NOAA Technical Memorandum NMFS-SEFSC-351

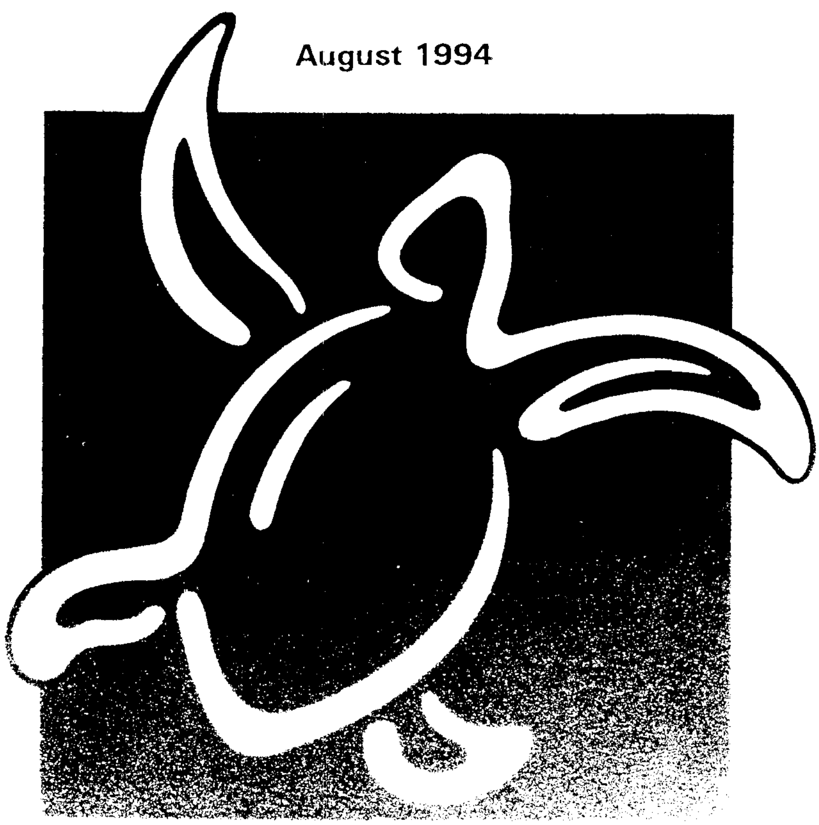
PROCEEDINGS OF THE FOURTEENTH ANNUAL SYMPOSIUM ON SEA TURTLE BIOLOGY AND CONSERVATION

1 - 5 March 1994
Hilton Head, South Carolina

Compilers:

Karen A. Bjorndal
Alan B. Bolten
Dale A. Johnson
Peter J. Eliazar

August 1994



U.S. Department of Commerce
National Oceanographic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, FL 33149

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U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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This publication should be cited as follows:

Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar (Compilers). 1994. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351, 323 pp.

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PREFACE

The Fourteenth Annual Symposium on Sea Turtle Biology and Conservation was hosted by the Marine Turtle Program of the Florida Department of Environmental Protection from 1 - 5 March 1994. The Symposium brought together 547 participants representing 21 nations. Eighty-five papers and 56 posters were presented on topics which covered all aspects of sea turtle research and conservation efforts. A meeting of the IUCN/Marine Turtle Specialist Group was convened following the close of the Symposium.

Many individuals worked very hard to make the Fourteenth Annual Symposium a great success. Ed Drane and Sally Murphy graciously assisted with all aspects of planning and logistics. Many people served as chairpersons for committees and were, in turn, assisted by others on their committees. Committee leaders included: Mailings, Sally Murphy and Joan Logothetis; Program, Allen Foley; International Travel, Karen Eckert; Logo Design Contest, Erik Martin; T-shirts and Mementos, Erik Martin; Registration, Thelma Richardson; Student Awards, Ken Dodd; Silent and Called Auction, Nelia Coyle; Audio and Visual Aids, Jamie Serino and Allen Foley; Food and Beverage, Ed Drane; Poster Room, Ron Mezich; Time and Place, Jeanette Wyneken; Nominations, Lew Ehrhart; Trivia Quiz, Blair Witherington; Symposium Proceedings, Karen Bjorndal and Alan Bolten; Symposium Photographs, Ray Carthy. The winning logo for the Symposium was designed by Dawn Russell. Rod Mast volunteered his talents again as auctioneer to help raise funds for international travel grants. Chris Koeppel helped in innumerable ways during the Symposium and I am very grateful for his cheerful assistance. Coffee breaks were graciously sponsored by Okeanos Ocean Research Foundation, The Museum of Hilton Head Island, Perran Ross, Geomar Environmental Consultants, and the Center for Marine Conservation. Thanks also to the U.S. Fish and Wildlife Service and the National Marine Fisheries Service for providing mailing and xeroxing services, respectively. The Center for Marine Conservation donated prizes for the trivia quiz winners. Ed Drane did a superb job of handling all of the finances involved with meeting. Finally, I would like to thank everyone who took part in the Symposium for sharing their talents, knowledge, and ideas to further sea turtle conservation and recovery efforts around the world.

Barbara Schroeder
1994 Symposium Coordinator and President

We would like to thank the session chairs and authors whose efforts allowed us to complete the compilation of these proceedings in a timely fashion. We especially want to thank Wayne Witzell, Chairman of the Publications Committee, for his guidance, Barbara Schroeder and Blair Witherington for sharing their experiences from the last proceedings, and Thelma Richardson for providing the list of participants and mailing labels. Publication and distribution costs are supported by the Southeast Fisheries Science Center, National Marine Fisheries Service, through the efforts of Nancy Thompson and Wayne Witzell.

Karen A. Bjorndal, Alan B. Bolten, Dale A. Johnson, and Peter J. Eliazar
1994 Symposium Proceedings Compilers

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PART I: ORAL PRESENTATIONS

FIBROPAPILLOMAS IN THE HAWAIIAN GREEN TURTLE: RESEARCH UPDATE

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Selected tissues from juvenile sea turtles (*Chelonia mydas*) afflicted with green turtle fibropapillomas (GTFP) were tested to determine their exposure to environmental pollutants. Egg shells and tissues from turtle hatchlings were also tested. This study indicated that none of the specimens analyzed contained any of the selected organochlorines, polychlorinated biphenyls, organophosphates, or carbamate insecticides in concentrations above the stated methods of detection limits. Most concentrations of selenium, thallium, and other heavy metals were also considered to be below levels reported normal in other animal species. Romanowsky-stained, thin blood smears from juvenile green turtles were examined for the presence of hemoparasites. Using light microscopy, more than 80% of blood specimens demonstrated the presence of erythrocytic inclusion bodies similar to *Tunetella* and *Plasmodium*. The determination of the true nature of these inclusion bodies, the identification of an intermediate host, and their relationship to green turtle fibropapillomas is being investigated. Current research has been focused on the identification of an infectious agent and measuring stress response of turtles afflicted with GTFP and free of the disease. In addition, we will evaluate cellular response to spirorchid trematode ova in tumors by histopathologic examination. A plasma antigen for the development of an ELISA test for the diagnosis of trematode infections is being identified. Although the causative agent of GTFP has not been isolated or characterized this study will provide new insights in understanding basic physiologic responses of green turtles to endogenous and environmental stressors.

VISITATION AND PREDATION OF THE OLIVE RIDLEY SEA TURTLE, *LEPIDOCHELYS OLIVACEA*, AT NEST SITES IN OSTIONAL, COSTA RICA

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The olive ridley, *Lepidochelys olivacea*, is one of only two species of sea turtles that nest in the phenomenon called an "arribada." An arribada occurs when 200 to 100,000 olive ridleys emerge from the ocean to nest, and usually lasts from three to seven nights. One of the most important arribada beaches where these turtles nest is at Ostional, on the Nicoya Peninsula of Costa Rica (Mo et al. 1990).

Natural predators of the olive ridley are crabs (*Ocypode sp.*), garrobos (*Ctenosaura similis*) a type of iguana, crocodiles (*Crocodylus acutus*), black vultures (*Coragyps atratus*), coyotes (*Canis latrans*), raccoons (*Procyon lotor*) and a close relative to the raccoon, the coati mundi (*Nasua narica*) (Cornelius, 1986). Some have observed uncommon predators, such as domestic cats, "raiding" turtle nests or eating their neonates (Wood, D. pers. comm., 1993).

The objective of this study was to determine what kind of predators "raid" olive ridley nest sites in Ostional, Costa Rica. The hypothesis was that there would be greater nest site predation by humans, and their cats and feral animals, than by naturally occurring predators. It was also predicted that man and domestic predators would have a greater effect on the less monitored solitary nesting beaches than on the "better protected" main arribada beach.

METHODS

Playa Ostional is divided into three equal beaches running north and south. The beaches are composed of black volcanic-like sand which ascends through a low and high beach, to thick tropical vegetation including red mangrove (*Rhizophora maugte*), spiny terrestrial bromeliad (*Bromelia pinguin*), and homes of local people. The 880 meter main "arribada" beach is separated from the two solitary nesting grounds -- to the north by the Ostional estuary, and to the south by a rocky outcrop (Cornelius et al. 1991).

This study took place July 31 to August 10, 1993, during the rainy season. During the project period, walks were done in the early morning, approximately 5 am - 7:30 am in search of fresh nests from the previous night. Olive ridley nest sites were found by following the turtle tracks from the water to the dig site. Data on over 1450 nests were then recorded. These included 1) the extent of the visitation or predation, 2) the specific beach, and 3) a disturbance description.

During this study, August 1-4 was considered an "arribada period." All "arribada period" days were determined by 200 or more olive ridleys nesting the previous night on the arribada beach as described by the Association of Integral Development of Ostional. Throughout these days a random number table was used to choose three 10 meter wide zones in which nest visitation and predation from vegetation to the ocean was recorded. These three zones represented the arribada beach activity during this period. July 31 and August 5-10 were considered the "non-arribada period" since less than 200 olive ridleys nested on the arribada beach the previous night.

RESULTS AND DISCUSSION

The initial hypothesis that there would be greatest predation to olive ridley nests by humans and their domestic or feral animals was mainly correct. The only case not reflecting this was the arribada beach, during the "non-arribada period." In this case the main predator was the vulture (40%).

A trend is seen that most of the time vultures were the main nest site visitor, but they played almost no role in predation, except on the arribada beach. One possible reason may be the high density of nests on the arribada beach. Another possibility may be the rainy season. Heavy rains wash away the top layer of sand opening nests to predation. Vultures being the most abundant animals visiting nests, take advantage of the situation and eat the eggs (Christens, E. pers. comm., 1993).

Another trend, during the "non-arribada period," on the north and south beach, shows that there was heavy predation by humans. In fact, 100% of predation to the south beach at that time was by humans (Fig. 2a). Between "non-arribada" and "arribada" periods, predation by humans on the south beach dropped significantly, but predation by dogs increased (Fig. 2a, 4a). Legal harvesting on the arribada beach apparently reduces man's predation on the south beach.

Between the two periods, the north beach actually showed an increase in predation by man (Fig. 2c, 4c). Although egg harvest is illegal north of the arribada beach, nonetheless, was noted the first 150 meters north of the estuary (Dean, J. pers. comm., 1993).

Another trend shows visitation of cats during the "non-arribada period" was closer to the village north of the estuary. This may be because cats are not inclined to cross the estuary. This may also help explain their higher predation rate on the north beach during the "non-arribada period" (Fig. 2c).

Another aspect of this study was to test the hypothesis that man, dogs, and cats affected solitary nesting beaches more than the main arribada beach. My data support this hypothesis. During the "non-arribada period" predation to the south, arribada, and north beach respectively, was 100%, 40%, and 82% (Table 1). During the "arribada period" domestic predation was 88% south, 65% arribada, and 86% north (Table 1). Both periods show that non-natural predation to the solitary nesting beaches is extensive. This suggests that the management plan of the Association of Integral Development of Ostional (ADIO) is working to reduce non-natural predation. The results also suggest that increased surveillance of the solitary nesting beaches may decrease the extensive domestic predation of these nesting sites. This is of particular significance given the higher survival rate of the non-arribada beaches.

Since there were time limitations and small sample sizes, further research on predation at Ostional appears to be indicated before the suggested management plans are implemented.

ACKNOWLEDGEMENTS

Special thanks go to the School for Field Studies (SFS) and their "Ecology of Endangered Sea Turtles" staff: Jorge Ballestero, Carlos Calvo, Bob Carlson, Elaine Christens, and Derek Madden for making this study possible, as well as the Association of Integral Development of Ostional (ADIO) for their assistance and cooperation. Thanks also to the students of the SFS sea turtle program, the University of Wisconsin-Stevens Point Biology Department, Dr. Kent Hall, and Julia Horrocks.

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Table 1

Period	Domestic Predation		
"Non - Arribada Period"	100%	40%	82%
"Arribada Period"	88%	65%	86%
Beach	South	Arribada	North

Fig. 1: Visitation -- "Non - arribada" Period

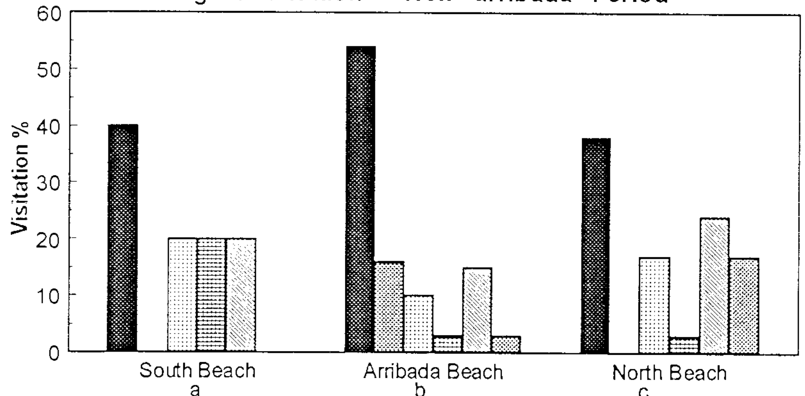


Fig. 2: Predation "Non - arribada" Period

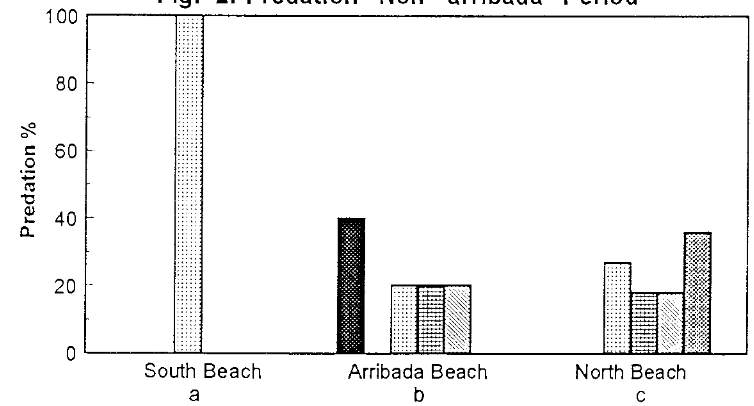


Fig. 3: Visitation -- "Arribada" Period

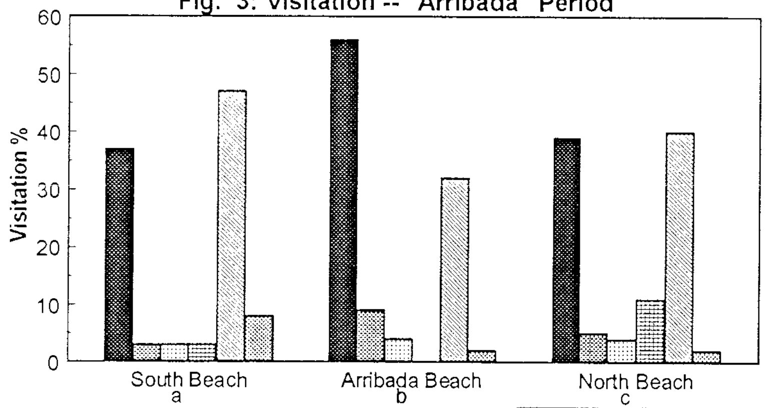
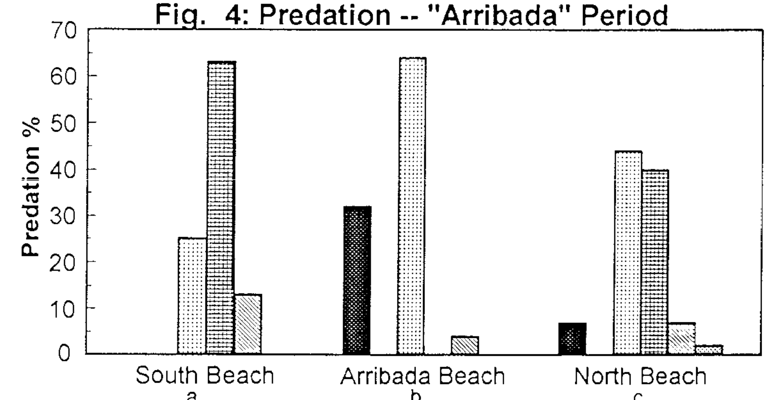
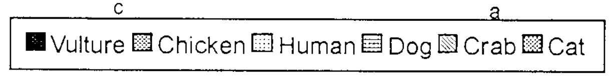


Fig. 4: Predation -- "Arribada" Period





HATCHING RATES OF OLIVE RIDLEYS IN A MANAGED ARRIBADA BEACH, OSTIONAL, COSTA RICA

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Ostional is a wildlife refuge in Western Costa Rica, and one of the 2 known arribada beaches in the country. Since 1987 egg harvesting in Ostional became legal during the first 36 hours of each arribada (Castro and Alvarado, 1987), because nest loss was greatest in this period. Cornelius et al. (1991) suggested that egg harvesting could increase hatching success in Ostional. These authors found hatching rates of 8.0% and 6.7% for Ostional and Nancite beach, respectively.

The objective of this study was to compare the hatching rates in Ostional beach, in areas where eggs are collected and areas where they are not collected, and between the intertidal zones.

STUDY SITE

Ostional Wildlife Refuge (10°00'N; 85°45'O) is located 360 km from San Jose, the capital of Costa Rica. The main nesting beach (where eggs are harvested) begins in the northern end of the Ostional estuary and it ends in the southern end of the Las Cocineras rocks. The second area, where there is no harvesting (no-extraction I), is located north of the Ostional estuary, and is separated from the harvesting beach by the same estuary. The third area (no-extraction II), where the October arribada was concentrated, is located between the estuary of Bicoyol stream and Ostional Rock, south of El Rayo beach.

METHODOLOGY

The study was conducted between May and December of 1992. On the main beach, here referred to as extraction area, there were a total of seven quadrats, conforming a control area within the harvesting area, one measuring 10x10m in the high tide zone, three 10x25m in the berm zone, and three 10x5m in the low tide zone, for a total of 1,000m^2 where eggs were not collected. The quadrats were marked with posts in each corner.

The nests were marked with a 3/4" wire mesh cage measuring 40x40x30cm. They were laid on top of the nest and buried with sand. After 40 days of incubation, the tops of cages were lifted 15 cm above the ground level, to allow room for the neonates to emerge. The total number of eggs in each nest was determined after 55 days of incubation, by counting the remaining eggs, egg shells, and neonates (Arauz, 1987; Crastz, 1982). For each nest the hatching rate (H.R.) was calculated by dividing the number of neonates by the total of eggs, and multiplying by 100.

Hatching rates for arribada and solitary nesters were determined according to the category of each female nesting turtle.

RESULTS AND DISCUSSION

A total of 913 nests survived the 55 days of incubation. Of these 831 were of arribada turtles and 82 of solitary turtles.

Hatching rates for the four areas were: extraction 8.7% ± 18.8 (n=384); quadrats 7.9% ± 14.8 (n=44); no-extraction I 11.3% ± 34.6 (n=370); no-extraction II 30.0% ± 36.6 (n=33). Hatching rate was significantly higher for the no-extraction II area as compared to the other 3 areas ($F=3.831; df=4.908; p=0.0043$). The second highest value was for the solitary nesters, although not statistically significant.

The intertidal zones H.R. were: high tide 24.1% ± 31.4 (n=53); berm zone 9.7% ± 28.3 (n=662); low zone 9.8% ± 1.9 (n=116). Among the intertidal zones, for the four areas studied, the difference was highly significant ($F=3.123$; $df=14.898; p=0.0001$). The comparison among the zones showed a similar pattern for all the areas, except for no-extraction II, which had higher H.R. in the high tide and lower in the low tide zones.

In every area the H.R. varied according to the month, but there was no pattern between the areas. The highest H.R. for arribada turtles were in May for the no-extraction II area (31.2% ± 29.1), and in October for the no-extraction area II (30.1% ± 36.6).

The average H.R. for arribada turtles was 10.7% ± 27.9 (n=831) and 14.9% ± 29.3 (n=82) for solitary turtles. There was no significant difference between these two groups when all intertidal zones were averaged ($F=2.821$; $df=1.911; p=0.093$). But when comparing the intertidal zones between arribada and solitary turtles, there was a significant difference ($F=4.434; df=5.907; p=0.0005$). The main difference seen between arribada and solitary turtles was a higher H.R. in the high tide zone for the former, and in the low tide and berm zone for the latter.

Neonate production was estimated according to the census of each arribada conducted by the resident biologist (Ballestero, pers. comm.), and it was estimated a total of 3,202,026 for the main nesting beach, during the period of this study. The month with the highest number of neonates was September (939,722), and the lowest May (269,890).

We did not corroborate Cornelius et al. (1991) hypothesis that harvesting eggs increases the hatching rates in the main beach. On the other hand, harvesting does not seem to have decreased the H.R. either, as similar results were found by Cornelius et al. (1991) and by this study (8.0% and 8.7%, respectively).

There are areas of the beach that are more favorable to hatching eggs, as it was seen in the no-extraction area II. This study did not determine the environmental differences among the areas studied, that could have affected the H.R.

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OVERWINTERING BEHAVIOR AND MOVEMENT OF IMMATURE GREEN SEA TURTLES IN SOUTH TEXAS WATERS

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Inshore bays and grassflats, jetties, and channel entrances along the central and south Texas coast serve as developmental habitats for juvenile and subadult green sea turtles (Manzella et al., 1990). Although a commercial green turtle fishery thrived in the lower Laguna Madre, Texas as late as 1890, this fishery completely crashed and the sea turtle population drastically declined by the turn of the century (Doughty, 1984). Tracking studies were implemented to characterize the recovery and life history of green turtles in south Texas waters. Radio and sonic telemetry was used to determine seasonal and diurnal differences in behavior and movement, and temporal and spatial habitat usage by green turtles in the lower Laguna Madre area near South Padre Island, Texas. Immature green turtles were captured during October through March using entanglement nets. The turtles were released at their original capture site and subsequently monitored. Turtles were tracked continuously for at least one hour during both day and night. Attempts were made to record the location of each turtle at every hour on the 24-hour clock each month. Hydrological data and other environmental information were recorded concurrent to tracking. Home range and temporal and spatial habitat utilization were characterized. Effects of size, water temperature and depth on behavior and movement of turtles were examined. The study is continuing for another winter to provide additional information on this important developmental habitat which supports immature green sea turtles year round.

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ECOLOGY AND CULTURAL SIGNIFICANCE OF SEA TURTLES AT PUNALU'U, HAWAII

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Long-term tagging studies of sea turtles in nearshore waters of the Hawaiian Islands have been underway to gather comprehensive data on growth rates, food sources, movements, health status, habitat requirements, and population trends (Balazs 1980a, 1982, 1991; Balazs et al. 1987, 1994). The isolated Hawaiian Archipelago contains 132 islands and reefs extending for 2400 km across the North Pacific, from Kure Atoll at the northwestern end (28°N, 178°W) to the volcanically active island of Hawaii at the southeastern extremity (19°N, 154°W). The eight large (or main) populated islands in the southeastern portion account for 96% of the coastal benthic habitats suitable for post-pelagic Hawaiian green (honu), *Chelonia mydas*, and hawksbill (honu-'ea), *Eretmochelys imbricata*, turtles. Green turtles throughout the chain migrate to breed at French Frigate Shoals at the mid-point of the archipelago (Balazs 1976, 1983). A gradual increase in the number of nesting turtles has been recorded at this site since protection was afforded in 1978 under the U.S. Endangered Species Act. About 350 green turtles nested at French Frigate Shoals during the 1993 breeding season. In contrast, nesting by hawksbills (also protected under the Act) is confined to a few remote beaches exclusively in the main islands, where only small numbers continue to come ashore to lay eggs (Balazs 1978, Balazs et al. 1992).

Discrete foraging areas under systematic investigation in the Hawaiian Islands have been selected on the basis of (1) sufficient numbers of turtles residing in an area, and (2) the accessibility of the area for safely and successfully capturing the turtles for tagging. Punalu'u, a small sheltered bay and black sand beach in the Ka'u District on the east coast of the island of Hawaii, fully meets these requirements. This study site has been periodically visited to tag turtles since 1976. Students from the University of Hawaii at Hilo have served as field assistants to the senior author, thereby playing an essential role in all work accomplished. In addition to sea turtles, the sparsely populated and rural region of Ka'u is characterized by a rich Hawaiian cultural heritage.

METHODS

Turtles were captured by hand while snorkeling and scuba diving. Prior to 1988, large-mesh nets were set at night and monitored using a spotlight from shore and by swimming along the bottom to check for entangled turtles. Since 1988, turtles have been commonly found feeding in the daytime inside the bay, rather than at night. Consequently, during recent years nets have been effectively used by quickly surrounding turtles seen foraging close to shore. Turtles were measured, weighed, identified with two or more Inconel size 681 flipper tags, and carefully examined for health problems before being released. Food sources were determined by direct observations of foraging turtles, oral inspections, examining the butchered remains of illegally taken turtles, and by harmless esophageal flushing (Balazs 1980b, in press). Twenty-six expeditions have been made to Punalu'u ranging in duration from 1 to 4 days. For the past 4 years (1990-93) during April, July, and November study visits have been made three times a year for 2 days each.

RESULTS AND DISCUSSION

Since 1976, 183 green turtles ranging from 35.1-95.1 cm in straight carapace length (SCL) and weights of 6.8-115.0 kg have been captured at Punalu'u. Sixty-three turtles (34%) have been recaptured one or more times after 0.2-16.0 years in the wild, resulting in 121 carapace growth increments. Three turtles tagged at Punalu'u were later resighted nesting at French Frigate Shoals, a distance of 1200 km. In addition, two males and a female originally tagged at French Frigate Shoals were recaptured at Punalu'u. Except for these six distant migrations of adults, no turtles tagged at Punalu'u have been captured elsewhere, and none of the turtles tagged at other study sites have been found at Punalu'u.

No hawksbills were captured at Punalu'u, although on rare occasions immature individuals were seen outside the bay in nearshore waters of the adjacent coastline. In 1989 a hawksbill nested at Punalu'u, and the hatchlings were disoriented by lights from the nearby beach park. A documented hawksbill nesting also occurred at Punalu'u in 1975, but the eggs were destroyed by a tsunami. The only other known nesting at Punalu'u within historical times happened in 1974, and again involved a hawksbill. Balazs (1978, 1991) and Katahira et al. (this volume) summarize the status of hawksbill nesting at several small isolated beaches in Ka'u and other coastal areas of the main Hawaiian Islands.

<u>Food sources</u>-- The exclusive food source selected by green turtles foraging at Punalu'u is the red alga, *Pterocladia capillacea*. The distribution of this species is limited to shallow rocky areas close to shore, often in the lower portion of the intertidal zone where freshwater springs discharge into the sea. The thermal influence of these springs within the bay results in temperatures ranging from 19°-26°C. Ocean temperatures immediately outside the bay, where turtles rest on the bottom at depths of 5-25 m when not feeding, range from 24°-28°C. *P. capillacea* occurs at certain other coastal areas adjacent to Punalu'u where turtles are also known to forage.

<u>Growth rates</u>-- The 121 growth increments recorded at Punalu'u yielded a mean growth rate of 1.9 $\pm$1.4 cm/yr. Similar results were obtained (2.1 $\pm$1.2 cm/yr) when only one growth increment was used from each of the 63 turtles recaptured (i.e., growth between initial capture and the most recent recapture). Growth rates decreased considerably with increasing size after about 50 cm SCL. For example, turtles 50-55 cm had a mean growth rate of 3.7 cm/yr, turtles 70-75 cm grew 1.1 cm/yr, and turtles 75-80 cm only 0.5 cm/yr. The smallest size class (35-40 cm) also displayed slower growth

(1.0 cm/yr), although a larger sample size is needed to confirm these data. The initial slower growth may be due to dietary adjustments to herbivory when small turtles (35-40 cm) first arrive at Punalu'u from pelagic habitats where carnivory prevails. Studies of immature green turtles in the Southern Bahamas (21°N) also revealed decreasing growth rates with increasing size (Bjorndal and Bolten 1988). However, depressed growth was not seen in the smaller size classes.

<u>Population trends</u>-- More turtles have been captured during recent visits to Punalu'u than in past years, thereby suggesting an increase in the resident population. However, this tentative conclusion is complicated by the shift to predominantly daytime foraging and the increasing tameness to humans exhibited by the turtles. Presently the turtles are far more visible and easier to catch when feeding in the bay. In addition, difficulties exist in standardizing units of capture effort due to modifications in netting and hand-capture techniques. On any given day, 20 or more foraging turtles can usually be seen by observers standing along the shoreline or snorkeling 200 m from one side of the bay to the other. Somewhat comparable capture techniques and efforts have been used for the past 12 visits (1990-93). The annual number of turtles caught for these four years was 41, 59, 61 and 53, respectively. The number captured per visit ranged from 12-26. Recaptures of previously tagged turtles on each trip during this same time period ranged from 33-88% (mean 65%).

<u>Disease</u>-- Only two of the 183 turtles examined and tagged at Punalu'u have had tumors indicative of fibropapillomatosis. One was captured in 1984 and the other in 1990. Both turtles had a single

0.5-1.0 cm growth associated with an eye. One of these turtles also had a few leeches, *Ozobranchus branchiatus*, and patches of leech eggs. Small numbers of leeches have also been found in the mouths of two turtles without tumors at Punalu'u. All other turtles captured at Punalu'u have been judged healthy. The prevalence of tumors on turtles is exceedingly high at some study sites in Hawaii, such as Kaneohe Bay on Oahu (Balazs 1991).

Mortality-- Before protection under the U.S. Endangered Species Act, turtles at Punalu'u were regularly hunted and killed by nets, spearguns, firearms, and grappling hooks attached to bamboo poles. During the 1960s and early 1970s turtles taken at Punalu'u (and other prime foraging/resting sites throughout Hawaii) were sold to restaurants catering to the growing tourist trade. Heavy hunting mortality continued at Punalu'u until the mid-1980s, when enforcement agents of the National Marine Fisheries Service apprehended four persons identified by a witness as having caught and killed a turtle. The successful prosecution of this case, along with several others, and the resulting publicity especially in the rural Ka'u District, helped to considerably reduce turtle mortality. The current tameness of turtles at Punalu'u along with the shift to daytime foraging are believed to be the direct result of reduced hunting pressures. It should be noted that non-human predators of turtles, such as large sharks, have never been documented at Punalu'u.

Cultural significance-- Punalu'u is bordered on both sides of the coastline by religious stone structures and other archeological remains. Punalu'u is also the setting for probably the most significant legend relating to sea turtles in the ancient Hawaiian culture. The story, as documented by Hawaiian historian Mary Kawena Pukui, tells of two kinds of supernatural sea turtles (honu-po'o-kea and honu-'ea) that came to Punalu'u where the mother gave birth to an egg she buried in the sand. A freshwater spring was then formed by digging into the earth. Later, when the egg hatched, a turtle emerged the color of polished kauila wood (*Alphitonia ponderosa*). This "turtle girl" was named Kauila. At will, she was able to assume human form and play with the children, but would change into a turtle again before going back into the water. "Children used to catch fish and shrimp in the spring, and Kauila watched lest the little ones fall in. The people loved Kauila for this and because her spring gave them drinking water" (Handy et al. 1972). Despite so many turtles being killed at Punalu'u during past decades, there are people who believe that Kauila's presence can still be felt there today and that she is, indeed, the "mystical mother" of all Hawaiian sea turtles. Plans are now underway to construct an educational sign and monument at Punalu'u telling about Kauila and the turtles using the bay.

Ecotourism-- Turtle-watching by tourists and residents alike is becoming an increasingly popular activity at Punalu'u and elsewhere throughout Hawaii. Each day several bus loads of tourists stop at Punalu'u for a short time to enjoy the beauty and tranquility of this secluded Hawaiian setting. Visitors clearly enjoy the experience of seeing turtles undisturbed in their natural environment. The careful use of turtles in ecotourism in this manner should be encouraged whenever possible. Sea turtles have considerable potential for economically benefiting Hawaii through ecotourism. In addition, tourists often serve to protect the turtles by reporting illegal activities.

ACKNOWLEDGMENTS

The on-going research program at Punalu'u would not have been possible without the generous cooperation and valuable assistance of A. & J. Howard, C. Bangay, D. Mazarakis, P. Hanoa, W. Dana, B. Tissot, T. Hammond, M. Childers, and M. Clapper. Many other people, too numerous to name here, have contributed time and talent to this work over the years. We sincerely thank them for their involvement. We also thank J. Beasley for editorial assistance in the preparation of this paper.

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OBSERVATION ON THE INCIDENCE OF FIVE EXTERNAL LESION TYPES IN 506 OLIVE RIDLEY *LEPIDOCHELYS OLIVACEA* (ESCHSCHOLTZ) NESTERS IN THE OSTIONAL WILDLIFE REFUGE, GUANACASTE, COSTA RICA

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This is one of the first reports about the health condition for the Ostional's arribadas nesters in the Ostional Wildlife Refuge, Guanacaste, Costa Rica. Ostional beach, located in the North Pacific coast of Costa Rica, is one of the most important beaches in the world for the reproduction of the Olive Ridley turtles *Lepidochelys olivacea*. Numbers between 50,000 and 150,000 nesting female turtles had been reported on this beach (Ballestero, 1991). During the reproductive process, the olive ridley turtles are affected by many different problems and obstacles, like predation, ocean currents, rocky shores, pollution,incidental capture and others. Some of these problems may cause damage or injuries and induce diseases. Some of the damage is related to mating, because the males grasp the female turtles with their nails, leaving big scars in the neck and in the upper front part of the carapace. Other lesions appear as a result of shark attacks or due to the wave action, which lead the turtles against the rocks causing serious shell damages.

For not well understood causes, the scars can become infected and originate a cutaneous tissue growth, giving the possibility for the apparition of fibropapillomas. There is a lot of references about the causes that may produce the fibropapillomas, including the water pollution, the stress and the sun radiation (Jacobson, 1990; Balazs, 1986).

Epizoa or epibionts are commonly carried by the marine turtles (Caine, 1986). These sessile organisms include leaches, algae, eggs, fishes, bryozoa, amphipods, barnacles and many others. Some of them can not be considered dangerous, but in some cases the high density of the not parasitic epibionts can affect the turtles' sight, the swimming activity and the nesting process as well (J. Frazier, pers. comm.). Obviously, many of the epizoa are truly parasites.

There are no previous studies about carapace dimensions and the health condition of the olive ridley nesters (Frazier, 1983). By these reasons, the main objectives of the present study are:

1.- To determine the incidence of five external lesions in Olive Ridley nesters.
2.- To find a correlation between the carapace size and the occurrence of mating scars.
3.- To find a correlation between the fibropapillomas, shell ruptures, shark bites and barnacles, and the position where they appear.

METHODS

The 506 *Lepidochelys olivacea* were tagged and measured using standard methodology (Bjorndal and Balazs, 1983). Five types of external lesions were checked: shark bites, mating scars, fibropapillomas, shell ruptures and barnacles. Three size classes were established. Size class 1: curved carapace length greater than 66.0 cm and curved carapace width greater than 69.0 cm. Size class 2: curved carapace length greater than 69.0 cm and curved carapace width greater than 72.0 cm. Size class 3: curved carapace length greater than 74.0 cm and curved carapace width greater than 78.0 cm. The five different injury categories were clustered as follows:

1. Three groups of 30 individuals for turtles with shark bites.
2. Three groups of one hundred individuals for turtles with mating scars.
3. Three groups of 30 individuals for turtles with fibropapillomas.
4. Three groups of one hundred individuals for turtles with shell ruptures.
5. Three groups of 50 individuals for turtles with barnacles.

For the clustered turtles, a summary statistic was calculated including their corresponding carapace measurements. To facilitate the data collection, code numbers were assigned to the different body sectors: (1) Head and neck, (2) Right carapace sector, (3) Rear carapace sector, (4) Left carapace sector, (5) Right front flipper, (6) Right fore flipper, (7) Left fore flipper, (8) Left front flipper.

RESULTS AND DISCUSSION

Only 61 of the turtles checked were absolutely clean, 12% of the total sample. These 61 turtles correspond to the lower size category situated between the 66.0 cm carapace length and the 69.0 cm width class. All the turtles without any evident damage look very young.

For the three clustered groups of each one of the five external lesions, we found the data included in Tables 1 and 3. This table shows that the shell size is important for the occurrence of the five external lesions considered. Big turtles (size class 3) are possibly more affected by the factors which determine the injuries occurrence, when they are compared with the turtles in the lower size class. The distribution of the different injuries is the following: shark bites, 19.1%, mating scars, 61.6%, fibropapillomas, 5.8%, shell ruptures, 59.6%, barnacles, 30.0%.

Shark bites were found mainly in the rear carapace and the fore flippers. Mating scars are common in zone 1 (76.7%, see Table 2) and in size class 3, the larger turtles. We believe that these are the older and very experienced turtles. For the turtles with fibropapillomas, the dominant position where they appear was zone 1 (head and neck). The fibropapillomas have a range of size which goes from a dime shape tumor to a cauliflower shaped mass, covering the head and obstructing the turtle eye. The shell ruptures occur in the whole carapace. Barnacle distribution is not limited to the carapace; they may appear over the head and flippers. Therefore, although barnacles are not parasites, they can cause eye obstruction, affecting the turtle's sight.

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TABLE 1
EXTERNAL LESIONS DISTRIBUTION BY SIZE CLASS FOR 506 OLIVE RIDLEY NESTERS

CLUSTERED GROUP	FIBROP.	BARNAC.	SHELL RUPTUR.	MAT. SCARS	SHARK BITES	SIZE CLASS
1	11	36	87	49	30	1
2	21	40	96	98	33	2
3	26	76	129	155	26	3
TOTALS	58	152	312	302	97	
PERCENTS	5.8%	30.0%	59.6%	61.6%	19.1%	

TABLE 2
PERCENT DISTRIBUTION OF INJURIES BY POSITION FOR 506 OLIVE RIDLEY NESTERS

POSITION	FIBROPAP.	BARNACL.	MAT.SCARS	SHARK BITES	SHELL DAMAGES
1	88.1%	11.7%	76.7%	0%	0%
2	0%	47.1%	15.8%	0%	39.1%
3	0%	10.3%	0%	50.4%	29.4%
4	0%	9.7%	7.5%	10.1%	31.5%
5	3.2%	10.8%	0%	0%	0%
6	3.0%	2.5%	0%	19.2%	0%
7	2.6%	3.2%	0%	20.3%	0%
8	3.1%	4.7%	0%	0%	0%

TABLE 3
DESCRIPTIVE STATISTICS FOR INJURIES AND CARAPACE MEASURES IN 506 OLIVE RIDLEY NESTERS

VARIABLE	MEAN	S.D	N	MEDIAN	MIN.	MAX.
LENGTH	62.3	4.9	3	62.2	57.3	67.2
WIDTH	67.1	5.0	3	67.1	62.1	72.1
SHARK	32.3	9.4	3	29.0	25.0	43.0
FIBROPAP.	50.7	61.0	3	20.0	11.0	121.0
BARNACL.	50.5	18.6	3	55.8	31.0	66.0
RUPTURES	50.6	17.7	3	53.0	33.0	64.0
MAT.SCARS	68.0	18.3	3	68.0	55.0	81.0

POPULATION STRUCTURE OF HAWKSBILL ROOKERIES IN THE CARIBBEAN AND WESTERN ATLANTIC

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The hawksbill marine turtle, *Eretmochelys imbricata*, is second only to the Kemp's ridley, *Lepidochelys kempii*, in degree of endangerment. Very little information has been gathered on the behavior of this species besides what can be obtained from nesting females. Migratory behavior has been documented rarely, and reliable information as to their movements between nesting seasons is not available. Due to the continued exploitation of this species, the resolution of reproductive populations is essential to current conservation plans. To define maternal (nesting) lineages in the hawksbill turtle, 15 samples, consisting of either doomed nestlings or blood aliquots, were obtained from nesting sites in Belize, United States Virgin Islands, Antigua, Barbados, Brazil, Mexico, and Puerto Rico. Polymerase chain reaction (PCR) methodology and Sanger sequencing of a 386 base pair region of the control region (displacement loop) were utilized to document haplotypic diversity within and among sampled rookeries. Eight haplotypes were observed among the 68 samples processed to data. Only two of these eight haplotypes were shared among sampled rookeries, and every nesting area was distinguished by significant haplotype frequency shifts as indicated by a G-test of Independence.

USE OF LENGTH-FREQUENCY ANALYSES FOR ESTIMATION OF GROWTH PARAMETERS FOR A GREEN TURTLE POPULATION

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Since 1978, we have captured green turtles over foraging grounds at Great Inagua, Bahamas, during a two-week interval each year. The turtles are tagged and measured. Growth rates have been determined for individual green turtles from capture-recapture data (Bjorndal and Bolten 1988). Length frequency distributions for each of ten years (1983-1992) were used to generate von Bertalanffy growth parameters with four length-frequency analysis programs. The four programs are ELEFAN I, projection matrix method, Shepherd's length composition analysis (SLCA), and MULTIFAN. The ability of each program to generate accurate growth parameters was tested by comparing the predicted length distribution for each year with the length distribution generated from the capture-recapture growth estimates.

Both ELEFAN and the projection matrix method failed to generate an acceptable set of parameters. The parameter estimates generated by SLCA successfully described six of the ten length distributions from the green turtle population. MULTIFAN generated a set of growth parameter estimates that successfully described all ten length distributions. Although MULTIFAN had the best performance, it requires substantially more initial information and estimates than do the other programs. Initial analyses with SLCA followed by analyses with MULTIFAN may be the best approach--particularly with a poorly studied population.

Length-frequency analysis is a valuable tool for the study of growth in immature sea turtle populations (Bjorndal et al. in press; Bjorndal and Bolten in press). Studies are needed to determine whether these methods are appropriate for populations that include mature sea turtles.

ACKNOWLEDGMENTS

This study was funded by the National Marine Fisheries Service (NMFS) and by the U.S. Fish and Wildlife Service (USFWS). The long-term research at Great Inagua that was the basis for this study has been supported by the Caribbean Conservation Corporation, NMFS, and the Bahamas National Trust (BNT). We thank Wayne Witzell (NMFS) and Richard Byles and Jack Woody (USFWS) for their support of this study. We are grateful to our colleagues at the Department of Oceanography and Fisheries, University of the Azores, Horta, for constructive discussions. The long-term work at Great Inagua would not have been possible without the years of dedicated effort by BNT wardens Jim Nixon, Henry Nixon and Sam Nixon. We thank Morton Bahamas Limited and the U.S. Coast Guard for logistic support.

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BIOLOGY OF PELAGIC-STAGE LOGGERHEADS IN THE ATLANTIC

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We reviewed our recent research on the pelagic stage of the loggerhead sea turtle (*Caretta caretta*) in the eastern Atlantic. This pelagic-stage population is believed to be an early life history stage of the nesting population of the southeastern USA. This relationship is based on complementary size distributions (Bolten et al. 1993a) and mitochondrial DNA analyses (Bolten, Bjorndal, Bowen, and Martins, unpublished data). Predicted movement patterns of pelagic-stage turtles with respect to the North Atlantic Gyre (including the Gulf Stream Current and Azorean Current) are substantiated by recaptures of tagged turtles (Eckert and Martins 1989; Bolten and Martins 1990; Bolten et al. 1992a, b; Bjorndal et al. 1994). The pelagic stage is characterized by turtles 5 to 65 cm straight carapace length. The duration of the pelagic stage is estimated from both recaptures of tagged turtles and length frequency analysis. Length frequency analyses have been demonstrated to be a successful method to estimate growth rates in juvenile sea turtles (Bjorndal et al., in press; Bjorndal and Bolten, in press).

Longline fisheries have an impact on the pelagic-stage loggerheads in the eastern Atlantic. The largest size classes of loggerheads present in the eastern Atlantic are most frequently caught in this fishery (Bolten et al. 1993b). This source of mortality could have major demographic implications as indicated by Crouse et al. (1987).

This work has been supported by the Marine Entanglement Research Program of National Marine Fisheries Service.

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EVALUATION OF ACCURACY AND PRECISION OF A SONIC TELEMETRY SYSTEM IN CORE SOUND, NORTH CAROLINA

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Telemetry has been used to investigate movements of threatened and endangered sea turtles within developmental habitats, however, no tests of triangulation system accuracy have been performed. Thus, we evaluated the accuracy and precision of a directional sonic telemetry system for application in studies of sea turtle habitat use in Core Sound, North Carolina. We obtained independent bearings from multiple receiver/transmitter stations in each of three habitats of Core Sound: channel, embayment and grassbed. Known geographic locations of stations were obtained from Differential Global Positioning System. Angle errors for all three sites averaged -15° ± 7° (SD) for an error arc of 14°. System bias, including magnetic deviation and hydrophone/compass alignment error, was corrected for before estimating point locations. Median location error was greatest in the channel (41.9 m) and smallest in the grassbed (8.9 m). Location error increased with increasing geometric mean distance between receivers and transmitters, and may have been compounded by variation in depth. Grassbeds range in size from 0.1 to 3189.0 ha in southern Core Sound. Our largest 95% confidence area was 5.7 ha. Almost 70% of the grassbeds in southern Core Sound are smaller than 5.7 ha, but represent less than 2% of the total seagrass area in the sound. Even sea turtle use of these small beds may be detected, given the contagious distribution of the beds. We have shown that directional sonic telemetry is adequate to conduct meaningful habitat use studies which could then be used to designate critical habitat, as required by the Endangered Species Act.

STUDYING PIGS FOR THE CONSERVATION OF SEA TURTLES: THE IMPORTANCE OF KNOWING YOUR ENEMIES

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At many locations throughout the world, wild and feral pig populations are among the most important predators responsible for the destruction of sea turtle nests. It is proposed that the design of basic ecological studies and collection of supportive data concerning these pig populations themselves could lead to more effective and ecological methods of pig depredation control. Frequently, data useful for this purpose may be collected from pigs which are routinely eliminated in the course of predation control programs, although animals taken in such efforts are frequently discarded without collecting such potentially useful information. Examples are given of particular locations around the world where pig depredation has become a source of concern for sea turtle nest survival. Particular attention is also given to those less well-known situations where wild and in some cases feral pig populations are found in important areas of sea turtle nesting without significant nest depredation occurring. It is proposed that these latter situations, if properly studied, might provide important information which could lead to the alleviation of nest depredation impacts in other areas. It is suggested that fruitful interactions for the benefit of sea turtle conservation interests could result from an increase in the communication and collaboration between sea turtle biologists and those individuals studying the basic population biology and methods for control of wild and feral pig populations throughout the world. Recent state-of-the-art methods are described for the control/eradication of unwanted pig populations. These methods, which have been developed in New Zealand and are based on the use of specially-trained hunting dogs, are described in detail elsewhere in a poster presentation at these meetings.

THE EFFECTS OF FLASH PHOTOGRAPHY ON NESTING BEHAVIOR OF GREEN TURTLES (*CHELONIA MYDAS*) AT TORTUGUERO, COSTA RICA

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Ecotourism has increased dramatically in recent years and can provide incentive for habitat and species protection. Where nesting beaches are accessible to humans, ecotourism may be a viable conservation strategy for protection of nesting sea turtles. Common activities of turtle watching include talking, touching the turtle, using flashlights, and taking flash photographs of the nesting turtle. The potential negative impacts of these activities to nesting turtles have not been quantified, and this has resulted in a variety of guidelines being used around the world. Nesting turtles are sensitive to some types of artificial light, but we are unaware of their sensitivity to intense bursts of light like those of a camera flash. This study focussed on identifying negative effects of flash photography on the nesting behavior of green turtles at Tortuguero, Costa Rica. More complete and thorough information will be available in a future publication.

METHODS

One group of turtles was systematically exposed to a camera flash during oviposition, covering and camouflaging stages (flashed group, $n=30$), while the duration of stages was recorded. The same information was obtained for another group of turtles that were not exposed to the flash (undisturbed group, $n=31$). Data were also collected on clutch size and turtle size for both groups.

RESULTS AND DISCUSSION

Oviposition means were not significantly different between the two groups, however, the variance for the undisturbed group was significantly greater than the flashed group ($p = 0.02$). Clutch size was correlated with oviposition time for both groups. However, the strength of the relationship was considerably less for the flashed group than the undisturbed group. The data suggest that flashed turtles laying larger clutches lay their eggs faster than undisturbed turtles.

The flashed group spent significantly less time covering the nest than the undisturbed group ($p = 0.04$), with the flashed group spending on average 1.4 minutes less time covering the nest than the undisturbed group.

The camouflaging means were not significantly different between the two groups. However, the flashed group had a significantly greater variance ($p = 0.03$) than the undisturbed group. The flashed group ranged from 9.8 to 80.2 minutes compared to 28.6 to 67.5 minutes for the undisturbed group. On average the expected response to the flash during camouflaging would be a decrease of approximately four minutes during this stage.

There is sufficient evidence to conclude that when green turtles are exposed to multiple camera flashes there is an overall decrease in the duration of covering and camouflaging stages. In addition, some individuals are very sensitive to a flash disturbance. Without knowing the effect of reduced covering and camouflaging times on hatching success, flash photography should not be permitted on the Tortuguero nesting beach. Quality photographs should be made available for purchase in local hotels and tourist shops. Further research is needed to determine the effects of changes in covering and camouflaging duration on incubation and hatching success.

ACKNOWLEDGMENTS

I would like to thank the following for financial support: Caribbean Conservation Corporation, Tropical Conservation and Development, and National Biological Survey -Sirenia Project. I would also like to thank the following people for assistance with study design and/or statistical analyses: A. Bolten, K. Bjorndal, R. Carthy, L. Branch, R. Franz, H. Kochman, C. Lagueux, and J. Mortimer. In addition, many thanks to my field assistants: F. Benlys, A. Jimenez, K. Miller, C. Taylor, and A. Webster.

LOGGERHEAD NEST MORPHOLOGY: EFFECTS OF FEMALE BODY SIZE, CLUTCH SIZE AND NESTING MEDIUM ON NEST CHAMBER SIZE

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The environment experienced by a clutch of sea turtle eggs during incubation is a function of how the physical attributes (temperature, hydric and gaseous regimes) of the nesting beach are presented by the female in the shape of the chamber she digs. The effects of the physical factors on individual eggs and clutches have been documented (Miller, 1982; Mrosovsky, 1982; Packard, 1990; Ackerman, 1990; Wyneken et al., 1988; Mortimer, 1990) as has the female's behavior in digging the nest (Hailman and Elowson, 1992). As part of a study examining the effects of nest chamber-mediated environmental factors on egg incubation, nest cavity casting was used to explore the nature of female investment and the effect of the nesting medium on nest chamber size in loggerhead sea turtles.

METHODS

Nest casting was done at Melbourne Beach and the beach at Patrick Air Force Base (PAFB) on the east coast of Florida from June through August of 1993. The latter beach was the site of a recently completed renourishment project. Females at the laying stage of nesting were located and the sand around the posterior third of the turtle was excavated down to the level of the body pit. A plastic sheet with a cutout accommodating the cloaca was placed under the animal's posterior end and rear flippers. The sheet prevented the turtle's first covering sweeps from depositing sand in the egg chamber. At the first covering movements the animal was lifted and moved 2-3 meters to the side and ocean-ward of the nest. The turtle was checked for tags, and measurements were taken of straight carapace length (SCL, notch to notch), straight carapace width (SCW), and both rear flippers from the knee joint to the distal tip (FL). A plumb line perpendicular to the animal's longitudinal axis (head-tail orientation) and level with the surrounding beach was placed across the chamber opening as a reference point for depth measurements. Measurements of body cavity depth (BCD) and beach surface to top of eggs (BTTOE) were taken.

A protective layer of thin plastic wrap was laid over the eggs, following their contours, and the neck of the chamber was filled with a polyurethane expanding foam product. After curing for 3 hours, sand surface level (at body cavity depth) and animal orientation were marked on the neck cast and it was removed. All eggs were removed from the chamber and counted (#EGGS); ten were chosen at random for min/max diameter measurements and all were reburied nearby. A total nest cavity depth (NCD) was measured, and the entire chamber was cast in foam. The entire cast was marked and excavated 3-4 hours later. Each nest site yielded a neck cast and an entire chamber cast unless circumstances made it impractical to do both. Of 51 sites cast, 20 from Melbourne and 15 from PAFB were used in the analyses.

In the laboratory, volumes of the neck and entire casts were determined by water displacement, and additional morphometric measurements were taken. Actual nest depth (AND) was calculated by subtracting BCD from NCD. Average egg volume was calculated from the egg measurements (AVEGG), and multiplied by #EGGS to obtain clutch volume (CLVOL). Clutch volume and neck cast volume were subtracted from entire chamber volume to calculate potential air space within the chamber (AIRSPACE).

Correlation analyses were done (SAS PROC GLM; Littell et al., 1991) to identify any relationships between nest chamber size parameters (BCD, NCD, AND, NEST VOLUME, AIRSPACE) and 2 sets of female-based parameters: body size factors (SCL, SCW, FL) and clutch size factors (#EGGS, AVEGG, CLVOL). Nest chamber size parameters were compared between the natural and renourished sites by ANOVA (SAS PROC GLM; Littell et al., 1991) and Levene's Test for Homogeneity of Variances (Conover et al., 1981).

RESULTS AND DISCUSSION

No significant turtle or clutch size correlations with the nest chamber dimensions were found (ANOVA, $p>0.05$), suggesting that construction of the chamber is primarily a behavioral function. Hailman and Elowson (1992) proposed that nest depth is limited by the animal's reach. However, the lack of correlation between nest depth and flipper size or body size refuted this. The observed dimensions may be the results of individualized Fixed Action Patterns (FAP's), causing some big animals to dig small nests and vice versa. Future experiments may include following an individual female over a nesting season and comparing the dimensions of her successive nests.

When BCD, NCD, AND and AIRSPACE were compared between the two beaches there were no significant differences between mean values at each site (Figures 1-4 respectively; mean represented by dotted line, ANOVA, $p>0.05$). Variances for each parameter at the renourished site appeared to be skewed; application of Levene's Test for Homogeneity of Variances indicated that AND and AIRSPACE variances were significantly different between the two sites (Figures 3 and 4; Levene's $F = 0.012$ for both variables). The nesting media at the natural and renourished areas are visually and texturally different. The renourished beach sand is darker, finer grained, and in places there is a definite denser, coarser, shell-filled layer beginning at 55-60 cm deep. This layer may be mechanically constraining the animals' ability to dig and buffering the kind of variance seen at the natural beach. Natural variance in nest depth can mitigate the effects of nesting beach vicariance by allowing differential nest survival under various stresses.

The variance in free airspace in the nest chambers at the renourished beach was significantly greater than that at the natural beach (Figure 4) but was skewed toward less air space. The decrease in potential airspace is likely due to widening of the chamber necks to achieve chamber-bottom dimensions comparable to those at the natural sites. Subsequent filling with sand reduces the size of the side air pockets that usually form. These spaces persist through incubation, allowing expansion of the eggs as they take up water, controlling the nature of the microclimate around each egg, and allowing hatchlings room to work as they pip and emerge.

The effects of nesting habitat alteration can be subtle but have serious implications for clutch and species survival. The use of nest-casting techniques allows fine scale examination of these effects. Future directions for research include further architecture work and comparisons of nest chambers between species.

ACKNOWLEDGMENTS

Special thanks to the following persons and agencies which provided assistance, funding, or permits to conduct this study: Karen Bjorndal and Alan Bolten, the Archie Carr Center for Sea Turtle Research, Lew Ehrhart and UCF Marine Turtle Research Group, U.S. Fish and Wildlife Service and Florida Cooperative Fish and Wildlife Research Unit, Florida Department of Environmental Protection, Clay Gordin - Natural Resources Manager PAFB, George Zug - Smithsonian Institution Herpetology Curator, Dale Johnson, Darrin Brager, Karen Edgemon, John Kitchens, Emile Ledee, and Parks Small.

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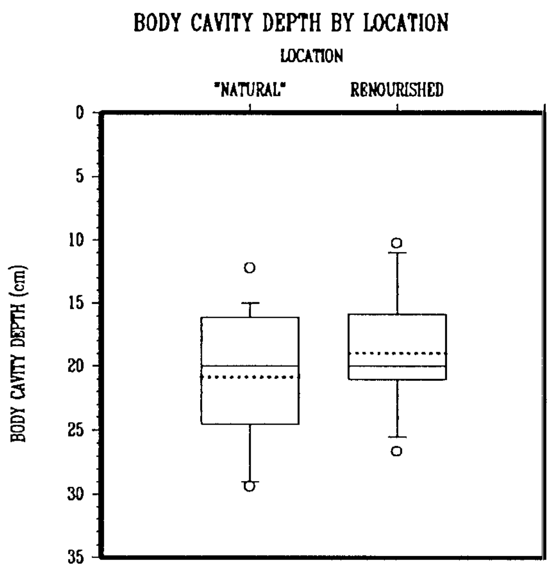
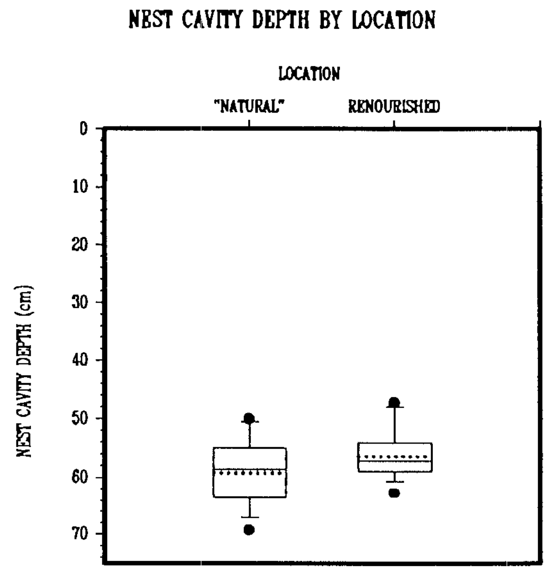


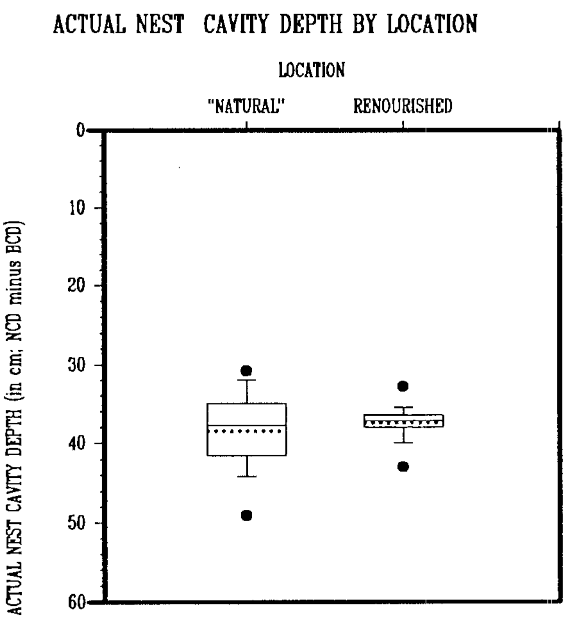
means NSD (ANOVA)

Figure 1.



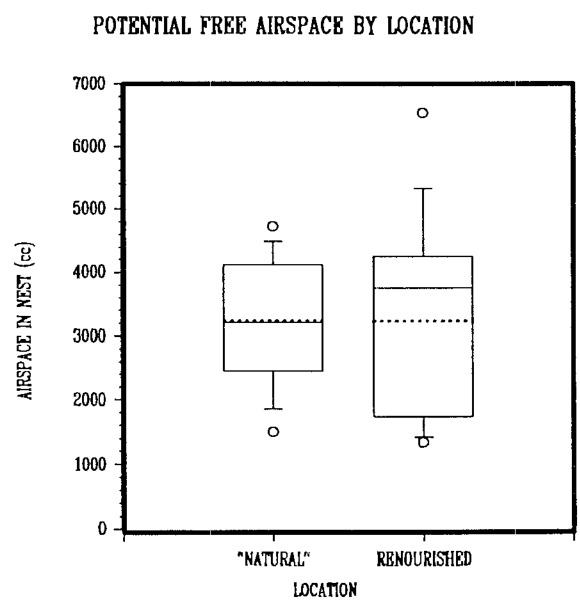
means NSD (ANOVA)

Figure 2.



means NSD (ANOVA)
variances SD (Levene's F = 0.0125)

Figure 3.



means NSD (ANOVA)
variances SD (Levene's F = 0.0122)

Figure 4.

<u>BOX PLOT KEY</u>
dotted line - mean
solid line - median
box - 50% of observed values
error bars - 80% of observed values
outliers - 90% of observed values

SEX RATIO OF IMMATURE KEMP'S RIDLEY SEA TURTLES IN THE NORTHWESTERN GULF OF MEXICO

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Increasing our understanding of sex-ratios in sea turtles is important for both conservation and management purposes. Few data exist on sexual dynamics of Kemp's Ridley sea turtles (*Lepidochelys kempi*) aside from those of stranded animals and sacrificed hatchlings. The assessment of dredging effects on sea turtles provided an opportunity to draw blood samples from 88 Kemp's ridleys captured in entanglement nets set at beachfront, jetty and channel habitats at Sabine Pass, TX during April - October 1993. Blood was drawn according to methodology developed by Owens and Ruiz (1980) immediately after capture, in early morning during holding (resting sample), and a few minutes after application of flipper and PIT tags. Samples were centrifuged within one hour of extraction, and the serum and red blood cells separated and frozen. A radioimmunoassay testosterone titer was performed on serum samples to determine testosterone concentration (Wibbels, 1988). Laparoscopies were performed on six individuals captured during September 1993 to verify true sex (Wood et al., 1983).

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DEVELOPMENT OF A NON-INVASIVE SEXING TECHNIQUE FOR HATCHLING LOGGERHEAD TURTLES (*CARETTA CARETTA*)

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Researchers need to know the sex of hatchling turtles, but currently no non-lethal method of sexing exists. In an attempt to develop a non-invasive method of sexing hatchlings, 28 loggerhead turtle (*C. caretta*) eggs were collected late in development from various beaches in Florida. Upon hatching, allantoic fluid, plasma, and gonads were collected. Gonad histology revealed 18 females and 11 males. Plasma and allantoic fluid were analyzed to determine testosterone and estradiol concentrations. Both plasma and allantoic fluid contained significantly higher concentrations of testosterone in males ($p<0.05$) and estradiol in females ($p<0.05$). High variance among concentrations made sex designation based on absolute hormone values difficult, so a ratio of estradiol to testosterone (E/T ratio) was made. Using the E/T ratio for allantoic fluid, only one of the 28 hatchlings was misidentified in respect to sex. It is concluded that sexing hatchling loggerheads using E/T ratios of allantoic fluid is a valid technique, and there are many potential field and laboratory applications of this technique.

SEA TURTLE CONSERVATION AND THE ENDANGERED SPECIES ACT: DOES GOOD BIOLOGY EQUAL GOOD CONSERVATION?

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This paper focuses on several aspects of endangered sea turtle conservation biology to explore the interface of science and policy. Endangered and threatened sea turtles, shrimp trawling, turtle excluder devices (TEDs) and the Endangered Species Act (ESA) reauthorizations of 1987 and 1993 provide a case study for questions such as: How much proof is necessary before theory should be incorporated into policy? How impartial should a scientist remain? In 1987, when the ESA was up for reauthorization, new regulations requiring certain shrimp trawlers to use TEDs contributed to a year's delay in reauthorization and an ESA amendment specifically addressing this issue. Currently the ESA is again up for reauthorization and last December new regulations greatly expanded the TED requirements; what might the implications be? What is your appropriate role in the current ESA reauthorization?

THE EFFECT OF TURTLE-EXCLUDER DEVICES ON LOGGERHEAD SEA TURTLE STRANDINGS IN SOUTH CAROLINA

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The South Carolina Wildlife and Marine Resources Department instituted a statewide data collection network to record strandings of sea turtles in 1980. Stranded turtles are those that wash up dead on beaches related, in part, to fishing activity (Murphy and Hopkins-Murphy 1989). In response to declines in sea turtle populations, both state and federal regulations have required turtle-excluder devices be used in trawl nets since the late 1980s. The South Carolina strandings data is clearly one of the best and longest running in terms of completeness and quality assurance in the US. Can we detect significant effects of the TED regulations in reducing loggerhead strandings?

METHODS

We analyzed data collected on stranded loggerhead sea turtles from South Carolina for the period before turtle-excluder devices (TEDs) were required (1980-87), during the period of intermittent use when TEDs were first being implemented due to state and federal regulations (1988-89) and for three years with good compliance with TED requirements (1990-92). Time series analysis considered the possibility of overall declines in loggerhead numbers in the region, the effect of seasonal fishing by the sturgeon gill net fishery and by the shrimp trawlers. We encoded biweekly strandings data as to whether shrimping season was open or closed and whether TEDs were required. Data were transformed $\ln(x+1)$ to stabilize variance.

RESULTS AND DISCUSSION

The time-series model showed a good fit to the natural log transformed data ($R^2 = 0.89$). The overall trend shows strandings declining at about 5-6% per year, which agrees with the results of aerial survey data of nesting females (Hopkins-Murphy and Murphy 1988). The trend data also includes a significant quadratic term which suggests that the rate of decline in strandings has diminished. This pattern, too, was observed in aerial surveys completed in 1992 (Hopkins-Murphy, unpublished data). The analysis also documents significant effects of both the sturgeon gill net fishery and the shrimp fishery on enhancing strandings. The effects of TED use were also significant-- TEDs reduce strandings by 42-52% depending upon whether one assumes the overall population trend is linear or quadratic. If reductions in stage-specific mortality rates are at all similar to the observed reductions in strandings due to TED use and other sources of mortality do not intervene, the outlook for loggerhead recovery based on population modeling is good (Crowder et al. 1994).

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TRADE OF HAWKSBILL CARAPACES IN SANTO DOMINGO, DOMINICAN REPUBLIC

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The industry of craftsmanship in the Dominican Republic is developing day by day, and one facet of this industry is the processing of the hawksbill carapace and its scales. This study shows evidence of the illegal trade of sea turtle products in the developed tourist areas of the Dominican Republic and of the need for a suitable management and control of the sea turtle species. This country is protecting the sea turtles by Fisher Law N 5914 (1962) and it ratified the Convention on International Trade in Endangered Species (CITES) in 1987. Previous studies about population status, distribution, breeding biology, exploitation, and management of sea turtles were conducted in the Dominican Republic (Ottenwalder, 1981, 1987). The main objective of this study is to collect data in order to develop an Environmental Information Program for the Tourist (PIAT) and for the Manatee and Sea Turtle National Conservation Project (PCMTM) that are being designed by PAD.

METHODS

Visits to gift shops were made in the Historic Center of Santo Domingo city from August to September (1993), and telephone inquiries were made later to the owners and/or employees of the gift shops previously visited. Data about types of items of hawksbill carapaces, their prices, and nationalities of the tourist buyers were collected.

RESULTS AND DISCUSSION

Fifty-five gift shops were visited from the main commercial streets, hotels and business centers in Santo Domingo city. Ninety eight percent of them sell hawksbill carapace products, among them 33 different items were detected including jewelry, decorative articles, cooking sets, personal use, and office accessories, each of them in a great variety of presentations. The most frequent items observed in stock were bracelets (84%), purses (73%), earrings (71%) and jewelry boxes (64%).

Previous evidences of trade of hawksbill carapace products were detected in other tourist areas of the Dominican Republic, as in Puerto Plata (Stam and Stam, 1992), La Romana (Domínguez, unpub. report) and Santo Domingo and other cities (Ottenwalder, 1987).

Fifty-three percent of the gift shops that were visited advertise the sale of hawksbill carapace products. The inquiries suggest that tourists which buy most of these items are European (88%), mainly Italian and Spanish.

Apparently the trade of hawksbill carapace products in the Dominican Republic is less now than in the past, because tourists are afraid of import restrictions, but actually the product is more diversified than in the past.

Finally, it is recommended that the Fisher Law 5914 (1962) of the Dominican Republic should be reviewed, and to start an information program for the tourist and an educational program for the Dominican people, especially the ones selling hawksbill products. Also the control mechanism needs to be reviewed and strongly reinforced, and it is further recommended that the Bonn Convention (22 June 1979) for the protection of migratory species be ratified.

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GENETIC POPULATION SURVEY OF LEATHERBACKS BASED ON mtDNA

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The control region, or D-loop, of mtDNA was sequenced for four individuals from each of Florida, St. Croix, French Guyana, Trinidad and Atlantic Costa Rica nesting populations in order to examine questions of natal homing and genetic population structure in Leatherbacks (*Dermochelys coriacea*). In addition, samples were sequenced from a Pacific rookery at Naranjo, Costa Rica. DNA purified from blood or tissue samples was amplified using primers from Allard et al. (1994) and sequenced using dideoxy chain termination.

Parsimony analysis of the D-loop sequences from all individuals revealed a lack of population structure within Atlantic rookeries. The same haplotyes were found in all populations, and where there were differences, they were only on the order of one to three nucleotides (.002-.006%). Sequence divergence between Atlantic and Pacific populations was relatively low, on the order of 1-2%, compared with 7-9% between Pacific and Atlantic green turtle rookeries. Furthermore, two of the Pacific individuals were more similar to the Atlantic haplotypes than the distinct Pacific haplotype.

These preliminary results do not support the theory of natal homing and suggest that a region-wide approach is needed when designing conservation strategies for leatherbacks. Further work is underway to look at nuclear markers and to complete a global mtDNA survey.

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Allard, M.W., M.M. Miyamoto, K.A. Bjorndal, A.B. Bolten, and B.W. Bowen. 1994. Support for natal homing in green turtles from mitochondrial DNA sequences. Copeia 1994:34-41.

THE EFFECT OF ABIOTIC FACTORS ON THE POSITION OF LOGGERHEAD TURTLES (*CARETTA CARETTA*) IN THE WATER COLUMN AT CAPE CANAVERAL, FLORIDA

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Depth sensing sonic biotelemetry units were used to determine the effect of abiotic factors on the position of loggerhead turtles in the water column. Eight loggerhead turtles, five juveniles and three males, were captured in the Cape Canaveral Channel and monitored for periods ranging from 20 to 48 hours. During turtle monitoring sessions, abiotic factors which included light intensity, water temperature, water depth, wind speed, wave height, cloud cover, and air temperature were measured.

Results of multiple regressions revealed that the surface duration and the number of surfacings of both male and juvenile loggerheads were influenced by cloud cover and water depth. The extent of the influence depended on the age of the turtle and the time of day. The light and temperature levels at which the turtles were found also varied with the age of the turtle and time of day. Males were found at warmer water temperatures while juveniles were found at cooler water temperatures. Some turtles also spent considerable time at or near the thermocline. Males were found at higher light levels than juveniles. Juveniles were never exposed to light levels greater than 600 $\mu Es^{-1}m^{2}$, while males were often found at light levels greater than this, at times experiencing light levels as high as 1200 $\mu Es^{-1}m^{2}$. However, rapid changes in light intensity did not result in corresponding changes in turtle depth.

Further studies correlating sea turtle behavior and abiotic factors may lead to more definitive predictions which may result in the development of a model to determine the position of sea turtles in the water column. A predictive model could be an important management tool to determine the best time to dredge the channels along the Southeastern coast of the United States with the least chance of harming sea turtles.

MITOCHONDRIAL DNA STRUCTURE OF ATLANTIC GREEN TURTLE NESTING GROUNDS

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The objective of this study was to determine the population genetic structure of green turtles in the Atlantic region by means of the use of direct sequencing of the mitochondrial DNA hypervariable control region. This was done by the sequence analysis of within- and between-population diversity, which were used to corroborate natal homing and the earlier observation that small green turtle rookeries have greater variation than larger ones (Lahanas et al., in press).

METHODS

This study was based on 147 individuals from nesting beaches in Hutchinson Island, Florida; Quintana Roo, Mexico; Tortuguero, Costa Rica; Aves Island, Venezuela; Matapica, Surinam; Atol das Rocas, Brazil; Ascension Island, U.K.; Pailoa, Guinea Bissau; and Lara Bay, Cyprus. All specimens were sequenced at the 5' end of the control region of the mtDNA using polymerase chain reaction (PCR) methodology and primers developed earlier by Allard et al. (1994) specifically for marine turtles. All samples were sequenced manually, except for the Mexican ones which were sequenced using the automated sequencer.

RESULTS AND DISCUSSION

Among the 147 individuals sequenced, there were 18 polymorphisms, which correspond to 18 transitions, 4 transversions, and one 10 bp repeat. On the basis of these control region differences, a total of 18 haplotypes were recognized for the 9 Atlantic populations, many of which were shared across rookeries. Haplotype and nucleotide diversities were calculated for the nine colonies (Table 1), the highest levels of diversity being exhibited by the Mexican colony. Overall, higher diversity was found among colonies with smaller rookery size, thus corroborating earlier observations of greater diversity of smaller nesting colonies. Variation between populations was quantified by comparisons of haplotype frequencies between pairs of populations. Except for the Surinam-Aves and Guinea Bissau-Ascension colonies, significant differences in haplotype frequency were found between all pairs of colonies compared. These statistics indicate that with the exception of these two pairs, each colony can be considered a demographically independent unit, and we can confidently conclude that the population genetic structure of green turtles in the Atlantic is indeed shaped by natal homing.

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Table 1. Estimates of haplotype (h) and nucleotide (π) diversities for nine Atlantic populations of green turtles.

POPULATION	HAPLOTYPE DIVERSITY (h)	NUCLEOTIDE DIVERSITY (p)
FLORIDA	0.56	0.00062
MEXICO	0.82	0.0026
COSTA RICA	0.13	0.00014
AVES	0.25	0.0026
SURINAM	0.26	0.0022
BRAZIL	0.68	0.00085
ASCENSION ISLAND	0.35	0.00039
GUINEA BISSAU	0.00	0.00
CYPRUS	0.22	0.00021
OVERALL	0.83	0.0050

MATING SYSTEMS AND MALE CONTRIBUTION TO GENE FLOW IN MARINE TURTLES: PRELIMINARY EVIDENCE FROM MICROSATELLITE DNA ANALYSIS

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One exciting aspect of genetic studies in marine turtles is an increased ability to answer the question "What are males doing out there?" In pursuit of this, we have developed microsatellite techniques for marine turtle nuclear DNA (nDNA) to analyze male-mediated gene flow among populations and paternity of clutches. Studies using mitochondrial DNA (mtDNA) analyses have allowed identification of significant population structuring and are contributing greatly to our understanding of female migration. But the question remains whether or not male migratory and breeding patterns vary substantially from females. By comparing genetic divergence in both mtDNA and nDNA among populations we can begin to assess male-mediated gene flow. Because microsatellite arrays have relatively high mutation rates they offer a robust comparison to mtDNA in analyses of population structure. Gene flow among breeding populations and effective population size may be influenced by male breeding success and the extent of multiple paternity of clutches. The tremendous effort that is expended for reproduction, particularly by females, suggests that selective pressures may have favored the evolution of highly efficient mating systems which may typically include multiple matings by both sexes and multiple paternity of clutches. Microsatellite analyses allow us to assign unique genotypes to individuals within a breeding population and determine paternal genotypes from sibling genotypes. We will present preliminary results from analyses of microsatellite alleles in several species and populations of marine turtles in Australia, as well as initial data on clutch paternity in green turtles.

THE NESTING ECOLOGY OF LOGGERHEAD TURTLES (*CARETTA CARETTA*) IN THE TEN THOUSAND ISLANDS (FLORIDA) AND IMPLICATIONS FOR CONSERVATION

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In the Ten Thousand Islands, loggerhead turtles nest on low-relief mangrove islands that have narrow, discontinuous beaches. Nesting takes place on open beaches, as well as under dense, overhanging vegetation. The incubation medium ranges from quartz sand to oyster shell gravel to mixtures of these with mangrove peat. Studies conducted in 1992 and 1993 showed that the hydric and thermal characteristics of incubation environments varied greatly depending on nest location. Water content of sand surrounding incubating clutches ranged from relatively dry (2%) to saturated (> 20%). In 1993, 16 of 30 monitored nests experienced some degree of groundwater inundation. The salinities of inundating water ranged from 2 to 38‰. Three of the clutches that endured multiple inundations had emergence successes of 69.7, 76.6, and 78.3%. Sand temperatures (at 45-cm deep) at nest sites ranged from 25°C to 35°C. Sites that were lower on the beach or that were shaded had lower sand temperatures than adjacent sites that were higher on the beach or not shaded. Because many activities conducted on loggerhead nesting beaches (e.g., beach replenishment, armoring, development, nest relocation) may alter the hydric or thermal characteristics of the incubation environment, it is important to properly evaluate how these changes may affect loggerhead hatchlings. In other turtles with flexible-shelled eggs, the incubation environment is known to influence several features of hatchling morphology and physiology that may, in turn, affect hatchling or population survival. Little is known about these effects in loggerheads and future studies in the Ten Thousand Islands will take advantage of the great variety of incubation environments to study this.

GROWTH AND ESTIMATED AGE AT MATURITY OF QUEENSLAND LOGGERHEADS

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Demographic models of loggerhead sea turtles *Caretta caretta* in Western Atlantic waters provided strong support for the regulated deployment of turtle excluder devices (TEDs) on shrimp trawl nets to reduce incidental take of larger juvenile and adult turtles deemed important for population stability (Crouse et al., 1987; Crowder et al., in prep). Such models also may be used to pose and answer interesting questions relating to the evolution of life histories (Lewontin, 1965; Dunham et al., 1989).

Developing demographic models of loggerhead sea turtle populations from South Pacific waters in eastern Australia is therefore of interest to students of both applied and theoretical biology. However, one of the main problems faced by sea turtle demographers is that of determining age at maturity. Zug et al. (1986) provided a method for estimating ages of loggerhead sea turtles by counting annuli in the long bones, but the method requires sacrificing individuals of this threatened or endangered species. There are at present no reliable, nondestructive means of determining an individual sea turtle's age in the wild.

One method that has been used to estimate growth and age at maturity of wild sea turtles is to fit growth curves with capture and recapture data using growth interval equations developed by Fabens (1965) for the von Bertalanffy equation and by Schoener and Schoener (1978) for the logistic. In this paper, we construct a growth model for loggerhead sea turtles, *C. caretta* in eastern Australian waters and use it to estimate mean age at maturity.

METHODS

Growth in carapace length was determined for loggerheads captured and recaptured at feeding areas in the Capricornia Section at the southern end of the Great Barrier Reef. The principal study site was Heron Reef, the reef surrounding Heron Island (23°S, 151°55'E), and adjacent Wistari Reef. The waters near Heron Island have been the site of a tagging study since 1974. Details of the capture procedure used in the feeding area study are described by Limpus and Reed (1985) and Limpus (1992). Curved carapace length (CCL) was measured along the midline from the junction of the skin and the carapace above the neck to the most posterior edge of the supracaudal scute with a flexible fiberglass tape measure. Sex and reproductive condition were determined by laparascopic examination (Limpus and Reed, 1985; Limpus, 1992). Only data from the first capture and last recapture of each individual were used, and turtles at liberty for fewer than 90 days (i.e. < 0.25 years) between the first and last capture were omitted from the analysis. Sizes at first capture ranged from 68 to 97 cm (mean = 82.3, s.d. = 5.37, n = 172). Time intervals between individuals' first capture and last recapture ranged from 0.43 to 15.4 years (mean = 5.2, s.d. = 3.55, n = 172).

Carapace measurements at capture and recapture and time intervals between first capture and recapture were fitted to von Bertalanffy and logistic growth interval equations following Frazer and Ehrhart (1985).

RESULTS

Nonlinear, least squares regression revealed no significant differences in parameter estimates for males (n = 130) and females (n = 34) for either model, based on overlapping 95% asymptotic confidence intervals for estimates of parameters a and k. Therefore, males and females were pooled along with eight turtles of indeterminate sex for a total sample size of n = 172. (Fig. 1). The von Bertalanffy model provided a better fit than did the logistic, based on slightly smaller mean residual sum of squares (Dunham, 1978).

DISCUSSION

Present evidence leads us to accept the von Bertalanffy model as a tentative working hypothesis for describing the growth of eastern Australian loggerheads in the wild. With appropriate caveats in mind concerning the interpretation of such growth models, the growth curve (Fig. 1) can be used to provide an estimate of mean age at maturity for loggerheads in the southern Great Barrier Reef.

Growth rates of captive loggerheads are dependent upon temperature (Hughes, 1974), food quality (Stickney, White and Perlmutter, 1973) and food quantity (Nuitja and Uchida 1982). Genetic composition, individual histories of injury, and the density-dependent effects of competition are also known to affect growth rates in reptiles (Dunham and Gibbons, 1990). Thus, growth rates of young captive loggerheads are highly variable (see Frazer, 1982 for review); individuals held in near optimum conditions and fed diets high in protein may attain carapace lengths of up to 43 cm in only 64 weeks (Swingle et al., in press). We are confident that not all individual turtles in a natural population will attain the same size at any particular age. On the other hand, the sizes of individuals of a given age should be distributed around some mean, and it is this mean size-age relationship that growth curves such as ours (Fig. 1) illustrate.

The average size of breeding female loggerhead turtles from the eastern Australian breeding unit, which includes Heron Island and Mon Repos (Gyuris and Limpus, 1988), was 95.7 cm. We assume that the average size of females at first maturity would be slightly smaller than this (Limpus, 1991, Limpus and Reimer, 1992). For instance, in the southern Great Barrier Reef feeding area, the mean CCL of female loggerheads first recorded as being structurally indistinguishable from ovulatory and post ovulatory adults via laparoscopy is 91.75 cm (s.d. = 2.607, range = 88.0-97.5, n = 19). In this same reefal feeding area, laparoscopy revealed that the mean CCL of females at their first observed ovulation is 93.0 (Limpus 1991: s.d. = 1.140, range = 91.5-94.5, n = 5). These observations indicate to us that eastern Australian female loggerheads are almost certainly maturing at average sizes of between 91.75 and 93.95 cm. Solving the von Bertalanffy growth equation for these sizes yields estimates of age at maturity of between 34.3 and 37.4 years. The von Bertalanffy equation (Fig. 1) projects that, on average, females have reached the average size at first ovulation (93.0 cm) at an average age of 35.9 years.

Given the variability of growth rates of loggerheads observed in captive studies, the temporal variability demonstrated in recent demographic studies of freshwater turtles, (Frazer et al., 1991, 1993), and advances in life history theory concerning phenotypic plasticity, (Caswell, 1983, Stearns and Koella, 1986) we would not be surprised to learn that mean growth rate and mean age at maturity vary both temporally and spatially for wild loggerhead populations. Until further studies can be completed, other investigators should not extrapolate our findings to their study areas.

ACKNOWLEDGMENTS

This research has been conducted as part of the Queensland Turtle Research Project of the Queensland National Parks and Wildlife Service. It was funded in part by grants from the Australian National Parks and Wildlife Service, Australian Department of Science, and the Great Barrier Reef Marine Park Authority. Transport of personnel and equipment between the mainland and Heron Island was provided by Heron Island Pty. Ltd. Some accommodation facilities were provided by the Heron Island Research

Station. Data analysis and the preparation of this paper were supported through contract DE-AC09-76SROO-819 between the University of Georgia's Savannah River Ecology Laboratory and the United States Department of Energy. Travel to Australia (NBF) was provided by GREENPEACE.

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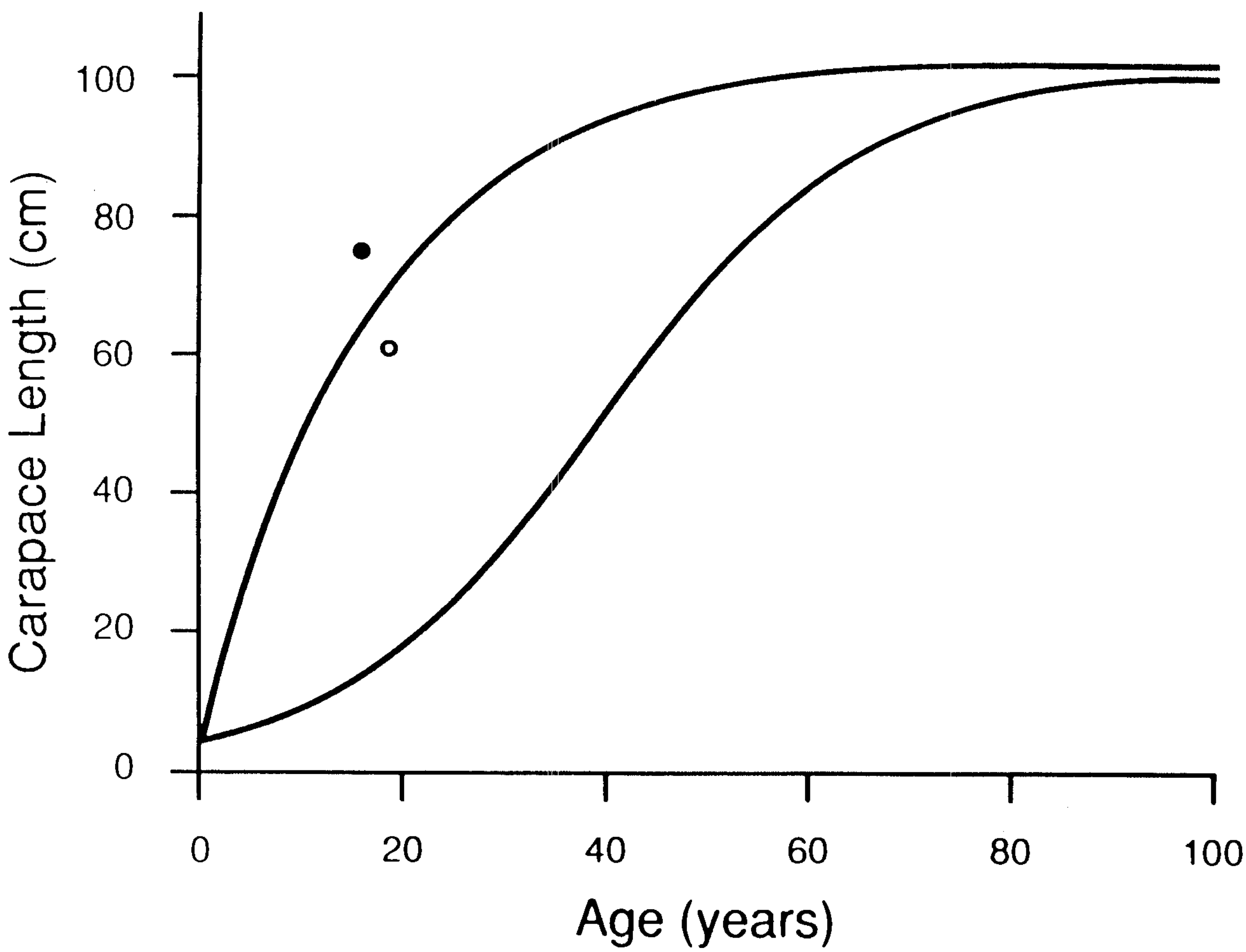
Figure 1. Alternative growth curves for loggerhead sea turtles (Caretta caretta) in the southern Great Barrier Reef. Upper curve: von Bertalanffy model $Y = 104.6(1-0.96e^{-0.06x})$. Lower curve: logistic model, $Y = 103.1\div(1+23.0e^{0.08x})$. Solid circle denotes a turtle of known age, recovered after release as a marked hatchling. Open circle denotes a dead, stranded turtle aged by counting annuli in its humerus after Zug et al.(1986).



BONE AND MUSCLE BIOPSY TECHNIQUES - FIELD PROCEDURES FOR OBTAINING TISSUE SAMPLES FROM LIVE SEA TURTLES

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The acquisition of quality tissue samples for use in histological and physiological studies is a challenging task. The samples must be as fresh as possible, and if not from a live animal, should be collected as soon after death as possible. Since it is not practical to sit and wait for an animal to die, or to euthanize a healthy individual of an endangered species to obtain tissue samples, the use of surgical biopsy techniques for tissue acquisition is a viable option.

Techniques for obtaining samples need to meet three criteria. The procedures should produce the exact tissue sample desired by the researcher, should be practical as well as cost effective, and should not impede the animal's function in its environment after release.

Skeletal muscle tissue can be obtained from the pectoralis major muscle of sea turtles. Such muscle samples have been used to study cellular metabolism (Penick et. al., 1993). The turtle is placed on its carapace and the front flippers restrained. The muscle is infiltrated with 2% lidocaine to provide analgesia and then prepped with iodine surgical scrub. A six cm incision is made on the ventral surface of the turtle's shoulder, just caudal to the scapulo-humeral joint. The incision is directed anterior and lateral. Subcutaneous tissue is separated and vessels are ligated. Once the pectoralis muscle is exposed, a rectangular piece of muscle of the desired size is excised. The defect in the muscle is sutured closed, the subcutaneous tissue is sutured and the skin is closed and sutured with simple horizontal mattress sutures of nylon. The surgery site is cleansed and the animal turned upright and allowed to return to the water.

This procedure has been performed on twenty leatherback sea turtles, *Dermochelys coriacea*. The surgery was uneventful, and all the turtles returned to the ocean without incident or apparent problems. Two of the animals were observed nesting two weeks later. Neither animal showed any adverse effects. The wounds were healed, and the sutures were removed by the personnel monitoring the nesting beach.

Bone can be obtained by taking a core biopsy from the mid-shaft of the humerus. These samples are typically used for age and growth studies (Klinger, 1988; Klinger and Musick, 1992). The turtle is given a general anesthetic by way of the dorsal cervical sinus. A combination of ketamine hydrochloride and acepromazine maleate is administered. A base dose of 30 mg/kg (George, unpublished data) for a 10 kg turtle is used, and each animal's dose is calculated using the principles of allometric scaling (Sedgwick and Pokras, 1988). Once the animal is anesthetized, it is placed on its carapace and prepped for aseptic surgery. The incision is made midway between the shoulder and elbow, parallel to the humeral axis and is one-third of the way back from the leading edge of the flipper. The subcutaneous tissue is separated and the incision is continued between the triceps brachii and internal brachial muscles. A Michelle trephine (7 or 9 mm) is used to remove a core of humeral bone. The muscle bundles and subcutaneous tissues are closed. The skin is sutured closed with monofilament nylon in a simple interrupted pattern. The animal is placed right side up and allowed to recover from the anesthesia in a small enclosure containing one to two inches of water. After a two to four hour recovery period the turtle is returned to deep water.

This procedure has been performed sixteen times on fourteen different animals: twelve *Caretta caretta* and two *Lepidochelys kempii*. No post surgical problems were noted. One turtle was recaptured one year post surgery, the humerus was radiographed, and the site of the bone biopsy appeared totally healed.

Both of the surgical biopsy techniques described here provide excellent quality tissue samples. The procedures require only minor surgical instrumentation and can be done in the laboratory or on the beach. The muscle biopsy requires ten minutes of surgical time, and the bone biopsy technique can be accomplished in less then twenty minutes. Neither technique causes the animal any undue discomfort or affects its ability to function in the wild.

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ACUTE CAPTIVITY STRESS IN THE LOGGERHEAD SEA TURTLE (*CARETTA CARETTA*)

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Glucocorticoids (corticosterone and cortisol) have been used extensively as indices of the presence of stress. Most studies on stress physiology have been conducted on captive or domesticated animals and relatively little research has been done with reptiles. This study provided baseline data on the effects of acute captivity stress (capture, repeated bleeding, and restraint up to six hours) on plasma corticosterone (C) concentrations in wild loggerhead turtles, *Caretta caretta*. Loggerheads were captured by trawl (25-30 min tow) at the Port Canaveral ship channel (east coast of Florida) from June-August 1992 (summer) and January-February 1993 (winter). Initial blood samples (n = 107) were taken 40 min immediately after deployment of the trawl, followed by 1 and 3 hour samples. Turtles were also captured opportunistically by tangle net at Cedar Key (west coast of Florida) from June-November 1992. Loggerheads captured in a tangle net were free to surface and initial blood samples (n = 11) were taken within 10 min of first sighting, followed by 30 min, 1, 3, and 6 hour samples. Overall, plasma C concentrations increased significantly over 3 hours with a marked decrease observed at 6 hours for turtles captured in a tangle net. Initial plasma C from small *C. caretta* (< = 80cm) captured in a trawl were 3.6-fold higher than those captured in a tangle net. However, any effects of location were confounded by capture method. Effects of size class and season were determined for turtles captured in a trawl. Plasma C concentrations of small turtles were significantly higher in summer than in winter. No significant difference in C concentrations of large turtles (>80cm) was observed between seasons until one hour after capture. Plasma C concentrations of small turtles were significantly higher than large turtles during summer. Henwood (1987) reported that abundances of large turtles at Port Canaveral were influenced by sex and season. In the present study, summer months were within the nesting season. Large turtles captured during summer were female (tail length <28cm) and of reproductive size. These results suggest that reproductive condition may inhibit the adrenocortical response during acute stress in *C. caretta*.

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THE SEA TURTLE NESTING BEACHES IN THE PENINSULA DE PARIA, SUCRE STATE, VENEZUELA

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Until the end of the 1980s, knowledge of the sea turtle nesting beaches in the Peninsula de Paria was scarce, and it was mainly derived from aerial surveys in the northern and southern peninsula (Carr et al., 1982; Cuellar, cited by Ogren, 1980; Laiz Blanco, 1979; Pritchard, 1980; Pritchard and Trebbau, 1984).

METHODS

Several terrestrial and aquatic surveys have been conducted since 1988. The presence of live sea turtles, tracks, nests and carcasses was recorded.

RESULTS AND DISCUSSION

Sixty seven localities were checked. In twenty beaches of the northern peninsula (Chaguarama de Loero, Mapurite, Puy Puy, Cangua, Querepare, San Juan de Las Galdonas, Purgo, Playa Colorada, Tortuga, El Guamo, El Tigrillo, San Juan de Unare, Guatapanare, Negra, Cipara, Los Cocos, Pargo, San Francisco, Playa Negra, Providencia) and in thirteen of the south (Manzanillo, Cerezo, Obispo 1, Obispo 2, Los Garzos, Lambato, Aricagua, Macuro, Macurito, Morrocoicito, Guinimita, Cumaca, Sivisa), sea turtle nesting was confirmed (Map 1) (Guada, 1993; Guada and Vera, in press; Guada and Vernet, 1988, 1989, 1991, 1992; Guada et al., 1989, 1994).

Suitable beaches in the north of the peninsula are used by the sea turtles, but in low densities. The beaches with major number of reproductive events are the larger localities (> 250 m): Querepare, San Juan de Las Galdonas, El Guamo and Cipara. In the north of the peninsula, the leatherback turtle (*Dermochelys coriacea*) was the species confirmed for more beaches (n = 11). The green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and hawksbill (*Eretmochelys imbricata*) turtles appear in fewer beaches (n = 9, n = 8, n = 6, respectively). *D. coriacea* is the species with the major number of nests within its range, using mainly the larger beaches. In the smaller and usually solitary beaches (as Mapurite, Tortuga, El Tigrillo), predominate the nesting of the green, hawksbill and loggerhead turtles. Several beaches remain unsurveyed, mainly between Cabo Tres Puntas and Ensenada Mejillones.

The confirmed nesting beaches in the southern Peninsula de Paria are concentrated to the east. Usually they do not surpass the 150 m of length (with the exception of Macuro), although those within the National Park do not surpass the 70 m. The most important beaches for the sea turtle nesting are Manzanillo, Los Garzos, Lambato, Macurito and Guinimita. In this area, the nesting of leatherbacks is extremely rare (only confirmed in Macuro). The species confirmed in more beaches was *Eretmochelys* *imbricata* (n = 7), followed by the green (n = 2) and the loggerhead turtles (n = 3). Most of identified nests between Manzanillo and Guinimita were from the hawksbill turtles. Along the Golfo de Paria coast, several suitable beaches are not used regularly. Within the National Park, all the beaches have been surveyed. Various beaches reported as nesting places, to the east of Guiria, must be evaluated.

The inventory of nesting beaches for sea turtles have to be completed. The terrestrial surveys must be conducted at least on a monthly basis, in order to get comparable data about the use of the beaches and to estimate adequately the numbers of the nesting females.

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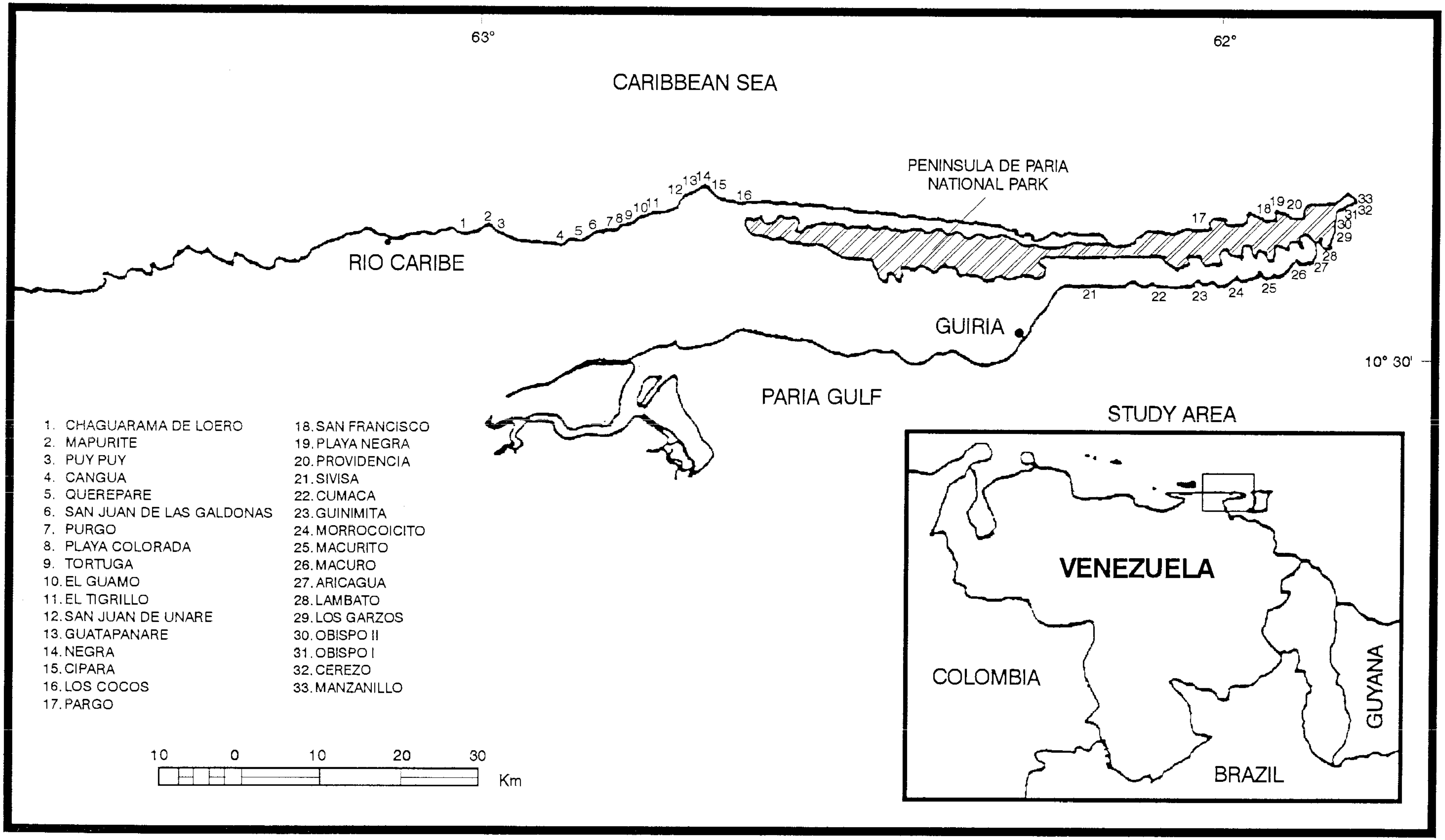

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MAP 1. SEA TURTLE NESTING BEACHES SURVEYED IN THE PENINSULA DE PARIA, SUCRE STATE, VENEZUELA

ANALYSIS OF A FISHERIES MODEL FOR HAWKSBILL HARVEST IN CUBA

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In a 1992 meeting supported by the Japanese Bekko (tortoise shell) Industry, a fisheries model was presented to estimate sustainable yield of Cuban hawksbill (*Eretmochelys imbricata*) for possible export to Japan. The model, originally designed for fisheries management, indicated that Cuba's "closed" population could sustain an annual harvest of 5500 turtles >70 cm CCL. We were commissioned by the National Marine Fisheries Service to analyze the model and its parameters, and to determine if the model is applicable to sea turtles.

We received a computer diskette of the model and documentation of the model equations and parameters. We planned to analyze the model to determine which parameters affect sustainable yield, to calculate new sustainable yields using the model with data from other Caribbean sources, and to create a stage-based model to determine which life history stages are most critical to hawksbill population growth rates. Problems with implementing the computer code have delayed our complete analysis, but we now have a good understanding of the model equations.

The fisheries model is complex, with over 20 parameters. Data on length at maturity and size composition of harvested turtles is converted to age using an age/length key calculated from a von Bertalanffy growth curve. This curve is now fit to three points: maximum attainable size of 100 cm CCL, and CCL at age 1 and age 2 for captive-reared turtles (17 and 25 cm CCL, respectively). Reducing the early growth rate by as little as 20-30% has a profound effect on the calculated age at maturity. The model now predicts an age at earliest maturity of 7 years (55 cm CCL) and all turtles mature by age 14 (78 cm CCL). With a 30% reduction in growth at age 1 and 2, turtles reach maturity in 10 to 21 years. This increase in age at maturity reduces the proportion of large turtles in the population. To implement this harvest model, one would need a much better understanding of hawksbill growth rates.

Fisheries models include a stock-recruitment relationship which includes density-dependence. At low adult population levels, the hawksbill harvest model uses a simple linear relationship between adult biomass and recruitment of 1 year-old turtles into the population. Once the adult biomass exceeds 50% of its pre-harvest size, recruitment becomes constant, and any additional adult biomass is harvestable. This is an arbitrary stock-recruitment relationship. Hawksbills nest at low densities in Cuba, and may or may not suffer density-dependent mortality during their first year of life.

Because we know little about density-dependent effects in sea turtles, and a reliable aging method is unavailable, the current fisheries model is not applicable to hawksbills. In addition, further modelling efforts have shown that large, mature turtle survival rates have a large impact on population growth. Fecundity and hatchling survival are much less critical, a pattern observed in loggerheads as well (Crouse et al., 1987).

Our continuing analysis will investigate the effect of various fishing rates, natural mortality, and age at maturity on the sustainable yield predicted by the model. We will incorporate new data on growth, fecundity, and survival from other Caribbean populations into the hawksbill harvest model and our own matrix models. We will prepare a document of our findings for the National Marine Fisheries Service and the CITES (Convention on International Trade in Endangered Species) committee by November 1994.

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GREEN TURTLE FIBROPAPILLOMATOSIS: TRANSMISSION STUDY UPDATE

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Results of preliminary experiments conducted in 1991 had suggested that green turtle fibropapillomatosis (GTFP) could be experimentally transferred in some form to disease free recipient turtles. These results were insufficient to implicate an infectious etiology and further experimentation was warranted. This paper reports the early results of the most recent set of transmission experiments. Five green turtles, *Chelonia mydas* from each of 4 separate clutches (N = 20) collected on Melbourne Beach were hatched and raised in captivity. The turtles were approximately one year of age when experiments were begun. One turtle from each clutch was assigned to one of 4 treatment groups (corresponding to one of 4 GTFP donors) or to the control group. The 4 tumor donors were wild caught or stranded juvenile green turtles with extensive fibropapillomatosis. External tumors were surgically removed from each donor animal and a 33% w/v crude homogenate was prepared in sterile saline. After several cycles of freezing and thawing to disrupt cells, the homogenates were centrifuged to pellet cellular debris. The cell-free supernatant was used to inject recipients directly or was filtered through 0.45 micron filters to exclude most bacteria and subcellular debris before use. Cell-free homogenate (0.1 to 0.2 ml) was injected intradermally or rubbed into scarified skin at several anatomic sites. Sham treated sites received sterile saline alone and control animals received no treatment. In the 6-9 months since the experiment began, 4 recipients have developed tumors at injection sites and no control sites or control turtles have developed disease. Latency to tumor development is about 4 months. These results strongly suggest that GTFP is caused by a filterable (subcellular) agent present in at least some natural lesions. The most likely subcellular infectious agent is a virus and studies are ongoing to try and identify viral particles within these tumors.

EFFECT OF RETAINING TURTLE HATCHLINGS IN TANKS BEFORE THEIR RELEASE

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Five sea turtle species *Chelonia mydas, Lepidochelys olivacea, Dermochelys coriacea, Eretmochelys imbricata* and *Caretta caretta* nest in Sri Lanka. Hatchery programmmes are implemented in Sri Lanka as a means of conserving turtles. In most of these turtle hatcheries hatchlings are retained in tanks for three days or more (until the abdominal opening is closed), before being released to the sea. The reason for this practice is attributed to a marine leech which is supposed to attack the hatchlings at the open abdominal opening. For three days (during which time food is refused) these hatchlings swim around frantically, in the sea water tanks, probably wasting their energy reserves which is needed for their 'swim frenzy'. This study was to find whether there is an effect on the activeness of hatchlings when retained in tanks for a few days before being released.

METHODS

The study was carried out during January - March 1989, and October - December 1989. *C. mydas* (n=375), *L. olivacea* (n=335), *D. coriacea* (n=50) and *E. imbricata* (n=42) hatchlings were used in this study. Soon after emergence, hatchlings were retained in sea water tanks at the Kosgoda Victor Hasselblad turtle hatchery. They were released on the beach between 7:00-8:00 a.m., on zero day (less than 24 hours), first day (24-48 hours), second day (48-72 hours), and seven days (one week) after the emergence. The sample of hatchlings released each day was dependent on their availability (generally 10-25). A surface without foot print depressions was selected each time along the same stretch of beach. Each hatchling was kept on a line drawn on the beach, facing the sea and was allowed to crawl. The route taken was marked on the sand using a long stick, without disturbing the moving animal. The distance crawled within 30 seconds was measured with a flexible tape.

RESULTS

Statistical analysis revealed a highly significant difference ($p < 0.01$), between the distance crawled by all four species of turtle hatchlings and the number of days retained in the tanks (Table 1). A pairwise comparison (independent t-test) showed a significant difference in the distance crawled between the zero day and the first day; zero day and the second day; zero day and the seventh day, for all four species of turtle hatchlings (Table 2).

DISCUSSION

In nature, emerging hatchlings move in a frenzy until they reach the sea. This exposure is assumed to imprint critical information about the beach that will enable the hatchlings to locate the same beach for nesting, when they are adults. Due to this reason, hatchlings kept in hatcheries are allowed to run down the beach to enter the sea.

However, imprinting in many animals occurs only during a specific time of their life, and it is possible that in turtles imprinting occurs during the 'swim frenzy' period (Mortimer, 1988). Any deviation from natural activity at the stage of imprinting may result in the turtle failing to migrate to the right place for nesting when it matures (Pritchard, 1980). If so, retaining turtle hatchlings in tanks during their 'swim frenzy' may affect the vital imprinting mechanisms, even though they are subsequently allowed to run down the beach.

If the distance crawled during 30 seconds is considered as an assessment of the level of activeness they possess, it is evident from this study that their activeness decreased with the duration they were retained in the tanks. It is likely that they become weak as a result of retention in tanks, and due to the slower speed become vulnerable to predators. During the crawl to the surf, hatchlings from hatcheries are protected from terrestrial predators by the hatchery keepers. Therefore, their weak condition will probably not be a disadvantage to hatchlings at this stage.

It was observed that, most of the 7 day old hatchlings, were washed back on to the beach by in coming waves before they could enter the sea. This was a very prominent feature even in the two day old leatherback hatchlings. In contrast, none of the zero day old hatchlings were washed back. Probably, the weak hatchlings do not possess sufficient energy to overcome the force of the waves.

A marine leech was found attached to the abdominal opening of hatchlings found in the reef on a few occasions. (C. Abrew, personal communication). The marine leeches reported to be parasitic on marine turtles are of the genus *Ozobranchus* (Dodd, 1988; Schwartz, 1974). Sanjeeva Raj (1959), recorded the occurrence of the species *Ozobranchus margoi* (Apathy), in the Indian Ocean. However, the presence of the seven pairs of digitiform branchiae on the leech (Sawyer et al., 1975) from Kosgoda, suggest that it is more likely to be *Ozobranchus branchiatus* (Menzies). This species of leech which is often found in association with fibropapilloma tumors of turtles may probably have some adverse effects on the hatchlings. This requires further investigation.

However, retaining hatchlings in tanks for three days or more, in order to avoid a leech attack, results in weakening of hatchlings. In nature, once the hatchlings enter the sea the 'swim frenzy' carries them beyond the shallow waters to their feeding grounds, beyond the reach of most predators. The post hatching yolk (remaining yolk) may support this frenzied swimming activity (Kraemer and Bennet, 1981). If so, weak hatchlings may probably not possess sufficient energy to escape the aquatic predators and may die even before they reach their feeding grounds.

The data from this study strongly suggest that the turtle hatchlings of all species should be released to the sea before they are one day old, in order to prevent them from becoming weak. The time, money and the energy spent on maintaining turtle hatcheries as a means of conserving turtles will serve no purpose if the hatchlings are released to die within the very early stages of their life.

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Table 1. Summary of ANOVA for the distance crawled by the turtle hatchlings.

Species	Source	df	S.S	F
C. mydas	Between days	3	2661526	95.25 **
	Within days	371	3455670	
	Total	374	6117196	
L. olivacea	Between days	3	517324	40.77 **
	Within days	331	1400103	
	Total	334	1917427	
D. coriacea	Between days	3	252258	37.68 **
	Within days	46	102642	
	Total	49	354900	
E. imbricata	Between days	3	386617	18.91 **
	Within days	38	259021	
	Total	41	645638	

** $p < 0.01$

Table 2. Summary of the pairwise comparison (Independent t-test) of the distance crawled by the turtle hatchlings.

Species	Pairwise comparisons	Mean difference	S.D.	t value
C. mydas	zero/1 day	107	13.49	7.93**
	zero/2 day	139	13.53	10.27**
	zero/7 day	229	13.75	16.65**
L. olivacea	zero/1 day	40.32	10.11	3.98**
	zero/2 day	96.70	1.59	8.34**
	zero/7 day	86.18	9.91	8.70**
D. coriacea	zero/1 day	67.95	25.21	2.69**
	zero/2 day	168.96	16.03	10.54**
	zero/7 day	170.88	13.30	12.85**
E. imbricata	zero/1 day	150.50	11.06	13.60**
	zero/2 day	173.00	35.04	4.93**
	zero/7 day	264.24	35.36	7.47**

** $p < 0.01$

THE HAWKSBILL TURTLES OF BUCK ISLAND REEF NATIONAL MONUMENT: A SHARED RESOURCE OF THE CARIBBEAN

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Research on the small population of hawksbill turtles *Eretmochelys imbricata* nesting at Buck Island Reef National Monument (BUIS) began in 1988. Nightly patrols during the peak nesting season, July to October, have found the turtles returning to Buck Island to nest within the season and after multiple year intervals. In 1991/92 pilot radio and satellite telemetry tracking studies were conducted to define hawksbill turtles internesting habitat and investigate whether or not hawksbill turtles migrate between feeding and nesting areas. Many factors have contributed to the programs success over the years, however the most critical element has been the dedicated help from local and international volunteers.

MIGRATION

The primary goals of the tagging program were to follow individual hawksbill turtles internesting activities, seasonal remigrations, and over the long term determine their migration patterns. When the program first commenced, information about hawksbill turtles from local sources, dive operators, fishermen, and BUIS marine field census studies indicated that there were few to no sightings of adult hawksbill turtles around the Monument prior to or after the nesting season (June - October). Between 1988 and 1993, 78 individual hawksbill turtles have been tagged while nesting and none have been seen resident around BUIS/St. Croix outside the breeding season. In 1991 we conducted a pilot radio/sonar telemetry study tracking the turtles from both shore stations and boat. At the end of the nesting season, 4 transmitter carrying turtles disappeared over the horizon (Starbird and Hillis, 1991). During the 1992 season, a cooperative USFWS/USNPS satellite tracking study of 7 nesting hawksbills showed that the females at the end of the nesting season dispersed outward from BUIS to different regions in the Caribbean. In 1991, hawksbill QQD033 was reported killed in the Miskito Cays, Nicaragua, Central America. The hawksbill turtles that nest on Buck Island do not live in the adjacent reef - they are all migratory!

REMIGRATION

Of the 73 hawksbill turtles tagged over the 6 years, 28 have remigrated back to BUIS for one or more breeding seasons from their distant, undetermined feeding grounds. Tagged hawksbill turtles are returning to nest on 2 to 3 year interval (mean = 2.46, sd = 0.66, n = 13, r = 2 - 4). To date none of the 73 turtles tagged prior to 1993 have been recovered nesting at any other patrolled rookery in the Caribbean (Figure 1).

For a cohort of nesting females recorded in any one year, >50%, possibly >80%, will return to nest on BUIS in a subsequent season (Figure 2). The low recovery rate for the 1988 cohort may be due in part to their having been single tagged in contrast to double tagging having been used in other years. In 1993, all four flippers received tags to improve recapture in subsequent seasons.

RECRUITMENT

If all turtles nesting at a rookery are tagged for a number of years, then untagged turtles should represent the new recruits to the nesting population. An estimation of recruitment into the BUIS nesting population was calculated using tagging census data (Figure 3). These data indicate that when the proportion of tagged turtles in the population stabilizes in a few years time, it will estimate a low recruitment rate (pers comm, C. Limpus, 1994).

NESTING BEACH FIDELITY

Individual hawksbill turtles nesting on BUIS are exhibiting fidelity to varying lengths of the 1.4km of available nesting habitat. Analysis of the 1993 data indicates that if a female lays three or more clutches for the season, then she will spread her clutches over an average distance of 314m (SD = 310, range = 44 - 1051, n = 12).

When a hawksbill turtle lays a clutch, she will return to attempt her next nesting after 15.5 days (SD = 1.95, n = 32, range = 13 - 24). If she is unsuccessful in her nesting attempt, she will return to the beach within one night to attempt nesting again (mean = 0.73 days, SD = 0.78, n = 26, range = 0 - 3) (Figure 4).

To test the impact of nesting success on nest site fidelity, a comparison was made between the distance moved from a successful nesting to the site of next emergence and the distance between the site of an unsuccessful nesting emergence (without laying) to the site of next return. Following a successful nesting, the turtle will next emerge at an average distance of 193 m (SD = 265, n = 37, range = 5-1100). Following an unsuccessful nesting emergence, a turtle will return at an average distance of 262 m (SD = 332, n = 26, range = 5-1040). There is no significant difference between these distances ($F_{1,61} = 0.84$, $p > 0.5$). These turtles appear to be as precise following a successful nesting as they are following an unsuccessful nesting. The nesting fidelity of BUIS hawksbill turtles is comparable to that reported for *C. mydas* (Carr and Carr, 1972), *N. depressus* (Limpus et al., 1984), *C. caretta* (Limpus, 1985).

HURRICANE HUGO EFFECT ON NESTING SUCCESS

It is now 4 years since hurricane Hugo devastated Buck Island. Steep berms, fallen trees, exposed root tangles, and reduced depth of nesting substrate over coral/rocks continue to interfere with hawksbill nesting success. The average number of times a hawksbill emerged for each clutch deposited was 1.55 crawls (SD = 1.12, n = 55, range = 1 - 7). To counter the residual impacts of hurricane Hugo, we will continue to do limited beach restoration and relocate nests laid in erosion zones until we can no longer detect an impact on hawksbill nesting success.

CONCLUSION

Marine turtle conservation does not work from a nesting beach alone. Studies should be expanded to determine the location of hawksbill feeding grounds and migratory routes to nesting beaches like BUIS. Caribbean wide nesting beach studies should be coordinated and the information available through a regional database to which data is reported with a consistency in methodology. The information gathered at BUIS and the other Caribbean hawksbill projects is critical to understanding our shared hawksbill turtle population and ultimately essential to the management and preservation of the species.

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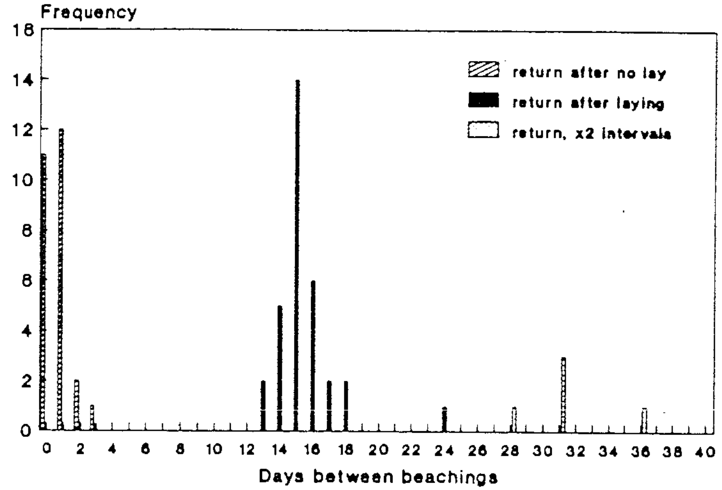
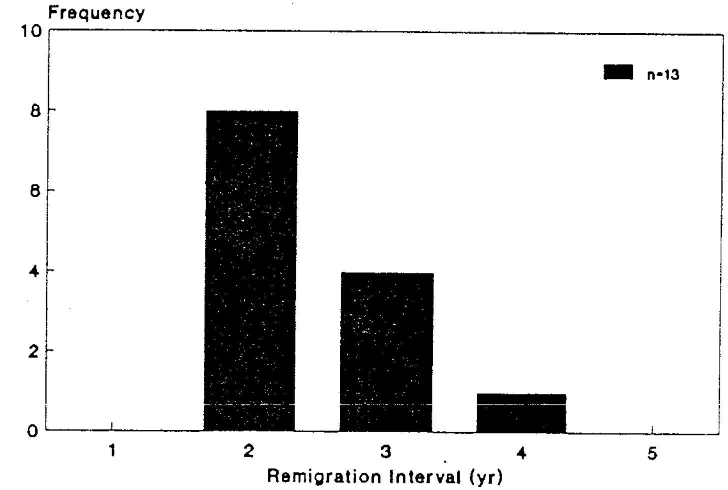
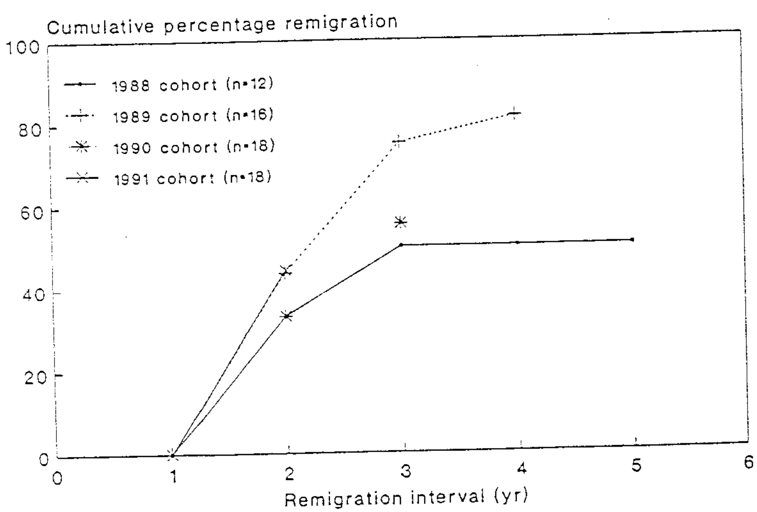
BUCK ISLAND Eretmochelys imbricata
Days between beachings



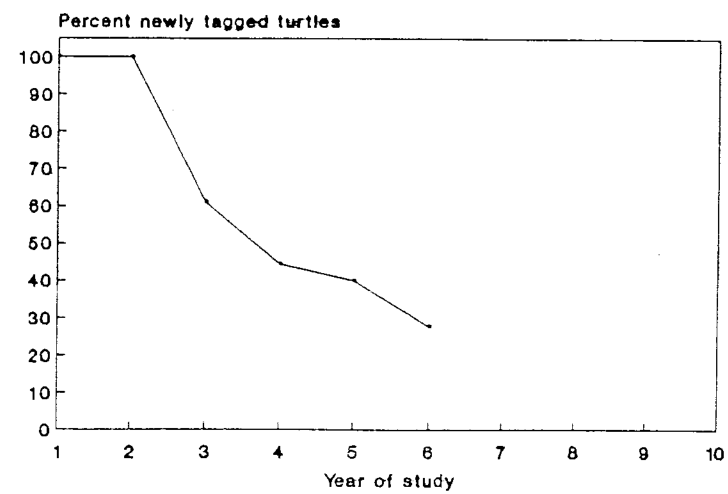
BUCK ISLAND Eretmochelys imbricata
Remigration interval : 1993



BUCK ISLAND Eretmochelys imbricata
Remigration



BUCK ISLAND Eretmochelys imbricata
Recruitment estimation by tagging census



STATUS OF THE LOGGERHEAD NESTING POPULATION IN SOUTH CAROLINA: A FIVE YEAR UP-DATE

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At the 8th Annual Sea Turtle Workshop at Fort Fisher, North Carolina, we reported on the status of the loggerhead nesting population in South Carolina (Hopkins-Murphy and Murphy 1988). In this report we provide a brief review of our methodology and previous data, followed by the most recent update with some interpretations of the results.

METHODS

In 1980, South Carolina DNR began aerial beach surveys designed to provide longterm monitoring of the loggerhead nesting population in South Carolina. A detailed description of the methodology is found in Hopkins-Murphy and Murphy (1983) and in Pritchard et al. (1983). Aerial surveys are flown in summer from Murrells Inlet to the Georgia state line. The northern portion of the coast is omitted since nesting along this highly developed beach is practically nil. Three consecutive days of flights are conducted every two weeks during June and July on a particular tidal cycle. This allows for 12 flights during the major part of the nesting season and provides approximately a 17% sample of the nesting effort. This tidal regime assists to avoid counting old crawls and standardizes the field signs for fresh nests. Flights begin at dawn and are completed by 0830. The aircraft, a Cessna 180 with high wing, is flown at approximately 150 feet and between 70-100 kt ground speed, depending upon nesting densities. Tracks are recorded using a digital counter or a tape recorder along beaches where ground surveys are used to verify aerial counts.

Ground truth is provided on three of the beaches at the same time as the flyover. All body pits are probed to verify the presence of eggs and to obtain 100% accurate ground truth. Ground truth beaches provide approximately a 40% sample of nesting effort for the flights and are used to adjust statewide aerial counts for bias. Flights are flown for three consecutive seasons and the average number of nests per set of flights is determined. According to Richardson (1982), approximately 83% of the nesting population would be monitored during a three-year period. The surveys are repeated on a five-year interval for longterm monitoring.

RESULTS

As previously reported at Fort Fisher, the loggerhead nesting population in South Carolina experienced a 26.4% decline statewide between the 1980-82 and 1985-87 survey sets, or in excess of 5% per season. The decline was similar in all parts of the coast and was just as severe on undeveloped, protected areas as on developed beaches. We flew our third set of flights during 1990-92 and are cautiously optimistic about the results. It appears that the statewide decline has slowed during this five year interval. However, when the new data are compared to the previous two sets of flights, some interesting patterns emerge. The northern portion of the coast continued a very slight decline while the southern portion increased by nearly 8%. We speculate that this may be a result of Hurricane Hugo in the fall of 1989. The eye of the storm came ashore at Charleston. With the counter-clockwise rotation, winds were onshore to the north of the city and from the landward side to the south. Therefore all of the dunes north of Charleston were levelled, but south of there, beaches were not affected. This is supported by the nest to false crawl ratio. There were nearly three times as many false crawls on beaches north of Charleston. Whether turtles shifted nesting to the south or whether extensive false crawling extended their internesting interval and resulted in fewer nests being laid is not known. There was a slight rise in nesting on Cape Island and a decline on other beaches in this same area. These results are discussed below. There continued to be a slight decline on developed beaches.

Although "site fixity" is documented for many species of marine turtles, we feel this may be influenced by the stability of the particular beach. South Carolina barrier islands are anything but stable. In fact, one of the islands only rose above sea level and became vegetated in the 1950's. We have a few examples that indicate turtles are redistributing themselves in response to the quality of nesting habitat. We compared several of the islands within the Santee Delta-Cape Romain Biosphere Reserve. Raccoon Key and Lighthouse are two islands just south of Cape Island. Raccoon Key once contained low dunes and about 250 nests per season. Now because of severe erosion, it is just a shelly overwash with only about three dozen nests per season. Also, as Cape Island's beach builds to the west in front of Lighthouse, it prevents access by turtles to that beach. Thus the 12.3% rise in nesting at Cape may be turtles that previously nested on Raccoon Key and Lighthouse. Sand and South islands show almost a "mirror image" as the nesting effort rises and falls on these two adjacent islands. In the southern part of the state, Fripp Island once had over 150 nests per season. Over the last decade, the property owners have placed rock revetments along the shoreline until now the entire island is armored. There is only a small sandbar at the north end and nesting has declined to less than 40 nests per season during 1990-92 and to only 4 nests in 1993. Meanwhile, just to the south, Pritchards and Little Capers islands, have shown increases in nesting. Here at Hilton Head, nesting increased by 38% following beach renourishment. We feel that these results show that loggerheads shift their nesting sites in response to changes in the quality of the nesting habitat.

We also wondered if there was a relationship between the change in the nesting population and the use of Turtle Excluder Devices (TEDs). South Carolina was the first state to enact regulations requiring their use in 1988 based on the first two sets of flights showing a 26.4% decline. Although both the state and federal regulations were involved in law suits for two seasons, there was at least partial TED use during 1988 and 1989. There has been good compliance in South Carolina since TED regulations went into full force in 1990. The mean number of strandings per season for juvenile and sub-adult loggerheads dropped from 146.6 to 50.3 and from 38.3 to 8.5, respectively before and after TED implementation. During this same time, the number of adult females stranding went from 27.1 to 13.8. We did not include any April strandings which were caused by a set net fishery for Atlantic sturgeon or any males. Juveniles composed approximately 69% of the total strandings for both periods. However, the percent composition of sub-adults declined from 18.1% to 11.7% after TED implementation, while the percent of adult females rose from 12.8% to 18.9% of the total strandings. This shift towards adult females indicates that TEDs may not exclude all size turtles equally.

SUMMARY

First, statewide aerial surveys and individual beach monitoring show that the decline has slowed. Second, on a smaller scale, we see a redistribution of nesting in response to changes in beach habitat. We feel that this is important for other monitoring projects to consider if some beaches are ground surveyed and then used as an index to the total nesting effort. We feel aerial surveys are still needed to determine the percent distribution that those index beaches represent. Third, TEDs may be less effective for adult sized turtles. State stranding coordinators should examine their data for any such trends. We hope that the drop in nesting during 1993 was a normal fluctuation in loggerhead nesting and not a continuation of the previous decline.

ACKNOWLEDGMENTS

This research is supported by grant-in-aid funding from the U.S. Fish and Wildlife Service under Section 6 of the Endangered Species Act. Special thanks go to Nora Murdock for her continuing support of this longterm monitoring effort.

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INFLUENCE OF ORGANIZED TURTLE WATCHES ON LOGGERHEAD NESTING BEHAVIOR AND HATCHLING PRODUCTION IN FLORIDA

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Loggerhead turtles are an important ecotourism resource in Florida. Each summer, thousands of tourists participate in organized turtle watches. Turtle watches provide an opportunity for the public to view a female loggerhead during her nesting process. To ensure as little disturbance as possible to the nesting female, the Florida Department of Environmental Protection has established guidelines that regulate how public turtle watches are to be conducted. However, no data were previously available to evaluate the effectiveness of these guidelines. We measured duration of various behavioral phases and evaluated hatchling production for turtles observed by an organized turtle watch group (watch turtles) and turtles not observed by a group (control turtles). The study was conducted along the east coast of Florida in central Brevard County during the summer of 1993. We found significant differences between watch and control turtles for mean duration of covering and camouflaging behavior phases. No significant differences between watch and control turtles were found for mean duration of body pit construction, egg chamber excavation, or oviposition. No significant differences in hatchling production were found between egg clutches deposited by watch and control turtles. Additionally, there was no significant correlation between duration of any behavioral phase and hatching success or hatchling emergence.

EFFECTS OF A NEST SCREENING PROGRAM ON RACCOON PREDATION OF SEA TURTLE EGGS AT CANAVERAL NATIONAL SEASHORE

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A study of 861 sea turtle nests deposited on the northern 12 miles of Canaveral National Seashore (Fig. 1) was conducted during the 1990 sea turtle nesting season. Eight-hundred thirty-four were from loggerheads (*Caretta caretta*), and the rest were from green turtles (*Chelonia mydas*). Six-hundred seventy-seven nests were screened with 4 X 4 ft sections of 2 X 4 in mesh galvanized welded wire within 4 hours of being deposited. The screens were anchored by 3 ft lengths of steel concrete reinforcement bar hooked at the top and hammered into the sand. One-hundred eighty-four nests were not screened due to either raccoon predation within 4 hours of deposition (167 nests) or lateness of season (17 nests). An additional 731 turtle emergences did not result in nests.

More nests were laid in June than any other month, August having the fewest of any month in the season (Fig. 2). The numbers of false crawls and aborted nests (cavity dug but no eggs deposited) also were highest in June (Fig. 3). August saw more false crawls than May but fewer aborted nests.

Eleven of the screened nests were completely destroyed by raccoon predation, with an additional 8 suffering only partial predation (Fig. 4). Thus 97% of screened nests were protected from raccoon predation. Forty-six of the screened nests suffered raccoon tampering but not predation. Human tampering was not a problem in this study, affecting only 4 screened nests. Flooding affected only 3.

No green turtles nested until June, and only 2 of their 27 nests were predated by raccoons. Only 1 was destroyed.

Hatching success rate was determined for 60 randomly selected clutches by dividing the number of eggs hatched by the clutch size. The average hatching success for screened nests laid in May, June and July was 82%.

Before Canaveral National Seashore's nest screening program was established, raccoons were known to destroy 90 to 98% of all sea turtle nests (McMurtray and Irwin, 1982). Nest screening is therefore highly recommended for the control of raccoon predation of sea turtle nests.

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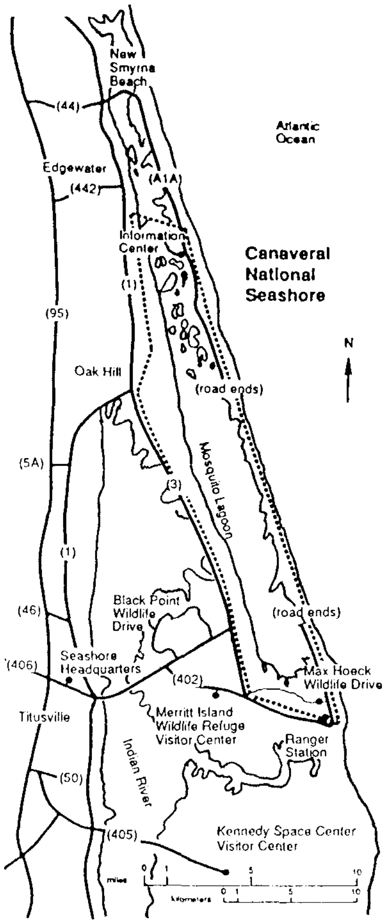

Figure 1. Canaveral National Seashore.

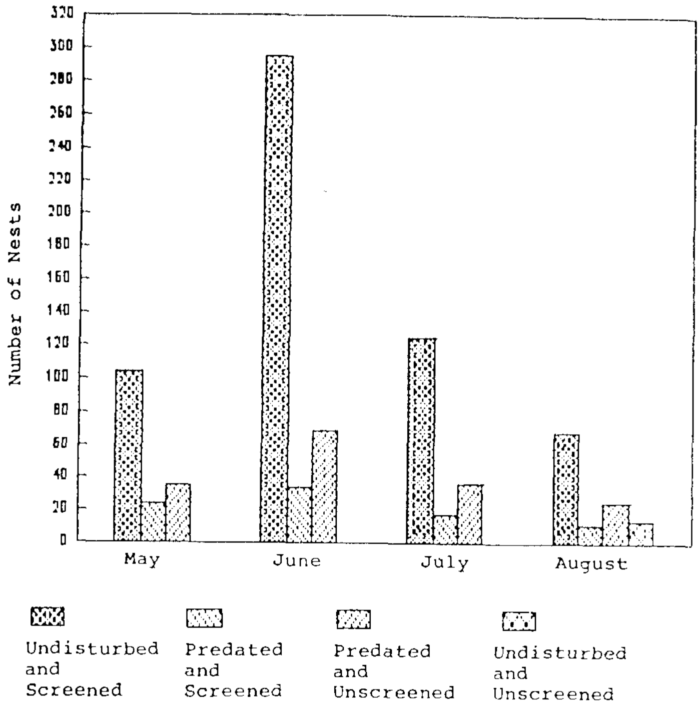

Figure 2. Treatment of new nests by month.

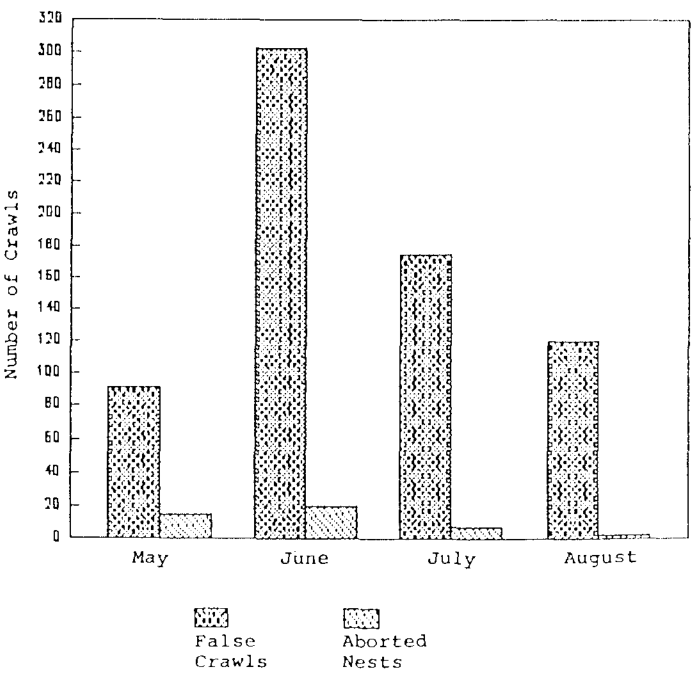

Figure 3. Crawl counts by month.

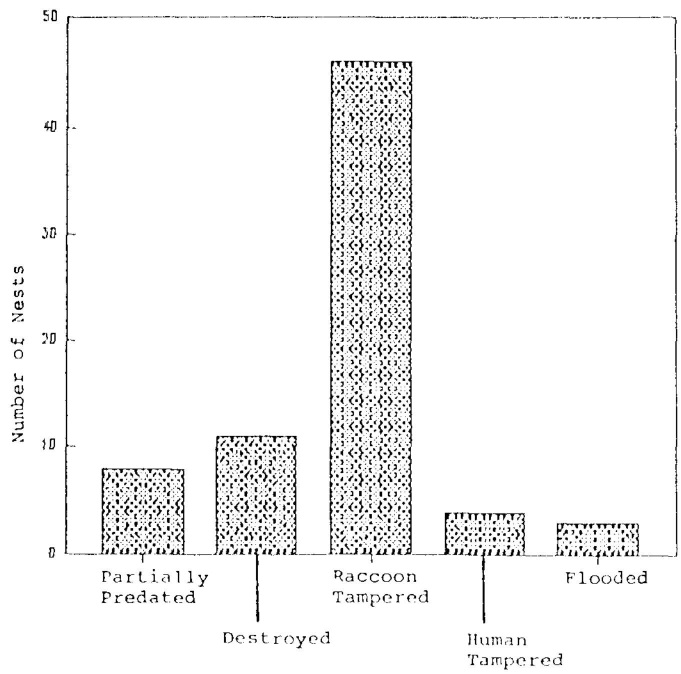

Figure 4. Types of damage to screened nests.

DIFFERENCES BETWEEN SOLITARY AND ARRIBADA NESTING OLIVE RIDLEY FEMALES DURING THE INTERNESTING PERIOD

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Female olive ridley sea turtles (*Lepidochelys olivacea*) exhibit a nesting behavior known as an arribada. This is a highly synchronous nesting phenomenon with several thousand females emerging from the sea to nest. Some females also nest alone out of sequence with the arribadas. The objectives of this study were to identify behavior patterns during the internesting period and to compare the behavior of arribada and solitary nesting females.

The study took place at Nancite beach in Santa Rosa National Park on the Pacific coast of Costa Rica during the summer of 1991 and the summer and fall of 1992. Radio transmitters were affixed to the carapaces of 15 arribada and 9 solitary nesters. Internesting intervals, subsequent nesting at Nancite, and movements offshore were monitored. When possible, additional data from recaptures of flipper tagged individuals were included in the analyses.

Arribada females have a longer internesting interval, probably influenced by external (environmental) cues, and remain within five km of the beach most of the time. Females that nest solitarily, at least once per season, have a shorter internesting interval, probably regulated by internal (physiological) cues. This interval is around two weeks and is similar to what is seen in other sea turtle species. In addition, solitary females are less likely to stay near Nancite during the internesting interval, and they are less likely than the arribada females to nest again at Nancite (the latter point is based on a very small sample).

RECENT FINDINGS AND MANAGEMENT OF HAWKSBILL TURTLE NESTING BEACHES IN HAWAII

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The Hawksbill turtle (*Eretmochelys imbricata*) is an endangered marine species, occurring in tropical waters of the Atlantic, Pacific, and Indian Oceans (Witzell, 1983). In the United States, nesting has been documented in southern Florida and Hawaii, however, in recent years Hawksbill turtles have rarely nested in Florida. Regular nesting activities are currently found only in the Hawaiian Islands, particularly on the southeastern coast on the Island of Hawaii.

From 1989 to 1993, Hawaii Volcanoes National Park (HAVO) located nesting beaches and followed-up with a monitoring and protection program. Eight beaches were found having nesting activities, two within HAVO (Apua and Halape) and six outside its boundaries (Kamehame, Punaluu, Horseshoe, Ninole, Kawa, and Pohue). Eighteen turtles were tagged and 98 nests were documented, most occurring at two principal sites, Kamehame (51 nests) and Apua (37 nests). The nesting season, from egg laying to hatchling emergence, began in late May and extended to early December with peak egg laying periods from late July to early September.

The limiting factors affecting nesting and hatchling success were predation by mongooses, hatchling strandings, overcrowding nests, artificial lights, unregulated vehicle traffic, fishing activities, and camping. During five years of monitoring nests and trapping predators at Apua, and three years of effort at Kamehame, approximately 2,750 hatchlings were rescued, 797 hatchlings died stranded on rocks, and 326 mongooses, 12 feral cats, and 141 rats were removed.

In addition to Hawksbill nesting activities at Kamehame, we observed nocturnal basking of Green sea turtles on about 75% of our visits. It is suggested that the Green sea turtles are utilizing this beach as a resting refuge.

Two additional nesting beaches were discovered by hikers in 1993. A nest with 205 hatched eggs was found at Pohue Bay which is located approximately 10 miles northwest of South Point. The other site, Papai, located approximately eight miles southeast of Hilo, has not yet been visited by HAVO personnel to confirm the nesting report.

To ensure the success for future nesting, an intensive management program on almost a daily basis from June through early December is needed to locate all nests for each beach, to control predators, and to rescue hatchlings. In addition, surveys need to be conducted at other potential nesting sites on the Island of Hawaii.

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KEMP'S RIDLEY SEA TURTLES FROM VIRGINIA WATERS

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The Chesapeake Bay is an important foraging area for Loggerhead (*Caretta caretta*) and Kemp's ridley (*Lepidochelys kempii*) sea turtles each summer (Barnard et al., 1989a, 1989b; Bellmund et al., 1987; Byles, 1988; Keinath et al., 1987; Keinath and Musick, 1991a, 1991b; Lutcavage and Musick, 1985; Musick, 1972, 1988). Ridleys were historically found within Chesapeake Bay (Hardy, 1962) and are the second most abundant sea turtles, with "probably hundreds" inhabiting the Bay each summer (Musick, 1988).

Juvenile Kemp's ridleys are found along the east coast of the United States as far north as New England (Carr, 1952; Danton and Prescott, 1988; Meylan, 1986; Meylan and Sadove, 1986; Ross et al., 1989). Recent data suggests young ridleys migrate northward from Florida as water temperatures rise in the spring (Henwood and Ogren, 1987), and the turtles utilize northern estuaries and Bays throughout the summer months as foraging areas (Keinath et al., 1987; Keinath and Musick, 1991b; Meylan, 1986; Ross et al., 1989). In Chesapeake Bay, ridleys forage in shallow water grass beds feeding on blue crabs (*Callinectes sapidus*; Bellmund et al., 1987; Byles, 1988; Keinath et al., 1987; Lutcavage and Musick, 1985). As the water temperatures cool in autumn, turtles exit the Bay (Byles, 1988; Keinath et al., 1987).

METHODS

Data from dead and live Kemp's ridleys were collected by VIMS personnel and the cooperating stranding network. When possible, carapace and plastron measurements, weight, and location of the animals were recorded. Live healthy turtles were flipper-tagged, injected with tetracycline for growth studies (Klinger, 1988), and released into Chesapeake Bay, its major tributaries, or the adjacent Atlantic Ocean.

Since ridleys are small and inconspicuously colored, standing stock of Chesapeake Bay's ridleys could not be determined by aerial observation. We used a model utilizing a ratio of loggerhead standing stocks and the number of ridleys and loggerheads which stranded along the shore of the lower Chesapeake Bay:

$$R = L * (S_r / S_l)$$

where

R = estimated standing stock of ridleys
L = standing stock of loggerheads estimated from aerial surveys
S_l = number of stranded loggerheads
S_r = number of stranded ridleys

This model assumes that ridleys strand in the same proportion as loggerheads. Byles (1988) estimated standing stock of loggerheads for the lower Bay (L). Because most of the lower Bay has had excellent stranding coverage, we consider S_l and S_r reliable.

RESULTS AND DISCUSSION

Between 1979 and 1993, 202 ridleys were examined. These consisted of 67 healthy, 10 sick or injured, and 125 dead turtles. Of the sick or injured turtles, five were rehabilitated and released, and five died. Most dead ridleys were found along the shore south of the mouth of Chesapeake Bay and in the lower Bay, while most live ridleys were captured by cooperative fishermen in the York and Potomac Rivers. The distribution of live turtles reflects capture effort rather than distribution of free ranging animals.

Over 70 ridleys have been flipper-tagged in Virginia from 1979-1993. Of these turtles, three were recaptured in Virginia, two in Maryland, two in Florida and one in North Carolina. Two turtles tagged in Florida and one tagged in Massachusetts were recaptured in Virginia. Recaptures indicate that young ridleys which inhabit Chesapeake Bay during the warmer months spend the colder months in the south-east. We have satellite-tagged seven Kemp's ridleys in Virginia. Data from these turtles shows that Kemp's ridleys travel south nearshore and overwinter as far south as Cape Canaveral (Keinath, 1993).

Number of ridleys observed has been inconsistent among years but, in general, total number of turtles observed has increased. Although this may be due to increased number of animals in the area, it also may be related to increased public education throughout Virginia, and the resultant increased reports of stranded turtles.

Monthly patterns of occurrence resemble those of loggerheads (Bellmund et al., 1987). Most strandings and live captures occurred in May and June and coincided with the spring immigration, followed by a sharp decline after June. Most spring strandings occur in Chesapeake Bay, while most fall strandings occur along the oceanfront where there has been active flounder trawl fishing. The cause of the spring mortality is uncertain, but may be related to interaction with various fixed net fisheries (such as the black drum gill net fishery which is active at that time of year). Some years the fall ridley (and similar loggerhead) mortality coincided with the flounder fishery off SE Virginia and northern North Carolina.

Ridley turtles most often encountered were 30 to 40 cm subadults. Mean size was 39.7 cm curved carapace length, notch to notch (SD = 10.1; range 16.0-68.2; N =118), which is larger than the ridleys found in Long Island Sound (28.2 cm, Meylan and Sadove, 1986) and Cape Cod Bay (27.1 cm, Danton and Prescott, 1988). We speculate that as Kemp's ridleys get older, they utilize more southern habitats, until most adults are found in the Gulf of Mexico. The largest ridley from Chesapeake Bay, 68.2 cm, is the size of adult Kemp's ridleys (Ross et al., 1989).

Sea turtle mortality in Virginia is caused by numerous factors (Bellmund et al, 1987). The cause of death of the majority of the ridleys found sick, injured, or dead could not be detected. Causes of death were, in order of decreasing frequency: propeller wounds, observed constriction wounds (suggesting entanglement in gill nets, crab pot lines, or pound net leaders and subsequent drowning), carapace damage (possibly from boat collisions), puncture wounds (possibly from gunshots or gaffs), cold stunning, an unknown disease, and bone disease.

The ridley recaptured in 1989 exhibited swollen joints at the distal end of each humerus, and this same condition was observed in two turtles in 1990. One turtle's condition deteriorated throughout its period of captivity at VIMS, and was euthanized in December 1990. The ends of most of the longbones were eroded, and the joints were encapsulated in cartilaginous material. *Pseudomonas* and *Proteus* were cultured, and the illness is being further studied.

Between 211 and 1083 Kemp's ridleys are estimated to inhabit the lower Chesapeake Bay during the warmer months. Summing the months by year gives estimates of 211-585, while summing the years by month give estimates of 289-1083. It is probable that pooling the data over the years provides the best estimate of the annual ridley population in the lower Chesapeake Bay (311-464 individuals).

Chesapeake Bay is an important summer foraging area for juvenile Kemp's ridley sea turtles. The biologically productive nature of the estuary provides the large amount of food needed by many growing animals, including juvenile sea turtles. Ridleys enter the Bay in May and June, forage throughout the warmer months, and depart when the water temperature drops. Evidence suggests these turtles travel south for the cold months, and may return in subsequent years. The interaction between sea turtles and the spring black drum fishery should be addressed. The contribution to mortality by the flounder trawl fishery during the fall migration should be monitored, since it is implicated in many ridley deaths.

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SPATIAL AND TEMPORAL DISTRIBUTION OF THE KEMP'S RIDLEY AT SABINE PASS, TEXAS

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The Kemp's Ridley Recovery Plan (United States Fish and Wildlife Service and National Marine Fisheries Service 1992), in an attempt to provide insight into the population status of the endangered ridley, mandates ecological and behavioral information on at-sea life history stages. Field investigation characterizing a Kemp's ridley (*Lepidochelys kempi*) index habitat at Sabine Pass, Texas, resulted in substantial captures of the species, and suggest adequate abundances exist upon which to conduct much needed population research. Identification of community dynamics occurring within the index habitat (i.e., water temperature and food availability), provided a seasonal description of Kemp's ridley occurrence in the northwestern Gulf of Mexico. Ridleys were captured at different habitats using 91.4 m long entanglement nets of different depths and mesh sizes. Turtles were transported to a holding facility immediately after capture, at which time carapace length and total weight statistics were recorded. Prior to release, turtles were flipper- and PIT-tagged. Turtles were then released at the original capture site. Ridley CPUE was compared across seasons and habitats. The influence of blue crab abundance, and bycatch from shrimping, upon the occurrence of ridleys in nearshore habitats was examined.

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BIOTELEMETRIC STUDIES ON THE GREEN TURTLES OF PULAU REDANG, MALAYSIA

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Pulau Redang, a coral fringed island located 45 km off the coast of Terengganu, has one of the largest green turtle rookeries in Peninsular Malaysia. Presently, the island is gazetted as a Marine Park, which prohibits fishing within one nautical mile from the coastline. Radio and ultrasonic telemetry devices were employed to study the inter-nesting movements and diving behavior of the turtles and to assess whether present park regulations provide sufficient offshore protection during the nesting season. Five adult female green turtles were equipped with these devices immediately after egg deposition and were monitored closely throughout an inter-nesting period. Results obtained showed that all five turtles remained close to the island and the nesting beach throughout the inter-nesting period. They spent the majority of their inter-nesting time resting on the sea floor at an average depth of 10 m. None of the turtles tracked appeared to engage in foraging activity. One of the turtles was mated during the tracking period. Present Marine Park regulations appear sufficient in providing offshore protection to most of the turtles during the nesting season but incidental capture in fishing gear is still a serious threat when they perform distant migrations at the beginning and end of the breeding season.

THE BASKING GREENS OF BOUNTIFUL ISLAND
KAY'S TURTLES REVISITED

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In 1973 William Collins Sons & Co Ltd published a book, "Kay's Turtles", recounting the adventures of Kay, a Torres Strait Island girl, with wild green turtles (Bustard, 1973). The book is illustrated with impressive photographs of mass strandings of basking and mating green turtles. The story is presented as "an authentic account" and the name and location of the island(s) is not supplied "lest it result in a rush of tourist-sightseers". The reader is only given Torres Strait, the narrow straight between eastern Australia and Papua New Guinea, as the general location for the site of the story.

The authors have extensively surveyed the marine turtle resources of Torres Strait, and we can categorically say that massed basking and mating by green turtles on the shore and immediately adjacent shallows does not occur on any island in Torres Strait.

However, this massed basking and associated mating behaviour of green turtles characterises the three major green turtle rookeries of the Wellesley Group in the southeastern Gulf of Carpentaria (Bountiful, Pisonia and Rocky Islands) in northern Australia. Some of the photographs in "Kay's Turtles" (opposite pp.64, 113) can be matched to particular lengths of the shoreline at Bountiful Island (16°40'S, 139°51'E). Bustard visited these islands prior to 1972 (Bustard 1972). These islands lie approximately 600km to the south of Torres Strait.

While the story of Kay and her turtles must be regarded as fiction, the basking green turtles of Bountiful Island and adjacent Pisonia and Rocky Islands are very real. They have been the subject of study during recent years and the following is a summary of observations of these basking turtles.

Although *Chelonia mydas* and *Natator depressus* nest in abundance at these uninhabited islands, especially in the winter months, only *Chelonia mydas* are stranding, sometimes as isolated turtles, sometimes in groups of up to 400 in a single small embayment. Most of the stranded turtles are found lying in the shallows with their carapaces partly exposed to the air or are lying completely exposed on the beach. These turtles give the appearance of "basking". The "basking" turtles are mostly internesting females with some adult males. This is interpreted as a voluntary behaviour, because the "basking" turtles can leave the beach or shallows at any time and return to the sea. These strandings have been recorded at the same sites on these islands over decades by local fishermen. While some turtles crawl out of the water to lie on the beach, most sit in the shallows and the falling tide exposes them. The largest concentrations of "basking" turtles are visible on low tides, especially on spring low tides during the middle of the year. The turtles do not appear to move away from these sites when the tide comes in and the water is deeper.

No immature turtles have as yet been found among the "basking" turtles. All females examined have had healing recent courtship bite marks on the neck and shoulders and/or claw marks on the anterior margins of the carapace. All have been recently mated. All females whose gonads have been examined by laparoscopy have been carrying oviducal eggs and/or fully formed mature follicles. When tagged some of these turtles can be found nesting on the island within a few nights. All males examined had recent courtship bites to the rear margins of their flippers and/or dorsal tail. While some courtship groups can be seen in the adjacent shallows, many adult females were seen submerged in the shallows but were ignored by the males unless the female began rapid swimming (as in escaping our capturing attempts). Of approximately 340 green turtles examined, none had scars indicating having been mauled recently by a shark.

It is our interpretation that internesting female turtles, i.e. females that are in the oviducal egg production phase, must have an empty gut and therefore can not be feeding. (None of the ~290 females examined in July 1992 were observed feeding, 2 of ~50 adult males were seen to feed.) If the females are not feeding they will not be thermoregulating to assist in food digestion. Whether there is thermoregulation for assisting egg production has not been addressed.

Our observations indicate that females do not have to enter the shallows to escape the attention of courting males (Bustard 1972). This is consistent with them being females that have completed courtship. With no evidence of significant shark attack on turtles in subtidal waters, it is difficult to argue for these turtles are "basking" as a strategy to escape marine predators.

CONCLUSION

These turtles appear to be functioning as normal internesting turtles, except for the "basking". As is normal for internesting females, there were a small numbers of sexually active males associated. If they are internesting turtles then it follows that for these rookeries, part of the internesting habitat occurs in intertidal waters. These "basking" turtles are very likely to be negatively impacted by regular human visitation to these islands. Management of these islands needs to consider not just the conservation of the turtle nesting populations but also this unique green turtle massed "basking" behaviour.

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THE LOGGERHEAD TURTLE, *CARETTA CARETTA*, IN QUEENSLAND: FEEDING GROUND SELECTION FOLLOWING HER FIRST NESTING SEASON

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Slow growth resulting in decades to reach maturity, their great longevity and the vast distances over which individuals migrate during a life time have hindered a good understanding of the demographics and conservation management of marine turtles. No one has followed a marine turtle in the wild through a complete life cycle from birth to sexual maturity. However, if the long term tagging studies that commenced in the 1960's and 1970's can be maintained operational, many of the questions relating to long term issues such as growth, age and dispersal will be addressed.

Some interim results from part of one of these long term studies of immature marine turtles in a coral reef feeding ground is presented. The results illustrate that systematically planned, long term tagging studies continue to provide valuable insights into the ecology and migration of marine turtles.

METHODS

Caretta caretta resident on Heron Island Reef and adjacent Wistari Reef have been part of a tag-recapture study of feeding ground turtles since 1974. Methodologies follow Limpus (1992a,b). The standard size measurement of these turtles is the mid-line curved carapace length (CCL) measured with a flexible tape measure. Approximately all *C.caretta* resident on Heron Island Reef have been tagged since 1976 and new recruits to the feeding ground are recognised by the absence of tags and tag scars, the atypical assemblage of epifaunal and epifloral commensals when compared to long term residents of these reefs and the black stained jaw sheaths within the buccal cavity. Commencing in 1982, turtles have been assessed for sex, maturity and current breeding status using a visual examination of gonads via laparoscopy. Most adult and near-adult females have had their gonads examined annually. Some of these same turtles also have been recorded during tagging studies of nesting turtles on numerous eastern Australian rookeries. These rookery tagging studies have been in progress since 1968.

RESULTS AND DISCUSSION

Ten female *C.caretta* have been followed since they recruited and established residency on this coral reef feeding ground (Heron Island Reef) to their first breeding season and beyond (Table 1). All recruited to residency in this feeding ground as large sexually immature females with a mean CCL = 83.3 cm (SD = 2.965, range = 80.0-87.5, n = 10). All were recaptured repetitively (11 - 55 captures per female) on Heron Reef or occasionally on adjacent Wistari Reef. During approximately annual laparoscopic examinations of their ovaries and oviducts, the maturation of these females to adulthood was observed. Subsequently each was observed to prepare for her first breeding season. A female was scored as having bred if she was observed laying eggs (X2757 at Lady Musgrave Is. and X9374 at Wreck Rock beach on mainland southern Queensland; X9334 at Isle de Pine, southern New Caledonia), if she had shelled oviducal eggs (T16312 at Fraser Island, south Queensland, autopsy results) or if she was recorded with ovarian scars (corpora lutea or corpora albucantia. Remaining 6 females in Table 1). As maturing females, they were resident at this feeding ground for an average of 11.6 yr (SD = 2.12, range = 8-14yr, n = 10) before they bred for the first time. The regular capture and slow growth of these maturing females is illustrated by the growth of three of them (Figure 1).

None of these females have been observed nesting on Heron Island or Wreck Island, the two closest *C.caretta* rookeries to this feeding area (<8km and 13km distant, respectively. Since 1974, all nesting *C.caretta* on Heron Island and most nesting *C.caretta* on Wreck Island have been tagged.). All of the resident females of the present study are presumed to have departed Heron Island Reef during their first breeding seasons. Four of these turtles were recorded migrating 67-1505km from the feeding area to their respective nesting beaches. For female X9334, this would have involved a two-way (1505 km each way) crossing of the oceanic waters of the Coral Sea. Such distances are within the migration range recorded for other *C.caretta* that breed in southern Queensland (Limpus et al., 1992). At first reproduction these females had a mean CCL = 93.9 cm (SD = 2.394, range = 90.5 - 98.3, n = 10), i.e. slightly smaller than the average size of all adult *C.caretta* at a rookery (Limpus, 1991).

At the completion of the first breeding season, nine of the ten females were recorded (2 - 12 recaptures per female) back at the same feeding ground as where each had completed her sexual maturation. The remaining female died following an attack by a large shark during her first breeding migration. Autopsy results following her being beachwashed alive on Fraser Island on 27 November 1993 and dying the following day, showed that she was in the process of shelling her first clutch of eggs.

On the basis of these observations, the long term fidelity to a feeding ground that characterises breeding adult *C.caretta* across their breeding migrations (Limpus et al., 1992) has its origins in an imprinting to the feeding ground at which the turtle grows to sexual maturity. It appears then that individual *C.caretta* will spend the greatest period of their lives within the developmental habitat at which they reach sexual maturity and specifically at a particular site within that developmental habitat. The association with this site should last many decades as the turtle not only grows to maturity but as she lives out her adult life, making only brief reproductive migrations away from her feeding ground site to her particular nesting beach. Demographically, this habitat in which she completes her developmental migration is highly significant, given that here she will spend the greatest part of her life. High annual survivorship of turtles in this habitat is essential if a life history strategy with a long life to maturity and an extended breeding life is to succeed (Crouse et al., 1987).

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Figure 1. Growth to sexual maturity of immature *Caretta caretta* following their recruitment to residency in a coral reef feeding ground in the southern Great Barrier Reef. "*" denotes breeding.

Caretta caretta : FEMALES
GROWTH TO MATURITY and BREEDING (*)

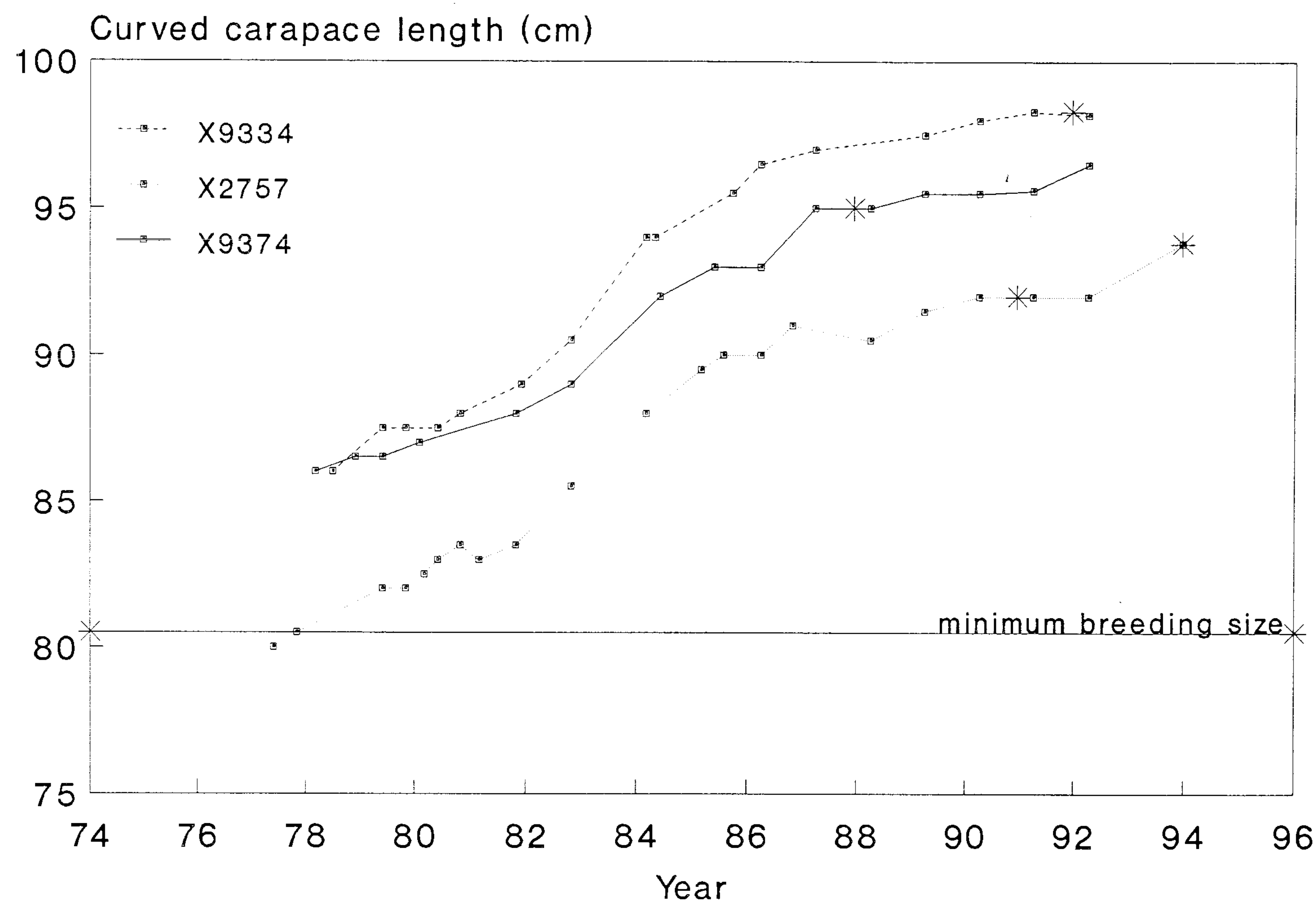

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Table 1. Data summary for female *Caretta caretta* that have been identified to the year they recruited to feeding ground residency on Heron Island Reef, southern Great Barrier Reef and which have subsequently grown to sexual maturity: date and size when first tagged by year of recruitment along with the time duration over which she was recorded at this site and the number of times captured before making her first breeding migration; breeding season and size at first breeding and minimum distance to nesting beach (when known); subsequent postbreeding return to the prebreeding feeding ground site and the number of additional postbreeding recaptures. n = number of captures. "*" denotes attack by shark during the breeding migration.

TAG	RECRUITMENT (to feeding ground)		DURATION AT SITE (n)	FIRST BREEDING			RETURN TO SITE (n)
	Date	CCL (cm)		Date	CCL (cm)	Migration	
X596	Nov 1974	80.5	14yr (55)	1988/89	94.0	- *	yes (7)
X2009	Oct 1974	80.5	14yr (32)	1988/89	95.5	-	yes (5)
X2065	May 1975	87.0	12yr (48)	1987/88	95.5	-	yes (10)
X2385	May 1976	83.5	11yr (27)	1987/88	92.5	-	yes (6)
X2392	May 1976	85.0	10yr (51)	1986/87	94.5	-	yes (12)
X2757	May 1977	80.0	13yr (33)	1990/91	92.0	67 km	yes (4)
X2764	May 1977	83.0	10yr (11)	1987/88	90.5	-	yes (3)
X9334	Nov 1977	87.5	14yr (28)	1991/92	98.3	1505 km	yes (2)
X9374	Feb 1978	86.0	10yr (14)	1987/88	95.0	102 km	yes (11)
T16312	Sep 1985	80.0	8yr (15)	1993/94	91.0	210 km *	no (killed-shark)

DETECTION OF MAGNETIC INCLINATION ANGLE BY SEA TURTLES: A POSSIBLE MECHANISM FOR DETERMINING LATITUDE

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For animals that migrate long distances, the magnetic field of the earth provides not only a possible cue for compass orientation, but a potential source of world-wide positional information. At each location on the globe, the geomagnetic field lines intersect the earth's surface at a specific angle of inclination. Because inclination angles vary with latitude, an animal able to distinguish between different field inclinations might, in principle, determine its approximate latitude. Such an ability, however, has never been demonstrated in any animal.

We studied the magnetic orientation behavior of hatchling loggerhead sea turtles (*Caretta caretta* L.) exposed to earth-strength magnetic fields of different inclinations. Hatchlings exposed to the natural field of their natal beach swam eastward, as they normally do during their offshore migration. In contrast, those subjected to an inclination angle found on the northern boundary of the North Atlantic gyre (their presumed migratory path) swam south-southwest. Hatchlings exposed to an inclination angle found near the southern boundary of the gyre swam in a northeasterly direction, and those exposed to inclination angles they do not normally encounter were not significantly oriented.

These results demonstrate that sea turtles can distinguish between different magnetic inclination angles and perhaps derive from them an approximation of latitude. Most sea turtles nest on coastlines that are aligned approximately north-south, so that each region of nesting beach has a unique inclination angle associated with it. We therefore hypothesize that the ability to recognize specific inclination angles may largely explain how adult sea turtles can navigate back to their natal beaches after years at sea.

MARINE TURTLE NESTING ACTIVITY IN THE STATE OF FLORIDA, 1979-1992

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Florida has the most diverse and abundant sea turtle fauna of any state or territory in the nation. Three species (*Caretta caretta, Chelonia mydas,* and *Dermochelys coriacea*) nest on a regular basis. Approximately 90% of the nesting activity of the southeastern United States loggerhead aggregation occurs in Florida; this aggregation is the second largest in the world. The number of loggerhead nests reported annually from track surveys coordinated by the state during 1979-1992 ranged from 10,121 to 68,614. Survey effort has increased markedly since 1979, and nearly 1100 km of beaches are currently monitored. The number of green turtle nests reported annually during this period ranged from 62 to 2509. Florida's green turtle nesting population is sufficiently large to be of regional significance. The only regular nesting by the leatherback turtle in the continental United States occurs in Florida, where between 10 and 188 leatherback nests were recorded annually during 1979-1992. Zero to two hawksbill (*Eretmochelys imbricata*) nests were also recorded annually; only one Kemp's ridley (*Lepidochelys kempi*) has ever been documented nesting in the state. Protection of nesting habitat is of critical concern for Florida marine turtle populations.

THE EFFECTS OF HURRICANE ANDREW ON THE SEA TURTLE NESTING BEACHES OF SOUTH FLORIDA

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Due to the close overlap of hurricane season (June - November) and sea turtle nesting season (March - November) in the Caribbean and northwest Atlantic, these storms are potentially damaging to sea turtle populations. No data has been gathered, however, on either the immediate or the long term effects of hurricanes on adult sea turtles or their nesting beaches.

Hurricane Andrew, which struck South Florida on August 24, 1992, provided a unique opportunity to define the impact of a category 4 hurricane on 6 Florida nesting beaches. It was determined that the storm affected turtle nests over nearly 90 miles of beaches on the east and west coasts of Florida. The greatest mortality was due to beach flooding associated with the hurricane produced storm surge. The greatest surge effect was felt on beaches nearest the storm's "eye", where egg mortality was 100%. As distance from the eye increased, storm surge and associated mortality decreased.

Detailed data on post-hurricane hatching success, mortality, and cause of death was collected from 8 nests previously relocated to Fisher Island, Miami, Fl, which suffered both flooding and extensive changes in beach topography. Sixty-nine percent of the eggs did not hatch after Hurricane Andrew and appeared to have drowned during the storm. Further mortality occurred when surviving hatchlings died in nests in areas of sand accretion. This later mortality could be substantially reduced if beach topography is returned to normal and beach debris removed after a hurricane.

ISLA HOLBOX, MEXICO: AN ANALYSIS OF FIVE NESTING SEASONS OF A MAJOR HAWKSBILL NESTING BEACH

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The Yucatan Peninsula is a prime hawksbill, *Eretmochelys imbricata*, nesting area, with about 1,000 nests annually. There are three disjunct nesting areas: Isla Aguada-Chenkán in Campeche; the north coast of the Peninsula (in the States of Yucatán and Quintana Roo); and southern Quintana Roo and Belize. The north coast beaches have nearly 600 nests per year, or about two thirds of all hawksbill nesting on the entire peninsula; these beaches include Las Coloradas, El Cuyo and Isla Holbox (Frazier, in press).

Nesting occurs over much of this low, coralline island, but the main nesting beach is 24 km long. Holbox may have been important for marine resources for Precolumbian peoples. It was settled by emigrants from the Canary Islands about 200 years ago, and since then fishing -including turtling- has been a main source of livelihood. The population is about 1,000 people.

The first study of sea turtles on Holbox, in 1988 (Durán, 1992), documented hawksbill nesting activity, and from 1990 to 1993 there have been beach patrols, monitoring nesting activity and nest ecology (Gil et al., 1993; Miranda, 1992). However, personnel, techniques and data analyses have varied from year to year, making comparisons between years difficult, or impossible.

All five years of data show that: (1) female carapace size, renesting interval, clutch size, and other variables related to nest ecology are comparable to results from other hawksbill beaches on the Peninsula (c.f. Frazier, 1993a); (2) the total number of hawksbill nests recorded each year on Holbox has been just under 200 (values for 1988 and 1990 are minima, and there are no data for 1989); (3) nesting occurs from late March to early September, with a peak in May and June; (4) nesting occurs along the entire 24 km of beach, with a peak between kilometers 2 and 6, and a dip between kilometers 8 and 10; (5) most nesting occurs well above the berm, amongst vegetation.

Sample sizes for different analyses varied, depending on the availability of data. In 1991 a total of 182 nests with eggs were confirmed, and between 40 and 143 nests in situ, and 16 transplanted nests, were analyzed. In 1992, a total of 172 nests with eggs were confirmed; from 65 to 149 nests in situ, and 9 transplanted nests, were analyzed. A correlation matrix for 16 variables was calculated for both 1991 and 1992 (data from the other seasons was either unusable, or not available). The variables for each nest include: date of nesting, date of emergence, in-nest period, beach sector, distance from nest to sea, beach zone, clutch size, hatching success, emergence success, and nest contents: live hatchlings, dead hatchlings, deformed hatchlings, predated hatchlings, dead embryos, undeveloped eggs, and rotten eggs.

There were no clear relationships between nest parameters and beach sector. However, hatching and emergence success appeared to be higher toward the western end of the beach, where there was also a peak in nesting activity.

Date of oviposition and in-nest period (incubation period + emergence period) were inversely related (1991: $r=-0.501$; $n=44$ $p<0.001$; 1992: $r=-0.439$; $n=65$; $p<0.001$). This indicates that nest temperatures decrease during the nesting season, which has implications on seasonal trends in sex ratios of hatchlings.

Hatching success was inversely related to in-nest period (statistically significant in 1992: $r=-0.256$; $n=65$; $p<0.02$). From the previous two relationships, it was expected that hatching success and date of oviposition would be correlated, but remarkably, there was no such relationship.

Clutch size showed no consistent relationship with other variables. This was not expected, for results from various nesting beaches on the Peninsula showed clutch size to be inversely related to hatching success (Frazier, 1993b).

In both 1991 and 1992, hatching success was inversely related to three measures of unhatched eggs: dead embryos, undeveloped eggs, and rotten eggs; this is to be expected. However, these three measures of within nest mortality were not generally cross-correlated. As expected, hatching success was strongly related to emergence success. It is remarkable that in about 10% of the nests the full potential of hatchling recruitment was not realized because large numbers of hatchlings did not emerge from the nest (Figure 1).

A usual management practice for sea turtles in Mexico is to relocate nests to protected hatcheries on the beach (Frazier, 1993b), an attempt to compensate for nest predation -mainly by people- and increase hatchling recruitment. A comparison between in situ and moved nests was made for both 1991 and 1992, using a Mann Whitney U test. Including only nests which survived the incubation period, it was found that clutch size and in-nest period did not differ significantly between treatments. However, hatching and emergence success were significantly greater in nests left in situ (Table 1A). In general, moved nests had more live and dead hatchlings in the nest after the main emergence, as well as more undeveloped and rotten eggs.

If nests predated by fishermen were included, in situ nests still had higher hatching and emergence success in 1991 (Table 1B). However, in 1992 predation by fishermen was at least 8% of all nests, and there was no longer a clear advantage to leaving nests in situ. (This does not include nests predated by raccoons, since it is not possible to quantify hatchling mortality; 8 and 13 % of nests in situ were disturbed by raccoons in 1991 and 1992, respectively.)

It is important to emphasize that few nests were transplanted at Isla Holbox, and it was therefore possible to give the transplanted eggs relatively careful treatment. When large numbers of nests are transplanted automatically, the care given to individual nests cannot be so great, and it is expected that there would be lower hatchling and emergence rates. The results show that nests in situ can have 10 to 20% better emergence success than transplanted nests. This means that leaving nests in the beach will produce at least as many hatchlings as nests in hatcheries if nest predation does not exceed 10 to 20%. Leaving nests in the beach is advantageous because it involves less materials, costs and effort, as well as guaranteeing that incubation conditions (such as temperature and humidity) are natural. However, if nest predation is high and cannot be controlled, transplanting nests may be necessary to insure higher levels of hatchling recruitment.

Although five years of data have been gathered, most of the analyses presented here were based just two years' data. Inconsistencies in field methods, data recording, data analysis, and even the theft and hiding of data, resulted in much of the field effort being unusable for analysis.

Finally, in the light of the results regarding the difference in emergence success in natural and moved nests, as well as the problems of consistency of data between years, it is important to point out that a coastal road is now being constructed just inland of the beach at Holbox. This will certainly result in increased predation of both nests and turtles by people, and also different monitoring techniques by turtle biologists in the coming seasons.

When technicians are active on the beach, predation by fishermen on nests and turtles is minimal. However, when there is no activity by conservationists, local fishermen may take more than half of the nesting turtles, as well as nonreproductive individuals and many nests; this occurs despite a nation-wide ban on sea turtle hunting. Because conservationists cannot always guard the turtles, there is an urgent need to incorporate the local fishermen in various sea turtle conservation activities, not only for the nesting beach, but also for the vast continental platform in the region, which appears to be important feeding habitat for hawksbills and other marine turtles.

The work, done with permits from SEDUE and SEDESOL, was supported by Calica, Chelonia Institute, Sistema Nacional de Investigadores, USFWS, CINVESTAV, and PRONATURA. Many people helped with the field work: Darwin Acevedo, Victor García, Reyna Gil, Alfredo Jiménez, Raúl Rodríguez, Gordon Seyfarth, Tom Van Eijck, Roberto Vázquez, and fishermen from Holbox; Ligia Uk and Roberto Vázquez helped with computation and graphics.

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Table 1. Average values for various nest parameters of nests *in situ* and moved nests of *Eretmochelys imbricata* at Isla Holbox in 1991 and 1992; and p values (one-tailed) of Mann-Whitney U comparing nests *in situ* and moved nests.

	1991			1992		
	in situ	moved	p (U)	*in situ*	moved	p (U)
A) ONLY NESTS WITHOUT PREDATION:						
Sample size	119	14		109	6	
Clutch size	143.4	138.7	0.284	149.5	141.0	0.223
In-nest period	64.9	64.9	0.267	63.5	64.0	0.234
% Hatching success	86.3	68.7	0.001***	88.0	84.5	0.137
% Emergence success	84.2	67.5	0.000***	86.7	79.2	0.012
Hatchlings in nest						
Live	0.5	2.6	0.001***	0.2	2.0	0.115
Dead	3.2	1.7	0.343	2.0	8.2	0.000***
Unhatched eggs						
Dead embryos	2.8	11.1	0.000***	5.1	2.0	0.329
Undeveloped eggs	1.6	3.3	0.000***	1.7	5.7	0.105
Rotten eggs	8.7	17.3	0.052	5.4	9.4	0.013
B) INCLUDES NESTS PREDATED:						
Sample size	130	16		143	6	
% Hatching success	77.3	43.1	0.001***	74.9	77.5	0.884
% Emergence success	77.1	44.7	0.002**	75.5	62.2	0.276

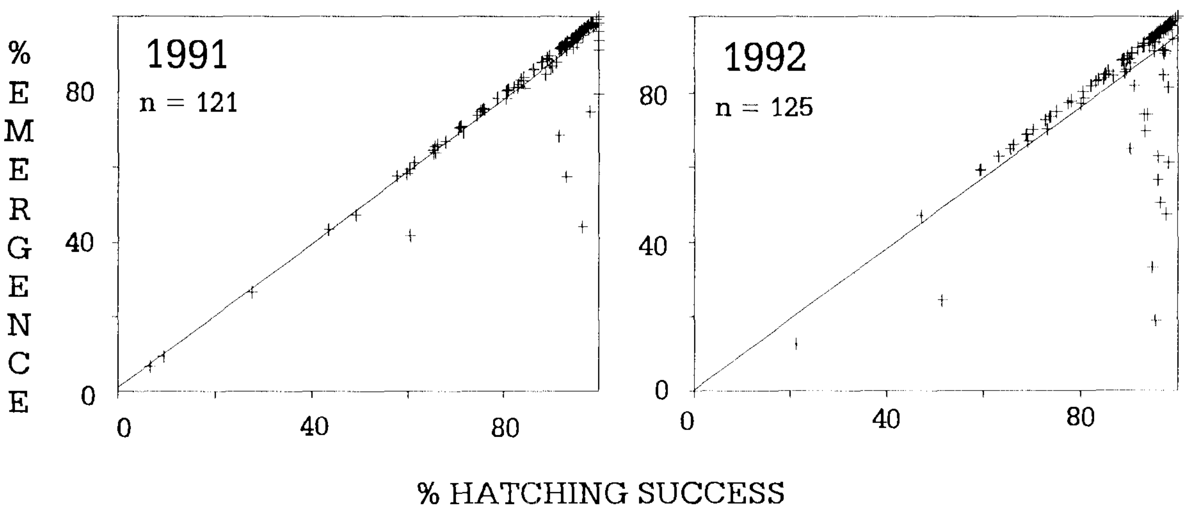

Figure 1. The relation between % emergence success (% of clutch that emerged) and % hatching success (% of clutch that hatched) in *Eretmochelys imbricata* nests at Isla Holbox during 1991 and 1992; points below the regression line represent nests in which there was mortality of hatchlings, which did not survive to emerge from the nest.

AUDITORY BEHAVIOR OF THE LOGGERHEAD SEA TURTLE (*CARETTA CARETTA*)

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Hopper dredging is the most effective way of both widening and deepening channels to accommodate deep draft shipping traffic. However, the National Marine Fisheries Service (NMFS) has concluded that the Kemp's ridley, loggerhead and green sea turtle may be at risk by hopper dredging activities (Joyce, 1982). The concern over the impact of dredging on the mortality of sea turtles was the motivation for examining the auditory behavior of the loggerhead in search of a possible repulsion device via auditory stimuli.

Until recently, little research has been performed on the auditory behavior of sea turtles, except for perhaps the anatomy. The anatomy of the loggerhead's middle ear suggests a compromise for sound conduction through two different media: bone and water. The use of bone conduction limits the range of frequency used by sea turtles to low frequencies (Lenhardt, 1982). There have only been a few successful attempts to perform localization studies and even fewer attempts to collect electrophysical responses. Consequently we were interested to see if electrophysical responses to auditory stimuli could be collected from loggerhead sea turtles using the technique of auditory evoked potentials and if so what would be the corresponding threshold level.

Data was collected using a computer capable of delivering stimuli and receiving bioelectric activity, the Nicolet Spirit Portable. Using electrodes, two channels of electroencephalographic activity (EEG) were amplified, filtered and fed into the computer. Evoked potentials were extracted from the EEG by repeating and averaging single responses. The stimulus was a broadband click encompassing the 250 Hz to 1000 Hz range, the frequencies found in our laboratory to be heard by loggerheads. This insured stimulation of the hearing apparatus. The stimulus intensity was manipulated, ranging from -30 to 7 decibels (in reference to one gravity unit), until the threshold level of hearing was found. Determination of threshold was achieved by examining an index wave on the EEG readouts. If this wave decreased in amplitude and increased in latency as the stimulus intensity increased, then the lowest intensity at which a visible index wave could be observed was termed the threshold.

Preliminary results show very little variability of the threshold among the turtles tested.

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BIOLOGY OF THE OLIVE RIDLEYS OF GAHIRMATHA, ORISSA, INDIA

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Gahirmatha in Cuttack district of Orissa, which extends from Ekakulanasi/Maipura river mouth to Barunei muhana, Hansua river mouth (Behera, 1989; Dash and Kar, 1990) has become an important area in turtle research since its discovery (Bustard, 1974). Out of the two to three million olive ridley (*Lepidochelys olivacea*) turtles in the world at present, nearly half visit the Gahirmatha coast each year for breeding and nesting purposes. Consequently, it has earned the distinction of being the largest rookery for the nesting of this species. There are two spectacular arribadas each year from January to mid April. The huge biomass of adult male and female turtles, millions of eggs laid by them and the resulting hatchlings play an important role in controlling the ecology of the area during the period.

During mid seventies, the entire 35 km of Gahirmatha beach was used for nesting purposes (Kar, 1980). During the nesting season in the past, the forest department of Orissa was issuing licenses for the collection of eggs containing roughly between 35,000 to 100,000 eggs and this was stopped when the surrounding area of Bhitarakanika was declared as a wild life sanctuary in April 1975.

Organized turtle fishery also existed in the past in Orissa and other parts of Bay of Bengal. In Orissa, fishermen used to capture adults at sea during the peak mating and nesting seasons which were regularly transported to Calcutta and Howrah markets (Dash and Kar, 1987).

The olive ridley has been placed in Schedule I of the Indian Wildlife (Protection) Act, 1972. At present complete protection has been given to the nesting females and their eggs. The drowning of the turtles at Gahirmatha during breeding season due to the movement of mechanized boats (trawlers, gill nets) has become a major threat at present. More than 1600 such vessels operate near the Gahirmatha rookery from fishing bases such as Dhamara, Talchua and Paradeep. Each year a large number of adult turtles die due to this reason. The Government of Orissa has proposed four more fishing jetties around Gahirmatha area; Talchua, Jamboo, Kharnasi and Tantiapal from which thousands of mechanized boats will operate from the area and compound the problem many fold. Talchua jetty has already created much concern among the environmentalists world over which is under construction only 10 kms away from Gahirmatha in the north-east direction.In addition, the Ekakulanasi area got separated from the main land Ekakula (local names of Gahirmatha) at the northern most end in a cyclone in May 1989. Now nesting is restricted to this Ekakulanasi island,the area of which is changing year to year due to erosional and depositional forces. The area of this island is insufficient to house the entire nesting population of Gahirmatha. As a result, a large number of eggs are being destroyed each year due to subsequent nesting activities. This is now a major threat for the survival of this population.

METHODS

We have monitored the nesting biology and related aspects of olive ridley turtles at Gahirmatha since 1984. The present paper describes some of the important aspects.

RESULTS AND DISCUSSION

NESTING PROFILE

The annual nesting at Gahirmatha occurs in two arribadas. The first batch of mass nesting occurs during late December to mid February and the second one during March to early April. In the first batch about 80% and in the second batch the rest 20% nest (Sahoo and Mohanty-Hejmadi, 1994). Apart from this, sporadic nesting takes place throughout the year around Gahirmatha (Dash and Kar, 1990; Mohanty-Hejmadi, 1993). The second mass nesting coincides with the hatching of the eggs of first mass nesting which takes about 50 to 60 days after the first mass nesting (Behera, 1989). About 80% male hatchlings are produced from the eggs of first mass nesting at Gahirmatha which develops in relatively lower ambient temperatures (January-March) and about 90% of female hatchlings are produced from the eggs laid in second mass nesting which develop during the warmer months of April and May (Mohanty-Hejmadi, 1993).

A detailed profile of nesting records of olive ridley turtles at Gahirmatha for the last 10 years is presented in Table 1. During these years the number of nesting individuals increased. The record number of 805,000 turtles nested in 1992. In 1985 a total of 286,000 turtles nested in three arribadas. In 1986, there was no first mass nesting and only 50,000 turtles nested during second mass nesting. During 1988, there was no mass nesting at all and sporadic nesting of few individuals occurred. Though 206,000 individuals nested in 1990, there was no second mass nesting. The nesting population has maintained a constancy (more than 600,000) from 1991 onwards. From this it appears that the Gahirmatha population has attained a stability as the number of nesting emergences is concerned.

BEACH PROFILE

Biotic factors such as predation on eggs and hatchlings and interspecific competition among the nesting females are more important than purely geological characteristics in determining worldwide nesting patterns of sea turtles (Mortimer, 1982). Remoteness of most of the nesting grounds for which they are relatively free from predators, including Gahirmatha, has vanished in recent years due to human encroachment and the subsequent disturbances and exploitations. During 1982 nesting season the mass nesting area shrank from the entire 35 kms to 10 kms coastline from Habalikhati to Ekakulanasi (Kar, 1982) and in 1989 only to 2 kms at Nasi end in the north ward direction. From 1990 onwards nesting is restricted to Ekakulanasi island. This island is relatively free from predators except for the birds. During 1990 and 1991 seasons, the Ekakulanasi rookery had an area of 0.338 sq kms in which 210,000 turtles could nest successfully considering the body pit area (average carapace length x average carapace width = 5626 sq cms) as the minimum required area for the development of a nest. A total of 206,000 and 610,000 turtles nested during the above two seasons, respectively. The random nesting by subsequent emergences damaged a large number of nests. In 1991, this loss was 74% (Table 2). In 1992, the rookery had an area of 0.416 sq kms giving enough space for 260,000 individuals for successful nesting during which a total of 805,000 turtles nested resulting in 52% destruction of nests (Table 1 & 2). During 1993 nesting season the area was reduced to 0.271 sq kms where only 85,000 turtles could nest successfully (Table 2). In the season, 665,000 individuals nested out of which about 87% nests were destroyed. For the 1994 season, the area has increased to 0.494 sq km. In addition to the destruction of nests by tidal/wave inundation and predation, a high percentage of nests are destroyed each year due to subsequent nesting emergences of the turtles. Thus the separation of Ekakulanasi from the mainland has made the Gahirmatha population endangered as the nesting ground is insufficient to support the nesting activities of such a large population.

CONCLUSION

At Gahirmatha, although trade in turtles and eggs is not there any more, considerable number of turtles are dying due to fishing activities in this area. Even then, if one considers the number of nesting turtles from year to year, it is reasonable to say that the population nesting at Gahirmatha has not been adversely affected by these activities. However, one of the major concerns for the population is the drastic geographic change in the main nesting area of Gahirmatha which is now cut off from the main land since 1989. This area is extremely prone to cyclonic storms and inundation. In addition, considerable number of eggs are destroyed by overlapping nesting activities of the turtles due to restriction of space. It is necessary to assess these aspects now so that alternative arrangements can be made for mass transfer and incubation of eggs in appropriate places.

ACKNOWLEDGMENTS

The authors are thankful to the authorities of Forest Department, Govt. of Orissa; Director and staff of Regional Research Laboratory, Bhubaneswar for their help in various aspects of this work.

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Table 1. Nesting profile of olive ridley turtles at Gahirmatha in the last 10 years.

Nesting season	Total nested	No. of mass nestings
1984	400,000	TWO
1985	286,000	THREE
1986	50,000	ONE, NO FIRST
1987	600,000	TWO
1988	N O M A S S N E S T I N G	
1989	318,000	TWO
1990	200,000	ONE, NO SECOND
1991	610,000	TWO
1992	805,000	TWO
1993	665,000	TWO
1994	451,000	IN FIRST

Table 2. Profile of Ekakulanasi rookery.

Nesting season	Average area(sq kms)	Carrying capacity of the available	Percent destruction
1990	0.338	210,000	00
1991	0.338	210,000	74
1992	0.416	260,000	52
1993	0.271	85,000	87
1994	0.494	*	*

* Only first mass nesting completed.

INDIVIDUAL AND AGE-DEPENDENT VARIATIONS IN CLUTCH FREQUENCY AMONG HAWKSBILL TURTLES AT COUSIN ISLAND, SEYCHELLES: 1973-1992

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The turtles of Cousin Island are probably the most intensely studied population of nesting hawksbills in the world. All nesting emergences have been monitored since 1971 and a tagging program has been underway since 1973 (Diamond, 1976; Garnett, 1978; de L. Brooke and Garnett, 1983; Frazier, 1984; Mortimer, 1984; Wood, 1986; Mortimer and Bresson, 1994). In the present study we examine 19 years of data (1973 to 1992) and report on the relationship between clutch frequency and relative age. Many sea turtle biologists have assumed that fecundity increases with the age of the turtle. This belief is based on the observation that "remigrant" turtles (i.e. those that arrive at the nesting beach bearing tags or tag scars from previous seasons) tend to lay significantly more egg clutches during the nesting season than do the neophyte or "recruit" turtles (i.e. previously untagged turtles). We examined two measurements of clutch frequency: the numbers of nestings recorded during consecutive remigrations to the nesting beach; and the time intervals that separated successive nesting seasons.

RESULTS

A large proportion of the turtles tagged at Cousin Island between 1973 and 1992 were recorded during only a single nesting season (79%). Looking in retrospect over those 19 years we found that a turtle that arrived at the nesting beach bearing either a tag or a tag scar from a previous season was more than twice as likely to be intercepted in a subsequent nesting season as was a turtle that arrived untagged.

For those turtles that were recorded nesting during more than one season, we performed an analysis of covariance using "annual clutch frequency" as the dependent variable and "season" and "tagging efficiency" as the independent variables. The analysis demonstrated that there is no steady increase in clutch frequency over time. It is possible, however, that clutch frequency increases during the first several nesting seasons of a turtle and then later declines. (At the time of this writing, we are analyzing all the data gathered through the 1993-94 season to determine whether such a pattern exists.)

Among 104 Cousin hawksbills, we recorded 186 remigration intervals (i.e. the number of years separating successive nesting seasons of a turtle.) The two- and three-year intervals together account for 85% of all intervals recorded. To test for bias caused by tag loss we compared the remigration intervals of the total population with those of a subset of turtles that were identifiable by a single tag throughout a period of eight or more years. A Kolmogorov Smirnov test showed no significant difference between the two patterns of distribution, thus demonstrating that the predominance of the (relatively short) two- and three-year remigration intervals is not an artifact of tag loss.

At Cousin, individual animals have been monitored over periods of up to 16 years. When we examined the lengths of consecutive remigration intervals for individual turtles we found no statistically significant changes in interval lengths over time.

DISCUSSION

In light of the predominance of the two- and three-year remigration intervals we find it surprising that such a large proportion of the turtles were encountered during only a single nesting season. Moreover, the numbers of clutches recorded during the first (intercepted) nesting season of the single season nesters was significantly lower than the numbers recorded for the multiple season nesters.

How can we explain such a large number of single season nesters? Some possible explanations include high tag loss and mortality from poaching. We know that both factors have been important at Cousin Island, especially during the 1970's. During recent years the percentage of single season nesters has declined significantly (Mortimer and Bresson, 1994). It is also possible that a combination of insufficient beach patrols at Cousin and imperfect site fidelity in the Cousin turtles causes some nesting emergences to go unrecorded. However, data available on nesting site fidelity in Seychelles hawksbills suggest that this may not be an important factor.

Other possible explanations for the large numbers of single season nesters recorded at Cousin and elsewhere in the world are the following. There may be a difference in reproductive fitness among individual turtles. This possibility has already been discussed by Richardson (1982) and Tucker and Frazer (1991). Another explanation may be that there is a high rate of mortality during the first nesting season. (Note that the females of some species of penguins experience high rates of mortality during their first nesting season. Those birds surviving the first season, however, show good survival in subsequent seasons.) It is possible that turtles generally exhibit low rates of fecundity during their first nesting season. If the first nesting season is then followed by a particularly long interval before a second nesting season, high rates of tag loss could occur. And in fact, a long interval between the first and second nesting seasons would not be surprising considering the very long interval we know occurs between hatching and first nesting.

Some combination of the above hypotheses probably explains the phenomenon of the "single season nesters." But, this mystery will probably not be solved entirely by studies on the nesting beach. More in-water work is needed. More subadult turtles need to be followed into adulthood and more adult animals need to be tracked after they leave the nesting beach.

ACKNOWLEDGMENTS

Funding for this study was provided by the International Council for Bird Preservation (ICBP), by the World Wide Fund for Nature (WWF-International) (Projects No. 1809 and MY0034/SC0009) and the Smithsonian Institution. We are also grateful for assistance from the U.S. National Marine Fisheries Service, Caribbean Conservation Corporation and the Archie Carr Center for Sea Turtle Research.

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WHAT IS A GIS AND HOW CAN IT BENEFIT SEA TURTLE RESEARCH AND CONSERVATION?

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A Geographic Information System or "GIS" is a system of hardware, software and procedures designed to manage, manipulate, analyze, model, and display spatially referenced data used in solving complex planning and management problems (E.S.R.I., 1990). A GIS stores and links data sets according to geographic location. Although the output is usually in map form, a GIS is not simply a computer system for making maps. The major advantage of a GIS is that it allows for identification of spatial relationships between map features. A GIS stores data about a particular feature (e.g., sea turtle nest, mangroves, oil spill), together with related geographic information to describe what the feature is, where the feature is located, and how it relates geographically to other features. Layers of data associated with a feature are called "coverages" and are overlaid to portray spatial and temporal relationships.

At the Florida Marine Research Institute (FMRI), several sea turtle data sets have been integrated with the Marine Resources GIS (MRGIS) for research and conservation projects. One of the most revolutionary uses of some of these data sets was in the emergency assessment of ninety-six loggerhead sea turtle nests on beaches threatened by a recent oil spill. On August 10, 1993, a barge collision in Tampa Bay near St. Petersburg, Florida, caused an estimated 388,000 gallons of heavy heating oil to be spilled into the bay, threatening environmentally sensitive mangroves and sea turtle nesting beaches. The FMRI's Marine Mammal Section used Global Positioning System (GPS) receivers in helicopters to determine the location of the changing perimeter of the spill, while FMRI sea turtle staff used GPS to record locations and physical conditions of sea turtle nests on the beaches threatened by the oil. Fortunately, all the nests had been marked and the stages of incubation of their eggs was known. This information was integrated into the MRGIS and within hours of the spill, FMRI staff produced maps that showed detailed information on the bay's natural resources (i.e., bathymetry, sea grass beds, mangroves, marshes, sea turtle nests) in relation to the current location and extent of the spill. State and federal agencies used these maps to respond to the oil spill emergency.

Mapping the distribution of sea turtle mortalities is a more common application. The Florida Sea Turtle Stranding and Salvage Network (STSSN), coordinated by the FMRI and led by NOAA's National Marine Fisheries Service (NMFS), has collected data on more than 8000 strandings in Florida since 1980. Data collected on each stranded turtle include: date, species, location, measurements, carcass condition, and information on obvious injury or disease (e.g., entanglement, propeller damage, fibropapillomas). The stranding data were analyzed using the MRGIS to determine spatial and temporal distributions of sea turtles in Tampa Bay, Florida. This GIS will be used as the base layer for mapping and analyzing data on the distribution of sea turtles in inshore waters of Florida. Additional coverages that will be overlaid include data on in-water captures, bathymetry, habitat type, and shrimp-fishing areas. Storing the stranding data together with geographic information gives researchers the resources to analyze spatial patterns of turtle mortality. For example, by overlaying coverages such as shrimp-fishing areas on the turtle-stranding layer, potential effects of the shrimp fishery on turtles may be identified.

Spatial analysis of research data is yet another application. A feeding-ground study GIS has been developed for the Bermuda Turtle Project. The project, which was initiated in 1968, is now a collaborative effort of the Caribbean Conservation Corporation and the Bermuda Aquarium, Museum and Zoo, under the scientific direction of Anne and Peter Meylan. The purpose of this study is to determine size composition, sex ratio, growth rates, habitat utilization, site fidelity, genetic identity, and migratory behavior of immature green turtles. Turtles are captured on grassbeds at more than 20 sites around the island with a large tangle net. The turtles are weighed, measured, and double-tagged. Blood samples are taken for sex determination and for genetic studies of population affinity. Some of the turtles are examined internally with a laparoscope to determine their sex and to evaluate the maturity of their gonads. The exact coordinates of the netting site are recorded using GPS, which facilitates incorporation of the data into the GIS. Individual points can be queried interactively to access capture and release information and other attribute data (sex, size, genetic identity, etc.) for all turtles associated with these coordinates. Results of any analysis can be portrayed spatially. The GIS is particularly useful for analyzing and displaying movement data such as those obtained from telemetry. Currently, remotely sensed data on marine habitats are being processed by scientists at the Bermuda Biological Station and will be overlaid on the turtle capture coverage to examine turtle habitat utilization.

There are an infinite number of applications of GIS to the many complex problems and questions scientists face about sea turtles. The Florida Marine Research Institute plans to apply GIS to many other projects in the future.

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THERMAL EFFECTS OF CONDOMINIUMS ON A FLORIDA BEACH: POTENTIAL IMPACT ON SEX RATIOS

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Beach temperatures at the depth of nests were studied at the loggerhead turtle rookery at Boca Raton, Florida. The sand at 30 and 60 cm depth in areas shaded by condominiums averaged about 1° C cooler than that in adjacent areas unshaded by buildings. With particularly large condominiums, differences were as large as 2° C. Longer incubation durations of nests laid close to buildings were consistent with such sites being cooler. In the heat of midsummer, when temperatures on this beach were almost always well above the pivotal level, the shade from condominiums probably did not alter the sex ratio of the hatchlings. However, at the cooler start of the season, shade reduced temperatures to below the pivotal level, presumably increasing the number of males produced at this time.

A REPORT ON MARINE TURTLE SURVEY (PRELIMINARY) ON PIRAMBYET ISLAND OFF GUJARAT COAST OF INDIA, INCLUDING RECOMMENDATION FOR CONSERVATION STRATEGY

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Concern over depleting marine turtle populations in the coastal waters of India due to disturbances of nesting sites has prompted this survey. This preliminary eco-survey was conducted to identify nesting sites in selected areas off the coast of Bhavnagar town of Gujurat, situated in western India. Preference was given to the nearby, almost uninhabited island of Pirambyet. This paper attempts to convey a framework of conservation management strategy particularly to this region.

Local information as well as field observations points to the fact that the Gulf of Khambat (Cambay) may well harbour the following three species of sea turtles: olive ridley (*Lepidochelys olivacea*), green (*Chelonia mydas*), and hawksbill (*Eretmochelys imbricata*).

METHODS

Beach combing was conducted along the mainland near the coast of Goga during which there was evidence of depredated turtle nests. Local inhabitants were interviewed ranging from fisherfolks, rural school children, teachers, forest department, custom officials and light house crew. All gave their account of sea turtles nesting in the mainland coast. The Island of Pirambyet was surveyed. Here a particular spot on the northern leeward side was favoured as a nesting site. From the carapace of a dead sea turtle it was confirmed that Olive Ridley turtles frequented, though there are reports of Green and the Hawksbill also nesting in the vicinity.

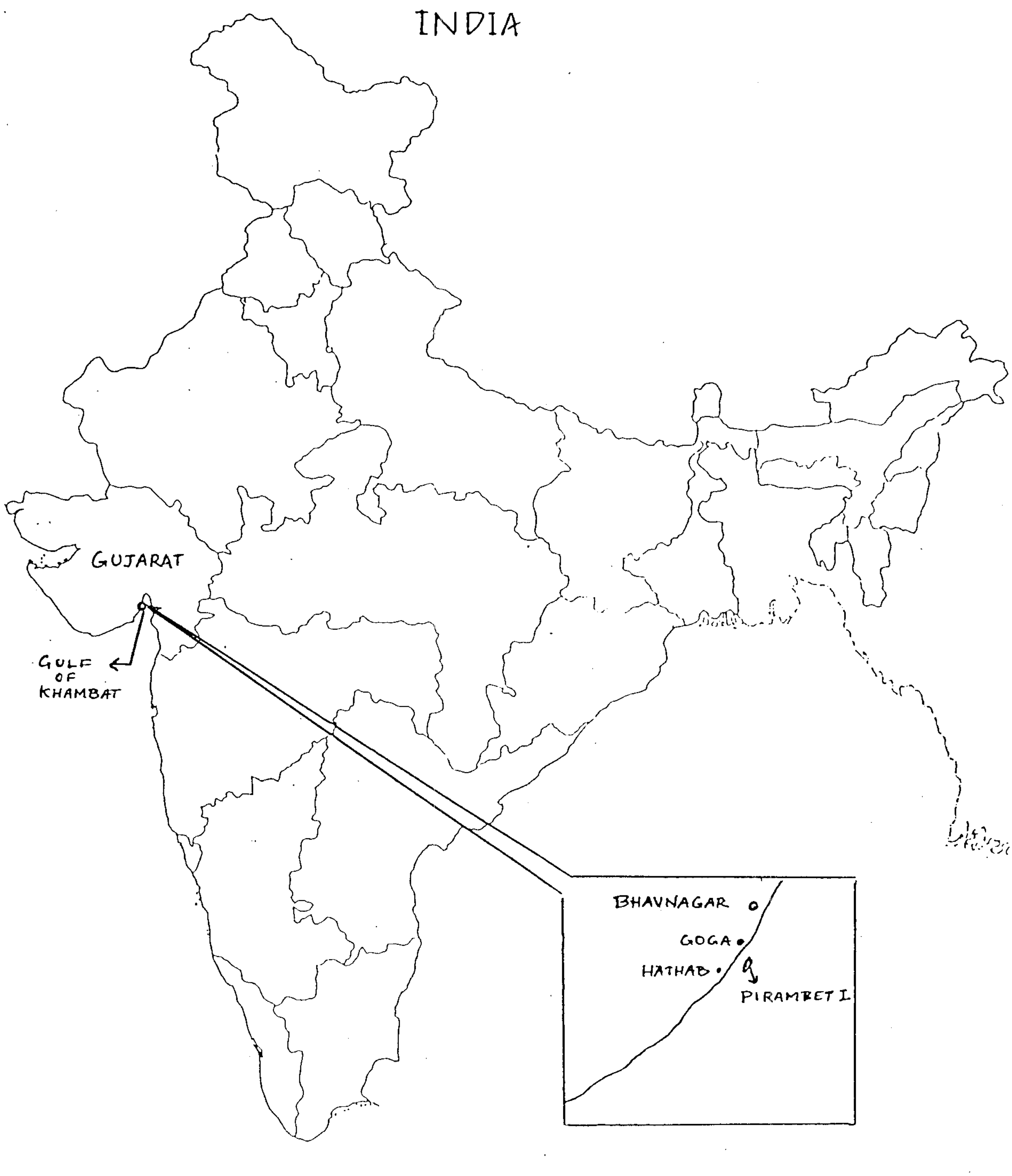
CONCLUSION

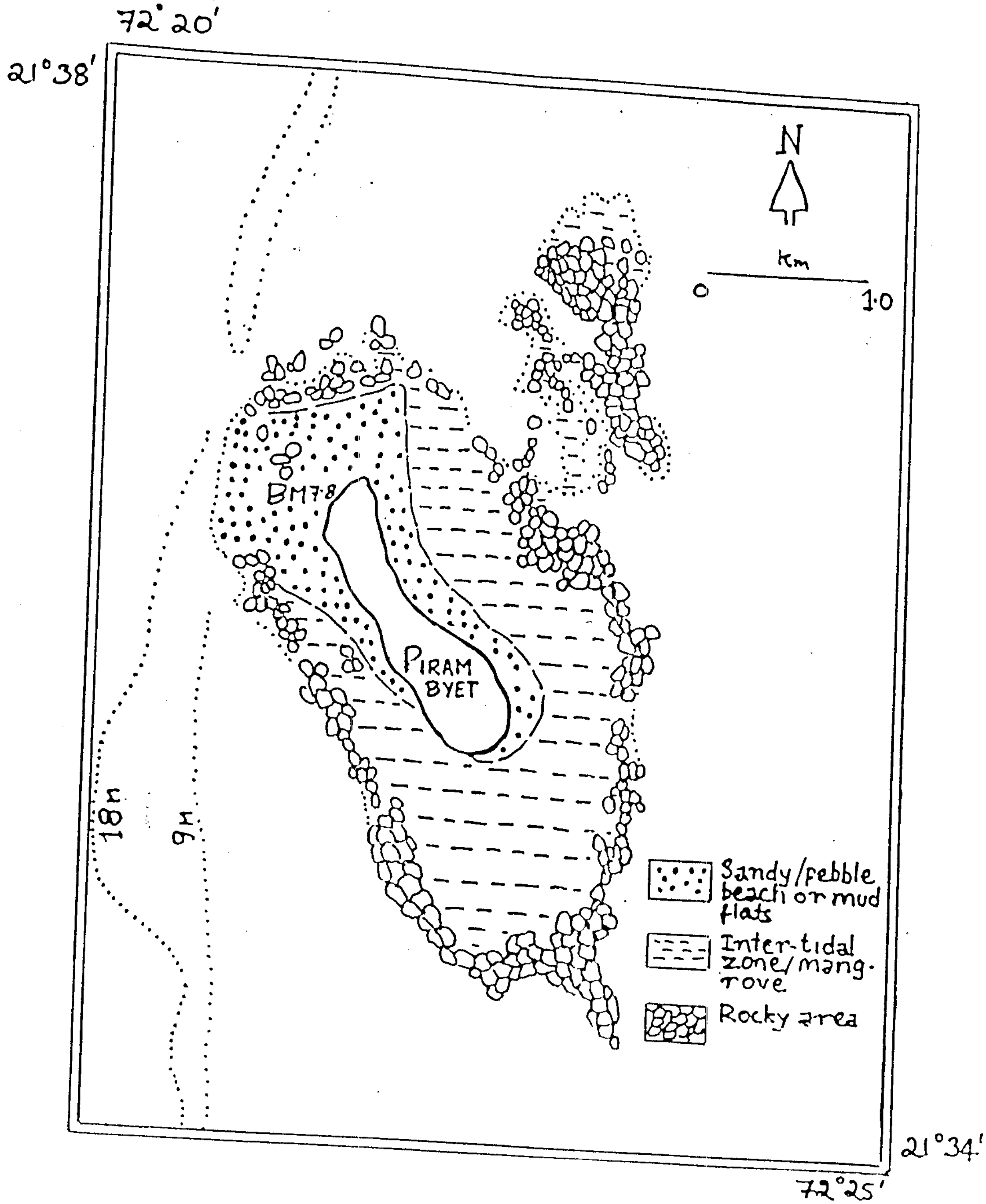
Recommendations for conservation strategy includes, headstart programmes, monitoring, training, and most of all stresses on community participation approach to sea turtle conservation supported by forest department involvement of voluntary agencies. The current status of the island and adjoining mainland areas are threatened due to shipbreaking yards in the vicinity. The mainland areas are an ideal refuge for a host of other wildlife species. A holistic approach to sea turtle conservation should be promoted.

Details of the survey is tabulated as follows:

SEA TURTLE SURVEY AT PIRAMBYET AND ITS ENVIRONS

Date/Time	Location	Observation: Species Identification Behavioural/ Tracks/Carcass	Morphometrics: CCL/CCW Clutch size	Remarks
Sept. 18 1993	Hathab area	Discovered 4 pilfered nests		Along approximately 4km stretch on mainland was surveyed. Predated nests indicative of area as favoured nesting sites. Reconfirmed from local people.
20 0930	Piram (near ferry landing point)	Freshly laid clutch		Visible tracks
		Predated nest		Predated by monitor lizard (<u>Varanus bengalensis</u>)
		Caracass of olive ridley	CCL=73 cm CCW=28 cm	Approx. a month old. Carapace and skull intact.
1730	as above	Partly exposed clutch of eggs		Clutch exposed but intact.
21 0330	as above	Clear entry and return tracks		Nesting occurred. Nest located.


INDIA
GUJARAT
GULF
OF
KHAMBAT
BHAVNAGAR
GOGA
HATHAB
PIRAMBET I.


72°20'
21°38'
N
Km
0
1.0
BM7.8
PIRAM BYET
18 M
9 M
Sandy/pebble beach or mud flats
Inter-tidal zone/mangrove
Rocky area
21°34'
72°25'

PRELIMINARY ASSESSMENT OF JUVENILE GREEN SEA TURTLE BEHAVIOR IN THE TRIDENT SUBMARINE BASIN PATRICK AFB, FLORIDA

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A preliminary assessment of the behavior of juvenile green sea turtles in Cape Canaveral Air Force Station Port Area (CCAFS), Trident Submarine Basin and Entrance Channel was conducted during December 1993. To determine green turtle activities and the feasibility of tracking within the basin, turtles were captured with tangle nets and had combination radio/sonic tags attached. The movements of the instrumented turtles were monitored for one week in the fall. This preliminary behavior study assessed and refined telemetry methods for the basin and small sized turtles. Conclusions and insights obtained from this study will be used to make recommendations to promote the conservation of green turtles in the Trident Submarine Basin.

STUDY AREA

The Canaveral Trident Submarine Basin is approximately midway along the eastern coast of Florida. The basin is roughly rectangular 600 m wide by 1400 m length and opens to the south into the Canaveral Entrance Channel. The shoreline is lined with large rocks (rip-rap) for most of the basins perimeter. However, the eastern shore has a large concrete dock facility for mooring submarines and other ships. The rocks on the shore are covered with algae and other epiphytes which are submerged at high tide and almost completely exposed at low tide. At the base of the rocky shoreline is a narrow shelf with water depths of 5 to 10 ft (1.5-3 m). From this narrow shelf, the water depth rapidly drops to a maximum depth of 44 ft (13.4 m). Water temperature within the basin ranged from 18.1° C to 19.8° C.

TURTLE TAGGING AND MEASUREMENTS

All captured turtles were identified, measured, tagged and released back into the basin at the approximate point of capture. Measurements were taken according to the protocol detailed in Pritchard et al. (1983). Morphometric measurements were taken immediately after capture. The turtles were examined and occurrence of embedded fishing tackle, marine debris, wounds, or disease were noted. Each turtle was tagged on the front flipper with a National Marine Fisheries Service inconel tag and a rototag (from the University of Florida). A Trovan Passive Integrated Transponder (PIT) tag was injected subcutaneously adjacent to the wrist area of the right front flipper. For visual identification, a unique number was painted with nontoxic white epoxy on each carapace. Seven green turtles were captured adjacent to the rocky shoreline, measured, and fitted with radio and sonic tags and released at their capture sites. Straight line carapace lengths ranged from 26.2 cm to 47.7 cm (mean ± SD, 36.3 cm ± 7.4 cm). Weight ranged from 2.9 kg to 14.0 kg (mean ± SD, 7.1 cm ± 3.9 cm). Behavior data was taken on 6 turtles. A seventh turtle was instrumented but became entangled in the nets and the tag broke loose before data was taken.

TELEMETRY SPECIFICATIONS

Turtles were tagged with both radio and sonic transmitters. The sonic transmitters were depth sensitive thus enabling us to locate turtles in the water column. The radio and sonic tags were embedded in syntactic foam for floatation. An 8 cm to 18 cm tether with an erodible link and breakaway link was attached to the posterior marginal scute of the turtle. Larger turtles had longer tethers. The instrumented turtle was released into a large plastic holding tank filled with salt water and monitored for at least one hour to verify that the tag had no apparent effects on the turtle's buoyancy or behavior. Initially each day the basin was surveyed for the presence of instrumented turtles. Positions of turtles were determined from triangulation of positions from two points from a boat. Once positions of turtles within the basin were recorded then continuous 8-12 hour monitoring periods for each turtle were conducted. To reduce the effects of capture on behavior results, turtle monitoring did not begin until at least 12 hours after release.

Pulsed signals were received from the sonic tags into a Sonotronics receiver and decoder unit and then into a portable microcomputer where times and counts were automatically recorded onto both the hard drive and removable diskette and also recorded manually. Radio transmitters (151 Mhz) were monitored with Advance Telemetry Systems (ATS) R4000 receivers modified for sea turtle telemetry. The transmission and cessation of a signal from the radio tag was entered manually into the computer and data book as surfacings (up) and descents from the surface (down), respectively.

The small sized, tethered, combination radio/sonic tag remained attached and produced excellent data on the very small green turtles released into the basin. Some sonic signal interference was caused by boat traffic and the rocky shore, however, these signals were saved and filtered to eliminate or correct faulty data. The 10 grams of buoyancy for the tag caused no apparent behavior modifications in the turtles. The erodible links released the tags from the turtles within 1 to 3 days of the predicted release date. One of the breakable links released the tag from the turtle when the turtle became entangled. Two of the instrumented turtles were captured approximately one month later, examined for any ill effects, and determined to be active and healthy.

SURFACE AND SUBMERGENCE BEHAVIOR

Since turtles may have been near the surface with the radio tag antennae extended into the air and transmitting a signal, times based on the presence or absence of a radio signal overestimates surface times and underestimates submergence time. Depths of less than one foot were defined as surface (near surface) from the sonic depth tag data. This tends to overestimate surface time and underestimate submergence time. Turtles were often found on the rip-rap shore in water depths less than 1 ft (0.3 m) which made it difficult to differentiate surface interval from near surface intervals. When submergence times where longer than 10 minutes surfacings could be distinguished from near surface activities, thus dives cycles greater than 10 minutes were used to calculate surface times, descent times, bottom times, and ascent times. Percent of time spent at various depth intervals was determined by the number of data points within that depth interval. Depths less than one foot tended to have fewer data points due to the signal interference caused by the rocky shoreline which slightly underestimates percent of time near surface. A dive cycle is defined as the time from when the turtle first surfaces to the time it resurfaces. Surface time was defined as time from when the turtle ascends to less than one foot until it descends to greater than one foot. Descent time is defined as the time when the turtle descends from one foot depth to the bottom. The bottom time is defined as the time between ascent and descent. The ascent time is defined as the time when the turtle leaves the bottom until it surfaces. Data was taken only taken during the day time (07:00 to 20:00), night time (20:00 to 07:00) dive information was not studied.

For the monitoring period the turtles generally moved very little within the basin. Based on position data, visual sightings during times of good water clarity, and tag depth, the turtles generally appeared to stay near bottom even in shallow water and would follow the bottom depth contours when they moved between deep and shallow water. This study examined daily movement patterns only during a 7 day interval, however one turtle captured in the basin in January 1994 was observed approximately 60 miles (96 km) to the south at Sebastion Inlet, FL. Mendonca (1983) reported ranges for juvenile green turtles in a Florida Lagoon of 0.48 to 5.06 km^2. Juvenile green turtles associated with jetties in Texas showed daily movements from 46 to 1000 m (Renaud et al. 1992).

For dives greater than 10 minutes for all turtles combined mean surface time was 70.2 sec (4%), mean submergence time was 1917.2 sec (96%), mean descent time was 37 sec (2%), mean bottom time was 1837.6 sec (92.4%), and mean ascent time was 42.5 sec (2%) (Table 1). The mean total dive cycle (surfacing to resurfacing) was 1987.4 sec.

For observations of all data (including dives less than 10 minutes, all turtles combined) time at the surface was 7.4% and time submerged was 92.6% (Table 2). This is very similar to the 91% submergence times reported for juvenile green turtles in Texas (Renaud et al 1992). Inclusion of data for dives less than 10 minutes gives a higher percent of time at the surface because dives that were less than 10 minutes were predominately at or near the surface in shallow water. Percent of data points at 10 ft depth intervals (all data, all turtles combined) was 52.7% for surface to 10 ft, 15.0% for 10 ft to 20 ft, 9.8% for 20 ft to 30 ft, 14.2% for 30 ft to 40 ft, and combined 8.3% for 40 ft to 50 ft. On average the green turtles spent greater than half of their time (night time excluded) in the shallow rocky shoreline habitat of the basin. This habitat is similar to the jetty areas preferred by subadult green turtles in Texas (Renaud et al. 1992, Landry et al. 1992,1993). The rocky shoreline provides cover and feeding habitat for the green turtles which was also pointed out by Renaud et al. (1992) and Landry et al. (1992) for green turtles in Texas.

Descent time and surface post-submergence correlated positively with bottom time, submergence time and total dive cycle time but did not correlate with surface time pre-submergence or ascent time. The correlation of higher surface time post-submergence with higher bottom times may be a requirement of the turtle to spend a longer duration respiring after a longer submergence. Neither time of day, water depth, turtle straight line length, nor turtle weight correlated with surface time, descent time, bottom time, ascent time, submergence time or total dive cycle time. Even though the largest turtle was nearly twice as long and nearly five times as heavy as the smallest turtle no correlation was found between submergence times and turtle length and weight.

While the time of day did not correlate with the various portions of the dive cycle, observations (dives greater than 10 minutes) grouped by dawn, day, and dusk had descent times for day higher than dawn; bottom times, submergence times, and total dive cycle times for dusk higher than dawn; and surface times following submergence for dusk higher than both day and dawn. The higher dusk surface times following submergence, bottom times, submergence times, and dive cycle times may be a reflection of night time submergence behavior, since submergence and surface times have been reported to be longer for night time by other researchers (Bjorndal 1980; Mendonca 1983; Ogden et al. 1983; Renaud et al. 1992). Inclusion of night time data would have likely increased overall mean submergence times and mean surface times.

One ship and one submarine accompanied by two ocean going tug boats entered the basin while monitoring was ongoing. The vessels interfered with the sonic signal, however observations just prior and following the vessel arrival did not indicate an obvious response by the instrumented turtle.

ACKNOWLEDGMENTS

This was a cooperative study of the USAE Waterways Experiment Station, University of Central Florida, Patrick Air Force Base, and Johnson Controls. Mr. Kevin Reine, USAE Waterways Experiment Station, assisted with field studies. Dr. Lew Ehrhart and Mr. Bill Redfoot, University of Central Florida directed turtle captures and measurements. Mr. Rick Owen, Dean Bagley, Elena Amesbury, Boyd Blihovde, Shane Belson, Tracy Cascio, and Danny Young of the University of Central Florida assisted with turtle captures. Mr. Clay Gordon was the project manager for Patrick Air Force Base. Mr. Mark Mercandante was the project manager for Johnson Controls. Additional thanks to Officer Brabitz for his assistance at the field site.

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Table 1. Summary of times for dives cycles greater than 10 minutes by green turtles, Patrick AFB (seconds).

ACTIVITY	n	MEAN	SD	SE	MAX
SURFACE	103	70.2	112.5	11.1	774
DESCENT	103	37.0	39.2	3.9	208
BOTTOM	103	1837.6	1376.9	135.7	7341
ASCENT	103	42.5	63.9	6.3	469
SUBMERGED	103	1917.2	1404.7	138.4	7452
CYCLE	103	1987.4	1424.3	140.3	7657

Table 2. Percent of data points for each depth interval by green turtles, Patrick AFB (Approximately equivalent to time).

TURTLE ID	Surface	1 to 50 ft	Surface to 5 ft	Surface to 10 ft	10 to 20 ft	20 to 30 ft	30 to 40 ft	40 to 50 ft
N2272	15.36	84.64	2.38	36.51	29.70	21.62	11.97	0.2
N3060	2.10	97.90	28.29	42.59	5.81	10.18	19.99	21.42
N3181	3.86	96.14	43.92	67.48	2.12	8.19	20.89	1.31
N3043	1.71	98.21	5.68	15.73	7.14	1.34	39.79	35.92
N3105	5.70	94.30	81.35	99.39	0.60	0.00	0.00	0.01
N3179	9.25	90.75	39.70	48.86	29.34	11.46	7.50	2.84
ALL	7.39	92.60	34.07	52.70	15.04	9.8	14.15	8.30

MARINE TURTLE NEST PRODUCTION AND REPRODUCTIVE SUCCESS AT ARCHIE CARR NWR: 1982-1993

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The UCF Marine Turtle Research Group has been studying loggerhead and green turtle nesting on a 21 kilometer stretch of beach in south Brevard County, Florida, since 1982. In 1990 the Congress of the United States authorized the creation of the Archie Carr National Wildlife Refuge, with three of its four "core areas" located within the boundaries of our South Brevard Study Area. In 1989 we expanded our survey coverage 19 km to the north of what is now the Carr Refuge area, in Central Brevard County. Most of this paper will concern nest production and reproductive success in the South Brevard or "Carr Refuge Area" but some reference will be made to the "Central Brevard Area" for comparisons and perspective.

METHODS

The 40.5 km stretch of beach in Central and South Brevard County is subdivided into .5 km sections. All nesting and non-nesting marine turtle emergences were identified as to species and enumerated during surveys conducted at dawn. In 1993 daily surveys were begun on May 6th, and were carried out seven days per week throughout the season. The last regular survey was conducted August 31st, 1993. Reproductive success has been studied at the Carr Refuge since 1985 by quantifying hatching and emerging success. The eggs within each sample nest were counted either as they were being deposited or within six hours of deposition. The sites were then marked precisely so that nest contents could be thoroughly inventoried after all viable hatchlings had emerged.

RESULTS AND DISCUSSION

During the 1993 survey period 10,591 loggerhead and 87 green turtle nests were recorded in the Carr Refuge area. Those nests produced an estimated 708,563 loggerhead and 7,045 green turtle hatchlings. Reproductive success rates have varied little over the past eight years with the exception of a dramatic decrease for green turtles in '89, attributable to the combination of a high raccoon depredation rate and to the effects of two late season storms. The 1993 results for both species fall within the previously observed ranges. There were 302 loggerhead and 44 green turtle nests inventoried in 1993. The mean emerging success rate for loggerhead and green turtles was 60.0 and 61.8 respectively. Raccoons destroyed only 14% of all eggs of the sample loggerhead nests. No raccoon depredation occurred to the sampled green turtle nests but this probably reflects the smaller overall number of clutches laid in 1993. Raccoon depredation has ranged from 10 to 19% for loggerheads and from 0% to 22.4% for greens during the past twelve years.

The spatial distribution of loggerhead and green turtle nests over the entire Central Brevard and Carr Refuge areas is exhibited in Figure 1. The data for loggerheads represent an overall mean of 208 nests/km in Central Brevard and 504 nests/km in the Carr Refuge for the '93 season. Any beach that supports more than 200 nests/km is important but the Central Brevard densities pale in comparison to the truly extraordinary levels of loggerhead activity seen on the adjacent beach, in the Carr Refuge.

The distribution of green turtle nests (Figure 1) is typical for a "low" year with 90% of the clutches being deposited in the Refuge area. The data for greens represent an overall mean of 4 nest/km in the

Carr Refuge and less than one nest/km in the Central Brevard area for the '93 season. The bimodal distribution of nests in the Refuge is typical. The noticeable trough (see • in Figure 1) in the center of the Refuge area coincides with the villages of Melbourne Shores and Floridana Beach which have lighted dwellings, street lights and lighted parking lots. As the entire south beach area of Brevard County continues to develop, more regions in the Carr Refuge area will come to resemble these back-lighted residential ones. To the extent that this happens, the quality of the south Brevard nesting habitat will deteriorate.

There are two ways to look at the overall trend in loggerhead nesting at the Carr Refuge. First, we have been documenting nest production there since 1982 and observed annual totals that did not vary very much around a mean of 9,400 nests, throughout the decade of the 1980's. Then in 1990 loggerhead nesting activity rose sharply to a level about 52% above the previously observed long-term mean. Nesting activity diminished only slightly in the two succeeding years and we have generally found it useful to compare these recent higher levels to the "long-term average of the 1980's". If we do that this year we find that the '93 total exceeds the old long-term figure by about 1200 nests (13%) and we are justified in calling '93 "an above average year." On the other hand, if one ignores the marked increase of the '90 thru '92 period and computes a comprehensive eleven-year average (ca. 10,400), then '93 must be described as "an average year". We believe that it may take another 10 years or more to determine just what the loggerhead trend line is really doing in modern times.

We are accustomed, now, to a biennial pattern of "highs" and "lows" in green turtle nesting activity. We expected a relatively "low" year in 1993 because 1992 was such a "good" one, but we never would have predicted a total of less than 100 nests. This year's nest production equates to an assemblage of only 15-25 adult females and does not inspire much confidence in or optimism for the recovery of this endangered form. Nevertheless, 1992 saw greater green turtle nesting activity than in any previous year (686 nests in the Carr Refuge area). It is true that each year's results bring greater insight to the status of the decimated form but, as in the case for loggerheads, it is far too early to confidently decipher any trend in the size of the Florida green turtle stock in the modern era.

To conclude, our south Brevard study area encompasses all of the Brevard portion of the Archie Carr National Wildlife Refuge and it is upon data such as those gathered during the past twelve years that the refuge concept is predicated. Total nest production in the Carr Refuge will undoubtedly approach 25% of the state-wide total for both species, again in 1993. In spite of the difficulty of settling on the meaning and reality of apparent trends, the numbers are important in and of themselves because such a large proportion of the reproduction of both stocks takes place in south Brevard. It seems reasonable that whatever demographic trends are occurring in the Western Atlantic loggerhead and the Florida green turtle stock, they will be detected most accurately here.

Development in South Brevard county is booming and land prices have risen sharply since last spring, when the Disney organization announced plans to build a seaside resort just south of the Carr Refuge lands. In spite of some local opposition, construction was recently begun on a shopping center on the west side of Highway A1A, in the northern "core area" of the refuge. It is located on the same section of the barrier island that supported the highest level of green turtle nesting in '92. The greater levels of loggerhead nesting seen here in the past four years, the uncertainty of the trend in green turtle nest production, and the threat of commercial development within and near the Carr Refuge area should provide a greater imperative for acquisition of lands by all levels of government and Non-Government Organizations.

We would like to thank the following for their support to this project: Florida Department of Environmental Protection, U.S. Fish and Wildlife Service, and Richard King Mellon Foundation.

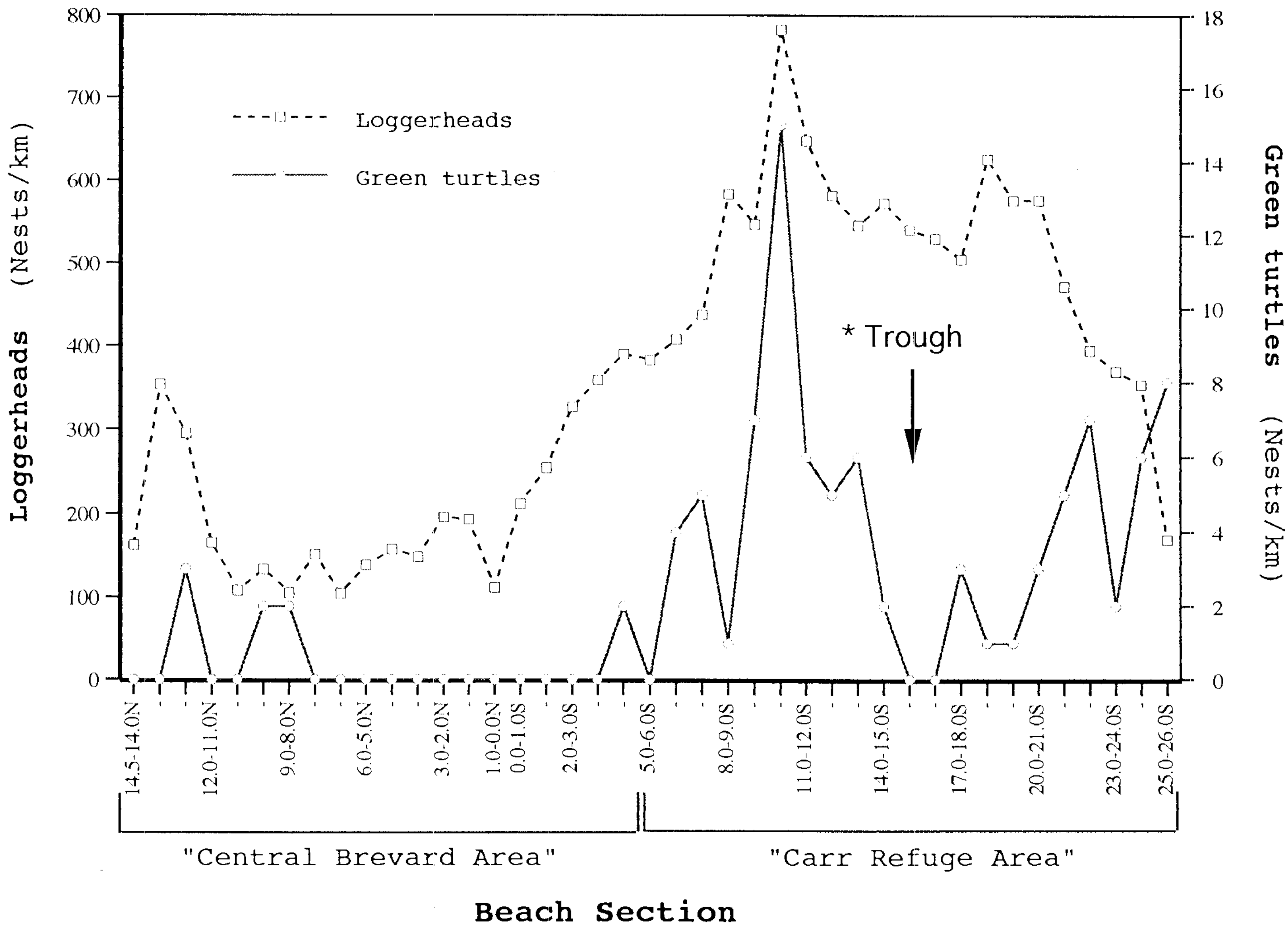

Figure 1. The spacial distribution (nests/km) of loggerhead and green turtle nests in the Central Brevard Study Area and the Brevard County portion of the Carr Refuge during 1993.

EFFECTS OF BEACH NOURISHMENT ON COMPACTION, GRAIN-SIZE, MOISTURE AND TEMPERATURE: SEBASTIAN INLET

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In April 1992, the Sebastian Inlet Tax District contracted FIT to initiate a long-term physical attribute monitoring program to begin in May 1992. The project was designed to compare control and treatment beaches using parameters thought to influence sea turtle nesting and hatching success. This report is addresses the results for 1993.

Two study sites have been selected for monitoring (figure 1). The control site (natural) is located approximately 3,000 ft north of Sebastian Inlet. The treatment (renourished) site is located approximately 4,000 ft south of the inlet. This area was most recently subjected to beach renourishment in Winter 1993. The specific aspects of the physical attributes monitoring program are summarized in Table 1. The general form of the null hypothesis for each physical attribute monitored during this project is:

> The specific physical attribute of the control (natural) beach is not significantly different than the specific attribute of the treatment (renourished) beach.

Statistical comparisons between the control and treatment beach were then conducted for each physical attribute to determine if the null hypothesis was to be accepted or rejected.

The results of this investigation suggest that there are very significant differences in sediment compaction, mean sand size and temperature. Significant differences in %gravel and %mud were detected 40% and 75% of the time. Significant differences in moisture content were noted 75% of the time. The results of the statistical comparisons are shown in Table 2.

Unfortunately, it is not possible to determine what effects these differences have had on sea turtle nesting and hatching success as a biological monitoring program was not conducted concomitant to this study. A previous study (Ryder, 1990) of the physical attributes associated with the 1989 beach renourishment at Sebastian Inlet has documented no discernible effects on sea turtle nesting and hatching.

In order to document if the differences in the physical attributes between the control and treatment beaches have a biological effect, physical and biological studies must be combined. This joint effort will facilitate the understanding of how physical attributes of a beach affect sea turtle biology.
A long-term monitoring program of the fill material is also proposed to reduce the discharge of inappropriate material onto the feeder beach.

Table 1. Summary of the physical attributes monitored at control and treatment beaches between the months of May and September, 1993, Sebastian Inlet, Florida.

Physical Attribute	Sample Interval	Sample Frequency
Compaction	-30, -60	monthly
Grain size Gravel:sand:mud Sand-size fraction	-30, -60	monthly
Moisture	-30, -60	monthly
Temperature	-30, -60	monthly

Table 2. Statistical significance of physical attributes measured on control and treatment beaches for each sampling date. Statistical significance: 95% confidence level *, 99% confidence level **, 99.9% confidence level ***, not significant ns.

PHYSICAL ATTRIBUTE	SAMPLING DATE 5-18	6-12	7-13	8-11	9-11
Compaction -30 cm	***	***	***	***	***
-60 cm	***	***	***	***	***
Grain Size % Gravel -30 cm	ns	**	ns	ns	ns
-60 cm	ns	*	ns	ns	ns
% Mud -30 cm	*	**	*	**	ns
-60 cm	ns	**	*	ns	***
Sand-Size -30 cm	***	***	***	***	***
-60 cm	***	***	***	***	***
Moisture -30 cm	**	*	***	*	*
-60 cm	***	ns	*	**	**
Temperature -30 cm	***	***	*	***	***
-60 cm	*	***	***	***	***

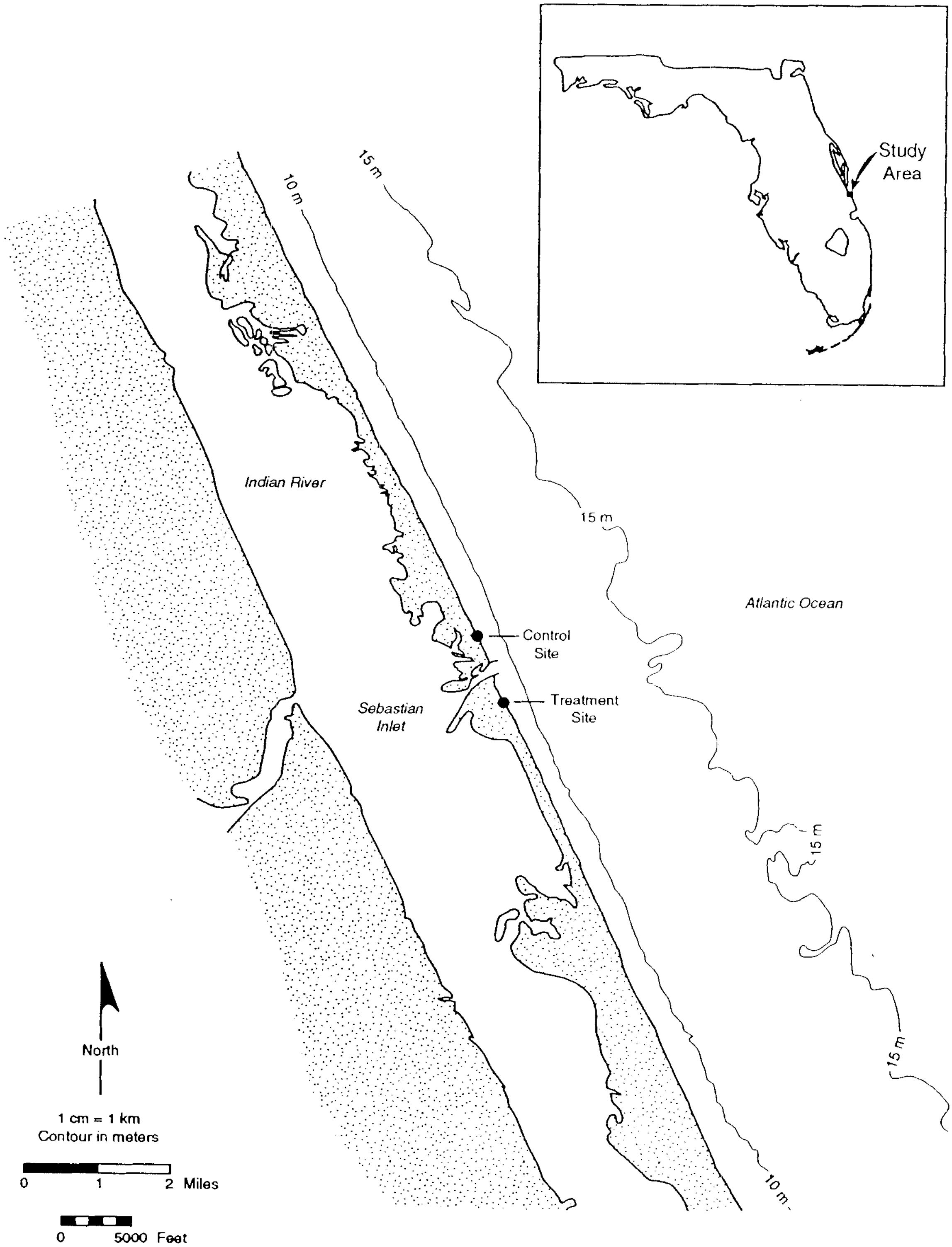

Figure 1 - Regional location map of study area showing position of control (natural) and treatment (renourished) beaches.

MULTIPLE PATERNITY IN GREEN TURTLES (*CHELONIA MYDAS*): CONSERVATION IMPLICATIONS

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For any declining population, a knowledge of the prevalent mating system is important because it directly influences the effective size of that population. The effective population size (which is a function of the number of breeding males and females) in turn determines the rate at which genetic diversity is lost through drift. In marine turtles the mating systems of different populations is difficult to determine and therefore information regarding breeding sex ratios are unavailable. In order to address this problem, we have used multilocus minisattelite DNA fingerprinting to estimate the number of males that female green turtles mated with to fertilize their clutches.

DNA fingerprinting is a high resolution molecular technique that uses special probes to detect highly variable regions of nuclear DNA. It screens dozens of loci simultaneously and produces individual-specific banding patterns that can be used for estimates of genetic similarity and in parentage analysis.

METHODS

Small blood samples (50-100μl) were collected from females nesting at Tortuguero, Costa Rica. The nests of these females were marked and when the hatchlings emerged, blood (10-20 μl) was collected from them as well.

For each of two partial families (mother and offspring) the DNA from these samples was run on fingerprint gels to produce individual-specific banding patterns (average of 29 bands per individual). For each family, any bands in the offspring lanes that were also found in the mother's lane were eliminated from the analysis, thereby leaving bands that were strictly paternal in origin. The proportion of paternal bands shared was then calculated for every hatchling/hatchling pair in each of the nests to get indices of genetic similarity.

RESULTS AND DISCUSSION

Because the loci visualized by using this technique assort in Mendelian fashion, full siblings are related to each other by one half. Therefore the expected genetic similarity value for full siblings is 0.5. Figure 1 shows the distribution of genetic similarity values for nestmates in each of two families. The shaded regions of the distributions show dyads for each family that had similarity values that were significantly lower than 0.5.

Fifty-four percent of the dyads in family 1 had genetic similarity values that were significantly below 0.5, and 59% of the dyads in family 2 had values that were significantly below 0.5. This suggests that a majority of the pairs scored for these families are actually half-siblings, and so there is strong evidence that these females have used sperm from at least two different males to fertilize their clutches.

Given this, a cluster analysis using the UPGMA method (Rohlf, 1990) was performed to examine the relationship of all hatchling/hatchling genetic similarity values from each family. Figure 2 shows the trees produced by this analysis, and how the hatchlings in each family cluster out in relation to one another.

The cutoff position on the tree stems which differentiate between full and half siblings is based on the binomial probabilities for dyads of hatchlings within each family. Members of pairs that had genetic similarity values of 0.39 or below were significantly distinct ($P<0.05$) and were therefore considered to be half-siblings. This cut-off value allowed us to distinguish between clusters and make an estimate of the number of fathers represented in each nest.

Using this approach, four fathers (A-D) are represented in our sample of 12 hatchlings from family 1, and three fathers (A-C) are represented in our sample of 14 hatchlings from family 2. The results from these first families suggest that there is some level of mixed paternity within clutches of green turtles nesting at Tortuguero. This provides evidence that the prevalent mating system of this population is promiscuity, where females mate with multiple males to fertilize each clutch.

Mating systems can influence the effective population size and the degree of genetic variability in the face of different levels of nest failure. For example, in a promiscuous mating system where each female mates with each male, the effective population size is always higher than for any other mating system because a nest failure removes only the genotype of the mother. All the fathers are all represented in other nests, so their genotypes are maintained.

In contrast, a nest failure in a monogamous mating system, where females have only one exclusive mate, would remove both the mother's and the father's genotypes from the population. In this way, mating systems can influence both the effective population size and the level of genetic variability.

Because small or declining populations are most susceptible to genetic drift and the detrimental effects of reduced genetic diversity, a knowledge of mating systems is important in order to effectively manage threatened and endangered species like marine turtles.

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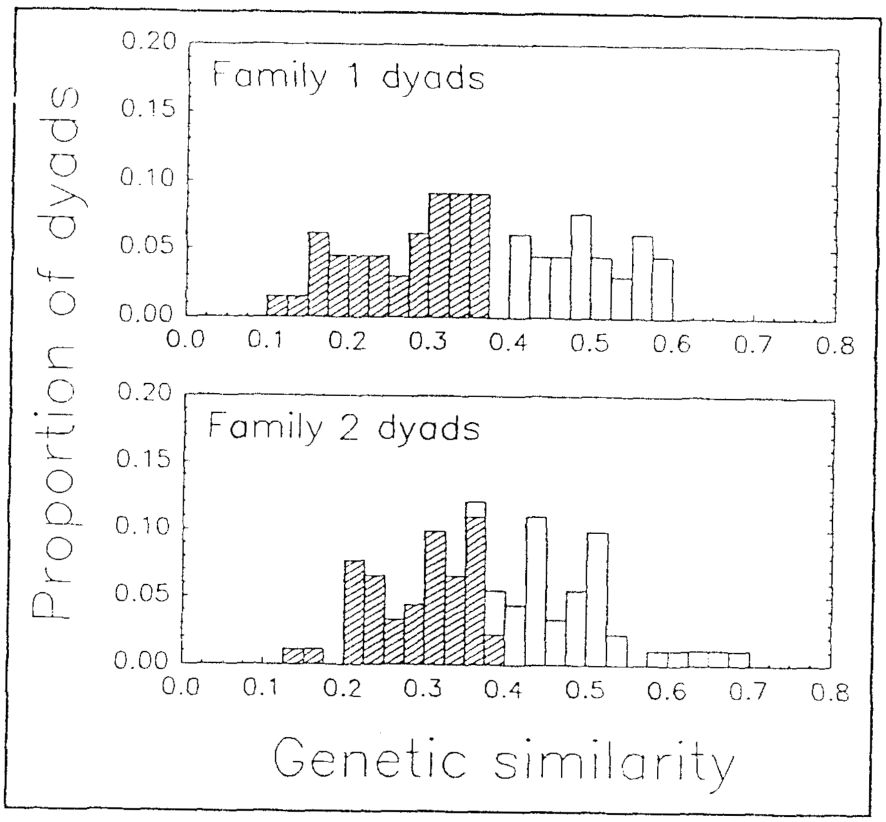

Figure 1. The frequency distributions of genetic similarity values (proportion of bands shared) for dyads of hatchlings in two families (N=66 and 91). The shaded regions identify those dyads with genetic similarity values statistically significantly below 0.5, which is the expected value for full-siblings.

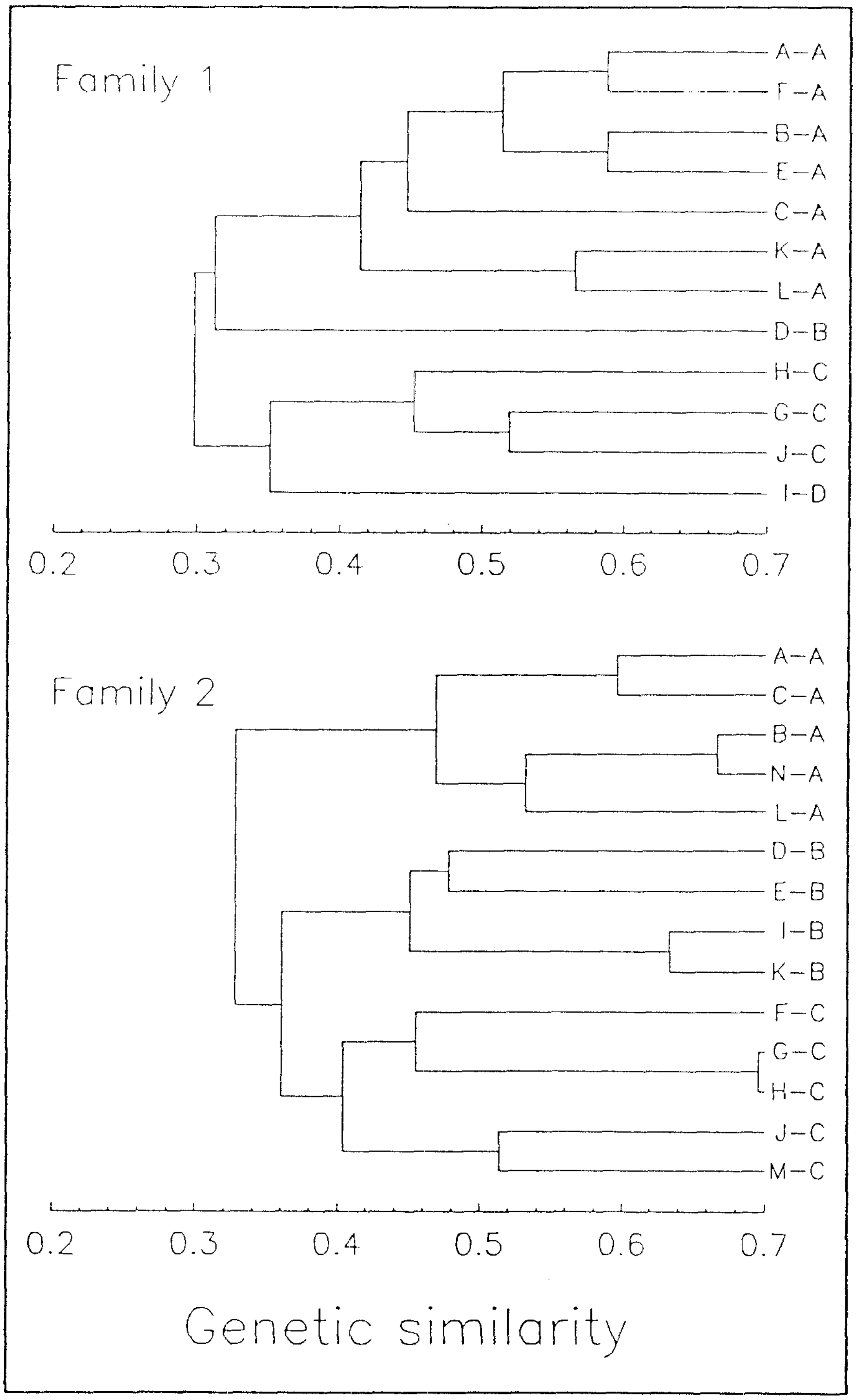

Figure 2. UPGMA cluster analysis for the two families. The first letter on the end of each branch tip is the hatchling identification code, and the second letter is the father's identification code. Family 1 has 12 hatchlings and 4 fathers. Family 2 has 14 hatchlings and 3 fathers.

POST-BREEDING MOVEMENTS OF MALE OLIVE RIDLEY SEA TURTLES *LEPIDOCHELYS OLIVACEA* FROM A NEARSHORE BREEDING AREA

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We attached radio (VHF) and satellite (UHF) transmitters to 11 reproductively active male olive ridley sea turtles (*Lepidochelys olivacea*) captured while mounted to female *L. olivacea* in the Gulf of Papagayo on the Pacific coast of Costa Rica. Telemetered male *L. olivacea* departed the Gulf of Papagayo by late September which coincided with a decrease in the number of mounted turtle pairs observed nearshore and with an increase in the number of female *L. olivacea* ovipositing at Nancite beach. Male *L. olivacea* post-breeding migrations traversed hundreds of km of deep (> 1,000 m) oceanic waters and were geographically distributed over a very broad range. In general, the males did not migrate to one specific foraging area. Rather, they appeared to occupy a series of foraging areas within their oceanic habitat of the eastern Pacific Ocean. These results are similar to the migratory behavior we previously have described for female *L. olivacea* from this same population.

TURTLES AND ARAWAKS: A MULTIDISCIPLINARY CONSERVATION ETHIC FOR INDIGENOUS PEOPLE IN GUYANA

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"Conservation Biology" may or may not be a science; certainly it also incorporates much that would normally be characterized as "art" or "politics." Nevertheless, in the course of three decades developing a marine turtle conservation program in North-Western Guyana, I have attempted to develop pragmatic approaches for effecting real-world change, and in the course of these efforts have sought to elucidate general principles of conservation biology that may apply to comparable situations elsewhere, and thus qualify as "real" science. Such "comparable" situations include scenarios where indigenous peoples, in protracted and partial transition to modern, cash economies, are operating within an essentially intact, non-urbanized ecosystem, but where the larger, edible, and most vulnerable wildlife species are fast disappearing.

This analysis suggests the following methodology for developing a sea turtle conservation program, with emphasis on finding workable solutions in Third World countries.

i) Determine that you really have a problem. Often we can be persuaded that a significant take of a given species inevitably constitutes over-exploitation. It may or may not. Any harvested species is likely to show certain adjustments to hunting -- it may become more wary, or its equilibrium population may be reduced somewhat. We are aware that the determination of the population trend of a sea turtle population takes many years, and we will often have simply to make an informed "best guess." We are aware, too, of the paradox that, if a given community catches turtles rather than raids nests, the nesting population may show a decline, but is unlikely to go extinct. On the other hand, heavy egg collection may seem tolerable for a while as nesting populations remain unaffected for decades, but ultimately, when they do start to drop, the drop is very steep and may be unstoppable. So we need a combination of good data on exploitation rates, a good population model, and a good crystal ball.

ii) Prioritize -- but don't necessarily neglect activities of secondary priority, although they may have to be done opportunistically. Very small populations of turtles that are abundant elsewhere may not attract priority 1 attention -- their loss will primarily be an inconvenience to local people (who should be helped to do something about the problem) rather than a global disaster. Priority 1 programs may include action on very rare species anywhere in their range; action to protect and consolidate the largest nesting colonies of other species; and action to reverse clearly unsustainable exploitation or incidental loss in populations that may or may not be especially large. The Sea Turtle Conservation Strategy included at the end of the Proceedings of the 1979 Washington Sea Turtle Conference (Ehrenfeld, 1982) still has merit. Re-read it.

iii) Having convinced yourself that there is a problem, devise a solution. Often this will involve attempting to get people to stop doing something that they have been doing for a long time. In other cases, it may not -- instead, we may have to operate a hatchery, headstart hatchlings, rescue adult turtles that have become entrapped or are in difficulties on the nesting beach, control feral mammals or raccoons, etc.

iv) Apportion responsibility for the solutions you recommend. Some components will have to be done by government, some you will have to do yourself. Lobby for the former, using all the standard techniques of coalition-building, educational programs, and so on. In Third World countries, even government programs may need external funding. Help them to find it if it is the only missing ingredient for necessary conservation action. Some things, like TED enforcement or import controls, obviously have to be governmental. Local educational programs do not. Few governments have coherent, fair, or defensible policies towards indigenous peoples within their borders, and if over-exploitation by rural or indigenous people is a problem, this may have to be tackled at the NGO or individual level.

v) Unless the area is actually uninhabited, work with the local people, befriend and understand them, and develop a consensus approach. You have the scientific or global knowledge of the species in question; they have the local knowledge. Together you have the material for a management plan. Determine that *they* believe that there is a problem, or you will start with a crippling disadvantage. For example, if a management plan for olive ridleys at Ostional, Costa Rica, started with a statement that the US Government classified this population as threatened, this conclusion would not accord with the local people's own experience and observations, and the plan would be doomed. But the population could be portrayed as vulnerable unless certain restraints were practiced.

vi) Make friends, understand the community leaders (official and unofficial) as well as the user and exploiter groups, and pick your team, using your best human judgement about whom to trust and who shows real interest and ability. Develop consensus on the nature of the problems, and then agree on the solutions. Guide the conversation where necessary, but do not be too dogmatic -- their ideas are as valid as yours. Tell them things they may not realize, such as the habit of sea turtles of nesting many times within a season, so that it is easy to overestimate a breeding population.

vii) Fund raise. You can do little if anything without money. It's not cheating to put some of the locals on payroll -- all sustained conservation programs require sustained funding. Before long, the project will capture the imagination of local officials as well as potential funding sources, who are generally tired of confrontational conservation and are delighted to find a case where conservationists and indigenous or local people are working together.

viii) Get community support for external threats that require police or enforcement action. People can generally agree on the need for sanctions against outsiders ripping off their resources, even if they are slow to restrain themselves.

ix) Establish criteria for success. For example, short-term criteria may simply reflect that a turtle that gets back to the sea alive after nesting is a unit of "success." So is a nest of hatchlings that enters the sea successfully. Longer-term criteria can be devised also, both in terms of measurably changed attitudes and also in terms of turtle population parameters.

x) Constantly, or at least annually, review options for improvement, or response to new threats and also new opportunities.

xi) Steadfastly oppose the irredeemably evil, but negotiate with other interests. Those who seem not to care, or to place quick profits above turtle survival, may simply never have thought of turtles the way you do, but may not be immune to that ethic if you take time to talk to them.

xii) Look for replication options. If a given program seems to be working for you, where else may it also work? For example, in Guyana, we have some confidence that we are on the right track in involving the Arawak community in marine turtle management, and now are attempting to replicate what we have learned with the Macusi and Wapisiana communities in the interior, where they traditionally exploit the giant river turtles of the genus *Podocnemis*.

xiii) Educate the young. Give them T-shirts as well as your time and attention -- they will value both. Bring them to the beach and show them the turtles nesting. Educate the adults also, and to the greatest extent possible have them do the science themselves -- there is nothing that can replace the experience of someone seeing a turtle back to re-nest after they themselves tagged it weeks (or years) earlier.

xiv) Seek out the people you inconvenienced. They may never confront you, but may mutter darkly -- or worse -- in your absence. Show an interest in their welfare and standard of living, and help them develop alternatives to turtle products. They may need a subsidy to get started, but avoid putting perfectly competent people on welfare.

xv) Don't assume that an appeal to aesthetic interests cannot work in poor communities. A child will appreciate the wonder of a turtle hauling ashore to nest, whatever his or her background.

xvi) Be prepared for unexpected, new problems that may require a complete reappraisal of priorities. In Guyana, for example, we have suddenly found ourselves having to fight beach mining, an issue that has simmered for decades but suddenly recrudesced as a real threat. By this time, you should have the locals or the indigenous people on your side, and they can be a much more potent lobbying force, if unobtrusively guided, than a visiting gringo ever could be.

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STATUS OF MARINE TURTLES IN THE PHILIPPINES

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Five species of marine turtles are known to occur in the Philippines, namely: green turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*).

The green turtle occurs widely throughout the country, with high nesting aggregations in Turtle Islands and San Miguel Group of Islands, both in Tawi-Tawi. The decline in the green turtle population is attributed to massive egg harvests that have been in progress for the past 43 years (PCP data). In the Philippine Turtle Islands for example, the egg production of Taganak Island was 137,254 from August 8 to September 11, 1951 (Domantay, 1953). Data collected by the Pawikan Conservation Project from 1984 to 1993 in the same island on the same dates revealed that there was a 81.43% decrease in egg production (range: 15,515 - 42,596 eggs).

The hawksbill is also widely distributed. However, unlike the green turtle, major nesting aggregation of hawksbills has not yet been recorded or identified. Hawksbills are known to nest on numerous, uninhabited islands throughout the archipelago. Lagunoy Gulf in the Bicol region has been identified recently as a developmental habitat of hawksbill turtles. The population of hawksbills is severely decimated as a result of excessive exploitation of eggs and the high international demand for tortoiseshell.

Although very rare, olive ridleys, loggerheads and leatherbacks are found in the Philippines. In the early 1900's, Taylor reported that olive ridleys were quite common in Manila Bay. Confirmed sightings have been reported from Palawan, Malabon, Carigara Bay in Leyte and Subic Bay in Zambales. Just recently, a male sub-adult was captured by local fishermen in Balayan Bay in Batangas (FAO reports and PCP data).

The loggerhead was documented only from old published photos by Seale (1911 and 1913) and Taylor (1920 and 1921) but Nishimura (1967) doubted the taxonomic classification of the species described by Taylor because loggerhead turtles are known to be warm temperate species. At present, there are only two documented tagged loggerhead turtles from Japan. These turtles were caught by fishermen in Pilas Island, Basilan in 1992 and Rapu-Rapu, Albay in 1993 (De Veyra, 1994).

Leatherback turtles are occasionally caught by local fishermen in southern Luzon, Visayas and Mindanao. These turtles are believed to come from the leatherback rookery of Terengganu, Peninsular Malaysia. No nestings have yet been documented in the Philippines.

In order to address the very rapid decline of the marine turtle population in the Philippines, the Task Force Pawikan (vernacular for marine turtle), now referred to as Pawikan Conservation Project (PCP) was created by virtue of Executive Order 542 on June 26, 1979. The primary objective of the PCP is to develop and implement conservation and protection policies to further balk the exploitation of marine turtles in the country. Massive information and education programs have also become a thrust of the project. Management-oriented scientific researches are conducted to ensure the survival and protection of the country's endangered marine turtle population. Three implementing units have been instituted in order to attain these objectives, namely: 1) Resource and Management Unit, 2) Research and Investigation Unit and 3) Information and Services Extension Unit.

In 1982, the Ministry of Natural Resources (now the Department of Environment and Natural Resources [DENR]) issued Administrative Orders 8 and 34 declaring the establishment and protection of eight (8) islands in the provinces of Antique, Palawan and Tawi-Tawi as marine turtle sanctuaries. But due to very limited resources (funds and equipment), conservation efforts have been concentrated only at the Baguan Island Marine Turtle Sanctuary (BIMTS), Turtle Islands, Tawi-Tawi. This sanctuary island contributes 55.19% of the total egg production (1987 - 1993) in the area. As stipulated in MNR Administrative Order No. 33, series of 1982, 40% of the total egg production in the islands shall be conserved while 60% of the eggs produced may be collected by local residents in the islands of Taganak, Lihiman, Langaan and Greater Bakkungan. A closed season (January to March) is also set each year to offset collection of eggs for the rest of the year. Conservation is very critical in these islands since they support the only major green turtle rookery (more than 1,000 nesters annually) in the ASEAN Region along with the Sabah Turtle Islands in Malaysia. From 1984 to 1992, over 14 million eggs were produced from the Philippine-Sabah Turtle Islands with approximately 78% coming from the Philippine Turtle Islands (Trono, 1994).

Nesting green turtles with Malaysian tags are occasionally encountered in the nesting beaches of Turtle Islands. Philippine tags are usually applied on the foreflippers of these turtles. On the other hand, turtles tagged in the Turtle Islands are also encountered in the Sabah Turtle Islands (De Veyra, 1994). From this, it can be inferred that although the area is separated by treaty limits, it is indeed a well-defined green turtle rookery (Trono, 1994).

A total of 5,324 neophyte nesters (presumed to have nested for the first time) were tagged from 1982 to 1993 in the Turtle Islands. Tagging data collected from BIMTS revealed that the internesting interval for green turtles is 11.08 days (n = 569). Renesting interval (period between two nesting seasons) is three (3) years (n = 166). Tag loss is the primary problem encountered for this activity.

From 1984 to 1993, 54,408 complete nests have been recorded in BIMTS. Complete nests recorded in BIMTS from January to April are relatively lower than the other month. Nesting peaks from July to August and slopes down in September to December. The highest number of complete nests monitored was recorded in 1991. The computed average number of eggs laid per nest in the BIMTS is 101. Based on this figure, BIMTS has produced 5,495,208 eggs from 1984 to 1993. Doomed nests (laid on the high tide mark) are transferred immediately to the hatchery. Nests laid on the pocket beaches and farthest from the field station are also transferred to the hatchery. This procedure is deemed necessary since egg poaching is a perennial problem in the sanctuary.

The male-female sex ratio (1:8) of hatchlings in the BIMTS nesting beach has also been determined in 1989. From this study, it was also found that hatching success of incubated eggs (n = 146) is 87.13% with an average incubation period of 54.32 days (Trono and de Veyra, 1990 unpub.). Hatchery experiments were also conducted to assess management procedures implemented in the area (Yaptinchay and de Veyra, 1994). At present, the PCP has shaded some portions of the hatcheries to offset the all female hatchling production in the past.

For the other parts of the country, the Regional Technical Director for Environmental Management and Protected Areas Services for each of the DENR regional offices were designated as field action officers (FAOs) whose function is to implement marine turtle conservation activities in their areas of duty. Some of the activities undertaken by the FAOs and their staff are tagging and releasing of incidentally caught or confiscated turtles and conduct information and education campaigns for coastal communities. Pre-paid postcards are distributed to regional offices, non-government offices and individuals all over the country to document marine turtle sightings in the Philippines. Data collected from the reports and the habitat surveys conducted by the technical staff of the PCP has enabled the project to gather insights on the general distribution of the five species of marine turtles in the Philippines.

As part of the PCP's mandate, the project produced radio plugs in different dialects on marine turtle conservation, emphasizing the need to conserve for the future generation. Posters, brochures, flyers, pamphlets, postcards and T-shirts were also produced as part of the information and education program of the project. Training workshops on the biology and conservation of marine turtles are held for DENR regional technical personnel to decentralize some of the functions of the project. The PCP also conducts seminars in all school levels nationwide.

The population of turtles in the Philippines has declined very rapidly through the years but collaborative efforts of the three units with international (WWF, USAID and US Fish and Wildlife Service) and local (Marine Turtle Foundation) institutions has greatly amplified marine turtle conservation in the Philippines. Yet still lacking in logistics and funds, the project is trying its very best to cope up with its problems.

ACKNOWLEDGMENTS

Dr. Karen Eckert and World Wildlife Fund for the travel grant; Mr. Romy Trono for editing the text and the PCP for their support.

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SATELLITE TRACKING OF JUVENILE KEMP'S RIDLEY SEA TURTLES NEAR SABINE PASS, TEXAS

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Hopper dredging by the U.S. Army Corps of Engineers (COE) has been identified as a notable source of mortality to sea turtles in inshore waters (Dickerson and Nelson 1990; Magnuson et al. 1990). Maintenance dredging of intracoastal waterways and about 45 ship channels in the Gulf and Atlantic, disposal of dredged materials, beach nourishment and marine construction (Thompson et al. 1990) all pose risks to sea turtles. Resolution of sea turtle/industry conflicts such as channel dredging, and implementation of proper management of existing stocks are severely compromised by the paucity of quantitative data on species composition, size distribution, spatial and temporal abundance, habitat preference, feeding grounds and nesting activity of sea turtles in nearshore and estuarine waters of the northwestern Gulf.

Texas waters provide essential habitat for Kemp's ridley and green sea turtles. Until recently, virtually no research had been conducted on sea turtle populations in Texas. Tracking and mark-recapture studies on green sea turtles in south Texas and numerous sightings by the public at jetties and channel entrances along the central and south Texas coast during the summer suggest these areas serve as developmental habitats for juvenile and subadult sea turtles. Further evidence indicates that jetties and channel entrances along the upper Texas and lower Louisiana coasts serve as developmental habitats for juvenile and subadult Kemp's ridley sea turtles.

METHODS

To learn more about the importance of these habitats, sixteen juvenile turtles (15 Kemp's ridley and 1 loggerhead) equipped with radio and sonic transmitters were released at Sabine Pass, TX and tracked intermittently during May through mid September 1993. One loggerhead and nineteen Kemp's ridleys were fitted with satellite transmitters and released near their capture site at Sabine or Calcasieu Passes.

RESULTS AND DISCUSSION

Straight carapace lengths and weights of turtles ranged from 25.9-59.5 cm and 3.0-30.5 kg. Both radio and satellite tracked turtles moved along shore during adverse weather in the direction of the prevailing winds and currents. The maximum distance moved by turtles, from their release sites, ranged 20 and 1700 km.

On five occasions, three of 18 radio tracked turtles were observed in the Sabine Pass Ship Channel, either between the jetties or off the seaward tip of the jetties. During these 12 hours of tracking, these turtles spent 24% of their time within the confines of the ship channel designated for potential biannual hopper dredging. For these three turtles, this translates into a minimum of 1.4-4.2% of their daily activities. Since radio tracked turtles were not monitored 24 hr/day, it was mere chance that we tracked turtles that happened to use the Sabine Pass channel. Thus, it is not inconsistent to expect the remainder of the radio tagged turtles to utilize a similar amount of their time in the channel.

Susceptibility to hopper dredging in the channel may occur when turtles 1) feed in the channel, 2) cross the channel as part of their normal movement, or 3) use the channel for passage to enter estuaries in Sabine and Calcasieu Lakes, and other bay systems of the Gulf of Mexico. Data are too sparse at this juncture to accurately identify the use of ship channels by the Kemp's ridley sea turtle.

This study increases our knowledge in movement behavior of juvenile Kemp's ridley turtles in the western Gulf of Mexico. Knowledge of the near simultaneous movements of 35 sea turtles is unprecedented. We are developing research plans to allow us to draw convincing conclusions about the utilization of nearshore nursery habitat for Kemp's ridley sea turtles. To this end, results and conclusions in this abstract should be considered preliminary.

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OBSERVATIONS ON THE REPRODUCTIVE PHYSIOLOGY OF THE LEATHERBACK SEA TURTLE (*DERMOCHELYS CORIACEA*)

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The reproductive physiology of the leatherback sea turtle (*Dermochelys coriacea*) has largely gone unstudied due to the inherent difficulties of working with this large animal. Recent advances in technology such as ultrasonography now make it possible to work on these animals without disturbing their reproductive cycles. During the 1992-1993 nesting season, nesting females were studied at Playa Grande, Costa Rica. Blood samples were collected from twelve nesting females in November 1992 and 11 nesting females in January 1993. Plasma testosterone and plasma calcium levels were measured. Nesting females were also scanned using ultrasonography to determine their reproductive state (i.e., presence or absence of pre-ovulatory vitellogenic follicles). Reproductive state as determined by ultrasonography was positively correlated with plasma testosterone levels. Females displaying mature ovaries with multiple large vitellogenic follicles had high testosterone levels (3.27 $\pm$ 0.44 ng/ml, SE, n = 10). Females with depleted ovaries lacking large vitellogenic follicles had low plasma testosterone levels (0.31 $\pm$ 0.09 ng/ml, SE, n = 7). Plasma calcium levels were not correlated with reproductive state during the nesting season. Circulating plasma testosterone levels in the female leatherback are higher than those observed in other sea turtle species. Plasma testosterone may prove useful for monitoring population dynamics of nesting leatherbacks around the world. Understanding the nesting physiology of the leatherback sea turtle will enhance our ability to monitor nesting populations. This research was supported by a grant from the Center for Field Studies (Earthwatch).

SEA TURTLE NESTING POPULATION AT PLAYA LA FLOR, NICARAGUA: AN OLIVE RIDLEY "ARRIBADA" BEACH

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Playa La Flor is a bay on the Pacific Ocean, very near the boundary with Costa Rica. It is the second beach in importance in Nicaragua because of the arribada quantity of Olive Ridley turtles. Actually the Ministry of Environment protects the turtle reproduction at this beach for 6 months of the year, from August to January.

The beach is sandy and narrow without a defined berm. It measures 1600 meters in length. There is a sea current from south to north at the bay.

METHODS

I defined an arribada as 50 females simultaneously on the beach. I delimited 16 sectors of 100 meters each and in every one of them there was a man from the local staff of the Ministry of Environment. They counted every turtle that arrived at the beach. I established plot areas starting at the vegetation line to count the hatchlings and to mark nests like Cornelius and Robinson (1984).

RESULTS AND DISCUSSION

There were 6 arribadas during the study period (see Table 1). The turtles nested at the north half of the beach only.

The main egg predators were domestic dogs, after them came *Coragyps atratus* and *Cathartes aura* to eat eggs from the partially destroyed nests. There were probably some crabs consuming eggs as well (Cornelius, 1986). The main consumer of hatchlings were *Fregata magnificens* which came in very big flocks. Second *Polyborus plancus* came with *Coragyps atratus* and *Cathartes aura*. Less important hatchling predators were *Egretta refescens*, *Calocitta formosa*, a young hawk (prob. *Buteogallus anthracinus*), dogs and crabs.

The arribadas came periodically, with 21-25 days between them, without relationship between the arribada date and the moon phase. The turtles preferred to lay their eggs close to the vegetation line, there was no defined berm.

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TABLE 1

ARRIBADAS OF OLIVE RIDLEY TURTLES AT LA FLOR, 1993

DATE		QUANTITY	TOTAL
AUGUST	18	930	
	19	161	
	20	107	
	21	195	1393
SEPTEMBER	10	1255	
	11	2654	3909
OCTOBER	5	1603	
	6	5763	
	7	1520	8886
NOVEMBER	4	3894	
	5	1893	
	6	613	6400
NOVEMBER	27	688	
	28	4106	
	29	395	5189
DECEMBER	22	940	
	23	710	1650
JANUARY		None Came	

DAILY MOVEMENTS OF ADULT MALE AND JUVENILE LOGGERHEAD TURTLES (*CARETTA CARETTA*) AT CAPE CANAVERAL, FLORIDA

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Many studies have focused on post nesting female movements, but relatively few have been conducted on adult male and juvenile daily behavioral patterns of habitat use. March and April are transitional months for loggerhead populations at Cape Canaveral Florida. Juveniles, which are thought to overwinter in the area are leaving, while adult males are migrating into the area to mate (Henwood 1987).

Eight loggerhead turtles (five juveniles and three males) were captured and tagged with radio and sonic transmitters. Each turtle was monitored for up to 48 hours to determine the rates of movement, direction, directness of travel, and the percent of time spent in different channel areas.

Two of the three males spent the majority of their time within a 3.5 km radius of the channel while all juveniles spent most of their time beyond 3.5 km from the channel. The resultant vectors for the juvenile movements showed a definite eastward movement while those for the adult males were northwest and southwest which correlated highly with the orientation of the channel. Two of the males had a high affinity for the channel while the remaining male headed eastward out of the area. This departing individual was the smallest of the males and may have been exhibiting juvenile behavior. All of the juveniles headed directly out of the area, but one showed circling patterns similar to that of males. This juvenile was the largest one monitored, and may have been demonstrating adult male behavior. The rates of movements of the males were significantly faster than those of the juveniles and the two age groups had very different daily patterns of activity. During the hours of 1600 to 2000 adult males were most active and the juveniles least active.

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FLORIDA INDEX NESTING BEACH SURVEYS: ARE WE ON THE RIGHT TRACK?

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Although limited nesting surveys in Florida began in the 1950's, it was not until the late 70's and early 80's that nesting surveys became more widespread. In 1979, the Florida Department of Environmental Protection (then the Florida Department of Natural Resources) began compiling and archiving these data into a statewide nesting database in an effort to piece together a more comprehensive picture of nesting activity across all monitored beaches. A simple examination of the number of sea turtle nests documented during statewide nesting surveys over the 14-year period from 1979 to 1992 would, in the absence of any additional information, indicate a trend of increasing nesting activity and might suggest that populations are recovering. However, there are important factors that must be considered when evaluating statewide nesting data. These factors include survey effort, survey standardization, and surveyor experience. In the Florida statewide nesting database, variability exists in annual survey effort, in the number of days per week each beach was surveyed, and in the experience of surveyors. The statewide nesting data provide important information regarding nesting distribution, nesting seasonality, and relative nesting densities. However, the limitations of the statewide nesting data to monitor nesting trends, prompted the development of a complimentary survey program that would provide, as a main goal, a valid index to monitor the long-term status of Florida's nesting populations.

The Index Nesting Beach Survey (INBS) program was initiated in cooperation with the U.S. Fish and Wildlife Service in 1989 and included four principal components: standardized effort, standardized methodology, training, and evaluation. Similar INBS programs are currently underway in Georgia and North Carolina. In South Carolina, a long-term aerial survey program has been implemented to monitor the status of nesting populations. This paper describes the Florida INBS program, focusing on the four principal components.

Standardized Effort: To standardize survey effort, 27 beaches (totalling 325 km in survey area) in the state were selected to serve as index nesting beaches - 24 along the east coast and 3 on the west coast. We selected beaches to ensure that the program encompassed a significant portion of the statewide nesting activity. Selections were also based on the level of effort in place prior to the index program, the experience of project leaders, and whether a long-term commitment to the program could be made. The beaches selected include publicly owned federal, state, or county lands and privately owned lands. A variety of land-use categories are represented at the selected beaches. Survey participants include state, federal, and county agency personnel; researchers; and local conservation organizations. The INBS beaches comprise, on average, approximately 80% of the reported statewide nesting activity for the loggerhead and green turtle in Florida. Each index beach is divided into equal-length zones so that nesting patterns can be evaluated on small geographic scales and so that factors affecting localized nesting activity can be examined in detail.

Standardized Methodology: To ensure that surveys would be conducted consistently so that we could compare data within and among index beaches, an INBS protocol for conducting surveys was developed. The protocol established the following parameters: the index survey period (May 15 - August 31), the timing of morning surveys, the methodology for identifying and verifying tracks, and the methodology for collecting data if any morning surveys during a given seven-day period are missed. All materials needed to report and submit data, including postage-paid envelopes, are provided so that data can be submitted weekly throughout the nesting season.

Training of Surveyors: Each year, prior to the nesting season, a series of workshops designed to orient surveyors is conducted. Attendance at the workshops is a requirement for INBS participants. The workshop consists of a classroom session focusing on nesting behaviors, track sign, and the differences between nesting and non-nesting emergences. Individual characteristics of the tracks of the three species nesting in Florida are described. The classroom session is followed by a beach session during which track identification procedures explained in the classroom are practiced in the field. An explanation of the INBS protocol completes the workshop. Inexperienced surveyors must work directly with experienced participants until they can demonstrate their ability to accurately identify tracks.

INBS Program Evaluation: The final principal component of the INBS program is designed to answer the question: Do the surveys provide an accurate picture of nesting activity on index beaches? No surveyor, regardless of experience, can differentiate, with 100% accuracy, nesting emergences from non-nesting emergences. We therefore asked the question, What is the error rate associated with morning crawl surveys? In 1993, we initiated a study to assess this. Night-time surveys were conducted so that we could observe the behavior of emerged turtles until they either deposited a clutch of eggs or returned to the water without nesting. A numbered stake was placed in the track and the emergence was recorded as a nest or a non-nesting emergence. The following morning, INBS participants recorded stake numbers and their assessments of the crawls (i.e., nests or non-nesting emergences). Based upon the data we collected on 102 emergences in 1993, survey error averaged 7%. All errors involved nesting emergences that were incorrectly identified as non-nesting emergences. During the 1994 nesting season, we plan to continue our evaluation of survey error, and we will look at the relationship between surveyor experience and error.

The Florida INBS program has been operational for five years. A review of the program and the information collected to date indicate that the four principal components of the program have been successfully implemented. We believe that the program will provide the long-term data necessary to monitor and evaluate the status of Florida's nesting populations and the successes or failures of our conservation and recovery efforts.

ACKNOWLEDGMENTS

The INBS program would not have been possible without the contributions of Earl Possardt of the U.S. Fish and Wildlife Service. Lew Ehrhart, Erik Martin, Anne Meylan, and Blair Witherington participated in the initial conceptual meetings for the program. Carrie Crady and Ron Mezich have been responsible for managing the INBS database. The U.S. Fish and Wildlife Service and the Florida Park Service provide logistical support each year. The Florida Game and Fresh Water Fish Commission supported the program through funding to the Marine Turtle Protection Program of the Florida Department of Environmental Protection. Most importantly, I would like to acknowledge and thank all participants in Florida nesting beach surveys, on index and non-index beaches, without whom the goals of this program could not be achieved.

ARAGONITE SAND AS A NESTING SUBSTRATE AND ITS EFFECT ON *CARETTA CARETTA* NESTS

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In the spring of 1991, the beach on Fisher Island, Miami, Florida, was renourished with commercially mined Bahamian aragonite sand. A 3 year study to evaluate the acceptability of aragonite as a nesting substrate for loggerhead (*Caretta caretta*) sea turtles was begun at the request of the Florida Department of Natural Resources. The study included a comparison of the physical parameters of Bahamian aragonite and Florida silicate sand including temperature, compactability, grain size and morphology, water potential, and permeability to gases. Physiological parameters of loggerhead sea turtle nests relocated to hatcheries containing each sand were also compared.

During the 3 year study we found no ill effects on the aragonite incubated nests on Fisher Island which could be attributed to the sand; while significant differences were found in some parameters, these were within previously reported ranges. Hatching success in both sands was consistently higher than previously reported for relocated nests (77% - 97%), and was similar in each sand. No significant differences appeared in hatchling emergence or mortality. We found no significant differences in hatchling mass (averaging 18.2 - 20.1 g over 3 years), carapace length, or carapace width.

Physical parameters of the sands were also similar. There were no significant differences in grain size, water potential, or gas exchange between the silica and aragonite sands examined. Oxygen tensions remained high and CO2 levels low throughout the study, indicating high rates of gas exchange in both sands.

Significant differences were found, however, in nest temperature and incubation times. Aragonite sand controls and nests were 1.4 - 2.4 degrees Celsius cooler than Florida sand nests and controls: average aragonite nest temperatures ranged from 26.2 C to 31.4 C during the 3 year study, while in Florida sand nest temperatures averaged 26 C to 35 degrees Celsius. The cooler temperatures present in aragonite nests resulted in incubation times 3 to 10 days longer (54 - 64 days) than Florida sand incubations times (46 - 56 days). Although these differences are within normal ranges, the cooler temperatures and longer incubation periods may have deleterious effects on nesting success and/ or hatchling sex ratios in cooler areas.

PRELIMINARY GENETIC ANALYSIS OF THE POPULATION STRUCTURE OF GEORGIA LOGGERHEAD SEA TURTLES

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Using restriction fragment length polymorphisms (RFLPs) generated by mitochondrial DNA, Bowen et al. (1993) genetically defined two major rookeries along the Southeast coast of the United States: Florida and a Georgia/South Carolina complex. This information formed the basis of a study (Sears 1993) involving RFLP analysis of 33 loggerhead juveniles from the Charleston Harbor Entrance Channel; Charleston, South Carolina. It was found that approximately 55% of the turtles were from the Georgia/South Carolina complex while 45% were from the Florida rookery (18:15 turtles, respectively). These data are consistent with nesting female tagging studies which indicate that turtles from Georgia and South Carolina tend to feed along the eastern coast of the United States (Bell and Richardson 1978).

A population demographic survey of juvenile loggerheads was extended to three locations in Georgia: Savannah, Brunswick, and King's Bay. Blood samples were taken from a total of 114 juvenile loggerheads, genomic DNA was isolated (White and Densmore 1992), and RFLPs were generated using four informative restriction endonucleases (Ava II, EcoR V, Hind III, and Stu I). Preliminary analyses on 97 of the 114 juvenile turtles indicate that 59% (57 of 97) of the juvenile turtles are from the Georgia/South Carolina rookery system while 41% (40 of 97) are from the Florida rookery (Table 1). For every haplotype, the feeding ground natal origins were determined by multiplying each rookery percentage with the total number of juveniles within the given haplotype.

The Roff-Bentzen test for heterogeneity (Roff and Bentzen 1989) performed on these data suggests that the probability of the entire Georgia juvenile feeding ground population being genetically identical to the two rookeries (Georgia/South Carolina and Florida) range from 0.0%-0.7% (Table 2). In other words, there is at least a 99.3% chance that the three populations (the two rookeries versus the study site) are different. This indicates that the Georgia feeding ground population is not representative of any one rookery but a combination of juveniles from throughout the Southeast rookery system (Figure 1). In categorizing the specific Georgia localities, it is noted that King's Bay and Brunswick comprise the majority of the 97 juvenile turtles tested (82 total - 84.5%) (Table 3). The natal origin data for these two areas show each population heavily comprised of Georgia/South Carolina turtles (59% and 62.5%, respectively) (Table 4).

It is known that 91% of loggerhead nests in the Southeast United States occur in Florida and 8% occur in Georgia/South Carolina (NMFS and USFWS 1991). If the Georgia feeding ground population is randomly comprised of turtles throughout the Southeast, one may predict that approximately 89 turtles should be from Florida and the remaining 8 from the Georgia/South Carolina complex. This is clearly not the case since the Georgia/South Carolina turtles are over 7 times more abundant than expected (Table 1) in the Georgia feeding grounds.

Since juvenile loggerhead sea turtles are commonly found along the Southeastern United States, it is in these coastal feeding grounds where the turtles are in the greatest danger of human activities where negative interactions include commercial fisheries, dredging, and recreational boating. The impacts of these actions are difficult to determine because the demographic affinities of the feeding ground populations are unknown. Using the knowledge gained from analyses of population structures, conservation issues can be addressed more fully. For example, when turtles are killed by human impacts in Georgian waters, the effect is greatest on the Georgia/South Carolina population since it is more heavily represented. Although neither population can tolerate heavy mortality rates, the Georgia/South Carolina nesting population is particularly susceptible because of its smaller size.

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Table 1. Mitochondrial DNA genotypes and composite haplotypes found in turtles from the Florida and Georgia/South Carolina rookeries. Juvenile turtles from the Georgia study sites are included for comparison. Numbers correspond to individuals per haplotype per locality.

GENOTYPE[1]	HAPLOTYPE[2]	FLORIDA[2]	GEORGIA/ SOUTH CAROLINA[2]	GEORGIA FEEDING GROUNDS[3]	NATAL ORIGINS OF GEORGIA JUVENILES[4]	
					FL	GA/SC
DCAB	A	0 (0%)	2 (100%)	1 [1%]	0	1
DCBB	B	9 (13%)	60 (87%)	59 [61%]	8	51
ACBC	D	19 (100%)	0 (0%)	32 [33%]	32	0
ABBC	E	0 (0%)	1 (100%)	5 [5%]	0	5
					TOTAL 40	TOTAL 57

[1] Genotype letters refer to RFLP profile designations for the following restriction endonucleases (in order): Ava II, EcoR V, Hind III, and Stu I.

[2] Composite haplotypes and rookery information from Bowen et al. (1993). Numbers in parentheses indicate haplotype percentages between each geographic rookery.

[3] Juvenile haplotypes from the current study. Numbers in brackets indicate percentages of haplotypes within the Georgia study site.

[4] Natal origins determined by multiplying each rookery percentage with the total number of juveniles within the given haplotype.

Table 2. Roff-Bentzen test for heterogeneity. Values are the probability that the populations in comparison are the same. Numbers of individuals from localities in Table 1 were used in value determinations.

	GEORGIA/ SOUTH CAROLINA	GEORGIA FEEDING GROUND JUVENILES
FLORIDA	0.00	0.007
GEORGIA/ SOUTH CAROLINA	X	0.00
GEORGIA FEEDING GROUND JUVENILES		X

Table 3. Haplotypes by specific geographic regions.

HAPLOTYPE[1]	GEORGIA FEEDING GROUND JUVENILES[1]	SAVANNAH	KING'S BAY	BRUNSWICK	UNKNOWN[2]
A	1	0	0	1	0
B	59	0	21	30	8
D	32	1	11	14	6
E	5	0	2	3	0
TOTALS:		**1**	**34**	**48**	**14**

[1] Haplotype and juvenile information from Table 1.
[2] Unknowns are samples with tag identifications but no specified collection area.

Table 4. Natal origins of King's Bay and Brunswick individuals[1].

HAPLOTYPE[2]	KING'S BAY[3]	NATAL ORIGINS FL	NATAL ORIGINS GA/SC	BRUNSWICK[3]	NATAL ORIGINS FL	NATAL ORIGINS GA/SC
A	0	0	0	1	0	1
B	21	3	18	30	4	26
D	11	11	0	14	14	0
E	2	0	2	3	0	3
TOTALS:		**14**	**20**		**18**	**30**

[1] Juvenile turtles from the Savannah and "unknown" locations were not used due to small sample sizes and unidentified points-of-collection, respectively.
[2] Haplotype information from Table 1.
[3] Juvenile totals from Table 3.

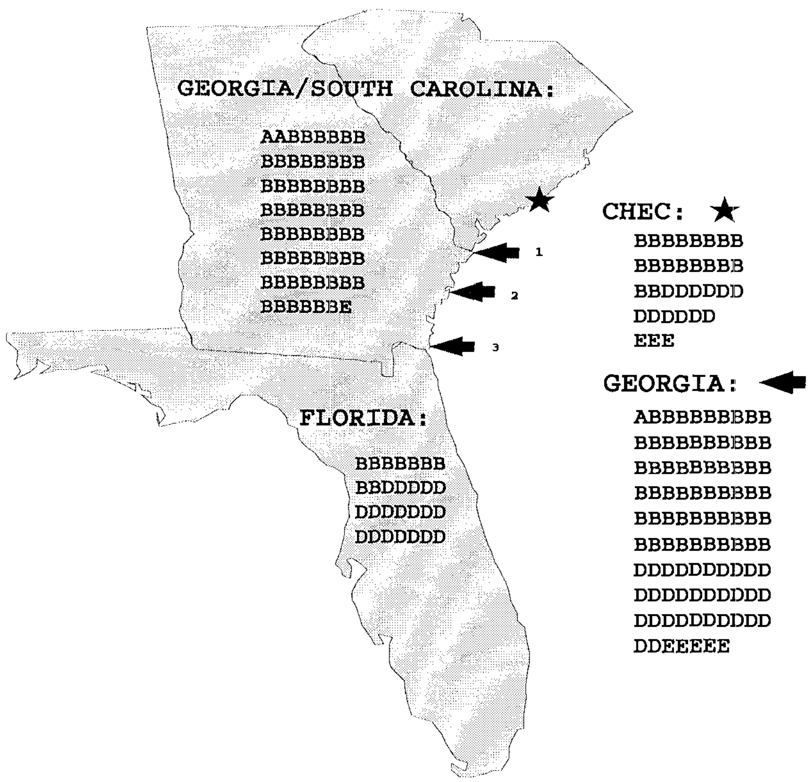

Figure 1. Rookery and feeding ground haplotypes (from Table 1) where 1, 2, and 3 indicate Savannah, Brunswick, and King's Bay, respectively. Haplotypes from the Charleston Harbor Entrance Channel (CHEC) study are included for comparison.

THE STATUS OF LAS BAULAS DE GUANACASTE NATIONAL PARK IN COSTA RICA

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Las Baulas de Guanacaste National Park protects the third largest nesting rookery for leatherback turtles (*Dermochelys coriacea*) in the world. The park was established in a decree by President Calderon in 1991, but is not yet permanently established in law. Approximately 1500 leatherbacks nest on the beaches of Playa Langosta, Playa Grande, and Playa Ventanas within the declared park. The park also includes two mangrove estuaries and a large marine area. In addition to the leatherback many other species are provided protection, including parrots, white ibis, roseate spoonbill, flamingo, several species of freshwater turtles, caiman, white face monkeys, howler monkeys, many species of lizards, numerous plants, and many insect species.

In the 1993-94 nesting season about 200 females nested on Playa Grande. This low number reflects the overall low number of leatherbacks nesting on the Pacific beaches of Central America and Mexico. This may be due to an El Nino effect. Progress has been made at Las Baulas over the last three years in reducing poaching and controlling tourism. A guide training program established by Randall Arauz is now functioning very well and the local guides association prevents poaching and controls lights and flash cameras of tourists. Local guards were hired for Playa Langosta by the Fundacion la Gran Chorotega with funds donated from supporters in the United States. They reduced poaching to near zero. An environmental education program at Playa Grande provided art lessons to local children as well as lessons in hatchling biology and recycling.

The park is increasing in acceptance and popularity in the local communities, especially in Salinas and Matapalo. Rapid development threatens the beach, however, the park can be secured by passage of the law and adequate funding for land acquisition and environmental education.

HOMING BEHAVIOR OF LOGGERHEAD TURTLES RELOCATED FROM DREDGING AREAS IN CAPE CANAVERAL CHANNEL, FLORIDA

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The Army Corps of Engineers is required to maintain the depth of the shipping channel at Cape Canaveral, Florida. To do this, dredging is required which has the potential to severely impact the sea turtle population residing in the channel. A relocation experiment was conducted to determine the distance and the direction to which loggerheads could be relocated to provide a two week turtle-free period in which to conduct maintenance dredging.

Thirty-four turtles were relocated out of the channel area to a total of six release sites. The sites were located at distances of 10, 40, and 70 km from the channel in each of two directions, north and south (Fig. 1). Six turtles were released at each of five locations, and four turtles were released at the 40 km north location. These turtles which were obtained by trawling were outfitted with radio transmitters. The turtles were taken by trawler to the 10 km locations and transported by land to the more distant locations. Six control turtles were similarly trawled, tagged, and released but were not displaced. These controls were used to determine the effects of handling on turtle behavior. Two automated radio receiving stations were strategically positioned north and south of the channel to monitor each turtle's return to the area.

Control turtles released into the channel lacked uniform behavior. There were no significant differences between the time required to return or the number of turtles returning and the direction of displacement. Turtles released to the south exhibited more predictable behavior than those released to the north. There was a significant difference ($p = 0.002$) between the time of return and the displacement distance. The longest time required for a turtle to return to the channel was 818 h for a turtle released at the far south location. The fastest returning turtle was back in the channel in only 43 h after being released at the near south location.

RELEASE SITES FOR RELOCATION STUDY

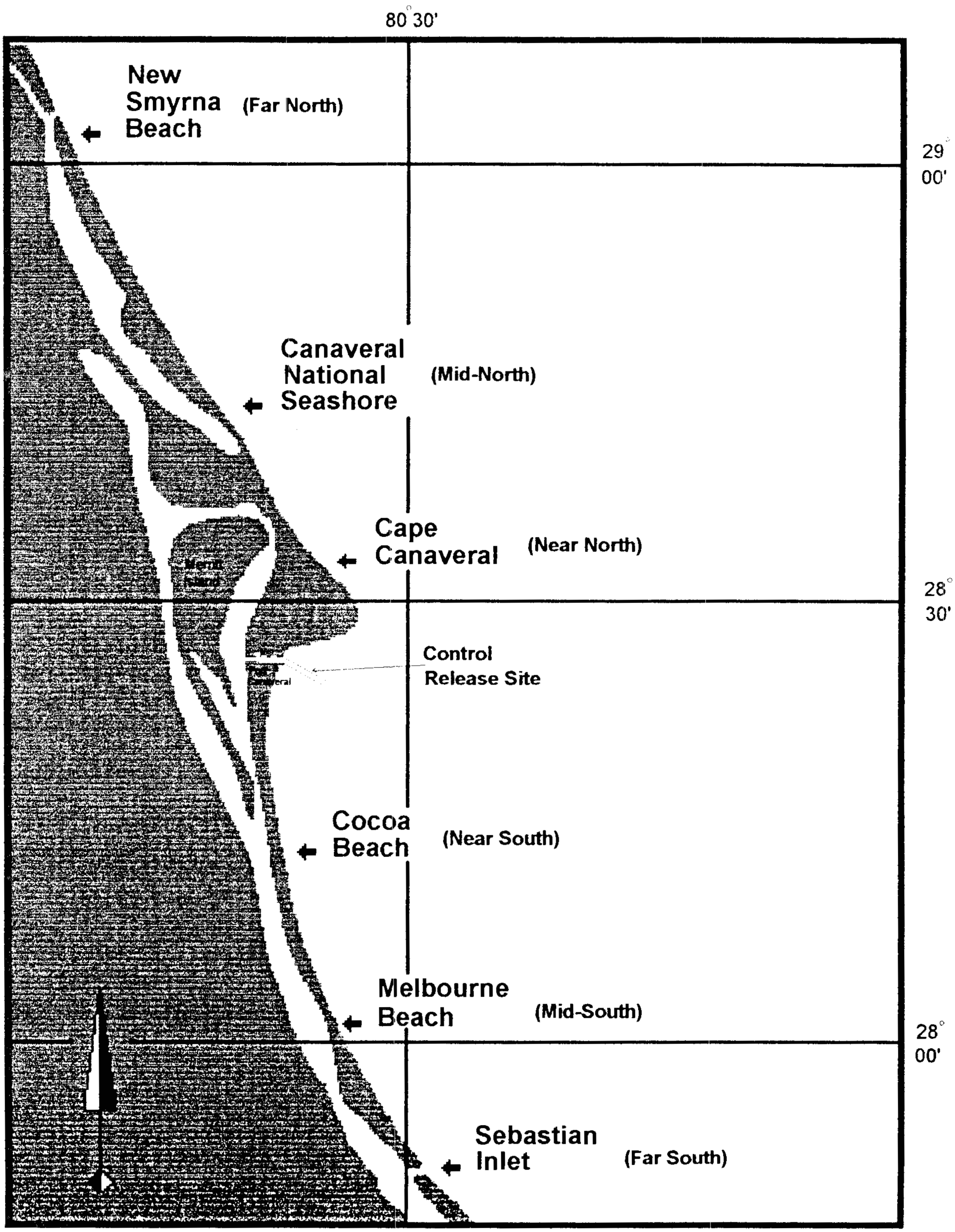

Figure 1.

LEATHERBACK SEA TURTLE NESTING ON THE NORTH VOGELKOP COAST OF IRIAN JAYA AND THE DISCOVERY OF A LEATHERBACK SEA TURTLE FISHERY ON KEI KECIL ISLAND

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The leatherback sea turtle (*Dermochelys coriacea*) population nesting on the north Vogelkop coast of Irian Jaya is the third largest in the world (Bhaskar 1985) and possibly the last in the western Pacific. This population of leatherback sea turtles may be declining due to predation by wild pigs (*Sus scrufa*) (Stark 1993), egg harvest, nest loss due to inundation and erosion, and hunting in neighboring islands (Bhaskar 1985).

Leatherback nesting on the north Vogelkop coast is concentrated on two beaches: Jamursba-Medi (18 km) and the War-Mon beach (4.5 km), 30 km apart (Fig. 1). Both beaches are high energy and dynamic with water depth of 3,000 m within 25 km of shore. High density nesting of 2,000-3,000 females annually occurs on this coast during the period of April-January. The peak nesting period on Jamursba-Medi is May-August and November-January on War-Mon beach (Bhaskar 1985; Bakarbessy 1993, unpub. report).

Kei Kecil is located in the central Maluku Province of Indonesia, between New Guinea and Australia (Fig. 1). The Kei Islands were historically renowned for their natural diversity and beauty but within the last three decades have been subject to intensive timber harvest. Very little forest remains on Kei Kecil, and its inhabitants subsist primarily on agriculture and marine resources, including sea turtles.

Objectives were to assess the status of both nesting beaches through communications with Department of Forestry personnel; quantify numbers of nesting leatherback sea turtles on War-Mon beach and identify threats to this population; and interview local peoples to determine the level of sea turtle exploitation both in Irian Jaya and the neighboring island of Kei Kecil.

METHODS

War-Mon beach was surveyed nightly from 6-22 December 1993. Length and width of nesting leatherback sea turtles were measured over-the-curve. Individuals were identified by distinctive scar patterns and size. The position of each nest was noted relative to the waterline, vegetation and wooden stakes placed at 250 m intervals along the beach. Nest disturbance was identified as human poaching, pig predation or unknown cause of disturbance. Jamursba-Medi beach was surveyed by three Department of Forestry (PHPA) personnel from May-July and data presented is on behalf of a collaborative effort with PHPA.

On Kei Kecil, village chiefs, fishermen and local officials were interviewed regarding the take of leatherback sea turtles.

RESULTS AND DISCUSSION

During 21 days of surveying a total of 101 nesting females were encountered on nightly patrols. Mean carapace length was 161 cm (N = 101, range 145-178 cm) and mean width was 115 cm (range 103-145 cm). Six internesting intervals ranged from 8-10 days (avg. = 9.3 day). Mean distance to waterline was 22 m and to vegetation was 7 m. A total of 406 nests and 74 false crawls were recorded on War-Mon beach (table 1). Nesting took place on each section of beach although it was concentrated westerly (6 Dec.-12 Dec.) and on the eastern half (2 km) of the beach (13 Dec.-22 Dec., Fig. 1). On Jamursba-Medi beach 3,356 nests and 291 false crawls were recorded during the months of May-July, 1993 (Bakarbessy 1993, unpub. report).

War-Mon beach is not of protected status and poaching accounted for over 60% of the nest disturbance. Villagers were observed collecting eggs for local consumption and to sell in the nearby village of Wau. Mass egg collection for commercial sale has been occurring Jamursba-Medi beach for over twenty years (Bhaskar 1985) but did not occur in 1993 when PHPA guards began patrolling the beach to count nesting individuals and deter poaching.

Pig predation has been a major cause of nest loss on these beaches in the past and continues to be on Jamursba-Medi (Bhaskar 1985, Bakarbessy 1993, unpub. report). On War-Mon beach pig predation accounted for less than 40% of the nest disturbance. The population of villages in the vicinity of War-Mon has increased in recent years (Bakarbessy, PHPA, pers. comm.). Villagers around War-Mon regularly take wild pigs with snare and spear. Increased hunting pressure has resulted in fewer pigs on War-Mon beach and a lower rate of nest predation then on Jamursba-Medi.

More than 150 leatherback sea turtles are killed each year in a traditional leatherback sea turtle fishery located on the south coast of Kei Kecil. Nine villages (pop.=5,000) hunt leatherback sea turtles at sea during the local calm period (Oct.-Dec.) in an area where they are known to congregate. Oarsmen using a six meter long dugout harpoon leatherback sea turtles within five kilometers of shore using a spear with rope connected to a detachable metal spearhead. Dead or dying turtles are lifted into the dugout and butchered on the island. The carapace is rendered for oil and the meat from the plastron is shared among the villagers.

RECOMMENDATIONS

War-Mon beach should be protected as a Nature Reserve administered by PHPA and patrolled from October-January to count nesting individuals and prevent poaching of nests. Offshore areas that are internesting habitat should be defined and protected. Hatcheries should be established on both beaches and predation by wild pigs should be controlled possibly through the systematic use of snares. An education program on sea turtle ecology for the villages around both rookeries would provide locals with useful information about threats to sea turtles with which they can establish a conservation ethic.

The traditional leatherback sea turtle fishery on Kei Kecil represents an unregulated and illegal take of an endangered species. Numbers taken annually by all nine villages and the ecological significance of this area should be determined. Future research should address whether this fishery is sustainable. Alternative sources of protein made available by the Indonesian government and conservation groups would reduce hunting pressure on the leatherback sea turtles. Workshops on leatherback sea turtle ecology and farming practice should be initiated.

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Stark, M. 1993. Field survey of leatherback nesting beaches in the Bird's Head Region, Irian Jaya, is renewed. Marine Turtle Newsletter 60:1-4.

Table 1: Number of leatherback sea turtle nests on Jamursba-Medi and War-Mon beaches Irian Jaya, Indonesia

	Nests	Avg./night
Jamursba-Medi:		
Bhaskar (1985)	9900*	--
Bakarbessy (1993)	3360*	--
War-Mon:		
Bhaskar (1984)	676**	16
Starbird & Suarez (1993)	406**	14

*(nests counted between June and August; Bhaskar (1985) reported an addditional 3885 nests during the months of April, May and September).

**(nests counted from 23 Nov.-30 Dec; Bhaskar (1985) counted an additional 336 nests from 1-24 Jan., 1985)

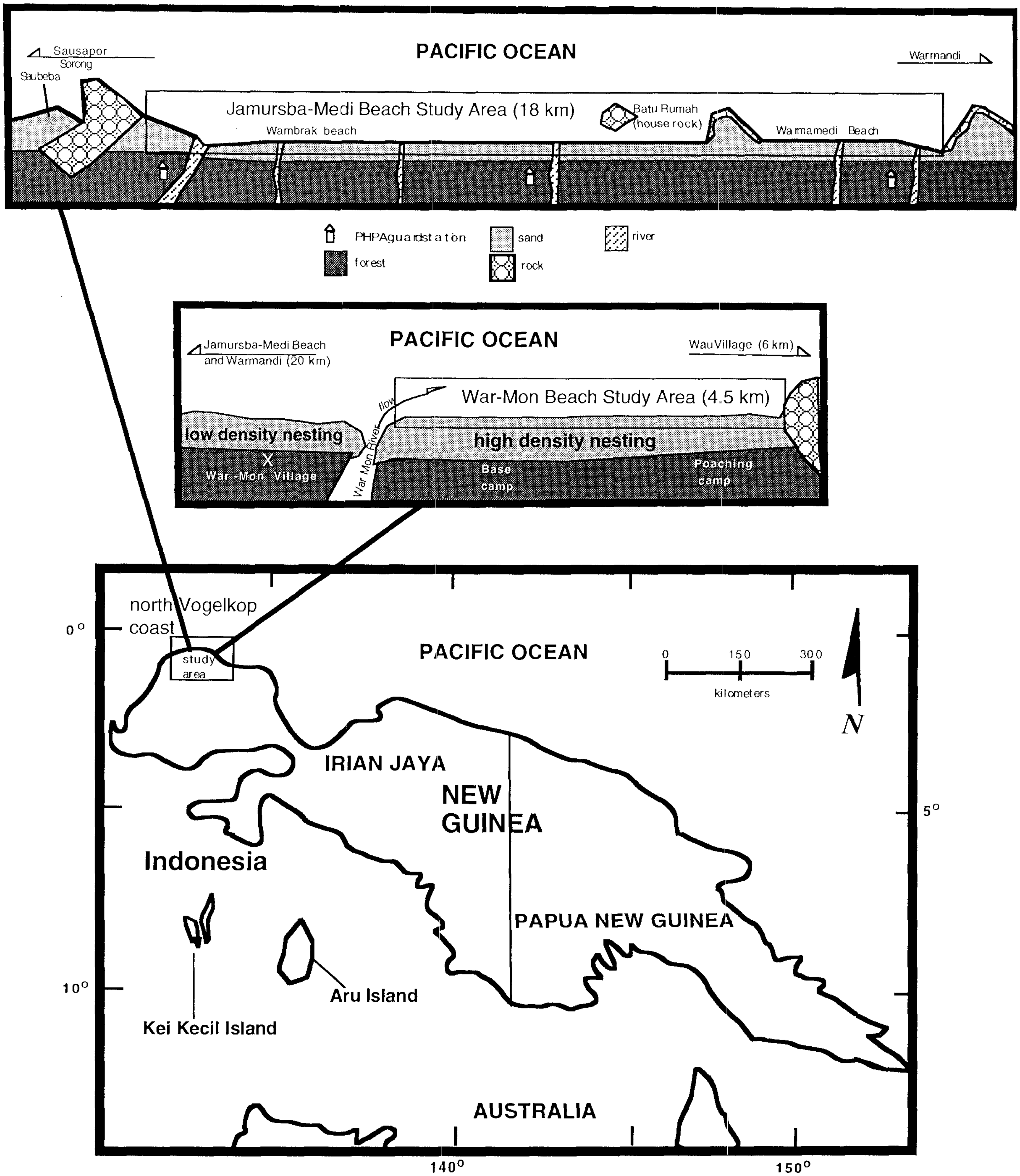

Figure 1: Map of New Guinea showing study areas on Kei Kecil Island, the north Vogelkop coast and detail of nesting beaches (above).

SEA TURTLE COMMUNITY STRUCTURE AT SABINE PASS, TEXAS

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Most sea turtle data from the northwestern Gulf of Mexico have come from either stranding or incidental capture events (Manzella and Williams 1992). The Kemp's Ridley Recovery Plan (U.S. Fish and Wildlife Service and National Marine Fisheries service 1992) mandates at-sea capture to identify index habitats and provide critical life history information about this endangered species. The current study characterizes population dynamics of sea turtles in nearshore waters of the northwestern Gulf of Mexico adjacent to the Sabine Pass border between Texas and Louisiana. Turtles were captured in 91.4m stationary entanglement nets, and their morphometric measurements recorded. After a period of 24 hours, turtles were tagged (coded monel flipper tags and PIT tags) and released. Capture statistics are presented for Kemp's ridley (*Lepidochelys kempi*), green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) sea turtles. Abundance and size are described for each species, and the contribution of headstarted individuals to the wild Kemp's ridley population examined.

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SCUTE DEVIATION OF GREEN TURTLE HATCHLINGS FROM A HATCHERY IN OGASAWARA ISLANDS, JAPAN

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Ogasawara Islands, located about 1,000 km south of Tokyo, Japan, are a rookery of green turtles. Gravid females captured by fishermen are kept in a pen during the nesting season. Eggs deposited at the attached small beach are collected and incubated in a hatchery. Deviations of the central and lateral carapace scutes of hatchlings from the hatchery, of hatchlings from natural beaches, and of adults are investigated. All live hatchlings from sample clutches were checked. Out of 190 hatchery clutches during 1991 through 1993, hatchlings from 178 clutches (94%) showed scute deviation: mean = 12.8%, SE = 1.0, range = 0 to 100%, n = 190. Out of 42 clutches from natural beaches during 1986 through 1993, hatchlings from 28 clutches (67%) showed the scute deviation: mean = 4.9%, SE = 0.8, range = 0 to 29.1%, n = 42. The scute deviation rate of the hatchlings from the hatchery was significantly higher than the ones from the natural beaches (Mann-Whitney U test, $p = 0.0001$). Five percent of adult females (n = 1252) and 3.3% of males (N = 661) showed the scute deviation. The difference in the scute deviation between the sexes was not significant ($X^2 = 2.96$, $p = 0.086$).

SAVING SEA TURTLES OR KILLING THEM: THE CASE OF U.S. REGULATED TEDS IN GUYANA AND SURINAME

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The objective of this study was to conduct a survey of the incidental capture of sea turtles by the shrimp trawl fisheries in Guyana and Suriname. The survey was undertaken in response to a U.S. regulation referred to as "Sea Turtle Conservation [or] Shrimp Embargo Regulation", U.S. Public Law 101-162, Title VI, Section 609, of November 1989. The regulation states that there will be an embargo on shrimp imports into the U.S., if it is shown that the shrimp fishery from which it came has an incidental capture of sea turtles. Countries that have conservation programs to control incidental capture, and whose programs have been certified by the U.S., will not be subjected to an embargo. The management strategy of choice to control the incidental capture of turtles is the turtle excluder device or the trawling efficiency device (TED).

Although this law was passed for political and economic reasons surrounding U.S. shrimpers and shrimp imports to the U.S., it has the potential of contributing to the conservation of sea turtles in other countries.

METHODS

The survey was conducted during the summer of 1991 in the port cities of Georgetown, Guyana, and Paramaribo, Suriname. The primary source of information was through informal interviews with fishing crew members, industry management personnel, and government officials. Secondary sources included unpublished data and reports that were obtained from the respective governments and non-governmental organizations.

The analysis of anecdotal information must be reviewed with some caution, as accuracy cannot be expected of information that was considered unimportant in the daily activities of those interviewed. Further, there were many limitations to the access of data and people. Nevertheless, some valuable guesstimates and qualitative information can be distilled from such information in order to understand the magnitude of the problem.

RATES OF CAPTURE, MORTALITY, TOW TIMES, AND OUTCOMES

Nobody denied that turtles were being caught in trawl nets. The total capture estimate for Guyana was 1,300 turtles/year, with a total mortality of 800 turtles/year (mortality rate = 60 percent). In Suriname the total capture rate was 3,200 turtles/year and the total mortality was 1,600 turtles/year (mortality rate = 50 percent). The high rate of mortality can be attributed to the long drag times, averaging 4 hours/drag, that was reported from both countries.

Most often, the turtles caught were tossed overboard irrespective of whether they were dead or alive. Few turtles, about 3 percent of the yearly total, were collected for human consumption, either being consumed while out at sea (especially during long trips), or being brought back to port by crew members for personal consumption. It was reported in Guyana that small turtles caught (ie., around the 12 inch size class) were taken to the museum to be mounted.

SEASONALITY AND LOCATIONS

Both in Guyana and Suriname trawling takes place throughout the year and throughout their respective fishing zones. In Suriname, however, there are two areas that have the greatest concentration of shrimp, one of which coincides with water off Eilante and Galibi nesting beaches. Eilante contains the most important olive ridley nesting beach in the western Atlantic. As a result, the greatest numbers of sea turtles are caught in these waters.

Turtles are caught throughout the year, with the highest numbers being caught between the months of June and October. This period coincides with peak shrimp-catch in inshore waters (July-September). The respective periods of increased capture also coincide with the end of the nesting period for almost all species of sea turtle. During this catch period, most turtles caught are adults, and are taken at night in inshore waters. These reports indicate that the nesting adults are at the greatest risk of capture.

SPECIES

The leatherback, green, and olive ridley turtles belonging to size classes from 12 inches upwards were reported as being caught in trawls. Of these the leatherback has the best chance of surviving incidental capture. Crew members said that they immediately felt a difference in tow when a leatherback was caught in the net, and it was to the crew's advantage to immediately rid the net of the turtle than continue to trawl with less efficiency. In addition, the strong dislike for leatherback meat and the odor surrounding this animal increases its chance of not being killed for human consumption and instead being rolled overboard as soon as possible.

The olive ridley was reported as being the most common turtle caught. The peak capture period for this species (ie., 65 percent of total catch) was from January-March, which coincides with the period immediately preceding the "arribadas" at Eilanti in Suriname. The peak shrimping season also overlaps with this period (February-May). These surveys support the claims made by Pritchard, Reichart, and Fretey (who are working in Guyana, Suriname, and French Guiana respectively), that the capture of olive ridley by shrimp trawls is a significant source of mortality, possibly the primary cause of population decline experienced across the Guianas. It is their belief that the olive ridley is indeed the most endangered sea turtle species in the western Atlantic region.

TEDs, TURTLES, AND BY-CATCH

Given the current rates of sea turtle exclusion by TEDs in the U.S. (as much as 97%), the conservation impact of TEDs in Guyana and Suriname will be enormous, saving as much as 4,000 turtles from capture. TEDs will especially be invaluable in the recovery of the olive ridley. TEDs will also, at best, using U.S. estimates, reduce by-catch by 50-70 percent. Such a reduction in the U.S. is invaluable given the fact that by-catch is discarded, and therefore wasteful, and that such by-catch is destroying fin-fish populations in U.S. waters. However in Guyana and Suriname, by-catch is neither incidental or wasteful, but rather intentional and valuable. Trawling in these countries are both for shrimp and fish.

A reduction in the quantity of by-catch will affect the availability of the main source of cheap protein. It will also affect the fishing industry by reducing income from the sale of by-catch (especially when the quantity of shrimp caught is low). The government of Guyana requires a minimum landing of 1,335 metric tons/year of "by-catch" for local distribution, which provides for at least 10 percent of all fish available in the local market. Similarly in Suriname, fish caught by shrimp trawlers provides 23 percent of total fish supply and 50% of all fish available in the local market. Due to the economic conditions in Guyana and Suriname, the possible loss of by-catch through TEDs has been described by some of the people interviewed as reason for a "social revolution".

GILL NETS AND THE DOMINO EFFECT

As a result of the importance of "by-catch", the employed TED will have to serve the added function of capturing and retaining fin-fish. This could be achieved by using the TED design that is most amendable to this task.

In the worst case scenario, an inappropriate TED could begin a domino effect that could kill more turtles than save them. Under such a scenario, the loss of "by-catch" from TED drawn shrimp trawls will create a dearth for cheap fish. The resulting vacuum will be filled by the gill net industry, which will in turn, increase its level of activity. Since gill nets catch and kill more turtles, a greater number of turtles will be killed as a result. Simply summarized, at the current state, shrimp trawlers with TEDs that exclude fish "by-catch" may have the potential to contribute towards the death of more turtles than shrimp trawlers without TEDs!

This scenario is possible because of the negative impact of gill nets on sea turtles (something that the U.S. regulation does not address). For the combined activities of Guyana and Suriname the gill net fishery is responsible for the capture of 21,600 turtles/year of which 16,200 turtles/year will be killed. The high mortality rate of 75 percent is due to the fact that the fishing people will cut off the flippers of the turtles in order to remove entangled turtles from their nets. In addition, the peak capture periods (April-June and July-August) coincide with the peak capture periods reported by the shrimp trawlers, that is the periods immediately preceding the "arribadas" at Elianti in Suriname, and the period immediately following the peak nesting periods of other species in both countries. Therefore, when compared with the shrimp trawl fishery, the impact of the gill net fishery is certainly more acute, and together they are extremely destructive.

CONCLUSION

Based on this study, the following recommendations are proposed: 1) specifically, we need to facilitate the development and/or use of a "turtles out- fish in" device, and such an activity should be developed and organized by the fishing people of Guyana and Suriname in collaboration with the U.S.; 2) we need to evaluate and mitigate all types of incidental capture not just by shrimp trawlers; 3) we need to use a more country-by-country evaluation and implementation approach in regards to this U.S. regulation; and 4) in more general terms, we need to study and incorporate political, economic, and social aspects surrounding incidental capture, and not just focus on the protection of turtles.

While the survey draws attention to the magnitude of the incidental capture problem and the endangered status of the olive ridley, it also draws attention to the need for a management solution that is applicable to Guyana and Suriname, not one that is just satisfactory to the U.S. We need to recognize that there is much variation between over-developed countries and developing countries, and even between developing countries themselves, in terms of ambient political, economic, social, and ecological realities. Solutions, therefore, may not be easily transferable, and every effort should be taken to ensure that we do not recreate the conflicts that surrounded the implementation of TEDs in the U.S.

In closing I want to stress that this paper was developed to portray the reality surrounding the implementation of the U.S. regulation, and that I am not advocating a repeal of this regulation.

A SURVEY OF SEA TURTLES IN THE ANDAMAN AND NICOBAR ISLANDS

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The Andaman and Nicobar archipelago in the Bay of Bengal, consisting of over 300 islands with a land area of 8239 sq km and a coastline of 1962 km, has been a blind spot in the Indian Ocean in the worldwide study of sea turtles. Field surveys of the islands in the late 1970's and the early 1980's (Bhaskar, 1979; 1980; 1984) showed that the islands were important nesting grounds for the leatherback, the green turtle, the olive ridley and the hawksbill. The main nesting areas for the leatherback were found to be on Little Andaman Island and in the southern Nicobars. The three smaller species were found to nest throughout the archipelago, though the greens and the hawksbills nested in greater numbers in the Andamans. Except for the leatherback, the three smaller species were also known to feed around the islands. Since these early surveys there had been no follow-up study to determine the effect of increasing disturbances and settlements on the nesting population of sea turtles in these islands. The complete lack of empirical first-hand data prompted my survey in 1991. The survey covered six islands in the southern Nicobars many of which had not been surveyed before.

The Nicobars are separated from the Andamans by the turbulent Ten Degree Channel which prevents smaller boats from plying between the two groups of islands. The isolated location of the islands from the tourism and activity of the Andamans and the fact that they are restricted tribal reserves for the Nicobarese and the Shompens combine to discourage outsiders.

METHODS

Sandy beaches were surveyed on foot for evidence of nesting turtles, tracks, nests, hatchlings, carcasses, bones, egg-shells and nest markers made by humans. Tribals and Forest Department workers were interviewed for information on the nesting species, beaches and nesting seasons.

RESULTS

Nineteen beaches and sandy stretches were surveyed during a three month period (February - May 1991), of which 10 were potential leatherback nesting beaches. A total of 433 leatherback nests were counted. Fewer nests were counted for the other three species: 14 olive ridley nests, 12 green turtle crawls and 6 green turtle body pits and 9 hawksbill (maybe confused with the olive ridley) crawls.

The number of nesting turtles in the southern Nicobars appears not to have declined significantly in the last ten years and the islands are still important leatherback rookeries. Continued, extensive nesting of this species is probably because the females are allowed to return to the sea unharmed. The green, ridley and hawksbill turtles are under greater pressure since they form part of the traditional tribal diet. The tribals are exempt from the Indian Wildlife (Protection) Act of 1972. Surveys during the monsoons will provide vital information on these smaller species. Most nests are emptied by the tribals or destroyed by their domestic pigs and dogs and few eggs make it through incubation to hatching. It would be important to involve the tribals in any conservation activities. Basic data on the number of turtles and nests taken by the tribals and a count of predated and inundated nests is needed to determine the potential of each beach.

In the Andamans and the Nicobars there has been an increase in human activity and in the spread of settlements. The building of roads and jetties is making the islands more accessible to people.

There is a vast area to be covered and the logistics are complicated. Boats, vehicles and trained personnel are urgently needed besides an effective and efficient conservation programme.

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STATUS REPORT ON THE ARCHIE CARR NATIONAL WILDLIFE REFUGE

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Archie Carr National Wildlife Refuge was established in 1990, for the protection of the largest population of sea turtles in the western hemisphere, and their nesting habitat along the central Atlantic coast of Florida. Approximately 25% of the loggerhead (*Caretta caretta*) and 30-35% of the green turtle (*Chelonia mydas*) nesting in the U.S. occurs along a 20.5 mile stretch of barrier island coast, between Melbourne Beach in Brevard County and Wabasso Beach in Indian River County. The refuge acquisition area is divided into four core segments. Segments 1,2, & 3 (located in Brevard Co.) are 3.2, 0.5 and 2.5 miles long, respectively. Segment 4 (located in Indian River Co.) is 2.8 miles long.

The Final Environmental Assessment (FEA) and Land Protection Plan (LPP) for the Archie Carr NWR (August 1990), established a goal of acquiring about 500 acres of undeveloped, privately-owned land through fee title acquisition from a list of 202 properties totalling 620 acres, located within and between the core segments. As of February 1994, a total of 118 acres have been purchased. The U.S. Fish and Wildlife Service (FWS) has acquired 18 acres, the State of Florida has acquired 62 acres, and a private conservation organization has acquired 38 acres. Therefore, only about 25% of the 500 acres identified in the LPP have been acquired, thus far.

The LPP also identified over 760 acres, already in public ownership (the State, Brevard and Indian River Co.), to be protected through cooperative agreements. These parcels are located within the core segments, except Sebastian Inlet State Recreation Area which borders Segment 3 and links the two counties. A working group was formed in January 1994, to develop, as part of its mission, cooperative agreements between the respective agencies.

About 54 acres of developed parcels, within the core segments, were also identified in the LPP to be protected through conservation easements with 58 property owners. As of February 1994, there have not been any conservation easements acquired. This is primarily due to the priority of acquiring the last remaining undeveloped tracts, which are rapidly being developed.

The Archie Carr NWR land acquisition picture is further complicated by the presence of state and local acquisition initiatives that target properties outside the FWS' acquisition boundary. Although most of the parcels the State of Florida is buying, for the Archie Carr Sea Turtle Project, are within the FWS' proposed boundary, some of the parcels are not. Some of the parcels in the FWS' boundary are, also, not in the State's project boundary. The State is buying land through its Conservation and Recreation Lands (CARL) program. The Archie Carr Sea Turtle Project is ranked fourth on the CARL list for funding. The CARL program also includes a Maritime Hammock Initiative, which targets over 1,500 acres of pristine maritime hammock and coastal strand habitats that, in most cases, border the Archie Carr NWR boundary.

Brevard County's Environmentally Endangered Lands (EEL) program has joined the State's effort to acquire lands adjacent to the refuge. About 77 acres of maritime hammock within segment 2, but west of the FWS' acquisition boundary, has been acquired through the EEL program. Brevard County has about 200 more acres of county parks within the vicinity of the refuge.

Indian River Co. is in the process of acquiring a parcel of land, part of which is included in the State's Archie Carr project boundary, but outside of the FWS' Archie Carr NWR boundary. (Coincidentally, the same tract is within the FWS' Pelican Island NWR boundary, which also borders Archie Carr NWR).

Though these other programs make it more difficult to get a clear picture of the Archie Carr NWR acquisition status and progress, they do serve a valuable function by linking the refuge's ocean-front properties westward to properties along the Indian River. Preserving these lands benefit nesting sea turtles by retaining an undeveloped dark corridor, and thereby reducing potential impacts from cumulative lighting ("halo effect") and human disturbance. East-west acquisitions also benefit the juvenile green turtles, that forage in the Indian River, by reducing the potential impact from human pressures on the Indian River.

The future status of the Archie Carr NWR will depend, in large measure, on the combined efforts of federal, state, and county governments in concert with conservation organizations, private property owners, and concerned biologists.

HORMONE LEVELS AND OVULATION CORRELATES IN THE OLIVE RIDLEY SEA TURTLE

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The study was carried out at Nancite Beach, Santa Rosa National Park, Costa Rica. The purpose of the study was to examine the effects of short and long term stress on circulating sex steroid levels in wild populations of olive ridley (*Lepidochelys olivacea*) sea turtles. Short term effects of stress were examined by subjecting three different groups of sea turtles to stress by placing the animals on their backs for a period of six hours. Blood samples were taken at zero and six hours and the levels of corticosterone (B), progesterone (P), and testosterone (T) were measured. B levels indicated that all groups were stressed given the significantly elevated levels of this hormone at six hours over basal levels. Preliminary statistical analysis revealed an overall significant change in P and T at the end of this experiment. Long term stress effects were assessed by subjecting arribada nesters to an initial stressful stimulus (animals were placed on their backs for four hours) and then injected with either saline solution (controls) or adrenocorticotropic hormone (ACTH). Animals were allowed to wander in a corral where they were kept for an extra 24 hours. B, T, and P were measured at zero, 17, and 28 hours postnesting. Once again, B levels indicated that control and ACTH injected animals were stressed over the term of the experiment. Looking only at those animals with initially high T levels we were able to observe a decrease in this hormone at about the same time that ovulation had been previously described in one of our earlier studies. On the other hand, P levels did not reach ovulatory levels in the saline-injected nor in the ACTH-injected turtles, indicating that these animals did not ovulate. We conclude that circulating steroid levels may be altered in the short term by stress. We recommend that blood samples be taken as soon as possible after capture in order to avoid any stress-related confounding effects. In addition, we suggest that long term stress may effectively preclude postnesting animals from ovulating.

PUTTING "ACTION" IN THE SEA TURTLE RECOVERY ACTION PLAN FOR BONAIRE

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Bonaire (12°12'N, 68°77'W), an island of the Netherlands Antilles, is situated close to the mainland of Venezuela and is world famous for its unspoiled coral reefs. Reefs and lush seagrass meadows provide forage and refuge for two species of endangered sea turtles, the green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*). Loggerhead (*Caretta caretta*) and leatherback turtles (*Dermochelys coriacea*) are less common but are occasionally encountered. In the local language (Papiamentu) these species are known as 'turtuga blanku', 'turtuga karet', 'turtuga kawama' and 'turtuga drikil', respectively. The turtles are regularly captured and processed, despite the fact that this is illegal at all times under the Marine Environment Ordinance (A.B. 1984, no. 21), as amended on 27 June 1991. Turtles are killed mainly for their meat, and, in the case of karet, for their shell. A few years ago, concerned citizens of Bonaire and The Netherlands had quite enough of the slaughter of sea turtles and decided to do something about it. Their first efforts included the purchase (and release) of live turtles from the fishermen. But they knew something more was needed.

In 1990, Mr. A. de Soet, a resident of The Netherlands, decided to establish the Sea Turtle Club Bonaire (STCB) with the objective of raising funds for the protection of local sea turtle populations. In the last two years the STCB has raised a considerable amount of money by, among other things, selling special commissioned turtle necktie for US$ 50 in The Netherlands and, in February 1992, hosting a fund-raising dinner in Bonaire attended by wealthy and prominent persons, including the Prime Minister of The Netherlands and his wife (who is the patron of the Turtle Club). The dinner raised nearly US$ 15,000.

In May 1993, the STCB appointed the author to undertake the first thorough survey of Bonaire's sea turtles, and to implement an awareness program on sea turtle conservation. The recent published WIDECAST Sea Turtle Recovery Action Plan for the Netherlands Antilles (Sybesma, 1992) provided an integrated blueprint for conservation action and has served as the basis for the implementation of the project. The STCB invited Dr. K.L. Eckert of WIDECAST to visit Bonaire in May 1993, to assist the Project Coordinator in developing the project.

METHODS

The activities undertaken during the project, which was from May throughout October, consisted of daily surveys of all potential nesting beaches, in-water surveys of potential foraging habitat, interviews with fishermen, establishment of a sighting-network for divers, and an awareness campaign targeting schools, the dive tourism industry, law enforcement agencies (Park Rangers, Customs Officers, Police), and the general public. This campaign was undertaken by means of slide-shows, regular press-updates, a column in the main Papiamentu newspaper, and the production of a flyer, a booklet and a color poster about the sea turtles of Bonaire.

RESULTS

The results show that Bonaire is still visited by nesting hawksbill and loggerhead turtles, but not by green or leatherback turtles. Some nesting took place on the island itself, but the majority of the crawls (31 out of 40) was encountered on a small, uninhabited island in front of Bonaire's west coast, called Klein Bonaire.

Of the 40 crawls found, 18 were from hawksbill turtles, 4 were from loggerhead turtles, and 18 could not be identified. Of the 40 crawls, only 6 nests (3 loggerhead, 2 hawksbill, and 1 unidentified) could be found and excavated, showing hatching success percentages of 46% - 100%. The low number of nests actually encountered can first of all be explained from the fact that the crawls were not probed thoroughly, because there was too much danger to damage the nests. Therefore, no accurate estimation of the total nesting population can be given, though it may be as low as 5-10 individuals per season.

Results from the sighting-network and the in-water surveys show that the reefs of Bonaire and Klein Bonaire are inhabited by populations of juvenile hawksbill and green turtles (shell length: about 20-50 cm), which use the reef to forage.

Around the island, several "hot-spots" for observing juvenile sea turtles can be found, indicating that the juveniles visit these locations regularly to forage. Although no serious attempts to study the size of the population were made, it is estimated that there were at least about 45 juvenile green and hawksbill turtles residing in Bonairian waters at any given time last year.

From several fishermen interviews it became clear that both the nesting and the juvenile populations have dwindled considerably. Several beaches, which were once known to be turtle nesting beaches, showed no activity at all during this project. This may be due to touristic developments in the recent past (for example at the west coast), to ongoing poaching of turtles and their nests and to sand mining (especially at the northeast coast). In Lac Bay, which is known to be a foraging area for green turtles, a considerable number (20-30) of subadult greens was captured just before the Marine Environment Ordinance became effective in 1991. According to the fishermen, the sea turtles still illegally captured at this moment are "much smaller than they used to be", an indication that the juvenile population is seriously being stressed.

A general recommendation about future awareness programs about sea turtles is to integrate them in a more general environmental education program about sea life around Bonaire (i.e. coral reefs), which also covers the other endangered species on Bonaire (like flamingos, parrots and iguanas). In this, it is important to ask for cooperation from the tourism/business community, like the dive tourism industry, and to attract local people to participate in future projects.

For future research it is recommended to focus on Bonaire's main nesting beach on Klein Bonaire, and to implement in-water surveys of Bonaire's east coast, which has not been studied so far, due to rough sea conditions.

ACKNOWLEDGMENTS

The author wishes to thank everyone who made this first conservation project on Bonaire's sea turtles possible, especially the Sea Turtle Club Bonaire and its chairman Albert de Soet; the Wider Caribbean Sea Turtle Conservation Network (WIDECAST) and its Executive Director Dr. Karen L. Eckert; the Bonaire Trading Company and its General President Hugo Gerharts; the WIDECAST Executive Coordinator for the Netherlands Antilles, Jeffrey Sybesma; STINAPA Bonaire and its manager Roberto Hensen; the staff of the Bonaire Marine Park and its manager Kalli de Meyer; the management of Marcultura; the Educational Department of Bonaire; the Diving Tourism Industry and the Bonairian fishermen Doei Diez and Chibo Domacassé.

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SEA TURTLE CONSERVATION IN PERU: THE PRESENT SITUATION AND A STRATEGY FOR IMMEDIATE ACTION

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There had been little information about marine turtles in Peru until the research of Frazier (1979), Hays Brown and Brown (1982) and Aranda and Chandler (1989), which provided general information about biological aspects, exploitation, distribution and nesting. Each of these authors mentioned the conservation problems involving sea turtles in Peru, giving special emphasis to the indiscriminate and continual capture, with no effective control. This situation has not changed, and intense exploitation of this resource continues. Hence, there is a pressing need for a conservation strategy with immediate action for the conservation of these species.

METHODS

The initial stage of the research has focused on monitoring the capture of the sea turtles at different ports along the Peruvian coast. The most frequent species captured is *Chelonia mydas agassizzi*. The sites monitored, and the periods involved were: in the north, principally in Constante Port during the period November 1989 to April 1990 (17 days, N=108), September 1993 (8 days, N=109) and in January 1994 (7 days, N= 21), and in the south in San Andres Port in January 1994 (4 days, N= 83). Specimen measurements included straight carapace length (SCL) and straight carapace width (SCW).

RESULTS AND DISCUSSION

Along most of the Peruvian coast, marine turtles are captured offshore from boats of about 3 tons displacement, using nets with about a 25 cm mesh width and 40 m long, which are made specifically for turtles. There is a marked difference in the situation between the north coast, where there is little consumption of turtles, and the south coast, where they are highly appreciated as a food source. In the North, the main locality of capture is Constante Port, on Sechura bay (Fig. 1), where two boats out of a fleet of 30 boats specifically fish for turtles. These boats go to sea once a week for 3 to 4 days; the turtle nets are set for 12 hours, from 6:00 pm to 6:00 am. During the summer (January, February and March) capture is difficult because of rough seas, and they land 8 to 15 turtles per trip. During the rest of the year, especially in September and October, it is not difficult to capture 80 to 100 turtles per trip. The turtles are landed alive and are stored on their backs, sometimes for many days. In the north coast, the demand for meat is low. In the north it is rare to find turtle meat in markets, and it rarely sells for more that US$2.00/kg. The mean SCL of sea turtles captured in the north, recorded during some monitoring in 1993 and 1994, was 70 cm. In 1989-90, it was 67 cm. It seems that the turtles captured recently are larger than those of the previous research period, but it is necessary to monitor for a longer period to find out the real situation of our sea turtle populations (Fig 2).

In southern Peru, San Andres port is the principal locality for the marine turtle fishery (Fig 1). There is a great demand for turtle meat. There are about 25 restaurants, which sell dishes with turtle meat that cost from US$3.00 to US$6.00. They also sell varnished turtle shells for US$7.00 each. During a single summer, the season when turtles are most abundant, about 100 shells can be sold. In Lima, a varnished shell sells for US$10.00. There is a place called Acapulco, near San Andres where the turtles are killed, and accumulated shells can be counted. However, the shells are burned, and it is not easy to estimate the number that have been captured. For example, we visited San Andres recently and recorded 55 turtle shells that had been captured a few days before, after three days we came back and all of these shells had been burnt, and we recorded 16 new shells. The meat is taken to the market in Pisco and sold to the restaurants at US$4.00/kg. We recorded the turtles captured recently (1994) in southern and northern Peru. The mean SCL for turtles captured in the south was 68 cm, and for the north 70 cm (Fig 3). The amount of sea turtles captured in the north has no relation with the low demand for turtle meat in the area. Probably the meat is transported to the south (San Andres) to be sold (it is only an 18 hour drive). A turtle of US$7.00 with about 8 kg of meat in the north is sold for US$16.00. In San Andres this meat could be sold for US$30.00 or US$40.00. Also it is important to note that when in the south there are few turtles (especially in winter season), in the north it is possible to find high concentrations of sea turtles, so the demand in the south always can be covered. The first evidence of nesting was recorded at Malpelo Point (3° 30' S). A nest of *Lepidochelys olivacea* was found (Hays Brown and Brown 1982). In November 1992, two hatchlings of *Lepidochelys olivacea* were found in Punta Capones (3° 24' S).

In 1993 in Chimbote Port we recorded two green turtles and one leatherback with mature eggs inside. Probably these two species nest in the north coast of Peru. It is necessary to conduct further studies of nesting in this area (Fig.1). Also it is important to find the origin of the Peruvian sea turtle populations. Hays Brown (1979) found 7 tagged green turtles from Galapagos in turtles captured at San Andres. Aranda (1989) found another 8 tags, so in Peruvian waters probably there are feeding grounds for sea turtles that nest in Galapagos beaches. About legislation, in 1977 the Ministerio de Pesqueria pronounced a Resolution allowing the capture of *Chelonia mydas agassizi* of 80 cm of total length or above. This law lacks previous research, and nobody enforces the law.

CONCLUSIONS AND RECOMMENDATIONS

A long term conservation program for marine turtles is needed in Peru, with three principal aspects:

- Monitoring of fishery, exploitation and commerce, with emphasis in San Andres port and Constante port.
- Biological research, to find out basic information about feeding, nesting, diseases and distribution of the sea turtles populations in Peru by genetics research and a tagging program. - - Training of Peruvian conservationists and biologists to promote future investigations.
- Environmental Education, realize two different strategies one for the north to increase the knowledge of marine turtles in fisherman and show them that the sea turtle conservation will be in their benefit, work hard with the children as a good way to educate the parents. And in the south, work hard with the consumers, a key group in San Andres, let them understand their important position in marine turtle conservation because of the demand that they originate. Authorities must change the actual legislation. The main point of this strategy is involve local people (fishermen, authorities, consumers and traders) in our efforts for marine turtle conservation in Peru; only with their cooperation will we have success in this task.

ACKNOWLEDGMENTS

We would like to thank the following institutions for support: The World Wildlife Fund, Center for Environmental Education, Greenpeace International, Van Tienhoven Foundation of Amsterdam. Special thanks to Marinex S.A. from Peru, for giving us financial support for the continuation of marine turtle research, to the Grupo de Cetaceos de ECCO for providing us information about the marine turtle fishery and the Asociacion de Ecologia y Conservacion (ECCO) for logistic support. Finally, our gratitude to Antonio Salas and Tony Luscombe, for providing constructive criticism, guidance and encourage during our studies.

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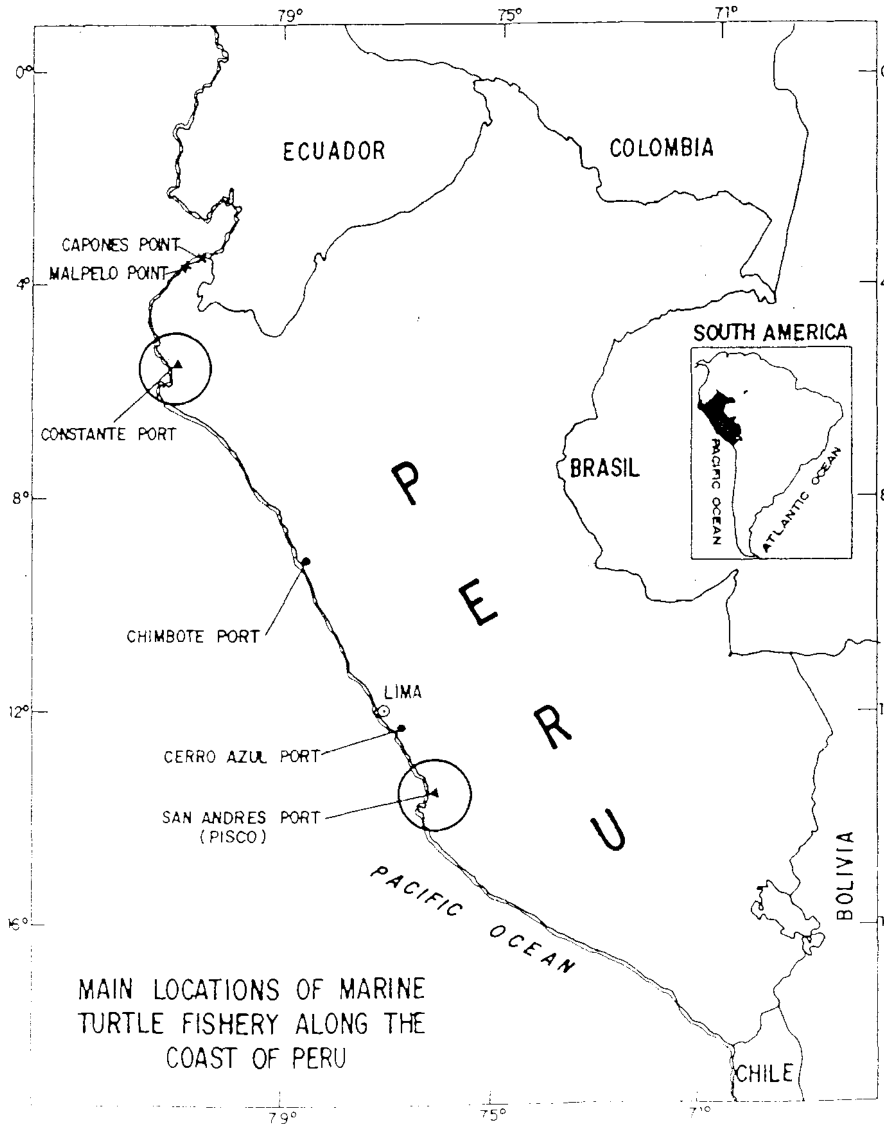
FIG. 1



MAIN LOCATIONS OF MARINE TURTLE FISHERY ALONG THE COAST OF PERU

(162)

FIG. 2 MARINE TURTLE FISHERY ON THE NORTHERN COAST OF PERU

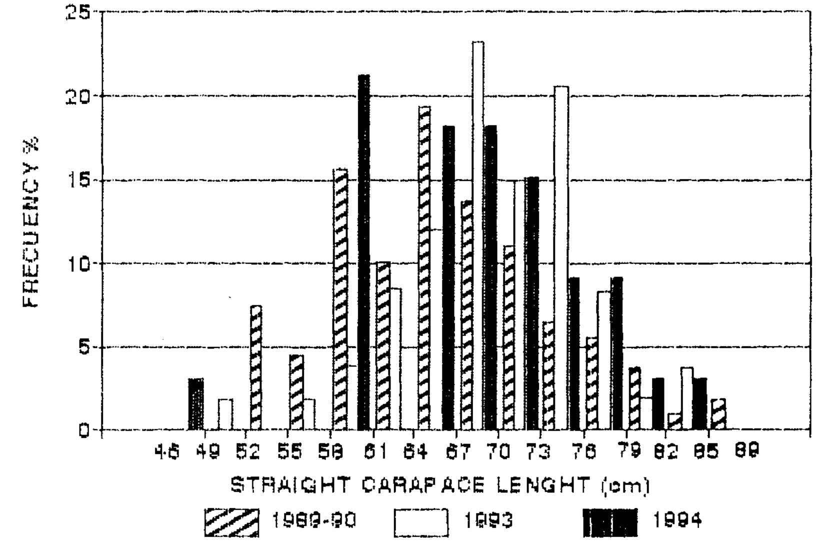
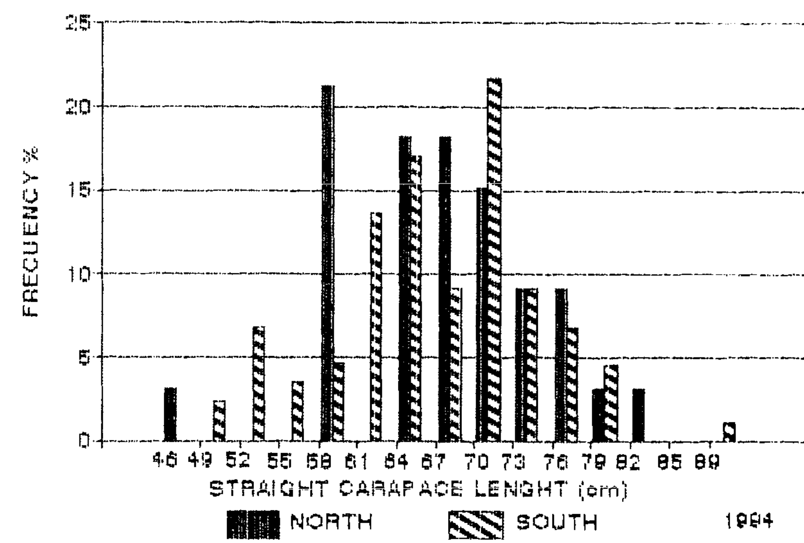


FIG. 3 MARINE TURTLE FISHERY ON THE COAST OF PERU



FEEDING ECOLOGY OF WILD AND HEAD STARTED KEMP'S RIDLEY SEA TURTLES (*LEPIDOCHELYS KEMPII*)

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Fecal samples from 86 Kemp's ridley sea turtles captured at a Sabine Pass index habitat were examined to describe foraging habits of this species in nearshore waters. Entanglement netting during April through September yielded 74 wild and 12 head started ridleys with the majority being ≤40 cm SCL (straight carapace length). Fecal matter in six categories (crab, fish, mollusk, vegetation, debris, and other) was collected and identified to the lowest possible taxon. Each sample was dried in an 82°C oven for 24 hours, then weighed to the nearest thousandth of a gram. Frequency of occurrence and percent dry mass were calculated for each food item. No significant difference was detected between wild and head started turtles with regard to frequency of occurrence of individual food categories. Vegetation (mostly sargassum) exhibited the highest frequency of occurrence, while crab (mostly blue crab) yielded the highest percent dry mass. These preliminary results indicate that immature ridleys forage both at the surface and on the bottom and consume a wide variety of items.

CHARACTERISTICS AND MANAGEMENT POTENTIAL OF SEA TURTLE NESTING AREAS IN THE FLORIDA KEYS NATIONAL WILDLIFE REFUGES

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Little is known about historic numbers of sea turtles nesting in the Florida Keys National Wildlife Refuges (FKNWR). An active turtle fishery in the Florida Keys removed an unknown number of adult green turtles. The eggs of loggerhead and green turtles were harvested occasionally by local residents (Hampton Walters, pers. comm.).

Sea turtle nesting beaches in FKNWR vary in length from only a few hundred meters to 2.5 kilometers. All are very narrow, low-energy sites that are inundated by higher than normal tides several times during the nesting season.

Irregular surveys of nesting sea turtles on selected beaches were carried out between 1986-89. Systematic weekly monitoring of all potential sea turtle nesting habitat was performed season-long between 1990-93, during which time sea turtle nests were found on 9 different islands, including 6 in the Marquesas Keys, some 37 km west of Key West, FL.

From 50-67 loggerhead and 2-9 green turtle nests were found annually from 1990-93. Reproductive success was determined for each nest; yearly productivity for both species was erratic. The number of loggerhead nests on the 5 primary nesting beaches fluctuated widely (Figure 1). Green turtle nests were found on only 3 islands, and nesting did not occur on the same island in consecutive years. It appears that only 3-4 breeders comprise the entire green turtle nesting population in FKNWR.

Most loggerhead and all green turtle nests were found landward of the beaches. On Boca Grande and Marquesas Keys, several green turtle nests were found beyond the dunes in shaded strand-scrub hammocks.

Illegal camping and invasion of exotic plants, particularly Asiatic colubrina (*Colubrina asiatica*), lead tree (*Leucaena leucocephala*), and Australia pine (*Casuarina equisetifolia*) negatively impact sea turtle nesting areas in FKNWR. Illegal camping was observed on all the primary sea turtle nesting beaches, and was of particular concern on Boca Grande Key, where tents were often found in an area where green and loggerhead turtle nests were concentrated (Figure 2).

For many years, vandals quickly removed or destroyed "No camping" signs and signposts; the remoteness of the areas and lack of personnel precluded effective enforcement. During the autumn of 1992, a new method of posting was implemented in 6 chronic problem areas. Signs were riveted to steel backing plates that had been welded to thick-wall steel posts, which were then imbedded in buried 55-gallon drums filled with concrete. To date, the signs have required virtually no maintenance. This measure, augmented by public education (brochures) and limited enforcement, reduced observed instances of camping in 1993 to less than half that of 1992.

Invasive exotics were found in scattered areas on 7 of the islands. Australian pine and lead tree proved relatively easy to control with Garlon 4. Asiatic colubrina was more problematical, especially when its dense foliage was intertwined with or sprawled over desirable native vegetation. Most colubrina was uprooted; large trunks were cut with chain saws and then sprayed with Garlon 4. It was necessary to revisit treated areas several times to kill seedlings and stump sprouts.

Figure 1. Numbers of loggerhead turtle nests on the primary nesting beaches in Key West National Wildlife Refuge, 1990-93.

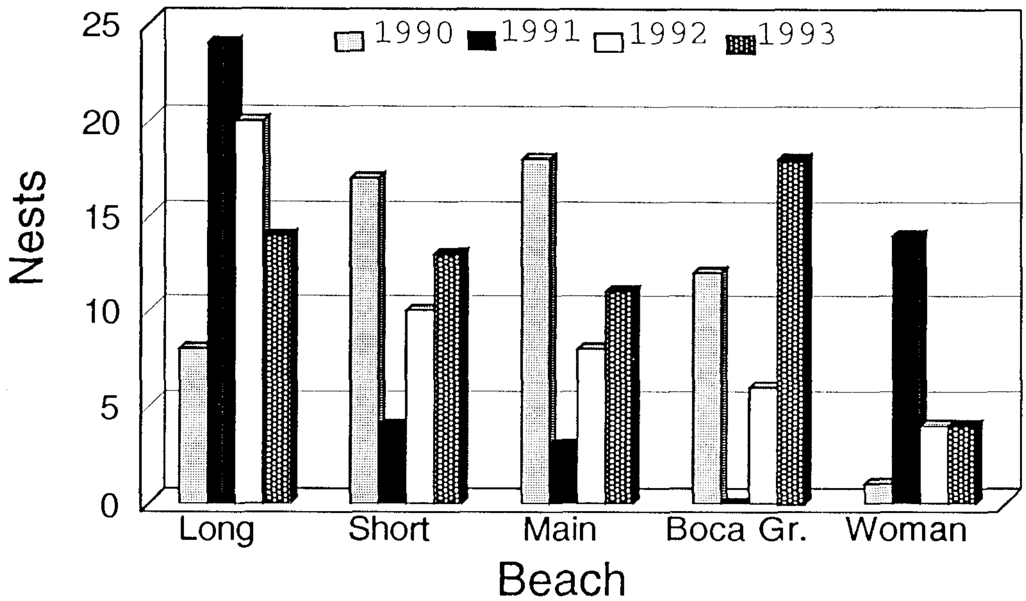
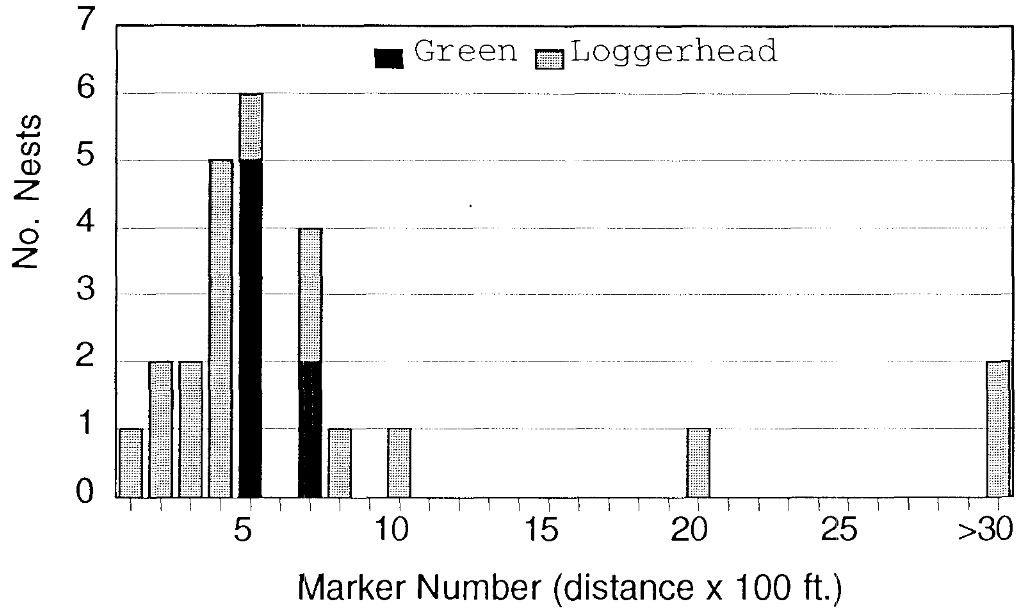


Figure 2. Distribution of loggerhead and green turtle nests by 100-foot intervals on Boca Grande Key, 1993



FLOTSAM, JETSAM, POST-HATCHLING LOGGERHEADS, AND THE ADVECTING SURFACE SMORGASBORD

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The eastern coast of Florida, USA, serves as a focal point for loggerhead reproductive effort in the Western Hemisphere and, as such, stages a great dispersal of neonate loggerheads into the North Atlantic. The work discussed here is part of an ongoing study on the dispersal and behavior of neonate loggerheads (Witherington, 1994). The objective of this account is to describe food items ingested by post-hatchling loggerheads captured at sea off Florida.

METHODS

An assistant and I made 12 trips into the Atlantic Ocean off Florida in a 6.6 m motor vessel in search of post-hatchling loggerheads during the hatching season, July through October 1993. Our search targeted areas where there were conspicuous features of convergence zones or where weed lines were present. These areas have yielded post-hatchling loggerheads in previous studies (Witherington, 1994). Sites where turtles were captured in 1993 were 8-35 NM east of Cape Canaveral and Sebastian Inlet, Florida, near the western edge of the Gulf Stream. We idled with our boat along weed lines and fronts, and when turtles were observed, we noted their behavior and surroundings, and captured them with a dip net. We timed our searches and recorded the positions of the captures we made.

We made attempts to determine food items taken by captured turtles by examining oral cavities and/or flushing items from stomachs and esophagi with a sea-water lavage. The lavage apparatus consisted of a 3 mm diameter flexible-vinyl tube and a rubber ear-wash bulb. Discharged items were fixed in 10% buffered formalin to be later examined microscopically. All turtles were active when released at respective capture sites.

RESULTS AND DISCUSSION

We captured 160 post-hatchlings from the areas we searched, approximately one turtle for every five minutes spent searching. Turtles were generally at the surface near patches of *Sargassum*, inactive, and in a tuck position (with fore-flippers flat against carapace) when discovered.

Captured turtles ranged in standard carapace-length straight-line (measured from nuchal to pygal tip) from 40.3 to 56.3 mm, and ranged in weight from 15.5 to 36.0 g. The largest captured post-hatchlings were approximately twice the average weight of a hatchling as it leaves the beach.

We lavaged 50 turtles and obtained macroscopic, discharged items from all but eight. Discharged items were later divided into 43 categories of animal, plant, and synthetic material. The most frequently-found animal material was from jelly animals, predominately medusae and ctenophores (Table 1). Crustaceans were common in samples and were primarily represented by larval shrimp and crabs. There were three species of hydrozoans found, with many colonies still attached to *Sargassum* floats, leaves, or stipes. Two turtles had eaten insects, one buprestid beetle and an ant, winged-sexual. The largest animal found was a 21 mm (greatest length) nudibranch.

The most sobering discovery was the frequency of tar in lavage and mouth samples. At least 34% of the turtles had tar flushed from their stomachs and esophagi, and over half of the turtles I examined had tar caked in their jaws (Table 2). I also found a wide variety of plastics and other anthropogenic material, including plastic sheets (as from plastic bags), plastic chips and strips of various colors, single and multi-filament fibers, caulking material, and vermiculite (Table 2).

In keeping with our behavioral observations, loggerhead post-hatchlings seem to prefer slow-moving or non-moving food items. Their choices seem quite varied, although not entirely indiscriminate. For instance, the most common item in these fronts, *Sargassum*, is not represented in proportion to its occurrence. It may be that *Sargassum* is only taken incidentally. The feeding strategy of post-hatchling loggerheads may be to focus on visually-unique items amongst the *Sargassum*.

Whereas plastic was best represented in stomach lavage samples, tar was best represented in mouth samples (Table 2). It may be that 1) more tar is bitten than is swallowed, 2) tar is more persistent in the mouth, or 3) tar is less easily flushed from the stomach than are other items.

The ingestion of tar and plastics by sea turtles is not a new discovery (Carr, 1987). The evidence presented here is particularly alarming, however, in that such high proportions of a particularly vulnerable life history stage are involved. A close monitoring of this problem and a further elucidation of its effects are warranted.

ACKNOWLEDGMENTS

This study was funded by a grant from the U.S. Air Force to B. Witherington, K. Bjorndal, and A. Bolten, through the Archie Carr Center for Sea Turtle Research, University of Florida, and by grants from the U.S. Fish and Wildlife Service and the Florida Game and Freshwater Fish Commission to the Florida Department of Environmental Protection. J.G. Altman assisted with the field work.

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Table 1. Items discharged from stomachs and esophagi of 50 post-hatchling loggerhead turtles captured in the Atlantic Ocean off Florida.

CATEGORY	NUMBER OF TURTLES
LARGER JELLY ANIMALS AND TENTACLES	20 (40%)
UNIDENTIFIED ANIMAL TISSUE OR OVA	10 (20%)
CRUSTACEANS	9 (18%)
HYDROZOANS	8 (16%)
INSECTS	2 (4%)
GASTROPODS	2 (4%)
TURBELLARIAN FLATWORM	1 (2%)
ACTINID ANEMONE	1 (2%)
SARGASSUM	13 (26%)
OTHER PLANT MATERIAL	4 (8%)
TAR	17 (34%)
PLASTICS AND SYNTHETIC FIBERS	16 (32%)
NO VISIBLE ITEMS DISCHARGED	8 (16%)

Table 2. Incidence of tar, plastics, and other synthetic materials found in samples from gastric lavage and oral examinations of post-hatchling loggerheads.

	LOGGERHEAD POST-HATCHLINGS		
	WITH PLASTICS	WITH TAR	TOTAL EXAMINED
MOUTH EXAMINATION	2 (2%)	53 (56%)	95
STOMACH LAVAGE	16 (32%)	17 (34%)	50
STOMACH OR MOUTH EXAMINATION	18 (17%)	65 (63%)	103

THE TRIALS AND TRIBULATIONS OF SWIMMING IN THE NEAR-SHORE ENVIRONMENT

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Hatchling sea turtles may face a variety of threats to survival as they swim offshore. Nearshore waters are believed to be predator-rich. We asked how hatchlings contend with predators as they swim offshore. The goals of this study were to (1) describe how hatchling sea turtles respond to threats in their environment, and (2) identify nocturnal hatchling predators in the waters off the beaches of southern Palm Beach and northern Broward Counties.

METHODS

Loggerhead (*Caretta caretta*), green turtle (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) hatchlings were released individually in shallow water and allowed to swim offshore. These releases were during the diurnal period so that the behavior of hatchlings could be observed. A boat and snorkeler followed behind the turtle for 1 hour. Its behavior was documented as it swam. All responses to fish and overhead objects were noted.

At night we documented hatchling predators by (i) fishing using hook and line and examining the stomachs of the fish we caught. (ii) Using a spotlight and flash photography we were able to identify fish patrolling the waters near nest sites.

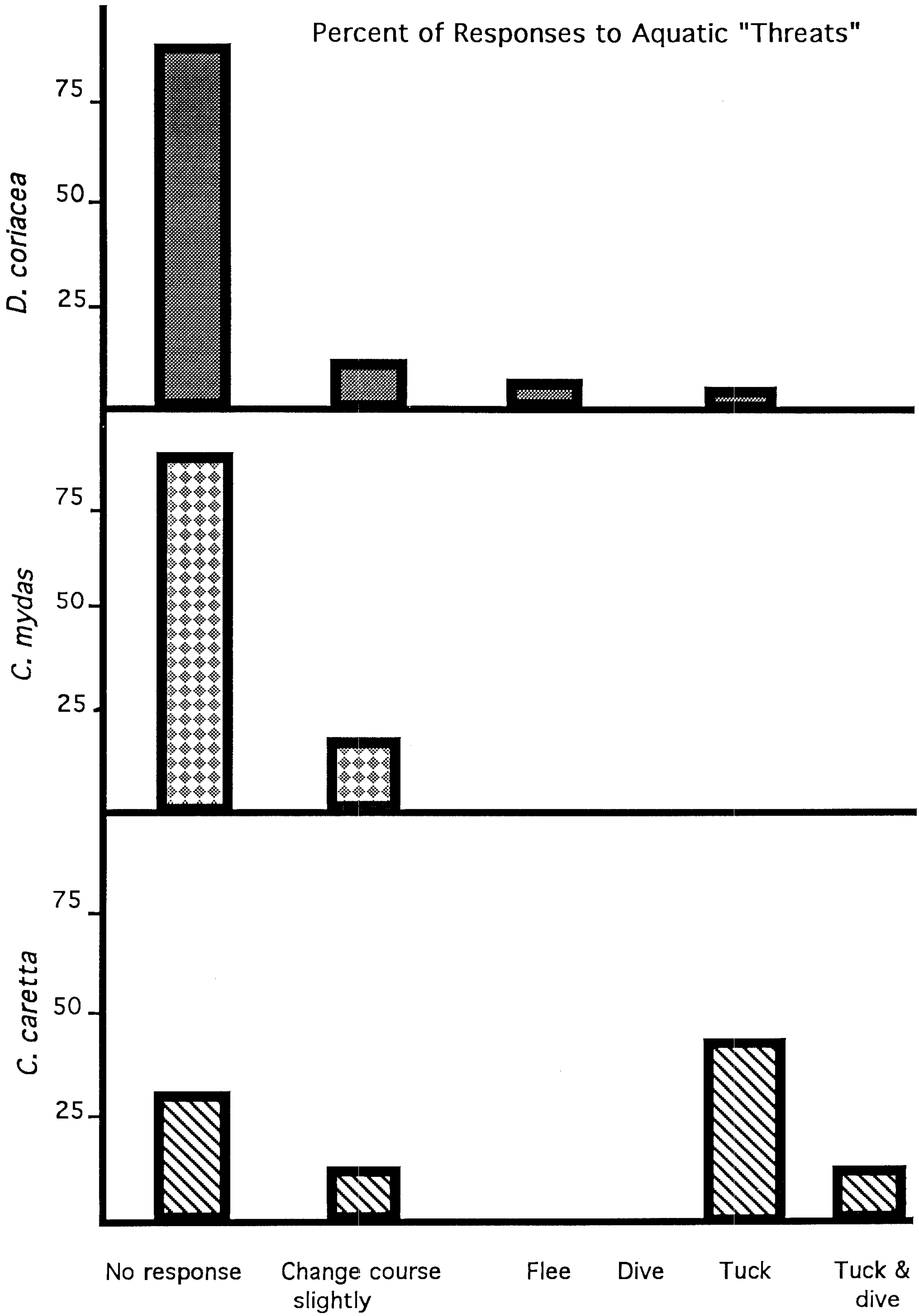
RESULTS AND DISCUSSION

Potential threats were defined as organisms moving toward the turtle with the possibility of attack or those attacking the turtle. Additionally organisms or objects that the hatchlings responded to were also defined as potential threats. Threats were divided into aerial and aquatic categories.

At our urban site, hatchlings responded to single engine airplanes, single-rotor helicopters, and double-rotor helicopters as is if they were aerial threats. Seventeen of 18 turtles encountering an overhead flying object dove in response. One leatherback hatchling ignored a plane, however it was already swimming at a depth of 4-5 m.

Eighty three percent of the leatherback and loggerhead groups encountered aquatic "threats" while only 33% of the green turtles encountered other organisms. We believe this lower encounter rate may be due to the protective coloration of green turtles. Their counter shading may make them more difficult to see.

Aquatic "threats" were all fish, squid, jellyfish, and portunid crabs. A total of 22 species of fish approached the hatchlings. Several individuals attacked the hatchlings. Responses to aquatic threats (Fig. 1) varied and were categorized in roughly increasing order of action. These behaviors ranged from no response (appearing to ignore fish) to going into a tuck position alone or followed by a dive. The species differed in their responses to threats. Most leatherback and green turtle hatchlings ignored threats; some turtles did not alter flipper stroke rates or course even when bitten. When a response occurred, frequently it was a change in course (slight or dramatic, defined as fleeing). No green turtle opted for immobility and only one leatherback responded by going into a version of the tuck. Loggerhead hatchlings were less likely to ignore threats in the water. Their most common responses


Percent of Responses to Aquatic "Threats"
D. coriacea
C. mydas
C. caretta
75
50
25
No response
Change course slightly
Flee
Dive
Tuck
Tuck & dive

were to change course or to go into a tuck for several seconds or minutes. Two animals went into a tuck then dove.

Nocturnal predators were caught in front of areas with high numbers of turtle nests. The stomach contents of these fish showed that Gray Snapper (*Lutjanus griseus*, 12 of 16 fish) and Blue Runners (*Caranx crysos*, 1 of 4 fish) were eating turtles. We also caught one Tarpon (*Megalops atlanticus*) that we strongly suspect was eating turtles but we had to release this fish so no stomach contents were obtained. Other fish that visited these nest sites nightly were identified by eye shine when we flashed a spot-light into the water or when flash photographs were taken on calm nights.

SUMMARY

Hatchlings face a variety of real threats and objects they perceive as threats when swimming offshore. All species responded to the aerial "threats" in the same manner: they dove. Aquatic threats were dealt with differently by each species. Green turtle and leatherback hatchlings were more likely to ignore threats than respond with some action. Loggerheads varied in their responses from ignoring the threats to becoming immobile.

ACKNOWLEDGMENTS

We thank R. Cauffiel, R. Ernest, L. Fisher, K. Lohmann, M. Salmon, R. Reiners, B. Squillante, J. Steinitz, J. Weege, S. Weege, L. Wood, Gumbo Limbo Environmental Complex, and the Marinelife Center of Juno Beach.

BEHAVIOR OF FLATBACK SEA TURTLE (*NATATOR DEPRESSUS*) HATCHLINGS

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Recoveries of adult, juvenile, and post-hatchling flatbacks (*Natator depressus*) are within the limits of the continental shelf (which includes waters near Indonesia and New Guinea) of Australia. For this reason, it is assumed that the habitat of post-hatchling flatbacks is different from that of other species such as loggerheads (*Caretta caretta*) that are known to disperse to the open ocean. If the frenzy swim has been finely tuned by natural selection to form the bridge between the natal beach and the post-hatchling habitat, differences in the frenzy swim are predicted. In January and February 1994, we studied the flatback frenzy swim to determine how it differed from that of other species of sea turtles, if at all. Two approaches were used. We compared the behavior of flatback hatchlings with the behavior of loggerhead hatchlings released into experimental tanks and released 2 nautical miles from shore. We present preliminary behavioral observations on locomotor patterns including surface swimming, underwater swimming, and dive behavior. Additional studies are planned that will address the following questions. How does the orientation of flatbacks differ from the other species, if at all? How does the behavior of flatbacks allow them to remain offshore but within the confines of the continental shelf? These questions are asked within the framework of the larger evolutionary question of why this ancient line of sea turtles is confined to the continental shelf of Australia?

PART II: POSTER PRESENTATIONS

A COMPARISON OF GALVANIZED WIRE MESH CAGES VS. FLAT CHAIN-LINK SCREEN IN PREVENTING *PROCYON LOTOR* DEPREDATION OF *CARETTA CARETTA* NESTS

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On many beaches in southwest Florida *Caretta caretta* (loggerhead sea turtle) nests are heavily depredated by *Procyon lotor* (raccoon). This is particularly true on the southern 4 mi. of the nesting beach on Key Island. Unprotected nests on this beach are invariably destroyed by these mammals.

In 1992, a pilot study was conducted on Key Island to compare the relative efficiency of 2 methods of preventing nest depredation by raccoons. The first technique, flat screens, consisted of 4 ft x 4 ft squares of vinyl coated chain-link fence. They were centered over nests and held in place with 12 in plastic tent stakes. To reduce visual cues, the screens were covered with 1-2 in of sand. The galvanized wire mesh cages used in the second method measured 3 ft x 3 ft x 2.5 ft, with the bottom .5 ft bent outward to form horizontal flaps. The flaps anchored the cages and prevented raccoons from digging into the nests from the side. The mesh size was 2 in x 4 in. Cages were centered over the nests, then removed and a 3 ft x 3 ft trench 1 ft deep dug around the nests. Cages were placed in the trenches and the furrows refilled. This left 1 ft of the cage exposed, preventing raccoons from digging into shallow nests from above.

The efficiency of the two methods was tested using a t-test to compare 28 randomly selected nests protected with flat screens (total $n=87$) with the total number of galvanized cages covering nests ($n=28$). Two repetitions using the flat screens were conducted. In each case, the cages were more effective in preventing depredation (Test 1, $P<0.1$; Test 2, $P<0.01$). Overall 11.4% of the nests covered with flat screens were partially depredated, while an additional 13.6% were totally depredated. Caged nests experienced 0% partial predation, while 3.6% were totally depredated. Although both methods protect nests, cages were clearly more effective. It was also found that cages reduce the need to relocate shallow nests, which would otherwise be depredated if screened in situ.

STATUS OF THE MARINE TURTLES *DERMOCHELYS CORIACEA, CHELONIA AGASSIZII,* AND *LEPIDOCHELYS OLIVACEA* AT PLAYA NARANJO, PARQUE NACIONAL SANTA ROSA, COSTA RICA

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Egg laying by marine turtles *Dermochelys coriacea*, *Chelonia agassizii*, and *Lepidochelys olivacea*, has been previosly reported along the Pacific coast of Costa Rica (Richard and Hughes, 1972). Cornelius (1976) described the first observations on egg-laying activities of three species in Naranjo Beach. From December 1983 and March 1984 on the same beach, Cornelius and Robinson (1985) registered 312 tracks of *Dermochelys coriacea* and 63 of *Chelonia agassizii*. Between October 1989 and February 1990, the present authors registered 466 tracks for *D. coriacea*, 431 for *C. agassizzi*, and 308 for *L. olivacea*. Between 1990 and February 1991, the number of tracks for the three species, respectively, was 1212, 364, and 447. During two short periods between November 1993 and January 1993 these numbers were 152, 53, and 185.

Observations conducted up to the present date indicate that this particular beach is highly important in nesting activities by the three species. However, predation of eggs by mammals, particularly by coyotes, is responsible for a great reduction in nesting success for the three species. Some management is required to afford greater egg laying and hatching success.

METHODS

The number of females laying eggs was assessed by direct count during nocturnal hours and by both authors plus an assistant. This was supported by track counts made early on the following mornings. After identifying and locating nests, a patrol was conducted to determine the quantity of nests destroyed by mammalian predators and to identify specific predators when possible.

RESULTS AND DISCUSSION

An evaluation of data indicates fluctuations in frequencies of egg laying by the three species when comparing the three study periods comprising this study. Further studies over a longer period of time may help provide evidence for establishing distinct cyclic egg-laying behaviors in the three species. Due to discrepancies in the lengths of the three periods mentioned and due to differences in the actual months covered, no obvious trends are seen from the present study.

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HATCHING RATES FOR *LEPIDOCHELYS OLIVACEA* IN PLAYA OSTIONAL, GUANACASTE, COSTA RICA

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Populations of the marine turtle (*Lepidochelys olivacea*) have been affected in Central America by uncontrolled. The commerce of such eggs has been highly successful in the area (Cornelius et al., 1991).

The controlled harvest of eggs in areas of massive rookeries and the relocation of egg clutches in hatcheries or in other beach areas are management activities which enhance the species future survival (Castro and Alvarado, 1987). Through management it is possible to maintain and possibly increase population size in the olive ridley, and even benefit economically, coastal communities.

Citizens organized within the Association of Integral Development on Ostional are dedicated to the controlled and legalized harvest of eggs. Through this, income is derived for the majority of that community's families and a curbing of poaching activities is provided. Hatching rates were compared for eggs of *Lepidochelys olivacea* for Ostional beach, from one area in which legal harvest is permitted and three areas free of harvest.

METHODS

Ostional Beach was divided for analytic purposes in three major areas, and these further divided into three vertical intertidal zones. A total of 1205 nests was examined which had been previously marked and protected by metal cages and selected at random in all four areas within three distinct intertidal zones.

RESULTS AND DISCUSSION

The hatching rates in the area with harvest were significantly different from those in areas lacking removal (P=0.004). In the main nesting beach the rate for that area with egg harvest was 8.7 with a standard deviation of ± 18.8% (n=384), indicating no statistical significance and for areas ("quadrants") without harvest, 7.9 ± 14.8% (n=44). In the areas one and two without harvest, the rates were 11.3 ± 34.6% (n=370) and 30.0 ± 36.6% (n=33), respectively. The hatching rate for turtles in solitary arrivals was 14.9 ± 29.6% (n=33), higher than that for turtles in "arribadas", 10.6 ± 27.8% (n=831). Rates calculated for the three intertidal zones, averaged collectively for all four beach areas, were 24.1 ± 31.4% (n=53) for the "high" zone, 9.7 ± 28.3% (n=662) for the "middle" zone, and 9.8 ± 1.9% (n=116) for the "low" zone. Among those management recommendations directly derived from the present study are (1) the utilization of the "middle" zone within the main nesting beach for purposes of harvest, (2) the protection of the "high" zone of that beach since it contributes the highest number of neonates to the total hatching rate for Ostional Beach, and (3) the total protection of beach areas I and II since these two areas had the highest observed hatching rates. Recommendations for future studies are included.

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MARINE TURTLE CONSERVATION IN GUATEMALA: WORKING WITH COMMUNITIES

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Marine turtle conservation in Guatemala consists of a system of hatcheries that dot the coasts; 24 on the Pacific and 1 on the Atlantic. The beaches of the Pacific coast host nesting populations of olive ridleys (*Lepidochelys olivacea*) and leatherbacks (*Dermochelys coriacea*). The hatcheries are administrated by DIGEBOS— Dirección General de Bosques y Vida Silvestre (Forest and Wildlife Service). DIGEBOS is supported in this effort by several governmental and non-governmental organizations (NGOs).

The NGO role in marine turtle conservation in Guatemala is small but is a growing trend. Governmental support is dwindling and it is becoming increasingly clear that NGOs will have to take the initiatives necessary to ensure long-term success of present and future programs. Amigos del Bosque (Friends of the Forest) has helped DIGEBOS with hatchery management, educational activities, and other community involvement initiatives for several years. ARCAS—Asociación de Rescate y Conservación de Vida Silvestre (Wildlife Rescue and Conservation Association)—is a newcomer to the marine turtle field.

ARCAS is a Guatemalan NGO dedicated to the conservation of Guatemalan wildlife and their rapidly diminishing habitat. ARCAS is nationally and internationally recognized for its conservation efforts in Guatemala's Maya Biosphere Reserve, department of Petén, where they established Central America's first wildlife rescue and rehabilitation center, as well as several community-based programs which combine conservation and sustainable economic development.

Unlike many conservation organizations which only treat the symptoms of environmental degradation, ARCAS attacks these problems at their roots: underdevelopment and lack of education. ARCAS recognizes that the key to any successful conservation effort, especially in developing countries, depends on the participation of local communities whose actions directly affect the conservation of species and the sustainability of natural resource management. ARCAS' successes include a successful initiative to redesign the region's primary educational curriculum to integrate environmental concerns into all core materials in collaboration with local teachers.

ARCAS in 1993, after establishing a solid track record in Petén, expanded its mission in order to include marine and coastal conservation. The resulting program—the ARCAS South Coast Project—focuses on conserving the Pacific coast's rich biodiversity by integrating mangrove reforestation, environmental education, sustainable economic development, and marine turtle conservation in Hawaii National Park, Santa Rosa, Guatemala, and surrounding areas. In 1949 after seeing a postcard of Hawaii, USA, Alberto Montepeque decided to name the rich area which he and his family had settled "Hawaii" by virtue of its volcanoes, black sand beaches, palm trees, and nesting turtles which so resembled that far way place.

Although legislation mandates that commercialization of all turtle products is prohibited, in practice eggs can be sold under the condition that one dozen eggs from each exploited nest are donated to the local hatchery. Therefore hatcheries rely almost exclusively on the participation of egg collectors for their success. Due to lack of enforcement and community initiative, collaboration has dropped drastically in recent years.

In order to directly involve the community in the marine turtle conservation effort ARCAS is instituting local education programs and initiatives to promote economic alternatives to the exploitation of marine turtle eggs. For the 1994 nesting season ARCAS plans to add a new dimension to the hatchery system by constructing satellite hatcheries in local schools.

These school hatcheries will receive a percentage of the eggs that are donated from their respective villages. Through the responsibility of managing turtle hatcheries, children (and consequently their parents), the project aims to develop a more sympathetic bond with the species that contribute to the economic well-being of the community and the beauty of the area. Increased community involvement should translate into higher hatch and release rates and increased recruitment into breeding populations.

MARINE TURTLE NESTING AT PATRICK AIR FORCE BASE, FLORIDA; 1987-1993: TRENDS AND ISSUES

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The summer of 1993 was the seventh consecutive season in which U.C.F. Marine Turtle Research monitored the levels of nesting activity, distribution, and reproductive success over the 7 kilometer stretch of beach at Patrick Air Force Base, Florida (PAFB).

Surveys were conducted 7 days a week from 6 May 1993 to 31 August 1993, during which observations of nest disturbance, evidence of hatchling emergence, and other relevant circumstances were noted. To assess clutch mortality and reproductive success of clutches deposited within the study area, a representative sample of nests was marked.

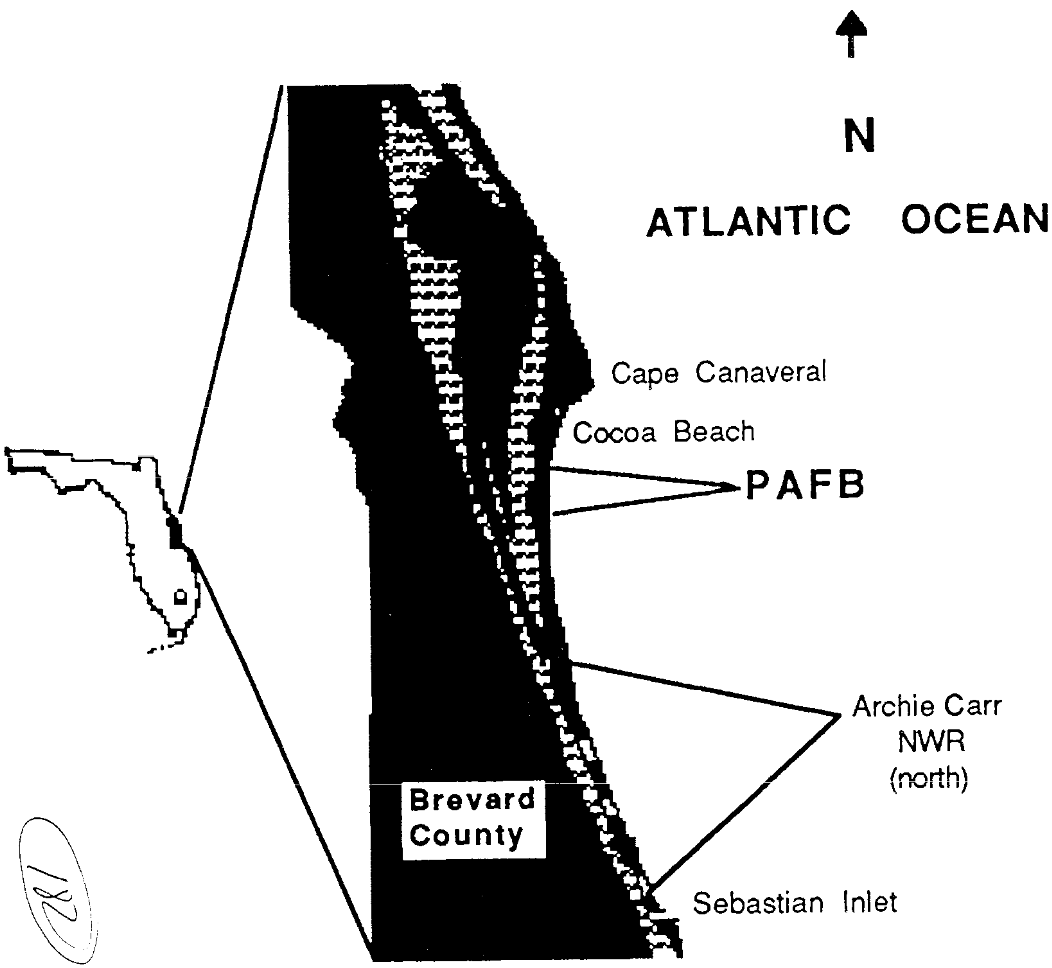
Survey results of nest production at PAFB in previous years are shown in Figures 1 and 2. This year's *Caretta caretta* nest production was 1203 nests, (an average of 172 per km) which was slightly above the overall 1987-1992 average (Figure 1). There was no *Chelonia mydas* activity at PAFB in 1993, which was to be expected as *C. mydas* in Florida adheres to a biennial pattern of high and low nesting and in previous years of lowered activity we obtained the same results (Figure 2).

The PAFB landscape is characterized by a predominately flat beach with several short sections of rip-rap. This year another significant feature was added: a coastwise berm of sand, silt and shell; the result of a beach and dune nourishment project that was completed before the beginning of the nesting season. In the first 1.5 km of our study area, the slope of this berm was fairly gentle and presented no problem for nesting females. From 1.5-3.4 km, however, the slope changed significantly to a vertical scarp 2-3 meters high that was virtually impossible for turtles to climb, resulting in an excessive number of "false crawls" (Figures 3 and 4). From 3.5-7.0 km, there remained good quality nesting beach, virtually flat from the water's edge to the natural dune scarp. In every previous year, Section 3 produced the highest nesting success rates (Figure 5) and, in most years, nearly twice the number of nests found in any other section.

Each interaction between emerging *C. caretta* females and this manmade wall was carefully scrutinized and recorded (Figure 4). When nesting females actually contacted the scarp wall, the result was a failure to nest in the great majority of cases from 1.5-3.4 kms. While a few of these turtles actually climbed the vertical berm and nested at the top, lowered nesting success rates in this area (as compared to 1992 data) suggests that most went elsewhere to nest. The fact that nesting success did not fall in Section 4 begins to explain the overall effect of the scarp on turtle nesting at PAFB. Previous studies have shown that thwarted females become less selective when choosing subsequent nest sites, often failing to ascend the beach to normal height, depositing eggs too close to the water, thereby subjecting them to a greater risk of inundation. It is important at this point to remember that good nesting beach was available on the northern side of the nourishment project from 3.5-7.0 km. Inspection of Figures 3 and 5 reveal that, for the first time since 1987, the nesting success in Section 4 was greater than in Section 3. We believe that this is indicative of the displacement of nesting females thwarted in Sections 2 and 3. The final outcome was that although the 2-3 meter scarp produced dramatic changes in nesting success rates and greatly affected the overall distribution of nesting, the total nest production and reproductive success were apparently not affected because there was suitable nesting habitat nearby. It is our understanding that the beach nourishment project will be extended to cover the entire length of our study site and is expected to be ongoing for the next five years.

Since the beginning of our study in 1987, the most impressive aspect of sea turtle nesting at PAFB has been the consistently high reproductive success rates (Figure 6), here defined as the emerging success rate, or the percentage of eggs producing hatchlings that escape the nest. We continue to attribute this success to the lack of raccoon predation which is so prevalent on other beaches in this region. Whereas raccoon predation can be estimated to destroy 10-20% of the nests in any given season, we have documented only one nest destroyed in this manner during the past seven years.

Although we have become accustomed to relatively high hatching and emerging success rates at PAFB, the means for those parameters observed in 1993 were astonishing. Reproductive success rates greater than 80% are seldom seen, even in protected, artificial hatcheries, and the true worth of a nesting beach is measured not by the number of eggs deposited there, but by the number of hatchlings that emerge and enter the sea. High rates of reproductive success have become the hallmark of the nesting colony at PAFB; they elevate its relative importance above other beaches of similar size and with similar levels of nesting activity and contribute to the recruitment of the Western Atlantic *Caretta caretta* stock at a rate that is beyond commensurate with the extent of nesting habitat.



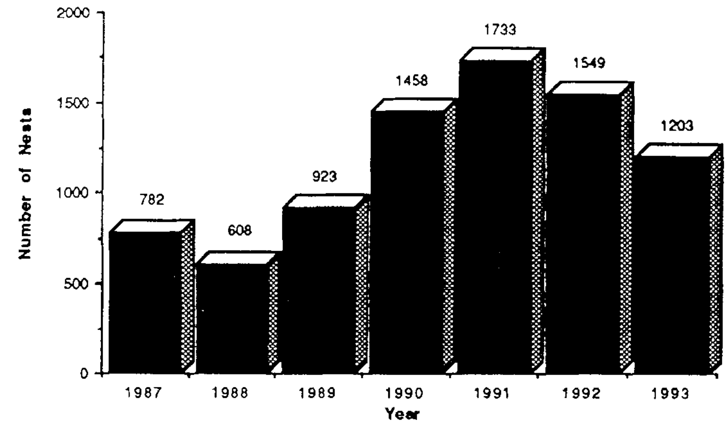


Figure 1. C. caretta nest totals by year at PAFB, 1987-1993.

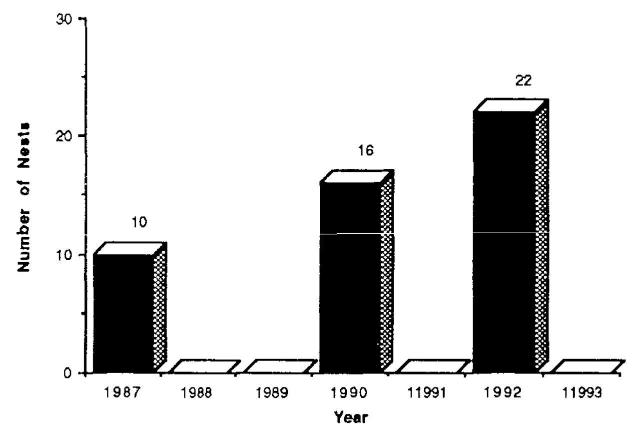


Figure 2. C. mydas nest totals by year at PAFB, 1987-1993.

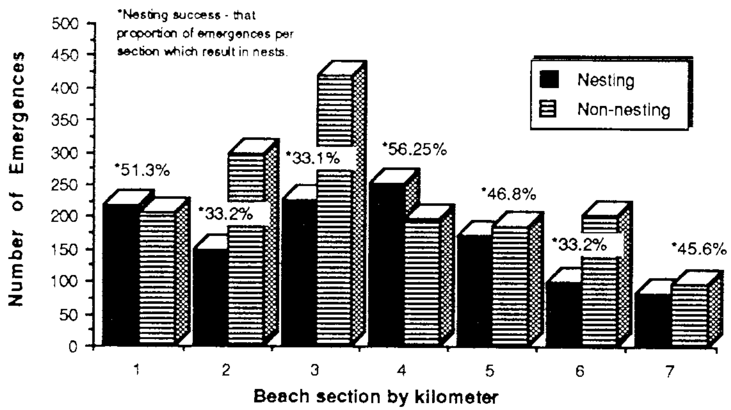


Figure 3. C. caretta emergences by location at PAFB in 1993. Section 1 begins at the southern boundary of PAFB; Section 7 ends at the northern boundary.

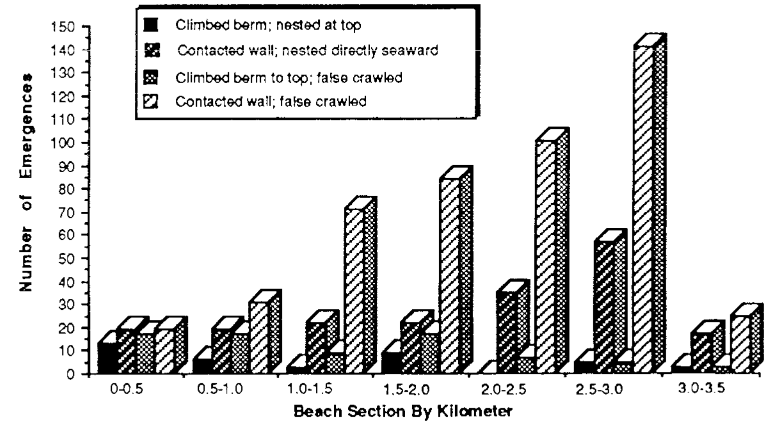


Figure 4. Outcomes of C. caretta encounters with nourishment berm.

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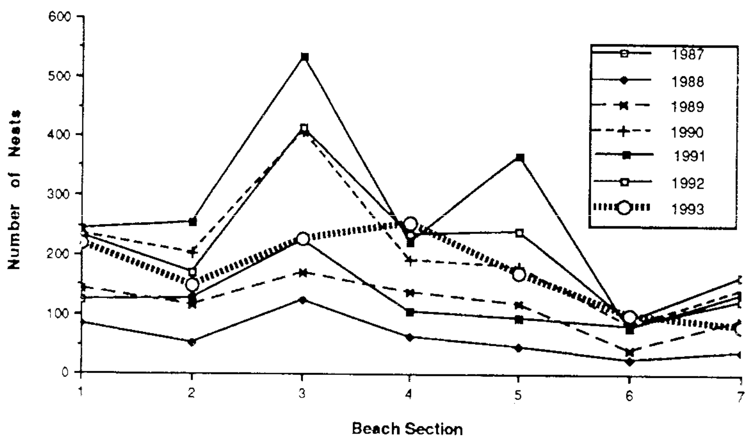

Figure 5. C. caretta nest totals by location at PAFB, 1987-1993.

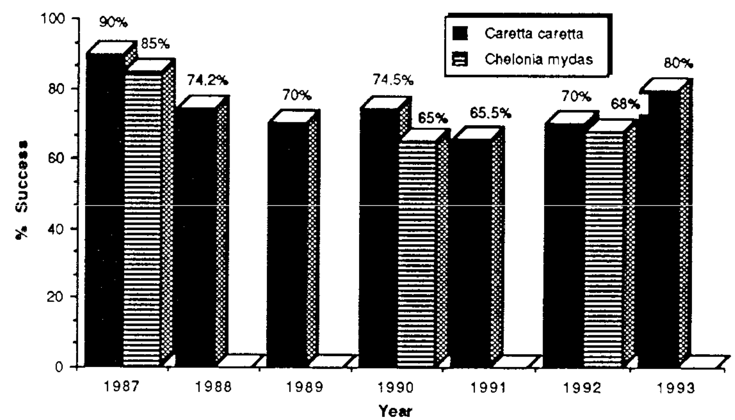

Figure 6. Reproductive success rates for C. caretta and C. mydas by year at PAFB, 1987-1993.

SATELLITE TELEMETRY OF GREEN TURTLES NESTING AT FRENCH FRIGATE SHOALS, HAWAII, AND ROSE ATOLL, AMERICAN SAMOA

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Biotelemetry using the Argos satellite system was conducted for the second consecutive year in the Hawaiian Islands to determine migratory routes, swimming behaviors, and resident foraging pastures of green turtles, *Chelonia mydas*, nesting at French Frigate Shoals. In addition, in a cooperative study with the American Samoa Government, transmitters were deployed in the South Pacific during 1993 on green turtles nesting at Rose Atoll, the easternmost island of the Samoan Archipelago.

Satellite telemetry of sea turtles in Hawaii was initiated in 1992 and resulted in the first known successful high-seas tracking of a green turtle migrating from a nesting site to a resident foraging pasture (Balazs 1994). Satellites have not been previously used to study sea turtle migrations elsewhere in the oceanic islands of Polynesia, Melanesia, and Micronesia. Both French Frigate Shoals (Balazs 1976, 1983) and Rose Atoll (Sachet 1954, Balazs 1982, Tuato'o-Bartley et al. 1993) are historically prominent nesting sites for green turtles in this region. Although relatively small numbers nest at these isolated rookeries, both are important components to the overall survival and ecologic understanding of green turtles in the insular Pacific.

Intensive flipper tagging at French Frigate Shoals since 1973 has shown that reproductive migrations of green turtles take place to and from numerous coastal foraging areas throughout the 2400 km span of the Hawaiian Archipelago. In contrast, few turtles (50 since 1980- all *C. mydas*) have ever been tagged at Rose Atoll. Only two distant recoveries have thus far resulted from this intermittent work. A turtle tagged at Rose in 1980 was captured and killed in a net in 1986 at Kadavu, Fiji; and another one tagged at Rose in 1988 was reported speared in the Sikatoka area of Viti Levu, Fiji, in 1992 (Balazs 1993).

METHODS

Telonics ST-3 transmitters configured for backpack mounting were deployed on two turtles at French Frigate Shoals during August 1993, and on three turtles at Rose Atoll during November 1993. The transmitters were safely and securely attached using thin layers of fiberglass cloth and polyester resin. This technique was patterned after procedures used by Byles and Keinath (1990), Beavers et al. (1992), and Renaud et al. (1993). However, Rolyan Silicone Elastomer, a two-part splinting agent used in human medicine, was incorporated into the procedure. This product made it possible to rapidly and effectively custom-mount the transmitter against the contour of the carapace (at the second central scute). Silicone Elastomer cures within a few minutes after mixing, and no heat is produced in the process. During the two hours required to accomplish transmitter attachment, the turtles were harmlessly confined in a prone position using a shaded portable plywood container designed for this purpose. The ST-3 transmitters weighed 765 g and measured 17 x 10 x 3.5 cm with the antenna extending 13 cm from the top. The transmitters were programmed with a duty cycle of 6 hours on, 6 hours off.

RESULTS

Detailed high-seas tracking was successfully accomplished for the post-nesting migrations of all five turtles, as shown in Figures 1 and 2. These results are summarized as follows.

HAWAIIAN TURTLE 4803--Turtle 4803 departed French Frigate Shoals on 9/4/93, 11 days after being fitted with a transmitter during the latter part of the nesting season. She accomplished an 1180 km migration to the southeast, arriving at Kaneohe Bay, Oahu, on 9/30/93. The voyage took 26 days and followed a course well away from land, against prevailing winds and currents, over water thousands of meters deep. Her swimming speed averaged 1.9 km/hr. After reaching Kaneohe Bay, satellite monitoring continued for another 3.5 months. During this time she stayed entirely within the bay. Turtle 4803's route was very similar to those taken by the two turtles satellite-tracked from French Frigate Shoals to Kaneohe Bay in 1992 (Balazs 1994). Both of these previous turtles swam 2.0 km/hr during their migrations, taking 23 and 26 days each to cover 1130 and 1260 km.

HAWAIIAN TURTLE 4804--Turtle 4804 departed French Frigate Shoals on 9/1/93, 7 days after being deployed with a transmitter. She also swam southeast to Kaneohe Bay but, unlike other satellite-telemetered turtles traveling to this location, turtle 4804 followed a route mainly between the islands and reefs along the Hawaiian chain. On this pathway she periodically encountered relatively shallow water and benthic habitats. However, the total distance covered (1100 km), the time in transit (26 days), and the swimming speed (1.8 km/hr) of turtle 4804 were almost the same as the turtles that traveled offshore over open ocean. After arrival, turtle 4804 was recorded within Kaneohe Bay for 3.5 months before the transmitter signal terminated.

SAMOAN TURTLE 4807--A transmitter was deployed on turtle 4807 on 11/4/93. She subsequently stayed within or near Rose Atoll for 72 days, renesting on several occasions. On 1/15/94 she embarked on a 36-day migration, traveling to the southwest, across 1475 km of open ocean to the north of Tonga. She arrived in the Lau Group of Fiji on 2/20/94, averaging 1.7 km/hr. As of late March 1994, turtle 4807 was still transmitting from Lau in the vicinity of Argo Reefs (Mbukatatanoa), just south of Lakemba Passage.

SAMOAN TURTLE 4808--Turtle 4808 was fitted with a transmitter on 11/3/93 and subsequently remained within or near Rose Atoll for 47 days, renesting on several occasions. She departed on 12/20/93 and migrated 1450 km to the southwest, following a route well to the north of the one taken by turtle 4807. She arrived at Vanua Levu, Fiji, in the vicinity of Nateva Bay and Undu Peninsula, on 1/23/94. Her trip took 34 days and averaged 1.8 km/hr. As of late March 1994, she continued to remain in this same nearshore area.

SAMOAN TURTLE 4809--Turtle 4809 remained within or close to Rose Atoll for 22 days after being fitted with a transmitter on 11/3/93. She then left on a 10-day excursion, traveling 60 km to the south on a figure-eight course that covered 300 km at an average speed of 1.4 km/hr. She arrived back at Rose Atoll on 12/5/93 and remained there for 22 more days before departing again on 12/27/93. This time she continued to the southwest, across open ocean, following a route very similar to the one taken by turtle 4807. Turtle 4809 arrived at Vanua Levu, Fiji, on 2/10/94, after swimming 1750 km in 45 days at an average speed of 1.6 km/hr. Her migration terminated in the vicinity of Naweni Point, to the east of Savu Savu Bay on the south shore of Vanua Levu. As of late March 1994, transmitter signals were still being received from this same coastal area.

ACKNOWLEDGMENTS

The following individuals and organizations are acknowledged for their generous contributions to this study: S. Beavers, E. Flint, G. Grant, K. McDermond, P. Trail, R. Tulafono, F. Tuilagi, M. Webber, D. Yamaguchi, the American Samoa Government, American Samoa Environmental Protection Agency,

U.S. Fish and Wildlife Service, National Park Service, and Sea Life Park Hawaii. Dr. Archie Carr is remembered for giving inspiration to track the ocean migrations of green turtles using earth-orbiting satellites.

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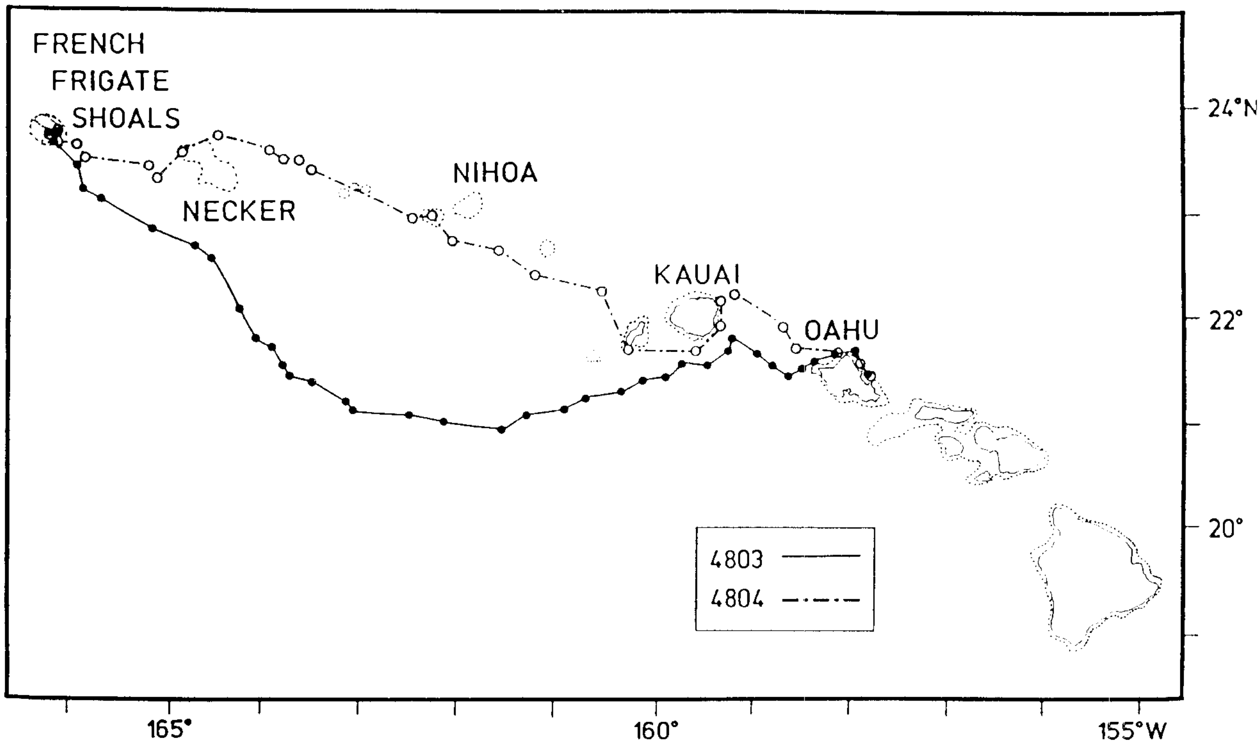

Figure 1. Migratory routes taken by Hawaiian turtles 4803 and 4804 from French Frigate Shoals to Kaneohe Bay, Oahu, in the North Pacific Ocean.

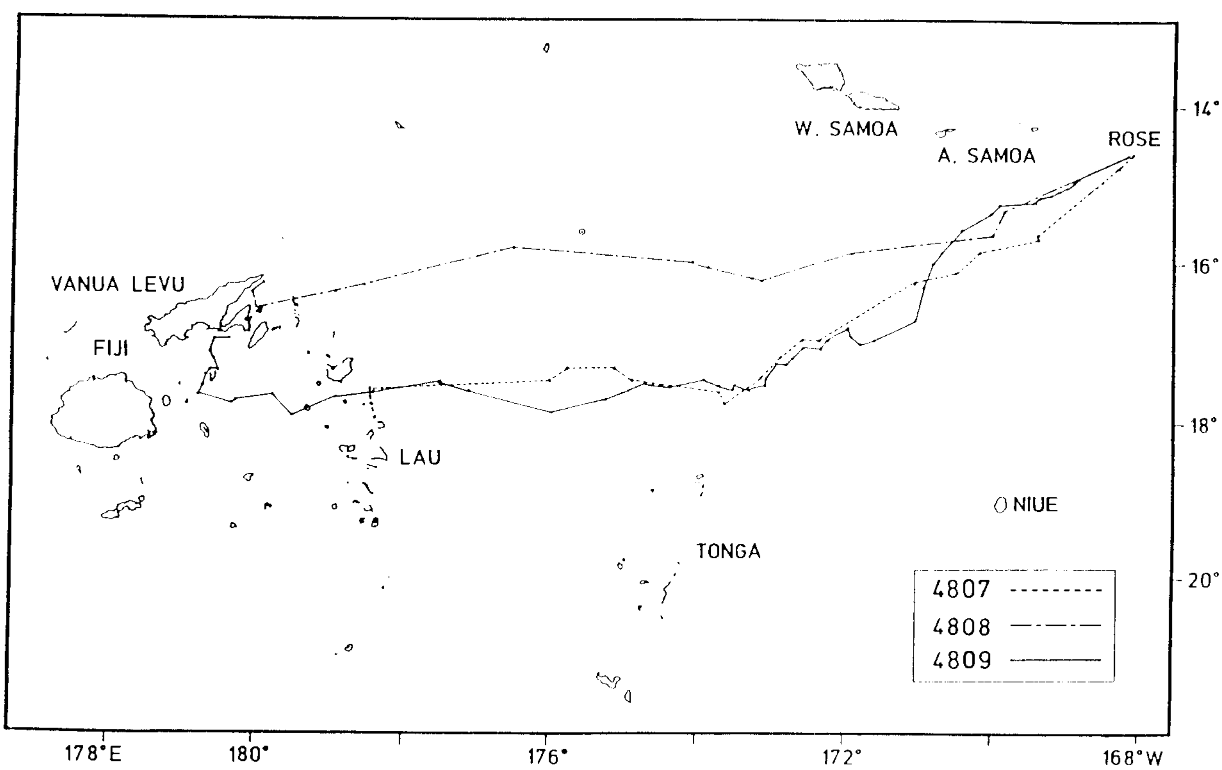

Figure 2. Migratory routes taken by Samoan turtles 4807, 4808, and 4809 from Rose Atoll, American Samoa, to the Fiji Islands in the South Pacific Ocean.

THREATS TO *CARETTA CARETTA* IN THE GULF OF NAPLES

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The Naples Aquarium is an integral part of the Stazione Zoologica di Napoli, which is an international research center. Our laboratory initiated a project to safeguard sea turtles after our government established laws that banned the fishing, holding and commercial transport of sea turtles. Many of the illegally captured turtles were brought to us, particularly the most common sea turtle in Italian waters, *Caretta caretta*. Often they were damaged or were unhealthy. Therefore, we treated them and established a release program.

METHODS

Our loggerhead turtles were kept in large circular tanks (from 2 to 7 cubic m) supplied with flow-through seawater pumped from the Gulf of Naples. The water temperature varies depending on ambient temperature (13-25°C) with a difference of only +/- 1°C. Turtles are fed with fresh food (anchovies, cuttlefishes or squid), according to the specific needs of the animals and their activity patterns, which change as a function of temperature. All surgery was done with the aid of the Veterinary faculty of the University of Naples. After rehabilitation, the animals are released near southern Italy (Sicily) because of pollution and heavy boat and fishing traffic in the Gulf of Naples.

RESULTS AND DISCUSSION

The health problems that we found can be divided into two categories: wounds, caused mainly by contact with boats or fishing gear, and sickness, mostly caused by pollution problems. None of the loggerheads captured were larger than 70 cm shell length. No animal was smaller than 20 cm. The months in which most animals were found are between late spring and the beginning of summer (May, June, July) and the winter months (January, February and March). In these months, the water temperature in the Gulf of Naples is at the seasonal maximum and minimum: 25°C in July and 13°C in March. We have cured 33 individuals, 22 of which have been released and 11 are still under our care.

The presence of *Caretta* in the Gulf of Naples is not for the purpose of reproduction. Most of the turtles we find are juveniles or subadults (Margaritoulis, 1988). We have never seen nesting sites or a female on the beach. There seems to be no tendency to lay eggs in this part of Italy. Most likely, the sea turtles come into the Gulf in search of good feeding grounds or suitable conditions for the winter period. Prevailing current patterns (Ovchinnikov, 1966) facilitate sea turtle entry into the Gulf. It is possible that most of the sea turtles arrive from the eastern basin of the Mediterranean, where there are still nesting sites because of less beach development (Venizelos, 1991). Capture data indicate that *C. caretta* pass between Italy and Sicily on their migration (Argano et al., 1992). On the basis of these considerations, it is necessary to have more stringent protection of our coastline and we will use our data to support this cause via public outreach projects and professional organizations.

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LEATHERBACK TURTLE (*DERMOCHELYS CORIACEA*) NESTING BIOLOGY, SANDY POINT, ST. CROIX, U.S. VIRGIN ISLANDS: 1981 - 1993

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Leatherback sea turtles have probably been nesting on Sandy Point, St. Croix, USVI throughout all of recorded history. This nesting population was first brought to the attention of biologists in the mid 1970's by Otto Tranberg, a VI environmental enforcement officer. Tags were first put on some of these turtles in 1979. In 1981 the Division of Fish and Wildlife, Department of Planning and Natural Resources, initiated a comprehensive study of the nesting biology of leatherbacks on Sandy Point with Section 6 funds from the US Fish and Wildlife Service. The 1981 season suffered from lack of adequate personnel and this resulted in an incomplete data set. Since 1982 the Division of Fish and Wildlife has run the project by contracting two Field Directors and using Earthwatch (of Belmont, MA) volunteers. Critical habitat was established for the leatherbacks at Sandy Pt. in the water (NMFS) and on the land (USFWS) in the late 1970's. Sandy Point was acquired as a National Wildlife Refuge (NWR) in 1984 by the USFWS.

METHODS

The study area is a 3.0 km long portion of the Sandy Pt. NWR. This is a classic leatherback nesting beach, having a broad profile and nearby deep water access. To ensure encountering every turtle that nests on this beach, the area is patrolled hourly from 2000 to 0500 hours every night from late March until 10 days after the last nest. All turtles that nest on Sandy Pt. are measured and tagged on their front and rear flippers. Monel and inconel tags are used as plastic tags tear out of the flippers and titanium tags are subject to excessive biofouling and stress on the attachment point. Beginning in 1992, each turtle has also been tagged with a PIT (Passive Inductive Transponder) tag. The tiny, glass-encased microchip is injected into the shoulder muscle and read with a scanner.

All nest locations are recorded using numbered stakes placed every 20 m around the inside perimeter of the beach. Triangulation from the nearest two stakes provides precision location to within 10 cm. Erosion is the most serious natural threat to nests on this beach. To obviate this threat, all nests laid in historically erosion prone areas on the beach are relocated at the time of laying to stable parts of the beach. Nest dimensions are duplicated and relocated sites are chosen to be physically similar to that of the original nest site. Relocation generally is accomplished within one hour with a minimum of handling.

RESULTS

Since 1981, 293 individual leatherback turtles have been tagged on Sandy Pt. with a range of 18 to 55 turtles nesting per year. Annual remigration rates have averaged 31.4%. Remigration intervals have most commonly been two years (62%), followed by three years (30%), nine four-year (7%), and one one-year interval (.8%). Twenty one turtles have returned with definite tag scars but, in the absence of other identifying marks, are not able to be classified by interval. As with most other turtle nesting studies, the vast majority of Sandy Pt. leatherbacks are only observed one season (77%). Fourteen percent have nested in two seasons, 5% in three, 2% in four, 2% in five, none in six, and

.7% in seven. One of the two seven season nesters is turtle G603, originally tagged in 1979. This turtle has returned in 1981, 1983, 1985, 1987, 1990, and 1992, for fourteen years of observation.

During the course of this project a number of inter beach and inter island movements and nesting activities have been documented within seasons. With the start of the Manchenil Beach (St. Croix) project in 1983 and the Culebra Island (Puerto Rico) project in 1984, the documentation of these movements became possible. Since 1984, five turtles have nested on both Sandy Pt. and Culebra, and eleven have nested on both Sandy Pt. and Manchenil. All had nested at least once on the original beach during the season in which the inter beach movements occurred. In 1989 a turtle fitted with a satellite transmitter was documented to nest three times on Sandy Pt., once on Vieques Island and finally four times on Culebra during that season. In 1988, another turtle nested eight times on Sandy Pt. and then was observed nesting in Anguilla, BWI. In 1981, one of 20 turtles tagged that season was found stranded in Atlantic City, NJ, 85 days after her last nest on Sandy Pt. Death was due to blockage of ileocecal valve by a clay-like mass. In 1988, a turtle who had nested two years previously on Sandy Pt. was caught by a shark fisherman in the Triangle Cays, Campeche, Mexico.

Turtles nesting on Sandy Pt. since 1981 have ranged in carapace length from 137 to 177 cm (over the curve). Weights (N = 134) have been obtained from 1985 to 1990 from 102 turtles and range from 259 to 506 kg. Length vs weight shows a positive regression of $y = 5.2076x - 468.84$ with $R^2 = 0.0551$. Since 1981 nesting activity has ranged from an early season nest on February 9 to a last nest on August 11. The peak nesting period occurs in mid to late May. During the past twelve years, 71.5% of all nesting activities have resulted in egg deposition (range = 54.7 to 87.0 per annum, SD = 9.19). Turtles have laid a mean of 5.21 nests per season (range = 3.9 to 6.14 per annum, SD = .67) with a maximum of 11 nests laid for a single turtle in one season. The mean internesting interval has been 9.6 days (range = 9.4 to 9.8 per annum, SD = .15). Mean total clutch size has been 116.3 eggs (range 112.7 to 119.3 per annum, SD = 2.21) with a mean of 79.5 yolked eggs (range = 72.9 to 85.9 per annum, SD = 4.12) and a mean of 36.5 yolkless eggs (range = 31.2 to 41.6 per annum, SD = 3.27). Incubation periods have ranged from 57 to 76 days per annum, with a mean of 63.3 days (SD = 1.37). The longer incubation periods occur early in the season when sand temperatures are cooler and shorter incubation periods occur later in the season when sand temperatures are warmer. Since 1981, 2,345 nests have been laid with a range of 82 to 345 laid in any one season. Since 1982, successful hatching has occurred in 63.47% of all eggs laid in nests that have survived to term.

Since 1982 48.54% of all nests laid on Sandy Pt. have been relocated to prevent loss to erosion. Success rates for relocated vs in situ nests have varied considerably. In three of the years, nest success for relocated nests has been higher than for in situ nests and the opposite for eight years. In 1993 there was no significant difference. Overall, in situ nest success has been higher at 67.16% than for relocated nests at 60.42%. Since 1982, an estimated 98,688 hatchlings have emerged from nests on Sandy Pt.

Prior to the initiation of nest relocation we estimate that up to 60% of all nests laid on this beach annually were potentially lost to erosion. Relocation efforts have reduced this loss to between 0.7% and 9.8% annually. Some loss has still occurred during tropical storms or when early season nests (Feb. - Mar.) were not observed at the time of laying. Likewise, prior to 1981, poaching of nests was reported to approach 100% annually. Our nightly presence on the beach throughout the nesting season has reduced that amount to between 0 and 1.8% per year with no known poaching during the last eight years.

During the thirteen years of this project the education value has increased remarkably. In St. Croix, both locals and visitors to the island have demonstrated an increased awareness and desire to learn about sea turtles in general and leatherbacks in particular. As more people have become exposed to leatherbacks, proprietary interest has increased the protection afforded this population. Since 1981, over 4900 people have visited this project with an annual maximum of 750 in 1992.

CONCLUSIONS

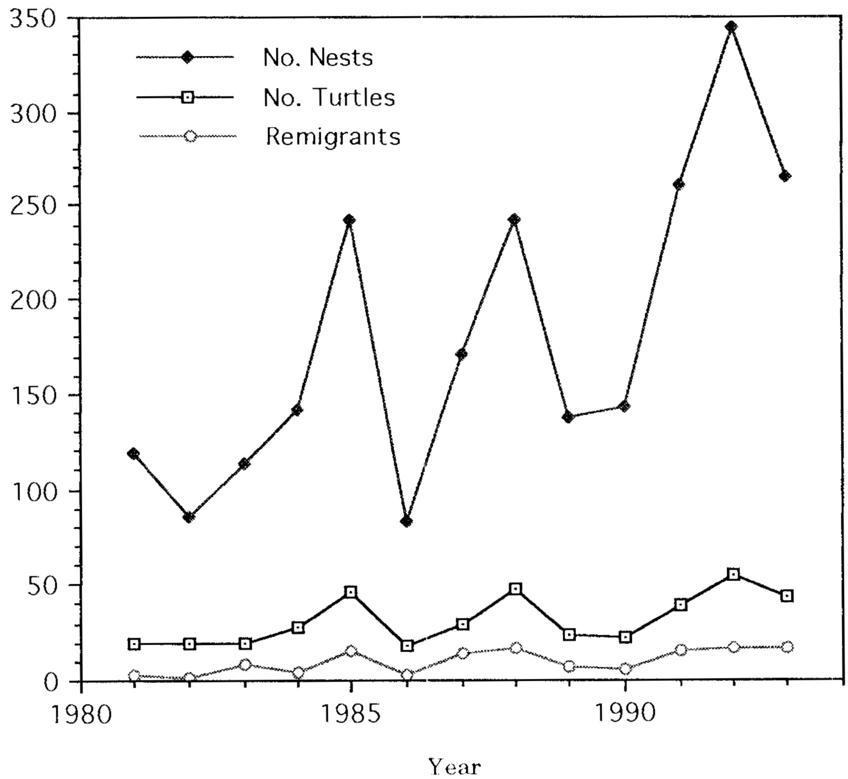
The Sandy Pt. population of leatherback turtles is the largest known nesting aggregation of leatherbacks under US jurisdiction. Given the movements between this and other nearby aggregations, the Sandy Pt. aggregation may represent part of a larger population with subgroups having stronger fidelity to particular beaches. It is tempting to correlate an apparent incline in numbers of nesting turtles since the project started with beach and nest protection efforts. However, it would be premature given the annual variation in nesting numbers common in sea turtles. Populations must be monitored for many years before a trend can be established.

Continued relocation of nests is essential for the long term recovery of this population of leatherbacks. While hatching success is slightly lower in relocated nests, any success is an increase in numbers of hatchlings reaching the sea as these nests might otherwise be lost to erosion. Likewise, although the leatherback has become a symbol of the conservation effort on St. Croix, in the absence of all-night patrols, poaching of nests would most likely occur again. This project offers a unique opportunity for the long term acquisition of data on the biology of this species since every individual to nest on Sandy Pt. can be monitored. The project also offers opportunities for visiting researchers to collect data on a variety of questions not obtainable from other larger, less discrete populations of leatherbacks.

ACKNOWLEDGMENTS

The success of this project is due in large part to Earthwatch of Belmont, Mass. and 791 Earthwatch volunteers. US Fish and Wildlife Service Section 6 appropriations have provided most of the funding for the project. Special thanks are due to past Field Directors of the project; Scott and Karen Eckert, Susan Basford, and Robert Brandner. Many Division of Fish and Wildlife and Division of Environmental Enforcement (DPNR) personnel have given of their time over the years as well as Gregg Hughes and Mike Evans, past and present Refuge Managers, and many local volunteers. Pat and Mac McFee, and Ray and Deanne Norton of Cottages By The Sea have been wonderful hosts to the project and to all the volunteers since its inception.

Number of Turtles, Remigrants, and Nests Per Year.
Sandy Point, St. Croix, U.S.V.I., 1981 to 1993.



GENERAL ANESTHESIA OF SEA TURTLES USING A MIXTURE OF NITROUS OXIDE AND ISOFLURANE

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This report describes some of the protocol modifications that have been made at The Turtle Hospital to improve sea turtle anesthesia. Primarily, we have found that N_2O is a valuable component of inhalation anesthesia. Sea turtles are apneustic breathers, capable of prolonged periods of breath holding. This breathing pattern, coupled with large body size and jaw strength makes the induction of general anesthesia in these animals challenging. Mask induction with a single inhalant anesthetic is possible but often takes a long time before endotracheal intubation can be achieved, resulting in wastage of anesthetic during the induction period. Premedication with Telazol[R] has been used to cause sufficient muscle relaxation to allow intubation but this and other injectable agents often contribute to prolonged recoveries in turtles and their elimination from the body cannot be controlled by the anesthetist. We have found that the addition of nitrous oxide to isoflurane gas anesthesia facilitates the induction of general anesthesia in marine turtles, often allowing rapid induction by mask without using injectable premedications. In addition, surgical levels of anesthesia could be maintained with lower levels of primary inhalant anesthetic (isoflurane) which saves money and shortens recovery time. Mask induction of turtles could be economically achieved by leaving the vaporizer off during the apneic phase of the respiratory cycle and then turning it to maximum at the beginning of each breathing cycle. This technique using a mixture of nitrous oxide and isoflurane allowed endotracheal intubation within 3-4 breathing cycles.

NESTING TRACES OF THE LOGGERHEAD SEA TURTLE (*CARETTA CARETTA* (Linne)), ST. CATHERINES ISLAND, GEORGIA

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Although sea turtle body fossils have an extensive geological record extending at least into the Early Cretaceous, fossil traces of their nesting activities have not been noted in the literature. Study of nesting loggerhead sea turtles on St. Catherines Island, Georgia, has demonstrated that several types of traces are made by nesting recent sea turtles which should be represented by trace fossils in ancient near-shore marine sedimentary rocks. These traces include crawlways produced by mature female turtles crawling across the beach to nest, small scale crawlways made by hatchlings as they emerge from the nest and crawl to the sea, and distinctive nest structures disrupting backbeach stratification. Observed nests on St. Catherines consist of a broad, shallow depression [the body pit] overlying a small, vertical-walled, cylindrical egg chamber. Egg chambers of loggerhead turtles tend to be about 20 cm in diameter and extend 25 cm beneath the body pit which is usually 20 cm deep, placing the bottom of the egg chamber at a depth of about 50 cm near the base of the active beach zone.

BACKBEACH PROCESSES AND SEDIMENTARY STRUCTURES

Sediment of the backbeach is periodically sorted by wave activity superimposed upon storm surges or spring tides driven by Nor'easters. This process results in erosion of a scarp marking the landward side of the backbeach and in the sorting of the sediments being moved along the beach and eroded by the event. This activity results in the development of discrete layers of heavy minerals interbedded with quartz sand. The top-most 50 cm of St. Catherines' backbeach is actively involved in these repetitive events and forms the active beach. The basal layer of the active beach is characteristically a heavy mineral layer which often reaches a thickness of 10-15 cm and has been measured with a thickness of 23 cm. Repetitive sedimentological events may erode and redeposit (i.e., resort) sediment to less than the full thickness of the active beach resulting in multiple sedimentological units each with "basal" heavy mineral layers represented as several thick heavy mineral beds or layers. Normal resorting by waves or spring tides not associated with storms results in thin layers of heavy mineral sands interstratified with quartz sand. Other processes active on the backbeach include scour and fill, migration of sand waves or dunes moved by sea water or wind, and biological activity such as burrowing by terrestrial and marine organisms which introduces additional sedimentary structures (i.e., cross-bedding and burrows) into the dominantly seaward dipping interlaminated sediments of the backbeach. Heavy mineral sands are finer grained than quartz sands normally found on St. Catherines backbeaches and therefore are thought to drain more slowly than quartz sands.

NESTING SEDIMENTARY STRUCTURES

Crawlways of nesting females and emerging hatchlings are extremely ephemeral and have a very low probability of preservation in ancient sediments. Emergence craters and nests of sea turtles have a more significant signature on the beach and a higher probability of preservation. The sediment filling the egg chamber and the body pit differs from the interstratified backbeach sediment by being homogenized by the turtles nesting activity, often appearing brecciated or mottled. This fact allows one to easily locate the egg chamber by scraping a horizontal surface down through the body pit until the laminated sands of the backbeach are encountered as evidenced contour-like patterns or as a discrete, black heavy mineral layer which often stands in stark contrast to the neck of the egg chamber filled by homogeneous brecciated or mottled sand. Using this technique, it has been possible to validate virtually all sea turtle nests deposited on St. Catherines Island for the last two years. This technique should be applicable to all beaches which exhibit contrasting backbeach interlaminations.

BEACH DRAINAGE

Turtle researchers on the Georgia coast have often remarked on discovering undeveloped eggs in nests deposited in heavy mineral sand layers which often exhibit blackened (reduced) shells. Initial observations on St. Catherines seemed to confirm this conclusion, but subsequent observations have indicated that proximity to black heavy mineral sands may not be as important as we once thought. If the egg chamber is sufficiently close to well drained quartz sand, nests deposited in thick heavy mineral layers will be successful. The cause of unsuccessful development leading to blackened eggs seems more likely to be proximity to impermeable mud layers lying beneath the egg chamber or due to proximity to areas prone to high levels and/or continuous flows of groundwater through the beach.

CONCLUSIONS

The nesting behavior of loggerhead sea turtles produces discrete traces which consist of adult crawlways, hatchling crawlways, and nests. These sedimentary structures should have the same stratigraphic range as body fossils of sea turtles. The absence of cited sea turtle nesting trace fossils may indicate they have a low preservation potential or that they are currently unrecognized by geologists. The total spectrum of nesting structures remains undescribed and is not completely typified by the structures described in this paper. Especially pertinent are beaches which have intensive nesting, perhaps so many as to produce intersecting nests, which could produce a disrupted layer along the backbeach for several kilometers. The following conclusions can be drawn:

- Nesting sea turtles leave a suite of distinctive traces on the beaches used for rookeries consisting of ephemeral crawlways and more permanent nesting structures.
- Gravid females leave large crawlways on the beach as they unsuccessfully (non-nesting crawls) or successfully nest on the back beach.
- Sea turtle nests consist of a body pit which forms a broad depression in the drier sand and a narrow, vertical-walled, cylindrical egg chamber.
- Sea turtle nests form discordant sedimentary structures which are characterized by a homogenized, bioturbated texture cutting across and downward into interlaminated backbeach structures characteristic of near-shore dunes and backbeach sediments.
- Emergence craters of hatchling loggerheads follow and resort sediment within the egg chamber as turtles work their way to the surface.
- Sea turtle hatchlings leave unidirectional, small scale, subparallel crawlways on the beach when they crawl for the sea.
- Crawlways would be difficult to recognize in vertical exposures while nesting cavities and emergence craters should be easily recognizable.

ACKNOWLEDGMENTS

Direct or indirect support has been received from the Edward John Noble Foundation administered by the American Museum of Natural History, The St. Catherines Island Foundation, Inc., the Georgia Department of Natural Resources, Georgia Southern University through the Faculty Research Committee, and the Eisenhower Higher Education Program.

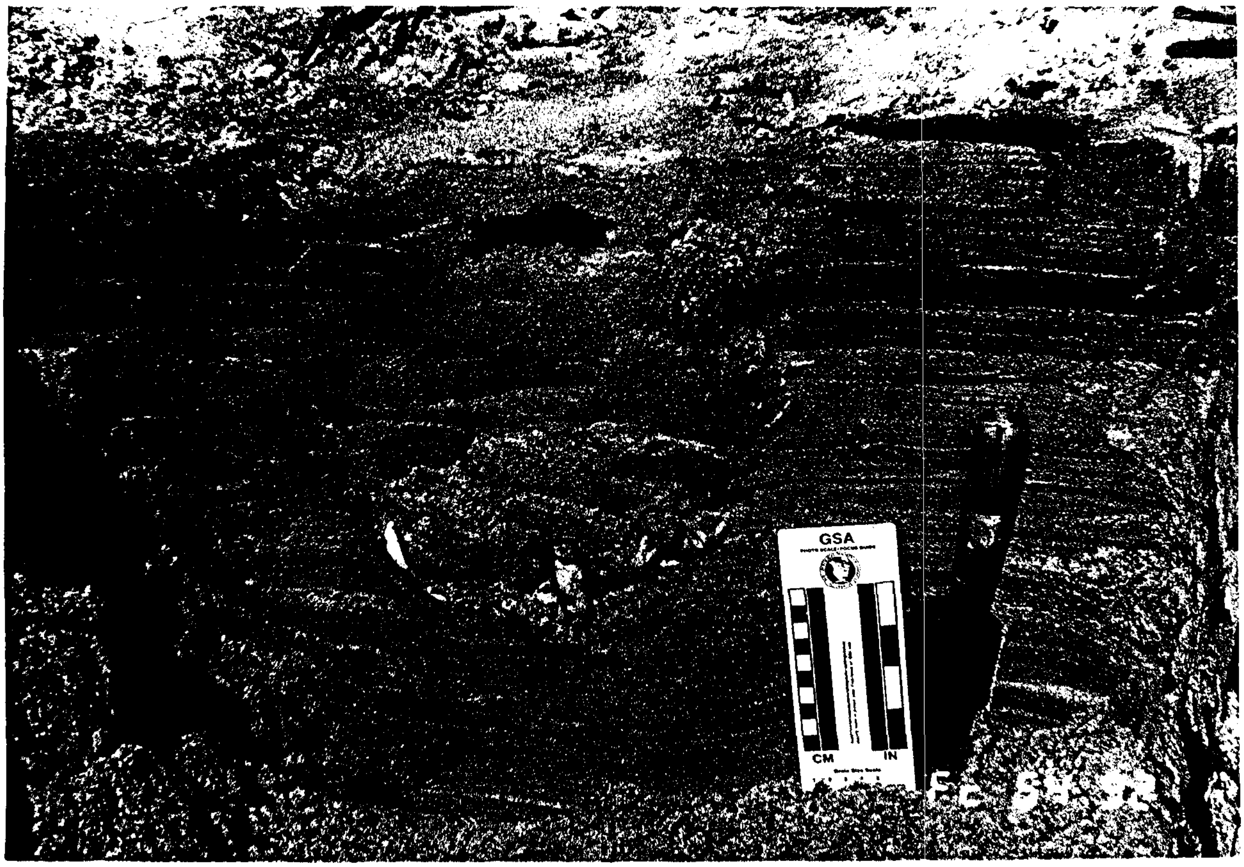

Figure 1.--Vertical cross section of loggerhead sea turtle nest in backbeach interlaminated quartz and heavy mineral sands, St. Catherines Island, GA. Note hatched egg shells at bottom of egg chamber which cuts across horizontal backbeach laminations. This sedimentary structure should be preserved in ancient sandstones of Mesozoic and Cenozoic age.

BITMAR'S SURVEY OF SEA TURTLE NESTING BEACHES IS PART OF NEW APPROACHES TO CONSERVATION IN MEXICO

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Mexico, a country with one of the world's highest levels of biological diversity is also rich in sea turtles which are not only abundant in terms of population sizes but also in numbers of species: seven of the eight extant species can be found in Mexican waters. In spite of this, overexploitation of these organisms over the last 100 years throughout their global range has provoked their listing as threatened species and prompted a permanent government ban on their harvesting in Mexico since 1990. Even more recently, developments in Mexico's policies, particularly the establishment of a National Commission for the Study and Use of Biodiversity (CONABIO) in 1992, have provided significant support for activities related to research and conservation of biological resources in the country.

Through CONABIO, Mexico is consolidating a national program for (1) generating and managing a permanently updated information system on Mexican biodiversity, (2) promoting and financing projects related to the understanding and sustainable use of biological resources, (3) advising government and private organizations on technical and research aspects related to the sustainable use and conservation of biological resources, and (4) promoting an awareness of the existing national and regional biological wealth, its rational utilization by human beings and adequate means to prevent its deterioration or destruction. Government development planning and decision-making which may affect the nation's biological diversity will now hinge on information concentrated in CONABIO. These developments are, in general, reflections of statements issued over the last decade by organizations such as the World Conservation Union (IUCN), the World Wide Fund for Nature (WWF) and the United Nations Environment Program (UNEP) in numerous forums that have recommended strategies for the preservation of biodiversity (World Conservation Monitoring Centre, 1992).

The survey being carried out by the Sea Turtle Information and Data Base Center (BITMAR) on sea turtle nesting beaches in Mexico, is one of the projects now supported by CONABIO. It aims to capitalize on the country's experience of more than thirty years gathered by one of the world's largest turtle research and conservation groups. It is gathering information on the status of the breeding populations and their reproduction environments, and is also consolidating a nation-wide network of turtle biologists capable of providing and updating reliable data from first-hand experience in all Mexican coasts. The project is implementing a standardized minimal set of indicators capable of characterizing species, geographical location and ecological setting of the nesting areas, and also of estimating breeding population sizes, degree of human impact and protection. By updating these standardized evaluations on a seasonal basis, not only will long-term studies be feasible but also critical populations be identified on which to prioritize conservation activities. The linking of databases generated thus by BITMAR's network to CONABIO will provide updated dependable information to policy-makers in government or private agencies which should encourage more enlightened conservation decisions over development affecting sea turtle environments in the country.

For the 1990-1991 nesting season, BITMAR conducted an initial survey for which we gathered information on 66 beaches. Since then, we have identified more than twice that number of nesting beaches, incorporating additional information published by the national programs of SEPESCA and SEDESOL (Ministries of Fisheries and of Ecology, respectively), and by project leaders carrying out local conservation and research activities. The list of nesting beaches with our information source and institutions responsible for conservation (Table I) is preliminary and being used as a working document for our project, although it is the most comprehensive listing to date. Nonetheless, considering that wild habitat loss (Shaffer, 1987) and the elimination of individual populations (Ehrlich, 1991) are key elements in the species extinction crisis, the inventory of nesting beaches permits a national and periodic monitoring of critical zones with which to identify trends and prioritize conservation resources. An additional benefit of this approach is that the health of whole communities associated with the sea turtle nesting beaches will be monitored as well.

This table is being distributed to network participants for updating and comments or corrections. Some outstanding problems, such as unavoidable duplicity of names for single beach areas should be corrected as we regularize a nomenclature for nesting beaches. We are also concentrating efforts on identifying the lesser known nesting zones which are still lacking in current inventories.

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	Beach	State	Local.	Species: Lo	Cc	Dc	Ei	Ca	Lk	Cm	Source	Institution	Status
	Pacific Ocean												
1	EL ALACRAN	BC									Resendiz, A.	SEPESCA-INP-CRIP- Ensenada	♦
2	PTA COLORADA-PTA ARENA	BCS									Rodríguez, A. et al. 1991	SEDESOL-Baja California Sur	♦
3	PTA ARENA-LA ABUNDANCIA	BCS									Rodríguez, A. et al. 1991	SEDESOL-Baja California Sur	♦
4	B DE LAS PALMAS-LOS ZACATITOS	BCS									Rodríguez, A. et al. 1991	SEDESOL-Baja California Sur	♦
5	LOS ZACATITOS-LAGUNA HILLS	BCS									Rodríguez, A. et al. 1991	SEDESOL-Baja California Sur	♦
6	LAGUNA HILLS-EL MIRADOR	BCS									Rodríguez, A. et al. 1991	SEDESOL-Baja California Sur	♦
7	PLAYA MELIA	BCS									Rodríguez, A. et al. 1991	SEDESOL-Baja California Sur	♦
8	PLAYA EL FARO	BCS									Rodríguez, A. et al. 1991	SEDESOL-Baja California Sur	♦
9	PLAYA SAN CRISTOBAL	BCS									Rodríguez, A. et al. 1992/Villanueva, D.	SEDESOL-Baja California Sur	★
10	PLAYA LAS MARGARITAS	BCS									Rodríguez, A. et al. 1992	SEDESOL-Baja California Sur	●
11	PLAYA POZO DE COTA	BCS									Rodríguez, A. et al. 1992/Villanueva, D.	SEDESOL-Baja California Sur	●
12	PLAYA MIGRIÑO	BCS									Rodríguez, A. et al. 1992	SEDESOL-Baja California Sur	●
13	PLAYA LAS CABRILLAS	BCS									Rodríguez, A. et al. 1991	SEDESOL-Baja California Sur	♦
14	PLAYA MAR AZUL	BCS									Rodríguez, A. et al. 1991	SEDESOL-Baja California Sur	♦
15	PLAYA EJIDO ELIAS CALLES	BCS									Rodríguez, A. et al. 1991	SEDESOL-Baja California Sur	♦
16	B. DEL PALMAR-LOS CERRITOS	BCS									Rodríguez, A. et al. 1991/Villanueva, D.	SEDESOL-Baja California Sur	♦
17	P. LOBOS-B. EL CARRIZAL	BCS									Rodríguez, A. et al. 1991	SEDESOL-Baja California Sur	♦
18	CEUTA	SIN									Enciso, F.	UAS-ECM	★
19	EL VERDE	SIN									Rios, D.	SEPESCA-INP-CRIP- Mazatlán	★
20	PLAYA NORTE-SABALO	SIN									Osuna, M.	Acuario, Mazatlán	●
21	ISLA DE LA PIEDRA	SIN									Enciso, F	UAS-ECM	♦
22	GUASIMA/EL CAIMANERO	SIN									Lizárraga, J. et al. (1992)	UAS-CGIP	★
23	PLATANITOS	NAY									Bermejo, A.	SEDESOL-Nayarit	★
24	CHACALA	NAY									Pulido, R.	SEDESOL-Nayarit	★
25	CUSTODIOS	NAY									Pulido, R.	SEDESOL-Nayarit	♦
26	BOCA DE CAMICHIN	NAY									Pulido, R.	SEDESOL-Nayarit	★
27	BOCA DE CHILA	NAY									Pulido, R.	SEDESOL-Nayarit	★
28	PLAYON DE MISMALOYA	JAL									Godinez, E. y Loera, M.	U. de G.	★
29	LA GLORIA	JAL									Loera, M.	U. de G.	★
30	CHALACATEPEC	JAL									Godinez, E. y Loera, M.	U. de G.	★
31	CUITZMALA	JAL									García Aguayo/Loera, M.	Fundación Ecológica Cuitzmala	●
32	TEOPA	JAL									Peña de Niz / Loera, M	Costa Careyes/U. de G.	●
33	EL TECUAN	JAL									Godinez, E. y Loera, M.	U. de G.	★
34	MAJAHUAS	JAL									López, J.	U. de G.	★
35	PLAYA DE ORO	COL									SEDESOL	SEDESOL-Colima	♦
36	VOLANTIN-TEPALCATES	COL									Macías y Hernández	SEDESOL-Colima	★
37	TECUANILLO	COL									SEDESOL	SEDESOL-Colima	♦
38	BOCA DE APIZA-CHUPADERO	COL									Barajas, N.	SEDESOL-Colima	★
39	ISLA CLARION	COL	A. Revillag.								Sarti, L.	F. C.-UNAM	♦
40	ISLA SOCORRO	COL	A. Revillag.								Sarti, L.	F. C.-UNAM	♦
41	MOTIN DEL ORO	MICH									INP-PESCA		●
42	COLOLA	MICH									Alvarado, J., Figueroa, A. y Sánchez, R.	UMSNH	★
43	MARUATA	MICH									Alvarado, J., Figueroa, A. y Sánchez, R.	UMSNH	★
44	CHIMAPA	MICH									INP-SEPESCA		●
45	P. DE NORIA	MICH									INP-SEPESCA		♦
46	CACHAN	MICH									INP-SEPESCA		♦
47	CALABAZAS	MICH									SEDESOL	SEDESOL	♦
48	SACATOZA	MICH									INP-SEPESCA	SEPESCA/SEDESOL	♦
49	EL FARITO (MEXIQUILLO)	MICH									Sarti, L. , López, C. y Sevilla	F. C.-UNAM/SEDESOL	★
50	MEXIQUILLO	MICH									Sarti, L. , López, C. y Sevilla	F. C.-UNAM/SEDESOL	★
51	CHUCUTITAN	MICH									INP-SEPESCA		♦
52	MEZCALHUACAN	MICH									INP-SEPESCA		♦
53	PIEDRA DE TLACOYUNQUE	GRO									Balbuena, M./SEDESOL	ITMAR 27- SEP/SEDESOL	★
54	LA ROPA	GRO									SEDESOL	SEDESOL	★
55	ESTERO COLORADO	GRO									Doseano, A./SEDESOL	ITMAR 27- SEP/SEDESOL	★
56	HDA. DE CABAÑAS	GRO									Valenzuela, S./SEDESOL	E.S.E.M.-U de GRO/SEDESOL	★
57	LUCES EN EL MAR	GRO									SEDESOL	SEDESOL	★
58	PICO DE MONTE	GRO									SEDESOL	E.S.E.M.-U de GRO/SEDESOL	★
59	MARQUELIA	GRO									SEDESOL	E.S.E.M.-U de GRO/SEDESOL	♦
60	VENTURA	GRO									SEDESOL	SEDESOL	★
60	TIERRA COLORADA	GRO									Valenzuela, S./SEDESOL	E.S.E.M.-U de GRO/SEDESOL	★
61	CHACAHUA	OAX									Peñaflores, C./Aguilar, H.	CRIP- S. Cruz/SEDESOL-Oaxaca	★
62	LA ESCOBILLA	OAX									Peñaflores, C. /Guerrero, L.	CRIP -S. Cruz/PRONATURA	★
63	BARRA DE LA CRUZ	OAX									Peñaflores, C./López	CRIP-S. Cruz/UABJO	★
64	MORRO AYUTA	OAX									Peñaflores, C./Aguilar, H.	CRIP-S. Cruz/CIIDIR-Oaxaca	♦
65	PUERTO ARISTA	CHIS									Zenteno, R.	Sría. Des. Rural y Ecología-Chiapas	★
66	BOCA DEL CIELO	CHIS									Zenteno, R.	Sría. Des. Rural y Ecología-Chiapas	★
67	BARRA DE CAHUACAN	CHIS									Huerta, R.		★
68	COSTA AZUL (CHOCOHUITAL)	CHIS									Zenteno, R.	Sría. Des. Rural y Ecología-Chiapas	★
	number of beaches with nestings by this species in this coast:			65	0	47	6	23	0	0			
	% of beaches with nestings by this species in this coast:			94	0	68	9	33	0	0			

	Beach	State	Local.	Species Lo	Cc	Dc	Ei	Ca	Lk	Cm	Source	Institution	Status
	Gulf of Mexico / Caribbean												
69	BARRA OSTIONAL	TAMP									SEPESCA-INP	SEPESCA	★
70	BARRA DEL TORDO	TAMP									SEPESCA-INP	SEPESCA-INP	★
71	RANCHO NUEVO	TAMP									Márquez, R. / Díaz, F.	SEPESCA-INP	★
72	ARENALES/CABO ROJO	VER									Santander, J/Licona, G.	SEDESOL/U.V.	●
73	BOCA DE LIMA/COSTA ESMERALDA	VER									Santander, J/Licona, G.	SEDESOL/U.V.	●
74	BARRA TECOLUTLA	VER									SEDESOL	SEDESOL/SEPESCA	★
75	BARRA DE CAZONES	VER									Huerta Escalante, A.	SEDESOL	♦
76	PUNTA ANTON LIZARDO	VER									Huerta Escalante, A.	SEDESOL	♦
77	ISLA AGUADA-SABANCUY	CAMP									Escanero, G.	SEPESCA	★
78	SABANCUY-CHAMPOTON	CAMP									Martínez, R. 1992	SEDESOL	★
79	CHAMPOTON	CAMP									Ayuntamiento/SEDESOL	Ayuntamiento/SEDESOL	●
80	SEYBAPLAYA	CAMP									INP-SEPESCA	SEPESCA	●
81	CHEN-K'AN	CAMP									Carranza, J.	SEDESOL/GOB ESTADO	★
82	CELESTUN	YUC									Rodríguez/Durán	PRONATURA/SEDESOL -Yucatán	★
83	EL PALMAR	YUC									Serrano, I./ Miranda, R.	SECOL Yucatán	★
84	RIO LAGARTOS-COLORADAS	YUC									Garduño, M.	SEPESCA/INP	★
85	EL CUYO	YUC									Aguirre, I.	SEDESOL	★
86	PTA. MOSQUITO-R. YULUC	QROO	I. Holbox								Zurita, J. et al. 1993/Miranda, E.	CIQRO/PRONATURA Yucatán	★
87	CABO CATOCHE	QROO									Zurita, J. et al. 1993/SEDESOL	SEDESOL	★
88	ISLA CONTOY	QROO	I. Contoy								Zurita, J. et al. 1993		●
89	ISLA BLANCA	QROO	I. Blanca								Zurita, J. et al. 1993		●
90	ISLA MUJERES	QROO	I. Mujeres								SEPESCA/INP	SEPESCA-INP	●
91	ISLA CANCUN	QROO									Zurita, J. et al. 1993		♦
92	NIZUC -PTO MORELOS	QROO									Zurita, J. et al. 1993	SEPESCA-INP/CIQRO	●
93	CAPITAN LAFRITE	QROO									Zurita, J.	CIQRO	●
94	PLAYA DEL CARMEN	QROO									Zurita, J. et al. 1993	CIQRO	♦
95	MEZCALITOS	QROO	I. Cozumel								Presas , B./Zurita, J. et al. 1993	CIQRO	●
96	PUNTA MORENA	QROO	I. Cozumel								Presas , B./Zurita, J. et al. 1993	CIQRO	●
97	FIDECARIBE	QROO	I. Cozumel								Presas , B./Zurita, J. et al. 1993	CIQRO	●
98	CHEN-RIO	QROO	I. Cozumel								Presas , B./Zurita, J. et al. 1993	CIQRO	●
99	SAN MARTIN	QROO	I. Cozumel								Presas , B./Zurita, J. et al. 1993	CIQRO	●
100	BASURERO	QROO	I. Cozumel								Presas , B./Zurita, J. et al. 1993	CIQRO	●
101	PUNTA CHIQUEROS	QROO	I. Cozumel								Presas , B./Zurita, J. et al. 1993	CIQRO	●
102	BOSH	QROO	I. Cozumel								Presas , B./Zurita, J. et al. 1993	CIQRO	●
103	CINCO PUERTAS	QROO	I. Cozumel								Presas , B./Zurita, J. et al. 1993	CIQRO	●
104	MIRADOR	QROO	I. Cozumel								Presas , B./Zurita, J. et al. 1993	CIQRO	●
105	CELARAIN	QROO	I. Cozumel								Presas , B./Zurita, J. et al. 1993	CIQRO	●
106	PAAMUL	QROO									Zurita, J.	CIQRO	●
107	CHENYUYU (AVENTURAS)	QROO									Zurita, J.	CIQRO	●
108	FATIMA	QROO									Zurita, J.	CIQRO	●
109	XPU-HA	QROO									Zurita, J.	CIQRO	●
110	KANTENAH	QROO									Zurita, J.	CIQRO	●
111	AVENTURAS DIF	QROO									Zurita, J.	CIQRO	●
112	YANTEN	QROO									Zurita, J.	CIQRO	●
113	CHEMUYIL	QROO									Zurita, J.	CIQRO	●
114	XCA-CEL	QROO									Zurita, J./SEDESOL	CIQRO/SEDESOL	★
115	XEL-HA	QROO									Zurita, J. et al. 1993	CIQRO	●
116	TANKAH	QROO									Zurita, J.	CIQRO	★
117	KAN-ZUL/OJO DE AGUA	QROO	Sian Ka'an								Zurita, J. et al. 1993		●
118	CAHAPECHEN	QROO	Sian Ka'an								Zurita, J.	CIQRO	●
119	YU-YUM	QROO	Sian Ka'an								Zurita, J. et al. 1993		●
120	SAN JUAN	QROO	Sian Ka'an								Zurita, J.	CIQRO	●
121	MOSQUITEROS (RS)	QROO	Sian Ka'an								Barrios Martínez, C.	AMIGOS DE SIAN KA'AN	●
122	ENS. TANTAMAN (RS)	QROO	Sian Ka'an								Barrios Martínez, C.	AMIGOS DE SIAN KA'AN	●
123	ENS. SAN MARTIN (RS)	QROO	Sian Ka'an								Barrios Martínez, C.	AMIGOS DE SIAN KA'AN	●
124	ROMPE OLAS (RS)	QROO	Sian Ka'an								Barrios Martínez, C.	AMIGOS DE SIAN KA'AN	●
125	TAMPALAN (RS)	QROO	Sian Ka'an								Barrios Martínez, C.	AMIGOS DE SIAN KA'AN	●
126	PTA. PAJAROS	QROO	Sian Ka'an								Zurita, J. et al. 1993		♦
	P. HERRERO-XCALAK	QROO									Zurita, J. et al. 1993		♦
127	MAJAHUAL	QROO									Zurita, J. et al. 1993	SEDESOL	●
128	PUERTO ANGEL	QROO									Zurita, J. et al. 1993		●
129	HERRADURA	QROO									Zurita, J. et al. 1993		●
	number of beaches with nestings by this species in this coast:			0	43	3	17	0	8	52	*Symbols used:*		
	% of beaches with nestings by this species in this coast:			0	70	5	28	0	13	85	conservation project		●
	TOTAL NUMBER OF BEACHES (BY SPECIES)			65	43	50	23	23	8	52	conservation camp		★
	% OF THE BEACH TOTALS WITH NESTINGS BY THIS SPECIES			50	33	38	16	16	6	40	prospections		♦

A. Revillag. = Archipiélago Revillagigedo; CGIP-UAS = Coordinación General de Investigación y Posgrado-Universidad Autónoma de Sinaloa; CIQRO= Centro de Investigaciones de Quintana Roo; CIIDIR-Oax = Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional-Oaxaca; CRIP = Centro Regional de Investigación Pesquera; SEPESCA = Secretaría de Pesca; ECM-UAS = Escuela Ciencias Marinas-Universidad Autonoma de Sinaloa; ESEM-UGRO = Escuela Superior de Ecología Marina-Universidad Autónoma de Guerrero; F.C.-UNAM = Facultad de Ciencias- Universidad Nacional Autónoma de México; ITMAR-SEP = Instituto Tecnológico del Mar- Secretaría de Educación Pública; SECOL Yucatán = Secretaría de Ecología, Gobierno del Estado de Yucatán; SEDESOL = Secretaría de Desarrollo Social ; U de G = Universidad de Guadalajara; UABJO = Universidad Autónoma Benito Juárez de Oaxaca; UMSNH = Universidad Michoacana de San Nicolás Hidalgo; UV = Universidad Veracruzana

POST-NESTING MIGRATION OF *ERETMOCHELYS IMBRICATA* IN THE YUCATAN PENINSULA

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We estimate from known studies and knowledgeable sources that in excess of a thousand hawksbill sea turtle (*Eretmochelys imbricata*) nests per year are laid on the western and northern Yucatán Peninsula of México, from Isla Carmen to Isla Holbox. In this study, two adult female hawksbills from Playa Chenkan, Campeche, a nesting beach in the southwestern Peninsula, and two from Playa El Cuyo in Yucatán State, a northeastern nesting beach, were equipped with satellite radio transmitters in preliminary efforts to monitor migrations. All four turtles have been tracked for 8 months, since late June 1993. Three of the four swam to Campeche Banks, where two have remained in relatively confined areas, while the third has exhibited a much broader range. The fourth turtle swam from El Cuyo into the Caribbean where she has remained in a relatively confined area.

We suggest that fewer positions have been obtained from these hawksbills than were received from similarly telemetered Kemp's ridleys because of: 1) shorter surface periods for the hawksbill, 2) reduction in radiated signal strength due to antenna damage, and 3) use of the less powerful Telonics ST-6 PTT on the hawksbills instead of the older, more powerful ST-3 PTT as was applied to the ridleys. Despite the relatively short period of time spent at the sea surface, it appears that the hawksbill is a good candidate for satellite telemetry. Using the more powerful PTTs available with some antenna modification and employing the same method of attachment as presented in this study should result in good global positions for the species.

BLOOD CHEMISTRY COMPARISON OF HEALTHY VS HYPOTHERMIC JUVENILE KEMP'S RIDLEY SEA TURTLES (*LEPIDOCHELYS KEMPI*) IN THE NEW YORK BIGHT

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It appears that juvenile Kemp's ridley sea turtles (*Lepidochelys kempi*) utilize the waters of the New York Bight during their developmental migration (Meylan and Sadove, 1986; Morreale et al., 1992). This is supported by the large numbers of uniformly sized, immature turtles that have been recovered by the Okeanos Ocean Research Foundation from the waters of Long Island Sound and the eastern bays of Long Island, New York (USA). Since 1979, 132 ridleys have stranded cold-stunned on Long Island shores. During an ongoing tag and release program begun in 1986, 60 healthy turtles have been recovered from commercial trap nets through a cooperative effort with area fishermen. Thirty one additional turtles captured in trawl or gill nets or found dead on area beaches brings the total number of *L. kempi* recovered from New York waters since 1979 to 223.

This study examined the physiological changes that occur in blood chemistry due to apparent hypothermia. Blood samples were obtained from healthy turtles to establish standard blood values for juvenile *L. kempi*. These normal values provided a basis for comparison for the blood values obtained from hypothermic turtles.

An objective of the present study was to determine possible methods of treatment for live cold-stunned specimens. Cold-stunning events have also been reported in the Indian River Lagoon System, Florida (Witherington and Ehrhart, 1989) and New England (Danton and Prescott, 1988; G. Early, pers. comm.). In view of the endangered status of *L. kempi*, these events affect a large proportion of the remaining ridley population.

Sea turtles are present in Long Island waters during the months of June through December. Healthy pound net captured turtles were collected through a tag and release program with the cooperation of local fisherman. Each animal was photographed, measured, weighed, tagged and had a blood sample taken. Fifty net captured ridley turtle blood samples represent the standard blood values. The majority of these turtles was taken from the Peconic and Shinnecock Bay Systems.

Cold-stunned turtles were retrieved in late fall and early winter. Most of these turtles stranded on beaches of the north-eastern shore of Long Island Sound. Ten fresh dead ridleys represent the hypothermic values.

Net captured turtles were bled on a table slanted 60 degrees to allow blood to pool in the dorsal cervical sinuses. Blood was placed in two blood tubes: one containing sodium heparin for hematology and the other a serum separator containing clot activator and gel. Blood was spun at 3600 rpm for approximately five minutes. All samples were refrigerated and sent to a diagnostic laboratory for testing within 48 hours.

Blood values were entered into a data base file and transferred for statistical analysis. A two-way analysis was performed to determine which serum chemistry and hematology value differences were statistically significant. The mean and standard deviation were also computed.

A profile consisting of twenty-five parameters was selected for analysis. A listing of the mean values and standard deviations obtained for serum blood chemistries for healthy and hypothermic *L. kempi* is shown in Table 1. Statistical analysis comparing the data yields significant differences for eleven of the twenty-five parameters. Mean values of these biochemical differences are plotted in Figure 1.

Hypothermic turtle blood samples exhibited a rise in plasma levels over normal values for several parameters. Magnesium increased 108% (mean 7.54 meq/l), calcium rose 13% (mean 8.39 mg/dl), potassium was up 297% (mean 14.12 meq/l), and inorganic phosphate rose 165% (mean 18.06 mg/dl). The enzymes exhibited the greatest increases with creatine kinase (mean >10,000 u/l), alkaline phosphatase (mean 136.3 u/l), AST (mean 776.3 u/l), ALT (mean 27.7 u/l) and LDH (mean 7122.7 u/l) rising by >124%, 64%, 436%, 608% and 448%, respectively. Decreased values were evident for BUN (mean 19.9 mg/dl), down 73% and carbon dioxide (mean 22.11 meq/l), down 23%.

Although there is evidence that marine turtles hibernate (Felger et al., 1976; Carr et al., 1980), it appears that not all turtles of a given population do so (Carr et al., 1980). Sea turtles often migrate offshore or to warmer waters to avoid cold water conditions. *L. kempi* in New York waters appear to employ both methods of behavior in response to the onset of cold weather. One of us (Kiehn) has seen or received reports of ridleys bearing distinct mud lines on their carapaces, indicative of having spent considerable time buried in the substrate. These turtles were observed during late winter. Of the sixty net captured *L. kempi* tagged and released by Okeanos, none have stranded cold-stunned or been recaptured in subsequent years, indicating that these turtles migrated out of the area. To support this statement, one of these turtles was recaptured off Cape Hatteras, North Carolina three months after its release in Long Island waters. In addition, data recovered from satellite tracking by Okeanos provide us with concrete evidence of the southward migration of released *L. kempi* from Long Island (Morreale and Standora, 1992).

For reasons unknown, many turtles remain in New York waters through the fall and do not hibernate, but strand dead or suffering from apparent hypothermia. Previous work on the behavior and tolerance responses to cold water by sea turtles (Schwartz, 1978) indicates that at temperatures below 13.0°C, *L. kempi* begin to exhibit sluggish floating behavior, breathing is labored, feeding ceases below 10°C, and they succumb between 6.5 and 5.0°C.

Physiologic responses to hypothermia include peripheral vasoconstriction, decreased heart rate and blood pressure, hyperventilation, electrolyte imbalances and metabolic acidosis. Blood chemistry analysis of apparently cold-stunned *L. kempi* suggest a similar response in sea turtles.

Cardiovascular response to hypothermia appears to play a significant role in cold-stunning. Cold-stunned turtles typically have dramatically lowered heart rates. Decreased cardiac output results in less oxygen delivered to the tissues with subsequent metabolic consequences such as acidosis and electrolyte imbalances. Ischemia can lead to cellular damage and observed increases in LDH, CK and liver enzymes. Additionally, decreased renal perfusion may also play a role in and would support the findings of increased potassium and inorganic phosphate. An increase in uric acid would also be expected. There is a need for further study of uric acid levels in cold-stunned turtles.

It is not known if marine turtles typically exhibit increased respiratory rates when exposed to cold water temperatures, however, hyperventilation would explain the observed decrease in carbon dioxide levels. Hyperventilation could be a direct response to cold temperatures or an attempt to counter metabolic acidosis, possibly a combination of both mechanisms.

Goals of treatment include increasing cardiac output, increasing oxygen perfusion to tissues, correcting acid/base abnormalities, and decreasing risk of rewarming shock. Therapies to be explored include parenteral warm fluid therapy, administration of cardiac drugs such as dopamine, epinephrine and atropine, and delivery of oxygen to the lungs via tracheal intubation and ventilation.

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SERUM CHEMISTRIES ANALYZED Mean and Standard Deviations		
SERUM COMPOUND	POUND NET CAPTURED	COLD-STUNNED
Calcium mg/dl	7.42 sd0.98	8.39 sd2.18
Cholesterol mg/dl	334.17 sd119.14	360.10 sd156.33
Sodium meq/l	153.33 sd21.38	150.90 sd10.82
Inorg. Phosphate mg/dl	6.79 sd1.41	18.06 sd8.70
ALT (iu)	3.91 sd4.14	27.70 sd46.70
LDH (iu)	1298.67 sd638.11	7122.70 sd3432.37
AST (iu)	144.72 sd42.32	776.30 sd566.67
Alk. Phos. (iu)	83.19 sd57.26	136.30 sd49.26
Potassium mmol/l	3.56 sd1.32	14.12 sd10.58
Chloride mmol/l	115.22 sd14.03	113.30 sd12.30
Globulin g/dl	1.76 sd0.39	1.67 sd0.30
Carbon Dioxide meq/l	28.76 sd7.88	22.11 sd6.86
Lipase (iu)	25.29 sd51.80	70.60 sd60.93
Amylase (iu)	665.18 sd181.79	495.00 sd142.88
Creatinine-K (iu)	4460.82 sd3074.21	>10,000.00
Gamma-Glu_Xfrase (iu)	6.33 sd24.74	4.60 sd6.50
Total Protein g/dl	3.08 sd0.53	2.91 sd0.61
Glucose mg/dl	115.19 sd41.55	133.20 sd83.07
Creatinine mg/dl	0.38 sd0.20	0.44 sd0.13
BUN mg/dl	73.70 sd21.11	19.90 sd16.56
T-Bilirubin mg/dl	0.10 sd0.05	0.10 sd0.05
Albumin g/dl	1.32 sd0.25	1.24 sd0.39
Magnesium mg/dl	3.63 sd1.09	7.54 sd2.34
Triglycerides mg/dl	122.70 sd80.35	167.80 sd51.29
Hematocrit	31.09 sd13.55	27.67 sd15.36

Table 1. Mean serum chemistry values for wild caught and cold-stunned sea turtles for all chemistries tested.

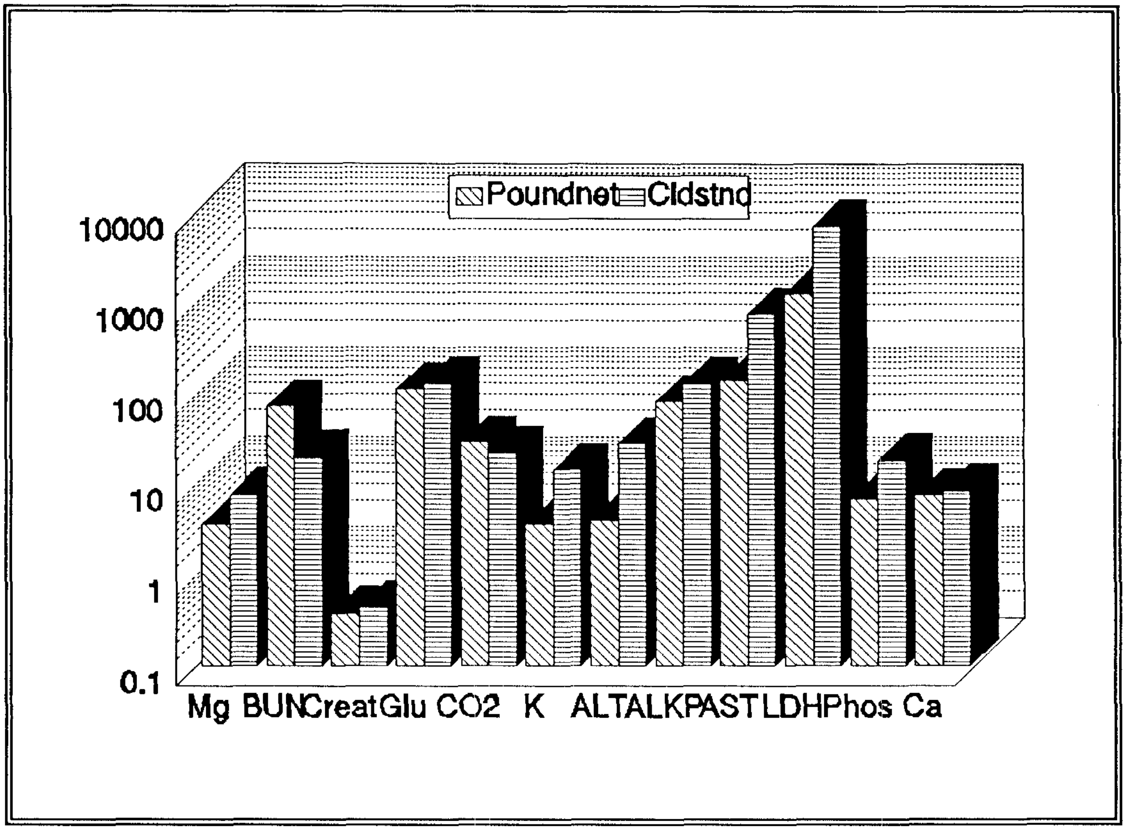

Figure 1. Mean serum chemistry values for cold-stunned and wild caught ridley sea turtles. Only statistically significant chemistries are plotted. Scale is logarithmic to reflect all chemistries.

OSTIONAL BIOLOGICAL STATION: A SITE FOR RESEARCH AND EDUCATION

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Ostional is a rural community located at the Peninsula de Nicoya, Guanacaste province, Costa Rica. It is part of the Ostional National Wildlife Refuge.

In this town a historical relation between man and sea turtles takes place, because it is one of the few beaches in the world with the mass-nesting phenomenon called "ARRIBADAS," in which several thousands of olive ridley turtles (*Lepidochelys olivacea*) emerge together to nest on a small portion of the beach.

The ARRIBADAS follow a lunar cycle. The sea turtles nest during the quarter moon, in the darkest nights, starting during the high tide. In Ostional the size of the arribada is variable and the bigger ones (ca. 120,000 turtles) occur during the rainy season (May-October), but it is possible that the phenomenon occurs all year long.

OSTIONAL DEVELOPMENT ASSOCIATION

The massive activity of turtles laying eggs at the beach made necessary that the Ostional community learned to use the sea turtle eggs as a way for survival. Before the 70's, however, an irrational exploitation of the resource as well as an illegal market to the rest of the country were under way.

Dr. Douglas C. Robinson started the scientific research by evaluating the natural loss of eggs. He pointed out some reasons for it: the mass-nesting by itself, pollution by broken eggs, predation, erosion, etc.

For this reason, the Ostional Association and the University of Costa Rica promoted a project for the rational use of the natural resources, through research and conservation of *L. olivacea*. During 1987 the community got the first legal authorization for rational use and commercialization of turtle eggs. At present, the sale of turtle eggs from Ostional is permitted by law, and those eggs are less expensive than the illegal ones.

This management project is unique in the world and it is an example of a community that organizes itself for the use of the natural resources. They work for their sustainable socioeconomic development, while promoting research and conservation of sea turtles and other natural resources.

The management project allows, based upon scientific research and monitoring, the legal extraction of eggs during the first 36 hours after the beginning of the arribada. This gives other eggs the opportunity to hatch, especially when the number of turtles is not big enough.

BIOLOGICAL STATION

This is a small place that has the basic things necessary for research and education. That makes Ostional a perfect place for organized groups (up to 15 people) who want to do some volunteer work or to learn about sea turtles and natural resources.

At present, the Biological Station is working on the construction and equipment supply of the Ostional Research Laboratory. Therefore, Ostional offers great opportunity for researchers, as well as people interested in organizing advanced courses about sea turtles any time of the year.

For more information and reservations, please contact:

Sea Turtles Program
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University of Costa Rica
2050 San Pedro, Costa Rica

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NEW ZEALAND PIG DOGS AND THE CONSERVATION AND CONTROL OF PIGS

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Pigs are major enemies of sea turtles. Control of feral pigs is required to protect sea turtle and tortoise eggs and hatchlings from pig predation. In New Zealand, highly trained pig dogs are used by hunters to harvest feral pigs, and are now being used by pest management agencies to control pig populations and in research programmes. Landcare Research is applying this novel use of high performance pig dogs to international problems of pig control and conservation, and has operated in Hawaii and the Philippines. Other potential international operations with dogs include pig eradication on the Galapagos Islands where green sea turtles (*Chelonia mydas* L.) and giant tortoises (*Geochelone elephantopus*) are threatened by pigs. For Isla Santiago, Coblentz and Baber (1987) consider intensive pig control would improve recruitment of land tortoises, and greatly increase survival of sea turtles (from <2% hatching success to c. 70%, Green, 1984).

We see no reason why highly trained New Zealand pig dogs could not be used to protect sea turtle or tortoise nesting zones. Different levels of control could be imposed, depending on local requirements. If only the pigs that depredate nesting zones are to be removed, the dogs could be used to patrol beaches and scent and track pigs from recent activity (up to 10 hours old) and bring them to bay. Alternatively, they could be used to clear all pigs from larger buffer zones. Finally, eradication of pigs from islands or areas that can be physically isolated could also be achieved by the use of dogs. To date, international operations involving high-performance dogs have of necessity involved New Zealand hunters and research personnel but with increased breeding and training programmes we envisage there will eventually be sufficient dogs to allow other local people with dog management and hunting skills to own and operate the dogpacks with these skills. The use of dogs can be integrated with other control techniques, including aerial poisoning or bait stations.

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SEA SURFACE TEMPERATURES AND SEA TURTLE POSITION CORRELATIONS

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Juvenile loggerhead (*Caretta caretta*) and Kemp's ridley (*Lepidochelys kempii*) sea turtles utilize the Chesapeake Bay as an important foraging area (Byles, 1988; Keinath et al. 1987; Keinath and Musick 1991 a,b). The sea turtles enter the Chesapeake Bay during the spring and migrate out of the Bay in the fall after the first winter storms, and move to the south of Cape Hatteras (Byles 1988; Keinath 1993). The zeitgebers (cue for beginning migration) for sea turtle migration are poorly understood, although temperature may have the greatest influence.

Recent aerial surveys of turtle distribution in North Carolina waters indicate that turtle distribution may be related to minimum water temperatures, with turtles occurring in water greater than 11°C (Epperly et al., in press). But, there is currently no known correlation between the location of sea turtles and sea surface temperatures. By analyzing satellite derived images of sea surface temperatures and aerial survey positions of observed sea turtles, correlations between temperature and turtle location can be determined.

Aerial surveys for sea turtles were conducted along the outer banks of North Carolina. The surveys were flown in a DeHavilland U-6A Beaver at an altitude of 152 m with a velocity of 128 km/hr (Keinath 1993). Surveys were flown in a saw-toothed pattern along the outer banks of North Carolina with individual flight lines being approximately 28 km long, extending to the thermal edge of the Gulf Stream. Data for each turtle sighting was recorded.

Sea surface temperature (SST) images were obtained from the advanced very high resolution radiometer, which is on board the NOAA-11 polar orbiting weather satellite, obtained through the NOAA coastal program's coastwatch project. The digital images were mapped on a Mercator projection (1.47 km/pixel resolution), with multichannel atmospheric correlation algorithms producing SST estimates accurate to 1°C in cloud free images (Epperly et al., in press).

Each survey's flight lines were digitally reconstructed with NOAA's (IDIDAS) imaging software. The turtle positions were calculated and plotted along the flight lines.

The sea surface temperature for every pixel along each flight line was recorded from the image. The temperature for each pixel corresponding to a sea turtle location was also recorded. The means and variances of sea surface temperatures were analyzed with SAS statistical software. Initial image analysis results show that cloud bands in the images have large temperature changes across their boundaries. Image pixels that lay on the boundary of, or inside a cloud did not accurately portray real sea surface temperatures. The effect of cloud cover was to artificially lower the temperature in the image, often to sub zero temperatures. To determine if there was any effect of cloud cover a 3X3 average for each pixel was compared to non-averaged temperature data. For the data that we used there was no difference between the averaged and unaveraged flight temperature means (Paired t-test: $t = 1$, $DF = 1{,}000$, $\alpha = 0.05$). The similarity between the two temperature groups indicate that there was very little, or no influence of cloud cover on the samples. If cloud cover obscured any portion of the flight lines, or if the comparison of averaged data and pixel data was significantly different the flight data set was discarded.

Variances of the flight and turtle temperatures were compared to determine whether the turtles were randomly distributed throughout all possible sea surface temperatures measured. We found that there is a significant difference between sea surface temperature variance of sea turtle positions and all observed sea surface temperature variances (temperatures along the flight lines)(ANOVA: $F = 2.18$; $DF = 2370, 85$; $\alpha = 0.05$). The difference suggests that sea turtles are not randomly distributed, but stay within a preferred temperature range. This was supported by determining the temperature range available for turtles, 5°C to 34°C for all flights. The turtles, however, only utilized a range of 14°C to 28°C. There is an upper limit as well as a lower limit to preferred turtle temperatures. The lower limit we observed is a little higher than the low temperature determined by Epperly et al. in press, but lower than that associated with sea turtles in the Chesapeake Bay (Lutcavage and Musick 1985). This study also suggests that the preferred temperature range is seasonally variable. Statistical verification of this is not currently possible due to the large variation in sample sizes.

Sea turtle temperature correlation analyses will become more detailed as historical satellite images become available for flights flown between 1986 and 1991.

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SALVAGING, IDENTIFYING AND MARKING SEA TURTLES IN THE BAY OF PARITA, PANAMA

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This study is monitoring marine fish and sea turtles captured in a stationary intertidal fish trap set at the edge of a mangrove-fringed estuarine inlet in central Pacific Panama (Estero Palo Blanco, Aguadulce, Parita Bay). Stationary intertidal fish traps, made of stakes, netting and/or wire, were once employed widely in Pacific Panama estuaries to catch fish and turtles, but are becoming rare (Cooke and Tapia, in press). Most fish trapped are small (100-300 mm SL), but large predatory teleosts (0.5-5 kg) and very large rays and sea turtles (>20kg) are sometimes recovered (Cooke and Tapia, in press).

This trap is the sole survivor in Parita Bay of a once widespread artisanal technology. Simple, effective and easily sampled, it provides expeditiously quantified data on marine fish and turtle diversity, abundance and seasonality, in a biome and region whose faunas are but rudimentarily studied, in spite of their importance to local and regional economies. We made four collections a month, at the highest and lowest tides of the major cycle and at peak intermediate tides.

Much more is understood about sea turtle behavior at breeding beaches than away from them. More information is available on Caribbean sea turtle populations, than on Pacific ones. In the tropical eastern Pacific, Mexico, Costa Rica, and Colombia have provided more published information than Panama. Our observations on artisanal turtle fishing in Parita Bay, central Pacific Panama, suggest that mangrove-estuary embayments are regularly used by the black sea turtle (*Chelonia agassizii*), which is considered to be a transient species in Central America. Since the mangrove-fringed inlets of Parita Bay are important loci for gill-net fishing with small canoes, these turtles are caught regularly, butchered and sold by fisherfolk at the El Rompío village (see geographic location figure). In order to devise practical methods for alleviating or terminating this predation, it is necessary 1) to determine precisely when, and at which life- and reproductive stages, black turtles enter Parita Bay, and 2) to mark captured individuals with a view to studying subsequent movements.

Currently we are seeking funds to continue this project and to assess the influence of seasonality on black turtle movements: preliminary data suggest that they may move inshore mostly in the dry season (December-May).

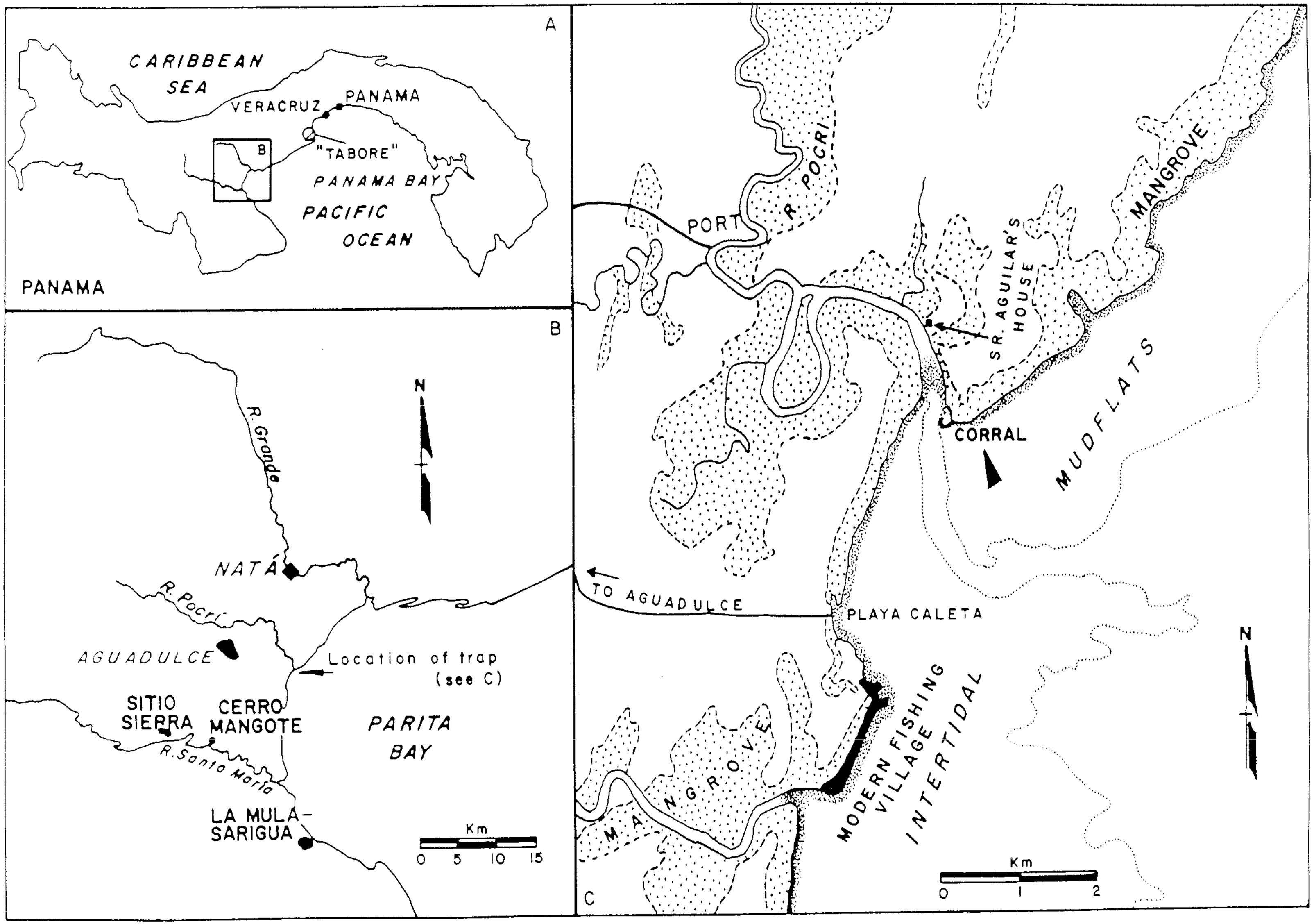
We plan to continue monitoring black turtle movements in Parita Bay in the following ways:

1) By studying all individuals that enter a stationary intertidal fishtrap in a small inlet (Estero Palo Blanco). We were studying fish distribution and abundance in this trap with the aid of a grant from the Directorate of International Activities, Smithsonian Institution. Seven adult black turtles recovered during our quatri-monthly collections and five kept alive by the trap owner (Sr. Pablo Aguilar) on other occasions, have been marked (University of Costa Rica Tagging Program).

2) By evaluating the nature of black turtle fishing at the village of El Rompío where our personal observations in 1992 suggest that at least one adult turtle is butchered every two days during the dry season (December-May).

3) Through systematic interview and observational surveys of turtle fishing at other points along the Parita Bay coast (making taxonomic and biological evaluations as we go).

We stress the fact that the preliminary and primary purpose of this study is informational: turtle conservation in an area where many poor people depend on fishing, requires unambiguous data on their abundance and habitat-partitioning, and sensible, politically viable implementation measures. In this sense, we conceive our role as advisory to the Department of Marine Resources and to the Renewable Natural Resources Institute, to whose final policy decisions must, logically, correspond. Nevertheless, it would make little sense for us to recover and mark black sea turtles, in an area where we know they are being heavily fished, without establishing positive interactions with local people and fomenting a conservation mentality. We think we can achieve these goals: Cooke has been working in Parita Bay for twenty years and already knows most of the fisherfolk. Gonzalo Tapia, our field assistant is a resident of Aguadulce. Ruiz Guevara has had several years experience on turtle monitoring projects in the area.


A
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Location of trap (see C)
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CERRO MANGOTE
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OBSERVATIONS ON THE TESTICULAR CYCLE OF THE GREEN TURTLE, *CHELONIA MYDAS*, IN THE CARIBBEAN

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Seasonal changes in the gross morphology of the testes and epididymides of *Chelonia mydas* were studied using samples from 40 males from a subsistence fishery in Panama. Data indicate that this species does not follow the pattern of post-nuptial spermatogenesis that has been observed in most other turtles. Instead, the green turtle appears to exhibit the pre-nuptial pattern of spermatogenesis previously described for another marine turtle, *Caretta caretta*, in which testicular recrudescence and active spermiation antecede mating. It is suggested that the timing of the male reproductive cycle in *Chelonia mydas* may be a contributing factor in the restriction of male-mediated gene flow between populations that are known to exhibit a high degree of genetic isolation.

BEACH COMPACTNESS AS A FACTOR AFFECTING TURTLE NESTING ON THE WEST COAST OF FLORIDA

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Sediment compactness measurements were taken on the west coast of Florida on four barrier islands and correlated with the nesting activity of *Caretta caretta*. The measurements were made with a cone penetrometer at three depths (0-6, 6-12 and 6-18in (0-30cm)) and at three distances from the shoreline (just above high water, mid beach and upper beach or near vegetation line. The readings were taken at 1000ft (305m) intervals which coincided with DNR monument markers. Approximately 21 miles or 34 km were surveyed.

The results of the compactness measurements are summarized in Table 1 where means of the three (lower-mid-upper beach) readings were used. Table 2 summarizes the nesting/false crawl observations for each key. Both compactness (at two depths) and nesting data are shown in Figure 1 where symbols are shown side by side for each 1000ft area (n = 130) with darker symbols representing softer sediment and higher counts of nests/false crawls, respectively. From Table 1 and Figure 1 it may be seen that the southern portion of the study area was favored for nesting and was the location of predominantly soft sediment. Longboat Key to the north was the site of beach nourishment during 1993 which may explain the abundant false crawls apparent in Table 2 and Figure 1. Due to this, 1992 data from Longboat Key were also included in statistical tests. A one-way anova (Kruskall-Wallis non-parametric) applied to the compactness data showed that Casey Key sediment was significantly softer than any other key for the 0-6in readings and significantly softer than Longboat Key for 1992 and 1993. The data are further expanded in Figure 2 and Tables 3 and 4 where the percentage of total compactness readings in ranges of 100 units is compared to the percentage of nests or false crawls in the corresponding compactness range. Both figures suggest a negative correlation of compactness to nesting but analyses (Pearson Product Moment) of the parameters of compactness at each depth, counts of nests and false crawls showed no significant correlations. It is of note that 8.6% of the 1993 nests occurred in areas with cone index values of greater than 500 cone index units.

The high variability in these data prevent conclusions regarding the effects of sediment compactness and turtle nesting (e.g., a few areas of high compaction had high nest numbers and some soft areas had low nest numbers). Also no correlations appeared between compactness at the three depths measured. However, the compactness measurements do provide a data set that illustrates general differences in geographic areas and a baseline for monitoring natural or man-made changes to the areas.

Table 1. Summary of average and standard deviation of sediment compactness measurements (cone index units) taken at 1,000 ft (305 m) intervals from keys on the west coast of Florida 1993.

	Count	0-6 inches Mean	0-6 inches S.D.	6-12 inches Mean	6-12 inches S.D.	12-18 inches Mean	12-18 inches S.D.
Longboat Key	47	430	152	849	200	984	56
Lido Key	12	435	104	757	190	942	110
Seista Key	23	446	265	712	320	811	253
Casey Key	34	220	545	542	161	820	158

Table 2. Summary of nest and false crawl data for each key.

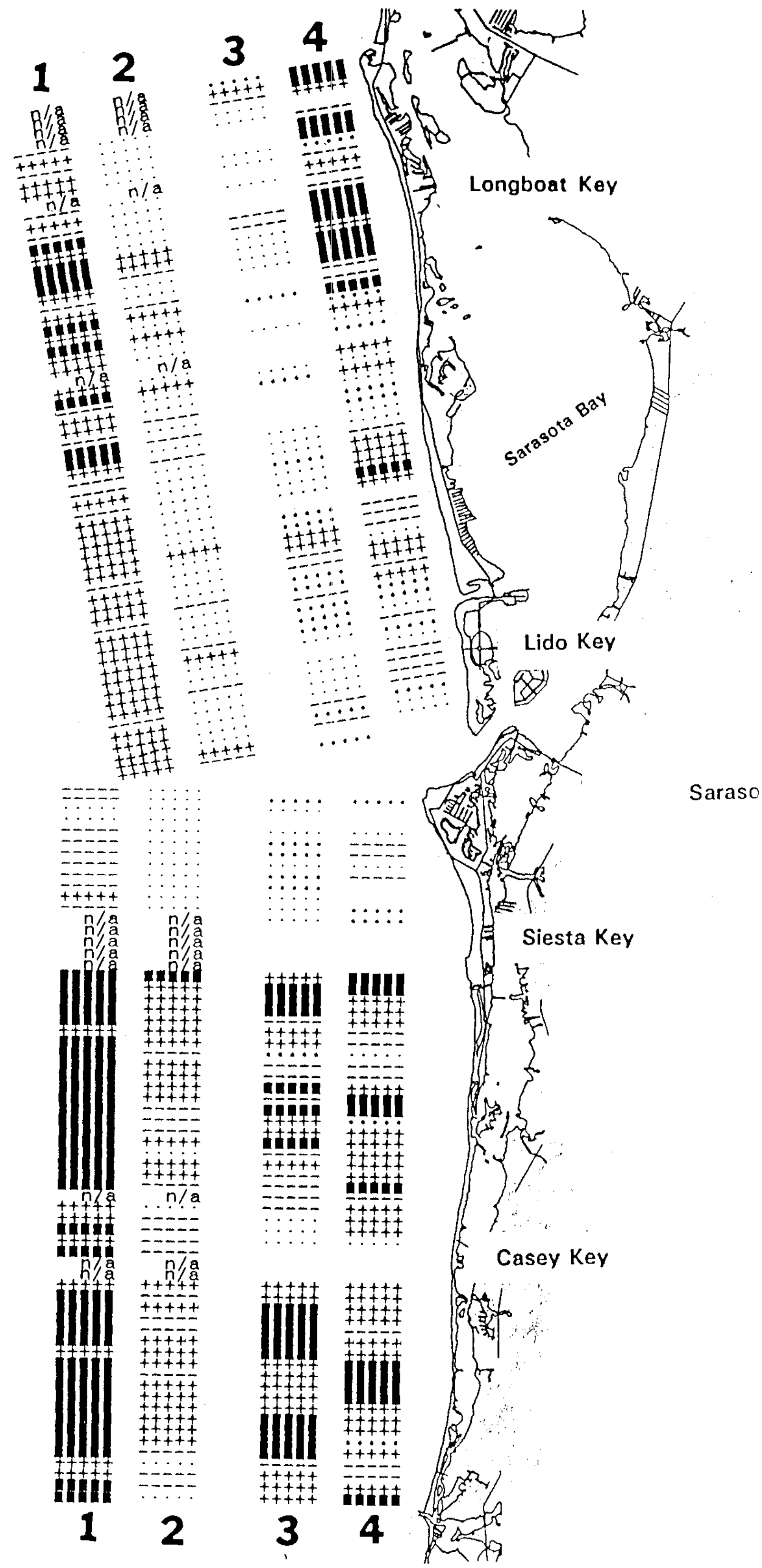
	Nests	False Crawls	Nest/False Crawl Ratio
Longboat Key	130	497	0.26
Lido Key	32	43	0.74
Seista Key	187	147	1.27
Casey Key	475	440	1.08
Total	824	1,127	

Table 3. Number of nests and false crawls from all keys combined and sediment compactness (intervals of 100 cone index units) at three sediment depths.

Cone Index Units	Number of Monuments (0-6 in)	Number of Nests (0-6 in)	Number of False Crawls (0-6 in)	Number of Monuments (6-12 in)	Number of Nests (6-12 in)	Number of False Crawls (6-12 in)
0-99	0	0	0	0	0	0
100	16	273	199	0	0	0
200	35	347	438	3	65	46
300	18	60	122	9	136	108
400	17	47	102	14	180	188
500	14	31	74	20	158	206
600	8	18	57	6	57	59
700	7	19	60	12	56	74
800	0	0	0	11	46	93
>899	1	0	0	41	97	278
Total	116	795	1,052	116	795	1,052

Table 4. Percent of nests and false crawls from all keys combined and sediment compactness (intervals of 100 cone index units) at three sediment depths.

Cone Index Units	Monuments (percent) (0-6 in)	Nests (percent) (0-6 in)	False Crawls (percent) (0-6 in)	Monuments (percent) (6-12 in)	Nests (percent) (6-12 in)	False Crawls (percent) (6-12 in)
>0-99	0.0	0.0	0.0	0.0	0.0	0.0
100	13.8	34.3	18.9	0.0	0.0	0.0
200	30.2	43.6	41.6	2.6	8.2	4.4
300	15.5	7.5	11.6	7.8	17.1	10.3
400	14.7	5.9	9.7	12.1	22.6	17.9
500	12.1	3.9	7.0	17.2	19.9	19.6
600	6.9	2.3	5.4	5.2	7.2	5.6
700	6.0	2.4	5.7	10.3	7.0	7.0
800	0.0	0.0	0.0	9.5	5.8	8.8
>899	0.9	0.0	0.0	35.3	12.2	26.4
Total	100.0	100.0	100.0	100.0	100.0	100.0



SEDIMENT COMPACTNESS

Cone Index Units	0-6 inches (Col. 1)	6-12 inches (Col. 2)
>750	·····	·····
501-750	-----	-----
251-500	+++++	+++++
<251	■■■■■	■■■■■

TURTLE NESTING ACTIVITY

Count	Nests (Col. 3)	False Crawls (Col. 4)
0		
1-2	·····	·····
3-4	·····	·····
5-8	-----	-----
9-16	+++++	+++++
>16	■■■■■	■■■■■

Figure 1. Chart of study area with four columns of symbols on left representing for each 1,000 ft (305 m): 1) sediment compacness 0-6 inches (15 cm), 2) sediment compactness 6-12 inches (15-30 cm), 3) number of turtle nests, 4) number of false crawls.

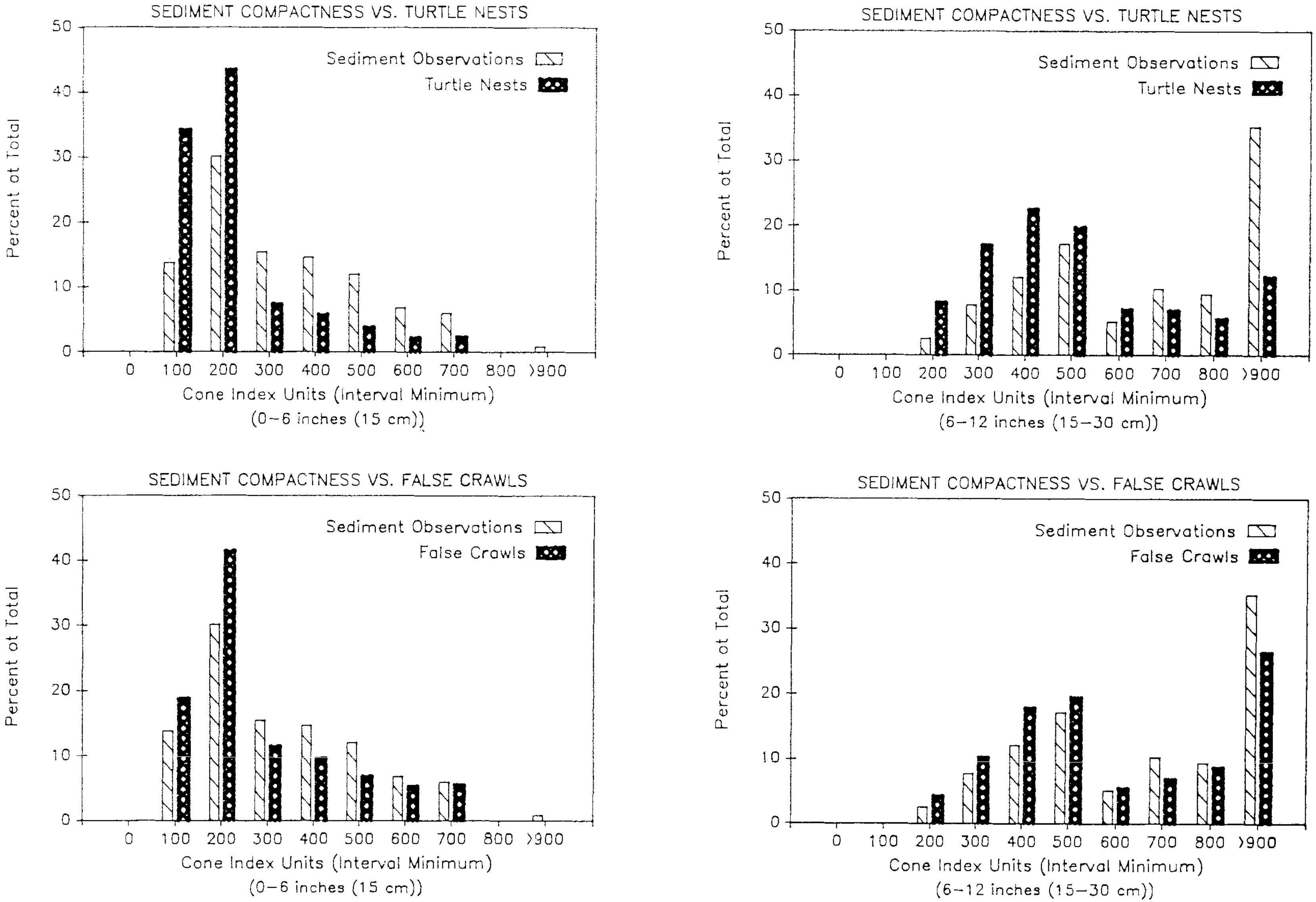


Figure 2. Percent of total compactness observations in intervals of 100 cone index units with the percent of total nests or false crawls in the corresponding sediment categories. (Upper left: Sediment 0-6 inches [15 cm] vs. nests; Lower left: Sediment 0-6 inches [15 cm] vs. false crawls; Upper right: Sediment 6-12 inches [15-30 cm] vs. nests; Lower right: Sediment 6-12 inches [15-30 cm] vs. false crawls).

A GROWTH CURVE FOR WILD FLORIDA *CARETTA CARETTA*

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Perhaps the single most valuable aspect in determining the impacts of man and the environment on a species and then implementing conservation measures is growth rate and age at maturity. One of the problems that continues to handicap conservation efforts is the lack of a quick reliable method for aging marine turtles. Length measurements are used to estimate age in other species, but carapace measurements are very often hard to interpret. Measurements are not easily duplicated even if taken by the same investigator and have by nature a high potential for error. The problem is further compounded by longevity and the highly migratory nature of the species rendering the effects of conservation measures inconspicuous for many generations.

Several studies have estimated growth parameters for loggerheads but only a few were able to use measurements from wild animals (Frazer and Schwartz, 1984; Frazer and Ehrhart, 1985). The growth parameters and age at maturity are estimated here using data from the Cooperative Marine Turtle Tagging Program's tag and recapture databases.

METHODS

This study uses data from 54 wild turtles recaptured a total of 60 times. Recapture measurements resulting in negative growth were not included in the calculations, however, zero growth measurements were used. Nesting turtle recaptures were only used to estimate size at maturity. Original straight line measurements ranged from 62.2 to 104.2 cm. Recapture straight line measurements ranged from 41.0 to 104.3 cm. Time at large ranged from 1 day to 5 years 361 days. These data were then fit to the Von Bertalanffy Growth Function as estimated by Fabens (1965): $X=A*[1-B*\exp(-KT)]$ using FSAS software. In this equation K represents the growth rate, A represents the asymptotic length or the length at which K is constant, B represents a hypothetical age at birth and T is time.

RESULTS AND DISCUSSION

The predicted lengths at age (Table 1) were estimated using 4.5 cm as mean straight length at birth (Frazer and Ehrhart, 1985; Dodd, 1988). In this study K was estimated to be .063, A was 96.7, and B was .95. Frazer and Ehrhart (1985) estimated .120, 94.6, and .952 for K, A and B respectively for loggerheads. The findings here are within range of the values previously estimated.

To estimate age at maturity the smallest and the mean size of nesters were chosen from data from Florida-Gulf and Florida-Atlantic loggerheads (80° 30.0′ W longitude divides the Gulf and Atlantic coasts). These turtles were assumed to be the same population since there is considerable migration between the two coasts. 74 was the smallest and 91.2 was the mean nesting female carapace straight length. These lengths are comparable to those found by Frazer and Ehrhart (1985) of 74 and 92 cm at Mosquito Lagoon, Florida. Bjorndal et al. (1983) found 92 cm to be the mean straight carapace length for nesters at Melbourne Beach, Florida. Ehrhart and Yoder (1978) obtained a mean of 91.7 cm at Kennedy Space Center, Florida, and Davis and Whiting (1977) obtained a mean of 92.4 cm from nesters at Everglades National Park, Florida. According to the growth curve presented here (Figure 1) maturity is reached between 22 and 45 years based on the smallest and average nester. Other studies have estimated values between 6 and 30+ years (Dodd, 1988). The von Bertalanffy growth equation is suggested as the best fit for capture data with uneven intervals at recapture (Frazer and Ehrhart, 1985; Ehrhardt and Witham, 1992; Saila et al., 1988). The equation fit the data given here well. Standard errors, coefficients of variance and r^2 were calculated using FSAS software. The variance is zero, the standard errors are negligible, and the r^2 are one all indicating a good fit of the data to the model. This, however, is a preliminary study and the numbers generated here need additional analysis.

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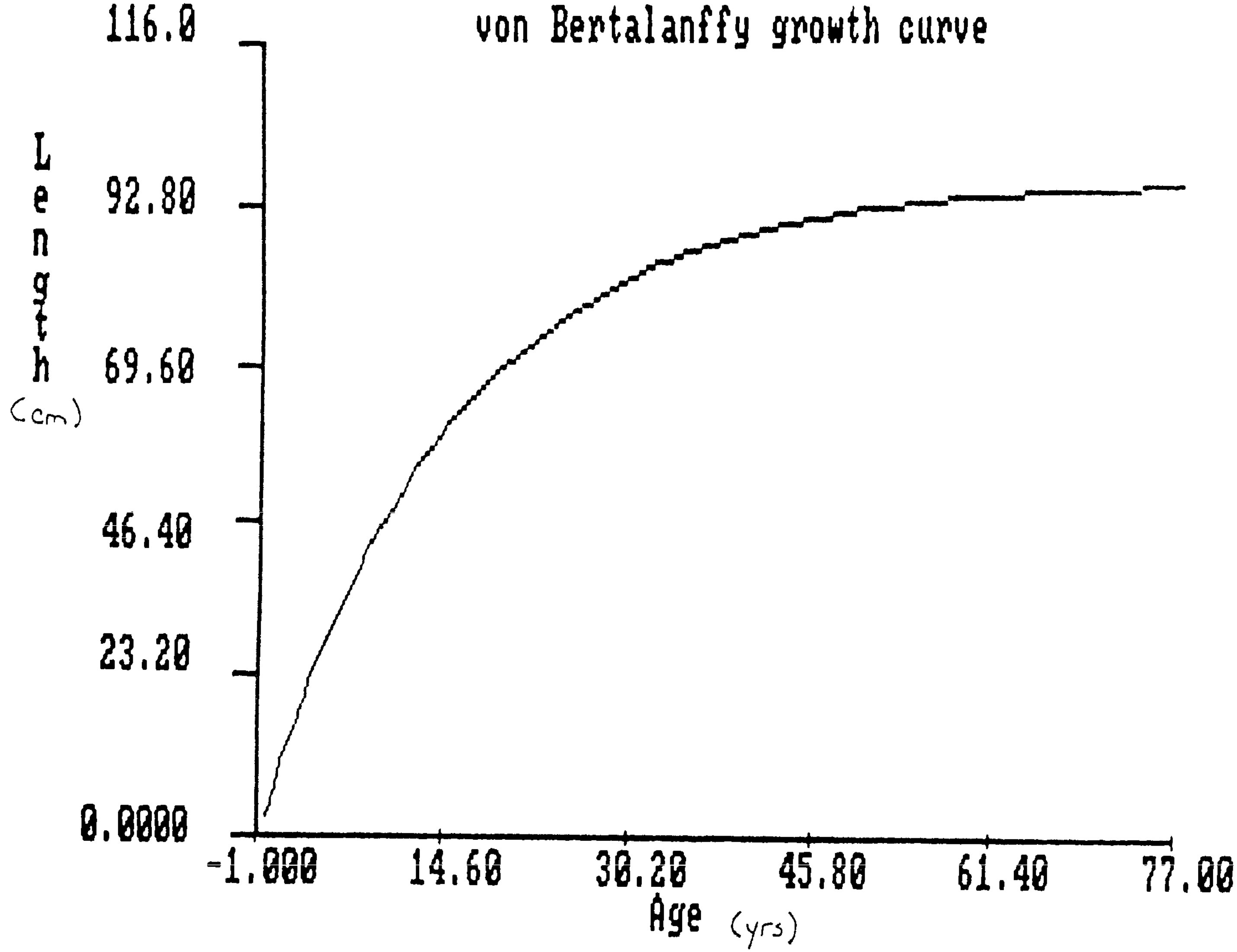
Table 1. Predicted parameters and age at lengths for CMTTP data.

Parameter Estimates		Asymptotic Std Error	CV
A	+9.674+01	+1.718E-04	0.000
K	+6.368E-02	+3.529E-07	0.000
t_o	-74.81E-01	+2.956E-05	-0.000
B	+.9538	----------	-----

AGE (yrs)	LENGTH (cm)
0	4.5
1	10.19
2	15.53
3	20.54
4	25.24
5	29.65
6	33.79
7	37.67
8	41.32
9	44.74
10	47.94
11	50.95
12	53.78
13	56.43
14	58.91
15	61.23
16	63.44
17	65.49
18	67.42
19	69.23
20	70.92
21	72.52
22	74.01
23	75.41
24	76.73
25	77.96
26	79.12
27	80.21
28	81.23
29	82.18
30	83.08
32	84.71
34	86.15
36	87.42
38	88.53
40	89.51
42	90.38
44	91.14
46	91.81
48	92.40
50	92.92


von Bertalanffy growth curve
Length (cm)
116.0
92.80
69.60
46.40
23.20
0.0000
-1.000
14.60
30.20
45.80
61.40
77.00
Age (yrs)

239

CAPE CANAVERAL AIR FORCE STATION SEA TURTLE PRESERVATION PROGRAM

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In 1984, the U.S. Air Force initiated a program to protect and conserve sea turtles nesting on Cape Canaveral Air Force Station (CCAFS), Florida. As a Federal agency, the Air Force is required to protect threatened and endangered species in accordance with Section 7 of the Endangered Species Act. Biologists with Johnson Controls World Services (JCWS), the Launch Base Support (LBS) contractor, implement a program consisting of conservation, protection and management of sea turtles and their nests.

The beach at CCAFS provides prime nesting habitat for Atlantic loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtles. Survey results show that nesting activity on CCAFS contributes significantly to the annual loggerhead sea turtle productivity in the State of Florida. The 1993 nesting season was characterized by a decrease in loggerhead and green turtle crawl activity; however, the number of nests that successfully hatched was the second highest season total since surveys began on CCAFS. This poster describes the CCAFS program and summarizes the results of the 1993 sea turtle nesting season.

STUDY AREA AND METHODS

The survey area comprises the entire eastern Atlantic shore of CCAFS, approximately 21 kilometers in length (Figure 1, Kilometer Section Map). The beach is characterized by a high energy surf zone, a gently sloping sandy beach, and a substantial dune system. Each of the 21 kilometer sections is delineated into five 200-meter sectors. These sectors serve as reference points for all marine turtle activity recorded on CCAFS.

The CCAFS beach is included in the State Index Nesting Beach Survey and all nesting survey activities are conducted as outlined in FEDP beach indexing protocol. Nesting surveys are conducted seven days per week, May - September, beginning at 0700 hours. New nests are sequentially numbered using wooden survey stakes placed near the nest site. In addition, the following activities are also performed: nest fate determination, including clutch evaluation, installation of light shields, disorientation documentation, predator control, in situ nest protection, and stranding documentation.

RESULTS AND DISCUSSION

The 1993 CCAFS crawl survey identified a total of 4,254 adult female loggerhead turtle emergences (Table 1, 1993 Marine Turtle Nesting Summary). One thousand nine hundred sixty (1,960) emergences resulted in egg deposition. A nest to non-nesting ratio was calculated to be 1:1.2. This represents a 17% decrease from 1992; however, loggerhead turtle nesting activity in 1993 was still higher than the nine-year (85-93) average of 1,811 nests (Figure 2, Loggerhead Nests Deposited, 85-93). A total of 13 green turtle emergences were observed in 1993, with five resulting in egg deposition. This represents a 90% decrease from the 55 nests deposited in 1992; however, green turtle nesting has been shown to be highly variable from one year to the next.

Nest productivity was determined by excavation of undisturbed clutches which had resulted in successful hatchling emergence. One hundred thirty loggerhead nests were excavated with clutch size ranging from 70-154 eggs. Average clutch size was 110, with an average emergence of 98 hatchlings (89%) per nest. Two green turtle nests were excavated and both contained 152 eggs. Average emergence was 138 hatchlings (91%) per nest.

Nest fate determinations were made for 1,944 loggerhead nests and five green turtle nests. Of these, 1,488 loggerhead and three green turtle nests successfully hatched and emerged. Raccoons continued to be the major predator of sea turtle nests on CCAFS in 1993, along with feral hogs and bobcats. Predation of 243 loggerhead nests by raccoons, 100 by feral hogs, and 2 by bobcats was observed. No green turtle nests were disturbed by predators. Twenty-nine loggerhead nests were lost as the result of tidal inundation/erosion, and 28 were located in dune vegetation roots and failed to hatch. In addition, 10 nests contained infertile eggs, 44 nests failed to hatch for unknown reasons, and 16 nests could not be found.

Sea turtle nest predation by raccoons and feral hogs continues to be a problem on CCAFS (Figure 3, Nest Disturbance by Raccoons and Feral Hogs, 85-93). Predator control techniques include trapping and removal of raccoons and feral hogs, and installation of predator control screens on in situ nests. In addition, Security Police and the Florida Hog Hunter's Association remove feral hogs through periodic hunting activities. A total of 152 raccoon and 83 feral hogs were removed from CCAFS during 1993. Twenty-nine loggerhead nests and five green turtle nests were covered by wire mesh in 1993; all were successful in deterring predators.

A total of 18 loggerhead nests were disoriented by artificial light sources on CCAFS in 1993. No green turtle nests were affected by lighting. Approximately 544 hatchlings were disoriented, of which 245 (45%) were able to re-orient and reach the ocean. This represents a 1% hatchling incidental take, which is below the 2% authorized by the U.S. Fish and Wildlife Service (USFWS) Biological Opinion for the 1993 season. Figure 4 summarizes disorientation incidents observed on CCAFS since 1987. The USFWS authorizes the use of portable light shields as a temporary method of reducing hatchling disorientation. Erected landward of the nest cavity, these shields block illumination from disorienting light sources. During the 1993 season, biologists deployed shields at 695 nest sites (690 loggerhead and five green turtle nests) in areas known to be affected by artificial lighting. Only seven of the 695 nests shielded showed signs of disorientation. These incidents occurred beyond the influence of the shield. To further address disorientation, the Air Force has developed Light Management Plans (LMP's) for facilities known to be sources of disorientation. These plans direct the removal of excessive lights, replacement with low pressure sodium light fixtures, operational constraints, and the shielding of exterior lighting directly visible to the beach. Projects to implement the LMP's have been completed, resulting in a significant decrease in lights visible from the beach and the reflective glow generated by inland light sources. The Air Force's light management program is the only activity of this type and magnitude known to be implemented specifically for the protection of nesting and hatchling sea turtles.

CONCLUSION

After analyzing the results of the 1993 season, the primary goal for the 1994 nesting season will be to reduce the overall depredation rate and continue efforts to minimize hatchling disorientation. The Air Force continues to improve sea turtle nesting habitat by removal of concrete armoring and funding of additional light management projects. The future of marine turtle nesting on CCAFS continues to be promising with additional projects to restore nesting habitat and implement light management requirements.

TABLE 1
1993 MARINE TURTLE NESTING SUMMARY
CAPE CANAVERAL AIR FORCE STATION, FL

CRAWL SURVEY	Loggerhead	Green
Nests	1,960	5
False Crawls	2,294	8
Total	4,254	13
NEST PRODUCTIVITY		
Average Clutch Size	110	152
Average Number Emerged	98	138
Hatchlings Produced	146,020	414
Average Incubation Period	52 days	51 days
NEST FATES		
Nests Monitored	1,960	5
Successful Emergences	1,488	3
Nest Failures		
Raccoons	243	0
Feral Hogs	100	0
Bobcats	2	0
Tidal Inundation/Erosion	29	0
Other	82	2
Undetermined Fate	16	0

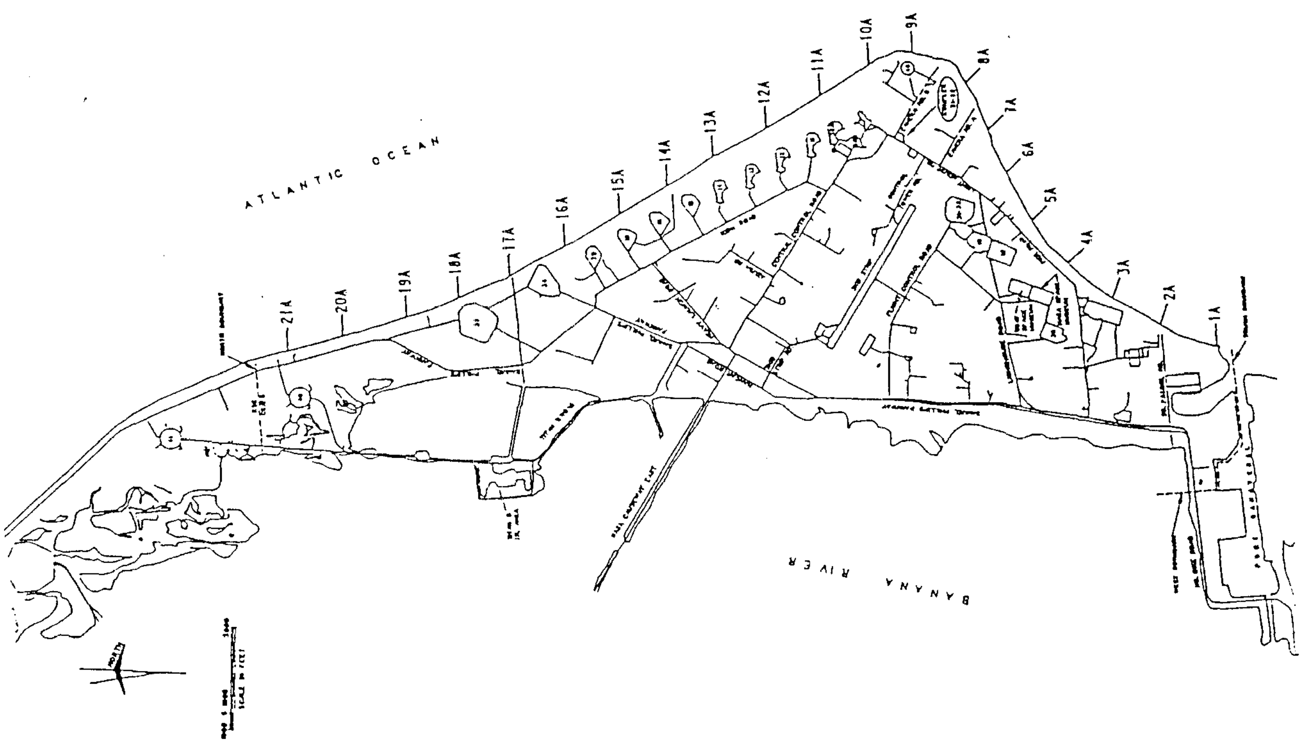


Figure 1.
Kilometer Section Map, CCAFS

Figure 2. LOGGERHEAD TURTLE NESTS DEPOSITED, CCAFS 1985-1993

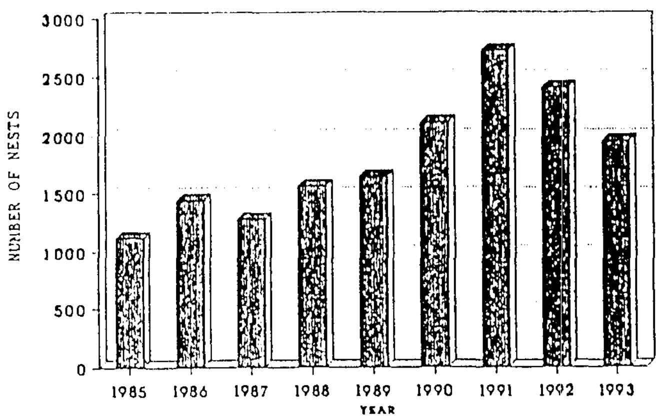


Figure 3. LOGGERHEAD TURTLE NEST DISTURBANCES BY RACCOONS AND FERAL HOGS CCAFS, 1993

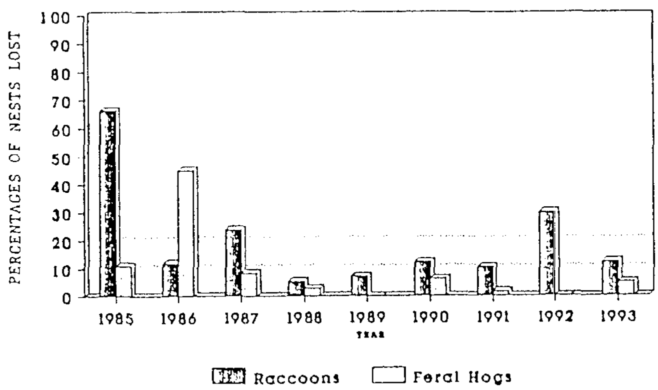
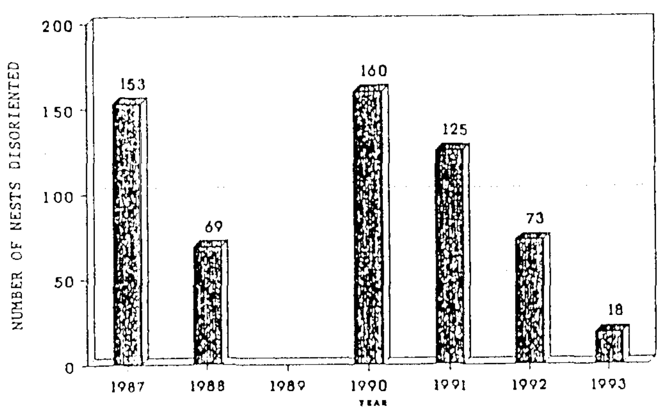


Figure 4. SEA TURTLE HATCHLING DISORIENTATION, CCAFS 1987-1993



* No data available for 1989.

* Light management plans went into effect in 1990.

LEPIDOCHELYS OLIVACEA'S SEX PATTERN YIELD IN OPEN HATCHERY

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The phenomenon of temperature sex determination (TSD) has been confirmed in seven of the eight marine turtle species. Moreover, it has been demonstrated that the species studied present a similar pattern: in low temperatures males are produced, while high temperatures produce females, and medial temperatures produce both (an even) sex ratio in the same nest (Janzen and Paukstis, 1991).

Although the TSD phenomenon in marine turtles is relatively well known, the sex ratio regulatory mechanisms of populations are unknown. This paper deals with sex ratios that were produced in one common central hatchery on the beach in the 1991 nesting season.

METHODS

The study area was located in the "Zone of Ecological Reserve and Site of Refuge for the Marine Turtles Playón de Mismaloya", state of Jalisco, Mexico (20°00' N, 105°29' W).

Three sensors (thermocouples) were buried in the sand 40 cm deep in the open hatchery (two in opposed corners and one in the middle). Daily, during the study period, both the maximum and minimum sand temperatures were recorded. The three sensors were calibrated periodically against a mercury centigrade thermometer. Twenty five nests were selected, and ten hatchlings from each nest were sexed according to Van der Heiden et al. (1985) and Vogt and Flores-Villela (1992).

RESULTS AND DISCUSSION

Overall 25 nests were sampled, and 250 hatchlings were sexed: 204 females and 46 males. The dates of the nestings were from 9 August to 16 November 1991.

The sex ratio of analyzed organisms changed throughout the nesting season. The nests incubated in the hatchery from August to the beginning of October yielded 100% females; turtles from nests incubated during October were 63.33% females and 36.66% males; and the nests incubated beginning in November yielded 100% males (Fig. 1). The stationary of the sex ratio in hatchlings of marine turtles has been demonstrated in other studies (Benabib-Nisenbaum, 1984; Mrosovsky et al., 1984; Mrosovsky and Provancha, 1992; Provancha and Mrosovsky, 1988).

The sex ratio yielded in the open hatchery during the study period, estimated from the different sex ratios observed, the nesting abundance, and survival percent, was of 4:1 skewed to female (Table 1).

Marine turtle conservation programs have been criticized because the transfer of eggs of natural nests to protected sites on the beach could result in different incubation temperatures, and therefore alter the wild population sex ratio (Mrosovsky and Yntema, 1980). In the Playon de Mismaloya beach, 80% of nests are depredated by men and only 20% of nests are protected in open hatcheries. This situation started twenty years ago. The only population recruitment during this period has been from the open hatcheries. The sex ratio in wild populations and their regulatory mechanisms are unknown; therefore, the impact of these protection techniques on the wild populations also are unknown.

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Table 1. Monthly hatching success, sexes and nest abundances.

	Nests	Incubated Eggs	Emerged hatchlings	Hatching Success %	Female	Male
July*	22	2186	1231	56.31		
August	165	16165	11950	73.93	11950	0
September	147	13575	11184	82.39	11184	0
October	94	8827	6344	71.87	3172	3172
November	51	4715	3127	50.8	0	3127
Total	479	45468	33836		26306	6299

• Sex not computed

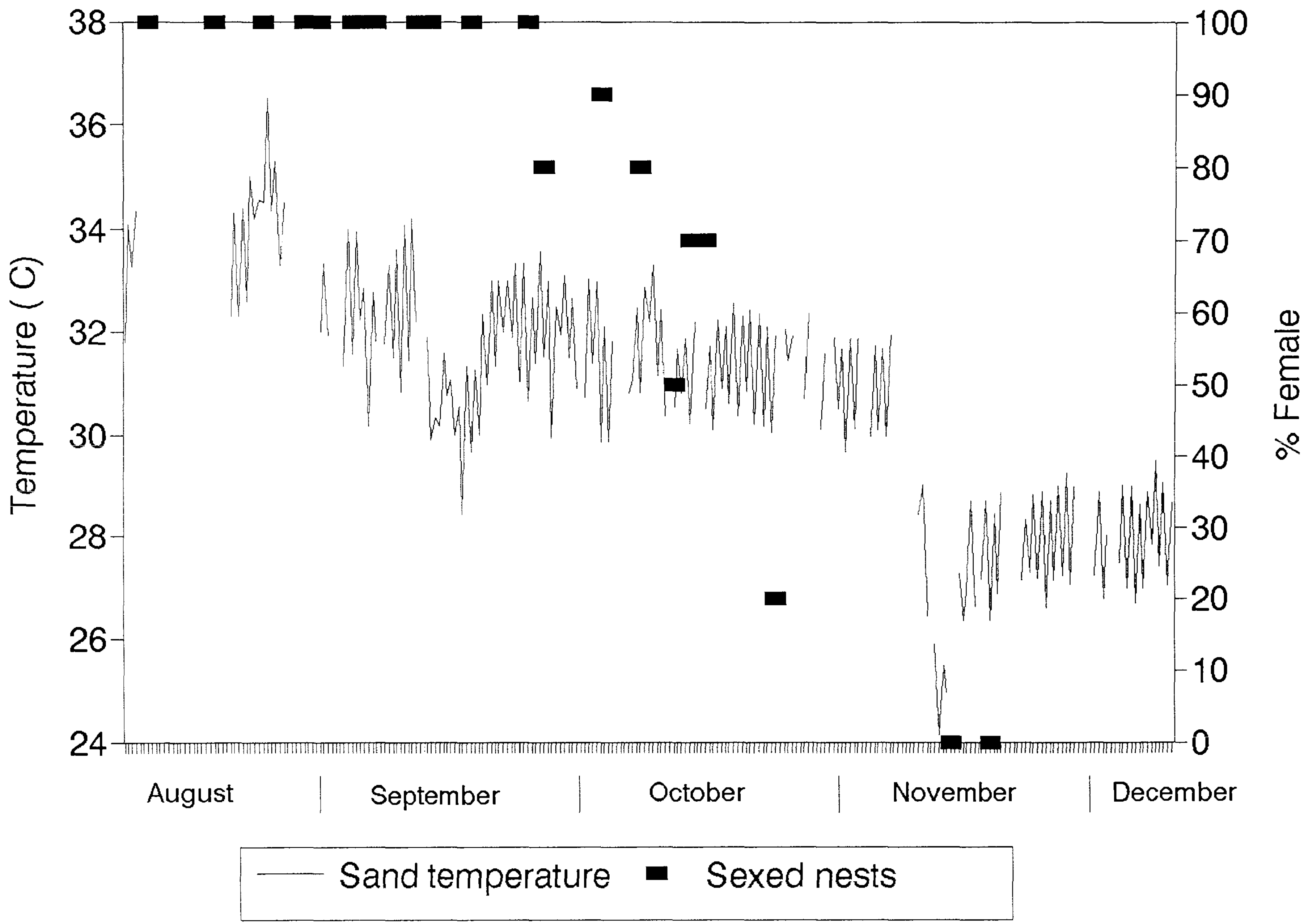

Figure 1. Sand temperature and sex ratio of sampled nests (marks are date nesting)

1993 COURSES ON SEA TURTLE BIOLOGY AND CONSERVATION IN VENEZUELA

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During 1993, three short courses on sea turtle biology and conservation were organized in Venezuela. The first of them was the Second Course for Park Rangers, in this opportunity from the Morrocoy National Park (Falcon State). It took a day and several aspects of sea turtle biology and monitoring techniques were covered. A total of ten persons participated, mainly Park rangers.

The II Course on Sea Turtle Biology and Conservation was held between July 26-30, in the School of Applied Marine Sciences (ECAM) of the Universidad de Oriente (Boca del Rio, Isla de Margarita, Edo. Nueva Esparta). The course was under the auspices of INPARQUES, CCEXU-UDO-NE, Universidad de Oriente, Nucleo Nueva Esparta (UDO-NE) and the Wider Caribbean Sea Turtle Conservation Network (WIDECAST). We had 20 participants from the Universidad de Oriente, Universidad Simon Bolivar, a technology institute, Ministry of Agriculture and Husbandry (MAC), Coastal Vigilance Detachment (DEVICOFAC 910), Los Roques Scientific Foundation (FCLR), PRO VITA, the Fauna Service (PROFAUNA-MARNR) and INPARQUES Nueva Esparta. The course had theoretical, practical (including surveys of two nesting beaches) and video sessions.

The III Course was in Maracaibo (Zulia State), between November 9-11, in the facilities of the Ministry of the Environment and Natural Renewable Resources (MARNR). The course was under the auspices of INPARQUES, the Fauna Service (PROFAUNA-MARNR, Zulia), the Ministry of the Environment and Natural Renewable Resources (MARNR-Zulia), the Wider Caribbean Sea Turtle Conservation Network (WIDECAST) and Conservation International (CI). Twenty-eight persons participated from the Universidad del Zulia, the Ministry of Agriculture and Husbandry (MAC), MARNR-Zulia, the Fauna Service (PROFAUNA) and INPARQUES Zulia. The course had theoretical, practical and video sessions.

The IV Course on Sea Turtle Biology and Conservation is planned for July 30 - August 4, 1994 in the School of Applied Marine Sciences (Universidad de Oriente, Boca del Rio, Isla de Margarita). The course will be under the auspices of INPARQUES, CCEXU-UDO-NE, Universidad de Oriente, Nucleo Nueva Esparta (UDO-NE), the Work Group in Sea Turtles of Venezuela (GTTM), WIDECAST and Conservation International.

ACKNOWLEDGMENTS

We are deeply grateful to several persons and organizations that provided several types of support: Karen L. Eckert (WIDECAST), Scott A. Eckert (Hubbs-Sea World Research Institute), Richard B. Byles (USFWS), Roderic Mast (Conservation International), John G. Frazier (CINVESTAV), FUDENA, Jo Williams (NMFS), Maria A. Marcovaldi (TAMAR), Julio C. Zurita (CIQRO), Javier Alvarado (Universidad de Michoacan), George Balazs (NMFS), Anne B. Meylan (DNR), PROFAUNA, Mosquito Coast, Quimica Venoco, Carbones del Guasare and Maraven.

THE CLEARWATER MARINE SCIENCE CENTER'S ROLE IN SEA TURTLE CONSERVATION

Glenn R. Harman

Clearwater Marine Science Center, Florida 34630 USA

This poster attempts to illustrate the efforts put forth by the Clearwater Marine Science Center to protect loggerhead (*Caretta caretta*) sea turtle nests in Pinellas County. The poster also illustrates the effects of the oil spill in 1993 and the efforts contributed by the Science Center to both clean oiled turtles as well as protect nests from the oil that was washing ashore.

The Clearwater Marine Science Center is a non-profit organization in Clearwater, Florida dedicated to the rescue, rehabilitation and release of sea turtles and marine mammals that strand in the Gulf of Mexico.

ACKNOWLEDGMENT

Some of the pictures displayed in this poster were taken by Dr. Anne Meylan.

DECLINE OF OGASAWARA GREEN TURTLE POPULATION IN JAPAN

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The Ogasawara Islands (N 27:33-28:44) are located at the northern edge of green turtle rookeries in the western Pacific region. When Japanese first colonized the islands in 1876, the government encouraged the green turtle fishery. The fishery records show a steady decline from the 1880-1890s when around 1,000-1,800 adult turtles were harvested for the most years until the mid-1920s when fewer than 250 were caught each year (Figure 1). During the American occupation, 1945-1972, the harvest effort was reduced because of fewer inhabitants: 20-80 turtles each year. Since the return of the islands to Japan in 1973, the annual harvests fluctuated from 45 to 225 turtles. Current beach census data show that 170 to 649 clutches were deposited in the islands each year, 1985-1993. If we assume that a female deposited four clutches during a season, only 43 to 162 nesting females were estimated to have survived through each season. The Ogasawara green population has already declined because of the past commercial exploitation. If the current level of fishery effort continues, the population will be depleted soon.

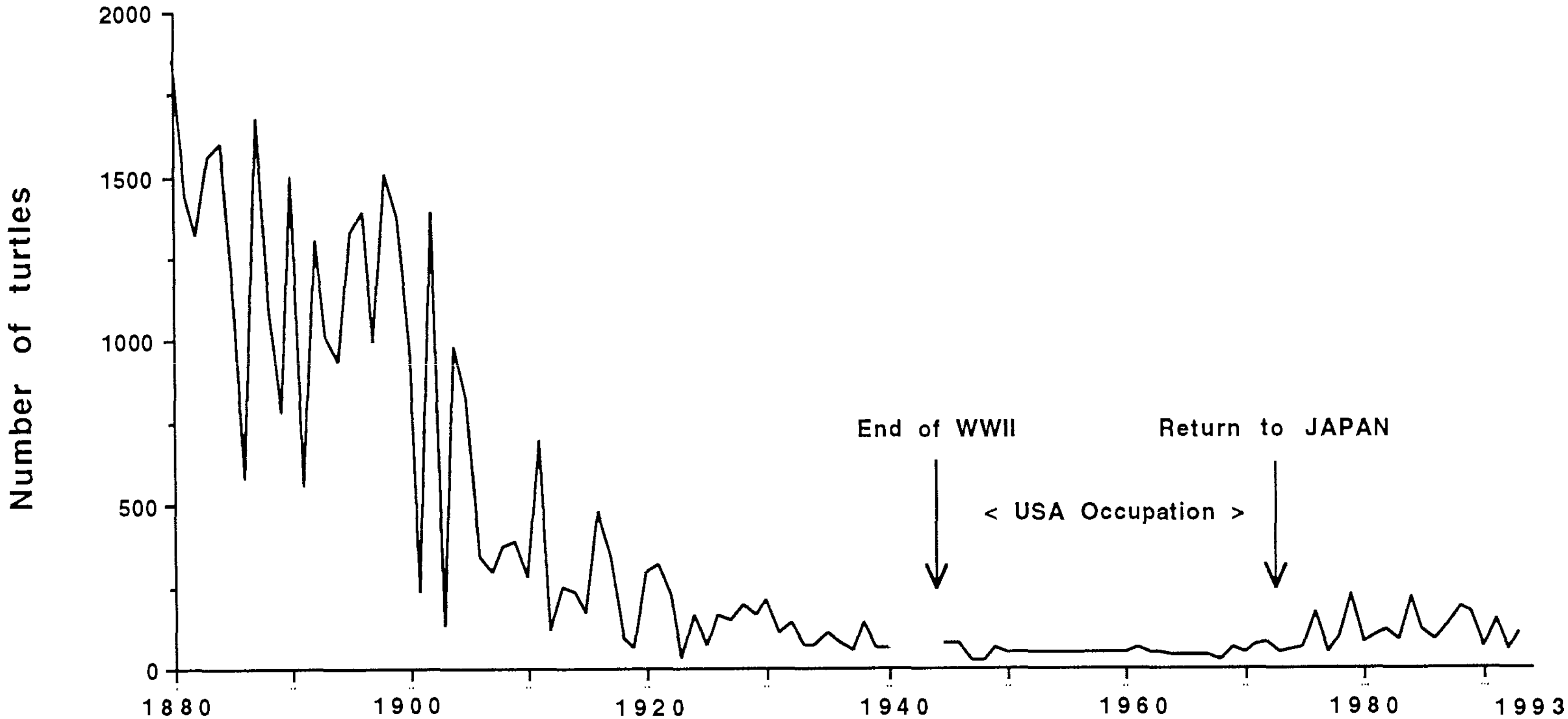

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Figure 1. Histrical decline in Ogasawara green turtle population as reflected in the numbers of turtles caught each year.

THE EFFECT OF BEACH FEATURES ON HATCHLING LOGGERHEAD SEA TURTLES

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This study investigates how loggerhead (*Caretta caretta*) hatchlings deal with objects encountered in their beach-to-ocean crawl. During nesting the majority of female turtles locate some kind of vegetative cover or dune into which they lay their eggs. Later, upon emerging, hatchlings must quickly orient themselves through vegetation and other debris to reach the ocean (Hosier et al., 1981). This experiment is based on the fact that hatchling sea turtles must quickly orient to the ocean to avoid stress and predation. Therefore, the length of time the hatchlings spend on the beach dealing with the debris and other obstacles is critical to their survival.

METHODS

This project was conducted through a three-part experiment consisting of Area A (cleared of all beach debris), Area B (natural beach debris), and Area C (human traces and tracks). Each hatchling entering the area was timed. Hatchlings' paths and major changes in orientation were charted. Throughout the experiment any stops made or difficulty encountered was recorded.

RESULTS AND DISCUSSION

The results of this experiment showed that hatchlings experienced greater difficulty in areas B and C due to the introduction of obstacles. Large objects caused hatchlings to momentarily stop and change direction while no changes in course were noted with smaller objects. Findings suggest that hatchlings have different methods of dealing with different obstacles. Sand formations and seagrass (wrack line) caused considerable difficulty and were navigated through trial and error while other obstacles were dealt with more effectively. The response from this experiment shows that hatchlings, after exiting the nest cavity, waste no time in orienting in the most direct seaward path even when confronted with obstacles. Findings suggest that although hatchlings have developed a very efficient method of dealing with most beach topography, clearing the areas in front of hatcheries and nests would facilitate ocean access.

LITERATURE CITED

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SEISMIC AND VERY LOW FREQUENCY SOUND INDUCED BEHAVIORS IN CAPTIVE LOGGERHEAD MARINE TURTLES (*CARETTA CARETTA*)

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Little is known about the hearing range of marine turtles and even less is known how they use their hearing in surviving. These animals possess ear structures similar to that of stem reptiles, from which modern reptiles, birds and mammals have evolved. It is very likely then, that a sense of hearing proved to be advantageous in biological adaptation.

The electrical responses of the ear, i.e. cochlear potentials, yield a reasonable estimate of the frequency and intensity range of hearing in reptiles (Wever, 1978). The cochlear potential audiogram for *Chelonia mydas*, performed by Ridgway et al. (1969) is redrawn in Figure 1. These data were collected for air conduction hearing. An audiogram for a marine species in air is informative, in that sexually mature females spend a portion of their lives on shore, but that time is relatively short. Turtles do surface to breathe and, as a consequence, the eardrum is near the air/water boundary. The effect of water loading the eardrum, with varying degrees of pressure has not been studied. Placing a turtle underwater changes the mechanical impedance matching demands of the ear, hence the sensitivity. Using the air-water cochlear potential threshold difference for *Terrapene carolina* (Wever, 1978) as an approximate correction factor, the projected underwater audiogram of *Chelonia mydas* also appears in Figure 1.

Audiograms can be divided into three parts, the upper frequency range, the range of maximum sensitivity and the lower frequency range in which hearing feeling and seismic/gravity reception merge. The area of maximal sensitivity in marine turtles is from 100 to 800 Hz. The upper limit is about 2000 Hz. Hearing below frequencies of 80 Hz is less sensitive, nonetheless potentially serviceable to the animal. Behavioral responses to low frequency stimulation will be assessed in this pilot study.

METHODS

Two Atlantic loggerheads (*Caretta caretta*), weighing about 25-30 kg were maintained in separate circular tanks 1m in depth. Turtles were acclimated to the tank before testing. A specialized water coupled speaker (Vibra-Coustics) was placed next to the tank, coupling the water bladder of the speaker to the tank wall. A low frequency accelerometer (1-200 Hz) was placed at the abutting surfaces. A second accelerometer (.5 Hz-1gHz) was affixed to the opposite tank wall. The first accelerometer monitored the transfer of acoustic pressure into the tank and the second the interaction of the speaker with tank mechanics. A hydrophone was also suspended in the tank to measure sound pressure.

Testing did not initiate until the turtle exhibited a repeatable breathing cycle of surfacing about every ten minutes. Following breathing the turtles would rest on the bottom. After the turtles were on the bottom and motionless for two minutes, low frequency sound was presented continuously near maximal output of the amplifier, but below the point of overdriving distortion as monitored by accelerometer input into a real time spectral analyzer. Tones at 1/3 octave intervals (20, 25, 31.5, 40, 80 Hz) as well as linear ramps over the same frequency range were employed. The saltwater loaded tank did interact with the low frequency tones such that overtones were produced 20-30 dB down from the fundamental. No attempt to attenuate the overtones was made during this preliminary study. Sound stimulation terminated after one minute or upon activation of the turtle. Five trials were run in clear water and five in algae clouded water to control for inadvertent visual cues.

RESULTS

Both turtles always responded to low frequency sound by swimming. The typical response to the onset of sound was to swim to the surface and remain there or stay slightly submerged. No animal returned to the bottom or stopped swimming. The maximal level of sound stimulation delivered to the tank is depicted as vibration (and labeled "startles") in Figure 2. The zero dB reference is displacement re: one micrometer RMS. Ridgway et al. (1969) placed a vibrator on the eardrum of *Chelonia mydas* and produced a vibration (bone conduction) audiogram. His data are also redrawn in Figure 2. Note that the sound energy that elicited the startle responses are within the measured hearing range.

DISCUSSION

Stimuli from 30 to 80 Hz are probably treated as auditory in the sense that the inner ear is likely the strongest responder. The ear anatomy of *Caretta caretta* suggests that since the saccule is connected to the middle ear bone by fibroelastic strands (Lenhardt et al., 1985) this otolith organ is also stimulated by low frequency sound when the eardrum is displaced. Such displacement would be present in the intense sound field of the tank and was certainly present in eliciting cochlear potentials (Ridgway et al., 1969). It is quite possible that only the saccule (or perhaps the lagena too) is responding in this low range since neurons in the auditory brainstem have center frequencies no lower than 140 Hz (Manley, 1970). The lower frequency response of some units with 140 Hz center frequency extend only to 50 Hz and only if the stimuli are of sufficient intensity. It is also possible that there is an increasing degree of overlap between saccular and auditory neural tuning in these low frequencies. Auditory and otolith organs are not the only possible receptors. With the frequencies and driving intensities employed, whole animal displacement is possible. Bodily displacement could also be differentiated by eardrum phase response difference and coded in eight nerve discharge patterns.

For frequencies under 40 Hz somatosensory receptors on the skin and around internal organs that can be set into sympathetic resonance with low frequency sound are also sources of neural activation. Sound, at comparable levels, could also activate the semicircular canals, which might induce positional disturbance. The turtle could lessen the effects of the sound by staying near the air/water boundary, which appears to be the overwhelming response.

Sounds between 100 and 800 Hz can be detected at lower energy levels and are likely purely auditory. Far field evoked potentials have been recorded from loggerheads (see Moein et al. this volume) and thresholds using clicks delivered by a vibrator affixed to the eardrum are in good agreement with cochlear potentials thresholds (see Figure 2). Evoked potentials can also be recorded with the turtle submerged in sea water. The difference in far field evoked potential voltage between the animal in either medium is approximately 10 dB, adding external validity to the 10 dB less sensitivity estimate of the ear underwater contrasted to the ear in air.

The use of sound stimulation in the range of maximal sensitivity has been disappointing in that consistent responses were not observed placing into doubt the feasibility of an acoustic repellent. Although limited to data on two animals in tanks, the use of very low frequency and seismic frequencies is promising. Since the patented speaker used in this study is an air type modified with a water coupling (Alton, 1994), mounting the speaker against the inside of a boat hull would result in efficient delivery of sound underwater bypassing the problems of conventional underwater sources as projectors and air/water guns. The cost of a hull mounted water coupled speaker would be economically viable for commercial marine operations.

ACKNOWLEDGMENTS

Sound Related Technologies of Virginia Beach VA kindly supplied the Vibra-Coustics hydrocoupled loudspeaker, animal maintenance costs were partially offset by a Grant-in-Aid to the author from Virginia Commonwealth University and the laboratory facilities were graciously provided by the School of Marine Science of the College of William and Mary.

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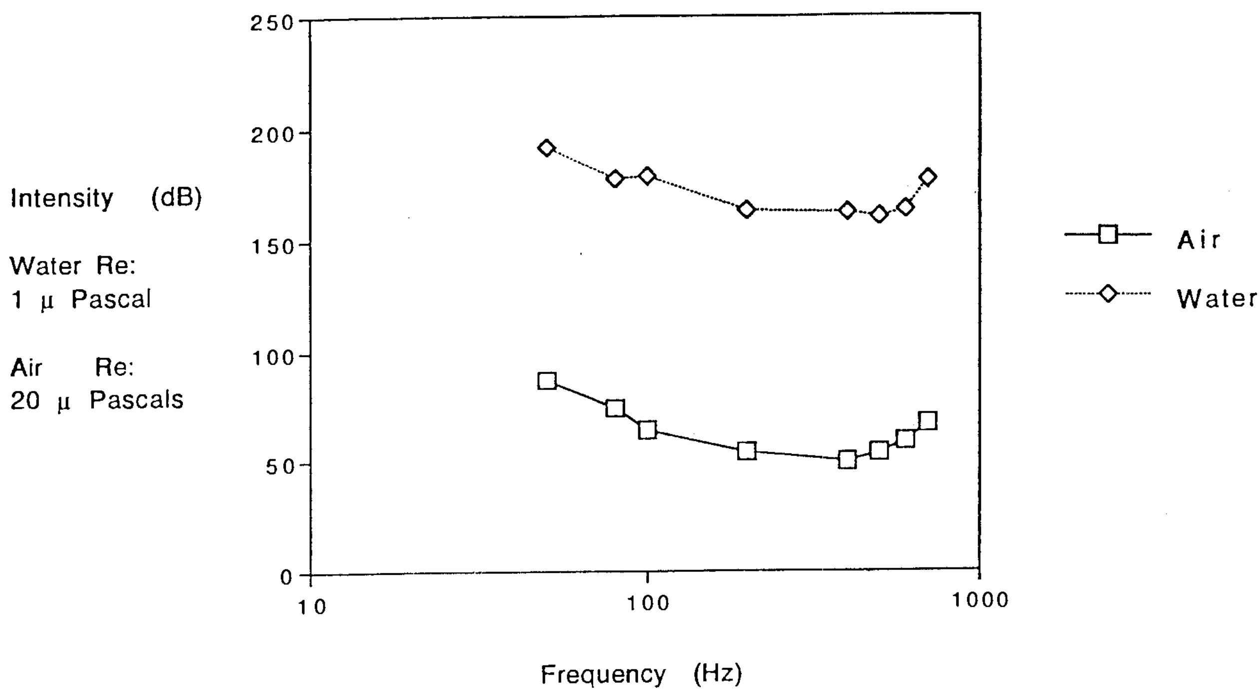
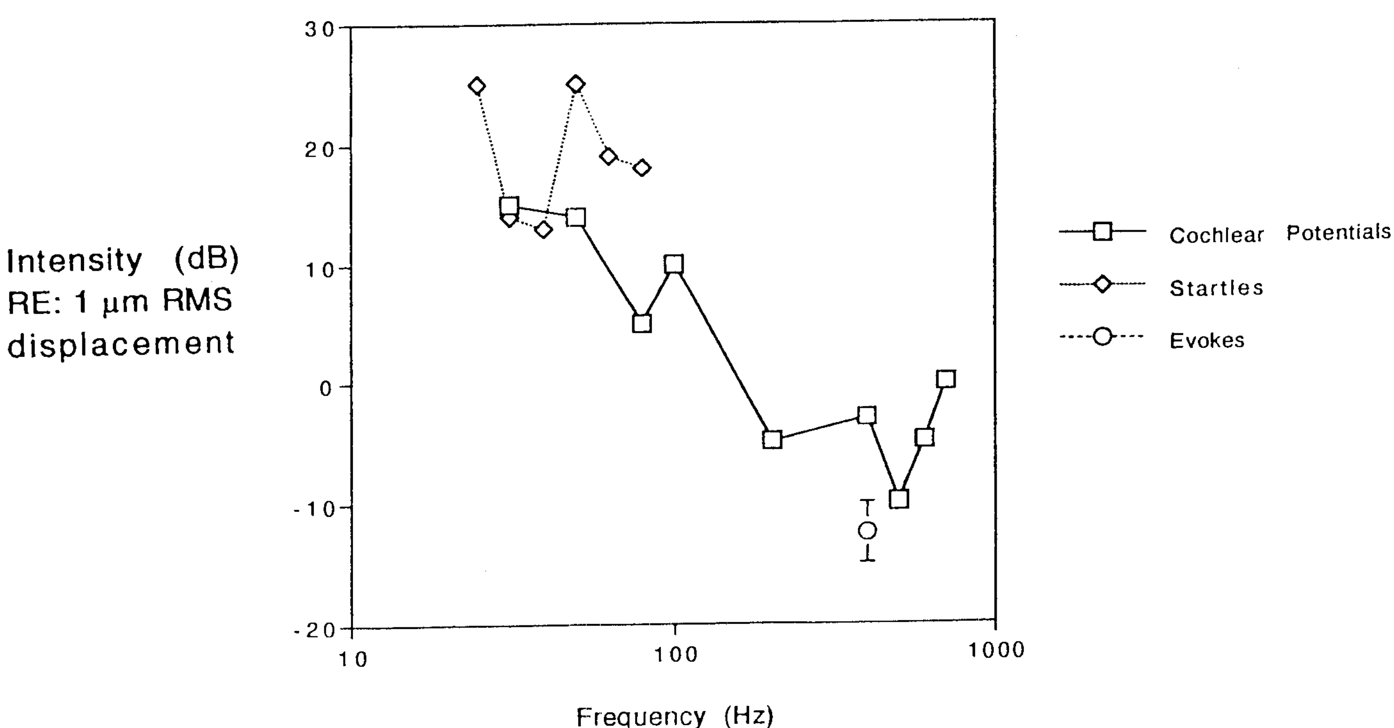
Wever, E.G. The Reptile Ear. Princeton U. Press, 1978.

Turtle Audiogram



SEA TURTLE HEARING



EFFECTS OF PREDATOR CONTROL ON SEA TURTLE NEST SUCCESS ON THE BARRIER ISLANDS OF APALACHICOLA BAY

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The loggerhead sea turtle (*Caretta caretta*) is a threatened species worldwide. It is not known if the Southeastern U.S. coast and Gulf of Mexico (GOM) represent separate or one large nesting aggregation (NMF and USFWS 1991). In either case, undeveloped beaches in the Northeastern GOM provide important habitat for maintaining the historic nesting distribution of the loggerhead sea turtle. Two such beaches are protected on separate islands of the Apalachicola Bay, FL.

The recovery plan for the U.S. population of loggerhead sea turtles (NMF and USFWS 1991) identifies twelve threats to nesting environments. Nesting depredation is the only serious threat on Cape St. George (CSGI) and St. Vincent (SVI) islands. This sole threat can be reduced substantially through predator control and proper nest management. We include St. George Island (SGI), a developed island, to elucidate low predation rates due to predator dependence on human derived food items such as garbage and pet food.

STUDY AREA

Apalachicola Bay, located along the panhandle of FL is enclosed by four barrier islands. They include Dog, SGI, CSGI, and SVI islands. We conducted our study on sea turtle nesting beaches monitored by ANERR and SVNWR staff on the latter three islands. These barrier islands are important loggerhead nesting areas in the Northeastern GOM.

SGI is a narrow, part private and part state owned island. The section of SGI monitored includes approximately 17.7 km of privately owned residential beach. CSGI is a narrow, 931 hectare, island generally unaltered by human development. It contains 14.97 km of nearly pristine nesting beach. The state owns and manages CSGI as part of the ANERR. SVI is an undeveloped, 5,003 hectare, federally owned island managed by the USFWS. Unlike most barrier islands SVI is triangular with extensive upland and freshwater lake ecosystems and has 14.48 km of nearly pristine nesting beach.

METHODS

On SVI we conducted beach patrols daily. On CSGI patrols were done weekly in 1992 and 2-3 times/week in 1993. ANERR staff responded to public observations on SGI to protect nests there. Patrols occurred May-October on all beaches. We protected nests with self-releasing screens. We checked nests weekly for signs of predation and hatching. Raccoons (*Procyon lotor*) and feral hogs (*Sus scrofa*) are the primary nest predators on SVI and CSGI. Raccoons also pose threats to nests on SGI. SVI conducts an aggressive predator control plan employing trapping, public hunts, and control by staff. Very little predator control is done on CSGI and SGI.

RESULTS AND DISCUSSION

The principle sea turtle nest predator in the U.S. is the raccoon (NMF and USFWS 1991, Ehrhart and Witherington 1987). Feral hogs are also serious nest predators. Prior to control, hogs destroyed 45%

and 90% of nests at Canaveral Air Force Station, FL and Ossabaw Island, GA, respectively (NMF and USFWS 1991). Nest predation rates and predator harvest (Tables 1 and 2) suggest that both predators occur in sufficient numbers to severely impact nest success on both SVI and CSGI. Raccoons are also abundant on SGI (personal observation).

CSGI experienced 73% and 33% nest depredation in 1992 and 1993, respectively and totaled 41% depredation over two years. Without nest protection few nests would survive. Increased nest patrols and a slight increase in predator control in 1993 contributed to the reduction in depredated nests. SVI by comparison experienced 17% and 28% nest depredation in 1992 and 1993, respectively and totaled 25% depredation over two years. Predator control efforts allowed 15 of 25 (60%) nests where staff did not locate eggs to survive until hatching on SVI. The diverse nature of SVI supports larger predator populations than CSGI. An interagency fire management review team noted widespread disruption of habitats by hogs and characterized the raccoon population as superabundant. Without predator control losses would be substantially higher on SVI. In contrast, SGI experienced 0% nest depredation although raccoons are abundant. The raccoons rely heavily on garbage and pet food (personal observation).

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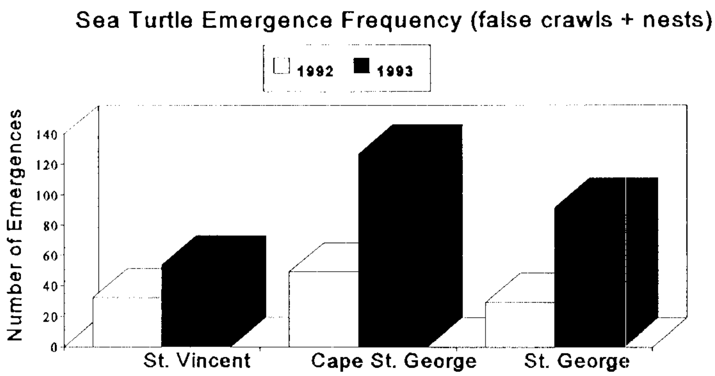
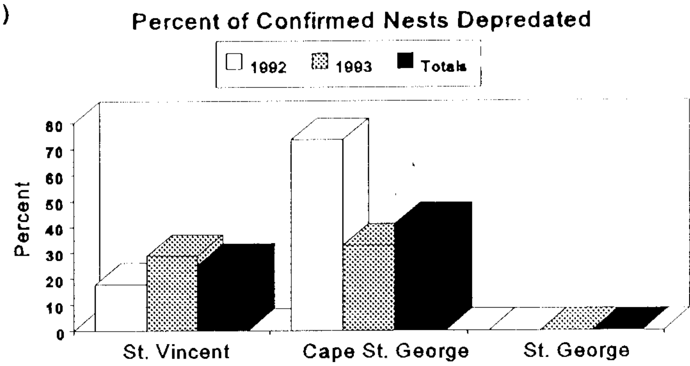
Table 1

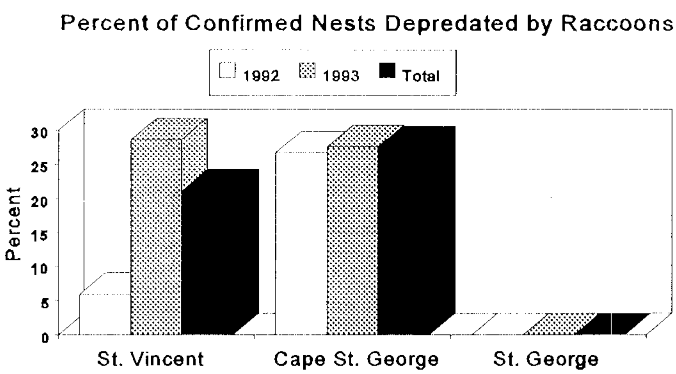
Sea Turtle Nesting and Predator Activity	St. Vincent			Cape St. George			St. George		
	1992	1993	Total	1992	1993	Total	1992	1993	Total
Emergences (false crawls + nests)	32	54	86	49	127	176	29	92	121
Confirmed Nests (eggs present)	17	35	52	15	58	73	14	61	75
Screened Nests (All nests protected with self-releasing screen)	11	18	29	6	28	34	14	61	75
Screened Depredated Nests(Nests which were depredated in spite of screening)	2	2	4	5	1	6	0	0	0
Partially-Depredated then Screened Nests	1	1	2	1	5	6	0	0	0
Screened and undepredated (no depredation after screening)	8	15	23	1	27	28	14	61	75
Un-screened Depredated Nests(totally depredated when found)	1	3	4	9	30	39	0	0	0
Unscreened Partially Depredated at Hatching	0	4	4	0	0	0	0	0	0
Unscreened and undepredated	5	10	15	0	0	0	0	0	0
Totally Raccoon Depredated Nests	0	3	3	3	11	14	0	0	0
Partially Raccoon Depredated Nests	1	7	8	1	5	6	0	0	0
Unsuccessful Raccoon Attempts	2	4	6	0	0	0	0	0	0
Totally Hog Depredated Nests	1	0	1	7	3	10	0	0	0
Partially Hog Depredated Nests	1	0	1	0	0	0	0	0	0
Unsuccessful Hog Attempts	0	2	2	0	0	0	0	0	0
Combined Totally Depredated Nests	1	3	4	10	14	24	0	0	0
Combined Partially Depredated Nests	2	7	9	1	5	6	0	0	0
Overall Depredated Nests	3	10	13	11	19	30	0	0	0

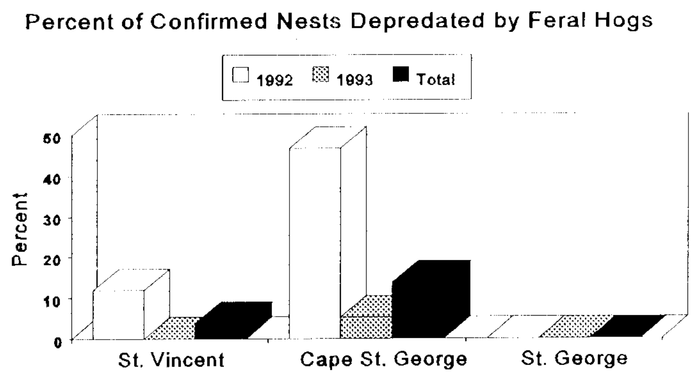
Table 2

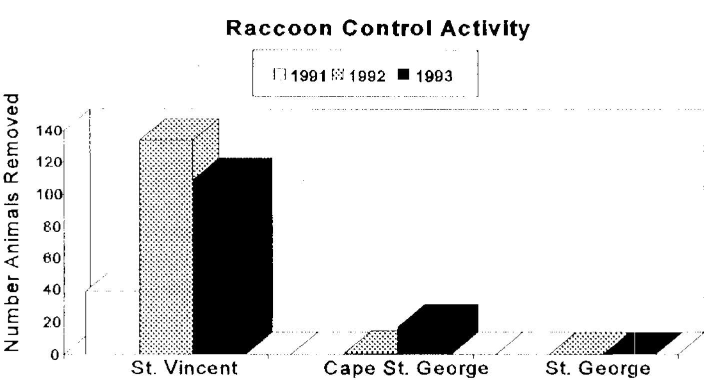
Predator Control Activity	St. Vincent				Cape St. George				St. George			
	1991	1992	1993	Total	1991	1992	1993	Total	1991	1992	1993	Total
Agency Raccoon Control	36	133	106	275		1	16	17	0	0	0	0
Public Raccoon Control	3	1	3	7		0	1	1	0	0	0	0
Total Raccoon Control	39	134	109	282		1	17	18	0	0	0	0
Agency Feral Hog Control	7	40	68	115		0	5	5	0	0	0	0
Public Feral Hog Control	82	65	43	190		2	0	2	0	0	0	0
Total Feral Hog Control	89	105	111	305		2	5	7	0	0	0	0

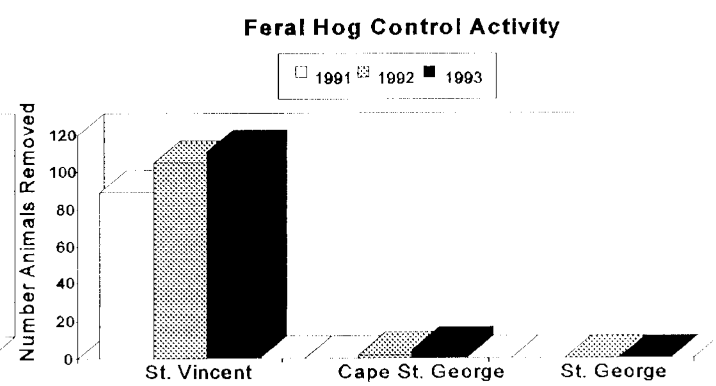

Sea Turtle Emergence Frequency (false crawls + nests)
1992
1993
Number of Emergences
0
20
40
60
80
100
120
140
St. Vincent
Cape St. George
St. George


Percent of Confirmed Nests Depredated
1992
1993
Totals
Percent
0
10
20
30
40
50
60
70
80
St. Vincent
Cape St. George
St. George


Percent of Confirmed Nests Depredated by Raccoons
1992
1993
Total
Percent
0
5
10
15
20
25
30
St. Vincent
Cape St. George
St. George


Percent of Confirmed Nests Depredated by Feral Hogs
1992
1993
Total
Percent
0
10
20
30
40
50
St. Vincent
Cape St. George
St. George


Raccoon Control Activity
1991
1992
1993
Number Animals Removed
0
20
40
60
80
100
120
140
St. Vincent
Cape St. George
St. George


Feral Hog Control Activity
1991
1992
1993
Number Animals Removed
0
20
40
60
80
100
120
St. Vincent
Cape St. George
St. George

MARINE TURTLE POSTAGE STAMPS OF THE WORLD

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Postage stamps offer an excellent and novel means of promoting the conservation of sea turtles, as well as stimulating an interest in their biology. The popularity of issuing stamps depicting sea turtles has increased considerably during recent years. When the list was published in the Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation in 1990 (Balazs et al., 1990), there were known to be 285 stamps from 77 countries. The most recent version of the list (as of 1 January 1994) features 416 stamps from 90 countries and territories.

Chelonia mydas is the most popular species, featured on 123 stamps, followed by *Eretmochelys imbricata* on 106, *Dermochelys coriacea* on 41, *Caretta caretta* on 31, *Lepidochelys olivacea* on 11, *Lepidochelys kempi* on 4, *Natator depressus* on 2, and the prehistoric Archelon on 2. The remaining stamps feature what might be called a "generic" or stylized sea turtle, either not identifiable to a particular species, or shown as a drawing or cartoon.

The majority of the stamps feature the sea turtle as their main subject, with others featuring the turtle as part of the stamp's background or border design. Both the Cayman Islands and the Solomon Islands have a sea turtle in their Coat of Arms; 27 stamps show the turtle in this manner, sometimes barely visible to the unaided eye. Sea turtles on coins and currency are visible on 7 stamps which show those items; 5 sea turtle stamps are featured as "stamps-on-stamps".

Many of these stamps are quite beautiful, with some of the more recent additions reflecting an increased awareness and interest in the sea turtle's behavior, depicting nest digging, egg laying and hatchling activity. On the other hand, 7 stamps show turtles being chased, restrained, netted or stepped on; 2 even show them killed or being butchered by fishermen.

With only modest expense and effort, it is now possible for the amateur philatelist and sea turtle enthusiast to assemble a substantial collection of attractive and interesting stamps. It is hoped that even more such stamps will be issued during coming years, including ones from the United States, Australia, and others not yet featuring this topic on their postage.

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SEA TURTLE ACTIVITY SURVEY ON ST. CROIX, U.S. VIRGIN ISLANDS (1992-1993)

Amy L. Mackay

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Three species of marine turtles utilize the beaches of the United States Virgin Islands (USVI): the green turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and leatherback (*Dermochelys coriacea*). Historically, these species have been important components in the culture and economy of the USVI. The commercial slaughter of adults for their shell and/or meat and the consumption of eggs have been implicated in the sharp decline of sea turtle populations in the USVI (Eckert, 1989). Today, islanders will tell you stories about how abundant sea turtles were less than fifty years ago. In my own family, I have heard stories of the markets where green turtles were held in large corrals, awaiting sale to provide ocean-going vessels with fresh meat.

St. Croix, the largest of the U.S. Virgin Islands, has many small and undeveloped beaches. Existing information on sea turtle nesting in St. Croix is fragmented and, at times, inaccurate. The unavailability of information on green and hawksbill sea turtle nesting is particularly pronounced. Therefore, regulatory agencies lack basic data on the status of sea turtle populations using the island. Without this information, it is impossible to prioritize and address specific conservation needs. This deficiency is even more regrettable when we consider the recent appearance of large-scale coastal development on St. Croix.

In 1992, a survey was initiated in order to establish which beaches on the island support sea turtle nesting. During the subsequent nesting season (1993), we expanded the survey in order to provide an accurate estimate of sea turtle activity on St. Croix. Future survey work will define trends in sea turtle populations and provide data for estimates of population abundance.

METHODS

In 1992, preliminary survey work was conducted from 1 July to 31 December. During this time, we worked to establish which beaches support sea turtle nesting. Coastal areas, which were later incorporated into the more comprehensive survey, were judged "possible nesting areas" during island-wide, on-site inspections. Interviews with officers from the USVI Bureau of Environmental Enforcement, long-time island residents, local fishermen, beach residents, and hotel owners also helped identify potentially important and active breeding sites for further study. The initial survey period was also used to develop methodology used in the subsequent nesting season.

In 1993, thirty-one beaches were monitored for sea turtle activity. Regular foot patrol commenced 1 July and ended 31 December. Beaches were patrolled as often as possible but the interval between patrols varied depending on how active the area was with respect to both turtle activity and daily beach traffic which might obscure turtle crawls. The interval between subsequent patrols ranged from as few as three days to as many as fourteen days. Five beaches were patrolled by local volunteers trained in sea turtle activity identification.

Whenever possible, patrols took place during the early morning hours in order to avoid beach traffic. This was especially important during the weekend when traffic was heaviest. During patrol, all turtle activity was identified to (1) species and (2) outcome (nest, false crawl, poached, depredated). Data collection also included potential threats to nest success such as artificial lighting, nest compaction, and erosion.

RESULTS AND DISCUSSION

In order to simplify this poster presentation, we have characterized each of the survey beaches according to the number of recorded sea turtle nests (of any species): 1) little or no nesting (0-10 nests) and 2) moderate nesting (10-30 nests) and 3) heavy nesting (greater than 30 nests). After two seasons of survey work, our data show that sea turtle nesting on St. Croix is widespread but the majority (65%) of the study sites are characterized by little or no nesting. Only two beaches (6%), Sandy Point National Wildlife Refuge (Henry, 1993) and Jack's Bay, support heavy nesting. The other nine beaches (29%) in the survey support moderate nesting. Hawksbill activities were recorded on twenty-five (81%) beaches while green turtle activities were documented on seventeen (55%) beaches.

Artificial lighting affected nest success on seven beaches and poaching was recorded on eight beaches. Predation by mongoose (*Herpestes auropunctatus*) was observed in hawksbill and green sea turtle nests (10 and 2, respectively) on Sandy Point (Henry, 1993) and in more than fifty percent of the hawksbill nests laid on Jack's Bay. The exotic mongoose was seen in other areas but predation was not observed. This phenomenon requires further study.

Overall, our survey methods proved effective but in some areas heavy beach traffic and beach maintenance made survey work difficult. On these beaches, sea turtle nesting may be higher than reported and threats to the population are pronounced. More frequent patrols would provide more accurate activity profiles in these areas.

It is clear that subsequent surveys will add to our understanding of sea turtle nesting in St. Croix. These data are crucial if we are going to evaluate potential damage to important habitats by coastal development. The past two years of survey work have begun to address conservation needs by establishing a list of important nesting areas. Additionally, we have begun to work with local hotel owners to mitigate problems created by artificial lighting. Yet, there is still much to do. More beach residents need to be trained in sea turtle activity identification and through education, we hope to encourage even greater community awareness of sea turtles.

ACKNOWLEDGMENTS

Major funding for this project was provided by the Division of Fish and Wildlife, U.S. Virgin Islands Department of Planning and Natural Resources. Additional technical support was provided by the U.S. Fish and Wildlife Service, Department of the Interior.

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GEORGIA SEA TURTLE STRANDING AND SALVAGE NETWORK: 1979 - 1993

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Georgia has a 150 km coastline, consisting of a series of barrier islands separated by deep sounds and rivers. The vast estuarine systems of the state provide foraging opportunities for large numbers of sea turtles. Historically, in warmer months, these turtles experienced a negative interaction with shrimp trawlers. Resulting mortalities here and in other states precipitated the turtle excluder device regulations now in effect. GDNR also directed a program using public monies to purchase TEDs for every qualified shrimp trawler in the state. Stranding surveys are an index for determining relative mortality rates of sea turtles in the state.

METHODS

The Georgia Department of Natural Resources (GDNR) has coordinated the Sea Turtle Stranding and Salvage Network (STSSN) since 1980. Carol Ruckdeschel collated stranding data in 1979. Sampling effort has been consistent with the NMFS STSSN sampling protocol, and observer training has reduced the incidence of misidentification of species. Examinations of carcasses reveal probable cause of death in some cases and provide information on overall health of the turtle at the time of death.

RESULTS

From 1979 to 1993, 4024 sea turtles were reported by the stranding network in Georgia. In the period 1979-1988, an average of 309 sea turtles stranded in the state annually. Since 1989 (the "TED era") the average has dropped to 183. *Caretta* comprises the largest component of species breakdown, followed by *Lepidochelys kempi* and *Dermochelys* (Fig. 1). While loggerheads define the overall stranding "season," other species exhibit strandings patterns with distinct temporal (Fig. 2) and spatial characteristics (Fig. 3).

During the "TED era," monthly totals of stranded turtles have been lower than the historical average for that month (Fig. 4). With the TED induced reduction in total strandings, other threats to turtles in the water are more readily detectible. Examples include the mortality associated with dredging, the suspected mortality of shark drift-gill net bycatch and the occasional simultaneous arrival of migrating leatherbacks and roe shrimp in Georgia's offshore waters, which places the leatherbacks and other species at risk for incidental capture.

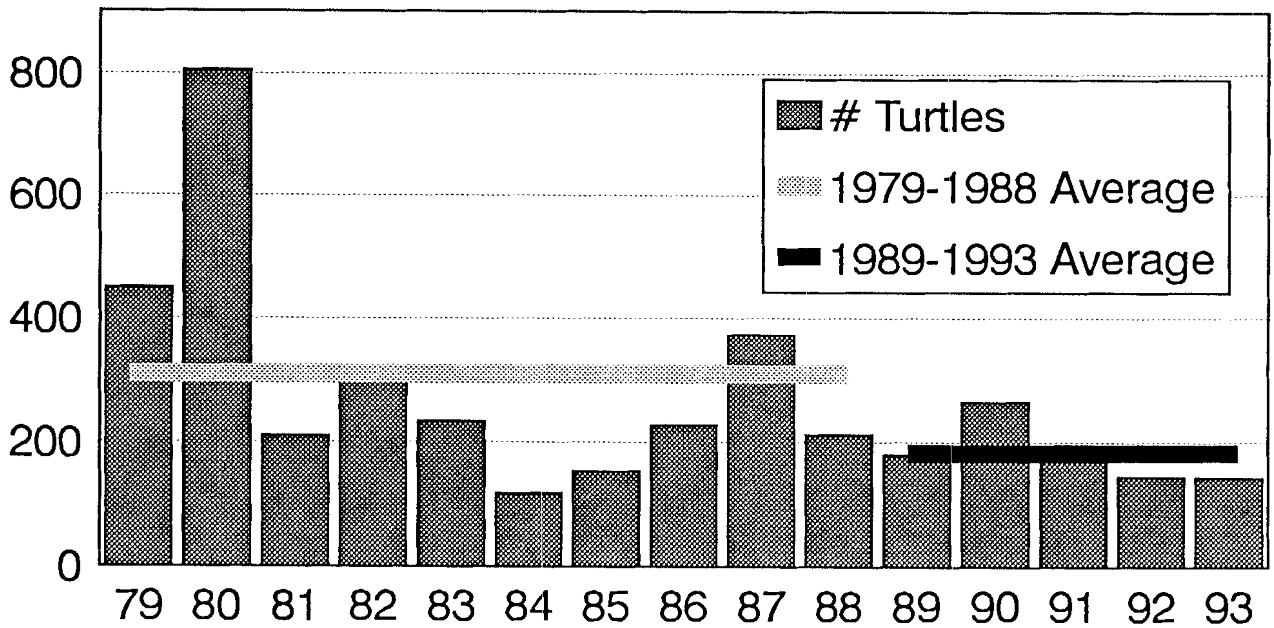
DISCUSSION

Implementation of TED rules in southeast U.S. waters has reduced, although not eliminated mortality of sea turtles. Recent surveys indicate a high level of compliance with TED regulations on the part of shrimp trawlers in Georgia. The U.S. Army Corps of Engineers has instituted a seasonal moratorium on channel dredging in the southeast U.S. to protect sea turtles. Observers will monitor gillnetters in waters offshore of Georgia beginning during the 1994 shark netting season. Aerial surveys are being conducted in the spring to alert shrimpers to the presence of leatherbacks in coastal Georgia and offshore, and NMFS technicians and fishermen have refined techniques to release large leatherbacks when incidentally captured. GDNR will continue to strive for reduction in human caused sea turtle mortality wherever possible.

ACKNOWLEDGMENTS

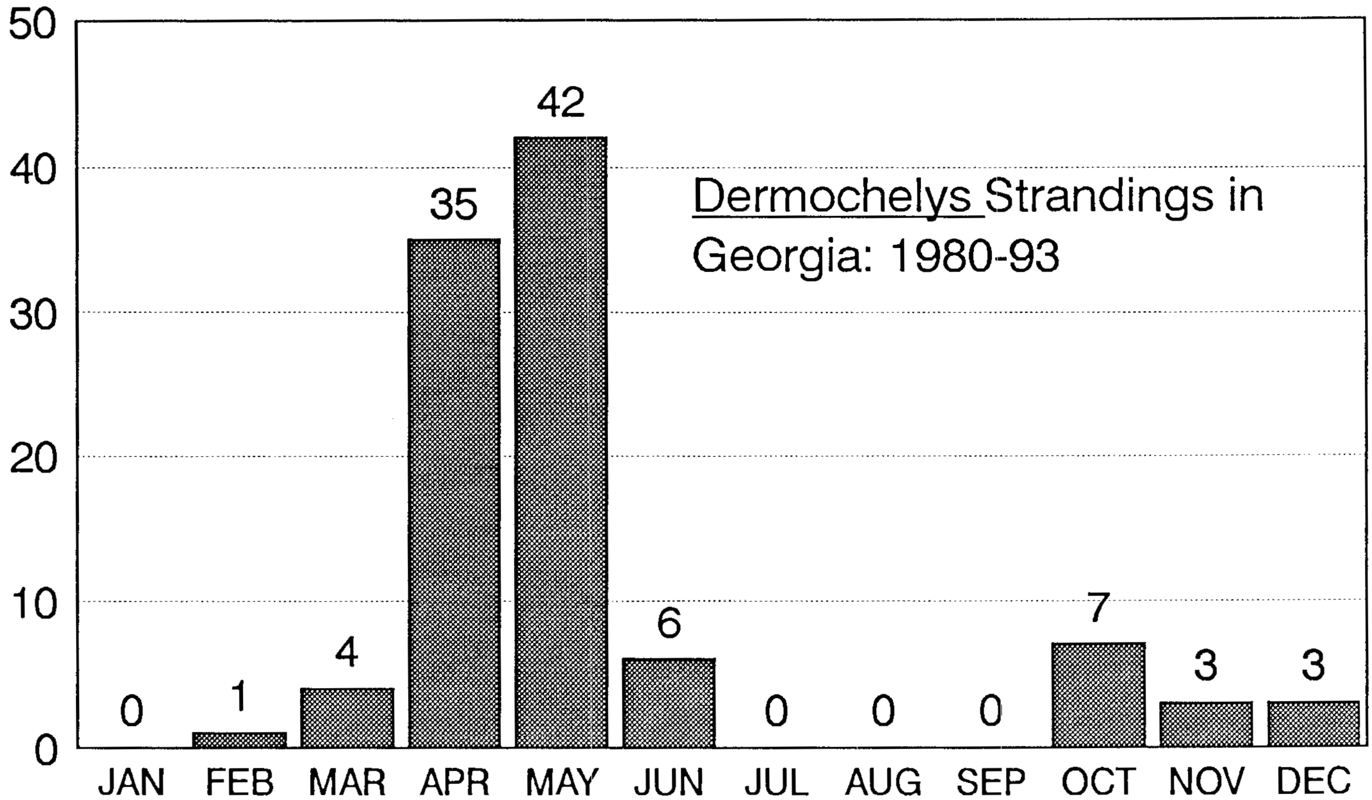
The authors would like to thank all the past and present volunteers of the GDNR STSSN. Their contributions are critical for the recovery of sea turtles in Georgia and the western Atlantic.

Fig. 1 Sea Turtle Strandings (all species) in Georgia: 1979-1993



• **TOTAL ALL SPECIES**	**4024**
• **Loggerheads**	**3508**
• **Kemp's ridleys**	**277**
• **Leatherbacks**	**102**
• **Greens**	**25**
• **Hawksbills**	**3**
• **Unidentified**	**109**

Figure 2. Temporal Distribution of Sea Turtle Strandings in Georgia



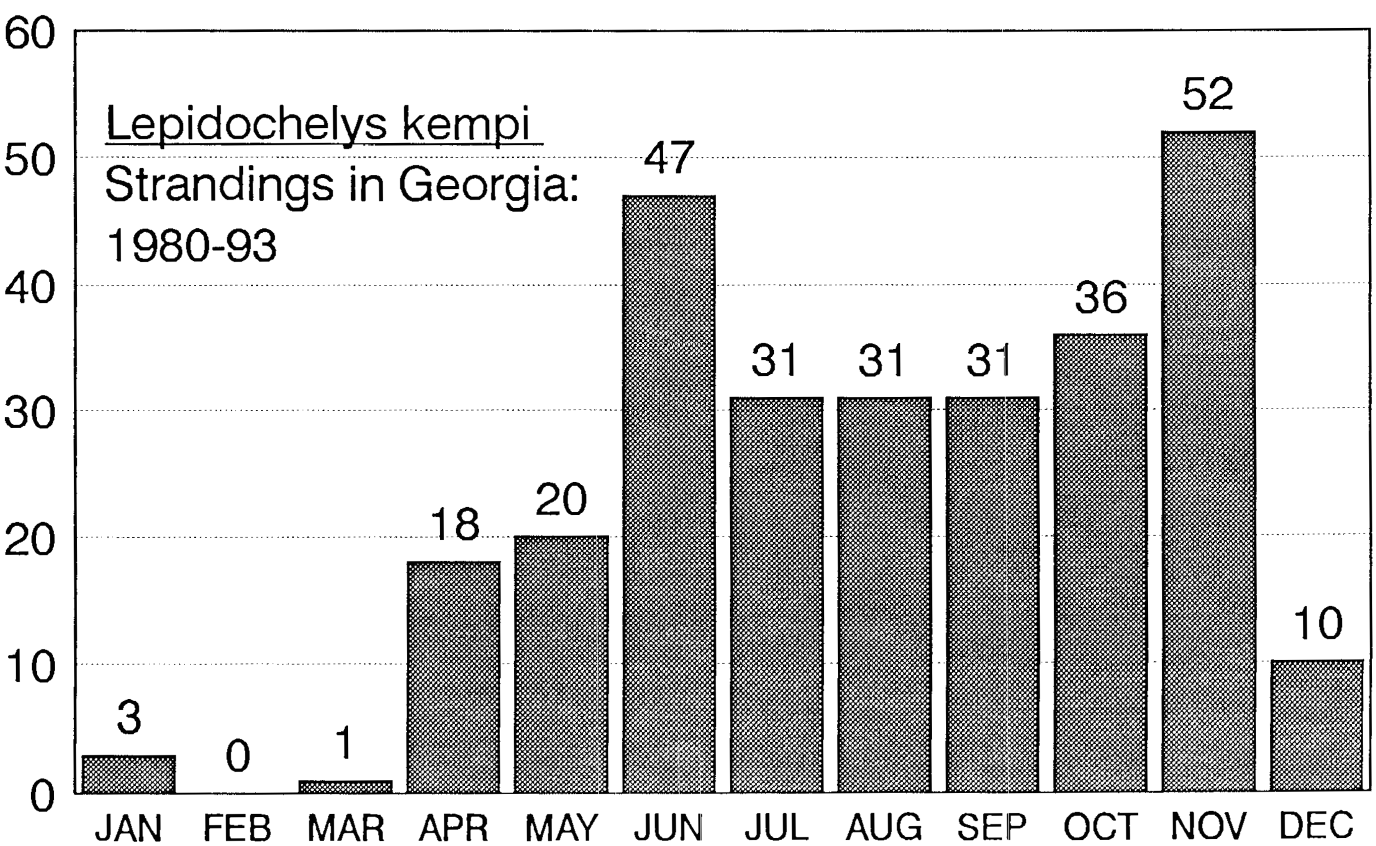


Figure 3. Distribution of Marine Turtle Strandings in Georgia by County (%)

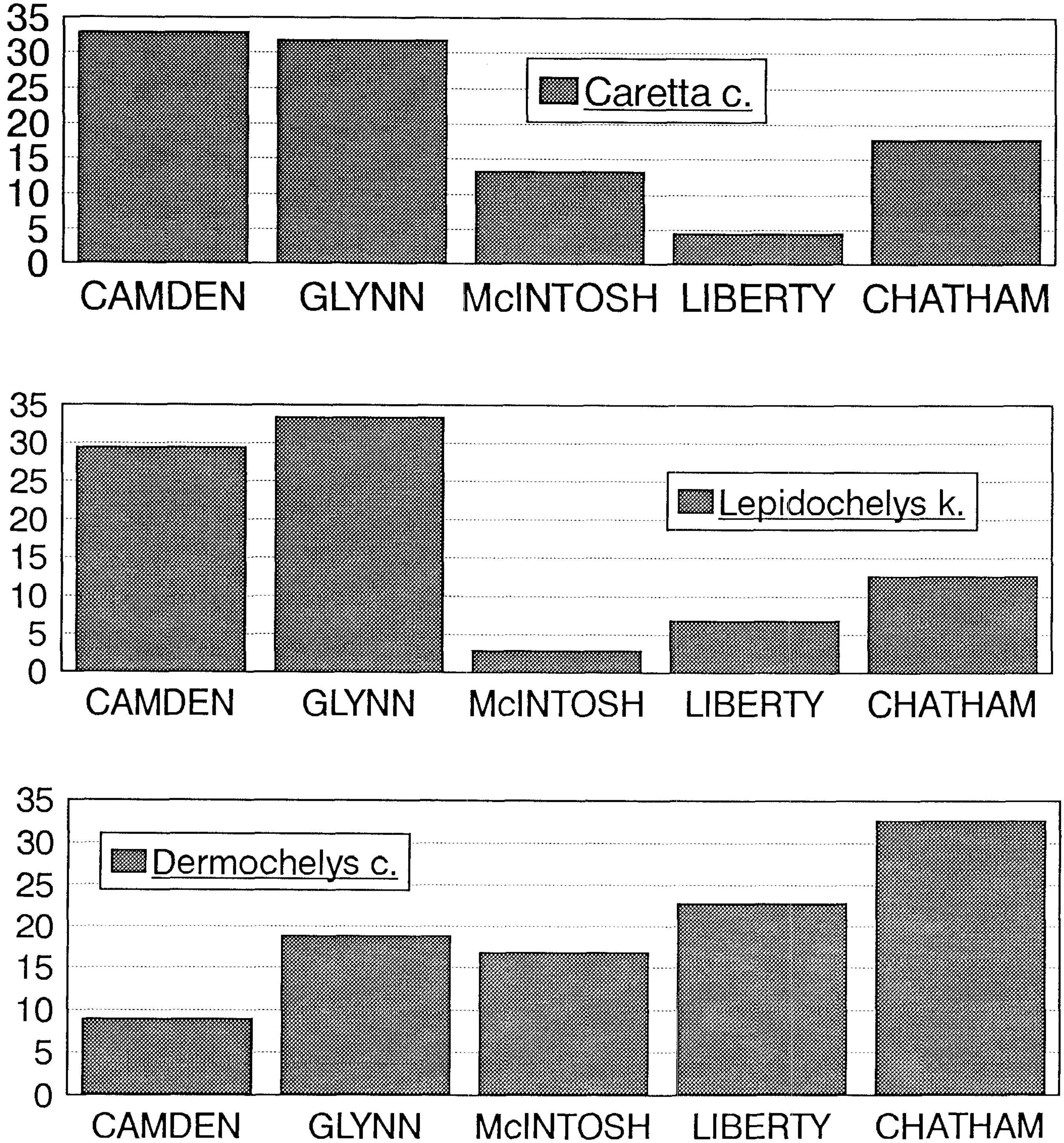
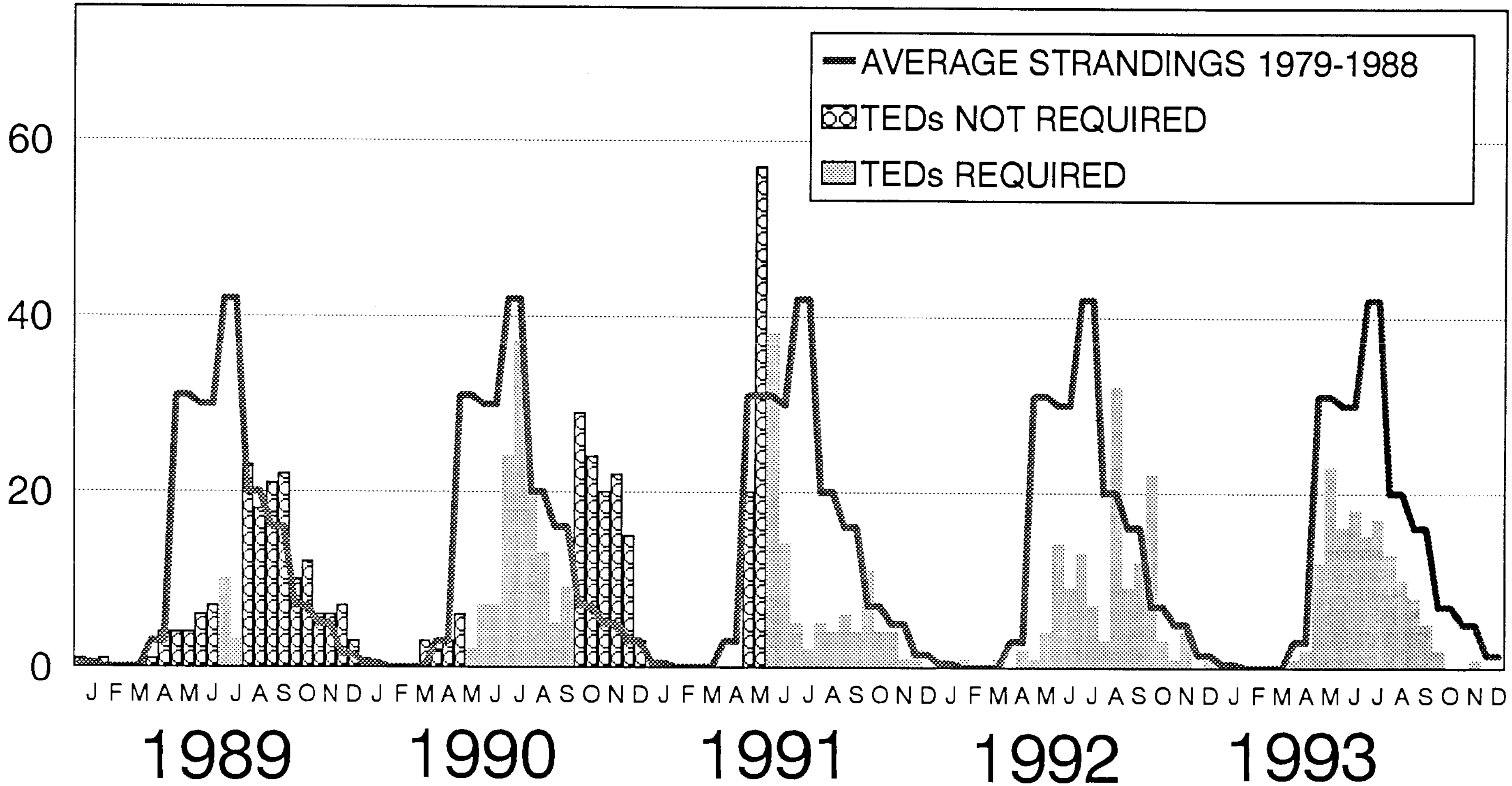


Fig. 4 STRANDINGS OF MARINE TURTLES IN GEORGIA BEFORE AND AFTER TEDs



TEDs have been successful in reducing turtle strandings. The overall reduction in strandings allows for the recognition of mortality trends which can be addressed by refinements to fishing gear or other management actions.

A RETROSPECTIVE STUDY OF KEMP'S RIDLEY (*LEPIDOCHELYS KEMPI*) AND LOGGERHEAD (*CARETTA CARETTA*) IN THE AREA OF THE NORTHEAST STRANDING NETWORK AND ASSOCIATED CLINICAL AND POSTMORTEM PATHOLOGIES

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The New England Aquarium (NEAq) is the northernmost institution in the East Coast Stranding Network. The NEAq responds to all strandings of sea turtles from Boston, north. The Massachusetts Audobon Wellfleet Bay Wildlife Sanctuary, responds (with the help of volunteers and local organizations [C-MARC]) to all turtle strandings in Massachusetts south of Boston and on Cape Cod. All live turtles from this area are transported to NEAq for treatment and short term holding. Once stabilized the turtles are transported to Marineland of Florida for further treatment and release.

Three species of turtles strand most frequently in this area. Leatherback turtles, *Dermochelys coriacea*, generally strand in the mid-summer through fall, randomly distributed, but predominantly on ocean facing beaches of Cape Cod. Kemp's ridley, *Lepidochelys kempi*, and loggerhead, *Caretta caretta*, strand predominantly in Cape Cod Bay during the early winter.

The purpose of this retrospective study was to examine the locations, frequencies and sizes of Kemp's Ridley and Loggerhead turtles that live stranded on Cape Cod, Massachusetts from 1985-1993. Additionally, a systematic postmortem evaluation was performed on mortalities from the 1993 stranding season. 1993 survival rates for each species are presented.

METHODS

All live turtles stranded on Cape Cod, MA, are recovered and transported to the New England Aquarium. The exact stranding locations, dates of stranding, weights and measurements were recorded. {this refers to all live stranded turtles from 1987-1993, the remaining methods and subsequent results pertain only to animals recovered during the 1993 stranding season}

Upon arrival physical examinations were performed, blood was drawn and radiographs were taken (these results are not included in this paper). Subsequent diagnostic tests and treatments were performed as necessary. Some animals received Computer Aided Tomography scans and Magnetic Resonance Imaging scans as indicated by their medical conditions.

Animals were housed in various sea water recirculating systems, initially at a water temperature no greater than 10^{o}F above current ocean temperature. Water temperature was raised slowly over 1-2 months. Animals were initially fed a diet of live green and/or rock crabs but were weaned onto a diet of previously frozen squid, capelin and herring.

On-site necropsies were performed on all animals that died while under our care. Tissues samples were saved from all necropsied animals, however, histological examinations were performed only in cases where autolysis was minimal (9 out of 15 cases). Bacterial and fungal cultures were initiated when appropriate.

RESULTS

Stranding Locations

During the years of 1989-1993 Kemp's Ridley turtles stranded most frequently on the eastern shore of Cape Cod bay.

During the years of 1989-1993 Loggerhead turtles stranded most commonly on the southern shore of Cape Cod bay but with a more even distribution as compared with Kemp's Ridleys over this same time period.

Stranding Frequencies and Temporal Distribution

During the 1985-1993 stranding seasons the live Kemp's Ridley stranding frequency ranged from 0 to 16 individuals per year.

During the 1985-1993 stranding seasons the live Loggerhead stranding frequency ranged from 0 to 9 individuals per year.

Live turtle strandings occurred in the months of November and December. Most Kemp's Ridleys stranded in November while the vast majority of Loggerheads stranded in December.

Sizes of Turtles

The average straight lengths, straight widths and weights for live stranded Kemp's Ridleys were 28.15cm, 27.32cm and 4.27kg, respectively.

The average straight lengths, straight widths and weights for live stranded Loggerheads were 47.95cm, 42.44cm and 27.35kg, respectively.

Gross Necropsy and Histological Evaluation

The most common gross necropsy findings were as follows:

Finding	*Percentage of Cases*
Shell Discoloration	100%
Lung Lesion	80%
Dilated Intestine	60%

2) Live Kemp's Ridleys tend to strand in greater numbers than Loggerhead turtles. Most Kemp's Ridleys strand in November while Loggerheads generally appear in December.

3) Kemp's Ridley and Loggerhead strandings on Cape Cod are composed entirely of sub-adult animals.

4) The most common gross necropsy findings in Kemp's Ridley turtles were shell, lung and intestinal lesions (in descending order of occurrence).

5) The most significant histological findings in Kemp's Ridley turtles were fungal/bacterial respiratory infections, intestinal nematodiasis, and renal disease (in descending order of occurrence).

6) Live stranded Loggerhead turtles are easily rehabilitated while the survival rate of Kemp's Ridley turtles is very low.

HABITAT SELECTION IN THREE SPECIES OF CAPTIVE SEA TURTLE HATCHLINGS

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EXPERIMENT 1

The "standard" theory of hatchling sea turtle development claims that after successfully swimming away from the shore they eventually reach floating weedbeds where they then reside for their early developmental period. If this theory is correct, we hypothesize that captive hatchlings should congregate in weeds placed in their tanks rather than remaining in open water parts of their tanks. Therefore we presented a floating weedbed in one part of a large tank housing several hatchlings and recorded the number of turtles in that area of the tank (one fourth of the total area) preceding the introduction of the weedbed (baseline) and following its introduction (test). Each baseline and test period (referred to as a "trial") lasted for 15 min and the number of turtles in the area was recorded once each minute. Since real seaweed might attract the turtles for feeding we used plastic weeds in an artificial weedbed so that habitat selection and foraging would not be confounded.

We used 6 partial clutches of *Caretta caretta* hatchlings (N = 44-50 each), 2 of *Eretmochelys imbricata* (N = 42 and 40 each) and one of *Chelonia mydas* (N = 31). Most of the trials were given over the first 6 days post emergence, although some trials were given on later days. The holding tanks measured 1.09m X 2.36m and was .41m deep. Sea water pumped directly from the Caribbean was circulated through the tanks and the tanks were partially shaded by thatch and canvas roofs, but otherwise were open to the elements. They were located on the beach at Xcacel, Mexico, approximately 60m from the high tide line. The artificial weed bed was made out of plastic weeds found in aquarium stores.

Figure 1 shows that the loggerhead hatchlings were significantly more likely to occupy the weedbed area of the tank (test trials) than on baseline open water trials. (On 14 of 15 trials there were significantly [$p < .01$] more turtles present on the test than on the baseline). The hawksbills were also attracted to the weeds, although not quite so much as the loggerheads (6 of 9 trials were significant). The green hatchlings, on the other hand, avoided the artificial weeds, with fewer turtles being present on the test than during baseline. (On 3 of 6 trials there were significantly more turtles present on the baseline than the test).

We also conducted a trial using real seaweeds and the results were the same as those when artificial weeds were used, except that the green hatchlings showed an increase on this test trial. However, their increase is accounted for by feeding on the part of these turtles, unlike the loggerheads and hawksbills who simply remained immobile within the weeds.

Loggerhead and hawksbill hatchlings behave in a manner consistent with the theory that hatchlings spend their early developmental period in floating weedbeds. The green hatchlings did not behave in the same way and actually tended to avoid the artificial weeds. The relative preference for the weedbed did not change systematically over the first 6 days post hatch.

The strongest conclusion from these data is that the green turtles occupy a different habitat than loggerheads and hawksbill turtles, who might occupy similar niches. A weaker conclusion is that all turtles may occupy a similar general habitat, but their microhabitat preferences are different.

EXPERIMENT 2

The results of the first experiment suggest that green hatchlings do not exhibit habitat preferences shown by loggerheads and hawksbills. Instead, green hatchlings avidly swam through open water habitats in preference to areas with artificial weeds. So, questions we address in this experiment are, "What is the basis for habitat selection among green turtle hatchlings? Do they simply swim in a random and unpredictable manner?" We had noticed a tendency for the green hatchlings to congregate in the end of the holding tank nearest to the sea. We conducted a series of trials to determine if their orientation and location in the tank was determined by some aspect of their habitat, or if their orientation and location were simply matters of chance.

The clutch of green hatchlings ($N=31$) was gently gathered together in a net while still in the water and released at the midpoint of the tank. The last 29 cm end of the tank was marked by a string above the water level. Observers recorded the presence of turtles in the end zones by measuring the latency to cross into the area and whether individuals were present each minute in the area for minutes 6-10 post release.

The mean number of minutes that each end of the tank was occupied (out of a possible 5) are shown for three trials in Figure 2. The differences between the two ends of the tank are significant in all cases using dependent t-tests ($p<.05$). Latency scores (in sec) for the turtle to enter each end are also shown in Figure 3 (a turtle that did not enter an end was given a score of 300 sec). The differences in latencies were significant on trials 1 and 3 ($p<.05$), but failed to reach an acceptable level of significance on trial 2. Several other kinds of trials were conducted (e.g., varying the starting location of the hatchlings in a particular tank, and using different tanks that were further away from the sea and under a more complete roof). The results of these trials suggest that the hatchlings were using the open, brightest part of the horizon to guide their behavior (Ehrenfeld and Carr, 1967).

In conclusion, hatchling green sea turtles show a strong preference for maintaining a particular orientation in a holding tank, consistent with swimming away from shore. Observing different species of hatchling sea turtles under controlled, captive conditions yields interesting data that may be relevant to their survival under natural conditions (e.g., Wyneken and Salmon, 1992). The results of these experiments suggest that green hatchlings may live their lost year differently than loggerhead and hawksbill hatchlings.

ACKNOWLEDGMENTS

This research was supported by NSF Grant IBN-9300264 and the Research Enhancement Program of the University of Texas at Arlington. We thank Susan Sterling and Amy McSwain for their help in preparing this abstract.

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SIGHTINGS OF LEATHERBACK TURTLES IN THE U.S. GULF OF MEXICO

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Ongoing aerial surveys, conducted by the National Marine Fisheries Service (NMFS), have yielded several leatherback turtle (*Dermochelys coriacea*) sightings. These surveys include offshore (GULFCET) and inshore (GOMEX) studies in the U.S. Gulf of Mexico. To date, GULFCET and GOMEX surveys have completed 40,000 and 18,000 transect kilometers, respectively. Data collected during these surveys are used to determine distribution and abundance of many species of marine animals, including *D. coriacea*. These studies will be completed in late 1994.

METHODS

Transect lines are flown aboard a DeHavilland Twin Otter turboprop aircraft specially equipped with plexiglass viewing bubbles. While on transect the aircraft maintains an altitude of 229 m (750 ft) and a true airspeed of 110 kts. Observers, on both sides of the aircraft, scan the area from the transect line to a distance of about 1,300 m perpendicular to the transect line. Sightings of cetaceans, turtles, fishes, other marine organisms, and pollution are entered to a laptop computer. The laptop computer is interfaced with the aircraft's Global Positioning System (GPS) navigation device to provide sighting position coordinates.

RESULTS AND DISCUSSION

To date, the offshore GULFCET study has recorded 33 on-effort leatherback turtle sighting, inshore GOMEX study has recorded 22. As the GULFCET and GOMEX studies are concluded, cc analysis of the sighting data will begin.

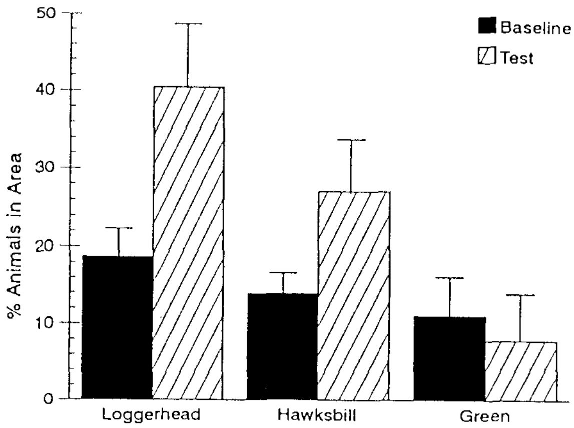

Figure 1. Mean percentage of turtles present during baseline and test periods.

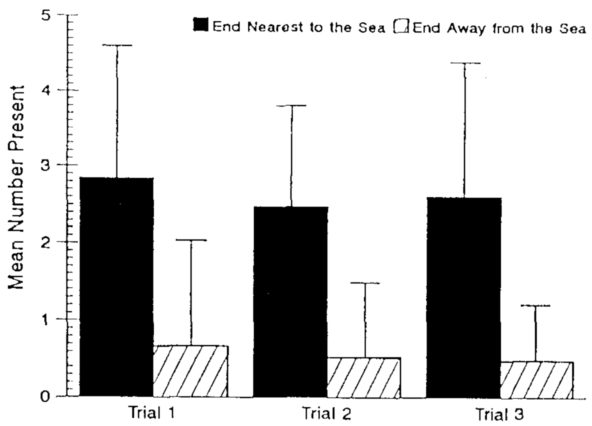

Figure 2. Mean number of turtles in each end of the tank during 5 min. (maximum score = 5).

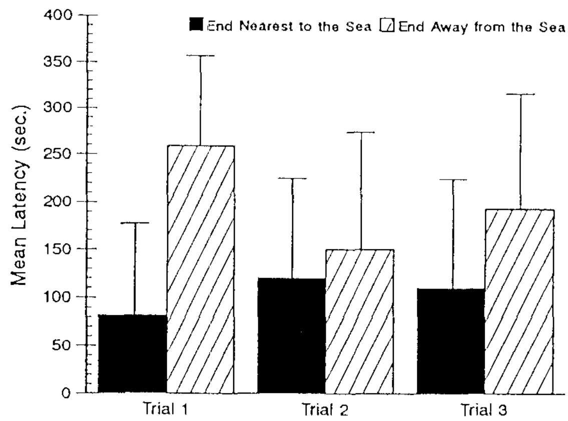

Figure 3. Time in sec. to enter each end of the tank following release from the center of the tank.

ONE IF BY LAND, TWO IF BY SEA: A MYSTERY NEST ON THE MARYLAND SHORE

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In June of 1993, a turtle nest was reported on the shore of a resort island in Maryland. The nest was investigated on-site by biologists from Maryland and Virginia, and was generally assumed to be a loggerhead turtle nest because of its proximity to the ocean and isolation from normal nesting grounds for freshwater and terrestrial turtles. The reported nest caused considerable media coverage and controversy, as Maryland is well out of the historical nesting range for marine turtles. Three eggs were sent to the NMFS-Charleston Laboratory for analysis of the egg yolk lipids. These data were used in conjunction with data on the size of the eggs, clutch size, and nest site for species identification purposes. It was determined that the eggs were not those of a marine turtle, but are suspected to be those of a common snapper (*Chelydra serpentina*). Species identification was not confirmed due to the lack of authentic snapper eggs for comparison. Though snappers have been known to wander far in their search for a suitable nest site, it is unusual to find a snapper nest on a beach in a highly urban area. Some question remains as to how the suspected snapper and/or its eggs came to be on the beach of the resort island.

SEA TURTLE NESTING AND MANAGEMENT IN GEORGIA

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This presentation examines the distribution of ownership, management, beach length, and the number of nests (in regard to the historical range) on each Georgia barrier island.

Island	Ownership	Turtle Management Team	Beach Length (km)	Number of Nests Historical Range
Ossabaw	Georgia Department of Natural Resources	Georgia DNR	15.2	56 - 218
Tybee	City of Tybee	City of Tybee	5.6	0 - 9
Wassaw	U.S. Fish and Wildlife Service	Savannah Science Museum / USFWS	9.6	35 - 100
Blackbeard	USFWS	USFWS	14.4	56 - 234
Sapelo	Georgia DNR	Georgia DNR	8.8	24 - 74
Sea Island	Sea Island Company	Sea Island Company	7.2	19 - 114
St. Simons	Glynn County	Georgia DNR	4.8	4 - 8
Jekyll	Jekyll Island Authority	Jekyll Island Authority	12.8	40 - 88
Little Cumberland	Little Cumberland Homeowner's Association	Georgia Sea Turtle Co-op	4.0	35 - 155
Cumberland	National Park Service	NPS / Georgia DNR	28.0	92 - 245
St. Catherines	Noble Foundation	Georgia Southern University / Georgia DNR / St. Catherines Island Foundation	17.6	71 - 148

ACKNOWLEDGMENTS

The Georgia Department of Natural Resources would like to thank all of the following groups for their continuing efforts in the management of Georgia's sea turtles and beaches: Cumberland Island Museum, City of Tybee, Georgia Sea Turtle Co-op, Georgia Southern University, Jekyll Island Authority, Little St. Simons LTD., National Park Service, St. Catherines Island Foundation, Sea Island Company, Savannah Science Museum, University of Georgia Marine Extension Center, and all other individual participants.

NATIONAL INITIATIVES IN ENVIRONMENTAL EDUCATION

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Centre for Environmental Education, Ahmedabad, India

The Centre for Environment Education (CEE) plays a pivotal role in the nationwide effort to increase environmental awareness. The Centre is supported by the Ministry of Environment and Forests, Government of India, and was established in August 1984 under the Ministry's scheme for promoting Centres of Excellence. The foremost objective of CEE is to create environmental awareness among children, youth and the general community. The Centre has been implementing a number of EE programmes of national significance, in the following thrust areas: environmental education in schools, interpretation, training, ecodevelopment, experiencing nature, media, and urban programmes.

The Centre also compiled a country report on behalf of the Government of India, which was presented at the United Nations Conference on Environment and Development (UNCED), the Earth Summit at Rio de Janeiro, 1992. The Centre has initiated regional networking called the South and Southeast Asia Network for Environmental Education (SASEANEE).

METHODS

CEE has been implementing its EE programmes primarily through Non Governmental Organisations (NGOs). Ecodevelopment programmes are designed to involve community participation, considering the importance of sustainable development. Information dissemination is mainly through the media, where inhouse facility such as the News and Feature Service plays a vital role. The Centre runs an animal park for children called "Sundarvan", which is basically a Nature Discovery Centre, where environmental awareness is promoted through bird shows and snake demonstration including outdoor activities such as camping.

In certain EE programmes the Centre has a network of NGOs for the purpose of implementing teacher training, school programmes follow-up and monitoring. EE materials such as publications with reference to curricula are translated and modified by those NGOs who wish to incorporate them in their programmes. All materials are tried and tested before being infused in the various programmes.

For the purpose of effectiveness of EE programmes, the Centre has created a computerized data bank known as the "EE Bank". Training is realized as an important component as far as awareness and action is concerned. There are tailor made training programmes in EE catering to a very wide target group from school teachers to resource persons drawn from NGOs, State Department of Education, Forest Department, and recent university graduates.

CONCLUSION

Inculcating environmental awareness in the case of a developing country such as India encompasses locale specific aspects such as traditions and values. The goal is to initiate appropriate action towards environmental conservation. In which case programmes must be envisaged in such a manner where the community is the beneficiary, in terms of better standards of living and sustainable utilization of natural resources.

SEA TURTLES AND DREDGING: POTENTIAL SOLUTIONS

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To prevent the entrainment of sea turtles in hopper dredges the US Army Corps of Engineer conducted studies on biological and engineering alternatives. Biological investigations included studies on the relative abundance and behavior of sea turtles in channels, census techniques, hydroacoustic detection of sea turtles, relocation of turtles out of channels, acoustic response of turtles, and acoustic response of marine mammals. Engineering investigations included studies on a rigid deflector draghead and air and water deterrent devices. These studies included participation by Federal agencies, state agencies, universities, and private organizations. The relative abundance studies have helped to define and refine seasonal windows when turtles are present in the channels. The behavior studies document turtle activities in the channels and give input into design of engineering techniques. The relocation studies demonstrate the potential of this management alternative particularly in moderate to low densities of sea turtles. The hydroacoustic studies demonstrated that detection of turtles was feasible but will require additional refinements to segregate a definitive turtle signal from other biota. Acoustic studies on manatees indicate that they are not likely to be affected by sea turtle deterrent devices. Sea turtles acoustic responses have been better defined. The air gun device shows promise as a deterrent while the water gun has probable unacceptable side effects. The air gun requires additional testing to determine turtle response in situ. The rigid deflector draghead has proven to be viable in operational tests with simulated turtles. A field test with live turtles is required before the rigid deflector draghead receives wide spread implementation. These studies were funded by the US Army Corps of Engineers, South Atlantic Division, Wilmington District, Charleston District, Savannah District, Jacksonville District, and Mobile District.

SEA TURTLE CONSERVATION AND MANAGEMENT: OSTIONAL DEVELOPMENT ASSOCIATION WORK DURING 1993 IN THE OSTIONAL WILDLIFE REFUGE, GUANACASTE, COSTA RICA

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The Ostional Wildlife Refuge was created in 1984 for the protection of four sea turtle species. The leatherback turtle *Dermochelys coriacea*, the Pacific green turtle *Chelonia agassizi* and the hawksbill *Eretmochelys imbricata* nest seasonally in the refuge's beaches. The olive ridley sea turtles nest, in a phenomenon known as "arribada", from January to December.

In 1984 through a government executive decree the Ostional Development Association got the first legal permit for the olive ridley egg harvest. Then in 1987 sea turtle protection law was modified in order the rule the egg extraction and commerce. The law also established the need for a management plan as a requirement for the egg harvest regulation. This plan has been presented to the government since 1987 and is fully based on the research programs developed by University of Costa Rica (UCR) biologists.

EGG HARVEST PROCESS AND OSTIONAL DEVELOPMENT ASSOCIATION WORK

Ostional Development Association (ADIO) is a 190 person community group with a guiding head, which is the ADIO Board of Directors (BOD). All the work is planned by the 8 member BOD. Different jobs are in charge of the 11 community groups, with 15 people each one.

The first morning after biologists declare the arribada beginning, Ostional locals go over the 880 main nesting beach, looking for the eggs laid by the previous night's turtles.

Egg searches and loaded sack transfers are the men's jobs. Using their heels, the searching groups locate the nests. Then, all the women start the egg extraction and sack loading. The eggs are then carried to the packing center using horses, trucks, or people's strength, as well. Eggs are washed and carefully checked to insure their quality before packing in plastic bags. These pre-stamped bags hold 200 eggs.

Egg transport, distribution and marketing correspond to the association's affiliates. Ministry of Agriculture and Livestock extend the licenses for the egg sale.

Ostional eggs need to reach all the illegal markets in order to fight against unauthorized exploitation. Although this is not an easy goal to reach, the Ostional harvest project has demonstrated that it can reduce the poaching in many solitary nesting beaches and is now covering almost 60% of the country with legal eggs.

SOCIAL IMPACT

The main attainments reached by the community from the egg sales are as follows:

1. Way of life improvement, like better houses and wardrobe.

2. A better nutritional and health condition.

3. Town growth: the Ostional Village is now bigger. There are some new buildings like: The Ostional Sea Turtle Lab Station, the ADIO offices, the People's House and the Packing Center. ADIO is also helping with the school maintenance.

4. Ostional locals are also in charge of the road and aqueduct repair and maintenance.

5. A better conscience for sea turtle and other resource conservation.

OTHER ACTIVITIES AND FUTURE GOALS

Environmental Education Program is presently developed by university students from UCR. Nevertheless, Ostional community is seeking international help and support in order to get a permanent and sustainable educational program. Other of our goals is to find alternative ways for our social improvement. We are thinking of agriculture projects, craftsmanship sales and ecotourism.

MAIN THREATS

One of the strong needs is to find the way to stop the unplanned tourist development. For this reason we need an Integral Management Plan. It is necessary to include in this plan some regulations for the land use and ownership, economical activities and building construction. In order to conquer Ostional's dependence on sea turtle eggs, regulated tourism could be an alternative source for economical profits, but the first step is the integral management plan. Once again Ostional needs international support, not only from the economical or technical points of view, but also denouncing the resource destruction and bad use of these resources that are the results of the wrong development policies in our country.

COMPARISON OF BLOOD IONIC COMPOSITION BETWEEN AUSTRALIAN POPULATIONS OF *CHELONIA MYDAS*

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An investigation was undertaken to determine the concentration of several ions in the blood of Australian populations of *Chelonia mydas*. The levels of Sodium, Potassium, Lead and Zinc were measured in the blood of turtles from different locations and of different ages. This information was used to determine if differences existed which might be attributed to age or proximity to mining activity.

METHODS

Blood samples were collected by syringe from the cervical sinus of captured turtles. Four groups of animals were studied:
1) Adult male and female turtles from Moreton Bay, QLD; 2) Adult male and female turtles from Heron Island, QLD; 3) Hatchling turtles from Heron Island; 4) Adult female turtles from Bountiful Island, Gulf of Carpentaria.

Heron Island is free from mining activity, Moreton Bay is used for dredging of coral, and the Gulf of Carpentaria is a site of lead and zinc mining.

Atomic absorption spectrophotometry was employed for ion determination with samples of plasma diluted in 0.2N HCl for measurement of sodium and potassium concentration, while samples of plasma and whole blood were diluted with 2% HNO_3 for measurement of zinc concentration. Lead was measured using ICP-MS. Unpaired T-tests were applied to data to determine if significant differences existed between groups.

RESULTS

Mean ionic composition and statistical differences are displayed in Figures 1, 2, 3, and 4.

1) Hatchling turtles have a significantly higher concentration of sodium in the plasma than adult animals. The concentration of sodium in whole blood does not differ significantly from that in plasma.

2) Plasma potassium concentration was different with age and location, although differences were small.

3) Zinc concentration is higher in the whole blood than in the plasma for adults, but not hatchlings. Whole blood and plasma zinc concentration did not vary between adults from mined and non-mined areas.

4) Lead levels in plasma and whole blood are extremely low compared to levels in human blood and seawater.

DISCUSSION

Differences in sodium and potassium concentrations seen between adult animals and hatchlings may be associated with diet. Hatchlings feed typically on macroplankton, which has a very high sodium content but lower potassium content compared to the sea grasses on which older animals feed. It is possible that the difference in dietary intake of these ions is reflected in a change in the concentration of these ions within the body. The intake of sea water to increase hydration following emergence from the nest may also influence the level of these ions.

The concentration of zinc is greater in the whole blood than in plasma, and is probably associated with the zinc-containing enzyme carbonic anhydrase which is found in red blood cells. Plasma levels of zinc were the same for adult and hatchling animals, although the concentration in whole blood was higher in adults than hatchlings. This may be due to the higher haematocrit found in adults (hatchlings approx 25-30%, adults approx 30-35%) increasing the absolute amount of zinc present in the blood due to the greater number of zinc-rich red blood cells. However, it cannot be ruled out that zinc has accumulated in the whole blood of animals as they age, but the proximity to mining activity does not appear to influence this increase.

Lead concentration is higher in whole blood than in plasma, but is extremely low. Plasma concentration does not appear to vary with proximity to mining activity, but further sampling is required to determine if whole blood concentration is affected by location.

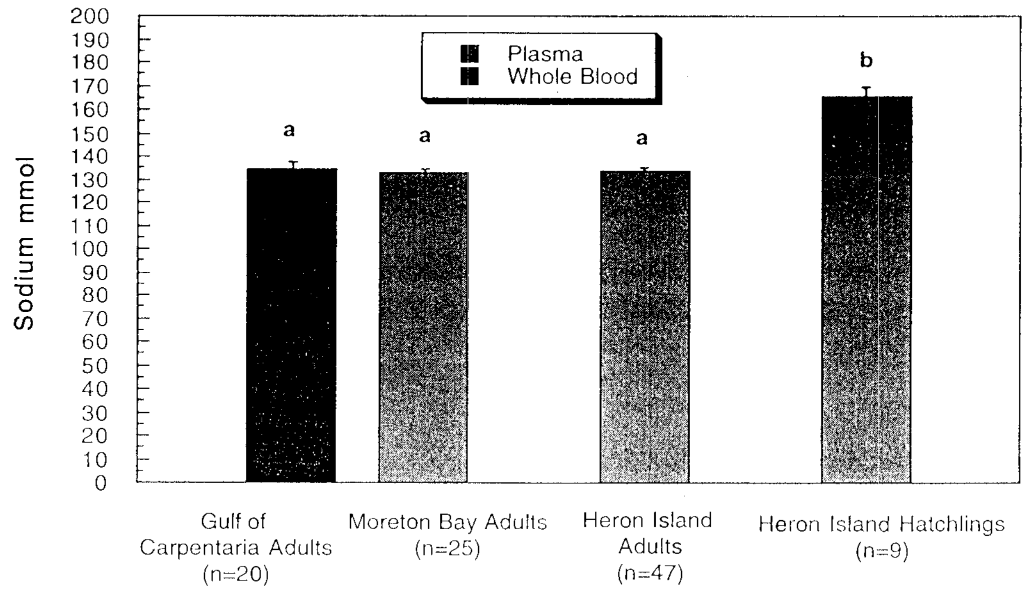

Figure 1 Sodium concentration in plasma and whole blood
Histogram of mean measured sodium concentration with standard error indicated. Different letters indicate statistical significance at P<.05 level.

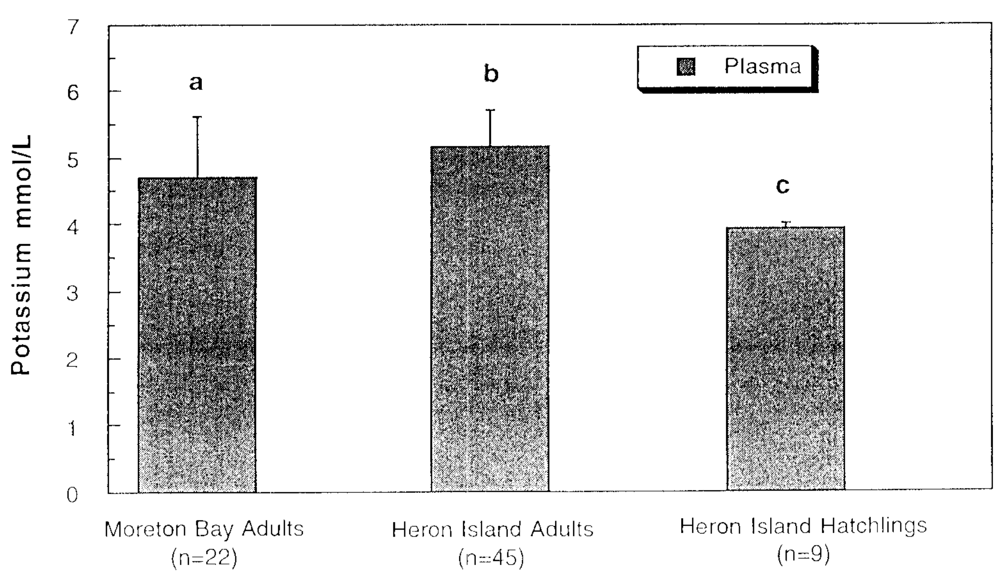

Figure 2 Potassium concentration in plasma and whole blood
Histogram of mean measured potassium concentration with standard error indicated. Different letters indicate statistical significance at P<.05 level.

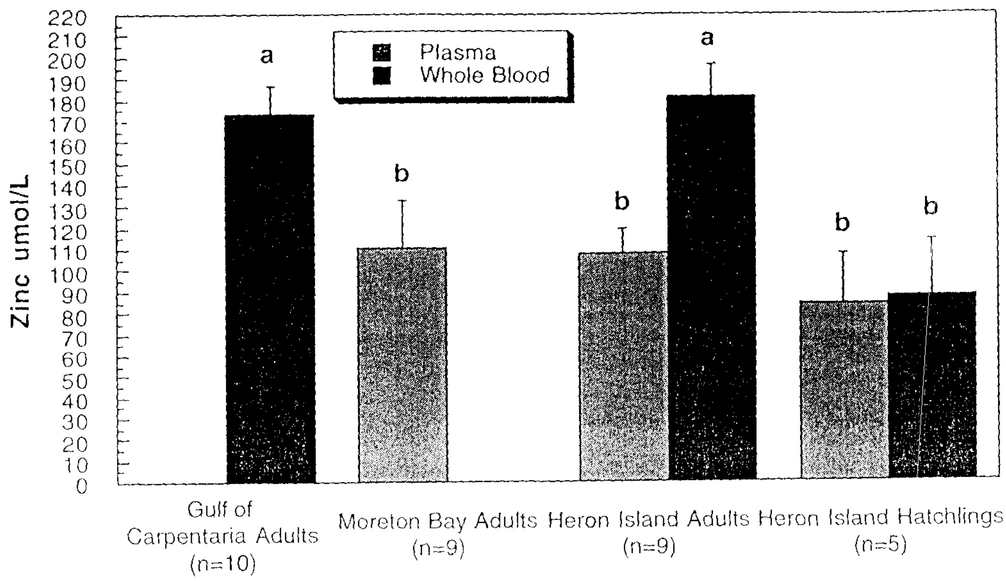

Figure 3 Zinc concentration in plasma and whole blood
Histogram of mean measured zinc concentration with standard error indicated. Different letters indicate statistical significance at P<.05 level.

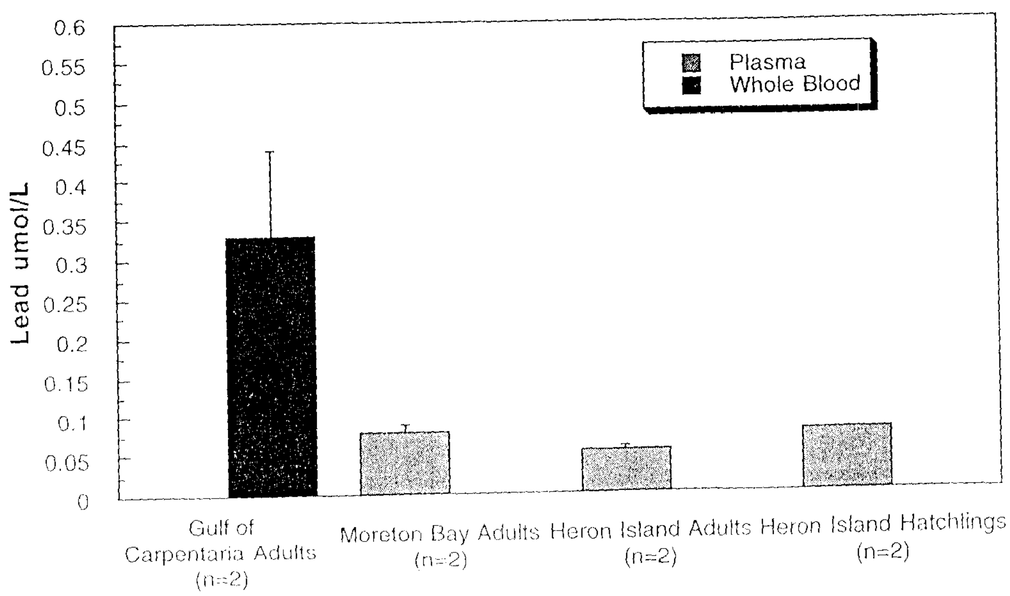

Figure 4 Lead concentration in plasma and whole blood
Histogram of mean measured lead concentration with standard error indicated. Statist tests were not conducted because of the small sample size.

RELATIONSHIP BETWEEN ORGANOCHLORINES AND LIPID COMPOSITION IN SEA TURTLES

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Organochlorine pollutants are a ubiquitous, environmentally persistent family of anthropogenic compounds. Polychlorinated biphenyls (PCBs), a class of organochlorines characterized by low water solubility, high dielectric constants, low vapor pressures and low flammability, were widely used in industry until the 1970s. Due to their low water solubility, they are lipophilic and partition into tissues with high percentages of lipid, particularly neutral lipids such as triglycerides. The tissue distribution patterns of polychlorinated biphenyls (PCBs) observed in loggerhead sea turtles (*Caretta caretta*) from Virginia and North Carolina are presented, relative to tissue lipid class composition.

METHODS

Five loggerhead sea turtles from Virginia and North Carolina were analyzed for organochlorine pollutants, total lipid and lipid class composition (Table 1). Samples of subcutaneous fat, liver and pectoral muscle were collected in solvent rinsed jars and frozen until analysis.

Subsamples of the tissues were homogenized, chemically desiccated and Soxhlet extracted with dichloromethane for 48 hrs. Organochlorines were separated from high molecular weight biogenic compounds in the extracts by preparative gel permeation chromatography (GPC). The fractions containing the organochlorines were eluted through a Florisil column to remove any remaining polar compounds. The purified extracts were analyzed on a high resolution gas chromatograph (GC) equipped with a Hall electrolytic conductivity detector (ELCD). Identifications were confirmed using gas chromatography - mass spectrometry (GC - MS) in the negative chemical ionization mode.

Portions of the tissues were extracted with chloroform:methanol:water in the final ratio of 2:2:1 v/v/v. Total lipid was determined gravimetrically. Lipid classes were separated by thin layer chromatography on silica gel G plates with a mobile phase of hexane:diethyl ether:glacial acetic acid in the ratio of 85:15:1 or 90:10:1 v/v/v. The plates were charred with 3% cupric acetate in 8% aqueous phosphoric acid and lipid classes were identified by retention index comparison with standards. Quantification was conducted with a transmittance/reflectance scanning densitometer and peak areas were measured on a Numonics digitizer using UNIX based ARC/INFO software.

RESULTS AND DISCUSSION

Organochlorine contaminants were detected in the μg/kg, or parts per billion (ppb), range. All pollutants were determined on a wet weight basis. The distribution of PCBs corresponds well to the amount of lipid in the tissues. The lipid composition of the tissues greatly affected the partitioning of PCBs (Fig. 1). Subcutaneous fat, composed predominantly of triglycerides, had the highest concentration of PCBs. Pectoral muscle had a large percentage of polar lipids and contained the lowest concentration of PCBs. Liver, with a more even distribution of lipid classes, had intermediate PCB concentrations. Lipid utilization trends in these animals must be interpreted with care. Because sea turtles are endangered, only euthanized and deceased animals could be used. Euthanasia was employed only after prolonged illness and failure to feed. The stranded animals were put on ice immediately upon discovery, however, some decomposition had already begun. This degradation may have contributed to the high percentage of free fatty acids, which are hydrolysis products of saponifiable lipids, in the tissues analyzed. The results of this study indicate that the optimal sea turtle tissue for organochlorine pollutant monitoring is subcutaneous fat, followed by liver.

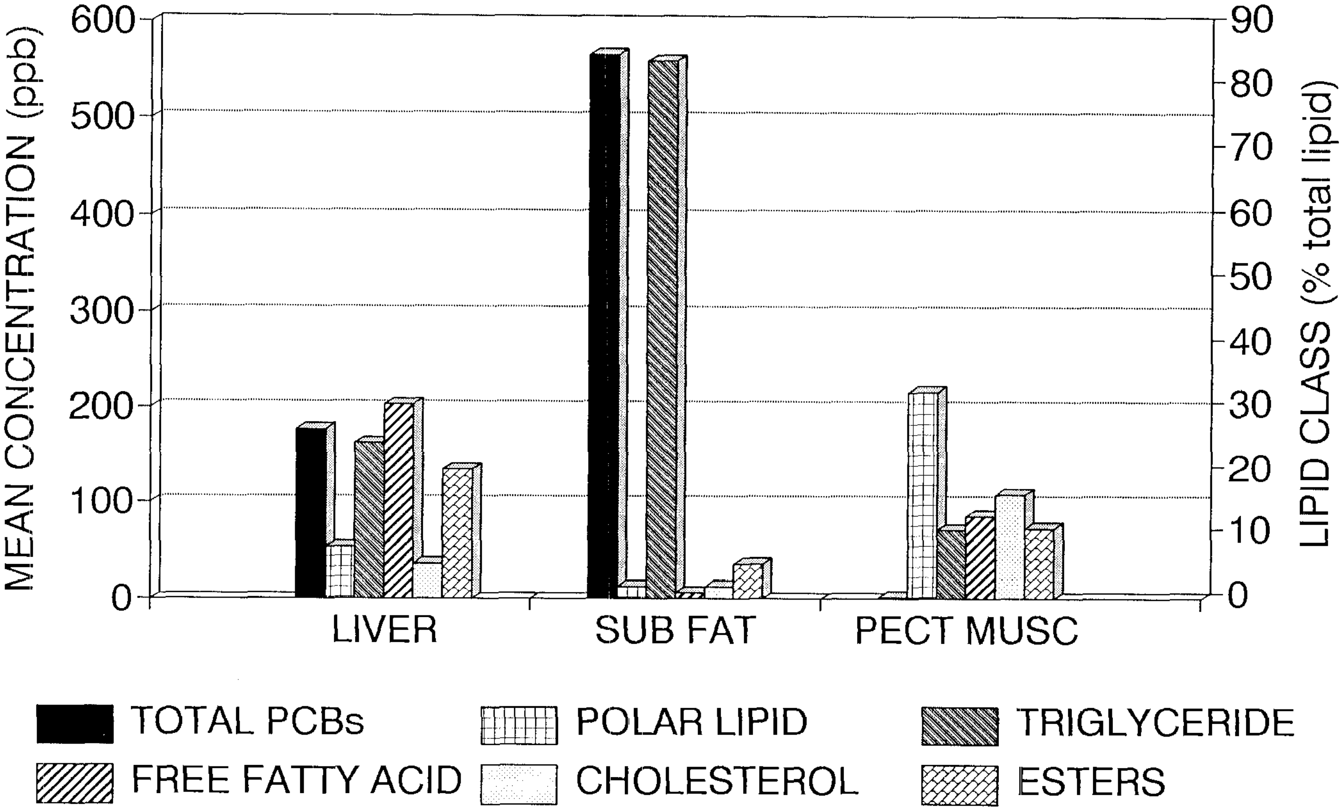
Table 1. Loggerhead turtles used in lipid analysis

Stranding Date	Location	Condition	Straight Carapace Length (Notch to Notch) (cm)	Sex
29 Jun 1991	Kilmarnock, Va.	E	46.2	F
19 Sep 1991	North, Va.	E	83.7	U
20 Dec 1991	Virginia Beach, Va.	E	54.8	F
11 Nov 1991	Gwynn's Island, Va.	3	47.5	F
09 Dec 1991	Beaufort, NC.	3	64.9	M

Where E = euthanized, 3 = dead, slight bloat, F = female

M = male, U = undetermined.

TOTAL PCBs vs.
LIPID COMPOSITION



MISORIENTATION, MOONLIGHT, AND THE SEAFINDING BEHAVIOR OF LOGGERHEAD HATCHLINGS

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Loggerhead hatchlings emerge from their nests at night, then crawl to the ocean. Under natural conditions, this "seafinding" orientation is remarkably accurate. But on developed beaches, seafinding may be disrupted by lights from streets, apartments, parks, or patios behind the beach. These luminaires attract turtles, which then crawl up the beach toward the source instead of down the beach to the sea. The attraction of hatchlings to lights is known as "light-trapping"; the orientation they show ("misorientation") may ultimately lead to death by exposure, predation or crushing by cars.

Workers who manage urban beaches must frequently deal with problems of beach lighting and misorientation. Initially, they need to identify where lighting problems exist. That task may be difficult because turtles can show misorientation on some evenings but not on others. Why? To find out, we did experiments at Boca Raton's beach where lights from parks, patios, and condominiums can cause misorientation.

Hatchlings were released in the center of a circular arena, drawn on the beach. Their paths were recorded as they crawled to the arena periphery. Sites were in locations where light sources varied in intensity from weak to bright.

When exposed to weak light sources before moonrise, turtles showed more scattered seafinding orientation than normal, but most crawled toward the ocean. Tests done the same evening in the presence of a quarter moon resulted in less scatter and improved orientation accuracy

Hatchlings released at sites where lights were bright were strongly misoriented, with most individuals crawling up the beach toward those lights. Quarter moon illumination did not improve orientation but under a full moon, seafinding behavior was normal.

On the East coast of the U. S., turtles often crawl toward a rising moon to reach the sea. Did orientation improve because the moon attracted the turtles? To find out, we did experiments when a full moon was present in the east, southeast or southern portions of the sky. Hatchlings crawled east toward the ocean no matter where the full moon was located.

These findings lead to the following conclusions. First, moonlight can reduce the attractiveness of anthropogenic lights as misorientation stimuli. Weak moonlight reduces the effects of weak light sources, but a full moon is necessary to counter the influence of brighter lights. Second, moonlight exerts these effects by increasing levels of background illumination. This, in turn, reduces the contrast between bright lights and background. Third, lunar illumination is probably responsible for much of the variation in misorientation behavior seen at specific sites on nesting beaches. Efforts to locate sites with misorientation problems should be made on dark nights, in the absence of lunar illumination. Fourth, quantitative approaches should be used to measure hatchling responses, and for determining if corrective steps (turning off or shielding lights; reducing their intensity) have been effective.

We thank Lisa DeCarlo, Matt Goff, Jackie Fernandes, and Melissa Tolbert for assistance in the field, and Jeanette Wyneken for comments. The Gumbo Limbo Nature Complex provided nest lists and a supply of hatchlings. Supported in part by a cooperative agreement from the NOAA. The views

expressed are those of the authors', and do not necessarily represent those of NOAA or its subagencies.

A GIS MODEL FOR THE ANALYSIS OF MARINE TURTLE HABITAT ASSOCIATIONS

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Habitat analyses usually deal with three aspects of the wildlife-habitat relationship: availability, utilization, and preference. Availability is the area of each habitat type within a defined boundary. Utilization is the amount of time an animal spends in the various habitat types. Preference is a statistical test of whether an animal selects some habitat types more than others and spends more time in these habitats than would be expected based on the availability of each habitat type.

Characterization of developmental and foraging habitats has been identified as the highest priority in the Marine Turtle Habitat Plan (Thompson et al. 1990) and as a priority one task in the Recovery Plan for the Kemp's Ridley Sea Turtle (USFWS and NMFS 1992). Another important aspect of these plans is the utilization of foraging habitats by marine turtles. This project presents the methodology used to integrate the results of telemetric monitoring with a Geographic Information System (GIS) habitat map and to derive the baseline habitat associations for marine turtles.

METHODS

Telemetric monitoring of Kemp's ridley turtles (*Lepidochelys kempi*) was conducted east of the Cedar Keys, FL. Each turtle was outfitted with a sonic transmitter, attached posteriorly to the marginal scutes, and a buoyant radio transmitter, tethered to one of the postcentral scutes. Turtles were immediately released in the area of capture, at which time mobile tracking began. Latitude and longitude were recorded hourly as degrees/minutes/seconds and later converted to decimal degrees. The telemetry file used in the analysis consisted of 26 positions of a single turtle collected over a three week period.

The nearshore waters from the Cedar Keys to the Withlacoochee River were chosen as the study area for the analysis. The coastline and other major geographic features were digitized from a National Oceanic and Atmospheric Administration nautical chart (Crystal River to Horseshoe Point). Marine habitats within the study area were digitized from U.S. Fish and Wildlife Service biological resources maps. General characteristics of each habitat type are as follows: 1) Seagrass - Several species of seagrass occur in Florida waters. *Thalassia testudinum* (turtle grass), *Syringodium filiforme* (manatee grass), and *Halophila* sps. have been observed in the study area. 2) Oyster - *Crassostera virginica* reefs and shell mounds. 3) Other - Includes intertidal unvegetated bottom areas (mud flats and sand bars), areas of limestone outcropping, and mud bottom sloughs.

Analyses of habitat associations were run with ARC/INFO version 6.1.1 (Environmental Systems Research Institute, Redlands, CA) GIS software. Figure 1 summarizes the analysis procedure developed in this study. Detailed descriptions of the steps presented in this flowchart are provided throughout the text. A polygon coverage of the digital habitat map was generated and projected in Universal Transverse Mercator (UTM) coordinates. The polygon coverage was converted from vector to raster format (15 m cell size) in the GRID environment of ARC/INFO.

A menu-driven procedure was developed to display telemetry data on the habitat map and to perform the analyses of habitat associations. The IMPORT option selects a database file of latitude/longitude positions from diskette, imports the file to a data directory, generates a point coverage of the positions, and projects the point coverage to UTM coordinates. The DISPLAY option displays the study area as color-coded habitat types. A menu appears that allows the user to choose a telemetry point coverage, which is converted to raster format in GRID, and to select the cell size (15 - 100 m) of the telemetry grid. The selected telemetry coverage and cell size are overlaid on the habitat grid. The ANALYSIS option uses GRID zonal functions to conduct the habitat analyses. The ZONALGEOMETRY function calculates the area of each habitat type. Availability is calculated as the percentage of each habitat type to the total area. The ZONALSTATS function calculates the number of telemetry points in each habitat type. Utilization is calculated as the percentage of telemetry points in each habitat to the total count. Results of these analyses can be exported for analysis of habitat preference in a statistical software package.

RESULTS AND DISCUSSION

Results of the spatial analyses conducted on the habitat map and the telemetry data are presented in Table 1. The analysis of habitat utilization indicates that the telemetered turtle occupied the seagrass habitat exclusively. However, it is known from field observations that the area occupied by the turtle is a mosaic of the three habitat types defined in this study. The biological resources maps used to produce the habitat map do not have the fine scale resolution needed to accurately characterize the bottom types. A comprehensive field study, in this case benthic sampling, is needed to increase the accuracy of the habitat map.

Available habitat is usually determined from the total study area, the boundaries of which are arbitrarily defined. In other words, habitat availability is dependent upon what an investigator deems available to the animal. To overcome this problem, availability should be considered in two stages (Aebischer et al. 1993): those habitats available within an arbitrarily defined study area and those habitats available within an area delimited by the animal (home range). However, just as designation of a study area is arbitrary, so is the selection of a method for estimating home range. Different home range estimators produce different results.

A protocol involving radio and sonic telemetry has been developed to intensively monitor marine turtles. A general bearing is obtained from the radio transmitter. The location of the turtle is determined by homing-in on the sonic transmitter. The turtle's position is estimated by recording the latitude/longitude of the tracking vessel. There is some error associated with this procedure because the animal is usually not directly observed. The model described herein attempts to account for this error by buffering the vessel's position a chosen distance (15 - 100 m) to encompass the actual location of the turtle. The habitat(s) within this buffered area is assumed to be representative of those encountered by the turtle.

Geographic Information Systems are becoming increasingly important in conservation biology and wildlife management because of their ability to analyze the spatial relationships of species and habitats. This model is in the early stages of development and will be expanded to include more menu options, such as exporting analysis results and calculating home range estimators. Furthermore, improvements will be made to the habitat database to improve its accuracy.

ACKNOWLEDGMENTS

I would like to thank Alan Bolten and Karen Bjorndal for their advice and support throughout this study. I would also like to thank David Lambert and Paul Zwick for their insight in GIS technology; Ed Standora and Steve Morreale for instructing me in the art of marine turtle telemetry; and Kris Fair, Debbie Weston, and Lisa Gregory for their assistance in collecting field data.

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Table 1. Results of the GIS analyses of availability and utilization.

Bottom type	Area (hectares)	Availabilty	Count	Utilization
Seagrass	20896.34	41.94	26	100
Oyster	316.19	0.63	0	0
Other	28609.50	57.42	0	0

Digital habitat map of study area.
▼
Create polygon coverage and project coordinates to Universal Transverse Mercator.

Database file of Lat/Long positions.
▼
Create point coverage and project coordinates to Universal Transverse Mercator.

Convert coverages from vector to raster format in GRID environment.

ZONALGEOMETRY
Data table with area of each habitat type.
▼
AVAILABILITY
Determine percentage of each habitat type to total area.

ZONALSTATS
Data table of points in each habitat type.
▼
UTILIZATION
Determine percentage of points in each habitat type to total count.

Data file of results with items: habitat type, area, availability, count, and utilization.
▼
PREFERENCE
Export file of results for statistical analysis.

Figure 1. Flowchart of ARC/INFO analysis strategy.

MIGRATION OF THE *CHELONIA MYDAS* POPULATION FROM AVES ISLAND

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Data presented here are the result of a tagging project of green turtle (*Chelonia mydas*) at Aves Island (15° 40' 30" N, 63° 36' 26" W), initiated in 1973 by W. Rainey until 1975, and continued since 1979 by the Foundation for Defense of Nature - FUDENA. More than 4,000 green turtles have been tagged until now by FUDENA personnel, with monel metal tags. Recapture of 43 turtles tagged at Aves Island, indicate post nesting dispersion to feeding grounds widely distributed in 12 islands in the Caribbean Sea and 5 continental countries in the Caribbean and Atlantic Ocean (fig. 1). There have been recaptures in Dominican Republic, Nicaragua, Guyana, Nevis, St. Lucia, Venezuela, Cuba, Guadeloupe, Martinique, Puerto Rico, Brazil, Carriacou, Colombia, Grenada, Haiti, Mexico and St. Kitts (table 1). Just one recapture involved a nesting turtle, reported at Mona Island, Puerto Rico; the rest of the turtles were captured at sea. 37.2 % of recaptures were made in Dominican Republic and Nicaragua (fig. 2). Apparently, this concentration of recaptures represents a characteristic distribution in the feeding grounds for the Aves Island population. The most distant recovery was made in Maranhao, Brazil, more than 2,500 km from Aves Island. The shortest was in Nevis, at 180 km. Recapture in Brazil (125 days after being tagged at Aves Island) and another in Guyana (less than 120 days), with movements against the South Equatorial current, show that migration does not always occur by simple drift (table 2). Recaptures in Nicaragua, Cuba, Mexico, Dominican Republic and the belt of islands in the southeast section of the Caribbean Sea, show that the Aves Island population shares feeding grounds with the *C. mydas* population from Tortuguero, Costa Rica. One recapture in Brazil shows that the Aves Island population and the population from Ascension Island (South Atlantic) are probably sharing feeding grounds. Results show that Aves Island constitutes an important center of reproduction for different populations of *C. mydas* dispersed in the Caribbean and in the occidental region of the Atlantic.

TABLE 1
Green Turtle (Chelonia mydas) Recaptures Tagged at Aves Island
1973 - 1993

Tag	Place of Capture	Date of Capture	Time (months)	Distance (km)
T484	La Galera, Dominican Rep.	11-Apr-76	31	722
T864	Punta Goleta, Dominican Rep.	29-Nov-76	28	849
B3977	Punta Arena, Dominican Rep.	1979-80		880
T1849	Miches Bay, Dominican Rep.	1-Jan-82	5	693
B4029	Miches, Dominican Rep.	11-Dec-82	41	693
T1960	Miches Bay, Dominican Rep.	30-May-84	21	693
T2451	Saona Island, Dominican Rep.	26-Sep-89	48	600
P1622	Higüey, Dominican Rep.	2-Nov-89	37	600
T1025	Morrison Dennis Cays, Nicaragua	Jan-77	17	2.100
B5000	Miskito Keys, Nicaragua	1987		2.090
P1647	Miskito Keys, Nicaragua	17-Feb-88	16	2.090
B6268	Miskito Keys, Nicaragua	20-23-Feb-89	5	2.090
T2653	Miskito Keys, Nicaragua	13-15-Dec-89	38	2.090
B5648	Muerto Key, Nicaragua	19-Dec-90	27	2.070
P1935	Witties Cay, Miskito Keys, Nicaragua	6-Apr-91	44	2.090
T1975	Witties Cay, Miskito Keys, Nicaragua	1990		2.090
B4645	50 Km N Berbice River , Guyana	Jul-84	4	1.273
B5079	Guyana	1988		927
B6674	50 Miles NE Port Georgetown, Guyana	10-Aug-90	3	1.173
?	Nevis, British Antilles	1978		180
?	Nevis, British Antilles	1978		180
B6367	Nevis, British Antilles	1993		180
T406	Vieux Fort, St. Lucia	25-Jan-74	5	406
B4066	St. Lucia	25-Sep-80	14	340
B5018	Vieux Fort, St. Lucia	1986		406
T987	La Tortuga Island, Venezuela	12-Jun-76	9	567
T2408	Los Roques, Venezuela	1985		533
T1964	Castilletes, Venezuela	May-89	83	940
B3934	Los Bajos (Gibara), Cuba	19-May-82	31	1.600
P1911	Cabo Cruz, Oriente, Cuba	12-Aug-90	36	1.600
T1992	Guadeloupe	1-15-May-88	70	207
P1662	Guadeloupe	1-15-May-88	19	207
G999	Southwest Martinique	18-Apr-74	7	342
486	Ste. Anne, Martinique	17-May-74	8	315
P949	Cabo Rojo, Puerto Rico	5-Oct-74	2	460
B5234	Mona Island, Puerto Rico	31-Aug-85	13 days	513
B4664	Maranhao, Brazil	7-Oct-87	4	2.870
H1505	Carriacou, Granadines	7-Mar-76	6	430
B4047	Boca La Raya, Colombia	19-Apr-90	130	1.140
T1022	Black Bay, Grenada	16-May-76	8.5	420
P1556	Jacmel, Haiti	1-Jul-89	7	1.020
P1803	St. Kitts	19-Aug-87	8 days	193
?	Mujeres Island, México	?		2.540

TABLE 2

Minimum Speed of Travel Recorded for Green Turtles (<u>Chelonia mydas</u>) Tagged at Aves Island

1973 - 1993

Tag	Place of Capture	Date of Capture	Time (months)	Time (days)	Distance (km)	Speed (Km/day)
B5234	Mona Island, Puerto Rico	31-Aug-85		13	513	39
P1803	St. Kitts	19-Aug-87		8	193	24
B4664	Maranhao, Brazil	7-Oct-87	4	125	2.870	23
B4645	Berbice River, Guyana	Jul-84	3-4	78-108	1.273	12-16
B6268	Miskito Keys, Nicaragua	20-23-Feb-89	5	143-146	2.090	8-15
P949	Cabo Rojo, Puerto Rico	5-Oct-74	2	47	460	10

RECAPTURE PERCENTAGE BY COUNTRY

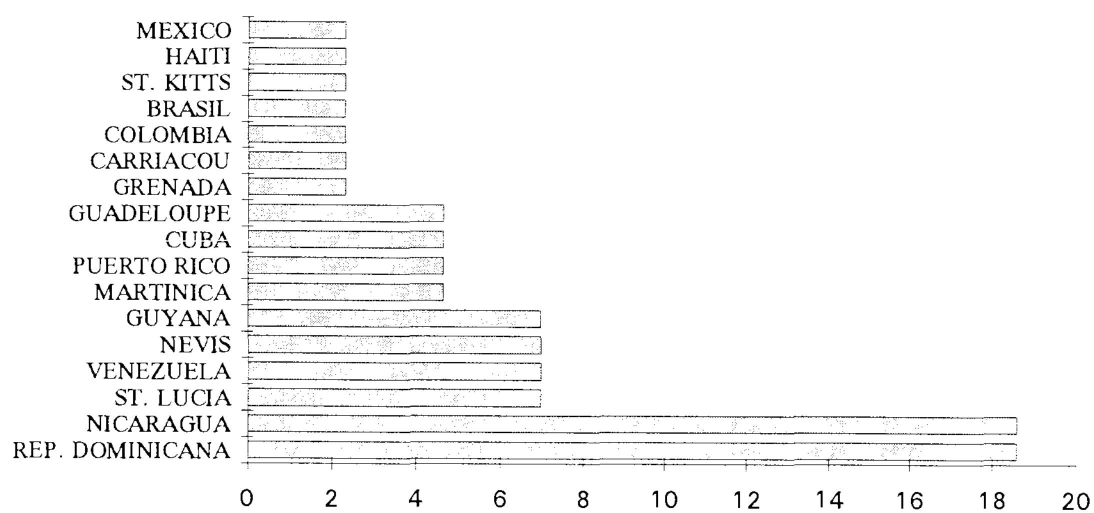
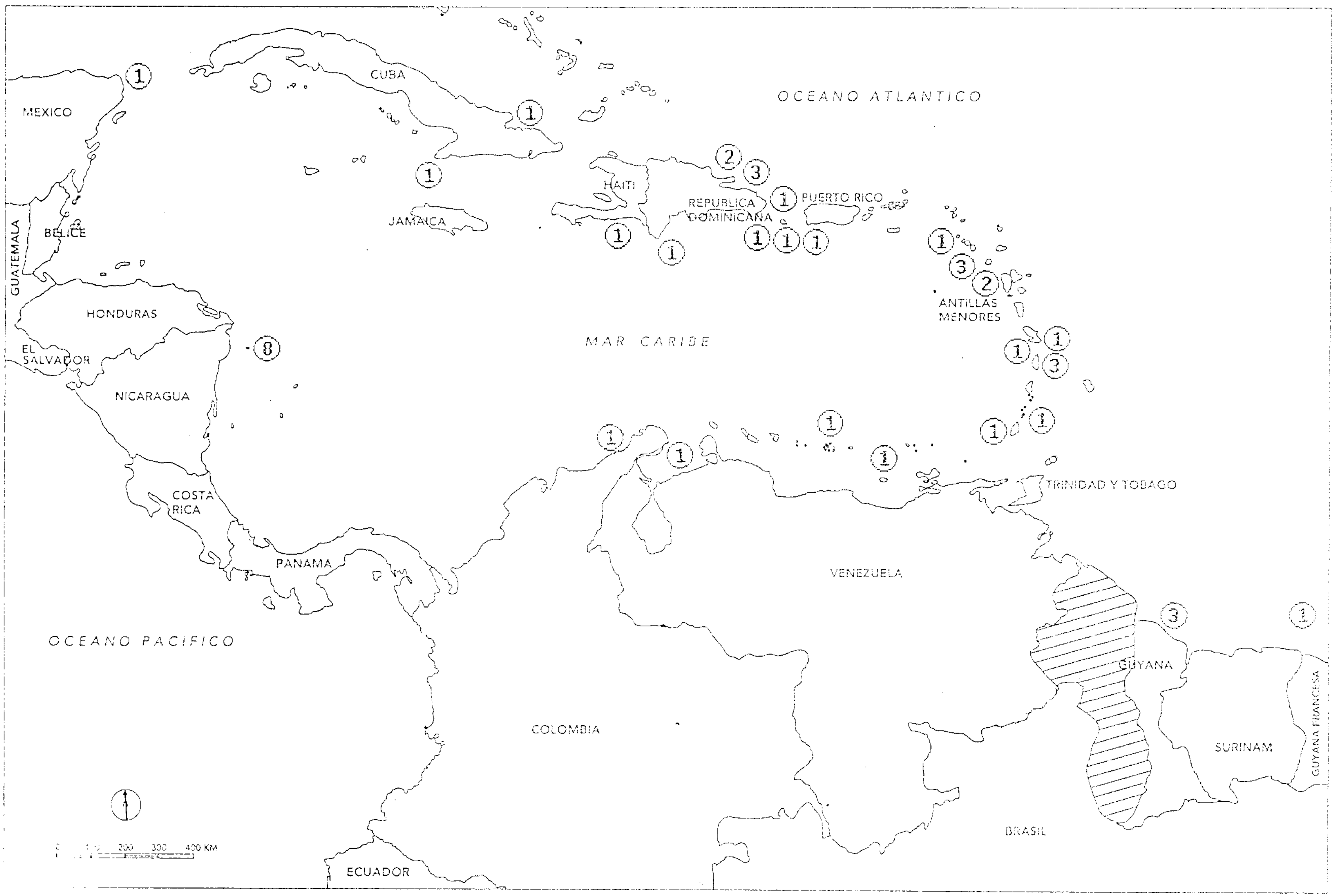


Figure 2

Figure 1

Recaptures of green turtles (Chelonia mydas) tagged at Aves Island, 1973 - 1993



FROM AN EQUILIBRIUM OF EXTINCTION TO A SUSTAINABLE HARVEST: MANIPULATING THE ECONOMIC INCENTIVES DRIVING THE EXPLOITATION OF SEA TURTLE EGGS

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This paper applies micro-economic models to describe the incentives driving the exploitation of sea turtle eggs in Aldea Hawaii, Guatemala. Economic incentives have resulted in complete harvesting of all eggs, a clearly unsustainable practice which can only lead to the extinction of the local nesting population. A clear understanding of the incentive structure aids in the analysis of practical strategies for shifting harvesting towards a sustainable level through the manipulation of economic incentives. Rather than attempting to quantitatively define a sustainable level of harvest, this paper aims to evaluate the potential for various strategies of manipulation to reduce harvest to a sustainable level irrespective of the particular target level deemed appropriate. Incentive manipulation techniques evaluated include the present strategy of donations to a hatchery, as well as monopoly, moratorium, mariculture, hiring of poachers, ecotourism, indirect purchasing of eggs, "turtle-safe eggs," adopt-a-nest, and a conservation tournament.

The economic incentives driving the exploitation of sea turtle eggs in the village of Aldea Hawaii, Guatemala encourage harvesting of all available eggs, so few nests escape poachers to hatch naturally on the beach. The current strategy for sea turtle conservation in Guatemala is centered around a network of twenty-five hatcheries which the government has established along Guatemala's Pacific coast. These hatcheries are intended to incubate enough eggs each year to maintain Guatemala's nesting sea turtle populations.

Hatcheries are supplied with eggs by "donations" from poachers. Since the donations represent a loss to the collectors for which they are not compensated, there is little incentive to comply. To encourage donations the government has authorized the hatchery personnel to issue permits to collectors in exchange for their donations. These permits, which are proof of collaboration with a hatchery, permit the eggs to be transported and sold. Any eggs which are not accompanied by a permit are subject to confiscation by the police. In theory the "donations" are mandatory, but in practice they actually are donations.

This hatchery strategy is based upon the assumption that there is some level of harvesting which is sustainable. The goal of the program is to allow harvesting at a sustainable level, and incubate the remainder of the eggs. Although the question of the sustainability of any level of harvesting at Aldea Hawaii is highly contentious, strategies of manipulation the economic incentives which drive exploitation can be evaluated on the basis of their potential to increase donations to hatcheries and/or the number of nests left to incubate naturally.

SUPPLY OF SEA TURTLE EGGS IN ALDEA HAWAII, GUATEMALA

The chain of supply for Olive ridley (*Lepidochelys olivacea*) and Leatherback (*Dermochelys coriacea*) eggs exploited in Guatemala's Hawaii Reserve consists of egg collectors, middle-men, and vendors. The turtle egg collectors, or recolectores as they are called locally, are responsible for the initial stage of exploitation. They walk the beach at night in search of completed nests or emerging turtles, collect the eggs, and sell them to middle-men in the village. The middle-men, or compradores, transport the eggs to vendors in the cities via a 45 min boat ride and a bus trip of up to 3.5 hours.

Inputs: unskilled labor, which is cheap and abundant; a bag for the collectors to put the eggs into; a small motor boat and gasoline to transport eggs to the bus; a bus ticket; and of course, nesting turtles.

Fixed costs: bags in which to collect eggs and boats to transport the eggs to the bus. (Because bags are inexpensive and can be used for other purposes, fixed costs for the collectors are negligible and capital is not fixed in the short run. Thus, the production function is essentially long run.)

Variable costs: labor, gasoline, and bus tickets.

Opened access resource: nesting turtles.

CONCLUSIONS

Strategies for manipulating the economic incentives which drive the exploitation of sea turtle eggs can be divided into four major areas: closing access, raising the collector's costs, decreasing demand, and beneficiaries pay. Access can be closed through monopolies or moratoriums. The simplest means of raising an egg collector's costs are to increase his/her opportunity costs through ecotourism, economic development, and education. Through education and regulation demand can be decreased, and with it the potential revenues to be gained from harvesting also decrease. Other strategies are designed to bring social costs and benefits into the harvester's private cost-benefit calculation by enlisting the beneficiaries of conservation to help pay the costs of conservation—costs which are often bourne by the harvesters—through ecotourism, turtle-safe eggs, adopt-a-nest, indirect purchasing of eggs, and conservation tournaments.

Conclusions on the potential of each strategy to manipulate the economic incentive structure driving the exploitation of sea turtle eggs in Aldea Hawaii are not firm enough to clearly rank the strategies. However, it is clear that a combination of strategies is in order. Those showing the most promise include strategies which aim to raise the opportunity cost of egg collectors and those which enlist the beneficiaries of non-consumptive use values, existence values and option values of sea turtles to help cover the costs of conservation efforts.

ACKNOWLEDGMENTS

This paper was made possible by a generous grant from the Coca-Cola World Fund, at Yale University. The author would also like to thank ARCAS, the people of Aldea Hawaii, and J. Shogren.

LOGGERHEAD SEA TURTLE HEAD-START EVALUATION: CAPTIVE GROWTH RATES AND POST RELEASE MOVEMENTS AND BEHAVIOR

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Growth rates of loggerhead sea turtles, *Caretta caretta*, have been reported for more than 60 years. Considering this great time span and the large number of loggerheads which have been captive-raised or head-started, there have been few published studies examining their growth. Most of these studies have concentrated on captive-raised animals and often had small sample sizes. Details of the husbandry conditions were often not reported. As a result, comparisons of data and applications of these figures to the calculation of true growth rates for loggerhead sea turtles have been difficult (Dodd, 1988).

Previous studies of captive-raised loggerheads have reported a wide range of growth rates as summarized by Frazer (1982). Variations in quality and/or quantity of food probably account for much of the observed differences (Stickney et al., 1973; Nuitja and Uchida, 1982), while rearing conditions such as water temperature, salinity and light quality can be contributing factors. The most rapid loggerhead growth rates were reported by Parker (1929) and Uchida (1967). In these studies, mean weights were reported between 10 and 19 kg at 3 years.

Despite the popularity of head-starting during the last 30 years, little is known of the post-release viability of captive-raised sea turtles. This question is of such concern that many major regulatory agencies have withdrawn their support for the use of head-starting as a conservation tool (Huff, 1989). Recent advances in satellite biotelemetry have made long term monitoring of free-swimming sea turtles a practical reality. This tracking method has been used extensively with wild caught sea turtles and has provided valuable new information on their at-sea movements and behaviors (Keinath et al., 1989; Byles and Keinath, 1990).

METHODS

In October of 1989, Virginia Institute of Marine Science (VIMS) researchers removed hatchling loggerhead sea turtles from NEST A in the Back Bay National Wildlife Refuge (USFWS), Virginia Beach, VA. Following initial acclimation and assessment at VIMS, hatchlings were distributed to the Virginia Marine Science Museum (VMSM) and Columbus Zoo (Table 1) for commencement of the growth and feeding studies.

Seawater systems in each institution were designed to maintain specific physical and qualitative parameters. Salinities ranged from 28-35 ppt and temperatures from 25-29 °C during the study period for all institutions.

Food for the loggerheads consisted of a marine animal gelatin diet developed at VIMS (Choromanski et al., 1987). This diet was prepared by each institution using raw materials originating from a single source and lot, assuring qualitative uniformity of food. The amount of food consumed by each individual sea turtle was recorded on a daily basis during much of the study period (Table 2).

Growth of the loggerheads was recorded weekly by straight-line caliper measurements of carapace and plastron dimensions and by total weight. For the purposes of this poster total weight was used for growth comparisons.

Satellite telemetry was coordinated by VIMS and utilized 6 backpack style transmitters produced by Telonics, Inc. of Mesa, Arizona USA. Transmitters were cemented to the carapaces using fiberglass resin, which separates from the keratin of the scutes over time. Anti-fouling paint was used to prevent marine epibiota from overburdening the turtles or adversely affecting transmitter capabilities. Transmitters recorded number of dives, dive durations, ambient temperatures and position locations.

RESULTS AND DISCUSSION

Comparison of the growth rates from this study (Table 3) with those from previous studies reveals extremely rapid development of young loggerhead sea turtles. Mean weights for NEST A individuals at one year ranged from 4.5 kg at VMSM to 6.9 kg at Columbus Zoo. These values indicate growth rates 4-5 times greater than those from comparable time periods in previous studies. Furthermore, results from this study surpass the most rapid growth rates previously reported. One exceptional loggerhead (#92) at the Columbus Zoo reached a weight of 21.6 kg in 1.65 years. This level of growth was not reached before the age of 3 by any of the loggerheads in previous studies (Dodd, 1988).

In September of 1991, 6 of the head-started loggerheads were released at BBNWR carrying satellite transmitters. Preliminary results of the satellite tracking part of the project are presented here. Though the satellite transmitters did not perform as expected and no more than 6 weeks of data were obtained, certain characteristics of the turtles' behavior are worth noting. Data indicated that these loggerheads were spending only 50% of their time submerged. Previous studies of wild loggerheads showed that more than 90% of their time was spent submerged. Average dive time was also very short when compared to previously tracked wild loggerheads. Finally, the tracks of the head-started loggerheads were not consistent in terms of directional movement. Some turtles were plotted moving northeast into the North Atlantic with the Gulf Stream while others were meandering in coastal waters near the release site. These data suggest that, at least initially, the head-started loggerheads in this study were not exhibiting normal behavior. Whether these behavioral characteristics can be overcome or will affect the ultimate survivability of the turtles requires further study. Improvements to satellite transmitters and detailed examinations of the physiological condition of the sea turtles prior to release are future objectives of this project.

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Nest	Eggs Laid	Eggs Hatched	Distribution		
			VIMS	VMSM	Columbus Zoo
A	7-25-89	10-3-89	3	4	5

Table 1. Distribution of loggerhead sea turtle hatchlings from Nest A in BBNWR, Virginia Beach, VA.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VMSM	25.3	36.2	44.7	51.5	44.5	48.1	63.2	68.6	93.3	123.0	146.8	149.0
C-Zoo	28.9	44.3	59.8	81.1	93.7	143.0	160.7	194.4	193.8	156.0	151.6	171.7

Table 2. Rate of food consumption for loggerhead sea turtles at VMSM and Columbus Zoo during 1990. (Shown as Avg amount consumed(g)/turtle/day)

	VMSM (N=4)		Col.Zoo (N=5)		VIMS (N=3)		Col.Zoo (#92)	
Age	Wt	CLTT	Wt	CLTT	Wt	CLTT	Wt	CLTT
12	120	92	151	96	158	98	160	95
17	375	132	416	137	301	122	480	140
21	704	160	729	167	576	152	860	175
25	1,089	183	1,170	193	950	181	1,360	201
29	1,538	213	1,761	220	1,363	205	2,204	231
34	2,021	231	2,512	248			3,113	260
38	2,401	243	3,392	274			4,202	287
43	3,054	261	4,515	305			5,477	316
47	3,564	278	5,755	331			7,003	346
51	4,448	296	6,863	355			8,334	370
56	5,316	317	8,445	384			9,777	397
60	6,444	338	9,539	405			10,767	416
64	7,265	355	11,278	429			12,821	439
69	8,315	372	13,812	459			15,566	473
73	8,933	385	15,213	478			17,394	489
77	10,140	400	17,328	498			19,505	514
81	10,842	411	18,664	517			21,090	535

Table 3. Nest A mean weights (Wt,g) and mean carapace lengths (CLTT,mm) versus age (Age,weeks) for loggerhead sea turtles during study period ending in April 1991.

MARINE TURTLE STRANDING TRENDS, 1986-1993

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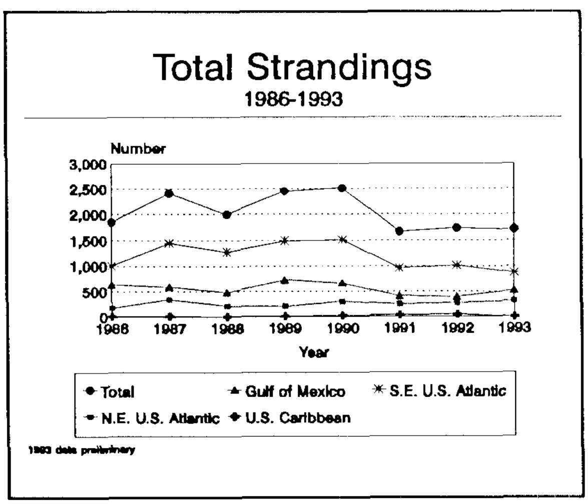
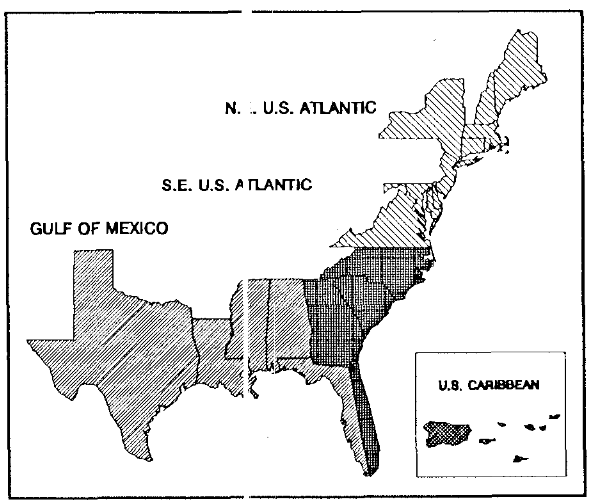
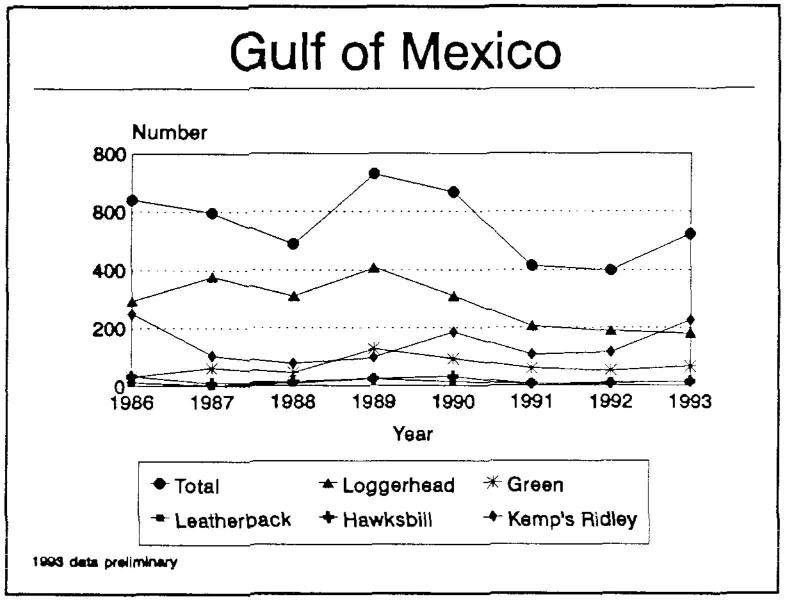
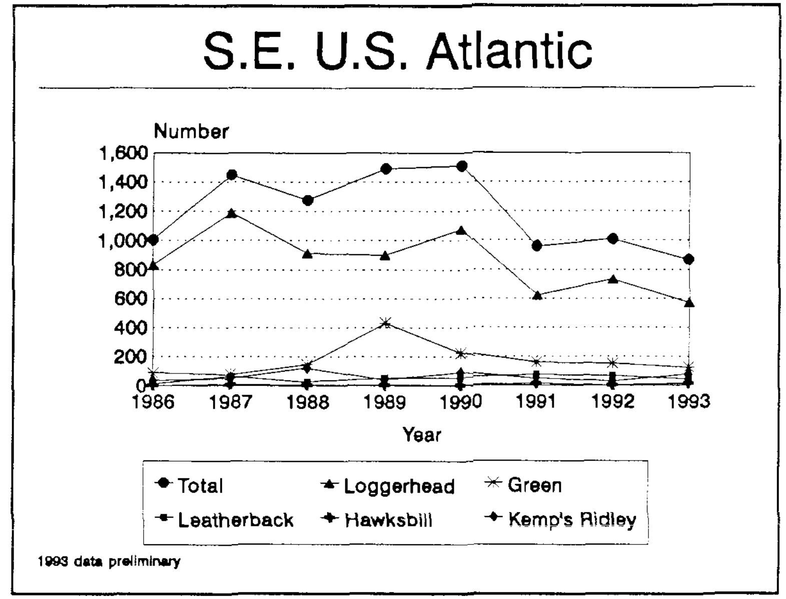
The Sea Turtle Stranding and Salvage Network (STSSN) was established in 1980 to document strandings of marine turtles along the U.S. Gulf of Mexico and Atlantic coasts. The network encompasses the coastal areas of the eighteen state region from Maine through Texas, and includes portions of the U.S. Caribbean (Puerto Rico and the U.S. Virgin Islands). This poster summarizes data compiled through the efforts of network participants from 1986 through 1993.

Special thanks to all of the state coordinators and network participants who document marine turtle strandings in their respective areas. This poster is made possible through their hard work and dedication.






Gulf of Mexico
Number
800
800
400
200
0
1986
1987
1988
1989
1990
1991
1992
1993
Year
Total
Loggerhead
Green
Leatherback
Hawksbill
Kemp's Ridley
1993 data preliminary


S.E. U.S. Atlantic
Number
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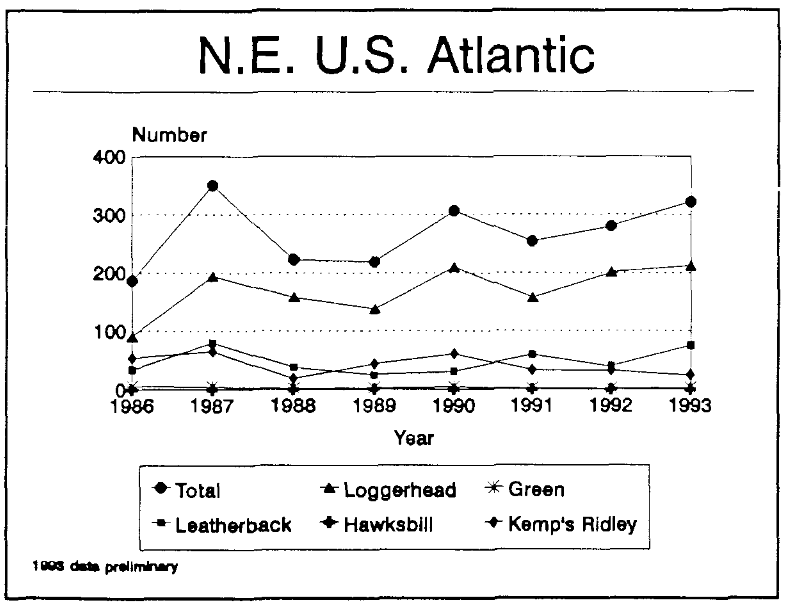
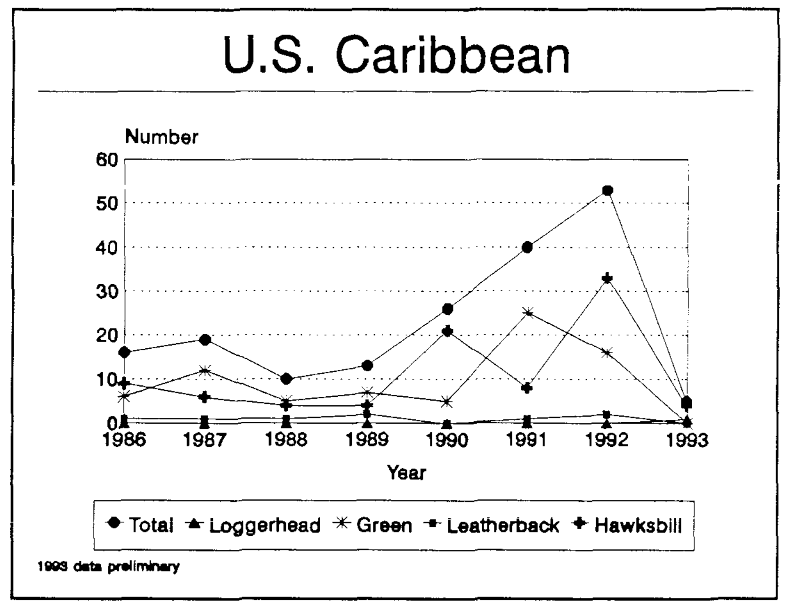
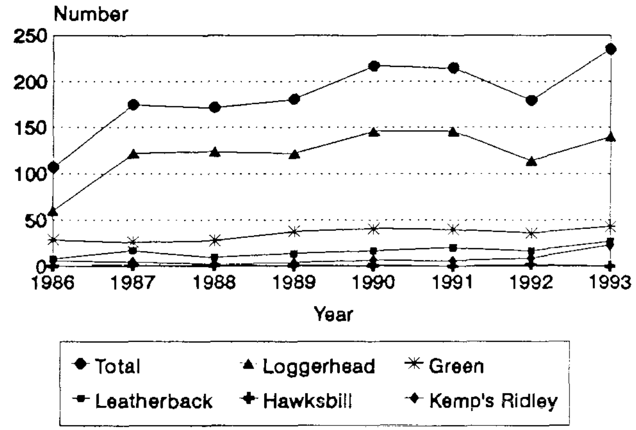
1,400
1,200
1,000
800
600
400
200
0
1986
1987
1988
1989
1990
1991
1992
1993
Year
Total
Loggerhead
Green
Leatherback
Hawksbill
Kemp's Ridley
1993 data preliminary


N.E. U.S. Atlantic
Number
400
300
200
100
0
1986
1987
1988
1989
1990
1991
1992
1993
Year
Total
Loggerhead
Green
Leatherback
Hawksbill
Kemp's Ridley
1993 data preliminary

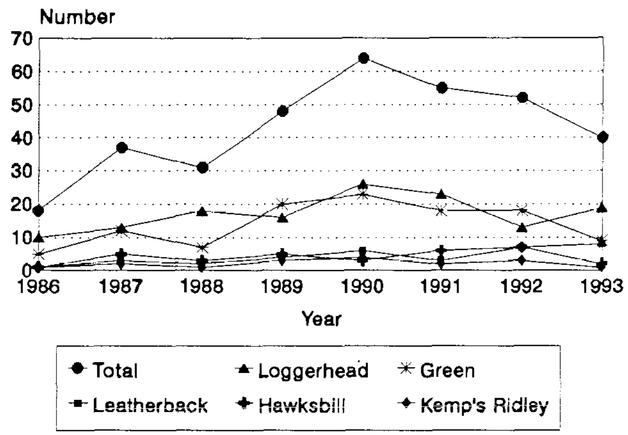

U.S. Caribbean
Number
60
50
40
30
20
10
0
1986
1987
1988
1989
1990
1991
1992
1993
Year
Total
Loggerhead
Green
Leatherback
Hawksbill
1993 data preliminary

Prop Wounds/Boat Collisions



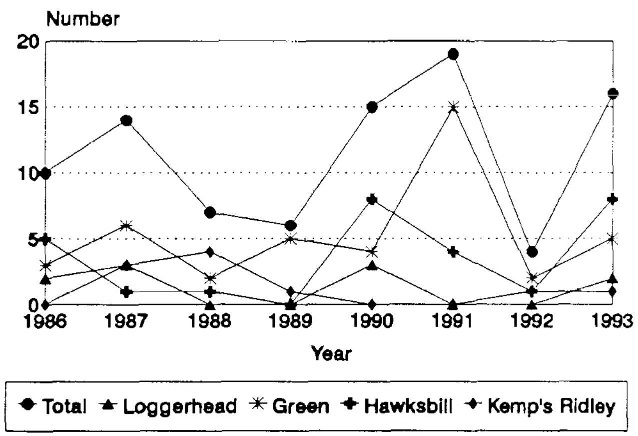
1993 data preliminary

Entanglement



1993 data preliminary

Tar/Oil Impacts



1993 data preliminary

INTERNESTING HABITAT USE BY LOGGERHEAD TURTLES IN WOONGARRA MARINE PARK, QUEENSLAND: HOW WELL PROTECTED ARE THEY?

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We investigated internesting habitat use by loggerhead turtles (*Caretta caretta*) at Woongarra Marine Park, Queensland. Turtles were followed with radio telemetry and by visual sightings of paint-marked turtles. Following nesting, turtles typically swam to an underwater structure or stable substrate and confined their movements for 2-4 days, followed by a wider scope of longshore movements, with a return to the rookery at the end of the 14 day internesting period. Movements were generally longshore oriented within 10 km north or south of the rookery, offshore movement was limited to 1-2 km of the coast, and movements were independent of currents in the region. A different movement pattern was exhibited after the final nest of the season; females departed the region immediately and directionally with none of the localized movement characteristic of the internesting period. Density estimates during the peak of the nesting season were 12.7 turtles/km^2 in the Protection Area and 0.6 turtles/ km^2 in the Monitoring Area. Densities outside the northern Park boundary were comparable to those in the Protection Area. The area within a 3 km radius of the Burnett River channel contains a high concentration of migrant females from the Mon Repos rookery. During the latter part of the internesting interval, turtles were as likely to be outside protected management zones as within. The likelihood of turtle-trawler interactions in the Woongarra coastal region is considered and the value of turtle excluder devices (TEDs) as a conservation measure is discussed.

TREATMENT OF TRAUMATIC CARAPACE INJURIES OF SEA TURTLES

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Sea World of Florida's Rescue and Rehabilitation Program receives thirty-five to forty sea turtles per year. Our records indicate that since 1985 approximately twenty percent of these animals were presented with traumatic shell injuries. These include injuries from propellers, blunt trauma from watercraft, and injuries of unknown origin. There have been a number of methods used to treat these injuries with each having advantages and disadvantages.

Some of the techniques used to treat carapace injuries have included fiberglass patches, boat mending compound, dental acrylic and Elastikon™ medical tape. Fiberglass is very sturdy once set, however the heat generated during set-up can be harmful to the exposed muscle and tissues. While boat mending compound or dental acrylic generate little or no heat when affixed, they too create a hard covering over the wound. All three of these methods trap and retain debris within the wound often proving to be counterproductive to the healing process by possibly sealing in an infection. Also, with time, the patch may loosen around the edges acting as a possible point of entanglement or come off completely thus allowing access of debris. The Elastikon™ medical tape was an improvement that allowed easy access to the wound for frequent cleansing. However, it was not water resistant and the sea turtles were able to loosen this bandage. They often had a tendency to rub their flippers over the bandage and pull it off either by curling up the edges or by catching their nails in the tape.

The current method being used at Sea World of Florida utilizes a semi-permeable wound dressing called Tegaderm™. This product allows oxygen and moisture-vapor in, but is impermeable to liquids and bacteria. It adheres well to the shell and tissue surfaces but does not leave a sticky residue when removed. Also, Tegaderm™ is transparent which allows for direct inspection of the wound. This product creates a water resistant healing environment that can easily be removed for access to the wound for periodic cleansing.

When a sea turtle is presented to Sea World of Florida's Rescue Program, the initial diagnostic techniques include a complete physical examination, complete blood cell counts, serum chemistries, x-rays, and a blood glucose test for hypoglycemia. Initial treatments may include administration of fluids, glucose, antibiotics and/or tube feeding. Any or all of these treatments may be adjusted as the condition of the patient changes. The wound therapy starts by debriding the area of any detritus, dead tissue, or shell fragments. The site is then rinsed with a 10% Betadyne solution to flush out any remaining loose particles and to decrease surface bacteria. This may need to be done several times during the debridement process to clear the field of sight. A final 10% Betadyne rinse is done when debridement is complete and is followed with a rinse with normal saline solution. If there are loose fragments of opposing shell, they can be stabilized by making small holes in the shell edges, lacing a shoestring through the holes and tying the ends together. This allows easy access to the wound for future cleansing and does minimal harm to the shell. The wound is then filled with petroleum based antibiotic ointment that is packed to cover the entire wound space. The surrounding shell is cleansed and dried to allow application of the bandage. The Tegaderm™ is then applied to cover the wound with about a one inch overlap onto the shell edges. The adhesion of this material is enhanced by rubbing your hands together and then placing your warmed hands on the patch for thirty to sixty seconds. Finally, all the edges and seams are super glued for a complete seal. This dressing holds up well in the saltwater environment once the edges and seams are glued thus providing a water resistant bandage that will maintain the ointment and last for one to four weeks. The wound should be cleansed at least weekly initially and eventually bi-weekly or monthly as deemed necessary by the veterinarian.

This method has been used at Sea World of Florida for approximately the past two years and the results have been very favorable. This technique does require a long rehabilitation time and frequent care, however it is our opinion that this is the most beneficial treatment available to date. The sequence of healing that occurs in these types of wounds, once debridement and treatment of infection have been done, starts with granulation of healthy tissue, followed by re-epithelization, then invasion of pigment into the new epithelium. Finally, calcification occurs and completes the healing process. Regular wound maintenance promotes the removal of debris allowing faster healing, a smoother granulation surface and a more normal appearing calcification process. Once the wound has thoroughly healed and body weight and behavior are sound, the sea turtle is tagged and released near the sight at which it was found.

PRODUCT LIST:

Tegaderm™;	3M Health Care St. Paul, MN 55144-1000
Elastikon™;	Johnson and Johnson Med. Inc. Arlington, TX 76004-0130

SUSPECTED GAS BUBBLE DISEASE IN CAPTIVE LOGGERHEAD SEA TURTLES

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Gas Bubble Disease is a known cause of mortality amongst captive fish housed in recirculating systems using pressure water pumps. Gross lesions result from prolonged exposure to supersaturated gases which have been entrained into solution by the pressure pump and absorbed across the gill membranes by the fish. Histological lesions consist of multifocal intradermal vesicle formation with minimal lymphocytic and granulocytic inflammation. The use of desaturation towers, where water returning from the pressure pump is agitated over media to allow dissolved gases to escape, are commonly employed to prevent this malady.

In 1991, five sub-adult loggerhead sea turtles, *Caretta caretta*, were housed in five separate 250 gallon holding vats connected to a common closed recirculating filter system. Damage of a water recirculation line allowed air to become entrained and supersaturated into solution. Within a week, the two turtles closest to the return water line developed classic symptoms of gas bubble disease. Lesions were first seen around the eyes and the roof of the mouth. Within two weeks the dermal emphysema extended to all skin surfaces. The turtles recovered with symptomatic care over the following 8 weeks.

The use of a desaturation device on the circulating system may have prevented this problem. Exhibits and holding systems housing sea turtles should be equipped with desaturation devices.

SEA TURTLE TAGGING PROGRAM IN QUINTANA ROO, MEXICO

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Sea turtle tagging programs in the Mexican Caribbean began in 1966, when personnel from the Secretaria de Pesca (SEPESCA) began marking turtles in Isla Mujeres. In 1983 a turtle program was begun at the Centro de Investigaciones de Quintana Roo (CIQRO); most work has been concentrated on nesting beaches along the central coast of the state. In subsequent years biologists from other organizations have tagged turtles along the northern and southern beaches of Quintana Roo. The majority of the animals tagged have been nesting *Caretta caretta* and *Chelonia mydas*, from the central coast.

In 1990 personnel in CIQRO's sea turtle program began compiling a data bank of sea turtle tagging activities in the state. The present report is a synopsis of the results of this study.

METHODS

The tagging records have been revised and compiled in reports of sea turtle studies that have been carried out in Quintana Roo; we researched the files of various offices of SEPESCA and other governmental organizations in the state that have worked with sea turtles (excluding the SEPESCA offices in Manzanillo, Colima and in Mexico City and CIQRO's data from 1983 to 1986). The period reviewed was from 1966 to 1993.

RESULTS AND DISCUSSION

The only tags known to have been used in the tagging programs in the state are monel cattle ear tags (sizes 49 and 56), these have been placed in the trailing edge of a front flipper, close to the shell. At least 164 individual turtles have been double tagged. In addition to an identification number, each tag carries an offer for a reward and a return address; most tags used have the SEPESCA address (PESCA/CRIP-Manzanillo, 28200 Mexico), but about 500 have carried the CIQRO address (Apartado Postal 886 Cancun, QR, Mexico). There are an additional 20 tags with the inscription "USNPS" for which data are not available, but known to have been used in 1984. The total number of individual turtles tagged during the 27-year period in the Mexican Caribbean (Fig. 1 insert) are: 2,348 *Caretta caretta*; 2,017 *Chelonia mydas*; 158 *Eretmochelys imbricata*; and 3 *Dermochelys coriacea* (Table 1).

Remigration intervals for nesting female *Caretta caretta* and *Chelonia mydas*, based on the CIQRO data between 1987 to 1993 from the central coast of the state, are shown in Tables 2 and 3. The most common intervals between nesting seasons were 2 and 3 years for both *Caretta caretta* and *Chelonia mydas* (Table 4).

Only five wild caught turtles (all of them tagged while nesting in Quintana Roo) are known to have been recaptured at any place other than the original nesting beach. One *Caretta caretta* was reported from Nicaragua; three turtles (species not reported) have been recaptured, one each from Cuba, Honduras and Nicaragua; and one *Dermochelys coriacea* was recaptured in Arcas Cay Campeche (Fig. 1). Other long-distance recaptures are suspected to have been reported to SEPESCA, but we do not have access to these data.

Of the 399 captive-reared *Chelonia mydas* which were released from Puerto Morelos when 2 to 3 years old, four were recaptured in Cuban waters (Fig. 1). All four turtles were between 7 and 9 years old when recaptured.

A fifth turtle from this captive-reared cohort was captured in 1990, by personnel from the Centro Regional de Investigaciones Pesqueras (CRIP), south of Isla Mujeres; this is about 45 km in straight line distance from Puerto Morelos (Fig. 1 Insert). This turtle was 11 years old and its straight carapace length measured 84 cm, 2 cm less than the smallest size recorded for nesting females *Chelonia mydas* from this region. The turtle was placed, together with other turtles of the same species, in a pen which extended from the beach to 50 m out to sea. CRIP personnel reported that this turtle nested four times during 1990, but they did not know if it copulated while in the pen. This is the first record of a head-started sea turtle being recaptured from the Mexican Caribbean.

ACKNOWLEDGMENTS

We express our sincere thanks to all the personnel involved in the sea turtle tagging programs in Quintana Roo in the following institutions for their help and contributions for the information contained in the data bank: SEPESCA; SEDESOL; Amigos de Sian Ka'an; Facultad de Ciencias, UNAM; PRONATURA; Grupo Ecologista del Mayab, A.C.; Comite de Cozumel. The data on the recaptured, head-started Green turtles from Cuba were provided by Jose A. Ottenwalder. We also wish to thank individuals who have returned tags to us. And finally many thanks to Julio Espinoza and Jack Frazier for reviewing earlier drafts of this paper.

Table 1. Numbers of sea turtles, of different species, sex and age classes, tagged in Quintana Roo during the period 1966 to 1993.

Species	Adults Female	Adults Male	Immature	TOTAL
Caretta caretta	2,335	1	12	2,348
Chelonia mydas	1,315	30	671*	2,017
Eretmochelys imbricata	106	1	51	158
Dermochelys coriacea	2	1	0	3
TOTAL	3,769	33	735	4,535

*includes 399 turtles which were reared in captivity in the SEPESCA station at Puerto Morelos, tagged and released in 1981 when they were between 2 and 3 years old.

Table 2. Remigrations of nesting *Caretta caretta* from the central coast of Quintana Roo.

Number	Tagged			YEAR OF REMIGRATION				
YEAR	TOTAL	1988	1989	1990	1991	1992	1993	%Recaptured
1987	296	7	**29**(3)	13(5)	17(10)	7(6)	12(9)	18
1988	341	--	7	**35**(1)	22(3)	21(8)	14(12)	20
1989	335	--	--	5	**16**(1)	12(3)	13(7)	10
1990	213	--	--	--	2	**23**	12	17
1991	215	--	--	--	--	2	**36**	18
1992	265	--	--	--	--	--	1	0.4

*The number of turtles recaptured after 2 (or more) remigrations are indicated in parentheses(x).

Table 3. Remigrations of nesting *Chelonia mydas* from the central coast of Quintana Roo.

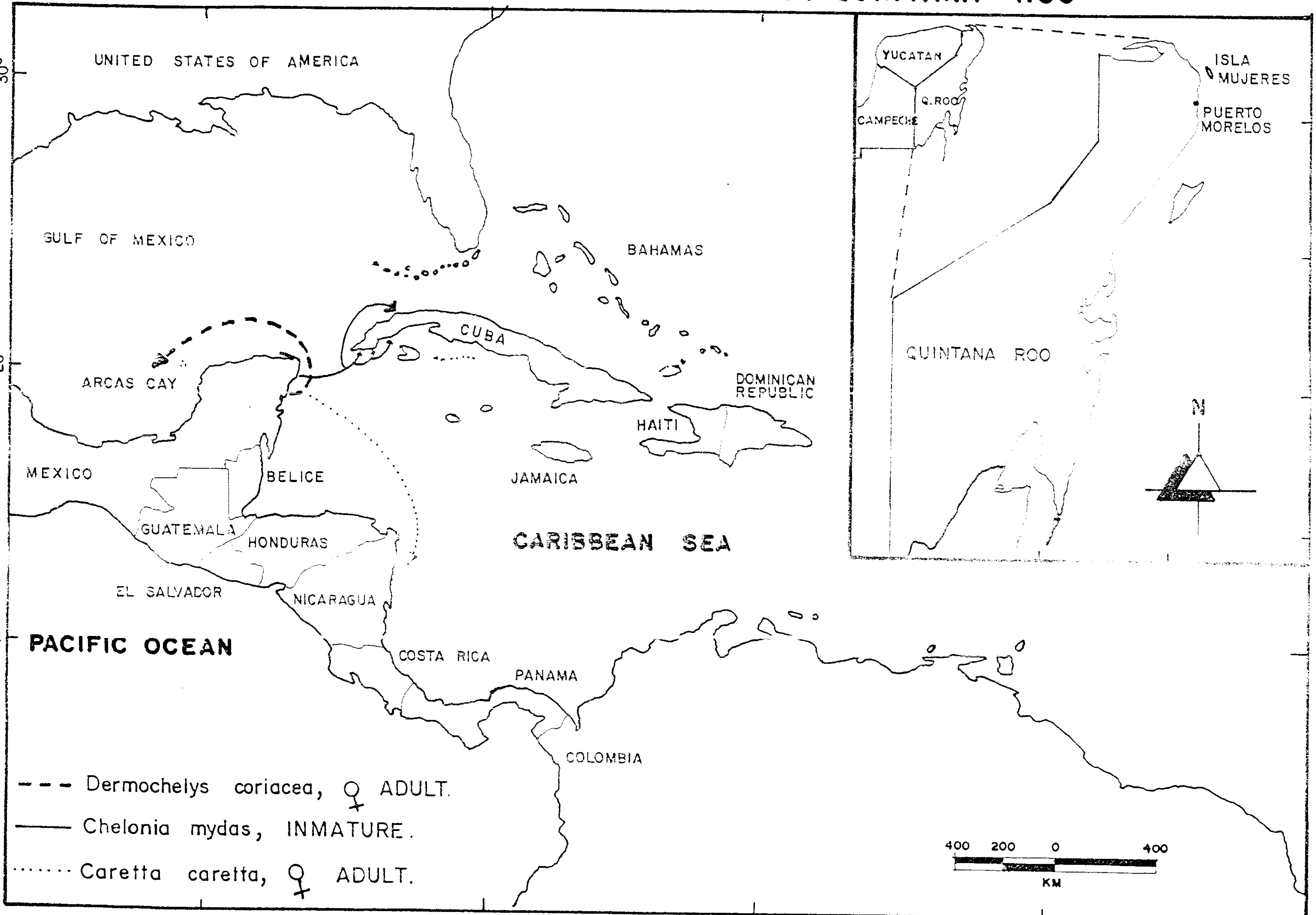
Number	Tagged			YEAR OF REMIGRATION				
YEAR	TOTAL	1988	1989	1990	1991	1992	1993	%Recaptured
1987	98	3	4	7	1	2(2)	1	16
1988	149	--	1	**3**	2	**3**(1)	0	5
1989	93	--	--	0	4	**5**	1(1)	10
1990	167	--	--	--	0	**33**	1	20
1991	31	--	--	--	--	0	**6**	19
1992	195	--	--	--	--	--	0	0

*The number of turtles recaptured after 2 (or more) remigrations are indicated in parentheses (x).

Table 4. Remigration intervals *Caretta caretta* and *Chelonia mydas* from the central coast of Quintana Roo.

		REMIGRATION INTERVALS (years)						
SPECIES	TOTAL TAGGED	1	2	3	4	5	6	TOTAL RECAPTURED
C. caretta	1703	24	134	48	26	3	3	238
C. mydas	733	4	50	15	3	0	1	73

FIG. I MIGRATORY ROUTES OF TURTLES TAGGED IN QUINTANA ROO



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APPENDIX I: PRESENTATIONS GIVEN AT WORKSHOP BUT NOT INCLUDED IN THESE PROCEEDINGS

APPENDIX I

The following papers were presented at the Workshop but are not included in this volume at the authors' request. They are documented here for completeness; some will be published elsewhere. Only the first author's address is given.

ORAL PRESENTATIONS:

TRANS-OCEANIC LOGGERHEAD MIGRATIONS DEMONSTRATED WITH GENETIC MARKERS

Brian Bowen, Alberto Abreu Grobois, George Balazs, Naoki Kamezaki, Colin Limpus, and Rob Ferl
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C.I.T.E.S.: PROPOSED CHANGES JEOPARDIZE SEA TURTLES

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POSTER PRESENTATION:

GROWTH, FORAGING AND SEX RATIO OF IMMATURE HAWKSBILLS AT MONA ISLAND, PUERTO RICO

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