any severe problems to date. Oil and tar are also released into the marine environment during pumping of bilges on large vessels. In a review of available information on debris ingestion, Balazs (1985) reported that tar balls were the second-most prevalent type of abiotic debris ingested by marine turtles.

Pollution: The effects of pollutants resulting from industrial agricultural or residential sources are difficult to evaluate. Pesticides, heavy metals and PCB's have been detected in turtles (including eggs), but levels which result in adverse effects have not been quantified (Nelson, 1988). Sandy Point NWR is downcurrent from the Cruzan Rum discharge of "rum slops" which contains the by products and wastes from the rum distillery. This discharge chronically affects the water around Sandy Point NWR. What effect, if any, this has on either adults or hatchlings is unknown.

Conservation Accomplishments

Conservation efforts for the leatherback have greatly improved since it was federally listed as endangered on June 2, 1970. During the 1970's, nest survey and protection efforts were generally sporadic and did little to reduce the widespread egg poaching on U.S. Caribbean beaches. Beginning in 1981, however, intensive nest survey and protection efforts were initiated on the single most important leatherback nesting beach in the U.S. Caribbean, Sandy Point, St. Croix. Prior to this the majority of the 150 to 250 nests deposited annually were lost to poaching or erosion. Now overall hatch success exceeds 50 to 60 percent in most years. The FWS in cooperation with Earthwatch initiated similar measures on the other main U.S. Caribbean leatherback nesting beaches on Isla Culebra in 1984. Prior to the intensive nighttime patrolling, a high percentage of the nests on this island were poached. Overall hatch success is now greater than 75 percent in most years. Nest survey and protection efforts occur on several other U.S. Caribbean beaches of lesser but still significant importance such as Manchenil, St. Croix, and Piñones, Humacao, and Luquillo beaches in Puerto Rico. In Florida leatherback nesting data are collected in conjunction with loggerhead nesting surveys which generally begin in early to mid-May. While a portion of the leatherback nesting season is missed by the systematic loggerhead and green turtle surveys, most nests are observed by someone and probably reported because of intensive public use of the main leatherback nesting beaches in Florida.

Along with the basic information on nest numbers, clutch size, and hatching success the Sandy Point and Culebra projects have included additional studies of the nesting females and provided information on intra- and inter-nesting frequency, movements, survivorship, turtle size and weight, diving behavior, pre-reproductive migrations, nest temperature and expected hatchling sex ratio, depredation rates, nest site selection and embryonic deformities.

In 1982, 776 acres of land on Isla Culebra, including Playas Resaca and Brava, were transferred to Culebra NWR. In 1984 the FWS purchased the 2.4 km long leatherback nesting beach at Sandy Point, St. Croix, establishing Sandy Point NWR. These actions ensure the long time protection of the most important leatherback nesting beaches in the USVI and Puerto Rico although neither area is immune from external threats such as light pollution.

Lighting ordinances designed to control light pollution on nesting beaches have been passed by 9 counties and over 20 towns or cities on Florida's east coast. In the USVI, the Coastal Zone Management Commissions have imposed lighting and monitoring conditions on projects being built adjacent to nesting beaches (C. Ehle-Jewet, pers. comm.). In 1986 it became illegal to drive vehicles or ride horses on beaches in the USVI. The Governor and Cabinet of the State of Florida approved a beach armoring policy on December 18, 1990. This policy restricts armoring (seawalls, rip-rap, revetments, groins, and sand bags) to structures threatened by a 5-year return interval storm event and slows the rate of coastal armoring in Florida. Recent reviews of sea turtle conservation efforts in the southeastern United States appear in Hopkins-Murphy (1988) and Possardt (1991).

In the early 1980's fishery regulations were amended in Puerto Rico to ban nets with greater than 4 inch mesh in an effort to protect marine turtles. In 1985, regulations were passed for the management and regulation of endangered species in Puerto Rico with administrative fines assessable up to $5,000. While USVI has no restrictions on net mesh size, the capture of marine turtles is illegal and fishing with set nets has virtually ceased.

A number of regulatory measures have been implemented by several governmental agencies providing increased protection for leatherbacks or their habitat. On December 31, 1987, the United States ratified Optional Annex V of the International Convention for the Prevention of Pollution from Ships, also known as the MARPOL Protocol. Annex V prohibits the dumping of all plastic wastes, including plastic packaging materials and fishing gear, from all ships at sea. Not only does this mark the first effort in United States law to address the problem of plastic debris in the oceans, but the ratification of Annex V enables the law to come into force internationally. According to United States law, it is now illegal for any ship of any size to dump plastic trash in the oceans, bays, rivers and other navigable waters of the United States (O'Hara et al., 1988).

A substantial effort is being made by government and non-government agencies and private individuals to increase public awareness of sea turtle conservation issues. Federal and State agencies and private conservation organizations such as the Center for Marine Conservation, Greenpeace and National Audubon Society, have produced and distributed a variety of audio-visual aids and printed materials about sea turtles. These include: a booklet on the various types of light fixtures and ways of screening lights to lessen their effects on hatchlings (Raymond, 1984b), the brochure "Attention Beach Users, "Lights Out" bumper stickers and decals, a coloring book, video tapes, slide/tape programs, full color identification posters of the eight species of sea turtles, and a hawksbill poster. Florida Power and Light Company also has produced a booklet (Van Meter, 1990) with general information on sea turtles. In the USVI, the St. Croix Environmental Association, the University of the Virgin Islands Extension Service, the VIDFW and NPS are actively involved in circulating newsletters and information packages, and in presenting slide shows and seminars. EARTHWATCH-supported projects in Puerto Rico and in the USVI have involved many people in sea turtle conservation efforts. These projects on Sandy Point NWR, St. Croix, and Culebra, Puerto Rico, have both brought a great deal of attention to this species and have generated high levels of local involvement and awareness. In both locations, the general public has become aware of the problems facing the species and in general has developed protectionist attitudes, in contrast to previous attitudes of exploitation.

In the USVI school children are being introduced to the problems that sea turtles face and ways in which people can help them. Problems associated with disposal of plastics in the ocean have also been brought to the public's attention via news releases, public service announcements and television programs. In Puerto Rico, presentations on sea turtle biology and ongoing projects are made at all school levels from kindergarten to college. Projects on the east coast of Puerto Rico and in Culebra have involved many segments of the community including volunteers, the Chelonia Society, Boy Scouts, 4-H groups and various other clubs.

PART II. RECOVERY

A: Recovery Objectives

The U.S. population of leatherbacks can be considered for delisting if the following conditions are met:

1) The adult female population increases over the next 25 years, as evidenced by a statistically significant trend in the number of nests at Culebra, Puerto Rico, St. Croix, USVI, and along the east coast of Florida.

2) Nesting habitat encompassing at least 75 percent of nesting activity in USVI, Puerto Rico and Florida is in public ownership.

3) All priority one tasks have been successfully implemented.

B: Stepdown Outline and Narrative

1. Protect and manage habitats.

11. Protect and manage nesting habitats.

Coastal development has already destroyed or degraded many miles of nesting habitat in the Southeast, Puerto Rico and the USVI. Development pressures are great and the cumulative impacts will result in increased degradation or destruction of nesting habitat. This could eventually lead to a significant population decline if not effectively combated.

111. Ensure beach replenishment projects are compatible with maintaining good quality nesting habitat.

Beach nourishment can improve nesting habitat in areas of severe erosion and is a preferred alternative to beach armoring. The quality of material should be similar to that on local natural beaches.

1111. Implement and evaluate tilling as a means of softening compacted beaches

Poor-quality material deposited on nesting beaches can result in increased false crawls, aberrant nests, increased digging times for nesting females, and in some cases, broken eggs from clutches deposited in too shallow an egg chamber. Where beach compaction exceeds local natural conditions, tilling to a depth of at least one meter should be used to soften beaches. The effectiveness of tilling in softening beaches should also be fully evaluated by the COE to determine the persistence of beach softening, frequency of tilling required and the best mechanical method for beach softening.

1112. **Evaluate the relationship between sand characteristics (including aragonite) and hatch success, hatchling sex ratios and nesting behavior.**

Gas diffusion could be affected by sand grain shape, size, and compaction, and thus alter hatch success. Sand color and moisture influence temperature and can affect hatchling sex determination. The effect of importing non-native materials such as aragonite to United States beaches for beach replenishment introduces additional unknowns which could affect hatchlings and should be discouraged until fully evaluated.

1113. **Re-establish dunes and native vegetation.**

Dune restoration and revegetation with native plants should be a requirement of all renourishment projects. This will enhance beach stability and nesting habitat and require fewer replenishment activities.

1114. **Evaluate sand transfer systems as an alternative to beach replenishment.**

Sand transfer systems can diminish the necessity for frequent beach replenishment and thereby reduce disruption of nesting activities and eliminate sand compaction. The construction and operation of the systems must be carefully evaluated by the COE to ensure important nearshore habitats are not degraded or sea turtles injured or destroyed.

112. **Prevent degradation of nesting habitat from sea walls, revetments, sand bags or other erosion control measures.**

Seawalls and revetments have already destroyed or degraded many miles of nesting habitat on the southeast Atlantic coast and Puerto Rico. Beach armoring still occurs illegally or through devices such as sandbags which are still allowed. The filling and burial of long plastic bags to protect coastal property is a common practice in Florida. Buried bags exacerbate erosion when uncovered by storm events and prevent nesting when uncovered or buried too close to the sand surface.

1121. **Evaluate current laws on beach armoring and strengthen if necessary.**

Regulations prohibiting or discouraging some forms of beach armoring now exist in Florida and USVI. FDNR, VIDPNR and PRDNR should review current regulations related to beach construction and ensure seawalls, revetments, sandbags and other armoring measures contributing to the degradation of nesting habitat are prohibited.

1122. **Ensure laws regulating coastal construction and beach armoring are enforced.**

Illegal sand mining and construction in the maritime/terrestrial zone in Puerto Rico and the USVI is a major contributor to beach degradation. VIDPNR and PRDNR must frequently monitor beaches and maintain strict enforcement when violations are observed. When illegal beach armoring occurs appropriate regulatory agencies must take effective action to ensure the perpetrator removes the material and restores the habitat. Illegal beach armoring can cumulatively cause significant degradation of nesting habitat.

1123. **Ensure failed erosion control structures are removed.**

Failed erosion control structures such as uncovered plastic bags or tubes and fragmented concrete or wooden structures degrade nesting habitat and deter nesting activities. FDNR, VIDPNR and PRDNR should ensure that failed structures are removed from nesting beaches.

113. **Identify and ensure long-term protection of important nesting beaches.**

Coastal development is degrading nesting habitat and public use is causing significant disturbance to nesting turtles in some areas. Key nesting beaches in Florida and Puerto Rico in particular should be identified and appropriate measures taken to protect them. Of particular concern are the privately owned uplands adjacent to Brava and Resaca beaches on Culebra which are the second most important leatherback nesting beaches within the United States. Long-term protection should be accomplished through acquisition, or conservation easements by FWS, VIDPNR, PRDNR and FDNR.

12. **Protect marine habitat.**

Leatherbacks utilize both coastal and pelagic (open water) habitats. These habitats have been severely abused and degraded. Among the factors contributing to this trend are coastal development and industrialization, increased commercial and recreational vessel activities, open ocean contaminant dumping, river and estuarine pollution, channelization, offshore oil and gas development, commercial and recreational fishing activities. If present trends continue, the cumulative loss of suitable habitat could reduce the likelihood of recovery of the species.

121. **Identify important foraging and other marine habitats and ensure long-term protection.**

Leatherbacks are known to feed in areas of high jellyfish (*Aurelia cyanea, Stomolophus , Physalia*) concentrations. Feeding areas extend into the temperate north Atlantic and also include pantropical waters. In the absence of migrational and distributional information, important foraging areas and migration routes for the leatherback are unknown. Research is needed to determine if foraging areas for this species can be identified. This research should be conducted in conjunction with other research needs outlined in 2211, 2212, and 2213. NMFS, FWS and coastal resource agencies should support this research and implement measures to protect key foraging habitats as appropriate.

122. **Prevent degradation of habitat from oil and gas developments, refining and trans-shipment activities.**

Oil refinery activities along the coasts of Puerto Rico and the USVI represent a threat to marine habitats as a result of vessel traffic, vessels cleaning oil compartments, pumping bilges, oil spills associated with transfer of oil from tankers to onshore facilities and spills. Oil activities may negatively impact sea turtle habitat during exploration, development, production and abandonment phases. Of particular concern are impacts of oil spills, drilling mud disposal, disposal of other toxic materials, pipeline networks associated with oil and gas fields, onshore production facilities, increased vessel traffic, domestic garbage disposal and explosive removal of obsolete platforms. MMS, COE and the oil and gas industry should take appropriate actions to ensure that known sources of pollution and toxic waste disposal are eliminated. Additional precautions are needed to prevent oil spills. The Coast Guard should ensure that its strike teams maintain a high state of readiness and are knowledgeable of the highest priority nesting beaches for protection in the event of an oil spill.

123. **Prevent degradation of coastal habitat from industrial and sewage effluents.**

Increased industrial and urban development in the U. S. Caribbean is creating an industrial waste and sewage disposal problem. Many industrial wastes are being dumped offshore and sewage is being pumped several miles offshore through pipelines. Upstream water treatment plants could compound this problem if operational standards are not maintained. These effluents may alter water quality such that the suitability of some marine environments for foraging, resting, development, or mating are negatively affected. The number of vital functions provided by coastal marine habitats affected by these effluents is unknown. EPA, EQB, the appropriate Territorial environmental quality agency, PRDNR, VIDPNR, FWS and NMFS should take the appropriate measures to insure that water quality standards are enforced.

124. **Identify other threats to marine habitat and take appropriate actions.**

Coastal habitats may be subject to other threats which would render them unsuitable for leatherback populations. PRDNR, VIDPNR, FWS, NMFS and other appropriate agencies should be alert to the general status of coastal habitats, identify threats and take appropriate actions.

2. **Protect and manage population.**

21. **Protect and manage population on nesting beach.**

Predators, poaching, tidal inundation, artificial lighting and human activities on nesting beaches diminish reproductive success. Monitoring of nesting activities is necessary to implement and evaluate appropriate nest protection measures and determine trends in the nesting population.

211. **Monitor nesting activity trends on important nesting beaches with standardized surveys.**

Nesting surveys are conducted annually on the two major nesting beaches in the U.S. Caribbean (Sandy Point NWR and Culebra) which account for approximately 50 percent of the leatherback nesting activity in the United States. Coverage on other beaches may vary from year to year. Surveys in Florida do not routinely cover the first 2 months of the leatherback nesting season. Consequently, FWS, FDNR, PRDNR and VIDFW should develop a standardized nest survey protocol to ensure the collection of consistent and meaningful nesting trend data. Elements of the survey scheme should include survey period, frequency, selection of index survey beaches representative of the regional nesting distribution and training for surveyors.

212. **Evaluate nest success and implement appropriate nest protection measures.**

Nest and hatching success on important nesting beaches should be evaluated. Appropriate nest protection measures should be implemented by FWS, FDNR, PRDNR and VIDFW to ensure at least 60 percent hatch rate, a rate commensurate with natural success. Efforts should be directed at reducing effects of inundation, beach erosion, livestock, foot traffic and poaching on hatching success. Nest inundation can diminish hatch success depending on frequency, duration and developmental stage of embryos. Beach erosion problems require nest relocation to higher and safer beach zones. In all cases the least manipulative method to enhance hatch success should be employed to avoid interfering with known or unknown natural biological processes. Artificial incubation should be avoided. Nest protection measures should always require hatchling release on the night of hatching. Until recovery is ensured, however, projects on key nesting beaches such as Palm Beach County (Florida), Brava and Resaca (Culebra, PR), Sandy Point NWR and Manchenil (St. Croix) and Humacao and Piñones (Puerto Rico), should strive for a higher rate of hatching success. FWS, FDNR, PRDNR and VIDFW should assess hatching/emergence success on important beaches and develop recommendations for nest protection as appropriate.

213. **Reduce effects of light pollution on hatchlings and nesting females.**

Hatchling sea turtles orient primarily to the blue-green wave lengths to find the ocean and consequently many artificial lights disorient or misorient hatchlings, indirectly leading to high hatchling mortality. Recent studies have also demonstrated that artificial lights significantly deter nesting activities.

2131. **Determine effects of artificial lighting on nesting females and emerging hatchlings.**

While phototropic orientation is known to be the primary hatchling sea finding mechanism, these findings are based on research with almost every other sea turtle species but the leatherback. The spectral sensitivity of leatherbacks must be known to understand species specific nuances which may significantly influence management strategies for solving light pollution problems. Also orientation mechanisms in the marine environment need further clarification. If light is the primary determinant, lighting from coastal development could be altering hatchling dispersal patterns on some nesting beaches and lowering survivorship. FWS, FDNR, VIDFW and PRDNR should support appropriate research.

2132. **Implement, enforce and evaluate lighting regulations or other lighting control measures where appropriate.**

Where lighting regulations have been adopted and enforced, hatchling disorientation and misorientation have been drastically reduced. All coastal counties and communities with leatherback nesting should adopt regulations March through September. Increased development activities in the Fredriksted area, St. Croix, is of particular concern because of the high density nesting beach at Sandy Point NWR. Prevailing coastal development trends represent an ever increasing threat to areas of high nesting activities in Puerto Rico. FWS and NMFS should encourage and provide necessary technical information to Commonwealth and Territorial resource agencies to enact appropriate lighting regulations. State, Commonwealth and Territorial resource agencies should adopt available guidelines and regulations.

2133. **Enforce take provisions of Endangered Species Act and evaluate need for Federal lighting regulations.**

Enforce take provisions of Endangered Species Act of 1973 relative to hatchling disorientation and misorientation. Where State, Commonwealth or Territorial lighting ordinances have not been implemented or are ineffective, Federal regulations should be promulgated under the authority of the Endangered Species Act on the most important nesting beaches.

214. **Eliminate vehicular traffic on nesting beaches during nesting and hatching season.**

During the nesting season non-mechanized beach cleaning alternatives should be implemented. The adverse effects from vehicular traffic and mechanized beach cleaning practices on nests and hatchlings may be severe. Potential impacts may include sand compaction, alteration of nest site micro-environment by sand removal, and crushing hatchlings prior to emergence. Vehicular traffic and mechanized beach cleaning practices should be prohibited seasonally on key nesting areas by PRDNR, VIDPNR and FDNR.

215. **Ensure beach replenishment and coastal construction activities are planned to avoid disruption of nesting and hatching activities.**

These activities can cause significant disruption of nesting activities during the nesting season when viewed cumulatively over the nesting range. Nest relocation can result in lowered hatch success and altered hatchling sex ratios and therefore is not an acceptable alternative to altering the timing of projects. The COE, FWS, and appropriate State, Commonwealth or Territorial agencies should ensure beach replenishment and other beach construction activities are not permitted during the nesting season on locally or regionally important nesting beaches.

216. **Prevent waste disposal on nesting beaches.**

Human encroachment on coastal areas is decreasing the number of suitable nesting beaches for the leatherback. This problem is compounded if remote, but suitable nesting beaches are used as garbage dump sites as occurs on some U.S. Caribbean beaches. Garbage of various kinds and shapes can discourage nesting, inflict injuries and obstruct hatchlings as they crawl towards the ocean. Additionally, garbage will enhance the proliferation of stray pets, rats and mongooses which could prey on hatchlings. Measures to discourage this practice should be taken (see 34) and enforced by the appropriate Commonwealth or Territorial agencies.

217. **Ensure adequate law enforcement activities prevent poaching and harassment.**

Poaching can be a significant source of egg loss on some nesting beaches without law enforcement deterrence. Also, harassment can adversely affect nesting turtles by causing the potential displacement of nesting females to unsuitable beaches. FWS and NMFS should work closely with PRDNR, VIDPNR, and NPS to intensify law enforcement activities in known problem areas in the U. S. Caribbean to curb the incidence of poaching and harassment.

218. **Determine natural hatchling sex ratios at selected nesting beaches.**

It is well documented that incubation temperature determines hatchling sex. Sex ratios of hatchlings on natural beaches throughout the nesting range should be determined over several years in order to evaluate management programs which could be altering natural sex ratios. FWS, PRDNR and VIDFW should support the necessary research and evaluate all nest relocation projects to ensure natural sex ratios are not altered. Research should include establishment of temperature transects on the appropriate nesting beach. A standardized protocol for the temperature monitoring using a non-sacrificial technique should be developed by FWS, Commonwealth or Territorial resource agencies and adopted where relocation is done.

219. **Determine genetic relationship of U.S. Caribbean populations to other major nesting populations.**

Due to the migratory habits of leatherbacks, long-term management and conservation strategies necessitate that the genetic relationships of U. S. Caribbean populations to other populations be ascertained. The degree of relatedness, perhaps an indicator of gene flow, is essential for defining management units and evaluating recovery objectives, and assessing the viability of U. S. Caribbean populations. FDNR, PRDNR, VIDFW and FWS should fund this research.

22. **Protect and manage populations in the marine environment.**

Management and protection of sea turtles in the marine environment is a difficult task. The foremost problem in management and conservation of sea turtles is the lack of basic biological information. To adequately protect and enhance survival of sea turtles, we must know where they occur, in what numbers, at what times and what factors contribute to mortality. As sources of mortality are identified, steps can be taken to reduce or eliminate their impacts on populations.

221. **Determine distribution, abundance and status in the marine environment.**

To assess threats and formulate appropriate protection measures, basic information is needed as to when, where, and in what abundance turtles may occur over the various stages of their life cycles. In the case of sea turtles which exhibit great longevity, it is important to protect all age classes so that a sufficient number of individuals survive to reach sexual maturity.

2211. **Determine hatchling dispersal patterns, juvenile distribution and abundance.**

The distribution and fate of hatchlings after reaching the ocean is unknown. Juveniles may occur throughout Caribbean waters as indicated by specimens salvaged in southeastern Puerto Rico (29 cm curved carapace) and Barbados (19 cm straightline carapace). Knowledge of hatchling dispersal patterns, and distribution and abundance of juveniles, would facilitate the development of appropriate conservation measures to enhance survival in these life stages. PRDNR, VIDFW, NMFS and FWS should fund appropriate research.

2212. **Determine migratory pathways, distribution and internesting seasonal movements.**

Nesting migrations and subsequent dispersal of post-nesting females has been studied principally through tagging on nesting beaches. Movements and distributions of adult males, which may or may not migrate with the females, have not been studied. Female turtles are known to return to nest in the same general areas at 2, 3, and 4 year intervals throughout their reproductive lives. Mechanisms which allow turtles to navigate over great distances and to exhibit nesting beach fidelity are poorly understood. Research is needed to determine the migratory pathways of sea turtles, and habitat use and internesting seasonal movements. In the case of the leatherback, long-distance movement studies will require satellite technology. Research is also needed to determine how turtles navigate and what underlying factors (e.g., olfactory, magnetic, visual) control this ability. NMFS, COE, MMS, FWS, PRDNR and VIDFW and other interested resource agencies should fund appropriate research.

2213. **Determine growth rates, age of sexual maturity and life stage survivorship rates.**

Information on survivorship rates is an essential component of a comprehensive sea turtle conservation plan. Available information suggests that sea turtle population dynamics are very sensitive to survival rates during the late juvenile and sub-adult life stages. Estimating these rates is an extremely difficult task, particularly for the leatherback. To achieve this objective, knowledge of life stages and the establishment of age to sexual maturity is necessary to define meaningful demographic units in a population. An invaluable tool for this purpose is the study of growth rates in wild populations. In addition, the comparative study of growth rates may also serve as an indicator of habitat suitability and quality. The development of field techniques and design of research projects to study growth rates, ascertain age of sexual maturity, and estimate life stage/age survivorship rates is needed to monitor and achieve sea turtle recovery actions and objectives. FWS, NMFS, FDNR, PRDNR and VIDFW should support this research.

2214. **Quantify present or potential threats to adults and juveniles along migratory routes, internesting habitat and on foraging grounds.**

Little is known about the foraging grounds of the U. S. Caribbean leatherback nesting population. Threats to internesting or migrating turtles are virtually unknown because there is little information on their distribution, habitat use, pathways or the mechanisms of migration. Before action can be taken to eliminate threats to sea turtles, information on factors affecting the survival of turtle stocks must be available. NMFS, FWS, COE, MMS and other State, Commonwealth, or Territorial resource agencies should fund needed research.

2215. **Evaluate effects of industrial and sewage effluents on population.**

Ever increasing amounts of industrial and sewage effluents are reaching marine environments. These effluents may alter water quality such that the suitability of some marine environments for foraging, resting, development, or mating are negatively affected. The number of vital functions provided by coastal marine habitats affected by these effluents and which ones are most sensitive is unknown. This information is necessary to implement marine habitat protection measures to ensure the recovery of the species. Research is needed to identify the composition and quantities of effluents gaining access to marine environments and what impacts these effluents are having on sea turtle habitat resources and quality. NMFS, COE, FWS, PRDNR, VIDPNR and other appropriate State resource agencies should support needed research.

222. **Monitor and reduce mortality from commercial and recreational fisheries.**

Leatherbacks are incidentally taken by several commercial and recreational fisheries. Fisheries known or suspected to incidentally capture leatherbacks include those deploying bottom trawls, off-bottom trawls, purse seines, bottom longlines, hook and line, gill nets, drift nets, traps, haul seines, pound nets, beach seines, and surface longlines.

2221. **Implement measures to reduce capture and mortality from commercial shrimping vessels.**

Although turtle excluder devices are now routinely required and used by the shrimp industry, they do not exclude adult leatherbacks or large sub-adults. At times large numbers of leatherbacks are attracted to high densities of jelly fish on heavily fished shrimping grounds. NMFS has estimated about 640 leatherbacks are captured annually with a mortality rate of 25 percent. Given the enormous weight and size of these animals it is extremely difficult for even the most conscientious fishermen to handle and release live animals without some injury or trauma to the animal. Consequently, mortality is likely much higher than the drowning data suggests. NMFS and appropriate coastal State resource agencies should identify shrimping/leatherback spatial and temporal conflicts and develop a strategy to reduce incidental captures.

2222. **Evaluate the extent of incidental catch due to hook and line, drift net, gill netting, and other fisheries related mortality.**

Although it is known that leatherbacks are incidentally taken in various fishing operations, the magnitude of this mortality is unknown. This is particularly true in the U. S. Caribbean where nesting females gather seasonally and in the Northeast where leatherbacks are known to get entangled in lobster trap gear. Monitoring efforts are needed to determine the extent of incidental catch by fisheries type in U. S. coastal waters. FWS, NMFS, PRDNR, VIDFW and other resources agencies should support initiation of needed monitoring efforts.

2223. **Promulgate and enforce appropriate regulations to reduce hook and line, drift net, gill netting and other fisheries related mortality.**

Once the extent and types of fisheries associated with incidental catch are identified, NMFS in conjunction with PRDNR and VIDFW should promulgate appropriate regulations and enforce them to reduce this mortality.

2224. **Maintain carcass stranding network.**

Most accessible beaches are surveyed for stranded sea turtles by volunteer or contract personnel. Through the sea turtle stranding and salvage network, stranding data are received and summarized by the NMFS Miami Laboratory. These data provide an index of sea turtle mortality and basic biological information. NMFS and FWS should continue systematic stranding surveys of index areas and support and augment the network. Periodic review of the efficacy of surveys should be conducted.

223. **Prevent oil spills, and monitor and prevent adverse impacts of oil spills and gas activities.**

Oil can alter respiration, severely damage skin, interfere with or stop salt gland function and ultimately lead to the death of sea turtles.

2231. **Determine effects of oil and oil dispersants on all life stages.**

Oil spills resulting from blowouts, ruptured pipelines or tanker accidents could have a major impact on the recovery of sea turtles. As evidenced by the recent Exxon catastrophe in Alaska, Federal and industry ability to respond to a major oil spill can be woefully inadequate. It is essential that we have knowledge of the effects of oil and oil dispersants on all sea turtle life stages to allow adequate assessment of risks and implementation of contingency plans should a major oil spill occur. The effects of oil and oil dispersants have never been studied in leatherbacks, a species which may be extremely sensitive to such contaminants. MMS, COE and the oil and gas industry should fund appropriate research.

2232. **Determine sea turtle distribution and seasonal use of marine habitats associated with oil and gas development areas.**

Oil and gas activities occur over vast areas of the Gulf of Mexico and southern North Atlantic. Recent technological advances have made it possible to conduct exploration and development activities in deeper waters. Despite the continuing offshore movement of the industry, little effort has been expended in determining distribution, abundance and seasonality of various life stages of leatherbacks in offshore waters. MMS and COE should fund needed research to evaluate the effects of oil and gas activities on sea turtles in offshore waters.

2233. **Ensure impacts to sea turtles are adequately addressed during planning of oil and gas developments.**

In assessing the potential impacts of oil and gas activities, it is necessary to look beyond the exploration, development, production and abandonment of single wells, and consider the industry as a whole. In the Gulf of Mexico alone, there are 4,500 existing offshore structures and thousands more projected over the next twenty years. These structures are linked by miles of underwater pipelines, and are supported by fleets of vessels and aircraft. Production and storage facilities onshore supply refined products for tanker transport and land transport throughout the country. The chances of isolated accidents, when considering the existing infrastructure, are very high. Additionally, the cumulative impacts of chronic discharges from thousands of independent structures could be significant. Explosive removal of structures during the abandonment phase of these activities has also been identified as a potential source of mortality to sea turtles. NMFS, MMS, COE and the oil and gas industry should take whatever precautions are necessary to avoid impacts to sea turtles.

224. **Reduce impacts from entanglement and ingestion of persistent marine debris.**

The ingestion of marine debris and the entanglement of marine organisms in discarded nets, monofilament lines and ropes has received considerable attention in recent years and may be an increasing source of mortality to all life history stages.

2241. **Evaluate the extent of entanglement and ingestion of persistent marine debris.**

Limited information on the frequency of entanglement and ingestion of marine debris by sea turtles is available. Stranding data and necropsies have provided evidence that suggests some leatherback mortality has resulted from ingestion of debris. Additionally, stranded turtles have been entangled in lost or discarded netting, monofilament lines and ropes. NMFS, FWS and EPA should expand efforts to document cases of entanglement and ingestion, the extent of marine debris in U. S. waters, sources of these contaminants and the impacts of these materials on various life stages of leatherback populations.

2242. **Evaluate the effects of ingestion of persistent marine debris on health and viability of sea turtles.**

In addition to mortality resulting from ingestion of plastics, hydrocarbons or other toxic substances, debilitating non-lethal impacts are possible. Research is needed to evaluate the long-term effects of ingestion of marine debris, particularly with regard to early life stages. NMFS, MMS, COE and EPA should fund this research.

2243. **Formulate and implement appropriate measures to reduce or eliminate persistent marine debris in the marine environment.**

Marine debris may originate from land or sea, primarily through careless disposal of non-biodegradable refuse. Suspected sources of these materials are large transport vessels pumping bilges and discarding garbage, commercial and recreational fishermen, oil and gas platforms, beachgoers, boaters, and cruiseliners. To eliminate the problem, the public must be informed of the long-term consequences of using the oceans as a garbage dump. Point sources of pollution must be identified and eliminated by EPA, Coast Guard, State and Federal agencies. Appropriate agencies should vigorously enforce MARPOL regulations. NMFS and State, Commonwealth, and Territorial resource agencies should promulgate regulations governing abandonment of fishing gear and impose severe penalties for discarding these materials.

225. **Centralize administration and coordination of tagging programs.**

Sea turtle researchers commonly tag turtles encountered during their research projects, and usually maintain independent tagging data bases. The lack of centralization for administering these data bases often results in confusion when tagged turtles are recaptured and delays in reporting recaptures to the person originally tagging the turtle.

2251. **Centralize tag series records.**

A centralized tag series data base is needed to ensure that recaptured tagged turtles can be promptly reported to persons who initially tagged the animal. The tag series data base would include listing of all tag series that have been placed on sea turtles in the wild, including the name and address of the researcher placing these tags on turtles. This would eliminate problems in determining which researcher is using which tag series or type of tags, and would preclude unnecessary delays in reporting of tag returns. NMFS and/or FWS should establish and maintain this data base.

2252. **Centralize turtle tagging records.**

In addition to the need for a centralization of tag series records, there are advantages in developing a centralized turtle tagging record data base. Such a data base would allow all turtle researchers to trace unfamiliar tag series or types to their source, and also to have immediate access to important biological information collected at the time of original capture. The major disadvantage is that this data base would require frequent editing and updating, and would be costly and somewhat time consuming to maintain. It would also make it possible for unethical researchers to exploit work of others, while providing no guarantees that such contributions would be acknowledged. NMFS and FWS should determine whether such a data base can be established and is feasible to maintain.

226. **Ensure proper care of rehabilitating sea turtles in captivity.**

Leatherbacks have never been kept in captivity successfully over the long-term, and thus proper care standards and procedures are not available. In the absence of such information, but in the unusual situation of being confronted with the need of providing rehabilitation facilities for a leatherback, standards and procedures followed for other sea turtles species should be adopted until more appropriate ones are developed.

2261. **Develop standards for care and maintenance including diet, water quality, tank size and treatment of injury and disease.**

None of these requirements have been scientifically evaluated to determine the best possible captive conditions for leatherback sea turtles. The FWS and NMFS should support the necessary research to develop these criteria, particularly relating to diet and the treatment of injury. These criteria should be published and required for any rehabilitation facility permit. FWS, NMFS, and appropriate State, Commonwealth or Territorial resources agency representatives should inspect permitted facilities at least annually for compliance with permit requirements.

2262. **Designate rehabilitation facilities.**

FWS and NMFS in coordination with the appropriate State, Commonwealth or Territorial agencies should designate rehabilitation facilities for Atlantic and Gulf Coast States, and the U. S. Caribbean. Designation should be based on availability of veterinary personnel with expertise or experience in reptilian care and the institutions ability to comply with care and maintenance standards developed in step 2261 above. Each facility should be inspected by a team including a NMFS, FWS and appropriate State, Commonwealth or Territorial resource agency representative prior to its designation as a rehabilitation facility. Inspections should be conducted at least annually thereafter.

3. **Public information and education.**

Sea turtle conservation requires long-term public support over a large geographic area. The public must be factually informed of the issues particularly when conservation measures conflict with human activities such as commercial fisheries, recreational boating, beach development, and public use of nesting beaches. Public education is the foundation upon which a long-term conservation program will succeed or fail.

31. **Develop and provide slide programs and information leaflets on sea turtle conservation for the general public and for special interest groups.**

The FWS has developed a bi-lingual slide tape program on sea turtle conservation. The FWS should keep the program current and available for all public institutions. The FWS and State, Commonwealth and Territorial resource agencies should continually develop, update and supply the public with informational brochures on sea turtle ecology and conservation needs.

32. **Develop brochure on recommended lighting modifications or measures to reduce hatchling disorientation and misorientation.**

All lighting ordinances require lights be shut off or modified to prevent direct lighting on the nesting beach. However, it is not always clear what types of lights, screening or shading work best. The FWS, NMFS and State, Commonwealth or Territorial resource agencies should jointly develop, publish and update a brochure or booklet with recommended lighting fixtures, lights, shading modifications and operational constraints.

33. **Develop public service announcements (PSA) regarding the sea turtle conservation issues.**

A professionally produced public service announcement for radio and TV would provide tremendous support and reinforcement of the many coastal lighting ordinances as well as the adverse impacts of waste disposal and entanglement on all life stages of sea turtles. It would generate greater support through understanding. The FWS and State, Commonwealth and Territorial resource agencies should develop high quality PSAs which could be used throughout the southeast and U. S Caribbean.

34. **Post information signs at public access points on important nesting beaches.**

Public access points to important nesting beaches provide excellent opportunities to inform the public of necessary precautions for compatible public use on the nesting beach and to develop public support through informational and educational signs. FDNR, FWS, NPS, PRDNR and VIDPNR should post such educational and informational signs on the important nesting beaches as appropriate.

35. **Develop criteria and recommendations to allow public participation in research and recovery activities.**

Public participation (primarily observation) in research and recovery activities can be a very effective education tool. Criteria must be developed by FWS, NMFS, and State, Commonwealth or Territorial resources agencies to permit such participation. Among other things, criteria must address group size, frequency of visitation and nature of participation.

4. **International cooperation.**

41. **Develop international agreements to ensure protection of life stages which occur in foreign waters.**

Leatherbacks are long-distance migrants. Foraging grounds for adults, juveniles or subadults while largely unknown, almost certainly encompass waters outside of the United States. Therefore, the long-term preservation of the Florida, Puerto Rico, and USVI nesting populations will require more than protection within United States jurisdiction. Ultimately, a comprehensive leatherback conservation plan will have to encompass essential habitats outside of the United States. Once these habitat and conservation strategies are identified, the NMFS and FWS in conjunction with the State Department should develop cooperative international agreements and programs with the appropriate foreign governments.

42. **Ratify Protocol to Cartagena Convention concerning specially protected areas and wildlife.**

Parties to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention) adopted the Protocol for Specially Protected Areas and Wildlife in January 1990. Annex II of this Protocol prohibits the taking, possession or killing or commercial trade in such species, their eggs, parts or products, and the disturbance of such species, particularly during periods of breeding, incubation, estivation or migration, as well as other periods of biological stress. All six sea turtle species in the wider Caribbean, are included under Annex II. Ratification by the 19 parties to the Convention will enable the provisions of the Protocol to be implemented within the member countries not entering reservations within 90 days and provide increased protection of sea turtles within many of the member countries. The FWS and NMFS should work with the State Department to encourage ratification by the United States.

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III. IMPLEMENTATION SCHEDULE

Priorities in Column 4 of the following Implementation Schedule are assigned as follows:

Priority 1 An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 All other actions necessary to provide for full recovery of the species.

GENERAL CATEGORIES FOR IMPLEMENTATION SCHEDULES

Information Gathering - I or R (research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

IMPLEMENTATION SCHEDULE

Leatherback Turtle (Recovery Priority#7)

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency	Estimated Fiscal Year Costs $000 Current	Fy 2	Fy 3	Fy 4	Fy 5	Comments/ Notes
M-3	Implement and evaluate beach tilling	1111	3	continuing	COE, Project sponsors						No estimate; costs to be borne by specific replenishment projects
R-3	Evaluate the relationship of sand characteristics to hatch success, sex ratios and nesting behavior	1112	3	4 years	COE, Project sponsors				35	35	
M-3	Re-establish dunes and native vegetation	1113	3	continuing	COE, Project sponsors						No estimate; costs to be borne by specific replenishment projects
M-3, R-3	Evaluate sand transfer systems as an alternative to beach replenishment	1114	3	continuing	COE						Routine
O-3, M-3	Evaluate current laws on beach armoring	1121	2	continuing	FDNR PRDNR VIFWS						Routine
O-3, M-3	Ensure laws regulating coastal construction are adequate and enforced	1122	2	continuing	FDNR PRDNR VIDFW						Routine
M-3	Ensure failed erosion control measures are removed	1123	3	continuing	FDNR PRDNR VIDFW						Routine
M-3	Identify and ensure long-term protection of important nesting beaches	113	1	continuing	FWS PRDNR VIDFW FDNR						No estimate; costs will be related to acquisition if new areas are identified for long-term protection

IMPLEMENTATION SCHEDULE

Leatherback Turtle (Recovery Priority#7)

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency	Estimated Fiscal Year Costs $000 Current	Fy 2	Fy 3	Fy 4	Fy 5	Comments/ Notes
R-2	Identify important marine habitats	121	1	continuing	NMFS, VIDFW PRDNR, east and gulf coast resource agencies						Funds are identified under 2211 and 2212 because of research overlap with population studies
M-3	Prevent degradation of habitat from oil and gas developments, refining, and transhipment activities	122	2	continuing	USCG, NMFS, MMS, FWS, FDNR, PRDNR, VIDPNR						Routine
M-3, O-3	Prevent degradation of coastal habitat from industrial and sewage effluents	123	2	continuing	NMFS, EPA, coastal resource agencies						Routine
I-2	Identify other threats to marine habitat	124	2	continuing	NMFS						Routine
I-1	Monitor trends in nesting activity	211	1	continuing	FWS	85	85	85	85	85	
					VIDFW	10	10	10	10	10	
					PRDNR		10	10	10	10	
					USN		10	10	10	10	
					FDNR		10	10	10	10	
R-1, R-9 R-14, M-4	Evaluate hatch success and implement nest protection measures	212	1	continuing	FWS, USN, VIDFW, PRDNR, FDNR						Costs included in task 211
R-14	Determine effects of artificial lighting on hatchlings and nesting females	2131	2	2-3 years	FWS, PRDNR, VIDFW, FDNR				20	20	Routine

IMPLEMENTATION SCHEDULE

Leatherback Turtle (Recovery Priority#7)

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency	Estimated Fiscal Year Costs $000 Current	Fy 2	Fy 3	Fy 4	Fy 5	Comments/ Notes
O-3	Implement, enforce, and evaluate lighting ordinances where appropriate	2132	2	continuing	VIDPNR, PRDNR, FDNR, Florida east coast Counties						Routine
O-2, O-3	Enforce take provisions of Endangered Species Act and evaluate need for Federal lighting regulations	2133	2	continuing	FWS						Routine
M-7	Eliminate vehicular traffic on nesting beachs	214	2		PRDNR, VIDPNR FWS, FDNR						Routine
M-7	Ensure beach replen-ishment and coastal construction avoid nesting/hatching season	215	2		PRDNR, FWS FDNR, VIDPNR						Routine
M-3	Prevent waste disposal on nesting beaches	216	3	continuing	PRDNR, VIDPNR FDNR						Routine
O-2	Ensure law enforcement prevents poaching and harassment	217	2	continuing	FWS, NMFS						Routine
R-14	Determine natural hatchling sex ratios	218	2	3 years	FWS, VIDFW				25	25	
R-1, R-14	Determine genitic relationship of U.S. Caribbean population to other major nesting populations	219	2	3-5 years	FWS, NMFS, FDNR, PRDNR, VIDFW			50	50	50	

IMPLEMENTATION SCHEDULE

Leatherback Turtle (Recovery Priority#7)

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency	Estimated Fiscal Year Costs $000 Current	Fy 2	Fy 3	Fy 4	Fy 5	Comments/ Notes
R-14	Determine hatchling dispersal patterns and juvenile distribution and abundance	2211	2	3-5 years	NMFS, FWS			50	50	50	Costs for all agencies
R-8, R-14	Determine migratory pathways, distribution and internesting movements	2212		5-10 years	NMFS, FWS, VIDFW, PRDNR FDNR		150	150	150	150	Costs for all agencies
R-1,R-6	Determine growth rates, age at sexual maturity, survivorship rates	2213	2	10-15 years	NMFS, FWS, VIDFW, PRDNR FDNR		100	100	100	100	Costs for all agencies
R-1, R-14	Quantify threats to adults and juveniles along migratory routes and on foraging grounds	2214	2	5-10 years	NMFS, VIDFW PRDNR, FDNR						Unable to determine costs which are dependent on results of 2211 and 2212 tasks
R-14	Evaluate effects of industrial and sewage effluents	2215	3	3 years	EPA, FWS, NMFS				100	100	
M-7, 03	Implement measures to reduce capture and mortality from shrimp vessels	2221	1	2 years	NMFS, FDNR, GDNR, SCWMRD, NCDNR						Routine
I-14	Evaluate extent of incidental take from other commercial fisheries	2222	2	5-10 years	NMFS			50	50	50	Some overlap with task 2214
0-3	Promulgate and enforce appropriate regulations to reduce mortality from other commercial fisheries	2223	2	continuing	NMFS						Routine

IMPLEMENTATION SCHEDULE

Leatherback Turtle (Recovery Priority#7)

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency	Estimated Fiscal Year Costs $000 Current	Fy 2	Fy 3	Fy 4	Fy 5	Comments/ Notes
I-14	Maintain carcass stranding network	2224	3	continuing	NMFS,FWS, coastal resource agencies						Volunteer efforts or costs associated with surveys identified in Loggerhead/Green Turtle Recovery Plans
R-14	Determine effects of oil and oil dispersants on all life stages	2231	2	continuing	MMS,industry						No estimate
M-7	Determine sea turtle distribution and use of marine habitats associated with oil and gas developments	2232	3	3-5 years	MMS, COE, NMFS						Costs are included in Loggerhead/Green Turtle Recovery Plans
O-4,M-7	Ensure impacts are addressed during planning of oil and gas development	2233	3	continuing	MMS, COE, NMFS, industry						Routine
R-12, R-14	Evaluate extent of entanglement and ingestion of persistent marine debris	2241	1	3-5 years	NMFS, coastal resource agencies		10	10	10	10	costs for all agencies
R-12, R-14	Evaluate effects of ingestion of persistent marine debris	2242	1	3-5 years	NMFS, coastal resource agencies		50	50	50	50	Costs for all agencies
O-2	Implement and enforce MARPOL	2243	1	continuing	USCG						Routine
O-3	Implement other measures to reduce persistent marine debris	2244	3	continuing	USCG, NMFS						Routine

IMPLEMENTATION SCHEDULE

Leatherback Turtle (Recovery Priority#7)

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency	Estimated Fiscal Year Costs $000 Current	Fy 2	Fy 3	Fy 4	Fy 5	Comments/ Notes
I-14, 0-4	Centralize tag series and records	2251	3	1 year	NMFS, FWS						Routine
I-14, 0-4	Centralize turtle tagging records	2252	3	continuing	FWS, NMFS						Costs identified in Loggerhead/ Green Recovery Plans and inclusive of leatherback costs
R-14, M-7	Develop care and maintenance standards for captive leatherbacks	2261	3	5 years				20	20	20	
M-7	Designate rehabilitation facilities	2262	3	continuing	NMFS, FWS						Routine
O-1	Provide slide programs and information leaflets	31	2	continuing	NMFS, FWS, coastal resource agencies		10	10	10	10	All agency costs
O-1, M-7	Develop brochure on recommended lighting modifications	32	2	1 year	FWS, NMFS						Costs identified in Loggerhead Green Turtle Recovery Plans and inclusive of leatherback requirements
O-1, M-7	Develop public service announcements on sea turtle conservation issues	33	2	3 years							Costs included in Loggerhead/ Green Recovery plans and inclusive of leatherback requirements
O-1, M-7	Post information signs on important nesting beaches	34	3	continuing	NPS, PRDNR, VIDPNR, FDNR						Routine
M-7, O-1	Develop criteria for public observation of recovery and research activities	35	3	continuing	FWS, VIDFW						Routine
M-7, O-4	Develop international agreements	41	2	continuing	FWS, NMFS						Routine

IMPLEMENTATION SCHEDULE

Leatherback Turtle (Recovery Priority#7)

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency	Estimated Fiscal Year Costs $000					Comments/ Notes
						Current	Fy 2	Fy 3	Fy 4	Fy 5	
M-7, 0-4	Rayify Protocol to Cartagena Convention	42	2		FWS, NMFS State Dept.						Routine

APPENDIX I. TABLE 1. Records of leatherback turtles nesting on beaches in the U. S. Virgin Islands. "BEE" = data reported to the author (K. Eckert) by USVI Bureau of Environmental Enforcement officers. Beaches listed in geographical order. Table adapted from Eckert(1989).

Beach	Comments	Source
ST. CROIX		
Sandy Point	82-242 nests/yr (1982-1988)	Basford et al., 1988
Campo Rico	abundance unknown	BEE
Carlton (Hope to Long Point)	< 10 nests/yr	Otto Tranberg
Manchenil/Ha'penny	3-11 turtles/yr (11-52 nests/yr; 1983-1988)	Tom Adams, 1988
Grapetree Bay	< 10 nests/yr	Otto Tranberg
Jack's Bay	0-2 turtles/yr	Boulon, 1987
Issac's Bay	0-1 turtles/yr	Boulon, 1987
Teague Bay (Reef Beach)	one nest (year?)	Otto Tranberg
Yellowcliff/Solitude (Banana Gut)	0-1 turtles/yr	Boulon, 1987
Coakley Bay	0-3 turtles/yr	Boulon, 1987
Pull Point/Prune Bay	< 5 nests/yr 0-3 turtles/yr	Otto Tranberg Boulon, 1987
Green Cay Beach/ Tamarind Reef Beach	< 10 nests/yr 0-2 turtles/yr	Otto Tranberg Boulon, 1987
Shoy's Beach	± 20 nests/yr 0-2 turtles/yr	Otto Tranberg Boulon, 1987
Buccaneer Beach	< 5 nests/yr	Otto Tranberg

APPENDIX I. TABLE 1. Continued.

Little Bay	0-1 turtles/yr	Boulon, 1987
Fangselet/Pelican Cove	< 5 nests/yr	Otto Tranberg
Davis Beach	< 10 nests/yr	Otto Tranberg, Toby Tobias
	0-1 turtles/yr	Boulon, 1987
Sprat Hall	1985 landing (nest?)	Otto Tranberg
BUCK ISLAND		
Buck Island (general)	0-18 crawls/yr (1982-1989)	Zandy Hillis
	1-2 turtles/yr	Boulon, 1987
	abundance unknown	Zullo, 1986
GREEN CAY		
Green Cay Beach	0-2 turtles/yr	Boulon, 1987
ST. THOMAS		
Pineapple Beach	0-1 turtles/yr	Boulon, 1987
Coki Point	0-1 turtles/yr	Boulon, 1987
Sandy Bay/Inner Brass	0-1 turtles/yr	Boulon, 1987
Neltjeberg Bay	0-1 turtles/yr	Boulon, 1987
Botany Bay	0-1 turtles/yr	Boulon, 1987
LITTLE HANS LOLIK		
unnamed	0-1 turtles/yr	Boulon, 1987
ST.JOHN		
Trunk Bay	0-2 turtles/yr	Boulon, 1987
Cinnamon Bay	0-1 turtles/yr	Boulon, 1987

APPENDIX I. TABLE 2. Records of leatherback turtles nesting on beaches in Puerto Rico, including Islas Culebra, Vieques, and Mona.

Beach	Comments	Source
PUERTO RICO		
Añasco	unspecified	Matos, 1986,1987
Ballena	unspecified	Cintron and Cintron, 1987
Humacao	4 crawls (1986) 1-15 nests/yr	Matos, 1986 Cintron and Cintron, 1987
Isabela	1 nest (poached, 1983) unspecified	Gonzáles, 1984 Matos, 1986,1987
Jobos	1 crawl (1983) 1 nest (hatch, 1988)	Gonzáles, 1984 Kathy Hall
Larga (NE of Punta Tuna)	1 crawl (1983)	Gonzáles, 1984
Manatí	1 nest (1987)	Cintron and Cintron, 1987
Maunabo	unspecified	Matos, 1986,1987
Paulinas Luquillo-Fajardo	6 crawls (1986) 4-15 nests/yr	Matos, 1986 Cintron and Cintron 1987
Piñones	10 crawls (1986)	Matos, 1986
Rincón	unspecified	Matos, 1987
Rio Grande	unspecified	Matos, 1986,1987
Tres Hermanos	< 10 nests (1987)	Cintron and Cintron, 1987
Yabucoa	unspecified	Matos, 1987
CULEBRITA		
Playa Este	1-7 nests/yr	Tucker, 1988

APPENDIX I. Table 2. continued.

CULEBRA (1984-1987)		
Brava	68-95 nests/yr	Tucker, 1988
Cayo Norte	1 nest (1984)	Tucker, 1988
Flamenco	0-2 nests/yr	Tucker, 1988
Resaca	39-80 nests/yr	Tucker, 1988
Tórtola	1 nest (1984)	Tucker, 1988
Zoní	0-7 nests/yr	Tucker, 1988
VIEQUES		
(general)	26 crawls, April-October(?) (1981)	Pritchard and Stubbs, 1982
2nd beach W of Punta Icacos	1 crawl (1983)	Gonzáles, 1984
"east end"	9 crawls, 6 May-6 June 1978	Carr, 1978b
Purple	1 crawl (1983)	Gonzáles, 1984
Turtle	2 crawls (1983)	Gonzáles, 1984
Yellow	1 crawl (1983)	Gonzáles, 1984
MONA		
Punta Arenas-	2 crawls (1983)	Gonzáles, 1984
Playa Las Mujeres	5 crawls (1987)	Kontos ,1988
Playa Las Mujeres	11 nests (1985)	Kontos, 1985

APPENDIX 1. TABLE 3. Reported nesting activity of leatherback turtles in Florida, 1979 - 1990. Survey effort was not consistent from year to year and numbers reflect imcomplete coverage. (Source: Florida Department of Natural Resources, Statewide Nesting Survey Data Base.)

COUNTY	RANGE IN ANNUAL NUMBER OF NESTS (1979 - 1990)
Brevard	0 - 3
Broward	0 - 26
Dade	0 - 5
Flagler	0 - 2
Indian River	0 - 1
Martin/St. Lucie	4 - 60
Palm Beach	4 - 81
St. Johns	0 - 4
Volusia	0 - 2