NOAA Technical Memorandum NMFS-SEFSC-361

PROCEEDINGS OF THE TWELFTH ANNUAL WORKSHOP ON SEA TURTLE BIOLOGY AND CONSERVATION

25-29 February 1992
Jekyll Island, Georgia

Compilers:
James I. Richardson
Thelma H. Richardson

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
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February 1995

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PART II: POSTER PRESENTATIONS

PREFACE

The Twelfth Annual Symposium on Sea Turtle Biology and Conservation was held 21-25 February 1992 at Jekyll Island, Georgia. The Symposium was hosted and organized by the Georgia Department of Natural Resources, Coastal Resources Division, and the Georgia Sea Turtle Cooperative Research and Education Program at the Institute of Ecology, University of Georgia. The Symposium brought together 544 registered participants from around the world, representing 36 states and 28 nations and commonwealths. U.S. Representative Lindsey Thomas was this year's honored participant. A broad range of topics was covered in the areas of sea turtle research, conservation, and management. Ninety papers and 50 poster sessions were presented. Fifty-one papers and 32 poster sessions have been compiled in these Proceedings as extended abstracts. The extended abstract format was chosen because it provides a means of disseminating more complete information than simple abstracts, while leaving the option open for authors to submit full length papers to peer review journals. This format involves negligible editorial control. The content of these extended abstracts does not necessarily reflect the views of the compilers, the Georgia Sea Turtle Cooperative, or the National Marine Fisheries Service. Our hope is that these Proceedings will serve as a useful source of information and contribute to sea turtle conservation and recovery.

On behalf of the Symposium Planning Committee (Rebecca Bell, Brian Bowen, Vincent Burke, Joe Ferris, Sandy Green, Mike Harris, Lloyd Logan, Charles Maley, Marcy Nejat, Steve Owens, Jim Richardson, Thelma Richardson, and Charles Warnock), we wish to express our great appreciation to everyone who participated in the Symposium and helped to make it a success. Copier and facsimile services were provided as a courtesy of Acme Business Products. Appreciation is extended to Don R. Simpson, Account Executive for Acme Business Products in Brunswick, Georgia, for this service. A very special thanks goes to all of those groups who provided hospitality assistance for our coffee breaks: Broad River Outpost, Walker Biology Club from Campbell University, Coastal Georgia Audubon Society, Georgia Southern College, Georgia Sea Turtle Cooperative, Sea Life Park of Hawaii and The Jekyll Island Garden Club. The evening refreshments crew is duly acknowledged. Lloyd Logan created the artwork for the Symposium T-shirt. Greg Bruce provided the artwork for the agenda cover. Rod Mast was auctioneer for our annual fund raising experience; thanks to everyone who donated so generously to this auction. Jim DeRevere of DeRevere Travel (Athens, Georgia) assisted with reservations and general travel needs. The Georgia Department of Natural Resources (Coastal Resources Division), University of Georgia Institute of Ecology, Jekyll Island Authority, and Villas by the Sea on Jekyll Island provided vital logistical support for the Symposium. Our thanks to the Southeastern Fisheries Center, National Marine Fisheries Service, for funding, duplicating, and distributing the Proceedings.

James I. Richardson
Thelma H. Richardson

February 1995

PART I: PAPER PRESENTATIONS

IMPACT OF SPANISH SWORDFISH LONGLINE FISHERIES ON THE LOGGERHEAD SEA TURTLE *CARETTA CARETTA* POPULATION IN THE WESTERN MEDITERRANEAN

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SUMMARY: More than 20,000 subadult loggerhead turtles are incidentally captured every year as a result of the Spanish longlining fishery activities. Turtles are usually released alive with the longline hook still lodged internally. However, at least 20% of the sea turtles captured by this fishing gear could eventually die, due to the injuries caused by the hooks. Observers on board 26 fishing boats during a period of 143 days, between the summer months of 1990 and 1991, recorded the captures of 1,098 loggerhead (*Caretta caretta*) and two leatherback (*Dermochelys coriacea*) sea turtles. 94% of the turtles captured while observers were onboard were tagged and released to investigate the origin of the Mediterranean sea turtle populations.

INTRODUCTION: The waters of the South Western Mediterranean are the fishing grounds for a fleet of Spanish surface longliners dedicated to the capture of swordfish (Figure 1). The activities of this fleet seem to have an important impact on the population of loggerhead sea turtles (*Caretta caretta*) present in the area. The fleet is composed of some 30 boats using longlines throughout the year and is joined during part of the year by a further 30 ships. The highest concentration of boats is during the summer months, when between 60 and 80 Spanish ships work in the area. A typical Mediterranean swordfish longliner is a wooden boat of 15 meters length, with a gross tonnage of 40 tons and a 300 HP engine. The crew consists of approximately 8 persons.

The basic fishing gear is composed of a mother line 300 m long, stretched between two buoys. From this line hang 12 hooks, attached to thinner lines that secure them at approximately 25 meters depth. The distance between hooks is around 20 meters. As many as 200 of these longline units can be joined together, reaching a length of up to 60 kilometers, with a possible 2,400 hooks. The most usual baits are flying squid (*Todarodes sagittatus*), mackerel (*Scomber scombrus* and *S. japonicus*) and gilt sardine (*Sardinella aurita*). Hook size is 90mm per 35mm. The gear is set at sunset and the hauling-in operation begins just before sunrise. The hauling operation takes up to 7 hours.

Although directed at swordfish (*Xiphias gladius*), this fishery produced by-catches of other species, such as loggerhead sea turtles (*Caretta caretta*), stingrays (*Dasyatis pastinaca*) and several species of tuna and sharks. During the last six years, Greenpeace has been carrying out research work to determine the impact of this fishery on the sea turtle population. This work has been combined with a tagging programme attempting to determine the origin of the western Mediterranean loggerhead turtles population.

MATERIAL AND METHODS

Questionnaires completed by the skippers of the longliners since 1986 have provided data on the number of sea turtles incidentally captured per boat and month for the duration of one year by the fleet landing its catches in the port of Alicante (SE Spain), the main harbour for this fishery. This information was later supplemented with the establishment of an observers programme onboard the boats.

In July, August and September 1990, observers were situated onboard 15 longline boats for a period of 73 days. In June, July and August, 1991, 11 boats were monitored in the same way for a period of 70 days. For every sea turtle captured by the longlines, the observers recorded several types of geographical and biological data, including date, location, species and size. Other data on parasites, pollution, wounds, etc., were also recorded. In 1991, information about the characteristics of the fishery (number of hooks, type of bait, gear setting and hauling times, time of every catch) and weather conditions (atmospheric and sea conditions, surface water temperature) were registered. Locations were determined by the information provided by the skippers. Turtle shell sizes were measured using a flexible tape and correspond to the curved carapace length of the individuals.

The observers were provided with tags from the University of Florida, and 94% of the captured animals were tagged in one of their flippers. Immediately the animals had been measured and tagged, they were released into the sea. In some cases it was possible to remove the hook before their release, but in the majority of animals the hook was located deep inside the digestive tract, making its removal impossible under field circumstances.

Since 1986, a number of sea turtles captured by this fishery, with hooks still present in their bodies, have been kept alive in captivity in large aquaculture pools with the aim of estimating the mortality rate of the individuals released with hooks still in their bodies. The capacity of each pool is 7,000 litres. The salinity ranges between 43.056 $^{o}/_{oo}$ and 48.070 $^{o}/_{oo}$ and the temperature range is between 9.60 C and 27.62 C. The bottom of the tanks is cleaned once a day to monitor the presence of expelled hooks and the state of digestion of food in feces.

RESULTS

In the period between July 7th and September 9th, 1990, a total of 673 loggerhead turtles was incidentally captured by the boats while observers were onboard (Figure 2). Between June 21st and August 30th, 1991, the number of loggerheads captured was 425. During that period, two leatherback turtles (*Dermochelys coriacea*) were also captured. Of the total of 1,098 loggerheads, only 4 were dead when hauled onboard. 1,035 animals were tagged before being released back to the sea. The removal of the hook was only possible in 171 cases, when the hook was found in the mouth, the tongue or, in a few cases, in which it was attached externally to the flippers or to other parts of the body.

A total of 865 individuals were measured. Of those, 473 correspond to 1990 and 392 to 1991. Figure 3 shows the carapace length distributions for 1990 and 1991. The range of length values was between 27 cm. and 76 cm., with a concentration of values between 40 cm. and 55 cm. Mean length values were 47.4 cm. for 1990 and 48.8 cm. for 1991.

Figure 4 shows the time of day when turtles were landed, compared to the total period of hauling back the hooks. Despite the fact that the largest effort happens between 0400 and 0800 h (LT), the largest concentration of turtles hauled in happens between 0800 and 1100 h.

Table I describes the results of the experience of captivity monitoring of individuals with the hook in the body. It shows: number of turtles kept by year, number of deaths, number of individuals which expelled the hook, number of days in captivity that the hook remained in the body before expulsion, and number of days that hooks have been in the bodies of live individuals still under observation.

Table I: MORTALITY ON HOOKED LOGGERHEAD SEA TURTLES
(Observations in captivity)

Year	No. Turtles	Deaths	Hooks expelled	Observations
1986*	5	1	4	Hook expelled after 53, 82, 109, and 123 days
1987*	3	2	1	Hook expelled after 285 days
1988*	6	1	1	Hook expelled after 55 days 4 turtles released without expulsion after 93 days(1) and 123 days(3)
1989*	7	2	0	5 turtles released without expulsion after 73 days(2) and 116 days(3)
1990	8	2	0	6 turtles released without expulsion after 81 days(2), 98 days(1) and 106 days(3)
1991	9	3	0	6 individuals still under observation.

* Mas and Garcia (1990)

DISCUSSION

Only the data from the months of July and August have been taken into account to estimate the number of loggerhead turtles incidentally captured by the Spanish Mediterranean longline surface fleet. This is the period in which, during both years, there were Greenpeace observers onboard some of the boats. These months are not only those with a larger concentration of boats - at least 60 - but also the months in which, due to the favourable weather conditions, the number of sets per month is higher than average, reaching 20 sets per month and boat.

In 1990 in the monitored boats, a total of 655 loggerheads were captured in 67 sets, with a mean catch of 9.8 turtles per day and boat. In 1991, 414 loggerheads were captured in 64 sets, with a mean catch of 6.5 turtles per day and boat. Based on this information, the incidental catch of 60 boats working during 40 days gives an estimation of 23,520 loggerheads captured by the fleet in July and August, 1990. For 1991, the same method gives an estimation of 15,600 turtles.

A second method of estimation can be used taking into account the total number of hooks set in July and August, 1991, by ten boats for which Greenpeace observers recorded the number of hooks that were set. 367 turtles were captured with 82,146 hooks in 60 sets, with a mean of one turtle every 224 hooks and 1,369 hooks per boat and set. 60 boats setting 1,369 hooks during the 40 fishing days corresponding to those two months represent 3,285,600 hooks set by the whole fleet during that period. The estimated incidental catch would therefore amount to 14,668 turtles.

The data provided by the questionnaires completed by the longline skippers indicates that 66% of the captures of turtles occurs during the months of July and August (Figure 5). Taking this into account, it is estimated that in the whole of 1990, the number of turtles incidentally captured was 35,637 and in 1991, the number ranges from 22,225 to 23,637, depending on which of the two methods of calculation is used for that year. These high levels of loggerhead by-catches were already suggested by Caminas (1988) and Mayol et al. (1988).

Table II: ESTIMATE OF INCIDENTAL LOGGERHEAD CAPTURES IN SURFACE LONGLINES

Author (year)	Argano et al. (1983)	Mayol et al. (1988)	Camiflas et al.[1]	Camiflas (1988)	Mas et al. (1990)
Year (estimate)	1978 (650-3750)	1985 (17712)	1984 (17092) 1985 (20326)	1986 (16697) 1987 (16315)	1989 (5935-7568)[2]

1 Results not published.
2 The fishermen called a strike during the months of June and August of this year. As a result the level of incidental captures decreased considerably.

An unknown number of individuals are repeatedly captured by the longlines. This has been proven by the fact that some of the observed turtles were carrying other hooks, and few of the tagged and released turtles were recaptured in the same area.

The data shown in Table I - which is based on a small number of individuals - seems to indicate that between 20% and 30% of the sea turtles may die after having been captured by a longline. These results are similar to those obtained by Mayol (19901), also with a limited number of individuals.

Based on the length distribution shown in Figure 2 it can be determined that all the logggerheads captured by this fishery are subadults. Although the ongoing intensive taggging programme to determine the origin and movements of this population is not expected to provide short term results, it is possible to surmise that in the South-western Mediterranean there is an important concentration of subadult loggerheads.

It is important to remember that the estimation of incidental captures of loggerhead turtles presented in this study deals only with the Spanish swordfish longline fleet. It is known that sea turtle by-catches also occur in relation to the longline fleets of other Mediterranean countries, particularly those of Italy and Malta. The turtle population almost certainly suffers, in addition, the effects of the activity of a fleet of 30 large Japanese tuna longliners and a similar number of boats of the same type under convenience flags, which enter the Mediterranean following the migration of bluefin tuna (*Thunnus thynnus*). Mediterranean driftnet, gillnet and trawler fleets, among others, are known to incidentally capture sea turtles in the Mediterranean. Therefore, the total number of sea turtles which are incidentally caught in the Mediterranean is undoubtedly much higher than that suggested by the present study.

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Mayol, M. 1990. Impact of Balearic Island Longline Fishery on Accidental Catches of Marine Turtles. *Grup D'Ornitologia i Defensa de la Naturaleza (GOB). WWF Project 3803* Spain.

Figure 1: Spanish longline fishing grounds in the Southwestern Mediterranean.

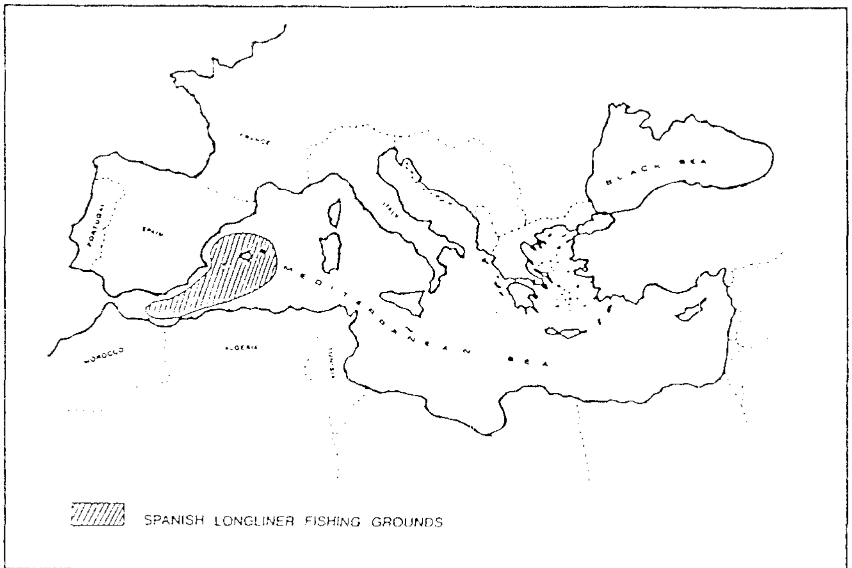


Figure 2: Fishing area, divided into sectors, and the number of turtles captured, tagged, and released in each sector.

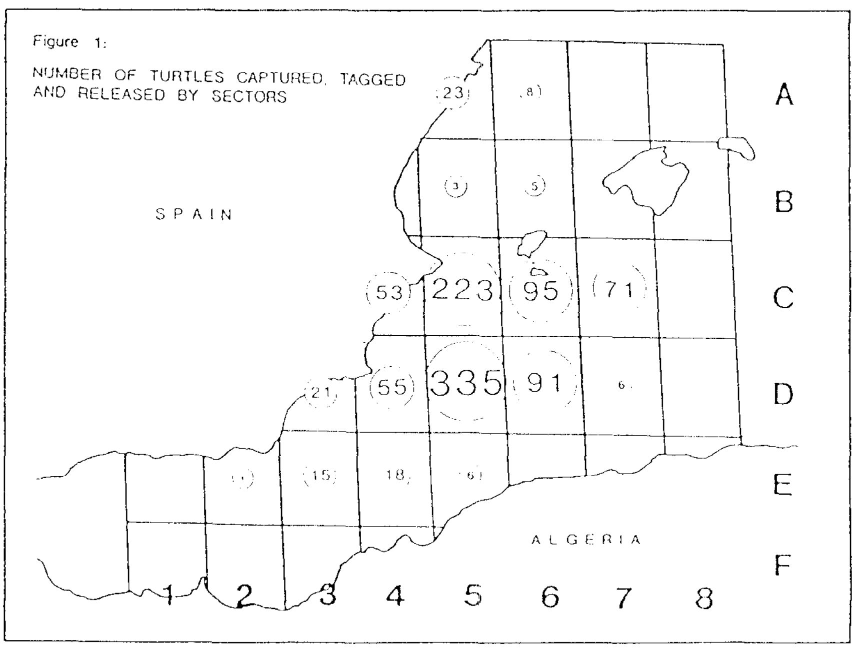
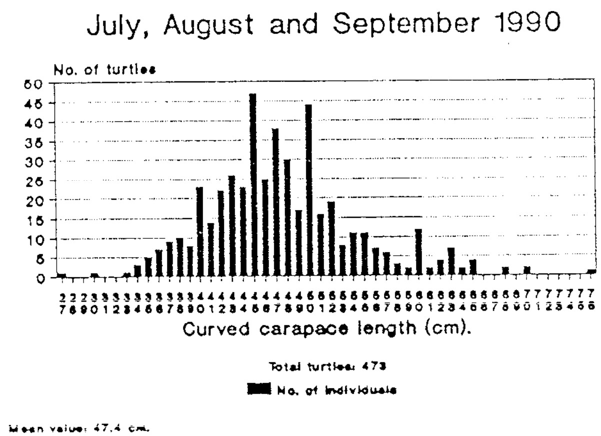


Figure 3: Carapace lengths of captured turtles for 1990 and 1991.



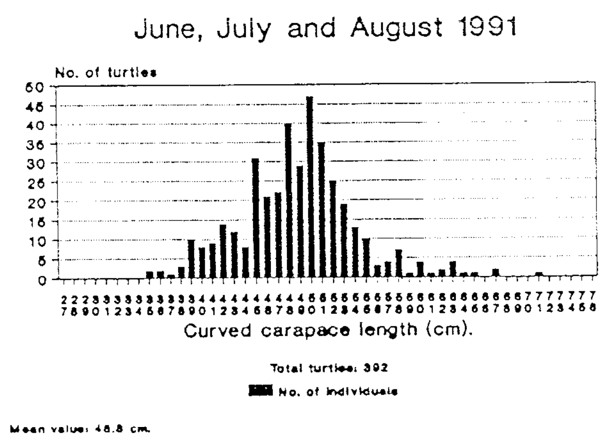


Figure 4: Time of day when turtles were landed, compared to time of fishing effort.

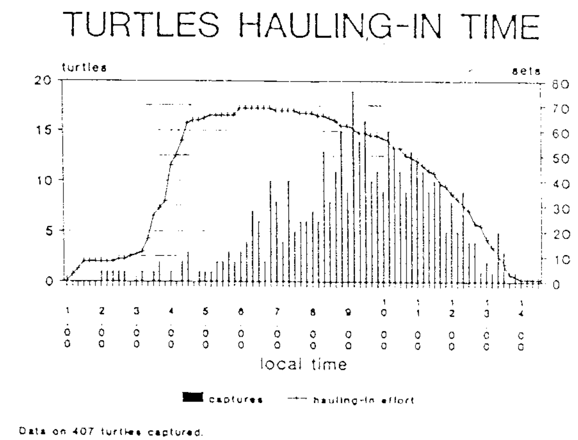
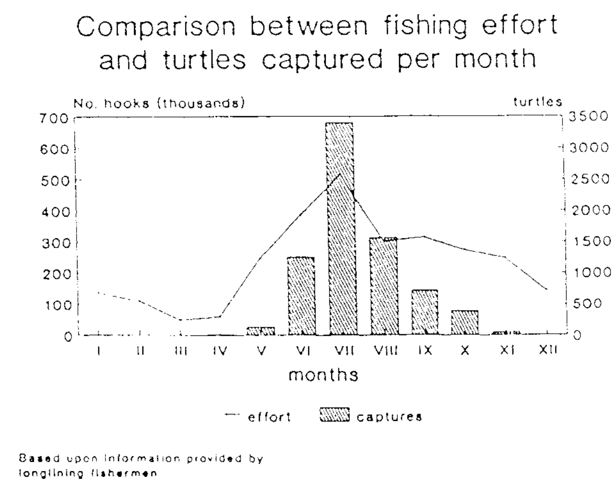


Figure 5: Turtles captured per month and the comparison to fishing effort.



ECOLOGICAL ASPECTS OF GREEN TURTLES NESTING AT SCILLY ATOLL IN FRENCH POLYNESIA

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INTRODUCTION: The three small neighboring atolls of Scilly (16°30'S, 154°40'W), Motu-one (15°49'S, 154°31'W), and Mopelia (16°49'S, 153°57'W) are located in a remote and seldom-traveled region of the South Pacific at the western limits of French Polynesia. Maupiti and Bora Bora, two high volcanic islands with permanent human habitation, are situated 250-300 km to the east. Tahiti and the capital city of Papeete lie another 300 km to the southeast of Bora Bora. Although green turtles, *Chelonia mydas*, used to nest in great numbers at Scilly, Motu-one, and Mopelia, considerable declines have occurred during recent decades due mainly to commercial exploitation for markets in Tahiti. At present, only Scilly continues to have significant numbers of nesting turtles. Few researchers have visited these three isolated nesting sites to tag turtles and gather relevant ecological information. However, turtles intermittently tagged there in the past by local authorities have shown some amazing long-distance migrations across a broad expanse of the Pacific: from longitudes 155°W to 165°E (Doumenge 1973, Anon. 1979). These movements, ranging up to 4000 km, represent some of the longest migrations ever documented for green turtles worldwide. Except for Scilly, there are no other known nesting sites of any magnitude for sea turtles throughout the 130 islands and atolls comprising French Polynesia.

During October 1991, we visited Scilly and Motu-one via Bora Bora aboard the 20-m research vessel Aorai to conduct biological studies that included tagging nesting turtles. Several hundred eggs and hatchlings also were collected for ongoing captive-rearing experiments in Tahiti. The expedition was undertaken by EVAAM, an agency of the Government of French Polynesia. Additional financial assistance was provided by the Regional Marine Turtle Conservation Programme of the South Pacific Regional Environmental Programme. An overview of the results of the expedition are presented herein, along with some historical aspects of green turtles in the area and preliminary conservation recommendations aimed at preventing the further depletion of this important resource.

HISTORICAL OVERVIEW: As elsewhere in Oceania, green turtles have been and continue to be a prized food to the native people of French Polynesia (Leach et al. 1984). In ancient times, turtles were held "sacred for the gods" and only eaten by kings, priests, and marae (temple) keepers (Henry 1928). Icons of turtles were associated with royalty, the supernatural, and the afterworld. Petroglyphs of turtles as sacred symbols were carved on certain boulders and limestone slabs incorporated into the marae. In the interior of Bora Bora a boulder known as ofai honu (turtle stone), contains numerous turtle petroglyphs. This stone was believed to be the parent of the island and its chiefs.

There is no evidence that permanent human settlements ever existed on Scilly, Motu-one, or Mopelia until recent times, although historically the rugged seafaring people of Maupiti visited these sites to obtain turtles and other resources. Beginning in the late 1800's, longer and more frequent visits occurred to make copra. Mopelia, the closest of the three atolls to Maupiti, appears to have had the most continuous human occupation for copra production. During the 1950's, as many as 200 copra workers occupied Motu-one where a concrete warehouse and other facilities were constructed. However, during the 1960's with the advent of nuclear testing and associated higher paying jobs elsewhere in French Polynesia, Motu-one was virtually abandoned along with many of the other atolls worked for copra. During our short two-day visit in October 1991, only eight people were living at Motu-one. The relatively small numbers of nesting turtles remaining today at Motu-one and Mopelia are undoubtedly the direct result of persistent exploitation associated with human habitation.

At Scilly, the earliest settlement established to make copra appears to have been about 1952. The elder of the Taputu family (deceased in 1985) arrived in 1952, and his descendants continue to live there. Rene Taputu, who was born at Scilly in 1955, currently oversees 25 residents that include many children. Rene Taputu is also the principal person knowledgeable about the atoll's turtles, since they continue to be a prominent component of the local diet. Up to 50 adult turtles of both sexes are consumed annually under special permission previously granted by government authorities.

The main nesting season extends from October to December, but some turtles sporadically nest throughout the year. Very few immature turtles are encountered, and the green turtle is the only species ever seen. The Taputu family has a history of raising small numbers of hatchlings in captivity for a year or so prior to releasing them as a restocking effort.

According to Rene Taputu, and verified by other sources, between 1952 and 1969 about 1000 adult turtles of both sexes were taken annually for markets in Tahiti, as well as for local consumption that included food for pigs. Eggs are not presently eaten, but it is unclear if they were in the past. During 1967, 100 nesting turtles were captured in a single night on the most southerly islet of Motu Honu. A stone flung by a turtle nesting at this site fatally struck one of the atoll's inhabitants. Pens constructed on the islets of Motu Rahi and Motu Oia along the east side of the atoll made it possible to hold several hundred turtles alive for months until a transport vessel arrived from Tahiti, Maupiti, or Bora Bora.

During September 1970, FAO consultant Harold Hirth visited French Polynesia as part of a broader survey of sea turtles in the South Pacific region (Hirth 1971). The visit included an overflight of Scilly and Mopelia. Partly because of Hirth's conservation recommendations, legislation was enacted in 1971 prohibiting the sale of turtles throughout French Polynesia. Restrictions were also placed on the time of year and minimum size that turtles could be captured. However, enforcement of these laws has been difficult. In separate legislation that same year, Scilly and Motu-one were given "sanctuary" status that provided some additional but limited protection for turtles.

In April 1972, 67 adult females held in pens at Scilly were confiscated, tagged (with Monel alloy tags supplied by Hirth), and released by government officials. Later that year in December, 168 more females and 13 males were tagged and released from the same holding pens. During 1973- 74, an additional 131 adult females were tagged at Scilly. Of these 379 turtles tagged during 1972-74, 12 long-distance recoveries were made, encompassing the islands of Tonga (1 turtle; 2000 km), Fiji (5 turtles; 3000 km), Wallis (1 turtle; 3000 km), New Caledonia (2 turtles; 4000 km), and Vanuatu (3 turtles; 4000 km). All recoveries were made to the west of Scilly, and none occurred within French Polynesia. Two of the recoveries involved males that were recaptured in Kandavu and Druadrua, Fiji. Also, a female, and one of the males, tagged in December 1972 were recaptured nearly 2 years later within 12 days of one another both in Kandavu, Fiji. All of the 12 recoveries were made in coastal waters and presumably involved turtles remigrating to seagrass or algal foraging pastures where they resided before migrating to Scilly to breed. During 1979, 42 females were tagged at Scilly by government officials, and 40 more were tagged in 1983-84 by Lebeau (1985). One turtle from this latter group was recaptured 3 months later in the Cook Islands, 500 km to the southwest of Scilly.

In 1990, several hatchlings were collected at Mopelia by EVAAM and transported to the University of Georgia, via Honolulu, for use in mitochondrial DNA studies of globally distributed green turtle populations. The extensive black pigment seen for a short time in the plastron of post-hatchling green turtles from Hawaii (Balazs 1986) was documented as also occurring in turtles from Mopelia.

FINDINGS AT SCILLY ATOLL: Nesting activity was monitored at Scilly for 10 consecutive nights (14-23 October 1991) on the islets of Motu Honu and the southern portion of Motu Oia. This fairly

comprehensive level of coverage was made possible by the fine cooperation of Rene Taputu and several family members who assisted in walking the beaches throughout the night. The northern segment of Motu Oia, Motu Rahi, and other islets to the north were not surveyed. Eleven nesting turtles were tagged on Motu Honu and 39 were tagged on Motu Oia. Two other adult females were tagged and released from a pen where, along with eight other turtles, they were being held for food. All turtles were triple or quadruple tagged on the flippers (both front and hind) with titanium tags and/or Inconel alloy tags. No previously tagged turtles were encountered, nor were any recently seen by Rene Taputu. Based on limited data, Lebeau (1985) estimated that 300-400 turtles nested annually at Scilly during the 1982 and 1983 seasons. With some speculation, our survey suggests that a similar number of nesting turtles may have been present throughout the atoll during the 1991 season.
The curved carapace lengths of 51 of the 52 tagged turtles that we measured ranged from 95 to 112 cm (mean, 103 cm). Six shells used by Rene Taputu as ornaments at his home on Motu Oia ranged from 94 to 109 cm (mean, 99 cm). Carapace coloration was predominately mottled brown, amber, olive, and black-- similar to green turtles seen nesting at Rose Atoll in American Samoa and Fakaofo Atoll in Tokelau. Plastrons were yellowish-orange; however, three of the turtles examined had distinct black spots ranging 1-5 cm in diameter. One of these turtles had multiple spots scattered throughout the plastron, while the other two only had a couple. Rene Taputu indicated that about 10% of the turtles he eats have these spots which he calls, roughly translated, "chicken fecal-drop turtles." Although externally these turtles appear healthy and fat, when butchered they have a thin fat layer, and excessive water comes from the meat when cooked.

Turtles tagged at Motu Honu were found to nest mainly on the lagoon side of the islet where the beach consists entirely of fine-grained coral sand with no offshore obstructions. This beach is accessible at all tidal stages. In contrast, all nesting turtles encountered at Motu Oia, except one, came ashore on the ocean side of the islet, which is bordered by a very shallow fringing reef that drops abruptly into deep oceanic waters. Access along this coastline is further hampered by rugged, often sharp limestone onshore that a turtle must crawl over once it leaves the water. Expanses of this beach rock extend for 10-50 m above the high-tide mark and must be crossed to reach sand areas suitable for nesting. The lagoon-side beach of Motu Oia is narrow and free of obstruction, but composed of coarse coral sand and rubble. Nevertheless, nesting can successfully occur there, as shown by the turtle encountered and information supplied by Rene Taputu.

During one of our nightly surveys, hatchlings were found from a newly emerged nest close to Rene Taputu's home on Motu Oia. The hatchlings were reportedly from oviductal eggs removed from a butchered turtle that were buried as a conservation effort about 2 months earlier. No predation on these hatchlings was observed, nor was the presence of potential terrestrial or marine predators noted in abundance anywhere in or around the atoll. A partially filled stomach from a nesting female butchered a week earlier was salvaged from a garbage pit near Rene Taputu's home. The contents were found to consist of 50% *Microdictyon japonicum*, 25% *Caulerpa serrulata*, and 25% *Turbinaria ornata*. These benthic algae were not seen in abundance in the lagoon or along the fringing reef. However, *Caulerpa racemosa*, an alga sometimes grazed by green turtles elsewhere, commonly occurs in the lagoon at Scilly and is often eaten by human inhabitants.

Mating turtles were seen both in the lagoon and just outside the seaward edge of the fringing reef where courtship and copulation, according to Rene Taputu, most commonly occur. Turtles mating in this latter area are openly susceptible to capture by high-speed 12-m bonito fishing boats visiting waters surrounding the three atolls. A month prior to our arrival, seven turtles and a bonito boat were taken into custody at Maupiti for violating the August through March closed season for taking turtles. Considerable incentive exists for poaching, since an adult turtle can be illegally sold in Tahiti for about US$1000. Turtles inside the lagoons at Scilly, Motu-one, and Mopelia are safe from hunting by bonito boats, because it is impossible for vessels of that size to enter the narrow and extremely hazardous passes. In addition, turtles in the lagoons at Scilly and Motu-one are legally protected under the 1971 sanctuary designation.

A nesting turtle that we tagged on Motu Oia on 18 October 1991 was recaptured 5 months later in a fishing net near Suva, Fiji. A photograph taken shortly after capture showed an otherwise healthy turtle with numerous, partially healed, deep gouges in the plastron. Injuries to this extent were not seen when the turtle was originally tagged, nor on any of the other turtles examined. Possibly they were caused by the effects of cyclone Wasa that passed by the three atolls on 9-10 December 1991 with winds of 180 km/h.

CONSERVATION RECOMMENDATIONS

- The number of turtles taken for food by the residents should be limited to two per month, and preferably should be male turtles.
- The number of people allowed to live at the atoll should be stabilized at the current level or less.
- Rene Taputu should be designated as the official warden of the atoll under the sanctuary status. He should also be supplied with a portable shortwave radio to allow communications with Tahiti.
- The sanctuary status of Scilly and Motu-one should be redefined to include the surrounding waters within one kilometer of both atolls.
- Turtle poachers should be apprehended, prosecuted, and heavily fined.
- Additional tags, applicators, and data books should be supplied to Rene Taputu so he will continue to be motivated, and have the ability, to tag turtles following the training provided during our visit.
- Satellite telemetry should be conducted with several nesting turtles to determine migratory routes, speed of travel, and ultimate foraging pasture destinations. This work should be in conjunction with additional saturation tagging throughout as much of the nesting season as possible.
- The number of nests (eggs or hatchlings) removed annually for experimental captive rearing and restocking efforts in Tahiti should not exceed 3% of the estimated total available.

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ANATOMICAL AND HISTOLOGICAL STUDY OF THE HEART IN TWO SEA TURTLE SPECIES (*LEPIDOCHELYS OLIVACEA* AND *DERMOCHELYS CORIACEA*)

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In a study of the anatomical structure of the sea turtle heart we examined hearts of 14 olive ridley (*Lepidochelys olivacea*), 8 leatherback (*Dermochelys coriacea)* hatchlings, and one adult olive ridley. Methods of examination included scanning electron microscopy, serial histology with Masson trichromic staining and macroscopic dissection.

In general there were no differences between hearts of the two species. All had two distinct atria with the right atrium larger than the left. The interatrial septum was intact and separated a single atrio-ventricular ring into two distinct orifices leading to respective left and right atria. Each orifice contained a valve which consisted of a single septal leaflet, and no lateral leaflets. Lateral leaflets appeared to have been replaced by endocardial thickening. Each of the septal leaflets contained a single superior insertion point and two ventricular insertion points, and there were no papillary muscles nor chordae tendinae.

The atria were separated from the ventricle by a right and left A-V groove. The A-V orifice communicated with a single ventricular cavity, named the main chamber, which is divided into three portions (after Andersen and Becker, 1981): an inlet portion, a trabecular portion, and an outlet portion. The inlet portion contained the A-V valvular apparatus.

Significantly, there was no interventricular septum in the trabecular portion of the main chamber of the ventricle. The outlet portion of the ventricle consisted of an accessory chamber from which emerged the pulmonary artery. This outlet chamber communicated with the main chamber through an interchameral foramen which is roofed by the semilunar valves of the left aorta. The right aorta emerged directly from the main chamber.

Based on the anatomical features described here, anato-functional and hemodynamic studies of the sea turtle heart will be necessary to clarify function of the morphological structures defined in this study.

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PRELIMINARY ANALYSIS OF POST-NESTING MOVEMENTS OF THE BLACK TURTLE (*CHELONIA AGASSIZI*) FROM MICHOACAN, MEXICO.

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After the Kemp's ridley (*Lepidochelys kempi*), the black turtle (*Chelonia agassizi*) is the most endangered sea turtle in Mexico. Declines have been documented for the Mexican state of Michoacan from thousands of nesting females per night in the 1960's (Cliffton, Cornejo and Felger 1982) to an estimate of 1382 females nesting in the entire season in 1990 (Alvarado et al. 1992). Black turtles nest on 15 beaches on the Pacific Coast of Michoacan, but the most concentrated nesting and breeding areas described for the species in Mexico are Maruata Bay and Colola, Michoacan, which contain 80 percent of the of the nests laid annually (Alvarado et al. 1992).

Information on movements between feeding and breeding areas has been obtained by marking turtles with numbered tags on these two nesting beaches. A total of 5,176 turtles were marked between 1981 and 1987. As of December 1988, 47 tags were recovered from locations beyond the state of Michoacan. Sixty percent of these tag recoveries were reported from south of Mexico and 40 percent were from Mexican waters. Of the tags recovered from south of Mexico, 18 were from El Salvador, 6 from Guatemala, 2 from Nicaragua, 1 from Costa Rica and 1 from Colombia. Within Mexico, 11 recoveries were reported from north of the nesting areas, mainly from the Gulf of California and adjacent waters, and 8 were reported from south of the nesting beaches, mainly from the coast of Oaxaca (where a large turtle fishery was prosecuted until 1990). The geographic distribution of the recovery sites indicates that after nesting in Michoacan, black turtles follow two general dispersion routes. Some turtles disperse to the northern region of the Mexican Pacific, mainly the Gulf of California and the rest travel southward to Central America and Colombia. No tagged females have been encountered in Michoacan outside the breeding season although fishermen report that males remain near the beaches year-round.

Since most commercial fishing in the east Pacific occurs on the narrow continental shelf, it is not surprising that most of the tag recoveries were from coastal waters. Fishermen reported the distance of three turtles from the nearest shore as 17, 25 and 26 km. The average depth at 11 reported capture sites was 31.8 meters. These data suggest that black turtles remain close to the coast in their return migration to their feeding grounds. The average minimum swimming speed estimated for six turtles was 23.3 km/day.

Although the mark-recapture technique using numbered tags provided information on point-to-point movements of the recaptured black turtles, no data on migratory pathways and behavior at sea during migrations were obtained. To remedy the lack of knowledge concerning migration routes, 5 nesting black turtles were outfitted with satellite transmitters in 1991. This study used the Tiros-Argos satellite system. Transmitters (ST-3, Telonics, Inc., Mesa, AZ, USA) were small (dimensions of 2x13x9 cm, weight in air of 822 g) and were mounted on the highest portion of the carapace "backpack style" (Byles and Keinath 1990). Fiber-glass cloth and polyester resin were used to attach the transmitters over the area of the second neural scute. In order to avoid damage to the transmitters likely to occur during courtship and mating, we attempted to select satellite tracking subjects that had completed nesting for the season and were due to leave the breeding area. Turtles were examined with ultrasound to predict breeding condition (Rostal et al. 1989). Post-nesting turtles with depleted ovaries or with only atretic follicles were chosen for tracking, as they were deemed about to migrate from the breeding/nesting area.

The turtles were tagged with satellite transmitters in late November and early December, 1991, at the nesting beach of Colola, Michoacan. Turtle 1 swam east of Colola. We were able to monitor her for approximately one week, after which transmissions ceased. The last signal indicated she was ashore about 80 km east of Colola. Turtle 2 swam immediately northwest along the shoreline into the Islas Marias located about 90 km offshore. She remained around the islands for nearly three months until transmissions ceased. Turtle 3 swam southeast very close to shore until she reached the vicinity of the Gulf of Tehuantepec where she moved offshore. Although she stayed very close to shore up to this point, the farthest distance between her track to the shoreline was about 280 km at the Gulf. The water depth in this area is about 4 km. She returned to the coast and was last located off Guatemala 2.5 months after being released. The track of turtle 4 was very similar to that of turtle 3, following a southeast course, close to shore and looping offshore around the Gulf of Tehuantepec. Turtle 4 came back to shore east of the Gulf and continued swimming southeast. The transmitter ceased transmitting two months after she was released. In that time she swam about 2,000 km with an average daily speed of 33 km. The last position-fix for turtle 4 was on land south of Managua, Nicaragua. Turtle 5 swam offshore to the south from Colola and in three months completed a large loop east of the Tehuantepec ridge over 700 km offshore, never close to land. This turtle is still transmitting after three months and in that time has remained in water of over 4 km depth.

The data from long distance tag recoveries had suggested that black turtles remained close to the coast in their migration back to their feeding grounds, but bias due to the recapture method (fishing gear) did affect the results. The more continuous location data from the satellite tracking study revealed that at least some turtles take paths hundreds of km away from land in very deep water. In order to reverse the population decline, protection must be afforded the species beyond the breeding/nesting areas. We need to expand this initial research to reveal the migratory paths and destinations of the black turtle.

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ACCOMPLISHMENTS OF THE KEMP'S RIDLEY HEAD START EXPERIMENT

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Kemp's ridley sea turtle (*Lepidochelys kempi*) head starting is a reintroduction experiment initiated in 1977 as a subsidiary part of a recovery program carried out by the Kemp's Ridley Working Group. The Working Group includes representatives of Mexico's Instituto Nacional de la Pesca (**INP**), U.S. Fish and Wildlife Service (**FWS**), National Park Service (**NPS**), Texas Parks and Wildlife Department and National Marine Fisheries Service (**NMFS**). Purposes of head starting ridleys are to (1) increase their survival during the first year of life, (2) release healthy survivors into the known breeding range of the species, and (3) establish a nesting colony at the Padre Island National Seashore near Corpus Christi, TX, thus supplementing the species' nesting capacity. One working hypothesis of head starting is that Kemp's ridleys imprint to the beach to which they are exposed as eggs, hatchlings or both, so they will return there to reproduce when they mature. Another is that survival of captive-reared ridleys after release is as good as that of their wild counterparts of similar age or size.

The **NMFS** Galveston Laboratory developed successful methods for captive-rearing, tagging and releasing large numbers of ridleys. **INP**, **FWS**, Gladys Porter Zoo and **NPS** provided hatchlings "imprinted" at Rancho Nuevo or Padre Island. Of 21,682 live hatchlings of the 1978-1990 year-classes received alive by **NMFS**, 18,690 (86 %) healthy survivors were released into the Gulf of Mexico or adjacent estuaries, most (15,490 or 83 %) at an age of 9-11 months. The experiment also provided animals and opportunities for research on reproductive physiology and behavior, sex determination, temperature-sex relationship, captive-propagation, and physiology of exercise, physical fitness and submergence in trawls.

All head started ridleys were tagged with external flipper tags. Like other sea turtles, many probably lose such tags within a few years. Notable exceptions occur, as shown by a ridley that retained its flipper tag almost 9 yr after release. Beginning with the 1984 year-class, some head started ridleys were also tagged with living tags (mark formed by tissue graft from plastron to carapace) and internal magnetic tags. Still fewer have been tagged with passive integrated transducer (PIT) tags in recent years.

Mark-recapture experiments on marine animals usually are conducted on species legally exploited by commercial or recreational fisheries, in which cases the investigators either control or are able to assess the amounts of effort allocated to recapturing tagged animals. This could not be done with head started ridleys, so sources such as the Sea Turtle Stranding and Salvage Network, fishermen and the public were relied on for reporting tag returns. Not surprisingly, strandings (51 %) and incidental capture in shrimp trawls (25 %) dominated the tag returns for which a method of recovery was reported. Therefore, caution must be exercised in interpreting tag returns which could be biased. For example, were it not the vagaries of reporting and the loss of tags, survival rates of head started ridleys might be estimated from tag recoveries in a series of consecutive years.

The primary purpose of tagging the turtles was to provide a means of identifying them as head started when found on nesting beaches, but flipper tag recoveries also made it possible to monitor their growth and distribution. Tag recoveries showed that head started Kemp's ridleys adapt, grow and survive in the wild. Head started Kemp's ridleys have been found throughout the natural range of the species, and in habitats where wild Kemp's ridleys occur.

Age to maturity is unknown for wild Kemp's ridleys, but has been estimated to be as young as 6 yr and as old as 15 yr or more. The younger age to maturity was estimated from growth in tagged wild Kemp's ridleys in the

Gulf of Mexico, and the older on skeletochronological studies of wild Kemp's ridleys in the Atlantic. The Von Bertalanffy growth curve fitted to size at age based on Gulf of Mexico tag recoveries of head started Kemp's ridleys from standard releases (those made in consecutive year 1; i.e., year-class + 1) ascended to 60 cm by age 7 yr. Head started ridleys grew slower in the Atlantic than in the Gulf, so Kemp's ridleys probably take longer to reach 60 cm in the Atlantic than in the Gulf. Regardless, there is no evidence that Kemp's ridleys in the Atlantic return to the Gulf.

Success of the head start experiment depends on corroborated evidence that significant numbers of head started Kemp's ridleys reproduce in the wild. Success with regard to the imprinting hypothesis requires proof that the turtles return to the beach to which they were exposed as eggs, hatchlings, or both. Neither criterion has been met so far. Assuming that survival of male Kemp's ridleys is not greater than that of females, fewer head started females than males would be expected to have survived to maturity from male-dominated year-classes 1978-1984 (33 % female). Female-dominated year-classes from 1985 on (89 % female) have not been at large long enough to have matured. If head started Kemp's ridleys have nested, chances are remote that anyone saw the turtles or recognized them as head started. The direct observation of any Kemp's ridley nesting is a rare event. Even at Rancho Nuevo, beach patrollers frequently locate nests without observing the turtles that laid them. It takes less than an hour for a Kemp's ridley to leave the water and return after nesting, so the time for observing a nester is short. If seen nesting by a casual observer, a head started turtle with flipper tag intact may not be reported. Trained observers at Rancho Nuevo probably are more likely to assume that Kemp's ridley nesters found there with a flipper tag scar but no tag are wild rather than head started. All these factors work against documentation of nesting in head started Kemp's ridleys.

Though no nestings of head started Kemp's ridleys in the wild have been documented to date, observations of nestings and occurrence of hatchlings in the surf have increased at the National Seashore since 1979. However, no evidence has been provided to link such events with head started Kemp's ridleys.

Head starting was planned as a 10-yr experiment, but in 1989 the NMFS Southeast Regional Office selected a panel of sea turtle experts who reviewed the Galveston Laboratory's head start experiment, examined its facilities, staff expertise, and methods, and evaluated its results and accomplishments. The panel concluded that head started Kemp's ridleys adapt and grow in the wild, but mortality rate at sea is so high that few head started or wild Kemp's ridleys can be expected to reach maturity. Because the major human cause of sea turtle mortality is shrimp trawling, the panel recommended that head starting be continued, but not expanded, for an additional 10 yr after installation of turtle excluder devices (TEDs) on all shrimping vessels in U.S. Gulf and Atlantic waters.

Quality of habitat and control of limiting factors are prerequisites to successful reintroductions. Head started ridleys apparently experience the same kinds of at-sea mortality to which wild sea turtles are exposed. Therefore, we agree with the review panel that experimental head starting of Kemp's ridleys should continue under conditions in which TEDs are required in shrimp trawls. In the interim, additional steps should be taken to improve survivability of head started Kemp's ridleys; e.g., by exposing them to semi-wild conditions for a month or so prior to release.

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AN OFFSHORE SANCTUARY FOR THE LEATHERBACK TURTLES OF RANTAU ABANG, MALAYSIA

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The leatherback turtles of Rantau Abang, Malaysia are critically endangered, with nesting ranging from only 200-280 per year (Fisheries Department, Terengganu). The current population represents barely 2-3% of the numbers recorded in the 1950's (Chan, 1991).

In recognition of the imminent extinction of the leatherbacks, the Terengganu State Authorities have intensified conservation efforts in an attempt to provide maximum protection to the remaining turtles and to boost the current population.

The sale and consumption of leatherback eggs have been banned by law since 1988. All eggs deposited on the beaches are replanted in government hatcheries or allowed to incubate in-situ in locations where 24-hour surveillance is possible. A sanctuary has also been established in Rantau Abang to provide protection to nesting turtles and prevent further development of the critical nesting beaches.

Most of these earlier conservation measures concentrated on the protection of eggs, nesting turtles and beaches. Protection of leatherback turtles shoud not be confined to the time when they land on the beaches to nest. It is well documented that incidental captures in fishing gear contribute significantly to the mortalities of the turtles at sea during the nesting season (Chan, et al., 1988). Therefore, offshore protection from fishing gear is critical if the adult female turtles are to survive their long nesting seasons in the territorial waters of Terengganu. Because of the variety of gear involved, the establishment of restricted fishing zones appears to be the most practical approach in providing offshore protection to the turtles. In order to be effective such zones must encompass as accurately as possible the areas most frequently utilised by the turtles during the nesting season.

The strategy adopted by the authors to seek the establishment of an offshore sanctuary or restricted fishing zone was to present accurate scientific data on the internesting habitats of the leatherbacks to the Turtle Sanctuary Advisory Council of Terengganu.[1] The data serves to provide a sound basis for the proposal to establish an offshore sanctuary with well-defined boundaries.

To achieve the above objectives, a radio-tracking study was conducted on the internesting leatherbacks of Rantau Abang in 1989 (Chan, et al. 1992). In the study, 12 individual turtles were fitted with radio-transmitters and their movements tracked over the internesting interval. The results showed that the turtles travelled over an extensive range. Their movements covered a longshore distance of more than 100 km and extended seawards to about 40 km off the coastline (Figure 1 & 2). However, the locations where turtle traffic appeared to be concentrated occurred within 10 km of the coastline, stretching from Kuala Merchang to Kampong Tanjung Jara, i.e. spanning a longshore distance of about 30 km. The nesting beaches occur in the central portion of this coastline.

[1]The Turtle Sanctuary Advisory Council of the State Government of Terengganu was constituted in 1988 under the provisions of the Turtles (Amendment) Enactment 1987 to "advise His Highness the Ruler in Council on matters relating to the protection, conservation, utilization, care, control, management and development of sanctuaries and such other matters as His Highness the Ruler in Council may from time to time refer to it."

In December 1989, a proposal was tabled by the authors at the Turtle Sanctuary Advisory Council meeting for the establishment of an offshore sanctuary. The sanctuary was to extend from Kuala Merchang to Kampong Tanjung Jara and cover 10 km of water from the coastline. This proposal was formally accepted and adopted in 1990, with the offshore boundary extended to 10 nautical miles (18.5 km). In July 1991, "the Rantau Abang Fisheries Prohibited Area" was legally endorsed under the Fisheries (Prohibited Areas) (Rantau Abang) Regulations 1991. Fishing is prohibited in the said area, except fishing employing the anchovy seine net, hood and line, life net and squid jigging. The exceptions to the gear mentioned had to be made to accommodate the small-scale traditional fishermen operating in the affected area. Gear which has been identified to be detrimental such as drift-nets, trawlnets and fish traps have been banned. It is understood that enforcement of the regulation will be strictly adhered to during the nesting season from May to September each year.

We believe that Malaysia now has the first offshore sanctuary established mainly for the protection of internesting leatherbacks at sea. We hope that this will serve as a model for endangered sea turtles elsewhere in the world.

ACKNOWLEDGEMENTS

The Malaysian Council for Scientific Research and Development provided major funding for the radio-tracking project. The State Govenemnt of Terengganu, Greenpeace-USA and WWF International contributed toward a travel grant for Drs. Scott and Karen Eckert, the co-researchers of the project. Universiti Pertanian Malaysia, the Terengganu Fisheries Department, the egg-collectors of Rantau Abang and WWF-Malaysia are acknowledged for their assistance and cooperation. A special word of commendation is recorded for the Turtle Sanctuary Advisory Council of Terengganu and the Federal Fisheries Department for seeing the establishment of the offshore sanctuary to fruition.

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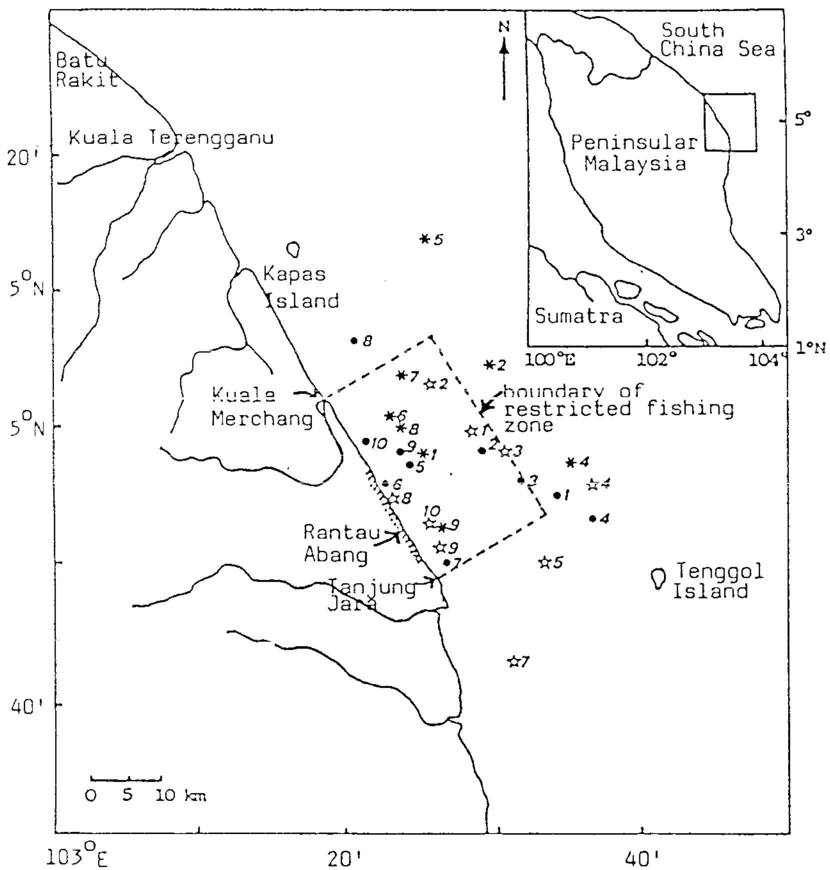

Figure 1. Position fixes for turtles 1-3 tracked from 11-25 June 1989. Each symbol represents a different turtle while numbers indicate the sequence of the inter-day the fix was determined. Stipled section of the coastline represents nesting beaches.
(extracted from Chan, et al., 1992)

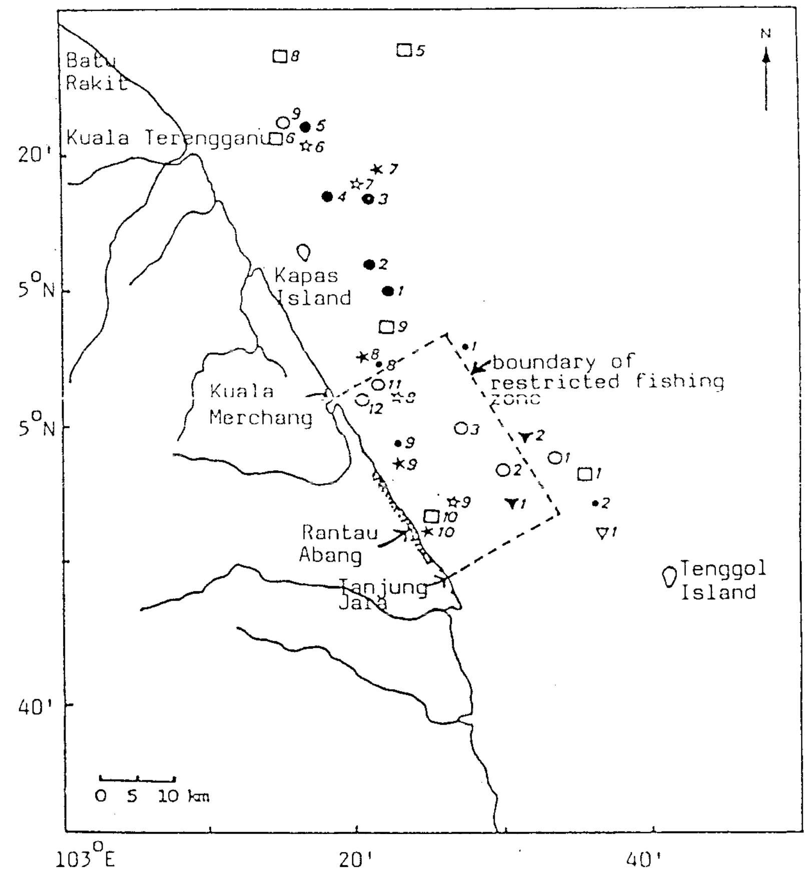

Figure 2. Position fixes for turtles 4-11 tracked from 13 June - 24 July 1989. Explanations for figure follow that of Fig. 1. (extracted from Chan, et al., 1992)

HABITAT PREFERENCE AND FEEDING ECOLOGY OF THE GREEN SEA TURTLE (*CHELONIA MYDAS*) IN SOUTH TEXAS WATERS

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INTRODUCTION

Little is known of the life history of sea turtles from the time hatchlings leave the nesting beach until they reach sexual maturity and return to their natal beach. This lack of knowledge leaves a gap of 10 to 35 years in which we do not properly understand the habits of, and the habitats utilized by, sea turtles. It is important that we fill this information gap in order to make proper management decisions. This report presents preliminary findings of an ongoing study of sub-adult green turtles in south Texas waters.

STUDY AREA AND METHODS

Turtle capture and habitat characterization were conducted in Brazos Santiago Pass and lower Laguna Madre habitats near South Padre Island, Texas during April - December 1991. This study area contained three distinct turtle capture/habitat characterization sites: Brazos Santiago Pass site, consisting of the Brazos Santiago Pass and adjacent North and South Jetties; South Bay/Mexiquita Flats site, consisting of grassbed and channel habitats along the easternmost reaches of the Brownsville Ship Channel; and lower Laguna Madre site, encompassing grassbeds in the lower Laguna Madre immediately north of the Queen Isabella Causeway.

Netting Effort/Turtle Capture: Turtle capture was accomplished with 91.5 m long entanglement nets of different depth and mesh size specifications deployed in two configurations. These nets were 3.7 m deep with 12.7 cm bar mesh of #9 twisted nylon or 4.9 m deep with 25.4 cm bar mesh of #9 twisted nylon. Shallow coves of Brazos Santiago Pass and grassbeds and channels of South Bay/Mexiquita Flats and lower Laguna Madre were sampled during the day with one to four stationary entanglement nets set adjacent to one another for 8 to 12 hours. Sampling at the deeper jetty habitat was modified to a more active capture method of encircling turtles with entanglement nets. Divers entered the encircled area to close off any escape routes and to catch or maneuver a turtle into the net.

Immediately following capture, all turtles were transported to the University of Texas' Pan American Laboratory on South Padre Island where they were held for 24 hours before being tagged and released. All turtles were measured (straight and curved carapace length and width), photographed, tagged with monel flipper tags and then released at the same location as captured.

Visual Observations: Visual sightings were conducted along the North and South Jetties at Brazos Santiago Pass to aid in turtle capture and identify the habitats they frequented. Random observations were made by 2-5 individuals surveying the jetties on random days throughout the study period. Date, time, location, and species were recorded each time a turtle was sighted.

Habitat Characterization: Five turtles captured during netting activities were provided to NMFS personnel who equipped them with radio and sonic tags (see Renaud, M. L. Radio and sonic tracking of green and loggerhead sea turtles at South Padre Island, Texas. This publication). Data from NMFS tracking efforts were used by the authors to pinpoint eight grassbed habitats occupied by the tracked turtles whose attributes were characterized from 1 July - 25 October 1991.

Characterization efforts consisted of underwater visual observations and sample quadrates. Visual observations were accomplished using SCUBA to determine prevailing conditions and describe the habitat. Quadrates were utilized to measure the vegetative biomass. Three to fifteen 0.25 m^2 quadrates were placed randomly at each grassbed station, and all algae and seagrasses were cut approximately 2.54 cm above the sediment, bagged, preserved in 10% formalin and returned to the laboratory for analysis. Nine quadrates were deployed at each of the five Brazos Santiago Pass stations where all algae were collected to develop a qualitative species list for each station. Each sample was separated in the lab to the lowest possible taxon, dried, and weighed (to the nearest 0.01g). The resulting weight was used as the dry mass for each species.

Feeding Ecology: Periodic checks of each turtle's condition were made during the 24-hr holding period, and fecal samples were collected from the holding tanks. All fecal samples were preserved in 10% formalin, labelled and held for laboratory analysis. Each sample was pulse blended to an even consistency in the laboratory. These contents were then poured into a #35 sieve and rinsed with sea water. Three samples were removed from each fecal solution with a spoon and then observed under a dissecting scope to identify particulate plant and algae matter to the lowest possible taxon.

RESULTS

Netting Effort/Turtle Capture: Netting efforts conducted from 12 April - 12 December included 90 net sets totalling 905 hours across 50 days and 16 locations. Total netting hours ranged from 118 at lower Laguna Madre to 427 at Brazos Santiago Pass. In addition, there were 11 encirclement attempts at Brazos Santiago Pass. The combined capture effort produced 19 sea turtles: 17 in entanglement nets and 2 by incidental capture. These turtles consisted of 4 greens from the Brazos Santiago Pass site (CPUE = 0.10 capture per kilometer of net fished each hour), 12 greens from the South Bay/Mexiquita Flats site (CPUE = 0.36) and 1 loggerhead from the lower Laguna Madre site (CPUE = 0.09). Five turtles were captured in 3.7-m deep nets and the remaining 12 in 4.9-m deep nets. Turtle captures occurred from 12 April - 22 November, with monthly totals ranging from 0 in December to 5 during both October and November. The latter two months each yielded one multiple catch of three turtles in one day. Over one half of all turtles were captured between 1100 - 1300 hours. Straight carapace length (SCL) of the 17 green turtles ranged from 28.9 to 58.9 cm and averaged 44.3 cm. All green turtles captured from Brazos Santiago Pass jetties were less then 40 cm SCL while those captured from the South Bay/Mexiquita Flats grassbeds/channels all exceeded 40 cm SCL. The one loggerhead was 72.5 cm SCL.

Visual Observations: Two-hundred-eighty-one sightings of a possible 106 individual turtles were recorded during 27 days of observation effort conducted from 3 July - 12 December. Nine additional sightings of a possible seven turtles were recorded from incidental observations. Ninety-seven turtles were observed along the jetties while nine turtles were seen in adjacent coves. All sightings were of green turtles except for three individuals that could not be identified. One of the most frequently seen and easily identifiable turtles was a 34.2-cm SCL, radio/sonic tagged green turtle initially captured within the Brazos Santiago Pass on 15 July . This turtle was observed along the Gulf side of the North Jetty at least monthly during August - October.

Habitat Characterization: Jetty habitat consisted of three distinct biological and physical zones which differed in depth, topography, and concentration and species diversity of fouling communities (flora and fauna) and associated biota. Zone 1 contained partially exposed and submerged (≤ 3 m deep) granite boulders with barnacles, algae (*Ulva fasciata, Podina vickersiae*, and *Bryocladia thysigera*), sea urchins, and oyster spat as the dominant fouling organisms. This zone extended 5 - 10 m away from the jetty proper. Zone 2 consisted of scattered granite boulders (> 3 m deep) and rubble with oyster spat (the dominant species), stony coral, gorgonia, and sparse concentrations of the filamentous algae, *Ectocarpus silicilosus*, which occurred along the shallowest edge of this zone and decreased with depth. This zone began 6 - 15 m from the jetty proper and was 5 - 10 m wide. Zone 3 was scattered rubble to flat barren bottom with no vegetation and very sparse biota (few hermit crabs and scattered gorgonia). This zone began 10 - 25 m away from the jetty proper with a depth range of 2.1 - 7.5 m.

Dominant vegetation species included manatee grass(Syringodium filiforme) at south Bay/Mexiquita Flats stations and turtle grass (*Thalassia testudinum*) and algae at lower Laguna Madre stations (Figures 1 and 2). Physical arrangement of constituent sea grass and algae species was fairly consistent. Sea grasses were randomly intermixed with algae including *Dictyota dichotoma, Laurencia poitei, Hypnea musciformis, Solieria tenera, Corallina cubensis, Spyridia filamantosa, Chondria littoralis,* and *Gracilaria foliifera.* Algal species often were attached to, or wrapped around, seagrass blades.

Feeding Ecology: Fecal samples obtained from 18 green turtles contained minute, partially digested pieces of algae and/or sea grass. Advanced digestion prevented algae from being identified to species. Sea grasses also were unidentifiable for the most part, except that about 20% of the epidermal tissue layers present in samples exhibited a speckling characteristic of manatee grass. The first four fecal samples were from green turtles captured at the Brazos Santiago Pass site during April - July and consisted mainly of algae. The remaining 14 fecal samples were taken from 12 turtles captured at the South Bay/Mexiquita Flats site and 2 incidental captures at the Brazos Santiago Pass site after July. These fecal contents were dominated by sea grasses.

DISCUSSION

Turtle captures and sightings combined with NMFS's tracking data indicate that jetty and Brazos Santiago Pass environs were a primary habitat for younger green turtles. Fecal pellet analyses suggest the possibility of young greens grazing on algae at the jetties and older greens feeding on dominant sea grasses in the bay. In addition to using jetties as a feeding ground, younger green turtles exhibited a propensity for occurring at specific locations along the jetties. This behavior and the size difference noted between greens captured at the two sampling sites may indicate that jetties provide younger cohorts with refuge or a seasonal residence as well as a foraging area. Upon attaining sizes > 40 cm SCL, greens become more dependent upon grassbeds as feeding habitat.

Additional investigations are needed to better define the life history of young green sea turtles in south Texas waters. Monitoring of sea turtles during winter and spring months must be expanded through increased netting effort and use of longer lived batteries or more efficient use of battery power in the tags. Duty cycles should be instituted with on/off periods to extend the life of the battery. An increased capture effort should be expended in the lower Laguna Madre to assess the potential attraction of sea turtles to its rich seagrass habitats. Fecal pellet analysis provided limited insight to sea turtle feeding ecology. A more detailed cellular examination or a lavage method to obtain "fresher" samples is needed. An analysis of caloric content and nutritional value of dominant seagrass and algae species is needed to better define the role that jetty and grassbed habitats play in feeding ecology of green turtles. Blood samples obtained from captured turtles should be used to determine a sex ratio for the community. Additionally, blood samples should be used for a mtDNA analysis to determine from which nesting beach each turtle emerged.

ACKNOWLEDGEMENTS

We would like to thank all of those people whose help in the field and the lab was invaluable: Kelly Craig, Russell O'Brien, Karen St. John, Randy Clark, John Christensen, Stacie Arms, and a cadre of Texas A&M at Galveston undergraduate student workers. Funding for this project was provided by the U.S. Army Corps of Engineers and Texas A&M Sea Grant College Program.

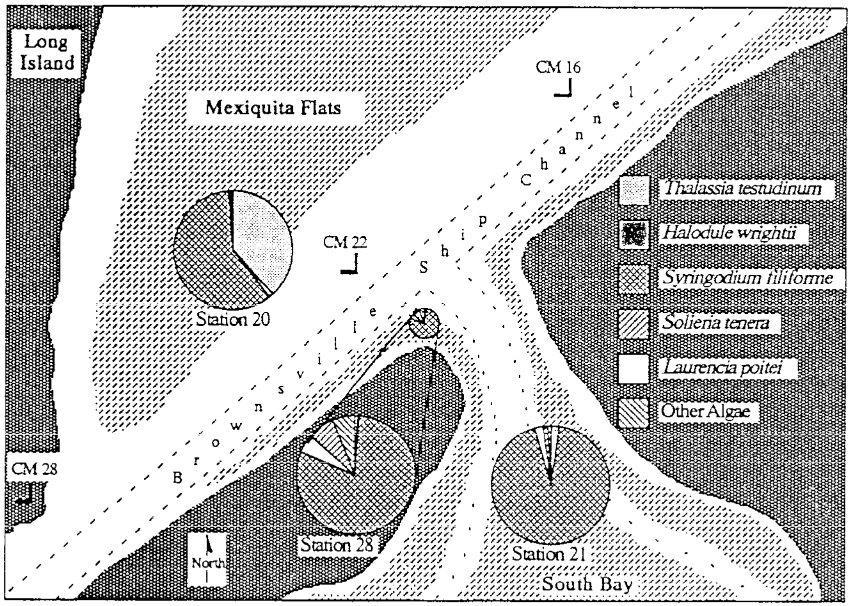

Figure 1. Dominant flora at South Bay/Mexiquita Flats grassbed stations.

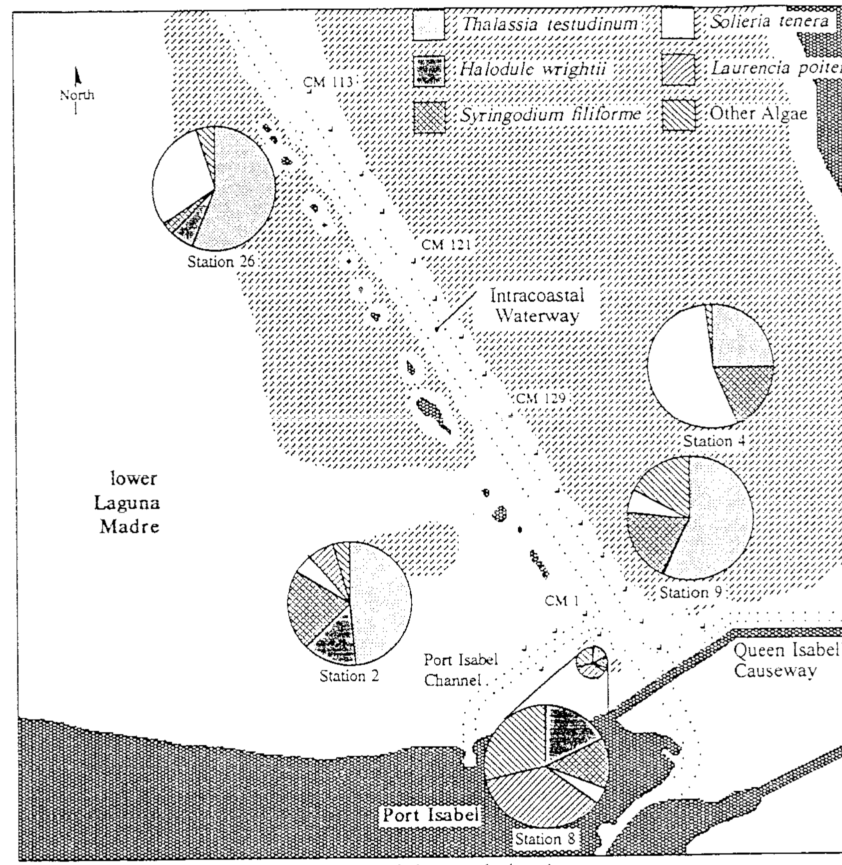

Figure 2. Dominant flora at lower Laguna Madre grassbed stations.

A STAGE-BASED POPULATION MODEL FOR AUSTRALIAN LOGGERHEAD SEA TURTLES

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A stage-based population model for southeastern U.S. loggerheads (Crouse et al. 1987) has provided a useful mechanism for evaluating the relative efficacy of different management regimes focusing on different life stages (NRC 1990). But the parameterization of the original model was estimated from data obtained from a population known to be declining and which is likely below carrying capacity. The parameters for juvenile growth rates and survivorship had to be interpolated in some cases. It is unknown what effect these factors may have on the model and its outputs.

In this paper, a similar, preliminary model is developed for Australian loggerheads, based on data collected from the Heron Island feeding grounds. This population is as close to unexploited as is likely to be found anywhere in the world. Individual turtles on the Heron Island reef are examined yearly, providing direct measures of individual reproductive state and survivorship. Recent declines in adult breeding females at Mon Repos Beach, one nesting area used by turtles from the Heron Island feeding gorunds, are evaluated with respect to this model. Despite differing growth rates and other factors, the model indicates that, as with the U.S. loggerheads, survivorship of the juvenile stages is most important to population stability. In the Australian model, population growth rate is most sensitive to changes in survivorship of the pelagic juvenile and resident immature stages.

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ASPECTS OF SEA TURTLE CONSERVATION EFFORTS IN GREECE WITH EMPHASIS ON THE ISLAND OF ZAKYNTHOS

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The extensive coastline of Greece (approx. 15,000 km) hosts the most important loggerhead sea turtle nesting areas in the Mediterranean. Of these, Zakynthos constitutes the single largest rookery with about 1,800 nests (in a "good" season) on 3.5 km of beach length. The Bay of Kiparissia in western Peloponnesus hosts about 600 nests on a total of 44 km (Margaritoulis, 1988). During 1990 and 1991 the STPS completed a survey of almost all of the Greek coastline in search of new nesting areas. Turtle nesting was recorded in several localities, Crete being the most important one with an estimated 800 nests (Margaritoulis et al., in press).

The island of Zakynthos remains the focal point for sea turtle conservation efforts in the Mediterranean. In Greece it epitomizes the conflict between coastal development at any cost and nature preservation. To protect this unique habitat, the Greek government introduced legislation in 1984 to regulate human activities on land and at sea. But this proved to be ineffective, as restrictive measures were coupled with the incompetence of the authorities to enforce legislation and a reluctance to provide alternatives for the affected landowners.

Zakynthos has become in the last few years a major tourist destination. In 1991 alone, 1,257 chartered flights transferred 181,432 tourists, a 20% increase compared with 1990, of whom over 40% stayed on resorts bordering the nesting beaches. Thus, STPS with the support of the EEC and WWF, initiated a Public Awareness Programme in 1987 mainly through Information Stations, slide shows in hotels, and informative beach patrols. The establishment in 1991 of a branch office in the main town of Zakynthos contributed to the promotion of public awareness throughout the whole year. The objectives of this programme are to raise awareness among tourists, to minimize disturbances to turtles and hatchlings, to increase local participation and to campaign for the establishment of a National Marine Park (Dimopoulos, 1991).

During the 1991 season, over 40,000 tourists visited the two Information Stations and 12,069 visitors (23.4% more than 1990) attended the 147 slide shows (63% more than 1990) held regularly in the major hotels of the area. The Information Stations were erected with the consensus and support of the local Communities, and the slide shows were conducted in cooperation with the hotel owners and managers.

Protection efforts on the nesting beaches at night with wardens hired by the Prefecture of Zakynthos would have been more effective if the wardens had received proper training. STPS volunteers assisted Port Police with guarding the seaside access to the East Laganas beach. Data collected from 4 July through 31 August 1991 demonstrate that 1,017 individuals, representing 3% of the total number of tourists staying on the nearby resorts of Kalamaki and Laganas, attempted to trespass at night on this restricted beach. On the other hand, an increase in nesting activity in this area, recorded during the last years, is attributed to the minimization of human interference which comes as a result of intensive education and the close cooperation with the neighbouring hotel owner.

The growing local concern for the conservation of Zakynthos nesting areas was made public for the first time in a common declaration signed by three local communities with access to the nesting areas, the Local Union of Municipalities and Communities of Zakynthos, the Hoteliers Association of Zakynthos, the Zakynthian Ecological Movement and the STPS. All signatories agreed that stronger pressure needs to be exerted on the government to compensate the aggrieved landowners and to proceed with the establishment of a National Marine Park that will protect the sea turtle habitat.

It is a fact that a large portion of the local population has realized that sea turtle conservation and the protection of the environment need not conflict with their interests but, on the contrary, may offer long term and viable options for a rational development. This definite change in attitude was expressed in a massive local demonstration that thwarted attempts to develop on the islet of Marathonissi, one of the protected nesting beaches. The demonstration was attended by the Mayor of Zakynthos, the local MP, representatives of the Church, the Local Communities, the Hotel Owners and many local organizations.

Furthermore, there has been great progress with the planned acquisition by WWF of a large plot of land backing Sekania beach which hosts over 50% of all nests in the Bay of Laganas. This will have a positive impact on the other landowners who have been waiting desperately and long for a solution to their problem. It is worth mentioning that this is the first time ever in Greece that land has been purchased for the purpose of protecting an endangered species' habitat. After the acquisition, Sekania may become the core area in the proposed National Marine Park.

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DISTRIBUTION AND ABUNDANCE OF SEA TURTLES IN NORTH CAROLINA COASTAL WATERS IN WINTER MONTHS

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The annual occurrence of a relatively high number of sea turtle strandings during late fall and early winter on the northern coast of North Carolina has raised concern for potentially harmful sea turtle/fishery interactions. For example, in late November - early December, 1990, about 80 sea turtle strandings were reported in the vicinity of Cape Hatteras, NC, coincident with the onset of the summer flounder trawl fishery. The National Academy of Sciences' report (1990) on sea turtles cited the flounder fishery as a possible source of this mortality and recommended further study of fall and winter strandings. The multispecies-multigear fishery is conducted in North Carolina's and Virginia's nearshore waters from late November through January and in deeper waters from December through April (Ross et al., 1990). In the South Atlantic Bight and southern reaches of the Middle Atlantic Bight, the density gradient between nearshore waters and the Gulf Stream is strongly temperature controlled. This density gradient is at its maximum in the winter especially where the continental shelf is narrow. Warmer, less dense water from the Gulf Stream overrides the colder, more dense nearshore waters. Consequently, Raleigh Bay is far warmer in the winter than bays to the south of it (Onslow Bay and Long Bay) where the continental shelf is two to three times as wide. Also, aperiodic Gulf Stream meanders can introduce warm (20-25°C) water directly into the nearshore waters of Raleigh Bay, adjacent to the barrier islands. From coastwide aerial surveys and reported sightings, sea turtles are known to emigrate from the Chesapeake Bay by October (Keinath, 1987), and from North Carolina sounds by December (Epperly et al., 1990). Turtles can remain offshore for the rest of the winter (Thompson, 1984; Shoop and Kenney, in press; Epperly et al., 1990). Thus, sea turtles may be found in the summer flounder trawl fishing grounds. To address this question, the National Marine Fisheries Service, in cooperation with the North Carolina Division of Marine Fisheries, instituted a sea turtle protection plan for the 1991-92 season. In addition to monitoring the fishery and attempting to minimize turtle/fishery interactions, we hoped to document the distribution and species composition of sea turtles in North Carolina's nearshore waters.

State and Federal regulations restricting "on bottom" tow times and initiating observer coverage were implemented during the 1991-92 fishing season. During the early part of the fishing season (November-December), fishing effort was primarily confined to the nearshore waters from Chesapeake Bay to south of Oregon Inlet and in northern Raleigh Bay (Figure 1). In January and February, fishing effort continued in Raleigh Bay and off Oregon Inlet but was increasingly directed offshore and to the north - Norfolk Canyon and northward.

Twenty-one observers made 42 trips and observed over 2700 hours of trawling (1397 tows) (Figure 1). Throughout the fishing season, observers reported 66 sea turtles captured within Raleigh Bay, 17 captured north of Cape Hatteras and none captured north of Cape Charles. Of these 83 sea turtles, 50 were loggerheads (*Caretta caretta*), 30 were Kemp's ridleys (*Lepidochelys kempi*), two were greens (*Chelonia mydas*) and one was a hawksbill (*Eretmochelys imbricata*). All but 7 were returned to the sea alive and 70 were tagged prior to release. Seven turtles had to receive some form of resuscitation, and two of the seven mortalities had been dead prior to capture. Of the 56 sea turtles caught south of Cape Hatteras in November - December, 60% were Kemp's ridleys. Overall catch rates south of Cape Charles, Va (0.05 turtles/30.5m net hour) were comparable to rates reported for the southeast U.S. Atlantic shrimp fishery (Henwood and Stuntz, 1987; Renaud et al., 1990, 1991).

Aerial surveys for abundance and distribution of sea turtles were conducted from the NC/VA state line to Cape Lookout (Figure 1). Surveys were initially conducted only within state waters (3 miles from shore); however, after December 7, 1991, surveys were extended to 15 miles from shore. A total of 165 sea turtles were sighted within the survey area during 31.8 hours of flight. Twenty additional sea turtles were sighted in transit to the survey area. Turtles were sighted throughout the winter, and were generally found along warm water gradients, but also were seen in waters of approximately 8°C. Surface densities ranged from 0 to 10.85 turtles/100km^2. The greatest density of sea turtles was in Raleigh Bay and north to Oregon Inlet.

Sea turtle captures were documented throughout the observer coverage period (November-February). Offshore, sea turtles were sighted throughout the aerial reconnaissance period (November-March) both north and south of Cape Hatteras and within those waters fished by the summer flounder trawl fishery, up to 15 miles from shore. Data on sea turtle encounters from other concurrent finfisheries in the area are not yet available.

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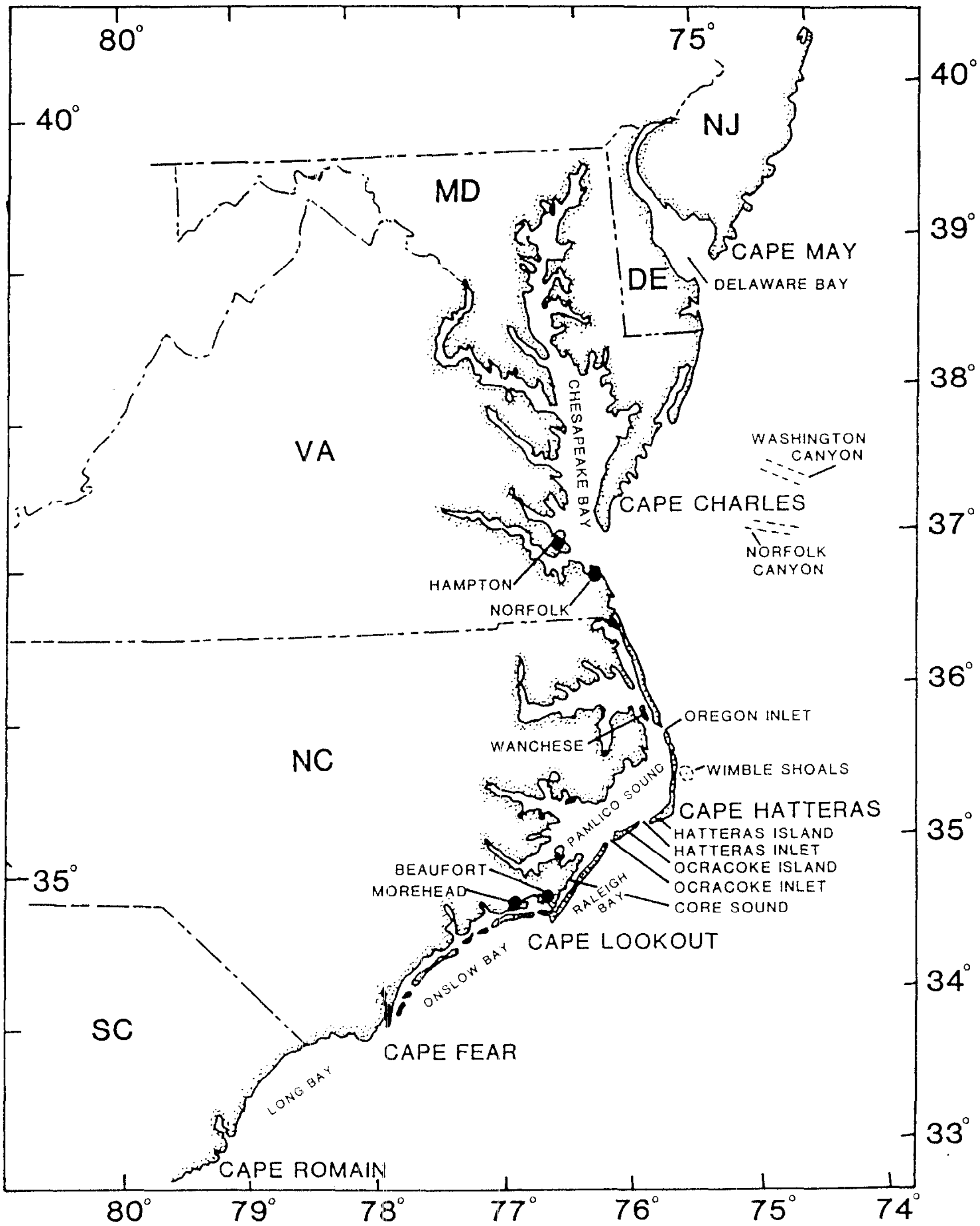

FIGURE 1. SUMMER FLOUNDER FISHERY GROUNDS AND SURROUNDING AREA

UTILIZATION OF ATYPICAL HABITAT FOR NESTING BY *CARETTA CARETTA*: THE UNRECOGNIZED IMPORTANCE OF LOW RELIEF MANGROVE ISLANDS

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Coasts may be categorized by the amount of wave energy they normally experience. Tanner (1960) used the average annual breaker height as a measure of this energy and defined low-, moderate-, and high-energy coasts as those that encounter average annual breaker heights of <10 cm, 10-50 cm, and >50 cm, respectively. In the southeastern U.S., almost all of the coastlines directly adjacent to open marine waters face moderate- to high-energy wave conditions (Tanner, 1960). These same areas also support the vast majority of loggerhead nesting in the U.S. (Dodd, 1988).

The naturally wide beaches that occur along moderate- to high-energy coasts are characterized by well-developed dunes and high relief and provide a similar nesting habitat for loggerheads throughout the southeastern U.S. (Caldwell, 1959; Witherington, 1986). Turtles nest on these beaches between the high-tide line and the base of the foredune (Carr, 1952) in an area that is relatively safe from tidal inundation. Although some turtles breach the dune and nest amid vegetation, nesting sites on these beaches are ordinarily unshaded.

The only open, low-energy marine coastlines in the southeastern U.S. occur along the west coast of Florida. One is located in northwest Florida in the bend between the peninsular and panhandle coasts (from Franklin County south to Pasco County); the other is located in southwest Florida between Naples and Florida Bay (from Collier County south through the Ten Thousand Islands and the coastal areas of Everglades National Park) (Tanner, 1960). Most of these coasts contrast sharply with areas of higher energy and of described loggerhead nesting habitat. Marshes and swamps predominate, and sandy beaches, if they exist at all, are usually scattered, narrow, and of very low relief.

Except for low levels of nesting on the barrier islands of Franklin County, regular loggerhead nesting has not been reported on the low-energy coasts in northern Florida. Personnel from Everglades National Park (ENP) have, however, reported substantial loggerhead nesting on the low-energy coasts in southern Florida since 1964 (Davis and Whiting, 1977). During the 1972 and 1973 nesting seasons, Davis and Whiting (1977) estimated that a total of 1,644 and 1,068 nests, respectively, were made within the boundaries of ENP on less than 57 km of beach (densities of 28.8 nests/km in 1972 and 18.7 nests/km in 1973). Although nesting surveys in ENP were most consistently conducted on the beaches of Cape Sable, park personnel occasionally conducted nesting surveys in the southern portion of the Ten Thousand Islands. They did not, however, describe the atypical nesting habitat that exists on these low-energy islands.

The Ten Thousand Islands are a wide band of low-relief, small mangrove islands stretching 40 km along the southwest coast of Florida from Cape Romano southeast to Pavilion Key. These islands formed approximately 3,000 years ago when mangroves colonized emergent oyster bars (interior and middle islands) and vermetid gastropod reefs (seaward islands) (Parkinson, 1987). Parkinson (1987) attributed the very low-energy setting of the Ten Thousand Islands to a dampening of waves by the wide continental shelf and the Cape Romano Shoals, and to the northwest-to-southeast orientation of the coastline. This positioning makes the islands vulnerable only to waves from the southwest, and wind from this direction is normally infrequent and weak. Many of the seaward islands are also fronted by shallow, vermetid reef rock (Shier, 1969) which effectively dissipates surviving wave energy.

On 6 June 1991, personnel from the U.S. Fish and Wildlife Service began a marine turtle nesting survey in the northern portion of the Ten Thousand Islands (area outside ENP which later became the Ten Thousand Islands National Wildlife Refuge). Nine of the most seaward keys (Brush, "B", Turtle, Gullivan, Whitehorse, "C", Hog, Panther, and Round) were surveyed once a week from 6 June to 10 September and twice a week from 17 June to 18 July. Most, but not all, of these keys were surveyed each time.

Because surveys did not begin until June, were not conducted daily, and did not entirely cover each island, it is unlikely that all nesting activity was discovered. Additionally, very narrow beaches and the presence of dense vegetation increased the likelihood that nests would be overlooked (the dense vegetation would also make it difficult to see nests during aerial surveys). Nevertheless, a total of 197 emergences were documented, 159 of which were known to result in nests (false crawl to nest ratio of 0.24:1.00). The total length of shoreline surveyed was 4,390 m, giving a density of 36.2 nests/km. This density is higher than any reported for the west coast of Florida during the period of 1979 - 1985 (Conley and Hoffman, 1987). Of the 159 documented nests, at least 129 were depredated (81%). Raccoons were the only predators implicated in nest depredations. Despite the high depredation rate, we have no reason to believe that raccoon populations are unnaturally high on these remote and uninhabited islands.

Fourteen nests were inventoried after emergence. Mean clutch size was 100.3 eggs (range of 84 - 124 eggs). Mean emergence success was 69.3% (range of 0 - 100%) with the fourteen nests producing 973 hatchlings from 1,404 eggs. Most of the eggs that did not hatch had no grossly discernable signs of embryonic development (91.2% of unhatched eggs). Only 37 unhatched eggs contained grossly discernable embryos; six hatchlings were found dead in the nests, and one hatchling was found alive in a nest. Either hatchlings or well-developed embryos found in eight of the fourteen inventoried nests were identified as loggerhead turtles (*Caretta caretta*).

In the Ten Thousand Islands, loggerhead nesting sites may exist anywhere turtles have access to sandy areas above the mean high tide line. Many turtles nest on the most prominent beaches. These occur along seaward shores that are not fronted by vermetid reef rock (i.e., shores with a deeper approach). These beaches are free of mangroves, composed of white, quartz sand, and vegetated by sea oats (*Uniola paniculata*). Although these beaches are the most similar to those found in higher energy settings, they are still very narrow and typically have only 1-2 m of open, sandy beach above the mean high-tide line. Beach relief is greatest in these areas, but it is no more than about 1-1.5 m in elevation.

Some islands have one or two long (e.g., 740 m on Panther Key, 610 m on Gulliver Key) stretches of more prominent beach, but much of the area used by nesting turtles is fronted by very little or no beach. At many nesting sites, turtles thread their way through less dense stands of red (*Rhizophora mangle*) or black mangroves (*Avicennia germinans*) to reach sandy areas to nest. In some cases, turtles are able to locate very small pockets (<30 m) of suitable nesting habitat among what are otherwise long stretches of dense mangrove stands.

Turtles commonly nest beneath red, black, and white mangroves (*Laguncularia racemosa*). At low tide, the broad area of vermetid reef rock fronting many of the nesting sites is exposed, presumably limiting nesting to times of higher tides. Many of the beaches are so narrow that turtles emerging at high tide gain immediate access to the more heavily vegetated areas behind the beach. Turtles crawl 5 - 15 m through sometimes dense ground cover (including the prickly-pear cactus, *Opuntia stricta*) and make nests among vegetation such as buttonwood (*Conocarpus erecta*), seagrape (*Cocoloba uvifera*), gray nickerbean (*Caesalpinia crista*), gumbo limbo (*Bursera simaruba*), bay-cedar (*Suriana maritima*), indigoberry (*Randia sp.*), and Jamaica dogwood (*Picidia piscipula*). Turtles nest in media ranging from quartz sand to oyster-shell gravel to mixtures of these two with mangrove peat. Although there is great potential for turtles to become trapped by ground cover, which sometimes includes dead trees, we found no evidence of this.

The sexual differentiation of loggerheads is temperature-dependent. Eggs incubated at the pivotal temperature produce equal numbers of male and female hatchlings, whereas eggs incubated below that temperature produce mostly male hatchlings and eggs incubated above that temperature produce mostly female hatchlings (Yntema and Mrosovsky, 1980). Pivotal temperatures for loggerheads nesting in the southeastern U.S. have been estimated to be close to 29°C (Mrosovsky, 1988). Mrosovsky and Provancha (1989) estimated that, in 1986, greater than 93% of hatchlings produced at a major Florida loggerhead rookery (Cape Canaveral) were females. Based on these results, they suggested the possibility that Florida may produce a preponderance of female hatchlings and that perhaps "few, if any, males can be expected [from Florida, especially] if the greenhouse effect results in global warming of a few degrees centigrade." In the Ten Thousand Islands and perhaps other areas in ENP, many nests are made in heavily vegetated areas or are more frequently inundated by tides then are nests made on beaches of higher relief. Future studies may reveal that incubation temperatures in these areas are often below the pivotal temperature for loggerheads, thus producing a preponderance of male hatchlings. If so, hatchlings from these areas may be of unrecognized importance to each loggerhead year class from Florida.

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Key (# of Days Surveyed)	Beach Description	# of Nesting Emergences	# of Nests	# of Nests Depredated	Nesting Media	General Nest Locations
Brush (19)	30m of open beach; 131m of beach fronted by mangroves	6	4	1 (25%) *one nest screened	20cm of oyster shell gravel over quartz sand	on open beach and under black and white mangroves
B (19)	177m of beach fronted by mangroves	23	19	18 (95%)	oyster shell gravel with some mangrove peat	under buttonwood, gumbo limbo, white mangrove, seagrape, and bay cedar
Turtle (19)	161m of open, white sandy beach with sea oats; 145m of beach fronted by mangroves	18	12	8 (67%) *two nests screened	quartz sand; mixtures of sand, oyster shell gravel, and mangrove peat	on open beach and under black and white mangroves
Gullivan (18)	611m on SW side of mostly white, sandy beach with sea oats, some areas fronted by mangroves; 76m on NE side of mostly open, sandy beach (grassy but no sea oats)	33	28	27 (96%) *one nest screened	mostly quartz sand; some mixtures of sand, oyster shell gravel, and mangrove peat	most on open beach, some under seagrape and white mangrove; three nests on NE side in dense stand of gray nickerbean
Whitehorse (20)	150m on NW tip of white, sandy beach with sea oats; 840m of beach fronted by mangroves	16	11	4 (36%) *three nests screened	quartz sand on NW tip; mixture of sand, oyster shell gravel, and mangrove peat	few on open beach, most under red and white mangroves, seagrape, and bay cedar
C (12)	30m on NE side of open, sandy beach (grassy but no sea oats)	3	2	1 (50%)	quartz sand	one in grass and one under prickly-pear cactus
Hog (17)	488m of beach fronted by mangroves	5	2	2 (100%)	mostly oyster shell gravel with some mixtures of sand and mangrove peat	under red and white mangroves and seagrape
Panther (15)	740m on W side of mostly white, sandy beach with sea oats; 494m on E side of beach fronted by mangroves	69	63	63 (100%)	quartz sand on W side; mixture of sand, shell gravel, and peat on E side	most on open beach (W side), some under black and white mangroves (E side)
Round (18)	317m of mostly heavily vegetated beach fronted by mangroves	24	18	5 (28%)	mixture of sand, oyster shell gravel, and mangrove peat	almost all under red, black and white mangroves, buttonwood, seagrape, and bay cedar

Table 1. Results of nesting survey and beach descriptions. Surveys conducted from 6 June - 10 September 1991.

PRELIMINARY AGE BASED POPULATION MODELS FOR AUSTRALIAN LOGGERHEAD SEA TURTLES.

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Data gathered in a long-term study of loggerhead sea turtles, *Caretta caretta*, in Australia (Limpus, 1985) provide information used to model population dynamics. Capture-recapture measurements indicate that Pacific Australian loggerheads are growing more slowly than those in western Atlantic waters (Frazer and Ehrhart, 1985; Bjorndal and Bolten, 1988). Female Australian loggerheads are probably reaching maturity at an average age in excess of 30 years (Limpus et al., in prep).

Model A: Observed rates of egg deposition, egg survival, hatch rate, and survival of large juvenile and adult turtles in the water were input into the model to estimate survival rates of smaller juveniles necessary to maintain a stable population. Small turtles must survive at rates greater than 90% per annum over a period of up to 20 years to maintain a stable population. Such survival rates for small juveniles would have to be higher than any recorded for extant vertebrate species (Congdon et al., in prep.) Thus, it seems highly unlikely that this population is actually stable at present.

Model B: Observed rates of population decline of a nesting colony (a documented 50% reduction in nesting females in the last 10 to 11 years) were used in the model along with observed survival rates of adult nesting turtles and observed rates of egg deposition, egg survival, hatch rate, and measured survival rates of larger juveniles in the pelagic habitat. This model, which "mimics" the observed decline in nesting females over the past decade at some nesting beaches, still requires survival rates of small juveniles to average 87% per anum over a 20 year period.

Model C: Model B was run again with the added assumption that observed increases in egg predation by foxes in some areas would continue unabated. In this scenario, the rate of population decline eventually will effectively double, with 50% of the nesting females being lost in only 5 or 6 years instead of 10 to 11 years.

All three models require extremely high rates of young juvenile survival to mimic reality (e.g., a 5-6% decline in nesting females per year) or stable populations. It is unlikely that any conservation effort directed at small juveniles (e.g., head-starting) would be able to raise juvenile survival sufficiently above these levels to reverse population declines or to make up for any increase in directed fisheries or incidental catch that kills adults or larger juveniles. Protection of eggs from excessive destruction on nesting beaches, however, is essential if further increases in rates of population decline at some rookeries are to be avoided. All three models show that adults and resident immature turtles on the reef are extremely important components of population stability.

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HAWKSBILL TURTLES IN THE YUCATAN PENINSULA: AN UPDATE

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Ever since marine turtle surveys of the Yucatán coast were carried out a decade ago, there has been ever-growing interest in the region. Both world and regional reviews of hawksbill turtles, *Eretmochelys imbricata* (L.), (Groombridge and Luxmoore, 1987; Meylan, 1989) have emphasized that the annual number of nesting females on the Peninsula is important on a world scale. This area is even more significant because this turtle is regarded as seriously threatened by world trade, and because major exporters of tortoise-shell are in neighboring countries (Donnelly, 1989).

Basic information on hawksbills is incomplete and often misleading. As has been explained (Groombridge and Luxmoore, 1987; Meylan, 1989), in addition to inherent biological problems in studying this species, many of the assessments of nesting populations are based only on interviews with fishermen; there simply are no biological data to support many of these estimates.

A score of field sites in the Peninsula, covering most of the coast, have recorded hawksbill nesting; some programs have been active for nearly a decade: e.g., Isla Aguada, Campeche (Escanero and Vigilante, 1991). Although there are still many basic problems in standardization of methodology and quality of data, valuable information is accumulating on the biology and status of the hawksbills in the Yucatán Peninsula. Of especial import is work done at: Isla Aguada (Escanero *et al.*, in press), Celestún (Rodríguez *et al.*, in press), Las Coloradas (Carrasco *et al.*, in press), El Cuyo (Vázquez, in press; Rodríguez and Zambrano, in prep.), Isla Holbox (Gil *et al.*, in press; Miranda, in prep.), and Belize (Smith, 1991). This note is based on a compilation of studies done in the Península (Frazier, in press).

1) Where are hawksbills nesting on the Yucatán Peninsula ?

There are 6 major foci: Isla Aguada to Chenkán (>120 km of beach worked by two institutions), Celestún (<20 km), Las Coloradas to Boca Cipepté (~40 km worked by two institutions), Isla Holbox (~35 km), Herradura (or Mahahual), and Mullins River to Manatee Bar, Belize (8 km). Hence, there are 2 major sites in each of three coastal provinces: Campeche Bay, Yucatán Channel, and Western Caribbean. The Manabique Peninsula, Guatemala (~50 km), a major nesting area, is just outside the Yucatán Peninsula.

2) When do hawksbills nest in the Yucatán Peninsula ?

In nearly all sites, nesting has been recorded from mid-April to early August; in several sites it goes on to September or even October. Peak nesting activity is in May and June.

3) How many hawksbills nest each year on the Yucatán Peninsula ?

Each of the 6 major sites has between 60 and nearly 400 nests per year, so that each of the three nesting "juntas", or provinces, has at least 200 nests per year; one has nearly 600. Dividing the annual nest counts by 3 yields rough estimates of about 100 or more females nesting per year in each junta. The total annual number of female hawksbills estimated to nest on the Yucatán Peninsula is in the order of 400. In addition, there are reported to be between 380 and 760 nests yearly on nearby Manabique Peninsula (Rosales in Smith, 1991). This might represent an additional 100 to 250 females per year. In total, these figures indicate an increase in earlier estimates of hawksbill nesting in the region of the Yucatán Peninsula (c.f. Groombridge and Luxmoore, 1987; Meylan, 1989).

Annual number of hawksbill nests at major sites on the Yucatán:

BEACH	Low	High	PROVINCE:	Low	High
Isla Aguada(*)+Chenkán	96+74	233+98	Campeche Bay		
Celestún	63	63	Campeche Bay	233	394
Las Coloradas+El Cuyo	114+118	193+196	Yucatán Chan.		
Isla Holbox	"63"	187	Yucatán Chan	295	576
Mahahual	?	?	W. Caribbean		
Manatee Bar, Belize	200	250	W. Caribbean	>200	>250

(*) values for Isla Aguada may be 50% of the annual total.

4) What is the fate of these nests?

Hatchling production at the major nesting sites in México ranges from 7,000 to 21,000 per year, and the cumulative production in nesting juntas ranges from 24,000 to 47,000. Nest predation on the Belizian beaches is reported to be very heavy, so hatchling production there may be extraordinarily low. If 1 in 1,000 hatchlings survives to the juvenile stage (as some people have suggested), the annual recruitment of juveniles from the entire Yucatán Peninsula would be in the order of 100.

5) What trends in hawksbill reproduction can be detected ?

The only site from which there are several years of data that are comparable is Isla Aguada. Over the past decade, the number of nests recorded yearly has increased, but there has been increased effort and efficiency in beach patrolling. Average annual hatchling emergence success in transplanted nests has increased over the same period. It is important to point out that styrofoam boxes were used in all but the last year. The trend indicates better management of eggs in boxes, up to about 65% emergence success, increasing to 70% in 1990 when eggs were transplanted to beach corrals. Nests which were left *in situ* for 6 to 7 weeks, then transplanted, showed no noticeable annual trend and no consistent difference with nests which had been transplanted immediately. It is remarkable that when left *in situ* for the full incubation period, the success of nests was greatest.

6) What factors are related to hatchling recruitment ?

Average annual emergence success is, as expected, very strongly related to average annual fertility rate. This is true for both treatments on Isla Aguada, transplanted and "*in situ*". Average annual fertility rate is *negatively* related to average annual clutch size, opposite to the expected positive relationship between these two variables; it is unclear what the explanation is. It does, however, suggest a management tool: raising production by reducing the size of the incubated clutch. It may be relevant that the annual variance of clutch size is negatively related to the annual average of clutch size. This suggests the effect of extremely small clutches: to decrease the average and increase the variance. However, it is unclear how this is related to average rate of fertility.

The annual variance in hatchling emergence is negatively related to annual average in hatchling emergence. This indicates the effect of extremely low values of emergence success: lowering the average and raising the variance. However, it may as well be simply a function of the binomial distribution (there are only two possible values for emergence success: positive or negative). It is notable that the annual variance in hatchling emergence has decreased over a seven-year period of the study. The explanation for this decrease in variance may be an increase in experience and efficiency in nest management techniques.

CONCLUSIONS

Increasing recruitment into the population is a priority of conservation programs, and hatchling recruitment from nesting beaches is a first place to start. The importance of understanding the various trends and relationships described above is simply to increase hatchling recruitment.

When explaining variation in emergence success, it is important to take into account effects of individual variation, age and experience along with other ecological factors. For example, at Cousin Island, clutch size and reproductive success both seem to increase with increasing experience of the female (Garnett, 1979). In Barbados, nests on the east coast not only have lower emergence and hatching success, but also fewer eggs than nests on the west and south coasts (Horrocks and Scott, 1991). Evidently, females with lower fecundity also have lower fertility; they also nest on the least preferred beaches.

How do these variables in nest ecology interrelate? Is the explanation solely the effect of environmental factors? or, is there also endogenous variation? For example, do less experienced females (e.g., those in their first or second breeding season) select lower quality beaches? do they also, for physiological and behavioral reasons, have lower rates of fecundity and fertility?

If experience is part of the explanation, it shows the importance of not just reproductive, but seasoned females. Reducing life expectancy of breeding females, e.g., through intense exploitation of females on nesting beaches, could have drastic effects on hatchling recruitment. Looked at another way, if consistent protection of a nesting beach finally results in a pulse of first time breeders, one might expect a lowering of overall reproductive output on that beach.

An additional effect which must also be looked for is that of senility. If predation on nests and/or nesting females is intense and hatchling recruitment into the population is impeded, the recruitment into the population will depend on ever-older females. How does senility affect nest site selection, fecundity, fertility and hatchling emergence success?

Because of various exploitation histories of the hawksbill on the Yucatán Peninsula, all of these scenarios are likely. However, it is not yet known how to identify either inexperienced or senile breeders. Clearly, this information will be invaluable for conserving and managing these populations.

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ENCEPHALITIS: A NEW REASON WHY APPARENTLY HEALTHY SEA TURTLES STRAND IN WARM WEATHER

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Between June and December of 1991 four loggerhead sea turtles, *Caretta caretta*, were found live stranded in the Chesapeake Bay. The turtles, three females and one male, weighed from 16 to 35 kg. The first three animals were robust and appeared to be in good physical condition. The fourth turtle was emaciated and carried a heavy epibiotic load. All four turtles showed signs of a central nervous system disturbance. They were lethargic and inactive, but when handled they were spastic and exhibited uncoordinated movement. The most unusual sign found in all four animals was a marked flexion of the neck, which was accentuated when the animals were handled.

Most of the plasma chemistry values were within the range of values expected for normal turtles from the Chesapeake Bay. Creatinine phosphate (CK) values were elevated in two of the affected individuals. Elevated CK levels indicated necrosis of the skeletal muscle, cardiac muscle, or brain tissue. The two others showed a high white blood cell count.

Necropsies were performed on each turtle. Except for the brain, all tissues from the animals were grossly and histologically normal. The brains and meninges of the turtles showed areas of hemorrhage and caseous necrosis. The lesions were mainly in the regions of the optic lobe, cerebellum, fourth ventricle, and medulla. Only one turtle had grossly visible lesions in the anterior cerebrum.

Histological lesions consisted of inflammatory meningitis and areas of neuronal degeneration, perivascular cuffing, and ischemic necrosis. These lesions were found primarily in the areas with grossly visible lesions. The areas of necrosis contained large numbers of multi-nucleated giant cells. Giant cells are often found in the presence of infections caused by higher organisms such as parasites, fungii, or mycobacterial organisms. Special stains were employed to try and identify such organisms but none were noted.

Tissue samples were cultured for a variety of micro-organisms. Both *Vibrio* and *Pseudomonas* organisms were isolated. These two pathogenic bacteria are common in the marine environment and were most likely contaminants. No tentative etiology was cultured.

It appears this is a well defined and often repeated disease process that attacks the brains of sea turtles from the Chesapeake Bay. These symptoms, indicating a central nervous disease, have been observed in previous years. Because of the scattered nature of the affected animals, the dearth of external signs, and the problems of examining the brain, this disease probably often goes undetected. Until an etiology is discovered, this disease process should be referred to as Giant Cell Meningo-encephalitis (GME). GME should be considered in animals showing no apparent reason for a live or dead stranding. If the animal is alive and shows signs of a CNS problem GME should be suspected. The presence of high CK values in plasma chemistry tests can be used to confirm the presence of GME. If the animal is dead the brain should be examined for the characteristic lesions.

FALL MOVEMENT AND MIGRATION OF KEMP'S RIDLEYS OFF THE GEORGIA-FLORIDA COAST: A TELEMETRY STUDY

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In October 1991, a shrimp trawler conducting surveys for the U.S. Army Corps of Engineers captured two subadult Kemp's ridley sea turtles in Brunswick Channel, Georgia, and one adult female ridley in St. Mary's Channel on the Georgia-Florida border. The subadults were equipped with radio, sonic, and depth sensitive sonic transmitters. A satellite transmitter was attached to the adult female ridley. After tagging, all turtles were released in the channels at the same location where they were captured. Radio and sonic transmitters were monitored during a six to seven week period. The satellite transmitter was designed to record data on location, number of dives, mean dive time, duration of last dive before each transmission, and tag temperature. The system was designed to provide discontinuous data for up to 18 months.

Although turtles were both captured and released in channels, they were rarely observed in channels after release. All three turtles moved south into Florida waters. Night dives were longer than day dives for one of the subadult ridleys. Although water temperatures were well above the lower limit of thermal stress, there was evidence that some movements may have been related to changes in water temperature.

IMMATURE GALAPAGOS GREEN TURTLE GROWTH RATES

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Green turtles in the Galápagos Islands, Ecuador, were captured in lagoons either by nets or by hand. Hand methods included diving from a skiff or from land, SCUBA and snorkeling. The straight carapace length (SCL) was taken using wooden calipers and a yardstick. Before release, each turtle was double-tagged, a numbered metal cattle-ear tag being inserted into the trailing edge of the right foreflipper, and a numbered, colored plastic tag inserted into the trailing edge of the right hindflipper. Recaptures of these turtles provided data on growth rates in the wild. Turtles were classified as immatures if they had an SCL smaller than 66.7 m, the size of the smallest nesting Galápagos green turtle female recorded thus far.

Growth rates proved to be slower than recorded elsewhere. Twenty-four immature green turtles with SCLs ranging from 46.2 cm to 66.3 cm recaptured after intervals of 8 to 30 months showed a mean increase in SCL of 0.31 cm/yr (range = 0-1.6 cm/yr; SD = 0.41). Such slow growth rates place age at sexual maturity in the Galápagos population at well over 50 years.

SPIRORCHIID FLUKES IN GREEN TURTLES WITH FIBROPAPILLOMAS

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During the first year of study, only *Learedius learedi* was recovered from the circulatory system of 4 of 6 green turtles, *Chelonia mydas* collected in Florida waters. From 1 to 5 adult flukes were obtained from the juvenile turtles examined. All of these turtles had fibropapillomas and spirorchiid eggs were recovered from these nodules. Small skin nodules (< 1 cm diameter) contained from 16 to 6000 spirorchiid eggs per gram (EPG) and large skin tumors (>1 cm diameter) had from 0 to 900 epg. One turtle with internal nodules yielded the following egg profiles: spleen >3000 EPG, kidney 1100 EPG and lung 1200 epg. All seven of these turtles were moribund when submitted to the College of Veterinary Medicine and they were necropsied in fresh condition following euthanasia.

Trematode eggs were recognized in fibro-epithelial tumors from green turtles as early as 1939 (Smith and Coates, 1939). While these authors did not feel that these eggs were the cause of the tumors, they did not present any evidence to support their contention. Because some chelonian digenetic trematodes (family Spirorchiidae) live in the blood vessels and heart, their eggs must travel through host tissue in order to exit from the green turtles to complete their complex life cycles by infecting a snail intermediate host. Flukes that reside in the lumen of the intestinal tract do not have to do this as their eggs will simply pass out of the host with the feces into the abiotic environment.

There is a great deal of mechanical damage caused by these eggs moving through host tissue. Whether there is also an invasion of fluke egg damaged tissue by other pathogens as bacteria, fungi or viruses or whether these agents or environmental contaminants are carried along with the eggs is unknown. Thus there is a possibility that these trematodes eggs are directly or indirectly involved with the formation of green turtle fibropapillomas. It is with respect to this potential that studies have been initiated on causes of fibropapillomas in green turtles in Florida waters. This paper deals with the preliminary data on the presence of adult spirorchiid flukes in green turtles with fibropapillomas and the presence of spirorchiid eggs in the nodules.

All of the these green turtles originated in the Florida Keys and ranged from 23 to 50 cm curved carapace length. Once the plastron was removed from the dead turtle, the heart and as much of the associated major vessels as possible were removed and placed into a container. All chambers of the heart and all vessels were opened and rinsed to free adherent flukes. Flukes were concentrated by sedimentation in large flasks. The urinary bladder was ligated, removed, and examined after it was slit open. The gall bladder was removed with some of the adhering liver parenchyma and then the bladder was opened and examined for flukes. The liver was removed and sliced into 1 cm thick pieces and then these were compressed to squeeze out flukes from the bile ducts and blood vessels and then the slices were rinsed in water and the resultant material was sedimented in large flasks to concentrate the flukes. The entire digestive system was removed from the upper esophagus to the cloaca. The esophagus and stomach were separated and examined individually by slitting them lengthwise and then washing their contents and mucosal surfaces into small buckets. This was then rinsed through a #40 standard sieve and the contents were backflushed into a clean labeled container. The intestine was divided into halves and the upper portion was treated separately from the lower gut. A fecal sample was obtained from the cloaca. Both the contents from the gut and the scraped gut mucosa were treated as were the stomach and esophagus. Once all of these were washed or sedimented, the material was returned to the parasitology laboratory where the helminths were recovered by using an illuminated viewing box. Flukes were relaxed and then fixed in AFA. Representative flukes were stained by standard procedures with hematoxylin and identified.

Fibropapillomas were removed from the turtles. Some of these were examined histologically and others were examined to determine the number of spirorchiid eggs present per gram of tissue. Skin nodules were classified as small if their diameter was less than 1 cm and large if their diameter exceeded 1 cm. Internal nodules were classified by their organ of origin. Three nodules were examined from each site or size category (except the single stomach nodule found in one turtle). Portions of these nodules (0.1 to 0.5 g) were placed into small blenders with pepsin digestion fluid and homogenized until only small bits of tissue remained. The contents were then washed into 15 ml centrifuge tubes with more digest fluid and these were allowed to incubate for at least 4 hr and sometimes overnight in a water bath at 37 C. The sediment was centrifuged and the digest fluid was replaced with normal saline. The sediment was then placed into small petri dishes to facilitate observing and counting eggs. Representative eggs were placed on microscope slides to allow measurements to be made and the eggs to be photographed.

Learedius learedi adults were recovered from 4 of the 7 turtles examined and a range of 1 to 5 adults/host were found. These were removed from the heart and associated major vessels. No other adult spirorchiid flukes were detected in these turtles, but there were numerous intestinal trematodes that are beyond the confines of this paper and will be dealt with elsewhere.

While fibropapillomas were present on all of these turtles, the first three turtles were only examined for the presence of adults and nodules were not removed for digestion and recovery of eggs. Three types of eggs were detected in the nodule digests indicating that at least two other taxa of spirorchiid flukes had to be present that were not recovered from these turtles. The large distinctive eggs (250 - 280 _m long including the two polar spines) of *L. learedi* were found in only one turtle. This turtle harbored 5 adults of this fluke in its vasculature. Spirorchiid taxon B was represented by dark brown, ellipsoid eggs (70 - 81 x 45 - 50 _m) and was present in 3 turtles and the final type (spirorchiid taxon C) had dark brown, ellipsoid eggs (44 - 50 _m x 33 - 44 _m) and it was present in one turtle. The egg counts varied tremendously from host to host. The small fibropapilloma vs large fibropapilloma egg counts suggested a trend of decreasing numbers of eggs per gram of tissue as the tumors increased in size. The numbers of eggs in small vs large tumors were as follows: 40:14 EPGs of taxon B, 16:0 EPGs of taxon B, and 6000:900 EPGs of taxon C. The one turtle in which *L. learedi* eggs were recovered had 1 EPG vs 13 EPG of taxon B. One turtle had a nodule on the stomach and it contained 22 taxon B EPG. Another turtle had multiple internal tumors and those from the spleen averaged 3000 EPG, those from the lung 1200 EPG and those from the kidney 1100 EPG. The latter turtle was the one with the very high EPGs in skin nodules.

Spirorchiid flukes are difficult to recover at necropsy as they could be located in a variety of locations in the body, even in some of the minor vessels of the circulation system. Smith (1972) listed 8 species of spirorchiid trematode from the green turtle. Daily et al., (1991) described a new species of blood fluke from Hawaiian green turtles. Associations between spirorchiid and pathologic changes in green turtles have indicated problems in finding the adult blood flukes and associating these with the eggs found in tissue or the associated pathogenesis observed in marine turtles (Wolke et al., 1982, Glazebrook et al 1981, and Glazebrook and Campbell 1990).

The eggs of taxon C are similar to those found in loggerhead turtles by Wolke et al., (1982) which they felt were the eggs of *Neospirorchis* spp. Eggs of taxon B do not correspond to any of the described eggs and thus their identity is even more uncertain. Whether the apparent reduction in number of eggs in larger tumors in comparison to smaller tumors is real might indicate that eggs are not continually released into the tumors and that they are diluted as the tumor grows. This might be related to movement of the eggs through the tumor as the eggs move by body flection and this might not happen except at the site of attachment of the tumor to the integument.

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Buck Island Reef National Monument Hawksbill Sea Turtle Research Program, 1991.

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1991 was a hallmark year for Buck Island Reef NM's (BUIS) sea turtle research program. This was the fourth year of the nocturnal research program on nesting hawksbill sea turtles, *Eretmochelys imbricata*, and the first ever attempt to track by radio, sonar, and satellite the hawksbills' in-water movements during their internesting period and their possible migrations after completing nesting for the season. The objectives for the nesting beach study remained the same, to continued collecting basic biological information on nesting hawksbills and their nesting requirements as well as follow the recovery of the nesting beaches two years after hurricane Hugo and the continued effects on hawksbill nesting.

At Buck Island the hawksbill nesting season began in early May and continued through December, spanning 8 months. Peak hawksbill nesting occurred in July, August, and September. Two hundred forty hawksbill nesting activities were recorded for all three BUIS nesting beaches. Distribution of nesting activities between the three beaches was similiar to that observed in 1990; north shore received 42% (101 activities), south shore/Turtle Bay received 42% (100 activities), and West Beach 16% (39 activities). This pattern of use is consistant with years not disrupted by a hurricane. False crawl to nest ratio (1.2 to 1) was lower in 1991 (see Figure 1 presented in poster section).

The fallen vegetation created by hurricane Hugo has not disappeared and continues to interfer with hawksbill nesting attempts in the beach forest. Hawksbills were observed making repeated attempts to penetrate brush piles and returned to the water. On 3 occasions hawksbills were observed struggling through thick piles of tree branches and logs on their return crawl, only to come out on top of a pile of debris and fall 2-3 feet to the sand beach below. The animals were momentarily stunned but soon resumed their crawl to the water.

The nocturnal research program began in July and continued through the first week of October; 95 nights were spent on the island and 101 hawksbill activities were observed. This is double the number of nights spent on the island, doubling the number of hawksbills activities ever previously observed during the program. This greatly increased the information gathered and the accuracy of that information on the hawksbills. During the research program, 26 female hawksbills were observed. Of those, 16 were new hawksbills identified and tagged this season; although several had tag scars, there were no available methods to confirm their prior identities. Six hawksbills were remigrants from 1989, still carrying their inconel tags (NMFS Series PPW); the tags were clean and legible in all cases. Two hawksbills were remigrants from 1988, and their inconel tags were clear. However, the tags were loose in the flipper scale and would have eventually pulled out. Table 1 shows tagging results from this season. In all returning hawksbills some carapace growth was recorded. Female hawksbill with tag number PPW839/838/QQD105 is the largest nesting hawksbill recorded for BUIS, measuring 100 cm over-the-curve carapace length.

Nest site fidelity was frequently observed (see Table 2) . Seventy-five percent of the tagged females were observed nesting in the same, or within meters of, previous nests 75% of the time. Hawksbills returning from 2 and 3 year cycles also exhibited site fidelity to a nesting beach. Inter-nesting interval was determined to be 15.6 days (N = 45 nestings, SD = 2.75). This is consistent with known internesting intervals for BUIS' hawksbills, 14 - 15 days. The inter-nesting interval was increased when females had to make 1 - 2 days of false crawl/nesting attempts prior to locating a suitable nest site.

Due to increase patrol nights and excellent technician vigilance, we have the best season's information on tagged female's successive clutches and number of eggs per clutch. Hawksbills laid a mean of 3.1 nest/female, ranging from 1 to 5 nests. This year the mean clutch size was 142.7 eggs ranging from 79 to 202 eggs. Table 3 shows successive clutch sizes for 14 females.

Of the 240 activities recorded, 99 were confirmed nests (80 in-situ and 19 relocated from threat of erosion), 22 remained suspected nests/unconfirmable, and 119 were false crawl/nesting attempts. Seventy-seven hawksbill nests were confirmed and excavated for hatching success, producing 7281 live hatchlings. Nest outcome ranged from less than 1 % to 99 %. One nest had 19 yolkless eggs of various sizes out of 139 eggs. Whole beach nesting success was 66.2% (N = 77 nests, SD = 28.8), determined from all nests excavated for success determination, including nests with less than 25% success for no apparent reason, 5 nests affected by predation, 4 affected by erosion/wash-over, and 4 affected by dehydration, suffocation, and compaction. Nest success for nests reaching full term without obvious detrimental effects was 77.6% (N = 59, SD = 17.6); this was lowered by 4 nests with less than 50% success for no apparent reason. The success of nests relocated by technicians was highly variable; out of 19 nests moved, 17 were excavated for success determination. The mean hatch success for these nests was 51.1 %, with a SD = 31.3, and success ranged from less than 1 % to 94 %. There was no apparent reason for the low success.

In conjunction with the nesting beach study, BUIS initiated a radio/sonar telemetry study to track the in-water movements of hawksbills during their inter-nesting period. With the assistance of the nesting beach technicians, 7 transmitters were deployed, and turtles were tracked for 3 months. The results will be presented in a paper by Christopher Starbird. 1991 was a very ambitious year for BUIS; in addition to the nesting beach study and the radio/sonar study, U.S. Fish & Wildlife Service began a satellite telemetry study to determine whether or not hawksbills make seasonal migrations. The first 3 satellite transmitters were deployed in October. So far, the first satellite hawksbill has been recorded north of BUIS in the U.S. Virgin Islands and British Virgin Islands. FWS will continue this study in 1992.

The results of this season's research on the BUIS hawksbill population is a direct result of the personal and superhuman efforts of the technicians, interns, and volunteers. Without their creative, energetic and sometimes heroic output, fewer turtles would have been tagged, less nests relocated, more radio telemetry devices would have been lost to sea or not deployed at all, and far less information would have been gathered for my presentation. It was my honor and privilege to work with and now thank the following turtle technicians: Chris Starbird, Lincoln Maynes, Bill Shaw, Matthew Godfrey, Ruth Barreto, Solvin Zankl, Karen and Karla Collins, Erica Molz, and Linda Hannigan. There were so many people watching the hawksbills this year, nothing slipped by. Thank you all.

Table 1. Tagging information on female hawksbill sea turtles nesting on Buck Island Reef NM, U.S. Virgin Islands, 1991.

National Marine Fisheries Tags (Series PPW & QQD)*		First Observed	Tagging Location^	Other Dates Observed
	LFF/RFF"			
PPW	810/881	6/27/91	SS/24	6/28;7/14;7/17
PPW	877/879	6/27/91	NS/03	7/11;7/13;7/27
PPW	872/894	6/27/91	WB/14	6/28;7/12;7/27;8/9
PPW	890/856 (FWS)"	8/23/91	TB/38	8/17;8/31
PPW	870/862 (NPS)'	7/03/91	TB/42	7/5;7/22;8/6;8/24
PPW	888/845	7/05/91	NS/07	7/22;8/5;8/20;9/9
PPW	837/836	7/08/91	NS/03	7/10;7/11;7/26;7/27
PPW 818	QQD 111/QQD 121	7/09/91	NS/05	8/8;8/25;8/26
PPW 839	QQD105/PPW838(NPS)	7/14/91	NS/03	7/14;7/30;8/15
PPW	887/884 (NPS/FWS)	7/25/91	SS/26	8/23;8/24;9/7;9/20
PPW	891/QQD113 (NPS)	8/08/91	NS/05	8/23;9/8
PPW	889/883 (NPS)	8/21/91	NS/03	9/5;9/20;10/4
PPW	853/BI007 (FWS)	8/09/91	WB/18	8/27;9/9;9/24
QQD	109/PPW848	8/21/91	SS/30	9/6;9/20
QQD	115/PPW864	7/26/91	NS/07	8/11;8/28;9/13
QQD	101/102 (NPS)	7/10/91	NS/03	7/25;8/10;8/25
QQD	108/122	7/25/91	WB/16	8/9;8/25;9/8;9/22
QQD	117/118 (FWS/sat.)	9/12/91	SS/26	9/26
QQD	126/114 (FWS)	8/24/91	NS/11	9/25;9/10;9/23
QQD	128/129 (NPS)	9/01/91	SS/34	9/13;9/28
QQD	/132 (FWS)	9/09/91	SS/34	9/25
QQD	149/148 (FWS)	8/30/91	SS/30	8/30;9/14;9/15

* National Marine Fisheries Service, Inconel Tags, Series PPW & Series QQD both used for tagging in 1989, 1990, 1991.

^ Location of nesting beach where hawksbill was first observed in 1991 (SS = Southshore; NS = Northshore; WB = West Beach; TB = Turtle Bay) and corresponding marker number. (See Fig.)

' NPS denotes a National Park Service radio/sonar telemetry transmitter was attached.

" FWS denotes a U.S. Fish & Wildlife Service radio telemetry transmitter was attached. "Sat." indicates a satellite transmitter was attached.

Table 2 . Nesting site fidelity for hawksbill sea turtles nesting (including false crawl/nesting attempts and confirmed nests) at Buck Island Reef NM, U.S. Virgin Islands, 1991.

	LOCATION OF NESTING ACTIVITIES*							
TAG #	Act.1	Act.2	Act.3	Act.4	Act.5	Act.6	Act.7	Act.8
810/881	SS24	SS22	SS20	SS22				
877/879	NS03	SS30	SS24	SS26				
872/894	WB14	NS03	NS03	NS07	NS05			
890/856	SS38	SS38	SS36					
870/862	TB42	SS34	SS26	NS07	SS30			
888/845	NS07	NS05	WB14	NS09	NS07	NS05	NS11	NS07
837/836	NS03	NS03	WB14	WB18	WB13	NS07	WB13	
818/ 111/121	NS05	NS05	SS24	WB15				
839/838 105	NS03	NS07	NS07	NS05				
887/884	SS26	SS34	TB38	SS32	SS32			
891/113	NS05	NS05	NS03	WB14				
848/109	NS11	SS30	NS03	WB14				
889/883	NS03	NS05	NS03	NS03				
853/007	WB18	WB15	WB14	TB42				
864/115	NS07	NS03	NS07	WB14				
101/102	NS03	WB13	NS05	WB15	SS24	WB15		
108/122	WB16	WB18	WB18	SS24	WB18	SS22		
117/118	SS26	SS26						
126/114	NS11	NS11	WB18	WB15	NS03			
128/129	SS38	SS28	NS07					
/132	SS34	SS34	SS34	SS26				
149/148	SS26	SS26	SS28	SS30				

* Locations correspond to nesting beach markers on study site map.
Note: Hawksbill females, tag number 869 and 900/899 were not shown.

Table 3. Successive clutch sizes of tagged hawksbill nesting on Buck Island Reef NM, U.S. Virgin Islands, 1991.

INDIVIDUAL TAG #s	NUMBER OF EGGS/CLUTCH Nest 1	Nest 2	Nest 3	Nest 4	Nest 5	$\bar{x}$	SD
PPW836/837	128	154	163	XXX		131.5	10.2
PPW838/839 QQD105	163	167	112			147.3	30.6
PPW888/845	XXX	XXX	174	170	170	171.3	2.3
PPW853/007	XXX	141	131	XXX		139.5	2.1
PPW883/889	133	138	129	108		127.0	13.2
PPW856/890	118	141	130			129.6	11.5
PPW864/QQD115	123	153	161	168		151.3	19.8
PPW870/862	129	139	XXX			134.0	7.0
PPW877/879	XXX	158	128			143.0	21.2
PPW884/887/840	140	131	79	XXX		116.6	32.9
QQD101/102	118	129	139	140		131.5	10.3
QQD108/122	124	122	112	119	121	119.6	4.6
QQD126/114	125	XXX	121			123.0	2.8
QQD128/129	145	157				151.0	8.4

NOTE: XXX Denotes clutches not reported because they were either lost to erosion, predation, or not found post-hatching to conduct hatching success.

THE ORGANIZATION OF SWIMMING BEHAVIOR IN LOGGERHEAD HATCHLINGS FROM THE FLORIDA WEST COAST

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A great deal of research has been done on the largest sea turtle population in the United States, the loggerheads of Florida's east coast. However, little work has been done with another interesting population, the Florida west coast loggerheads.

During summer 1991, we conducted studies of swimming behavior using hatchlings from nests deposited on beaches along the west central Florida coast (the approximately 56 km of Sarasota County shoreline where, during the summer of 1991 alone, we recorded 2,350 nests). The hatchlings used in this experiment were from nests laid on Siesta Key and Longboat Key, two barrier islands at the northern end of Sarasota County.

We recorded the behavior of these hatchlings as they swam in seawater-filled orientation tanks for their first six days in the water. Just after emergence from the nest, the turtles were placed in nylon-lycra harnesses attached to lever arms that freely rotated throughout 360°. Each lever arm was connected to either a chart recorder or a computer, allowing us to record when the turtles were actively swimming and when they were inactive.

We characterized the duration and diel patterning of the frenzy and postfrenzy swimming activity in these west coast loggerheads and compared these data with those obtained from east coast hatchlings (Salmon and Wyneken, 1987). When the turtles were considered as a group, swimming activity differed across the days. The turtles were most active during their first 24 hours in the water and became less active during the remaining days. We calculated the proportions of the respective light or dark periods spent active to determine how swimming activity is patterned through the frenzy and postfrenzy periods and to account for differences in swimming behavior associated with photoperiod change across the hatching season. The proportions of the light periods spent active varied little throughout the experiment, while the proportions of the dark periods the turtles spent swimming differed across time. The hatchlings were considerably more active on their first night than on successive nights.

We found that the overall organization of swimming activity across the experimental period is virtually identical between the two coasts. There is a one-day frenzy followed by several days of lesser activity. From Day 3 onward, west coast hatchlings were more active than the east coast turtles, and their pattern of activity more variable. Although there was no statistical difference between coasts for the proportions of the light period spent active, there was a consistent trend for the west coast loggerheads to swim less during light hours. When looking at the proportion of night activity, we saw that west coast turtles swim 35-50% of the night from Day 3 onward, while east coast turtles swim very little after their third day in the water. By Night 6, east coast turtles are not swimming at all!

To summarize the differences in swimming behavior between the west coast and east coast hatchlings, we saw that the total amount of time spent swimming did not differ in turtles from the two coasts. However, west coast turtles tended to spend less of the daylight hours active and more of the nocturnal period swimming than did east coast turtles.

These experiments allowed us to document differences in the two groups, but they did not address why these differences in swimming behavior occur. This question alone warrants future investigation. Our data suggest that the west coast turtles have diverged behaviorally from the east coast population. Perhaps this divergence is the result of natural selection. The coast-specific patterns of swimming activity may be associated with environmental or ecological differences faced by hatchlings leaving the two coasts. For example, hatchlings leaving Florida's west coast encounter complex variations in current patterns within the Gulf of Mexico. When looking at drift bottle trajectories from the Hourglass Cruise Report (Williams et al., 1977), we see that (if hatchlings are conveyed like drift bottles) some of the west coast hatchlings could be transported to waters of the western Gulf of Mexico, while most would be carried along the southeast coast of Florida. Hence, it would not be difficult to end up in the Gulf Stream with all of its possibilities for dispersal.

A more speculative interpretation of the differences between hatchlings from the two coasts may be that groups are genetically differentiating. Behavior frequently indicates incipient genetic differentiation. There is reasonably good evidence that loggerhead sea turtles from the west and east coasts behave as members of discrete populations. Virtually no females nest on both coasts (LeBuff, 1974; Bjorndel et al., 1983). Tagging data suggest that nesting females remain partial to their respective coasts, and we have seen through this study that west coast hatchlings exhibit different behavioral characteristics from east coast hatchlings.

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REPRODUCTIVE ECOLOGY OF THE FLORIDA GREEN TURTLE *(Chelonia mydas)* AT MELBOURNE BEACH, FLORIDA, 1991

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INTRODUCTION

The designation "Florida Green Turtle" is reserved for those individual *Chelonia mydas* which have at least one stage of their life history associated with a Florida beach. At present the breeding fraction of the Florida green turtle population is listed as Endangered. Very little is known about the reproductive characteristics of this Endangered chelonian. Ehrhart's (1980) statement; "There is, however, virtually no information in the literature concerning the specifics of Florida green turtle reproduction..." is still quite valid today. This is seen in the fact that only a few researchers have documented intraseasonal recaptures (Gallagher et. al., 1972; Worth and Smith, 1976; Fletemeyer, 1983). With this in mind the first phase of a two year study was initiated during the summer of 1991 at Melbourne Beach, Florida. This research project is one of the first ever aimed specifically at the study of reproduction in the Florida green turtle.

METHODS

The study site is a 21 km stretch of beach in south Brevard County known simply as "Melbourne Beach". The University of Central Florida Marine Turtle Research Group has been monitoring marine turtle nesting here since 1982. At present "Melbourne Beach" can be considered partially developed. While there are a few large condominiums, most of the development consists of single family homes, with a few small non-franchise motels. A number of undeveloped stretches of dune also remain intact.

The study is divided into two major components: (i) nightly surveys in which individual females are encountered during nesting emergences; (ii) quantification of reproductive success through assessment of clutch mortality and egg fate.

<u>Nightly Surveys</u>
Nightly surveys were conducted from 25 May through 12 September on the southern 12 km of "Melbourne Beach". A small ATV was employed to traverse the study area. Surveys generally began at 2200 hours and continued until 0500 hours. The entire study area was usually traversed 4 times per night.

<u>Reproductive Success</u>
Florida green turtle nests deposited throughout the 21 km stretch were marked for reproductive success assessment. Clutches were counted as they were being deposited or within six hours of deposition. The location of each nest was precisely marked via the placement of a pair of wooden stakes at a measured distance from the eggs. Nests were monitored throughout incubation, and any sign of predation or disturbance was noted. Approximately 70 days later, after all viable hatchlings had emerged, each nest was relocated, and the contents exhumed. Each egg was individually examined, and percent hatching and emerging success were calculated. Hatching success is defined as the percentage of yolked eggs in a clutch that produce hatchlings. Emerging success is defined as the percentage of yolked eggs in a clutch that produce hatchlings that escape from the nest.

RESULTS & DISCUSSION

Nightly Surveys

As a result of the nightly surveys 28 Florida green turtles were encountered on 98 different occasions during the 1991 season. Four of these were individuals tagged during previous nesting seasons at "Melbourne Beach". Three of these had been encountered during the 1989 season and thus exhibited 2-year remigration intervals in this instance. The fourth turtle had been seen in 1987 and thus exhibited a 4-year interval. It is likely that this individual nested unseen in 1989. These data tend to substantiate the predominance of a two-year remigration interval for the Florida green turtle as reported by Witherington and Ehrhart (1989).

One of the specific reproductive characteristics that was evaluated was seasonal clutch frequency. Both observed and estimated clutch frequencies were determined for each of the 28 identified individuals. Observed frequencies represent actual encounters with each turtle during initial and renesting events. Estimated frequencies represent what we believe to be a better indicator of the true number of clutches deposited by a particular turtle during the 1991 nesting season. Estimated frequencies were calculated in a manner similar to that reported by Frazer and Richardson (1985). Daily nest counts as well as our knowledge of individual nesting activity were also used. These estimated values are of a conservative nature and must be viewed as estimated minimum values. The mean observed and estimated clutch frequencies for the 1991 season were 2.5 and 3.6 respectively.

Observed and estimated internesting intervals were also calculated for each individual. Observed intervals represent the number of days between subsequent nesting events in which the turtle was encountered. Estimated intervals represent what we believe to be a better indicator of the actual length of these internesting intervals. Estimated intervals were determined in a fashion similar to that for estimated clutch frequency and are also of a conservative nature. The mean observed and estimated internesting intervals for the 1991 season were 19.1 and 12.3 days.

Until this study, data relevant to seasonal clutch frequency as well as internesting intervals for the Florida green turtle were virtually nonexistent. However these data represent only one season's work, and the presented values for clutch frequency and internesting intervals at this point should be viewed as preliminary.

Reproductive Success

We documented 161 Florida green turtle nests during this nesting season (Ehrhart et. al. 1992). Of these 161 nests, 99 were inventoried to determine reproductive success. Hatching and emerging rates inclusive of all 99 nests were 54.3% and 53.4% respectively. Causative agents of egg and clutch mortality included plant root infiltration, tidal inundation, and depredation by ghost crabs and raccoons. Raccoons destroyed 10.5% of all the eggs (n=13,100) within the 99 sample nests. Most of the raccoon-depredated nests were those deposited within heavily vegetated sites. The dense vegetation often caused inadequate nest construction (shallow egg chambers and smaller amounts of sand thrown during covering behavior).

Reproductive success data have been gathered for the green turtles at "Melbourne Beach" since 1985. Although sample size for some years is small, it is becoming apparent that for normal seasons mean emerging success is between 55% and 75% (Ehrhart et. al. 1992). The emerging success rate at "Melbourne Beach" is equal to or higher than that reported for the few other Florida beaches for which comparable data are available (Leach, 1991; Lowers et. al. 1991; Stiner, 1991; C. Ryder, pers. comm.). Taking into account the emerging success rate as well as mean clutch size and the total number of nests deposited, we estimate that 11,375 Florida green turtle hatchlings were produced here in 1991. Given the relatively large number of nests deposited each year (ca. 30-35% of the state's annual total) as well as the high emerging success rate, "Melbourne Beach", now synonymous with the Archie Carr National Wildlife Refuge, may very well produce more Florida green turtle hatchlings annually than any other beach in the state.

The recovery of the Florida green turtle will depend upon the effectiveness of conservation and management efforts. Land acquisition constitutes one of the most effective means of conservation. It goes without saying that the acquisition of beach front property by state and federal agencies will benefit the Atlantic loggerhead stock as well. Currently the greatest opportunities for acquisition of critical nesting beach are the initiatives of the Archie Carr National Wildlife Refuge. Three of the four parcels of land proposed for inclusion in the refuge occur at "Melbourne Beach". Florida green turtles require dark undisturbed beaches for successful reproduction and "Melbourne Beach" possesses these characteristics. However, real estate development in the area is proceeding at an increasing rate. This lends a great sense of urgency to the expedient purchase of the Carr refuge in its entirety. It seems clear that the Archie Carr National Wildlife Refuge is a key element in the eventual recovery of the Florida green turtle.

ACKNOWLEDGEMENTS

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WHAT IS THE REPRODUCTIVE PATCH OF THE OLIVE RIDLEY SEA TURTLE?

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Olive ridley sea turtles (*Lepidochelys olivacea*) nest along the western coast of Costa Rica at Playas Nancite and Ostional in arribadas where large numbers of females nest synchronously during one or more subsequent nights. The "reproductive patch" (RP) is a large aggregation of olive ridleys located just off the arribada nesting beach. These aggregations were first observed by Richard and Hughes (1972), while conducting aerial surveys over the Pacific coast of Costa Rica. They estimated that over 10,000 individuals were gathered in front of Playa Nancite in August of 1970. We became interested in this RP as it related to our primary projects studying the arribada behavior. To better understand the RP we asked three questions: Who is in the RP? Are these individuals residents or transient in the RP? and, What are the dynamics and environmental parameters of the RP?

Who is in the RP? Observations were recorded from July to September, 1990 and 1991. Direct observations of courtship and mating within the RP were made from a boat. Individual females were collected and ultrasounded to determine the presence of mature follicles and/or eggs. All females were in a reproductive state. In addition, during the arribadas, post-nesting females where painted with a white, quick-drying enamel to indicate that they had successfully nested. These females were visible in the RP throughout the month. Thus, the patch appears to consist of only sexually mature and reproductive individuals.

To determine if individuals are residents or transient in the patch during their reproductive season, we radio-tracked ten females. Two tracking stations were established 1.2 km apart on the rocky headlands that rise above both ends of the beach. Individual locations were determined by triangulation from the stations. The close proximity of the two stations causes an increase in the amount of error for individual locations as the turtles move further from shore. Thus, we only use locations over 10 km to indicate that the turtle was at a distance from the shore. Each tracking session consisted of four-hour tracking periods at approximately midnight, noon, dusk, and dawn. Sessions were conducted every five days. The transmitter range was approximately 30 km. Transmissions from two females were lost almost immediately after tagging, four females moved out of range from 1 day to 2 weeks before returning to nest, and four individuals stayed within range for 3-5 weeks.

More than 75% of the locations determined by triangulation were within 5 kms of shore (60% were within 3 km) (Figure 1). This area, approximately four by three km, is what we consider the RP, though this is actually a sum of the movements of the RP over the tracking periods. The data suggest that females spend a large percentage of their time in the RP but are transient within the patch during the internesting period.

Finally, what are the dynamics of the RP? Transects were conducted to determine relative number of turtles in various depths off shore. These were conducted by taking the boat straight off shore at one compass setting, recording the number of turtles seen on the surface and measuring the depth with a depth sounder. The RP appeared to remain in water 40 to 130 ft deep, with the highest proportion of individuals appearing in water 90-110 ft deep. An obvious exception occurs during arribadas when the RP moves into the shallow water directly off the beach (Plotkin et al., 1991). During 1991 we estimated the perimeter of the patch by encircling it with a boat and determining locations by compass readings back to shore. This indicated that the RP fluctuated in surface area size. Some days it was very dense and located within 1 km off shore; other days it was widely dispersed and up to 3 km offshore.

Within the above limitations, the RP sometimes appeared to shift. This was observed during one tracking session. During the first three periods the turtles remained in the same vicinity; during the last 4-hour period every female moved to the southwest about 1-2 km (Figure 2). This shift was confirmed for the RP by evaluating the perimeter with the boat. The next day the turtles were back in the initial location where they were regularly observed over the next two months.

CONCLUSIONS

1. The Reproductive Patch is composed of mature reproductive males and females engaged in courtship and mating or waiting for the next arribada.

2. During the internesting period, females are transient, moving in and out of the RP, but always returning to the RP at some point.

3. The RP is usually situated in water 40-130 ft deep and within 3 km of Playa Nancite.

4. The RP is dynamic throughout the summer, varying in surface area and occasionally in location.

In the future, we hope to correlate the fluctuations in size and location with environmental factors, as well as with arribada timing and size. We also hope to make some direct observations of the turtles' underwater activities and ocean floor habitat.

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FIGURE 1 More than 75% of all locations plotted (n=8 females) were within a very discrete area, directly in front of Playa Nancite. We call this area the reproductive patch.

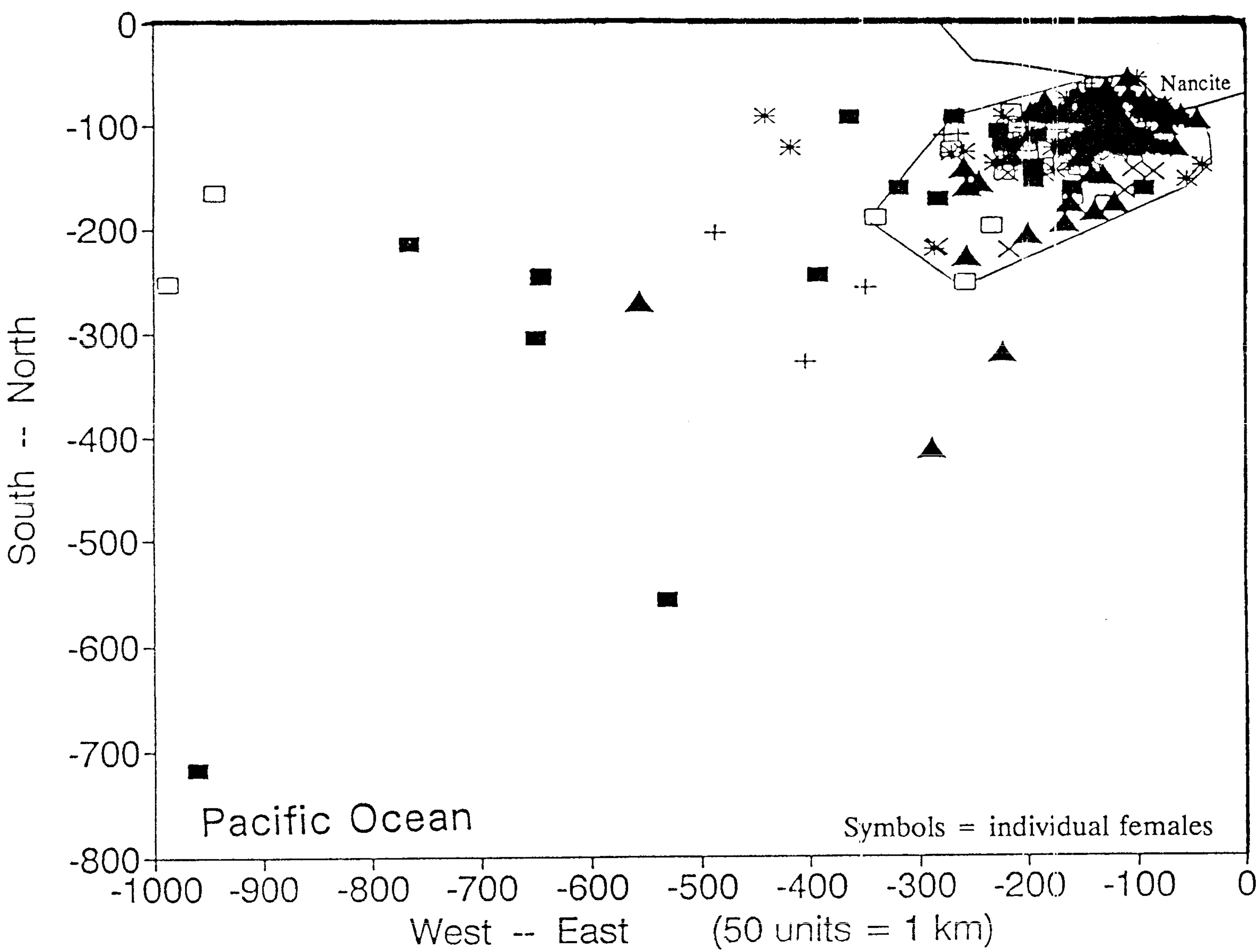
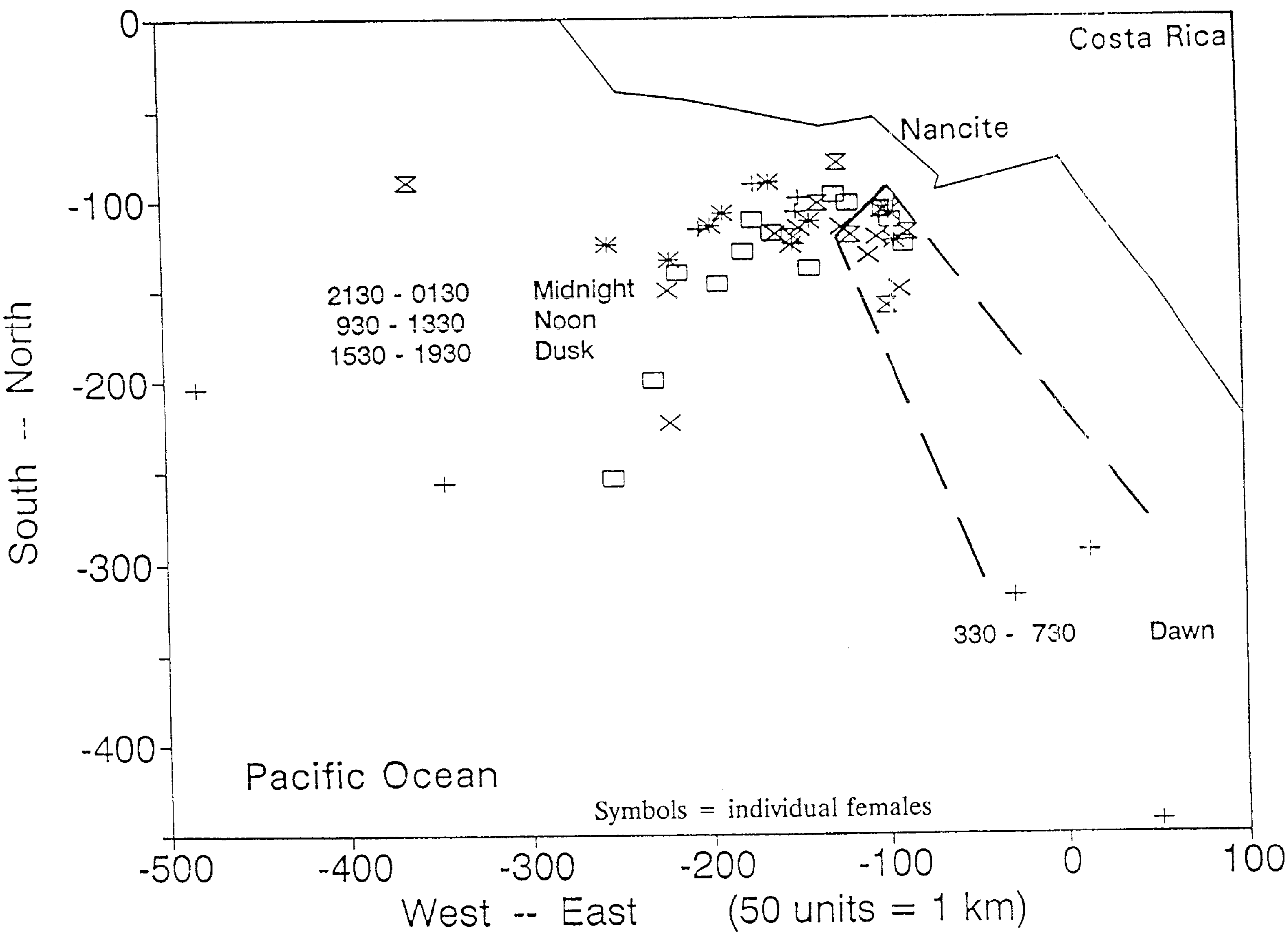


FIGURE 2 Radiotelemetry indicated a shift in the location of the RF. During the first three tracking sessions the females movements overlapped, both spatially and temporally, but during the last session at 3:30 am, all the females had moved to the south-west and did not overlap with any of their previous positions.



NESTING HABITS AND HABITAT OF MARINE TURTLES

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ABSTRACT

Marine turtles have been associated with tradition and livelihood in some parts of the Philippines archipelago. Because of this, indiscriminate gathering has reduced their number to the verge of extinction. In an effort to conserve and protect sea turtles, base line studies needed for the management of turtle resources were undertaken in 1981-1984 in Quiniluban, Northeastern Palawan. Data on biology, nesting habits and preferences, ecology as well as traditional practices on exploitation and trade were obtained through interviews, nightly vigils and observations, field surveys, collection of sand samples, and identification of aquatic macrophytes and terrestrial vegetation.

INTRODUCTION

Marine turtles form a conspicuous member of the Philippine fauna, although there are evident gaps in our knowledge as to their status and distribution in any particular region in the country. The Quiniluban group of islands, located on the northernmost part of the Cuyo Islands, was chosen as the study site of this project (Figure 1) due to numerous sightings of marine turtles in the area. It is composed of several islands and rock islets on a circular reef complex 1.6 km in diameter. The reef is a sand flat with numerous coral heads. A shallow lagoon with depths ranging from 15 to 33 feet is situated in front of Algeciras Island (southwest of the reef). It has a sand bottom with several coral mounds. Breakers appear at the windward edge of the reef whenever the monsoons are blowing. From the breakers, the reef drops vertically to deeper depths notably on the southeast, south and southwest sides.

This island group is composed of the islands of Algeciras, Quiniluban, Tayay, Tinituan, Mandidt, Silad, Maligum and Halog. The majority of these islands are populated, mostly by people coming from the Aguitaya municipality and a few from Cebu, Bohol and Cavite in their fishing operations. People from Barangay, Algeciras and Barangay Concepcion depend on fishing as their main source of livelihood. Subsistence farming or kainging is done during the occurence of the "amihan" or northeasterlies from November to March. Seaweed farming is also undertaken by a few families in Bgy. Concepcion. Peak months of fishing are April to October when the southwesterly monsoon or "habagat" prevails. Popular fishing gear are gill net, hook and line and speargun. Illegal methods of fishing, such as dynamiting and the use of sodium cyanide as well as drive-in nets (Muro-ami) and kayakas, are rampant in the vicinity. Fishermen engaged in these destructive activities come mostly from Cebu, Bohol and Cavite. Due to the geographical location of the islands, rough seas are experienced during the northeast monsoon. Likewise, these islands are open to the southwest monsoon and cyclonic storms. Because of these, fishermen in the area do not operate and thereby enable the turtles to lay eggs undisturbed.

This study was undertaken to determine the nesting habits and physical characteristics of the habitats of marine turtles. It was designed to determined the peak nesting activites and select sites for the proposed marine turtle sanctuary. The data gathered can serve as baseline information for the protection and management of the country's turtle resource.

METHODS AND MATERIALS

This study was conducted from January 1981 to December 1984. Nine field surveys were undertaken in the Quiniluban Island group. Various methods were employed, including:

- Personal interviews, especially with the village elders, barangay leaders, fishermen and other people who have special knowledge on the study conducted.
- Field surveys on the nesting beaches, conducted with the help of local guides. (Nightly vigils were made in anticipation of the appearance of nesting turtles. Nest location was defined with the use of a Bronton compass. Beach length and width as well as distance of nests from the shoreline were measured with a calibrated twine.)
- Collection of specimens of beach vegetation from the different islands. (The specimens were preserved and later submitted for identification.)
- Collection of samples from the different nest sites. (From each site one kilo of sand was packed in a plastic bag and labelled. The samples were later brought to the Bureau of Soils for laboratory analysis of the following:
  1) pH of sand with the use of the Beckman pH meter;
  2) color of both wet and dry sand obtained by comparing the samples with the Munsell Color Chart;
  3) organic matter taken by S.A. Wilde's method;
  4) mechanical analysis (sand fraction determined by using the Boyoucos hydrometer method.)

RESULTS

Of the five species found in the Philippines, three species are present in Quiniluban, namely hawksbill turtle (*Eretmochelys imbricata*), green turtle (*Chelonia mydas*) and leatherback (*Dermochelys coriacea*). Green turtles sighted in the area were immature, with curved carapace length ranging 108-120 cm. Those slaughtered for meat reveal the absence of eggs inside the body. Sandy bottoms near seagrass beds were the usual areas where green turtles were sighted. Hawksbill turtles, on the other hand, can be seen only in rocky areas or near coral crevices. Sightings are made at night by divers and turtle hunters, when the turtles are resting. No hawksbill sighting was made during the day. Leatherback is encountered through accidental catches in fishing nets. Nesting was reported in Maligun Island by turtle wardens. Nesting season was established to be during the Northeast Monsoon with peak months during December and declines by March.

Turtle Industry of Quiniluban

Marine turtles form an important diet among the residents. It is usually their main source of meat during the onset of the Northeast Monsoon (Oct-March) when the area is not accessible by watercraft. It is also at this time when rampant egg gathering takes place, but usually the activity is confined to home consumption. Turtle eggs are boiled and eaten with salt, soy sauce and other condiments. The turtle meat is made into stew or preserved by drying.

The years 1975 and 1976 may be considered the peak years of turtle hunting in the area. In those years approximately 500 immature turtles were hunted and captured for commercial purposes. Boy Ortega of Mindoro was involved in the export of stuffed turtles to Japan. Immature green and hawksbill turtles with size ranging from 12-20 inches are hunted by divers. Spears attached to ropes are aimed at the turtle's flippers. At least 6 persons are involved in the capture of these turtles. Often times divers visit the resting places of these turtles (12-15 feet in depth) and measure the turtles, capturing those that fall in the above size range. Workers involved in the cleaning and preserving process are paid P10.00 per turtle. Usually only three turtles can be processed per day. The turtles are immersed overnight in concentrated formalin, cotton is stuffed inside the body, and the bodies packed in big plastic bags and transported to Mindoro. In two months of operation (April-June), more that 200 animals were colleced by Boy Ortega.

Nardo Ardanel (Ilonggo) employed the same method of capture except that spears are aimed at the neck and flippers of the turtle. He does not employ divers; instead he buys turtles that are not smaller than 4 inches at the cost of P3-4 per inch. The maximum size limit is 20 inches. Nardo bought 50 marine turtles of mixed species in Quiniluban. Very scanty information was gathered from Ely, a turtle businessman from Cebu. His base of operation is on the small islets behind Manamoc Island. He also brought along divers and, in a month's operation, more than 200 turtles were caught.

Traditional Capture Methods

Nesting habits of sea turtles have long been studied by the people to facilitate the capture of sea turtles. Turtle hunting and egg gathering can therefore be described as highly efficient. Whenever calm weather prevails, people with experience in tracking and detecting turtle nests are able to dig and collect all the turtle eggs. Those that have mastered the art of capturing turtles based on traditional practices wait for nesting females to emerge and slaughter these defenseless creatures. During capture, hunters visit the resting places of hawksbill turtles. They have reported that most turtles sleep with their posterior positioned near the entrance of the crevices. Prior to capture, these hunters feel or measure the carapce length to determed the correct sized required by buyers. People experienced in tracking and detecting turtle nests are able to locate them by observing the presence of sand flies and bite marks on terrestrial vegetation. Nest detection is usually accomplished by poking the sand. The nest is usually detected when the tip of the stick is wet and odorous. Renesting and capture is usually determined by counting the total number of eggs found in the nest. Although it has no scientific basis, it is highly effective. After counting, the eggs are grouped by the hundred. The number of eggs exceeding one hundred is added to the date of laying to obtain the expected date of renesting. Other residents have reported that slaughtering is also rampant in areas where seaweed farms are present. At night, green turtles found grazing on Euchu plants are usually speared by the caretakers. It was observed that as many as 8-10 green turtles visit the seaweed farms in Bgy. Concepcion per night.

Nesting Habitat

Of the 12 islands surveyed in Palawan and Mindoro, only four warrant a closer look as study areas. These islands are as follows:

A. Halog (11^{0} 22'30" N, 120^{0}52'E), comprised of two islets, is located 8 nautical miles southeast of the Quiniluban Islands. The northeastern islet in only a rock outcrop, 24 meters high, while the southwestern side is a sandy islet, 2 to 3 hectares. A narrow band of coral reefs surrounds the entire island where outlying waters have depths ranging from 10 to 27 meters. The beach length of Halog taken during the calmer months varies from 10 to 246 meters and is 20 to 59 meters in width from the vegetation line to the highest high tide marks. Nesting beachers are on the eastern, western and northeastern portions where nesting mostly occurs. Thirty-five nests were found on the northeast sides. Generally the nests were situated along the windward sides. Due to its geographical location, Halog Island is relatively exposed to both the northeast and the southwest monsoon winds. As a result, there was sand shifting and erosion, resulting in 425 spoiled eggs. The beaches are predominantly coarse with sand particles ranging from 1 to 0.5 mm is size. Sand colors were in different shades of white: 2.5YR 8/2; 10YR 8/2; 10YR 8/1. Very pale grains of brown sand 10 8/3 were also observed on the island. These beaches have an average pH of 7.74 and $CaCO_3$ content of 96.2%.

The island is inhabited mostly by seabirds (terns). Only three types of vegetation are found, namely, the halog trees (*Tournefortia sarmentosa*), which the island was named after, *Scaevola taccada* and a few species of grass, *Portularea* spp. A narrow strip of coral reefs surrounds the islands which tapers off in the north end. The south side is 85% covered with hard coral, with table and staghorn corals predominating. Soft corals are also present but of negligible quantity. Only 5% of this side is covered with sand. A wide sand flat with a gentle slope characterizes the west side of the island where encrusting and massive corals seem to dominate. The north side, on the other hand, is relatively sandy with massive type of corals predominating. *Halimeda* spp. were found to be the dominant flora; seagrasses and other aquatic macrophytes are generally absent.

B. Tayay Island (11^0 25'45"N, 120^0 45'30"E) is a low, flat crescent-shaped island located half a nautical mile from Concepcion Island. The length of the beach varies from 135m to 528 m in the northwest. The width of the island is quite narrow, measuring only 12 to 19 meters. Only the northern and eastern portions are utilized as nesting grounds by marine turtles, where as the other areas are occupied by transient fishermen who utilize the beaches as drying areas for their catch. Medium sized grains of sand comprise the dominant type. The whiteness of the sand is similar to that on Pamalikan (5Y 8/1 and 5 YR 8/1). The sand has a high $CaCO_3$ content of 96.3%, and a relatively high pH of 8.1 was obtained. The organic matter content of the sand is also vey low at only 0.18%.

C. Pamalikan Island (11^0 12"N, 120^0 43'30"E) has the most extensive beach, measuring from 19 to 2,638 m in length with widths ranging from 9 to 12.6. Pamalikan also has the whitest sand, 5Y 8/1, and the most diverse flora. The sand grains are medium in size (0.5 to 0.25mm in diameter), while the pH is 8.1.

The organic matter content was placed at 0.22% and the $CaCO_3$ was 94.44%. The northwestern portions were observed as resting and foraging areas for green turtles by fishermen in the area. Although the surrounding areas revealed the absence of seagrasses, two species of algae, *Caulerpa sentilaroids* and *Caulerpa* spp., were seen in the area. A few nests were seen scattered all over the island, especially on the northeast and southeast sides. A wide band of reef area surrounds the northwest and east sides of this relatively flat, narrow island. Green turtles are the dominant nesters on this island.

D. Mandit Island (11^{0}24'N, 120^0 49'15"E) is a small coralline island of approximately 10 ha. It has a highest elevation of 56 meters. The island is half a nautical mile from Algeciras Island. It is rocky, and the turtle nests are located in the isolated beaches on the eastern portion. These beaches measure from 35 to 126 m in length and 11 m in width. The medium-sized sand grains are the darkest in color (very pale brown, 10YR 8/3) among others. It also has a lower $CaCO_3$ content of 93.8% and a pH of 7.46 but a relatively high organic matter content of 0.38%.

DISCUSSION

Marine turtles are quite choosy in selecting sites for their nests. Scientists think that certain beach characteristics influence turtles in nest selection. Among the nesting grounds, hawksbills were found to be the dominant nesters in Halog, while green turtles are abundant in Mandit. Because data are quite scarce, it is not safe to conclude that Tayay and Pamalikan are dominated by green turtles alone, since hawksbills were also found to nest on these islands but in limited numbers only.

From the data gathered on the physical and chemical characteristics of the different beaches, hawksbill turtles and green turtles nested in soils which are sandy in nature; the sands have relatively high pH and calcium carbonate ($CaCO_3$) content but are low in organic matter content. The relatively high pH may be attributed to the mineral content of the sand. Since the islands are coraline in nature, a high $CaCO_3$ content of 96.25% was obtained. Furthermore, it is also the mineral content of sand which contributes to the resulting sand color; thus, a lighter color was obtained. The relatively high pH of the sand may be the factor to explain the scarcity of vegetation in the area. In calcareous soils, certain minerals needed by the plants are not assimilated at very high pH values. These plants can be described only as highly tolerant to alkaline medium. No correlation was found between the frequency of nesting and sand color, pH, $CaCO_3$ and organic matter.

The hawksbill turtles seem to be a more sensitive nester than the green turtle. The former prefer to nest in remote, isolated islands like Halog. Likewise the type of sand was found to be coarse with particles ranging from 1-0.5 mm in diameter. Nests were located under the low shrubs or within the vegetation line. No hawksbills turtles were found to lay eggs among the grassy areas. It was also observed that hawksbill turtle nests are situated in areas where extensive beach rocks are absent. Hawksbill turtles prefer low, flat, isolated islands.

Since nesting coincides with the northeast monsoon, Halog is subjected to strong winds and waves; likewise, the absence of physical barriers can increase the forces of these elements. At this time of the year, the area is inaccessible to many fishermen, and hawksbill turtles are safe from all kinds of human disturbances. The big waves and strong winds can be an added advantage to emerging turtles. Efforts exerted during emergence will definitely lessen since these turtles can depend on the waves to reach the shoreline. This may also explain the concentration of nests on the windward side of the island. Since sand shifting is evident according to prevailing wind, there would be shorter distance to be crawled by a nester. In spite of the advantage brought about by the northeast monsoon, eggs are exposed when the nests are eroded and reached by seawater. Rains induced by weather disturbance have led to egg decompostiton. Data from PAGASA revealed that frequency of cyclones in the area was placed at 19%. Eggs are also preyed upon by monitor lizarets (*Varanus* ep) and ghost crabs (*Ocypoda* sp).

Green turtles were observed to frequently nest on Mandit Island. Their preference to nest in rocky areas where extensive beach rock is present is very noticeable. Nests were also found along steep embankments and not necessarily near or under vegetation. Likewise, the green turtles seem to prefer to nest on islands where sand grains are medium sized with particles of 0.5 to 0.25 mm in diameter. Likwise, green turtles are attracted to islands that have high elevations and are not necessarily uninhabited. Sightings of green turtles in the Quiniluban Island group are numerous during the northeast monsoon; sandy bottoms are the usual habitat of green turtles. Hawksbills, on the other hand, can be observed only in coral crevices. Sightings of green turtles in the Quiniluban group are numerous, because the areas covered by the Algeciras, Concepcion and Silad Islands are utilized by green turtles for foraging. Since these areas are sheltered from weather disturbances and the elements, seagrass which forms the diet of the green turtle is plentiful in the area.

Incidence of nesting in Tayay is quite low since transient fishermen occupy some sides of the beach. Further rampant dynamiting has scared most of the turtles sighted in the area.

CONCLUSIONS

Based on the findings of the team, Halog, due to its proximity to the Barangay Islands, highest nesting incidence and least disturbance from human stresses, was recommended to be a turtle sanctuary. Manamoc was recommended as a site for head starting of marine turtles.

In 1982 Halog Island was officially declared a marine turtle sanctuary under MNR Order #8 Series 1982.

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Figure 1. The Quiniluban Islands.

RADIO-TRACKING LEATHERBACK HATCHLINGS DURING THEIR SWIMMING FRENZY.

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Sea turtle hatcheries all over the world release thousands of hatchlings into the sea each year. However, knowledge about their survival, behaviour and movements thereafter remains limited. This stems mainly from difficulties in tracking them for long periods, particularly at night. Previous attempts have met with limited success, with tracking durations ranging from 13 minutes to less that eight hours (Frick, 1976; Hall, 1987; Salmon and Wyneken, 1987; Stoneburner, et al., 1982). In this paper, a method for radio-tracking leatherback hatchlings which allows 24-hour radio contact with the hatchlings is described.

Subminiature radio transmitters (Wildlife Materials SOPB-1070-MVS) were deployed on leatherback hatchlings using miniaturized harnesses made from soft black polyester ribbon, following the harness design for adult leatherbacks by Eckert and Eckert (1986). The movement of the hatchlings were tracked using a radio mounted to one side of a research vessel. At intervals of one or two hours, the locations of the hatchlings were recorded by bringing the research vessel close to the hatchling. Locations were confirmed on most occasions by actual visual sightings.

Two leatherback hatchlings from the Rantau Abang Hatchery, Malaysia, were tracked (Figure 1). Hatchling No. 1 (body wieght, 35 g. and restrained for 12 hrs.) was equipped with a transmitter (2.46 g, inclusive of harness) and released at 0804 hrs. on Sept. 5, 1991, approximately 200 m from shore. Upon release, it dived under the boat, reappeared on the other side and started swimming just below the sea surface, heading toward the waves in an east-southeast direction. Strong southerly winds and choppy seas in the afternoon caused a significant shift in the movement of the hatchling, bringing it northwards. At dawn, with the abatement of the storm the previous night, the hatchling reorientated itself and progressed offshore in an easterly direction until stronger currents carried it north. Tracking of this hatchling was terminated after 34 hrs., when the hatchling appeared to be swinning abnormally due to the weight of its back-pack. The hatchling was netted, relieved of its back-pack and released. Hatchling No. 1 had covered a distance of 39 km. in 34 hours.

Hatchling No. 2, body weight 38 g., was equipped with a lighter transmitter-harness assembly (1.72 g.). It was released soon after emergence and allowed to crawl down the beach. It entered the sea at 2144 hrs., Sept. 14, 1991, and headed east-southeast until it reached the stronger offshore currents which carried it progressively north and seawards. Tracking was teminated after 39 hrs. when the hatchling was more than 63 km. offshore, beyond the capability of our vessel to fix position by radar. It was similarly netted, relieved of its back-pack and released. It disappeared from our sight within seconds. Hatchling No. 2 had covered a total of 82 km in 39 hours.

The swimming behavior of the hatchlings appeared to be little affected by the transmitter pack if it weighed less than 5% of the body wieight of the hatchling. During the swimming frenzy, the hatchlings were swimming between 5 - 10 cm just below the sea surface and capable of speeds averaging 2.13 km/hr. The paths taken by the hatchlings were very much influenced by prevailing currents and sea conditions, whereas wave direction and position of the morning sun appear to be important cues in guiding them offshore. This method of tracking also permits easy recovery of the hatchlings and transmitters, hence opening the scope for future studies on hatchling ecology in the open sea.

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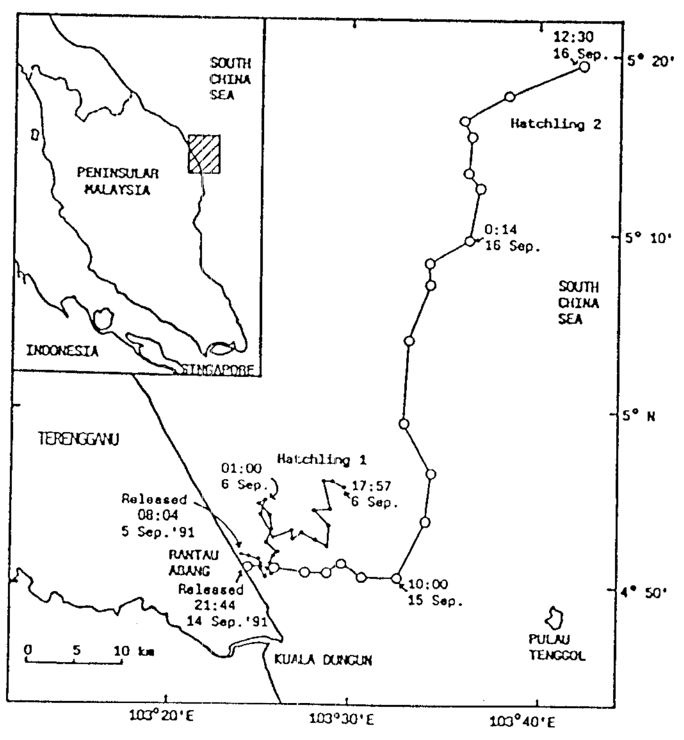

Figure 1. Movements of leatherback hatchlings 1 and 2 tracked during their swimming frenzy in the waters off Terengganu, Malaysia.

GEOMAGNETIC ORIENTATION BY SEA TURTLE HATCHLINGS

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To investigate the ability of loggerhead hatchlings to detect the earth's magnetic field, we designed a laboratory arena in which the orientation of hatchlings under different magnetic fields could be assessed (Lohmann, 1992). Each hatchling was placed in a circular tank containing sea water and tethered to a rotatable lever arm. The lever arm was wired to a computer which recorded the direction toward which the hatchling swam.

The orientation tank was placed inside a Rubens cube coil (Rubens, 1945). When turned on, the coil generated a magnetic field twice as strong as the natural magnetic field of the earth, but opposite in direction. The field generated by the coil combined with the earth's field to produce a resultant field inside the coil equal in strength to the earth's field but opposite in direction. When the coil was activated, the direction of the field around the orientation arena was therefore reversed.

At the beginning of each experimental trial, a dim light placed in the east (at 90°) was turned on. When a tethered hatchling was released into the tank, it would typically swim directly towards the light with little or no deviation; hatchlings that failed to swim toward the light were not used. After 1 hr the light was turned off and the hatchling was allowed to swim in darkness either in the earth's field (Rubens coil off) or in the reversed field (Rubens coil on). Observers periodically stationed in the room were unable to perceive any light leaks even after an hour or more in darkness, indicating that light or visual cues did not influence the behavior of the hatchlings.

When the trial was over, the data were analyzed using criteria established previously (Lohmann, 1991) to determine the average direction toward which the hatchling swam in darkness (after the light was extinguished).

Results indicate that, as a group, hatchlings tested in the earth's magnetic field swam east with a mean angle of 70° ($n=19$, $r=0.50$, $p=.007$). Hatchlings that were tested when the magnetic field inside the orientation arena was rotated swam on average southwest with a mean angle of 245° ($n=8$, $r=0.6$, $p=0.05$). Thus, when the magnetic field was shifted 180° , the mean angle of orientation showed a corresponding shift of 175°. These results are consistent with those obtained previously (Lohmann, 1991) and imply that loggerhead hatchlings have the ability to detect and orient to magnetic fields .

In this work and in earlier work, loggerhead hatchlings demonstrated an apparent preference for magnetic east. Because the turtles were presented with a light in magnetic east before each trial, we hypothesized that the turtles might choose a magnetic direction based on the position of the light. To test this hypothesis, we tested the orientation of hatchling turtles that had been exposed to a light in the west rather than in the east. 12 such turtles were tested in the earth's field in darkness and swam on average between southwest and west (mean angle = 230°, $r=0.53$, $p<0.035$) suggesting that the magnetic preference of the turtles was based on the light cue to which they had been exposed.

We conclude therefore that, in the laboratory, hatchling loggerheads can orient to magnetic fields in complete darkness and that the preferred direction of orientation can be altered by altering the position of light cues that they encounter prior to each trial. Further work (Lohmann et al., this volume) suggests that the effect of light cues on magnetic orientation may have importance in the natural history of the turtles.

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EVIDENCE THAT BEACH CRAWL DIRECTION SETS THE MAGNETIC COMPASS IN LOGGERHEAD HATCHLINGS

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Sea turtle hatchlings emerge from underground nests on sandy oceanic beaches and find the ocean by scrambling toward visual cues associated with the seaward horizon. Once in the ocean, hatchlings establish a course toward the open sea and maintain it as they migrate offshore for several days. The course adopted by a swimming hatchling often resembles a continuation of the course it took while crossing the beach (Ireland et al., 1978; Witherington, this volume). Because orientation on the beach is mediated by visual cues not available to turtles at sea, however, the orientation cues used on the beach and offshore cannot be the same. Thus, if hatchlings migrating through the open ocean maintain a course initiated on the beach, then the course established on land using one set of environmental cues must be transferred to a similar directional path mediated by different cues that can function in the open sea.

Hatchling loggerhead sea turtles are able to orient using the magnetic field of the earth (Lohmann, 1991; 1992). One possible explanation for the ability of hatchlings to maintain seaward courses while far offshore is that turtles may normally swim toward a specific magnetic direction corresponding to the open ocean. Moreover, hatchlings might learn the direction of the open sea while crawling across the beach toward light cues associated with the seaward horizon.

To determine whether hatchlings can acquire a magnetic directional preference during a short beach crawl, we constructed a runway (about 8 m in length) in the laboratory. The runway was aligned east to west, and a dim light was placed behind a plastic screen at the east end so that a narrow band of light could be projected (to simulate the horizon glow hatchlings encounter on the seaward horizon when emerging at night). The light intensity was adjusted to match that of dark, natural, nesting beaches on a moonless night as measured by a photometer. Hatchlings were placed one at a time into the western end of the runway and permitted to crawl east down the length of the runway toward the dim light.

As soon as each hatchling reached the end of the runway, the turtle was picked up and the dim light was turned off. In complete darkness, the hatchling was immediately carried to an orientation arena inside a magnetic coil system, where it was tethered and released in accordance with procedures previously described (Lohmann, 1991; 1992). While tethered to an electronic tracking system (Lohmann, 1991), each hatchling then swam in complete darkness for 35 min. under one of two ambient magnetic field conditions. Half of the turtles swam in the unaltered magnetic field of the earth. The other half swam under identical conditions except that the magnetic coil system reversed the horizontal component of the earth's field.

Hatchlings tested in the earth's field were significantly oriented as a group ($n = 12$, $r = 0.54$; $p = 0.027$), with a mean angle of 71° (where 0° is geomagnetic north, 90° is east, 180° is south, and so on). Those tested in the reversed field were also significantly oriented, but with a mean angle of 266° ($n = 15$, $r = 0.54$; $p = 0.01$). The two distributions were significantly different ($p < 0.001$, Watson test), indicating that the magnetic field influenced the direction turtles swam following their simulated beach crawl.

To determine whether the magnetic direction toward which hatchlings crawled influenced the direction they subsequently swam toward, we conducted a second experiment in which hatchlings were subjected to one of three treatments. One group of hatchlings crawled toward a light in the east. A second group crawled toward a light in the west. A third group was placed in the west end of the runway with all lights in the room and in the runway turned off (this group crawled in complete darkness). After each hatchling completed its crawl, it was carried to the orientation apparatus in darkness and tested as before.

The results indicate that the magnetic direction turtles crawled toward when light cues were present influenced the direction they subsequently swam toward in darkness. Turtles that crawled toward a light in the east swam eastward (mean angle of group = 60°; n = 12, r = 0.52, p = 0.035), whereas those that crawled west swam west (mean angle = 278° ; n = 12; r = 0.52, p = 0.035). Hatchlings that crawled in the runway in the absence of any light cues had orientation that was statistically indistinguishable from random (mean angle = 177° ; n = 16, r = 0.28, p = 0.29). Among those that crawled in complete darkness, there was no difference between those that reached the east end of the runway within 5 min. and those that did not (Watson test); neither group was significantly oriented.

These results suggest that hatchling loggerheads emerge from their nests without an established preference for swimming toward a specific magnetic direction. While crawling toward the ocean or soon after entering it, hatchlings may determine the direction of the open ocean from light cues. We hypothesize that later, when hatchlings have distanced themselves from shore, they continue on the magnetic course corresponding to the seaward direction by relying on their magnetic compass sense.

Although our results are preliminary in nature, our experiments may have important implications for sea turtle conservation practices. If the magnetic directional preference cannot be altered once it is established, then present conservation practices may result in hatchlings acquiring inappropriate magnetic preferences. For example, if caged hatchlings are kept within view of condominium lights before release, the possibility exists that they may subsequently swim in the wrong magnetic direction after release into the sea. Future experiments are planned to address these issues and to determine whether concern is warranted.

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HAWKSBILL NESTING ON MILMAN ISLAND, GREAT BARRIER REEF, AUSTRALIA JANUARY - MARCH 1991

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Milman Island, Australia is an uninhabited, densely wooded sand cay approximately 28km east of Cape York Peninsula and 600km north of Cairns, Queensland, Australia. The island measures 2396m in circumference and contains a closed forest with open shrub and grassland along the beach front dunes. Beachrock covers approximately one-third of the beach, including a 500m long section on the western side of the island. A large reef flat extends around 95% of the island and is fringed with a rubble reef crest. This area dries during low tide, making the island accessible to the turtles only at the northern-most tip.

A study of hawksbill sea turtle nesting was conducted on Milman Island to: 1. identify nesting behavior patterns of hawksbill turtles, 2. describe morphometrics of nesting hawksbill turtles, and 3. characterize clutch dynamics of hawksbill turtles.

These goals were accomplished through an 11 week study (January 11 - March 28, 1992) on Milman Island. The island was divided into 46 sectors 50m long and one sector 26.7m long. Beach patrols were conducted on 76 consecutive nights, to locate nesting hawksbills. Behavior patterns were identified through tagging nesting hawksbills with titanium tags. Nesting interval for each tagged turtle was easily calculated when the turtle was recaptured at a later date. Generally turtles were permitted to begin laying eggs before being tagged, so as to cause as little disturbance as possible. Turtles were tagged through the last scale (the one closest to the body) on the left flipper. Nest site location was described with respect to vegetation and sector around the island. Curved carapace length (CCL) and curved carapace width (CCW) were measured with flexible fiberglass measuring tapes and the weight (WT) of the turtle was determined after the animal had laid her eggs. Clutch dynamics were characterized in two steps. First, when eggs were laid, the number in each clutch was counted and a random sample of 10 eggs per clutch was weighed and measured. Second, nests were marked immediately so that they might be used to determine length of incubation and emergence success rates. A random sample of ten hatchlings per clutch was weighed and measured upon their emergence.

The nesting season was already in progress when the research team arrived on January 11 as evidenced by hatchlings emerging the first night. Three species of sea turtle utilize the island for nesting. Hawksbills (*Eretmochelys imbricata*) were the dominant species, but green turtles (*Chelonia mydas*) and a few flatbacks (*Natator depressus*) also nested on the island. Only hawksbill data will be presented here. During the 76 nightly beach patrols, 315 hawksbills were single tagged and 50 double tagged for a total of 365 hawksbills tagged during the 11 week study.

An average 15 turtles emerged in a 24-hr period (Range 3-32) while over 105 hawksbills emerged each week (Range 52-150). Hawksbills tended to emerge just on high tide or just as the tide began to ebb, waiting for the large reef flat surrounding the island to be covered with water. Over 98% of hawksbill emergences occurred during night-time hours. Daytime emergences (1.84%; n=21) coincided with daytime high tides. Nearly 87% of hawksbills nested successfully on their first observed emergence, with those not laying on their first observed emergence returning either the same night or within the next four nights to lay.

Nearly 24% of turtle emergences occurred on a 250m section of beach on the northwestern end of the island (n = 5 sectors; n = 244 emergences) while 35% occurred on a 650m section on the southeast end of the island (n = 13 sectors; n = 399 emergences) . The 500m section of beachrock on the western side of the island yielded the fewest emergences at 2.84% (n = 10 sectors; n = 14 emergences), with the remaining 38.60% scattered around the other 19 sectors of the island.

Nearly 67% of the hawksbills nested well underneath trees that were on or behind the sand dunes, often wedging themselves close to the trunks of the trees and under the roots. Fewer than 6% (n = 46) of the hawksbill clutches were laid below the high tide mark. Twenty of these clutches were impacted by tidal action eroding many dunes to steep slopes, preventing the turtles from climbing to the top of the dune. (Table 1).

Hawksbills exhibited an average renesting interval of 14.22 days (Range 10-20 days) and laid up to 6 clutches during the study period (average 2.6). This low average is most likely the result of not monitoring the whole nesting season, but since there is year round nesting on the island, it is just not feasible to cover the entire nesting season.

The average nesting hawksbill had a CCL of 81.73cm (Range 63.5-91.9cm), a CCW of 70.61cm (Range 57-82.5) and weighed 50.28kg (Range 32-70kg). There was a positive correlation between CCL and CCW (r^2=0.504) and between CCL and WT (r^2=0.646).

Nesting hawksbills laid from 50 to 215 eggs in a clutch, but the average was 124.09 eggs. These eggs averaged 3.48cm in diameter (Range 2.97 - 4.09cm) and 25.7g in weight (Range 15.5 - 45.0g). There was a positive correlation between CCL of the nesting turtle and the number of eggs laid in a clutch (r^2=0.213). Incubation took between 51 to 61 days and averaged 56.88 days. The average emergence success, that is, those hatchlings that actually made it out of the nest, was 79.94% (range 6.25 - 95.24%). The clutch with the lowest emergence success occurred as the result of high tides inundating the nest prior to hatchling emergence.

The average hawksbill hatchling exhibited a straight carapace length of 3.96cm (Range: 3.20-4.36cm), straight carapace width of 2.93cm (Range: 2.51-3.25cm) and weighed 13.26g (Range: 8.0-16.5g)

In summary, Milman Island functions as a significant rookery for hawksbill turtles on the Great Barrier Reef and also appears to be the largest known rookery for hawksbill turtles around the world.

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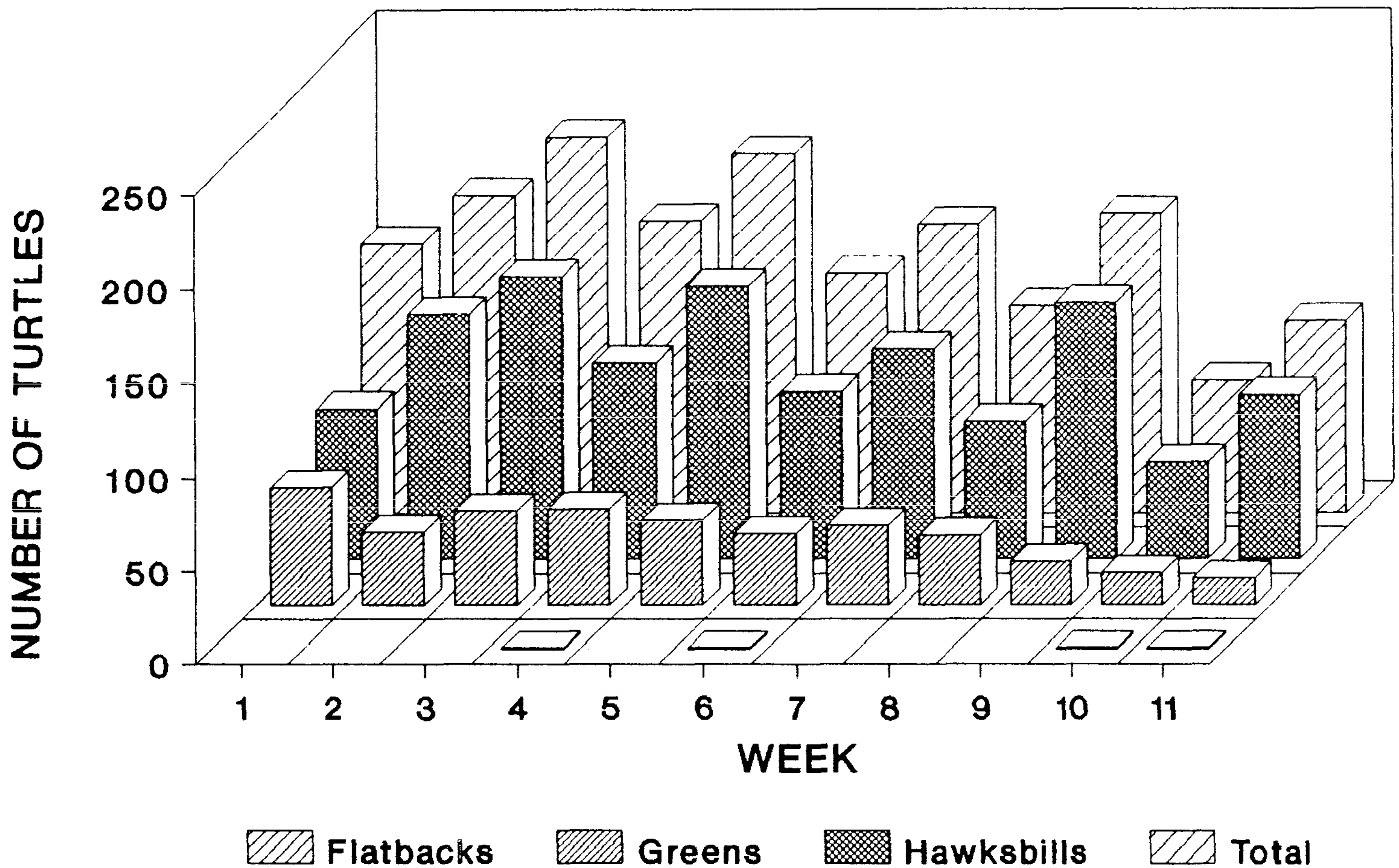
TURTLES / WEEK



NEST SITE PREFERENCE

VEGETATION COVER	ON OR BEHIND DUNE	DUNE SLOPE	BELOW HIGH WATER MARK	TOTAL	%
TREE	535	2	0	537	66.79
GRASS	86	0	0	86	10.70
BARE SAND	128	7	46	181	22.51
TOTAL	749	9	46	804	100.00
%	93.16	1.12	5.72	100.00	

SEA TURTLE STRANDINGS IN GEORGIA IN THE TED ERA: A MATTER OF TIMING

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Five species of sea turtles have been identified in the coastal region of Georgia: leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*) and the loggerhead (*Caretta caretta*). Reports of dead or weakened specimens stranded on the beaches or banks of creeks, sounds and rivers reveal apparent relative abundance and seasonal frequency of each of the species.

In 1979, when Carol Ruckdeschel began to quantify these strandings, 459 turtles stranded in Georgia. In 1980, NMFS instituted a centralized database (STSSN) and coordinated stranding information from Gulf of Mexico and Atlantic coastal states. From 1979 to 1991, 3,727 stranded sea turtles have been reported in Georgia, an average of 287 turtles per year (Range: 117-805). Of these, most have been immature loggerheads in the 50-70 cm size class (Hillestad et al, 1977, Maley, unpub.). Leatherbacks strand most often in early spring, and green turtles exhibit no seasonality. Kemp's ridleys strand in spring, summer, and more frequently in the fall. Loggerheads strand in greatest numbers in May-August.

Sea turtle mortality has been linked with shrimp trawling (Ulrich, 1978, Murphy and Hopkins-Murphy, 1989). In Georgia, turtle strandings coincide with the heaviest trawling seasons, which is also the nesting season for loggerheads. TED guidelines were defined by these strandings in the 1987 Final Rule. The requirements were to be effective in May, 1988, through the end of August, an interval that historically accounts for 92% of all strandings in Georgia for the years 1979-1988. Insofar as strandings represent a minimum measure of at-sea mortality for sea turtles, it was hoped that stranding patterns would reveal the efficacy of TEDs in reducing the accidental take of sea turtles in the shrimping industry.

The required use of TEDs in May of 1988 was delayed for one year by U.S. District Court in Louisiana and then delayed again until July of 1989 by the Department of Commerce. Because the 1987 TED rule had been placed under a 60-day moratorium mere hours before the proposed enforcement period in 1989, there was not ample time or incentive for trawl fishermen to change gear back to TED-less nets. As a result, voluntary use was perceived to be widespread.

Strandings of marine turtles were reported at below average levels in May and June. Significantly, stranding reports dropped to even lower levels after 1 July, the first ever enforcement period for TEDs in the Southeast U.S. Strandings in the state were reduced 90% during the three weeks that TED rules remained in effect. Despite the lifting of TED requirements on 22 July, Georgia tallied the fewest strandings for the month of July in the history of the STSSN in Georgia.

Immediately after July 21, when TED enforcement was suspended by the Coast Guard, strandings increased to levels equal to or greater than the ten-year average compiled by the STSSN. (Maley 1990)

On 1 May, 1990, TED rules went into effect as planned. A massive freeze in the coastal area precipitated the closure of the 200 mile EEZ to all shrimp trawling until June 1. Some confusion as to the TED requirements was evident, and law enforcement agencies made several TED cases in Georgia in June, bringing compliance up to acceptable levels in the industry by mid-July. Following this law enforcement effort, strandings for the month of August reached a record low of 15 turtles (1980-1989 August mean is 40).

As in 1989 after August 31, strandings accelerated to levels above the ten year average in 1990. In fact, strandings for September 1990 (53 turtles) were the highest since 1980, and the total for October (50) was the highest ever. This suggests that turtles protected by the use of TEDs in summer were at risk to trawlers after August when TEDs were no longer required.

To address this situation, and to further protect the Kemp's ridley turtle which strands in this area in greater numbers in the fall, GA DNR enacted a rule in October 1990 to require TEDs until late November in the northern part of the state, and until late December for the waters in the southern half. This was augmented in the fall of 1991 by Federal action which extended TEDs to all waters seaward of the COLREG line for the part of the year not already covered by the 1987 Final Rule. This was an interim rule, subject to reauthorization each year.

For 1991, anticipation was high for a showcase of TED efficiency. Ironically, in April when TEDs were not required in Federal waters, unusual environmental conditions produced a new situation for the agencies and individuals involved in sea turtle recovery. Warmer than usual water temperatures, the early maturation and movement offshore of roe shrimp, and the arrival of sea turtles produced negative results for turtles in Georgia.

Incredibly, the GA STSSN reported ninety-one turtles stranded in April 1991, including 30 leatherbacks. The average was 5.6 turtles per April. Coincidentally, shrimp harvest in April 1991 was the highest for this month since records have been kept (441,000 lbs compared to 1957-91 mean of April catches of 36,000 lbs). In May, shrimp harvest was double April's total, but strandings totaled less than half of April's. By all accounts, strandings should have increased or maintained the pace of April. The difference was the beginning of the 1991 TED enforcement season on 1 May.

By June, the stranding rate had diminished by 86.5% of the historical level, and Georgia experienced record low stranding totals for July and August. The shift to late season mortality seen in 1989 and 1990 never materialized in 1991. Trawl capture of 71 turtles and radio tracking of juvenile loggerheads by the US Army Corps of Engineers indicated the presence of substantial numbers of turtles in the St. Simons Sound, and the tendency for these juveniles to remain in the area for extended periods (D. Nelson, pers. comm.). This, along with low mortality reports, indicates the capture avoidance of turtles by TED-equipped trawlers, not the worst case alternative scenario, or the depletion of stocks to low density levels that would make even intentional capture difficult.

DISCUSSION

When requirements are enforced, TEDs successfully prevent mortality of sea turtles in shrimp trawls. In all months with TED laws in place, strandings were below the ten-year average and, more often, reduced up to 90%.

TED-reduced mortality allows closer examination of all salvageable carcasses, and a chance to identify other possible causes of turtle deaths. A shark-bitten turtle was revealed to be undernourished; upon closer examination, necrotic tissue surrounded a wound on the lower jaw, thought to have been caused by a fish hook (Jennings, per. comm.). Other turtles washed in with heavy trauma to the carapace. At about the same time, observers aboard hopper dredges noted the incidence of turtles entrained in the dragheads and pumps with trauma similar to that observed on turtle carcasses on adjacent beaches.

This precipitated efforts to reduce entrainment by the dredges by sweeping the channels with specially equipped trawlers. Turtles caught in this way were relocated outside the project area. Some of these turtles were radio-tagged and released. The preliminary results of the radio tagging indicated that juvenile sea turtles in St. Simons Channel remained there for several weeks, exploiting available food items, as mentioned above (Nelson, 1991). The result was the imposition of a warm-weather moratorium by the State and NMFS on hopper dredging when turtles are present in a project area.

Leatherback turtles present a special case for fishing gear specialists, as they are too large for most TEDs to kick out of trawls. Certified TEDs were designed to exclude the average-sized turtles as determined from stranding records, those of the 50-70 cm class. The migration of leatherbacks through Georgia commences in early-mid spring with large feeding groups nearshore, usually before roe shrimping seasons. When this migration coincides with the movements of roe white shrimp in Georgia, the results are disastrous for the turtles. In 1987 and 1991, April and May combined for 66% of all leatherback strandings for Georgia (56 of 85) since the inception of the STSSN. Options for a suitable approach towards a solution should be explored before the next leatherback season this Spring.

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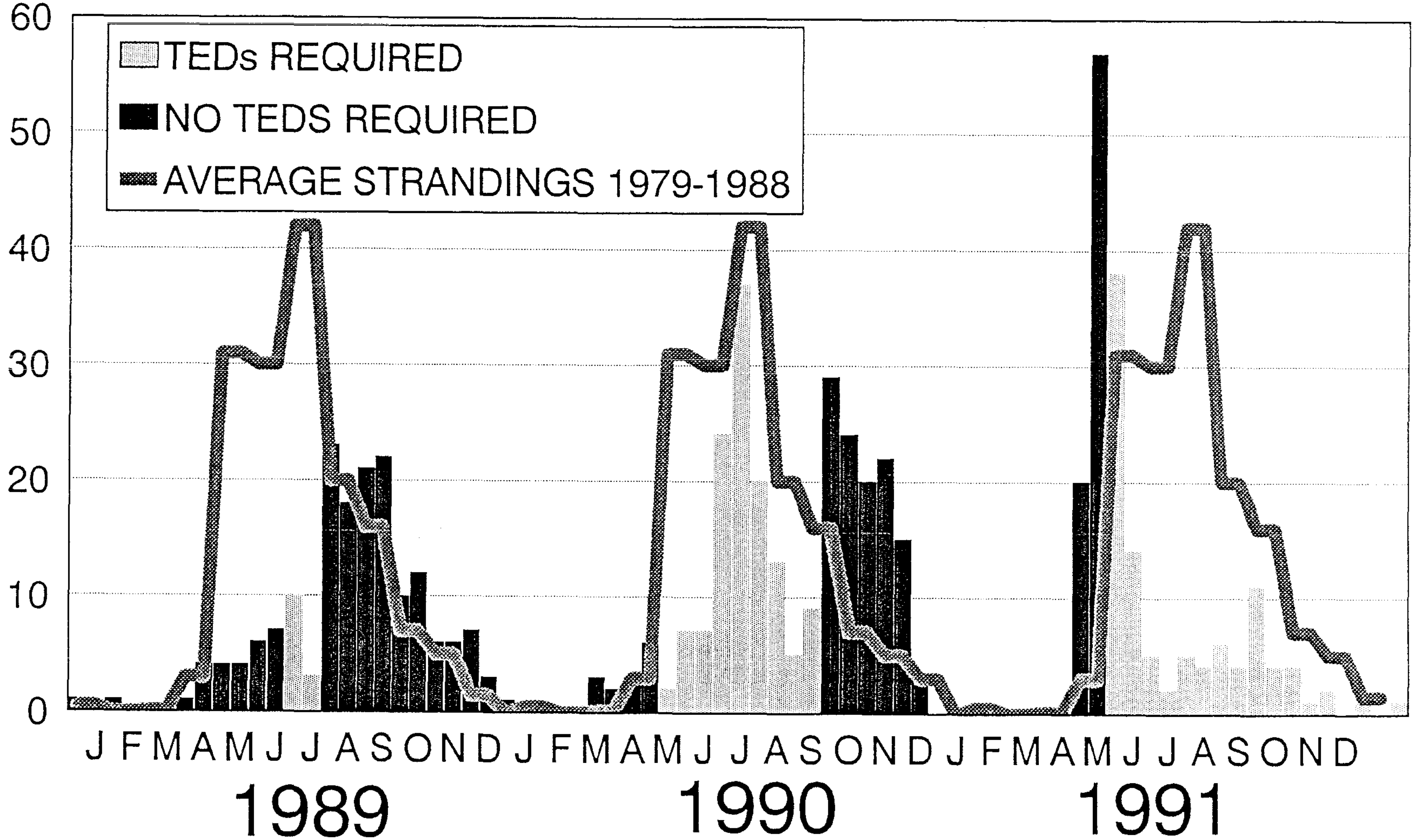
FIGURE 1. STRANDINGS OF MARINE TURTLES IN GEORGIA DURING THE TED ERA



MICROORGANISM INFECTION OF OLIVE RIDLEY EGGS

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ABSTRACT

Nest success among olive ridley turtles nesting in arribadas in Costa Rica is extremely low, ranging from 4-8%. One of the presumed causes of egg loss is fungal and bacterial infection in the beach. We undertook an extensive study of the role of microorganism infection in natural and artificial nests of olive ridleys to determine if bacteria and fungi are primary or secondary agents in embryo death. We found no correlation between level of bacteria or specific fungi in sand and hatching success in Playa Nancite, Santa Rosa National Park, Costa Rica. Experimental infection of eggs in controlled environment in the laboratory showed no difference in hatching rates between infected eggs and controls. The rates varied from 0 to 100% success, with an average of 52.5%. Our results show that when eggs are well hydrated and in optimum temperatures, they can hatch despite the presence of bacteria and fungi. Therefore these should be considered opportunistic agents in egg death caused by other environmental causes.

INTRODUCTION

Massive synchronous nesting of sea turtles is peculiar only to the genus *Lepidochelys*. This rare phenomenon in nature, known as "arribada", occurs in few places in the world: one site in Mexico, two in India, two in Costa Rica, and a few small arribadas in Nicaragua (Cornelius, 1986). The olive ridley sea turtle, *Lepidochelys olivacea,* nests in large numbers in Costa Rica at Nancite and Ostional beaches. During a 3-7 day period as many as 100,000 turtles may emerge to nest on these sites (Hughes & Richard, 1974). Arribadas occur from July through December, with peak numbers in October.

Although large numbers of olive ridleys nest, recruitment is very low. Hatching success at Nancite and Ostional is only 4% and 8% respectively (Cornelius *et al.*, 1990). The major cause of nest loss is attributed to microorganism contamination (Cornelius *et al.*, 1990).

Several authors have found certain bacteria and fungi to be pathogenic to turtles, although their effect on embryos has not been established (Marcus, 1981; Murphy and Collins, 1980; Hoff *et al.*, 1984; Jacobson, 1981). Egg-borne aspergillosis has been documented in poultry (Eggert & Barhnhart, 1953). *Salmonella* can penetrate turtle eggs, and neoneates emerge from eggs already infected (Murphy & Collins, 1980).

High bacterial species diversity inside eggs and bacteria occurring in both females and their eggs were correlated with lower hatching success in the loggerhead sea turtle, *Caretta caretta* (Wyneken *et al.*, 1987). Embryo mortality was also associated with infection of green turtle (*Chelonia mydas*) eggs by *Aspergillus spp.* (Solomon & Baird, 1979).

The objective of this study was to determine the role of bacteria and fungi in the hatching success of olive ridley eggs. To achieve this goal, a three phase project was conducted. From March though December 1987, we conducted a survey on the microflora found in eggs and sand at Nancite beach and in sand from adjacent Naranjo beach. Naranjo is an 8-km long beach rarely visited by olive ridleys, but a known nesting site for leatherbacks (*Dermochelys coriacea*). From September through November 1987, we artificially incubated turtle eggs in 7 different substrates. From May 1988 through November 1991, with several months of interruption, we experimentally infected eggs with bacteria and/or fungi and artificially incubated them.

METHODOLOGY

Materials and methods used for identification of beach microflora and comparison of 7 different substrates for artificial incubation have been previously described (see Mo *et al.*, 1990).

A complete factorial design with 4 variables at 2 levels was performed with 2 replicates per treatment. The variables were: temperature, humidity, fungi and bacteria (Table 1). The measured response was number of turtle hatchlings. Eggs were collected in a clean plastic bag as they were laid by the turtles and transported to the laboratory within 10 hours of oviposition. Upon arrival to the laboratory, all eggs were cleaned and disinfected by mechanical action combined with a solution of iodine-alcohol, followed by 70% alcohol. They were then put in sterile broth or broth containing a pool of bacteria, in petri dishes, in such a way that only the bottom part of the eggs touched the liquid. After 6 hours all eggs were transferred to large glass jars lined with a foam pad and covered by a double layer of cotton pad lined with gauze. Each jar contained 10 eggs. Broth containing fungi was poured directly onto the eggs in the jars. There were control eggs with only sterile broth or no broth at all. Incubation rooms were kept at the desired temperatures ± 1 C. Neonates were counted as they hatched, and all remaining eggs were opened after 60 days of incubation.

Results were analysed by multi-variate factor and an *a posteriori* Tukey test.

RESULTS AND DISCUSSION

Results of microflora found on the beach and of artificial incubation in 7 different substrates have been described in Mo *et al.*, (1990).

In the experimental infection of eggs, hatching rates varied between 0 and 100%, with no significant difference among the treatments. These data corroborate our earlier findings in natural nests and in artificial nests with substrates from Nancite and Naranjo, in which the presence of high levels of bacteria and fungi were not correlated with hatching rates.

We observed that whenever we achieved an optimum humidity level, fertile eggs were successful in producing a neonate, despite the presence of fungi and/or bacteria. The range of temperatures we chose were within the normal observed during the rainy season in Nancite and Ostional (Cornelius *et al.*, 1985). It is well known that during the dry season no eggs hatch on the beach, due to the extremely high sand temperatures. The eggs literally cook in the hot dry sand.

In earlier trial runs we observed that eggs dehydrated progressively and were subsequently invaded by bacteria and fungi. This was noticeable when the otherwise white color of a healthy egg turns into a yellowish, pinkish, purple or black egg. Hatching success was near zero in such cases. When we devised the best artificial nest system, and achieved an optimum humidity level, hatching success increased to an average of 52.5% among all treatments. If we take into account the normal number of infertile eggs, plus the manipulation in the first 17 h after oviposition, this rate is quite high.

Several authors have established early embryo mortality caused by movement of the eggs in the first 24 or 26 hours (Limpus *et al.*, 1979; Parmenter, 1980; Blanck & Sawyer, 1981; Whitmore & Dutton, 1985).

Our results show that bacteria and fungi naturally found in Nancite sand are not responsible for embryo death, but are opportunistic agents that invade the egg after it has lost its natural defenses, probably due to physical environmental factors. Development of eggs with fungi is known in other species, such as the domestic chicken (Eggert & Barhnhart, 1953), and bacteria can penetrate and be found in successful turtle eggs (Murphy &

Collins, 1980). Further studies of environmental physical factors and also of pollutants may contribute to explain the low hatching success in Nancite and Ostional beaches.

Table 1. Variables and levels of complete factorial design.

Variables	Level+	Level-
Temperature	32.5 C	28.0 C
Humidity	0-160ml/day	0-80ml/day
Fungi*	Present	Absent
Bacteria**	Present	Absent

*Pool of fungi consisted of *Saksenaea, Aspergillus sp*1, *Aspergillus sp*2, *Fusarium, Cladosporium, Mucor, Allescheria, Acremonium*, and *Penicillum*, grown for at least 7 days.

**Pool of bacteria consisted of *Acinetobacter, Pseudomonas sp, Pseudomonas aeruginosa, Bacillus, Staphylococcus*, and *Vibrio*, all individually grown to a concentration of 10^5 colonies/ml.

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CUMULATIVE EVIDENCE OF SOUTHWARD MIGRATION OF JUVENILE SEA TURTLES FROM TEMPERATE NORTHEASTERN WATERS

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Each summer large numbers of juvenile sea turtles, including Kemp's ridleys (*Lepidochelys kempi*), loggerheads (*Caretta caretta*) and green turtles (*Chelonia mydas*), immigrate into New York waters (Morreale and Standora, 1991). Questions have long been raised regarding the potential costs for sea turtles in northeastern waters, so far removed from their southern nesting beaches. In addition, extreme annual declines in temperature make New York waters lethal to individuals that remain into the winter (Burke et al., 1991; Morreale et al., in press). Our primary research goal has been to define the importance of New York waters in the life history of sea turtles. Through our long-term research, which includes both telemetric monitoring of juvenile Kemp's ridleys (Standora and Morreale, 1991) and an extensive mark-recapture study, we have been able to elucidate some key aspects of sea turtle ecology in New York waters. These ongoing studies over the past five years indicate that each year, after their arrival in June and July, sea turtles remain and forage in the shallow waters for up to several months. The highly productive waters where these turtles are most often observed provide an abundant supply of benthic crustaceans (Morreale and Standora, in press) which are the predominant item in the diets of both loggerheads and Kemp's ridleys. Upon recapture within New York waters, the observed growth rates are extremely high for the three species of chelonid turtles.

The results of our ongoing research support those of previous studies in which it was suggested that the waters of the Northeast play a key role in the lives of many sea turtles (Lazell, 1980; Shoop, 1980). Moreover, with the exception of the leatherback (*Dermochelys coriacea*), the sea turtles that occur in New York waters are small and presumably young animals. Thus, northern waters are more specifically important to the turtles during an early developmental life stage. Despite the obvious benefits of these productive areas to sea turtles, it remains to be seen whether there is a connection between the sea turtles inhabiting the Northeast and those of the distant southern waters in which the adult turtles are reproductively active. Our radio telemetry studies show that many turtles leave inshore waters of New York as temperatures fall in October (Morreale and Standora, 1991). Until recently, however, there has only been one documented case of a sea turtle moving from Northeastern U.S. waters to southern waters (Shoop, 1989).

A preliminary analysis of our long-term tagging data indicates that there is movement of turtles between the Northeast and the Southern U.S. To date, nine turtles of three species (loggerhead, Kemp's ridley, and green) have been recovered in out-of-state waters, one as long as 454 days after being tagged and released in Long Island Sound, New York. Most of these turtles were recovered in Southeastern U.S waters, some as far south as South Carolina and Florida.

While these tag returns indicate a southern migration route for turtles emigrating from New York, they do not provide us with the specific pathways of travel taken by the migrating turtles. Recent technological advances in satellite telemetry have enabled us to accumulate data on late season emigration routes for the small Kemp's ridleys as they leave New York waters in the fall. The patterns of movement exhibited by these juvenile turtles to and from southern waters underscore the role of Northeastern waters in a successful early life stage strategy for sea turtles.

ACKNOWLEDGEMENTS

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PIVOTAL AND BEACH TEMPERATURES FOR HAWKSBILL TURTLES NESTING IN ANTIGUA

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Eggs of hawksbill turtles, *Eretmochelys imbicata*, from Antigua were incubated at constant temperatures. The pivotal temperature (50% of each sex produced for the sample) was close to 29.2°C. Sand temperatures at turtle nest depth were recorded over 2 nesting seasons at Pasture Bay, Antigua. Although sand temperatures were sometimes higher than the pivotal level, more usually they were lower. On this basis, it is unlikely that hatchling hawksbills in this area have the highly female-biased sex ratios reported for some other reptiles.

The STATUS OF SEA TURTLE CONSERVATION IN THE BRITISH VIRGIN ISLANDS

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The British Virgin Islands (BVI) are located in the Caribbean, approximately 60mi (96km) east of Puerto Rico, just east of the United States Virgin Islands (USVI), and consist of about 36 islands with a total land area of 59mi^2 (151km^2).). The population of the BVI was last recorded at 17,733 people in 1991, and the major industries are tourism, offshore financing, artisanal fisheries and agriculture. Sea turtles that are known to nest on BVI beaches include the leatherback or trunk turtle (*Dermochelys coriacea*), green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles, with loggerhead turtles (*Caretta caretta*) occasionally reported in the area.

With respect to the status of sea turtle conservation in the BVI, the Conservation & Fisheries Department (CFD) of the Ministry of Natural Resources and Labour has been monitoring nesting turtle activities, drawing up new legislation based on monitoring results and, through an environmental awareness programme, has been educating the public through talks in primary schools, brochures, press releases and public talks and plays. Here it should be noted that this has only been possible as a result of an increase of personnel from one Conservation Officer in 1985 to a full fledged Conservation and Fisheries Department of 12 staff members in 1992.

Historically, leatherback turtles as well as hawsbill and green turtles were once very common in the BVI. Fishermen will tell of times when an average of six leatherback females would come to each nesting beach each night during the nesting season, and of days where it was literally impossible to row their way through a bay swarming with hawksbills and greens, because their oars would only hit and bounce off of the shells of those animals. Unfortunately, sea turtle populations have declined drastically in past years, and the need for monitoring these endangered animals became apparent.

This task of monitoring has been undertaken by the CFD which has organized two periods for the monitoring of nesting sea turtle activities. Starting in 1990, with the assistance of the World Wildlife Fund - United Kingdom, aerial surveys using a Cessna 172 airplane were flown from April to July, during which the majority of known leatherback nesting beaches in the BVI were surveyed. These surveys were usually performed at six day intervals in the early mornings when the sun was low and therefore there were no shadows on the beaches to interfere with the sighting of tracks. In the event of a sighting from the air, ground truths were performed as soon as possible

From September to December, surveys of nesting activities of hawksbill and green turtles are performed by volunteer residents of the BVI who walk the beaches in the mornings as often as they can and are asked to complete data forms for each walk performed. These volunteers have been recruited over time, mostly through press release and word of mouth, and workshops have been held to teach them the basics of sea turtle identification, biology and conservation.

From these surveys, it has been shown that nesting leatherback turtle numbers have declined from nine in 1987 to two in 1991. Here it should be noted that there were possibly four nesting leatherbacks in 1991; however, two of these were slaughtered by local fishermen.

With respect to hawksbill turtles, there were a total of 28 nesting activities observed for 1990 and 1991. Although there was an increase from 1990 to 1991, it is difficult to determine whether this is a result of more turtles nesting or having more volunteers involved in the survey.

There are many reasons for the decline and present threat to sea turtles in the BVI. One of these, of course, is the harvesting of sea turtles for both economic and cultural reasons. "Trunking", that is the harvesting of leatherbacks in the BVI, was more a traditional fishery surrounded by an aura of mysticism. Fishermen will often tell of noises or whistling on the beach where a trunk turtle will come up to nest, or sightings of the silhouettes of "trunks" in the clouds pointing towards a nesting beach . Using those cues the fishermen were able to predict where a nesting female would come up. Although it was not as important economically as the hawksbill or green fishery since there was not a large market for the oil derived from the trunk, the meat and eggs were distributed at a subsistence level among the community. The tradition of trunking still exists today among some local fishermen despite the low numbers of turtles recorded in the BVI.

Another major but inevitable challenge faced by our sea turtles is the advent of development as a result of a growing tourism industry. As in most small island nations, the majority of this development has occurred within the cosastal zone, and much of this has been along our beaches. Of the almost 50 miles of beach lining our islands, only two miles of this remain inaccessible by land, With the imminent construction of a new, larger cruise ship dock and an expected increase in visitors, local businessmen and taxi drivers who directly benefit from these visitors have suggested that these beaches be made accessible in order to accomodate these visitors, which wouild directly impact these very important turtle nesting beaches.

Also as a result of increasing development activities is the increase in sand mining activities for the production of concrete for construction. This has proven to be a major threat to nesting beaches in the BVI where some beaches have completely disappeared or are severly eroded, such as Josiah's Bay where the beach has receded at least 50 feet and several rows of vegetation have been washed away as a result of uncontrolled sand mining.

With charter boats being a major component of tourism in the BVI, there are large numbers of marine vessels traveling and anchoring around our waters. This has contributed to a decline in the health of coral reefs and seagrass beds in the BVI and subsequently in the adjacent beaches. However, a collaborative effort between the National Parks Trust and the Dive Operators'Association of the BVI has resulted in the installation of 120 moorings throughut the BVI at the more popular diving and snorkeling sites which should improve the health of the important foraging and nesting habitats of our sea turtles. There is also a threat of high ground seas at the remaining northern beaches, especially on the main island of Tortola, which have resulted in a number of turtle mortalities as a result of nests being washed away. During a one year period from 1990 to 1991, this accounted for the loss of at least three turtle nests in the BVI.

These threats to our sea turtle populations have not gone unnoticed, and several steps have been taken to assist in their recovery. One of these was the development of the WIDECAST RECOVERY PLAN for The BVI which is in its last stage before publication. The next step was public awareness in the form of an environmental education programme, where primary school students were taught about sea turtles and brochures were produced and distributed to the public. Although the CFD personnel originally went into the schools to give the talks and slide shows, these have been duplicated and distributed to the teachers, along with helpful backgound material, so that they may teach the students themselves.

With respect to legislation, the Coast Conservation Management bill, which will provide for the protection of beaches and sustainable development is presently being reviewed and revised prior to resubmission to the Executive Council of the Governament of the BVI. Although present turtle legislation simply allows for an open and closed season on all three species of sea turtles (the closed season being from April 1 to November 30), there is legislation pending which would declare a complete moratorium on leatherback turtles and a maximum size limit on hawksbills and greens.

With the passing of new legislation in the near future and an ongoing environmental awareness programme in the BVI, it is hoped that these endangered creatures may avoid their seemingly inevitable fate in the BVI and surrounding areas.

BIOLOGY AND CONSERVATION OF SEA TURTLES ON MONA ISLAND, PUERTO RICO, 1991

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INTRODUCTION

The beaches around Mona Island, Puerto Rico provide nesting sites for the adult females of the Hawksbill sea turtle (*Eretmochelys imbricata*) and occasionally for the green turtle (*Chelonia mydas*) and the leatherback turtle (*Dermochelys coriacea*).

Mona Island was designated Critical Nesting Habitat for the Hawksbill in 1982. For ten years from 1974 to 1984, no studies were conducted on Mona Island. Since 1984 beach surveys on nesting beaches were developed.

The sea turtle management project started in 1989 and is a joint effort of Chelonia, Puerto Rico's Herpetological Society, and the Puerto Rico Department of Natural Resources.

Night patrols were made on accessible beaches in order to tag and measure as many turtles as possible. Daytime surveys were made on the remaining beaches to record previous nesting activity. In order to determine reproductive success, hatching activity was documented.

RESULTS

Between June 7 and December 10, some three hundred and thirty (330) emergences were recorded, with one hundred and forty-two (142) nests and one hundred and eighty-eight (188) false crawls observed. The crawl effort was estimated at 2.32 crawl/nests. In 1991 Sardinera Beach was the favored beach with fourteen percent (14%) of the total nests. The ocean flood of October 30, 1991, during which waves reached more than 10 feet, resulted in the loss of eighteen (18) nests on seven beaches. Hawksbill nesting occurs year round on Mona Island. Our study, conducted for twenty-six (26) weeks, showed that the peak of the season was recorded from August 21 to September 18 with fifty-one (51) nests.

Twenty-four (24) new turtles were tagged while nesting on beaches from Sardinera to Mujeres. One nesting turtle was tagged by Anastasia Kontos in 1987 on Mona Island, and another turtle showed tag scars. Two daytime nesters were observed.

Beaches from Sardinera to Mujeres suffer extensive damage that includes erosion and vegetation removal. Another fifteen (15) nests were relocated to safer grounds, taking care not to rotate or otherwise hurt the eggs. During four (4) days of heavy swells no turtle activity was seen. A week after, turtles were seen to nest at any time during the day or night. Almost all nests were dug up after hatching to determine hatch success and to liberate trapped hatchlings. In this way we also found the following deformities: partially undeveloped front flippers, carapace deformities and a well-developed hatchling but with its carapace and plastron reversed.

The incubation period was observed to be 54.5 days with a range of 54 to 63 days. The average number of eggs per nest was 149.5 and ranged from 70 to 226. Hatching success was estimated at 78%.

DISCUSSION

The remote nesting beaches makes it difficult to observe every emerging turtle; therefore, frequent daytime censuses were made if nesting occurred. Every crawl was erased and the eggs located in order to confirm nesting. Whenever necessary, nests were relocated. The emergence success was low due to the loss of nests, changes in temperature, heavy surf and excessive rain. No nests were lost to feral pig predation because of fences put up by the Department of Natural Resources in 1990.

CONCLUSIONS AND RECOMMENDATIONS

The turtle take is still continuing on Mona Island. Before the project, one hawksbill carcass was found on Playa Brava. From August 28 to December 10, fishermen were aware of our constant presence on all beaches and during this time, no turtles were taken while nesting. After our departure from Mona Island, four (4) juvenile green turtles were slaughtered. The DNR Rangers have the task to board any fisherman's boat, but they are afraid of having their findings reversed and the frustrations which inevitably follow. Egg poaching has not been assessed, but there is no doubt that it is happening according to coastal people.

We hope to continue our work on the island in the years to come to protect this important nesting habitat for hawksbills in the Caribbean.

SEA TURTLE MORTALITY ASSESSMENT AND THE NEWLY ESTABLISHED CARIBBEAN STRANDING NETWORK

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Sea turtles form an integral part of the marine and coastal fauna of the Caribbean Sea, with many areas serving as primary habitat for the mating, foraging and nesting of marine turtles. Six species of sea turtles have been identified to date as inhabiting the waters of the Caribbean Sea. All sea turtles are classified as threatened or endangered by international agreement and, in some countries, local legislation protects them.

The mortality and stranding of these creatures in the Wider Caribbean has not been directly addressed previously, despite the fact that, for example in Puerto Rico and the Virgin Islands, many sea turtles have been found stranded, dead on shore or killed in past years. Undoubtedly many more deaths have gone unreported. In the past, lack of general knowledge and public, scientific and government indifference resulted in little or no data being collected, and a great number of animals were left on the beach or buried without proper analysis.

A preliminary assessment of stranding events in the US Virging Islands and Puerto Rico in 1991 showed that out of 96 dead strandings, 76% of reported mortalities point to human intervention such as illegal capture, boat collision and incidental catch as the cause of death. Six percent of deaths were related to papilloma tumors. The remaining 18% were of unknown causes, mainly because no post-mortem study was conducted, or the carcass was already decomposed when reported to officials. Entanglement with marine debris is also a matter of concern due to the increasing number of entanglement cases per year. Clearly one of the most urgent problems for sea turtles in the Caribbean lies in their unnecessary mortality due to human activities, such as the green sea turtle which died entangled in a fishing line and shoe string.

In 1991 we attended 116 live strandings which was 61% of our total strandings, but 15% die soon after from illness and injuries, among other causes. Live stranding of sick and injured animals has posed a problem because, until recently, no facilities and few trained personnel existed to carry out the rescue and rehabilitation of these creatures. In such cases, improvisation has been the call of the day. Some of these animals could be treated if a response team could be promptly notified and arrive at the location in a timely manner.

A practical approach to unraveling the mortality and stranding problem of sea turtles in the Caribbean requires an integrated, funded program focusing the talents and efforts of all those responsible for, and interested in the survival of, these creatures to assess their mortality. It also requires an integrated protocol to rescue, rehabilitate and hopefully release those which strand alive.

It was not until October 1989 that, in the absence of an active program for endangered marine vertebrates, and with the initiative of local biologists, a first step was taken by creating the Caribbean Stranding Network. The Network is composed of volunteer participants from private, university, Commonwealth and Federal agencies who agree to rush to the scene of a stranded sea turtle, bird or marine mammal and transport it either for treatment or proper salvage and disposal. The Network is based at Isla Magueyes Marine Laboratories, an 18 acre island belonging to the University of Puerto Rico's Department of Marine Sciences, and is composed of participants and consultants from over 32 organizations and government agencies from nine Caribbean countries: Puerto Rico, US Virgin Islands, British Virgin Islands, St. Lucia, Venezuela, Colombia, Mexico, Jamaica and Dominican Republic.

A Steering Committee, chaired by an Area Coordinator, oversees the running of the Network. A local veterinarian and two experienced animal rehabilitators are participants to the Network's animal care staff for live strandings. The Network also serves as clearinghouse for data and shares these data with other regional networks like the Sea Turtle Stranding and Salvage Netwok and the Marine Mammal Stranding Network.

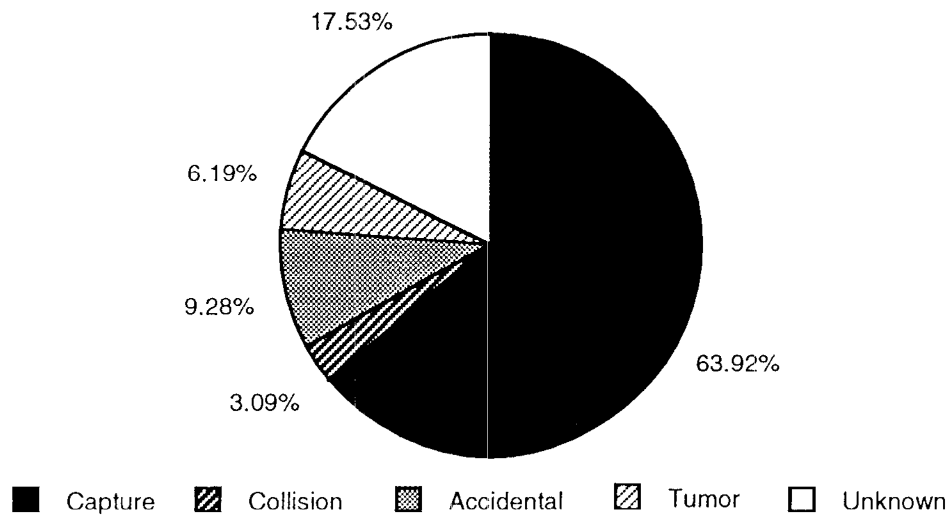
The Caribbean Stranding Network's primary objective is to unite stranding efforts throughout the region and effectively coordinate the assessment of marine vertebrate deaths. In this way we hope to aid in the amelioration of those deaths not related to natural mortality. To accomplish this, the Network has the operational functions of education, notification, coordination, response, assessment, reporting and recording. These are implemented through two projects: (1) the mortality assessment, rescue and rehabilitation project, and (2) the endangered marine vertebrates education project, the latter in conjunction with the Chelonia Society and the Department of Natural Resources' Wildlife Refuges and Natural Reserves Division in Puerto Rico.

In order to put all this into practice the Steering Comittee began a campaign to let residents know of the need to report cases, by using as much media coverage as possible. There was also a recognized need for initial training. To accomplish this, six of us travelled to Florida for a month-long internship in 15 different institutions, where we were lectured on mortality assessment, observed general husbandry protocols and first aid facilities, and were introduced to rehabilitation techniques. Upon returning to Puerto Rico, we immediately passed along the information obtained by training other participants in Puerto Rico, Colombia, Dominican Republic, and the Virgin Islands, among others. In addition, we initiated the construction of the Network's headquarters and facilities for necropsy and rehabilitation.

Also throughout this past year, we have tended more than 60 stranding and mortality cases, averaging one every 12 days. A green turtle covered with papillomas was caught in a gillnet, held for rehabilitation, and was released in good condition after removing biopsies of the tumors. We have also dealt with cases of live dolphins, and we have been taking care of an orphaned manatee for the past three months. This baby suffered initially from constipation due to ingestion of mud, sea grass, two types of plastic bags, and monofilament line and now is doing well and gaining weight.

A fully developed Caribbean Stranding Network could properly assess not only marine vertebrate mortality but could also aid in averting the steep population decline of these endangered species suffering from direct or indirect human activities by prescribing preventive measures. The first step is to know truly what is actually happening to the populations. It is only through education and this type of cooperative assessment and rescue action, not reaction, that these marine vertebrates, some highly endangered, will have a chance to survive.We encourage everyone in the Wider Caribbean Region to join us in this stranding reporting network.

Causes of Sea Turtle Mortality 1991



INVESTIGATION OF COHORT COHESIVENESS IN MASS EMERGENT NESTING BEHAVIOR OF *LEPIDOCHELYS OLIVACEA*

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The synchronized mass emergent nesting behavior of large numbers (10,000 - 100,000) of the female olive ridley sea turtle *Lepidochelys olivacea* is perhaps the most extraordinary example of group coordinated behavior known for any reptile. These reproductive events, commonly referred to as *arribadas*, occur at only a few select beaches within the olive ridley's nesting range. Observations made during *arribadas* in Surinam (Pritchard 1969) and Costa Rica (Cornelius and Robinson 1986) similarly describe the emergence of many small groups of ridleys onto the beach, suggesting that these groups or cohorts of female ridleys might migrate together and arrive at the nesting beach at the same time. Cornelius and Robinson (1986) also proposed that these groups or cohorts might remain cohesive after an *arribada*, during the internesting and postnesting periods when the turtles disperse from the nesting beach.

Satellite telemetry was used to determine if female ridleys that are closely associated at the nesting beach during an *arribada* (a cohort) remain associated during the internesting period, during successive *arribadas*, and during the postnesting period. We defined a cohort as being a group of female olive ridleys in the same or similar reproductive state, nesting at the same beach, at the same time, in close proximity of one another, well into a large *arribada*. Members of a cohort that met these criteria were chosen for telemetry.

Members of three cohorts were captured during *arribadas* at the nesting beach at Playa Nancite, Costa Rica in September 1990 (Cohort A), September 1991 (Cohort B), and November 1991 (Cohort C). Reproductive status of postnesting turtles was determined by ultrasonography. All cohort members contained numerous preovulatory vitellogenic follicles >2 cm diameter in their ovaries indicating each turtle was likely to lay another clutch of eggs. Satellite transmitters (Telonics, Inc., ST-3) were attached over the second neural scute of the carapaces of cohort subjects with polyester resin and fiberglass cloth. Turtles were released from the beach and their movements monitored via the ARGOS-TIROS satellite system.

The turtles from all three cohorts dispersed independently of one another and did not remain cohesive during their internesting period. The six Cohort A turtles tagged in September 1990 did not nest in October. Contrary to our expectations, there was no October *arribada*. All six Cohort A turtles returned to Playa Nancite to nest in a successive *arribada* in November 1990 and five of the six turtles were recaptured nesting on the same night, at the same time period, in or adjacent to the same section of the beach during this *arribada*. In contrast, only three of the six Cohort B turtles tagged in September 1991 returned to Playa Nancite to nest in the successive *arribada* in October 1991. The three Cohort B turtles that returned to nest in October were recaptured on different nights, at different times, and on different sections of the beach. We do not know for certain how many of the Cohort C turtles tagged in November 1991 returned to nest in the successive *arribada* in December 1991 because we were not present at the beach during the *arribada*. However, the location data collected by ARGOS suggests that three of the five Cohort C turtles returned to Playa Nancite to nest in the December *arribada*. The turtles from each of the three cohorts dispersed independently of their fellow cohort members and did not remain cohesive during the postnesting period after their final nest deposition.

The female olive ridleys associated at Playa Nancite during an *arribada* did not remain together during the internesting period nor during the postnesting period. Female olive ridleys are capable of reassociating or reassembling during a successive *arribada* as occurred with Cohort A. The reassociation of Cohort A turtles at Playa Nancite following a long, unassociated internesting period suggests that the turtles were reacting in concert to common stimuli.

This work was supported by the National Science Foundation (Grants #BNS-9000075 and BNS-8819940), Texas A&M Sea Grant College Program (Grant #NA85AA-D-SG128), the U.S. Fish and Wildlife Service, and Sea Turtles, Inc.. Special thanks are also due to: Programa de Tortugas Marinas U.C.R., Parque Nacional Santa Rosa, Janice Grumbles, Heather Kalb, Roldan Valverde, Nonita Villalba, Susana Salas, Anny Chavez, Steve Cornelius, Thomas Bright, Cindy Liles, Carlos Calvo, Luis Torres, Guillermo Marin, Val and Kathleen Lance, Nancy Fitzimmons, Anton Tucker, and Ignacio J. Fernandez.

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RADIO AND SONIC TRACKING OF GREEN AND LOGGERHEAD SEA TURTLES AT SOUTH PADRE ISLAND, TEXAS

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It is well known that hopper dredging can be fatal to sea turtles (Dickerson and Nelson, 1990). Due to mounting concern by the U. S. Army Corp of Engineers (Galveston and New Orleans Districts), a plan to study sea turtle behavior near dredged channels was funded in 1990. The objectives of the study were 1) to determine sea turtle behavior and movement in the lower Laguna Madre and Brazos Santiago Pass area near the jetties and 2) to characterize these habitats and available food items (Landry et al., 1992). This paper deals with the movements and submergence patterns of sea turtles.

Four green sea turtles (*Chelonia mydas*) and one loggerhead sea turtle (*Caretta caretta*) were fitted with radio and sonic transmitters and released at their capture sites near South Padre Island, TX. Four of the 5 sea turtles exhibited what could be interpreted as home range behavior, i.e., they remained in a 0.6-3.9 sq km area encompassing their capture/release site. Feeding preferences may account for the limited movement of these sea turtles. All of the tracked green sea turtles were in or close to habitats abundant in food items: algae at the jetties or seagrass in the Laguna Madre. One green sea turtle remained at the jetties during the entire study. Three other green sea turtles were associated with seagrass beds and the margins of ship channels and intracoastal waterway (ICWW). All were active during daylight hours, with little or no movement at night. It was hypothesized that channels were used as thoroughfares for quick transit from one area to another. The loggerhead sea turtle was always in close proximity to the ICWW and adjacent seagrass beds which contained an abundance of food items such as crabs and small fish.

Two types of submerged behavior were exhibited by the sea turtles. Periods of high activity (submergence of less than 20 minutes), possibly foraging, occurred during the daytime for both green and loggerhead sea turtles. Loggerhead sea turtles apparently spent some time foraging at night based on moderate periods of activity. Resting behavior (submergence greater than 20 minutes), generally observed at night, also occurred minimally during the day for both species of sea turtles.

Seagrass beds typically border the navigable channels of the lower Laguna Madre. Daytime observations reflect sea turtle movement in or adjacent to the channels and in seagrass beds. Sea turtles tracked in this study, however, spent most of their time on the edge of the channels or at the jetties. Movement into the channel proper occurred but was uncommon. The extent and duration of these excursions into the channel habitat is unknown at this time. Turtles may be susceptible to dredging when in the channel. Information on habitat utilization by these animals needs further detail to assess the full impact of hopper dredges on sea turtle populations in inshore areas.

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THE IMPACT OF BEACH RENOURISHMENT ON THE HYDRIC CLIMATE OF SEA TURTLE NESTING BEACHES ALONG THE ATLANTIC COAST OF FLORIDA

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INTRODUCTION

Extensive beach renourishment has occurred along the Atlantic coast of Florida in response to beach erosion. Artificial beach renourishment can not duplicate the natural cycle of beach renewal (Carter, 1988). The successful development of sea turtle embryos requires the presence of a limited set of hydric, thermal, and respiratory conditions during incubation. These conditions are provided by the beach incubating the eggs and are influenced by the physical characteristics of the beach. We assessed the impact of beach renourishment on the hydric climate of nesting beaches by measuring the hydric climate and associated physical characteristics of selected natural and renourished beaches.

MATERIALS AND METHODS

The physical and hydric properties of 12 beaches were assessed. These beaches were arranged into 6 pairs consisting of one renourished and one natural beach separated by between several hundred to several thousand meters. The beaches ranged along the Atlantic Coast of Florida from Daytona Beach in the north to Boca Raton in the south. The first three sets consisted of a natural and renourished beach on each side of an inlet: these were Ponce, Sebastian, and Fort Pierce Inlets. The next set consisted of Hobe Sound National Wildlife Refuge (NWR) and Jupiter Island Beach (renourished). The fifth set was comprised of Highland and Delray (renourished) Beaches. The final set was at South Beach and Spanish River (renourished) Parks. Six sets of beaches were used to provide adequate replication for the experimental analysis.

A grid was setup on each of these beaches, by first finding the center of the beach (Figure 1). The remaining sites were arranged around the center site, so that at least ten and preferably twenty meters were between each site. This distance was chosen to provide statistical independence among the sites. Samples have been shown to influence each other at considerable distances (Warrick, Myers and Nielsen, 1985). Samples were taken from the surface and then every 10 cm down to 50 cm at sites 2, 5, 6, 7, and 10. Sites 1, 3, 4, 8, 9, 11, and 12 were sampled at 20 and 30 centimeters as a reference for the other sites. Additionally, an undisturbed core and one liter of sand was taken from site 6 at 20 cm to be analyzed further.

The water content was determined on each of the samples taken down to 50 centimeters. Particle size distribution, mean weight diameter, saturated hydraulic conductivity, osmotic potential, and bulk density values were obtained as well as characteristic curves generated for each beach from the undisturbed cores and the liter of sand.

RESULTS AND DISCUSSION

A number of measurements from natural and renourished beaches were quite similar. These included particle size distribution, mean weight diameter, saturated hydraulic conductivity, and bulk density values. The natural beaches showed a range that fully encompassed the range seen in the renourished beaches. Water content, characteristic curves, and osmotic potential values showed a greater degree of difference. Therefore, these factors were examined more closely. An analysis of variance was performed on the water content data comparing natural and renourished beaches. On all pairs of beaches it was evident that the renourished beach had a significantly higher water content than the natural beaches on the order of 1-4% by mass ($P < 0.05$).

The water content of each sample was determined and plotted versus depth (Figure 2). The water content pattern is the same for both types of beaches: dry at the surface with a relatively constant wetness below the surface. The renourished beach is wetter closer to the surface as well as in the humid layer. We conclude that the renourished beaches do not drain as well as the natural beaches. The reason for these differences in drainage is likely due to differences in construction of the two beach types. The renourished beaches are constructed by bulk exudation and therefore are very homogeneous in structure. A natural beach is constructed by a layer of sorted particles being layered on top of other layers of sorted particles. This natural arrangement may facilitate better drainage.

If renourished beaches are wetter, then this may influence egg water balance. There are two ways in which the water exchange of eggs could be influenced. First the thermal exchange of the eggs could be altered by different heat conductivities of the sand at different water contents (Kam and Ackerman, 1990). The thermal conductivity of the natural and renourished sands is currently being examined in our lab. The second way the egg water exchange may be influenced is through an alteration in the water potential difference during water exchange across the eggshell. This alteration could occur in several ways. The effects could be due to osmotic potential differences related to the presence of salt. This is an immediate concern because during the beach renourishment process sand is often exuded on to the beach in a slurry of salt water. A problem would exist if the salt remained in the sand, and a sea turtle nested in this sand. There could be some effect with respect to the amount of water available to the eggs. Therefore, the osmotic potentials of natural and renourished beaches were measured to see how much of this salt remains after renourishment (Figure 3). The values for the natural beach at Hobe Sound NWR are extremely high in two months compared to all other months (and beaches). This is attributable to inundation by salt water within days of the sampling. Fort Pierce was renourished one month previous to the first sampling, and the levels here were initially slightly elevated, but by July the level of salt is very near the level seen in the other beaches. This indicates that the salt is flushed out quickly by subsequent rains and should have little to no effect greater than those seen on a natural beach. Matric potential is another possible source of influence on egg water exchange. To examine this effect it is necessary to examine characteristic curves for the two beach types. The characteristic curves, which are obtained by subjecting the undisturbed core to different amounts of pressure and recording the weight of the sample under that tension, are presented in Figure 4 as volumetric water content versus water potential. Note that as water potential becomes more negative, the water content first decreases very rapidly, then levels out at a relatively constant water content. The important part of this curve is between .05 and .1 water content values (Figure 5). An equation fitted to the data (Mualem, 1985) allows one to predict water potential values from the measured water content values. The distribution of curves presented in Figure 5 allows a renourished beach that looks wetter with respect to water content to have a water potential similar to that of the natural beaches. Water potential will predict the availability of water to eggs and therefore is a more meaningful indicator of the hydric environment. Figure 6 shows the relationship of water potential versus depth. Note that the water potential of these two beach types are very similar once the humid zone is encountered.

CONCLUSION

Renourished beaches are wetter than natural beaches. However, the water potential is influenced only slightly. Egg water exchange due to water potential differences is probably not affected. However, the thermal conductivity of renourished beaches is likely to be higher than the natural beaches, and this may influence the nest/egg water exchange.

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Figure 1. Layout of sampling grid on natural and renourished beaches. Sites 1-3 represented the upper beach. Sites 4-8 represented the middle beach. Sites 9-11 represented the lower beach.

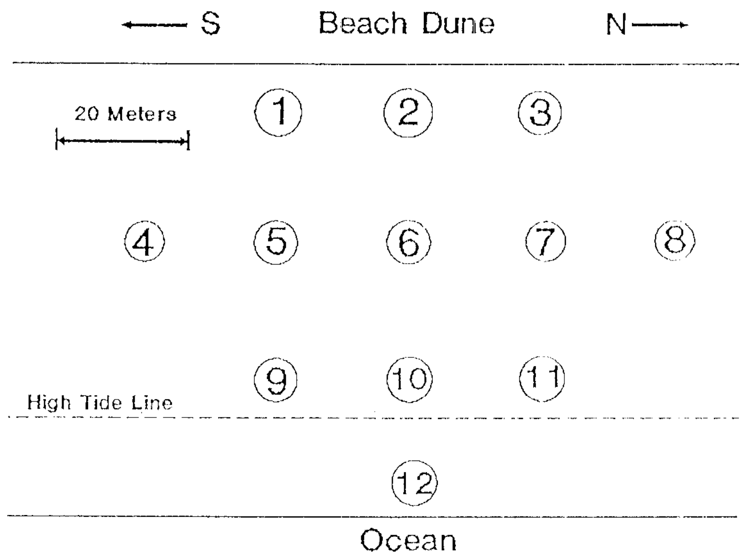


Figure 2. The variation of water content averaged over four months with depth, for one pair of beaches. Note that the renourished beach has a higher water content once below the surface, but that the general pattern is the same for both beach types.

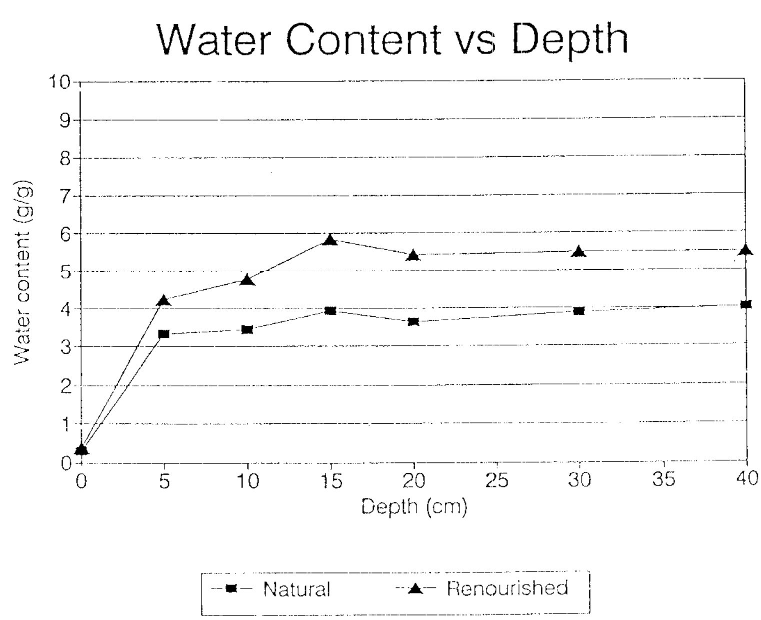


Figure 3. The osmotic potential observed each month for three pairs of beaches due to the presence of salt in the sand. The natural beaches are Hobe Sound NWR, Ft. Pierce North, and South Beach Park.

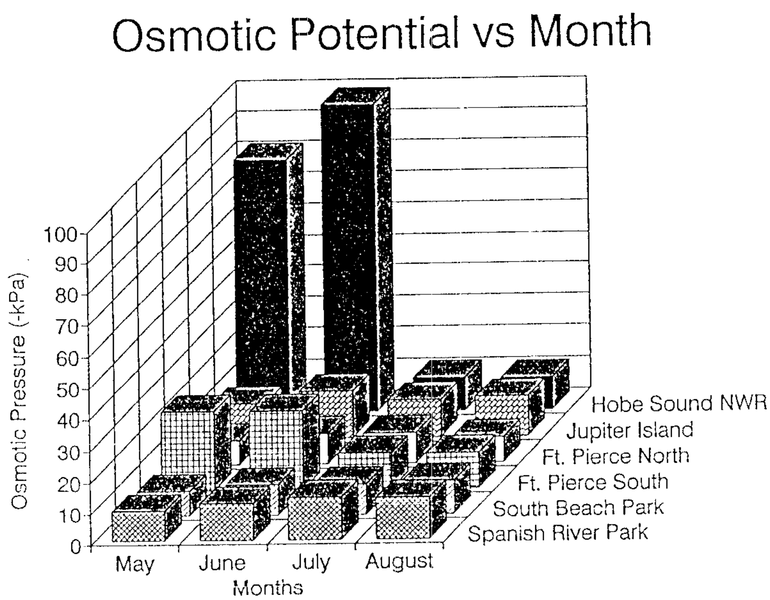


Figure 4. The water retention characteristic curves relating sand water content on a volumetric basis to matric water potential. The curves were generated from undisturbed cores from a natural and a renourished beach pair.

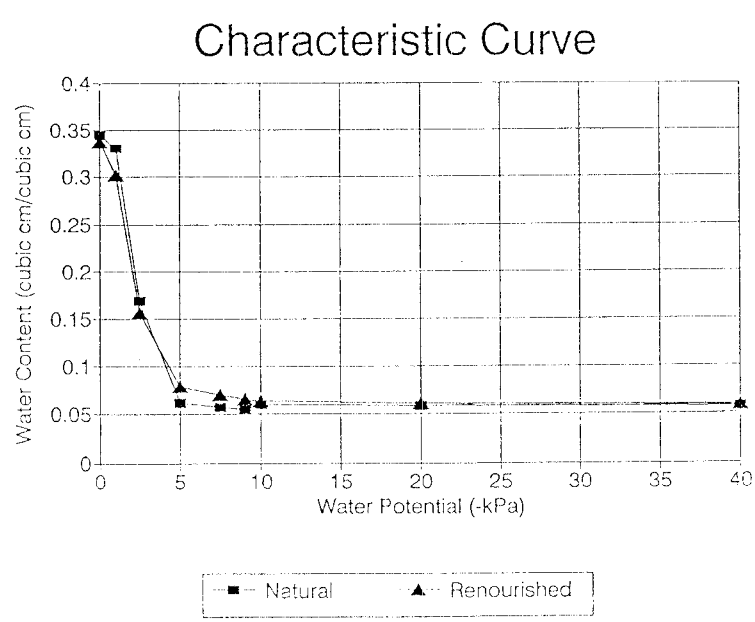


Figure 5. A close up of water content values between 0.05 and 0.15 of Figure 4.

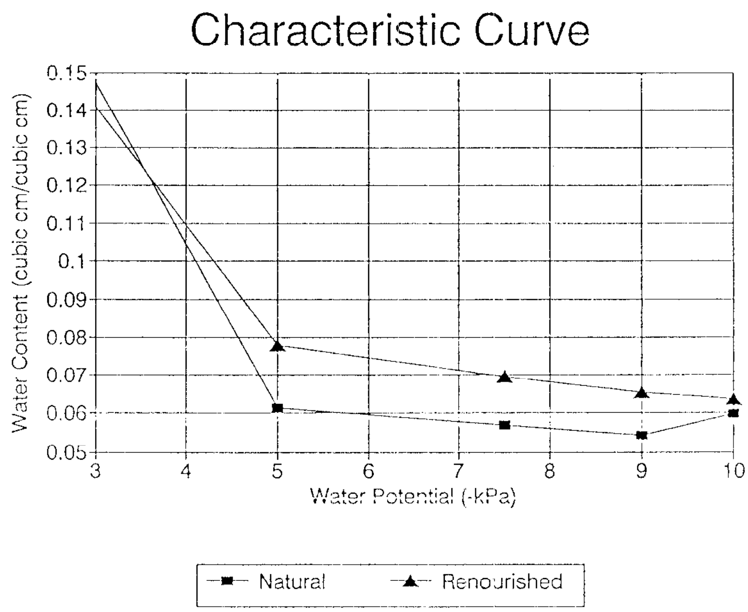
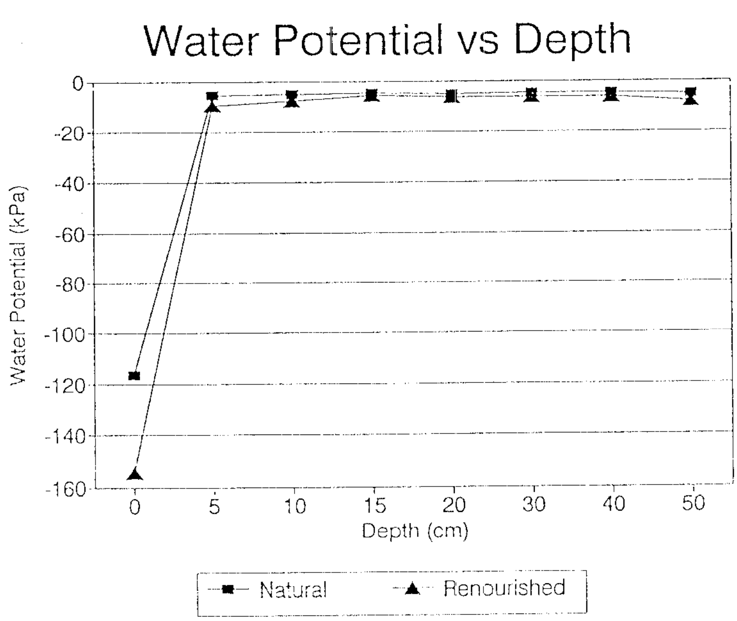


Figure 6. The variation of water potential averaged over four months with depth for one pair of beaches. Note that once below the surface, the water potential values are relatively constant with depth.



CHARACTERIZATION OF AN INSHORE POPULATION OF THE KEMP'S RIDLEY SEA TURTLE IN THE NORTHEASTERN GULF OF MEXICO

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The Atlantic or Kemp's Ridley sea turtle, *Lepidochelys kempi*, is considered to be the most endangered of all sea turtles and among the most critically endangered of any species on earth. The survival of the species is threatened by increasing human activity throughout the species range, particularly including commercial trawl fishing, recreational boating, plastic and petroleum pollution (Teas and Martinez, 1989). In particular, efforts to mitigate losses to commercial fishing by requiring Turtle Excluder Devices on trawlers have generated enormous controversy.

Efforts to restore its populations are seriously hindered by our lack of ecological knowledge of the species in non-breeding beach environments. As part of an effort to better understand the occurrence of Kemp's ridleys in inshore waters, the present study was undertaken. The goal was to capture, tag and release Kemp's ridley sea turtles, *Lepidochelys kempi*, from the waters of Franklin and Wakulla Counties, Florida, to generate fishery independent data on seasonality, frequency of occurrence and habitat preference of this endangered species in the northeastern Gulf of Mexico. Such information will contribute both to our basic knowledge of the species and provide information relevant to the needs of fisheries managers. It is a continuation of prior tagging efforts in the same area from 1984-1988 that produced 106 tagged animals (Rudloe, Rudloe, and Ogren, 1991).

Our current knowledge of the biology of the species is reviewed in the 1990 National Academy of Science report, "Decline of the Sea Turtles: Causes and Prevention." The species is concentrated in the Gulf of Mexico (Hildebrand, 1982). Ogren (1989) reported that the species feeds mainly on crustaceans. Byles (1989) reported that blue crabs, *Callinectes sapidus*, are their major diet and that crabs are taken by turtles primarily in shallow coastal grass beds. Shallow coastal grass beds are reported to be critical foraging areas for young Kemp's ridleys by Ogren (pers. comm.). Ogren (1989) has summarized juvenile and adult habitat distribution and relative abundance of ridleys in the northern Gulf of Mexico. Henwood and Ogren (1987) examined seasonal distribution, size and movements of Kemp's ridley in the coastal waters of the US and found mostly subadult animals. Zug and Kalb (1989) provide growth rate estimates.

METHODS

Trawl sampling was done monthly from June, 1990 through May, 1991 for 12 hours a month with a 40 foot trawl at Alligator Point, Franklin County, Florida.

The procedure for net sampling involved approximately 12 hours per week of sampling with a 300 yard, 15 "mesh" nylon turtle net at several different sites in the vicinity of Panacea/Piney Island and Shell Point Reef in Wakulla County waters (Figure 1). Net sampling began in May, 1990 and continued through November, 1990. It was discontinued for 3 months of December, 1990 and January-February, 1991 due to poor weather and the seasonal movement of macrofauna out of the shallow bays where sampling was being done. Net sampling resumed in March, 1991 and continued through August, 1991. A total of 8 sites were sampled. Two, Levy Bay and Dickerson Bay, which were the only one where turtles could be taken repeatedly, became the primary net sampling locations.

RESULTS

Turtles were taken from 6 locations in Wakulla and Franklin County waters: 10 from Dickerson bay, 7 from Levy Bay, 9 from Alligator Point, 5 from Shell Point Reef/ Piney Island, and 2 from Wilson Beach. They were taken in all months except December, January and February. All were ridleys except for 1 adult loggerhead and 1 juvenile green turtle. All the ridleys were subadult. Straight line carapace lengths of the ridleys ranged from 56.9 cm to 23.8 cm. The mean was 33.8 cm.

Including both turtle net and trawl sampling and incidental take, a total of 33 turtles were taken in 36 separate captures. Eighteen turtles were taken during the course of project sampling while 13 were taken incidently to other collecting operations. (Table 1).

During net sampling, seven ridleys were taken in Levy Bay and 7 in Dickerson Bay. In addition to the sampling effort, Dickerson Bay yielded 3 ridleys taken incidently for a total of 10. Of other sites that yielded a netted turtle, Shell Point Reef proved to be too exposed for safe net operations. Piney Island yielded one. Of the 17 captures made during net sampling, 8 were taken on a rising tide, 8 on a falling tide and one on slack tide. This involved 16 individual animals. Catch per unit effort in turtles per hour ranged from .02 to .10. Values for Levy Bay and Dickerson Bay were .06(L) and .03(D). For net sampling, 17 captures were made in 543 hours of fishing for a CPUE of .03.

Three ridleys and one loggerhead were taken during trawl sampling. Of these, one had been dead several days prior to capture and one (a mature loggerhead) died within hours of capture despite a 30 minute tow. A subsequent autopsy (see attached report) indicated pneumonia. The other 2 were healthy and released routinely. In addition, 5 more turtles were taken incidently at Alligator Point for a total of 9.

Eight turtles were recovered multiple times. Of these, 5 were headstarted NMFS turtles from Galveston or Padre Island, Texas. Times at large ranged from 19 to 72 weeks. Growth rates ranged from .043 cm/week to .237 cm/week (Table 2).

Of the 13 incidental turtles, 9 were taken in trawls, 2 in gill nets, 2 by hook and line off the Gulf Specimen Marine Laboratory dock, and 2 were observed and reported by other individuals without being returned to shore.

DISCUSSION

We have tagged and released 32 ridleys and one green turtle and documented the repeated movement, rates of travel and growth rates of headstarted specimens from Texas coast into the waters of north Florida. The headstarted animals appeared to be integrating themselves into the wild population and growing vigorously. They represented 16% of all ridleys taken during this study.

Efficient netting requires detailed local knowledge of the bottom topography and the movement patterns of the target species.

While turtles may be present throughout an area, they are not equally vulnerable to net capture at all points. Rather, a locality in which Kemp's ridley turtles can be <u>repeatedly caught</u> by a turtle net as well as sighted appears to require an embayment with limited points of entry and exit on rising and falling tides. A tidal channel passing through shallow intertidal flats seems to be most effective. The turtles appear to move in and out of the shallows along tidal channels and can be intercepted and caught if the net is placed across the tidal channel. In other areas, turtles are taken rather more haphazardly if they should happen to swim into a net, presumably while foraging. Tidal currents were strong on spring tides and kept the net taut at times, probably reducing its fishing efficiency considerably.

As a research tool for determining the inshore distribution of Kemp's ridleys, trawl sampling was found to be relatively ineffective, at least at the level of effort (12 hours per month) employed in this study. The species is clearly vulnerable to incidental trawl catches, however, with 9 taken that way.

The use of blue plastic tags on headstarted turtles rather than metal ones resulted in 3 cases out of four of massive barnacle fouling and ugly festering wounds as the heavy mass slowly pulled through the flesh of the flipper. In addition to the damage to the animal, the eventual loss of the tag was inevitable. Plastic and fiberglass materials are often highly attractive to barnacles in our experience. The use of these blue plastic tags is, based on our observations, highly undesirable.

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Figure Legend: Localities from which turtles were collected: 1. Shell Point Reef; 2. Piney Island; 3. Bottoms Fishery; 4. Dickerson Bay; 5. Levy Bay; 6. Panacea Channel; 7. Elmour Cove; 8. Alligator Harbor; 9. Wilson Beach; 10. Alligator Point

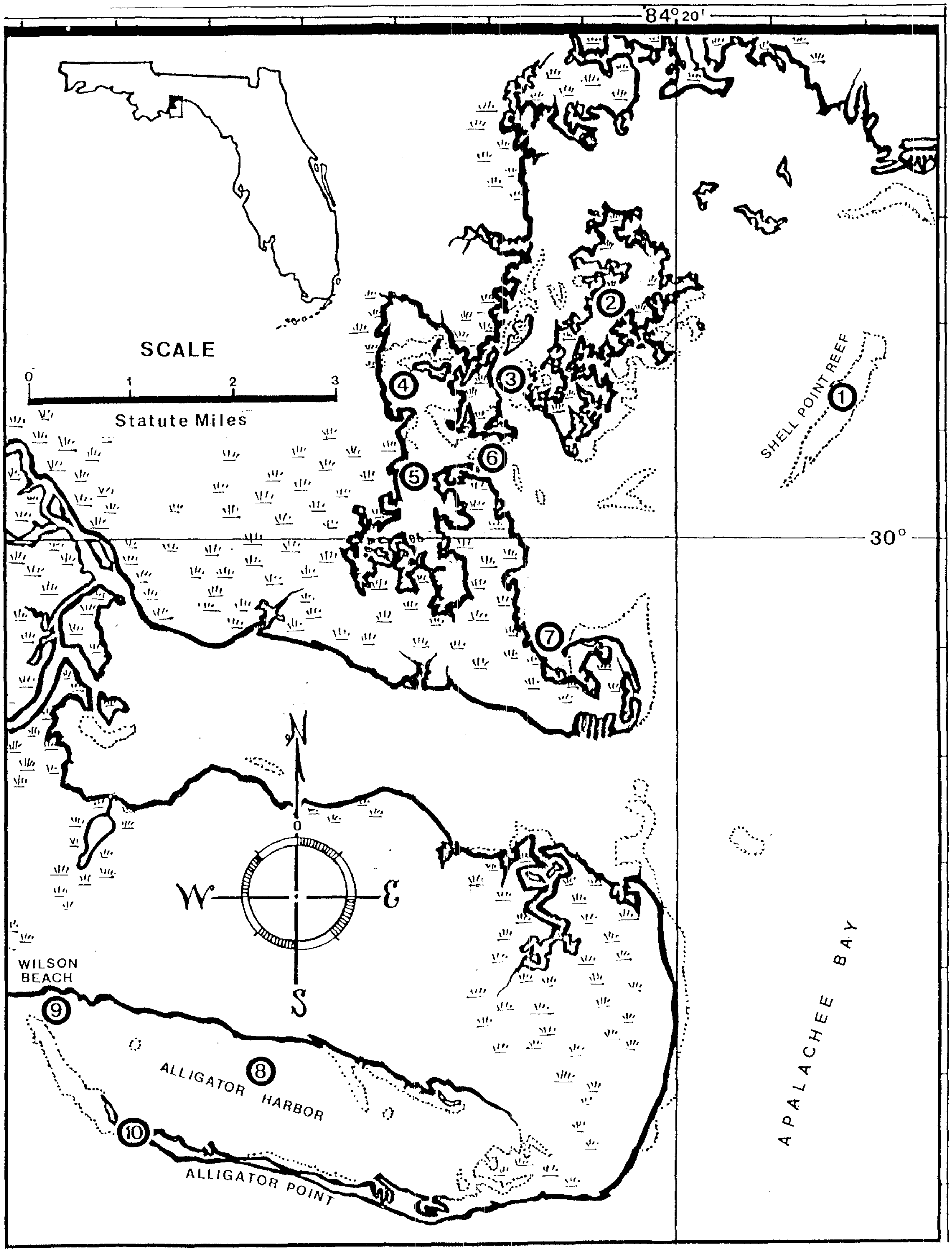
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TABLE 1: *Summary of turtles collected by locality.*

LOCALITY	# FROM PROJECT SAMPLING	# TAKEN INCIDENTLY	TOTAL
DICKERSON BAY	7	3	10
LEVY BAY	7	0	7
ALLIGATOR POINT	4	5	9
SHELL POINT REEF	1	1	2
WILSON BEACH	0	2	2
PINEY ISLAND	1	2	3
TOTAL	20	13	33

TABLE 2: Multiple recoveries.

TURTLE	1ST RELEASE	LAST RELEASE	WEEKS AT LARGE	CL GROWTH	GROWTH RATE	LAST CL
BBC112	08/16/90	03/01/91	30	1.3 cm	.043 cm/wk	32.8 cm
*BBC101	05/05/89	09/22/90	72	12.9 cm	.179 cm/wk	29.7 cm
PPJ963	04/04/90	08/10/90	19	3.3 cm	.174 cm/wk	33.0 cm
*QQA576	05/25/89	10/30/90	75	9.2 cm	.123 cm/wk	26.9 cm
*PPJ976	08/15/90	06/07/91	44	6.7 cm	.152 cm/wk	24.1 cm
*PPJ977	08/15/90	04/28/91	38	9.0 cm	.237 cm/wk	26.2 cm
*QQF409	08/15/90	05/02/91	40	-	-	-
PPJ978	08/24/90	05/19/91	41	2.8 cm	.068 cm/wk	34.3 cm

* Headstarted animals released by NMFS from Galveston or Padre Island, Texas

QQF409 was taken and released by a local resident and reported later

THE SEARCH FOR THE GREAT TURTLE MOTHER

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There is a myth among native peoples along the Miskito Coasts and Costa Rica that a 550 foot hill called "Cerro Tortuguero" serves as a beacon and guides sea turtles to the shore. Also, that a rock called "Turtle Mother" that is roughly the size of a mature green sea turtle revolves and points like a compass needle, to let the villagers know when the nesting season is about to begin. Turtle Mother, so says the legend, previously existed in Great Sandy Bay in the Miskito Keys. But when people ate too many turtles and harassed the rock, trying to force it to turn with crow bars, or move it from its perch, the rock vanished taking her turtles with her. Simultaneously the nesting beach washed away. The legend provides an important ethic in conservation as Dr. Bernard Neitchmann described in his book, "Caribbean Edge":

> Turtle mother.. was a benevolent spirit that acted as the intermediary between the world of animals and the world of humans. (She) could increase the likelihood for success by magically controlling a person's luck and the movements of turtles. If, on the other hand, an individual or the human community collectively did not observe specific taboos, and restrict over-exploitation, taking only what they needed and wasting nothing, the "Turtle Mother" would send the turtles far back out to sea beyond the reach of the turtlemen and cause their luck to turn bad.

Most of the old turtle fishermen claimed they last saw the rock in the late 40's sitting on the beach, near the red earthed Turtle Mountain that perches on the black basaltic magnetic sands. As exploitation escallated from the calipee market, and green turtles were butchered and left to rot on the beach, the Turtle Mother rock ascended the mountain. Finally it vanished completely into a cave. The entrance was then sealed by a landslide.

A few villagers ventured into the cave looking for the rock back in the 50's, but turned back because of the bats, the spooky feelings and the darkness. Some said the cave was filled with poisonous gas. The legend of the turning rock has remained amazingly consistent over the past twenty-five years. In a war-torn community where rumors run rampant, such consistency, according to Bernard Neithman who has lived with and studied the Miskito Indians, is highly unusual.

Generally the size, shape and type of rock has remained the same. Turtle Mother has been described as a basaltic "black rock, or reddish", as well as "white, like limestone." But like all legends there are certain minor variations in the telling, such as the rock that now lies hidden in the cave has "diamond eyes", or is made of "solid gold".

A new twist however was added in the lore in 1988. Some retired fishermen in Corn Island, Pearl Lagoon and Bluefields stated that they heard that "the rock was broken." Allegorically, I conjectured the breaking of the rock symbolized the Miskito world being cracked from war, dislocation and malnutrition. Their explanation however, was that scientists broke it by studying it, and some fool wrote a book about it.

By 1989 on my last visit to Nicaragua, the quest to discover the origins of Turtle Mother was at a stand still. It remained an isolated mythological oddity, restricted to the Miskito Coast of Central America. Then Jean Mortimer of the World Wildlife Fund wrote me of a similar turtle rock legend in Malaysia. A large rock that sat upon a hill called leatherbacks to the beach. But the rock was "deteriorating", and this was the reason the turtle populations were declining. In August, 1991 I visited Rantu Abang in the State of Terengganu on the East Coast of Malaysia and there was indeed a large limestone rock, approximately 3 meters long that lay shattered on top of a hill overlooking the ocean, somewhat shaped like leatherback.

Malay people told me during my visit that the rock was the "mother of the turtles" and called them to the beach during nesting. Some of the language was almost word for word as the Miskito Myth. Residents of Rantu Abang said the rock was broken because people no longer venerated the turtle rock, or laid flowers on it, or sprinkled holey water as they did thirty years ago. Instead, they paraded up to it, to get a four diget number for the lotto. Slash and burn agriculture for rubber plantations, and deforestation, they said, was responsible for its breakage.

Over-harvesting of the eggs, and the multitudes of tourists blasting strobes in the eyes of nesting turtles,was not considered to be a major cause of the decline. In Malaysia the turtle population, particularly the leatherback has all but ceased nesting on Malaysian beaches. Dr.Chan Eng predicts that by 1997, leatherbacks may cease to nest in Malaysia.

The persistence of this pantheistic myth among dominant contemporary religions is extraordinary. When I asked several ministers along the Miskito Coast if they thought the magic rock was inconsistent with their Christian beliefs, they said that it was "God's Creation," or "one of God's great wonders." Likewise, in Malaysia devout Moslems told me that the rock was created by Allah, to tell people when the turtles were coming to shore. Because the rock was benign, put there to help people, neither religion saw any conflict whatsoever with their beliefs.

Dr. George Balazs of the National Marine Fisheries Service noted in personal correspondence that there is similar turtle rock legend in the Hawaiian Islands. On the grounds of a hotel on the Big Island of Hawaii there is a rock called "Pohaku Honu" or turtle stone. If the stone was cared for properly, the legend said, the turtles in Hawaiian waters would be large, plentiful and tasty. Dr.Balazs said he grooms it every time he visits it.

Until recently there were numerous taboos regarding sea turtles in Hawaii and the Caroline Islands as to what one may or may not do when fishing for turtles. And who may or may not eat the meat. In Hawaii only the high chieftains were allowed to eat the meat; it was forbidden to everyone else. In Madagascar, Sakalava hunters had to obstain from sex for a week and use special "odoy's" or charms before hunting.

After the turtle was harpooned, or caught with a remora it was brought into the village and slaughtered. The blood was ritualistically sprinkled on the canoe, and the bones were put back into the sea, and the head placed on a special alter. Taboos served a necessary function in controlling surpluses and protecting natural resources.

Likewise today elaborate rituals and taboos exist among our regulatory agencies. Such taboos have been carried over into NOAA Fisheries, and the U.S. Fish and Wildlife, along with state natural resources agencies who demand elaborate rituals on paper to be performed before turtles may be taken. Those of you who sometimes feel that you have to walk over hot coals, fast, climb mountains and abstain from sex to get permits to study sea turtles under the Endangered Species Act, should not feel hard at the regulators. For they are carrying out ancient traditions thousands of years old that were ultimately created to prevent over-exploitation and should be thanked for it.

Science is by no means removed from ancient traditons. Even in our language we say that an animals is "sacrificed," for an experiment, not killed. Turtle science is also riddled with myths. "One percent of all the turtles hatched out of a nest survive to maturity" is good example. While such statements have no basis of fact and no experimental evidence to support them, they are repeated by rote over and over again. However, like the Turtle Mother myth, there is a germ of truth behind them. Seeing ghost crabs, birds and fish gobble up turtles, we know that relatively few survive.

Likewise we know that sea turtles do indeed orient to rocks and seek shelter beneath them. And that alone could be the origin of the Turtle Mother manifesting itself in the form of a rock. Colin Limpus in Australia and Norine Rouse in Florida have demonstrated the fidelity of loggerheads to specific rock outcrops. In Nicaragua, Bernard Neitchmann observed that hawksbills repeatedly returned to the areas where they tagged them. And Jean

Mortimer while tracking adult greens in Ascension, found that they concentrate around submerged rocks. Likewise Lou Erhard found juvenile greens stay around the worm rock reefs off southeast Florida.

Hence mythic associations between rocks and turtles can be easily established. More perplexing is the magnetism. The turning of the rock is analogous to a compass needle and the behavior of sea turtles. Norine Rouse told me that, while swimming with one of her loggerheads who was headed back to his home rock, she spun him around three times, deliberately trying to disorient him. Each time the turtle instantly turned back, and resumed its course.

There is growing scientific evidence that sea turtles may orient to the earth's magnetic field, beginning with the discovery of ferromagnetic crystals of biogenic magnetite near the brains of green turtles by Joe Kirschvinc of Cal Tech. The work was further expanded by Jack Music of the University of Maryland. Kirschvinc also demonstrated, using NOAA aerial surveillance data that loggerheads travel between magnetic anomalies while migrating up the Atlantic coast, orienting to magnetic minimas. Then Kenneth Lohman at the University of Illinois discovered that loggerheads change their swimming direction in a circular tank when the polarity is reversed.

But equally amazing was Dr. Vincent Malmstrom of Dartmouth College discovery of a Pre-Olmec stone turtle head with a lodestone nose. It was carved nearly four thousand years ago from a basaltic boulder at an Izapan Ceremonial Site on the Pacific plane of Mexico. While charting the astronomical alignments of pyramids to the summer winter solstice, he discovered the head to be highly magnetic, capable of deflecting a compass needle 60 degrees. In his paper in Nature, Dr. Malmstrom suggests the possibility that ancient peoples, possibly traveling across the Pacific in rafts, had some knowledge of sea turtles and magnetism. Our subsequent discovery of magnetic "fat boys" in La Democracia, Guatemala in 1978 proved the latter.

And two years ago Jim Spotilla of Drexel University merged both science and myth when he found that Cerro Tortuguero, the mountain where the Turtle Mother is said to now reside is highly magnetic. Using a magnetometer, he found that the mountain itself, and the lagoon had far higher readings than the beaches to the north and south.

Archie Carr wrote in "So Excellent A Fishe,"

"It is Cerro, the local legend says, that draws in the green turtles each July from all over the Caribbean. It is just folklore, of course, that wild notion about the mountain being a beacon for migrating turtles. But I have spent ten years looking for a better theory to explain how they find the place, so I never argue the point."

Unfortunately Cerro Tortuguero is in jeopardy. Plans are underway by the Ministry of Transportation to dig out 1500 cubic yards of aggregates to resurface the air strip in front of Casa Verde, the turtle station. Around the time of the earth day Earthquake on April 22, 1991, excavation began on the western side of the mountain by a construction Company mining aggregates for the airport in Barro del Colorado. A gaping hole was made in the red earth and a dozen huge rain forest trees were pushed over before the operation was stopped by the villagers of Tortuguero.

Shortly thereafter the earthquake killed approximately a hundred people, and destroyed the nearby Village of Martinis,where egg poaching and slaughter of nesting leatherbacks for their eggs was rampant. The earthquake raised the canal, draining it of water and making navigation almost impossible. Although it is being opened, it has caused a severe economic loss to the village of Tortuguero.

If the Mountain is taken down to make an aerial door mat for ecotourism, will the Turtle still come? or will Turtle Mother withdraw her turtles and send them far out to sea where no one will catch them, and the flocks of tourists that provide an economic base for the village vanish as well? If there is anything to the old legends that the mountain guides the turtles to the beach, the magnetic mountain at Tortuguero should be left alone.

The big turtle beneath our feet may become even more disgruntled and aroused. The myth that the world rests on the back of a giant turtle is world wide, found among the Indians in North and South America, the Chinese and the Hindu, and with continental plates sliding over the earth's firey core, it may be true.

So what does this have to do with us at this conference?

The answer is obvious. The Turtle Mother in Malaysia is shattered. The Turtle Mother in Costa Rica has hidden in a cave and slammed the door behind her.

The traditional relationships of humans to the earth is almost gone. Everywhere we face the consequences of global warming, ozone loss and extinction.

Our job, as we share information this week, and after we go home, is to make the turtle rock whole again. As one young biologist said in Malaysia, "we must ascend the mountain with a bag of mortar, and put the Turtle Mother rock back together again."

MEDASSET'S 1990-91 RESEARCH CONCLUSIONS FOR THE ENDANGERED MEDITERRANEAN SEA TURTLE

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Presented by **Lily Venizelos**

INTRODUCTION

The threats to the survival of the marine turtle in the Mediterranean are no different than those in the rest of the world; loss of habitat to tourism, injury and death via fisheries, pollution of the sea and direct human predation has put their very existence in these waters at jeopardy.

Mediterranean Association to Save the Sea Turtles (MEDASSET) recognised these problems and placed emphasis on field research on a broad number of topics for 1990 and 1991. It was a very busy period, and five research projects were carried out. Sadly, in too many cases the "success" of the project was only in confirming that nesting was not successful, mainly due to human interaction.

PROJECTS

A survey of all potential nesting beaches and sand dune status on the mainland and islands of the North Aegean Sea, Greece.

Nesting in the North Aegean Sea has apparently never been proved, though there are many reports that turtles occur there. Furthermore, the finding of several leatherbacks (*Dermochelys coriacae*) started speculation as to whether this species might even breed somewhere in the region.

The aim of the research project was to survey this, the remaining outstanding Greek coastline, for the incidence of marine turtle nesting, and to prioritise that areas for marine turtle conservation. The North Aegean coast from Macedonia and Thessalia in the west, to the Turkish border in the east, including four islands, was surveyed for sea turtle nesting in the summer of 1991. 2078km of coastline with a total of 213 beaches comprising 664km, were surveyed. Forty-nine beaches with a total of 140km looked to the experienced eye, always a subjective decision, like possible nesting beaches. Another 42 beaches (150km) looked like less suitable, but still possible, nesting beaches.

In total, only one false crawl was found on the island of Limnos. Therefore it can be stated that no significant breeding occurs in the North Aegean; this in turn confirms the importance of key nesting beaches in the Ionian Sea (Greece), the Turkish Mediterranean coast and along the Cypriot coast. The reasons for the lack of nesting turtles in the North Aegean is thus not a lack of suitable habitats. The reason could be climatic. A study was made to compare the climate of the nesting and non-nesting sites in Turkey and Greece. The Aegean region is a transition area between the Mediterranean climate of the eastern Mediterranean and the continental climate of Bulgaria. The duration of the hot season is decisive for sea turtle nesting. The summer may be too short for the successful establishment of a sea turtle population in the North Aegean Sea. If occasional nesting does occur the population size must be said to be unimportant compared to those others found in Greece and Turkey.

Several small loggerhead turtles, *Caretta caretta*, were found dead washed ashore (ccl <40cm for four specimens and <67cm for two others), and interviews with local people brought some information. It became evident that the North Aegean holds an important sub-adult, non-nesting population of loggerhead turtles. They may come from Turkish and Greek nesting localities because both areas are equidistant from the North Aegean. All loggerheads were found in the eastern half of the study area, and also all reports of local people refer to this location. The reason may be that there is a very large area of shallow sea providing a rich, relatively warm feeding ground with extensive sea grass beds. Almost all of the 213 beaches were polluted in some way, most commonly with litter washed ashore, but also sewage and oil leaking from barrels was noted. A detailed inventory of all the beaches and sand dunes was made.

A nesting beach and sand dune assessment of Sardinia (with emphasis on the Gulf of Orosei), and an investigation of reported exploitation of loggerheads, *Caretta caretta*.

Loggerheads are regularly recorded around the southern Italian coast and Sicily, but females are reported to nest there only once or twice per season. This area of the Mediterranean is also witnessing many intentional and accidental turtle captures by fishery operations based in Italy, Tunisia and especially Malta. It was therefore considered urgent to conserve any surviving nesting habitats in order that some recruitment might offset losses of such a slowly maturing species. This initial short term study was designed in the absence of any previous comprehensive survey for nesting in Sardinia, and in the light of increasing uncontrolled tourism. Eastern and south-western Sardinia were surveyed during mid-summer in 1990 and 1991.

This time of year was chosen to try and enhance the possibility of finding tracks, nest pits or hatchlings. Again a subjective method of defining suitable nesting beaches was used. Physical suitability, the type of development and the density of daytime visitor use were the three parameters in the categorization. A detailed inventory of the sand dunes was also made. No evidence of current nesting was found, and significant breeding populations are unlikely to be present. However, daytime tourist pressures on many beaches greatly reduced the chances of locating low density nesting. Increasing tourism is rapidly destroying nesting potential, but 5 particularly good beaches were identified and need more detailed study. The continuing local presence of adult and sub-adult loggerheads offshore was confirmed particularly around the Gulf of Orosei. Whether low level nesting still occurs in Sardinia by loggerheads has yet to be ascertained, but any such recruitment could prove crucial for their stocks in the western Mediterranean.

The first ever survey of the entire coastline of Syria for the occurrence of green and loggerhead turtles.

Along the Syrian coast four areas were found that could, in principle, provide nesting facilities for both *Chelonia mydas* and *Caretta caretta*. The Syrian coastline was found to be amongst the most severely polluted in the Mediterranean, with plastic rubbish forming a 30cm thick layer on the sand and in the splash line. Sewage pipes ran directly into the sea, and the water was usually dark gray to black and covered with floating garbage. Only some 20-30m from the shore did the water become blue. The one area with significant nesting was between Jeble and Latakia in the centre of the Syrian coast.

On June 22, 1991, scientists surveyed the 15.5km beach and found 24 fresh tracks. Four of the tracks were false crawls, two were unclear as to whether nesting had occurred, and the remaining 18 had nested successfully. All the nests had been opened by predators. Surprisingly there were no egg shell remains or tracks. The predator may be human. Upon a second visit three days later another five tracks were found. Again all the nests had been opened. The Latakia-Jeble beach should be protected from tourist or industrial development, and the nests should be protected from human exploitation. A futher recommenation is that the Syrian government should be offered international support to solve the immense garbage and sewage problem that occurs along its coast.

Incidental catch of loggerhead turtles on swordfish long lines in Greek Ionian waters.

Most research over the last decade in the Mediteranean Sea concerning sea turtle conservation has been on nesting beaches. However, very little is known about the threats in the turtle's principal habitat, the sea. One major threat is long line swordfishing. Many turtles may survive this experience, and the actual mortality so caused is unknown, but estimates have been between 15 and 50%. The data shows considerable catches, but the information is very incomplete, particularly that for the Ionian Sea. The need for further data is evident in order to assess the impact of the swordfish fisheries on this long-lived species in one of its most important nesting areas.

Monitoring of incidental catches of turtles in the central and southern Ionian Sea continued during the fishing season for swordfish, May-Sept., in 1990. The data were collected and evaluated by the captains of three vessels and biologist Aliki Panou. All fishing trips and catches were recorded. The size of caught turtles was estimated and, whenever possible, their sex recorded. All turtles were released alive with the hooks in the mouth cavity by cutting the nylon line while hauling in.

Of the 171 registered fishing trips, 43 of them caught 49 turtles. All of them were loggerheads. The size of the animals varied between 20cm and 70cm. Only one turtle was of adult size, about 100cm. No significant difference in the frequency of catches was found betweeen the northern part of the study area, where there is no known nesting, and in the south where the largest known concentration of turtles nesting in the Mediterranean Sea occurs. Although the data are incomplete, the monthly frequency of catches per fishing trip indicates that most of them occur during the nesting period from May to August. A major factor for the conservation of turtles is the attitude of the fishermen. Among the Greek captains working on the swordfish boats, the attitude is very positive towards the turtles, and they are keen to participate in the research efforts. Another severe threat to the loggerhead's population is most likely posed by drift nets which are heavily used not far from the study area. The data have shown that most of the turtles caught on the swordfish lines were relatively small. This may indicate that the adult fraction has decreased due to death in drift nets. The use of such fishing methods may prove fatal to the species, combined with long line catches and the loss of nesting sites in one of the main loggerhead breeding areas.

A conservation assessment of the South West Pelepponese, Greece, for *Caretta caretta.*

The status of *Caretta caretta* in the Mediterranean, as estimated by Groombridge 1989 and UNEP 1989, suggests that between 3000-4000 nests are laid on Mediterranean beaches each year. A major percentage of these nests are laid in the Laganas Bay area of Zakynthos. The SW Pelepponese coast is directly southeast of Zakynthos Island, less than 100km away. Loggerhead nesting has been recorded in Kiparissia since 1987 by the Sea Turtle Protection Society of Greece. A 3km area of particularly high density nesting was found along the 44km of sandy beaches in the bay. A total of 598 nests were recorded from the bay during the 1987 season.

This study is concerned with the current and potential impact of tourism and other development in the SW Pelepponese on the conservation of the loggerhead through distrubance or damage to the nesting areas and breeding grounds. The study provides an assessment of potential hazards to breeding turtles in the areas found to be used by *C. caretta* and identifies the areas with greatest priority for protection in terms of having the greatest numbers of nests. The beach between Kalonero and Bouzi was found to be the most important section of the coast as regards numbers of nests, 94 in total representing 65% of nests seen on all sites. The highest density was 20 nests/km. In terms of the nest numbers, the area is clearly of less importance than Laganas Bay in Zakynthos, but a tagging program has been set up by the STPS and may answer the question of whether the populations of turtle rookeries nesting on Zakynthos and the Pelepponese are separate or interchangeable.

At present the area identified here as being of most importance to turtle conservation is remote from any tourism development. Three hazards to the turtles were noted however; tracks of heavy vehicles and signs of sand mining; a rough road running along the back of the beach causing erosion of the protective sand dunes; and several nests destroyed by animals. The conclusions drawn from this research are that this area of the Pelepponese has not received the attention of the large scale tourism developers. However, the area provides attractive beaches and scenery, and this study was catalysed by reports of plans to develop sections of the coast. It is recommended that before development is permitted, an EIA with special regard to its potential impact on the rookery should be carried out.

CONCLUSION

MEDASSET's conclusions can be none other than to keep up this vital assessment of the status of the marine turtle in the Mediterranean, not only to discover any as yet unknown nesting, feeding and over-winter sites, but to try and maintain and protect those areas already known to us that are in grave danger of being destroyed. We have learnt recently that this job is to become even more difficult. In the future, grants from the European Community (EC) are to be cut to only 50% of the total budget for research projects (previously, they provided 90%), leaving the penniless NGOs like MEDASSET to provide the other 50%. One recent glimmer of hope seen on the horizon is that the DGXIB Habitats Directive of the EC has included *Caretta caretta* as one of only six reptiles to be protected. Sadly *Chelonia mydas* does not get such protection because the main breeding sites of the species of turtle in the Mediterranean do not occur on the shores of EC countries.

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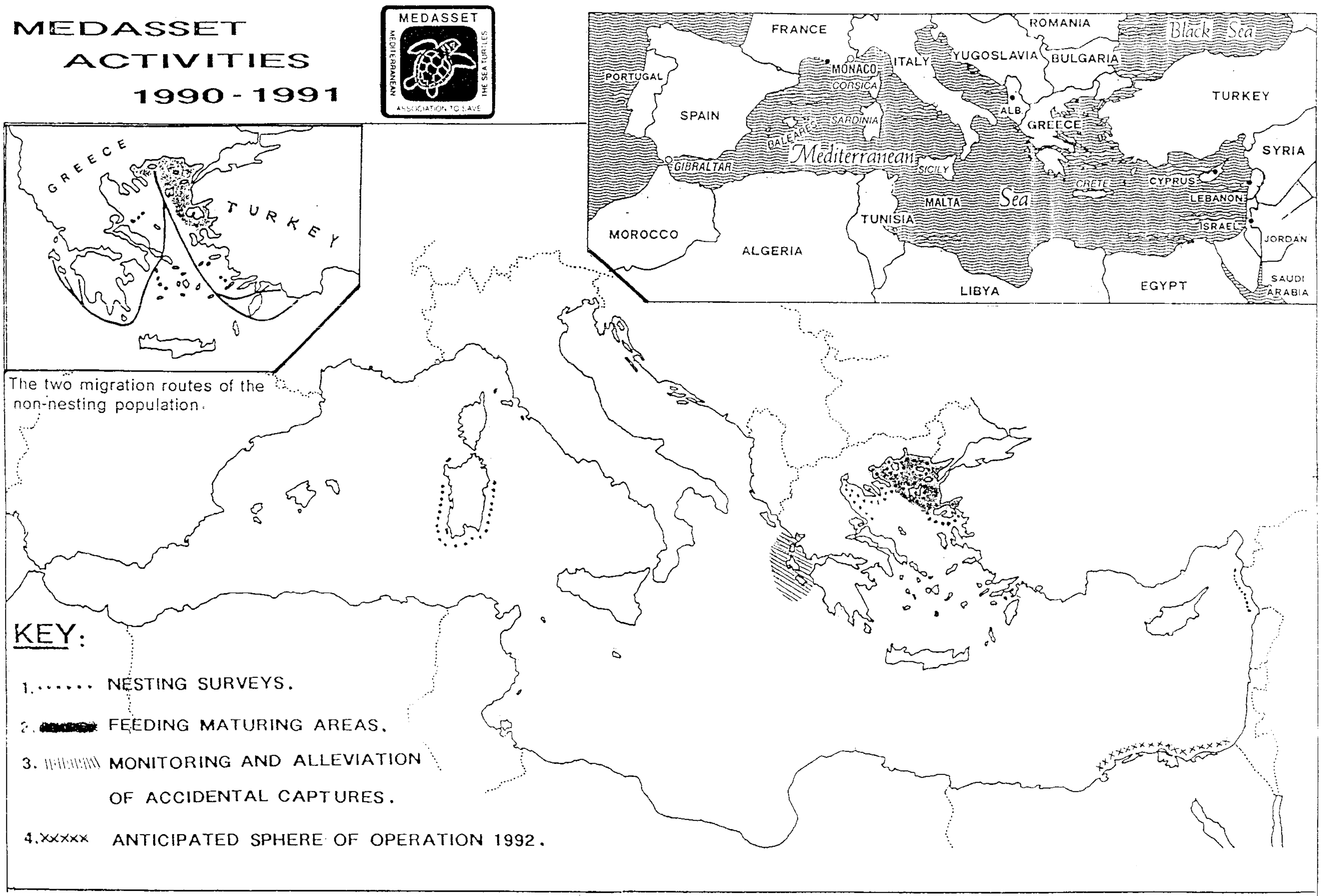
* EC requested MEDASSET to do this work. MEDASSET contacted name above and coordinated work.
** MEDASSET coordinated and sponsored these programs.

MEDASSET ACTIVITIES 1990 - 1991



POPULATION STUDIES OF MARINE TURTLES IN FLORIDA BAY

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Population studies of marine turtles in Florida Bay, Florida were initiated in June 1991 with the cooperation and logistical support of Everglades National Park. Florida Bay is a large triangular-shaped body of water approximately 2200 km^2 in area located at the southern terminus of the Florida peninsula. The primary objectives of the study are: 1) to examine species composition and population structure, 2) to investigate the seasonal occurrence and geographic distribution of turtles in the study area, and 3) to document the occurrence of fibropapilloma and examine the distribution, species composition, and population structure of infected turtles. Turtles are captured by several methods depending upon water clarity, tidal conditions, and type of habitat. Capture methods involve large-mesh stationary tangle nets, large-mesh tangle nets drifted with the current, hand capture by snorkelers towed behind boats, and hand capture by divers jumping from the bow of a slow moving boat. All turtles are measured, weighed, and doubled tagged with 681 Inconel and Dalton rototags. A blood sample is drawn for sex determination via testosterone assay. During the first eight months of the study, we sampled a total of 21 days and captured 49 loggerheads (*Caretta caretta*), 26 green turtles (*Chelonia mydas*), and one hawksbill (*Eretmochelys imbricata*). The mean straight-line carapace length for loggerheads was 82.1cm (range 48.9 - 98.7cm); green turtles averaged 50.2cm (range 37.0 - 62.9cm). 69.2% of all green turtles captured exhibited fibropapilloma. Study continuation and future plans include: 1) continue monthly sampling and explore new sampling sites within Florida Bay and along the Cape Sable-Shark River area, 2) implement aerial overflights immediately prior to monthly sampling, 3) investigate radio and/or sonic telemetry as a tool for studying local movements and behavior, and 4) investigate satellite telemetry as a tool for studying long range migratory behavior of adult male loggerheads in the southeast United States.

OBSERVATIONS AND DATA FROM MARICULTURE LTD., GRAND CAYMAN ISLAND

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In 1968, Mariculture Ltd. was capitalized at a million dollars. Salt Creek, the first Grand Cayman site, was an extension of the floating cage concept my wife and I had used in the Florida Keys. The Northwest Point site was land-based. The first thing we did there was dig a breeding pond: we wanted to produce our own eggs as soon as possible.

We collected eggs from Costa Rica, Ascension Island, Suriname, and Guyana. Our first hatches were 50% to 60%, but we improved with practice. Our last Ascension and Tortuguero hatches were 82% and 90%. I opened every egg that failed to hatch, and classified it "Dead at Hatching," "Dead at Term," "Dead at Midterm," "Dead Embryo," or "Infertile." We measured temperature and humidity in wild nests and selected nest boxes, and tried to match the natural parameters in our hatchery.

Once we got it right, the only significant losses were in the "Infertile" category. The 8% difference between those Ascension and Tortuguero hatches was over a thousand dead eggs from Northeast Bay, stained rust-red by volcanic ash. Eggs packed in Southwest Bay's shell sand hatched 91%. Relative humidity in Northeast Bay upper-beach nests averaged 80%. Humidity in Tortuguero nests averaged 92%. In our hatchery, eggs in an experimental nest box were desiccated at 80% humidity. We found it best to collect eggs as early as possible. When we could, we caught them as they were laid. Usually we stopped collecting about 2:00 A.M.; by daylight, sea turtle eggs are getting sensitive to angular acceleration.

I think Ross Witham is right about hatchling green turtles eating jellyfishes. Like leatherbacks, they have soft, backward-pointing spines in the esophagus, but they probably eat anything they can catch. They do in captivity. Wild 2 to 3 kg Florida Keys turtles I examined had eaten only *Chondrilla nucla*, chickenliver sponge. Turtles of 5 to 15 kg had eaten *Chondrilla* and *Thalassia* grass in alternating layers. The smaller turtles had eaten very little grass. The largest had thick wads of grass separated by thin layers of sponge. None had mixed grass and sponge. Captive green turtles as large as 15 kg could not maintain weight on grass alone, but needed some dry feed.

Although little green turtles will eat almost anything, they can not digest everything they will eat. Wheat gluten can cause fatal bloating in turtles up to three years old. Our first good diets were floating trout feeds based on fish meal. Later, Hal Yacowitz's lab in New York analyzed *Chondrilla* and *Thalassia* for us. Central Soya used the data to compound #9346 "Sponge Cognate" for small turtles, and #9347 "Grass Cognate" for larger ones. Turtles of all ages ate "Sponge Cognate" eagerly, but not "Grass Cognate," which was cheaper. Hatchlings still needed a 50% ground squid supplement for the first couple of months.

Hatchling green turtles can double their weight every ten days. 3600 Ascension hatchlings I raised myself in crude wooden tanks averaged 5 kg at one year. The best tanks converted dry feed to live turtle at a ratio of 0.89 to one, like turkeys or chickens. With reasonable care, two-year turtles averaged 15 kg and three-year turtles 30 to 35 kg. The turtles appeared to grow in spurts, increases in carapace length alternating with weight increases.

With proper nutrition and clean water, the only disease problem was a yellow infection on lesions, and in hatchlings' eyes and nostrils. This tended to disappear with age and improved diet. Chlorinating and ozonizing the water both looked promising, but were not followed up, at least to my knowledge. We treated the yellow infection with gentian violet, and devised techniques for clearing hatchlings' eyes and nares. This involved considerable labor, but was fairly effective. After Jean and I left, there were periods of poor feed conversion ratio, slow growth rate, and explosive mortality, but that is another story.

We put 16 adult Costa Rican females in the breeding pond Sept. 6, 1969. The night of Sept. 7th, two emerged to dig three body pits and nest holes. Turtles nested almost every night that month. We didn't find all the nests; the night of Nov. 13th, the watchman called to say the pond was full of hatchlings. We bought breeding stock from the schooner "Maitland Adams" when she finished her final cruise. A collecting party brought turtles from Guyana. I brought two large males from Ascension Island. Jim Wood now has an F-2 generation that almost certainly is hybrid.

Fat, healthy adult green turtles will mate and produce eggs. If they can't find their natal beaches, they will nest on any beach available. Jim Wood's F-1 generation was hatched in boxes and put straight into tanks. When they grew up, they mated, "migrated" about 50 feet, and nested. Even badly "disoriented" turtles probably will nest somewhere, if not on their natal beaches.

We released about 5000 tagged turtles in Florida and the Caymans. Several yearlings released at Cape Sable were caught in the Keys and returned alive. They had grown about as fast as our captives, though at varying rates. A 2 or 3 kg turtle released on Cape Sable Beach tried to dig a body pit. That's real disorientation! Several turtles in the 1 kg range were found stranded on nearby Keys, emaciated and stuffed with *Laurencia*, a red alga. Turtles that small probably are not viable in the coastal shallows.

On Grand Cayman, I got back tags from Cuba, Nicaragua, Honduras, and Florida. Yearling green turtles will swim all over the place. I suspect that is natural behavior, not disorientation. "Headstarted" green turtles do survive and grow. I can't even guess what percentage reach sexual maturity. Those that do probably will breed, but I don't know that enough survive to justify the cost. Very likely, there are better ways to increase recruitment.

Do hatchlings or older turtles imprint on beaches or navigation cues? If so, on what do they imprint? How do they use the data? Do they have innate orientation mechanisms? Site imprinting of sea turtles is not classical imprinting. Suggestions:

Scent: adult sea turtles breathe through their mouths, not their nostrils. They do pump water through their nostrils, occasionally holding a throatful for a time, then expelling it and drawing another. A migrating turtle might carry a water sample a distance and compare it directly with the next sample, greatly increasing the apparent scent gradient. Egg slops from thousands of nests must give rookery beaches a characteristic smell. Rivers' unique scents may be beacons; the Tortuguero and Parismina effluents define Turtle Bogue. Breeding turtles may smell Ascension Island's guano, littoral fauna, or volcanic ash a thousand miles downcurrent. Rathke's gland scents may assemble breeders, and guide subadults to parental breeding populations.

Sound: turtles may hear seas break on beaches and island shores. Many littoral organisms like Alpheid shrimps, grunts, drums, and toadfishes make loud noises. Under water, even I can hear the surf rattle on a pebble beach, and the roar of breakers. Sharks are attracted from afar by low-frequency vibrations. Why not sea turtles? They may hear these sounds a hundred or more miles away.

Light: turtles must know the sun rises east and sets west, and likely respond to changes in the length of day. In a year, the sun's apparent altitude swings up and down 47 degrees. Archie Carr wondered how coastal Ridleys move north and south with the seasons: perhaps they chase the sun. The same response might cue hatchlings to turn south as the Gulf Stream sweeps them northeast toward Europe. They would only need to detect a 20 degree change in solar altitude to follow the sun into the Sargasso Sea.

Waves: Salmon and Lohmann have shown hatchlings orient by waves and swells. Adults also may detect wave reflections from shores, and interference patterns around islands. Read Lewis's "We, the Navigators." If Polynesians can do it, so can sea turtles.

Magnetic Field: Kenneth and Catherine Lohmann have demonstrated hatchlings have a magnetic sense, and set their "compass" as they go down the beach (this volume). Perhaps they detect not only magnetic headings, but also the magnetic field's "dip" and anomalies.

Archie Carr concluded his turtle flights were a failure. I am not sure they were. I rode that flying boat, and followed several groups of hatchlings offshore. Predators were taken completely unawares. At Tortuguero, sharks and jacks wait in the surf, but not where turtles no longer nest. Archie was discouraged because turtles were not returning to beaches where hatchlings had been released. He assumed they would imprint on those beaches. They may, but we don't know on what they imprint, nor how they use it. Site imprinting may identify a beach once a turtle gets there, but be inadequate to guide its return. Breeders do not retrace their juvenile wanderings. Miskito Keys turtles form fleets that swim directly to Tortuguero, not all over the Caribbean.

Green turtle populations do differ genetically. Jean and I could distinguish yearlings from different rookeries by their shell markings, and Ascension hatchlings have a very short "swimming frenzy" compared to Costa Rican hatchlings. These differences would not exist if post-pelagic turtles randomly joined breeding populations. At some stage, they must find their parental stock. Many of Archie's released hatchlings eventually may have joined their elders on the Miskito Banks.

The most effective headstarting may be to scatter beach-imprinted hatchlings in their pelagic habitat. If so, an airfreighter could "headstart" tens of thousands in a few hours. But where? The Sargasso Sea? The Caribbean Gyre? The Florida Current? Or is the swim offshore necessary to orientation? We don't know.

There are indications. Unlike green turtle populations almost everywhere else, Florida's nesting population has grown rapidly. Florida's green turtles have several things in their favor: they suffer little human predation because both nests and adults are protected. There is no "beach patrol" of predatory fishes because the numbers of hatchlings entering the sea are small. The Gulf Stream is close to shore, requiring a relatively short swim to reach it, or, for that matter, the Sargasso Sea.

Nor would post-pelagic turtles need great navigational skill to find their way back. They need only swim west until they reach the coast, then turn north or south, depending on their approximate latitude. They need be in no hurry: they would not mature for years to come.

Florida green turtle DNA resembles Tortuguero green turtle DNA, suggesting they are the hatchlings Archie Carr sent on the Navy flying boat. That is evidence for at least approximate site imprinting, even if it only enables them to recognize a beach once they get there. Site imprinting and seeking a parental stock are not mutually exclusive.

I am uncomfortable with the idea that hatchlings are "plankton," carried helplessly by ocean currents. No creature that swims so actively as a hatchling sea turtle is truly planktonic. Although hatchlings could not breast the Gulf Stream, they quite easily could cross it. I cannot believe sea turtles have evolved no responses to guide hatchlings toward favorable pelagic habitats.

The notion that "lost" hatchlings die of starvation fills me with deep doubt. Hatchling green turtles that do not begin to feed remain active, and take months to starve. For anything that eats jellyfish, the sea is full of food. Those who believe hatchlings flounder helplessly once they are offshore should spend more time in the ocean. Even the most primitive sea creatures are amazingly responsive to environmental challenges. What kills hatchlings? Predatory birds and fishes. The "swimming frenzy" is a race for dispersal to areas of low risk. The hatchling a jack or kingfish spots is dead. Few hatchlings, I suspect, allow themselves to be swept helplessly away from favorable offshore habitats.

In addition to tagging small green turtles in Florida, why not take DNA samples and photograph scute markings? Since populations are distinct, turtles' origins can be identified. Once the data were correlated, the field scientist might identify juveniles from different rookeries at a glance, though Florida and Costa Rican turtles probably cannot be distinguished. Eventually, data might be accumulated to define the range and maturational migrations of each breeding population.

Great effort is expended on rookery beaches to reduce predation on eggs and hatchlings. It is accepted that the sacrifice of even a few for research is unjustified. Yet the predatory fishes that wait in droves off every major rookery beach receive very little attention! Sharks, jacks, tarpon, catfish, accustomed to a yearly bonanza of hatchlings, consume an unknown - but probably large - percentage of each year's hatch within a few dozen meters of the shoreline. Nor are their numbers necessarily reduced when the number of hatchlings is reduced; over half the year they depend on other prey. The matter could be investigated with some fishing tackle and a little time. Nor is the problem insoluble.

At present, Mexico and Costa Rica have excellent research and conservation programs. Caribbean green turtles and Kemp's ridleys are holding their own. But the world's troubles have not ended. Humankind continues its inexorable increase, and policies are the most ephemeral of human artifacts. If sea turtles are to survive, not only during this generation but the next, and the next, ways must be found to increase recruitment until they become not just a protected remnant, but a valued resource.

I don't know if it's possible to increase recruitment. Sea turtle fecundity tempts me to think it is, but the data do not yet exist to design a program. For starters, somebody should go offshore and find the "lost year" needle in the haystack. That will not be easy; for little turtles, safety lies in dispersal. But they are out there somewhere, and they can be found. Then, imprinting must be understood. Eventually, perhaps, imprinted hatchlings can be helped to bypass their most dangerous predators. Nothing more may be necessary to bring back the great fleets of the past.

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THE EFFECT OF PLASTIC INGESTION ON LIPID METABOLISM IN THE GREEN SEA TURTLE (*CHELONIA MYDAS*)

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INTRODUCTION

The increasing incidence of plastic debris in the ocean raises concerns for the well-being of marine species where foraging areas are being polluted. Sea turtles consume a wide variety of debris, with plastic bags and sheets appearing to be the most prevalent contamination. For example, in one study by Mrosovsky (1981), 44% of adult non-breeding leatherbacks necropsied were found to have plastics in their stomachs.

Clearly, if sufficient material is swallowed to cause a complete obstruction of the gut, death will result from starvation, and there are many such documented cases in the literature (Balaz, 1985; Cawthorn, 1985; Bolton and Bjorndal, 1991). However, the consumption of such large amounts of plastics will be a relatively rare event compared with the frequency in which smaller quantities are ingested. If these smaller quantities cause harm, then ocean plastic debris presents a much more serious threat to sea turtles than is currently appreciated.

In a previous study by Lutz *et al.* (1990) it was found that ingestion of plastic materials by sea turtles is not merely incidental to feeding but that, when hungry, these animals actively seek out and consume floating plastic sheeting, indicating that in polluted areas, rates of plastic ingestion are likely to be high. Although no acute harmful effects were observed in that study, concern was expressed over the observation that ingested materials could remain in the gut for up to 4 months.

The anatomy of the sea turtle gastrointestinal tract (GIT) certainly appears to be predisposed to obstructions. The esophageal papillae and the cardiac sphincter make it difficult to expel material once it is swallowed, and the highly convoluted intestine provides many sites for abrasions and accumulation of non-digested debris. In view of the great concern expressed over the ubiquity of plastic ingestion by sea turtles, it was thought important to carry out a concerted study on the effects of plastic ingestion on normal gut function, nutritional status and behavior. Extended intake of moderate size pieces of plastic debris was examined, since chronic ingestion of plastic debris over a prolonged period is likely to be a common occurence in heavily polluted areas.

MATERIALS AND METHOD

Four subadult green sea turtles (*Chelonia mydas*) ranging from 10-20 kg were used in this study. They were kept separately in tanks of approximately 1000 gallon capacity, which were supplied with running filtered sea water. Baseline blood profiles as well as fecal exams were taken, and each turtle served as its own control. Each turtle was offered a single 10x10 cm piece of plastic sheeting once per week for 4 weeks. Throughout the course of the experiment, they continued to be fed their normal diet (Purina Turtle Breeder Chow 35) until satiation. Each day the tanks were examined for excreted plastic, and an observer waited to collect fresh fecal samples. The feces were examined for free fatty acids, neutral fats and occult blood.

In addition to fecal analysis, blood samples were routinely taken from the dorsal sinus (method by Bentley and Dunbar-Cooper, 1980) for the measurement of glucose and fatty acids. Glucose and triglycerides were measured in a Kodak echtachem clinical spectrophotometer.

The stucture of the alimentary system and the presence of obstructions was assessed by radiography. For routine radiographic exams, barium powder was mixed with Purina turtle chow and shaped into small pellets as in Davenport *et al.* (1984). X-rays were taken at 75 kvp and 100 milliamperes at 1, 3, 5, 24, and 48 hours. In order to visualize the lower segments of the intestine, x-rays were repeated 7 days later when the turtles were first observed excreting white feces; this also gave us a good idea of the normal passage time of ingested food.

RESULTS

On all occasions when offering plastics to turtles, they actively swam towards it and ingested it. They maintained their appetite throughout the experimental period, consuming an average of 240 grams of turtle chow per day.

However their appearance seemed to deteriorate towards the end of the experiment, such that the animals appeared to have lost fat around the neck area, and 3 out of 4 developed a marked positive buoyancy, floating one side uppermost. When these turtles were x-rayed, it became evident that the cause of floating was a generalized accumulation of gas in the intestines, causing them to be severely distended.

No evidence of occult blood was found, thus ruling out mechanical damage to the gut. In the baseline measurements the free fatty acid levels were low, averaging 3 droplets per field. However, plastic ingestion resulted in a marked increase of both categories of lipids.

Of the sixteen pieces of plastic fed, the first piece was recovered after 14 days, and only 4 (one per turtle) were recovered after 4 weeks. In one instance material was voided months later, only after the ingestion of a barium meal prior to an x-ray exam. These values are much greater than the normal 6-7 days passage time previously reported.

The blood glucose levels were maintained between 50-140mg/dl throughout these experiments, although glucose values dropped after the second week in one animal and after the 3rd week in the other 3.

There was a substantial and significant increase in the triglyceride levels in 3 out of 4 animals during the period of plastic ingestion, rising from an average of 260 mg/dl in the control portion to an average of 680 mg/dl after 4 weeks of plastic ingestion.

Radiographies were performed in turtles where ingested plastic persisted for more than 2 weeks. X-rays of chronically floating turtles revealed an abnormal accumulation of gas throughout the large intestine. These turtles were treated by feeding them squid injected with simethicone 100mg.

DISCUSSION

The present study confirms the finding that turtles when hungry will ingest debris. Plastic debris will move through the GIT at a much slower rate than normal gut passage time, and in one turtle persisting for 6 months. Radiography indicated that material was being held up in the rostral portion of the large intestine, a site which corresponds to the functional cecum described by Bjorndal (1985) in the green sea turtle. It may be hypothesized that the greater the amount swallowed and the longer it remains in the gut, the greater the potential harm.

The absence of hemoglobin traces in the feces rules out tearing of the gut lining. However, gut function was compromised as shown by the increase of lipid content in the feces. Steatorrhea or fatty feces is a forerunner of all mal-absorption syndromes and may indicate a deficiency in mucosal transportation of lipids in the gut (Bartley, 1980). Mal-digestion of fats could also be the result of a disturbance in bacterial fermentation which could result in an abnormal production of gas in the gut.

Further evidence of an interference in gut lipid metabolism is shown by the increase in serum triglycerides and the fall in blood glucose. For mammals, FFA levels are used as a sensitive index of fat mobilization, and an increase in triglycerides may indicate hydrolysis of adipose tissues as a response to a decreased energy supply (Kronfeld, 1965). Indeed, it has been suggested that plasma concentrations of FFA be used as an index to estimate maintenance requirements. The observation of emaciation further strengthens the diagnosis of fat mobilization.

Perhaps the most important and troublesome finding was the floating syndrome identified by x-rays as caused by gas accumulation in the large intestine. It is very likely that this gas accumulation is related to a disturbance in the bacterial fermentation processes of the green sea turtle gut. Maintenance of microbial fermentation is crucial for hervivores, including green sea turtles as Bjorndal has previously described. The bacterial flora produce not only volatile fatty acids and vitamins but are also an important source of protein. It is well established that in mammalian ruminants any abrupt change in diet or interference in their gut bacterial flora can result in acute rumen timpany or bloat (Hungate,1966). The floating syndrome could have serious general effects by reducing the feeding time or by increasing the metabolic cost of diving, as well as reducing the ability to escape predators. Abnormal buoyancy may also be a factor in the death of many sea turtles hit by boats or captured in nets.

It can be concluded that plastic debris poses a much more serious threat to sea turtles than the occasional mortality caused by swallowing large amounts necessary for gut blockage. Even small amounts of plastic may remain in the gut for months, causing a disturbance in gut function, lipid metabolism and resulting in excessive gas accumulation in the gut.

BY-CATCH CAPTURE OF SEA TURTLES BY TWO KINDS OF EXPERIMENTAL LONGLINE GEARS IN PACIFIC COSTA RICA WATERS

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INTRODUCTION

The longline pelagic fishery of Costa Rica is an increasingly important activity, both economically and socially. During the last two years, the University of Costa Rica has been involved in two projects evaluating the national longline pelagic fishery, first with dolphin fish (*Coryphaena hippurus*) as a target species, then with yellowfin tuna (*Thunnus albacares*) and big-eye tuna (*T. obesus*). Data pertaining to sea turtle bi-catch were also recorded.

Preliminary results of the incidental capture of sea turtles during the first project are reported in Segura and Arauz (1991). Preliminary results of the second project are reported in the current paper, as well as combined data with the first report .

MATERIALS AND METHODS

Just as in the previous report, data were collected on the University of Costa Rica's "Searcher", a 25.6 m steel trawling vessel adapted for longline fishing activities. Fishing ground sites were selected following the criteria described in the first report.

From October 1991 to February 1992, 27 longlines were deployed, with an average length of 17,856 meters (range: 4,500-25,300 m), whereas the mean number of hooks cast per longline was 577 (range: 90-506), with hooks spaced 50 meters apart. Average fishing time was 12.3 hours (range 7-17 hrs). Jumbo squid (*Dosidicus gigas*) was the main bait, together with herring (*Opisthonema libertate*), although sail fish (*Istiophorus platypterus*) was used to a lesser degree.

Coordinates were recorded for sites where sea turtles were captured. When conditions permitted, sea turtles were brought on board to be identified, sexed and measured (CCL, SCL). Live turtles were released. Dead turtles were used for stomach content analyses and gonad development. Surface water temperature was also recorded.

RESULTS

Thirty-one sea turtles were captures in 13 of 27 deployments (48%). Twenty-nine were olive ridley (*Lepidochelys olivacea*), and two were Pacific green turtle (*Chelonia agassizi*). Twenty seven of the olive ridleys were sexed, 12 males and 15 females (0.8:1.0). Mean CCL of eigth males was 68.1 cm (range: 66-73 cm). Mean CCL of fourteen females was 58.9 cm (range: 49-69 cm).

Table 1 presents comparative fishing data obtained for each kind of longline.

Three turtles (all females) were dead (mortality=10.3%). In 22 cases, 19 olive ridleys (86.4%) were hooked in the mouth and 3 (13.6%) by a front flipper.

One male and one female Pacific green turtle were captured. CCL was 78 cm for the male and 70 cm for the female. One was hooked in the mouth and the other on a flipper. Both survived.

DISCUSSION

Interesting results comparing the sea turtles captured by two kinds of longlines are CCL, sex ratio, mortality and fishing effort.

The difference in length of turtles between the two longline types was small.

The sex ratio of the turtles captures in the dolphin fish longline was proportional, while in the tuna longline, more females were captured than males.

Mortality in the tuna longline was higher than in the dolphin fish longline; we attribute this to the fishing depth, in that the turtles can't get to the surface to breathe when captured by the deeper tuna longline.

The catch-per-unit-effort in our study (Table 2) was very high when compared to Nishemura and Nakahigashi (1990) and Witzell (1984). Our data were all collected in territorial Pacific waters by a single research vessel, often close to two important nesting beaches (Ostional and Nancite), whereas the afore mentioned authors cover an enormous expanse of ocean and a great number of fishing vessel (research and commercial).

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TABLE 1. Comparative fishing data for two kinds of experimental longlines.

	dolphin fish longline	tuna longline
length between hooks (m)	12	50
# hooks	mean 577 (max 750,min 150)	mean 477 (max 506,min 90)
#meters	mean 8000 (max 9000,min 1800)	mean 17856 (max 25300,min 4500)
fishing hours	mean 10 (max 11,min 5)	mean 12.3 (max 17, min 7)
# deployments	49	27
# deployments with turtles	31(63%)	13 (48%)
fishing depth	surface	up to 80 meters
turtles captured	83	31
# of black turtle	1	2
fishing effort each 100 hooks	0.3	0.3
length in cm. CCL	mean female 61.1 max.69, min.46 ST=6.7 mean male 67.3 max.71,min 65 ST=1.6	mean female 59.1 max.69, min.49 St=7.2 mean male 68.1 max. 73, min 66 ST=2.0
mortality	1.2 %	10.1 %

TABLE 2. Comparative cpue or fishing effort (per 100 hooks) of three studies.

STUDY	AREA	CPUE
Nishemura and Nakahigashi (1990)	Occidental Pacific and Central (35 N-35 S)	0.1
Witzell (1984)	Gulf of Mexico Atlantic fishing zone of USA	0.018 7.4 *10 (-4)
this study	Costa Rica Pacific Waters	0.3

A COMPARISON OF FLORIDA SILICATE AND BAHAMIAN ARAGONITE SAND AS SUBSTRATES FOR SEA TURTLE NESTING

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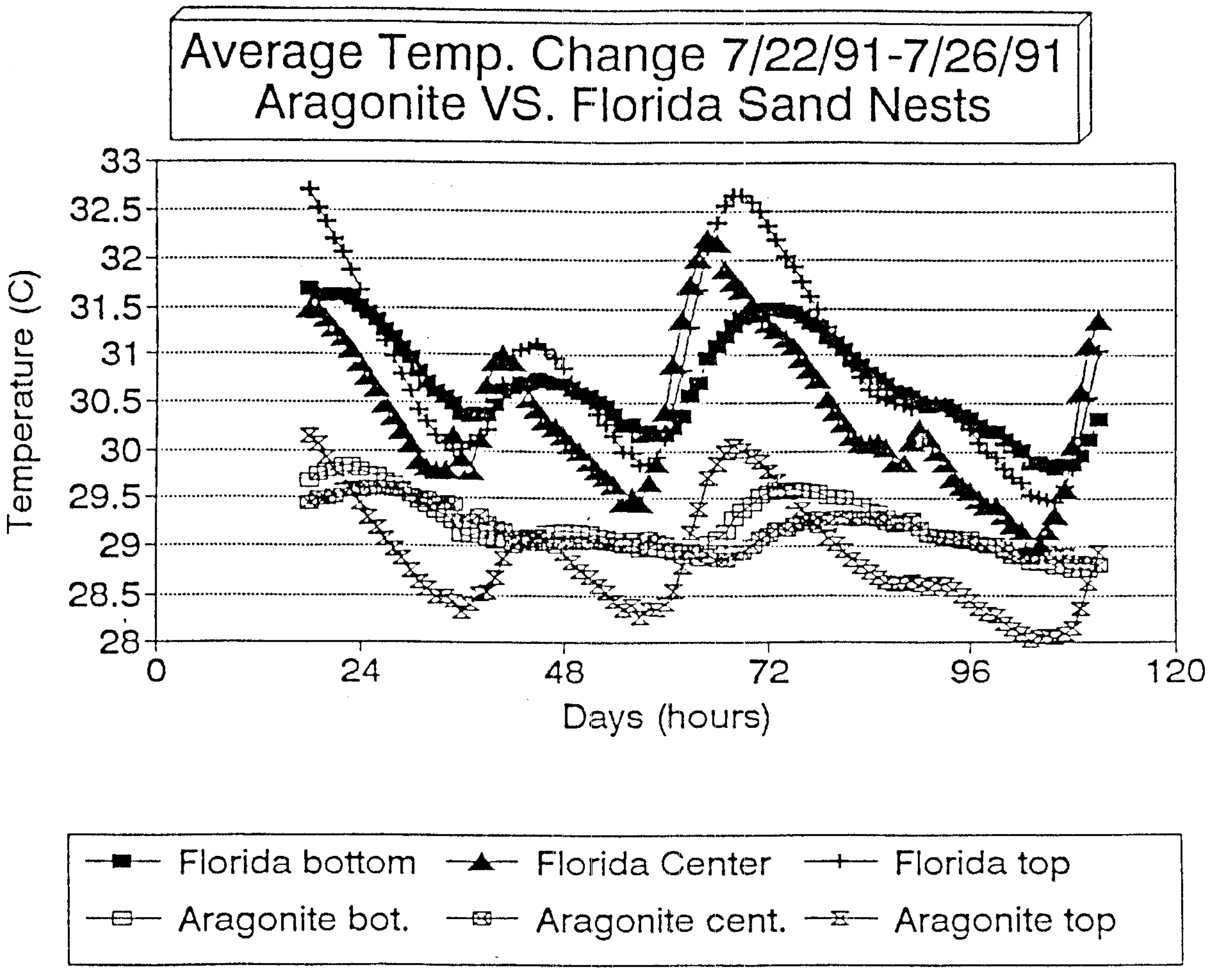
Although Florida beaches are composed primarily of silicate sand, oolitic aragonite commercially mined in the Bahamas is under consideration as a source of fill for beach nourishment projects. We are examining the suitability of aragonite as a substrate for loggerhead sea turtle (*Caretta caretta*) nesting on Fisher Island, Miami, Fl, where the first such large scale renourishment occurred in the spring of 1991. The three year study includes a comparison of the physical characteristics (grain size, water potential, compactability...) of aragonite vs. the native Fisher Island silicate sand and an evaluation of the main parameters of physiological importance to developing eggs. Hourly temperature measurements and weekly oxygen and carbon dioxide partial pressures are recorded throughout the incubation period in 10 nests relocated to enclosed hatcheries containing either Florida or aragonite sand. These parameters can then be correlated to differences in incubation time, hatching success, and hatchling fitness.

First year results (1991) revealed that aragonite sand on average is 2° C cooler than Florida silicate (Figure 1), significantly extending incubation times by 5 days (Figure 2) and quite possibly altering natural sex ratios. As sex determination is temperature dependent in sea turtles, temperatures in the observed 28-30° C range of the aragonite nests could result in a preponderance of male loggerhead hatchlings. There were no significant differences in hatchling mass or carapace length and width despite the difference in incubation time, however (Figure 3); nor were there any significant differences in hatching success. Large numbers (10-20%) of the hatchlings both from the Florida sand nests and from aragonite hatchery and naturally occurring nests carried supernumerary scutes.

The possible cause of these malformations, and the determination of hatchling sex ratios in nests from Florida vs. aragonite sand should be the focus of future work.

This study was supported by Island Developers, Ltd.

FIGURE 1:



Average Temp. Change 7/22/91-7/26/91
Aragonite VS. Florida Sand Nests
Temperature (C)
33
32.5
32
31.5
31
30.5
30
29.5
29
28.5
28
0
24
48
72
96
120
Days (hours)
Florida bottom
Florida Center
Florida top
Aragonite bot.
Aragonite cent.
Aragonite top

Figure 2: Incubation Times of Loggerhead Sea Turtle Eggs in Two Sand Types

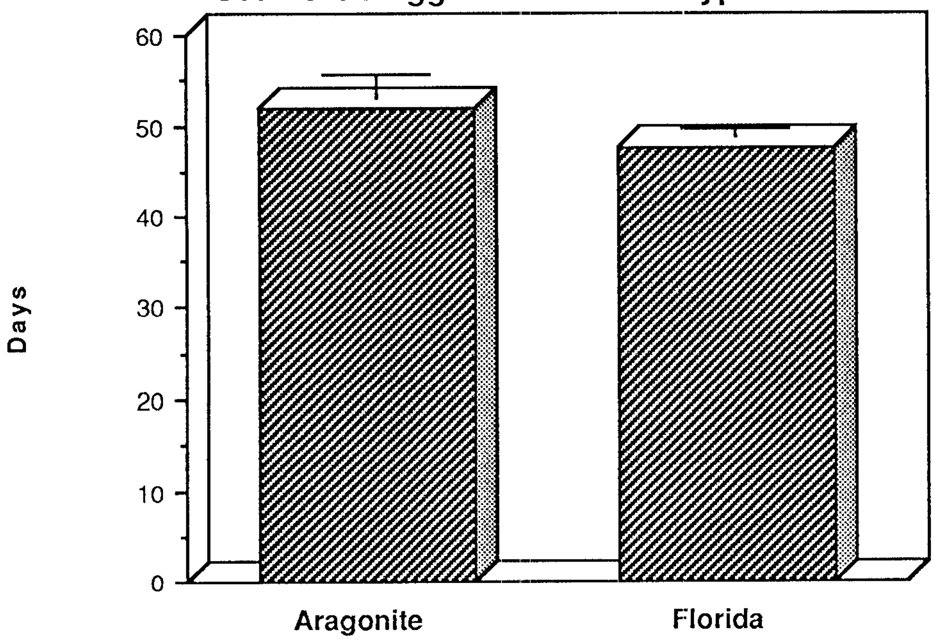
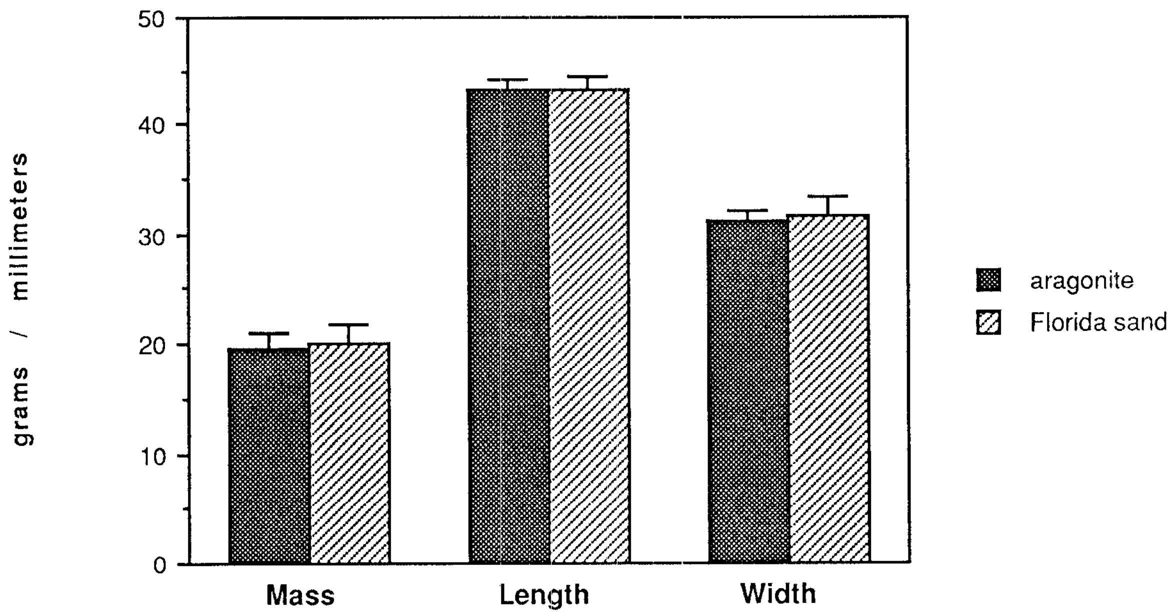


Figure 3: Mass, Straight Carapace Length and Width of Hatchlings



SEA TURTLE MORTALITY RELATED TO DREDGING ACTIVITIES IN THE SOUTHEASTERN U.S.: 1991

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INTRODUCTION: Sea turtle mortality was documented at three ports where hopper dredges were in operation during 1991. At least 38 mortalities associated with dredging were recorded in Brunswick, GA, Savannah, GA and Charleston, SC. These mortalities, documented by observers stationed aboard the sea-going dredges, led to an agreement between the National Marine Fisheries Service and the US Army Corps of Engineers, which restricts the use of hopper dredges in the southeast to the months of December through March. Thus, the impact of this type of dredging activity on sea turtles is mitigated by dredging when the turtles are least likely to be present.

BRUNSWICK: Dredging was conducted in the Brunswick Harbor Entrance Channel from **03/23/91** to **06/19/91** (89 days). There were two hopper dredges working in the channel for 19 days; one dredge worked the remainder of the time. Thus, the dredge effort is represented as 108 "dredge days" (one dredge/one day). Contract specifications for this project required that NMFS-approved observers be aboard the dredges at least 25% of the time that they were operating. This amount of coverage was achieved by placing an observer aboard the dredge(s) for at least 6 hours each day. The 6 hour shifts ran concurrently every third and fourth day, beginning at 1800 hours on the third day and ending no sooner than 0600 hours on the fourth day, thus providing full nighttime monitoring every three days. Meticulous records were kept of all specimens caught by screening apparatus insalled on the dredges to detect the presence of sea turtles and/or their parts. Other information was also recorded, detailing the dredges' activities, weather and tide data, etc.

Due to the alarming number of incidents involving sea turtles during the first five weeks of this project (13 incidents including one Kemp's ridley, *Lepidochelys kempi*, mortality), NMFS and the USACE agreed that observer coverage should be increased to 50%. This increased coverage was initiated on 05/01/91.

During this project there were 23 documented incidents involving sea turtles and/or their parts. Two of these incidents involved tissue which was obviously not fresh and may or may not be attributed to dredging. Two incidents involved turtles which became dislodged from dredge gear being lifted from the water. Both turtles were observed swimming vigorously away, extent of injury, if any, unknown. It is likely that all of the remaining 19 incidents can be associated with dredge-induced mortality. It should be noted that one-third of these incidents were first reported by dredge personnel and were later verified by an observer upon boarding. For details see Tables 1 and 2.

SAVANNAH: Hopper dredging occurred in the Savannah Harbor Entrance Channel from **06/20/91** to **08/14/91** (54 days). There were two dredges working at this site for 31 of those days. Thus, the dredge effort is represented as 85 "dredge days". Fifty percent observer coverage was required for this project and was scheduled to provide periods of day and night observation. Over the course of this job we documented 17 incidents involving sea turtles and/or their parts. One of these incidents involved a sub-adult loggerhead, *Caretta caretta*, which was removed from dredge gear unharmed, examined closely by an experienced observer, photographed and released. The other 16 incidents involved sea turtles or fresh turtle parts and can be associated with dredge-induced mortality. For details see Tables 1 and 2.

CHARLESTON: Hopper dredges worked the Charleston Harbor Entrance Channel three different periods in 1991: **08/01/91** to **08/22/91, 09/07/91** to **09/30/91, 12/01/91** to **12/31/91** (76 days). The dredge effort in Charleston totaled 87 "dredge days". Two observers lived aboard each dredge providing 100% (24 hour) coverage. Dredging was suspended when two sub-adult loggerheads were taken on 08/22/91. Dredging resumed 09/07/91 and continued until the end of the month. One sub-adult loggerhead was taken during this period. Dredging was not resumed until 12/01/91, which marked the beginning of the adherence to NMFS' recommended "window" of operation for hopper dredges in the southeast. No take was documented in 1991 after 12/01. See Tables 1 and 2 for details.

SINCE CHARLESTON 1991: At the risk of revealing my procrastination, I feel it is pertinent to note that, as of today (03/31/93), every shipping port between Cape Hatteras, NC and Cape Canaveral, FL (including the three above-mentoioned channels), has been dredged. This dredging has been conducted during the prescribed winter months. Three sea turtle mortalities have been documented in association with these projects. These have been the only documented "dredge takes" since September 1991 and interestingly, all of these occurred when water temperatures were 15.0+ C. Two sub-adult loggerheads were taken in the entrance channel at Port Royal, SC: one on 03/15/92, water temperature = 15.0 C; one on 03/16/92, water temperature = 15.6 C. A sub-adult loggerhead was taken at the channel in Savannah, GA on 12/02/92, water temperature = 15.0 C.

TABLE 1: DREDGE-RELATED TURTLE MORTALITY, 1991

Location/ Channel	Dredging Period	Dredge Effort	Observer Coverage	Number Of Incidents Total	Number Of Incidents Mortality
Brunswick	03/23-06/19	108 dd	25%/50%	23*	19
Savannah	06/20-08/14	85 dd	50%	17**	16
Charleston	08/01-08/21	23 dd	100%	2	2
	09/07-09/30	33 dd	100%	1	1
	12/01-12/31	31 dd	100%	0	0
TOTAL	03/23-12/31	280 dd	25%-100%	43	38

* Two incidents involved turtles which became dislodged from dredge gear and swam away before being brought on deck. Two other incidents involved tissue samples which were not fresh and may or may not be associated with dredging.
** One turtle released unharmed.
dd = "dredge days".

TABLE 2: SPECIES AND SIZE OF IDENTIFIED TAKE

Location/ Channel	Dredging Period	Total Take	Species C.c.	Species L.k.	Species Unid.	Carapace Length* *Range*	Carapace Length* *Mean*	Carapace Length* *n*
Brunwick	03/23-06/19	23	17	1	5	45-78	63.6	7
Savannah	06/20-08/14	17	13	0	4	23-108	63.4	8
Charleston	08/01-12/31	3	3	0	0	69-81	74.9	2
TOTAL	03/23-12/31	43	33	1	9	45-108	67.3	17

* Carapace length is given in centimeters. The character **n** represents the sample size from total take for which carapace length could accurately be determined.

TELEMETRY STUDIES OF THE INTERNESTING MOVEMENTS AND BEHAVIOR OF HAWKSBILL SEA TURTLES (*ERETMOCHELYS IMBRICATA*) AROUND BUCK ISLAND REEF NATIONAL MONUMENT, ST. CROIX, U.S. VIRGIN ISLANDS

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INTRODUCTION

Internesting behavior of sea turtles has been described using telemetry (green: *Chelonia mydas*, Dizon and Balaz 1982; loggerhead: *Caretta caretta*, Murphy 1979, Stoneburner 1982; Kemp's ridley: *Lepidochelys kempi*, Mendonca and Pritchard 1986). Methods have varied from the use of towed drogues with sophisticated satellite transmitters (Stonburner 1982), to the attachment of radio transmitters directly to the turtle's carapace (Dizon and Balaz 1982). Although the technology exists, telemetry had never been used to follow adult hawksbill sea turtles (*Eretmochelys imbricata*) during any period of their life cycle.

Hawksbill sea turtles nest an average of three times a season (n=23 indiv., SD=1.2, Hillis 1992 in press). The internesting period is the time between successful nestings within a season lasting 12-15 days (Ehrhart 1982). During the internesting period, sea turtles may mate and females carry out their seasonal nesting routine. At these times, sea turtles may be particularly vulnerable to commercial harvesting, incidental catch, collision with recreational boaters, and ecological disasters such as oil spills (Meylan 1984).

The objective of this study was to determine hawksbill sea turtle movements and behavior during and after internesting periods, quantify daily patterns of activity, and determine hawksbill sea turtle use of the near-shore reef area around Buck Island Reef National Monument.

METHODOLOGY

Buck Island Reef National Monument (BUIS) is located 2 km north of St. Croix, U.S. Virgin Islands and is composed of 176 acres of dry tropical forest surrounded by 300 acres of coral reef system (Hillis 1992 in press).

Data were collected during the peak of the 1991 nesting season (July-August). Nesting beaches (1.3 km) were divided into two sections and patrolled nightly (1830 hr-0530 hr) at 20 min intervals by two NPS employees. Nesting turtles were marked on both front flippers using numbered inconel tags issued by the National Marine Fisheries Service (NMFS). Curved carapace was measured along the median dorsal ridge from the nuchal scute to the posterior notch, and carapace width was measured at the widest point.

Radio and ultra-sonic transmitters were attached as one package to seven hawksbill sea turtles using dental acrylic (Den-mat Corp, San Diego, CA) and a 10 min marine epoxy (Evercoat 660, San Diego, CA). Transmitter packages weighed approximately 250 grams, and measured 13 cm by five cm. Radio transmitters (Telonics Inc., Mesa, Arizona) were hermetically sealed in electrical potting resin (Scotchcast 3M). Transmitters were attached to the anterior median ridge of the carapace following egg deposition.

Radio telemetry was used to locate and monitor free-swimming hawksbill sea turtles over a long distance and determine submergence behavior. Radio receiving stations were set up on BUIS (elev.=109 m) and on St. Croix (elev.=69 m, Figure 1). Receiving range from the BUIS station was estimated to be 30-40 km by positioning a boat with a radio transmitter offshore. Turtles were identified using distinct radio frequencies (i.e.,148.86 Mhz=.86). Positions of turtles, plus or minus five degrees, were determined by triangulating on signals from the two receiving stations as turtles surfaced. Tracking sessions were allocated among eight time periods during the day. If signals were not recorded during a tracking session then areas around St. Croix were monitored to determine if the turtle had left the area. Surface and dive interval durations were determined using a digital watch.

Ultra-sonic telemetry was used to pin-point positions of hawksbill sea turtles. Tracking sessions lasted three hours every other day. A hand-held compass was used to position the boat on the site of the turtle's last position determined by radio telemetry. The boat followed a heading parallel to shore at constant speed (0.5 km/hr) while a hydrophone was used to monitor for signals. Boat transects were distributed in a random systematic fashion and were100 meters apart and 1 km in length. Radio and ultra-sonic data on movements and behavior were analyzed for days 2 through 12 of the internesting period.

RESULTS

Carapace length of the 7 hawksbill sea turtles monitored ranged from 86.5 to 91.0 cm and width ranged from 78.0 to 90.0 cm.

Radio signals from turtles were monitored for 13-45 days at one station (n=307) or from both stations simultaneously (n=73). Acoustic fixes (n=16) were received for three hawksbill sea turtles.

Movements of all monitored turtles were confined to areas of approximately 1.5 km^2. The areas were within three km of BUIS and depth ranged from nine to 20 m. Four individuals were tracked in areas south of BUIS (.79, .03, .14, .54, .34A) and two in areas to the north (.86, .34B). Six hawksbill sea turtles monitored, returned to the same site after each subsequent nesting event. Movements of three individuals (.79, .86, .03) were concentrated in an area of 0.5 km^2 (Figure1). We were unable to get accurate fixes on two hawksbill sea turtles due to a damaged transmitter antennae (.54) and low battery power (.34B). The approximate area of movements of hawksbill .54 was estimated (Figure 1). Movements of .34A were estimated based on fixes and signal strength from the BUIS station only.

Cumulative mean dive time was 56.1 min (n=148, SD=17.3) and cumulative mean surface time was 1.7 min (n=331,SD=1.9). During the day, mean dive times ranged from 33.8 min to 63.5 min. At night this range was 41.7 min to 73.5 min. Four transmitters were lost when turtles left the area following a nesting event.

DISCUSSION

Movements of hawksbill sea turtles were directed toward specific areas around BUIS. Site specificity for offshore areas varies between and among sea turtle species. Differences in internesting movements may be related to the availability of food resources in the internesting habitat, an individual's preference for movements, and other unmeasured factors (Stoneburner 1982).

The distribution and abundance of prey may be an important factor affecting the movements of hawksbill sea turtles around BUIS. Stoneburner (1982) reported that loggerhead sea turtles in the Georgia Bight made directed movements towards small patches of natural and artificial stable substrate on which abundant prey organisms existed. These movements were in excess of 15 km, probably reflecting differences in stable substrate distances. Loggerhead sea turtles did not remain on patches but moved between them on a regular basis (Stoneburner 1982).

The Buck Island Channel is composed of a series of small patch reefs (16-20 m depth) that are high in sponge abundance (Gladfelter 1988), the primary prey of hawksbill sea turtles (Meylan 1988). Foraging hawksbill sea turtles would not have to move great distances around BUIS to obtain food. The distribution and abundance of prey around BUIS may be an important factor influencing movements of hawksbill sea turtles.

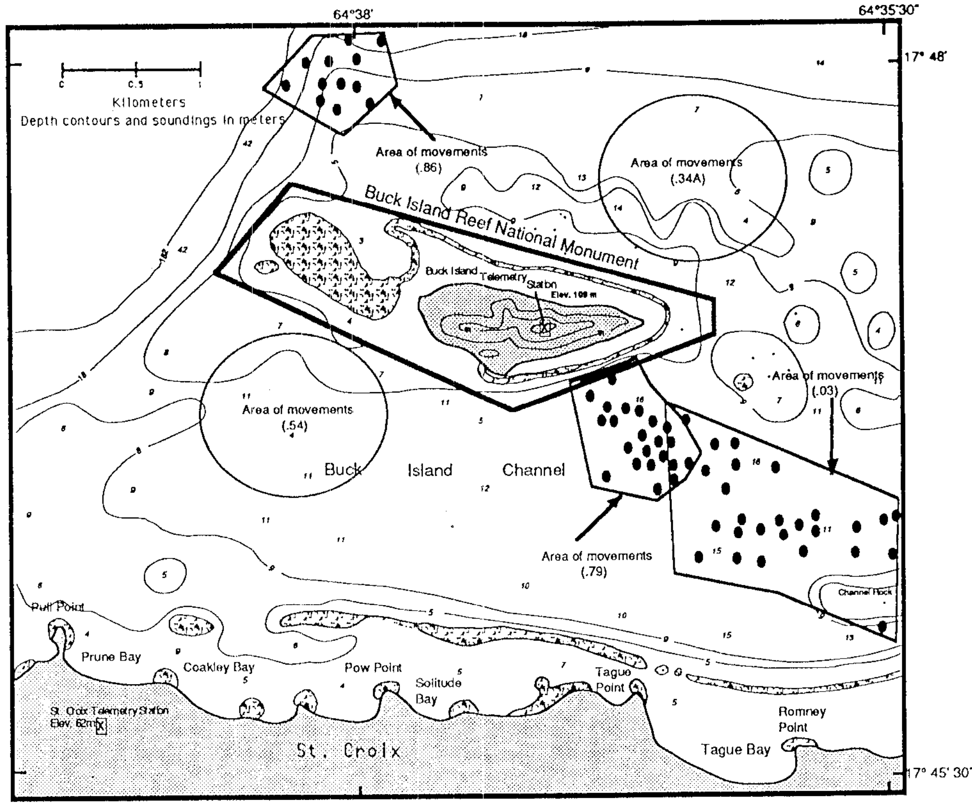

Figure 1. Map of study area showing areas of movements and telemetry fixes (dots)for 5 hawksbill sea turtles (.86, .03, .79, .54, .34A).

Movements of hawksbill sea turtles might indicate individual tendencies or preference for a specific site around BUIS. A loggerhead sea turtle associated with a specific refuge for the entire 1983 nesting season near Heron Island, Australia, while other loggerheads were observed moving through an area of 1 km^2 or more of the reef front (Limpus 1985). Two hawksbill sea turtles concentrated their movements within 0.5 km^2 while two were less specific and moved through an area as large as 2 km^2. Hawksbill sea turtles show a preference for specific refuges around BUIS, similar to that observed in loggerhead sea turtles.

In the past, hawksbill sea turtles have been considered sedentary species undergoing little or no annual migration (Carr and Main 1973, Bustard 1979). Contrary to this evidence, tag returns have indicated hawksbill sea turtles migrate several hundred to several thousand miles (Paramenter 1983, Marcovaldi and Filippini 1991). Four hawksbill sea turtles disappeared from the area around St. Croix immediately after nesting, indicating that some hawksbill sea turtles that nest on BUIS may come from elsewhere in the Caribbean. Our evidence supports the theory that hawksbill sea turtles undergo reproductive migrations.

Hawksbill sea turtle dive times were relatively long compared to other sea turtle species studied during their internesting period (leatherback, Eckert et al. 1989; loggerhead, Soma 1985; Kemp's ridley, Mendonca and Pritchard 1986). Reducing metabolic requirements by remaining inactive (less swimming) underwater can increase submergence time of diving animals (Kooyman 1981). Turtles seeking patchy prey underwater must move often and metabolic requirements will be high. Kemps ridley sea turtles exhibited short dive times (avg.=16.7 min, SD=22.7) which may have been related to horizontal movements of up to 10 km a day (Mendonca and Pritchard 1986). Within the Buck Island Channel, hawksbill sea turtles did not need to move far to find prey. Concentrated movements would allow longer dive times as metabolic constraints are reduced. The distribution and abundance of prey within the internesting habitat may be a important factor enabling hawksbill sea turtles to remain submerged for long periods of time

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INTEGRATED MANAGEMENT OF SEA TURTLES AMONG THE INDIGENOUS PEOPLE OF GUYANA: PLANNING BEYOND RECOVERY AND TOWARDS SUSTAINABILITY

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THE VIEW FROM ALMOND BEACH

Four species of sea turtles have been reported nesting on the beaches of Guyana, South America; they are *Chelonia mydas, Dermochelys coriacea, Eretmochelys imbricata,* and *Lepidochelys olivacea* (Pritchard 1988). The most concentrated nesting by these species takes place on the northwest coast of the country, in particular on Almond Beach (WIDECAST 1992). The forests and river systems adjacent to this coastal area are inhabited primarily by indigenous people of Arawak, Warau, and Carib descent (Forte 1990). The meat and eggs of all species of sea turtles are utilized by these people in their subsistence and local market economies.

Beach surveys conducted since 1964 by Pritchard have identified a high mortality of sea turtles with some evidence of "apparent decline" (Pritchard 1986, 1990). The take of sea turtles by the Amerindian people has been implicated as the most severe threat to the sea turtle populations (WIDECAST 1992). Such take is illegal under the national laws of Guyana, which protect all species of sea turtle and prohibit exploitation even by indigenous people (Government of Guyana 1966/1973). However, enforcement is almost nonexistent in the remote areas and therefore causes little concern to fisherpeople.

In 1988, Pritchard established a "conservation and research project" on Almond beach with the clear objective of population recovery. This field project employed three Amerindians, formerly active as sea turtle hunters, to patrol the beach during the nesting season and collect scientific data. Their primary task was to protect nesting sea turtles from the hunters (Pritchard 1988). The effort was successful in virtually eliminating exploitation on the protected beach within the first two years of operation (Pritchard 1990).

In 1990, I began working with the conservation project and with the Amerindian community most closely associated with Almond Beach. My goal was to facilitate an integrated and sustainable management program for sea turtles in the area. My approach included cultural, economic, political, and biological aspects of the use and management of sea turtles, and involved all parties associated with natural resource management and rural development.

TRADITIONAL HUNTERS VERSUS PROTECTIVE PROJECT PERSONNEL

Preliminary surveys conducted in 1990 indicated that the protected beach and its adjacent waters constituted one of the community's most important fishing grounds, despite the fact that the fishing grounds were a three-day journey by canoe from the community. My surveys revealed that fifteen to twenty boat captains and some hundred other people participated in various aspects of seasonal fishing and sea turtle hunting expeditions. Sea turtle hunting was identified as being a traditional activity. Such hunting was not considered the primary purpose of an expedition however, but rather one that was combined with collecting fish. Almost half of the income derived from an expedition was reported to be from the sale of sea turtle meat and eggs.

Not surprisingly, the hunters had reservations about the conservation project. They indicated little understanding of the project's legitimacy or its authority in protecting a traditional food resource. Those who strongly believed in the continued harvest and use of sea turtles reported a clandestine take of sea turtles from the protected beach and increased exploitation on other beaches. Such statements were confirmed by the frequent availability of sea turtle meat in the community and occasional evidence of the slaughter of sea turtles on the protected beach. Other hunters, who either did not have the equipment necessary to travel to remote nesting beaches or who did not want to battle with the law, increased their involvement in supplementary livelihoods, such as freshwater fishing, slash and burn agriculture, carpentry, and gold mining. Further complicating the issue, was the belief of some community members that the three project personnel, who were former sea turtle hunters, betrayed the community, or held an exclusive monopoly of the turtle resource.

Among the Amerindians hired by the project, there was a strong sense of prestige in being involved. They and their families also benefitted economically from the project. Although none of the hunters indicated any envy, such prestige and benefits could be contributing to the tensions between the fisherpeople and the project personnel. Project personnel indicated (and later proved) that hunting of sea turtles would resume whenever they were absent from the beach, demonstrating the polarity between the two groups.

Such animosity, suspicion, misunderstanding, and dependence certainly threatened the ability of the conservation project to implement long-term monitoring and recovery of the sea turtles. In order to establish sustainability and provide conservation benefit both to the resource and to the neighboring people, a more comprehensive and integrated resource management program needed to be explored, one that fostered cooperation between the Amerindian community and the conservation project. In furtherance of this goal, specific initiatives were identified; some have been implemented.

RESOLVING CONFLICTS AND FACILITATING COLLABORATION

The first initiative was a series of joint discussions and planning meetings that included fisherpeople, community leaders, and project personnel. The outcomes of these meetings were promising, considering that the groups had never before shared their common interests in sea turtles. The hunters shared their traditional and economic reasons for using sea turtles and their perceptions of the conservation project. The project personnel, in turn, shared with the community members their activities on the beach and the conclusions derived from the information collected thus far. They emphasized the impact of exploitation by the hunters and the need for a halt in further exploitation.

After much discussion on the declining status of sea turtles nesting in the area, the consensus was that the fisherpeople would establish a voluntary moratorium on hunting. No specific time frame was established for the moratorium; instead, a year-by-year review of the nesting information was recommended. It was decided that, in place of hunting sea turtles, the fisherpeople would investigate alternative forms of meat. The conservation project, in turn, agreed to provide seed funding to interested families for the establishment of small-scale meat operations. The project will also share with the community on a regular basis the results of its research, provide opportunities to train and involve fisherpeople in its activities, and provide compensation for fishing gear damaged during the release of entangled sea turtles. This will enable the community to maintain an awareness of their sea turtle resource and will enable trained fisherpeople to collect data on sea turtles encountered during their fishing trips and to release animals accidentally caught by their nets. The meetings concluded with the understanding that the community would cooperate in ensuring that these decisions were upheld by the respective parties.

Many community groups, some of them led by sea turtle hunters, have already presented proposals for the establishment of chicken and pig operations on a small commercial scale. Village leaders envision the development of these operations and the distribution of seed funding as an applicable function of the farmers' cooperative, a credit program currently active in the community.

AMERINDIANS IN FUTURE RESOURCE MANAGEMENT

The success of these decisions and ultimately of a management plan will depend greatly on the expectations and understanding of future fisherpeople, project personnel, and community leaders. With this in mind, a second initiative created the establishment of a student training and apprenticeship program. This initiative not only provided the obvious values of environmental education but also spread the benefits of the project over a greater part of the community. It also encouraged communication and cooperation between the community and the conservation project.

Fourteen students and two teachers from the community school participated in the pilot initiative. Through lecture and discussion sessions on thematic and site-specific biological and conservation issues, the participants gained an understanding on the nature of the conservation project, as well as the importance of managing their own natural resources. The lectures and discussions were supported by the students' enthusiastic participation in ongoing research activities. They also participated in the workings of a self-sufficient research station while on the beach.

To a majority of the students these expeditions were their first exposure to environments outside their own community. All of them had consumed sea turtle meat and eggs, but none of them had visited the beach and seen a nesting sea turtle. Many of the participants were children of sea turtle hunters, children who could become involved with hunting in the near future. This opportunity, therefore, helped them to place the foods they enjoyed within the context of a finite resource and a complex ecosystem, while better understanding the impacts of a family livelihood.

On returning to their community, the students established a conservation society. This was the first time that an Amerindian community in Guyana had established an organization to address the issue of natural resources and their management.

The pilot training program conducted was a great success, receiving enthusiastic support from all groups and initiating essential cooperation between the community and the conservation project. There have been numerous requests from students within this and other Amerindian communities to continue with and expand the training opportunity. The conservation project, in joint cooperation with the community church, plans to continue this initiative.

PLANNING BEYOND RECOVERY AND TOWARDS SUSTAINABILITY

It is expected that, through the fisherpeople and the students, the entire community will be exposed to issues surrounding sea turtles. However, such an awareness will be incomplete (and perhaps counter-productive) if the people do not place sea turtles within the context of the entire environment. The focus of the conservation project has so far been on sea turtle recovery. However, in order to ensure the long-term survival of the sea turtles currently protected, it is necessary to broaden the focus towards a more holistic and integrated program.

Such an approach is necessary because of the alternative activities that arose and the interconnected nature of the human and natural resources involved. Each activity that is facilitated, either to promote sea turtle conservation or to provide an alternative to sea turtle exploitation, carries with it cultural, economic, political, and biological concerns which cannot be ignored.

In the study area, the rivers are over-fished, clear-cutting of adjacent rainforests is rampant, and gold mining is destroying the health of people and their immediate environments. As resources grow scarce, Amerindian families fragment and scatter. Increasing numbers of children are brought into the work force and away from their education. The thought of what will become of the sea turtles when the community has overexploited the alternative natural resources is one to be reckoned with at an early stage of the conservation process.

The opportunity to address this concern through the creation of a broader environmental awareness in the community was identified in the current curriculum at the local school. Activities may include an environmental education seminar for teachers, so that trained teachers could address environmental issues within the context of traditional subjects. Plans for information sessions, readings, and competitions were enthusiastically supported as a means to enhance and maintain environmental consciousness within the community. Workshops on managing other natural resources and on creating small-scale rural cooperatives for natural resource products were requested by interested community members. An informal women's handicraft group was initiated, and some fisherpeople began revitalizing the community's inactive fisheries cooperative.

These activities, although directly unrelated to sea turtles, should not be viewed as external to the objective of sea turtle recovery and to the work of the conservation project at Almond Beach, but considered rather as a "life-line" to the environment as a whole. Supporting and facilitating these activities will help to ensure that sea turtle management is incorporated into the larger necessity of natural resource management and rural development. Conversely, portraying sea turtles as a resource receiving exclusive attention will perpetuate the unconcerned overexploitation of other available resources. Finally when sea turtles are identified as being the only intact resource left, all recovery efforts at Almond Beach will then be lost in an unprecedented wave of total exploitation.

THE WAKE-UP CALL

Many field projects, management strategies, and conservation policies addressing sea turtle exploitation and population decline in developing countries concentrate on sea turtle protection with the goal of population recovery. Such recovery is certainly necessary and should be supported. However, these recovery efforts will be futile unless a more integrated and sustainable approach to sea turtle conservation, such as that being developed in Guyana, is widely implemented. Such an approach is most important at the grassroots level in developing countries where sea turtles cannot be separated from the needs and involvement of coastal people or from ambient cultural, political, economic, and biological realities. I believe that the additional time, effort, and funds to promote local involvement, rural development, and sustainable management of the environment as a whole are a small price to pay for the long-term survival of sea turtles.

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POPULATION VIABILITY ANALYSIS FOR THE LITTLE CUMBERLAND ISLAND LOGGERHEAD TURTLE POPULATION

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INTRODUCTION

Population viability analysis is the analytical procedure used to estimate minimum viable population. Viability is defined as the probability a population has of persisting a given time. For this preliminary analysis a population is considered viable if it has greater than a five percent chance of persisting for 100 years. Published data for the Little Cumberland Island (LCI) population of the loggerhead sea turtle (*Caretta caretta*) were used in this preliminary analysis.

METHODS

The magnitude of change in population growth due to genetic factors which may occur at low population sizes is unknown. For this reason, consideration of genetics was excluded from the analysis which could cause an upward bias in predicted extinction times. Genetic evidence reveals that the Georgia population is isolated from the larger Florida populations. Brian Bowen (pers. comm.) found no overlap in mtDNA between these populations. The model was, therefore, based on population dynamics on LCI.

Numbers of nesting females from 1964-1989 were used to obtain the mean population growth rate: 0.957 (NRC 1990). Adult survival was estimated from data in Richardson et al. (1978). Assuming tag loss is a constant per year probability, adult survival is not age dependent, and all turtles reported were members of the LCI population, adult survival (s) is 0.755, annual tag retention is 0.872, and the proportion expected to die before remigrating is 60%. Because some of the assumptions of this model are suspect, the model used the following values for s: 0.75, 0.80, 0.85, 0.90. Survival to year 1 was left constant at 0.1. Two values were used for age of sexual maturity (ASM) (estimated from two growth models): 11 and 28 (Frazer & Ehrhart 1985). Juvenile survival (s_j) was constrained to not exceed adult survival. s_j was first calculated so that the population growth rate (λ) was stable ($\lambda = 1$). Survival in the sizes/ages taken in fisheries interactions was then reduced until $\lambda = 0.957$. Distributions for annual number of clutches laid and number of eggs laid were used in simulations of population trajectories (Frazer & Richardson 1985). Thus, environmental variance was introduced solely through the fecundity term.

1,000 simulations were run for each set of parameters (which differed by adult survival rate and ASM). Each simulation started in stable age distribution with the number of adult females estimated for the current population (75).

RESULTS

Fig. 1 shows an extinction distribution when s = 0.75 and ASM = 11. Note that the distribution is not Gaussian. Fig. 2 is the cumulative distribution for the same data. Over 20% of the simulated populations had gone extinct by 100 years. The 10th, 50th, and 90th percentiles of the extinction distributions for all models are shown in Fig. 3. There was no significant difference between any of the models which had the same ASM, but there was a difference between the models with different ASM's. Only one model where ASM = 28 had $s_j < s$. Expected values for extinction were about 100 years less for deterministic versus the more realistic stochastic models.

DISCUSSION

For none of the models could this population be considered viable. Under Mace & Lande's (1991) PVA criterion for risk assignment, this population would be considered endangered. As with deterministic models, the dynamics of the population are very sensitive to estimates of ASM. Narrowing the range of values of ASM should be a research priority. The model shows clearly that stochastic modelling is required. Research continues which will use the entire 30 year data base (with T. & J. Richardson) to increase precision of parameter estimates.

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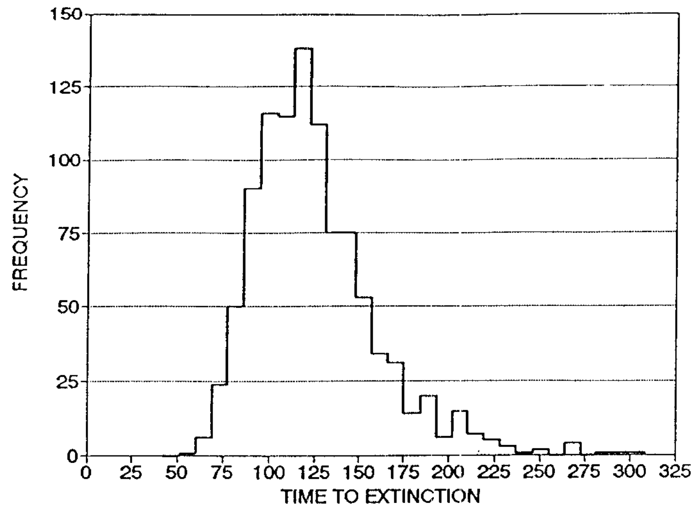

Figure 1. Distribution of extinction times for 1,000 simulations.

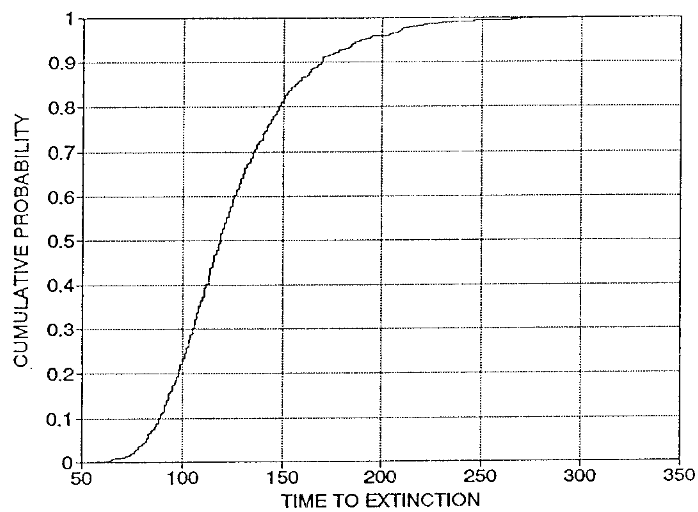

Figure 2. Cumulative distribution of extinction times.

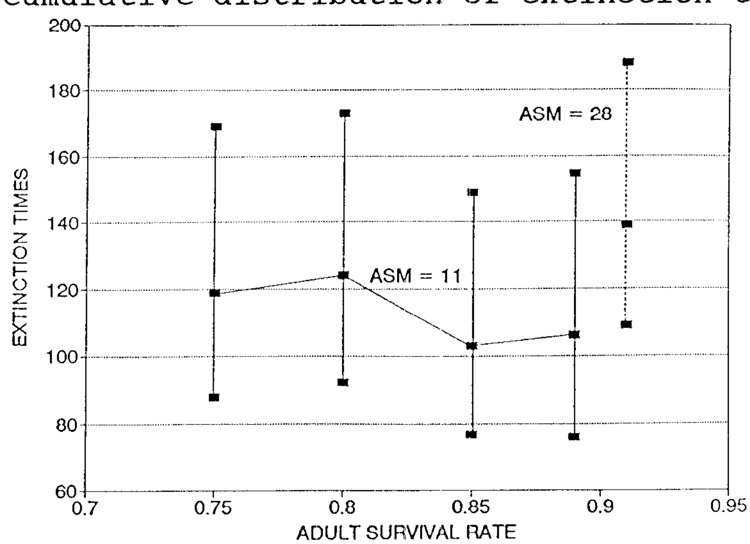

Figure 3. 10th, 50th, & 90th percentiles of extinction distributions for different models.

CHARACTERISTICS OF GREEN TURTLE (*CHELONIA MYDAS*) GRAZING GROUNDS IN SOME CARIBBEAN ISLANDS

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INTRODUCTION

In 1978, under the U.S. Endangered Species Act of 1973, *Chelonia. mydas* was listed as Threatened except for the breeding populations in Florida and on the Pacific coast of Mexico where they were listed as Endangered. *C. mydas* was also listed as Endangered by the International Union for the Conservation of Nature (Groombridge, 1982). This species is also included in Appendix I of the Convention on the International Trade in Endangered Species (CITES). The green turtle is also listed as Endangered by the Commonwealth of Puerto Rico (Wildlife Law of the Commonwealth of Puerto Rico of 1976, 12 LPRA: Secs. 81, et seq.). Despite international, national, and commonwealth laws and global conservation programs, *C. mydas* continues to be heavily poached. With simultaneous management actions (e.g. education, enforcement, nesting beach protection, increased hatchling production), this species may recover in nature only <u>if</u> its foraging grounds are protected simultaneously.

While IndoPacific green turtles graze mostly on macroalgae (Balazs, 1982), seagrasses are the major food resources of juvenile and adult green turtles throughout the Wider Caribbean Region. For example, Mortimer (1976) examined 202 green turtles and found that the stomach contents consisted of turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*) and shoal grass (*Halodule wrightii*). Bjorndal (1979) also found that *C. mydas* selectively grazes on turtle grass, and to a lesser degree on the sponge *Chondrilla nucula*. Under specific conditions in northern Caribbean waters, *C. mydas* may graze significantly on rhodophytic algae (Wershoven and Wershoven, 1991). However, green turtles grow faster when feeding on turtle grass (Bjorndal and Bolten, 1988).

Besides being a food source for Caribbean green turtles, seagrass beds modify the physical, chemical and geological properties of coastal areas in many beneficial ways (Vicente, 1992). Furthermore, they provide nutrients, primary energy and habitats which help sustain coastal fisheries resources while enhancing biological diversity and wildlife.

Poorly planned development, sediment runoff, increased turbidity, poorly treated sewage, and hurricanes have destroyed seagrass beds throughout vast expanses in Puerto Rico and surrounding islands (Vicente et al., 1990; Vicente and Rivera, 1982; Vicente et al., 1980). The US Fish and Wildlife Service is in the process of identifying and protecting those seagrass beds in Puerto Rico and the US Virgin Islands which appear to be critical for green turtles and other wildlife.

METHODOLOGY

We conducted surveys in six islands: Puerto Rico, Piñeros, Vieques and Culebra (Commonwealth of Puerto Rico), and St Thomas and Water Island (USVI). The purpose of the surveys was to locate and describe green turtle foraging grounds. Many of the bays surveyed were identified from a tagging program for juvenile, wild green turtles (Boulon and Olsen, 1982). The goal of this study was to establish a proper resource category designation to protect seagrass habitats. Underwater transects and photography were used to characterize foraging grounds. Herbivore exclusion and inclusion experiments were also conducted at Culebra Island to evaluate the influence of herbivores on external morphological characters of turtlegrass.

RESULTS AND CONCLUSIONS

The location of some of the important green turtle foraging grounds found are shown in Figure 1 (see Vicente et al., 1991 for location of grazing grounds at Piñeros and Vieques islands). Habitat characteristics of the foraging grounds are presented in Table 1. The major findings and conclusion of this study are listed below.

1. *Chelonia mydas* causes **ecophenotypic** expressions in *Thalassia testudinum* (short (3 - 5cm) and thin (4 - 5mm) leaves) as well as **highly specific scars** above the leaf meristem (straight horizontal cuts). These morphological criteria are useful in determining the locality and extent of a particular green turtle foraging ground.

2. *C. mydas* grazes more frequently along **extensive continuous or discontinuous bands** between deep coral reef habitats or barren mud bottom and dense grass beds (Pattern C in Table 1).

3. On extensive seagrass beds, green turtle grazing was always **limited to the deeper zones** of the bed.

4. Within a given island (e.g. Culebra), green turtle foraging habitats occur in both well **illuminated** (Mosquito Bay) and very **turbid** (P. del Manglar) environments.

5. Juvenile green turtles graze on **shallow** (1m) and **deep** (15.2m) grass beds.

6. Juvenile green turtles graze on both **exposed** and **protected** environments.

7. When all seagrass species occur together, green turtles do not **discriminate** among species. Species of Caulerpales (e.g. *Caulerpa sertularioides*, *C. mexicana*) are also grazed.

8. In some areas (e.g. Mosquito Bay at Culebra Island), green turtles appear to be **setting the maximum depth** to which seagrasses are found.

Figure 1: Location of some of the important green turtle foraging grounds in the vicinity of St. Thomas (VI) and Isla de Culebra (PR).

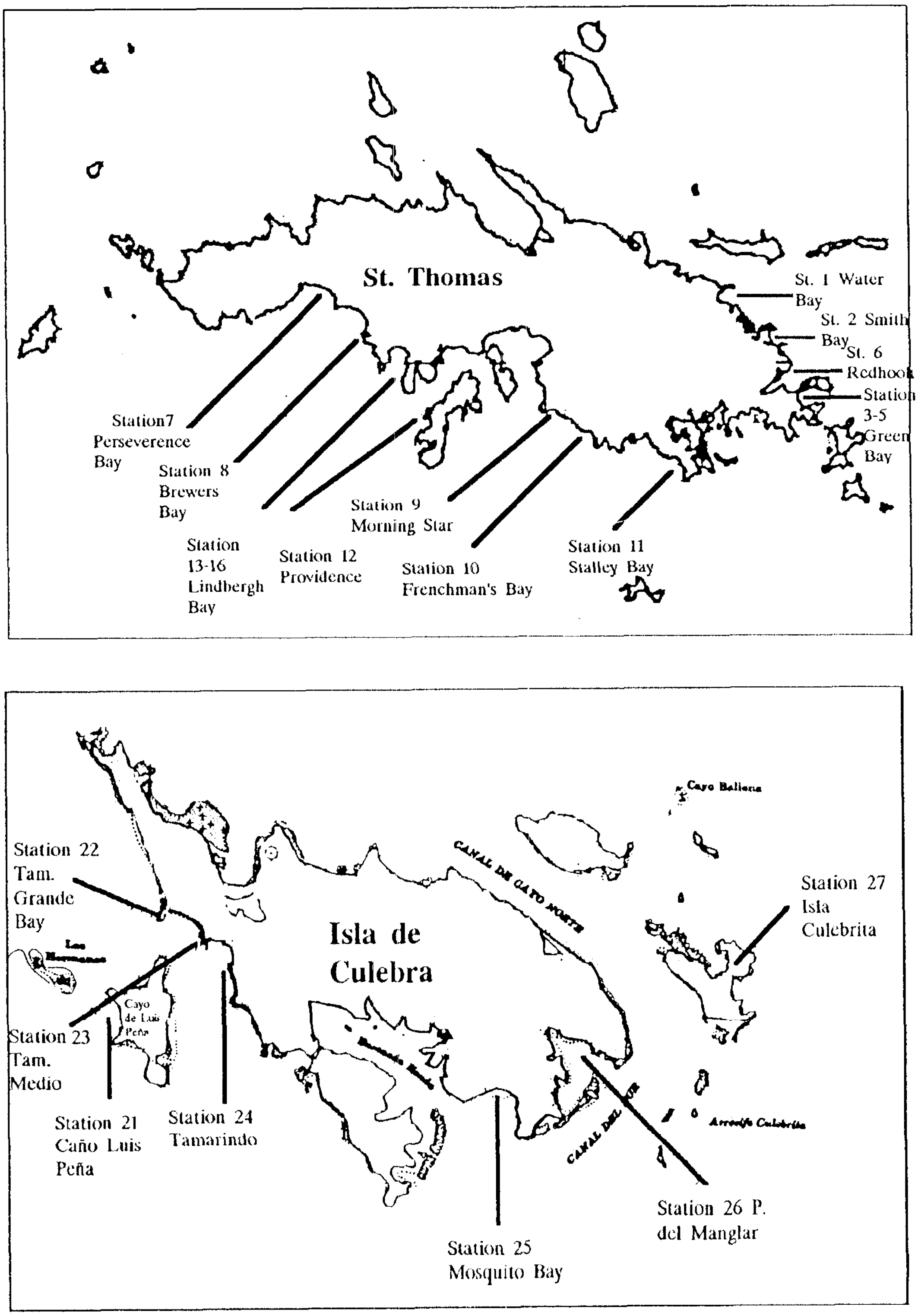

Table 1. General habitat characterization of green turtle foraging grounds: St. Thomas (Stations 1-16) and Puerto Rico (Stations 17-27). Tt= *Thalassia testudinum*; Sf=*Syringodium filiforme*; Hd=*Halophila decipiens*; Hw=*Halodule wrightii*; Cm=*Caulerpa mexicana*; Cs=*C.serrulata*; Cp=*C.prolifera* Cse = *C.sertularioides*; Pc=*Penicillus capitatus*; Pd=*P.dumetosus;* Hi=*Halimeda incrassata*; Hm=*H. monile*; Uf=*Udotea flabellum*; Uc=*U.cyathiformis*; OC=Other Caulerpales; Dd=*Dictyota divaricata*; R=Rhodophytes; Da=*Diadema antillarum*; Te= *Tripneustes esculentus*; Sg=*Strombus gigas*; Sc= *S. costatus*. Grazing Pattern:A= grazing on isolated shoots; B=small (1m2) well defined patches on edge of dense shallow beds; C=heavily grazed continuous or discontinuous band between deep reef or barren bottom and dense grass bed; D=heavily grazed submerged banks surrounded by sand or mud.

STATION	DEPTH	PATTERN	FLORA	OTHER HERB.	WATER	EXPOSURE
1 (WB)	3.0m	A	Tt,Sf,Hw, Hd,C,As	Sc,Te.	Turbid	Protected
2 (SB)	1.0m	B	Tt,Sf,Hw, Hm,Uf.	Da,Sr,Te.	Clear	Exposed
3 (GB)	5.2m	C	Tt,Sf,Hw, Pc,R.	Te,Sc.	Clear	Exposed
4 (GB)	2.0m	A	Tt,Hw,Dd, Hi,Uf,Pc	Da,Sg,Sv.	Turbid	Protected
5 (GB)	2.1-3.3m	C	Tt,Hw,Sf, Pc,Hm,Cs	Sg,Te	Clear	Protected
6 (RHB)	2.1m	C	Tt,Hw,Sf, Uf,OC	Da.	Turbid	Protected
7 (PB)	3.8m	D	Tt,Hw,Sf Uf.	None	Clear	Exposed
8 (BB)	2.1m	D	Tt,Sf,Hw, Pc.	None	Clear	Exposed
9 (MSB)	(?)	C	Tt,Uf.	Sg.	Clear	Exposed
10(FMB)	3.2-4.5m	C	Tt,Hm,Uf, Pc.	None	Clear	Exposed
11 (SB)	4.5m	C	Tt,Hw,Sf, OC.	None	Clear	Exposed
12 (PP)	3.0m	C	Tt	Da.	Turbid	Protected
13 (LB)	6.6m	C	Tt,Sf,Hi, Uf,Cp	Sg	Turbid	Protected
14 (LB)	9.9m	C	Tt,Sf,Hi, Uf,Cp,Cs,Pc	None	Clear	Exposed
15 (LB)	9.9m	C	Tt,Hd,Hw,Pc	None	Clear	Exposed
16 (LB)	9.9m	C	Tt,Hi,Uf,Cp Hi,Uf,Cp,Cs Cs,Cm,Pc	None	Clear	Exposed
17 (IP)	10.6-11.5m	C	Tt,Hd,Hi,	None	Clear	Exposed
18 (IP)	10.6-11.5m	C	Tt,Cp,Cm	None	Clear	Exposed
19 (VI)	11.0-11.2m	C	Tt,Sf,Hi,Uc Pc,Pd,Cp.	Sg	Clear	Exposed
20 (VI)	2.20m	?	Tt,Hd,Hi,Cm	None	Turbid	Exposed
21 (CLP)	13.6-15.2m	A	Tt,Sf.	Sg,Te	Clear	Exposed
22 (TG)	11.5m		Tt,Sf,Pc,Hi	None	Clear	Exposed
23 (TM)	10.6m	C	Tt,Sf,Hw	None	Clear	Exposed
24 (TC)	4.5-9.1m	C	Tt,Hw,Sf,Pc	None	Clear	Exposed
25 (MB)	3.0-4.5m	C	Tt,Cse,Sf,Hi Te		Clear	Protected
26 (PM)	1.0m	?	?	?	Turbid	Protected
27 (CI)	?	?	?	?	Clear	Exposed

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SEAWEED CLEANUP ON A SEA TURTLE NESTING BEACH

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ABSTRACT

Seaweed cleanup operations were conducted in 1991 on Panama City Beach along the northern gulf coast of Florida USA. Heavy equipment was used to bury the seaweed on the beach between the mean high-tide line and the frontal dune. Panama City Beach is a low-density nesting area (1 nest per mile) for loggerhead sea turtles. One loggerhead nest that was laid in buried seaweed produced only nine hatchlings from 109 eggs. This raised concerns about potential adverse effects of buried seaweed on sea turtle egg development. To protect turtle nesting habitat, the U.S. Fish and Wildlife Service has recommended against future beach burial of seaweed. The Florida Department of Natural Resources has a verbal policy prohibiting burial activities during the nesting season, although exceptions to this policy are permitted. The best strategy from an ecological and turtle management perspective is to allow seaweed to dissipate naturally and educate the public that beached seaweed is a valuable part of the coastal ecosystem.

INTRODUCTION

Seaweeds of the genus *Sargassum* commonly occur on United States coastal beaches where sea turtles nest. Primary *Sargassum* species in the western North Atlantic and Gulf of Mexico are *S. natans* and *S. fluitans*. Both are characterized by a brushy, highly branched stem with numerous leaf-like blades and berry-like floats (Coston-Clements, 1991). *Sargassum* originates from oceanic and coastal sources. Oceanic forms are generated primarily within circulation zones in the North Atlantic. Sessile plants in the Antilles and tropical waters of the Caribbean Sea are torn away during storms and carried into the sea. *Sargassum* drift lines are occasionally transported by winds and currents onto coastal beaches of the U.S. Atlantic and Gulf of Mexico.

Unusually large amounts of *Sargassum* washed onto Gulf of Mexico beaches in 1989 and 1991. The influxes appeared to be the largest in at least a decade. There is speculation as to whether these were random occurrences or part of a long-term natural cycle. The lack of historical records on seaweed incursions makes it difficult to place recent events into perspective. One explanation is that the Gulf was experiencing an unusual circulation pattern in '89 and '91. For example, the Gulf of Mexico Loop Current may have followed closer than normal to the coast, carrying with it the huge masses of seaweed that washed ashore.

Panama City Beach provides a case study of the management conflicts that arise when seaweed washes onto a multi-use beach. Located on the northwest Florida coast, Panama City Beach is a popular tourist destination. The beach annually attracts over two million visitors who contribute significantly to the local economy. Tourism is the area's top industry. Panama City Beach is also a low-density nesting area (1 nest per mile) for loggerhead turtles, (*Caretta caretta*), a threatened species under the U.S. Endangered Species Act. When seaweed washed ashore in 1991, the response of local and state officials raised questions concerning the management of the nesting loggerheads. This paper discusses events leading to the cleanup of the seaweed and the management implications for nesting turtles.

that was kept in a storage shed next to the nest. The U.S. Fish and Wildlife Service will perform contaminants analyses on the eggs to check for the presence of gasoline or other synthetic chemicals that may have contributed to the arrested egg development.

The failure of this nest raised questions about potential adverse effects of buried seaweed on the development of turtle eggs. A major concern is that decaying seaweed may suffocate the embryos by robbing them of essential oxygen. The decomposition of the seaweed could also create open spaces around the nest causing its collapse. Even if the eggs were able to successfully develop, the rotting seaweed could change the ambient temperature of the nest, thereby altering hatchling sex ratios. These concerns were addressed in an 18 June 1991 letter from the Panama City Field Office of the U.S. Fish and Wildlife Service to FDNR. The letter concluded by stating that, "the Service is of the opinion that burial of *Sargassum* seaward of the primary dunes adversely impacts sea turtle nesting and requests that this activity not be permitted in the future." FDNR notified the Service that potential impacts of seaweed burial on turtle nests would be investigated.

MANAGEMENT ISSUES

The seaweed incursions on Panama City Beach focused attention on the need for a long-term management plan to deal with beached seaweed. Clearly, from an ecological and turtle management perspective, the best strategy is simply to leave the seaweed alone. This was the policy of the St. Andrews State Recreation Area, located on the east end of Panama City Beach. Seaweed that washed onto the gulf shore of the recreation area was allowed to dissipate naturally. According to FDNR, dissipation occurred within seven to ten days through natural decomposition and wind and tidal-driven relocation. The coastal environment benefits from this natural process. Shorebirds feed on marine organisms living in the seaweed. Decaying matter is washed back into the water and provides food for marine plants and small marine animals. And the seaweed that stays on the beach is eventually covered with sand, providing nutrients for pioneer plants like sea oats, and temporary relief from shoreline erosion.

This passive management strategy is opposed by many beach business owners who depend on revenue generated by tourism. They argue that tourists will not visit a beach covered by seaweed. Proponents of disposal also note that impacts to nesting turtles are negligible on Panama City Beach, which has relatively few nests compared to the southeastern U.S. Atlantic coast. The Atlantic coast supports the second largest loggerhead nesting population in the world. The threat of major economic impact, and the low nesting density, were key factors in FDNR's decision to allow the cleanup on Panama City Beach.

FDNR currently has a "verbal" policy prohibiting seaweed burial seaward of the frontal dune during the nesting season. As noted above, any management plan allowing seaweed disposal during the nesting season will be forced to consider potential economic impacts and nesting density. Additionally, at least two other issues must be addressed. First, all turtle nests must be identified and protected prior to the start of cleanup operations. This requires daily surveys for nesting activity starting on the first day of the nesting season. Second, the disposal method must not impact turtles that may nest during or after cleanup operations. Prohibiting cleanup activities during the night when loggerheads nest will ensure that nesting turtles are not disturbed. Turtles must also be protected from laying their nests within buried seaweed. The preferred disposal method is to transport the seaweed off the beach to a site landward of the frontal dune. If beach burial is allowed, the seaweed should be buried sufficiently deep so that turtles will not encounter it while digging. The depth of a loggerhead nest from the beach surface to the bottom eggs ranges from 17 inches to 34 inches (Nelson, 1988). Consequently, the seaweed burial area should be covered by more than three feet of clean sand.

A question with long-term management implications concerns the time required for buried seaweed to decay. If complete decomposition takes a year or more, then the repetitive seasonal burial of seaweed could permanently alter the composition of the beach sand within much of the turtles' potential nesting area. To test this hypothesis, two Panama City Beach sites were sampled approximately seven months after burial. Post-hole diggers were used to sample down to a depth of about four feet. Scattered patches of *Sargassum* were observed on the surface and in the first six inches of sand. These patches were dry and crumbled when held. The sand below this surface layer was generally clean to a depth near the water table where the sand becomes wet and compacted (about 2.5 to 3.5 feet in the areas sampled). Thick mats of *Sargassum* were encountered below this depth. Very little decay was apparent. The leaves were still intact and there was a strong sulphide odor. Anaerobic conditions appear to exist at these depths. More information is needed on seaweed decomposition, and turtle monitoring programs should include observations of beached seaweed so that the magnitude of this problem can be assessed.

CONCLUSIONS AND RECOMMENDATIONS

Seaweed washed onto Panama City Beach in massive quantities during the summer of 1991. Heavy equipment was used to bury the seaweed on the beach between the mean high-tide line and the frontal dune. As a result, unreported turtle nests may have been destroyed and at least one loggerhead nest may have been impacted by decomposition of buried seaweed. To protect turtle nesting habitat, the U.S. Fish and Wildlife Service has recommended against future beach burial of seaweed. Currently, the Florida Department of Natural Resources has a verbal policy prohibiting burial activities during the nesting season, although exceptions to this policy are permitted. Management issues affecting the burial of beached seaweed are (1) dependence of the local economy on beach-related tourism, (2) turtle nesting density on the affected beach, (3) ability to identify and protect nests prior to and during cleanup operations, (4) ability to prevent turtles from nesting in areas of buried seaweed, and (5) potential long-term impacts of seaweed burial on the beach environment. Regarding the last item, two Panama City Beach sites were sampled seven months after burial; layers of partially decayed *Sargassum* were observed within four feet of the surface. These results suggest that all seaweed burial should be prohibited within the anticipated nesting zone of sea turtles.

The fundamental problem with beached seaweed is one of perception. Panama City Beach spent $150,000 to clean the beach in order to protect a multi-million dollar tourist industry. A better solution is to change public attitudes toward beached seaweed. Support of sea turtle recovery efforts is widespread. Therefore, it is likely that beach visitors would be more tolerant if they understood the benefits of leaving seaweed on the beach, as opposed to the threat to turtle nesting habitat that results from its burial seaward of the frontal dune. The best management strategy is one that allows seaweed to dissipate naturally and educates the public that beached seaweed is a valuable part of the coastal ecosystem. At worst, it represents a temporary inconvenience to beach users.

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OBSERVATIONS OF HATCHLING LOGGERHEAD TURTLES DURING THE FIRST FEW DAYS OF THE LOST YEAR(S)

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As hatchling sea turtles leave the nesting beach and enter the pelagic environment, they begin what is certainly the most enigmatic phase of sea turtle life history. Perhaps due to the difficulties associated with open ocean studies, what little is known of hatchlings at sea has been limited to the nearshore region traversed by hatchlings during the first few hours after leaving the beach (Frick, 1976; Ireland et al., 1978; Witherington, 1991; Witherington and Salmon, 1992). The purpose of this study was to expand what is known of the behavior, dispersal, and mortality of neonate sea turtles by tracking loggerhead hatchlings over a multi-day interval.

METHODS

The study area was a loggerhead nesting beach 3.6 NM south of Sebastian Inlet in East-central Florida, USA. I and two assistants released loggerhead hatchlings individually at this site, allowed them to walk down the beach and enter the surf, and tracked them until weather conditions, shortage of fuel, or depredation of the hatchling ended the effort.

We tracked hatchlings visually. Although difficult, this method allowed constant surveillance of the tracked hatchling. To facilitate tracking, hatchlings pulled a 1 x 8 cm balsa wood float (2.1 g) which was tethered to the hatchling with 1.5 m of nylon line and attached to the ventral surface of a pygal scute with a wire hook designed to corrode free of the hatchling. Tracking floats were white below, orange above, and equipped with a red, light-emitting diode powered by two, 1.5 V silver oxide batteries.

Hatchlings were kept in a darkened bucket following their collection from hatchery nests at night and released for tracking trials within 2 hr. I released each hatchling at the same site within 1.5 hr of midnight. The tracking vessel was a 6.8 m outboard powered boat with a crew of three. During tracking, we remained lateral to the direction of hatchling movement and 10 to 50 m away depending on conditions. Position was determined with LORAN C and recorded each hour in addition to wind speed and direction, air and water surface temperature, wave height and direction(s), and hatchling behavior and orientation. Every 4 hr, current speed and direction were measured from the paths of drift bottles tracked from a 4 m inflatable boat.

RESULTS AND DISCUSSION

We tracked 15 hatchlings for as long as 81 hr and 121 NM from the release point (Table 1). Most efforts ended when tracked hatchlings were lost due to wind, rain, or lighting conditions. Only one hatchling was depredated, most likely by a fish.

Hatchling behavior

Powerstroking--The most common behavior observed in hatchlings during the first 30 hr (n=8) was powerstroking. In powerstroking, hatchlings swam within 10 cm of the surface, moving their front flippers simultaneously. Hatchlings swam this way for 5-20 second bouts between breaths which lasted 1-3 seconds. During breaths, the head of the hatchling protruded from the water and the front and rear flippers moved in an alternating "dog paddle" fashion.

Table 1. Endpoint data from loggerhead hatchlings tracked off East Florida.

Hatchling	Hours Tracked	Final Distance (NM) and Bearing from Start	Fate
1	5	3 NE	Lost
2	29	12 ENE	Lost
3	68	22 ENE	Lost
4	17	9 E	Lost
5	55	13 NNE	Lost
6	8	4 NE	Lost
7	17	10 NE	Lost
8	55	12 ENE	Eaten
9	39	18 NNE	Lost
10	81	121 N	Retrieved
11	78	17 NNE	Lost
12	8	5 N	Lost
13	33	12 SE	Lost
14	15	7 NNE	Lost
15	38	27 NE	Lost

Rear flipper kick--This second swimming stroke was the modal behavior of hatchlings swimming at night, after the second day at sea. During rear flipper kicking, hatchlings had their front flippers laid flat over their carapace and swimming strokes were made with alternating movements of the rear flippers. Hatchlings swimming this way made less progress than during powerstroking. As during powerstroking, hatchlings maintained a constant orientation ($\pm$ 20°) except when hatchlings were adjacent to floating objects.

Fetal tuck--After the second day at sea, hatchlings spent some of each night in a fetal tuck position (similar to the position of the turtle fetus within the egg). Hatchlings in a fetal tuck had their front flippers laid flat over the carapace, neck withdrawn (as much as possible), and rear flippers overlapping one another covering the tail region. Hatchlings in this position were motionless and if taken from the water would remain so for several minutes while held. Presumably, flippers held tightly against the body like this are less likely to be nipped by fish.

Responses to flotsam--Swimming hatchlings that passed within 1 m of gulf weed (Sargassum) patches and other floating objects either continued swimming, or changed their behavior and orientation upon contact. Hatchlings that altered their behavior adjacent to weed patches would stop swimming and assume a fetal tuck, climb atop and through the patch, and/or encircle the patch, swimming with the rear flipper kick pattern. Although no hatchling was seen to engulf any object, the behavior suggests that hatchlings in weed patches were foraging. Hatchlings were active in weed patches (possibly foraging) only during the day and remained active for 1-20 min before moving away or becoming inactive. Hatchlings became inactive in weed patches for 5 min-2 hr (primarily at night) before moving away.

Responses to predators--Swimming hatchlings responded to threats looming overhead by immediately diving straight down to a depth of approximately 3 m, in dives lasting 0.3-2.6 min (n=93). The stimuli prompting this deep dive response were typically birds, but hatchlings responded similarly to airplanes directly overhead. When subsurface threats (typically fish) passed within approximately 5 m of a swimming hatchling, hatchlings ceased movement and assumed a fetal tuck position until 1-2 min after the threat moved away (n=8).

Temporal patterns of behavior--Hatchlings followed for more than two days (n=5) showed a similar temporal swimming pattern. Hatchlings swam most actively (powerstroking with few pauses) during the first 30 hr. On the second day, hatchlings began rear flipper kick swimming in addition to powerstroking. On the following night (42 hr post release), hatchlings were typically inactive (fetal tuck) or swam with the rear flipper kick pattern. Hatchlings followed more than three days (n=2) continued this primarily diurnal activity pattern (mostly daytime swimming) on the third day. These patterns are in keeping with observations of hatchling swimming under laboratory conditions (Salmon and Wyneken, 1987).

Orientation--Orientation of swimming hatchlings was generally east-northeast, and often did not coincide with the directions of wave propagation as measured. During the course of a single tracking session, long-wavelength swells were often too small to measure, but local wind-generated waves were prominent, and commonly originated from a direction other than the hatchling's course. This suggests that the ability for wave orientation in hatchlings (Wyneken et al., 1990) may function primarily in the surf zone where refraction effects of the shoreline make wave direction a more dependable indicator of the offshore direction.

Dispersal

Although the behavior pattern of tracked hatchlings was relatively stereotypical, the distance and direction of hatchling dispersal varied greatly (Table 1) as dictated primarily by variable nearshore currents. The hatchling traveling the farthest happened to have been swept into the Gulf Stream (30-100 NM offshore, 4 knots due north) by a northeast current near shore.

Effects of tracking methods

Two lines of evidence suggest that the tracking floats employed had little effect on the behavior and dispersal of tracked hatchlings. 1) Powerstroking hatchlings with floats swam at an average of 91% of their speed without floats (n=3), 16-22 m/min. 2) Sixteen living loggerhead hatchlings were discovered at sea during tracking. These hatchlings were similar in size (4.2-4.8 cm SCL), and were behaving and oriented similar to the hatchling being tracked at the time of discovery.

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PART II: POSTER PRESENTATIONS

INNOVATIVE TECHNIQUES TO FACILITATE FIELD STUDIES OF THE GREEN TURTLE, *CHELONIA MYDAS*

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INTRODUCTION

This paper describes five safe, simple, and inexpensive techniques to enhance research of green turtles in the wild. All of these methods have been successfully employed and are currently in use in the Hawaiian Islands. In most cases, the procedures are believed to also be applicable to other species of sea turtles. However, they have not yet been tested by the author in that capacity. In keeping with sound research practices and to prevent the possible spread of disease, any equipment coming into contact with a turtle should be properly cleansed before being used on another turtle. In those instances where disease may be a special concern, two complete sets of equipment should be used: One for turtles that appear to be healthy, another for those showing an affliction. It is also reminded that the appropriate federal and state permits, or authorization (whether U.S.A. or foreign), may be needed prior to implementing most of the procedures described here.

ORAL EXAM USING A SPECULUM: Carefully inspecting a turtle's mouth during field studies can yield valuable information that might otherwise be overlooked. Oral examinations can readily detect the presence of significant injuries or abnormalities, tumors such as fibropapillomas, foreign objects like fishhooks, and parasites including leeches and amphipods. Residual food particles may also be seen that can give insight into the turtle's natural diet. A vaginal speculum provides a safe and easy means for opening a turtle's mouth and holding it open without risk of injury to the turtle or the researcher. Once inserted and adjusted to the open position, the speculum will flex slightly to accommodate the turtle and prevent damage or undue stress as the animal intermittently bites down. Vaginal speculums are commonly used in veterinary and human gynecological medicine. They come in several different sizes and can be purchased for under $30 from most veterinary supply companies.

ESOPHAGEAL FLUSHING OF FOOD COMPONENTS: Techniques to safely sample food components for dietary studies of live green turtles have been used in Hawaii since 1976 (Balazs 1980). Oral examinations and the collection of fresh fecal pellets are two procedures employed to recover residual food particles for identification. However, the most productive technique has been the controlled infusion of water to flush out food items by using a plastic tube inserted partially into the esophagus. This method has been refined over the years to increase effectiveness and make it more applicable for quick and convenient use under field conditions.

The turtle is first placed on its back in a comfortable and accessible position. For turtles weighing less than about 25 kg, the researcher's lap offers an ideal working site. Once in position, the turtle's mouth is opened with a speculum, as previously described. An oral inspection is conducted to determine if there is any reason why the sampling protocol should not proceed. Once a favorable assessment has been reached, a short piece of thick-walled rubber hose of the appropriate size is inserted into the mouth while the speculum is removed (Figure 1). A stout rubber band is then carefully placed around the turtle's head and jaw to guard against the mouth opening wider and the hose falling out. The hose insert should be of sufficient size and firmness to prevent it from collapsing when the turtle periodically bites down. Fabric-reinforced automobile radiator hose, or washing machine drain hose, can be obtained for this purpose.

With a little resourcefulness, short sections of hose of different diameters can be inserted into one another to custom assemble the desired wall thickness and outside diameter needed for the turtles being sampled. A length of clear plastic aquarium tubing of suitable diameter for the size of the turtle being sampled is then securely attached to the screw-on top of an enema syringe. A small hose clamp works well for this purpose. Several different styles of enema syringes are available at drugstores for under $20. The diameter of the tubing used should be small enough for unincumbered entry through the hose insert into the esophagus, but not so small that the tube folds back on itself. Again, the size of the turtle being sampled will dictate what is actually used. It is helpful to have a wide assortment of aquarium tubing on hand to meet the different needs encountered. The preliminary testing and evaluation of an array of tubing diameters, wall thicknesses, and lengths during routine necropsies of turtles is advisable before working with live animals.

The next step in the sampling process is to liberally lubricate the end of the tubing with edible vegetable oil. A "no-stick cooking spray," like Pam, offers a convenient means of application. The lubricated tube is then gently passed through the hose and guided down the esophagus. There is no danger of entering the trachea because (1) the hose insert protects against this; (2) the glottis is locked shut during breath holds; and (3) the size of the tubing used is almost always larger in diameter than the open glottis. The movement of the tubing through the esophagus once inserted can be felt and monitored by placing your fingers on the ventral surface of the turtle's neck. The tubing only needs to be inserted to the approximate point where the anterior edge of the plastron meets the skin of the neck. Very little if any resistance will be encountered when properly inserting a lubricated tube for this limited distance.

With the enema syringe filled with clean seawater, the screw-on top is attached and the flow of water started. The stream of water, controlled by squeezing and releasing the syringe, serves to flush particles of algae or sea grass from the posterior region of the esophagus or "holding crop." Such food is held there in a compacted fashion before being passed along to the secretory stomach. No food is obtained by this technique from the secretory stomach. Only the flushing action of the water reaches the crop, and not the tubing itself. A holding container, or fine-mesh screen, can be used to catch (or filter) the water once the backflow starts out of the mouth. Alternately lowering and elevating the posterior of the turtle will aid in the flushing action. If a container instead of a filter is used to catch the backflow, the water can be easily decanted and the denser food particles collected. At least one assistant is needed to conduct this highly effective and benign food sampling technique.

DURABLE CARAPACE MARK FOR EASY VISUAL IDENTIFICATION: A simple and durable carapace marking method to individually recognize turtles from a distance constitutes a valuable research tool. The ability to identify turtles in this manner enhances data collection and sharply reduces the level of disturbance during encounters after the initial flipper tagging. Reidentifying a nesting turtle by having to read its flipper tag requires a researcher to closely approach and handle the turtle on each occasion. Eliminating this repetitious intrusion clearly is necessary if nesting turtles are to be studied with minimum impact.

Various kinds of paint have been applied to the carapace of sea turtles by other workers for identification purposes, but none is known to have remained readable over the several-month period of nesting. During 1989 a wide array of adhesives, paints, and other potentially tenacious agents were tested using captive green turtles at Sea Life Park in Hawaii (Balazs 1989). Two-part catalytic products were not included in this study as they were considered impractical to use under field conditions. A total of 59 items were examined in this study, ranging from peel-off adhesives to sealant foams, felt-tip markers, crayons, fingernail polish, and numerous brush-on and spray paints (complete list available upon request). With few exceptions, poor retention was shown by all of these products, and none proved acceptable for the purpose and time span intended. Based on this work, it was concluded that a combination of causes prevents lasting adhesion. Such adverse factors include constant immersion in seawater, abrasion to the carapace from several sources, and, perhaps the most important, normal constant shedding and regeneration of the scutes at the cellular level. Substances applied to the smooth carapace surface, even when scrubbed clean, are liable to early loss due to these factors.

Following some additional experimentation, a practical solution to the problem was finally achieved. Using a high speed (20,000 rpm) battery powered tool called a dremel "moto-tool," the desired identification numbers were mildly engraved 1-2 mm deep into (but not through) a carapacial scute. A light-colored paint was then applied to the inscription where it was retained and served to prominently display the numbers. The skillful use of this tool is easily mastered with little practice. There is virtually no response from the turtle during the 30-second engraving procedure; hence, no physical restraint of the animal is needed. At least 20 turtles can be engraved with up to four characters on each turtle by using a single fully charged dremel moto-tool. The tool is reasonably priced at about $60. Adult turtles marked in this manner at Sea Life Park still have readable engravings after nearly 3 years.

Field testing of the technique took place during the 1990 and 1991 nesting seasons at French Frigate Shoals in cooperation with the U.S. Fish and Wildlife Service. A total of 260 green turtles were marked without problems and easily identified during renesting encounters. Hawksbills and loggerheads also should be highly suited for this technique; however, ridleys, flatbacks (and of course leatherbacks) are not likely to be amenable because of their exceptionally thin scutes. Immature green turtles in Hawaii have also been engraved to facilitate easy recognition during underwater research activities. The technique again proved successful, although a shallower engraving is required, and the marks usually disappear as the result of regrowth within 6-12 months.

SIMPLE WAY TO CINCH A TURTLE: Field studies often necessitate that turtles be weighed. A piece of rope can be effectively used to rapidly secure a turtle for weighing (Figure 2). The manner of cinching the rope allows the carapace, and not the flippers, to support the turtle's full weight when lifted. This technique also provides a convenient way to transport a turtle with minimum stress. Several different lengths of rope are desirable when working with a broad size range of turtles. Braided 1/2-inch diameter nylon line of a high quality is recommended. Cinching a turtle in this fashion for weighing has been found to be superior to the use of cargo webbing and other contrivances. Such methods often enmesh and impede the head and flippers, resulting in more struggling and stress.

POSTPAID SIGHTING REPORT CARDS: The judicious use of postpaid, self-addressed, turtle-sighting report cards offers an excellent opportunity for researchers to receive potentially important information from the public. Observations that may be conveyed in this manner include the location, number, and activity of the turtles seen, as well as human and other adverse impacts. A card with a brief and uncomplicated format is highly recommended (Figure 3). A short conservation message or law enforcement reminder printed on the card is also advisable. Information received by the researcher can be acted upon by detailed telephone interviews, on-site studies, or in other ways deemed appropriate.

The actual scope and magnitude of distributing the sighting cards will be dictated by the specific needs and financial status of the project involved. The prepaid postage is essential for the successful use of the card. At current postal rates in the U.S.A., 1000 cards can be posted for only $190.

Lifeguards, tour boat operators, and recreational fishermen have proven to be especially worthwhile contacts for the use of these cards. However, virtually any conscientious individual who spends an extended time in, on, or along the ocean is a potentially valuable informant.

ACKNOWLEDGEMENTS

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Figure 1. Rubber hose insert in place with aquarium tubing passed through it in preparation for esophageal flushing of food components.

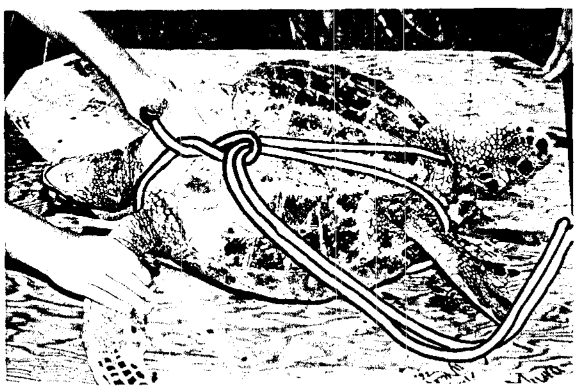
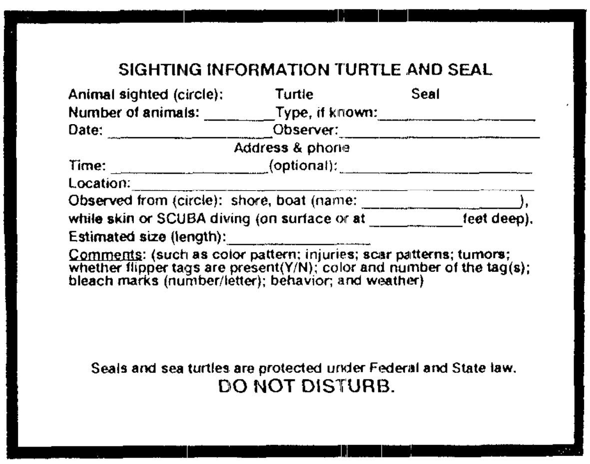


Figure 2. Method of cinching a turtle for weighing using a braided nylon line.



SIGHTING INFORMATION TURTLE AND SEAL

Animal sighted (circle): Turtle Seal

Number of animals: ________ Type, if known: ____________

Date: ________________ Observer: ________________

Address & phone

Time: ________________ (optional): ________________

Location: ________________________________

Observed from (circle): shore, boat (name: ________________),

while skin or SCUBA diving (on surface or at ____________ feet deep).

Estimated size (length): ________________

Comments: (such as color pattern; injuries; scar patterns; tumors; whether flipper tags are present(Y/N); color and number of the tag(s); bleach marks (number/letter); behavior; and weather)

Seals and sea turtles are protected under Federal and State law.

DO NOT DISTURB.

Figure 3. Postpaid sighting report card successfully used in the Hawaiian Islands.

RELATIONSHIP BETWEEN SAND MOISTURE AND HATCHING SUCCESS OF OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*), AT ESCOBILLA, OAXACA

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INTRODUCTION

Olive ridley (*L. olivacea*) arribadas at Escobilla, Oaxaca, offer the possibility of ecological, biological and behavioral research (i.e. reproduction, migration, inter- and intra-specific interactions, environmental conditions). These subjects are very important for the understanding of distribution and abundance of this important species and, at the same time, for the establishment of protection and conservation strategies.

Some technical reports have attempted to show the relationship between environmental conditions and the arribada, but much more work is necessary. In the laboratory, enviromental factors such as temperature and moisture have been correlated with hatching success (see McGehee, 1979; Yntema & Mrosovsky, 1980). However, it is important to test this relationship in the field.

OBJECTIVES

To assess the effects of sand moisture on the hatching success of olive ridley nests.

1. To estimate the influence of sand moisture on embrionic development stages, hatching and emerging of the turtles.
2. To establish the effects of sand moisture on hatchling size and weight.
3. To determine the relationship between sand moisture and incubation time.
4. To establish the relationship between sand moisture and insect predation (Diptera and Coleoptera).

METHOD

The study began on September 10, 1990. An area 15m wide in front of the camp was divided into 3 zones: Zone 1 or tidal zone; Zone 2 or middle platform, and Zone 3 or partially vegetated zone. Ten nests were transplantated into each zone, and ten additional nests were relocated to Zone 4 or the "corral".

Three samples of sand were taken from each nest on a weekly basis. One hundred gram sand samples were taken 30 cm. laterally from nest and at 40 cm. depth (Casas-Andreu, 1978). The samples were weighed (±0.01g), dried in an oven and reweighed. The dried sample difference was divided by the saturation constant (0.29 ml/g for Escobilla; in Bautista-Huerta, 1992), to give the value of the moisture saturation percentage (McGehee, 1979). The nests were observed for the number of hatchlings emerged, hatched and/or depredated by insect larvae.

RESULTS

Table I: Analysis of Variance and Correlation values between different variables.

Analysis of Variance with respect to the three Beach Zones:

	F	
Hatchlings emerged	13.84 *	
Hatched	12.84 *	
Predation by insect larvae	86.71 **	(All values significant at P < 0.001)

Correlation values (r) between sand moisture and the following variables:

	r	
Hatchlings emerged	0.67	
Hatched	0.62	
Predation by insects larvae	-0.80	(All values significant at P < 0.001)

DISCUSSION

No data were obtained from beach Zone 1 due to severe erosion and nest washout. The effect of beach erosion and nest washout has also been reported for leatherback by Tucker (1990), and for loggerhead by Hopkins et al. (1979).

Using a notched box-and-whisker plot analysis, only beach Zone 2 was found to be different with respect to the other two zones. The moisture saturation percent in Zone 2 was 14.07%, in Zone 3 was 12.77% and in Zone 4 was 12.67%.

Analysis of variance (ANOVA) showed differences in the level of predation by insect larvae among beach Zone 2, Zone 3 and Zone 4. Only beach Zone 2 was found to be different with respect to hatching and emerging success from the other two zones (Fig. 1, Table I). The same pattern was observed for *Chelonia agassizi* by Zamora (1990).

The values for moisture were positively correlated with hatching and emergence success and negatively correlated with insect predation (Table I).

It can be concluded that the beach platform (Zone 2) was the most suited for hatching successs, probably due to this area having the highest sand moisture content (McGehee, 1979). Zone 3 and Zone 4 were more vulnerable to beetle larvae predation, possibly because dry sand and organic matter offer the best conditions for insect growth in this area.

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Fig. 1: Percentage of *L. olivacea* hatchlings emerged, eggs hatched, and hatchlings depredated by insect larvae, compared with sand moisture for three beach zones.

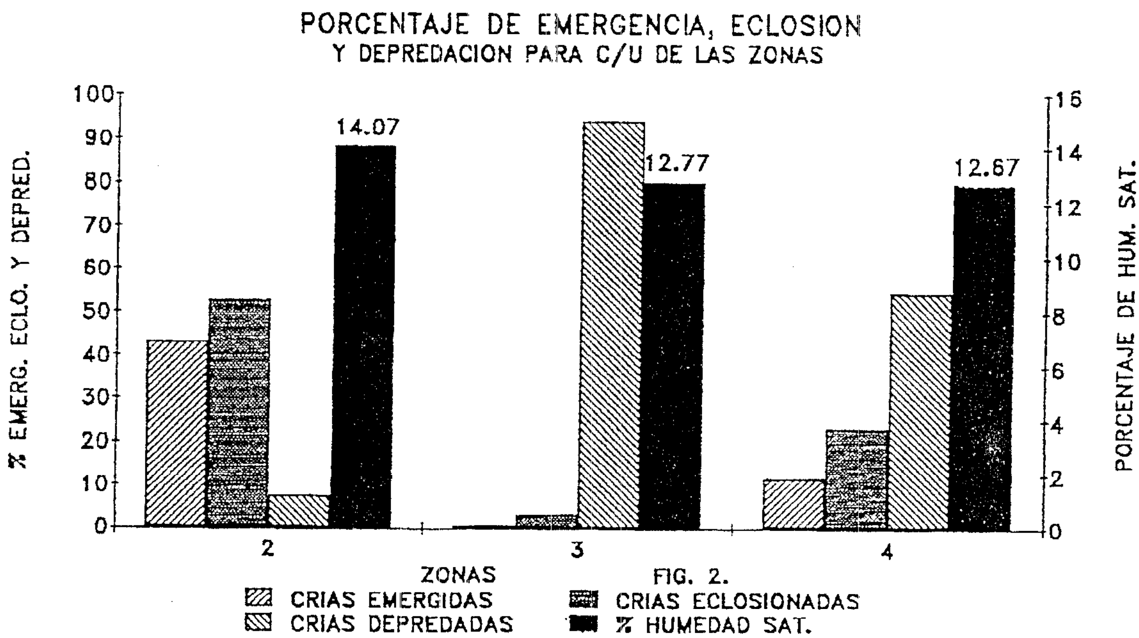

FIG. 2.

PRELIMINARY REVIEW OF DATA BASES OF SEA TURTLES IN THE NORTHEASTERN U. S.

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ABSTRACT: The purpose of this study is to document the known status and distribution of the four species of sea turtles that are commonly found in the Northeast region of the United States. These species are the leatherback (*Dermochelys coriacea*), the loggerhead (*Caretta caretta*), the Kemp's Ridley (*Lepidochelys kempi*) and the green (*Chelonia mydas*). The National Marine Fisheries Service (NMFS) has 15 data bases that have information on sea turtle sightings, strandings, and incidental takes in fisheries in the Northeast. As of February 1992, 10 of the 15 data bases have been accessed and reviewed. The information has been categorized according to the estimated number of turtles and the relative quality of the data. Based on analyses of these compilations, recommendations will be made to the NMFS on distribution of sea turtles in the Northeast region, documented threats, and areas in which further study and monitoring are needed.

INTRODUCTION: The Northeastern Region of the United States is defined as the area from Cape Hatteras, North Carolina, to Maine. The four speices of sea turtle that most commonly occur in this region are the leatherback (*Dermochelys coriacea*), the loggerhead (*Caretta caretta*), the Kemp's Ridley (*Lepidochelys kempi*) and the green (*Chelonia mydas*) (Carr 1952). Lazell (1980) suggested that this region is a critical feeding area for the Kemp's ridley, loggerheard, and leatherback turtles. Work conducted in embayments in the Northeast since that time (Burke 1990; Morreale 1990) support this suggestion; however, no feeding studies have been conducted in offshore waters.

Aerial surveys conducted over 10 years ago (Shoop 1981) provide the only accumulated observations of the pelagic distribution of these turtles north of Cape Hatteras. Opportunistic sighting data and data on incidental captures in commercial fisheries are currently located in 15 data bases collected under varying programs run by the National Marine Fisheries Service. The purpose of this project is to compile these data to establish the distribution of sea turtles, identify the threats facing them, and identify areas in which further information is needed.

Objectives

- Compile a list of all of the existing data bases within the National Marine Fisheries Service (NMFS) Northeast Region. The data bases include sightings, strandings, and fishery-related entanglements of sea turtles. This compilation will determine location and accessibility of the data.
- Evaluate the data to determine which data sets provide reliable information.
- Choose the most reliable and complete data sets and develop distribution plots by turtle species, fishery, and season using a Geographic Information System (GIS) for northeastern waters.
- Identify potentially important habitat and probable fisheries interactions.
- Make recommendations to the NMFS Northeast Regional Office for improving the quality of the data collection for each data set, and institute appropriate management measures concening these species.

METHODS AND RESULTS: Thus far, 10 of the 15 data bases that contain information on sea turtles strandings, sightings, and incidental takes in fisheries in the Northeast have been accessed and reviewed. Of the ten accessed data bases, six are fishery-dependent and four are fishery-independent. The fishery-dependent data bases are managed by three different programs: the Foreign Observer Program, the Domestic Observer Program (or Sea Sampling Program), and the Marine Mammal Exemption Program. The fishery-independent data bases are managed by the Bottom Trawl Survey, Manomet Bird Observatory (MBO) observer program, Cetacean and

Turtle Assessment Program (CeTAP), and the Sea Turtles Stranding and Salvage Network (STSSN). Aerial surveys, sightings, records of incidental takes from fishing and non-fishing vessels, and beach surveys were methods used to collect information contained in the NMFS data base sources.

The relative quality of the accessed data sets was evaluated by placing value judgements on the parameters measured (Table 1). The quality of each parameter was judged to be either poor or good in terms of its usefulness and reliability. Estimates of the numbers of sea turtles recorded in each data base (Table 2) show that the STSSN data base contains the most records, totalling 2,560 over an 11-year period. The estimated number of records in the other data bases were at least an order of magnitude lower.

With these compiled data, distributional plots by turtle species, fishery, and season will be developed. These plots will be completed with the use of a Geographical Information System (GIS), which is a specialized data base management system used to store, retrieve, and analyze cartographic data. It serves as a method of managing, analyzing, and displaying map information assembled from a number of diverse data bases. Distributions of sea turtles in the northeast will be derived from the compiled data to detemine spatial and temporal area of habitat use and potential fishery interactiosn.

DISCUSSION: Estimates of the number of turtles recorded as stranded, sighted, surveyed, or taken incidentally in fisheries (Table 2) are conservative because they reflect only a portion of the data available. All of the files have not been fully checked for turtle takes or sightings. The number of sea turtle sightings or entanglements is probably a lower number than what is realistically occurring because information on sea turtles is not often a priority research goal of the various programs. This factor emphasizes the need to adjust research effort in order to fulfill the requirements of a complete and usable data set to help these endangered sea turtles.

The records in the data bases vary in quality because of differences in time and effort allocated to the surveys from which they were obtained. Value judgements are essential due to the variation found within the data sets. For example, some sets of data were collected by volunteers rather than trained observers. This was considered in the assessment of the data's value.

This study will result in a synthesis and analysis of the data bases contained by the NMFS and will demonstrate which is lacking or irrelevant, and what is appropriaate in the available information and in the methodology used to obtain the data. Then, recommendations will be made to make the data bases more complete and statistically robust, which will help in developing guidelines for effective management of these endangered species.

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TABLE 1. RELATIVE QUALITY[1] OF 10 DATA BASES CONTAINING SEA TURTLE SIGHTINGS, STRANDINGS, AND CAPTURES IN THE NORTHEAST REGION

SOURCE[2]	YEARS	DATA BASE PARAMETERS											AVAILABILITY OF DATA	EST. NO. TURTLES/YR
		DATE	LOCATION	SPECIES	CONDITION	MEASURE	WEIGHT	SEX	EFFORT	METHOD	DEPTH	TEMP		
FISHERY DEPENDENT														
FT	77-90	2	2	2	1	1	1	0	2	2	2	2	1	1.5
OS	77-90	2	2	2	1	1	1	0	2	2	0	0	1	2.5
JLL	82-88	2	2	2	1	1	1	0	2	2	0	2	1	2.9
MMEP	89-90	1	1	1	1	0	0	0	0	0	0	0	2	26.0
DDGN	89-90	2	2	2	2	2	0	0	2	2	2	3	2	3.0
DOT	89-90	2	2	2	2	2	0	0	2	2	2	3	2	3.0
FISHERY INDEPENDENT														
BTS	81-90	2	2	2	3	2	2	2	2	2	2	2	2	5.3
MBO	80-88	2	2	2	0	0	0	0	3	2	2	2	2	20.9
CETAP	79-81	2	2	2	0	0	0	0	3	2	2	2	2	-----
STSSN	80-90	2	2	2	2	2	0	2	0	2	0	0	2	237.6

[1] 0 = ABSENT
1 = POOR
2 = GOOD

[2] FT = FOREIGN TRAWL
OS = OBSERVER SIGHTINGS
JLL = JAPANESE LONGLINE
MMEP = MARINE MAMMAL EXEMPTION PROGRAM
DDGN = DOMESTIC DRIFT GILLNET
DOT = DOMESTIC OTTER TRAWL
BTS = BOTTOM TRAWL SURVEY
MBO = MANOMET OBSERVERS
CETAP = CETACEAN/TURTLE SURVEY
STSSN = STRANDING/SIGHTING NETWORK

TABLE 2. ESTIMATED NUMBER[1] OF SEA TURTLES RECORDED IN STRANDING, SIGHTING, SURVEY, AND FISHERY DATA BASES[2] FOR THE NORTHEAST REGION, 1977 - 1990

	FISHERY DEPENDENT						FISHERY INDEPENDENT			
YEAR	FT	OS	JLL	MMEP	DDGN	DOT	BTS	MBO	CETAP	STSSN
1977	0	0	--	--	--	--	0	--	--	--
1978	0	0	--	--	--	--	0	--	--	--
1979	1	1	--	--	--	--	0	--	?	--
1980	0	8	--	--	--	--	0	16	?	267
1981	0	2	--	--	--	--	1	21	?	148
1982	7	4	3	--	--	--	2	10	--	161
1983	7	2	0	--	--	--	3	18	--	192
1984	0	4	4	--	--	--	1	24	--	213
1985	1	3	6	--	--	--	2	25	--	177
1986	3	7	5	--	--	--	2	12	--	207
1987	0	1	1	--	--	--	1	21	--	398
1988	0	0	1	--	--	--	1	20	--	255
1989	0	0	---	11	3	6	2	--	--	229
1990	0	0	--	41	3	0	1	--	--	313
TOTAL:	19	32	20	52	06	06	16	167	?	2,560

1
-- = NO DATA COLLECTED
00 = NO TURTLES
? =UNKNOWN NUMBER

2
FT = FOREIGN TRAWL
OS = OBSERVER SIGHTINGS
JLL = JAPANESE LONGLINE
MMEP = MARINE MAMMAL EXEMPTION PROGRAM
DDGN = DOMESTIC DRIFT GILLNET
DOT = DOMESTIC OTTER TRAWL
BTS = BOTTOM TRAWL SURVEY
MBO = MANOMET OBSERVERS
CETAP = CETACEAN/TURTLE SURVEY
STSSN = STRANDING/SIGHTING NETWORK

AERIAL SURVEYS FOR SEA TURTLES IN SOUTHERN GEORGIA WATERS

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Necropsies suggested that at least 9 sea turtles from a major turtle stranding event in spring 1991 along coastal Georgia had been impacted by hopper dredging activities in the Brunswick River Entrance Channel (Ga. Dep. Natur. Resourc. 1991). The U.S. Army Corps of Engineers requested that we determine the relative abundance of sea turtles in the vicinity of the channel by aerial reconnaissance.

As weather permitted, we conducted daily surveys of inshore and nearshore waters, including channels, between 30°42.0'N and 31°11.5'N (Figure 1) from 2-9 June 1991. We completed 2 offshore and inlet strata surveys and 3 inshore strata surveys; survey coverage averaged 43% in 6 inshore strata, 35% in 3 inlet strata, and 18% in 3 offshore strata.

We demonstrated that aerial surveys could be used region-wide to identify areas of relatively high sea turtle abundance. Sea turtles were sighted in turbid inshore waters with high tidal amplitudes. A total of 19 sea turtles - all chelonids - were sighted on the surface in 6.3 hours of actual survey time and a total of 15.7 hours of air time. Most sea turtles were sighted in the Brunswick R./Turtle R. stratum and the Jekyll Sound stratum, near the maintained channels. However, highest abundance of sea turtles was in Jekyll Sound, an area without a maintained channel (Figure 1). Surface densities ranged from 0 to 62.51 sea turtles/100km^2. Sighting a sea turtle on the surface is a rare event even in areas of relatively high abundance; the most sea turtles sighted within a single stratum during a survey was 3 individuals. Hence, variances for the estimates of number and density are high. Even with this variability, repetitive surveys (5 in Brunswick River, 2 in St. Simons Sound) of the Brunswick River channel did reveal an apparent association of sea turtles in proximity to the channel.

Thanks are extended to the U.S. Army Corps of Engineers for funding and the opportunity to evaluate this technique, National Marine Fisheries Service observer, N. McNeill, pilot J. Knight of Island Flyers, Inc. and C. Dickerson of the USACOE Waterway Experiment Station for assistance with the surveys. J. Richardson and G. Plumber, both of the University of Georgia, provided trawl capture and weather data, respectively. We appreciated the coordination efforts of J. Merriner and D. Nelson, NMFS and USACOE, respectively. S. Shipman, M. Harris and the Georgia Department of Natural Resources made the resources of their Brunswick facilities available to us. We would also like to thank A. Chester for statistical consultation and D. Vaughan, J. Merriner, A. Chester T. Henwood and N. Thompson for constructive reviews.

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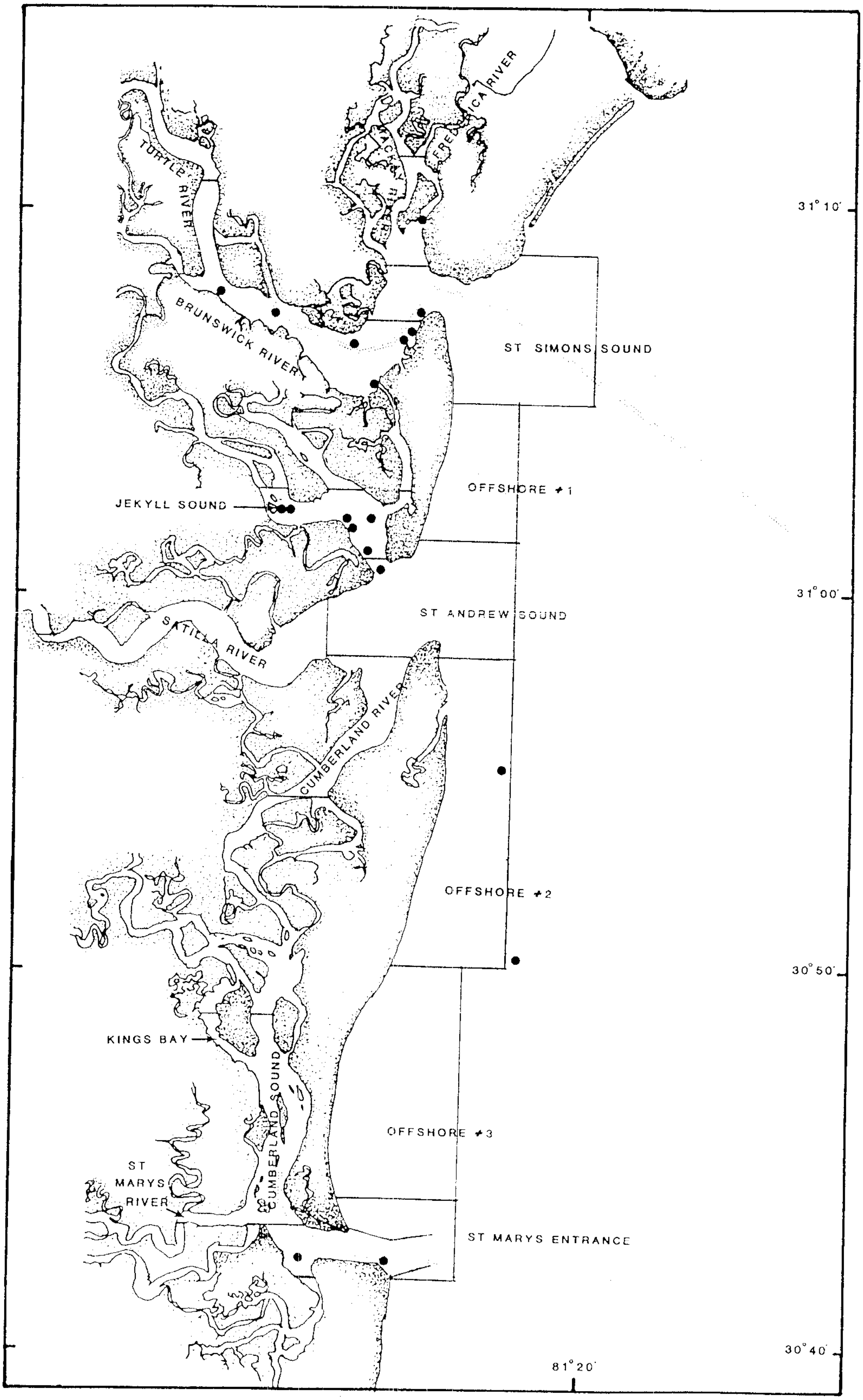

Figure 1. Survey strata of the inshore and nearshore waters of southern Georgia. Solid dots represent sea turtle sightings

PROTECTION OF NESTS AGAINST PREDATION BY FOXES AND RACCOONS

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INTRODUCTION

Loggerhead turtles (*Caretta caretta*) annually make their nests along the central eight miles of beach on Kiawah Island, South Carolina. Kiawah is one of the barrier islands along the coast of South Carolina, lying in an east-west orientation for a total length of nine miles. Real-estate development is advanced in the western portion, but homes and inns are set well back from the front dunes, and turtles lay their nests along the entire beach. Predation of the nests has been severe at the less developed eastern portion of the beach. For example, in 1989 and 1990 about 40% of the nests in this region were raided by grey foxes and raccoons. Once the animals discovered a nest and removed some eggs, they would return repeatedly, and often the nest was totally destroyed. This occurred despite installation of the customary wire screening over the nest. If the animal was prevented from digging down through the screen by addition of a 15" x 15" screen of finer mesh in the center, it would tunnel beneath the screen from the edge.

Early in the 1991 nesting season it became apparent that predation by these animals was becoming even more severe than in previous years. In desperation, we decided to protect the nests further by electric fencing.

METHODS

As illustrated (Figure 1), the endangered nest was identified with a numbered stake and covered with a 4' X 4" screen of 2" X 4" mesh wire plus a 15" square of finer mesh screen in the center. Wooden states of 15" length were driven into the sand to anchor the fence and extended above the sand about 10"; these had insulators or in some cases common nails affixed at the top. Stainless steel wire of a heavy gauge connected all four stakes and ran diagonally over the center of the enclosure. (Alternatively, a second 4' X 4" screen could be rested upon the top set of nails and replace the stainless steel wire. The latter arrangement was easier to install but was somewhat more expensive.) The positive pole of a small 12 volt storage battery of the type customarily used on garden tractors was connected to the top wires, and the negative pole was connected to the bottom screen as shown in Figure 1. Finally, the battery was covered by a wooden box or a plastic bucket to protect it from salt spray, rain and drifting sand, and a warning sign was installed.

About three weeks of incubation, the battery could be disconnected and moved to another nest that needed protection. The fence was left over the nest for the remainder of the two month incubation period, and its presence plus the probable loss of odor from the nest resulted in no further predation.

Usually a nest was not protected by the electric fence until it had been raided and some eggs lost; 29 nests were protected in this manner in 1991. After protection by the electric fence, the raccoons quickly abandoned any further attempts to dig (as determined by their tracks in the sand). The foxes were more persistent and would sometimes pass through the fence as though they were less sensitivie to the electric shock, but in no case did they dig into a nest protected by the current.

Table I shows the protection gained in 1991 in comparison with earlier years without the installation of the electric fence. The annual number of nests was variable, but the percentage at the eastern end of the island (the P-Zone) and the percentage raided were similar for each of the threee years. The protection in 1991 is demonstrated by the decrease to zero in the percentage destroyed by predators.

DISCUSSION

The electric fencing was accepted well by persons enjoying the beach during the neating season. It should be emphasized that the protected nests were at the undeveloped section of the island, and fortunately the developed section did not require protection in this manner. The only reference in the literature that is known to the authors for the application of electric fence for this purpose was the protection of a hatchery on Little Cumberland Island in Gerogia reported by Richardson in 1976.

Costs for this protection are difficult to determine precisely, because most items could be used for several seasons, but probably would be less than $2 per nest for screen and fence; the 12 volt batteries cost $34 each. Because the fence drew no current unless an animal momentarily completed the circuit, the batteries held their charge for weeks and even months. The only corrosion that was encountered was to the clamps from the electric lead wires to the fence and ground screen. Several clamps did need to be replaced during the season, and a search for a more corrosion-proof clamp is still in progress.

ACKNOWLEDGEMENTS

The Loggerhead turtle nesting program on Kiawah Island is financially supported by the Town of Kiawah Island and is possible only though the dedicated effort of a large team of volunteer property owners.

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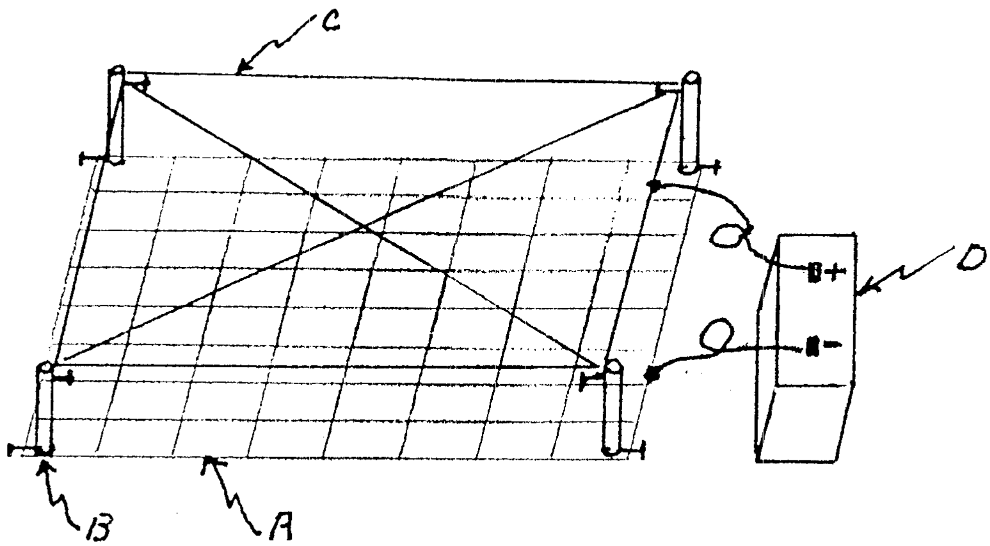
Table 1. Effect of Electric Fencing on Nest Protection in 1991.

Year	1989	1990	1991
Number of marked nests on the Kiawah beach	92	202	182
Percent of nests in the P-Zone*	50%	41%	50%
Percent of nests in the P-Zone raided sometime during incubation	42%	40%	44%
Percent of raided nests in the P-Zone that were destroyed ultimately by predators	35%	30%	0%

* P-Zone refers to the zone of heavy predation at the eastern portion of Kiawah Island.

Figure 1: Electric Fence Protection of Turtle Nests from Fox and Raccoon.



A: Wire screen (4' X 4") of 2" X 4" mesh sixe

B: Wooden stakes of 15" length with two common nails of 3" length in place at 1" and 8 " from the top. The lower nail secures the wire screen to the sand; the top hail supports the top wire or screen (see C).

C: Stainless steel wire of a heavy guage (other metals corrode rapidly). Alternatively, a seoncd wire screen (as described in A) can be rested upon the top set of nails of the four posts. The latter armagement was the easiest to install but was somewhat more expensive.
D: 12 volt storage battery (see text). This battery and wire leads were covered by an inverted plastic bucket to protect it from salt spray, rain and sand. A sign should be placed by the nest to warn people of the danger of the charged fence.

U.S. ARMY CORPS OF ENGINEERS SEA TURTLE STUDIES ASSOCIATED WITH HOPPER DREDGING PROJECTS

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ABSTRACT

Three threatened or endangered species of sea turtles are potentially affected by hopper dredging along the U.S. Atlantic coast. Measures to protect sea turtles have evolved since the first records of incidental captures at Cape Canaveral, Florida, in 1980, but mortality has not been eliminated. The substantial reduction in documented sea turtle mortalities has resulted from modifications in dredging equipment, operational procedures, and management practices. More complete sea turtle life history and behavioral information are necessary to develop a long-term management plan, including modifications to dredging technology, to most effectively minimize sea turtle mortalities during hopper dredging..

U.S. Army Corps of Engineers Headquarters, South Atlantic Division, and the Waterways Experiment Station are sponsoring and conducting sea turtle studies along the South Atlantic coast in order to develop a multifaceted management approach which will minimize impacts on sea turtles from hopper dredging. These studies involve both biological and engineering research approaches and include cooperative participation from the U.S. Army Corps of Engineers, Federal and state agencies, and academia.

Integrated trawling surveys, biotelemetry, and aerial survey efforts will provide basic biological information on the life history, behavioral patterns, and spatial/temporal occurrence of sea turtles in the South Atlantic ship channels maintained by hopper dredging. These studies will help define and refine windows of time when turtles are absent or least abundant. Measures being tested with potential for reducing turtle mortalities include: trawling to relocate turtles; hydroacoustics to detect turtles; techniques to disperse turtles from the dredging pathway; a flexible turtle deflector attached to the draghead; and a new draghead design. Promising dispersal techniques include seismic/acoustic devices, physical disturbance, and water jets. U.S. Army Corps of Engineers will continue to seek broad involvement from Federal and state resource agencies and academia in conducting these studies and interpreting data.

FOSSIL SEA TURTLES FROM THE EARLY PLIOCENE BONE VALLEY FORMATION, CENTRAL FLORIDA

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Four genera of cheloniid (*Caretta, Chelonia, Eretmochelys, Lepidochelys*) and one genus of dermochelyid (*Psephophorus*) sea turtles are recorded from the Bone Valley Formation of central Florida. The fossils derive from phosphate deposits of early Pliocene (late Hemphillian) age, 4.5-5 Ma. Although similar in age to fossils from the Yorktown Formation (Lee Creek Mine) in North Carolina, the Bone Valley sea turtle fauna appears to lack two genera found at Lee Creek (*Syllomus, Procolpochelys*) and contains one genus that is not found at Lee Creek (*Eretmochelys*). The *Caretta* from the two areas may not be conspecific. The fossil *Chelonia, Eretmochelys*, and *Lepidochelys* cannot be distinguished confidently from modern species, but conversely only the *Lepidochelys* appears obviously related to a particular modern species, *L. kempi*. This paper provides the first report of *Eretmochelys* in Pliocene deposits and the first association of *Psephophorus* with all living cheloniid genera except the Australian *Natator*. We suggest that shallow seas in the Bone Valley region provided rich feeding habitat for sea turtles in the early Pliocene in the same way that shallow water habitats in Florida and the Bahamas support a similar assemblage today.

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HATCH RATES OF LEATHERBACK (*DERMOCHELYS CORIACEA*) CLUTCHES REBURIED WITH AND WITHOUT YOLKLESS EGGS

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INTRODUCTION

A curious feature of leatherback turtle clutches is that they routinely include numerous non-viable eggs, usually referred to as "yolkless" eggs because they are deficient in yolk. These eggs are often small, thin-shelled, and irregular in shape, and are generally the last of the eggs laid in a clutch. Their function, if any, has not been determined, although it is possible that they may provide some selective advantage by improving the hatching success of the viable eggs in one or more of the following ways:

1) Yolkless eggs may be less palatable and act as a deterrent to predators.

2) Lying on top of the egg mass, yolkess eggs may satisfy or partially satisfy the predators, and so save some of the viable eggs below.

3) The irregularly shaped eggs could create extra airspace, facilitating gas exchange in the nest.

4) They may act as a barrier, or "lid", preventing sand from falling down between the viable eggs below. This mechanical function is also ultimately related to the need for sufficient oxygen.

5) They might help maintain moisture in the nest chamber.

Alternatively, they may have no particular function, but merely result from the physiological mechanisms of producing a large egg mass. Our intent was to find out whether the presence of yolkless eggs had any effect on the hatching success of the viable eggs. This is of practical interest since in St. Croix, as on other nesting beaches in the Caribbean, up to 60% of leatherback clutches are laid in areas of beach that are washed away by high tides. These "doomed clutches" are reburied on stable parts of the beach, and understanding the mechanisms affecting hatching success may help improve management practices.

METHODS

This study took place during the 1991 nesting season at Sandy Point, St. Croix, in the U.S. Virgin Islands. From April through July, clutches of eggs were collected as they were laid and reburied within 2 hrs at sites on stable areas of the high beach platform. The hand dug nests were 65-75cm deep and were similar in dimension and shape to natural nests. We counted and weighed the yolkless eggs and weighed a subsample of 10 of the yolked eggs. We reburied some clutches with all the yolkless eggs, which were positioned so that they were among the top portion of the clutch. We reburied other clutches without any of the yolkless eggs. We avoided temporal and spatial biases by interspersing nests with and without yolkless eggs on the same areas of the beach and at the same time of the season. We also avoided biasing either treatment toward clutches from individual turtles. After the hatchling emergence we excavated the nests and examined the contents to determine hatch rates. All unhatched eggs were opened to confirm initial viability.

RESULTS

Fifty-one clutches, containing an average of 77 viable eggs (range 32-114), were reburied with an average of 41 yolkless eggs (range 7-101). The average total weight of these yolkless eggs was 818 gms (+/- 50.8, range 121-1705 gms), representing 11% of the total clutch weight. Thirty-eight clutches, similarly averaging 75 viable eggs (range 20-112), were reburied without their yolkless eggs. Although the mean hatching success was slightly higher in clutches reburied without yolkless eggs (Table 1), this difference was not significant (t-test; $p>0.05$).

TABLE 1. HATCH RATES OF LEATHERBACK CLUTCHES REBURIED WITH AND WITHOUT YOLKLESS EGGS

Treatment	N	% Hatch Success	Standard Error
WITH YOLKLESS	51	59.9	2.83
WITHOUT YOLKLESS	38	67.6	3.45

CONCLUSIONS

As a management practice, reburying clutches with yolkless eggs does not improve hatch rates at Sandy Point. This suggests that the yolkless eggs do not have a function related to optimizing the nest environment for the developing embryo, and that the relatively large quantity of yolkless eggs in leatherbacks may merely result from some physiological process associated with their large reproductive output. This study should however be repeated on beaches where predation is more of a factor than on Sandy Point before ruling out predator satiation or deterrence as a possible function of yolkless eggs.

ACKNOWLEDGEMENTS

This work was done while under contract with the Virgin Islands Division of Fish and Wildlife, with a grant from Earthwatch. We thank all 64 of our Earthwatch volunteers who made this project possible. We also thank Amy Mackay for all her help with beach patrols and documenting hatching success.

LOGGERHEAD NESTING DATA FROM A SIX YEAR TAGGING PROGRAM ON CASEY AND MANASOTA KEYS, SOUTHWEST FLORIDA

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INTRODUCTION

While extensive tagging studies have been conducted on female nesting turtles on the east coast of Florida, few comprehensive tagging studies have been conducted on the west coast of Florida. In 1986, the Sarasota County Natural Resources Department initiated a tagging study on female loggerheads (*Caretta caretta*) during the peak nesting season (June and July) on the most active nesting beach in the Sarasota-Charlotte County area, Manasota Key. Mote Marine Laboratory joined the Sarasota County Natural Resources Department in their efforts in 1987 and began tagging on the second most active beach - Casey Key.

MATERIALS AND METHODS

Tagging surveys were conducted seven nights a week for eight weeks between the hours of 9:00 PM and 4:00 AM. In 1986, 11.3 km and in 1987-1991, 17.7 km of shoreline were covered. Data were collected to assess: 1) nest site fidelity; 2) internesting intervals; 3) size range and average growth rates of nesting turtles; 4) the relationship of moon phases to nesting turtles; 5) trends in the number of eggs per nest of successive nesting observations; and 6) hatching success. Monel or Inconel (National Band and Tag, Newport, Kentucky) noncorrosive metal tags supplied by the National Marine Fisheries Service were applied to the trailing edge of the right and left front flippers. Data sheets were filled out and the carbon copies were left at the nesting site for the beach patrol to retrieve the following morning. For these analyses, only tagged turtles that successfully completed nesting were considered.

RESULTS AND DISCUSSION

A total of 1,209 observations were made of 807 individual tagged loggerhead sea turtles. The number of turtles tagged and resighted during the six years is summarized in Table 1 and yearly return data are shown in Table 2.

In the field, beach areas were broken down into zones of approximately 1 km defined by either distance or natural barrier. Of the 258 repeat within-season (and on the same key) nesting observations, 66 turtles nested more than once within the same zone, 76 within an adjacent zone, 53 within two zones distance, and 63 nested in more distant zones (Figure 1). Less than three percent nested on the same key at a distance greater than 5 km.

Events where turtles nested successfully, then false crawled at a later date, were compiled to see if proximity to the location of the original nesting site might influence the likelihood of a subsequent nest versus false crawl. However, the same pattern is seen (Figure 1) for nest to nest occurrences as with nest to false crawl occurrences.

Examples of turtles that renested on different keys include forty-six who nested on both Casey and Manasota Keys within the same season. Four turtles originally tagged on Sanibel Island nested on Manasota Key beaches, a distance of approximately 90 km. One turtle tagged on Casey Key in 1989 nested on Kiwadin Island (175 km south) in 1991, and a turtle tagged on Kiwadin Island in 1987 nested on Casey Key in 1991. One turtle tagged on Casey Key in 1988 was captured in January 1991 offshore Yucatan, Mexico, and released alive(NMFS personal communication).

A single turtle was observed to nest at a one-year interval, 28 at two-year intervals, 22 at three-year intervals, 11 at four-year intervals, and one at a five-year interval. Successive nesting intervals were not always consistent, which corresponds to data by Frazer (1989).

Mean straight line (SL) length for nesting turtles was 90.3 cm (S.D. 6.3) and mean SL width was 70.1 cm (S.D. 6.8) (Figure 2). The smallest nesting turtle was 69 cm in length, 51 cm in width, and the largest nesting turtle was 110 cm in length, 105 cm in width. Annual growth rates, determined from measurements of 51 individual turtles who appeared in more than one year were 0.58 cm/year (S.D. 1.03) SL length and 0.24 cm/year (S.D. 1.77) SL width.

Turtles nested on Manasota and Casey Keys during all moon phases with peaks after the new, at the full moon, and during the third quarter waning moon (Figure 3). The range of nest counts per (synodic) day varied from 25 to 51.

The relationship of nesting interval to reproductive success was analyzed with 133 observations of within-season repeat nesting by tagged turtles. The total number of eggs per nest did not decrease significantly with repeated nesting. These data support similar studies on the east coast of Georgia by Frazer and Richardson (1985).

Hatch success ranged from 62 percent in 1986 to 82 percent in 1991. No correlation between the number of eggs per nest and the hatch success was identified.

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Table 1. Summary of tagging effort on Manasota and Casey Keys, Florida, from 1986 through 1991.

Yr	Percent of Emergences Observed	Number of Individuals Observed/Yr	New Individuals Tagged/Yr	Cumulative Number Tagged	No. Observed w/Previous Yrs Tags	% Observed w/Previous Yrs Tags
86	17.2	83	83	83	0	0
87	21.6	119	119	202	0	0
88	17.2	114	113	315	1	.88
89	19.0	153	143	458	10	6.54
90	16.8	171	147	605	24	14.04
91	16.7	230	202	807	28	12.17

Table 2. Number of tagged turtles observed between years on Manasota and Casey Keys, Florida, from 1986 through 1991.

YEAR TAGGED	BETWEEN YEAR RETURNS '86	'87	'88	'89	'90	'91
1986	–	0	1	1	3	1
1987	–	–	0	8	11	8
1988	–	–	–	1	10	10
1989	–	–	–	–	0	9
1990	–	–	–	–	–	0

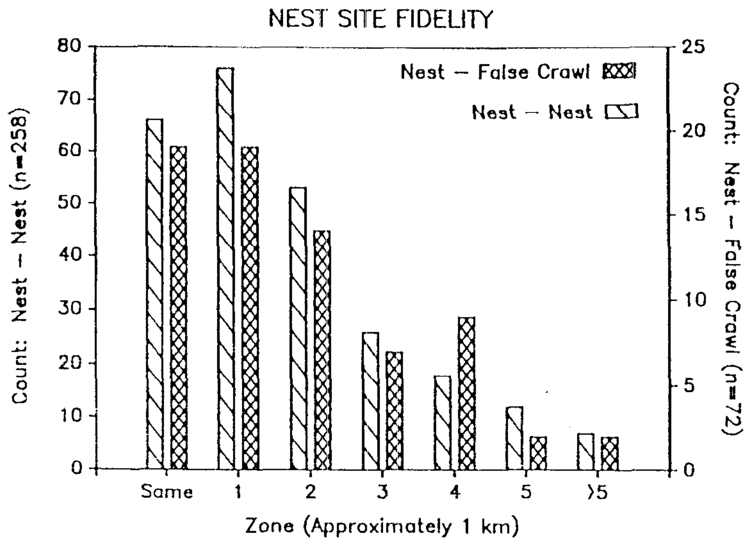

Figure 1. Comparison of site fidelity between successful nest to nest occurrences and successful nest followed by false crawl occurrences.

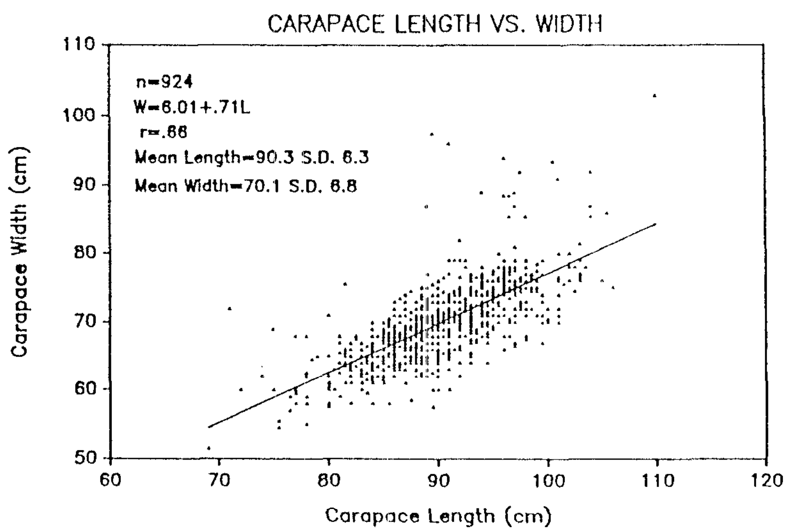

Figure 2. Relationship of loggerhead length and width (straight). Manasota and Casey Keys, FL 1986–1991

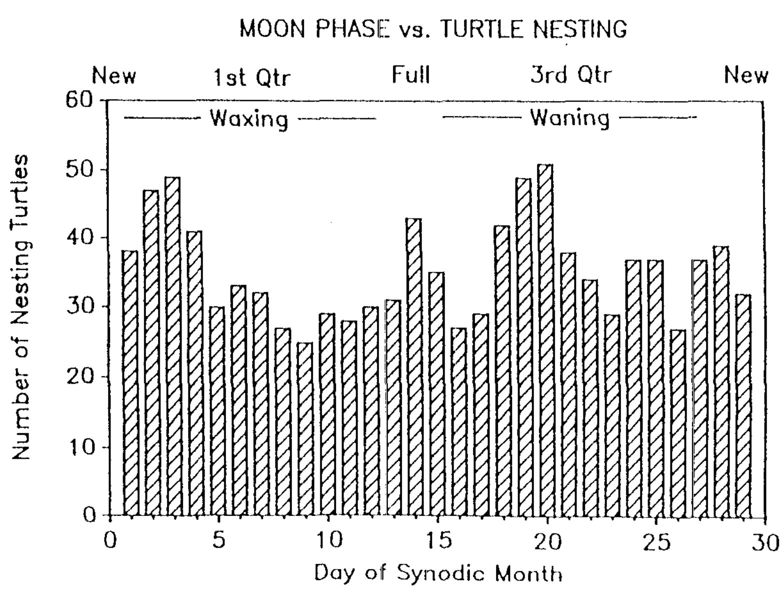

Figure 3. Number of turtles observed nesting and moon phase. Manasota and Casey Keys, FL 1986–1991

BILLFISH ATTACKS ON MARINE TURTLES

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INTRODUCTION

Billfishes (Istiophoridae and Xiphiidae) are known not only for their large size, elongated rostrum ("sword" or "bill"), and value as sport and commercial fish, but also for their highly active, specialized and aggressive behavior. An incredible variety of objects have been reported as being speared by these fishes: large sharks and bony fishes (billfishes included); whales; bales of rubber, boats, and ships; deep-diving vessels; people and a deep-sea diver, as well as a near miss of a skindiver. Remarkably, there is but one known published record of a sea turtle having been impaled by a fish (Yamaguchi, 1974; 1989). This note provides unpublished details on this previous record, as well as data on three additional records.

OBSERVATIONS

Case 1:

In September 1965, the *Seiryû-maru* was off of Cape San Lucas, Baja California, México, where tuna long lines were set at 50 to 170 m depth, and "many turtles were hooked". One day at about 1300 h, a sea turtle which had been hooked in the mouth was hauled aboard, along with a billfish which had impaled it.

Figure 1 shows a relatively small cheloniid turtle speared with the rostrum piercing the plastron and exiting from the left side of the carapace. The ventral color of the turtle is light, evidently not gray; the mandible is clearly visible, relatively wide and v-shaped. The turtle is thought to be an olive Ridley, *Lepidochelys olivacea*, of adult size. The fish, as identified by Yamaguchi (1974), is a swordfish, *Xiphias gladius*, and it appears to be of adult size.

Case 2:

In November 1983, a leathery turtle, *Dermochelys coriacea*, was caught in a trammel net set in Rio de la Plata, San José Department, Uruguay. During handling, a "pole" protruding from the carapace was grasped and broke, a portion falling into the sea. The turtle was landed and died several days later.

The "pole" (Fig. 2) is a bony rostrum identical in size, shape and form to that of a blue marlin, *Makaira nigricans*, estimated to have weighed between 100 and 140 kg; sex is unknown. A sketch made later (Fig. 3) shows that the turtle was large, possibly adult, and a fragment of rostrum is shown as protruding almost vertically from the center of the carapace.

Case 3:

On 21 May 1987 at Otouto-jima, Ogasawara (Bonin Islands), Japan, a male *Chelonia mydas*, mounted *in copula* was harpooned. The straight carapace length (SCL) and width (SCW) were 89.3 and 72.0 cm, respectively, and body weight was 96 kg. Protruding from the base of the tail, was a rostrum about 17 cm long; an area about 10 cm in diameter at the site of entry had necrotic tissue (Fig. 4). Four puncture wounds, with small pieces of bone embedded in them, were on the right side of the plastron and at least five additional, smaller punctures were nearby (Fig. 5).

The rostrum is a distal fragment, similar in size to that of a 45-80 kg swordfish, *X. gladius*. The distal 17 cm which protruded from the turtle's tail was well-worn and eroded to the bone, whereas the proximal 11 cm that was embedded in the turtle remained covered with the fish's skin (Fig. 6).

Case 4:

On 5 September 1989 at 14°20.1'N, 99°19.7'W (south of Acapulco, México), the fresh carcass of a female olive Ridley turtle was found floating. The animal, 63.1 cm SCL and 56.5 cm SCW, appeared to have been in good condition, with large fat bodies; the ovaries contained enlarged follicles. A fragment of rostrum jutted out of each side of the carapace, having entered on the left side and exited on the right (Fig. 7). The wound was surrounded by fresh necrotic tissue.

The fragment of rostrum, which is relatively slender, has features characteristic of a sailfish, *Istiophorus platypterus*, estimated to have weighed 30 to 40 kg; its sex is unknown.

DISCUSSION

The four localities reported here are consistent with what is known of the geographic distributions of these fishes and turtles. Nonetheless, the spearings may have occurred at places distant from where each turtle was found. The only site where the spearing can be assumed to have occurred is in Case 1, off Cape San Lucas, Baja California, but the exact position is not known. Likewise, only for Case 1 is there information on position in the water column where the spearing occurred: between 50 and 170 m deep. This is well within the known depth distribution of *X. gladias* (Nakamura, 1985), but little is known about the depth distribution of oceanic *L. olivacea*.

An extended debate has centered on the reasons why billfish spear large objects which they cannot eat, e.g. bales of rubber. Gudger (1940) compiled 100 pages of evidence and discussion, concluding that "unprovoked attacks" occurred not because the fish are pugnacious, but rather because while swimming at high speed they accidentally collide with large objects about which prey fishes are hiding; other authors have also concluded that spearing attacks are accidental (e.g. Aleyev, 1977). An account of a marlin nearly skewering a diver who had a wounded fish sheltering behind him (van der Elst and Roxburgh 1981) is a vivid example of the potential danger to non-prey items used as shelter by prey fish.

There is also a long-standing argument about the use of the rostrum and whether or not billfishes purposely spear their prey. Both turtles, especially *L. olivacea*, and prey animals are frequently found associated with floating objects (Pitman, 1990). As turtles are common at the surface, they may serve as shelters under which prey may accumulate. This association increases the chances of accidental spearing of the turtle.

In Case 3, the *C. mydas* at Ogasawara had multiple punctures in the plastron, in addition to a speared tail, indicating that repeated "attacks" had been made. However, since the plastron was only lightly stabbed, and it was the periphery of the turtle which had been speared, it would appear that the turtle was not the target, and possibly the predator(s) was (were) trying to capture prey sheltered around the reptile.

The consequences of a stabbing may be fatal for the turtle (evidently Cases 1 and 4). However, in half of the cases reported here, the stabbed animal was not only alive but apparently well; in Case 3 the speared turtle was caught when copulating, despite the deep puncture wound in its tail.

Whatever the case, it is unlikely that turtles are purposely attacked by billfishes, and the spearing of a turtle is probably only an accident during active feeding attacks. At most, it may indicate instances of prey animals sheltering close to turtles when billfishes are feeding excitedly.

These apparently unusual cases of turtles being speared by billfishes are yet further confirmation of the pelagic existence of marine turtles, and they may also be evidence of a remarkable ecological role for pelagic turtles - that of fish-attracting devices (FADs). Perhaps the spearing of sea turtles by billfishes is not as rare as it now appears?

ACKNOWLEDGEMENTS

Captain Y. Yamashita generously allowed us to use the photograph of the impaled turtle in Case 1 (Fig. 1) and Sr. L. Lucián sent in the rostrum in Case 2. Special thanks to R. Brill, D. Cupka, P. Davie, J. Femenías, G. Greenwald, R. McKay, J. Pepperell, P. Pristas, P. Speare, J. Squire, S. Tibbo and A. van der Heiden for providing skeletal material of billfish. N. Suzuki and K. Horikoshi kindly made translations of Yamaguchi (1974). The Pacific Ocean Research Foundation (Kailua-Kona, Hawaii) provided facilities for HLF to prepare billfish skeletons during the summers of 1981, '83, '85 and '88.

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FIGURE CAPTIONS USED TO IDENTIFY PHOTOGRAPHS FOR POSTER DISPLAY

Figure 1. Marine turtle (probably *Lepidochelys olivacea*) speared by *Xiphias gladius* off Cape San Lucas, Baja California, in September 1965 (photo by Capitan Yamashita).

Figure 2. Fragment of rostrum of *Makaira nigricans* removed from the carapace of a *Dermochelys coriacea* near Kiyú Seaside Resort, San José Department, Uruguay, in November 1983. The ventral and lateral surfaces are ornamented with denticles, which are larger along the lateral margins; there is a well-demarcated, denticle-free dorsal surface along its entire length: 9.3 cm long, 2.2 cm wide and 1.3 cm high at its proximal end (deposited in Herpetology Section, Museo National de Historia Natural, Montevideo, number 3857).

Figure 3. Sketch of *Dermochelys coriacea* caught with rostral fragment of *Makaira nigricans*, near Kiyú Seaside Resort, San José Department, Uruguay, in November 1983 (sketch by C. Prigioni).

Figure 4. Tail of male *Chelonia mydas* caught on 21 May 1987 at Otouto-jima, Ogasawara, Bonin Islands, Japan, showing impaled fragment of rostrum of *Xiphias gladius* (photo by H. Suganuma).

Figure 5. Plastron of male *Chelonia mydas* caught on 21 May 1987 at Otouto-jima, Ogasawara, Bonin Islands, Japan, showing punctures and small impaled fragments of bone, presumably from the rostrum of *Xiphias gladius* (photo by H. Suganuma).

Figure 6. Fragment of rostrum of *Xiphias gladius* removed from the tail of a male *Chelonia mydas* caught on 21 May 1987 at Otouto-jima, Ogasawara, Bonin Islands, Japan, showing highly eroded surface on distal end, which was projecting from the tail, and uneroded proximal end which was imbedded within the tail: 27.8 cm long, 4.2 wide and 1.0 high at its proximal end (deposited in the Ogasawara Marine Center, Japan).

Figure 7. Female *Lepidochelys olivacea* with fragment of rostrum of *Istiophorus platypterus*, found floating dead south of Acapulco, México, on 5 September 1989. The fragment measures 36.7 cm long, 2.0 cm wide and 1.0 cm high at its proximal end and has denticles on its dorsal and lateral surfaces. In cross section, the rostrum has relatively high nutrient canals as compared to the height of the rostrum (data no. 890905; Southwest Fisheries Center collection No. D0004; photo S. Beavers).

A SIMPLE METHOD OF ESTIMATING MEAN DAILY SAND TEMPERATURE

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For estimating the mean daily sand temperature, we have developed a device that memorizes the maximum and minimum temperature of a 24 hour period. The daily mean can be estimated by the simple formula:

$$\frac{[\text{MAXIMUM} + \text{MINIMUM}]}{2} \approx \text{DAILY MEAN}$$

The daily mean estimated in this way is close to the mean derived by averaging several sand temperature readings taken over a 24 hour period (eg. every two hours around the clock):

$$\text{"Round-the-Clock" Mean - "Max-Min" Mean} = 0.08°\text{C} \pm 0.01 \text{ SEM}$$

It is expected, however, that the size and sign of the difference between the two methods could vary between different locations and seasons. The method for estimating mean daily sand temperatures being presented above may be useful in studies of thermal influences on sex ratios of sea turtle hatchlings, especially in circumstances where other methods are too laborious and/or expensive.

NESTING SUCCESS OF LOGGERHEAD TURTLES ON TOPSAIL ISLAND, NORTH CAROLINA

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In eastern North America, the threatened loggerhead turtle (*Caretta caretta)* typically nests as far north as North Carolina (Ernst and Barbour 1972). Reproductive data on species at the edge of their breeding range is of value when examining environmental selective pressures on populations. Schwartz (1989) has summarized some nesting observations from Camp Lejeune and Cape Lookout National Seashore. In this paper we present loggerhead nesting data obtained from Topsail Island, NC, during 1990 and 1991.

MATERIALS AND METHODS

The Topsail Turtle Project enlists the aid of 50-200 volunteers to report crawls and other nesting activities on the 42 km beach of Topsail Island, NC. Nests with eggs below the high tide line or in areas subject to heavy human impact were relocated to more suitable areas on Topsail Island. Great care was taken to minimize rotational and thermal damage to the eggs (Limpus et al. 1979). Eggs were not turned and were transported either in styrofoam coolers or chicken egg cartons insulated with sand from the nest site. Nests were checked daily near expected hatching dates by volunteers. Nest analyses were performed 3+ days after emergence. Eggs and eggshells were counted to determine clutch size, % emergence, number hatched, number of live and dead hatchlings, and pipped eggs. Unhatched eggs were examined for the presence of an embryo. Eggs scored as "no discernable embryo" were either infertile or the embryo died very early during incubation. The probability levels calculated using the t-test are presented in the appropriate tables. Minimum significance levels here are $P<0.05$.

RESULTS

During 1990, 154 loggerhead nesting activities were reported: 48 were false crawls and 106 were nests with eggs. During 1991, 183 activities disclosed 54 false crawls and 129 nests with eggs. Several nests were excluded from this analysis because the date of laying could not be determined. Most nesting activities occurred in June and July (Figure 1). Twenty-two nests were relocated during 1990. Percent emergence was 88.2% for relocated nests and 88.7% for natural, undisturbed nests in 1990. However, both incubation period and clutch size for relocated and natural nests differed significantly in 1990 (Table 1). We relocated 8 nests in 1991. Percent emergence for relocated and natural nests in 1991 differed significantly (Table 1). Nesting data for all nests on Topsail Island in 1990 and 1991 are presented in Table 2. Most egg/hatchling data did not differ in the two years. However, incubation period, clutch size, pipped egg with dead embryo, and number of eggs with no discernable embryo differed (Table 2). Dead embryos were closely examined for developmental abnormalities. Fifteen nests contained abnormal embryos in 1990. These nests contained 2 twin embryos, 3 with deformed skulls, and 11 albino embryos. Ten nests contained abnormal embryos in 1991. These nests contained one Siamese twin, one embryo with two heads and three flippers, and 13 albino embryos (4 of these lacked eyes and maxillas).

DISCUSSION

Earlier studies have demonstrated reduced hatching success associated with relocating eggs (Bustard 1972, Limpus et al. 1979). Greatest success was achieved with relocated nests that are moved within 12 hours of laying or waiting until 14 days after laying (Limpus et al. 1979). We used these guidelines in relocating nests on Topsail Island. Percent emergence did not differ in 1990, but natural nests showed a higher rate of emergence in 1991

Table 1. Parameters of relocated and undisturbed loggerhead turtle nests on Topsail Island, NC.

Parameter	Year	Relocated Nests Mean	sd	n	Undisturbed Nests Mean	sd	n	Prob
Incubation	1990	57.0	3.5	22	59.4	2.9	58	0.002
Incubation	1991	58.0	3.5	8	62.5	7.0	113	0.072
% Emergence	1990	88.2	9.4	22	88.7	9.7	58	0.837
% Emergence	1991	83.3	16.4	8	91.9	8.8	89	0.017
Clutch size	1990	123.5	22.0	22	135.8	21.4	58	0.025
Clutch size	1991	122.4	34.6	8	125.3	22.2	89	0.733

Table 2. Nesting data for Loggerhead Turtles on Topsail Island, NC during 1990 and 1991.

	1990 Mean	sd	n	1991 Mean	sd	n	Prob
Laying Date	180.6	21.5	80	183.0	20.2	121	0.42
Incubation	58.8	3.3	80	62.8	4.0	121	0.000
% Emergence	88.6	9.6	80	91.2	9.8	97	0.082
Clutch Size	132.4	22.1	80	125.1	23.2	97	0.035
No. Hatched	116.8	21.3	80	114.4	24.4	97	0.48
Live in Nest	2.2	5.7	80	4.3	13.7	97	0.15
Dead in Nest	0.9	3.1	80	1.0	3.3	97	0.80
Dead Pipped	0	0	80	0.4	1.2	97	0.006
Live Pipped	0	0	80	0.1	0.6	97	0.20
No embryo*	11.8	12.5	80	6.8	9.0	97	0.002
Dead embryo	2.9	3.1	80	2.5	3.7	97	0.44

* no discernable embryo in egg

(Table 1) than did our small sample of relocated nests. Incubation period was significantly longer in undisturbed nests in 1990 but not in 1991. This may reflect the wider variability of natural nests with regards to elevation above high tide, slope, and depth of nests. Relocated nests were uniformly placed higher up on the dune face and were buried about 30 cm deep. Relocated eggs probably experienced higher average temperatures and thus hatched earlier (Mrosovsky and Yntema 1980). Clutch size was smaller in the 1990 relocated nests and slightly lower in the 1991 nests. Loggerhead turtles nesting on Topsail are not marked. Perhaps younger turtles tend to select sites lower on the beach face and may lay, on average, smaller clutches.

Incubation period averaged 4 days longer in 1991 than 1990. Rainfall and higher than usual tides experienced during the 1991 nesting season probably accounted for this difference, since the average laying date was not significantly different. Excessive rainfall and higher tides indirectly lower the sand temperature and thus would prolong incubation (Kraemer and Bell 1980, and references therein). We measured incubation period as that time span between laying and emergence. Emergence may be delayed (and thus extend incubation period) when rainfall compacts the sand above the nest chamber (Moorhouse 1933, Hendrickson 1958). These incubation periods are somewhat shorter than those presented for other loggerhead populations in North Carolina (Mrosovsky 1988, Schwartz 1989) but are within the range for loggerheads reviewed in Hirth (1980) and that reported in South Carolina (55 days) by Caldwell (1959).

Clutch size (132.4 eggs) was significantly higher in 1990 than in 1991 (125.1 eggs). Clutch size variation from year to year in loggerhead turtles in Georgia was minimal (Frazer and Richardson 1985)--the only significant differences over a 19-year period occurred when comparing mean sizes of the highest (127.5 eggs) and the lowest (114.4 eggs). Caldwell (1959) reported a mean clutch size of 126 eggs for South Carolina loggerheads. One might expect a difference in clutch size between 1990 and 1991, as loggerheads are thought to be on two- or three-year laying cycles (Ernst and Barbour 1972). Nearly equal numbers of eggs hatched in 1990 and 1991, with the difference in % emergence due primarily to a higher number of eggs with no discernable embryos in 1990. Caldwell (1959) reported 20.7% of all loggerhead eggs laid in South Carolina were infertile (this figure may also include eggs with small embryos).

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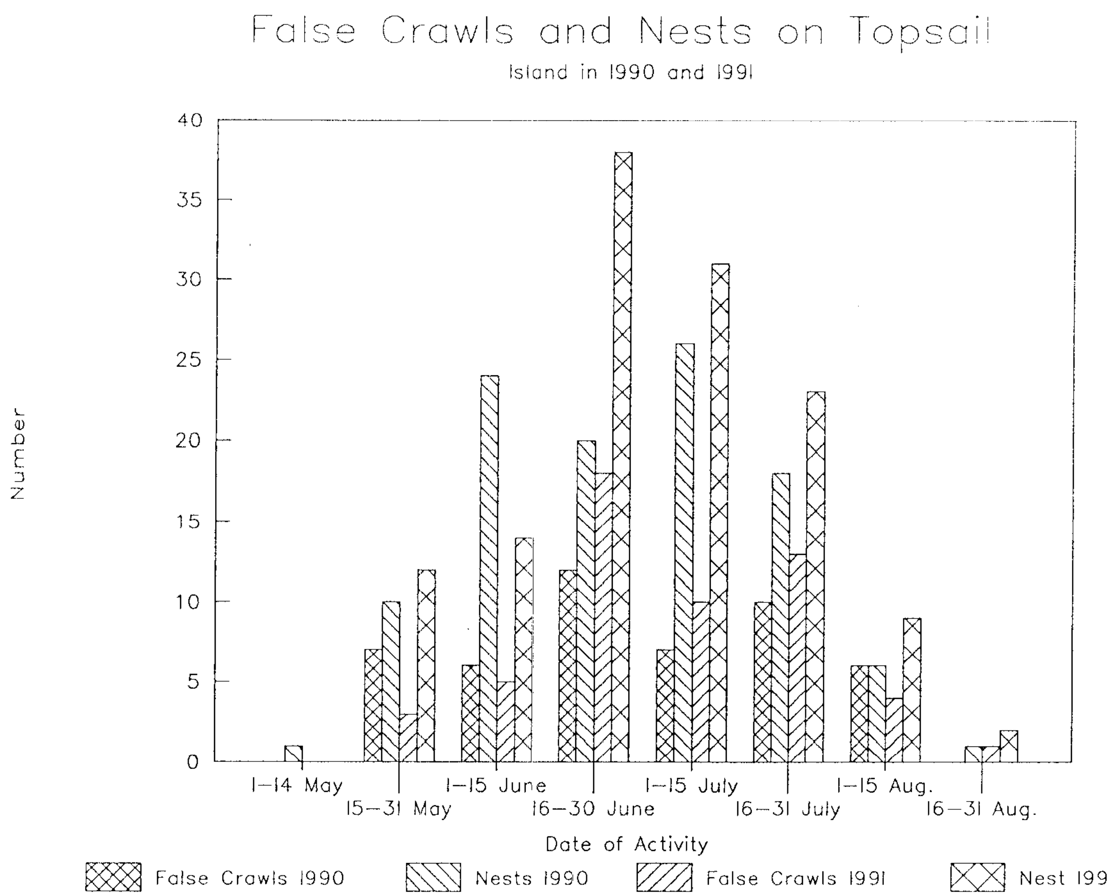
Figure 1. False crawls and nests on Topsail Island in 1990 and 1991.



SEA TURTLE CONSERVATION IN THE NATIONAL PARKS OF VENEZUELA

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Venezuela's first national park was established in 1937. Since then, most of the unique landscapes and biodiversity zones of Venezuela have been included within the National Parks system. Now, Venezuela has 39 National Parks and 41 Natural Monuments under the administration of the National Parks Institute (INPARQUES), representing more than 14% of all national territory. Eleven of these National parks have a coastal and/or marine area (see Map 1).

Coastal area parks serve as protection for sea turtles nesting in Venezuela. We have no evidence of sea turtle nesting in Turuepano and Mariusa National Parks (established in 1991), given that these parks do not offer suitable sites for nesting. Parks with a marine component are usually very important as foraging habitat for marine turtles.

Sea turtle conservation efforts in the National Parks began in 1976 in the Archipelago Los Roques National Park. In that park, the Fundación Científica Los Roques (FCLR) established a program to evaluate sea turtle nesting, hatchery, and headstarting of *Caretta caretta*, *Eretmochelys imbricata*, and *Chelonia mydas* (FCLR, 1984). Today, the program continues but at a much reduced level. A headstarting program was run in Mochima National Park during 1984 for *C. caretta* and *E. imbricata* (Manrique, 1986). Fundaciencia is the institution responsible for the work.

Between 1987 and 1988, the Fundación para la Defensa de la Naturaleza (FUDENA) produced an inventory of the status of sea turtles in Venezuela, primarly on the mainland coast, although some information was obtained from the islands (FUDENA, 1987; Guada y Vernet, 1988a,b). This project produced information for Medanos de Coro, Morrocoy, Laguna de Tacarigua, Mochima and Peninsula de Paria National Parks. In 1991, FUDENA began a sea turtle conservation project in Morrocoy National Park. FUDENA intends to initiate in Mochima National Park a sea turtle conservation project for sea turtles, managed cooperatively with the regional INPARQUES, including a hatchery and head-starting program and participation by local fishermen.

The Wildlife Program (formerly the Fauna Program) from the National Parks Authority (DGSPN) has a sea turtle project that was started in 1990. Since then, evaluations primarily of sea turtle nesting beaches have been done in the following areas: Medanos de Coro, Laguna de Tacarigua and Península de Paria. In addition, a course on the biology and monitoring of sea turtles was provided in 1991 for the park rangers of Laguna de Tacarigua National Park.

The information gathered during 1990 and 1991 allowed special zoning regulations to be created for the protection of sea turtles. One such regulation provided protection for the Boca de Tortuga and Laguna de Tortuga zones in Laguna de la Restinga National Park (Decreto No. 1641, Gaceta Oficial No. 34.758, July 18, 1991). Laguna de Tortuga is a protected lagoon and constitutes a feeding area for *C. mydas* and *E. imbricata* (see map 2). In addition, an offshore marine area extending one nautical mile seaward of the beach was added to this National Park (Decretos No. 1638, Gaceta Oficial No. 34.880, January 13, 1992) (see Map 2).

A second important zoning regulation established a restricted area along the sand bar of Laguna de Tacarigua National Park during the nesting season (from May until October), and an offshore marine area was also added to this National Park (see map 3). An important function of this offshore refuge was to protect nesting sea turtles from fishing trawlers (Decretos No. 1643, Gaceta Oficial No. 34.758, July 18, 1991 and No. 1639, Gaceta Oficial No. 34.820, October 15, 1991, respectively).

The 1992 sea turtle project of the Wildlife Program for 1992 has several goals, including:

- an instructional course on sea turtle biology, monitoring and conservation techniques to be given to park rangers representing most of the protected areas, in order to coordinate and improve the collection of data relating to the marine turtles of the National Parks.

-completion of the inventory on use of nesting beaches and feeding areas by sea turtles within the National Parks and neighboring areas. In this way, we will be able to develop the most efficient regulations for management and protection of the sea turtles.

- a proposal to add additional coastal and marine areas of importance for the protection of sea turtles near the National Parks (mainly in the Peninsula de Paria National Park) and to support the establishment of new protected areas (national parks, wildlife refuges, or private refuges).

- to provide information on endangered sea turtles and their survival status to local people within and near protected areas.

ACKNOWLEDGEMENTS

We appreciate support for this poster received from the Columbus Zoo (Doug Warmolts) and the Symposium (James Richardson). Concern by the National Parks Authority (DGSPN) for the endangered status of sea turtles in Venezuela's marine National Parks made the promulgation of new regulations possible. Vicente Vera (DGSPN) drew the maps.

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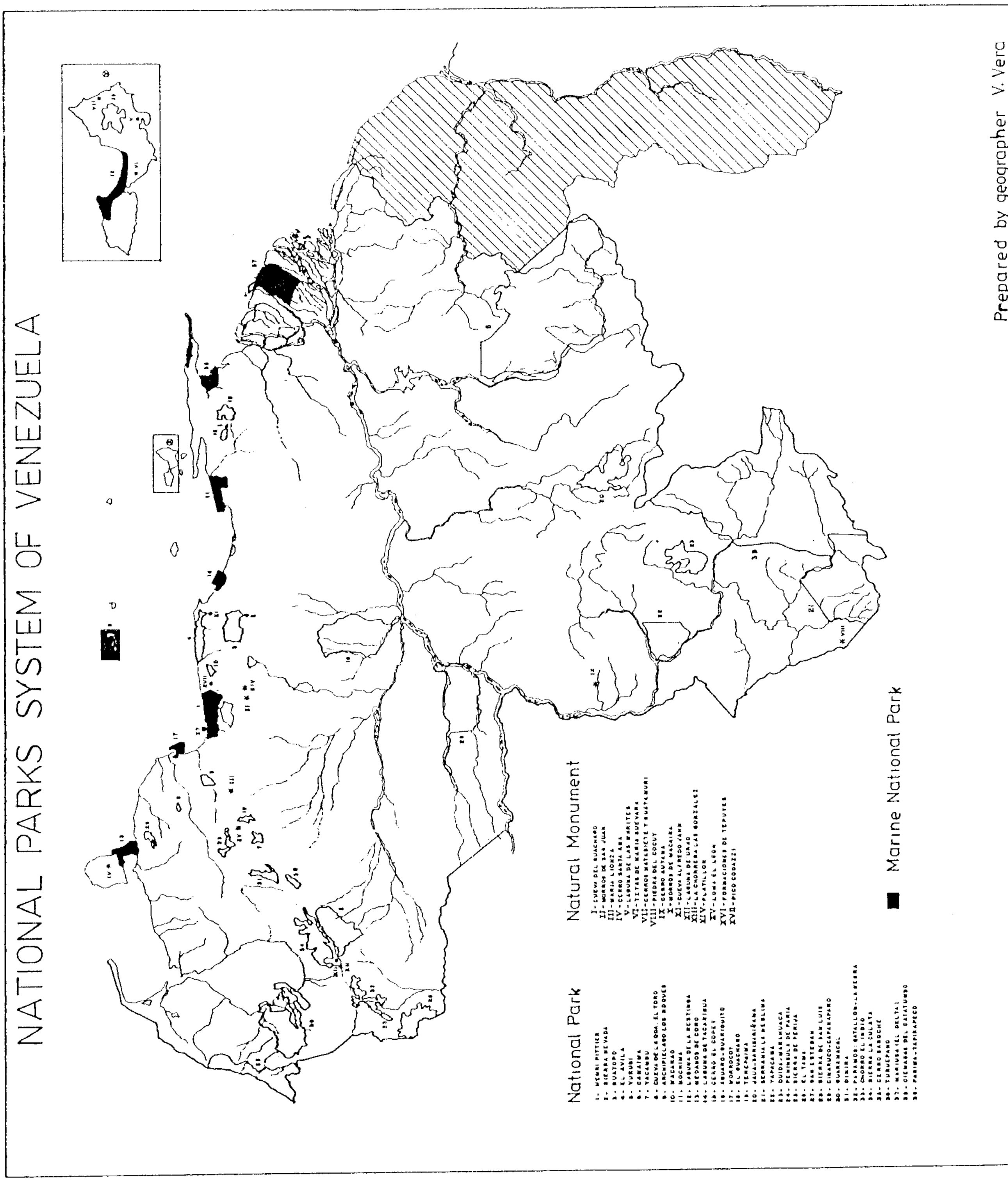
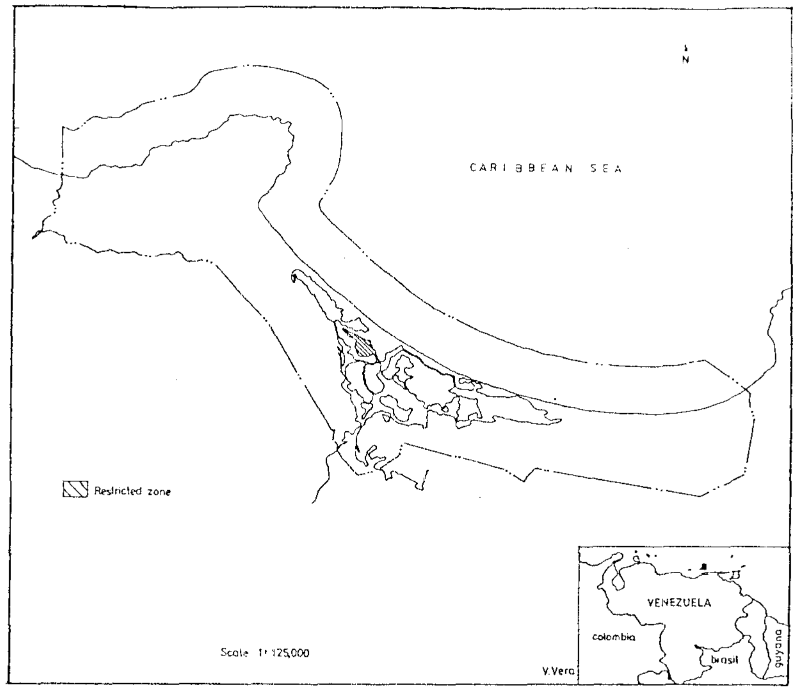
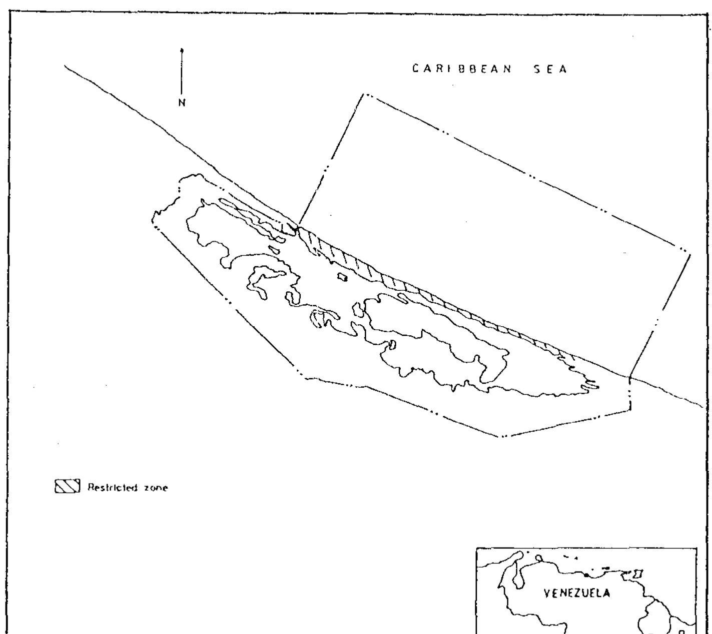
Map 1. The National Parks System of Venezuela



Map 2. The Laguna de La Restinga National Park, Isla de Margarita, Nueva Esparta State, Venezuela. It is showed the marine area now included and the restricted protected zones for sea turtles, Boca de Tortuga and Laguna de Tortuga.



Map 3. The Laguna de Tacarígua National Park, Miranda State, Venezuela. It is showed the new marine area and the restricted zone in the sand bar.



BUCK ISLAND REEF NATIONAL MONUMENT SEA TURTLE PROGRAM, 1991.

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The National Park Service's Buck Island Reef NM hawksbill sea turtle research program began in July and continued into October covering the peak 3 months of the hawksbill nesting season. This was the best year of coverage in all four years of the on-going program. The objectives for the nesting beach population study remained the same as previous years, with greater emphasis on complete seasonal census of nesting females. 1991 also marked the first attempts to track hawksbill in-water movements by radio, sonar, and satellite during the nesting season and afterward.

The Buck Island study site includes 3 principal nesting beaches: the north shore (215 meters), west beach (560 meters), and south shore/turtle bay (610 meters). A map of the study site can be found in 11th Annual Proceedings. The north and south shores are typical Caribbean hawksbill nesting habitat (beach forest, low berms, cobble or sand beaches, nearshore coral reefs), while west beach has a wide, exposed sand beach with no offshore reefs. It has been two years since hurricane Hugo tracked across St. Croix and Buck Island; however, its effects are still evident. Both the north shore and south shore areas are now largely forested with standing dead manchineel trees. The fallen trees continue to interfer with hawksbill access to the beach forest. However, selective clearing and berm reconstruction prior to the start of 1990 and 1991 season did improve hawksbill access to high activity areas.

Methods for this years program were consistant with previous years: hawksbills were approached during egg laying for data collection, and tagging was done during nest covering (NMFS inconel tags, Series PPW & QQD).

Nesting beach surveys conducted throughout the year recorded 240 hawksbill nesting activities. During 95 nights on the nesting beach, 101 hawksbill activities were observed. This coverage was accomplished by Park Service technicians, college interns, telemetry technicians, and with the indispensible assistance of Park Service volunteers contributing over 1600 hours of time to the program. Volunteer assistance increased beach coverage to 7 days per week, vastly improving the data gathered on hawksbills.

The nesting season spanned May through December, peaking through the months of July, August and September. False crawl to nest ratio was 1.2 false crawls to 1.0 nest. This is a reduction from 1990 which showed a false crawl ratio to nest of 2:1 (Figure 1). The hawksbill nesting activities were distributed between the three beaches; north shore received 42 % of the activities, west beach 16%, and south shore/turtle bay 42%. This distribution is similiar to that for 1989 and 1990 and indicates hawksbills may have a preference for beach forest areas (Figure 2). Nest site fidelity was frequently observed (See Table 2 presented in paper section). Hawksbills returned to the same nesting beach for subsequent nestings over 75% of the time this year. Their internesting interval was 15.6 days (N = 45, SD = 2.75).

Through increased program time on the beaches and staff vigilance, 26 hawksbills were observed on Buck Island this year. Sixteen new hawksbills were identified, 6 were remigrants from 1988, and 2 from 1989. Unfortunately, two hawksbills observed were not tagged. Remigrants exhibited site fidelity to their nesting beaches of previous years as well as within the season. Table 4 shows comparison of select data on remigrants. Various growth increases were observed between the 1988 and 1989 remigrants. The average carapace length was 90.1 cm (N = 20, SD = 4.4) and the average carapace width was 81.4 cm (N = 20, SD = 4.1). All measurements are made over-the-curve.

Out of 240 activities observed, 99 were confirmed nests, 22 remained suspected nests, and 119 were false crawls. The average clutch size was 147.2 eggs falling within the normal range for hawksbills. Whole beach nesting success was 66.2 %, a reduction from past years. Nests surviving to term was 77.6%, including several nests with less than 50% success for no apparent reason. The number of clutches per female hawksbill was 3.1 nests. This was calculated from 72 nest laid by 23 females (SD = 1.2, range 1 to 5 nests).

In 1991, National Park Service/Buck Island Reef NM initiated a radio telemetry study to track hawksbill in-water movements during their inter-nesting period (14 - 15 days between nesting). Transmitters were attached to 7 females during nesting and tracked for 3 months. Hawksbills did exhibit residency to an area 1-2 km off BUIS, to which they returned after subsequent nestings. Long dive intervals, ranging from 36 to 73 minutes, indicate that hawksbills were not active during dives. Four hawksbills with radio tags left the BUIS area during the study, going beyond signal range. NPS looks forward to the results of the FWS study to determine the possible migrations of hawksbills.

Also in 1991, U.S. Fish & Wildlife Service Cooperative Studies Unit at Virginia Polytechnic Institute, in conjunction with NPS, initiated a parallel study to determine if hawksbills migrate between nesting and foraging areas. Seven radio transmitters were deployed to track hawksbills determining presence or absence from BUIS after nesting. Both NPS and FWS radio tagged hawksbills moved out of signal range, possibly leaving the BUIS area. To follow hawksbills post-nesting, FWS deployed 3 satellite transmitters on hawksbills in October. The first hawksbill has been tracked throughout the USVI, north of BUIS, and to the British Virgin Islands. FWS will continue this study in 1992.

Future plans for the BUIS hawksbill program: The National Park Service plans to continue the nesting beach population study and maintain critical habitat management of the nesting beaches. Although nothing is funded to date, NPS hopes to repeat the radio telemetry study of hawksbills during the inter-nesting period and begin to describe hawksbill in-water habitat during the nesting period.

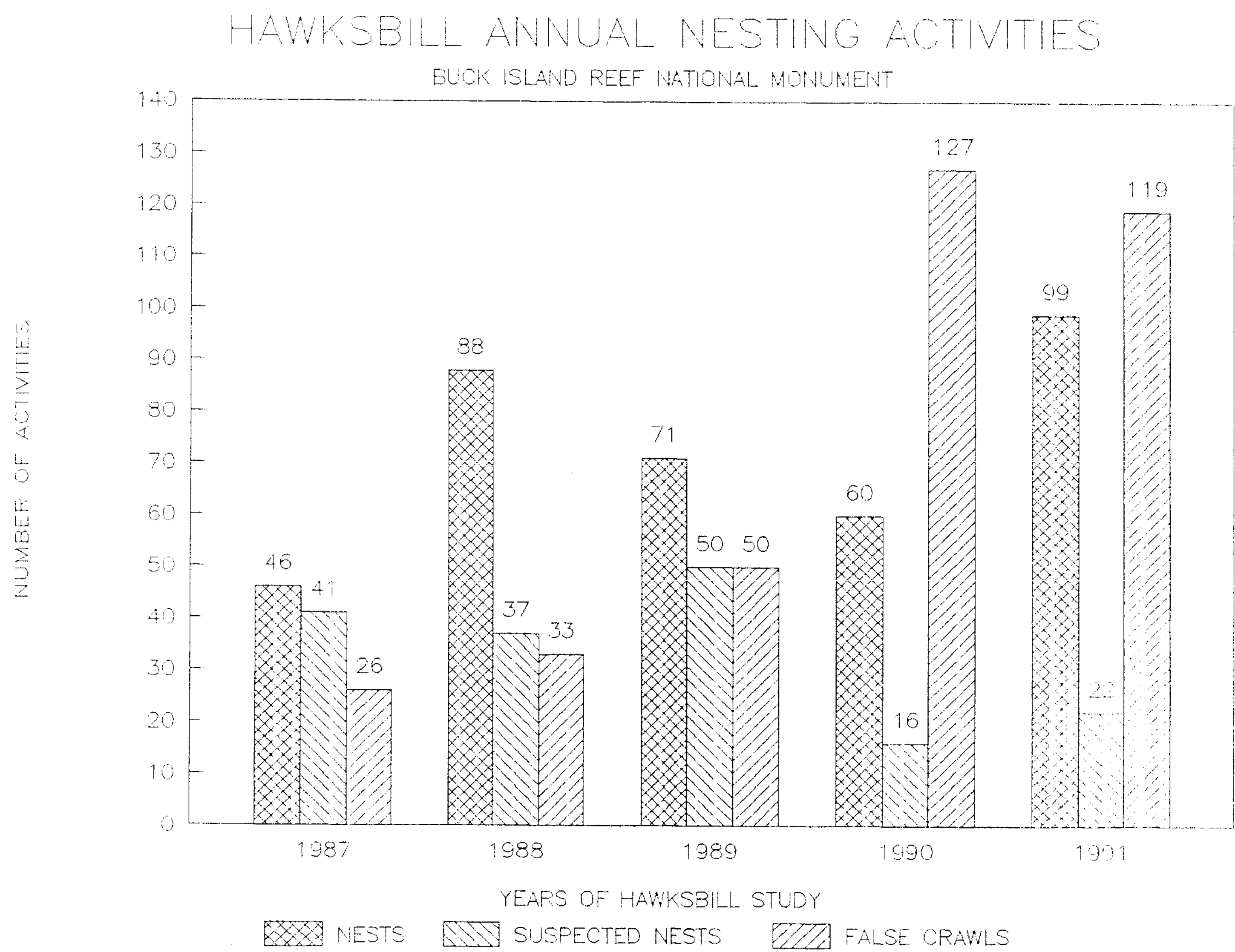

Figure 1. Hawksbill nesting distribution, including comfirmed nest, suspected nests, and false crawls, for 1987 through 1991 at Buck Island Reef NM, St. Croix, U.S. Virgin Islands, 1991.

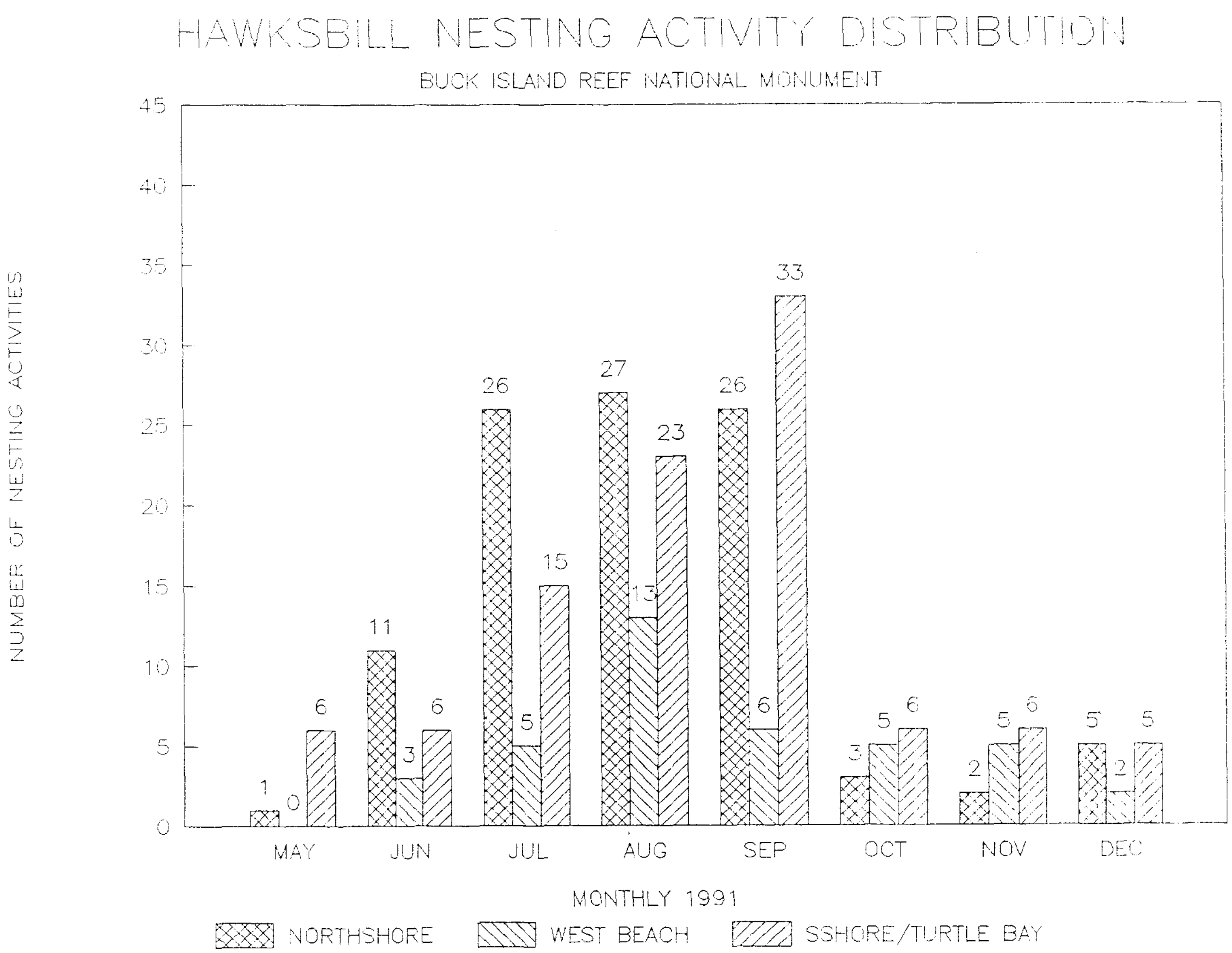

Figure 2. Monthly nesting distribution of hawksbill activities for 3 nesting areas, north shore, west beach, southshore/turtle bay, at Buck Island Reef NM, St. Croix, U.S. Virgin Islands 1991.

ENVIRONMENTAL CORRELATES OF NESTING AND HATCHING SEASONALITY OF HAWKSBILL TURTLES *(Eretmochelys imbricata)* IN BARBADOS

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The nesting season for hawksbill turtles (*Eretmochelys imbricata*) varies considerably with geographic location, but it is usually reported to occur in months of higher rainfall when wind velocity also drops (e.g. Gulf of Thailand; Sabah; Gulf of Aden; Suriname; Seychelles; Samoa; see Witzell 1983). Hypotheses for observed nesting seasonality are usually framed from the nesting female's perspective and include low winds = calm seas. This causative relationship may make it easier for turtles to mate and for females to emerge onto nesting beaches. A second hypothesis, increased rain = damper sand, may assist females in excavation of the nesting chamber. The objective of this paper is to investigate correlations of rainfall, wind velocity, and air temperature with the seasonal pattern of nesting by hawksbills in Barbados and to suggest possible adaptive explanations for the observed correlations.

METHODS

Data on the number of hawksbill nests recorded per month by the Sea Turtle Project (Bellairs Research Institute and Fisheries Division, Barbados) were used to characterize nesting seasonality of hawksbills over the 3-year period 1989-1991 in Barbados (Total n=232). Data on monthly rainfall, wind velocity and air temperature for the years 1989-1991 were obtained from the Caribbean Meteorological Institute, Barbados. To determine whether these years were representative of the typical seasonal profile for these factors, monthly means for rainfall, wind velocity, and air temperatures over a 40-year period were used to generate average seasonal profiles for each factor.

RESULTS

Correlations of environmental factors between years

Monthly rainfall was not correlated between years, suggesting considerable between-year variation in the seasonal pattern of rainfall. Mean monthly wind velocity was only correlated between 1989 and 1991 (Pearson's correlation coefficient, $r=0.74$, $P=0.006$), suggesting that the seasonal pattern of wind velocity also varies between years. Mean monthly air temperature was correlated across all three years ($P<0.001$ for each between-year correlation), suggesting little between-year variation in the seasonal pattern of air temperature. Monthly rainfall, monthly wind velocity and monthly air temperature for 1989, 1990 and 1991 were each correlated with the monthly means calculated for that factor from the 40-year data set. This suggests that, although there may be considerable variation in two of the three climatic factors between individual years, none varied significantly from the typical seasonal profile for that factor.

Environmental factors and nesting seasonality

The numbers of nests/month were correlated across all three years ($P<0.001$ for each between-year correlation), suggesting little variation in the seasonal pattern between years. Neither monthly rain nor monthly wind velocity in a given year were correlated with nests/month in that year. However, monthly air temperature in 1991 was significantly correlated with nests/month in that year ($r=0.65$, $P=0.02$), and the correlations between monthly air temperature and nests/month approached statistical significance in both 1989 and 1990 (1989: r=0.49, P=0.11; 1990: r=0.48, P=0.12). These results suggest either that rain and wind are unimportant to nesting seasonality, or that hawksbills can not adjust the nesting pattern in a given year in response to the seasonal pattern for rain and wind in that year.

The mean number of nests/month over the 3-year period was positively correlated with mean monthly air temperature for the 40-year data set (r=0.70; P=0.01) but not with mean monthly rainfall nor mean monthly wind velocity. Effects of rainfall on nesting and wind velocity on nesting may be hidden by a stronger effect of temperature on nesting. However, when effects of temperature on nesting were controlled by partial correlation analysis, correlations between rainfall and nesting and between wind velocity and nesting remained insignificant (rainfall; partial r=0.48; P>0.05; wind, partial r=0.50; P>0.05). The above analyses suggest that rainfall and wind velocity may be unimportant to hawksbill nesting seasonality but leaves open the possibility that hawksbill nesting is timed to match seasonal variation in temperature. Neither clutch size nor hatching success were correlated with temperature at time of laying (n=47; clutch size: r=0.073, P>0.05; hatching success: Spearman's rank correlation coefficient, r_s= 0.141, P>0.05), suggesting that any advantage accruing to nesting in warmer months is not realised through effects on these aspects of reproduction. However, the possibility that nesting in warmer months optimises hatchling sex ratio should be further considered.

Seasonal nesting has usually been viewed from the perspective of benefits to the nesting female. However, nesting may be timed to produce benefits to hatchlings. The same analyses as above were conducted but on nesting data lagged by 2 months (i.e. the typical incubation period) to investigate environmental correlates of hatching seasonality.

Environmental factors and hatching seasonality

The numbers of hatchings per month in a given year were not correlated with monthly rainfall, monthly wind velocity nor monthly air temperature in that year. This suggests either that these climatic factors are unimportant to hawksbill hatching seasonality, or that hawksbills can not adjust the hatching pattern in a given year in response to the seasonal pattern for the climatic factor in that year.

The mean number of hatchings per month over the 3-year period was not correlated with mean monthly air temperature calculated from the 40-year data set but was positively correlated with mean monthly rainfall (r=0.79; P=0.002) and negatively correlated with mean monthly wind velocity (r=-0.8; P=0.002). The relationship between temperature and hatchings remained insignificant, even when effects of rain and wind on hatchings were controlled by partial correlation analyses. The results suggest that seasonal hatching of hawksbills may be timed to coincide with periods of heavy rain and/or low wind velocity. Mean monthly rainfall and mean monthly wind velocity are negatively correlated in the 40-year data set (r=-0.79; P=0.002). When effects of wind on hatchings are controlled, the relationship between rain and hatchings becomes statistically insignificant (partial r=0.41; P>0.05). When the effects of rain are controlled, the relationship between wind and hatchings becomes statistically insignificant (partial r=-0.48; P>0.05). The similarity in correlation coefficent values between wind and hatchings (r=-0.80, partial r=-0.48) and between rain and hatchings (r=0.78, partial r=0.41) suggests that the relationships between wind and hatchings and between rain and hatchings were of similar strength.

Escape success of hatchlings (% hatchlings emerging from the nest) was not correlated with rainfall on day of emergence (n=47; r_s=0.23; P>0.05), suggesting that any advantage accruing from hatching in wetter months is not realised through effects on this aspect of reproduction. The correlation of hatching with low wind velocity, and hence perhaps smaller wind-generated waves, may maximize the % of hatchlings that successfully get out to sea. However, hawksbills prefer to nest on the more protected (leeward) coast, where effects of wind on wave size may be less marked.

It is possible that nesting and hatching seasonality is driven not by hatching success, escape success or the success of hatchlings in getting offshore but by hatchling survival thereafter. The hatching season of hawksbills in Barbados coincides largely with months in which waters around Barbados are most strongly affected by discharge from the Amazon and Orinoco rivers. Salinity around Barbados drops in these months and highly productive "green water", associated with good commercial catches of planktivorous fish, occurs. The increased primary production and increased flotsam, with attached pleuston, may be an important source of food for hatchlings. Lao (1989) measured the monthly amount of flotsam 9 nmi off the north-west of Barbados and found that organic flotsam is most abundant between May and September.

CONCLUSION

Seasonal variation in hawksbill nesting is such that most nests are laid when air temperature is highest, and most hatching occurs when rainfall is highest, wind velocity lowest, and primary production and flotsam abundance is highest. The data do not suggest that higher temperature at nesting increases clutch size or hatching success, nor that heavier rainfall at hatching increases escape success. The possibility remains that post-emergence survival of hatchlings may be enhanced by lower wind velocity/lighter wave action, and by increased food availability arising from increased primary production and flotsam abundance.

Mean monthly temperature for the 40-year data set is positively correlated with mean monthly rainfall with a 2-month time lag ($r=0.91$, $P<0.001$) and negatively correlated with mean monthly wind velocity with a 2-month time lag ($r=-0.683$; $P=0.01$). Temperature therefore predicts the occurence of maximum rainfall and minimum wind velocity with a 2-month lag. Consequently, it is possible that temperature is simply the proximate cue, controlling the timing of nesting such that most hatching occurs when environmental factors favour hatchling survival.

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ACKNOWLEDGEMENTS

We thank the Caribbean Meterological Institute, St. James, Barbados, for providing climate data and P. Govindarajulu and H. Wiltshire for assistance in collecting nesting data.

APPLICATION OF REMOTE SENSING AND GIS TO SEA TURTLE STUDY.

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A spatial analysis will be conducted of sea turtle sightings in the nearshore western North Atlantic from 1982 to 1983. Water temperature where turtles of various species were sighted will be examined in relation to concurrent sea surface temperatures (SST) locally, regionally, and along the entire eastern U.S. seaboard, as obtained from AVHRR satellite imagery. Sightings also will be examined in relation to bathymetric features such as natural and artificial reefs, bottom cover such as seagrasses, and oceanographic features such as currents, coastal upwelling, eddies, fronts, and river discharges, as interpreted from spatial patterns of SST and chlorophyll in satellite imagery (AVHRR and CZCS, repectively). Considerable environmental data, including water temperature (from a Barnes PRT-5S radiometer on board the survey aircraft) were recorded at the time of each sighting. Turtle tagging returns and nesting data also are available. Geographic information will be obtained from numerous sources. These data include locations of seagrass beds, reefs, mollusk beds, river mouths, etc. We will compare turtle densities by season and area, using number sighted per unit of sighting effort as our index of density. We will evaluate our analytical results in relation to reported species-specific temperature tolerance thresholds, reproductive phenology, feeding habits, breeding sites, and feeding habitat. Analytical results may provide insight on alternative hypotheses concerning migration patterns of juvenile and adult sea turtles. For instance, annual or longer-term migrations around the Atlantic gyre; annual inshore and offshore migrations, possibly across the Gulf Stream; or direct north-south migrations between tropical, subtropical, and termperate waters. Emphasis will be on loggerhead and leatherback turtles, as these two species make up roughly 85% and 5% of eastern U.S. seaboard sea turtle sightings, repsectively. The immediate purpose of the project is to demonstrate the usefulness of combined satellite-remote-sensing and geographic-information-system techniques applied to sea turtle ecology. The project is in its early stages so only preliminary information will be presented.

PRELIMINARY SURVEY OF COMMENSALS ASSOCIATED WITH *CARETTA CARETTA*

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ABSTRACT

Carapaces of thirty-one nesting *Caretta caretta* sea turtles on Casey Key, Florida, and one stranded male loggerhead on Siesta Key, Florida, were surveyed for commensal organisms. Relative quantities and positions of the organisms on the carapace were recorded. Organisms were sampled and identified to date from four of the turtles studied. Preliminary results indicate that the dominant commensals are algae, barnacles, and amphipods. This is the initial stage of an ongoing study of sea turtle commensals. More intensive sampling will be conducted in the future.

INTRODUCTION

Sea turtles are unique in that they have one of the largest hard shells in the ocean. The sea turtle's upper shell, or carapace, is typically encrusted with various commensal organisms. Algae, barnacles, bryozoans, amphipods, tunicates, and polychaetes have been described as potential sea turtle commensals. These organisms benefit from living on the carapace in various ways. For one thing, the carapace serves as a hard, living substrate that may not be easily found in the open ocean. For another thing, filter-feeding organisms benefit from the current that streams over the swimming turtle's carapace. In addition, by migrating thousands of miles between nesting seasons, sea turtles act as mobile dispersion units. A commensal that is able to survive the turtle's migratory range has the opportunity to expand the range of its species.

In a previous epibiont study Caine (1986) found that carapace communities differentiate between two separate sea turtle communities on Florida's Atlantic coast. Others have indicated that sea turtle migration routes can be followed by studying the associated commensal's range. Although sea turtle commensals are frequently noted adjunct to more extensive research, few studies have focused on these epizoic communities. In addition, no study found has focused on sea turtle commensals on Florida's southwest coast.

METHODS

A preliminary study of commensals associated with the loggerhead sea turtle, *Caretta caretta*, was conducted from June 1, 1991 through August 1, 1991 in Sarasota County, Florida. Thirty-one females nesting on Casey Key, Florida and one male stranded on Siesta Key, Florida were surveyed for commensal organisms.

All fieldwork was conducted in conjunction with Mote Marine Laboratory's Sea Turtle Program. The main study site was a 4.2-mile stretch of developed shoreline on Casey Key. Nesting females were surveyed while in the process of egg deposition. A sketch of a typical loggerhead carapace was used to record the relative locations and quantities of commensals on each carapace. Straight-line and over-the-curve lengths and widths were also recorded. In some cases, carapace commensals were collected, preserved, and later identified. The same process was used for the stranded male, which was surveyed and sampled in a holding tank at Mote.

RESULTS

The taxonomy of the commensals observed in this study are as follows:

Chelonibia testudinaria Linnaeus
Chelonibia caretta Spengler
Balanus reticulatus Utinomi
Gammaridea
Caprella spp. (*andreae* or *penantis*)
Tanaidacea
Spyridia filamentosa (Wulfen) Harvey
Centroceras clavulatum (C. Agardh) Montagne
Alga A
Alga B
Alga C
Alga D
Musculus lateralis
Chama spp.
Mollusc A
Bryozoa
Hydrozoa
Polychaeta

The distribution of commensals by size of carapace may be found in Figure 1. The zonation of commensals by location on the carapace is provided in Figure 2.

DISCUSSION

These results are the preliminary findings of a continuing study. Initial results indicate no correlation between length, thought to be related to age, and degree of fouling. Plots of both the major number of commensal groups present and the number of scutes fouled versus over-the-curve length indicate that fouling, as it relates to carapace size, is random. Initial results also indicate that the vertebral scutes receive the most fouling; so far the right costal and marginal scutes seem to be consistently second in degree of fouling. As neither the carapace community nor the degree of fouling changed significantly as the nesting season progressed, a single nesting population is still assumed.

ACKNOWLEDGEMENTS

This study is conducted in cooperation with the Sea Turtle Research and Conservation Program at Mote Marine Laboratory. Research and travel expenses were partially funded by the New College Foundation, Sarasota, Florida. I would like to thank Debbie Ingrao for pictures of critters and Jerris Foote and Sandra Gilchrist for their ongoing support of this ongoing project.

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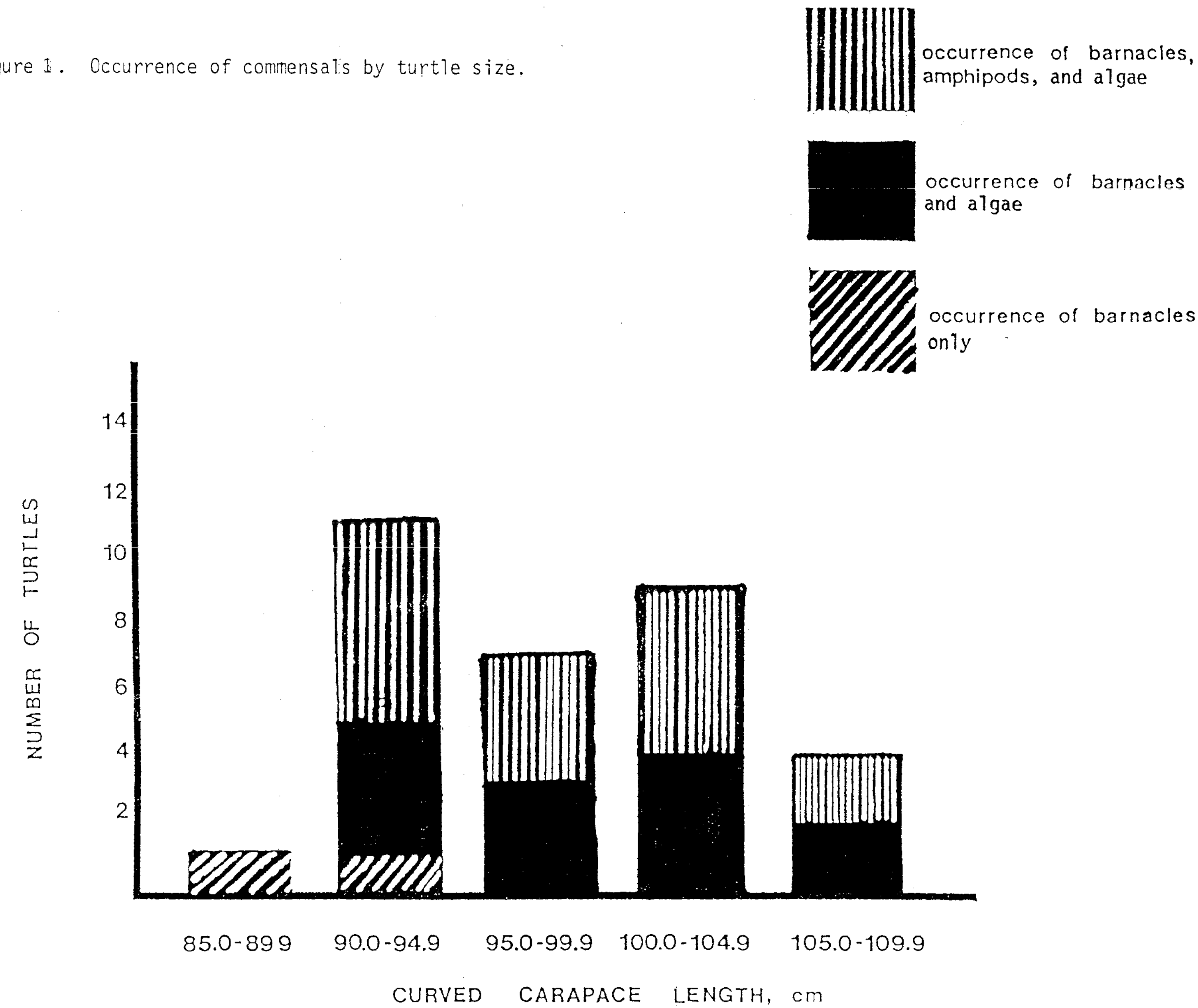
Figure 1. Occurrence of commensals by turtle size.



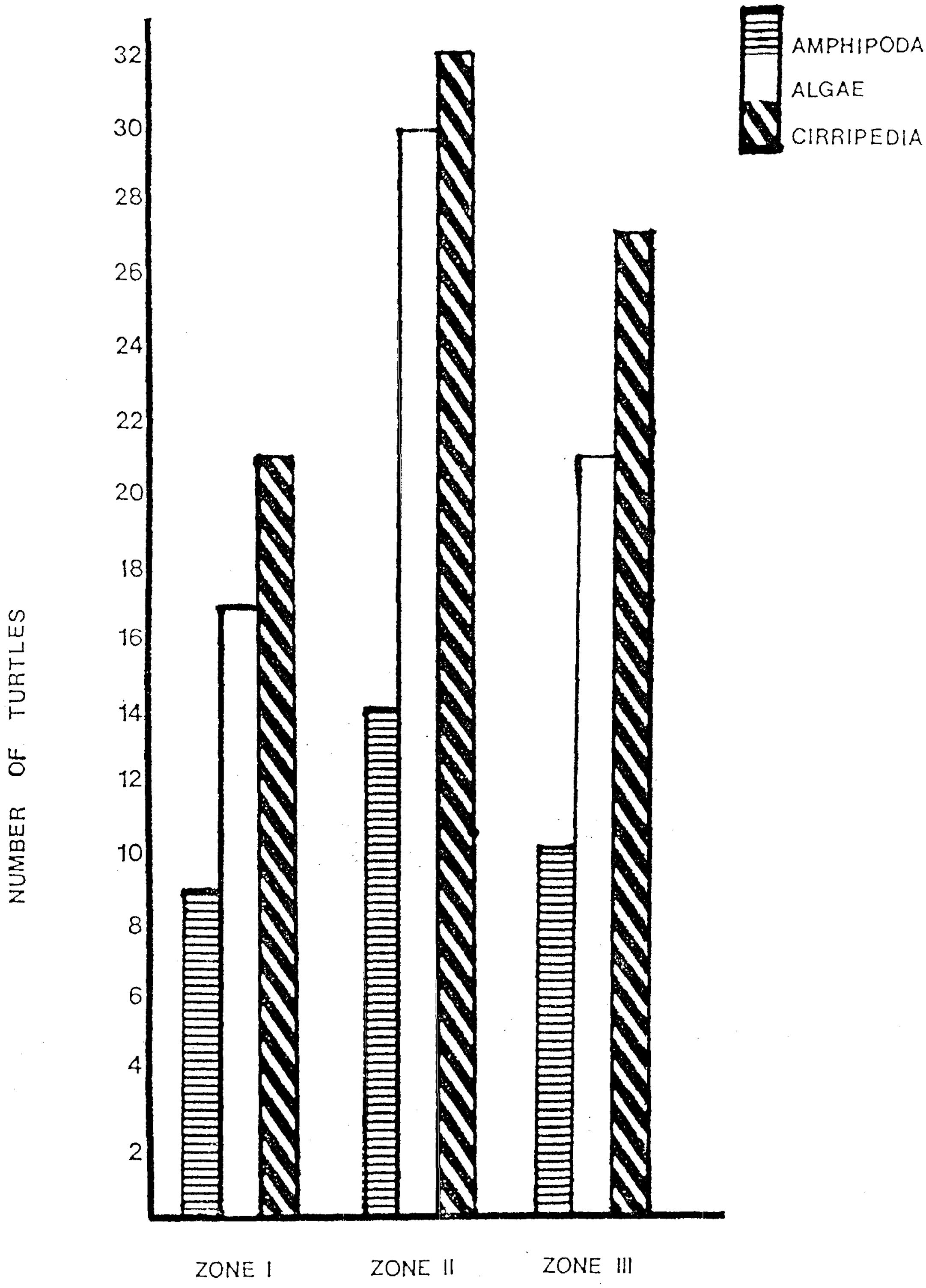


Figure 2. Commensal groups found by area of the carapace. Zone I represents the left marginal and costal scutes; zone II represents the vertebral scutes; zone III represents the right costal and marginal scutes.

HEADSTARTING OF MARINE TURTLES IN FLOATING CAGES

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Head starting is one conservation method tried out by the Bureau of Fisheries and Aquatic Resources in 1985-87 to increase the turtle population in the wild. About 220 green turtle hatchlings were raised in 1 M^3 floating cages in Apo Island lagoon, Apo Reef Occidental Mindoro. The hatchlings were fed in feeding trays at 8-10% body weight. Each cage was stocked with 10 hatchlings. After a year of culture, 135 turtles survived with mean total length of 24.6 cm, mean curved carapace length 17.7 cm, and mean weight of 715.8 g. Survival was placed at 75%. Mortalities were attributed to bacterial infection identified as *Klebsiella* sp., *Proteus*, and *Citrobacter*. Headstarting of marine turtles in cages eliminated the disorientation observed among headstart turtles cultured in tanks. Further, headstart turtles in cages displayed very good diving and swimming abilities. No adjustment problems were observed when turtles were released to their new environment.

A NESTING INVESTIGATION OF LEATHERBACK (*Dermochelys coriacea*) AND OLIVE RIDLEY (*Lepidochelys olivacea*) SEA TURTLES AT BARRA DE LA CRUZ BEACH, SANTIAGO ASTATA, OAXACA, MEXICO, 1990-1991

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INTRODUCTION

Herewith are presented the results of the Program of Investigation and Conservation of Sea Turtles at Barra de la Cruz, Oaxaca, Mexico. The period of fieldwork took place from November 1990 to March 1991. This is a preliminary report on activities of the laud or leatherback, *Dermochelys coriacea,* at this newly established research area.

SPECIFIC OBJECTIVES

- To estimate numbers of the nesting females during the season.
- To transplant the nests to a protected corral for incubation.
- To mark natural nesting areas.
- To mark and measure nesting females.
- To determine the correlation of the number of nests and lunar phases.
- To determine the thermal profile of the beach.

RESULTS AND DISCUSSION

Quantification of nesting females

There were a total of 669 leatherback nesting crawls after the installation of the camp, 26 in Zone A, 585 in Zone B, and 58 in Zone C. Two hundred and one turtles did not lay eggs, presumably due to dry sand conditions at the beach. In January, 85 females were recorded unable to construct an adequate egg chamber. The walls of the nests collapsed while the nests were being dug due to the lack of moisture. This resulted in the females making repeated nesting attempts without being able to lay their eggs. After installation of the camp, 192 nests were poached, 156 from the western area, and 36 from the eastern area. Dogs depredated 67 nests (Table 1). There were 281 olive ridley crawls, 3 in Zone A, 252 in Zone B, and 16 in Zone C. One hundred of these were unsuccessful nesting attempts.

Nests transplanted to the corral

One hundred and twelve leatherback nests were transplanted to the corral yielding a total of 6,697 eggs. Each nest contained between 25 to 86 eggs with an average of 60 eggs per nest. The average individual egg weight of the 6,697 eggs was 66gm with a range of 61.2 to 74.8gm. The average diameter of the eggs was 53mm with a range of 46 to 65mm.

Table 1. Total number of leatherback nesting crawls distributed according to three zones, including nests that were poached and depredated and non-nesting (false crawl) emergences.

	West	East	Total
Nests in Zone "A"	9	17	26
Nests in Zone "B"	337	248	585
Nests in Zone "C"	16	42	58
Poached Nests (Regardless of Zone)	36	156	192
Depredated Nests (Regardless of Zone)	21	46	67
Non-nesting Emergences	64	137	201

The percentages of survival in the nests of leatherback turtles transplanted to the corral varied from 5% to 95%. In March the percentages were the lowest, due to dryness and the highest seasonal sand temperatures. The period of incubation was 57 days with a range of 54 to 60 days. Of the 112 nests that were transplanted to the incubator 3,273 hatchlings survived, a 48.97% survival rate. One hundred thirty-nine hatchlings were found dead in the nest chamber. Upon analysis, 1,378 eggs (20.57%) were found to contain dead embryos in various stages of development. The majority were in the final phase. There were 992 (14.81%) hatchlings that had died in their eggs due to premature hatching. Eight hundred eighty-two (12.27%) of the eggs had a rosy tint, and no embryonic development was apparent. Ninety-one (1.36%) hatchlings were infested with fly larvae (Table 2).

Table 2. Hatching results of 112 leatherback nests transplanted to the corral.

Hatched	Number	Percentage
Hatchlings - Live	3273	48.87 %
Hatchlings - Dead	139	2.08 %
Hatchlings - Broke Shell and Died	992	14.81 %
Hatchlings - Infested by Maggots and Died	91	1.36 %
Sub Total - Hatched	4495	67.12 %
Unhatched		
First trimester of Embryonic Development	463	6.91 %
Second trimester of Embryonic Development	176	2.63 %
Third trimester of Embryonic Development	739	11.03 %
Infertile or No Embryonic Development	822	12.27 %
Albino	2	0.03 %
Sub Total-Unhatched	2202	32.88 %
Total Eggs	6697	100.00 %

Marking of natural nests

A total of 13 natural (in situ) nests (61 eggs/nest, range 36-84) were marked. One was destroyed by dogs. Of the remaining twelve nests, 735 eggs were analyzed for hatching success. Six hundred thirty small, infertile eggs were found, averaging 32 eggs/nest (range 19-76). Three hundred sixty-four hatchlings emerged successfully, with a survival rate of 49.51%. Sixteen hatchlings (2.18%) were found dead. Eighty-three of the eggs (11.30%) had died during various stages of development. Fifty-six (7.62%) of the hatchlings prematurely ruptured their shells and died. One hundred eighty-three (24.90%) of the eggs showed no sign of embryonic development. Thirty-three (4.49%) of the hatchlings were infested with fly larvae. Survival ranged between 0% and 78%, and the period of incubation was 55-59 days (Table 3).

Table 3. Results of 12 natural marked leatherback nests.

Hatched	Number	Percentage
Hatchlings - Live	364	49.52 %
Hatchlings - Dead	16	2.18 %
Hatchlings - Broke Shell and Died	56	7.62 %
Hatchlings - Infested by Maggots and Died	33	4.49 %
Undersize Eggs	630	n/a
Sub Total - Hatched	469	63.81 %
Unhatched		
First Trimester of Embryonic Development	29	3.95 %
Second Trimester of Embryonic Development	11	1.50 %
Third Trimester of Embryonic Development	43	5.85 %
Infertile or No Embryonic Development	183	24.90 %
Albino	—	—
Sub Total - Unhatched	266	36.19 %
Total Eggs	735	100.00 %

Investigation of unmarked natural nests

There were 2,281 eggs and shells analyzed from 41 natural leatherback nests. Clutch size (eggs per nest) averaged 56, with a range of 6-81. The proportion of hatchlings that emerged was 55.06%, with a range of 1.23-94.34%. There were 1,256 hatchlings that emerged, and 46 hatchlings (2.02%) were found dead in the nest chamber. There were 1,997 non-viable eggs. One hundred thirty-six hatchlings (5.96%) broke their shells prematurely and died. One hundred forty-nine hatchlings (6.53%) were infested with fly larvae. Four hundred fifty-four eggs (19.91%) contained dead embryos in different stages of development, primarily first trimester embryos. Two hundred forty apparently infertile eggs were found (Table 4).

Measuring and marking the nesting females.

One hundred twenty-one metal tags were placed on 98 leatherbacks and 22 olive ridleys. The "A" series tags were labeled "Reward for Return" Secretary of Fishery & Sea Turtles, Colima Mexico, Instituto Nacional de Pesca. The series "Y" tags were labeled "Reward for Return" Biol. UCR, Costa Rica.

Table 4. Hatching results of twelve natural unmarked leatherback nests.

Hatched	Number	Percentage
Hatchlings - Live	1256	55.06 %
Hatchlings - Dead	46	2.02 %
Hatchlings - Broke Shell and Died	136	5.96 %
Hatchlings - Infested by Maggots and Died	149	6.53 %
Undersize Eggs	1997	n/a
Sub Total - Hatched	1587	69.57 %
Unhatched		
First Trimester of Embryonic Development	210	9.21 %
Second Trimester of Embryonic Development	99	4.34 %
Third Trimester of Embryonic Development	145	6.36 %
Infertile or No Embryonic Development	240	10.52 %
Albino	—	—
Sub Total-Unhatched	694	30.43 %
Total Eggs	2281	100.00 %

A total of 65 recaptures of marked leatherbacks was made. The earliest recaptures occurred one day after the turtles had been tagged, because the females had not managed to lay their eggs. It became evident after study that the average interval between each successful nesting emergence was 10 days (Figure 3).

The mean straight-line length of the shell of leatherbacks was 150cm, ranging from 131cm to 158cm. The curved length of their shells averaged 158cm with a range of 131cm to 163cm. The average width of their shells was 103cm, ranging from 90cm to 115cm (see Fig. 4.1 & 4.2).

CONCLUSIONS

The preliminary results of the Barra de la Cruz project for 1990-1991 show that the area has a significant leatherback population nesting annually. A minimum of 884 nesting crawls were recorded from November 15, 1990, through March, 1991. Prior to this report, no published data were found for Barra de la Cruz, which makes trend analysis impossible. With the decline in the number of leatherback nestings on the San Juan Chacahua from 2,000 (Pritchard, 1982) to 404 (Aguilar *et al.*, 1989-1990), the importance of 884 nests on this beach is obvious.

The survival rate of the transplanted nests was similar to those of the natural nests. So, we feel the decision to expand the transplantation and protection process is well founded. This is the only feasible way to reduce poaching at present.

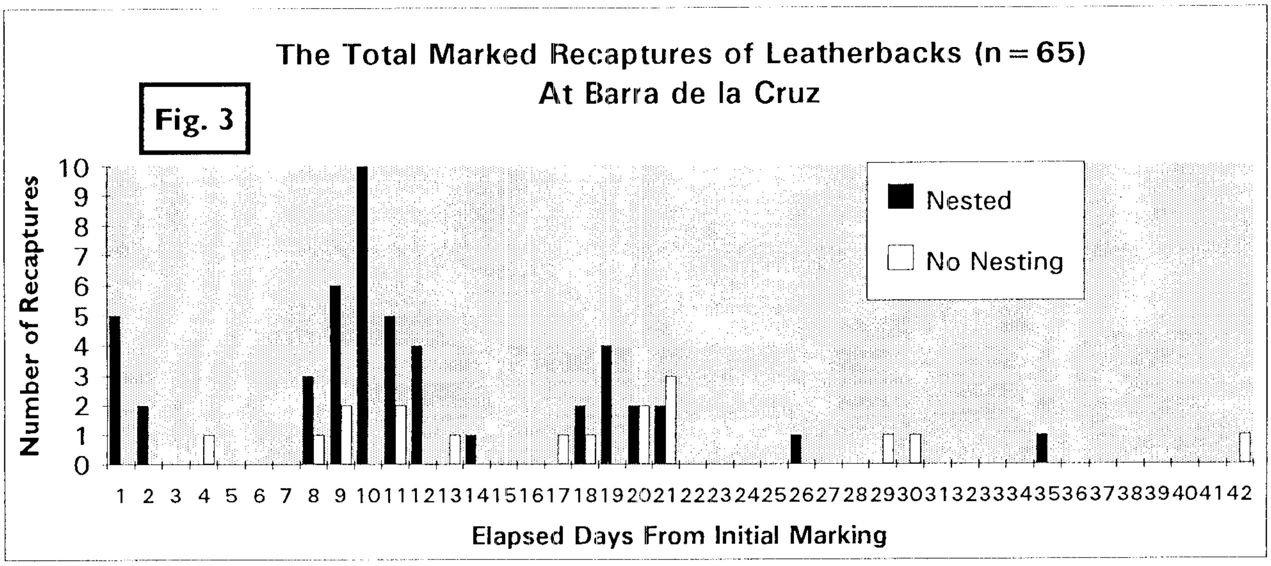
Nest mortality of transplanted nests, in order of importance, are: dead hatchlings which broke their shells and died inside of the egg; infertile eggs with or without any apparent embryonic development; and embryos that died in the last phase of development. At the end of the season, the survival rate declined markedly which coincided with results from Lopez et al. (1986-1987).

Although no objective data on sand moisture were obtained, moisture content plays an important role in this decline, and we propose that this hypothesis should be studied. Also at the end of the season, the number of returns from non-nesting emergences was increasing, similar to Lopez et al. (1986-1987), giving credence to the idea that lack of moisture impedes the nesting process.

The project at Barra de la Cruz has continued through the 1991-1992 leatherback season. Over 1,000 leatherback nests have been protected so far this season. We feel that this important beach urgently needs Mexican legislative protection.

ACKNOWLEDGEMENTS

Universidad Autonoma "Benito Juarez" de Oaxaca, Instituto Nacional de la Pesca, Richard Byles, Jack Woody and Patrick Burchfield (United States Fish and Wildlife Service), Gladys Porter Zoo and HEART (Help Endangered Animals Ridley Turtles), Matthew London (Animal Alliance), Judge R. K. Musgrave (Frances Seebee Trust), Mary A. Whited-Howell (The Frost Foundation).



The Total Marked Recaptures of Leatherbacks (n=65)
At Barra de la Cruz
Fig. 3
Number of Recaptures
Nested
No Nesting
Elapsed Days From Initial Marking

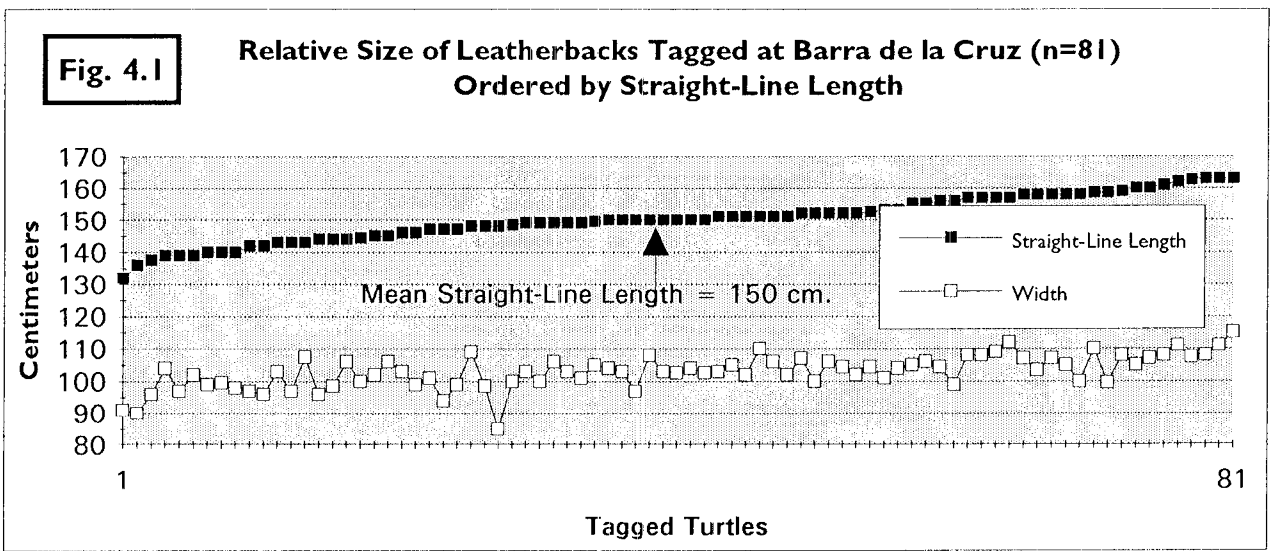


Fig. 4.1
Relative Size of Leatherbacks Tagged at Barra de la Cruz (n=81)
Ordered by Straight-Line Length
Centimeters
Straight-Line Length
Width
Mean Straight-Line Length = 150 cm.
Tagged Turtles

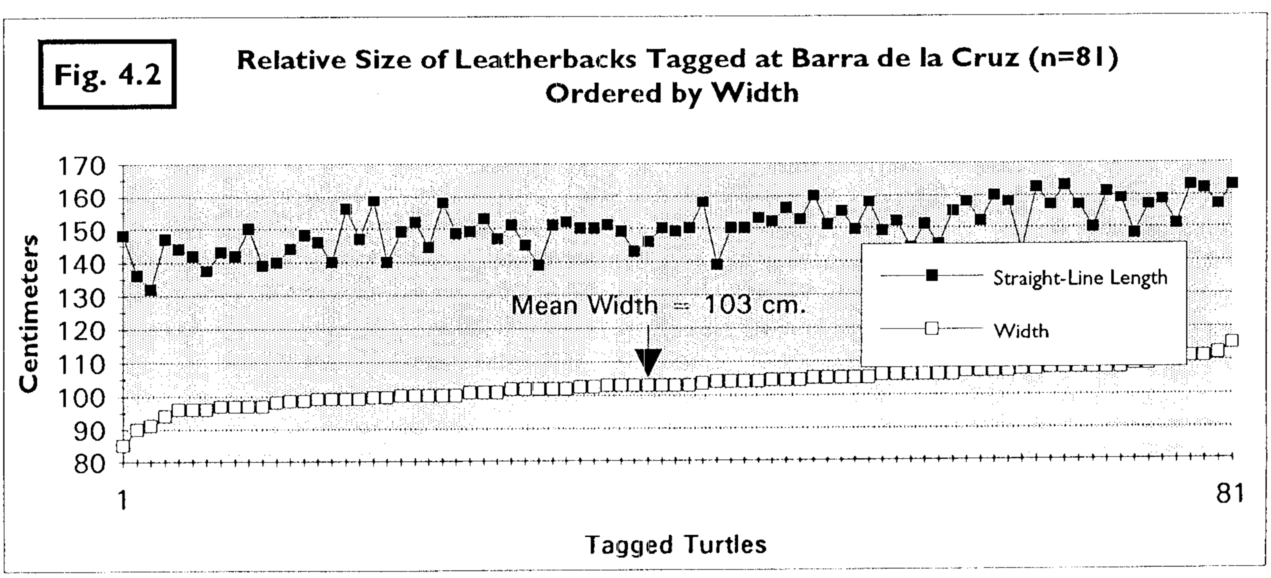


Fig. 4.2
Relative Size of Leatherbacks Tagged at Barra de la Cruz (n=81)
Ordered by Width
Centimeters
Straight-Line Length
Width
Mean Width = 103 cm.
Tagged Turtles

DISCOVERING NEW NESTING AREAS OF *CARETTA CARETTA* IN GREECE

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INTRODUCTION

Greece hosts some very important nesting areas of *Caretta caretta* in the Mediterranean (Margaritoulis, 1982; Margaritoulis, 1988). The nesting capacity of the known areas has been assessed in previous projects of the Sea Turtle Protection Society (STPS; Table 1).

Caretta caretta is considered an endangered species within the boundaries of the European Economic Community. The most serious threat is the tourist development of the nesting sites. With an expanding tourism, it is of high priority to determine all nesting areas in order to acquire an overall view of the actual situation and thereby decide on the necessary action. The STPS of Greece has launched a four-year (1989-1992) project to document all existing nesting areas of the loggerhead turtle in Greece.

Some provisional results on the 1990 and 1991 work are presented in this paper.

METHODOLOGY

Identification of beaches

The coastline of the study areas has been investigated from the ground in order to identify all beaches consisting of "soft" material and also to determine the most promising of them as far as turtle nesting is concerned.

Beach identification includes on-site estimation of length and width of the beach as well as its inclination, type and grain size of the loose material, description of the geomorphology of the area, including prominent features at the hinterland and the sea, superficial observations on the flora and fauna, description of access routes and of existing development and activities, as well as of developmental pressures and plans.

Code system - Beach inventory

For the needs of the project, the shoreline of Greece has been divided in eight parts, each with a coded prefix. Numbers 001 to 999 were assigned to each of these prefices. Thus, the code system has a capacity of incorporating about 8,000 beaches and/or beach sectors.

Identified beaches, generally longer than 100 m (or shorter if they presented a special interest) were located on 1:50,000 military maps and given a code number with the aim of assembling in due time a computerized inventory of all beaches in Greece. The coordinates of the approximate middle of the beach were taken on the maps with an accuracy of 5in. Care was taken to reserve code numbers for small or unidentified beaches, in case they would be included in the inventory at a later stage.

Beach surveys

After initial beach identification, promising sites were visited 2-4 times during the nesting season (June through October). Beaches were surveyed either on foot or by beach bikes. The aim of the surveys was to record any reliable sign of turtle nesting, i.e. tracks of adult turtles (emergences), nesting or non-nesting pits, tracks of hatchlings (hatching nests), and depredated nests.

Sites presenting a relatively high nesting density were surveyed more frequently than originally planned or were included in the monitoring program of the STPS (e.g. some beaches in Crete).

RESULTS

A total of 7,536 km of coastline were investigated during 1990 and 1991 along 11 major study areas (Table 2). The coastline of Greece is generally very much indented. The length of identified beaches represents about 12% of the respective coastline length. It must be noted that the term "beach" does not necessarily imply only a sandy beach, but it may also include shingly or pebbly beaches not suitable for nesting. Turtle nesting has been documented in seven of the eleven investigated study areas (Table 2 and Figure 1).

DISCUSSION

With the present study, it can be said that nearly the entire coastline of Greece has been investigated for sea turtle nesting. New nesting areas with concentrated or sparse nesting have been discovered. According to the provisional results of the study, the total number of clutches laid on Greek beaches during a nesting season ranges from 2,652 to 3,677. It is estimated that this figure represents about 85% of the actual clutches, the remaining 15% being diffuse nesting not possible to be located.

It is almost certain that some of the investigated areas sustained important turtle populations (e.g. Corfu, Kos) in the past, but today they can be considered lost due to intense development and heavy human use. However, the remnants of these populations are still visible.

Other areas, mostly featuring sparse nesting, either are not subject to strong developmental pressures (e.g. some beaches in Crete) or are very extensive in length (e.g. some beaches in Ipirus) which makes them in a way "self protected." These areas should be monitored in order to assess precisely their nesting capacity, but no immediate conservation action is needed.

Finally, some areas of the present study, although subject to tourist pressures, maintain important nesting populations (e.g. some sites in Crete). Conservation actions should be undertaken in order to improve the situation on these areas. The STPS initiated in 1990 a public awareness program on Crete which showed very promising results, and it should be continued.

ACKNOWLEDGEMENTS

The project was financed by the Commission of the European Communities (DG XI). Many thanks to all participants for their efforts to carry out successfully an enormous task in such a short time. We also thank Port Police Stations and Fisheries Departments for providing information.

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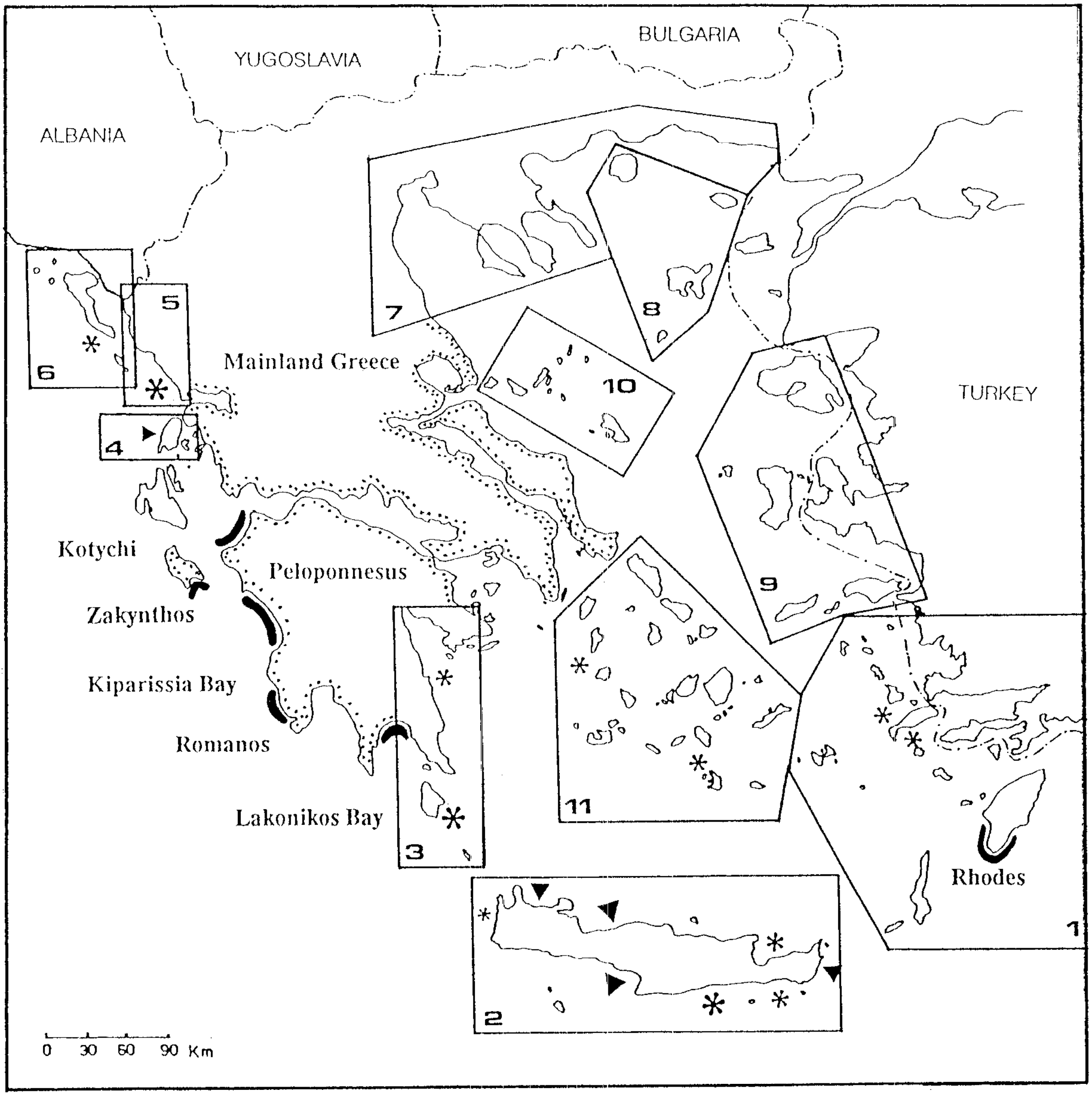
Figure 1. Sketch map of Greece showing known nesting areas (monitored by STPS), coastline surveyed during 1990-1991 and newly discovered nesting sites of *Caretta caretta*.



Known nesting areas monitored by STPS

Coastline surveyed before 1990 (occasional nestings were found in SW Peloponnesus and SW mainland Greece)

X Major areas surveyed by STPS during 1990 and 1991 (1:Dodecanese archipelago, 2:Crete, 3:Southeastern Peloponnesus, 4:Lefkas island, 5:Ipirus, 6:Kerkyra island, 7:Aegean coast of northern Greece, 8:Northern Aegean islands, 9:Eastern Aegean islands, 10:Northern Sporades islands, 11:Cyclades archipelago)

▶ Newly discovered areas with concentrated nesting

* Newly discovered areas with sparse nesting

TABLE 1. KNOWN NESTING AREAS (BEFORE 1990) IN GREECE AND THEIR NESTING CAPACITY DERIVED FROM STPS PROJECTS

Area	Nests/season
Zakynthos	857 - 1,822
Kiparissia	598
Lakonikos	154
Rhodes	9 - 21
Kotychi	32 - 80
Romanos	17

The two values represent the highest and lowest number of nests recorded in different seasons.

TABLE 2. NEWLY (1990-1991) INVESTIGATED AREAS AND ESTIMATED NUMBER OF NESTS PER SEASON (PROVISIONAL)

Major study area	Coastline length (km)	Nests per season
Dodecanese (Rhodes not included)	1,433	60
Crete (incl.neighbouring islets)	1,218	800
SE Peloponnesus (incl.Kythira, Elafonissos)	371	20
Lefkas island	117	50
Ipirus coast	190	40
Kerkyra island (incl.neighbouring islets)	263	15
Aegean coast of northern Greece (from Mountain Pelion to Evros delta)	1,112	-
Northern Aegean islands (Thassos, Samothraki, Limnos)	412	- (*)
Eastern Aegean islands (Lesvos, Hios, Samos, Ikaria)	844	- (*)
Northern Sporades islands (Skiathos, Skopelos)	111	A
Cyclades (18 islands were mapped out of 30)	1,465	B
Total Coastline	7,536	

*: Surveyed only once within the nesting season (more surveys planned for 1992 nesting season)
A: Not surveyed within the nesting season (planned for 1992)
B: Two emergences were reported on 2 of the 7 islands that were surveyed within the nesting season. The remaining islands will be examined during 1992 nesting season.

ULTRASONIC TRACKING OF SEA TURTLES IN SAN DIEGO BAY

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INTRODUCTION

Observations made since 1989 indicate that green turtles (*Chelonia sp.*) continue to frequent the effluent channel of the San Diego Gas & Electric power plant in south San Diego Bay (Figure 1). In 1991, we began attaching coded ultrasonic transmitters to the turtles in order to track their movements. Our goal was to determine whether the same animals remained in the area year-round, whether they ventured into other parts of the bay, and which areas were most frequented by them.

METHODS

The ultrasonic transmitters were manufactured by Sonotronics, and have ranges of either 1 or 3 km and a battery life of 14 months. We attached the transmitters with 1 mm thick, nylon-coated stainless steel wire inserted through two small (.8mm) holes drilled in the carapace, and fixed with brass leader sleeves. For the first three turtles, we reinforced this wire attachment with a coating of ten-minute epoxy. For the following four tags, we switched to fiberglass reinforced resin ("Bondo-Glass"), which sets to a hard finish in about 20 minutes.

The turtles were tracked weekly from a Boston whaler, using a Sonotronics directional hydrophone and a battery-powered receiver. Once a signal was detected, we slowly approached the estimated position. If the turtle was less than 300m away, we stayed in one place to track the signal. At no time did the turtles appear to alter their movements in response to our boat.

RESULTS

We attached transmitters to seven turtles: two adult males, two juveniles, and three females (Table I). We were able to locate all transmitters regularly. The three transmitters reinforced with epoxy came off the turtles by December 1991 (9 - 11 months after attachment), although they are still transmitting. Since then, we recaptured one of these turtles; there was no sign of the epoxy, and the holes were clean. We attached another transmitter through the same holes, using fiberglass resin. Four transmitters (attachment dates 11/10/91 and later) remain attached (Table I).

We usually find the "transmittered" turtles inside the effluent channel, although we have tracked them throughout south San Diego Bay (Figure 1). Often, individuals are found in the same spot and either remain there for at least 3 hours, surfacing to breathe every 15 - 60 min, or leave and return later. One adult female was tracked to just over 3 km north of the entrance to the channel. A second female (without a transmitter) was sighted with this animal. We have often tracked the turtles across the bay from the channel, near Coronado (approximately 2 km from the channel), where there is a thick stand of eelgrass (*Zostera marina*).

Water temperatures in San Diego Bay during the tracking period (January 1991 - January 1992) ranged from 12.2°C in January 1991 to 25.6°C in October 1991. Corresponding effluent channel temperatures were 16.7°C and 32.2°C. We saw turtles actively swimming in the bay in temperatures of 14.4°C. Water depth in which we find the turtles usually exceeds 2 m, although we have tracked them in water as shallow as 0.5 m.

CONCLUSIONS

1. At least some of the turtles are found in the area year-round and from year to year.
2. The turtles are usually found in or near the channel. Even when we cannot locate one in the area on a given study day, we usually pick up the signal on the next study day.
3. We often track the turtles into areas where there are stands of eelgrass. We know the turtles eat eelgrass, as we have seen this material in stomach samples taken by lavage and in feces. There is little or no eelgrass in the effluent channel. We hypothesize that they feed in the eelgrass beds, then return to the channel where the water is up to 8°C warmer than the rest of the bay. This warmer environment would increase digestive efficiency.

ACKNOWLEDGEMENTS

This project was done under NMFS permit #697 and California Department of Fish and Game permit #0411. It was funded by the San Diego County Fish and Wildlife Advisory Commission and Hubbs-Sea World Research Institute. San Diego Gas & Electric Power Company provided water temperature data.

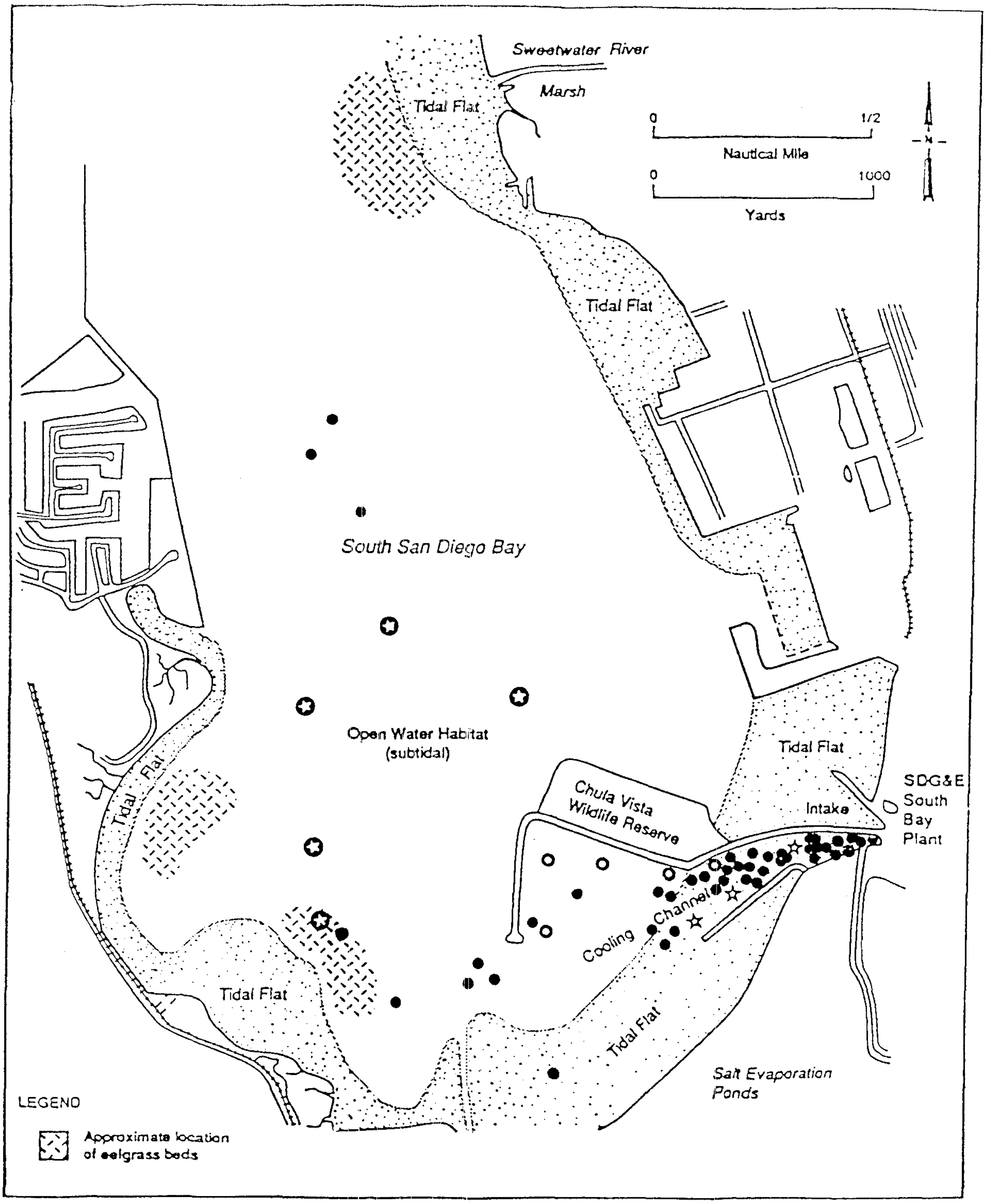

Figure 1. Map of South San Diego Bay, showing where turtles have been located (●). (✪, ☆, ○ = multiple locations where individuals were tracked).

Table I. Sea turtles tagged with ultrasonic transmitters in San Diego Bay, 1991 - 1992.

Tag Code	Range	Battery Life	Dimensions	Date Applied	Date Lost	Tag #	Turtle size (SCL), sex
Model CHP-87 (high power)							
249	3000 m	18 mo	100x18mm, 12 gm	1/28/91	12/91[1,2]	X-124,125	86.7 cm, F
267	3000 m	18 mo	100x18mm, 12 gm	3/16/91	12/91[2]	X-98,99	85.5 cm, F
294	3000 m	18 mo	100x18mm, 12 gm	11/10/91	-	X-103,104	85.7 cm, M
339	3000 m	18 mo	100x18mm, 12 gm	1/18/92	-	X-124,125	90.6 cm, F
Model CT-82							
258	1000 m	14 mo	60x16mm, 8 gm	1/14/91	12/91[2]	X-118,119	64.4 cm, J
276	1000 m	14 mo	60x16mm, 8 gm	12/16/91	-	X-127,128	54.4 cm, J
285	1000 m	14 mo	60x16mm, 8 gm	2/1/92	-	X-131,132	95.2 cm, M

[1] This turtle was recaptured 1/18/92; no sign of transmitter or adhesive, holes were clean.
[2] Tags still transmitting 2/1/92.

TEMPERATURE REGIMES FOUND IN RELOCATED AND NATURAL LOGGERHEAD (*CARETTA CARETTA*) NESTS IN SARASOTA COUNTY, FLORIDA

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In 1982, Mote Marine Laboratory (MML) undertook a sea turtle conservation program with the hope of learning more about the population of loggerheads (*Caretta caretta*) along the barrier islands of Sarasota Co., FL. The continuing goal of the program is to stabilize the Gulf of Mexico loggerhead sea turtle population. Of all the hours dedicated to the program, the greatest percentage is attributed to the daily monitoring of beaches and relocation of endangered nests. The goal of relocation is to provide a safer habitat for nests which, had they been left *in situ*, would have been subject to destruction (human or otherwise).

Given that sea turtles have temperature-dependent sex determination, it is important that relocation techniques provide a nest cavity approximating the temperature regimes found in a natural (*in situ*) nest. Of all the nests laid on Siesta Key, FL, in 1991, over 40% of the nests were relocated to a safer area. Therefore, I felt it important to study whether the man-made nest cavities were approximating the temperature regimes found in natural cavities. To do this, a relocated nest was placed within 2-3 meters of a natural nest laid the same night. A total of four such pairs were placed with K-type (Chromel-Alumel) thermocouples within 18 hours of oviposition. Thermocouples were placed at three different levels in the nest: 1) on top of the bottom layer of eggs; 2) the middle of the clutch; and 3) below the top egg in the cavity. Temperatures of the four different pairs of nests were monitored daily (using a Solomat 1000) during the middle third of the incubation period (taken as the critical period). Because of time constraints, the temperature readings were taken at different times everyday.

The temperature readings (Table 1) fluctuated as the temperature in the nest varied through the day as well as the season. In order to approximate the prevailing temperature in the nest, average observed temperatures were calculated. The mean temperatures of the four paired natural and relocated nests were compared at their respective levels in the nest (Table 1). Each pair showed a statistically significant difference at the top temperature level (two-tailed paired-sample t test). The fourth set showed significant differences at all three levels, with the greatest difference in the means (found at the top position) being 0.96°C.

Although there were significant differences in all four pairs of the nests at the top position, two showed that the relocated nests had higher mean temperatures, while the other sets showed the natural nests had the higher temperatures. These differences in temperature have potential consequences on the sex ratio of the eggs; however, with the differences being in both directions, the over-all effect on the sea turtle population is likely to be very small, if not negligible. I believe these small discrepancies should be regarded as minor consequences of relocation. The benefit of moving these nests to safer areas clearly outweights the potential alternative of nest destruction.

Table 1. The mean temperatures and statistical significance (two-tailed paired-sample t test) of four pairs of *Caretta caretta* nests. The differences are evaluated at three levels in the nest: A) bottom, B) middle, and C) top.

A. Bottom position.

	MEAN TEMPERATURES °C		STATISTICAL
	RELOCATED	NATURAL	SIGNIFICANCE
Set 1	28.47	28.46	0.5844
Set 4	29.21	29.43	0.0743
Set 5	28.95	29.04	0.4912
Set 7	28.79	29.30	0.0001***

B. Middle position.

	MEAN TEMPERATURES °C		STATISTICAL
	RELOCATED	NATURAL	SIGNIFICANCE
Set 1	28.45	28.70	0.4347
Set 4	29.21	29.39	0.1125
Set 5	29.16	29.25	0.4153
Set 7	28.78	29.16	0.0014***

C. Top position.

	MEAN TEMPERATURES °C		STATISTICAL
	RELOCATED	NATURAL	SIGNIFICANCE
Set 1	32.42	28.40	0.0001***
Set 4	28.94	29.44	0.0017***
Set 5	32.40	29.02	0.0128**
Set 7	28.31	29.27	0.0001***

* significance at .05 level
** significance at .01 level
*** significance at .001 level

LOGGERHEAD NESTING AT THE ARCHIE CARR NWR: RELATING 1991 RESULTS TO LONG-TERM TRENDS.

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INTRODUCTION

The Western Atlantic Loggerhead stock utilizes the beaches of southeastern United States as a major nesting rookery with concentrated nesting occurring from Brevard County south to Broward County, Florida. Prominent among these nesting beaches is one in south Brevard County commonly refered to as "Melbourne Beach".

The importance of "Melbourne Beach" was first elucidated through aerial reconnaissance flights in the late 1970's (Carr and Carr, 1977). The UCF Marine Turtle Research Group began to quantify the extent of loggerhead nesting in this region in 1982. The group has conducted season-long surveys to monitor nest densities in the area which is comprised of the southern 21km of Brevard County.

Beginning in 1985, reproductive success studies were initiated to quantify the overall reproductive output at "Melbourne Beach" by assessing the fates of clutches that were deposited each season. Reproductive studies at "Melbourne Beach" suggest that this beach is a vital source of hatchling recruitment into the Western Atlantic loggerhead population. As a result, state and federal officials have proposed significant portions of the beach and dunelands for inclusion in the Archie Carr National Wildlife Refuge (ACNWR).

The 1990 and 1991 nest totals at "Melbourne Beach" (now synonymous with ACNWR) were significantly higher than the average of the previous eight seasons. In 1991, the mean density of loggerhead nests was 628 per km; in 1990 the mean was 682 per km. Over the past seven years the population of loggerheads nesting at ACNWR rookery had the potential to produce an average of 1.25 million eggs per season.

ANALYSIS

Reproductive success has been studied on ACNWR since 1985 by quantifying hatching success and emerging success. Hatching success is defined as the percentage of yolked eggs in a clutch that yields hatchlings. Emerging success is defined as the percentage of yolked eggs per clutch that produces emergent hatchlings.

Loggerhead clutches were counted either as they were being deposited or within six hours of deposition. The sites of these nests were then marked precisely so that the nest contents could be thoroughly inventoried at a later date, after all viable hatchlings had emerged.

The results of 95 loggerhead nest inventories provide data for assessment of reproductive success for the 1991 nesting season. The mean hatching success rate for loggerhead nests was 54.21% and the mean emerging success rate was 53.99%.

In order to discern any possible trends in reproductive success, analysis of clutch sizes and emerging success rates were compared for the years 1985 to 1991. Mean clutch sizes at ACNWR varied significantly during this period. The results of the overall emerging success rates at ACNWR indicate no significant differences in emerging success rates among years.

CONCLUSION

Total nest production at the ACNWR ("Melbourne Beach") generally approaches 25% of Florida's statewide total. Also the area produces between 500,000 and one million hatchling recruits to the threatened loggerhead stock each year. Unquestionably this beach is critically important to the recovery of the Western Atlantic loggerhead, but the future of this south Brevard County shore as a nesting site for marine turtles is still uncertain. The beach is under constant threat by the pressures of real estate development. The reproductive success seen at ACNWR in the past and again in 1991 lend justification and a sense of urgency to the effort to acquire lands for ACNWR and to make it operational.

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ORGANOCHLORINES IN ATLANTIC LOGGERHEADS *(Caretta caretta)*

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ABSTRACT

The tissue distribution patterns of organochlorines accumulated in loggerhead sea turtles (*Caretta caretta*) in the Chesapeake Bay are presented. Polychlorinated biphenyls (PCBs) are also reported in terms of predominant congeners. The major organochlorines detected were PCBs, DDE, and chlordane. Subcutaneous fat had the highest concentration of organochlorines, followed by liver, kidney, and pectoral muscle. PCB congener 153 (IUPAC numbering) was the major PCB component and accounted for more than 25% of the total PCB content of all the tissues analyzed. Five congeners (153 138, 183, 180, and 118) accounted for greater than 50% of the total PCB concentration in all the tissues analyzed. The turtles in this study preferentially accumulated congeners with five or more substituent chlorine atoms.

INTRODUCTION

Anthropogenic organochlorines are persistent, lipophilic compounds that are of concern due to their widespread abundance in the environment and the existing evidence linking organochlorine exposure with various adverse effects. These effects include decreased reproductive success and immunosuppression. Polychlorinated biphenyls (PCBs), a major class of organochlorines, were manufactured as complex mixtures which were characterized by their chlorine content (e.g. Arochlor 1260 means a PCB mixture that is 60% chlorine by weight). Although there are 209 possible structural congeners, less than 100 account for most of the PCBs in environmental samples. The toxicity and potential for bioaccumulation of the various congeners are related to the structural pattern and degree of chlorine substitution. While organochlorines have been detected in virtually all environmental samples tested to date, very few studies have been published on reptiles.

OBJECTIVES

The objectives of this study were to provide preliminary data on pollutants in Chesapeake Bay loggerheads, specifically regarding major organochlorines present, levels observed, tissue distribution and PCB congener accumulation patterns.

MATERIALS AND METHODS

Samples of subcutaneous fat, liver, kidney, pectoral muscle, and gonad from three loggerheads stranded in the Chesapeake Bay (Table 1) were collected in solvent-rinsed jars and frozen until analysis. The tissues were homogenized, mixed with precipitated silica and anhydrous sodium sulfate, and allowed to dry for 48 hrs. Following the addition of decachlorobiphenyl (DCB) as an internal standard, the dehydrated tissues were Soxhlet extracted with dichloromethane for 48 hrs. A reagent blank was run with each batch of extractions. An aliquot of each extract was retained for gravimetric determination of methylene chloride extractable lipids. 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.

Table 1. Turtles involved in study

TURTLE	STRANDING DATE	LOCATION	SCL* NOTCH TO NOTCH (cm)	WEIGHT (kg)	SEX
1	21 MAY 1991	Mathews County	57.8	n/a	F
2	5 JUNE 1991	York County	60.4	36	F
3	29 JUNE 1991	Northumberland County	46.2	16	F

*STRAIGHT CARAPACE LENGTH

RESULTS and DISCUSSION

1.) The loggerheads mentioned above were analyzed for organochlorine pollutants. The major organochlorines detected were PCBs, DDE, and chlordane (sample chromatogram, Fig. 1). All contaminants were in the parts per billion (ppb) range.

2.) Subcutaneous fat had the highest concentrations of organochlorines, followed by liver, kidney, and pectoral muscle. No pollutants were detected in gonad tissue. The gonad tissue available from juvenile turtles is limited. This results in high method quantitation limits for this matrix. The lipid content of immature gonad tissue is low so it is expected that the levels of organochlorine accumulation in young animals will also be low. The distribution of organochlorines correlates well with the amount of lipid in the tissues (Fig. 2). In this study, lipid was determined gravimetrically as the amount of DCM extractable material expressed as percent of wet weight.

3.) Five congeners (IUPAC numbers 153, 138, 183, 180, and 118, Table 2) accounted for greater than 50 % of the total PCB concentration, with no. 153 representing more than 25 % of the total PCBs in all tissues analyzed (Fig. 3). The PCB accumulation pattern included predominantly congeners with higher levels of chlorination, i.e. penta- to nona- chlorinated homologs. This suggests that the distribution of PCB congeners in loggerhead sea turtles more closely resembles patterns reported for birds and mammals, than those of fish and invertebrates where less chlorinated homologs, i.e. mono- to tetra- chlorinated, are slightly more prevalent.

Table 2. IUPAC nomenclature for selected PCB congeners

congener number	structure
hexachlorobiphenyls	
153	2,2',4,4',5,5'
138	2,2',3,4,4',5'
heptachlorobiphenyls	
183	2,2',3,4,4',5',6
180	2,2',3,4,4',5,5'
pentachlorobiphenyl	
118	2,3',4,4',5

Fig. 1
TURTLE 1: Subcutaneous Fat

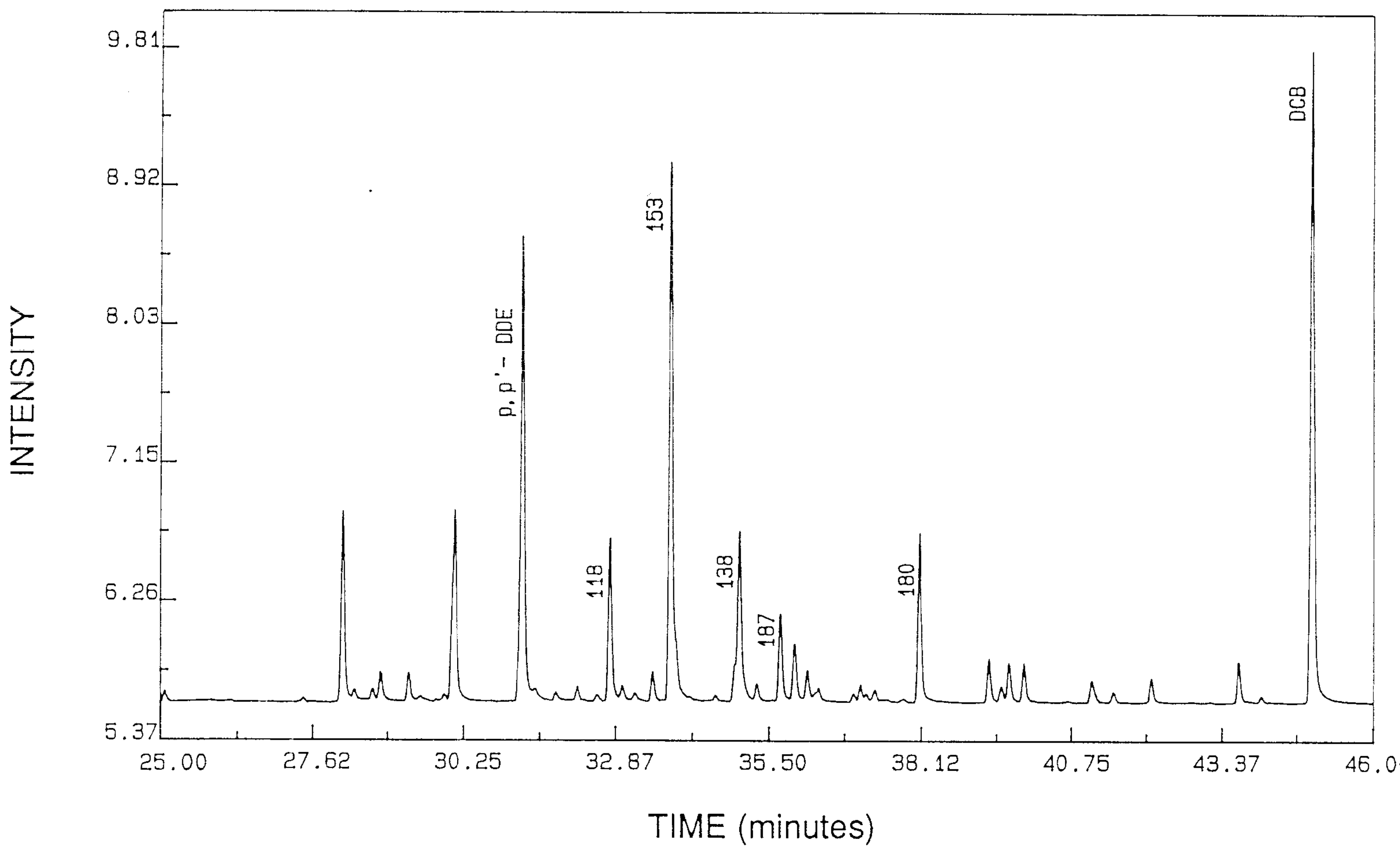


Fig. 2

MEAN % LIPID and TOTAL PCB

RELATIVE TO TISSUE TYPE

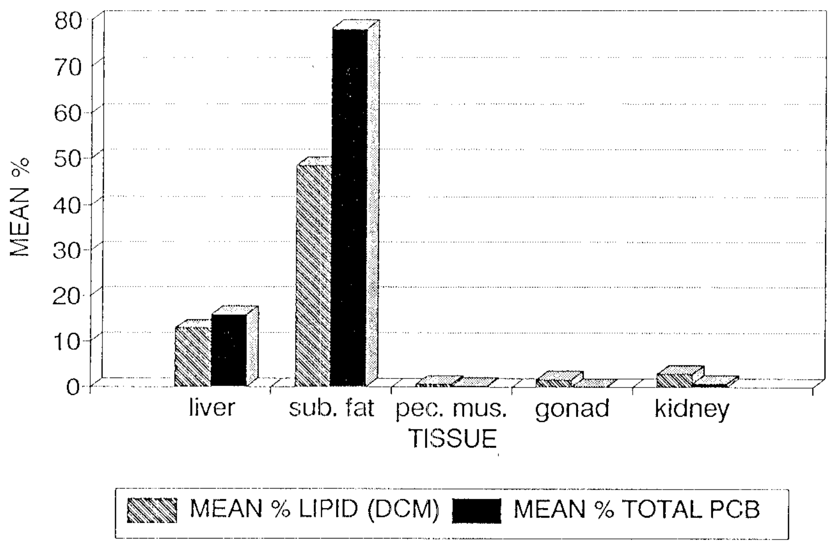
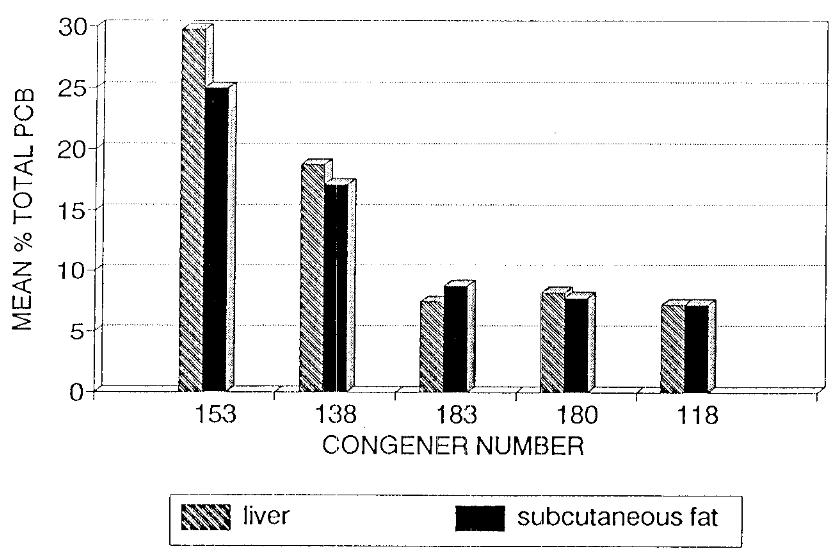


Fig. 3

MEAN % TOTAL PCB vs. CONGENER

RELATIVE TO TISSUE TYPE



THE EFFECT OF BEACH RENOURISHMENT ON SEA TURTLE NESTING AND HATCHING SUCCESS AT SEBASTIAN INLET STATE RECREATION AREA, EAST-CENTRAL, FLORIDA

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In April of 1990 the Sebastian Inlet Tax District received a long-term (25 year) permit to conduct maintenance dredging of the navigation channel at Sebastian Inlet, Florida. Approximately 115,000 cubic yards of sediment would be removed every two years and pumped to a feeder beach immediately south of the inlet. The renourished beach, a high density nesting beach for loggerhead *(Caretta caretta)* and green *(Chelonia mydas)* sea turtles, is within the proposed Archie Carr National Wildlife Refuge and will play a critical role in the long term maintenance of Sebastian Inlet as a navigable waterway. A turtle monitoring program was implemented by the District at the request of the USFWS. The following objectives were designed to provide comprehensive information on the biological and physical attributes of the study area:

- To determine loggerhead and green sea turtle nesting and hatching success on 503 m of renourished beach at Sebastian Inlet State Recreation Area and on a control site of equal length.
- To conduct monthly sand compaction profiles of the renourished and control beaches.
- To conduct monthly temperature profiles of the renourished and control nesting substrates.
- To coordinate compaction and temperature data with monthly sand and moisture analysis profiles.

The renourished and control beach were surveyed at dawn using an all terrain vehicle from 1 May until the last nest emergence in October in 1990 and 1991. Sea turtle crawls from the previous night were recorded as a successful nesting activity or a false crawl. All nests were marked and monitored throughout incubation. After evidence of emergence, or 70 days after laying, the nests were inventoried to determine hatching success. Night surveys were conducted to collect additional information on nesting behavior. Monthly compaction profiles were conducted using a cone penetrometer and recording cone index values at the 30 cm sand depth. Monthly sand temperature profiles were conducted with copper-constantin thermocouples along transects, recording the temperature at the 30 and 60 cm sand depth over a 24 hour period. Monthly sand and moisture analysis was conducted using a standard soil auger.

Nesting and hatching success were similar on both beaches in 1990 and 1991 (Table 1). It was concluded that the renourishment had no adverse effect on sea turtle nesting and hatching success. Compaction values averaged 700 PSI on the renourished beach, while values on the control were approximately 250 PSI (Fig. 1 and Fig. 2). Nests on the renourished beach failed to demonstrate the characteristic nest attributes and were of a different shape due to increased compaction. The geometry and structure of the nest chamber could be critical to the development of the clutch (Ackerman, 1980). Temperatures measured at 30 cm and 60 cm indicated that the renourished beach was consistently about 0.5 C• warmer than the control (Fig. 3 and Fig. 4). The direction of sexual differentiation in sea turtles depends on the temperature at which the clutch is incubated. An increase in the ambient incubation temperature could effect the sex ratio of the developing eggs (Mrosovsky, 1987). Grain size and moisture content were similar on the renourished and natural beaches (Parkinson, 1991).

The results of this project cannot be applied indiscriminately to other beach renourishment projects, but should be restricted to future dredging projects at Sebastian Inlet. If the physical parameters of a subsequent renourishment project are within the findings of 1990 and 1991, there should be no adverse effect on sea turtle nesting and incubation. Since the compaction levels were not related to incompatible beach fill, it was concluded that the manner in which the material was deposited resulted in the compaction. In the future, Sebastian Inlet could take the initiative at the outset of a project to insure a suitable nesting substrate rather conducting post-renourishment monitoring of effects. Although the results are not applicable to other locations, the methodologies developed over the two years to study the effects of renourishment on sea turtles could be applied to other beach renourishment situations. Future research should focus on how the physical aspects of a renourished beach effect the micro-environment within the actual nest chamber and at what stage of development increased compaction or temperature may play a critical role in the fate of the clutch. If we can anticipate the effects of various physical parameters, it will be possible to renourish our beaches and provide nesting habitat for endangered and threatened sea turtles.

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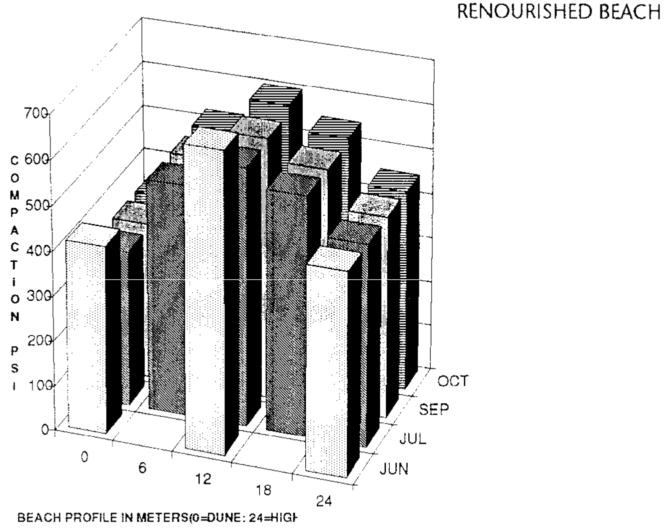
		RENOURISHED		CONTROL	
		1990	**1991**	1990	**1991**
NESTING	Total Crawls	245	**262**	142	**189**
	Caretta caretta Nests	103	**165**	64	**118**
	Caretta caretta False Crawls	141	**97**	77	**71**
	Percent Cc Nests of Total Crawls	42	**63**	45.4	**62.4**
	Chelonia mydas Nests	1	**0**	1	**0**
	Chelonia mydas False Crawls	0	**0**	0	**0**
HATCHING	Mean Clutch Size	110	**106**	106	**106**
	Mean Chamber Depth (cm)	51	**52.8**	51	**50.7**
	Mean Incubation Time (days)	51	**52.6**	53	**52.2**
	Percent Hatched: Caretta caretta	80.7	**70**	80	**67**
	Percent Live Emerged: C. caretta	79.6	**69.2**	79.2	**66.6**
	Percent Hatched: Chelonia mydas	84.2	**NA**	98	**NA**
	Percent Live Emerged: C. mydas	82.5	**NA**	98	**NA**
OTHER	Raccoon Predation	10	**15**	1	**1**
	Washed Out Nests	0	**1**	0	**1**
	Beach Width (m)	20-30	**20-30**	10-15	**8-10**

Table 1. Comparison of nesting and hatching on renourished and control beaches, Sebastian Inlet and Wabasso Beach, Florida, 1990 & 1991.



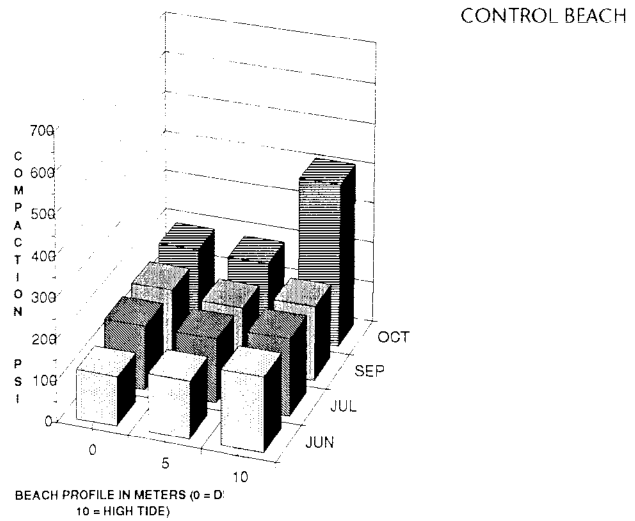
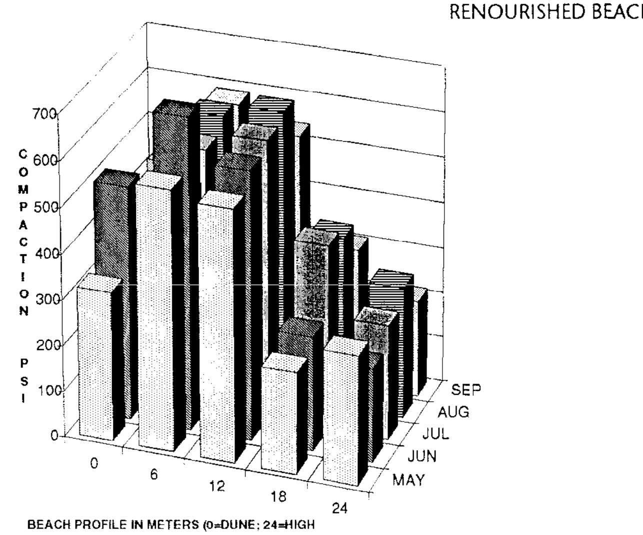


Figure 1. Mean monthly sand compaction profiles of renourished and control beaches, Sebastian Inlet and Wabasso Beach, Florida, 1990.



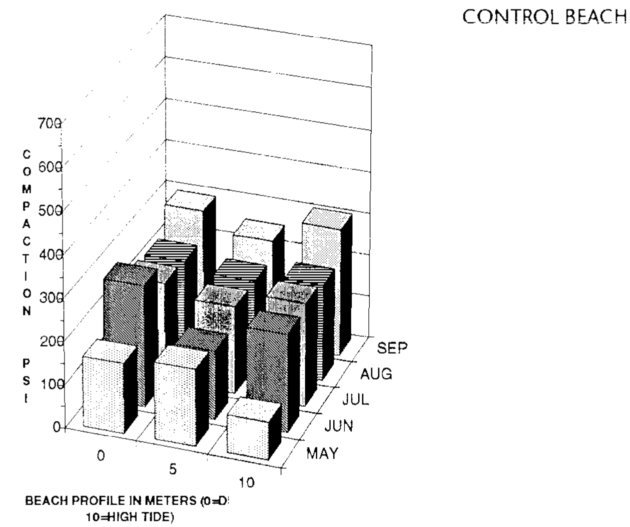


Figure 2. Mean monthly sand compaction profiles of renourished and control beaches, Sebastian Inlet and Wabasso Beach, Florida, 1991.

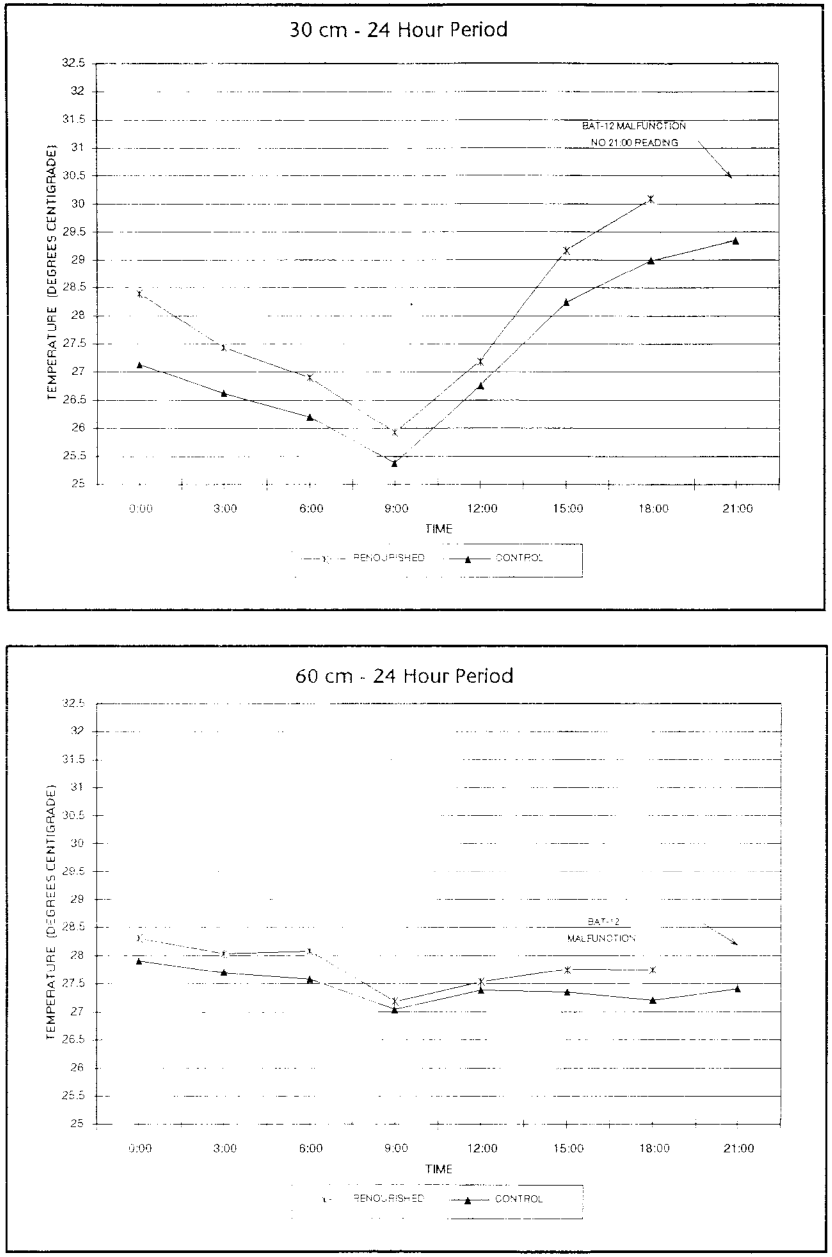


Figure 3. May sand temperature profile at 30 and 60 cm throughout a 24 hour period on renourished and control beaches, Sebastian Inlet and Wabasso Beach, Florida, 1991.

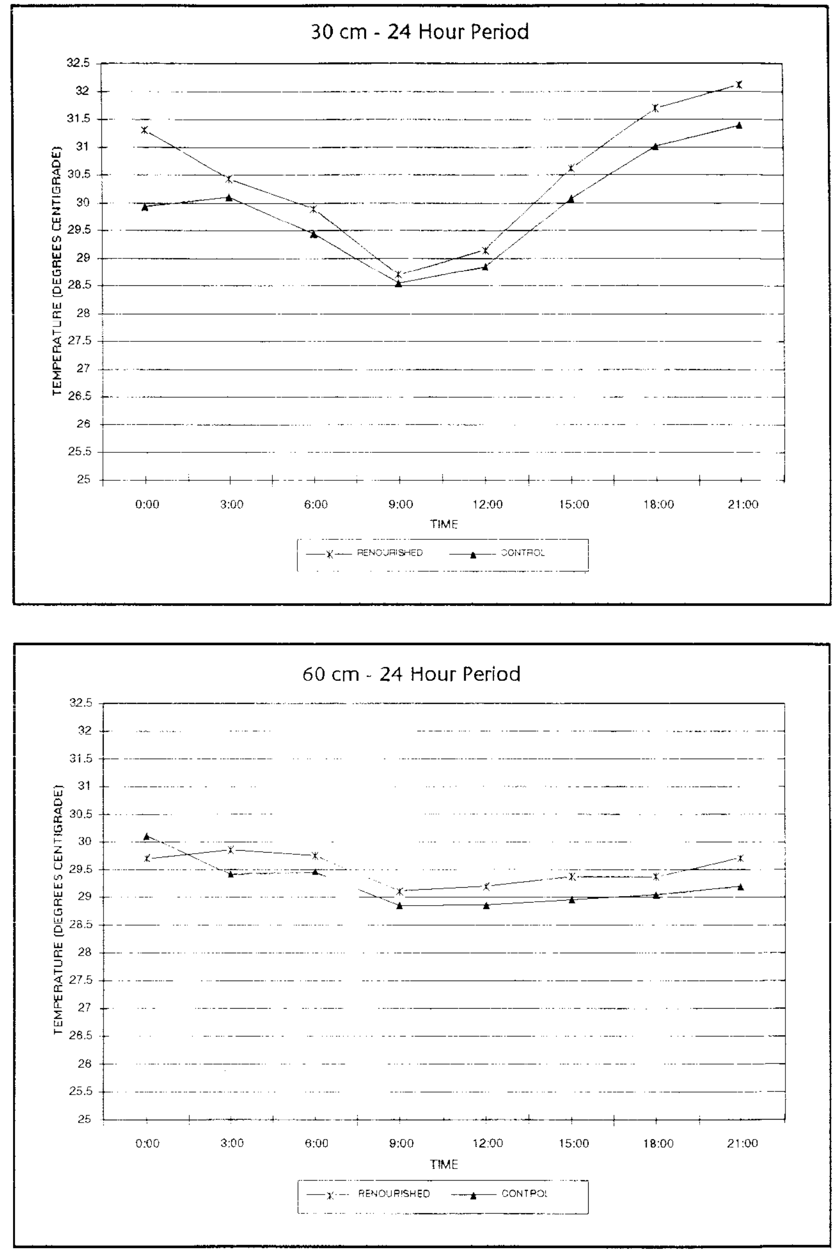


Figure 4. June sand temperature profile at 30 and 60 cm throughout a 24 hour period on renourished and control beaches, Sebastian Inlet and Wabasso Beach, Florida, 1991.

ANALYSES OF 12 YEARS OF SEASONAL AND SPATIAL NESTING PATTERNS BY LOGGERHEAD TURTLES *CARETTA CARETTA* ON ONSLOW BEACH, CAMP LEJEUNE, NORTH CAROLINA

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Many investigators of sea turtle nestings and sites often have impressions that no (Brooks 1989; Lind 1986) or some seasonal or spatial nesting concentrations or shift patterns occur along the beach being surveyed (Eckert 1987; Ehrhart and Raymond 1987; Hughes 1974; Martin et al. 1989; and Redfoot et al. 1990). Few, if any, have tested their observational data to see if there are yearly linear, seasonal and distance patterns or shifts in nest site preference and occurrence (Ehrhart and Raymond 1987; Hughes 1974; Provancha and Ehrhart 1987). This study statistically tests loggerhead sea turtles (*Caretta caretta*) seasonal and spatial nesting patterns, north or south of Riseley's Pier and nest site utilization of Onslow Beach, Onslow County, North Carolina during 12 years 1979 through 1991. Analyses compare dates of nesting, sites and distances north or south of Riseley's Pier, and nestings between years.

STUDY AREA AND METHODS

Onslow Beach is a 22.4 x 0.8 km long north-south positioned island, part of Camp Lejeune military base, in Onslow County, North Carolina. It is bounded on the north by Bears Inlet and on the south by New River Inlet (Figure 1). Nightly turtle nesting patrols, by two observers making at least four surveys per night, covered all but the northernmost 2-4 km of the island, a restricted bombing range, during the years 1979 through 1991. Patrols occurred from 2200 to 0500 hr to note time of nesting, nest location, size of turtle, and many environmental parameters such as wind, moon phase, cloud cover, tide height and state, etc.

Information about water currents along Onslow Beach are lacking or has not been measured precisely. However, areal flights have noted that, for nine months of the year, southerly or southwesterly winds prevail and move waters south to north along the beach, as segments of Gulf Stream water that come ashore at nearby Topsail or Indian Beaches, just south or east of Onslow Beach. Northerly or northeasterly winds, for 3 to 4 months of the year, carry waters from north to south along the beach as part of the waters that are driven ashore from the Gulf Stream and onto Indian Beach at Bogue Banks, some 5 km to the northeast, where they split with one branch flowing westerly toward Onslow Beach (pers. obs.). During nine months of the year winds are from the southwest and induce south to north water currents from Topsail Beach along Onslow Beach.

During the interval 1979 through 1991 the north end of the island has accreted about 13.7 m while the south end eroded a smiliar distance. A vehicular bridge located 2.4 km north of Riseley's Pier connects the island to the mainland at north end of recreation area (R, Figure 1). A public and military training area extends southward of the mainland bridge southward past the pier to near South Tower (Figure 1).

Each turtle nest was marked and protected by a piece of 1.2 m^2 wire made with 50 x 100 mm openings lying flat and tacked at each corner of the nest to prevent racoons and other predators from digging up or disturbing the nest. Following incubation of about 70 days (Schwartz 1989) the nest was dug up to note number of hatched and unhatched eggs, dead embryos, and other features of the nest.

ANOVA statistical analyses tested the relationships: year x direction north or south of Riseley's Pier, disregarding distance; year x distance N or S of Riseley's Pier disregarding date of nesting; distance (kilometers) x direction, disregarding year; and date of nesting x direction N or S of Riseley's Pier, disregarding year. Sands along the entire length of the island have also been analyzed for kurtosis, graphic mean size, standard deviation, and skewness for Schwartz (1982) has shown that there is a correlation of nesting with size of sand, but those new results will be reported elsewhere.

OBSERVATIONS

While more nestings occurred north than south of Riseley's Pier in 1982-1984, these differences were significant over time (years) when disregarding distance N or S of Riseley's Pier (Table 1). The same is true if year and distance away from Riseley's Pier were analyzed (disregarding date of nesting). If one examined year x date disregarding direction of the nesting, high significances were noted. Likewise, if one analyzed date x direction data, disregarding year, high significances were also noted (Table 2).

Thus, it was date of nesting that influenced the site location of the nest. Likewise, the occurrence of south to northerly water masses moving past Onslow Beach, usually driven by strong southwesterly winds early in the nesting season also influenced nesting south of the pier while weaker late summer currents permitted use of the northern portions of Onslow Beach for nesting. Schwartz (1989) has also commented on the yearly differences of whether waters along Onslow Beach warmed first from the north to south or vice versa such that during early water warming from the south nesting would begin earlier there than to the north and vice versa. For example, Onslow Beach experienced colder waters along its length in 1988; the reverse was true in 1986, 1987, and 1988 (Schwartz 1989). In general, early nesting in the south or north was determined by water temperatures, date, and water current strength.

Provancha and Ehrhart (1987) noted two spatial and temperal reoccurring trends for loggerheads nesting at Cape Canaveral. They were most evident in 1981, 1983, and 1984 but not 1980 (little is known of the water currents and directions along the Canaveral beaches). Ehrhart and Raymond (1987) noted seasonal beach nestings during a three year study of 21 km of beaches from southern Melbourne Beach south to Sebastian Inlet, Florida, where the south end of the study beaches were used more often in 1982, 1983, and 1984. Hughes (1974) noted a southerly turtle movement early in the season and a seasonal northerly shift later in the season on a South African beach but didn't note water current direction or strength. Brooks (1989) found no overall pattern of seasonal nesting for Bald Head Island, North Carolina, a beach about 55 km to the south of Onslow Beach, yet there seemed to be more nests between sectors 10 and 14. Martin et al. (1989) noted a decrease in nesting during cold snaps in the middle of their 18 yr observations of nestings on Hutchison Island, Florida, but found the best nesting occurred in the southern portion of their study area, even though a power plant, with its seasonally warmer water, occurred in the middle of their study area. Redfoot et al. (1990) noted that with a water temperature drop nesting still occurred to the south. All of the above say nothing of seasonal water current affects on the nesting intensity or if they were an influence on nesting or nest location. Several, however, measured the distance inland to a nest site and whether the nests were clustered or not but did not correlate them with any other factor of why the nest was located at a specific site.

Thus one should examine or pay more attention to seasonal shore water temperatures, currents, and sand size composition as they influence the area or location and season used by loggerhead sea turtles for nesting along a beach. Such observations will explain why and when the nesting occurs at a specific site. This will let one be better prepared to protect nests from marauders and/or the public, permit better and specific area use of one's personal and the better formulation of conservation measures when protecting nests and habitats from natural destruction and depredation.

ACKNOWLEDGMENTS: Thanks are extended Mr. J. Wooten and C. Peterson, Environmental Management Department, Marine Corps Base, Camp Lejeune, NC, for supplying the nesting data on which this study is based.

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Figure 1. Coastal map of the study area.

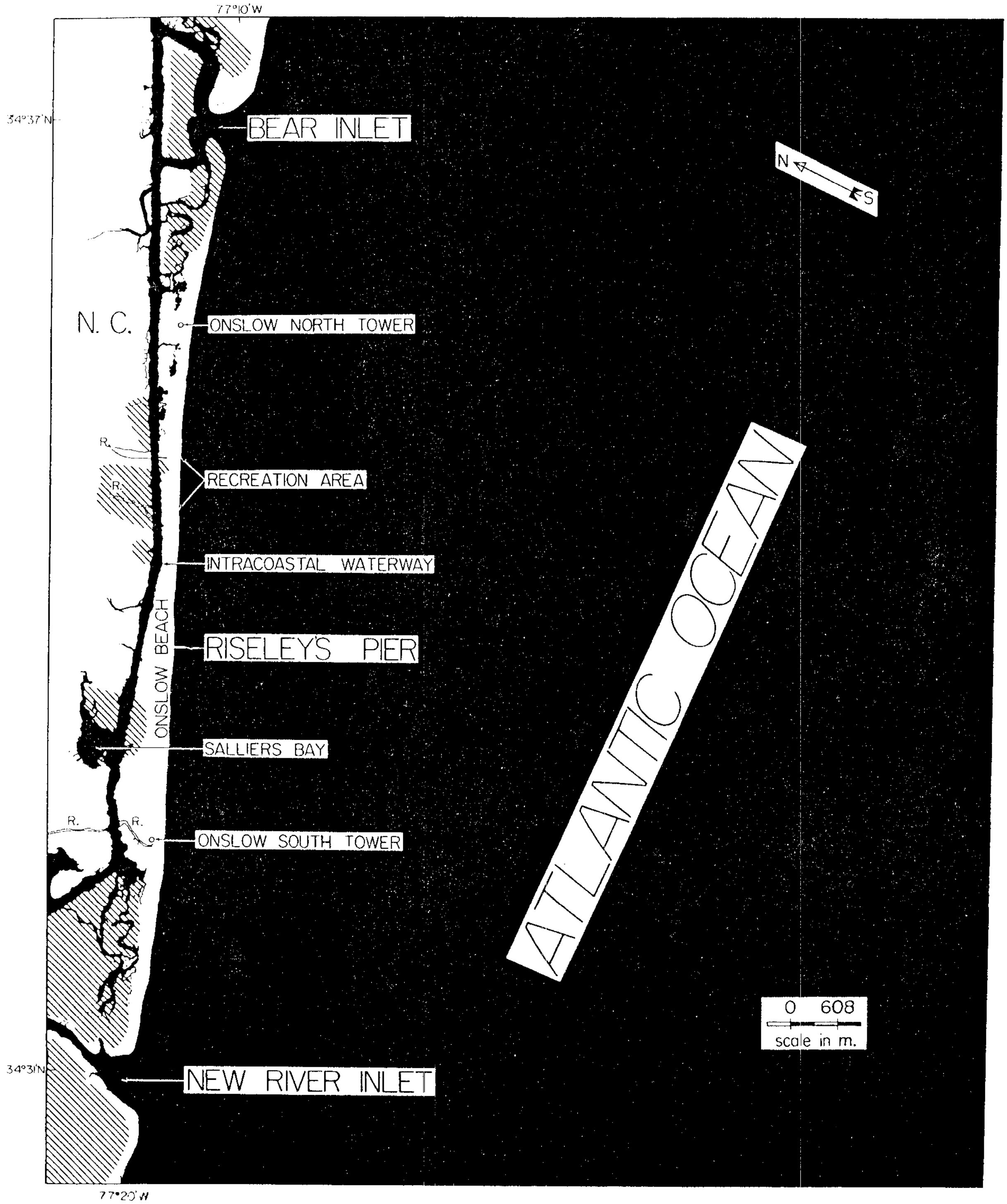

Table 1. Number of loggerhead nests on Onslow Beach, north or south, in kilometers, of Riseley's Pier 1979-1990.

km	1979 N=63		1980 N=65		1981 N=16		1982 N=57		1983 N=42		1984 N=62		1985 N=34		1986 N=32		1987 N=24		1988 N=35		1989 N=30		1990 N=50	
	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S
0 - 0.8	6	4	20	8	2	1	11		7	1	11		6	1	3	1	3	2	6	6	6	3	11	2
0.9 - 1.6	1	5	10	2			3		2		4		2		3	1	1	2	1	7	2	1	7	5
1.7 - 2.4	6	6	5		2		2	1	2		1	1	1	1	2	2	1	2	1	1	1		3	4
2.5 - 3.2	5	6	3	3	1		6	3	1	1	7	1	6	13	4		2	2	2	2	1		2	5
3.3 - 4.0	5	6	3		2		8	2	11	4	3	8	2	1	5		2	2	3	4	5	1	5	4
4.1 - 4.8	6	2	5		1		5	2	5		3	2		1		3	1			1	3	4		2
4.9 - 5.6	2		4		2	4	10	4	1		10	3			6		1	2	1		2	1		
5.7 - 6.4	3		2		1				6		4	4					1							
6.5 - 7.2									1						2									
Total	34	29	52	13	11	5	45	12	36	6	43	19	17	17	25	7	12	12	14	21	20	10	28	22

Table 2. ANOVA interaction comparisons by year, distance N-S, direction N-S, and date nested by loggerhead sea turtles on Onslow Beach, Camp Lejeune, North Carolina 1979 through 1991.

Factors Compared	Factor disregarded from analysis	Significance	
Year x Direction	Distance N-S of Riseley's Pier	Year	**
		Direction	**
		y x Di	NS
Year x Date nested	Direction N-S of Riseley's Pier	Year	**
		Date	**
		y x Da	**
Distance x Direction	Year	Distance	NS
		Direction	*
		Di x Dr	NS
Date x Direction	Year	Date	**
		Direction	**
		Da x Di	**

*=Significant; **= Highly significant

ISOFLURANE: A SAFE AND EFFECTIVE ANESTHETIC FOR SEA TURTLES

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The low and variable metabolic rates of reptiles make it difficult to anesthetize them safely. The endangered/ threatened status of the world's sea turtle populations makes it especially important that none are overdosed. However, surgery is sometimes required to repair injuries, remove papilloma tumors, etc. Commonly utilized injectable anesthetics such as Ketamine HCl and the barbiturates present difficulties since their effects can vary greatly depending on the dose, route of administration, and the health, sex, and age of the animal. These anesthetics tend to have variable rates of induction as well as times at surgical depth, while long recovery times and a narrow margin of safety between the effective and lethal dose can lead to poor recovery rates (Figure 1).

Inhalant anesthetics, on the other hand, provide the benefits of relatively short induction and recovery times, increased safety margins, and most importantly, precise control of the depth and time course of anesthesia. Of the most commonly used inhalants (isoflurane, halothane, and methoxyflurane), isoflurane has particularly rapid induction and recovery times due to its relative insolubility in, and rapid dissociation from, body tissues and fluids. Isoflurane (trade name AErrane by Anaquest) is also stable, non-flammable, and neither carcinogenic nor mutagenic. Unlike the other inhalants, isoflurane also has no known toxicity since <1% is metabolized in mammals vs. 20% and 50% for halothane and methoxyflurane. Mammalian cardiac output and cardiac rhythm are both maintained and stable; however, these factors have not been widely examined in reptiles.

We tested the effectiveness of isoflurane on two species and size classes of sea turtles: juvenile loggerheads (*Caretta caretta*) and juvenile and subadult greens (*Chelonia mydas*). Times and required doses to induce light and deep anesthesia, maintain a surgical plane for 1 hour, and to full recovery were recorded. Positive pressure ventilation was provided to ventilate the lungs, while a Verni-trol anesthesia machine with vapourizer maintained flow rates of 400 - 700 ml O_2/ min and controlled anesthetic concentrations. An isoflurane concentration of 4% was required to induce anesthesia while 1.5% - 1.7% was sufficient to maintain a surgical plane. Induction and recovery times varied between individuals (increasing with increasing size) but were generally quite short (45 - 65 mins. for induction, 2 - 6 hrs. for recovery) (Figures. 2,3). Cardiac rhythm is stable and heart rate is only slightly if at all depressed.

FIGURE 1:
BENEFITS of ISOFLURANE vs. POPULAR INJECTABLE ANAESTHETICS

	ISOFLURANE	KETAMINE HCl	PENTOBARBITOL	THIOPENTAL
DOSE	4%-1.5% [1]	60-90 mg/kg [1] 50-71 mg/kg [2]	10-18 mg/kg [2]	18.8-29.9 mg/kg [2]
INDUCTION	1-15 mins. [1]	30 mins. [1] 2-10 mins [2]	14-120 mins. [2]	5-10 mins [2]
TIME IN SURGICAL ANAESTHESIA	as needed	2-10 mins.	40-240 mins. [2] No relationship between dose and time at anaesthetic plane [2]	5-120 mins. [2]
RECOVERY	immediate up to 3 hrs [1]	=/> 24 hrs. [1] within 4 hrs [2]	4-24 hrs. [2]	up to 6 hrs. [2]

FIGURE 2: Time Required to Anesthetize 2 Species and Size Classes of Sea Turtle

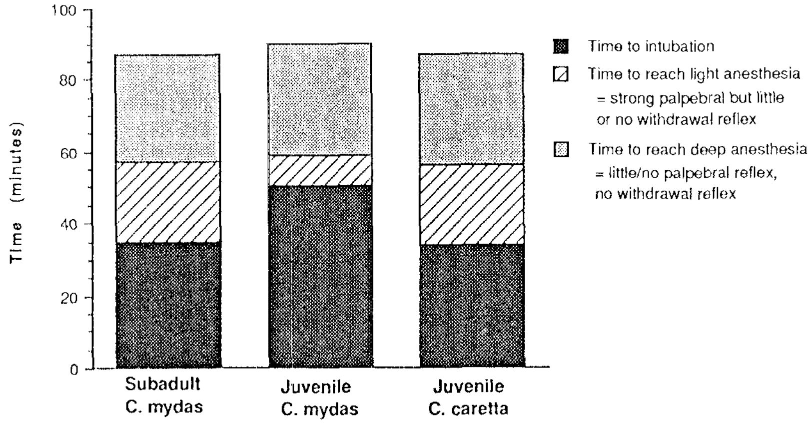
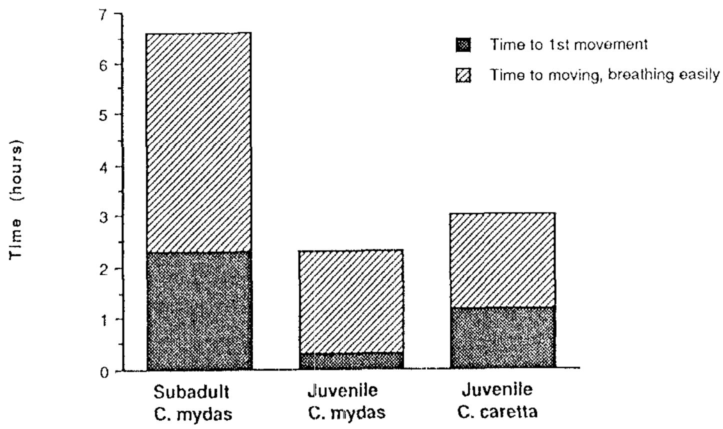


FIGURE 3: Recovery Times in Sea Turtles Anesthetized 1 Hour with Isoflurane



SEASONAL OCCURRENCE OF LEATHERBACK SEA TURTLES (*DERMOCHELYS CORIACEA*) IN THE MONTEREY BAY REGION

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INTRODUCTION

Leatherback sea turtles (*Dermochelys coriacea*) have the most extensive geographic range of all reptiles. They have been reported from 60° N to 42° S latitude and in all major oceans (Groombridge 1982).

Unlike other sea turtles, leatherback sea turtles can tolerate extreme temperature variations; they can swim vigorously in waters of 0 C° (Goff and Lien 1988). Leatherback sea turtles have maintained core temperatures 15°C above ambient water temperatures of 5°C (Frair et al. 1972).

Leatherback sea turtles nest between 30° N and 20° S latitudes. The two major nesting colonies in the Pacific are in Melanesia, on the northern coast of New Guinea, and on the southwestern coast of Mexico, in the states of Oaxaca, Michoacan, and Guerrero (Pritchard 1982). Because of insufficient tag returns, their distribution after nesting is unknown.

Ven Denburgh (1922) was the first to describe a leatherback sea turtle off California, and from Monterey Bay (Ven Denburgh 1924). Carr (1952) recorded the collection of a leatherback sea turtle near San Diego in 1907, and Myers (1933) reported two specimens collected near San Francisco in 1929. In 1984, a leatherback sea turtle washed up in Pebble Beach, Del Norte County, California, and there were numerous undocumented sightings along the California and Oregon coasts in 1984 (Smith and Houck 1984). Stinson (1984) reported 300 observations of leatherback sea turtles along the west coast of North America from 1900 to 1983.

Our objective was to compile observations of leatherback sea turtles in Monterey Bay from 1986 to 1991, and to correlate these sightings with sea surface temperatures. We hypothesized that the number of leatherback sea turtles in the Monterey Bay region was correlated positively with periods of warm surface water.

METHODS

Sightings of leatherback sea turtles within 50 km of Monterey Bay were collected primarily from selected recreational party boat skippers using the area from 1986 to 1991. Effort was assumed to be equal through time except for increased effort during salmon fishing season (March-October) of every year. Mean and standard deviation of monthly and annual sea surface temperatures for this area (1919-1983) are from Stinson (1984), and were considered normal monthly temperatures. Analysis of leatherback sea turtle observations relative to sea surface temperatures in Monterey Bay follows Stinson (1984). Each month of the study period was identified as "warm" if one standard deviation above the normal mean, or "cool" if one standard deviation below. Each turtle sighting was identified as having occurred during a month and a year characterized by "normal", "warm" or "cool" ocean conditions.

Assuming a normal distribution, 68% of the monthly and inter-monthly periods will have sea-surface temperatures within one standard deviation of the mean. Therefore, if temperature were not affecting leatherback sea turtles movements we would expect 68% of turtle sightings during periods of "normal" temperature, 16% during anomalous warm temperature and 16% during periods of cool temperature (Zar 1984). A Chi-square test for goodness of fit (Zar 1984) was used to determine if the frequency of sea turtles sighted during each monthly category differed from that statistically expected if leatherback sea turtles occurrence within Monterey Bay were not related to sea surface temperature. To meet the assumptions of the technique, monthly temperatures were tested for normality using a Kolmogorov-Smirnov test (Zar 1984).

We assumed all leatherback sea turtle sightings were independent of one another. No two sightings were used in one day unless observations were at least 5 km apart or were made by the same boat moving along one heading.

RESULTS

Ninety-six observations of leatherback sea turtles were recorded from 1986 to 1991. The greatest number of sightings occurred in August (n=47) corresponding to the greatest mean monthly temperature for the study period (Figure 1). Sightings in November, March, and April were not used in the analysis because these months accounted for only 3 sightings. There were significantly greater numbers of leatherback sea turtles sightings during months of warm surface water temperatures than during months of normal or cool surface water temperatures (X^2=120.5, $P<0.05$). Temperatures during August 1987, 1988 and 1990 were greater than normal, and these months accounted for 41% of sightings during the study period.

DISCUSSION

Stinson (1984) found observations of leatherback sea turtles corresponded with the movement of the 16°C isotherm along the west coast. During much of the year, this isotherm remains offshore but during early spring and summer, the coast of California is inundated by warmer offshore waters. These waters meet the coast south of San Diego and move north reaching central California during July and August (Roden 1961). As this water moved northward, leatherback sea turtles were observed progressively further north, and were observed more often in areas where the 16°C isotherm was encountered than elsewhere (Stinson 1984). Our results also indicated the presence of leatherback sea turtles along the west coast was influenced by temperature. During much of the year, Monterey Bay is dominated by upwelling and associated cool water, but in fall (Aug.-Sept.), warmer water may enter the bay directly from the west as upwelling favorable winds begin to relax (Breaker and Broenkow 1989). At these times, water temperatures increased to 15-16°C and leatherback sea turtles are observed most frequently.

While in Monterey Bay, leatherback sea turtles may eat large concentrations of scyphomedusae. Six species of large scyphomedusae *(Aurelia aurita, Polyorchis montereyensis , Cyanea capillata, Chrysaora melanaster, Pelagia colorata, Phacellophora camtschatica)* have been recorded in Monterey Bay, and occur during periods of warm water intrusion (F. Sommer pers. comm.). In Monterey Bay, leatherback sea turtles were photographed feeding on *Pelagia colorata* (F. Harmon, pers. comm.) and video taped eating large scyphomedusae similar to *Phacellophora camtschatica* (D. Shearwater, per. comm, Larsen 1990). Leatherback sea turtles have been observed feeding on *Aurelia* sp. off Washington (Frazier 1983). Swarming behavior of *Aurelia aurita* was observed in Tomales, Bodega, and Monterey Bay (F. Sommer pers. comm.) and large concentrations of *Chrysaora melanaster* may occur in summer and fall (J. Harvey, pers. observ.). Shenker (1984) found *Chrysaora fuscescans* reached densities of 1800 liters of medusae per $10^5 m^3$ during August in surface waters off Oregon.

Coastal areas of central California that have high scyphomedusae abundance may attract leatherback sea turtles from offshore areas. Lazell (1980) has suggested that densities of *Cyanea capillata* have an important influence on the distribution of leatherback sea turtles in the Atlantic Ocean, and this syphomedusa reaches greatest densities in calm embayments. In all months but May, the densities of *Chrysaora fuscescans* was greatest closest to the Oregon coast and decreased rapidly offshore (Shenker 1984). With its high seasonal abundance of scyphomedusae, Monterey Bay may be of great importance to leatherback sea turtles.

ACKNOWLEDGEMENTS

We wish to thank R. Ternullo and D. Lemon for collecting the turtle reports from the Monterey Bay fishing fleet and D. Shearwater of Shearwater Journeys for providing a platform of opportunity for observers. F. Sommer of Monterey Bay Aquarium provided useful discussion on local scyphomedusae. Collection managers at the California Academy of Science and Santa Cruz City Museum of Natural History provided specimen data. R.N. Lea, S.A. Eckert, and K.L. Eckert improved the manuscript.

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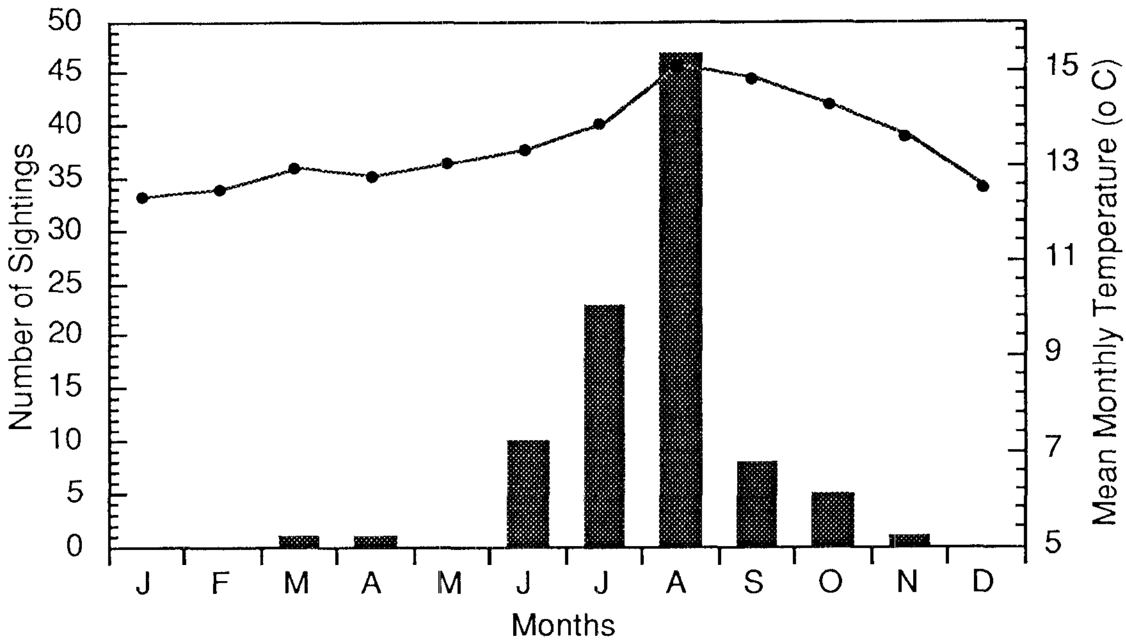

Figure 1. Number of cumulative sightings (bars) for each month of the study period (1986-1991) compared with mean monthly temperatures (line,1986-1991).

TEDS: INTERNATIONAL IMPLEMENTATION?

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INTRODUCTION

Global protection of five species of endangered sea turtles seriously threatened by the worldwide shrimp industry's fishing practices was the primary intent of a new U.S. law that went into effect in May of 1991. Public Law 101-162, section 609 (Figure 1) enacted by Congress in 1989 requires nations who wish to import shrimp into the United States to:

• adopt regulations governing the incidental taking of sea turtles comparable to those of the U.S., and that the average rate of incidental taking be comparable to the incidental rate of capture by U.S. vessels.

In addition, section 609 requires the U.S. to initiate as soon as possible:

• agreements with other countries for the protection and conservation of sea turtles, including the conservation of necessary land and marine habitats;

> • treaties for the protection of sea turtles with ALL foreign governments whose fishing activities adversely affect sea turtles; and
>
> • amendments to any existing treaties in order to make such treaties consistent with the protection and conservation of sea turtles.

CERTIFICATION OF COMPARABILITY OR BAN ON IMPORTED SHRIMP

The clear intent of this law is to encourage nations to adopt regulations requiring TEDs[1] on all shrimp trawling vessels fishing in waters where five species of sea turtles (loggerhead, green, hawksbill, leatherback, Kemp's ridley) occur. To compel nations to take these actions, the law specifically prohibits by May 1, 1991, the importation of shrimp into the U.S. from nations who have not adopted regulations that reduce incidental sea turtle capture to rates comparable to those of the U.S. In order to allow the shrimp fishing nations time to comply, Section 609 allowed 18 months from time of passage of the law in 1989 until the May 1, 1991 deadline.

STATE DEPARTMENT ISSUES AND REGULATIONS SEVERELY LIMITING SCOPE OF NEW LAW

Despite section 609's clear mandate to include "... ALL foreign governments which are engaged in ...commercial fishing operations which...may affect adversely [endangered] species of sea turtles...", on January 10, 1991, the Department of State issued regulations[2] which severely limit the scope of the law, and which greatly reduce its potential to act as a catalyst for international implementation of TEDs. Specifically, the State Department regulations limit coverage to only 14 nations in the wider Caribbean/western Atlantic region and only to that part of their fleets which operate in the Caribbean Sea and Atlantic Ocean (Table 1). These 14 nations represent less than 17 percent of the 85 countries that import shrimp into the United States and represent only 9 percent of the 155 nations whose commercial fisheries may adversely affect endangered species of sea turtles. In 1987, these 14 nations represented 9.1 percent, by metric tons (m.t.), of the world wild caught shrimp harvest (Figure 2).[3]

Furthermore, in clear violation of the plain language of section 609, the Department of State regulations extend by three additional years the May 1, 1991 deadline for compliance by the 14 Caribbean nations.

ENVIRONMENTALISTS EXERT PRESSURE

The Sea Turtle Restoration Project began discussions with the Department of State immediately after receiving the January 10, 1991 regulations. We made known our intention to sue the Department of State in federal district court unless:

1. immediate action was taken to revise regulations to include all nations who import shrimp into the United States whose fisheries adversely affect endangered sea turtles;

2. the U.S. government insisted on full compliance at the earliest possible date; and

3. the Department of State immediately initiated negotiations for multi-lateral treaties insuring worldwide use of TEDs.

Under pressure, the Department of State encouraged Mexico to include its Pacific coast fleet in its TED requirements, and agreed to encourage eight additional Asian nations (Table 2) to consider the use of TEDs (David A. Colson, Deputy Assistant Secretary for Oceans and Fisheries Affairs, Department of State, pers. comm.).[4] Unfortunately, the present recommendations are not binding for these eight nations and lack any enforcement mechanism. The Department of State has refused to revise its regulations to reflect the true scope of the law which mandates comparable reduction in sea turtle mortality by the shrimp fishing industry in more than 80 countries. To our knowledge the Department of State has not initiated any discussions to cultivate international treaties that require or even encourage use of TEDs.

SEA TURTLE RESTORATION PROJECT FILES SUIT

On 24 February, 1992, Sea Turtle Restoration Project's pro bono legal staff[5] filed suit over the Department of State's failure to comply with PL 101-162, section 609. Ultimately, the aim of our suit is the worldwide utilization of TEDs by all shrimp trawling vessels fishing in waters shared with sea turtles. We view immediate embargoes of shrimp from importing nations as a remedy of last resort; however, we do expect significant movement towards full TED implementation on the part of those nations who wish to continue to import shrimp into the U.S. We will use the lawsuit to leverage additional expenditures of U.S. funds to help nations implement TEDs compliance.

In addition, our legal staff is in the process of drafting international TEDs treaties and resolutions for introduction to appropriate international bodies such as the United Nations. We hope to compel the U.S. government through our lawsuit to introduce a U.N. resolution for the international implementation of TEDs.

Furthermore, we have filed a notice of intent to sue if U.S. TEDs regulations are not modified to include the recommendations of the 1990 National Academy of Sciences report which recommended "the use of TEDs in bottom trawls at most places and most times of the year from Cape Hatteras to the Texas-Mexico border."[6] A 1992 recent report by National Marine Fisheries Service estimated that a minimum of 4,360 sea turtles continue to die in shrimp nets under present regulations (in addition, they note that "based upon a recent analysis by the National Academy of Sciences, these estimates may underestimate true mortality by a factor of four").[7]

CONCLUSION

Implementation of PL 101-162 (sect. 609) is one tool for working toward the ultimate goal of TEDs on all shrimp fishing vessels of the world that share habitat with endangered sea turtles. Unfortunately, the U.S. Department of State is unlikely to vigorously enforce this new law without citizen pressure. The Sea Turtle Restoration Project believes that the lawsuit, by forcing the United States' government to assume a leadership role in developing international sea turtle protection measures, will be one valuable element in protection of sea turtles from incidental catch in international fisheries. Another objective of the lawsuit is to encourage the expenditure of additional U.S. funds to help nations implement TEDs compliance. Furthermore, we are exploring other avenues of implementing international sea turtle protection measures, including international treaties.

WHAT YOU CAN DO

The following individuals are available to receive opinions on PL-101-162: Mr. Curtis Bohlen, Assistant Secretary, Bureau of Oceans and International Environmental and Scientific Affairs, Department of State, Washington, D.C., 20520 and William W. Fox, Jr., Assistant Administrator for Fisheries, United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 1335 East-West Highway, Silver Spring, MD 20910.

CITATIONS

1. Report of the Secretary of State to the U.S. Congress on the Status of efforts for the conservation and protection of sea turtles pursuant to Section 609 of P.L. 101-162, "The Departments of Commerce, Justice, and State, the Judiciary and related agencies Appropriations Act, 1990" (November 1990).

2. Federal Register, Vol. 56, No. 7, Thursday, January 10, 1991: 1051-1052.

3. Fox, William F. Jr., NOAA Assistant Administrator for Fisheries, February 8, 1990, Implementation of Section 609, Public Law 101-162, Concerning Sea Turtle Conservation-- Information memorandum (for John A. Knauss, Under Secretary for Oceans and Atmosphere).

4. Ibid.

5. The law firm of Heller, Ehrman, White & McAuliffe, San Francisco, CA is providing all legal services at no charge. The lead attorneys are Deborah Sivas, Elisabeth Gunther and Joshua Floum.

6. National Academy of Sciences, National Research Council (U.S.) Committee on Sea Turtle Conservation, 1990, Decline of the Sea Turtles: Causes and Prevention, National Academy Press, Washington, D.C., 189 pp.

7. Henwood, T., W. Stuntz and N. Thompson, (in press), Evaluation of U.S. turtle protective measures of shrimp trawler related turtle mortality in the greater Caribbean, U.S. Dept. Commerce, National Marine Fisheries Service Technical Memorandum.

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We thank Deborah Sivas, Elisabeth Gunther, Joshua Floum and the law firm of Heller, Ehrman, White & McAuliffe, San Francisco, CA for providing all legal services at no charge; Dean Woerner of Golden Gate University School of Law for additional consultation; the National Marine Fisheries Service for quickly answering our Freedom of Information Act request; Sean Hastings, and anonymous persons who provided us with additional materials.

ANNULI ON CARAPACIAL SCUTES OF HAWKSBILL TURTLES (*ERETMOCHELYS IMBRICATA*) AT HERON ISLAND REEF

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INTRODUCTION

Accurate age determination of individuals is necessary to precisely determine age at maturity, longevity, mortality and other demographic parameters. Although skeletochronology is useful in determining the age of animals post mortem, no aging technique has been successfully applied to living sea turtles. Layers of arrested growth or annuli are often visible on the carapacial or plastral scutes of many freshwater turtles and provide a useful aging technique for live animals. However, the annuli which feature prominently on carapacial scutes of turtles and tortoises are generally absent or overlooked on sea turtles. Only the hawksbill (*Eretmochelys imbricata*) has sufficiently thickened scutes to possess distinct and readable annuli.

In the absence of other reliable aging techniques for living sea turtles, we are investigating the utility of the annuli counting technique as an aging tool. Because hawksbills scour the upper carapacial scutes during their residence at the reef, the posterior most scutes were selected because of their freedom from excessive abrasion. These posterior suprapygal scutes exhibit the most well defined build up of keratin responsible for annuli formation.

MATERIALS AND METHODS

Hawksbills were sampled from 1982-1991 at Heron Island Reef on the Great Barrier Reef by the turtle rodeo capture method. Turtles were flipper tagged using monel or titanium tags for re-identification. Annuli were marked using a drill and bit to notch the growing edge of the suprapygal scute after the overlying fifth vertebral scute was broken back to the growing edge beneath. Scutes were photographically recorded at each capture using macro lens photography and visually analyzed using slide projectors and a markable wyteboard. The enlarged image was projected onto the wyteboard so that the annuli could be clearly outlined and counted. The following data were recorded: number of annuli present and clearly visible at the time of initial capture or drill marking, number of annuli accumulated in the intervals between successive drill markings, and the number of clearly visible annuli at each successive recapture since each drill mark was applied.

We present examples from two animals to illustrate the technique and offer suggestions for refining its utility.

RESULTS

As this study is ongoing, we continue to gather information on previously marked turtles. Of the 35 turtles examined to date across multiple marking occasions, annuli could clearly be seen between successive markings. Preliminary analyses suggest that one annulus is deposited per year, although this cannot be stated categorically at present. Annuli seem to be most distinct in younger animals. The annuli were obscured or smoothed off near the older segments of the scute. However, the actively growing proximal portion always had well defined annuli that were easily read. Annulus width was also related to curved carapace length. This will limit the method in aging of older animals

The following figures refer to photographs used in poster presentation.

Figure 1. Turtle T16576, photographs of suprapygal scute of juvenile hawksbill turtle (*Eretmochelys imbricata*) captured at Heron Island Reef, Great Barrier Reef. Drill notches and year of marking are indicated and annuli are outlined. CCL is measurement at time of capture.

Figure 2. Turtle X13596, photographs of suprapygal scute of juvenile hawksbill turtle (*Eretmochelys imbricata*) captured at Heron Island Reef, Great Barrier Reef. Drill notches and year of marking are indicated and annuli are outlined. CCL is measurement at time of capture.

DISCUSSION

We are currently investigating the margins of error associated with discerning these annuli. In particular, we will assess potential errors attributable to the following causes.

1. Marking error: The overlying scute may not have been broken back to the absolute growing edge. In this case, drill marking would be distal to the newest (but concealed) growing interval which would be recorded only upon later recapture. This results in an additional annulus being counted at a later capture.

2. Healing or overlap: Drill marks may overlap or intersect an annuli providing a discrepancy in accurate determination. The broken back scute may cause growing sections adjacent to the drill mark to be keratinized in an aberrant fashion.

3. Photographic conditions: By comparing slides, we noted that some scutes could be more easily read when photographed dry, others when wet, and the lighting angle was critical for some annuli to be best discerned. Sufficient forethought and experimentation will yield the optimal distance and angle to record the annuli photographically, but generally the scute should fill the frame in order to provide a reasonable opportunity to examine an enlarged image later.

4. Reader error: Older animals that exhibit narrower intervals between annuli, are more difficult to count accurately. Scutes must also be closely scrutinized for the presence of secondary annuli. In all cases, annuli counts should be made by a consensus of at least two readers to check one anothers' accuracy. Although we wish to investigate the accuracy of the technique further, we believe that the technique has great potential.

Future extensions of the technique should include the quantification of erosion rates to determine if annuli do fade with time, derivation of age to size relationships from annuli counts, minimum ages for animals with eroded or unreadable annuli, growth rate estimates, and projections of age or size at maturity.

We encourage other researchers with access to juvenile hawksbills, particularly smaller size classes, to assess this method of scute marking. If the annuli counting methodology proves to be accurate and consistent across wider geographic areas, we will have successfully reapplied an old technique to gather new data for the species.

LIFE HISTORY VARIATION IN MARINE TURTLES.

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We studied correlations among reproductive traits of marine turtles. Our analyses focused on patterns of phenotypic covariation among species and among populations within species. We assembled morphometric and reproductive data from a total of 86 populations of eight species.

Analyses at the species level supported previous conclusions about the characteristic differences between marine turtles. Correlations among species showed that body size correlated positively with seveal reproductive traits, including egg size and overall reprodcuctive effort. A trade-off between clutch and egg size was confirmed for marine turtles, after factoring out the effects of body size. We also found that relatively high reproductive effort was found in species which experience low egg survival, perhaps to compensate for high mortality on the beach.

Phenotypic correlations among populations within species were strikingly different from those among species. For example, in six out of seven species there was a positive relationship between body size and cluthch size, although this correlation was not found at the interspecific level. Variation in reproductive allocation patterns within and between species also differed. Species with high reproductive effort produced many clutches per year and returned to nest after few yuears, whereas populations within species achieved high reproductive effort by producing large clutches and large eggs. We also found that the covariance structure of life history traits differed significantly among the species.

In general, patterns of life history covariation reflect clear constraints imposed by bodey size in addition to ecological conditions. To the extent that phenotypic correlations reflect underlying genetic constraints, our findings highlight important evolutionary differences between marine turtle species. We believe our approach may prove useful for extending demographic models developed for loggerhead turtles to less well-known species. even though many of the model parameters have not been estimated for other species.

THE NESTING BIOLOGY OF HAWKSBILL (*ERETMOCHELYS IMBRICATA*) AND GREEN (*CHELONIA MYDAS*) SEA TURTLES IN EL CUYO, YUCATAN; MEXICO

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Elvia Rodríguez
PRONATURA Península de Yucatán

INTRODUCTION

Since 1976, El Cuyo has had an active conservation program to protect nesting females, nests, and hatchlings of hawksbill (*Eretmochelys imbricata*) and green (*Chelonia mydas*) sea turtles. Theses programs were first initiated by Mexico's Regional Fisheries Research Center (CRIP). The Secretary of Urban Development and Ecology (SEDUE) thereafter took over the responsibility of patrolling the beaches of El Cuyo. Unfortunately due to limits in funds and personnel, the entire known nesting habitat could not be covered completely or be patrolled intensively.

In 1991, more complete funding made it possible to extend the study area and increase the number of patrols. In addition it also made it possible to gather more data on adult, juvenile and hatchling morphometrics. Tagging efforts, hatch success analysis, and predator monitoring also increased. Perhaps more important, a program of environmental education was started with children, fishermen, students, military personnel, boy scouts, and tourists. For the full results see Rodriguez and Zambrano (1991).

STUDY AREA

El Cuyo (21°31'N, 87°41'W) is located inside the Wildlife Reserve of Ria Lagartos. The reserve is situated in the northeast corner of the state of Yucatan, Mexico (Map 1).

In 1986, the federal government declared this zone as a special reserve for the conservation and nesting of sea turtles. The reserve is also considered a very important feeding and resting area for migratory birds. Various endemic plant species are also located here some like the palms chiit (*Coccotrinax readi*) and the kuká (*Pseudophoenix sargentii*) are in danger of extinction.

METHODS

In April, night patrols were begun on a weekly basis to determine the start of the nesting season. Once the season was fully underway, nightly patrols were begun. The patrols consisted of two permanent biologists using a four-wheel drive vehicle. Military personnel helped guard nests with day and night foot patrols. The patrols consisted of 12 km to the east of El Cuyo and 14.4 km to the west of it. Due to personnel and fuel limitations, only one patrol was done per side; however, upon reaching the limits of these patrols, time was given to allow more turtles to emerge from the ocean, before the return trip.

The majority of the nests encountered were left *in situ*. Whenever it was thought necessary, the nests were transplanted to a hatchery located in front of the military's post. The personnel in this post accepted the responsibility of watching over this hatchery 24 hrs. a day. Nests were transplanted if they were located too close to the town, in a high predation area or if located too close to the high tide mark. Certain nests were simply relocated to a more appropriate site on the beach if the dangers to it were not as great.

If a nesting female was encountered during the patrol, over-the-carapace measurements were taken with a flexible measuring tape. The turtle was also checked for any tags or tag scars. If no tags were present, a steel monel tag was applied in the right fore flipper. The beach location of the nest was recorded as well as its location with respect to the high tide mark, the sand dunes, and the vegetation.

Both *in situ* and transplanted nests were checked nightly after completing 58 days of incubation. If an *in situ* nest was encountered with the hatchlings out of the shells but still in the nest, they were excavated and counted. A sample of ten hatchlings were measured with calipers for straight-line carapace length and width. All the hatchlings were subsequently released from the beach. Neonates in the hatchery were allowed to emerge on their own, whereas the military personnel would immediately notify us. If the hatchlings had already left by the time of inspection in *in situ* nests, an estimate of the number was made by counting the empty eggshells. If a nest was discovered to have been preyed upon, its location and if possible the type of predator were also recorded. With the aid of local lobster divers, a pilot program of capturing juvenile hawksbills was also started. These juveniles were subsequently measured, tagged and released.

RESULTS

TEMPORAL DISTRIBUTION

In this study the hawksbill nesting season in the beaches surrounding El Cuyo was from the 6th of April (week 1) till the 6th of October (week 28). The peak was the 10th till the 16th of June (week 11). The green turtle nesting season began the 12th of June and lasted till the 6th of October. The peak took place from 29th of July till the 4th of August (week 18) (Fig. 1). For the hawksbill a total of 196 nests were registered and for the green, 34. The fate of these nests for both species is shown in Table 1.

Table 1. Number of nests recorded during the 1991 nesting season in El Cuyo, Yucatan.

CATEGORY	HAWKSBILL	GREEN
in situ	103	15
Relocated	8	0
Transplanted	12	4
transplanted*	11	0
Predated	35	3
Lost	18	7
Inundated by sea	3	2
Unchecked	8	3

* nests located by military personnel.

Relocated nests are nests moved to more appropriate sites (e.g. nests too close to the high tide mark were moved farther inland). Transplanted nests as mentioned above were nests moved to the hatchery. Nests transplanted by military personnel were counted separately due to differences in transplanting techniques from those of the authors. Depredated nests are all nests lost to natural predators, feral predators, and humans. Nests were considered "lost" if the markers used to locate them could no longer be found. Nests swept away or damaged by high tides were categorized as inundated by the sea. The "unchecked" category refers to nests which were registered but were never excavated for an analysis of hatch success.

SPATIAL DISTRIBUTION

To the east of the town there were no records of any green turtle nests or false crawls. Hawksbill turtles however were quite abundant to the east, and some frequently tended to nest in front of beach houses. Green turtles only nested to the west side of El Cuyo but at a distance of 5 km or farther. This was thought to be due to poor nesting habitat, the effect of erosion of the beach from an artificial jetty nearby. The high traffic of boats near this port was also believed to be a factor. Further evidence is that no hawksbill crawls took place within the first three kilometers from this port. Both the green and the hawksbill had a preference for nesting next to the sand dune vegetation or in it.

NESTING FREQUENCY

Through evidence from tagged turtles this season, it was found that the mean number of nests per hawksbill female was 1.78 SD=0.78 (n=28). Considering that the number of patrols were limited due to fuel limitations, the authors consider this number to be unrepresentative of the actual nests per female. Green turtles were too few for a good estimation, but the range was from 1-4.

The mean interval between successive nests per female was 16.6 days (SD=2.46, n=15) for the hawksbill and 13 days (SD=1.63, n=7) for the green turtle.

CLUTCH SIZE

The mean clutch size for hawksbills was determined to be 158 eggs (SD= 27.36, n=120, range 91-214) per nest. For the green turtle, the mean clutch size was 113 eggs (SD= 32.21, n=19, range 36-169).

INCUBATION PERIOD

The hawksbill mean incubation period for nests *in situ* was 63 days (SD= 2.83, n=78, range 58-71). Hatchery nests had a mean incubation period of 64 days (SD= 2.48, n=12, range 58-67). Relocated eggs had the same mean incubation period as *in situ* nests (Fig 2). The green turtle mean incubation period for nests *in situ* was 59 days (SD= 3.18, n=10, range 53-66). There were only two transplanted nests that hatched, one of 60 days and one of 64 days. The incubation periods for both species include the time till emergence.

EMERGENCE SUCCESS

The percentage of young which made it out of the nest, whether it was on their own or with human help, is shown in Table 2. The figure for *in situ* emergence success does not include depredated or damaged nests.

Table 2. Emergence success for the hawksbill and green turtle in El Cuyo, Yucatan; 1991.

	Hawksbill (%)	Green (%)
in situ	**82.77**	**86.51**
relocated	**82.22**	--
transplanted	**89.22**	**86.22**
transplanted*	**34.68**	--

* Nests transplanted by military personnel.

NEST PREDATION

A total of 38 nests were depredated in the study area. Three were green turtle and the rest were hawksbill. Feral dogs and foxes were responsible for the majority of depredation, 13 nests and 16 nests respectively. Only three nests were lost to humans before patrols started; none afterwards. The predator was unknown for six other nests. If these nests are included in the emergence success, the percentage drops to 62.48% for hawksbills and 70.81% for green turtles. Since the majority of nest predation was taking place on the beaches west of El Cuyo, it was decided late in the season to transplant all nests in this area to the hatchery.

MORPHOMETRY AND TAGGING

A total of 53 hawksbill turtles were measured this season. Out of those, 42 were tagged in El Cuyo; the rest were tagged in an adjacent town but renested in our study area. Two exceptions were turtles which had been marked in 1988 in El Cuyo. Ten green turtles were measured but only four were tagged, again for the reason given above. All tags on the turtles bear the label PREMIO-PESCA; CRIP-MANZANILLO; 28200, MEXICO. Only over-the-curve (OC) carapace measurements were taken for nesting green and hawksbill turtles (Table 3). For the hawksbill, three measurements were taken, two for carapace length (OCCL and OCCLm), and the third for carapace width (OCCW). Green turtles were only measured for OCCL and OCCW. Hatchling straight-line carapace length (SLCL) and width (SLCW) are given in Table 4. Morphometrics for captured juveniles are not given due to the low sample size. Measurements are explained in greater detail in Bjorndal and Bolten (1989).

Table 3. Over-the-curve measurements (cm) for nesting female green and hawksbill turtles in El Cuyo, Yucatan; 1991. See text for abbreviations.

	HAWKSBILL			GREEN		
	Mean	SD	n	Mean	SD	n
OCCL	96	3.69	51	108	5.39	10
OCCLm	93	4.10	53	--	--	--
OCCW	86	4.62	53	95	5.13	10

Table 4. Straight-line measurements (cm) for hatchling green and hawksbill turtles in El Cuyo, Yucatan, 1991. See text for abbreviations.

	HAWKSBILL			GREEN		
	Mean	SD	n	Mean	SD	n
SLCL	4.30	0.27	385	5.14	0.13	60
SLCW	3.18	0.18	385	3.95	0.14	60

ENVIRONMENTAL EDUCATION

In order to increase conservation awareness of sea turtles, short, informal talks were frequently given to the town children, local fishermen and the occasional tourists. If interested they were also invited to ride along and observe the sea turtle nesting process. The release of hatchlings was of particular interest with the smaller inhabitants. A small play with a conservation theme was also organized with the children. A program was also installed whereby university students and boy scouts could actively participate in this research and conservation program. Talks were also given to the military personnel who patrolled the beaches.

CONCLUSIONS

The sea turtle program in El Cuyo during the 1991 nesting season was by no means considered complete. There is still 5 to 10 km of beach in which nests have been found, but which could not be patrolled on a regular basis, again because of fuel limitations. More patrols per night are also needed to gather more data on renesting intervals, nest site fidelity, morphometrics, and population dynamics. Last but not least, a more intensive environmental education program is in dire need.

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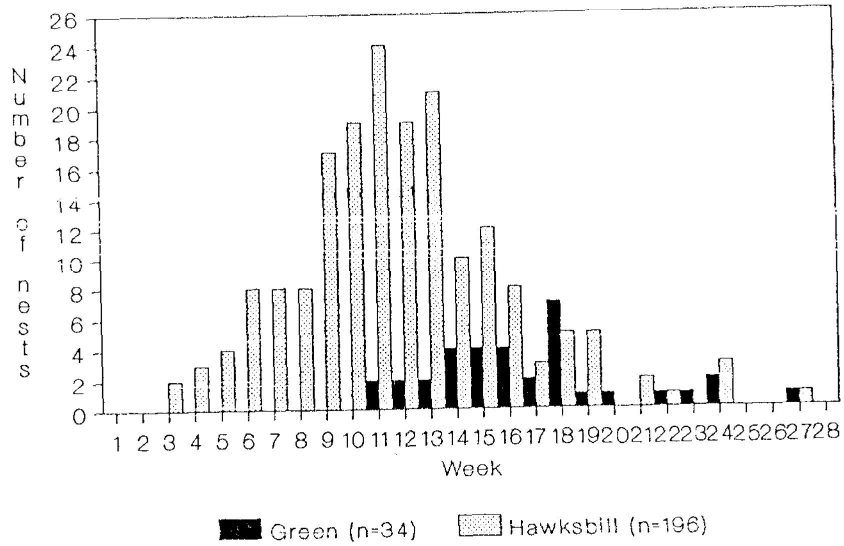

Fig.1. Temporal distribution for hawksbill and green turtles in El Cuyo, Yucatan; 1991.

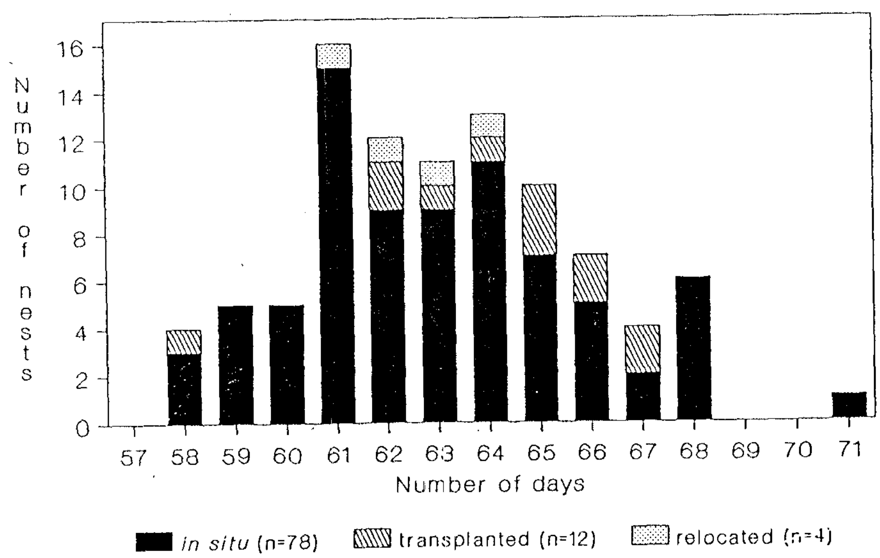

Fig. 2. Incubation period for hawkwksbill nests in El Cuyo, Yucatan; 1991.

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