NOAA Technical Memorandum NMFS-SEFC-278

# PROCEEDINGS OF THE TENTH ANNUAL WORKSHOP ON SEA TURTLE BIOLOGY AND CONSERVATION

February 20-24, 1990
Hilton Head Island, South Carolina

Compilers:
Thelma H. Richardson
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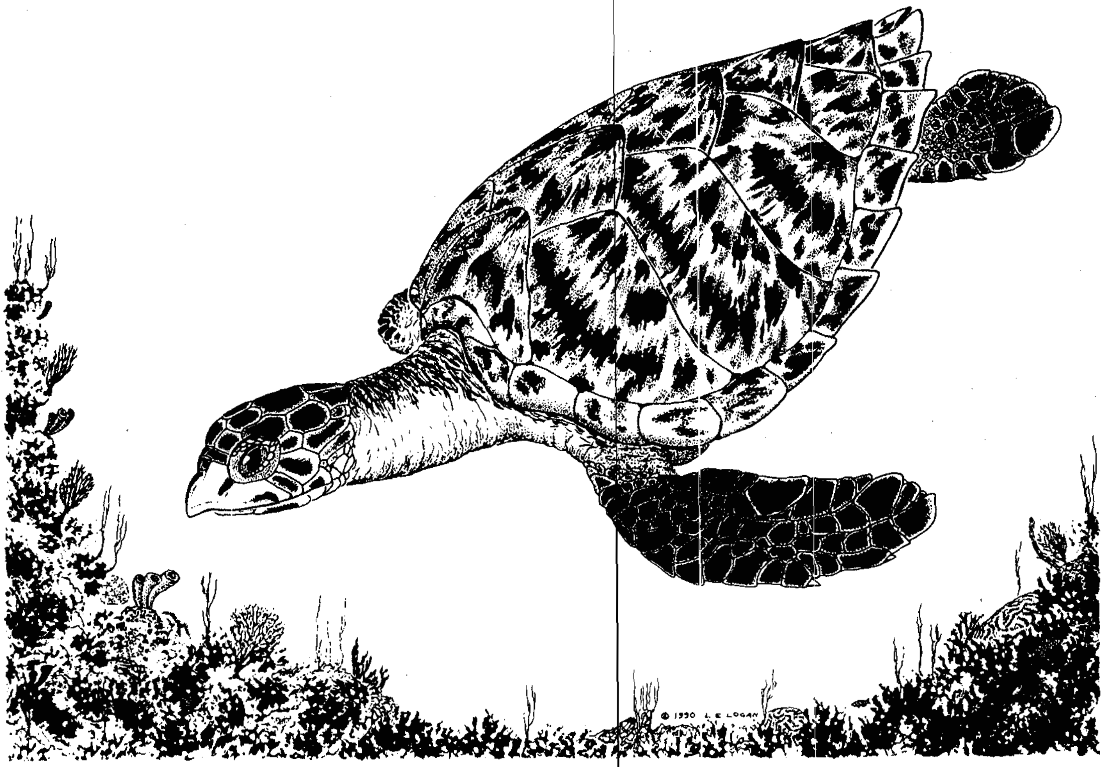
August 1990



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

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U.S. DEPARTMENT OF COMMERCE
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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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NATIONAL MARINE FISHERIES SERVICE
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## NOTICE

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# PREFACE

August 1990

The Tenth Annual Workshop on Sea Turtle Biology and Conservation was held 20-24 February 1990 at Hilton Head, South Carolina. The Workshop was hosted and organized by the Nongame and Heritage Trust Section, South Carolina Wildlife and Marine Resources Department, and the Museum of Hilton Head, Project Turtle Watch. More than 446 participants from 18 countries attended the Workshop, making it the largest to date. Eighty-one papers and 45 poster sessions were presented this year on sea turtle research, conservation, and management.

The Annual Sea Turtle Workshop serves various functions, from allowing researchers to share their unpublished research and theories in a critical yet friendly environment to building camaraderie among scientists, students and conservationists. Since the first workshop in 1980, these annual meetings have grown dramatically from a small group of researchers in the Southeast to an international meeting of hundreds of participants. It is most fitting that this year's organizers chose the theme... "a decade of knowledge, dedication and friendship" to mark the Workshop's tenth anniversary.

Sixty papers and 23 poster sessions have been compiled in these Proceedings as extended abstracts. The extended abstract format was chosen to allow authors to disseminate more complete information than simple abstracts, while providing the opportunity for authors to submit full-length papers to a peer-reviewed journal at a later time. This format involves no editorial control. The content of these extended abstracts does not necessarily reflect the views of the compilers, the Nongame and Heritage Trust Section of the South Carolina Wildlife and Marine Resources Department, the Museum of Hilton Head, or the National Marine Fisheries Service.

In the past, the extended abstract format was deemed appropriate to allow authors to later publish their papers in peer-reviewed journals. However, a recent controversy over the status of this publication, which is not peer-reviewed, has resulted in some papers not being included in these Proceedings to avoid potential conflict with publication in the future. After careful review of the situation, the editors of several prominent technical journals (Copeia, Herpetologica, Journal of Herpetology) have concluded that the annual Proceedings of the Sea Turtle Workshop **does** represent a significant publication in the field of scientific herpetology. This "vote of confidence" in the quality, professionalism and extended distribution of the Proceedings is a two-edged sword. On the one hand, we are justly proud of the reputation awarded our publication. On the other hand, the sharing of timely data by some authors will henceforth be limited by competition from certain of the technical journals. Authors wishing to publish their work in these other journals should limit the amount of original data, graphs, and figures contained in their extended abstracts. Reviews, methods, general results, and discussions are not usually deemed competitive by other journals, but authors are strongly encouraged to check with the appropriate editors if there is some question with procedure. It is now abundantly evident that the Proceedings will continue to grow in importance as a major contribution to the sea turtle profession.

Many individuals worked very hard to make the Tenth Workshop the resounding success that it was. Chief among these are the Workshop Planning Committee: John Coker, Ed Drane, Joan Logothetis, Sally Murphy, Jim Richardson, and Thelma Richardson. Special thanks are do to the Edisto Beach Volunteers, Fripp Island Volunteers, Kiawah Island Volunteers, Sandy Green, Lloyd Logan, National Wildlife Federation, Charles Maley, Earl Possardt, Project Turtle Watch staff and volunteers, Savannah National Wildlife Refuge, South Carolina Wildlife and Marine Resources Department, Institute of Ecology at the University of Georgia, the Nature Conservancy, and Waddell Mariculture Center.

We also owe a debt of gratitude to Rod Mast for his extraordinary job as the Workshop auctioneer; to Lloyd Logan who designed the beautiful artwork for the Proceedings cover and for the Workshop's t-shirt; to Jim DeRevere of DeRevere Travel in Athens, Georgia, for excellent travel arrangements; and to the Hilton Head Beach and Tennis Club for the comfortable accommodations and facilities.

The publication of these Proceedings was funded by the National Marine Fisheries Service, Southeast Fisheries Center, Miami Laboratory. A special thanks is due Dr. Nancy Thompson for printing and distributing the Proceedings.

# PART I: PAPER PRESENTATIONS

# FACTORS AFFECTING LOGGERHEAD SEA TURTLE (CARETTA CARETTA) PRODUCTION ON WABASSO BEACH, FLORIDA

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## INTRODUCTION

In an effort to identify and possibly preserve a portion of critical loggerhead sea turtle (Caretta caretta) nesting habitat, the U.S. Fish and Wildlife Service funded this study to evaluate sea turtle productivity and factors affecting productivity on Wabasso Beach in east-central Florida.

### Study Area

The study area encompasses 8 kilometers of shoreline habitat between Wabasso Beach Park and Sebastian Inlet State Recreation Area in east-central Florida. Portions of the area are secluded, while other sections have houses built up to the beach dunes.

### Study Period

The study was conducted during mid-May through October 1988 and 1989.

### Study Method

During the 1988 and 1989 nesting seasons the study beach was divided into 16 0.5 km sections and surveyed daily at dawn to record all signs of nesting loggerhead sea turtles within each beach section. Approximately 11% of the nests were selected for intensive study, marked, and their location in relation to the beach dune, high tide and spring tide marks (vertical beach location), was noted. Night surveys were conducted two to four times a week, to locate nesting females in the process of laying eggs. The number of eggs layed per female was recorded for average clutch size calculations. Straight-line and curved (or over the top) carapace lengths and widths as well as the longest straight-line carapace length were measured on egg laying turtles. Multiple regression analysis and ANOVA were used to determine correlations between clutch size and 1) date of nest deposition, 2) female carapace size, 3) vertical location on the beach, and 4) the presence of beachside development. Nests located at night also were marked, and all study nests were inspected daily for signs of disturbance and hatching.

A logistic regression was used to test for correlations between predation and 1) vertical beach location, 2) horizontal beach location (the study section in which the nest was layed), 3) clutch size, and 4) date of nest deposition. After signs of hatching, or at least 70 days of incubation time, study nests were excavated and inspected. Remaining eggs and egg shells were inventoried for use in emergence success calculations. If hatching occurred, incubation times were noted for use in determining the average incubation time on the study area. Nonparametric multiple regression analysis was used to determine the presence of any correlations between incubation time and 1) date of nest deposition, 2) clutch size, 3) vertical location on the beach, and 4) surf washovers. The exact number of eggs layed in night-marked nests was known and for these emergence success was calculated directly. In cases where the number of eggs layed was not known, the figure was estimated by piecing together the hatched egg shells. A correction factor was applied to the latter using the mean percent difference in known number of eggs/nest from night nests and the number of eggs/nest estimated for night nests by piecing shells together. In addition to calculating emergence success, nonparametric multiple regression analysis was used to find any correlations between emergence success and 1) date of nesting, 2) clutch size, 3) vertical location on the beach, 4) horizontal nest position, and 5) surf washovers.

## RESULTS

During the 1988 nesting season, 1197 loggerhead sea turtles nested on the study area (149.6 nests/km); 1256 loggerheads nested on the study area during 1989 (157 nests/km). Mean clutch size ('x' = 112 eggs/nest; N = 389) during 1988 and 1989 did not differ between years ($p<0.05$). Within each nesting season clutch sizes did not vary with date of deposition ($p<0.05$). Clutch size and straight-line carapace length were positively correlated ($R^2 = 0.27$). We also calculated two additional measures of overall carapace size. Both use a combination of carapace straight-line length (CL), straight-line width (CW), curved length (CCL), and curved width (CCW).

$$\text{Equation 1: } ((CL+CCL)/2)*((CW+CCW)/2)$$

$$\text{Equation 2: } ((CL*CCL)/2)*((CW*CCW)/2)$$

Both equations produce a significant p-value, and a slightly greater $R^2$ value ($p = 0.0001$; $R^2 = 0.33$). The mean incubation time over the two years was 53 days; mean incubation time during 1988 was 53.9 days, while mean incubation time during 1989 was 51.5 days ($Z = -7.65$; $p>0.0001$). In both years incubation time was negatively correlated with the date of clutch deposition. The mean emergence rate was 57% during 1988, and 44% in 1989 ($Z= -1.92$; $p>0.05$). In 1989 the mean emergence rate of nests hatching before September 6 (the beginning date of the first of two hurricanes) was 69% (n=117). The mean rate of emergence of nests hatching after this date was 15% (n=105). The mean emergence rates for these two periods during 1988 were 52% (n=193) and 72% (n=58) respectively. In 1988 emergence rates were significantly correlated only with horizontal beach location. In 1989 emergence success was negatively correlated with the date of deposition and with the number of times the nest was washed over by the surf.

Forty-one of 269 (15%) and 19 of 226 (8%) study nests were preyed upon by raccoons during 1988 and 1989, respectively, (Chisq = 7.24; $p=0.007$). During 1988 and 1989 raccoon predation was positively correlated with the presence of human beachside development. In 1989 predation rates also were negatively correlated with distance of the nest from the dune.

## DISCUSSION

The mean clutch size of 112 eggs/nest is consistent with mean clutch sizes reported for other studies conducted in this area (116 eggs at Melbourne Beach, Florida, Ehrhart and Witherington, 1987; 110 eggs at Cape Canaveral, Florida, Ehrhart, 1980).

In addition, the inconsistent pattern we observed between years in monthly clutch size is consistent with findings reported in the literature (Caldwell, 1959; Lebuff and Beatty, 1971; Kaufmann, 1975; Davis and Whiting, 1977; Frazer and Richardson, 1985; Ehrhart and Witherington, 1987). Correlation between clutch size and straight-line carapace length is not unusual. However, there are conflicting findings reported in the literature (Ehrhart, 1979; Ehrhart, 1980; Hirth, 1980; Ehrhart and Witherington, 1987). This relationship, however, has been reported more extensively in the green turtle (Carr and Hirth, 1962; Pritchard, 1969; Hirth, 1971; Ehrhart and Witherington, 1987), reinforcing the notion of the possibility of a similar relationship in loggerhead turtles. The increase in $R^2$ values with the two equations used to estimate overall carapace size suggests the possibility of the development of more indepth equations that may more accurately represent the relationship between carapace size and clutch size.

The mean incubation time of 53 days for the two study years also is consistent with other findings in this area (Ehrhart and Witherington, 1987). Since incubation is negatively correlated with incubation temperature (Bustard and Greenham, 1968; Harless and Morlock, 1979) it is not surprising that incubation time also was negatively correlated with the date of laying.

The emergence rates of 57% and 44% fall within the range reported in other studies (Stancyk et al., 1980, 67%; Ehrhart and Witherington, 1987, 56%; Hirth and Ogren, 1987, 42%; Wyneken et al., 1988, 87%). It seems obvious from the differing emergence rates of before and after the onset of the late season hurricanes of 1989, that these storms greatly reduced the emergence success for that year. The negative correlations of emergence rates in 1989 with date and washovers can both be attributed to the late hurricanes of that year. If nests layed after July 12 (53 days before the onset of the hurricanes) are eliminated from this analysis, these correlations are no longer found.

The predation rates of 15% and 8% for the two study years are low compared to the predation rates found in other studies (Davis and Whiting, 1977; Hopkins et al., 1978; Stancyk et al., 1980; Talbert et al., 1980). The low levels of predation found in this study may be related to the presence of highway A1A which runs along the entire study area. A high number of raccoons are killed by motor vehicles along this road, thus supplying a passive form of raccoon reduction (Ehrhart and Witherington,1987). Ehrhart and Raymond (1983) and Ehrhart and Witherington (1987) conducted studies under similar circumstances (along the same highway) and found similarly low predation rates. The positive correlation between human beachside development and raccoon predation is not surprising. High raccoon populations have been found in association with humans which often supply the raccoons with good sources of food and shelter (Kaufmann, 1982).

The difference between predation rates of the two study years offers some interesting possibilities. After the 1988 study year, there was some concern that researchers were repeatedly recording the presence of the same crab holes on or near a nest day after day, thus artificially inflating the figures for crab activity. As a result, in 1989 all crab holes were wiped-out from each nest daily to prevent multiple counting of the same crab holes. Given the significantly lower rates of raccoon predation found in 1989, the possibility that raccoons were using crab holes to locate clutches is suggested. Ehrhart and Witherington (1987) suggest that raccoons key in on olfactory ques which waft up through the sand after crab disturbance.

That 1989 predation rates were negatively related to the distance of the nest from the dune's edge suggests the presence of an "edge-effect." In an "edge-effect," the predators search for prey closer to the safety of cover, in this case the dune (Robinson and Bolen, 1984). Thus nests deposited closer to the dune should be subjected to greater predation pressure.

From these data it is evident that Wabasso Beach is an important loggerhead sea turtle nesting habitat. The combination of high nesting densities, moderate emergence success, and low predation rates combine with the relatively undisturbed and undeveloped nature of the area to provide an important source of loggerhead recruitment which requires little management. This is a luxury supplied by few areas, and it offers a management opportunity that should not be wasted.

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# RESULTS OF MARINE TURTLE NESTING BEACH PRODUCTIVITY STUDIES CONDUCTED IN CENTRAL AND SOUTH BREVARD COUNTY, FLORIDA, IN 1989

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The University of Central Florida's Marine Turtle Research Group established a study area in the lower end of Brevard County, Florida, in 1982. Termed the South Brevard Study Area (SBSA), it extends from just below the town of Melbourne Beach, southward for 21 kilometers to the northern boundary of the Sebastian Inlet State Recreation area. We have conducted systematic, season-long nesting surveys in that study area during each of the last eight years. Reproductive success studies were begun in 1985 to assess clutch mortality and fates of nests deposited within the study area.

In 1989 we became a part of the Index Nesting Beach Program conceived by the Florida Department of Natural Resources and the U.S. Fish and Wildlife Service. As part of this program, we expanded our survey effort to include an additional 19.5 kilometers of beach. Termed the Central Brevard Study Area (CBSA), it extends from the northern boundary of the South Brevard Study Area to the southern boundary of Patrick Air Force Base.

The beaches along the SBSA are fronted by single family homes, condominiums, small motels, and expanses of undeveloped property. Unfortunately, the amount of undeveloped property has steadily decreased with each passing year. Unlike the SBSA, much of beach in the CBSA is fronted by hotels and condominiums, especially along the northern portion. There are relatively few undeveloped areas.

## Nesting Survey

During the 1989 nesting season, both study areas were surveyed seven days per week from 15 May to 6 September. The study areas were divided into half kilometer sections, and counts of both nesting and non-nesting emergences were logged for each section. The greatest proportion of nesting occurred in the SBSA where 9,381 loggerhead nests were observed during the three and a half month survey period, or an average of 447 nests per kilometer. This was just above the average of 9,253 nests per season recorded during the previous seven years. In the CBSA 3,719 loggerhead nests were observed, or 191 nests per kilometer. An overall total of 13,100 loggerhead nests were counted in both study areas.

This year we noted an unusual temporal trend in loggerhead nesting. In previous seasons, nesting frequency increased through May, sustained a high overall frequency until the last of July, then tailed off. Although nest counts may have dropped below 100 per day for two or three consecutive days in June or July, they would quickly rebound to over 100 per day. This past season there was a span of 13 consecutive days from the 8th to 20th of June when daily nest counts were well below 100. For seven of those 13 days the nest counts were less than 60. This decline in nesting coincided with an unusual drop in water temperature which dropped from 28 degrees Celsius on the 7th of June to 17 degrees on the 10th of June and remained below normal for the rest of the month. We also noted an increase in "late nesters and late returners" encountered on our early morning surveys during the cold water spell.

This was the first time we had noticed a correlation between fluctuations in water temperature and nesting in South Brevard. But it has occurred elsewhere on the east coast of Florida. Eric Martin related instances during each of the last three nesting seasons at Hutchinson Island when substantial drops in temperature and corresponding decreases in nesting occurred. Such instances also occurred on Hutchinson Island during the 1970s (Williams-Walls, et al., 1983).

One hundred seventy-four green turtle nests were observed during the survey period in the SBSA. This count was higher than the overall average of 107 nests per season recorded from 1982 through 1988. However, it was lower than the 281 nests recorded in 1985 and 206 recorded in 1987. Fifteen green turtle nests were observed in the CBSA.

We also had representatives of two other species of sea turtles utilize the SBSA. A leatherback nested on the 6th of June, the sixth recorded in this study area since 1982. A hawksbill nested on the 15th of July, the first ever recorded in South Brevard.

## Reproductive Success

Reproductive success studies were conducted to assess clutch mortality and fates of nests. We marked the locations of a representative sample of nests throughout the season. The eggs in each sample nest were counted either as they were being deposited by the female or within 6 hours of deposition. The contents of each nest were inventoried 60 days later. When inventorying nests, we recorded the number of infertile eggs, addled eggs, eggs containing partially developed embryos or fetuses, eggs containing hatchlings that died while pipping, and hatchlings that had extracted themselves from their eggshells but died while still in the nest. Using these data we determined the emerging success of the clutch, which is the percentage of yolked eggs that yielded hatchlings which escaped from the nest.

Ninety-nine loggerhead nests were inventoried in the SBSA and 42 in the CBSA. The mean emerging success rate was 52.7 percent in the SBSA. Using the mean emerging success rate (52.7% ± 6.9%) and mean clutch size (111.1 eggs ± 4.1) of the sample nests, we calculated 548,838 hatchlings emerged in the SBSA. Both means were determined using a confidence interval based on a student's t distribution (P = 0.05). In the CBSA the mean emerging success rate for the inventoried sample loggerhead nests was 48.4 percent. Using the same method of calculation (mean clutch size = 108.7 eggs ± 5.3, mean emerging success rate = 48.4% ± 10.8%, nest count = 3,719), 195,686 loggerhead hatchlings emerged from their nests in the CBSA.

Overall, approximately three quarters of a million loggerhead hatchlings emerged in the combined study areas.

Twenty-eight green turtle nests were inventoried in the SBSA and one in the CBSA. The green turtle nests inventoried in the SBSA had a mean emerging success rate of 25.2 percent. This was a tremendous decrease as compared to the average 65.6 percent emerging success rate of the previous four years. It was probably due to the depredation of nests by raccoons and the effects of two late season storms. A tropical depression passed over Brevard County in late August, and Hurricane Hugo passed offshore in September. Both these storms generated high tides and surf which resulted in the prolonged inundation of nests by salt water and accretted as much as one and a half meters of sand on top of the nests. Because the greatest proportion of green turtle clutches were deposited in late July and during August, they were more severely affected than were the loggerheads.

## Concerns

The nesting beaches in the southern region of Brevard County are experiencing the same problems as most nesting beaches in the southeastern U.S., i.e., raccoon depredation, hatchling disorientation, and the effects of development. Almost all of the depredation of nests by raccoons occurred in the SBSA, relatively little took place in the CBSA. Nineteen percent of our sample loggerhead nests and 22 percent of the sample green turtle nests in the SBSA were either partially or totally depredated by raccoons. Unfortunately, this level of depredation translates into tens of thousands of hatchlings which might have otherwise emerged from their nests.

We observed very few incidents of hatchling disorientation due to beachfront lighting in the SBSA. This demonstrates the effectiveness of the county's beachfront lighting ordinance. On the other hand, in the portions of the CBSA which are exempt from the county's ordinance, 61 incidents of hatchling disorientation were observed.

A great concern about the long-term future of this critical nesting habitat is the combined effects of beach erosion and beachfront development. Beach erosion by itself will probably not have any lasting effect on sea turtle nesting. After all, these beaches and the barrier islands they front have been shifting and migrating for the last 15,000 years. It's the continued development of this severely eroding beach that is the cause of concern. If past experiences hold true, sooner or later there will be an organized, highly emotional campaign by beachfront property owners pressuring county and state officals to allow the construction of seawalls and revetments. In light of the constantly shifting political winds in Florida, especially on the local level, the only real solution to this potential problem is the establishment of the proposed sea turtle refuge in south Brevard County and northern Indian River County.

We thank the Florida Department of Natural Resources and the U.S. Fish and Wildlife Service for the funding which enabled us to conduct our studies, Eric Martin, Earl Possardt, and Barbara Schroeder for comments and data, and Ross Wilcox along with Florida Power and Light for the water temperature data.

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# A TEST OF THE SCATTER-NESTING HYPOTHESIS AT A SEASONALLY STABLE LEATHERBACK ROOKERY

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Leatherbacks generally choose dynamic, high energy beaches to nest (Bacon, 1970). A result of choosing this nesting habitat is a high rate of nest failure due to erosion and tidal inundation. A seemingly maladaptive pattern of nest distribution was noted by Mrosovsky (1983) when he initially framed questions involving this reproductive dispersion in theoretical terms. Theory that considers reproductive allocation in a temporally or spatially stochastic environment (Geisel, 1976) was thus extended to the spatial patterns of turtle nests by the scatter-nesting hypothesis (Mrosovsky, 1983). The hypothesis predicts that organisms reproducing in stochastic environments should exhibit patterns of nest placement that are random in time and space, considering that patterns of nest destruction are also unpredictable. As expressed by Cohen (1966), "most living organisms are faced with a considerable risk of failure when attempting to reproduce. One obvious way to survive and reproduce in a risky environment is to spread the risk so that one failure will not be decisively harmful." Iteroparous organisms, including sea turtles, spread the risk of reproductive failure in time. A scatter-nesting strategy allows them to also spread the risk spatially. This form of bet hedging allows the animals to maximize reproductive success by minimizing nest loss. The hypothesis was previously tested with empirical data from an erosion-prone rookery (Eckert, 1987) and found to be consistent.

The nest-scatter hypothesis will be examined in light of Culebra data to see if this spatial nesting pattern, presumably molded by evolutionary selection pressure persists in the absence of the environmental cues that would have shaped the behavior initially. A comparison of leatherback rookeries indicates that Culebra nesting beaches are unusually stable for the duration of the nesting season. This uniquely stable nest habitat offers an opportunity to retest the hypothesis under environmentally constant conditions and compare them to the conditions experienced by the erosion-prone rookery that was geographically proximate (Culebra and St. Croix rookeries are 90 km apart). Since the sole test of the nest-scatter hypothesis has been the work of Eckert (1987), terminology will remain consistent with her format to facilitate comparisons between stochastic and stable nesting environments. To test the validity of the scatter-nesting hypothesis, these data were examined to determine if there were no differences between spatial nesting patterns for erosional vs. stable beaches, supporting the scatter-nesting hypothesis, i.e., that the nest distribution is random.

Data were collected during the 1984-1987 nesting seasons at Culebra National Wildlife Refuge. Research efforts were concentrated on the study sites of Playa Brava (1.25 km) and Playa Resaca (1.0 km), located on the northern coast. Although separated by a narrow rocky prominence, the two beaches constitute a single nesting rookery. Winter storm profiles of the beach are relatively narrow and steep due to large ocean swells approaching from the north. Culebra's beach orientation and the protruding rocky points shelter the short beaches from wind and wave activity during the nesting season, however. With the advent of nesting in March, trade winds shift southeasterly and waves diminish greatly in size and effect upon the beach profile. Northward-projecting rocky points prevent substantial sediment movement by the westerly longshore current. Nearshore sediments are deposited by the gentler wave action during spring and summer months. As a result, beach accretion though the nesting season provides an unusually stable nesting habitat. Although erosion and accretion cycles are variable throughout the season, with corresponding changes in the lower beach foreslope, the upper beach platform beyond the high tide line (10-40 m wide) is relatively stable throughout the nesting season. On-site visits by researchers familiar with erosion-prone beaches (Surinam, Costa Rica, French Guiana, Mexico, and St. Croix, U.S.V.I.) confirm these observations (N. Mrosovsky, P. Dutton, A. Chavéz, J. Fretey, S. and K. Eckert, pers. comm.). Essentially all clutches of eggs were deposited above the mean high water mark on beaches that were relatively stable and erosion-free for the duration of the nesting season. Nest losses to erosion or saltwater inundation are generally high for this species worldwide, but in Culebra were found to be as low as previously recorded elsewhere (2.5 to 10.3% annually), as a result of the seasonal beach accretion.

Nest locations were triangulated from permanent numbered stakes located at 25 m intervals along the edge of the supralittoral beach vegetation. Measurements were obtained using a 50 m tape measure and compass. Triangulation records were used to relocate the nest and determine its fate after two months of incubation. Terminology remains consistent with Eckert (1987) to indicate "nest" as successful deposition of eggs and "landing" as contact with the beach. Landing locations were recorded between the two closest numbered stakes. Two types of data were used in the following analyses: (1) distributions from landing records (accurate to ± 12.5 m along both beaches), and (2) distances from nest to current water line (WL), high tide line (HTL), and proximal vegetation (V) or winter storm berm. Beach width measurements varied spatially and temporally and so were normalized to allow meaningful comparisons of nest location. Distances for HTL-N and N-V were summed to yield the cumulative beach width. Nest location was then expressed as a proportion of supralittoral beach width (HTL to N / HTL to V) with total beach width of 100%, 0.0 being the high tide line coordinate and 1.0 being the vegetation line.

The following hypotheses of Eckert (1987) were tested to descriptively determine the spatial arrangement of nests on the beach:

**Landing distribution along length of beach**

Ho1: Test for independence of beach preference
Ho2: Test for independence of beach segment preference
Ho3: Test for clumped distribution
Ho4: Test for uniform or regular distribution

**Distance traveled along width of beach**

Ho1: Test for independence of crawl length and beach width
Ho2: Test for independence of crawl length and beach foreslope
Ho3: Test for independence of crawl length and turtle size
Ho4: Test for independence of crawl length and previous false crawl
Ho5: Test for independence of distance from water and survival probability
Ho6: Test for independence of distance from vegetation and survival probability

The consequences of nest scatter and nest placement were tested at a seasonably stable environment. Iteroparity without parental care remains a game of chance according to game theory predictions. By comparing the nest placement in a constant nest environment (Culebra) to a study of a stochastic (St. Croix) nest environment, it was discovered that the behavior patterns molded by strong evolutionary selection pressure prevailed despite the unusual environmental stability. Leatherbacks at the anomalously stable beach of Culebra continued to play a "nest scatter game" by depositing nests randomly despite lesser risks of nest erosion. This conclusion suggests that nest scatter may be an evolutionarily stable strategy.

Bet-hedging by depositing nests randomly minimizes reproductive loss. So why do females continue nesting randomly if there is no apparent need to do so at a stable beach? They would if they could, but in order to lock into a more specific strategy (that of consistently nesting as far from the water as possible, resulting in a clumped nest distribution), females would have to be able to predict the stability of a beach. Culebra's population (>30 annually) is small compared to the leatherback metapopulation (> 100,000). Natural selection acts in the present, but the adaptative nesting behavior reflects past selection pressures that have molded the current pattern for nest distribution. Nest scatter would be maintained as an adaptive strategy for the leatherback metapopulation which generally nests on characteristic erosional beaches through most of its range. No additional energetic costs are associated with this strategy, and it still pays dividends under stable conditions while cutting reproductive losses under adverse conditions.

A conservative strategy of nest placement (nest scatter) is followed rather than a specific strategy (nest clumping). Females have chosen a nest-placement strategy that minimizes nest loss rather than maximizing reproductive gain. Intra-specific nest destruction is minimized as well. Random nesting is commonly observed on characteristic, erosion-prone beaches, but is also a pattern recorded for seasonally stable rookeries. The choice of minimizing nest loss rather than maximizing gain is a trade-off that can be assessed in terms of risk analysis of parents vs. offspring. The same bet-hedging strategy has been employed under varying levels of environmental stabilty. Behavioral adaptations may exist even though natural selection is not currently operating on them. Spatial nesting patterns may have been molded by past selection pressures (at the metapopulation level) operating under historically unpredictable conditions. Additional work directed toward quantifying the nesting pattern and fitting it to an underlying statistical distribution (a Poisson distribution) rather than the current descriptive use of the term random will be forthcoming. Preliminary results indicate that nesting patterns along the beach length do fit a Poisson distribution. A least three problem sets confound the analysis of the data in a width-wise manner. At present a nearest-neighbor fitted distances technique appears to be most promising solution to statistically determine the relationships of nest distributions in the beach-width dimension.

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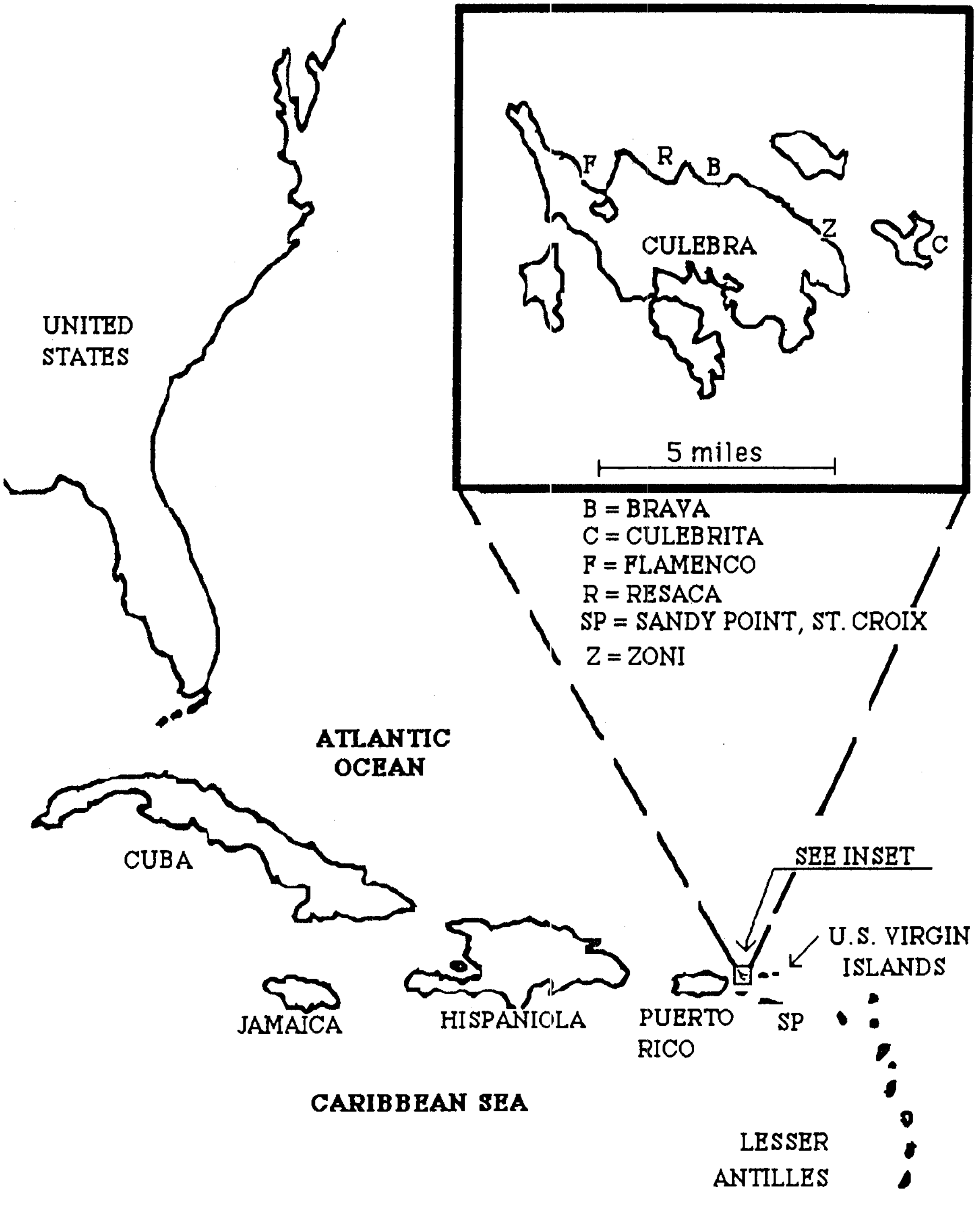

Figure 1. Map of Isla de Culebra, Puerto Rico with inset showing study site beaches, Plāyas Brava and Resaca, and additional beaches referred to in the text.

# BUCK ISLAND REEF NATIONAL MONUMENT SEA TURTLE RESEARCH PROGRAM: 1989 - THE YEAR OF HAWKSBILLS AND HURRICANES

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Buck Island Reef National Monument (BUIS), administered by the National Park Service, is a protected, undeveloped offshore island which provides stable nesting and foraging habitat for the hawksbill sea turtle, (Eretmochelys imbricata). The 1989 season marked the beginning of BUIS' second season of the nocturnal research program on nesting hawksbills and also the first major hurricane to hit the island of St. Croix in over 60 years and its effects on hawksbill nesting success.

The three principal sea turtle nesting sites are the North Shore, West Beach, and the South Shore/Turtle Bay (Figure 1). The north and south shore/Turtle Bay areas are typical hawksbill nesting habitat (beach forest, low berms, cobble or sand beaches, offshore coral reefs), while West Beach has a wide, exposed beach with no offshore reefs.

Day beach surveys are conducted before and continue after the nocturnal research program, recording all sea turtle activities on BUIS. Nest excavations are performed 60 days after laying. The nocturnal program began June 17 and continued through August 23, 1989. Research was conducted by a park biological technician, 2 field technicians, and an intrepid and invaluable contingent of volunteers contributing over 800 hours to the program.

Hawksbills were approached during egg laying only. All morphometric data, measurements, and diagnostic markings were recorded for each nesting female. Tagging was done during covering; National Marine Fisheries Service inconel tags were used (PPW Series 800). In mid-program, Dalton Rotoriese flexible plastic yellow tags, BUIS inscribed, became available and were used in combination with the inconel. All tagged hawksbill were photodocumented.

BUIS hawksbill nesting season spanned 7 months, peaking July through October; two nesting activities were recorded in January, 1990 (Figure 2). A total of 171 hawksbill nesting activities were recorded for all three BUIS nesting sites; 71 nests were confirmed; 50 activities were false crawls/aborted nesting attempts, and 50 nests remained suspected and/or unconfirmable (Figure 3).

During the 47 nights on the nesting beaches, 34 hawksbill activities were observed and 16 females tagged (only 3 Rotoriese tags were used due to the adverse hawksbill reactions to initial tissue plug removal prior to tag insertion).

The average length of nesting females was 87.6 cm; the average width was 79.4 cm (both measurements were taken over the curve). The longest stage of the nesting cycle was "covering," averaging 30 minutes. Only 2 animals were observed from approach through departure. Average total elapsed time on the nesting beach was 85 minutes.

Nesting beach patrol coverage was greatly improved over the 1988 season; tagged females were observed repeatedly. Average internesting interval for 17 observed hawksbill nestings was 14 days. Hawksbills were observed to nest up to 4 times, but no average number of nests/female could be calculated as many of our tagged females continued to nest after the nocturnal program ended.

In 1989 nest site fidelity was frequently observed. Tagged individuals nested repeatedly within a few meters of their previous nest sites (Table 1) and (Figure 4).

The results of the individual nesting beaches were 58 activities on the North Shore (34%), 37 activities on West Beach (22%), and 76 activities on the South Shore/Turtle Bay (44%). These results are consistant with the 1988 nesting totals for BUIS, showing each nesting site has its own peak of activities within the nesting season (Figure 5).

In 1989, 71 in-situ hawksbill nests were confirmed and excavated for hatching success, producing approximately 5700 live hatchlings. The average clutch size for these nests was 148.8 eggs (N = 45, SD = 23.87, Range 62 - 212). For 71 confirmed nests, 52 nests (73%) survived to term without predation, erosion, or poaching. The mean hatching success for these nests was 83.7% (N = 45, SD = 15.65, Range 36 100%). Thirteen nests (18%) were lost to erosion, including hurricane erosion and winter wave action. Six nests, (9%), all laid on the South Shore, were destroyed by predation from either the black rat or mongoose (Herpestes). Whole beach success was lowered from 83.7% to 53.7% by poor success in 3 nests not attributed to predation, erosion, or poaching.

In two South Shore nests full-term/dehydrated hatchlings were found with external tumor-like growths on their flippers and necks. Preserved, they have been transfered to the Universities of Georgia/Athens and Florida/Gainesville for analysis.

## HURRICANE HUGO, September 17-18, 1989

The results presented above include the impacts of Hurricane Hugo, September 17 - 18, 1989, on nesting beach success. Following are the dramatic changes the hurricane caused on BUIS nesting sites and in hawksbill nesting behavior following the storm.

Hawksbill nesting activities continued at peak numbers following the hurricane, but nesting site use changed (Figure 5). Nesting activities along the South Shore were impeded by an eroded berm 1.5 to 2 meters high along 75% of this shoreline, and many fallen trees and root tangles. Storm sand replenishment below the eroded berm extended out an additional 8 meters over shoreline reef. Hawksbills continued to nest along this shoreline; however, the nests laid below the eroded berm were lost to normal winter wave action. Normally, hawksbills nest an average of 7 meters into the beach forest, and winter swells will not effect nesting success.

The North Shore was completely closed to hawksbill nesting after the hurricane. Ninety percent of the shoreline trees were blown down parallel to the water, blocking access to beach forest nesting. False crawl ratio doubled from 39% to 60% after the hurricane, mostly due to fallen trees and eroded root tangles blocking nesting attempts (Figure 3).

The most dramatic effect of the hurricane was increased use of West Beach by hawksbills for nesting. Normally an atypical hawksbill nesting beach, supporting less than 5 to 15% of seasonal hawksbill nesting, hawksbill nesting activities on West Beach in October were twice those from September (Figure 5). Again most of the nests laid post-Hugo on West Beach were effected by winter wave action eroding the beach back to normal pre-hurricane dimensions. Overall, 19 hawksbill nests observed laid during the nocturnal program were lost to Hugo.

In non-hurricane years hawksbill nests laid in stable beach forest, on North and South Shores, are not affected by winter swells. However, these nesting areas were closed by hurricane erosion and fallen trees, shifting nesting to high erosion zones below eroded beach berms, placing nests within meters of the waters edge.

The success of the past 2 years of the nocturnal research program has proven the feasibility of a long-term hawksbill population study on BUIS and has begun to provide the necessary information to understand the hawksbill's nesting behavior and nesting beach requirements. BUIS has been included in the NMFS/USFWS Caribbean Marine Turtle Recovery Plan for hawksbill as one of three known Caribbean islands supporting concentrated hawksbill nesting (Mona Island, Puerto Rico, and Long Island, Antigua, are the others). We look forward to the annual continuation of this program and the development of a nesting beach management plan for BUIS.

## ACKNOWLEDGMENTS

Special thanks to our program field technicians, Jane Fleetwood, and Kevin McIntyre, and especially our lead volunteer Solvin Zankl for all his hours on the nesting beaches. Funding was provided by National Park Service, and our technical and administrative nightmares were expertly handled by the incredible staff of Christiansted NHS/Buck Island Reef NM. My sincerest thanks to all.

Table 1. Nesting Site Fidelity. Hawksbill sea turtle nesting. Buck Island Reef NM, U.S. Virgin Islands, 1989.

| Tag # | Nest* 1 | Distance (meters) | Nest 2 | Distance (meters) | Nest 3 | Distance (meters) | Nest 4 |
|---|---|---|---|---|---|---|---|
| 835/826 | 16 | 152m | 14 | | | | |
| 837/836 | 01 | 89m | 02 | 2m | 02 | 5m | 02 |
| 839/838 | 01 | 18m | 01 | 1m | 01 | 2m | 01 |
| 841/842 | 17 | 165m | 14A | 35m | 14 | | |
| 844/845 | 04 | 89m | 02 | 9m | 02 | | |
| 829/834 | 17 | 30m | 17A | 199m | 14 | | |
| 852/851 | 04 | 4m | 04 | | | | |
| 847/BI006 | 13 | 77m | 14A | | | | |
| BI007/853 | 10 | 164m | 06 | | | | |
| BI001/857 | 2A | 127m | 03 | | | | |
| 833/828** | 2A | 6m | 2A | | | | |

* Nest location of subsequent hawksbill nestings. See Figure 4.

** Remaining 1989 tagged hawksbill sea turtles were only observed once on the nesting beach.

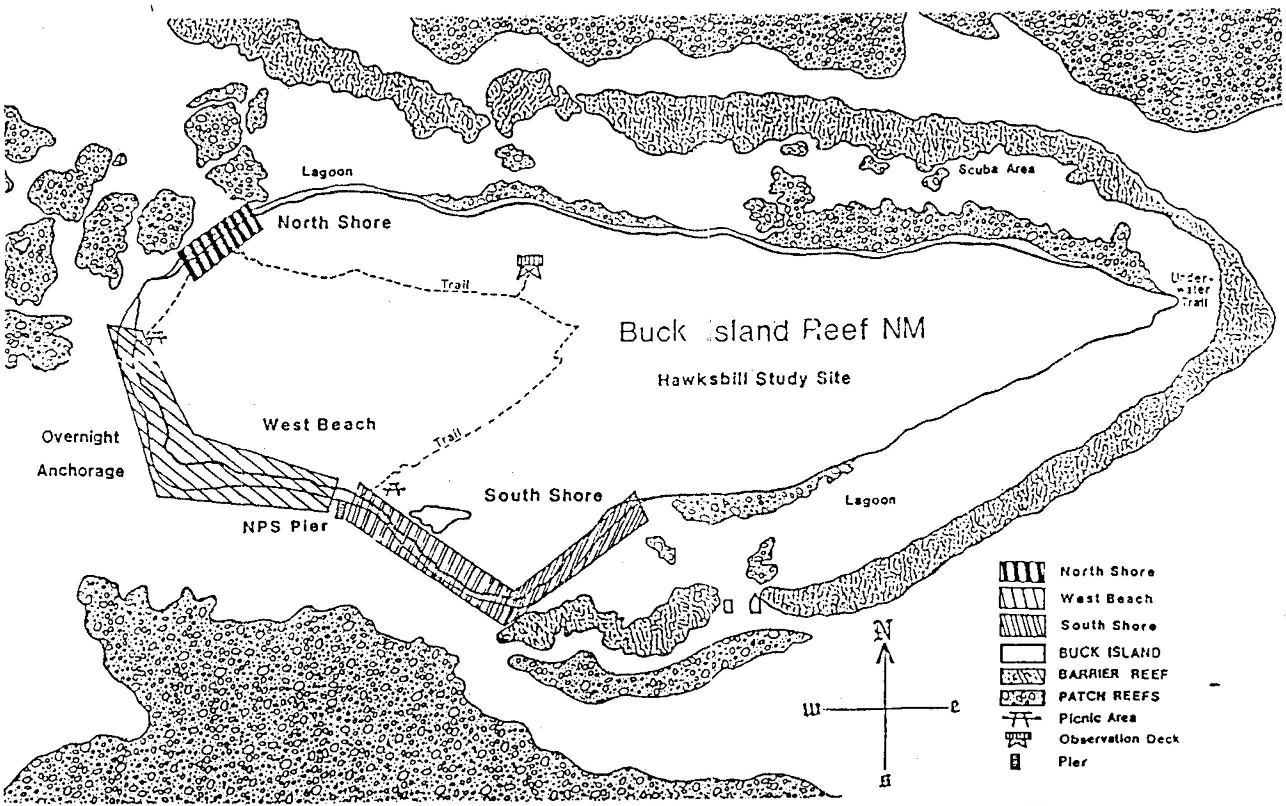


Figure 1. Buck Island Reef NM Study Site. Predominant sea turtle nesting area; North shore, West Beach, and South shore. 1989.

Figure 2.

HAWKSBILL SEA TURTLE ACTIVITY

BUCK ISLAND REEF NATIONAL MONUMENT

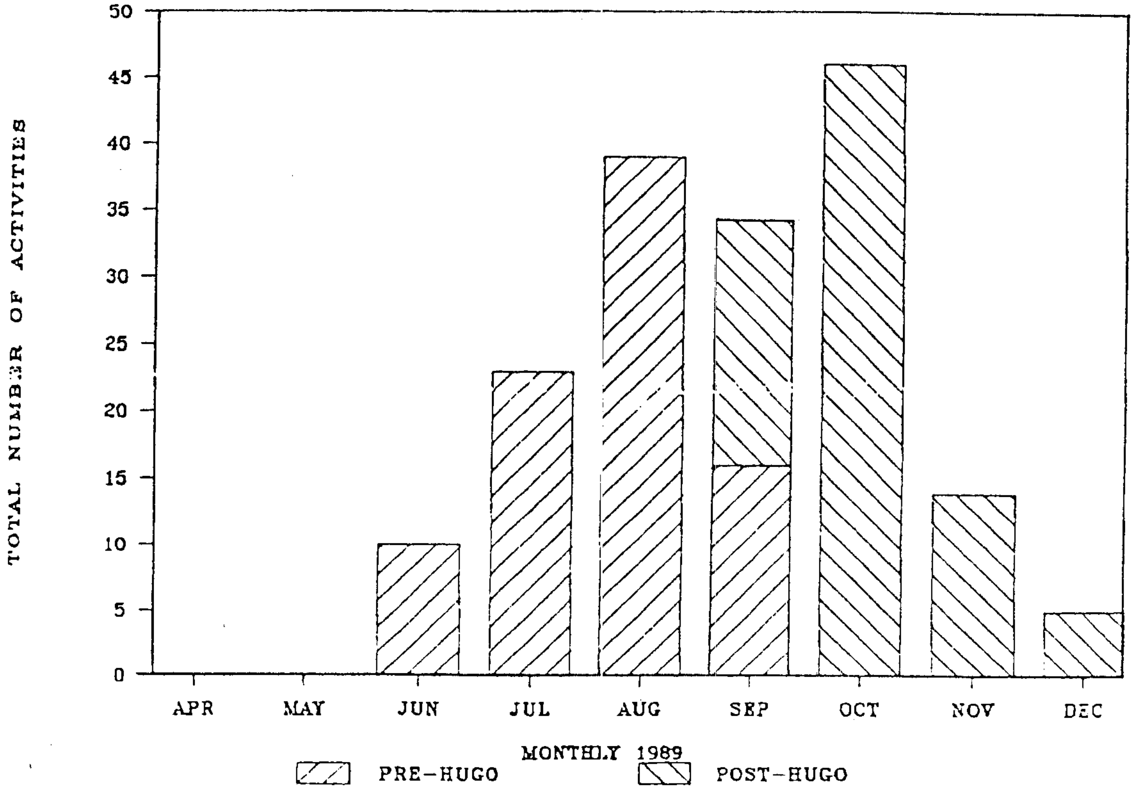
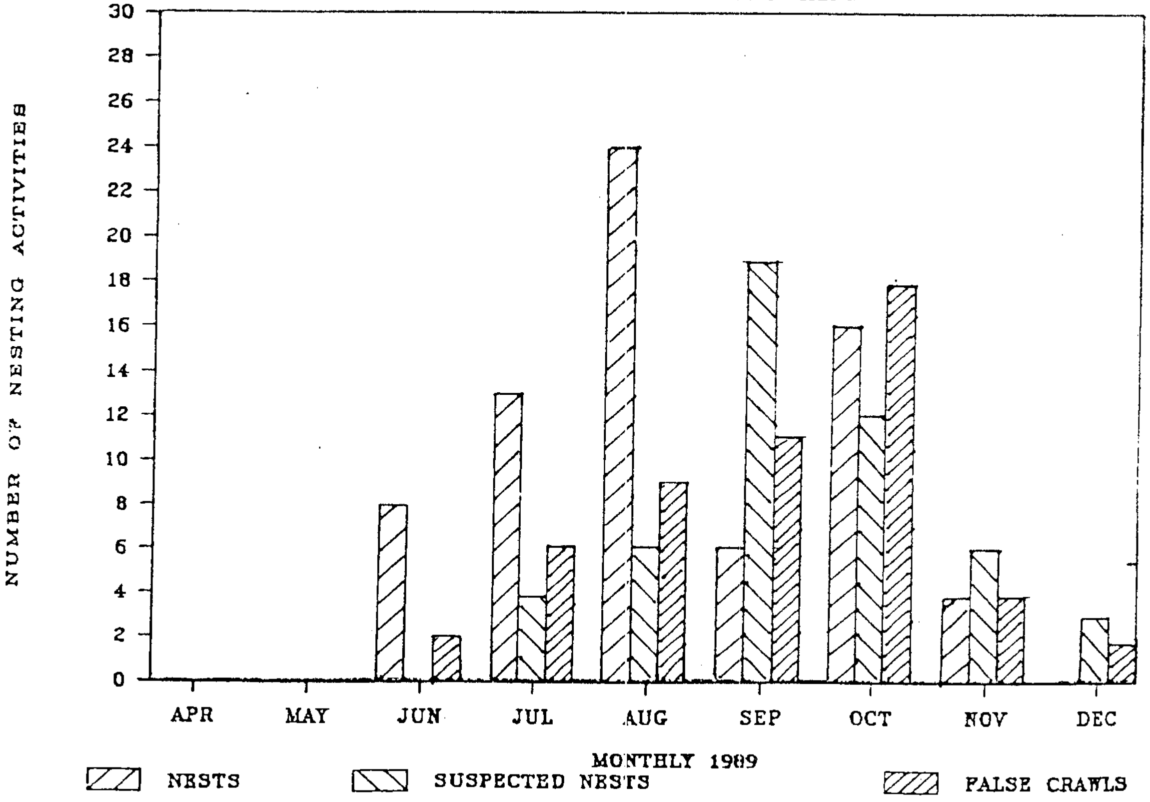


Figure 3.

HAWKSBILL NESTING ACTIVITY DISTRIBUTION

BUCK ISLAND REEF NATIONAL MONUMENT



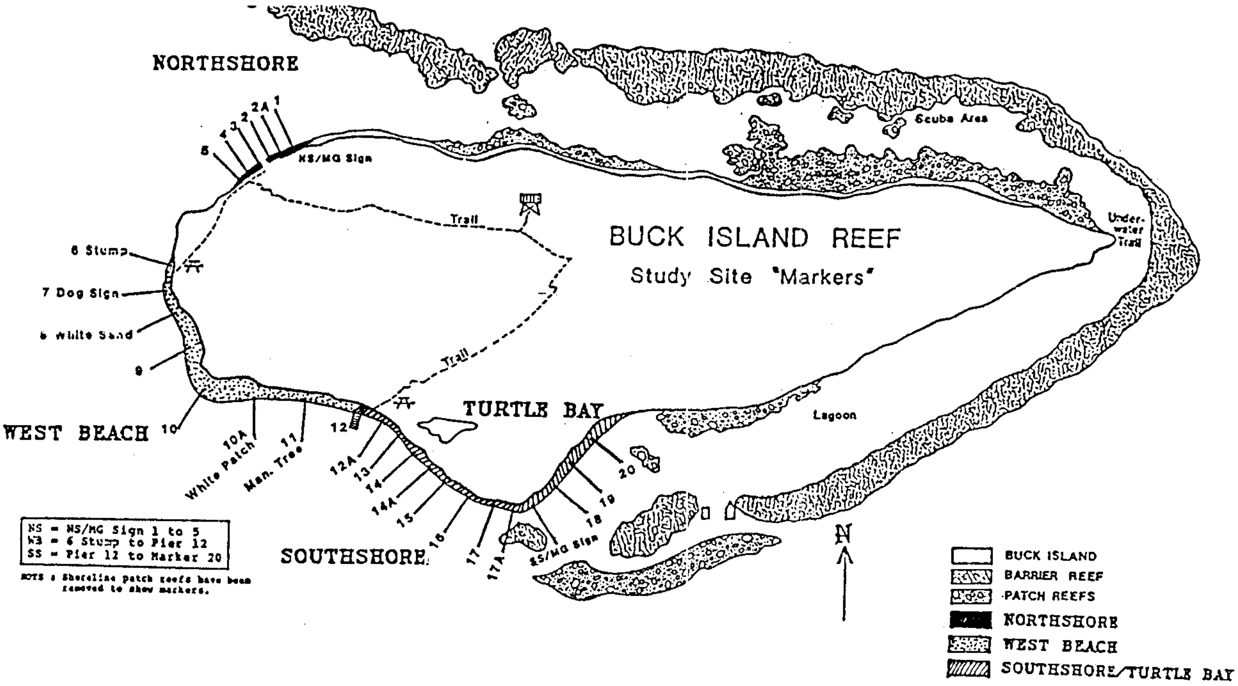
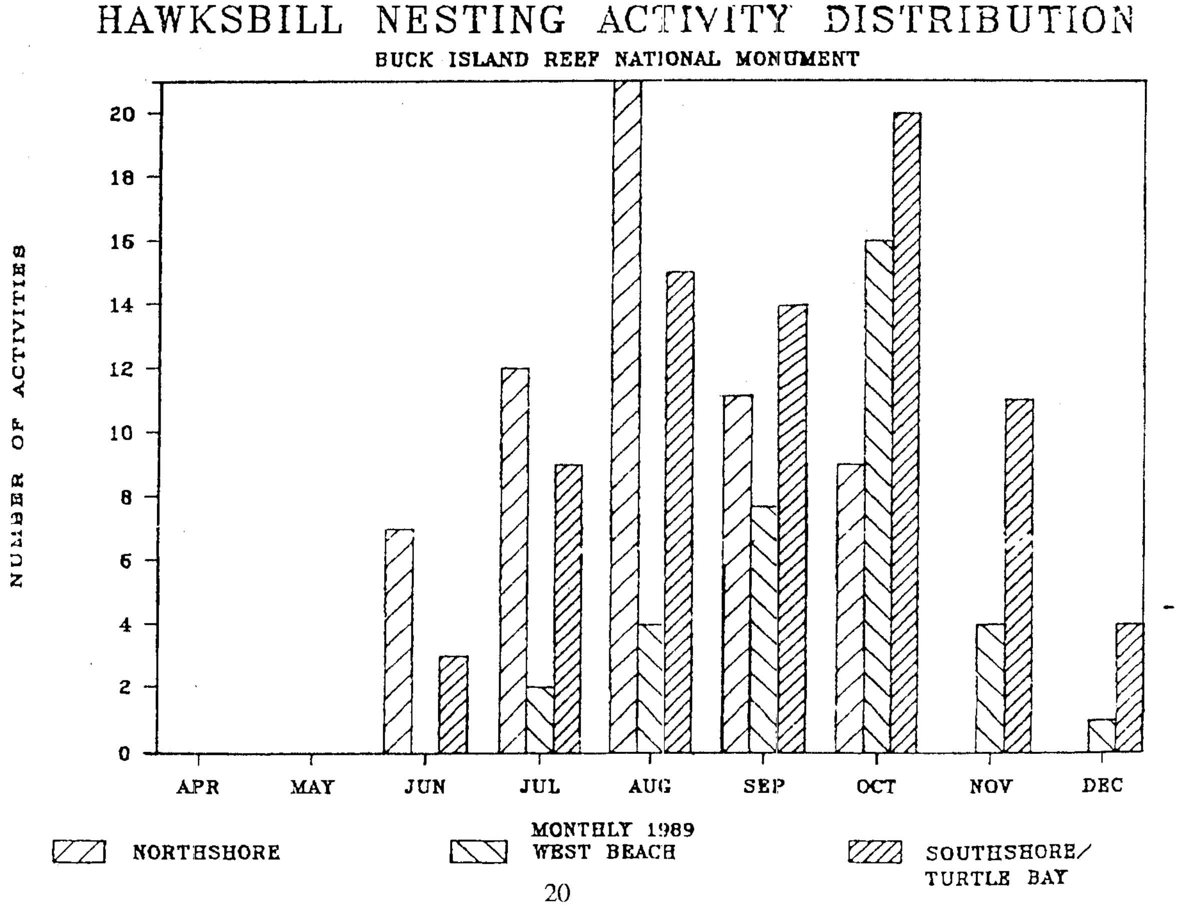


Figure 4. Buck Island Reef NM, Study Site. Location of Nesting Area Markers. 1987 - 1989.

Figure 5.



# MARINE TURTLE CONSERVATION IN MALAYSIA

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**Jeanne A. Mortimer**
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During the past year I have been working in Malaysia on a two-year contract with WWF, on invitation from the Federal Fisheries Department of Malaysia, to provide advice and assistance on matters relevant to sea turtle conservation. Malaysia is composed of three geographic units--Peninsular Malaysia, Sabah and Sarawak. The human population is predominantly Moslem, and Malaysian Moslems do not eat turtle meat. Unfortunately, they do eat large quantities of turtle eggs.

Four species of sea turtle nest in Malaysia--the green turtle, hawksbill, olive ridley and leatherback turtle--in decreasing order of abundance. Figure 1 shows an estimate of the average number of egg clutches laid annually during the past five years by each species in the Peninsula, Sabah and Sarawak. All four species are endangered in Malaysia, but most attention has focused on the plight of the leatherback population of Terengganu.

## The Leatherbacks of Rantau Abang--a Case Study

Malaysia has long been famous for the leatherback population that nests at Rantau Abang, in the State of Terengganu. In the late 1950s, an estimated 2,000 female leatherbacks laid about 10,000 egg clutches annually. Since then, the population has declined steadily and catastrophically (Figure 2). During the 1989 season, fewer than 200 egg clutches were laid.

Because a hatchery program has been in operation for leatherbacks at Rantau Abang since 1961, many Malaysians ask "what happened to all the hatchlings released from the hatchery?" Between 1961 and 1986, an average of about 33,000 eggs were incubated each year with a 50% rate of hatching success. This seems like a large number of hatchlings. But, if current estimates are correct that 1,000 to 10,000 eggs are needed to produce a single adult female, then the hatchery program would only have produced about 3 to 34 new adult females each year. Considering that 33,000 eggs represents fewer than 2% of the eggs laid annually in the late 1950s, perhaps we should not be too surprised to note a population decline of more than 98%.

Leatherback turtles are an important source of revenue as a tourist attraction, so the state government of Terengganu badly wants to save the population. (At the peak of the tourist season, I counted as many as 1,000 tourists around a single nesting turtle!) Conservation efforts on behalf of the leatherback have increased dramatically in Terengganu during the past few years. A sanctuary for the turtles has been established along 15 km of nesting beach. Last year the state government banned the sale and harvest of leatherback eggs--a courageous step, considering that leatherback eggs are generally preferred to those of the other species. By law, all leatherback eggs are protected and must be placed in hatcheries operated by the Fisheries Department. A Fisheries enforcement team also controls the behavior of unruly tourists on the nesting beach.

Although the turtles are now well protected on land, they are seriously threatened at sea by accidental capture in fishing gear. At least four adult leatherbacks (out of an estimated 30-50 females nesting last year) washed ashore dead at Rantau Abang during the 1989 nesting season. Two of these had become tangled in the lines of fish traps.

## The Other Sea Turtle Species

During much of the present century, in most parts of Peninsular Malaysia, virtually every sea turtle egg laid has been harvested for human consumption. Egg collection records for the State of Terengganu indicate that the numbers of green turtle, olive ridley and hawksbill eggs laid have declined by 52-85% from levels reported in the late 1950s. Similarly, the green turtle populations nesting in Sarawak and Sabah have both declined dramatically during the past five decades. Like the leatherbacks, these species suffer greatly from accidental capture in fishing gear such as trawl nets and a variety of drift nets. Rapid coastal development also threatens many important nesting beaches.

## Conservation Efforts and Dilemmas in Malaysia

In recent years, a great deal of popular interest in marine turtle conservation has been generated by concerned personnel in the Fisheries Department, interested faculty in Malaysian universities, WWF Malaysia, and the Malaysian press. During the past year, several important initiatives were taken by the Federal Department of Fisheries including a ban on the use of a large meshed drift net called the Pukat Pari (or "ray net"), known to be harmful to turtles; a press announcement formally recognizing all four species of marine turtle as endangered and proposing an educational campaign (with WWF Malaysia) to discourage the eating of all sea turtle eggs; and operation of almost 20 hatcheries in the Peninsula which have significantly increased the proportion of eggs from green turtles, hawksbills and olive ridleys that receive protection.

## The Problem with Hatcheries

In Malaysia, virtually every hatchling turtle that is produced comes out of a hatchery. But, the more I deal with hatcheries, the more disillusioned I become with them, for the following reasons:

1) Hatcheries are expensive to operate.

2) Their success depends greatly on well-trained, reliable staff. To maintain such quality staff is difficult when they are paid minimum wage, as is generally the case.

3) Hatching success in hatcheries is usually lower than in natural nests--even when the hatcheries are manned by conscientious staff.

4) Unnatural sex ratios can easily be produced in hatcheries. Since it is easier to dig a shallow nest than a deep one, artificial nests tend to be warmer than natural nests, and most hatcheries probably produce far too many females.

   Even given the best intentions and the most state-of-the-art knowledge, in many situations we still do not really know what we are doing. Conventional wisdom tells us to construct hatcheries in open sandy areas, in order to avoid problems caused by roots and ants, yet most hawksbill turtles and many green turtles lay their eggs in nests constructed in the vegetation.

5) Improper hatchling release is a problem whose magnitude I believe has been grossly underestimated. The hatchlings produced in a hatchery are dependent on their human caretakers for their release. At most hatcheries, release usually occurs at the same time (generally in the morning) and at the same place each day. This causes problems that include the following:

   a) Because hatchlings usually emerge from their nests early in the evening, they must spend the remainder of the night struggling to escape from the cylindrical wire mesh enclosures placed over their nests to restrain them. By morning, they are often exhausted by their fruitless struggle or weakened by attack from ants. Sometimes they are dead.

   b) The release of hatchlings at the same time and place each day produces fish feeding stations, for fish quickly learn where they can find easy prey. (Under natural conditions, groups of hatchlings enter the sea at random points all along the nesting beach, and at relatively unpredictable times.)

6) Hatcheries have a bad psychological effect on people. Because they are so labor-intensive, people tend to think they are doing far more good for turtles than they actually are. They feel so proud of the hundreds of squirming hatchlings produced, they lose sight of the fact that 1,000 to 10,000 hatchlings may be needed to yield a single adult female.

In Sabah and Sarawak, many hatcheries could be abandoned, and in fact, steps are now being taken along these lines. Throughout most of Peninsular Malaysia, however, hatcheries are a necessary evil. Virtually every egg laid is harvested by someone. If that egg is not put into a hatchery, it is eaten.

### The Need for Long-term Planning

Another dilemma we face in Malaysia is what to do with small populations of nesting turtles that have a long history of egg over-harvest. In some cases, we may be dealing with a population composed only of aging adults, which may already be effectively extinct. Because of the long age-to-maturity in sea turtles, management of their populations demands long-term planning. Almost by definition, long-term planning must begin when a population is still large.

## FIGURE LEGENDS

Figure 1. Estimates of the average numbers of egg clutches laid annually during the past five years by four species of marine turtle in Peninsular Malaysia, Sarawak and Sabah.

Figure 2. The numbers of egg clutches laid annually by leatherback turtles at Rantau Abang, Terengganu during the past three and one half decades.

Figure 1

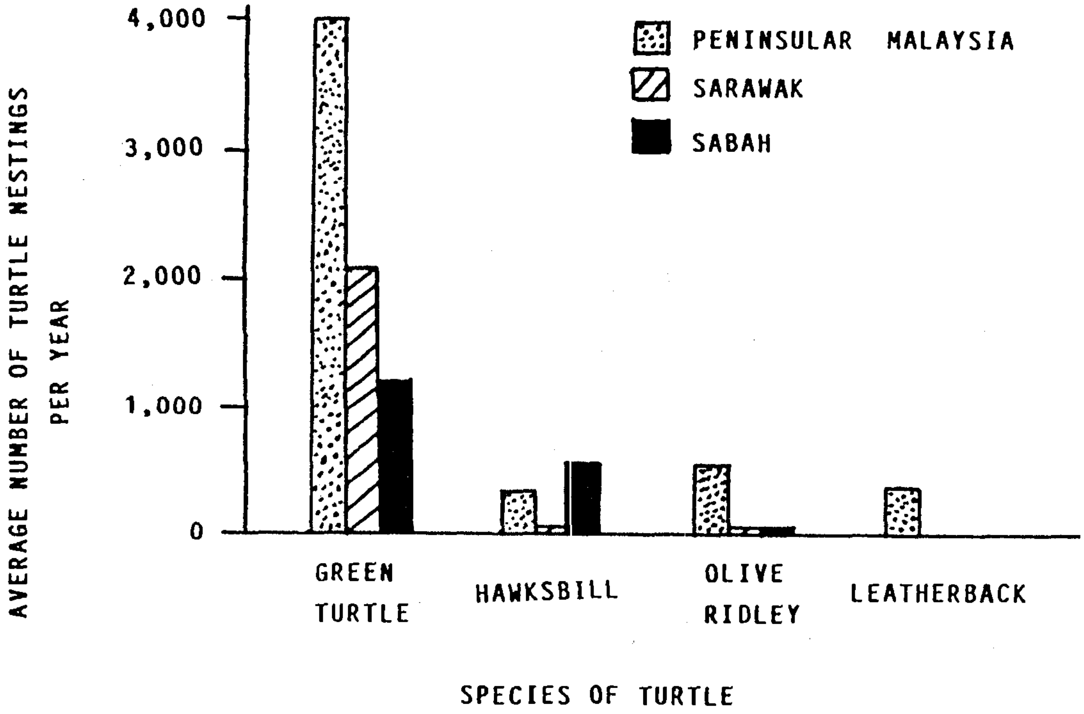
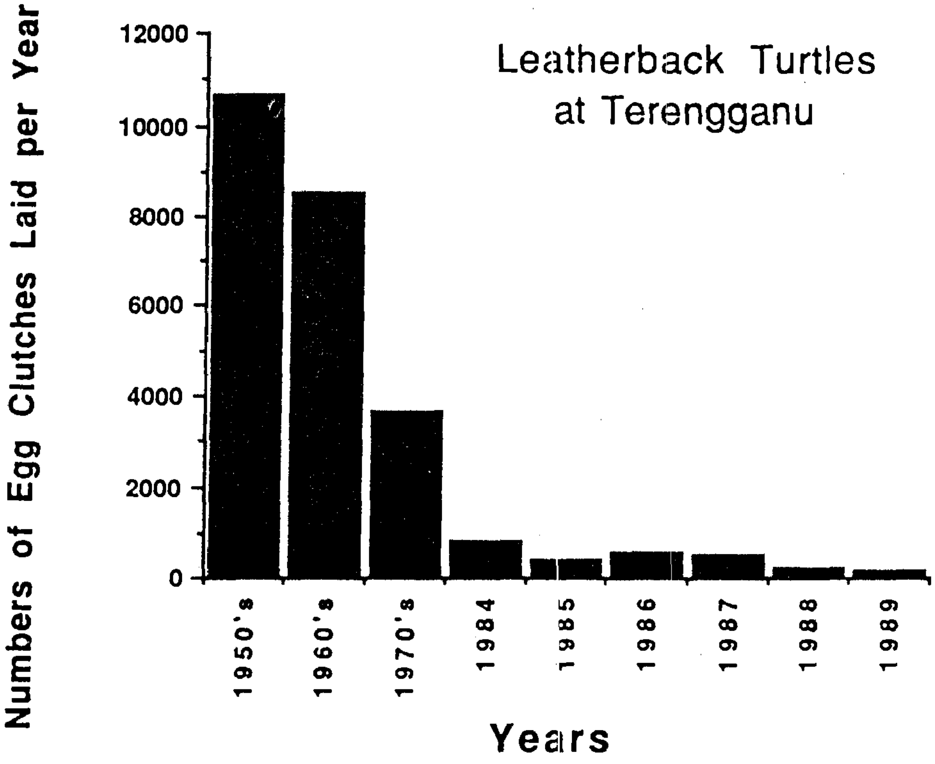


Figure 2



# SEA TURTLE ACTIVITY IN THE FLORIDA KEYS 1980-1989

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## INTRODUCTION

Prior to the 1980s little quantitative information was available for sea turtle stranding and nesting activity within the Florida Keys. Historic information documents sea turtle nesting and active harvesting of eggs and adult green turtles by the turtle fishery in the Keys. As the major portion of this stock was fished out, few adult green turtles (Chelonia mydas) currently remain in this area. Currently, species of sea turtle populations are severely pressured by the increasingly intense development of the Florida Keys.

## METHODS AND MATERIALS

Information presented is for the period 1980-1989 and can be found in the National Marine Fisheries Service, sea turtle stranding network data base and the state of Florida sea turtle stranding information. It is primarily the result of volunteer efforts by local interests. Information was collected as a cooperative stranding effort coordinated by Florida Department of Natural Resources (FDNR) park staff. The geographic area of this network extends from Key Largo to the Marquesas Keys and includes both Florida Bay and the Atlantic coastlines, covering over 376 kms. (or 234 miles) of shoreline (Schomer and Drew, 1982). The shoreline of this region is principally vegetated by the red mangrove, Rhizophora mangle, and is interspersed with small sandy beaches. This area contains extensive shallow marine environments, principally Florida Bay and the Florida Keys reef tract. These environments represent potential habitat for all life stages of sea turtles. Florida Bay contains extensive grass flats, primarily Thalassia and mixed Thalassia - Halodule beds (Zieman, 1982). Juvenile green sea turtles are routinely seen in this area. The reef tract provides habitat for adult, sub-adult and juvenile turtles including hawksbills, greens and loggerheads. Problems associated with these areas include a loss of habitat due to sea grass die-off in Florida Bay, impacts of fishing gear and line, oil from the shipping lanes, boating impacts, development, and the papilloma disease of green turtles.

## RESULTS AND DISCUSSION

Turtles found in the Florida Keys include both nesting and foraging animals that utilize the habitats available along the reef tract or in the grass flats of Florida Bay. Green (Chelonia mydas) and loggerhead (Caretta caretta) turtles are the species most frequently found in the study area. Hawksbills (Eretmochelys imbricata), although normally occurring in this area, are not commonly reported. Leatherbacks (Dermochelys coriacea) normally nest on Miami Beach and north along the coast to Jupiter; however, they are not commonly seen as strandings in the Florida Keys. Although Kemp's ridleys (Lepidochelys kempi) have been reported in the area, they are infrequently reported to the stranding network.

Nesting habitats in the Florida Keys can be currently described as marginal, due to a variety of factors including coastal beach morphology, vegetation characteristics, predation, and development. Nesting occurs primarily on low profile coastal berms on the Atlantic side of the Keys. Documented exceptions are bay-side nesting occurring on Sandy Key, Grassey Key, Sawyer Key and the Marquesas Keys. Both beach types are similarly low profile, narrow, coastal berms where nesting occurs in vegetation that is 3 m (10 ft) to 6 m (20 ft) beyond the high tide line and at elevations of 60 to 90 cm (2 to 3 feet). These low profile nests often are located in grass on the higher portions of the berm. It is not uncommon to find the bottoms of natural nests intruded by salt water. For this reason many nests on these beaches have a low potential hatching success. A few beaches with higher elevations occur that are utilized with varying hatching success. These beaches are found in the lower Keys at Bahia Honda, Woman, Boca Grande, and the Marquesas Keys.

Nesting and/or crawl activity has been documented on 20 of 30 beach areas identified by aerial surveys as being potential nesting beaches. Most of these beach areas are less than a kilometer (one half mile) in length. The only species regularly documented as nesting in the survey area is Caretta caretta. Currently the highest area of total verified nesting is found on Long Key. Occasional Chelonia mydas nesting has been documented on Boca Grande (one nest 1987) and on Marquesas Keys (one nest 1988). It is believed that the Marquesas Keys are more heavily used by green and hawksbill turtles than is currently documented. This assumption is based on earlier aerial surveys that were unsubstantiated by ground truthing. Natural predation (primarily by raccoons, Procyon lotor) is relatively low for most areas with the exception of Long Key. Long Key has the highest density of documented nesting within the Keys and has a predation rate approaching 100% (unpublished data).

Nesting turtles and hatchlings in the Florida Keys face many of the same problems as turtles in other developed areas. Beach front development results in ever increasing pressure on the few available nesting beaches. A great deal of emphasis should be placed on preserving the few remaining pristine beaches suitable for nesting such as those beach areas found in the lower Keys including Woman, Boca Grande, and the Marquesas Keys.

Strandings are found in Table 2. In general the numbers of reported strandings have increased over time. This trend is characteristic of better reporting, which has occurred as a result of the more formal stranding network established in 1985. Since 1980, 159 green turtles, 111 loggerheads, and 17 hawksbills have been reported for the Keys. Yearly totals have increased from 15 in 1980 to a total of 83 animals reported in 1989. Only 2 Kemps strandings have been reported over this period. Size information is found in Table 3. Annual mean curved carapace length for Caretta ranges from 66 cm to 87 cm, this includes an absolute range for individual animals extending from 14 cm to 121 cm (excluding the hatchling value of 6 cm reported for 1980). Annual mean curved carapace length for Chelonia for this area ranged from 41 cm to 54 cm, a much narrower range. Absolute sizes of individual Chelonia ranged from 12 cm to 94 cm. Although populations of both species tend to include a large component of juvenile animals, the majority of greens examined were immature or sub-adult animals. Documented adult green turtles recorded by the stranding network are rare. There are no distinct temporal monthly patterns for animal sizes for either species.

The frequency of animals stranded increases over the winter and spring months and declines over summer and fall months with a peak in April of 44 turtles and a minimum of 16 in September. Numbers are higher from December to June and decrease by 10 or more animals for the months July through August. Increased strandings during winter may be related to seasonal temperature fluctuations and the impact of winter cold fronts on the shallow environments of Florida Bay and the reef tract. This seasonal pattern of winter-early spring stranding also generally corresponds to dry and wet seasons, respectively, although the potential implications of this are not obvious (Shih, 1983). Patterns in annual stranding of animals could be related to foraging behavior, seasonal impacts on disease state, or may correspond to migratory shifts in the population.

Strandings reported may represent live or dead animals. Principal causes of injury and death are found in Table 4. Live animals are usually sick, injured, or are entangled. Injuries encountered in the Keys are often boat related. However, because of the nature of this type of injury and the extent of decomposition, the proportion of these injuries that are inflicted post-mortum are less well defined. Necropsies have been done over the last year to determine if other information can be derived beyond obvious gross condition at the time of stranding. Currently one of the most frequent problems seen in turtle populations of the Florida Keys is the papilloma disease of green turtles. Papillomas are exhibited in more than 50% of the stranded population of green sea turtles examined since 1983 as calculated from stranding form information. They account for over 25% of the injuries and conditions listed in all species of turtles examined. In addition, the characteristic condition or health and potential for recovery of any animal with the disease is generally unknown.

## CONCLUSIONS

Historically the Keys contained much larger populations of green turtles and most probably other species as well. Currently this area contains a vast amount of habitat; however, the extent of its usage by sea turtles remains unquantified. Problems within the area are dominated by development pressures, increased boat traffic, and the papilloma disease of green turtles. It is extremely important in light of the shift in habitats in Florida Bay to determine the extent of turtle populations within this area and any impacts it has on these animals. It is also critical to fund research to further define the papilloma disease, its pathology, and determine its implication for green turtle populations.

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### Table 1: Nesting for Florida Keys Turtles 1986-1989*

| | 1989 | | 1988 | | 1987 | | 1986 | | Total Nest activity by site | Total nests laid by site |
|---|---|---|---|---|---|---|---|---|---|---|
| | C# | N+ | C | N | C | N | C | N | | |
| Lower Matecumbe | 23 | 5 | 28 | 11 | 51 | 12 | 49 | 18 | 197 | 28 |
| Long Key | 35 | 11 | 58 | 9 | 101 | 29 | 34 | 9 | 286 | 58 |
| Grassey Key | 2 | 0 | 8 | 4 | 4 | 1 | 16 | 7 | 42 | 12 |
| Coco Plum Beach (Fat Deer Key) | 8 | 2 | 8 | 0 | 50 | 11 | 12 | 4 | 95 | 17 |
| Sombrero Beach (Vaca Key) | 29 | 9 | 3 | 3 | 2 | 0 | 17 | 5 | 68 | 17 |
| Sombrero Beach Rd (Vaca Key) | 1 | 0 | 24 | 3 | 13 | 5 | 5 | 1 | 52 | 9 |
| Bahia Honda Key | 19 | 2 | 32 | 13 | 20 | 4 | 21 | 2 | 113 | 22 |
| Long Beach (Big Pine Key) | 6 | 1 | 18 | 6 | 7 | 6 | 28 | 13 | 85 | 26 |
| Woman Key | 12 | 1 | 0 | 0 | 11 | 0 | NS | NS | 48 | 1 |
| Boca Grande Key | 11 | 3 | 6 | 4 | 4 | 1 | NS | NS | 29 | 8 |
| Marquesas Keys | 77 | 16 | 33 | 9 | 32 | 3 | 12 | 3 | 185 | 31 |
| Total activity by year | 223 | 50 | 218 | 52 | 295 | 72 | 194 | 62 | 1190 | 219 |

* All nest preseumed to be Caretta #C = total crawls on a beach + = actual nests located, NS = areas not sampled

### Table 2: Total Stranded Turtles by Species for the Florida Keys 1980-1989

| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Chelonia mydas* | 7 | 9 | 9 | 6 | 6 | 8 | 17 | 30 | 23 | 44 | 159 |
| *Caretta caretta* | 6 | 10 | 10 | 3 | 2 | 5 | 10 | 15 | 19 | 31 | 111 |
| *Eretmochelys imbricata* | 0 | 2 | 6 | 0 | 0 | 2 | 2 | 1 | 2 | 2 | 17 |
| *Dermochelys coriacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Lepidochelys kempi* | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *unknown* | 1 | 1 | 2 | 2 | 2 | 2 | 4 | 4 | 2 | 5 | 25 |
| Total | 15 | 23 | 27 | 11 | 10 | 17 | 33 | 50 | 46 | 83 | 315 |

### Table 3: Size Classes of Sea Turtles from the Florida Keys 1980-1989

| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Chelonia mydas* | | | | | | | | | | |
| Mean* (cm) | 48 | 44 | 49 | 53 | 41 | 54 | 47 | 44 | 50 | 46 |
| Range (cm) | 70-30 | 63-15 | 95-16 | 81-18 | 81-26 | 94-14 | 76-19 | 77-12 | 65-28 | 59-10 |
| sd | 11.1 | 15.1 | 25.1 | 19.8 | 18.7 | 23.6 | 16.7 | 18.1 | 10.9 | 12.4 |
| n | 7 | 9 | 9 | 6 | 7 | 6 | 11 | 26 | 19 | 14 |
| *Caretta caretta* | | | | | | | | | | |
| Mean* (cm) | 69 | 66 | 66 | 87 | 74 | 71 | 71 | 75 | 85 | 81 |
| Range(cm) | 122-6 | 99-14 | 102-15 | 105-63 | 92-66 | 104-16 | 93-47 | 101-23 | 112-17 | 93-60 |
| sd | 38.7 | 31.0 | 34.5 | 17.4 | 11.2 | 32 | 17 | 24.8 | 21.9 | 9.7 |
| n | 5 | 5 | 7 | 3 | 6 | 5 | 7 | 10 | 14 | 23 |

* Carapace length over the curve

### Table 4: Causes of Injury and Death in Florida Keys Turtles 1983-1989 *

| | *Chelonia mydas* | *Caretta caretta* | *Eretmochelys imbricata* | *Dermochelys coriacia* | Unknown | Total |
|---|---|---|---|---|---|---|
| Papillomas | 70 | 1 + | 0 | 0 | 0 | 71 |
| Propeller- boat injury | 11 | 28 | 0 | 0 | 2 | 41 |
| Various Damage | 26 | 21 | 4 | 0 | 5 | 56 |
| Entanglement | 14 | 15 | 0 | 1 | 0 | 30 |
| Shark injury | 7 | 2 | 0 | 0 | 0 | 9 |
| Tar / oil | 5 | 0 | 1 | 0 | 1 | 7 |
| Poaching | 1 | 1 | 1 | 0 | 2 | 5 |
| Unknown | 34 | 36 | 7 | 0 | 14 | 91 |

*Categories may be used more than once for the same turtle + Papilloma-like growth, not verified histologically

# NESTING OF THREE SPECIES OF SEA TURTLE IN THE NORTHEAST COAST OF THE YUCATAN PENINSULA, MEXICO

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Less than 30 years ago, sea turtle capture was still a very important resource in the Yucatan Peninsula. Now, due to over-exploitation, sea turtle numbers have diminished to such a degree that some species are considered endangered. In 1973, sea turtles were given complete protection by Mexican law within its Gulf of Mexico jurisdiction. Since then, field stations have been established there to protect and study sea turtles. Since much of this research has not yet been published, the information is new. In this paper, field observations on three species of sea turtle (hawksbill, loggerhead and green turtle) from three stations located on the northeast coast of the Yucatan Peninsula have been combined and summarized.

Isla Contoy, 6.17 km in length, is located 30 km north of Isla Mujeres in the state of Quintana Roo, México. The Contoy study was undertaken during the 1984 and 1985 nesting seasons. Isla Holbox is located on the north tip of Quintana Roo and covers 12 km. The Holbox study was conducted during the 1988 nesting season. Rio Lagartos Reserve is located in the state of Yucatan. This field study covered 30 km of coastline during the 1987 and 1988 nesting seasons. Information obtained at each of these three field stations on the number of nesting females per season, the number of eggs per nest, the incubation period and the percentage of hatchlings will be compared and reviewed in this paper, and possible protection measures will be discussed.

Table 1 shows the number of females recorded per season in each area. The low number of females observed during the 1984 season at Isla Contoy can be explained by the nesting cycle frequency. In the case of green turtles, the nesting cycle is every 2 to 3 years (Carr et al., 1978). The three female green turtles counted at Isla Holbox were observed before Hurricane "Gilbert" (September 1988). It is possible that more turtles came ashore afterward.

The hawksbill nesting season in 1984 and 1985 began toward the end of April at all three study sites (coinciding with the beginning of the rainy season) and ended during August (Table 2). Compared to other locations, the nesting season interval was similar to that reported for Venezuela (Caribbean Conservation Corporation, 1980) and was shorter compared with Tortuguero, Costa Rica, where it begins in May and ends in November (Carr et al., 1966).

The loggerhead nesting season on Isla Contoy was the same (May through August) as for the central coast of Quintana Roo (Gil et al., 1988) and in Florida (Ehrhart, 1979). The green turtle nesting season (July through September) was similar for Isla Contoy and Rio Lagartos, also coinciding with that reported for Tortuguero, Costa Rica (Carr et al., 1978). On Isla Holbox, due to Hurricane "Gilbert", it was impossible to determine the exact end of the green turtle nesting season.

During the 1985 nesting season on Isla Contoy, 11 of 41 nesting female green turtles were found to be infected by a free-living parasitic leech attached mostly around the turtle's necks. The leech was identified as Ozobranchus branchiatus (Menzies, 1971). It is important to point out that this parasite has not previously been recorded for the Caribbean zone (Dr. Lamothe, Institute of Biology, UNAM, pers. comm.). It has been recorded for Malaya and Sarawak (Hendrickson, 1959), and a similar species has been reported for North Carolina (Schwartz, 1974). This could be an indication of migrations undertaken by green turtles between feeding areas and breeding sites. Before any conclusion can be reached on the subject, a detailed study is necessary. Nine of the green turtles infected with parasitic leeches also exhibited tumors of approximately 2 cm in diameter, a condition also observed in Florida and Tortuguero, Costa Rica. It has been suggested that these tumors may be useful as a natural tag to determine a turtle's origin, especially if the turtles are concentrated in a restricted area (Ogren 1989, p. 98).

Mean clutch size for each species is presented in Table 3. These figures are within the ranges cited for various western Atlantic localities (Hirth, 1980). During the 1988 nesting season on Isla Holbox, three hawksbill nests contained small eggs no bigger than 1 cm in diameter (5 in one nest and one in each of the other two nests). Another hawksbill nest contained 17 eggs, all with fragile shells joined together by excrescences.

For the hawksbill, the average interval between nestings was 21 days on Isla Contoy and Isla Holbox and 23 days at Rio Lagartos (Table 4). This average is 5 days longer than that reported for other Atlantic localities (Hirth, 1980). In the case of the loggerhead, only one nesting individual was seen, and it was observed to nest on four occasions. Twelve green turtles were recorded, ten of these nesting on two occasions and two nesting three times. The average interval between green turtle nestings was 22 days.

Table 5 summarizes the data obtained for nests left in situ. and for those that were transferred. The incubation period can vary due to a variety of factors, such as the number of eggs per nest and environmental variations (Witzell, 1983). Table 6 shows hatch rates from each of the camp sites. It can be observed that, in general, hatch rates are lower for transfered nests than for those left in situ. This may be due to lack of care while transfering eggs to the protected sites. The low hatch rate on Isla Contoy reflects the dual problems of unusually high tides and heavy predation by ants that are attracted to the nest as the young are hatching. It is worth mentioning here that twins hatched from two hawksbill nests on Isla Holbox while, in another nest, two of 109 hatchlings were albinos. One of the albinos also had a malformed upper mandible, and both died only a few days after hatching.

Table 7 lists the factors affecting the survival of sea turtle eggs and young at each of the camp sites; affected nests are enumerated. In the case of Isla Contoy, the main cause of nest loss is due to high tides which erode the beach. At Rio Lagartos and on Isla Holbox, the main factor is nest robbery. At Rio Lagartos, natural predation by mammals is also of prime importance. In all three study sites, natural factors, such as Hurricane Gilbert, were responsible for the loss of a good number of nests. Another factor affecting turtle populations is the predation of adult females, as well as natural mortality.

**Isla Contoy**: The fact that Isla Contoy has been declared an Ecological Reserve and that the Federal Government of Mexico has decreed its beaches to be a refuge and protection zone for sea turtles does not in itself guarantee that there is no disturbance of the different nesting species. Fishermen from the north of Quintana Roo and Yucatan use Isla Contoy as a base during the lobster-tail (Panulirus argus) harvest season which begins on July 15th. Turtle eggs and turtle meat are traditional sources of food during this time. Total or partial flooding of nests is the next most important cause of nest loss at this island site. Because there is intense fishing activity around Isla Contoy, the problem of turtles becoming ensnared in the nets of shark or shrimp fishermen should not be ignored. We do not know with any certainty how many animals are captured in this way.

**Isla Holbox**: According to the data for hatch rates and field observations, there is very little natural predation at this site. It is worth noting that there are no records of predation by the raccoon (Procyon lotor), despite the fact that raccoons were observed wandering along this beach on two occasions. The main problem in the Isla Holbox area continues to be human predation. Boats use this part of the coast heavily, and we have evidence of 27 nests being robbed, three of them from within the area where this study was carried out. At the start of the season, we found carapaces of three hawksbills that had been killed and the plates removed.

The passage of Hurricane Gilbert caused the loss of 13 nests at the Isla Holbox camp site, 12 hawksbills and one green turtle. It also seriously affected the latter species' nesting season and undoubtedly caused the death of hatchlings, juveniles and possibly adults at sea. An exploration of the beaches five days after Hurricane Gilbert revealed two dead juvenile green turtles. However, despite this natural phenomenon, human predation is by far most serious cause of loss of both nests and adult females at this site.

**Rio Lagartos**: As with Isla Contoy, consideration as an Ecological Reserve and having its beaches decreed a Refuge for sea turtles by the Federal Government is no guarantee of protection at Rio Lagartos. In addition to heavy human predation in this area, there is also considerable natural predation by raccoons (Procyon lotor) and foxes (Urocyon cinereoargenteus). Another threat to the turtles of Rio Lagartos are the activities carried out by the salt extraction industry (ISYSA) in the vicinity of the town of Coloradas. These activities affect approximately 12 kilometers of coastal dunes and cause a further reduction of nesting sites. There were also a great number of nests affected by Hurricane Gilbert. It is calculated that around 8,000 eggs were lost from 128 nests.

The problems in the areas studied can be summarized by the following points.

1) Reduction of suitable nesting sites by human settlements and pollution.
2) Lack of respect for legislation.
3) Public unawareness of the turtles' real situation.
4) Lack of continuity and trained staff in the recording of data at the camp sites.
5) The capture of females by shrimp boats in the area.

Due to the country's economic crisis and the length of coastline, it has been impossible to develop an efficient beach patrol system. Also, there are serious socioeconomic problems involved in turtle conservation, since the animals represent both economic gain and a source of food. Another factor that daily assumes greater importance is the pollution of the oceans and beaches. We have recorded instances of turtles dying from ingesting plastic waste. International regulations are vital in this respect. Some possible protection measures are as follows:

- Since Isla Contoy and Rio Lagartos are Ecological Reserves, it is necessary to establish zones where fishermen are allowed to make their camps while restricting access to the main beaches used by turtles or sea birds for nesting. By giving talks, local people would be encouraged to participate in looking after their natural resources. It is worth mentioning here that, throughout our stay at the Isla Contoy camp site, we received the enthusiastic support of several fishermen who worked with us without pay.

- Some authors (Alvarado and Figueroa, 1988) suggest that ecotourism might be one way in which to solve socioeconomic problems. Funds could be raised in this manner for turtle protection.

- On Isla Contoy, where there is a loss of nests due to high tides, it was necessary to transfer threatened nests to another place on the same beach at least 3 meters above the highest tide mark. At Rio Lagartos, all nests that run the risk of being robbed should be placed within corrals for their protection.

- At Isla Holbox, the data on the survival rate of young, together with the low rate of natural predation, suggests that this is a viable site to obtain a good number of young for repopulation. To this end, it is necessary to set up a camp site to protect nests in situ. A patrol launch is also needed, and all this should be backed up by an environmental education program for the coastal settlements.

- It is indispensable to achieve coordination between the various institutions involved in the protection and management of sea turtle resources, so that continuity can be established in research programs. A non-profit organization called PRONATURA currently organizes annual sea turtle workshops to establish coordination between the various governamental and research institutions involved in the protection and management of sea turtle populations. The next workshop will be in Merida, capital of Yucatán, March 5th through 7th of this year.

- A study should be carried out to evaluate the problem of turtles caught accidentally in the nests of shrimp fishermen. The use of the turtle exclusion device (T.E.D.) should also be promoted.

## CONCLUSIONS

The fact that three species of sea turtles nest on Isla Contoy makes it an interesting and important place for research. Continuous protection is necessary, so that we may learn more about the nesting biology of these organisms. The data obtained on Isla Contoy, Isla Holbox, and at Rio Lagartos, though showing slight differences, are within the ranges cited by various authors for the west Atlantic region. An in depth analysis should be carried out on the epiparasites and diseases of sea turtles. This would enable us to further our knowledge of certain aspects of their life cycle, such as migration and habitat preferences which are difficult to observe directly.

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## TABLES

Table 1. Number of females per year per species at the three fields sites.

| Sites | Nesting Season | Hawksbill | Loggerhead | Green |
|---|---|---|---|---|
| Isla Contoy | 1984 | 5 | 6 | 3 |
| | 1985 | 11 | 10 | 41 |
| Isla Holbox | 1988 | 21 | - | 3 |
| Rio Lagartos | 1987 | 29 | - | 17* |
| | 1988 | 28 | - | 29 |

* An estimate calculated from observed nests, based on 2.8 nests per female (Carr _et. al._, 1978).

Table 2. Mean clutch registered for each site.

| Specie | Site | No. of Nests | Mean Clutch |
|---|---|---|---|
| _E. imbricata_ | Isla Contoy | 25 | 149 (047-194) |
| | Isla Holbox | 56 | 152 (100-188) |
| | Rio Lagartos | 120 | 153 (019-229) |
| _C. caretta_ | Isla Contoy | 21 | 110 (071-177) |
| _C. mydas_ | Isla Contoy | 55 | 106 (069-163) |
| | Isla Holbox | 1 | 105 |
| | Rio Lagartos | 34 | 128 (096-147) |

Table 3. Factors affecting the hatch rate of sea turtles (number of nests affected).

| Factor | Isla Contoy | Isla Holbox | Rio Lagartos |
|---|---|---|---|
| High tides | 39 | - | 3 |
| Ants | 11 | - | - |
| Crabs | 1 | 1 | 5 |
| Diptera larvae | 5 | - | - |
| Fox and raccoon | - | - | 58 |
| Dogs | * | - | 7 |
| Human predation | * | 27 | 67 |
| Shoreline development | - | * | * |
| Hurricane Gilbert | * | 13 | 128 |

* Negative influence not ruled out.

# SEA TURTLES ON THE CHANDELEUR AND BRETON ISLANDS, LOUISIANA

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## INTRODUCTION

The Chandeleur and Breton islands are barrier islands derived from wave action on a Mississippi River subdelta. These islands, commonly referred to as "the Chandeleurs" (Figure 1), form an arc of 5 islands about 48 km east of New Orleans, LA. Hurricanes greatly alter the amount of exposed beach, but recovery is rapid; and in August 1989, we estimated that a total of about 71 km of beach facing the Gulf of Mexico existed (from south to north, Breton 8.6 km, South Gosier 4.3 km, North Gosier 2.5 km, Curlew 11.1 km, and Chandeleur 44.5 km).

Generally, the Chandeleurs are flat and without trees, although black mangroves (Avicennia nitida) occur in some areas. Dunes are best developed (sometimes attaining heights of about 6 m) on the northern portion of Chandeleur Island. The islands have a sandy beach on the Gulf sides. The beach sands are very fine, dark colored, and tightly packed. Southern beaches have a very high shell content. Salt-water marshes border sounds and Chandeleur Sound has extensive flats of submerged seagrasses.

The areas above high tide line of Breton, the Gosiers, and Chandeleur islands are part of the Breton National Wildlife Refuge. Title to Curlew Island is held by the Louisiana State Land Office. Except for a pilot house on Breton Island and a few house boats, usually anchored in the Chandeleur Sound, the islands are uninhabited. The islands are heavily used for recreational fishing. Aircraft and "recreational all terrain vehicles" have been observed on the beaches. Commercial fishing for finfish and shrimp occurs in the waters surrounding the islands.

Popular accounts have reported sea turtles being taken from the Chandeleur islands for the New Orleans market throughout the 1800s and as late as the 1940s. Because the islands are fairly remote, what species and how many turtles have nested on the islands have, until recently, remained unknown. Ogren (1978, unpubl. man.), based on interviews with fishermen, reported nesting sea turtles were "numerous" during the 1930s and 1940s. Viosca (1961, Louisiana Conserv. 13:5-8) reported Kemp's ridleys (Lepidochelys kempi) nested on the Chandeleurs. However, Ogren (1978, op. cit.) visited the islands in May 1962, and verified that the nesting turtles were loggerheads (Caretta caretta).

Ogren's investigations in the early 1960s were the last reported accounts of sea turtles on the islands until 1986, when we began to investigate the occurrence of sea turtles observed near the islands and stranded sea turtles on the islands. Our purpose is to report the incidence of stranded and nesting sea turtles on the Breton and Chandeleur islands.

## METHODS

From May through August and in October 1986, and in May and September 1987, we used small aircraft to observe marine animals in the vicinity of the Chandeleur islands (Lohoefener, et al. 1988, NOAA Tech. Mem. NMFS-SEFC-214:47-50). Turtle crawls and strandings on the islands were recorded. Stranded turtles were examined in May and June 1987.

Portions of the islands were searched for stranded sea turtles on 21-22 June, 12-14 July, and 27-28 July, 1988 (Fuller 1988, unpubl. man.). In 1989, searches for stranded turtles were usually preceded by an aerial survey of the entire beach, and effort was concentrated where stranded turtles were most frequently observed (Fuller 1989, unpubl. man.). Portions of the beaches were searched for stranded sea turtles and crawls on 15-17 May, 5-7 June, 8-11 July, 27-28 July, and 10-11 August. Additionally, beaches were searched for nesting turtles from about 2200 to 0100 h the nights of 8-10 July.

From June through May 1988, and from July through September 1989, the association of sea turtles with petroleum platforms in an area directly offshore of Chandeleur Island has been studied (Lohoefener, et al., 1989. NOAA Tech. Mem. NMFS-SEFC-232:103-104). In addition to recording sea turtles and fishing boats in the study area, a low altitude survey of the entire Chandeleur islands' beaches was conducted at least once per month. Locations of stranded animals and turtle crawls were recorded.

## RESULTS AND DISCUSSION

Loggerhead sea turtles attempted to nest along the entire Breton and Chandeleur islands beach. In June 1960, Ogren (1978, op. cit.) observed 2 crawls on one of the Gosier islands and 29 crawls on both west and east beaches of Chandeleur Island. In May 1962, Ogren (1978, op. cit.) found 3 recent crawls and collected loggerhead eggs on Chandeleur Island. Hoese and Valentine (1972, Univ. S. Louisiana Res. Series 10, 43 pp.) reported 7 crawls and 1 nest in June 1972, and Ogren (1978, op. cit.) reported 4 crawls and 1 nest in June 1977.

In May and June 1986, numerous crawls were observed on Chandeleur and Curlew islands. In July 1986, 13 crawls were observed on Breton Island. In May 1987, numerous crawls were observed on all beaches except those on the Gosier islands, and in June 1988, crawls were observed on Breton and Chandeleur islands. In 1989, crawls were found on all islands except Breton Island. Two crawls and 1 probable nest were found on June 30. Five crawls, all with probable nests, and one nesting loggerhead were observed from 9 to 11 June. Fourteen crawls were investigated on July 27 and 28. Seven of the turtles were thought to have nested.

In July 1989, at about 0700 h, a professional fish spotter pilot (R. Waters, pers. comm.) observed a leatherback (Dermochelys coriacea) leaving a nest about 2 km from the northern end of Chandeleur Island. How many sea turtles nest on the Chandeleurs is still unknown. Results from the aerials surveys, when extrapolated from the beach out to the 25 m isobath, suggested that from April through July, about 1200 large loggerheads (95% CI ≈ 570 to 1910) may be offshore of the islands.

From 1987 through 1989, 54 stranded sea turtles have been examined. Most (74%) have been large (90 - 100 cm CL) loggerheads, about 18% have been Kemp's ridleys, and about 4% have been green (Chelonia mydas) and leatherback sea turtles. No hawksbills (Eretmochely imbricata) have been found. Beach surveys found from 0.29 to 0.52 stranded turtles/km. Aerial surveys found from 0 to 0.12 turtles/km. Both surveys found stranded sea turtles most common from May through July. Offshore of the Chandeleurs, shrimp boats were most common (73%) from May through July. Loggerhead sea turtles that nest on the islands may be especially vulnerable to fishing boats that trawl near the islands.

## CONCLUSIONS

The Chandeleur and Breton islands comprise a long stretch of remote beach. The Chandeleur islands are probably the major loggerhead nesting beach in the western Gulf and perhaps, in terms of nesting turtles per beach km, the major nesting beach in the northern Gulf of Mexico. Loggerheads that nest on the Chandeleurs may comprise a valuable gene pool for this threatened species. It is important that sea turtles and seabirds nesting on Curlew Island, not part of the National Wildlife Refuge, and sea turtles in the waters surrounding the Chandeleur islands be afforded more protection. More research is needed to estimate how many loggerheads nest on the islands and how many of these nests produce hatchling turtles.

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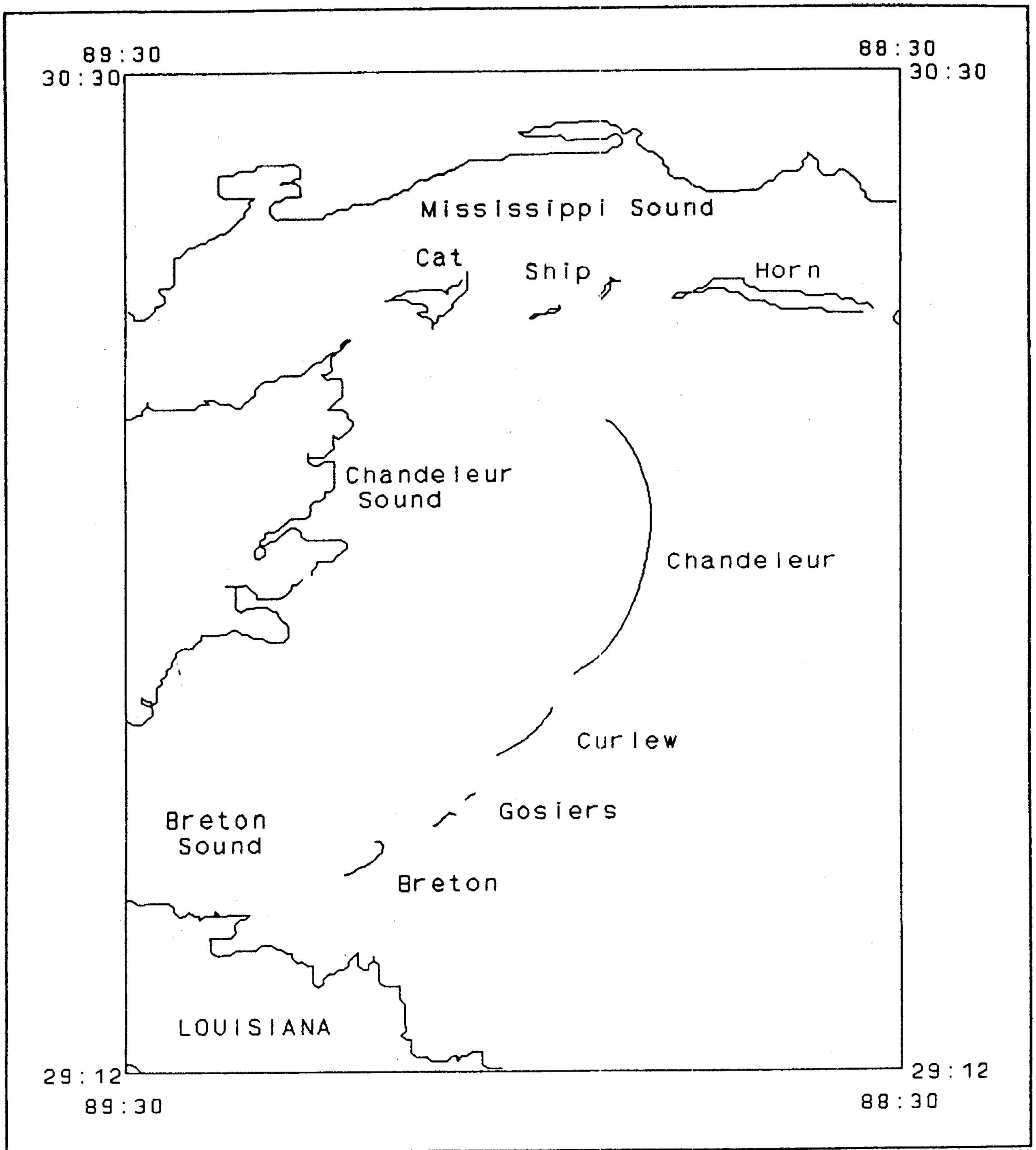

**Figure 1.** Location and extent (as of August, 1989) of Gulf beaches of the Breton and Chandeleur islands, Louisiana.

# MARINE TURTLES IN CHILE: AN UPDATE

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## INTRODUCTION

Despite its extreme austral position, Chile has great importance to marine turtles, both historically and biologically. The earliest published description of marine turtles in Pacific South American waters (outside of Galápagos) is from 1782 from Chile. There have been more scientific publications on Chilean turtles than from any other mainland country in western South America, or from many other countries in Latin America (Frazier and Salas 1983a; 1984; 1986; 1987). In addition, several new species, although not presently recognized, have been named from Chile; some of these have resulted in considerable confusion (Frazier and Salas 1984; Frazier 1985).

Four species are known to occur: Dermochelys coriacea, Chelonia mydas agassizi, Lepidochelys olivacea and Caretta caretta, in order of abundance. The most southern record of any sea turtle is from Chile, a Chelonia mydas agassizi at 52° 57' S. Chilean records of Dermochelys and Lepidochelys are the most southern in the world (Frazier and Salas 1984).

Nonetheless, Chile is frequently omitted in regional discussions of marine turtles (e.g., Symposio sobre tortugas marinas del Pacífico Americano, Robinson 198x). It is frequently assumed that the occurrence of these reptiles in Chile is irregular and that there is little biological importance in these austral records. Recent information (e.g., Cárdenas and Stutzin 1985; Frazier and Brito, in press; Frazier, in prep.) indicates that certain species occur regularly, and, in fact, the marine turtle situation in Chile must be taken into account to better understand these animals. The present note summarizes some of this information.

## REVIEW OF THE MARINE TURTLE SITUATION IN CHILE

During 1988 and 1989 there are records of no less than 30 D. coriacea from the swordfish fishery of San Antonio, Chile, most of which were captured incidentally between January and July (the main fishing season). A fisheries technician in San Antonio estimated that at least 250 Dermochelys are caught annually by just the San Antonio swordfish fishery, so the total annual capture for all Chilean ports would be several hundred. With few exceptions, all individuals reported have been of adult size. On several occasions two or three animals have been seen or netted together (Frazier and Brito, in press).

The appearance of Dermochelys coriacea in Chilean waters is a regular phenomenon. Sightings of several animals together indicate that some kinds of group movement take place. Curiously, there are as yet no indications of jellyfish blooms at the surface coinciding with the occurrence of the turtles, as happens in the North Atlantic. Although no marked animals have been recovered from Chile, it seems likely that the enormous nesting populations of México and Costa Rica are the sources of the Chilean Dermochelys.

Some animals are captured opportunistically with harpoons, and there is occasionally sale of meat and trophies (Cárdenas and Stutzin 1985; Frazier and Brito, in press). In Pucusana, Perú, there have been years when hundreds of these turtles have been caught on the high seas and sold in local markets (Hays Brown and Brown 1982). However, direct exploitation in Chile is apparently not common and represents little threat. On the other hand, the incidental capture of this species in Chilean swordfish nets has reached the level of an important threat for "migratory" adults.

Chelonia mydas agassizi is common along the Chilean coast, where it is recorded not only during the austral summer but also the winter. Adults and immatures have been documented (Frazier and Salas 1984). Stomach contents indicate that the animals are feeding on near-shore algae.

C. m. agassizi is the most abundant species in Perú, where adults and subadults occur (Frazier 1979; Hays Brown and Brown 1982; Frazier and Salas 1983b). In 1987 it was estimated that some 22,000 individuals were captured at San Andrés (Aranda 1989).

Numerous Chelonia tagged in Galápagos have been captured in Perú, indicating that there are regular migrations between the islands and the mainland (Hays Brown and Brown 1982; Aranda and Chandler 1989). Although no tagged Chelonia are recorded from Chile, it is likely that the Galápagos population is, at least partially, the source of these animals.

Lepidochelys olivacea is reported along the northern coast of Chile, and it may be common in certain seasons in the extreme north. However, earlier claims that it is abundant, and supports a fishery, have not been confirmed. The majority of the Chilean specimens are of adult size (Frazier and Salas 1984). Small groups of these turtles have apparently been seen in Chilean waters (Cárdenas and Stutzin 1985).

L. olivacea is not common in Perú (Frazier 1979; Frazier and Salas 1983b; Aranda and Chandler 1989). Remarkably, there is a record of nesting in the northern extreme of the country at 3° 30' S (Hays Brown and Brown 1982); this is the farthest south that this species is known to nest.

No tagged Lepidochelys have been documented from either Perú or Chile. However, by simple probabilities, it is likely that these austral individuals come from the massed nesting populations of México and Costa Rica. In spite of earlier claims, there is no evidence of regular or direct exploitation of this turtle in Chilean waters. On occasion the odd individual may be sold for a trophy, or the meat may occasionally be eaten.

Although earlier publications claimed that Caretta caretta is common in Chile, to date only two specific records are known, and only one can be verified with a specimen (Frazier and Salas 1984). There is a recent report of other specimens (Aranda and Chandler 1989), but it is not known on what this was based. The rareness of this species in Chile conforms to the overall pattern in the East Pacific, where the species is unknown from other South American countries and very rare in Mesoamerica (Frazier 1979; 1985; Frazier and Salas 1983a; b; 1986; 1987).

Despite numerous confused reports of Eretmochelys imbricata in Chilean waters, there is no verified specimen (Frazier and Salas 1984). This species is also uncommon in the East Pacific (Frazier and Salas 1983a; 1986; 1987). Several specimens were reported from the north of Perú by Hays Brown and Brown (1982), and more recently there have been claims of specimens south of Lima (Aranda and Chandler 1989). While it is unlikely to occur in continental waters of Chile, this species may exist in the tropical seas around Easter Island (part of Chile), but this has yet to be proven.

There are occasional reports of marine turtles nesting in Chile (Frazier and Salas 1984; 1986). In fact, one beach near Iquique is "famous" for its nesting turtles, but as yet there has been no verification of this claim. Indeed, nesting in Perú, although also rumored to occur, is virtually undocumented (Aranda and Chandler 1989).

During Niño years, large bodies of tropical water, with tropical organisms, replace the normally cold near-shore waters off Perú and Chile. The phenomenal 1987 catch of 22,000 Chelonia referred to by Aranda (1989) could be explained by this phenomenon, and years with exceptional numbers of marine turtles are normally Niño years. However, the occurrence of turtles in austral waters is not tied to the Niño.

There are depictions of marine turtles in rock paintings in northern Chile and a cranium in a Precolumbian site. Hence, man's knowledge of marine turtles in Chile is ancient, and exploitation evidently occurred during prehistoric times. Curiously, archaeological remains of marine turtles are remarkably rare in Perú, despite millennia of coastal cultures (Frazier and Salas 1983b; Frazier and Bonavia, in prep.).

## SUMMARY

Four species of marine turtle are documented from Chile; two, Dermochelys coriacea and Chelonia mydas agassizi, are common, widespread, and may occur year round. The source of these animals is unknown but likely to be Mesoamerican and Galápagos rookeries. Direct exploitation is not a threat, but incidental capture is, notably for Dermochelys.

## ACKNOWLEDGMENTS

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# PHOTOPOLLUTION ON SEA TURTLE NESTING BEACHES: PROBLEMS AND NEXT-BEST SOLUTIONS

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The artificial lighting of sea turtle nesting beaches is increasing. The term "photopollution" has been used to describe this condition, given the detrimental effect that artificial lighting has on sea turtles (Verheijen, 1985). Photopollution has been found to drastically alter the behavior of adult and hatchling sea turtles, resulting in harassment and mortality. In this outline, I review some recent work on how photopollution affects sea turtle behaviors, and what measures may be employed to mitigate these effects.

## Hatchling Orientation

It has long been known that artificial lighting can disrupt the ability of hatchling sea turtles to find the ocean following their nocturnal emergence from beach nests. In the presence of artificial lighting, hatchlings become misoriented (move in a direction other than the ocean, typically toward the light source) or disoriented (unable to establish a constant orientation). Hatchlings so affected often die due to exhaustion, predation or desiccation.

I have conducted experiments to determine what role light intensity and wavelength (color) play in the orientation response of hatchlings (Witherington and Bjorndal, in review), and how commercially available luminaires affect hatchling orientation on beaches (Witherington and Bjorndal, in press).

Intensity and wavelength. I examined the effect of light intensity and wavelength on hatchling orientation using two-choice experiments. The attraction that light has for hatchlings of loggerheads (Caretta caretta), green turtles (Chelonia mydas), hawksbills (Eretmochelys imbricata), and olive ridleys (Lepidochelys olivacea) generally increases with intensity. Some isolated wavelengths, however, are more attractive than others. Green turtles, hawksbills and olive ridleys are strongly attracted to near-ultraviolet (360 nm), violet (400 nm), blue (450 nm), and green (500 nm) light. They are weakly attracted to yellow and orange light (580-630 nm), and ignore red light (700 nm). Like the previous species, loggerheads are strongly attracted to light in the near-ultraviolet to green range. In contrast, loggerheads are not attracted to yellow-orange light but are averse to (move away from) light in this range. Loggerheads are attracted to red light only at high intensity.

Commercial light sources. I determined how commercial light sources affect hatchling orientation with controlled observations of hatchlings on beaches in the presence of various lighting types. Green turtles were strongly attracted to white, mercury vapor (MV) luminaires (400-700 nm) and weakly attracted to yellow, low pressure sodium vapor (LPS) luminaires (590 nm). Loggerheads were strongly attracted to white (400-700 nm) and red incandescent (570-700 nm, major; 400-450 nm minor) and high pressure sodium vapor luminaires (500-700 nm, major; 410-500, minor). Loggerheads showed a varied response to yellow incandescent (bug light) luminaires (500-700 nm) and were averse to light from LPS luminaires.

The aversion that loggerhead hatchlings show toward the yellow light of LPS luminaires makes these sources attractive as an alternative to other light sources on loggerhead nesting beaches. Because green turtle hatchlings are only weakly attracted to yellow LPS light, a similar argument can be made for substituting LPS luminaires on green turtle nesting beaches.

There are also indications that beach lighting may influence hatchling orientation at sea. The extent to which this may occur and how different commercial light sources affect this behavior are in need of additional study.

### Adult Nesting

Concerns with the effects that beach lighting may have on sea turtle nesting behavior prompted experiments I conducted with nesting adult loggerheads at Melbourne Beach, Florida, USA, and green turtles at Tortuguero, Costa Rica (Witherington, in prep.). White, MV luminaires discouraged both green turtles and loggerheads from emerging from the sea and nesting. Lighted LPS luminaires, equal in brightness (illuminance) to the MV luminaires used, did not significantly affect loggerheads or green turtles nesting or attempting to nest. Orientation of some adults attempting seaward returns was disrupted, primarily by MV luminaires.

## RECOMMENDATIONS

The most thorough way to eliminate problems caused by photopollution on sea turtle nesting beaches is to extinguish all artificial lighting visible to turtles from the beach. In many instances, however, local residents may be unwilling to adopt such extensive measures, leaving alternatives necessary. Some alternatives to complete beach darkening that have been proposed or are in practice are presented here. These alternatives are, at best, next-best solutions and vary in how acceptable they may be.

Time restrictions. This alternative involves restricting beach lighting to times of the night when the lighting will least affect sea turtles. In practice this solution may be a poor compromise, given that at least for loggerheads, hatchlings are emerging from nests all night long (Witherington et al., in press). On a larger time scale, sea turtle nesting and hatching at most areas are seasonal, leaving months when sea turtles are not present. Beach lighting may be used during these times without effect.

Area restrictions. Restricting beach lighting to areas of beach where little or no nesting occurs has been proposed. The effectiveness of this measure is diminished by the fact that light sources several kilometers away from emerging hatchlings can disrupt their sea-finding orientation.

Motion sensitive lighting. This sensor-activated lighting only comes on when a moving object (e.g., a person) approaches the luminaire. Such lighting would be expected to affect hatchling orientation minimally in "low-traffic" areas. Equipping these luminaires with yellow-tinted incandescent lamps may be the least disruptive application for loggerhead nesting beaches.

Shielding and lowering. Lowering light sources and shielding them away from the beach direction reduces the amount of light reaching the beach. Although reducing light reaching the beach will also reduce effects on sea turtles, it should be realized that very little light "leakage" (reflection, scatter) is necessary to disrupt hatchling orientation nearby.

Alternative light sources. The most acceptable luminaire tested has been LPS. LPS luminaires placed opposite the seaward direction of emerging loggerhead hatchlings will have no significant effect on their seaward orientation. For green turtle hatchlings, LPS lighting is a poorer alternative but preferable to other lighting types. Yellow-appearing incandescent lamps that emit primarily yellow and red light, and exclude shorter wavelengths (e.g., bug lights), constitute a good alternative to other types of lighting on loggerhead nesting beaches but a poorer alternative than LPS. Using these alternative light sources as substitutes for other lighting types, especially in combination with effect-reduction techniques listed above, is the best strategy for reducing the effects of photopollution on sea turtles, short of complete beach darkening. Light from these sources that reaches the beach incidentally is of a spectral quality that minimally affects the behavior of loggerhead and green turtle hatchlings and adults. Although laboratory studies suggest that hawksbill and olive ridley hatchlings are similar to green turtles in their response to spectral light, adults of these species, and hatchlings and adults of other species, have yet to be studied.

## ACKNOWLEDGMENTS

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# AN ALTERNATIVE PROTOCOL FOR THE QUALIFICATION OF NEW TURTLE EXCLUDER DEVICES (TEDs)

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## INTRODUCTION

Federal regulations have been implemented which require mandatory use of turtle excluder devices (TEDs) by shrimp trawlers (Federal Register, June 29, 1987). Ted use is dependent on boat size, location in the southeast Atlantic, Gulf of Mexico, and season. The regulations provide for the qualification of new TED designs if the new TEDs are found to be at least 97 percent effective in releasing sea turtles from shrimp trawls when tested according to specified procedures.

Certification testing of new TEDs has been based on a comparison of sea turtle catch rates between a standard shrimp trawl and a TED-equipped trawl when towed in the Cape Canaveral, Florida ship channel. This area has been used in the past because it has had a seasonally high sea turtle abundance. In March 1989, the National Marine Fisheries Service (NMFS) attempted certification testing of several new TED designs, however, too few turtles were present to permit testing. Thus, NMFS needed an alternate test procedure.

In August 1988, NMFS tested certified TED designs by using 2-year-old captive-reared green turtles (<u>Chelonia mydas</u>) as surrogate wild turtles. An operational technique was developed for the test in which scuba divers introduced the turtles into a TED-equipped trawl to evaluate small turtle behavior and rate of escape through the TED (Mitchell, et al. 1988). This technique was used again in May 1989 to study the feasibility of using the method as a TED qualification procedure.

## METHODS

Methods used for this testing procedure rely on evaluation of the candidiate TED by a team of NMFS scuba divers experienced in diving on operational trawling gear. Testing is conducted in clear, shallow waters offshore of Panama City, Florida or an alternate site if conditions are deemed suitable

Scuba divers conduct preliminary observations and make underwater video recordings of candidate TED designs. Video tapes are then reviewed by the participating TED designer in order to determine if tuning or modifications are necessary prior to testing. When the designer is satisfied with the configuration of his/her TED, testing is initiated. No further changes to the TED design are allowed once the test is started.

Turtles are transported from the vessel to divers on the trawl inside a herculite bag which is attached to and slides along a messenger wire. Once released into the trawl by a diver, a turtle is given a total of 5 minutes to escape through the candidate TED. At the end of the 5 minute time limit the turtle is scored as an escape (having successfully exited the trawl through the TED) or as a capture (the turtle did not exit the trawl within 5 minutes). Previous testing (Mitchell, et al., 1988) found that 87 percent of escaping turtles did so within the first 2 minutes after being released into the trawl. Therefore, the 5 minute time period has been determined sufficient to identify technical problems associated with a turtle's escape through a TED while minimizing physiological stress to the turtle.

If the turtle's health becomes endangered during a test, it is removed from the trawl, escorted to the surface by a diver, and returned to the vessel for recovery. The turtle is not included in the test's sample set.

This alternate test protocol requires an adequate supply of 2-to 3-year-old sea turtles. The qualification test for each candidate TED will be comprised of at least 25 turtle releases. Each year a quantity of headstarted Kemp's ridley sea turtles (Lepidochelys kempi) will be held back from the normal release program of the NMFS Galveston Laboratory. The turtles will be about the size of average 2-year-old Kemp's ridleys.

Sampling Procedure

To adjust for variability within the testing procedure, the turtle exclusion efficiency of each candidate TED will be compared to the performance of a control TED under the same test conditions. In the 1989 feasibility study, the NMFS TED was selected as the control. The NMFS TED is currently the only TED that has been tested using both certification techniques with loggerhead, (Carretta carretta), green and Kemp's ridley sea turtles, and has had exclusion rates confirmed during commercial fishing operations.

As the number of turtles available to conduct the tests is limited, a candidate TED may be declared as having failed to pass the test before a complete sample set of 25 has been used. This option is exercised if the TED has reached a maximum number of captures based on the performance of the control TED.

Statistical approach

The statistical approach used to compare performance of the candidate TEDs to the performance of a control TED is to test for the equality of proportions. The null hypothesis is: $H_0$: $P_1 \leq P_2$ or, the exclusion rate of the candidate TED ($P_2$) is equal to or greater than that of the control TED ($P_1$). The alternative hypothesis is: $H_1$: $P_1 > P_2$ or, the exclusion rate of the candidiate TED ($P_2$) is less than that of the control TED ($P_1$). The test statistic is:

$$Z = (\hat{p}_1 - \hat{p}_2) \; / \; ( [\hat{p}_1 \hat{q}_1 / n_1] + [\hat{p}_2 \hat{q}_2 / n_2] )^{1/2}$$

where

$\hat{p}_1$ = the observed proportion excluded by the control TED

$\hat{p}_2$ = the observed proportion excluded by the candidate TED

$\hat{q}_1 = 1 - \hat{p}_1$, and $\hat{q}_2 = 1 - \hat{p}_2$

$n_1$ = the number of turtles introduced throght the control TED

$n_2$ = the number of turtles introduced through the candidate TED

Then the calculated Z score is compared to the appropriate percentile Z score to make a decision. The probability of rejecting an acceptable candidate TED or of committing Type I error ($\alpha$) will be fixed at the 10 percent level. The probability of accepting a poorly performing candidate TED or of committing Type 2 error (B) will be "minimized" by increasing sample size if necessary. An illustrative example is provided in Figure 1.

Given the predetermined level of $\alpha$, the sample size and the exclusion rate of the control TED, the maximinm number of captures for the candidate TED can be determined which will lead to the rejection of the null hypothesis. These computations will allow for early termination of the test if the number of captures for the candidate TED reaches this predetermined number.

## SUMMARY

Upon completion of the qualification tests, a technical review committee may be convened to review all test results. The committee will be composed of industry, conservation and government representatives. The committee will review and confirm the results of the qualification tests and make certification recommendations to the NMFS Southeast Regional Director.

This alternative method of TED certification will help ensure that future TED designs will be efficient in excluding smaller sea turtles. Additionally, because this method requires in situ observation of TED performance, it can assist industry in designing new TEDs which will have minimal effect on overall trawl dynamics, thus maintaining trawl efficiency and catch retention.

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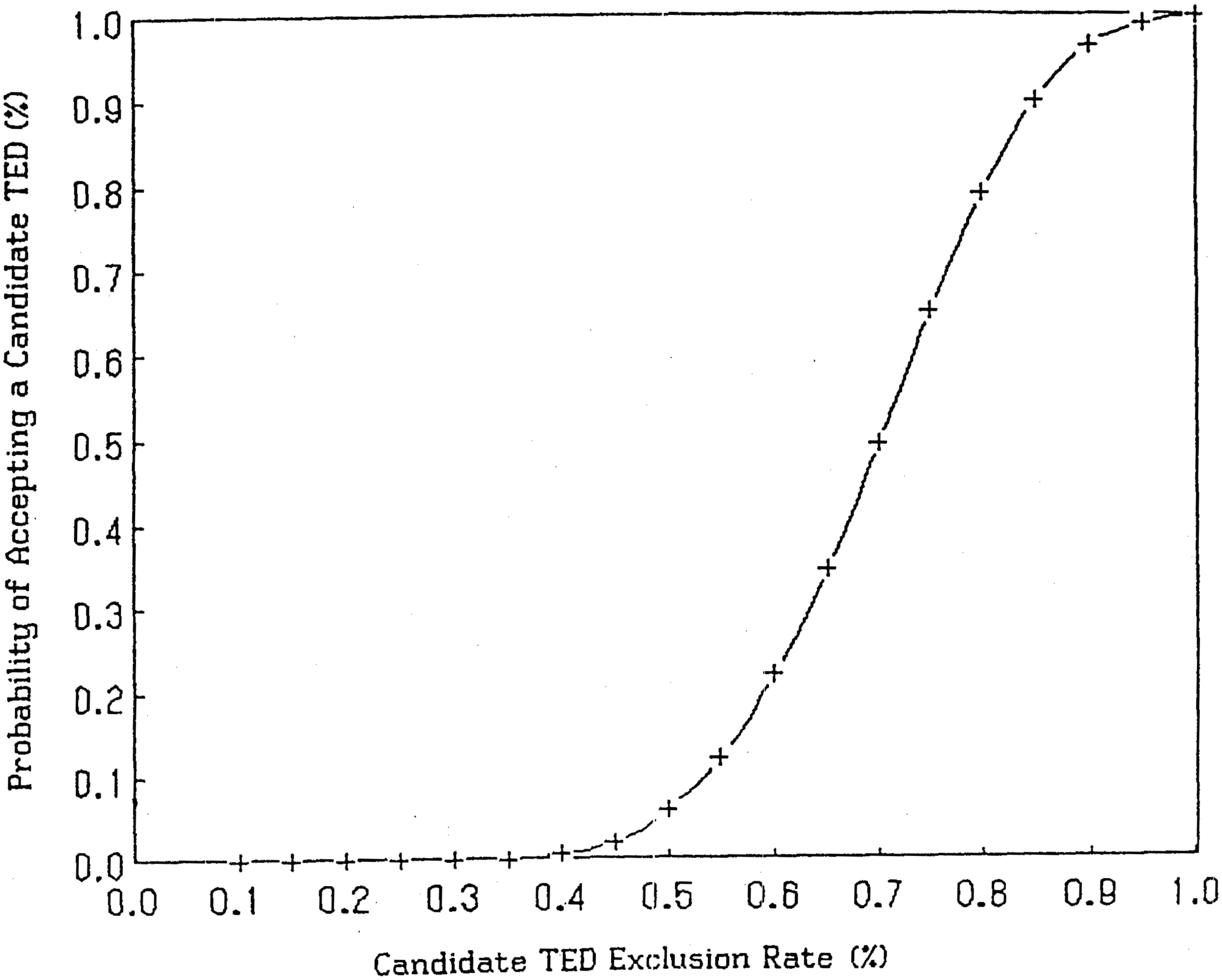

Figure 1. Probability of Accepting a Candidate TED
With Various Exclusion Rates
($\hat{p}_1 = 0.85$, $N_1 = N_2 = 25$, $\alpha = 0.10$)

# THE IMPORTANCE OF TESTING TED EFFICIENCY IN COSTA RICA

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Incidental capture of sea turtles by shrimp trawlers has mainly been evaluated in the south Atlantic shrimp fishery of the United States. This industry has proved to be major threat to the survival of loggerhead (Caretta caretta), Kemp's ridley (Lepidochelys kempi) and green (Chelonia mydas) sea turtles (Mager, 1985). The mandated use of TEDs in the United States is considered a critical sea turtle conservation measure (Donnelly and Weber, 1988).

In Costa Rica, the olive ridley (Lepidochelys olivacea) is the species most threatened by shrimp trawling activity (Cornelius, 1986). This species exhibits mass synchronous nesting involving as many as 150,000 individuals in the aggregation. The mass nesting phenomenon, called an "arribada" in Latin America, occurs monthly and may last from 3 to 5 nights. The largest arribadas occur between August and November. Two important arribada beaches, Ostional and Nancite, are located on the north Pacific coast of Costa Rica (Cornelius and Robinson, 1986). Olive ridleys are carnivorous, feeding on shrimp, crabs, sessile and pelagic tunicates and medusae in Costa Rican waters (Rice, 1973; Power and Moertel, 1980). The waters of Costa Rica's north Pacific coast appear to be especially important foraging habitats (Cornelius and Robinson, 1986), and they also happen to be important for the shrimp fishery. Rice (1973) estimated that a single trawler incidentally captures an average of 8.5 sea turtles per day during September, October and November in front of Ostional Beach. This equals an estimated 255 turtles captured per month or 1,020 turtles captured from August to November. According to Costa Rica's Fishery Service, 69 shrimp trawlers are registered to fish along Costa Rica's Pacific coast (MAG, 1987. pers. comm.), yet it is impossible to estimate how many of the 69 vessels actually fish in these waters, since they are free to fish anywhere. Nevertheless, if it is estimated that at least 20 trawlers work this area, then 20,000 olive ridleys could be incidentally captured by Costa Rican shrimp trawlers from August to November of each year.

Other estimates indicate that 200 turtles are incidentally captured daily, with up to 45 turtles in a single haul (Cornelius, 1986). Cornelius and Robinson (1986) suggested that an unknown but significant portion of each year's arribada aggregation remains in Costa Rican waters after the peak nesting season. Thus, incidental capture is expected to be high year round. Tag recovery data by Cornelius and Robinson (1986) indicate that, of the 71 tag recoveries received from territorial waters of Costa Rica, 65 recoveries were associated with artisanal and commercial fishermen (53 in shrimp trawls, 4 in nets for shark, and 8 on hooks or in other types of nets). On May 2, 1989, the government of Costa Rica prohibited by decree (#18944-MAG) all commercial fishing within 12 miles of Ostional Beach as a measure to protect the nesting population. However, the government order was later modified and limited to only 5 miles (Alvarado, pers. comm.). Alvarado (1990) believes that turtle strandings have increased at Ostional Beach since the modification took place, with up to 20 incident reports daily during periods of heavy nesting activity.

The mortality rate for incidentally captured turtles in the Pacific shrimp fishery of Costa Rica is about 35-50% (Rice, 1973; Power and Moertel, 1980), but live turtles are either sacrificed onboard in search of eggs or are thrown overboard without a chance of recovering from the stress and can drown. Cornelius and Robinson (1986) indicate that shrimpers report a 79.5% turtle mortality rate in trawl nets.

The people of Costa Rica's Pacific coast do not include turtle meat in their diet. However, demand for eggs is high primarily because of the aphrodesiacal powers attributed to them. A small town near Ostional currently exploits turtle eggs in a rational manner under a management program supervised by biologists. The egg harvest is conducted under a permit established through law #7064 dated 29 April 1987. This egg harvest not only helps local residents economically, but, by offering eggs legally and at lower prices, the practice also discourages turtle egg poaching which occurs on practically every other beach of the Pacific coast where solitary nesting occurs (A. Chaves, pers. comm.). If sea turtle populations decrease, so will egg production at Ostional, and poaching would again be encouraged and focused on solitary nesters. The contribution of solitary nesters to the populations of ridleys may be much more important than once suspected (Castro, 1986); thus, the importance of keeping poaching pressure off of these individuals is self-evident.

by-catch is very high in Costa Rica. According to Campos (1986), up to 6,000 metric tons of by-catch is discarded yearly by the shrimp fishery. An estimated 34.18% of the total catch by weight is shrimp, and 7.58% is marketable fish. The remainder of the catch is discarded, 70% of which is small fish including juveniles of commercial species that are discarded with the bi-catch because of their small size (Campos, 1983). Trawling activity in the outer part of the Gulf of Nicoya undoubtly imposes a serious fishing pressure on non-recruited juveniles of commercial fish species (Campos et al. 1984).

The importance of testing TED efficiency in Costa Rica is evident. In the United States, tests indicate that TEDs can reduce incidental capture of sea turtles by 98% and reduce by-catch by 70% without affecting significantly the shrimp catch (Christian and Harrington, 1987). The use of TEDs would not only protect sea turtle populations but would also support the programs of the citizens of Ostional and discourage illegal poaching. TEDs would focus fishing effort on target species such as shrimp and would protect other finfish resources that are now being affected by shrimp trawling.

A project is currently being developed jointly by the Sea Turtle Program of the School of Biology, University of Costa Rica, and the most important shrimp harvesting company of Costa Rica (Talmana). A major concern is the possibility that the United States could restrict shrimp imports from countries not using TEDs. by-catch composition and shrimp trawling conditions in the United States are different from those in Costa Rica. Thus, it is necessary for both industry and sea turtle conservation interests to determine the feasability of using TEDs in Costa Rican Pacific waters.

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# A DOCUMENTED CASE OF GREEN TURTLES KILLED IN AN ABANDONED GILL NET: THE NEED FOR BETTER REGULATION OF FLORIDA'S GILL NET FISHERIES

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The strandings of juvenile green turtle carcasses are common events along the southeast Florida coast. In the past two years at least 266 green turtles (most of them juveniles) have stranded in the six-county area from Brevard to Broward. These green turtles seem to have been ignored in the following two ways. First, we have failed to account for them in our attempts to model the ecologic geography of Western Atlantic green turtles. They have not, in other words, been assigned to a recognized life history stage. It's not that this neritic population of green turtles is completely unstudied. Over the past few years Martin and Ernest, working in Martin County, have suggested that the extensive near-shore reef system should be recognized as an important transitional habitat, used extensively by green turtles prior to entry into the lagoon system. Similarly, the Wershovens have documented the use of near-shore reefs by green turtles in Broward County.

J. L. Guseman and I have recently begun to study the population of green turtles on the reefs off northern Indian River County. Guseman's paper, presenting preliminary biological results, appears elsewhere in this volume. It is, however, important to point out here that there are rocky, algae-covered reefs, built by Seballariid polychaete worms, all along the southeast Florida coast. There is now reason to believe that a large assemblage of young green turtles resides on these reefs and that the reefs constitute a previously unrecognized developmental habitat.

The second way that we have ignored these southeast Florida green turtles is that we have taken a languid approach to their conservation and management. The numbers to the right of the east coast counties on Figure 1 indicate the minimum number of green turtle carcasses known to have stranded there in 1988 and 1989. The numbers rise sharply in the counties with near-shore reefs. The principal cause of the mortality reflected in these numbers appears to be drowning in the nets of two types of gill net fisheries. Until now, however, there has been little proof.

On 16 October 1989, the Florida Marine Patrol received reports of a gill net abandoned over the reef in northern Indian River County, off the town of Wabasso. A Coast Guard cutter was summoned from Ft. Pierce to retrieve the net, which was estimated to be >1000 yds. As the net was pulled over the high gunwales of the cutter, many carcasses fell into the water. How many were turtles is unknown.

In addition to a large number of dead stone crabs, Florida lobsters, and various cartilaginous and bony fishes, there were 10 green turtle carcasses and parts of one loggerhead. The dead green turtles ranged in carapace length from 27.0 to 58.2 cm. Morphometric data for these greens were statistically similar to those of the live green turtles we had been capturing and tagging nearby on the reef (Figure 2).

Another documented case of the killing of green turtles by a gill net occurred during the period from 9 to 11 February 1990, in Brevard County. In this case at least four greens died in a net set a few hundred yards off the beach at Patrick Air Force Base.

There is another gill net fishery off the southeast Florida coast that threatens turtles. It is the drift net fishery for king mackerel and sharks. It takes place farther off-shore, in federal waters which begin three miles out. The huge nets that are employed are often >4000 yds long and are hauled back by powered "hi-rollers." Occasionally the nets (or parts of them) are lost and become ghost nets, catching many things, including sea turtles, over the nets (or parts of them) are lost and become ghost nets, catching many things, including sea turtles, over long periods.

The peak period for drift netting for "kings" is April-May, and the season is closed November through March. During the closed season, however, the fishermen switch to larger-mesh nets, which are probably more dangerous to turtles, and fish for sharks. We know comparatively little about this fishery. One observer-based study of the fishery at Ft. Pierce produced results that were useful up to a point. It appears to us that encounters with marine turtles may have gone unnoticed, however. As a result, we are calling for the implementation of effective observer programs, carried out by adequately-trained observers throughout the year, in both the near-shore pompano fishery and the off-shore drift net fishery.

We offer the following further suggestions:

1) For both fisheries there should be tighter regulations regarding identification and/or registration of nets;
2) Gill netters should be required to "tend" their nets while they are soaking, as they do in the lagoon, and nets should be checked at least once per hour;
3) Any net left unattended should be considered abandoned, and officials should be authorized to pull and destroy it. Currently that is apparently not the case in Florida.

## CONCLUSION

There is an important assemblage of green turtles living over the reefs along the southeast Florida coast. These turtles are threatened by a near-shore gill-net fishery, primarily for pompano. Turtles are also threatened farther off-shore by the drift net fishery for king mackerel and sharks. We urge the conservation organizations to recognize this problem and take action. Also, state and federal agencies should, at the very least, begin effective observer programs and move quickly to install regulations that will protect this important green turtle population.

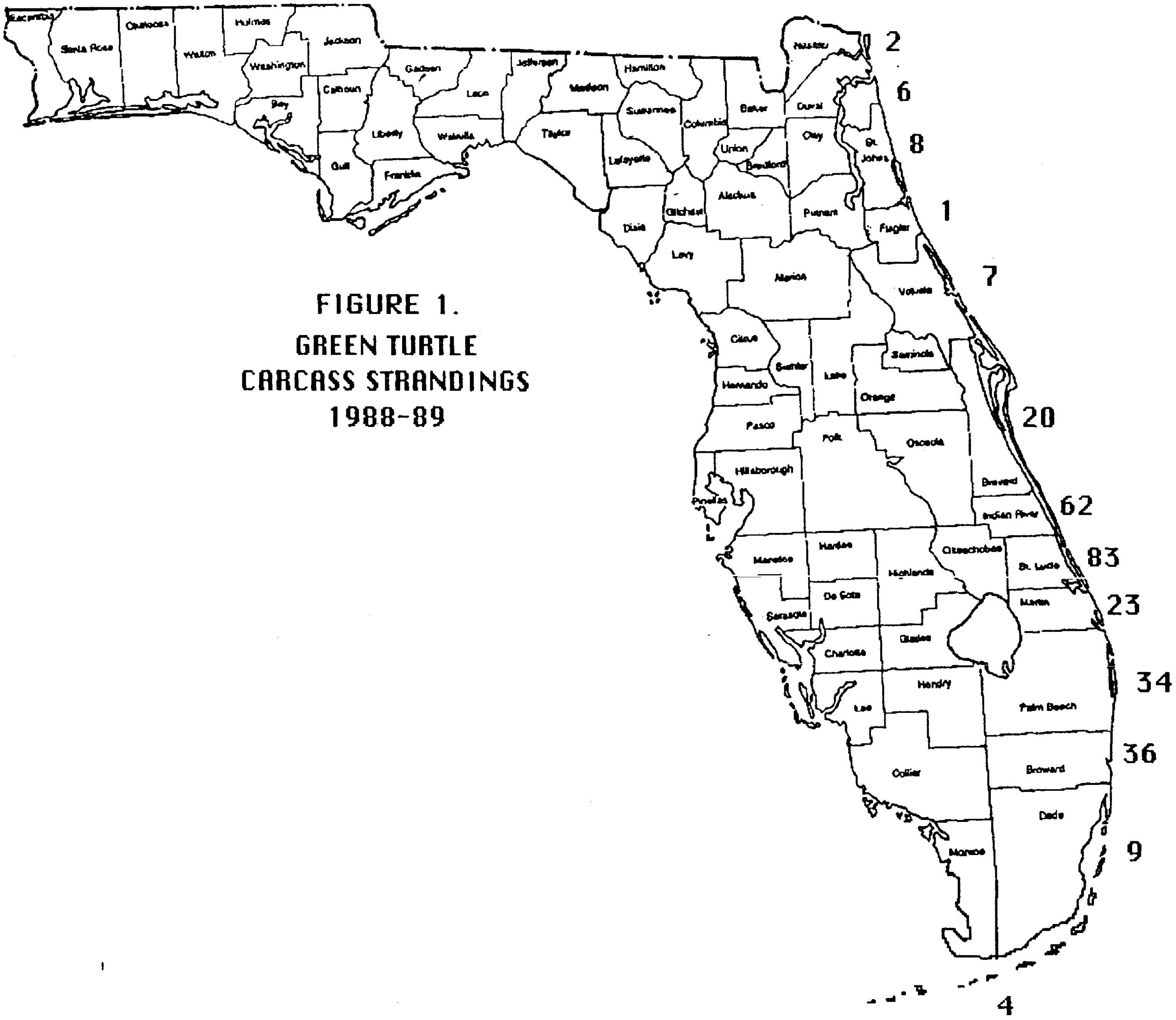
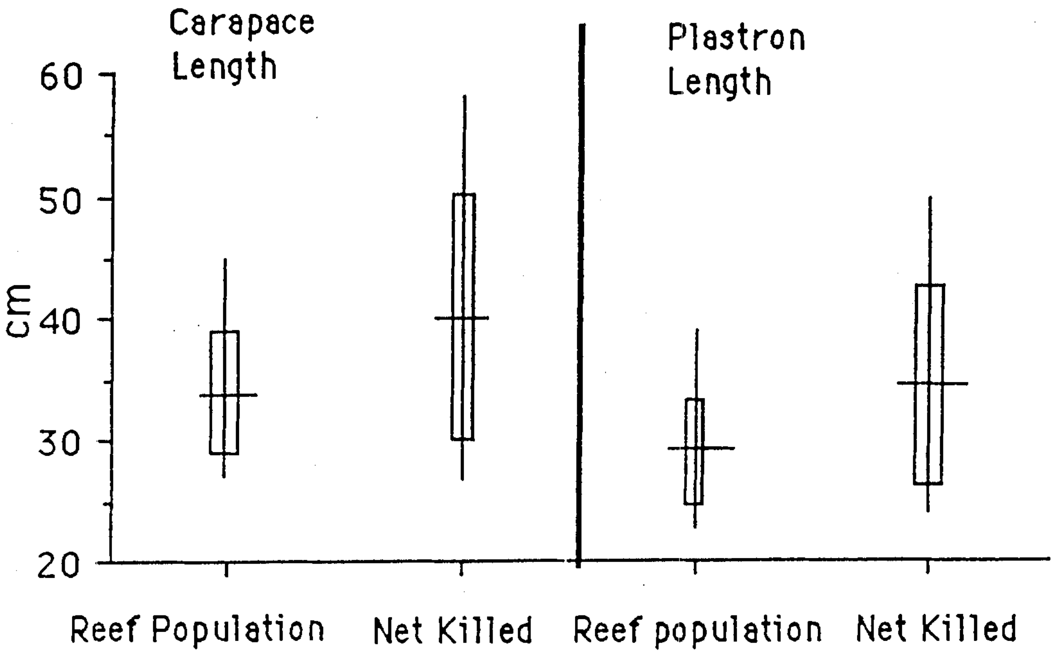


FIGURE 1.
GREEN TURTLE
CARCASS STRANDINGS
1988-89

FIGURE 2.


Carapace Length
Plastron Length
cm
60
50
40
30
20
Reef Population
Net Killed
Reef population
Net Killed

# NEST TRANSPLANTATION AS A DETERRENT TO MAMMALIAN PREDATION AT TORTUGUERO, COSTA RICA

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Simple nest transplantation has been touted as a way to protect newly laid turtle nests from predation by mammalian predators, particularly in localities where predation is high, labor scarce, and logistics difficult (Stancyk, Talbert and Dean, 1980; Stancyk, 1981). Our arguments have been based on work done on two barrier islands in South Carolina, where predation by raccoons ranged from 55-93% (about half first-night predation), and where removal of nests from cues left by nesting females to nearby open, uncaged areas reduced predation to between 6 and 19% (Stancyk, Talbert and Dean, 1980).

Further tests of the method have not been published, and a visit to Tortuguero, Costa Rica, presented the opportunity to examine the usefulness of transplanting on a more tropical beach with different turtle species (Chelonia mydas, Eretmochelys imbricata) and different predators. Predation was studied at Tortuguero by Fowler (1979), who found that 38% of marked nests were taken. In 1977, dogs took about 80% of the nests and coatis (Nasua narica) took only 8%. With the establishment of Tortuguero as a national park, however, free-roaming dogs were eliminated to a great extent, and the impact of coatis as predators has increased.

To test whether removal of freshly-laid turtle eggs from cues left by the nesting female reduces predation in a location where the primary mammalian predator is the coati, 39 nests were transplanted between July 18 - August 11, 1989. Nest were moved within two hours of the time they were laid to sites 10-30 m from their original location, and were marked, but left unprotected. An additional 61 unexcavated, suspected nests were marked as controls during the same period. At 2-3 day intervals until August 10, 1989, surveys were conducted to document the rate of first-night predation and to examine the fate of marked nests. After August 10, marked nests were surveyed at 10-16 day intervals until October 17, 1989.

Table 1 shows the fates of all marked nests. Nearly half (38% of transplants, 49% of controls) of the marked nests were obliterated by subsequent turtle nesting activity, reducing the sample size considerably. In addition, 12% of control nests did not hatch after 72-91 days, and probably were not nests. With obliterated nests included, transplants and controls both suffered 28% depredation; if only hatched/depredated nests are counted, transplants experienced 46% depredation, controls, 65%. This difference is not significant, however, and the basic result is that nest transplantation has little effect on the rate of mammalian predation on nests.

There are other characteristics of the data which relate to differences in predation behavior, and probably the cues used, by raccoons, dogs and coatis. Table 2 shows that although there were no differences in predation rate on transplants and controls in the vegetated or vegetation border zones (33 and 31%, respectively), predation is higher in these zones than on the open parts of the beach. This pattern was also observed by Fowler (1979) and the implication for nest transplantation is that one should transplant to unvegetated sites, if such sites can be found where erosion won't take the nests.

First-night predation of nests was relatively infrequent. Of an estimated 174 new nests counted during 10 surveys, only 5 (2.9%) were depredated. Figure 1 shows how many days after laying or transplantation marked nests were depredated. More transplanted nests were destroyed within 5 days of laying (18 vs. 6%), but fewer during the remaining observation period (10 vs. 23%). The pattern in Figure 1 is very different from that which would be expected if raccoons were the major predators. Raccoons take 50-90% of the nests on the first night (Stancyk, Talbert and Dean, 1980). Dogs also appear to be strong first-night predators; most of the first-night predation in Figure 1 was by dogs, and 5 of the 7 transplant predations under 5 days were due to dogs. Coatis, however, are diurnal predators which do not take markedly more newly-laid nests. I observed many examples of coatis exploring body pits for several consecutive days before finally excavating eggs. In Figure 1, about 67-73% of the known coati predation occurred after 5 days. This pattern is similar to that found by Fowler (1979), except that she found relatively constant predation throughout the first 6 weeks of incubation, while these data indicate that predation drops off between the third and the eighth week. In addition, Fowler found significantly more predation of 6-9 week-old nests than younger nests; although the sample size was small, this pattern does not appear in Figure 1.

In conclusion, the transplant method was not particularly successful on a tropical beach where predation was about 30% and the major predator was the coati. Patterns of predation appear to differ between predators such as dogs, raccoons and coatis, which may imply that they use different cues, or use the same cues differently. Transplantation may be more effective against first- and second-night predators such as dogs and raccoons, or on heavily-nested, heavily-depredated beaches with associated logistic difficulties.

## ACKNOWLEDGMENTS

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Table 1. Fates of all marked transplanted and control nests at Tortuguero, Costa Rica, July 18 - October 17, 1989

| | TRANSPLANTS | | CONTROLS | |
|---|---|---|---|---|
| | N | % | N | % |
| **LOST** | **15** | **38** | **29** | **49** |
| **HATCHED** | **13** | **33** | **8** | **14** |
| **DEPREDATED** | **11** | **28** | **15** | **25** |
| **UNHATCHED** | **0** | **0** | **9** | **12** |

Table 2. Nest Predation by beach zone, Tortuguero, Costa Rica, July 18-October 17, 1989

| ZONE | TRANSPLANTS | | CONTROLS | |
|---|---|---|---|---|
| | No. | No. Pred.(%) | No. | No. Pred.(%) |
| VEGETATED | 4 | 1 (25%) | 24 | 8 (33%) |
| BORDER | 29 | 10 (34%) | 21 | 6 (29%) |
| | 33 | 11 (33%) | 45 | 14(31%) |
| OPEN | 6 | 0 (0%) | 17 | 1 (6%) |

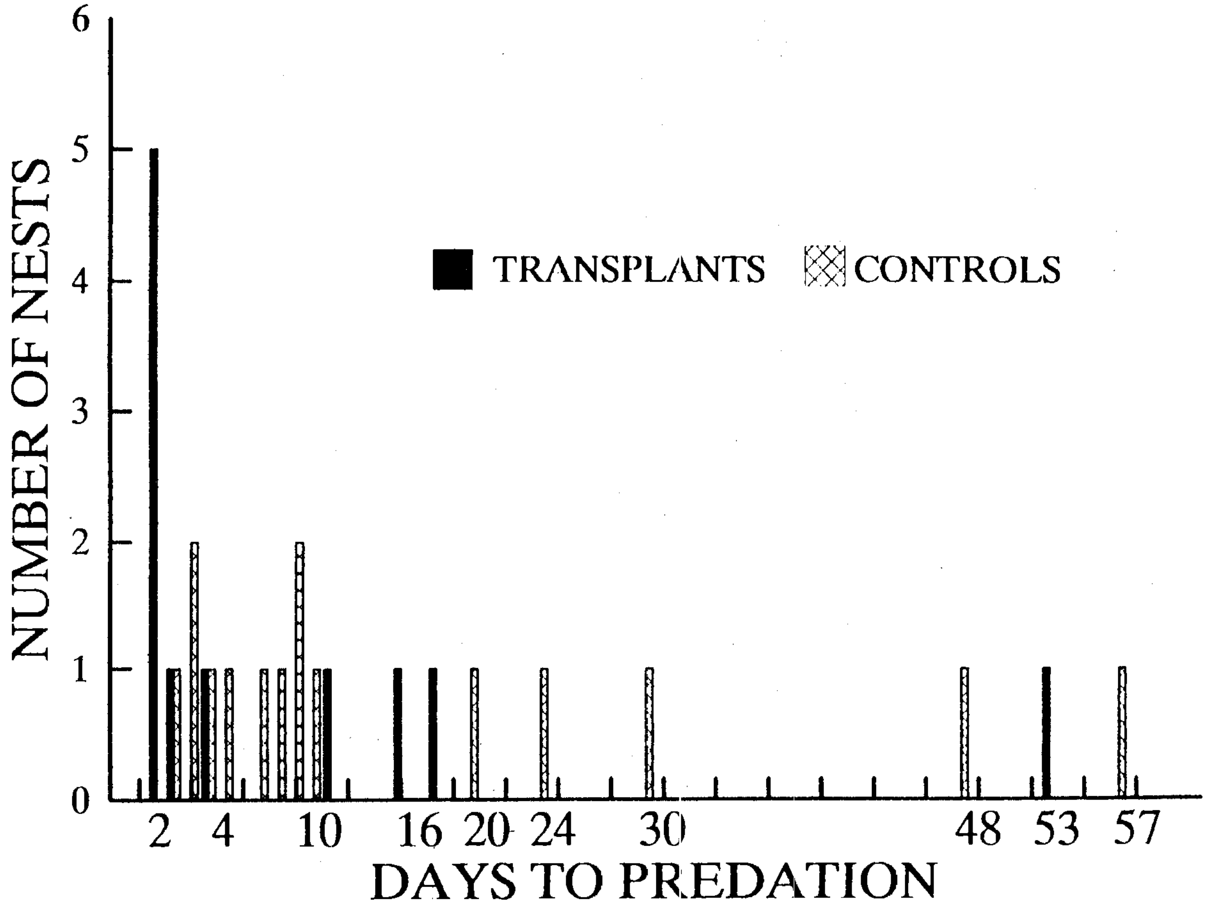

Figure 1. Day of predation of transplanted and control nests, Tortuguero, Costa Rica, July 18-October 17, 1989.

# PRELIMINARY ASSESSMENT OF THE IMPACTS OF HURRICANE HUGO ON SEA TURTLE POPULATIONS OF THE EASTERN CARIBBEAN

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## INTRODUCTION

Hurricanes are natural episodic events which cause widespread destruction in low-lying coastal areas. Severe storm events classified as major hurricanes frequent the eastern Caribbean approximately once every one hundred years; less severe tropical storms occur approximately every six years. Most impact assessment that is undertaken following a severe hurricane event concentrates on the damage done to terrestrial ecosystems, coastal landforms (especially beaches), and, of course, human habitation and industry. Very little attention is given to the impact of severe storm events on the marine ecology of the impacted area. This paper presents an overview of the diverse range of impacts that resulted from the 1989 passage of Hurricane Hugo in the eastern Caribbean. Although various kinds of impacts on marine and coastal ecosystems are discussed in general terms, the focus of this study is the probable effect of such environmental degredation on critical sea turtle habitats.

## STUDY AREA

Hurricane Hugo made its passage through the eastern Caribbean on September 17 and 18, 1989, with sustained winds in excess of 170 mph and gusts up to 20 mph over an 8-10 hour period. Post hurricane assessments were done during the period from October 20, 1989, through December 20, 1989. The study area included the islands most directly impacted by Hugo: Montserrat, Nevis, St. John, St. Thomas, and portions of Puerto Rico (Figure 1). Interviews were also conducted with residents of Anguilla and the British Virgin Islands. Some comparative data were used from a previous study site (Quintana Roo, Mexico) that was impacted a year earlier by Hurricane Gilbert.

## RESULTS

The overall but necessarily preliminary assessment of hurricane-induced damage to marine ecosystems and its probable impacts on sea turtle populations can be divided into two classes:

1) direct impacts on sea turtles and their critical habitats,
2) indirect and longer-lasting effects on sea turtle habitats.

The magnitude of damage to sea turtle populations is relatively easy to determine for direct effects but is only speculative for the indirect effects. No qualitative assessment was attempted for either direct or indirect impacts, however, since no data were collected immediately following the hurricane and since the survey time and depth of investigation was limited.

Direct impacts of Hurrricane Hugo in terms of mortality estimates for either the adult or young classes of resident green (Chelonia mydas), hawksbill (Eretmochelys imbricata), and leatherback (Dermochelys coriacea) populations or transitory loggerhead (Caretta caretta) or Kemp's ridley (Lepidochelys kempi) individuals are not available. Site-specific data on strandings and mortalities of sea turtles may have been collected by local agencies but were not availabe for this assessment.

Anecdotal information was collected on several successful post-hurricane hatches of both hawksbill and green nests, suggesting that not all in situ nests were destroyed by the wind-generated storm surges. This is in contrast to the situation in Quintana Roo, Mexico, following the 1988 passage of Hurricane Gilbert, when data from monitored hatcheries showed that all in situ nests were destroyed (accounting for approximately 80 percent of all translocated green turtle nests and a fifth of all translocated loggerhead nests for that nesting season (Agardy, 1989).

Direct impacts on important sea turtle habitats were more easily assessed in the months following the passage of Hugo. Significant portions of important nesting beaches in St. Croix, Nevis and Montserrat were eroded. However, further investigation suggests sand is accreting at those beach sites sufficiently fast to accommodate spring and summer nesting. Leatherback turtles, which seem to have the most stringent requirements for beach space and quality, may have to alter their nesting patterns in the upcoming season somewhat; further study is warranted. Data from the post-Gilbert nesting season at Rancho Nuevo suggests that, although dramatic hurricane-induced changes in beach profile were sustained over many months, nesting frequency was not reduced although nesting locations were shifted (J. Woody, pers. comm.)

Direct impacts on the marine environments critical to sea turtles were also observed. Seagrass beds, important foraging areas for Chelonia mydas, were widely decimated in Puerto Rico (V. Vincente, pers. comm.), St. Thomas and St. John (D. Moore, pers. comm.), St. Croix, St. Kitts, Nevis, St. Barths and St. Maarten.

New blowouts (areas where surge-generated currents have dug out large tracts of seagrass beds) are in evidence throughout the region, especially in the important foraging areas off the coast of Culebra and St. Croix. Such seagrass beds are typically assemblages of Thalassia testudinum, Halodule wrightii, and Stringodium filiforme. Detailed investigation by Vincente and Lopes (1989) at some of these sites shows that these hurricane-induced blow-outs were completely bare of colonizing vegetation and exposed rootmats. Whether these areas will regenerate to continue to supply important forage to resident green turtles cannot be determined without time-series study.

Other direct impacts of Hurricane Hugo on sea turtle habitats include destruction of coral reef habitats important to hawksbill and, secondarily, to green turtles. Storm surges cause breakage of many species of stony corals including the branching coral (Acropora species), boulder corals (Montastrea and Diploria species), and plate corals (Agaricia species). In some areas of the Virgin Islands, Saba and St. Kitts, the structure of massive reefs was completely undermined by the collapse or uprooting of immense stony corals that formed the framework for the reef community. Nooks and crannies in the reef used by hawksbills and greens for resting have been destroyed in some areas.

Soft corals and sponges suffered even greater damage from wind-generated surges and currents. Whether the loss to sponges represents a significant loss in forage for resident hawksbills cannot be determined without further study into the ecological requirements of this species.

Indirect and long-term insidous impacts on the marine and coastal habitats of sea turtles include pollution of nearshore waters from storm-associated run-off of nutrients, fertilizers, pesticides, and hydrocarbon compounds, sewage and oil spills, and persistent debris on beaches, on the sea floor, and in the water column. The eventual toll that this suite of environmental degredations takes on the threatened populations of Caribbean sea turtles is cause for both speculation and worry.

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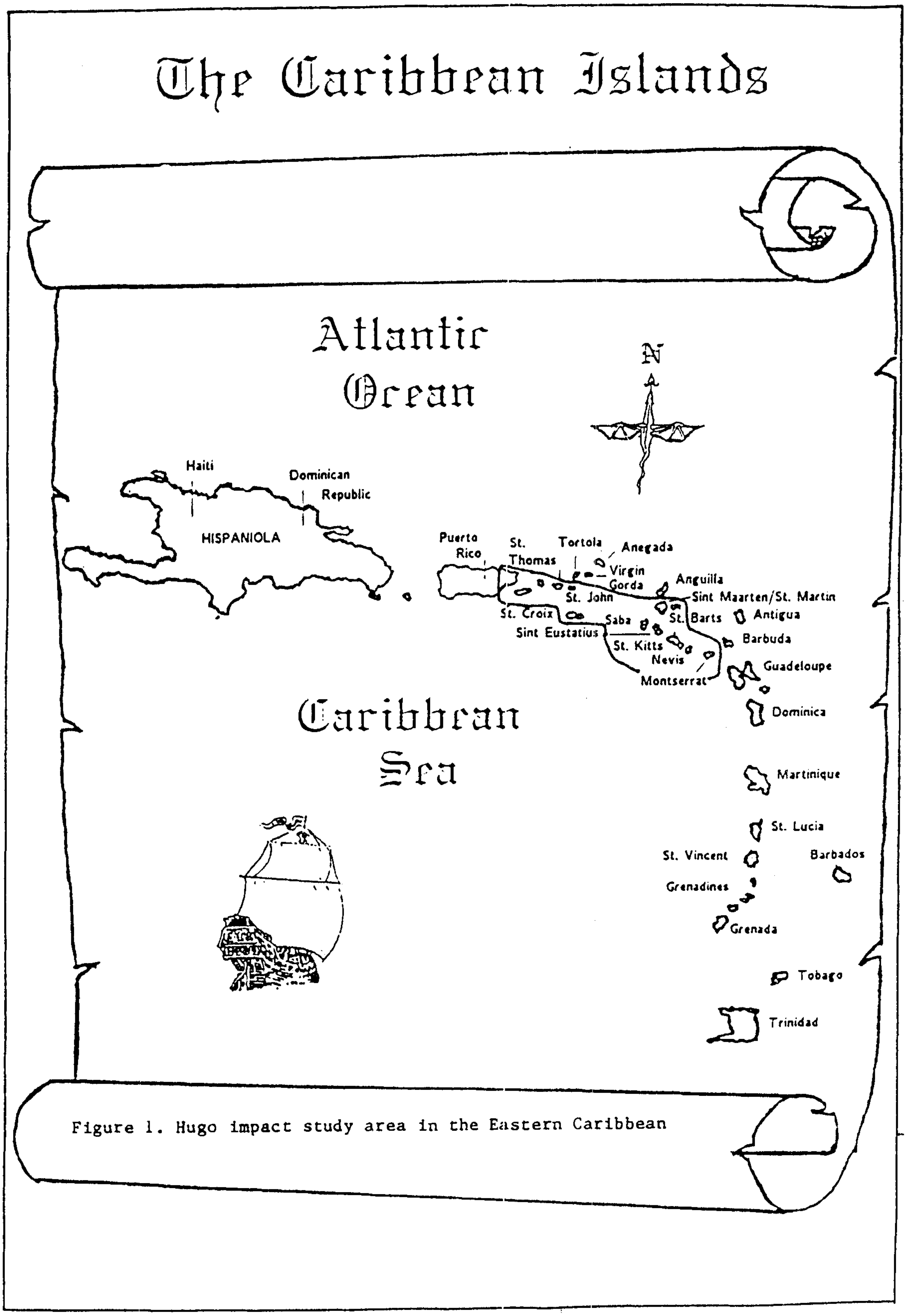

Figure 1. Hugo impact study area in the Eastern Caribbean

# COLD STUNNING OF MARINE TURTLES IN THE INDIAN RIVER LAGOON SYSTEM, FLORIDA, DECEMBER 1989

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Hypothermic, or cold stunning of marine turtles in response to low water temperatures has been reported from several geographical areas including Texas coastal waters; Long Island Sound, NY; Cape Cod Bay, MA; Chesapeake Bay, VA; and Florida coastal bays and lagoons. There are, however, no records where cold stunning events regularly involve as many turtles as those documented from the northern Indian River Lagoon System (IRLS) along the central east coast of Florida. Witherington and Ehrhart (1989) reviewed five cold stunning events occurring in this system from 1977 - 1985. Herein we present information about the most recent cold stunning event documented in the northern IRLS during a severe freeze in late December 1989.

The IRLS extends along Florida's central east coast behind the barrier islands from Ponce Inlet to St. Lucie Inlet, a straight line distance of approximately 200 km. The northern portion of the system consists of three principal bodies of water, Mosquito Lagoon and the Indian and Banana Rivers. Lagoonal waters are shallow, generally less than 2 m in depth excepting dredged channels and basins. During a six-day period 23-28 December 1989, 246 green turtles and 10 loggerheads were recovered cold stunned from the northern IRLS. Minimum air temperatures remained below zero for three consecutive days, with a low of -5 °C recorded on 24 December. Minimum water temperatures remained below 10 °C for seven consecutive days with the lowest water temperature of 4.4 °C recorded on 25 December. The majority of cold-stunned turtles were collected the day following the lowest recorded water temperature (Figure 1).

Turtles were collected by hand from boats and in all cases, turtles were either completely immobilized by the cold water or made feeble attempts to evade capture. Eighty-five percent of the turtles were collected from Mosquito Lagoon where they were concentrated along the eastern shoreline, primarily in the most southerly extension of the lagoon. Fifteen percent were collected from the northern extension of the Indian River, again primarily along the eastern shoreline. One turtle was collected from the eastern shore of the Banana River. Strong winds prevailing out of the NW were responsible for the easterly distribution of turtles. Mosquito Lagoon does not communicate directly with the Banana River to the south, and the northern reach of the Indian River is restricted by natural narrowing and two causeways which cross the system at Titusville. The closest ocean access is Ponce Inlet, located 50 km to the north through a maze of mangrove islands. Turtles are apparently unable to escape the system quickly, as when rapidly moving cold fronts occur.

Of the 256 individual turtles recovered, 26.5% (67 green turtles and 1 loggerhead) were either dead when collected or died within 12 hours. Percent mortality increased with each subsequent day of recovery efforts, emphasizing the need to rescue cold-stunned turtles as quickly as possible in order to reduce mortality. Based on comparisons to previous cold stunning events and the severity of this freeze, we believe that virtually all of the green turtles inhabiting this portion of the system were affected during the 1989 event.

Live green turtles were transferred on the day of or the day following collection to two aquarium facilities in nearby Orlando, EPCOT'S Living Seas and Sea World of Florida, where they were housed and cared for until their release. The loggerheads were maintained in temporary holding tanks at the Merritt Island National Wildlife Refuge. All turtles were photographed, measured, weighed, and double tagged with plastic rototags and 681 inconel tags prior to release. In addition, blood samples were obtained from 159 of the 179 live green turtles for subsequent sex ratio analyses. All dead turtles were retained for further study.

The loggerheads were released one week following their rescue into the Indian River Lagoon at a location 100 km south of their original collection site where water temperatures had warmed to 18°C. The green turtles were released back into the areas from which they were collected, six weeks following their rescue, after the risk of a second severe cold spell had passed. The total number of turtles affected in 1989 was 58-80% higher than turtles affected in previous cold stunning events in the northern IRLS documented since 1977. We suggest that the 1989 freeze which occurred 3-4 weeks prior to those documented in 1977, 1981, and 1985 and which was preceded by extremely mild weather may have occurred when more turtles were inhabiting the system than would have been present given an additional month to migrate in response to slowly cooling water temperatures.

Green turtles averaged 52.3 cm in standard straight line carapace length with a standard deviation of 10.9 cm and ranged from 26.6 cm to 77.0 cm. Mean standard carapace length for loggerheads was 66.6cm, SD=10.6cm, and ranged from 50.9 cm - 86.5 cm. This distribution of size classes illustrates the utilization of these lagoonal waters as developmental habitat. We compared sizes of green turtles collected during the 1989 cold stun to the three previous major cold stunning events of 1977, 1981, and 1985. A Kruskal-Wallis analysis of variance on carapace length revealed significant inter-year differences at the 5% significance level (P=0.0001). A nonparametric multiple comparison test indicated that turtles recovered during 1981 and 1985 were significantly smaller than turtles recovered both in 1977 and 1989. Sizes of turtles recovered during 1977 and 1989, however, were not significantly different from each other. A Kruskall-Wallis analysis of variance on loggerhead carapace length revealed no significant differences among years at the 5% significance level (P=.0766).

## ACKNOWLEDGMENTS

Numerous agencies, groups, and individuals contributed substantial time and resources to the success of the recovery efforts. In particular we wish to sincerely thank Merritt Island National Wildlife Refuge, EPCOT'S Living Seas, Sea World of Florida, Canaveral National Seashore, Florida Marine Patrol, and the Kennedy Space Center Fire Department.

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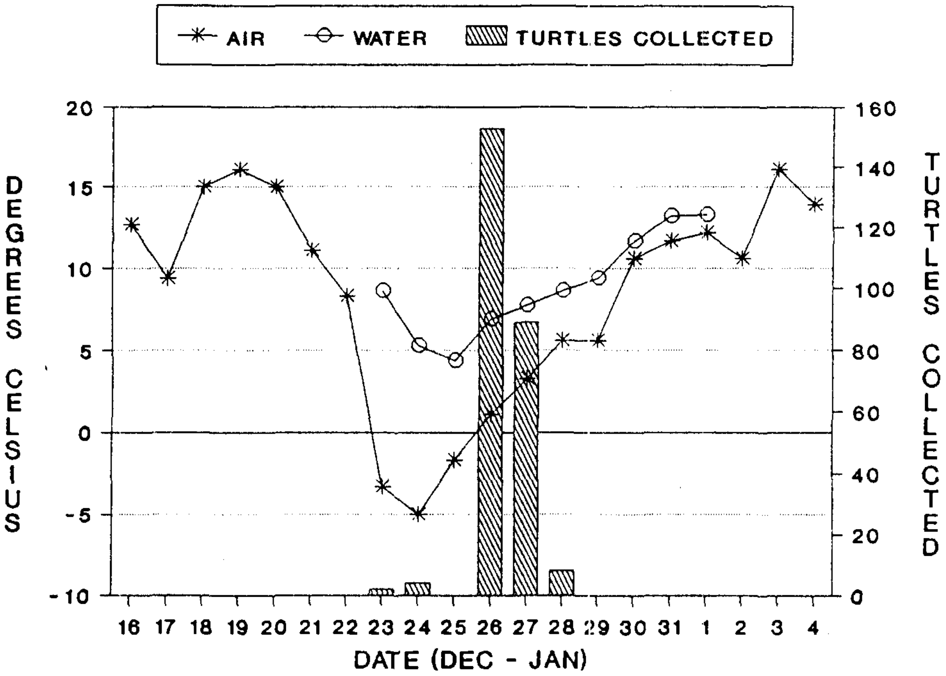
Figure 1. Minimum air and water temperatures in relation to cold-stunned turtles collected from the northern Indian River Lagoon system, Brevard and Volusia Counties, Florida, December - January 1989.



# SOCIAL BIOLOGY: ENVIRONMENTAL EDUCATION

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Natural resources contribute to a large proportion of a nation's economy. The economic conditions prevailing have created an instability in the utilization of such resources.

In 1980, the world's population was 4.4 billion, and in the 1990s it is projected to be 5.2 billion. Mankind continues to infiltrate more often than not, into economically depressed virgin areas impacting remote places previously only inhabited by plant and animal species. Forests are being cut down and turned into farm lands, and jungles and mangroves are being transformed into pasture lands to sustain current economic demands. Also in recent years, technology has developed to such an extent that it is having an adverse impact on our environment. Environmental problems are no longer limited to political boundaries. Aside from our different life styles, culture, and politics, a sustained concentrated effort must embody an interdependence of all the systems of our planet (Hertzig, 1989).

Conservation organizations must understand the problematic position of those communities depending on their natural resources. The Sea Turtle Center was founded from the idea of creating an alternative conservation organization to carry out intensive educational programs in the United States. We focus our research, conservation, and protection programs on sea turtles and other endangered species through the concept of "Social-Biology." In past decades biologists have been collecting data on sea turtles and recording their decline. However, the Center feels that in the 90s emphasis must be shifted from data collection to social awareness.

Since its creation in 1986, the Sea Turtle Center has concentrated its programs on education campaigns in the United States and collaboration directly with sea turtle conservation projects in Mexico. Of the seven species of sea turtles that inhabit the world, six live in Mexican waters, and in 1976 five of these were classified "threatened" and/or "endangered" by the Convention of International Trade in Endangered Species of Wild Flora and Fauna (CITES). Educational programs exploring the probable causes of the accelerated disappearance of sea turtle species have identified the U.S. as a key factor in the dramatic decline of sea turtle populations.

The problems of protecting endangered species is presented through documentary videos which are shown in schools and universities in an effort to increase environmental awareness among children and young people and make it clear that their actions could eliminate commercial pressures on endangered species. Samples of confiscated products are brought into the classroom to acquaint students with these examples and to bring them closer to the problem. In the United States, alone approximately $600 million is spent annually consuming articles manufactured from wild fauna (USFWS, 1987). The U.S. Fish and Wildlife Service (USFWS) states that the most commonly confiscated articles are sea turtle products on our Mexican borders. By actively conducting seminars in the United States about the "great American consumer," the Sea Turtle Center's goals are to promote the gradual decrease in the consumption of sea turtle products. With this in mind, the Center also collaborates with local action groups in Mexico.

The Sea Turtle Center also participates directly in project fieldwork, gathering data and trying to monitor negative impacts to sea turtles. It accomplishes this by organizing citizen volunteer programs to facilitate hands-on involvement, donating time and money and working directly with biologists as they are needed. This integration of STC volunteers and biologists creates a resource of 'teachers' who then bring back their first-hand experiences dealing with the biologists' and communitys' socio-economic problems. Since 1987 the Sea Turtle Center has been collaborating with the following projects:

- Conservation and Research Programs of Sea Turtles: Dermochelys coriacea and Lepidochelys olivacea at Playon Mexiquillo in Michoacan state, coordinated by biologists Laura Sarti and Carlos Santos, a joint project of the Secretaria de Desarrollo Urbano y Ecologica (SEDUE) and the Universidad Nacional Autonoma de Mexico (UNAM).

- Conservation and Education Program of Sea Turtles in Bahia de Los Angeles, B.C., coordinated by biologist Antonio Resendiz (UABC), under the auspices of the Fishing Institute.

- Finally, the Sea Turtle Center has begun the procedures to support a project on Conservation of the Sea Turtle in the Islas Marias Archipelago in Nayarit state. Coordinator: Raymundo Cervantes, Biologist. Under the auspices of the Secretaria de Gobernacion.

The Sea Turtle Center is a non-profit, tax-exempt corporation, which is always searching for additional economic support from corporate and international conservation organizations in order to continue to participate in sea turtle conservation efforts in Mexico. The Center also endeavors to be a communication link of scientific exchange among sea turtle research groups in Mexico and the rest of the world by publishing newsletters, technical papers and by participation in symposiums, conventions and lectures. In addition to its own publications, the Sea Turtle Center distributes educational material generated by other environmental organizations such as the World Wildlife Fund, U.S. Fish and Wildlife Service, and the Center for Marine Conservation. This material is distributed to our conservation projects and to other research programs throughout the world. The exchange of American and Mexican scientific knowledge must grow in order to develop new programs and solutions to the problems of endangered species, and the socio-economic impacts of those programs. Thus even though consumer markets determine the economics of conservation, Latin America must also be able to withstand these measures without detrimental economic effects.

We are convinced that the conservation of nature is necessary as a heritage of mankind. Slowly a process of social biology is necessary to integrate society and nature in harmony and increase the quality of life around the world.

## ACKNOWLEDGMENTS

The Sea Turtle Center would graciously like to thank the Mexican Government for their support and permission to collaborate with sea turtle projects in Mexico. We would also like to thank the U.S. Fish and Wildlife Service, World Wildlife Fund and especially Marydele Donnelly, Director of Sea Turtle Rescue Fund, Center for Marine Conservation for her continued support and guidance.

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# SATELLITE MONITORING SEA TURTLES

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Studies using satellites to monitor the behavior and movements of sea turtles have proliferated over the past decade. Forty-six sea turtles of four species have been monitored via satellite biotelemetry (Table 1). The first turtles tracked were loggerheads monitored in 1979 using the Nimbus weather satellite system (Stoneburner, 1982; Timko and Kolz, 1982). These early transmitters were much larger than present transmitters (Platform Terminal Transmitters or PTTs), and necessitated direct access to ground tracking stations to obtain data from the satellite. The current satellite system used for animal monitoring is the Tiros-Argos System. The system consists of a) polar orbiting Tiros satellites launched by the National Oceanic and Atmospheric Administration (NOAA), b) worldwide tracking stations maintained by NOAA, and c) a data processing and dissemination network, Service Argos, operated by the French government. Positions of PTTs are calculated from Doppler shifts in the PTT radio frequency. Other data may also be transmitted (e.g., temperatures, respiration, behavior). The data are re-transmitted to ground stations, processed by Argos and distributed through various means (e.g., telephone computer links) to the researcher.

Technical advances also have been made in areas of PTT size and style, attachment procedures, and data collection. Only recently has the methodology evolved beyond testing. There are several Argos-certified PTTs that can accommodate the size and weight constraints imposed by animal biotelemetry. For sea turtles, one of us (RAB) developed with Telonics, Inc., easily attached, positively buoyant, trailing floats of 6.9 cm diam. x 37 cm length. The floating PTTs evolved through several studies and have been used successfully on loggerheads (Table 1: Byles, 1988a; Keinath, et al., 1988; Byles and Dodd, 1989), the black turtle (Byles and Alvarado, unpubl.) and Kemp's ridley (Byles, 1988b). In efforts to further decrease size and attachment longevity, PTT units were reduced to 2 x 13 x 9 cm and mounted "backpack style" with fiberglass cement on the carapaces of hardshelled species (Table 1: Byles, 1988b; Keinath, et al., 1989; Renaud, et al., in press; and Byles and Alvarado, unpubl.). Current attachment life of PTTs is 8 months and still transmitting (Renaud, pers. comm.). We expect soon to be monitoring turtles on a year-long basis.

Satellite PTTs which require little adaptation for sea turtles are available from Telonics, Inc., and others make units adaptable for sea turtle research. We currently use PTTs that record dive durations and number and ambient temperature and shortly will deploy a depth sensing prototype. Expanded monitoring of physiological and environmental parameters will be available in the near future.

As a result of technical advances, satellite biotelemetry now can be used as a management tool. However, foresight should be used to plan research programs that will answer specific questions. It is quite costly to monitor a turtle for a year; hardware costs a minimum of $3,500 for a "basic" PTT, and Argos data charges are about $4,000 (government rate) per platform year (365 locations). Argos charges non-government users >$10,000 for a platform year. In contrast, the ship-time required to accomplish the same year of daily monitoring is roughly $730,000/year at $2,000/day. A well-planned experimental design is necessary to ensure that scarce research/management dollars are efficiently spent. We simply cannot afford to apply satellite technology in a haphazard manner. We should determine a) migratory pathways, b) swimming, respiratory and diving behaviors, c) wintering/feeding locations, etc. However, we cannot expect to discover much about population characteristics, recruitment, distribution and the like without long-term studies employing large numbers of PTTs.

In addition to the conceptual framework, care should be used to avoid adverse effects on turtle viability and behavior. The points enumerated below should minimize the impacts of PTT attachment on specimens.

**Weight.** Most large animal studies set a rule-of-thumb tag weight limitation of ten percent body weight. This also seems appropriate for sea turtles. However, for long-term studies, a tag mass five percent or less of body mass (calculated from submerged weights) is more desirable. With present PTTs of ~0.8 kg, it is feasible to monitor turtles weighing as little as 16 kg.

**Hydrodynamics.** If PTT weight is held to less than 10% of body weight, PTT size and shape becomes more important than weight. Small volume and low hydrodynamic profiles reduce the added drag of the PTT. For trailing PTTs, spherical or cylindrical with conical ends are the most efficient shapes. For directly attached tags such as the backpack style, flattened, smoothly contoured shapes are best.

**Attachment.** Two opposing purposes guide attachment design: the need to firmly attach the PTT for the duration of the study and the desire to have it shed in a reasonable amount of time. For floating tags, lanyard attachment is usually accomplished via an eyestrap bolted through the pygal bone of the carapace. We've found it best to attach the eyestrap to the turtle with ferrous, corrodible bolts. These oxidize to the breaking point in 9-12 months depending on the ambient conditions and the thickness of the bolts. An alternative is to place a corrodible link between the PTT and the attachment point, close to the carapace. When harnesses are necessary (e.g., for leatherbacks), a corrodible link is placed in the harness so the entire apparatus will be shed at once and not entangle the turtle. Backpack tags can be cemented on with fiberglass resin which separates from the keratin of the scutes over time. Estimates of the shedding time are not yet available, but Renaud, et al., (Table 1) currently have a backpack transmitter on a free-swimming loggerhead which has been transmitting more than eight months.

**Fouling.** Barnacles and other marine epibiota settle on nearly every material used thus far for PTT casings. Anti-fouling paint (low toxicity) is recommended to prevent overburdening the turtle or adversely affecting signal characteristics.

**Color.** Neutral colors should be used in order to prevent predator attraction. A shark's tooth was removed from the outer PVC casing of a PTT attached to a leatherback with a bright red harness (JAK). The turtle was unharmed by the shark. Other turtles have been known to bite trailing transmitters of telemetered turtles (RAB).

## TABLE 1.

## SEA TURTLES MONITORED WITH SATELLITE TELEMETRY

(CC = *Caretta caretta*, CA = *Chelonia agassizi*,
LK = *Lepidochelys kempi*, DC = *Dermochelys coriacea*)

| Species | Number | Year(s) | Time Deployed | Author/Publication |
|---|---|---|---|---|
| CC | 1 | 1979-1980 | 8 months | Timko and Kolz, 1982<br>Mar. Fish. Rev. |
|  | 8 | 1979 | 1-34+ days | Stoneburner, 1982<br>Copeia |
|  | 2 | 1985-1986 | 1-2 months | Byles, 1988<br>Ph.D. diss. |
|  | 8 | 1986-1990 | days-6 months | Keinath, et. al., 1989<br>Proc. Sea Turt. Wkshp |
|  | 1 | 1988 | 4+ months | Byles and Dodd, 1989<br>Proc. Sea Turt. Wkshp |
|  | 1 | 1989 | 2 months | Byles and Dodd, unpubl. |
|  | 3 | 1989-1990 | 4-8 months | Renaud, et. al., unpubl. |
|  | 2 | 1988 | 10 days each* | Naito, 1989<br>ARGOS Newsl. |
| CA | 2 | 1987-1989 | 1-4 months | Byles and Alvarado, unpubl. |
| LK | 2 | 1980 | < 1 month | Timko and Kolz, unpubl. |
|  | 18 | 1987-1988 | days-4 months | Byles, 1988<br>Final Rep. Nat. Fish Wildl. |
| Found. |  |  |  |  |
|  | 1 | 1989 | 5 months | Byles, unpubl. |
|  | 1 | 1989-1990 | 3 months | Renaud, et. al., unpubl. |
| DC | 1 | 1986 | 24 days | Duron, 1987<br>C. R. Acad. Sc. Paris |
|  | 1 | 1989 | 18 days | Keinath, unpubl. |

* designed to release after ten days

# SEX DETERMINATION IN THE CRITICAL RANGE OF TEMPERATURE FOR MARINE TURTLES

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Sex determination is often classified in two distinct types: Genotypic Sex Determination and Environmental Sex Determination (Bull, 1983). Marine turtles are in the second group because the influence of temperature in sex determination has been demonstrated in all marine turtles. This communication proposes to consider that the genetic basis of sex determination in marine turtles and, by extension, in reptiles with environmental sex determination, is more important than is usually thought. The data used to demonstrate this phenomenom are those obtained in marine turtles as well as in other species of reptiles, particularly in the laboratory of developmental biochemestry, in Claude Pieau's group.

Studies of temperature influencing the sex-ratio in marine turtles often stopped at the determination of "threshold" temperature, "pivotal" temperature or "critical" temperature according to the authors, one same temperature giving theoretically both sexes in equal proportion. Only two studies on marine turtles have looked for a possible genetic basis for this threshold temperature : Nicholas Mrosovsky (1988) and Colin Limpus et al. (1985) in Caretta caretta. In both cases, a significant difference of threshold temperatures has been determined for different clutches. These data have been interpreted as different individual responses to temperature with a possible geographic difference among the populations.

After the work of Patrick Zaborski, Mireille Dorizzi and Claude Pieau published in 1979, 1982 and 1988 with Emys orbicularis, a European fresh water turtle, a new description of temperature sensitivity has been proposed. In this model, the temperature acts on top of the genotypic sex determination. Sex determination around what is called threshold temperature is under genetic control by a unique gene, as in genotypic sex determination. Classical systems of genotypic sex determination are XX/XY and ZZ/ZW as a function of the heterogametic sex. This denomination does not imply cytologic difference of the sex chromosome.

Let us consider two alleles, a and b. Below a temperature t1, embryos differentiate as males, and above a temperature t2, embryos differentiate as females. Between t1 and t2, embryos differentiate within their genotype. The definition of a t3 temperature is necessary, because temperature sensitivity of heterozygote ab is certainly different than that of homozygotes aa or bb of the same sex (Fig. 1). By analogy with a genotypic sex determination, a and b could be renamed XY or ZW. At t1, t2 and t3 incubation temperatures, sex determination will result from the interaction of temperature with sexual genotype.

Differences of threshold temperature found in different clutches for the same species could be differently interpreted with this hypothesis. Consider two theoretical cases, a clutch with only aa genotypic embryos (from aa female crossed with aa male) and a clutch with only bb genotypic embryos (bb crossed bb). In the first case, the threshold temperature will seem to be t1, and t2 in the second. All the intermediates are possible. Moreover, Harry et al. have demonstrated the fertilization of a female by several males in Caretta caretta.

For example let us consider a female of ab genotype mated with two males, one of ab genotype and one of bb genotype. If each male contributes 50% in the fertilization, the offspring genotypic frequencies for this clutch will be: 12.5% of aa genotype, 50% of ab genotype and 37.5% of bb genotype. If we consider, that t3 is in the middle of t2 and t1, the threshold temperature (temperature which gives 50% of each sex) is shown on Figure 2.

At the molecular level it appears now clearly that estrogens are implicated in the sex differentiation. Hormonal thresholds have been forwarded by several authors as the cause of difference of sex differentiation among both sexes. If the enzymatic systems which produced estrogens are sensitive to temperature in reptiles with ESD, the classical response of sex ratio to temperature could be obtained (Fig. 3). Data obtained in our laboratory confirm this hypothesis. The genetic difference described here could be due to different levels of estrogens among the genotype or different sensitivity within the genotype for the same hormonal level.

The data of restriction fragment length polymorphism described at the previous workshop on sea turtles at Jekyll Island by Wachtel and Demas (1989) in Chelonia mydas and Lepidochelys kempii could also be explained by the same mechanism. They have described a restriction fragment of male specific DNA. But we don't have any information about the incubation temperature of eggs and probable parental relation between the individuals. However, this experiment is very interesting because it confirms the results of Wellins obtained in 1987 with H-Y antigen in Chelonia mydas. This species was classified as XX/XY sex determination. In this case, the restriction fragment of male specific DNA could be a marker of the Y chromosome.

Threshold temperature must be redefined. Classical definition was "--temperature which produces 50% of each sex," and it must be computed in the system described here by: (aa)'.t1 + (ab)'.t3 + (bb)'.t2 where (aa)', (ab)' and (bb)' are the offspring genotypic frequencies of a population. As the genotypic frequencies of the adult are not strictly constant in time, even if this population is at equilibrium, this threshold temperature could not be defined for a species nor for a population. The only non-fluctuant parameters as a function of the population structure are t1, t2 and t3. A possible geographic differentiation on these parameters can be evaluated, but it is very difficult to determine experimentally temperatures t1, t2 and t3. These temperatures must be considered as the real pivotal temperature. The temperature conditions to obtain both sexes differentiation must not be defined by a threshold temperature but by an interval of temperature. This interval is limited by two temperatures, tm and tf which are the lower and higher limits of the temperature range within which both sexes can be produced. Tm temperature is not necessarily equal to t1 temperature, and tf is not necessarily equal to t2, because t1 and t2 are temperature means and tm and tf are the lower and higher limits for these temperatures (Fig. 4). T1, t2 and t3 will be named the pivotal temperature for sex determination for a specific genotype, and the interval between tm and tf could be named the critical range of temperature for sex determination.

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**Figure 1**

## Different responses to temperature as a function of genotype

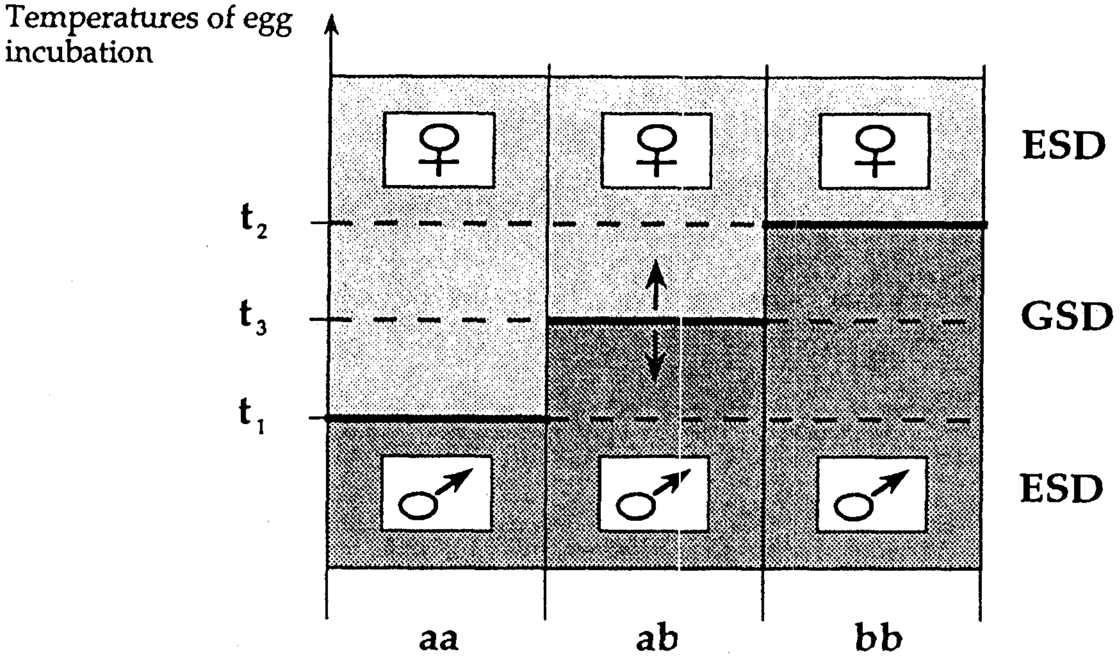


**Figure 2**

## Theoretical threshold temperature for a clutch

| | | aa | ab | bb |
|---|---|---|---|---|
| Female ab | First male ab | 0.25 | 0.5 | 0.25 |
| | Second male bb | 0 | 0.5 | 0.5 |
| | **Total in the clutch** | **0.125** | **0.5** | **0.375** |

Genotype frequencies of offspring with equal paternal contribution

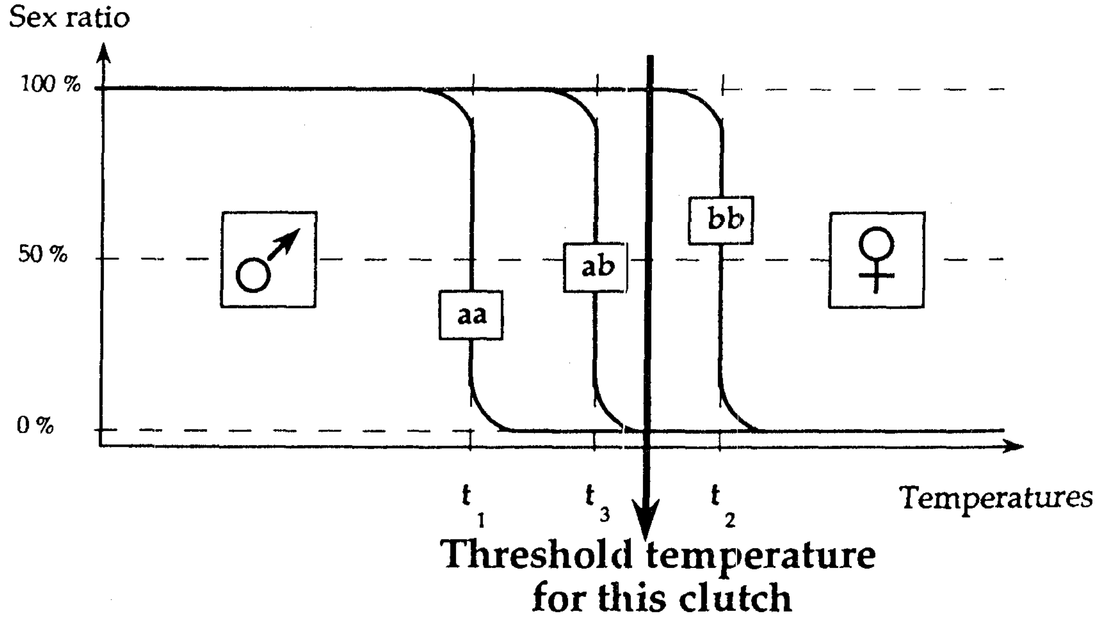


Figure 3

**Synthesis of estrogens as a function of the temperature in aa, ab and bb individuals (theoretical curves).**

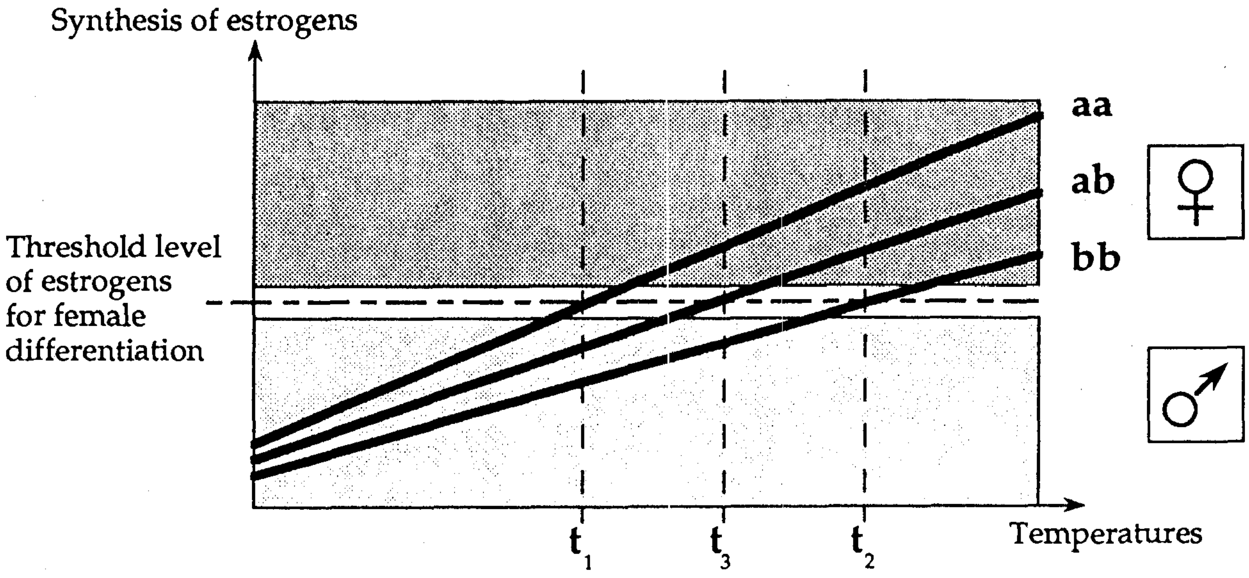
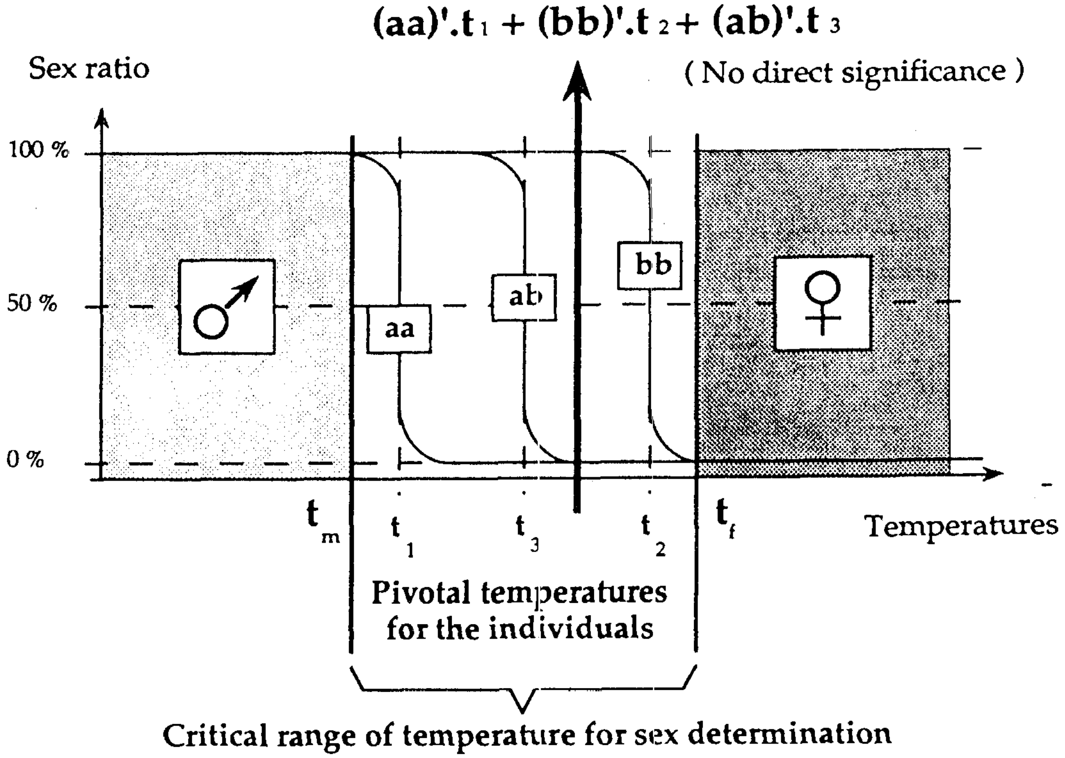


Figure 4

**Conclusion : new terminology in interaction of temperature with genotypic sex determination**



# PUBERTY AND FIRST BREEDING IN *CARETTA CARETTA*

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Long-term tagging studies in Queensland continue to provide insight into the development and growth of wild *Caretta caretta*. In this report, *C. caretta* as they prepare for and enter their first breeding season are addressed.

*C. caretta* that are residents of the foraging area of Heron Island Reef in the southern Great Barrier Reef have been under study since 1974. The population includes immature and adult females and males. The adult females migrate to breed at a number of western Pacific rookeries including Mon Repos (Limpus, 1989). The sex, maturity and breeding status of each resident turtle has been assessed by laparoscopic examination of the gonads and associated ducts since 1982 (Limpus and Reed, 1985). Among these turtles are females that have been observed to pass through the developmental phase (puberty) during which the reproductive system changes from that of an immature turtle to that of an adult. The structural changes observed in females during puberty include: the oviduct changes from being white, straight, approximately cylindrical and <2 mm in diameter as in the immature female to pink, very convoluted, flattened and at least 15 mm in diameter adjacent to the ovary in the adult. The ovary completes its enlargement to adult size at the same time.

At the commencement of puberty with females, curved carapace length was greater than the minimum breeding size of females within the eastern Australian nesting populations. It took four years for the enlargement of the oviducts to be completed such that structurally the female was indistinguishable from an adult. First vitellogenesis to form large numbers of mature-sized ovarian follicles has been observed in nine females followed through puberty. First vitellogenesis occurred in the second to fourth year of the female being rated as an adult. Two of these vitellogenic females were monitored via attached sonic tags, and they departed the foraging ground in late October - early November, commencing their breeding migration at the same time that other vitellogenic adults with a past breeding history commenced their breeding migration.

Only 2 of these 9 females in their first season of vitellogenesis ovulated that breeding season. The remaining 7, when recaptured back in their foraging ground, were found to have resorbed the large yolky follicles from their ovaries. In contrast, the resident adult females with a known past breeding history which subsequently were recorded to complete vitellogenesis, all (n = 23) ovulated in their respective breeding seasons. Of the 7 females observed not to ovulate following their first season of vitellogenesis, 4 were observed for their second season of vitellogenesis which occurred in the second to third year following the first vitellogenesis. First ovulation followed for 3 out of these 4 turtles that entered this second season of vitellogenesis. For the above females observed to develop through puberty to first ovulation, mean curved carapace length at first breeding = 93.0 cm (SD = 1.140, n = 5, range = 91.5 - 94.5).

The size at first breeding can also be examined via data from some nesting studies. For example, all nesting turtles at Mon Repos and the adjacent beaches on the Bundaberg coast in south Queensland have been tagged for 22 consecutive breeding seasons. Of 168 *C. caretta* recorded during the 1989-1990 breeding season, 71 had not been previously tagged. For the remigrants, the mean remigration interval was 3.75 yr (SD = 1.8295, n = 89, range = 1-8). None of the previously tagged females included turtles that had been tagged previously at other study rookeries outside of the Bundaberg area. Therefore, it could be presumed that the untagged turtles arriving at the rookery were new recruits to the breeding population. To test this, the ovaries of 20 of these 71 presumed new recruits were examined laparoscopically at the rookery following an oviposition. The ovaries of each were examined for the presence of corpora albucantia which result from the regression of corpora lutea formed at ovulations in past breeding seasons (= ovarian scars; Limpus and Reed, 1985). No corpora albucantia were observed on their ovaries. To test if corpora albucantia remained permanently visible on the surface of the ovary, 8 remigrants with long remigration intervals (3 x 6 yr, 2 x 7 yr, 3 x 8 yr) were examined using laparoscopy. All had distinct small corpora albucantia that were 2 mm or less in diameter on the ovaries (None had additional larger corpora albucantia that would have resulted had these turtles made unrecorded nestings in recent years.). These observations are consistant with corpora albucantia remaining as permanent scars on the ovary. Therefore it is concluded that the 20 presumed new recruits examined by laparoscopy were indeed new recruits to the breeding population and that most, if not all, of the 71 newly tagged females for the season must be regarded similarly as new recruits to the breeding population. These new recruits were significantly smaller in curved carapace length (mean CCL = 93.65 cm, SD = 4.253, n = 69, range = 84.5 - 103.5)) than the average for the entire population for the season (mean CCL = 95.13, SD = 4.501, n 164, range = 83.0 107.5) (F = 5.45; DF = 1,231; 0.05>p>0.02) (Figure 1).

## SUMMARY

For immature female Caretta caretta growing up in the southern Great Barrier Reef, puberty (enlargement of the oviducts to adult size) lasts 4 yr. While first breeding may occur 2 - 4 yr following completion of the enlargement of the oviducts, most females will not ovulate on this first season of vitellogenesis. Most will ovulate following their second season of vitellogenesis, 2 - 3 yr following the first. Thus approximately a decade will pass for the average large immature female from the time her oviducts commence to enlarge until her first ovulation.

The average female does not recruit to the breeding population at the minimum breeding size. Rather, the average female recruits at a size slightly smaller than the average breeding size for the entire population.

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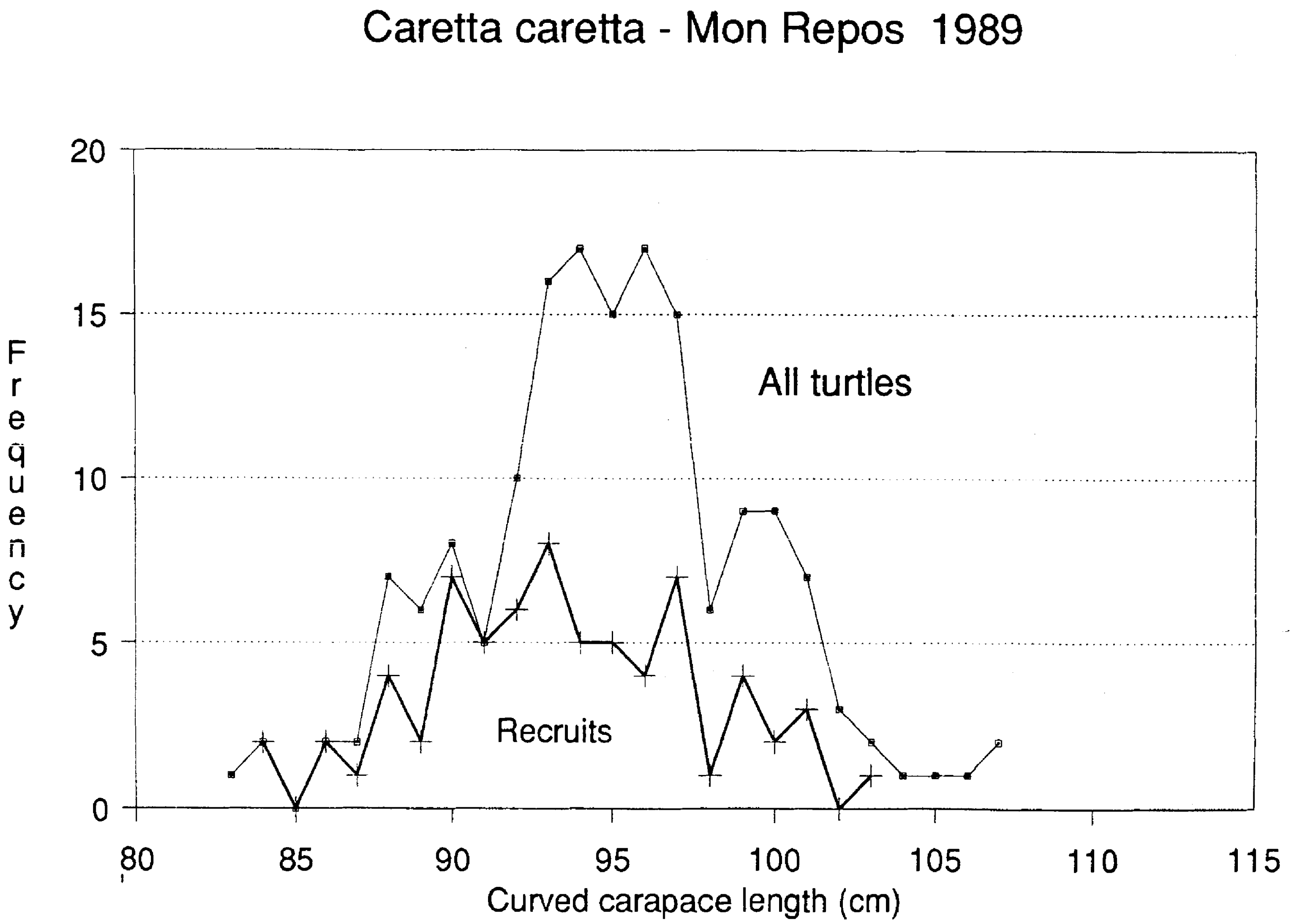
Figure 1. Comparison of size of new recruits to the breeding population relative to the size of the entire breeding population for Caretta caretta nesting at Mon Repos and adjacent beaches in south Queensland, 1989-1990 breeding season.



# THE MYTH OF THE DROWNED TURTLE

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Frequent references to drowning of sea turtles in shrimp trawl nets (e.g., Ross et al. 1989) assert that such drowning accounts for much of the mortality of sea turtles in waters off the southeastern United States. Evidence cited includes observations of turtles caught in nets, numerous stranded sea turtles on beaches, increases of strandings correlated with increases in shrimp fishing activity, and, most recently, increased strandings of sea turtles once enforcement of required excluder devices (TEDs) was relaxed. In addition, Shoop and Ruckdeschel (1989) found evidence of many stranded sea turtles having been in shrimp trawl nets just prior to death.

We concur that shrimp fishing activities are closely related to many, if not most, of the sea turtles found stranded on shores in the Southeast. We suggest, however, that sea turtles do not drown in shrimp trawl nets and that evidence of such drowning is lacking. We further suggest that sea turtles may not be dead when brought aboard shrimp trawlers, and that death of the sea turtles found stranded can be attributed to factors other than drowning.

Based on evidence we have gathered from hundreds of stranded sea turtles, known turtle physiology, and observations of the recovery of stranded sea turtles thought to have drowned in shrimp trawl nets, we believe the mortality of sea turtles caught by trawl nets may be drastically reduced by proper handling techniques following incidental capture. Recovery may require several days to many weeks, but even animals that appear dead when brought aboard fishing vessels may be comatose and can recover.

In the 1960s a series of astounding observations and experiments by Daniel Belkin (1962, 1963, 1968) opened an exciting area of research involving the ability of freshwater turtles to withstand prolonged submergence without apparent harm. He had noted that loggerhead musk turtles (Sternotherus minor) rarely surfaced to breathe in the freshwater springs in north-central Florida. After caging several on the floor of a spring run and returning many days later, he discovered the animals in good condition! His subsequent research and that of others, especially Donald Jackson (e.g., 1968, 1987), Peter Lutz and colleagues (e.g., 1985, 1987), Gordon Ultsch and co-workers (e.g., 1984), and Robert Gatten (e.g., 1987), have elucidated the amazing ability of turtles to function on anaerobic metabolic pathways for extended periods of time. While not yet fully studied in sea turtles, the data suggest that sea turtle physiology is intermediate with respect to anoxia tolerance.

While most of the approximately 1000 stranded sea turtles we have encountered have been dead, some stranded turtles were simply comatose and not breathing. Heartbeats were infrequent, and the animals presented a totally relaxed and non-responsive posture. Because many people are accustomed to such signs as indicating death in mammals, they might assume that such sea turtles were also dead. Some of those comatose turtles when returned to our facility and protected from vultures and raccoons, kept moist and shaded, began to breathe and respond to stimuli after a week or two. They were able to coordinate movements in several weeks, and began feeding within six weeks. All that survived the first few days went on to recovery and were released.

We have also found numerous stranded sea turtles that appeared to have died as a result of raccoon or vulture damage after the turtle stranded. Such animals bleed profusely and essentially soak the sand around them with blood. We believe that the famous D0004 female (with a 20-year nesting history) from the Little Cumberland Island population died in this way as a result of raccoon damage after stranding in a comatose condition. We have observed other comatose turtles, including a leatherback, that died from unknown causes after stranding.

We suggest that such adverse conditions as high temperatures or pathological complications along with the problems of deep anoxia or human-induced trauma may have contributed to the death of those turtles.

Rudloe (pers. comm.) has noted that some sea turtles in a comatose condition are removed from nets after only the short tow time of half an hour. Possibly, such turtles had been submerged for lengthy periods prior to incidental capture and thereby exhibited the effects of severe anoxia after only a relatively short time in a net. Balazs (1986) reported the recovery of a comatose green turtle (Chelonia mydas) after inflation of the lungs, suggesting that all sea turtles may become comatose if they enter deep anoxia.

Since about one-third of stranded sea turtles have suffered severe damage from sharks, probably after being dumped overboard from shrimping vessels as required by law, we suggest that such practices may not be in the best interests of comatose turtles. Those not attacked by sharks may go into deeper anoxia from which they cannot recover. But only by research into sea turtle anoxia and recovery can we make appropriate recommendations concerning comatose turtles.

Turtles do not drown in the classical sense of flooding the lungs with inspired water because they enter a state of glottal lock when submerged. Consequently, when forceably submerged, turtles become progressively more anoxic and acidotic, and the effects of the anoxia are temperature dependent. At low temperatures turtles can operate anaerobically for months or longer, but at higher temperatures activity is impaired within hours or minutes. Tolerable limits for sea turtles are unknown; hence, we have initiated a research program to define deep anoxia in sea turtles and the variables that affect such anoxia and subsequent recovery. From these studies we hope to develop protocols for recovery of sea turtles rendered comatose in fishing gear.

We still believe that use of TEDs would negate the need for recovery of many sea turtles, but TEDs are not 100% efficient. Some turtles will still be caught in trawls and fixed gear, making recovery facilities useful if our ideas about comatose turtles are correct. All of our suggestions, however, may be wrong; sea turtles may actually die in trawl nets as a result of deep anoxia. To date, no one has defined death in turtles, so researchers have set arbitrary criteria. Even Jackson noted that several of the experimental turtles he used in anoxia studies and recorded as dead were found crawling around in disposal containers many days later.

In summary, we do not believe that sea turtles drown, but they become increasingly anoxic in shrimp trawl nets. Severely anoxic turtles appear dead but are probably just comatose and may recover if appropriate means of resuscitation are implimented. We have observed stranded, comatose turtles that do not breathe for many days and have infrequent heart beats, but given protection from predators and dessication, recover apparently normal activity within several weeks. These observations suggest that once we understand the physiology of deeply anoxic sea turtles and their recovery from anoxia, such turtles can be returned to the population in good condition. We are implimenting a research program to address these suggestions.

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# HIBERNATION AND ANOXIC SURVIVAL IN THE SEA TURTLE

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Sea turtles are capable of dives lasting several hours (Rebel, 1974), and some observations suggest that they may hibernate underwater (Felger et al., 1976; Carr et al., 1980; Ogren and McVea, 1982).

During active dives, sea turtles will run out of oxygen within one hour or less (Berkson, 1966; Lutz and Bentley, 1985). So, how can they manage extremely long dives and underwater hibernation?

We may get some clues from the manner by which freshwater turtles (Pseudemys scripta) can remain submerged for months (Ultsch, 1989). This is principally due to their ability to stay anoxic for long periods of time.

For almost all vertebrates, the brain is the most anoxia sensitive organ. During anoxia, the mammalian brain suffers from a whole cascade of catastrophic events, all primarily caused by an inability to keep up the brain energy charge, i.e, its ATP level.

In contrast, the freshwater turtle brain is highly specialized in order to survive anoxia. In these animals, the falling rate of ATP production during anoxia is met by a falling rate of ATP consumption, allowing the freshwater turtle to maintain its brain ATP level (Lutz et al., 1985). Recent results suggest that the decreased energy consumption during anoxia is mediated by an increase in the levels of inhibitory neurotransmitters and neuromodulators like gamma-aminobutyric acid (GABA), glycine and taurine, combined with a decrease in the excitatory neurotransmitter glutamate and its main precursor glutamine (Nilsson et al., 1990). In contrast, in mammals, anoxia does not induce this consistent change in neuroactive amino acids (Siesjö, 1978). Indeed, anoxia may even cause an increase in the level of glutamate in the mammalian brain (Tews et al., 1963). Increased extracellular levels of glutamate is thought to be a major cause of anoxic brain damage in mammals (Benveniste et al., 1984).

So, does the pattern of change seen in neuroactive amino acids in freshwater turtle brain also occur in the anoxic sea turtle brain? We recently had the opportunity to study this in two female loggerhead sea turtles (Caretta caretta) that were to be euthanized by the Miami Seaquarium. Both individuals were so called saddlebacks.

Our results showed that the response to anoxia of the sea turtle brain was qualitatively identical to that of freshwater turtles. This indicates that the sea turtle brain has the same adaptations to survive anoxia as the freshwater turtle brain. We hypothesize that the possession of an anoxia tolerant brain is an adaptation to allow underwater hibernation, i.e., a very long breath hold dive essentially without access to oxygen, thus, very different from hibernation on land.

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# REPERCUSSIONS FROM RESPIRATION AND SWIMMING ACTIVITIES EXHIBITED BY TWO SPECIES OF SEA TURTLES

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Respiration rates and swimming activites were recorded for an adult male and female (21-yr-old), six subadult (12-yr-old ) loggerheads, and one subadult (12-yr-old) green sea turtle, held in outdoor concrete ponds subject to natural air and water temperatures and flow-through water salinities. Twenty-four hourly 10 minute observations were conducted biweeekly during the 30-week period 9 May through 19 November 1989. Males were more active than females and consistantly occupied surface to mid-depth waters, while females were less active and preferred to remain on the bottom. Daytime activities, for all specimens, were greater than at night, regardless of season. Respiration rates were higher during the cool or cold spring and fall, and decreased as water and air temperatures increased during the summer. Most breaths occurred within one hour of each other; although breathless intervals up to 19 hours were recorded. These observations have far reaching repercussions; in that aerial population estimates may be erroneous. The observations presented here explain why so few males are captured or stranded and affect federal agency suggestions regarding TED use, fishing time and interval, and tow duration. Sanctuaries and restricted fishing times and areas are the best solutions to the conservation of sea turtles.

# ENTEROHEPATITIS DUE TO ENTAMOEBA INVADENS IN CAPTIVE CARETTA CARETTA

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With the advent of head start programs, captive breeding projects, display, rehabilitation and research programs, the overall number of sea turtles in captivity has greatly increased over the last 10 years. This relatively large group of sea turtles has presented those of us interested in and responsible for their health with unique opportunities to study both natural and captive-induced disease processes.

The protozoan Entamoeba invadens is a common inhabitant among the alimentary microfauna of many species of reptiles. The amoeba, which is closely ralated to the human pathogen Entamoeba histolytica, resides in the intestinal tract of the host organism and causes little or no damage to its host. It is generally believed this commensal relationship is achieved because of the herbivorous nature of the host animal (Meerovitch, 1958). For the amoeba to complete its life cycle by forming cysts, it requires substantial levels of starches such as glycogen. High starch levels in a plant-rich diet meet these needs. While Entamoeba invadens may be a commensal organism in fresh water turtles, it is a relentless pathogen in snakes, some species of lizards, and now, we know, sea turtles. There are many well-documented cases of Entamoeba invadens epidemics in reptile colonies, but only one case of amebiasis has been reported in captive reared juvenile Caretta caretta and a juvenile Chelonia mydas (Frank, 1976). Although the protozoan is unable to survive in saltwater, these turtles became infected when held in the same tank with fresh water turtles. Once infected with Entamoeba invadens snakes invariably develop a fatal hemorrhagic intestinal disease unless treated with metronidazole or other amebacides. The carnivorous nature of these reptiles may be the factor that allows Entamoeba invadens to be destructive. The motile trophozoites, unable to satisfy their nutritional needs from the intestinal contents of the host animal, invade the host's intestinal wall. The subsequent erosion and ulceration of the wall provides the amebae with a source of mucopolysaccharides that can be converted to glycogen.

Once the trophozoite is able to accumulate enough energy in the form of glycogen, it forms a cyst. This quadrinucleate cyst, which is the infective stage of the organism, is then shed in the host's stool. Cysts are very resistant to desication and persist in the environment for considerable periods of time. When ingested by a suitable host, the cysts open and the amebae develop into unicellular trophozoites completing the life cycle. The mobile trophozoites attack the mucosal surface and cause ulcerative lesions in the intestinal tract, often resulting in bloody diarrhea. Invasive amebae and gram negative bacteria may enter the blood stream through the ulcers and be carried by the portal circulation to other organs such as the liver. Once in the liver, Entamoeba invadens causes a severe necrotizing hepatitis. This form of the disease is termed enterohepatitis. Untreated infections of Entamoeba invadens are invariably fatal. The course of the disease may be as short as 24 hours or as long as several weeks. Optimum host temperature range for Entamoeba invadens is 16-20°C, but it can grow well in hosts housed at temperatures up to 30°C. Diagnosis of entamebiasis is accomplished by finding either cysts or trophozoites in the feces of sick or well (carrier) individuals. The motile trophozoites or cysts may be seen in direct or stained microscopic preparations.

During the seven-month period from 9/6/87 to 3/31/88, three juvenile Caretta caretta died from amebic enterohepatitis. During this time air temperatures were maintained between 15.0°C and 30.0°C, water temperatures were between 22.0'°C and 28.0°C, and salinities varied from 15 to 25 ppt. Two of the sick turtles - were kept in separate fiberglass tanks with individual filter systems. One of the sick animals shared a partitioned tank with four other loggerheads, none of which showed any signs of illness. Food was supplied once daily as a pre-made gelatin diet (Choromanski, et al., 1987), supplemented with fresh spinach. Blocks of diet were thawed and kept refrigerated until fed. Turtles were individually hand fed.

At various times during the disease outbreak there were approximately 22 other sea turtles present in the holding facility, as well as substantial numbers of the following fresh water species: Terrapine carolina, Chelydra serpentina, Pseudemys scripta, and Chrysemys picta.

Blood samples are collected and plasma chemistries analyzed when any of our resident turtles display signs of illness. Results from tests performed on blood samples taken from turtles involved in this outbreak of amebiasis indicated liver disease. The plasma Aspartate Aminotransterase (SGOT/AST) enzyme level rises when dying liver cells release the enzyme into the blood stream. A second enzyme, Lactic Dehydrogenase (LDH), is also released with liver necrosis. Increased levels of both enzymes indicates the presence of dying liver cells, The AST test is more specific for liver disease and rises more dramatically than the LDH test. For our laboratory AST levels of 165 to 405 IU/L and LDH levels of 86 to 554 IU/L constitute normal ranges. The diseased turtles had AST levels as high as 6,380 U/L and LDH levels up to 1,484 IU/L. Both enzymes rose steadily in the turtles as the disease progressed.

All three turtles were empirically treated with broad-spectrum antibiotics and supportive medications. Despite treatment all three loggerhads became progressively weaker and died. Gross examination of the coelomic cavities revealed essentially the same lesions in all three turtles. Each animal had what appeared to be a severely necrotic and caseated right liver lobe. The liver tissue was gray, dry and clay-like. In addition, each sea turtle had pathologic changes of the right lung. Alterations in pulmonary tissue varied from mild inflammatory changes to severe necrosis with fluid in the air passages. In some areas the lung tissue was gray and consolidated like the liver. Examination of the digestive tract failed to reveal any changes to the intestinal wall, and the intestinal contents appeared normal. Microbial cultures of liver tissue yielded a different genus of bacteria for each individual cultured. Formalized tissue samples were sent to Dr. Elliott Jacobson at the College of Veterinary Medicine, University of Florida. The ensuing reports confirmed our suspicions of amebic enterohepatitis. Dr. Jacobson found Entamoeba invadens-like protozoans in histological prepartions from liver, lung, and intestinal tissues.

The obvious question to be asked following the death of three individuals from an infectious organism is, where is the lethal organism coming from? By the time a diagnosis of amebiasis was made, all the fresh water turtles were gone from the holding facility so they could not be tested. Different species of fresh water turtles were present in the turtle building at various times, but none of them were present during the entire period of the outbreak. It is possible that the earliest of the turtles seeded the area with cysts which could have remained in the environment for a prolonged period of time. A second possible source of infective cysts would be a home herpetological collection. Animal handlers with infected reptiles at home could carry cysts to work on their hands or clothes. The cysts probably were innoculated into the turtles by contaminated food. This mode of disease transmission would explain the intermittant nature of the problem and the fact that turtles sharing a common water supply with an infected individual did not get sick.

Entamoeba invadens is a potent and relentless pathogen in carnivorous reptiles, sea turtles included. Because the susceptibility of loggerhead sea turtles has been established, it is imperative that captive sea turtles be kept strictly isolated from fresh water turtles and other reptiles. Care should be taken to cleanse all food preparation areas and equipment with sodium hypochlorite solutions. All animal handlers should pay scrupulous attention to scrubbing and disinfecting their hands when going from one species of reptile to another. When circumstances require sea turtles to be in close proximity to reptiles that may be asymptomatic carriers of Entamoeba invadens, the suspect animals should be tested and/or prophylactically treated for the organism with oral metronidazole.

# DISTRIBUTION AND SPECIES COMPOSITION OF SEA TURTLES IN NORTH CAROLINA

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In the summer of 1988 the Beaufort Laboratory began conducting research on sea turtles in North Carolina waters. The research was initiated because the Pamlico-Albemarle Estuarine Complex (Figure 1) is the largest estuarine system in the southeastern United States, and there is a growing awareness that estuaries are important developmental and foraging habitat for several species of sea turtles. In addition, the Pamlico-Albemarle Estuarine Complex was historically the site of a large turtle fishery; the occurrence of loggerhead, green and Kemp's ridleys were documented in the landings of the fishery.

The study consisted of four discrete projects: 1) the public sighting program where posters were used to request that the public report sightings of sea turtles throughout the state's waters (Veishlow et al., in press), 2) the ferry boat program where sighting logs were carried on each public ferry in the coastal waters of the state (Veishlow et al., in press), 3) aerial surveys of Core and Pamlico Sounds where surface waters were surveyed monthly (Braun et al., in press), and 4) biological sampling where volunteer fishermen recorded their incidental catches and, when time permitted, measured, photographed and double tagged the turtles.

The results indicated that sea turtles were present in the offshore waters (seaward of the COLREGS Demarcation Line) of the state all months of the year. They were also relatively abundant inshore from April into December. The distribution patterns of sea turtles in estuarine waters indicated immigration in the spring, sorting (perhaps by habitat type) throughout the summer, and emigration in the late fall and early winter. In the spring, turtles were initially distributed in Core Sound and in the eastern portion of Pamlico Sound, with the highest density occurring in the southeast area. As waters warmed, the turtles dispersed throughout the sounds entering the lower portion of tributary rivers and penetrating into Croatan and Roanoke Sounds; none were reported from Albemarle or Currituck Sound.

Loggerhead sea turtles of all sizes, immature greens and Kemp's ridleys and a single adult green turtle were incidentally captured by volunteer fishermen in inshore waters; public sighting reports and aerial surveys revealed the infrequent occurrence of leatherbacks inshore. Similarly, confirmed public sighting reports, aerial reconnaissance, and fishermen's reports also indicated the presence of these same four species in the offshore waters.

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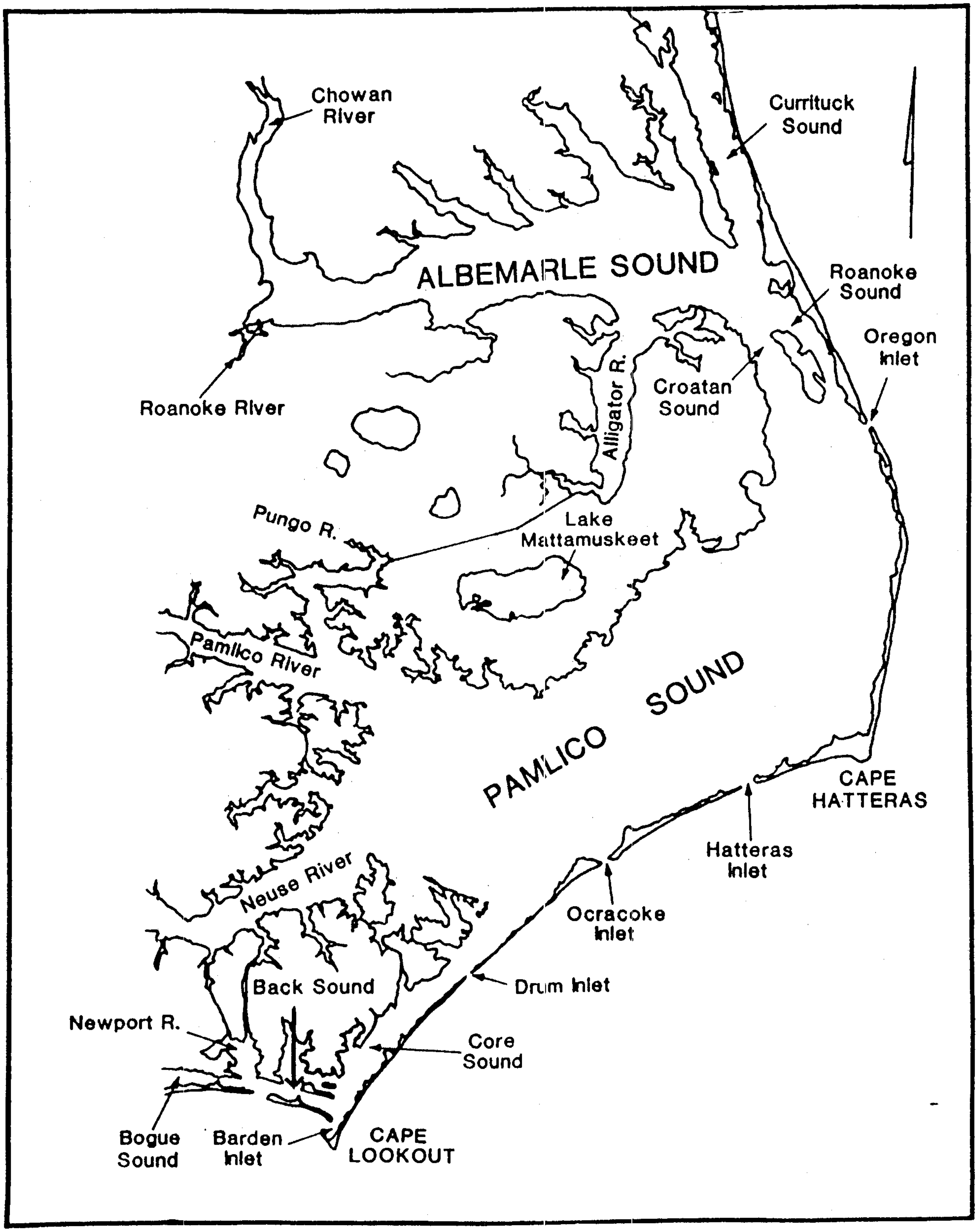
Chowan River
Currituck Sound
ALBEMARLE SOUND
Roanoke Sound
Oregon Inlet
Roanoke River
Alligator R.
Croatan Sound
Pungo R.
Lake Mattamuskeet
Pamlico River
PAMLICO SOUND
CAPE HATTERAS
Hatteras Inlet
Neuse River
Ocracoke Inlet
Back Sound
Drum Inlet
Newport R.
Core Sound
Bogue Sound
Barden Inlet
CAPE LOOKOUT

# SEA TURTLE RECOVERY GOALS AND OBJECTIVES OF THE U.S. FISH AND WILDLIFE SERVICE

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All species of marine turtles inhabiting the Western Hemisphere are listed as endangered or threatened and occur within U.S. jurisdicition at one time or another of their life cycles. All seven species within the Western Hemisphere are also international in range. The continental U.S. provides the breeding haitat for one of the world's two largest remaining populations of loggerheads, and we are a partner with Mexico in determining the recovery or extinction of the critically endangered Kemp's ridley. Neither nation alone can recover the species, but either can, independently, cause its demise.

The other five species exhibit a similar range of international management problems which must be recognized and addressed if we, or any nation, is to be successful in maintaining sea turtle resources at healthy, viable levels for the use and enjoyment of all people and all nations. Because of the exceptionally long period of time required from birth to sexual maturity (in excess of 30 years for some populations), there are no near term recovery success stories on the immediate horizon. Recovery for these animals requires a long term commitment of the United States and our hemisphere neighbors. The Service recognizes this need and commits itself to the following national goal:

> To Utilize All Available Service Authorities to Conserve and Recover Threatened and Endangered Species of Sea Turtles and Their Habitats World Wide--With Particular Emphasis Placed on Species, Populations, and Habitats of the Western Hemishpere. The Fish and Wildlife Service will Provide a Leadership Role in the Recovery and Management of All Species of Threatened and Endangered Sea Turtles and Maintain an Active Role in Recovery Plan Implementation.

This goal will be addressed through establishment and implementation of the following national objectives:

1. Utilize service authorities to provide maximum protection of nesting beaches, with special effort directed to management of nesting habitats located on National Wildlife Refuges (NWRs) and other areas under United States jurisdiction.

2. Maintain or initiate efforts to obtain highest possible hatch and hatchling escapement rates without jeopardizing the development of natural sex ratios. NWRs will set an international example.

3. Utilize Section 7 of the ESA to safeguard nesting areas and identified marine habitat use areas.

4. Encourage, cooperate with, and assist other federal agencies, respective states, private, and public institutions and individuals in the recovery and management of marine turtles, including their marine and onshore habitats.

5. Encourage and assist foreign governments and institutions in on-site field projects to understand and conserve international sea turtle resources, with primary emphasis on Mexico, Central America, and the Caribbean regions of the Western Hemisphere. This includes activities in support of international treaties, conventions, and accords to assure multi-nation cooperative management of the species and their habitats.

6. Conduct and cooperate in research projects to improve the biological/ecological understanding of sea turtle species, with priority emphasis on projects with direct management application.

7. Assist other nations through eduction and public awareness programs in developing realistic alternatives to commercial over-explotation of internationally depleted sea turtle resources.

8. Fully utilize Service law enforcement authorities to detect, apprehend, and prosecute all violations of U.S. laws, including treaty obligations, related to sea turtles. Emphasis will be placed on detecting and stopping illicit commercial trade and will include continuing and expanding international law enforcement cooperation and assistance.

# AERIAL SURVEYS OF MARINE TURTLE CARCASSES IN NATIONAL MARINE FISHERIES SERVICE STATISTICAL ZONES 28, 29, AND 30; 11 AUGUST 1987 TO 31 DECEMBER 1989

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## INTRODUCTION

Aerial surveys of marine turtle carcasses in National Marine Fisheries Service (NMFS) Statistical Zones 28 and 29 were conducted from 11 August 1987 to 31 December 1989. In January 1989, the survey area was expanded to include Zone 30. The objectives of the study were:

1. to establish a systematic weekly aerial survey of NMFS Zones 28 ,29, and 30;
2. to assist the efforts of the Sea Turtle Stranding and Salvage Network (STSSN), and ensure that all marine turtle carcasses were accounted for;
3. to obtain carcasses suitable for histopathological necropsy and perform necropsies on selected individuals;
4. to observe and record the daytime shrimp trawling effort within approximately 7.0 km of the shoreline, within the boundaries of zones 28, 29, and 30;
5. to examine the information collected from the aerial surveys together with STSSN data and investigate the possibility of any developing trends.

## STUDY AREA

The study area began at the 28th parallel, approximately 5.0 km south of Melbourne Beach, Florida, and ended at the 31st parallel, approximately 2.0 km north of Little Cumberland Island, Georgia. Zones 28 and 29 contain approximately 300 km of Atlantic coastline.

## METHODS

1. Every effort was made to conduct weekly surveys, weather permitting, for consistency.
2. The surveys began approximately one hour after sunrise.
3. A high-winged Cessna 182 aircraft was used during all flights.
4. A fixed altitude of 200 feet, 100 meters offshore, and an airspeed of 85 knots was maintained during the surveys.
5. All sea turtle carcasses observed during the surveys were circled for positive identification, given a fixed location, and investigated by ground personnel.
6. Sea turtle carcasses suitable for histopathological necropsy were placed on ice and transported to the University of Central Florida, Orlando, Florida.
7. All daytime shrimp trawler activity (nets down and trawling only) was logged by number and location.

## RESULTS AND DISCUSSION

The data collected during this study were compiled by statistical zone in order to focus on trends observed between carcass strandings and daytime shrimp trawling effort. Number of carcasses shown in Figures 1, 2, and 3 is defined as all species reported by month to the STSSN, and shrimping effort is the number of trawlers observed working (nets down) within 7.0 km of the shoreline per month.

A Turtle Excluder Device (TED) has been required within NMFS Statistical Zone 28 since 1 October 1987, except from 12 April 1988 to 1 September 1988 when federal courts enjoined TED regulations. Zone 28 extends from near Melbourne Beach on the south and New Smyrna Beach on the north. This zone includes the Port Canaveral Shipping Channel, which has a known high population of marine turtles year around.

A comparison between daytime shrimping effort and the number of carcass strandings per zone per month, combined (Figure 1), reveals the following trends. We believe that, at least in 1987 and 1988, the inverse relationship between TED use and the number of strandings shows the effectiveness of TED use in Zone 28. In 1989, however, there appears to be no correlation. Perhaps other factors such as currents, lag times, and other possible causes of mortality are affecting these data.

NMFS Statistical Zone 29, a non-TED regulated area, lies to the north of Zone 28, and includes the area from New Smyrna Beach north to St. Augustine. The total number of marine turtle carcass strandings reported from August 1987 to December 1989 in Zone 29 was 448. This is considerably higher than the 244 in Zone 28 for the same period. It also should be noted that three times as much shrimping effort was observed in Zone 29 as was observed in Zone 28.

When we compare shrimping effort to carcass strandings in Zone 29 (Figure 2), a modest trend appeared. The period from August through November 1987 exhibited an increased level of shrimping activity. In the same period it was clear that the number of strandings increased with the increase in shrimp trawling. From December 1987 to March 1988, a declining but still significant shrimping effort is seen. A decline in carcass strandings also occurred in these months. In June 1988 shrimping effort began to gradually increase. Likely as a response to the opening of shrimping season within state waters, carcass strandings also begin to increase at this time. From August 1988 through February 1989, a correlation between shrimping effort and carcass strandings is evident, with both strandings and trawling effort occurring at the highest levels for the year.

Beginning in January 1989 aerial surveys were extended to include NMFS Statistical Zone 30. Zone 30 begins approximately 15 km north of St. Augustine, Florida and ends at the 31st parallel, approximately 5 km north of Little Cumberland Island, Georgia. It should be noted that Zone 30 has essentially the same number of carcass strandings for the year as was seen in Zone 29. Zone 30 exhibits the highest level of shrimping effort within the three zones. There is five times more effort than in Zone 28, and twice the effort as seen in Zone 29.

A comparison of carcass strandings and shrimping effort (Figure 3), reveals an interesting trend. In February and March, both shrimping effort and carcass strandings are low. In March an increase in shrimping effort begins, peaks in April and decreases in May. Carcass strandings follow the same trend, but lag by about a month.

In June (the opening of shrimp season in Florida and Georgia waters) shrimping effort increases threefold, peaks in July and then begins a decline that culminates in December. Generally, strandings follow this same pattern. There is an obvious discrepancy in October, for which we have little or no explanation. Otherwise, the correspondence is quite good.

In conclusion, although the relationships discussed here are at times not entirely clear, we feel the trends observed add to the growing body of evidence for a correlation between marine turtle strandings and shrimping effort in Zones 28, 29, and 30.

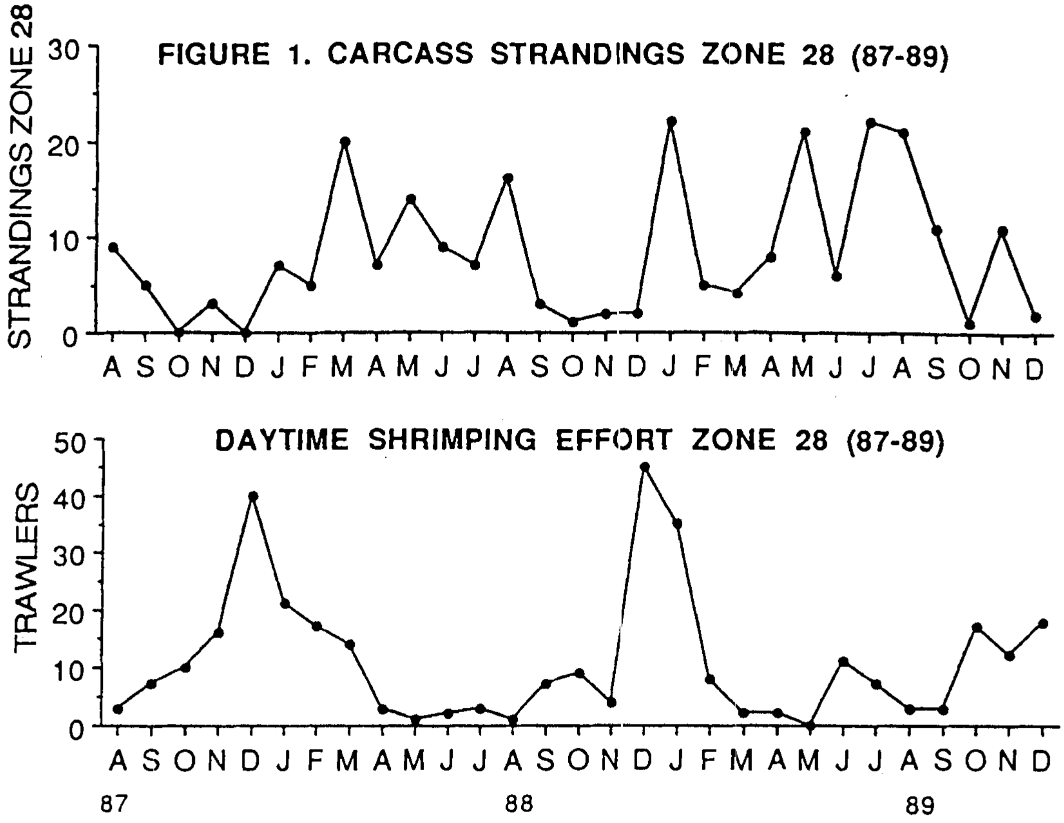


FIGURE 1. CARCASS STRANDINGS ZONE 28 (87-89)

DAYTIME SHRIMPING EFFORT ZONE 28 (87-89)

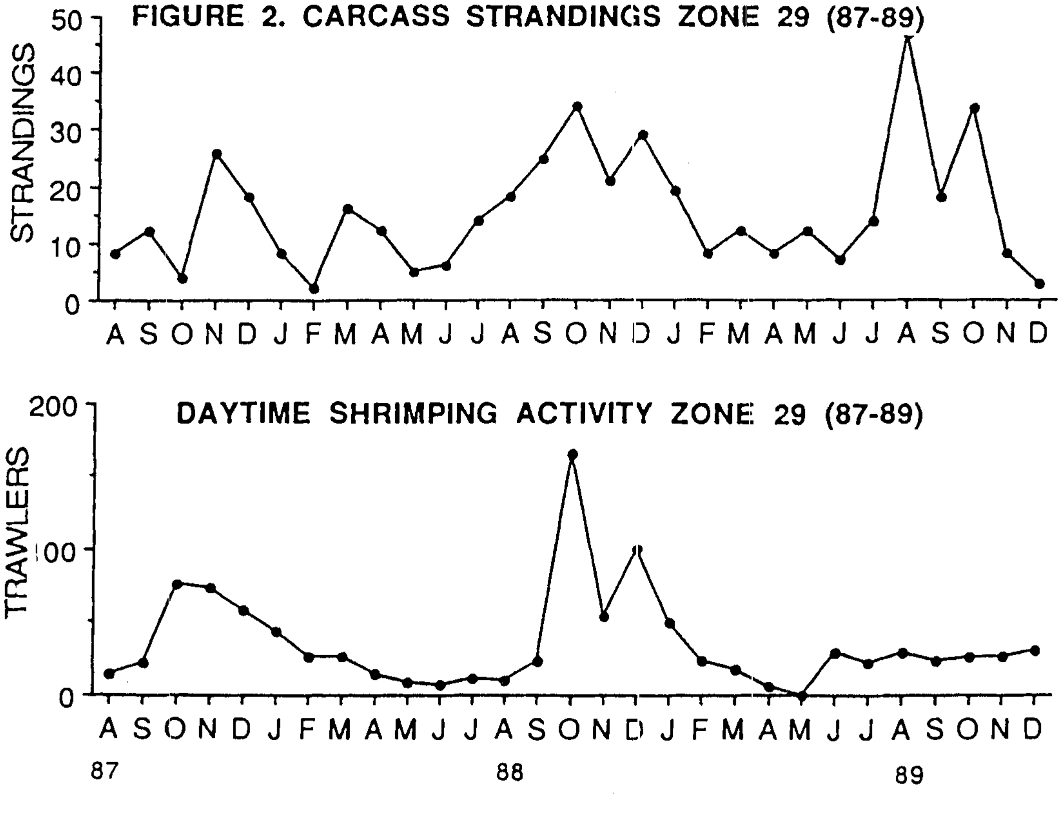
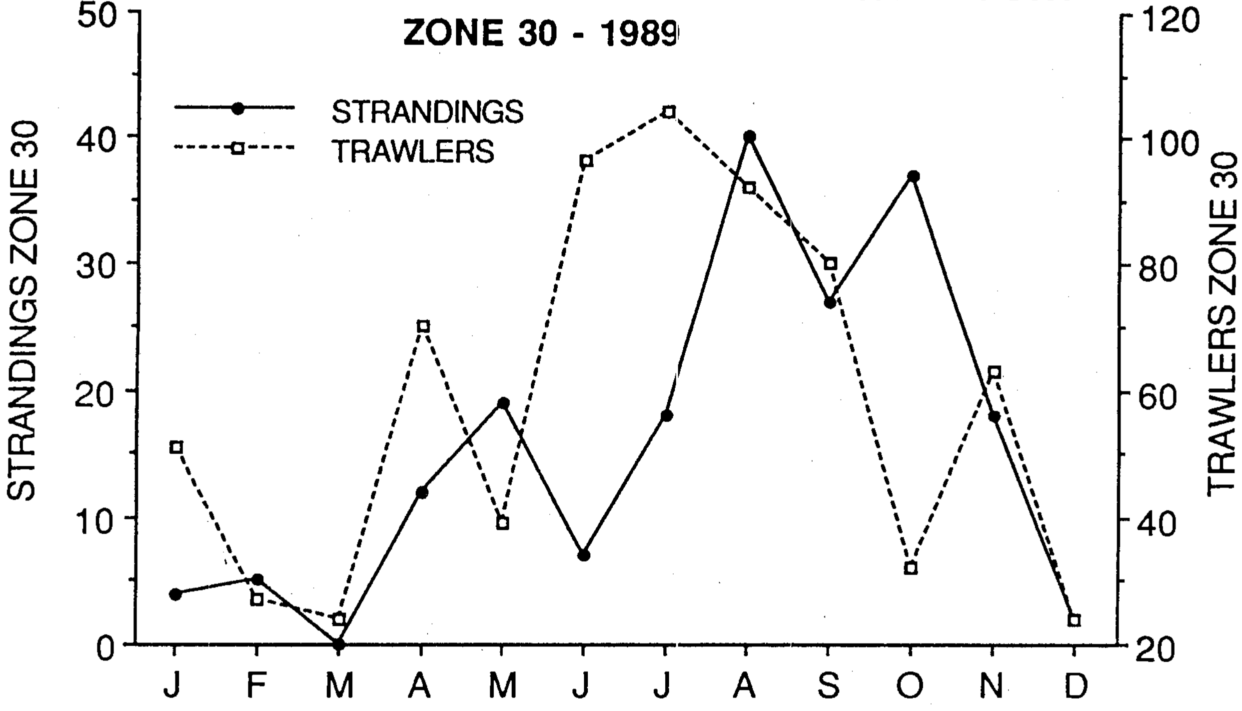


FIGURE 2. CARCASS STRANDINGS ZONE 29 (87-89)

DAYTIME SHRIMPING ACTIVITY ZONE 29 (87-89)

FIGURE 3. STRANDINGS VS. SHRIMPING EFFORT
ZONE 30 - 1989



# THE GEORGIA SEA TURTLE STRANDING AND SALVAGE NETWORK: HIGHLIGHTS FROM THE EIGHTIES

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Georgia's coast is a 100-mile segment of the Sea Turtle Stranding and Salvage Network, a study area comprised of over 2,400 miles of coastline. Georgia has participated in the network since it was formally organized in 1980. Ruckdeschel and Zug (1982) noted that prior to 1979, sea turtle strandings on Cumberland Island, near the Georgia/Florida border, had increased from 24 to 179 in six years. This led to the formation by Ruckdeschel of a Georgia stranding network in 1979. That year, 459 carcasses were counted statewide.

The barrier islands of Georgia account for less than 4% of the coastline monitored by the network. Loggerhead nesting in the state is less than 2% of that for the Southeast United States (Murphy and Hopkins, 1984). However, over 17% (annual range: 9%-38%) of all Atlantic and Gulf of Mexico strandings (all species) have been reported from Georgia, a total of 2,826 turtles in ten years (range: 120-806). Inclusion of data for 1979 raises this figure to 3,285. According to Ulrich (1978) and Murphy (unpub.), strandings represent a minimum estimate of at-sea mortality.

A breakdown of strandings by species (Figure 1) reveals seasonal trends for loggerhead, Kemp's ridley and leatherback turtles. A temporal pattern could not be distinguished for green turtles. The present federal TED rules for the exclusion of sea turtles from trawl nets would afford little protection in Georgia for the critically endangered Kemp's ridley, which strands in greater numbers in the fall.

The cause of death for most stranded turtles cannot be determined. The shrimping season coincides with seasons when turtles are abundant in our region. Hillestad et al. (1977) interviewed trawlermen in the early seventies and calculated that the area trawled by 321 resident vessels to be 100 times the total acreage of Georgia's near-shore waters. (Trawling licenses in Georgia have numbered between 606 and 1,471 since 1979, generally decreasing over time.) Short-term analyses of nominal trawling effort versus turtle strandings have provided inconclusive results. Increased motorboat traffic is a likely factor in turtle mortality. As coastal populations increase, vessel collisions are more likely. Dredging of shipping channels has been identified as a cause of sea turtle death, and smaller turtles (<40 cm) may not show 'characteristic' signs of this trauma (Richardson, Miles, unpub.). Death due to gunshot wounds also occurs. The authors have witnessed numerous anecdotal accounts from a variety of commercial crab potters relating elimination of 'pest' individuals. In summary, care must be exercised when attempting to ascertain cause of death of stranded carcasses.

The network has collected information from tags borne by the turtle carcasses that strand on our beaches. Most notable are long-distance returns from French Guyana (leatherback), Rhode Island (loggerhead), and Galveston, Texas (ridley head-start). While juveniles have always comprised the largest size group of loggerhead strandings (Hillestad, 1977: Maley, unpub.), mature females, identified by flipper tags from nesting beaches, wash ashore in June, July, and August. Only one tagged female has been observed stranded outside of those three months in 19 occurrences.

On July 1, 1989, after a one-year moratorium and an additional 60-day grace period, federal TED requirements were finally enforced for vessels operating in the state. Although June and July are the peak months for strandings in Georgia, 1989 totals for June were below average, and July experienced the fewest strandings for the month in the history of the network. Of particular note is the period in which TED use was enforced and compliance was perceived to be industry-wide. During this three-week period (1-21 July), seven turtles stranded in the state, compared to the average of the previous nine years of 70 loggerheads in the same period. A plot of C. caretta strandings tallied in 3-day increments shows this distinct hiatus (Figure 2).

Historical (1981-1988) strandings allow a simple statistical test of the chance occurrence of 1989 patterns. Application of a chi-square test for goodness-of-fit with three-day mean data specifying expected strandings shows that the 1989 strandings for the 21-day period are significantly different from the norm at a very high level of significance ($x^2=31.05$; $n=7$; $DF= 6$; $a<.01$).

Including the 1980 data (214 turtles) would only amplify this result. This statistical analysis suggests that the required use of TEDs was highly effective in preventing the trawling capture and mortality of sea turtles. It is unfortunate that politics played such an intense role in the deployment of TEDs during the 1989 season. However, the pattern of enforcement provided the opportunity to investigate their effectiveness.

Anticipating TED regulations becoming effective during 1988, the GA DNR had an opportunity to coordinate a TED distribution program. Enough TEDs were purchased to equip nearly the entire Georgia shrimping fleet in time for the effective date of TED requirement in May 1988. The total expenditure amounted to $240,000. Funds were available from the Georgia Office of Energy Resources oil overcharge account. Coastal Resources Division has opened a dialogue with the Georgia shrimping industry to address the problem of incidental capture. The Division will submit a rule for consideration by the Board of Natural Resources during 1990. This measure will be designed to augment the federal requirements with the precision necessary to protect turtles as they occur in the Georgia coastal zone. Not all strandings would be prevented by TED use, but it would be gratifying to increasingly witness turtles at sea, and to find that stranded turtles become the rarity.

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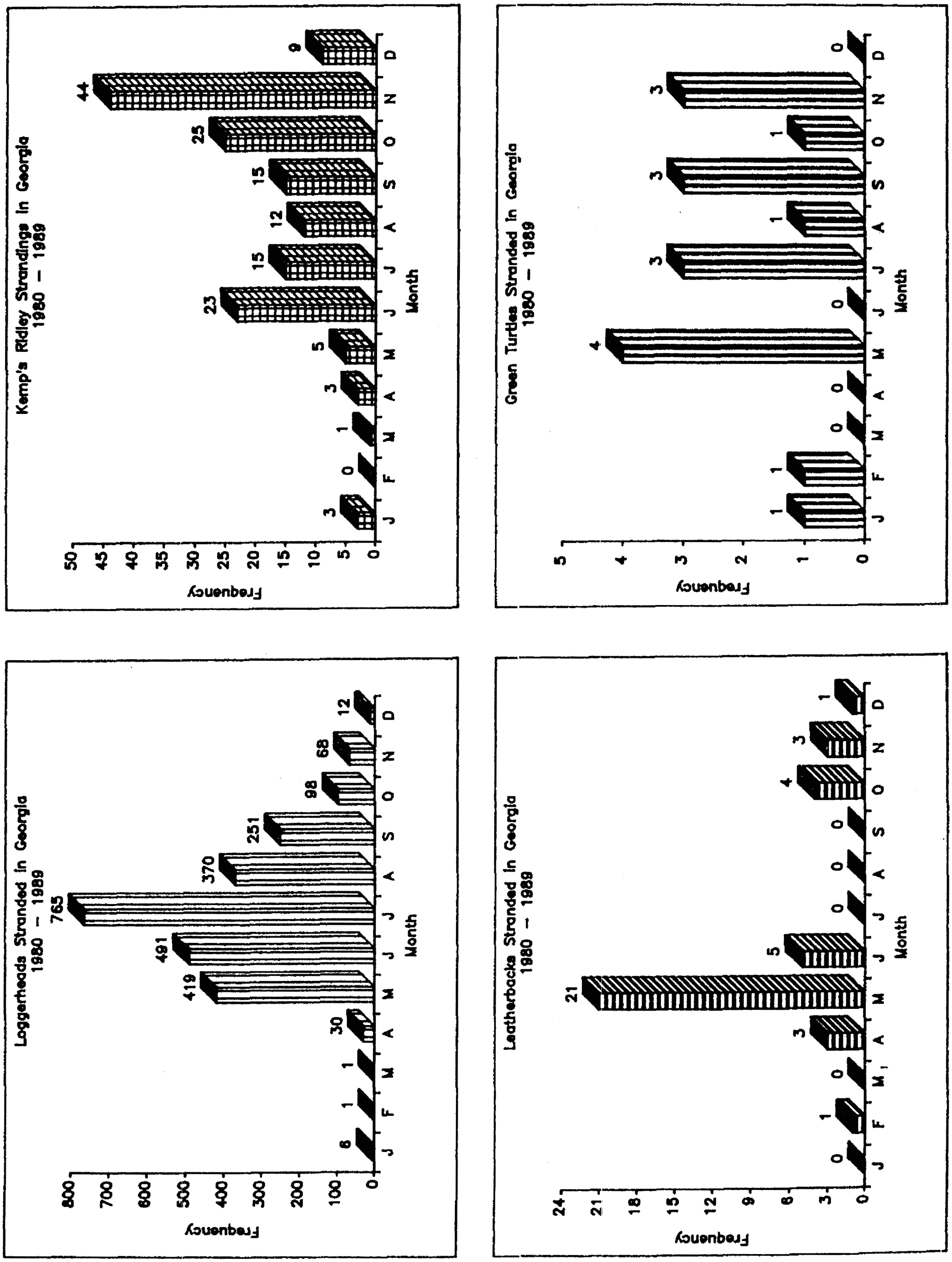
Figure 1



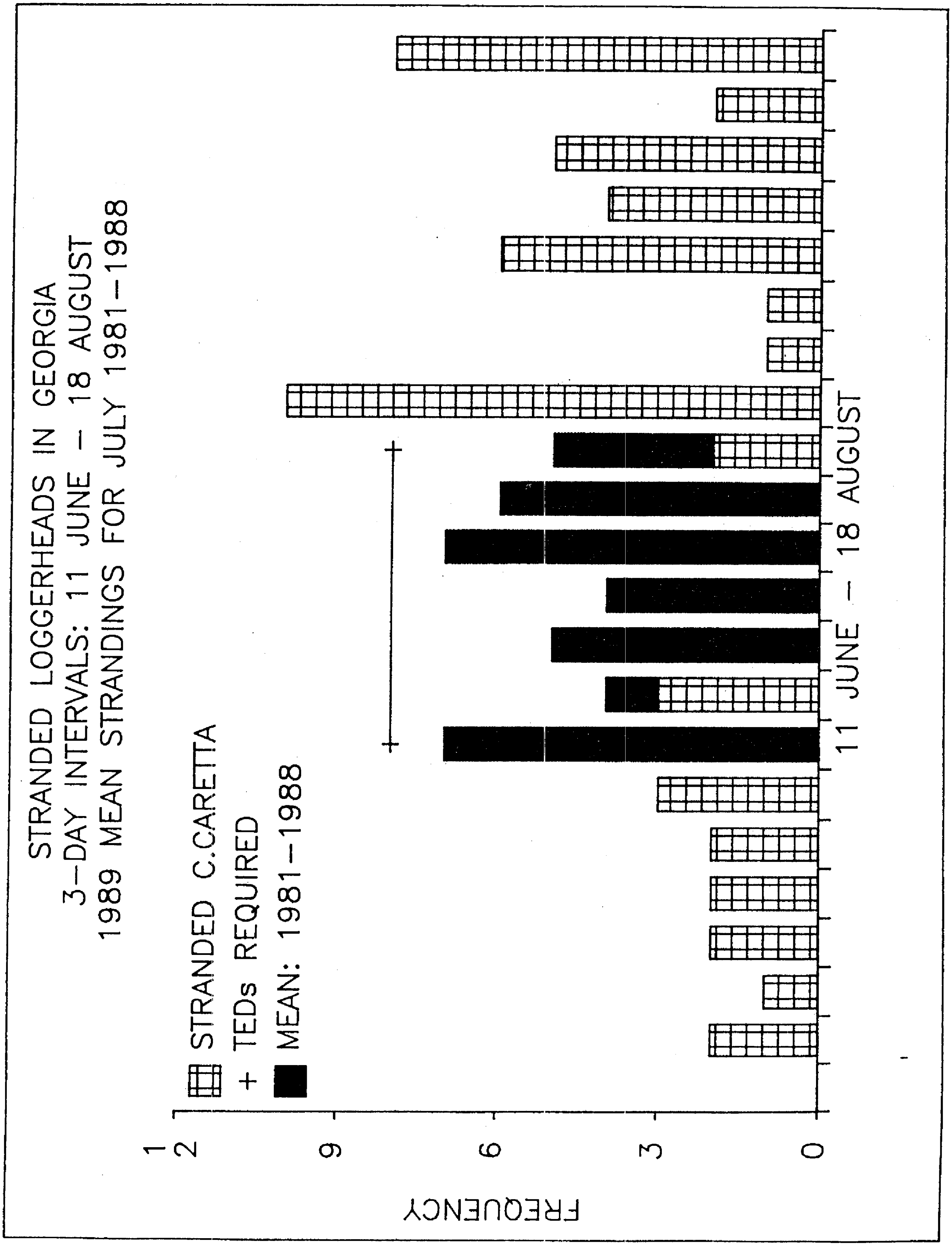
Loggerheads Stranded in Georgia 1980 – 1989

Kemp's Ridley Strandings in Georgia 1980 – 1989

Leatherbacks Stranded in Georgia 1980 – 1989

Green Turtles Stranded in Georgia 1980 – 1989

Figure 2


STRANDED LOGGERHEADS IN GEORGIA
3-DAY INTERVALS: 11 JUNE – 18 AUGUST
1989 MEAN STRANDINGS FOR JULY 1981-1988
▦ STRANDED C.CARETTA
+ TEDs REQUIRED
■ MEAN: 1981-1988
FREQUENCY
12
9
6
3
0
11 JUNE – 18 AUGUST

# ORIENTATION BY SWIMMING SEA TURTLES: ROLE OF PHOTIC INTENSITY DIFFERENCES WHILE NEAR-SHORE

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After crawling from their nest to the surf zone, hatchling sea turtles enter the ocean and swim in an offshore direction. What sensory cues serve as guideposts while in this "near-shore" environment? Visual cues are essential for orientation from the nest to the surf zone. But several km from shore, hatchlings swim into surface waves and swells. Under laboratory conditions, they can do so in the absence of visible light. Thus it is clear that visual stimuli are important during the terrestrial, but not during some portions of the aquatic, phase of migration.

In the near-shore environment, hatchlings are probably exposed to both surface waves and visual contrasts between the land-sea horizon. Thus turtles might continue to rely upon visual cues. We carried out experiments in the laboratory to determine if intensity contrasts serve as orientation cues for hatchling loggerheads shortly after they begin swimming. Our approach was to compare the behavior of crawling and swimming hatchlings to the same stimuli, within minutes after an initial exposure. We hypothesized that if intensity differences were used near shore, swimming turtles should show orientation responses similar to those observed in crawling turtles. The stimuli we used were artificial "horizons" (a horizontal band of light projected on half of a screen surrounding a circular orientation tank) and discrete images (circles, rectangles) of the same intensity. Of these two categories of stimuli, "horizons" more closely mimicked the broad expanses of visual contrast characteristic of those distinguishing landward and seaward directions.

Stimuli were no brighter than the seaward horizon present at nesting beaches on dark (moonless) nights. Hatchlings were tested at night in a light-tight room on the evening of their scheduled emergence. Orientation tanks were circular "kiddy pools," filled with sea water. During their "crawl," hatchlings moved on a platform elevated a few mm above water level. After their orientation behavior was recorded, the platform supports were released via a trip line, forcing hatchlings to swim. Five minutes later their orientation responses were once again noted.

In the presence of discrete light stimuli, crawling and swimming hatchlings behaved identically. Individuals always oriented on courses approximately toward the stimulus. However when artificial horizons were used as test stimuli, crawling turtles oriented toward the stimulus but swimming hatchlings no longer showed a positive phototaxis. Rather, turtles were equally likely to swim toward the illuminated or toward the dark horizon. Whatever their directional preference, swimming hatchlings maintained oriented headings. This response shows they still detect the stimulus as in total darkness, turtles swim in circles. It seems clear, then, that once turtles begin swimming they no longer respond to horizon brightness contrasts in the same way that crawling hatchlings do.

Two points deserve emphasis. First, we interpret our results to mean that responses to horizons, not discrete light sources, most accurately reflect how hatchlings behave in nature. We view the response to discrete photic stimuli as a light "trapping" effect, also common in insects, fishes, birds and many organisms. Light trapping occurs when organisms are exposed to near-by, concentrated, and man-made sources of light. In sea turtles, such responses now have serious consequences but probably bear little resemblance to those shaped by millions of years of sea turtle evolution.

Secondly, these results are consistent with our other findings, all of which suggest that hatchlings possess two systems of orientation: one for the terrestrial phase and another for the aquatic phase of migration. These systems involve different cues and can function autonomously. This interesting, and in many ways unique, behavioral attribute is probably a consequence of how sea turtle hatchlings migrate. They locomote across two ecologically distinct habitats (land and sea) which present very different assemblages of orientation cues. Through their behavior, turtles indicate that visual contrasts are choice guideposts on land but are either unavailable or unreliable once they enter the ocean. Thus even if intensity differences are present, swimming turtles no longer respond to them.

At this early stage of our work, these are the emerging hypotheses. Further studies will be necessary to thoroughly test their validity.

# SWIMMING THE OFFSHORE MARATHON: ANALYSES OF EARLY SWIMMING ACTIVITY IN LOGGERHEAD, GREEN TURTLE AND LEATHERBACK HATCHLINGS

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There are several weeks during the summer when loggerhead, leatherback, and green turtles all are found nesting on the same beaches on Hutchinson Island (St. Lucie and Martin counties, Florida, U.S.A). Several weeks later hatchlings of the three species emerge from nests on the same beaches and enter the ocean in the same region during the same time period. This set of circumstances provides good biological criteria in which to compare and contrast the swimming behavior in morphologically distinct species that are clearly faced with the same physical environment. These three species of sea turtle are interesting because, once they enter the water, difference in behavior and ecological specialization begin to appear.

In this study we recorded the behavior of hatchlings swimming in orientation tanks during their first 6 days in the water. Our purpose was to compare the duration and diel patterning of the frenzied swimming (the period of above average swimming) and the post-frenzy swimming activity.

The study was conducted in the laboratory using water-filled orientation tanks ("plastic kiddie" pools equipped to record directional swimming activity) located on a porch with windows open to the south and west. The turtles received ambient changes in light and temperature. All experiments began at midnight, just after emergence. The turtles were placed in nylon-lycra harnesses attached to lever arms that rotated freely in all 360°. Each lever arm was connected to a devise that allowed us to record when the turtles were actively swimming and when they were inactive. The turtles were fed from day three onward. Loggerheads and greens received shrimp or fish, and leatherbacks were given Cassiopia jellyfish.

Swimming was almost constant for all three species during their first 24 hours in the water and showed no differences between species. Activity levels fell during the second day. From the third day onward the three species show different patterns of activity. Leatherbacks consistently showed the highest activity levels, green turtles were intermediate, and loggerheads were the least active from the third day onward.

Our previous studies of loggerheads (Salmon and Wyneken, 1987) showed no night time swimming activity after the frenzy. We further analyzed the leatherback and green turtle data to see if there was a similar relationship to that seen in the loggerheads. The results showed no differences among species in the diurnal swimming activity. So, the differences in overall activity must be due to differences in nocturnal swimming. Comparisons of the nocturnal swimming activity in the three species shows that loggerheads typically become inactive at night after their second day in the water. After the third day green turtles swim little (an average of around 15%) of the night. Leatherbacks consistently swim 30-40% of the night.

We interpret the results of the study as follows. First, because the frenzy period is similar in duration for all three species, it probably serves the same purpose: to get the hatchlings away from near-shore waters as quickly as possible. Second, the differences in nocturnal activity patterns may ultimately reflect differences in food abundance, feeding habits or predation pressure upon the hatchlings. Typically, diel rhythms of animal activity are driven by food, predators, and/or the availability of mates. The last obviously does not apply. Food may be dispersed but continuously available for leatherbacks, specialists on jellyfish and siphonophores. Some species of gelatinous zooplankton are available during the daylight hours while others undergo nightly vertical migrations toward the surface. Hence different prey species may be available at night. In contrast, the green turtles and loggerheads, known to associate with sargassum, are likely to hunt visually for food that is spatially clumped (probably within the sargassum community).

With regard to predation, the three species may gain some protection under certain conditions in which their color patterns provide crypsis. Green turtle hatchlings are counter-shaded. Loggerhead colors provide camouflage when they reside in sargassum mats. However crypsis is only one way to avoid attracting predators, inactivity is another. It is likely that selection has acted to promote hatchling inactivity at times when they are least likely to benefit from movement.

## ACKNOWLEDGMENTS

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# THE INFLUENCE OF OCEANOGRAPHIC FEATURES ON POST-HATCHLING SEA TURTLE DISTRIBUTION AND DISPERSION IN THE PELAGIC ENVIRONMENT

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A conceptual basis for new approaches to ecological studies of post-hatchling sea turtles was suggested by Carr's (1986, 1987a) recognition that watermass boundaries, downwelling areas, and other physicochemical conditions and processes are important structural features of the oceanic environment. In some ocean areas, existing information in the plankton, fisheries, and physical oceanography literature can provide insight on how and where to focus ecological research on oceanic post-hatchlings. Off Tamaulipas, the Central American coasts, and in most other areas, however, this information is inadequate or lacking, and new biological oceanographic studies will be required to obtain basic information about the natural history of post-hatchlings. With careful attention to specific ocean areas and surface features discussed by Carr, I believe that much can be learned about what should still be considered "lost years" (Witham, 1980) in the lives of sea turtles. In the present paper, the influence of surface currents on the ecology and survival of oceanic post-hatchlings is discussed. Emphasis is placed on Kemp's ridley, and a diagrammatic sketch of circulation patterns in the Gulf of Mexico is used as a crude model (Fig. 1, adapted from Collard and Ogren, in press).

After emergence from the nest, hatchling sea turtles rapidly quit the beach and, with some exceptions, swim out to sea (Salmon and Lohmann, 1989; Witham, in litt.). If the offshore swim is of sufficient duration, and young turtles are not thrown back on the beach by storms (Carr, 1986) internal waves, tides, or wind drift (Olson and Podesta, 1987) or captured in regional longshore currents, some of them encounter boundary currents near the shelf break (Collard, 1987). From their point of entry, currents advect floating animals and other buoyant objects downstream, and stranding records show that small turtles are transported away from their natal beaches in this way (e.g., Carr, 1986; Henwood and Ogren, 1987).

Differences in continental shelf width off natal beaches may not be critical to the success of hatchling migrations offshore to boundary currents (see Salmon and Wyneken, 1987; Wyneken and Salmon, this volume), but a possible relationship between shelf width and the distribution of major nesting beaches needs to be examined. Perhaps it is only coincidence that Kemp's ridleys (for example) nest where the Gulf of Mexico shelf is narrowest (Fig. 1), but the north-south orientation of many major nesting beaches, and their often close proximity to major geostrophic currents supports the view that contact with boundary currents may be a precondition for the survival of young sea turtles (Carr, 1987a).

As noted, post-hatchling sea turtles seem to require long-term residence in offshore currents. Nothing has been published to suggest how an obligatory residence in currents or (often) long-distance dispersion may enhance their survival, however.

It is doubtful that currents transport planktonic post-hatchlings at the "correct" time to areas of optimal ocean conditions or geographic locations most appropriate for them to make an inshore habitat shift. Neither sargassum rafts nor suitable forage are restricted to currents or downwelling areas associated with them. What, then, are possible adaptive advantages of currents to young sea turtles?

As an hypothesis, I suggest that offshore currents remove post-hatchlings from ocean conditions that may prematurely transport them into coastal waters. Seasonally unfavorable temperatures and increased concentrations of aerial and aquatic predators occur in coastal and shelf waters, where post-hatchlings are also at increased risk of being cast ashore by surface drift (Collard, 1987) internal and tidal wave trains (Shaw et al., 1985; Shanks, 1987) or by upwelling events associated with frontal eddies and bottom intrusions (Ishizaka and Hoffman, 1988). Sequestration rather than dispersal may be the major, but not the exclusive, role played by currents. If post-hatchlings are planktonic in the conventional sense, they do not "migrate" after completion of their initial offshore swim, and dispersal may not be a developmental necessity but a consequence of drifting. This hypothesis is based in large part on physical oceanographic information described in Collard and Ogren (in press) (Fig. 1), on tagging and stranding records of sub-adult Kemp's ridleys (Henwood and Ogren, 1987), and on the observation of Ogren (this volume) that there have been no recaptures in the Gulf of Mexico of Kemp's ridleys that were tagged in the Atlantic.

There are several advantages in using Kemp's ridley as a model for future investigations attempting to falsify hypotheses in the field. First, structural features of the open ocean described by Carr (1987a) have been recently studied, and are well documented for the northern Gulf of Mexico (Waddell, 1986; Wallcraft, 1986). Using real-time satellite information, it is possible to access and sample current fronts, eddies, and downwelling areas, which I, and others, have done (Brooks and Legeckis, 1982; Weisenburg, 1984; Collard, 1987). The inshore distribution of Kemp's ridley is relatively well known (Henwood and Ogren, 1987). All wild Kemp's ridleys reproduce in the Gulf of Mexico, essentially at one place, during a relatively short period of time (Marquez, 1986). The general ocean basin circulation pattern of the Gulf of Mexico is driven by water entering through the Yucatan Straits, and virtually all water that leaves the Gulf does so through the Straits of Florida. The occurrence of juveniles on both Gulf and Atlantic coasts is unequivocal evidence that post-hatchlings inhabit and transit oceanic waters of the Gulf of Mexico. Last, consideration of one population of one species of sea turtle that reproduce in a marginal sea with one entrance and one exit, restricts the number of basin currents and consequent "most likely" dispersal paths of post-hatchlings (Collard and Ogren, in press).

Kemp's ridley hatchlings swim out to sea, and are not seen again for more than a year, or until they reach a size of ca. 20 cm TL. Hatchlings that do not reach the Mexican Current (see Sturges, 1976) off Tamaulipas may not survive. As illustrated in Figure 1, post-hatchlings in the Mexican Current may be swept to the east, enter the Loop Current, and leave the Gulf of Mexico to continue development in the Florida Current. Other post-hatchlings may be entrained by westerly moving eddies derived from the Loop Current, and complete the oceanic stage in the Gulf. Post-hatchlings embedded in current (eddy) cores may be favored over those advected by downwelling or entrainment to boundary areas, where they may be blown or drift into shelf waters and perish.

Considering the number of juvenile Kemp's ridleys observed along the eastern seaboard, and the number recorded from Gulf of Mexico coastal waters, I here risk the suggestion that a majority of post- hatchlings are swept out of the Gulf of Mexico, and few return. Carr, of course, considered this possibility long ago (Carr, 1957, 1958). Entire cohorts of Kemp's ridley hatchlings may be lost from the breeding population because of variations in the location of Gulf of Mexico currents. If this admittedly unsupported speculation is true, or may be, the significance of pre-adult Kemp's ridley deaths in the Gulf of Mexico due to shrimp trawls, ocean pollution, and other natural and anthropogenic causes, may be even greater than currently believed.

## ACKNOWLEDGMENT

Research was supported, in part, by National Marine Fisheries Service Contract 40-GFNF-5-00193. Shiptime was funded by grants from the Florida Institute of Oceanography.

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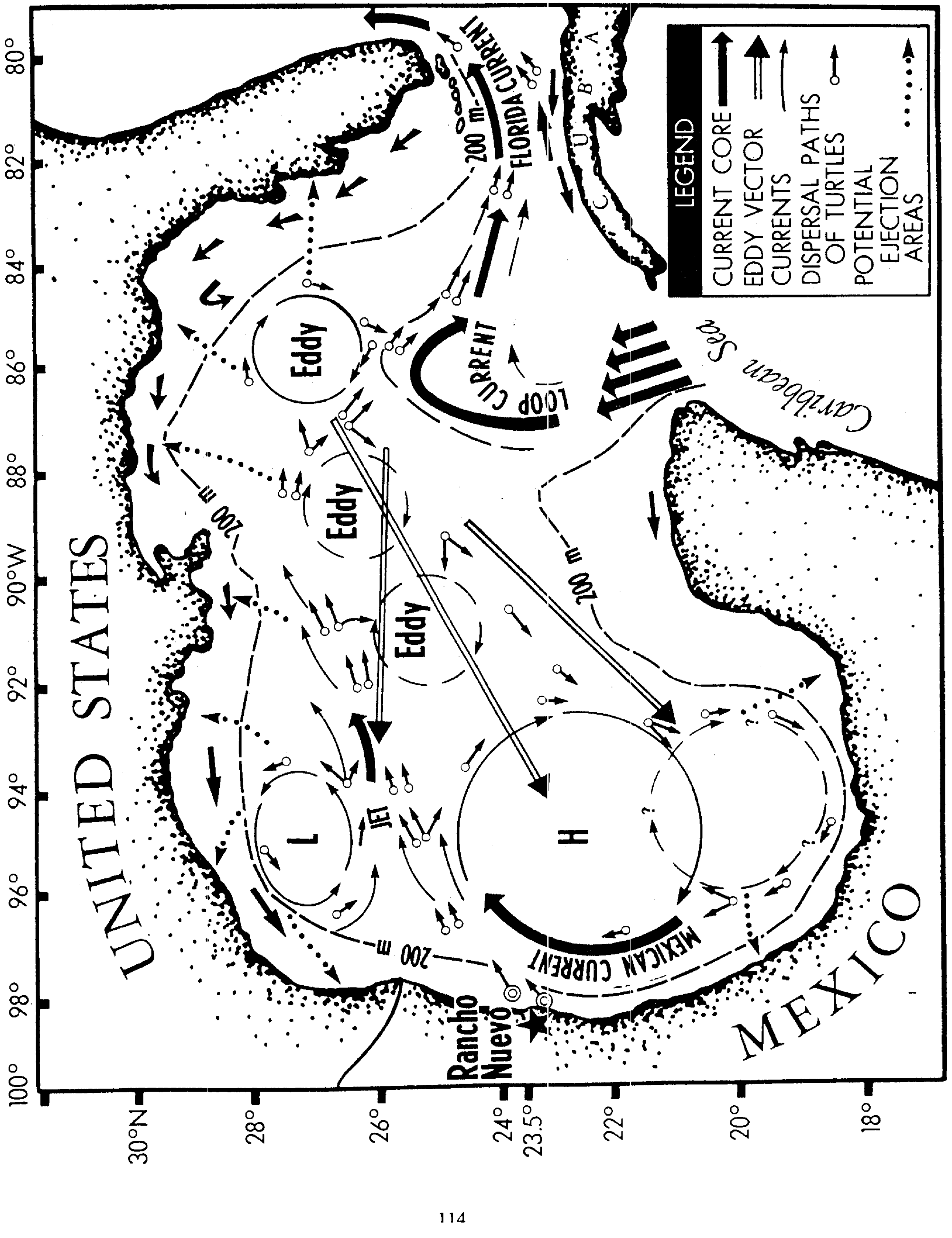
Figure 1. Sketch of surface circulation and hypothical dispersal paths of Kemp's ridley post-hatchlings in the Gulf of Mexico.



# RADIO AND SONIC TRACKING OF JUVENILE SEA TURTLES IN INSHORE WATERS OF LOUISIANA AND TEXAS

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## INTRODUCTION

Two separate inshore tracking studies were completed between September 1988 and September 1989. The first (study 1) in Lake Calcasieu, Louisiana, involved a 1985 year-class head started Kemp's ridley (Lepidochelys kempi) sea turtle (SCL=40.2 cm) that was originally released in May 1986 and was caught in a gill net in the West Cove area of Lake Calcasieu in April 1988. The turtle was re-released with radio and sonic transmitters in September 1988 and tracked for 24 days (23 Sept. - 16 Oct.). The second tracking study (study 2) involved a wild green (Chelonia mydas) sea turtle (SCL = 35.4 cm) that was found cold stunned in the southern Laguna Madre near Port Isabel, Texas in February 1989. The turtle was released with radio and sonic transmitters in August 1989 and tracked for 26 days (24 Aug. - 18 Sept.).

## MATERIALS AND METHODS

Study 1 was located in southwestern Louisiana, about nine miles to the north of Cameron. It is an estuarine environment (salinity ranged 5-19 ppt with a mean of 12 ppt) that supports both a small crab and shrimp fishery and some oystering. Both West Cove and Lake Calcasieu are shallow, less than 1.5 m and 2.1 m respectively, in most areas. The Intracoastal Waterway (ICWW) runs north to south and separates West Cove from Lake Calcasieu. Study 2 was conducted in the southern area of the Laguna Madre near Port Isabel and South Padre Island, Texas. This area is very shallow, less than 1.2 m in most areas, with a hard sand bottom that supports typical sea grass beds. Salinity ranged 29-34 ppt with a mean of 30.7 ppt. There is no commercial fishing, but it does support a major sport fishery for speckled trout and red drum. The ICWW, which runs north to south, bisects this southern section of Laguna Madre and is the deepest area around with a water depth of about 3.6 m.

In study 1 the turtle was tracked and monitored for 24 hours for the first three days after release and about 10-11 hours a day, weather permitting, for the remainder of the study. Most data were collected in daytime with some nighttime observations. If tracking by boat was not possible, we monitored radio signals from the turtle by vehicle. In study 2, sampling was the same except the turtle was monitored for 24 hours on days 1 and 3 after release.

For both studies, data collected included turtle movement , "surface" and submerged times, air and water temperature, and salinity. "Surface" times are defined as at or near the surface. In both cases the radio transmitter antenna would transmit once it broke the surface, which would occur even if the turtle was submerged slightly below the surface. Visual observations were made that verify this.

The type of tracking antenna and the attachment method of the radio transmitters were different for each study. In study 1, a hand-held, directional two-element "H" antenna was used, and in study 2, a boat-mounted, directional five-element "Yagi" antenna. The "Yagi" antenna receives a narrower signal pattern, which made locating the turtle much easier. The radio transmitter in study 1 was attached to a post central scute with a tether and floated behind the animal. In study 2, the transmitter was cemented to the second neural scute with dental acrylic, and then secured with fiberglass cloth and resin. In both studies sonic transmitters were attached to the posterior marginal scutes with nuts and bolts.

## RESULTS AND DISCUSSION

Study 1, West Cove / Lake Calcasieu, was our first attempt at this type of work, and we encountered some problems. The turtle was seen only four times after being released. We concluded the lack of sightings was due to inexperience on our part with the radio tracking gear and that the 2-element "H" antenna was not the best type of antenna available. When good signals were achieved, it was still quite difficult to get close enough to the turtle to hear the sonic transmitter and then to get a visual observation. The range of the sonic transmitter was about 92 m, and we believe the range was greatly reduced, mostly due to the bottom substrate, which was a soft, mucky mud. We feel this bottom type absorbs the sound waves.

The turtle spent most of the time underwater, as one might expect, as seen when comparing mean surface and submerged times by hour of day for the 24 days combined (Figure 1). The mean surface times were consistently short throughout the 24-hour day. The mean submerged times varied widely, with slightly longer submerged times occurring during the early to mid morning hours.

Figure 2 shows the release site and the four other sightings that were made throughout the study. "R" is the area of release on 23 September 1988. The turtle stayed in this general area for the first two days. The second sighting occurred on 25 September and was at location "2". The third contact "3" was on 1 October, but was only sonic contact. Tracking had to be terminated due to approaching thunderstorms before a visual observation could be made. A visual observation was made the following day at site "4". We observed the turtle in a behavior that seemed to be "working a line of crab pots." (By this we mean the turtle was possibly feeding on crabs.) The turtle would surface at one trap float and then 10-15 minutes later it would surface at the next one that was set about 18 m away. This behavior was observed for a little over an hour. The turtle was not seen again until 16 October at site "5" in Lake Calcasieu. At this time the transmitter looked like it was entangled with grass. The following night while monitoring the radio signal by vehicle, a constant signal was received. On 18 October the transmitter was found floating free, a little further north in Lake Calcasieu. The transmitter was overgrown with hydrozoans, and the added weight almost certainly caused the transmitter to fall off. This terminated the study.

For study 2, southern Laguna Madre, mean surface and submerged times by hour of day for all 26 days combined are shown in Figure 3. There is a sharp difference in the amount of time the turtle spends submerged, depending upon the time of day. This change in length of time submerged corresponds to dawn and dusk. Surface times also increase slightly during the nighttime hours when the turtle is most likely resting. The short amount of time spent both on the surface and submerged during daylight hours is probably due to periods of high activity.

During this study the turtle was tracked and monitored for 26 days, including 17 days on the water. Visual observations were made on 11 days (Figure 4); on two days only sonic contact was made, and on six days signal triangulations were calculated but with no visual or sonic contact. Triangulations were taken when problems were encountered in receiving the sonic signal through heavy vegetation and very shallow water. The sonic range diminished from .8 km to 1.5 m. After being released and initially crossing the ICCW, the turtle's movement was scattered on the eastern side of the ICWW. The turtle was not seen to the west of the ICWW for the remainder of the study. This was most likely due to the fact that no sea grasses have been reported to the west of the ICWW ( pers. comm., Millicent Quammen, USFWS, Corpus Christi, TX, 1989). The turtle was detected by sonic on day 26 of the study near the Brazos Santiago Pass and in the direction of the Gulf of Mexico. The following day, no radio signal could be heard and the turtle could not be located. The area was searched for several days, but no signals were heard and the study was terminated. We believed the turtle went into the Gulf of Mexico.

Apparently the turtle left the Laguna Madre shortly after the passage of two minor cold fronts that caused air temperatures to drop an average of 6°C after each passage, with intervening warming between the two fronts up to 30°C. Water temperatures dropped from 30°C to 26-27°C. Even though these temperatures are far from "cold stunning" levels, it may have triggered the turtle to leave the area. Another possibility is that the turtle may have drifted with the current in the ICWW toward the Gulf. The turtle was seen in the ICWW for the first time since release, the day before being heard near the Brazos Santiago Pass.

# ACKNOWLEDGMENTS

Thanks go to the USFWS personnel of the Sabine National Wildlife Refuge in Louisiana and the Laguna Atascosa National Wildlife Refuge in south Texas, and to Don Hockaday of the Pan American University's Coastal Studies Lab in South Padre Island, Texas for all the help given to us while working away from our home base in Galveston. Also a special thanks to Richard Byles (USFWS, Albuquerque) for answering the many questions we had about radio tracking and to NMFS personnel who assisted us in these studies.

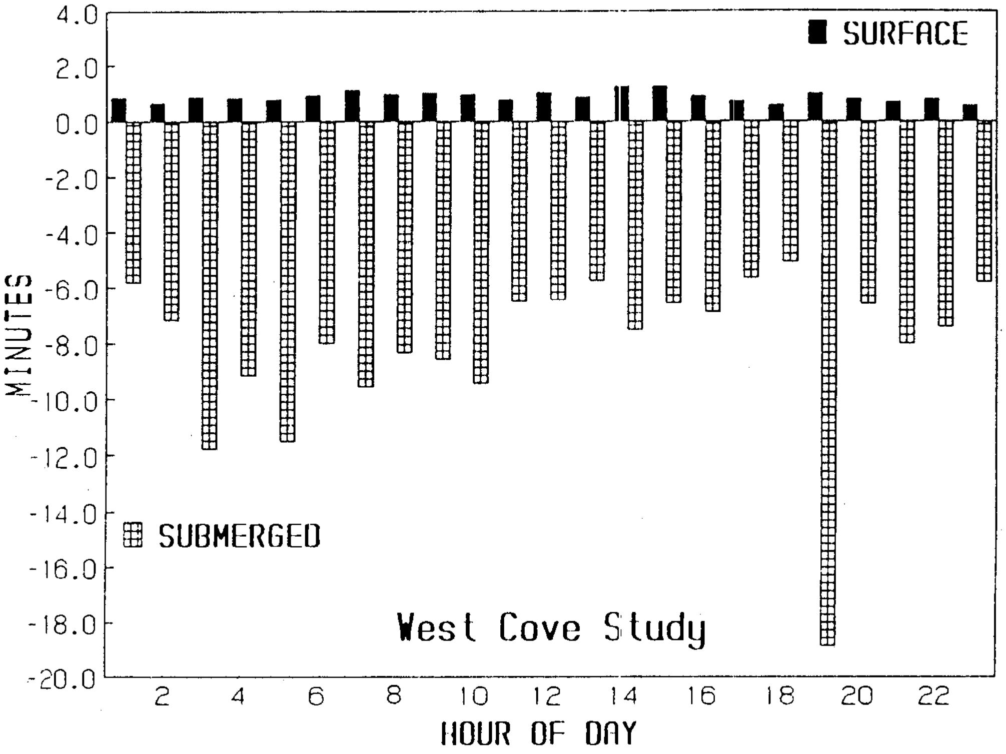

Figure 1. Mean surface and submerged times by hour of day for all 26 days combined.

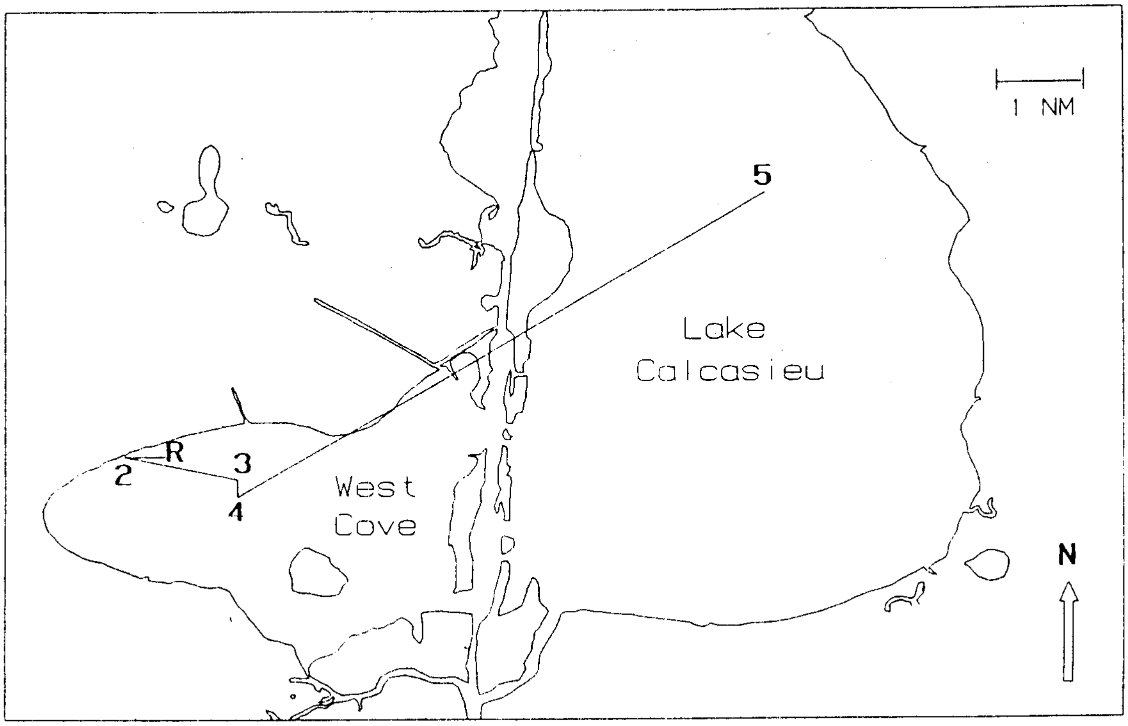

Figure 2. Locations of Head started Kemp's ridley sea turtle from 23 September - 16 October 1988. (R=release site.)

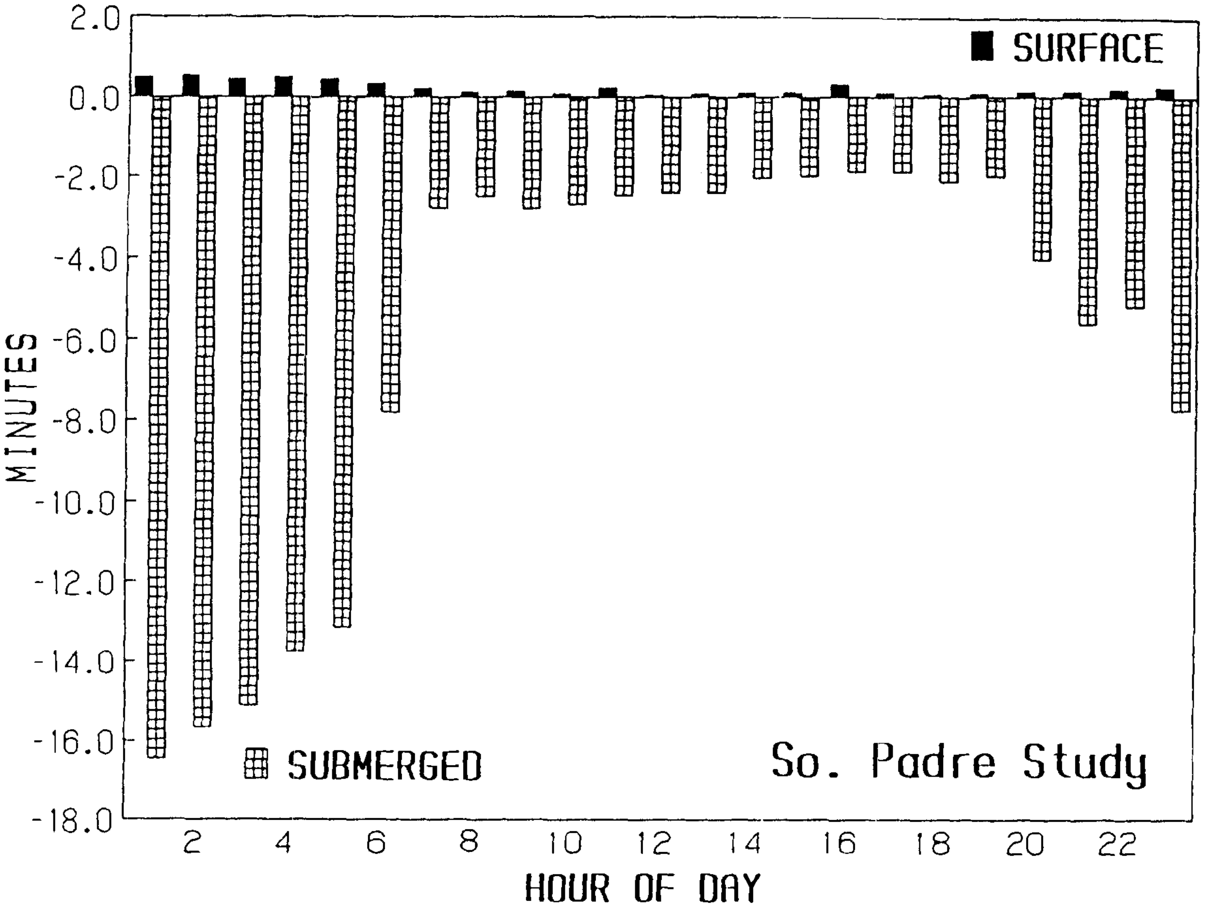

Figure 3. Mean surface and submerged times by hour of day for all 26 days combined.

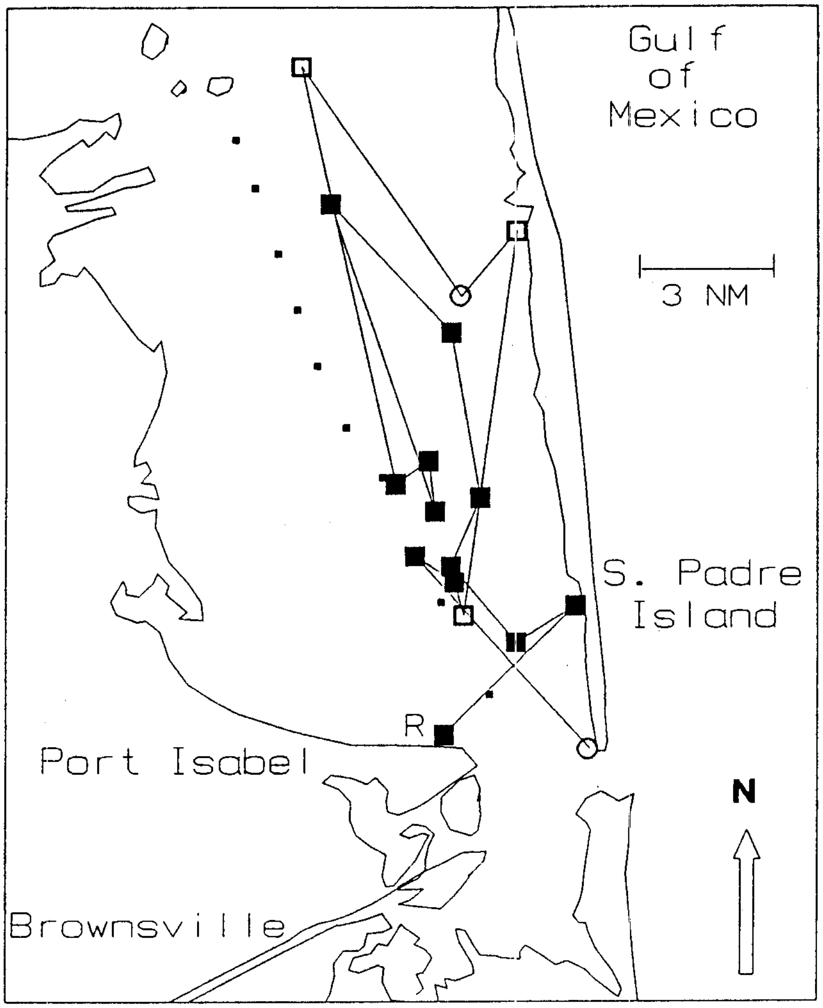

Figure 4. Locations of wild juvenile green sea turtle from 24 August - 18 September 1989. (Small solid squares=ICWW; R=release site; Large solid squares=visual observations; Open circles=sonic contact only; Large open squares=triangulated positions.)

# SEA TURTLES AND SATELLITE TAGS: MOVEMENTS AND DIVE PATTERNS

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The collection of long-term, detailed information on sea turtles via satellite telemetry is a relatively new methodology. The use of satellite tags and their attachment to research animals has evolved from the trailing of a cylindrical transmitter to a compact backpack, fiberglassed to the carapace of the turtle. Satellite tags offer a cost effective means of obtaining information on sea turtles for up to 9 months. After tagging a turtle, data can be accessed at home or at the office using a computer and a telephone modem, or it can be accessed by mail if you care to wait that long.

Objectives of this ongoing study are to 1) explain the movement and dive patterns of sea turtles in relation to ocean currents and temperatures, 2) develop a biological model to make these patterns more predictable, and 3) explain the interactions between sea turtles and offshore oil and gas structures.

Three loggerheads are presently being tracked in the Gulf of Mexico and range in straight length and weight from 56-93 cm and 28-98 kg, respectively. Data is also being collected on the movement of one Kemp's ridley (51 cm, 20 kg) off the east coast of Florida.

A cursory view of the data suggests that these loggerhead turtles 1) spend time in association with oil and gas structures and 2) have a home range which may encompass 30 to 100 sq miles. Dive times appear to vary by day, night and season. Movement of the Kemp's ridley in the Atlantic appears to be in response to water temperature and ocean currents. It should be stressed that all data are preliminary and more information is needed on these turtles, as well as data from additional turtles to provide information for our biological model.

# HOMING OF TRANSLOCATED GRAVID LOGGERHEAD TURTLES

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Thirty-three Caretta caretta were intercepted on the nesting beach prior to oviposition. Each turtle was transported 60 km, fitted with radio transmitters and released. Six turtles provided no useful data due to transmitter failure or detachment. Thus 27 turtles provided information on the response of loggerheads to translocation.

Of these 27 turtles, 17 (63%) returned to the home area and 6 (22%) were in route when contact was lost. A total of 23 (85%) of 27 turtles which were translocated showed evidence of returning to the home beach indicating a strong tendency to return to a home or primary beach. Four (15%) showed no movement towards home.

Two areas in South Carolina were used during this study. The northern study area involved translocating 11 turtles from South Island 60 km north to Myrtle Beach State Park. Ten of eleven (91%) homed and the other turtle was in route. This turtle showed a slower rate of movement because approximately one half of the right front flipper was missing. Discounting the handicapped turtle, the mean time spent in the residual area was 20.9 hr. The mean time to return to the home area 46.5 hr. The mean minimum speed to home was 1.32 km/hr, but the mean minimum speed outside the residual area was 2.28 km/hr. Of these eleven turtles, five were intercepted or monitored on a nesting beach following release. All five were in the home area.

The southern study area involved the translocation of 16 turtles from Botany Bay, South Carolina, south to Hilton Head Island. Of these 16 turtles, seven (44%) homed, five (31%) were in route and four (25%) showed no homing movements at all. The mean time to return to the home area was 138.3 hr. The mean residual time was 62.5 hr. The mean minimum speed to home was 0.54 km/hr, and the mean minimum speed outside the residual area was 1.19 km/hr. Of the 16 turtles translocated in the southern study area, a total of 13 encounters on beaches were confirmed. Of these, five were in the home zone, six were in or south of the residual area, and two nested in route.

Thus turtles translocated in the northern study area had a low residual time, homed rapidly, and were never known to accept an alternate area for nesting. The turtles translocated in the southern study area had a minimum residual time and a minimum homing time which was three times greater than for the northern study area. Twenty-five percent of the turtles in the southern study area were not known to home, and more were recorded nesting outside the home area then within it.

The northern study area produced a consistent homing response. Five southern turtles homed in 81, 80, 71, 65, and 68 hours similar to translocations in the northern sudy area. However, the southern translocations produced a wide variety of responses. For example, T-23 nested at Hilton Head two nights after release and then returned to the home area to nest 12 nights later. T-30 probably nested at Hilton Head and then nested three more times at Wassaw Island, Georgia. This is approximately 43 km south of the translocation site and more than 100 km south of the original encounter site. This might be dismissed as the coincidental encounter of a Wassaw Island turtle on Botany Bay Island except that:

1) the turtle was untagged;

2) she nested on Hilton Head before moving to Wassaw;

3) a second turtle, T-25, also probably nested on Hilton Head on night two and then nested on Wassaw Island 13 nights later.

## CONCLUSIONS

1) Translocated loggerhead turtles can orient and return to a primary nesting beach when moved 60 km north or south of the site of a nesting emergence.

2) Loggerhead turtles exhibited straight line movements from the translocation site back to the home beach at sustained speeds in excess of 4 km/hr.

3) There was a dominant pattern of homing and nest site tenacity exhibted by translocated loggerhead turtles.

4) There is, however, a plasticity to site selection which allows for the acceptance of suitable alternate sites for one or more nesting events.

5) The reasons for the different responses of turtles at the two study sites is unknown. Differences may be due to latitude, direction of translocation, offshore topography, and/or the suitability of the beaches for nesting at the translocation site.

# GREEN TURTLES ON SABELLARIID WORM REEFS: INITIAL RESULTS FROM STUDIES ON THE FLORIDA ATLANTIC COAST

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Along the east coast of FLorida from about Cape Canaveral south to Biscayne Bay, there lies an extensive reef system created by a species of polychaete worm in the Sabellariid family. These worms, Phragmatopoma lapidosa, build tubes by agglutinating fragments of shells, mineral grains, and other small debris held together with a proteinaceous, glue-like substance secreted by the worms. The worms are dependent on a turbulent water column in order to gather fragments to create the tubes. Florida's east coast provides the appropriate high energy situation necessary for this species. The colonies are formed at right angles to the approaching waves and thus appear parallel to the shore.

The reefs provide an important habitat. Upon the reefs are anchored a diverse marine flora including species of red, green and brown algae. No seagrasses are found on these reefs in Indian River County. A study conducted on the reefs off of Vero Beach in Indian River County by Juett et al. (1976) reported 109 species of benthic algae, the majority of which consisted of red algae. The reefs in Indian River County also provide a habitat for marine invertebrates (stone crab and lobster, for example), for fishes (including barracuda, angelfish, and grunts, from our own observations), and an aggregation of marine turtles, including juvenile green turtles, loggerheads, and an occasional juvenile hawksbill.

This important developmental habitat has been largely ignored in the past years, but work by Ernest and Martin, who have been assessing this population from captures in the intake canal at the St. Lucie Power Plant in southern St. Lucie County about 100 km south of our study site in Indian River County, has provided morphometric data on this aggregation of marine turtles since 1976. Wershoven and Wershoven have also contributed information on this poorly understood group of nearshore reef turtles and their habitat in Broward County.

Our work is centered in northern Indian River County, about 3 km south of Sebastian Inlet. Capturing of marine turtles was accomplished using a nylon mesh net hung in the water column in three to five meters of water about 200 meters from shore just outside of the surf zone but within the reef area. Depending on conditions, 60-200 meters of net are deployed from the bow of a 17-foot Boston Whaler usually parallel to shore. Floats are attached to the topline in order to prevent sinking of the net. The net is constantly checked by pulling up on the net from the bow of the boat and snorkeling along the length of the net.

When a turtle is encountered, it is either untangled from the net by a snorkeler or brought onto the bow for untangling. It is then weighed, measured, and photographed. Two types of tags are applied, an inconel tag in one front flipper and a plastic Roto tag in the remaining front flipper. The turtle is then released at site of capture.

Results from the summer of 1989 suggest that this population on the Sabellariid worm reefs off of Indian River County consists mainly of small, juvenile green turtles. The mean straight-line carapace length of the 17 green turtles captured from June through September was 34.0 cm and ranged from 26.7 cm to 45.3 cm. The mean weight of this group was 6.2 kg. One subadult loggerhead captured during the summer measured 61.3 cm in carapace length and weighed 37 kg. In October, a juvenile hawksbill was captured weighing 1.6 kg and measuring 24.8 cm in straight line carapace length.

The nearby Indian River lagoon also provides an important habitat for juvenile green turtles as well as subadult loggerheads. The lagoon is brackish with extensive seagrass beds, mainly shoal grass and manatee grass. Study of the populations of marine turtles occurring in this lagoon have been underway by Ehrhart since 1982. An area in the lagoon system about 2 km south of Sebastian Inlet has been the primary netting site. In the summer of 1989, 44 juvenile green turtles and 10 loggerheads were captured using the same netting method as previously described. However, because of somewhat constant and benign conditions, a greater length of net is usually deployed (about 450 meters).

The mean straight line carapace length of the green turtles caught in the lagoon was 37.8 cm ranging from 28.8-66.8 cm. The loggerheads captured averaged 61.4 cm in carapace length and ranged from 52.4 cm to 77.4 cm, categorizing almost all of them as subadults. When compared to Sabellariid reef green turtles, the lagoon green turtles captured were significantly bigger ($\alpha = .05$). Ernest et al. reported that over 80% of the green turtles captured in the intake canal were less than 40 cm, suggesting a size similarity to the reef population in Indian River County (1989).

Relative capture rates were converted to catch-per-unit-effort units (CPUE) in order to compare capture rates between the Indian River lagoon and the Sabellariid reef. For the summer 1989, catch-per-unit-effort for the reef totaled 4.35 turtles per km-hr compared with 2.44 turtles per km-hour from the lagoon. The netting operation in the lagoon has been ongoing since 1982 and is considered a site with "good" catch-per-unit-effort. The reef site exhibits a CPUE of nearly double that of the lagoon. Loggerheads make up only 5.2% of the total catch on the reef. Contrastingly, in the lagoon loggerheads constituted 18.4% for the summer of 1989. However, in past seasons, loggerheads on average constitute almost half of total catch in the lagoon. These figures indicate that the reef supports a large group of green turtles when compared to the lagoon.

Green turtles on the reef are different from the lagoon population not only in size but in the absence of fibropapillomas which regularly occur on the lagoon population. In the lagoon, 45% of the green turtles captured during the summer of 1989 were infected with fibropapillomatosis. No turtles captured on the reef were infected. Furthermore, only two of the 62 carcasses from the beaches of Indian River County in 1989 showed signs of this disease. Wershoven and Wershoven also report no turtles infected in Broward County (1989). The implication of this major difference is unknown.

Because of the significant differences found between the Sabellariid reef and the Indian River lagoon populations, they may be considered as two groups in different stages in development as hypothesized by the model in Figure 1. The reefs may constitute an intermediate developmental habitat between the pelagic stage and lagoon stage in the life history of the green turtle. The CPUE data collected from our work, the multitude of captures from St. Lucie and Broward Counties, and the large number of strandings implies that Florida's east coast supports a significant population of juvenile green turtles.

If we expect this species to recover from its endangered status, this important nearshore reef habitat must be protected in order to support the large number of green turtles that utilize it. Secondly, as reported by Ehrhart elsewhere in this volume, the juvenile green turtle population on these reefs is suffering losses from a fishery which must be regulated in order to reduce the mortality during this developmental stage.

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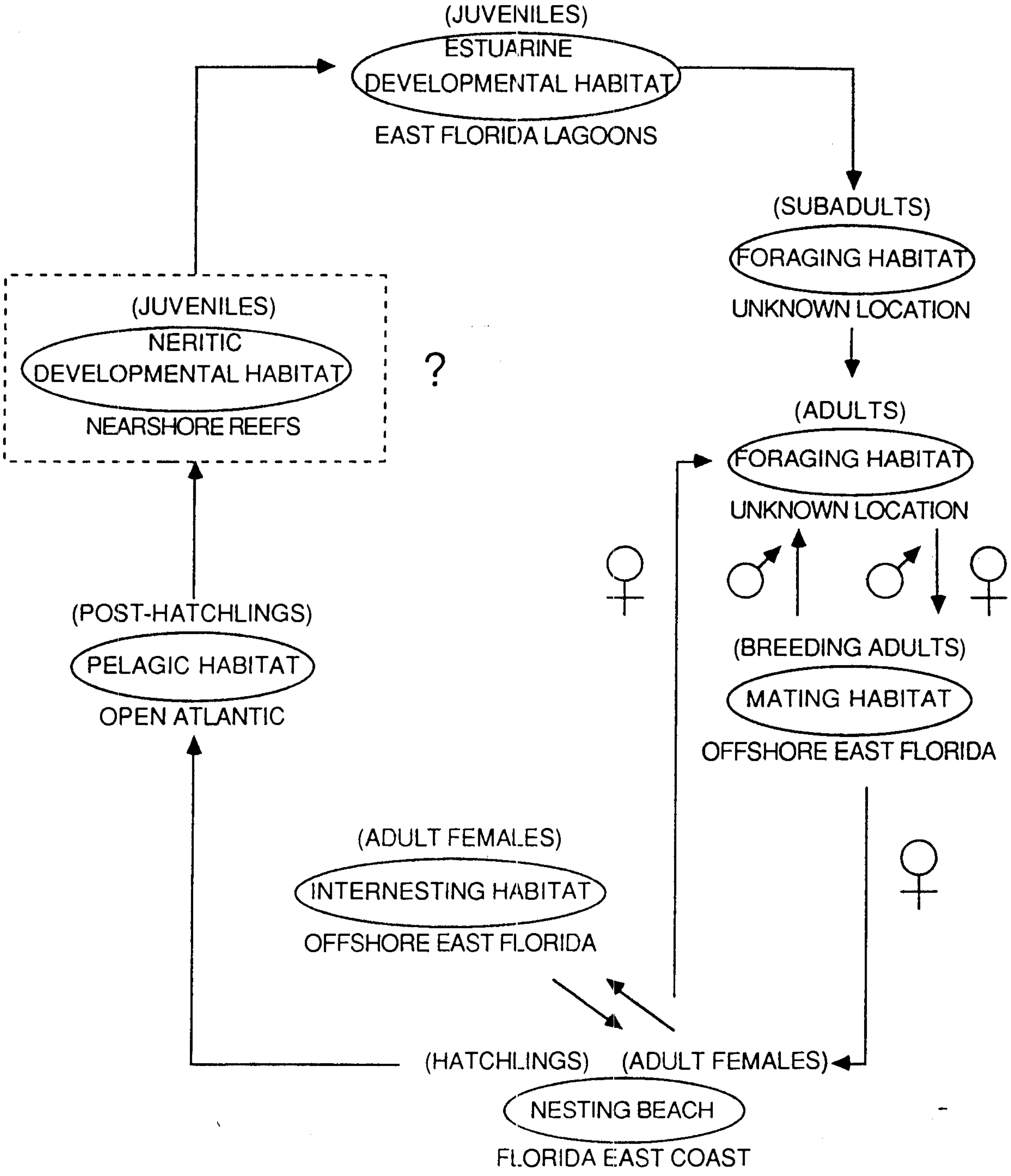
FIGURE 1. SUGGESTED MODEL OF GREEN TURTLE LIFE HISTORY



# RESULTS OF A TAGGING STUDY AT CEDAR KEY, FLORIDA, WITH COMMENTS ON KEMP'S RIDLEY DISTRIBUTION IN THE SOUTHEASTERN U.S.

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In 1985, the NMFS Panama City Laboratory began a long-term study to establish the distribution, seasonal occurrence, growth and structure of the sea turtle populations of Waccasassa Bay on Florida's west coast. The current study is modeled after earlier investigations by Carr and Caldwell (1956) and utilizes large-mesh tangle nets (51 cm stretch mesh, 50 m length) formerly used in the commercial turtle fishery. Waccasassa Bay is a shallow, turbid embayment located east of the Cedar Keys. The study area is divided into two main features. Corrigan Reef, in northwestern Waccasassa Bay, is a series of oyster and sand bars on rocky bottom. The eastern half of the bay is comprised of three parallel seagrass-covered shoals known as Waccasassa Reefs. Although Kemp's ridley, green and loggerhead turtles have been captured or observed at the different netting locations, there is a preference by each species for a particular habitat. Kemp's ridley and loggerhead turtles are caught by the crustacean-rich oyster bars of Corrigan Reef compared to the capture of green turtles on the seagrass shoals of Waccasassa Reefs.

Since 1986, 99 Kemp's ridley, 9 green and 2 loggerhead sea turtles have been measured (straight-line), weighed, tagged and released. With the possible exception of the loggerhead, the sea turtle populations of Waccasassa Bay are composed of subadults. Loggerhead carapace lengths range from 57 to 88 cm. Mendonca and Ehrhart (1982) reported a 70.5 cm female loggerhead nesting on Florida's east coast. Green turtle carapace lengths range from 49.5 to 74 cm with a mean of 66 cm. For Kemp's ridley turtles, the carapace lengths range from 30 to 57 cm with a mean of 46 cm. Length frequency data shows the majority of captured ridleys are in the late subadult phase. However, it is unclear whether the data reflect the actual size-class distribution of the population or bias due to our large-mesh nets.

Historically, the turtle netting season on Florida's west coast began in April and ended with the first cold front of fall. Our netting efforts began in May and extended to early December, with turtles captured from May to November. Analysis of the Kemp's ridley recaptures suggests the majority of growth occurs within a netting season as opposed to between netting seasons. Perhaps this is indicative of local winter dormancy or movement to deeper, warmer waters where prey are less abundant, resulting in reduced growth. Many local fishermen believe the turtles "bury-up" in mud holes when the water temperature drops, as evidenced by the muddy carapace of turtles captured in spring.

Other long-term studies on the distribution and abundance of subadult sea turtles are being conducted on the northwestern and central east coast of Florida. Kemp's ridleys captured in the Apalachicola Bay-Panacea area range from 20 to 58 cm CL (mean=36.7 cm, n=106) (Rudloe, Rudloe and Ogren, 1989). Length frequency data show the majority of these turtles are in the early subadult phase, in contrast to distribution of Waccasassa Bay ridleys. In addition, the ridley population on the northwestern Florida panhandle appears transitory, with turtles recaptured only within a season. Cedar Key recaptures indicate a more residential population. Kemp's ridleys captured in the Cape Canaveral area range from 21 to 60 cm CL (mean=36 cm, n=90) and have a length frequency distribution similar to northwest Florida. The Atlantic population is highly migratory, traveling between summer foraging grounds north to Chesepeake Bay and winter foraging grounds off of Cape Canaveral (Henwood and Ogren,1987).

The fate of the Atlantic ridleys remains an enigma. None of the Kemp's ridleys tagged in the Atlantic have been reported or recaptured in the Gulf of Mexico. Ridleys are not observed along the southeastern Florida coast below the Palm Beaches. Captain Edgar Campbell of Cedar Key has never caught or observed a ridley during 14 seasons (October to March, 1963-1978) of netting out of Marathon, Florida. Florida Bay has been identified as subadult ridley habitat, but information is lacking (Carr,1980). If Atlantic ridleys do return to the Gulf of Mexico, the route they follow has yet to be determined.

Other puzzling aspects of the Kemp's ridley life history include the current mediated movements of neonates and the duration of pelagic development in the Gulf of Mexico. There are no documented observations or collecting records of neonates from the Gulf of Mexico pelagic habitat. Collard (1987) and Collard and Ogren (in press) have suggested dispersal scenarios based on major oceanographic features operating in the Gulf of Mexico. The minimum size of post-pelagic ridleys (20-25 cm) are reported from western Louisiana and the Florida panhandle. Preliminary skeletochronological estimates by Zug (1989) indicate that these individuals may be two years old, and that would then be the length of their pelagic developmental life stage.

Continuation of these studies on the distribution and abundance of subadult ridleys in the coastal zone will hopefully shed more light on the dependency of the smaller size classes on the shallow bays and sounds of the inshore area. These individuals, having survived the vulnerable first years from their natal beach and through the pelagic life stage, have successfully adapted to their marine environment. As potential recruits to a declining adult population, their importance to the successful recovery of this endangered species cannot be underestimated.

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# SEA TURTLES IN SOUTH TEXAS INSHORE WATERS

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Numerous historic accounts substantiate that large numbers of green turtles once occupied Texas bays. A turtle fishery, dependent upon green turtles (Chelonia mydas), began in Texas during the mid-1800s. However, by 1900, the catch had declined to such an extent that the turtle fishing and processing industry virtually ceased. Overfishing and severe freezes in the 1890s probably led to the demise of this industry.

Little is known about sea turtles currently occupying Texas inshore waters. Nearly all information available has been derived from stranding and incidental catch records. In June 1989 Padre Island National Seashore and the U.S. Fish and Wildlife Service undertook the first systematic field study of sea turtle occurrence in Texas inshore waters, specifically within the Upper Laguna Madre and waters surrounding the Mansfield Channel jetties. Data on species composition, relative abundance, distribution, size, growth, seasonality, and residency are being collected using a variety of techniques. Information is being gathered from historic literature, museum records, stranding databases and reported sightings. Also, attempts are being made to capture turtles by netting.

The study area includes Baffin Bay and Laguna Madre waters between the J.F.K. Causeway and Mansfield Channel. The average depth of the Laguna Madre is 1.2 m, and grass flats occur in shallow, quiet areas there. Mansfield Channel is 91.4 m wide and 4.3 m deep, cuts through Padre Island and the Laguna Madre to the mainland, and is also referred to as East Cut. A pair of 700 m long jetties armor the Gulf of Mexico entrance to the channel, and a number of algae species grow on the jetty rocks.

The Texas Sea Turtle Stranding and Salvage Network database was searched for records of sea turtles found stranded within state inshore waters between 1980 and 1989. A total of 166 wild individuals of five species was documented (Fig. 1). One hundred turtles (5 species) were found north of the study area. This included 16 greens, 41 Kemp's ridleys (Lepidochelys kempi), 30 loggerheads (Caretta caretta), 8 hawksbills (Eretmochelys imbricata), 1 leatherback (Dermochelys coriacea), and 4 unknown species. Twenty-two green sea turtles were found within the study area and 40 greens and 4 loggerheads were found south of the study area. Green turtles stranded more frequently than any species. Overall, 78 had stranded inshore statewide. The highest concentration was within the study area and south of it. Thus, from stranding records it would appear that green, Kemp's ridley, and loggerhead turtles are the most abundant species in Texas inshore waters and that Kemp's ridleys are distributed more northerly and greens more southerly.

Ninety-seven head started Kemp's ridley turtles stranded within Texas inshore waters, and 93 of those were found north of the study area. Four were found within the study area, near the J.F.K. Causeway. Twenty-two green turtles stranded within the study area, most near the J.F.K. Causeway, Land Cut, and East Cut. Twelve of the 22 were found during or shortly after the freezes of December, 1989, February, 1989, and December, 1989 and were probably cold stunned. Similarly, 41 of the 56 other greens found within the state were also probable hypothermic stunning victims.

Attempts were made to document and investigate sea turtles sighted by the park staff and public. National Park Service (NPS) staff at Padre Island National Seashore recorded dates, locations, times, sizes, and other pertinent information about the turtles they saw. Posters with return forms requesting people to report turtles sighted in inshore waters were distributed at various boat launch and rental facilities, restaurants, marinas, and convenience stores surrounding the study area. Fishermen and boaters were interviewed about sightings while on the water and at launching facilities. Also, persons reporting turtle sightings at park facilities were interviewed. Letters requesting information about turtle sightings were sent to all spoil island permit structure holders in the Laguna Madre.

Forty-three reports of turtles sighted within the study area were filed. NPS interviews, in the field and at facilities, resulted in 20 reports, NPS sightings in 14, posters in 7, and letters to cabin lessees in 2, for a total of 43 reports. Most sightings occurred during summer months. Generally, the turtles could not be identified to species. The majority were in the Mansfield Channel area, with 28 at the jetties and 9 in, or adjacent to, East Cut. Also, two turtles were sighted just south of the J.F.K. Causeway and 4 in, or near, the Land Cut.

A 2.4 m deep, 91.4 m long tangle net with 25.4 cm stretch mesh was used to capture sea turtles. It was set at dawn and generally retrieved one hour prior to dusk. The net was set at 6 locations per month from June through October and 2-4 locations per month in November, December, and January, for an average of 4.9 sites/month. The only site sampled each month was the Mansfield Channel jetty area. Other sampling sites varied each month and were established in areas where turtles had been stranded or sighted, where potential turtle habitat, such as grass beds, channels, deep holes or rocks occurred, or where water depth was sufficient for boat operation and net placement. Captured turtles were measured for straight-line carapace length and width and weighed using a spring scale. Each was tagged on one or both of the front flippers and sometimes a rear flipper.

Due to the disparity of catches within the Laguna Madre and at the jetties, results from these two areas will be discussed separately. Only one green sea turtle was captured during 261 hours of netting effort on 32 days in the Laguna Madre. It was caught just north of the Land Cut on 29 July and measured 33.5 cm straight-line carapace length. One possible reason for the low catch rate of greens is that the February 1989 freeze may have killed a large proportion of the population in that area. The drop in temperatures was abrupt and pronounced, and the total of 45 green turtles recorded cold stunned in Texas was much higher than during any other cold stunning event in the last 2 decades. At least 10 from the study area were killed during the freeze and this comprises almost half the total number of green turtles stranded in the study area from 1980-1989. Another possible reason for the low catch might be the relatively high winds and heavy grass loads encountered. Grass in the net can greatly reduce catch by weighing it down and making it visible to turtles. It is also possible that only low numbers of turtles occur in the Laguna, that they may be dispersed within the large study area, or that the nets were not deployed in locations where turtles occur.

The net was also set at the Mansfield Channel entrance one day per month during all months except August, when it was set for two days. It was placed parallel to the north jetty and extended west from the tip of a wing jetty, cutting off most access into and out of a protected cove area. Thirty-five green turtles were caught during 86 hours of netting on 9 field days. The catch per unit effort, or number of turtles caught per netting hour, ranged from a low of 0 during December and January, to a high of 1 during July, when 11 turtles were caught on one day. Most turtles were caught during the early morning, between 0600 and 1000 hours, and during the mid-afternoon, from 1400 to 1600 hours.

This study is scheduled to continue through at least May 1990. If extended, we hope to concentrate work at the Mansfield jetties and expand the scope to include study of sex ratios, tag retention, population estimates, feeding ecology, and relationships between turtle abundance and various environmental parameters.

# TELEMETRIC MONITORING OF DIVING BEHAVIOR AND MOVEMENTS OF JUVENILE KEMP'S RIDLEYS

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From July through October 1989, ten juvenile Kemp's ridleys (mean SCL = 33.0 cm) were telemetrically monitored in the waters surrounding Long Island, New York. Nine of the turtles were wild-caught individuals. The other was a rehabilitated turtle which had been cold stunned in 1988. Each turtle was fitted with a radio transmitter, and eight of the ten were also equipped with depth sensing sonic transmitters. The telemetry program sought to address three major questions. Are the movement patterns of the turtles consistent with what would be expected of a population seasonally exploiting an area? What is the relationship between diving behavior and environmental conditions? Is there a correlation between the growth rates of the turtles and the time of year during which the growth occurs?

Mean track duration was 22 days with the longest being 45 days. Tracking was terminated for a number of reasons (e.g., to follow another turtle, because the turtle left the area, or the signal was lost). Three of the turtles were observed leaving the Long Island area, and one of these was later reported from North Carolina. All other turtles were moving eastward at last contact. Movement in this direction would take them into the Atlantic and is the only plausible emigration route from Long Island's estuaries. Turtles monitored during periods of favorable water temperatures ($T_w > 15^oC$) exhibited nondirected movements (gross movements 49 times greater than net), while those tracked during October ($T_w < 15^oC$) showed more directed movements (gross movements 13 times greater than net). The nondirected movements during periods of favorable $T_w$ suggest foraging behavior, while October movements suggest emigration.

Dive profiles were analyzed for six of the Kemp's ridleys equipped with depth sensing transmitters. The mean descent rate was equal to the mean ascent rate (0.12 m/sec). However rates were not correlated for individuals (e.g., turtles with slow descent rates did not necessarily exhibit slow ascent rates). Turtles rarely dove deeper than 13 m (max = 19 m), with most dives reaching depths of only 8 m. Changes in temperature and light availability as functions of depth were measured and analyzed with respect to diving behavior. Thermal profiles failed to show distinct differences related to depth. Surface $T_w$ rarely exceeded bottom $T_w$ by more than $2^oC$. Light intensity, however, decreased rapidly with increasing depth. Ninety percent of the light was extinguished at a depth of 3 m. Less than 1% of the light reached depths below 8 m. Light penetration, therefore, was considered a possible factor limiting dive depth.

Growth rates of the turtles were correlated with season. Kemp's ridleys monitored during July and October lost weight ($\overline{X}$ = 3.4%/month), while those monitored during August and September grew rapidly ($\overline{X}$ = 16.3%/month, max. = 25.2%/month). It is possible that the juvenile Kemp's ridleys require time to learn how to exploit the area's resources (July turtles) and are negatively affected if they experience lower water temperatures by remaining too long (October turtles).

These data suggest that the behavior of Kemp's ridleys in Long Island is adjusted for the seasonal nature of the habitat. Kemp's ridleys move about the area extensively upon arrival, learn to exploit the shallow water habitats, grow rapidly, and generally leave the area prior to the onset of low water temperatures.

# COMPARISONS OF DIET AND GROWTH OF KEMP'S RIDLEY AND LOGGERHEAD TURTLES FROM THE NORTHEASTERN U.S.

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Only limited information is available on the feeding habits and growth rates of Kemp's ridley (Lepidochelys kempi) and loggerhead (Caretta caretta) sea turtles living sympatrically. During 1989, we examined the diets and growth rates of these species in the waters adjacent to Long Island, N.Y. Individuals occurring in Long Island are exclusively juvenile.

Sea turtles first appeared in the area in June. Between June and November, 36 live loggerheads and 18 live Kemp's ridleys were captured in the study area, generally during commercial fishing operations. The turtles were maintained in individual 2100 liter tanks, and fecal samples were collected for two days following capture. Samples were obtained from 25 loggerheads and 15 Kemp's ridleys. Crabs comprised over 75% of the diets of both loggerheads and Kemp's ridleys. The remainder of the diets for both species were divided among mollusks, algae, synthetics and natural debris. Spider crabs (Libinia sp.) and Atlantic rock crabs (Cancer irroratus) were the major components of the diets of both species as analyzed using both nonpooled percent dry weight and percent occurrence techniques. Other investigators have suggested that Kemp's ridleys and loggerheads living sympatrically do not prey on similar species. However, our research indicates a general overlap of the prey species in the diets of the two species in Long Island.

Six Kemp's ridleys and three loggerheads were recaptured during the study. Minimum interval between captures was greater than 14 days ($\overline{X} = 32$ days). Both species exhibited mean weight gains. The mean growth rate was 0.35%/day for L. kempi and 0.23%/day for C. caretta.

# THE FEEDING ECOLOGY OF KEMP'S RIDLEY IN SOUTH TEXAS WATERS

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The diet of Kemp's ridley (Lepidochelys kempi) is poorly known and has not been studied in the northwestern Gulf of Mexico. The little information available has been derived from qualitative examination of digestive tract contents of a few geographically scattered samples from the Atlantic and Gulf of Mexico coasts. Additionally, virtually nothing is known about foraging by head started Kemp's ridleys that had been fed a dry, floating pellet diet while held for 8-10 months at the National Marine Fisheries Service Laboratory, Galveston. A total of 14,592 head started ridleys was released between May, 1979, and May, 1989, most in the Gulf of Mexico off Padre and Mustang Islands. However, 96 were placed into Nueces Bay and 519 into Copano Bay.

One hundred and one carcasses found on Gulf and bay beaches along the lower Texas coast from 1983 to 1989 were salvaged for study of food consumption. Gut contents were quantitatively examined to: 1) characterize diet and determine principle or preferred prey species, 2) compare the diet of wild and head started turtles, males and females, and juveniles, subadults, and adults, 3) compare diet by season, and 4) gain insight into foraging areas and patterns.

The 101 carcasses represented only a portion of those found stranded in the study area. Some were too badly decomposed and others were not collected. They were found during all months except September and October. Seventy-two stranded during the spring (March, April, May), 20 during the summer (June, July, August), one during the fall (September, October, November), and eight during the winter (December, January, February). Fifty were wild turtles and 51 were head started. Of the latter, those recovered within fewer than 10 days of release were eliminated from analysis. The 51 head started turtles analyzed were recovered from 10 to 2,100 days after release (mean=114.2, SE=45.3). Forty-one had been released in Copano Bay, one in Nueces Bay, and nine offshore. All of those released in the bay and four of those released offshore were recovered from bay beaches, the other five from Gulf beaches. In contrast, 45 wild turtles were recovered from Gulf beaches and only five from bay shores.

Curved carapace and length measurements were recorded for each salvaged turtle. Curved carapace lengths of wild turtles ranged from 5.2 to 71.0 cm (mean=43.3, SE=2.2). Curved carapace lengths of head started turtles ranged from 14.6 to 48.2 cm (mean=23.3, SE=0.8) and were significantly smaller than those of wild turtles ($t=-8.68$, $P<0.0001$). Size categories described by Ogren (1989) were used to group samples. Two wild and three head started juveniles (<20 cm), 38 wild and 48 head started subadults (20-60 cm), and 10 wild adults (>60 cm) were salvaged.

A general necropsy was performed on each salvaged turtle. During necropsy the sex of the turtle was determined by visual examination of the gonads. Forty-one were males, 40 were females, and 20 could not be sexed. Twenty-five of the males were wild and 16 were head started; 14 of the females were wild and 26 were head started; 11 of the undetermined gender turtles were wild and nine were head started.

The entire digestive tract was removed from each salvaged turtle, and the contents were sieved, rinsed with water, and preserved in 10% buffered formalin. Consumed items were identified to the lowest taxonomic level possible. Sorted samples were then baked in a drying oven for 24 hours to obtain dry weights. Individual food items were classified into the following general food groups: crabs, molluscs, fish, vegetation, shrimp, other materials, and trash. Percent dry weight and percent frequency of each food item and group were calculated for wild and head started turtles.

The food group ingested most frequently and in greatest quantity was crabs; fourteen species of crabs were found. Molluscs, vegetation, and other materials were also consumed, but the combined dry weights of these food groups was less and may have been ingested incidentally rather than intentionally. Since there may be important differences in feeding of wild and head started turtles, the bulk of dietary analyses were conducted considering these two groups separately. Also, juveniles, subadults, and adults were considered separately, since consumption of certain types of food varied with size.

It has been suggested that young pelagic sea turtles probably enter sargassum drift lines, convergences, eddies, and rings where they feed at the surface of the water on floating organisms. The juveniles analyzed in this study probably fed in these same oceanographic features. Wild ones fed upon sargassum, molluscs often found within sargassum, and crabs and unidentifiable material that could have been present there. Head started individuals also fed upon sargassum and floating items that could have occurred in sargassum mats or convergences.

Kemp's ridleys apparently become benthic carnivores once they enter shallow coastal areas. Subadults and adults analyzed fed primarily in benthic environments. However, some food items, including jellyfish, floating vegetation, and floating debris could have been taken in the water column or at the surface. Crabs were the primary dietary constituent, by frequency and mass, of both wild and head started turtles. It has been widely reported that Kemp's ridleys feed primarily on portunid crabs and that their distribution along the coastal United States is frequently correlated with areas abundant in these swimming crabs. Although substantial quantities of portunid crabs were consumed by the turtles examined, relatively large quantities of other crabs were also eaten frequently. Hence, ridleys may be feeding opportunistically rather than selecting for a particular crab species, and their distribution may be more closely related to the distribution of all the major crab species consumed rather than just that of portunids. The five crab species taken in greatest mass and frequency occur primarily in shallow waters from shore to 50 m depth. Kemp's ridleys tracked and captured in the Gulf of Mexico were found in the same depths (Byles, 1989; Ogren, 1989).

Overall, 25.74% of the turtles had consumed fish and 8.91% had consumed shrimp. However, in most instances only minimal amounts were found. Likely, these items were dead when eaten and were either unwanted catch of shrimping vessels or discarded bait. Little difference was found in foods consumed by males and females, and there was little seasonal variation in diet of wild turtles detected. Direct statistical comparisons of the diet of wild and head started juveniles, subadults, and adults were not performed because most of the wild turtle were found on Gulf shores, whereas most head started individuals were retrieved from bay areas. The diets of wild and head started Kemp's ridleys examined were similar, except that head started turtles consumed slightly less material, fewer crabs, and more molluscs. However, most of these differences were probably related to the significantly smaller size of head started turtles and differences in prey distributions in bay and Gulf waters. In general, head started Kemp's ridleys examined appeared to have adapted to feeding in the wild.

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# SEA TURTLES PRESENT IN SAN DIEGO BAY

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## INTRODUCTION

At least five species of sea turtles are known to occur in the Eastern Pacific; the loggerhead (Caretta caretta), the leatherback (Dermochelys coriacea), the hawksbill (Eretmochelys imbricata), the olive ridley (Lepidochelys olivacea), and the black (Chelonia agassizi), which some consider to be a subspecies of the green (Chelonia mydas).

San Diego Bay is the only bay on the west coast of the United States where sea turtles are known to aggregate (Stinson 1984). This group of turtles appears to be attracted by the warm water effluent discharged by the San Diego Gas & Electric (SDG&E) power plant into the southernmost end of the bay. During the late 1970's, Stinson (1984) observed a group of approximately 30 green turtles (Chelonia mydas) frequenting the power plant area. She studied their movements in relation to tidal flow, water temperatures, and a number of other parameters and concluded that the turtles migrated out of the bay at the onset of the warm summer months, and were only present during November through April (Stinson 1984). However, the origin and migratory habits of these turtles remain a mystery.

Since Stinson's study there have been sightings of turtles in the bay (Balazs, unpublished observations; Fredrik Jacobsen, SDG&E, pers. comm.) but no effort to identify individuals, study their biology, or determine their origin. The present study was undertaken in order to assess the current status of sea turtles in San Diego Bay. The following are some preliminary observations based on sightings during 1989-90. Further work to identify individuals, size, sex, health status, origin and migration is ongoing.

## METHODS

We began observations in May, 1989. Observations were made once a week over a 1 hour period from shore and from a bridge over the warm water effluent channel adjacent to the SDG&E Power Plant. The temperature of the water in both the effluent and inlet channels to and from the power plant was recorded, along with the number of turtles sighted in the area of the power plant.

## RESULTS

Between May 1989 and February 1990, the temperature differential between the inlet and effluent channel ranged from 6 - 15°F, so the water in the effluent channel was usually at least 10 F degrees warmer than that of the rest of the bay, and at least 20 F degrees warmer than that of the ocean off San Diego. Bay water temperatures ranged from a high in August of 83.5 to a low in February of 56.5°F. The corresponding effluent channel temperatures were 94.4 and 67.0°F.

Turtles were observed throughout the year in the effluent channel, except on two occasions during July and August (Figure 1). This period of absence corresponds to the time when temperatures in both the inlet and outlet channels were highest (Figure 1).

We saw at most nine turtles at any one time, although we usually saw six. We were able to identify four individuals: one extremely large mature female with a deformed carapace, which appears to be Chelonia mydas, two mature males with a black colored, elongated torpedo-shaped carapace, characteristic of Chelonia agassizi (one of them is covered with large barnacles), and one juvenile C. agassizi less than 50 cm in carapace length.

## DISCUSSION

We observed fewer turtles than Stinson did in the late 1970s, when she estimated the population size to be around 30 individuals (Stinson 1984). This may represent an annual variation in the number of turtles present, or could represent a decline in the number of turtles in the Bay. Contrary to Stinson's observations, we observed turtles almost throughout the year. Although we did not see turtles in July, we received a report from power plant workers of turtles in the effluent channel two days prior to our July visit. These observations suggest that the turtles may have dispersed into the bay when temperatures in the effluent channel rose above 85°F in July, and returned into the channel when temperatures cooled again (Figure 1). It remains to be seen whether turtles continue to be present in the summer of 1990, and whether the same individuals are present from year to year. Our sighting of at least two very small turtles (<50cm carapace length) suggests that "younger" turtles continue to recruit into the bay.

The large female with the deformed carapace that we have seen is identical to one photographed by Stinson in 1979 (*in* Stinson 1984). Questions arise as to the movements of this turtle, which weighed 172 kg in 1979, during the 10 year period since Stinson's study. Could she have undertaken a nesting migration and then returned to San Diego? Laparoscopic or ultrasonic examination of the oviducts could determine the reproductive history of this individual.

We plan further studies which will include capturing and tagging individuals in order to obtain growth data from any turtles recaptured from Stinson's study, and from turtles recaptured in subsequent years. We hope that by employing satellite telemetry and genetic studies, we may be able to satisfy our curiosity as to the origin and migratory habits of the San Diego turtles.

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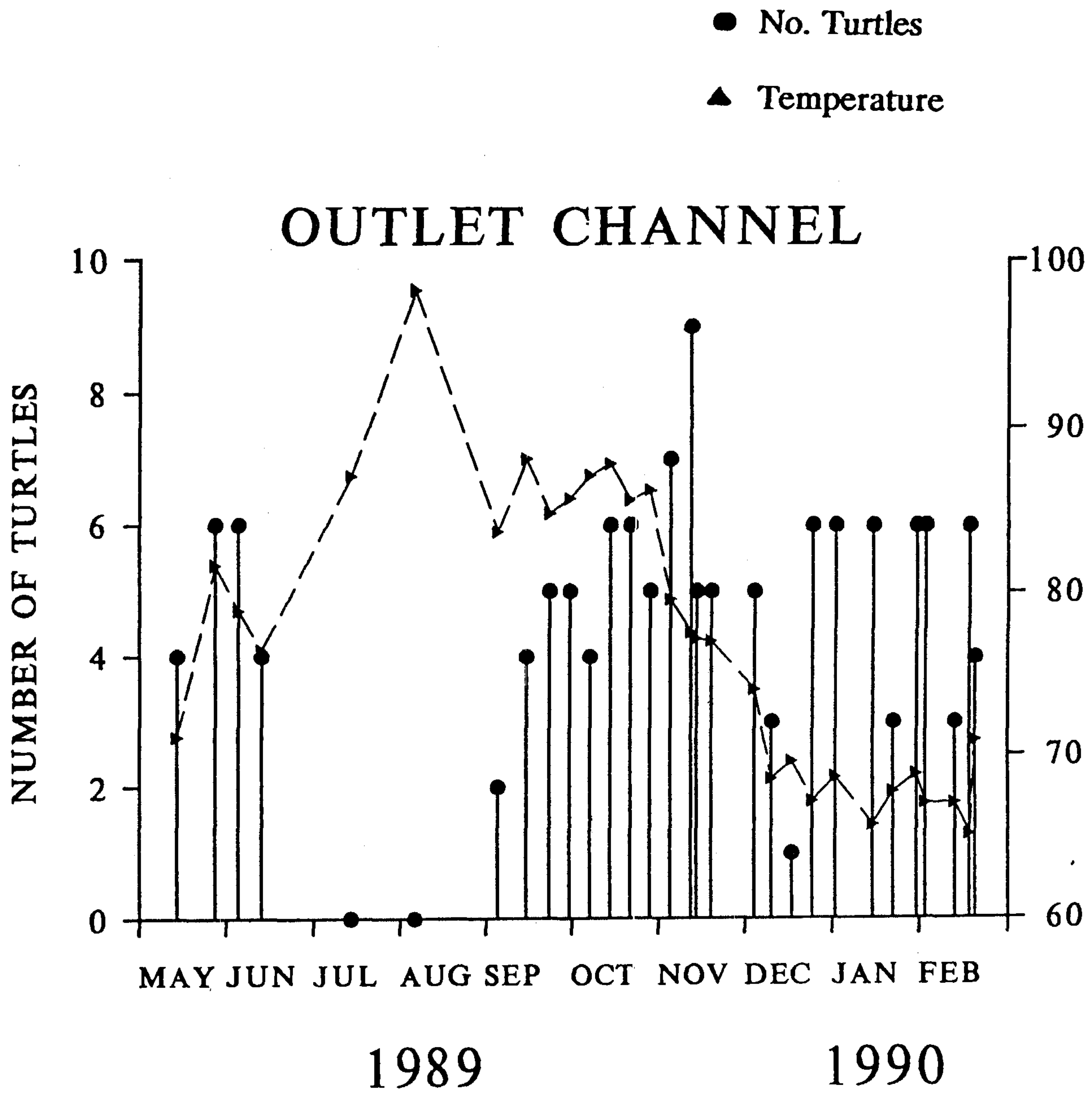

FIGURE 1: **Sightings of sea turtles (*Chelonia* sp.) [number of turtles ●] and the water temperature [ °F▲] in the effluent channel adjacent to the San Diego Gas & Electric Company Power Plant in San Diego Bay, from May 1989 through February 1990.**

# PELAGIC DISTRIBUTION AND BIOLOGY OF SEA TURTLES IN THE EASTERN TROPICAL PACIFIC

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## INTRODUCTION AND METHODS

During the past 15 years I spent over 60 months at-sea in the eastern tropical Pacific (ETP) participating in NOAA research cruises. During those cruises I was part of an observer team that used high-powered, mounted spotting binoculars to survey marine bird and dolphin populations and I took the opportunity to record incidental sightings of turtles on the high seas. The study area (Figure 1) included most of the eastern half of the tropical Pacific. Species of hard-shelled turtles are difficult to differentiate under normal field conditions, so starting in 1986 I was allowed to divert the ship to take photos of turtles that were close to the trackline in order to obtain a sample of identified individuals. In addition to my own observations, I analyzed data collected in 1975 by SWFC personnel placed on tuna purse seine vessels operating in the ETP. Those observers recorded at-sea sightings of turtles, and identified and measured any individuals that came onboard during regular fishing operations. The combined effort by research and tuna vessels represents a total of 4,179 at-sea days. I present here the results of these efforts.

## RESULTS AND DISCUSSION

A total of 2,742 sea turtle sightings were recorded: 1802 from research vessels and 940 from tuna vessels (these do not include sightings of leatherbacks; see below). Figure 1 is a plot of all hardshell turtle sightings, including identified and unidentified individuals, and shows the maximum number recorded per day per 2 degree square. Sea turtles were common and widespread throughout the pelagic waters of the ETP but with a very evident inshore/offshore gradient. Below is a discussion of results by species.

**Olive Ridley** (Lepidochelys olivacea) (Figure 2). This was by far the most abundant and widespread sea turtle in the ETP (247 identified individuals) and undoubtedly accounted for nearly all of the turtle sightings south of the tip of Baja (see Figure 1). It occurred only within warm tropical waters of the eastern Pacific; its range to the north was bounded by the cold California Current that veers southwest off the southern tip of Baja California, and to the south by the cold Humboldt Current that veers northwest off the coast of northern Peru at approximately 5°S.

Figure 3 shows the locations of 62 pairs of mating turtles recorded during the cruises, including 29 pairs of olive ridley and 30 pairs of unidentified (probably ridley) turtles. Turtles were observed mating at sea during every month of the year except March and December; a sharp peak in August and September corresponds to peak breeding activity for olive ridley in the eastern Pacific. From this it is apparent that olive ridleys regularly mate on the open ocean, at least as far as 1850 km from the nearest mainland, and that this breeding activity is synchronous with mainland breeding populations.

**Loggerhead** (Caretta caretta) (Figure 2). This was the only hardshell species identified in the cool offshore waters of Baja, and this was the only area where this species was identified (19 identified individuals). By inference, most, if not all, of the turtles recorded north of the tip of Baja were this species. In this area we saw up to 133 turtles in a day and it is likely that this population numbers in the thousands, if not tens of thousands.

The turtles we saw off Baja were all small (usually 30-40 cm), and the area therefore appears to be important habitat for juveniles. The provenance of those turtles is unknown; this species is not positively known to breed in the eastern Pacific; and juveniles off Baja likely came from western Pacific stocks. If so, loggerhead developmental migrations in the Pacific may be analagous to what has recently been postulated for Atlantic populations, i.e., breeding adults occur primarily in the western ocean basin; hatchlings disappear after departing from nesting beaches there and show up as juveniles in the eastern ocean (off the Azores in the Atlantic); they then migrate back to the western ocean as subadults to complete the cycle (Carr 1986).

Loggerheads off Baja may have been feeding on the vast swarms of pelagic red crab (Pleuroncodes planipes) that occur off the coast there. The crab occurs in such numbers as to turn the ocean red at times and was always abundant in areas where loggerheads were common. The distribution of the loggerhead off Baja was coincident with the range of the crab (Figure 4), and the occurrence of the crab may be an important factor in determining the distribution and relative abundance of the loggerhead in the offshore waters of Baja.

**Leatherback** (Dermochelys coriacea) (Figure 5). The relative abundance of this species was exaggerated by the fact that it was much easier to identify than any of the other species. Though the sample size was small (39 individuals), the distribution showed a distinct preference for water with a shallow thermocline. A sharp, shallow thermocline is characteristic of the easternmost waters of the ETP and western extensions along the 10_N latitude and the equator (Wyrtki 1964). A well-defined, shallow thermocline is not only indicative of higher productivity (i.e., food resources), but also offers a more accessible source of colder water which may be important if maintaining thermoneutrality is a significant consideration for leatherbacks in the tropics.

**Green/Black** (Chelonia mydas agassizi) (Figure 6). Ten individuals were identified, including 3 mating pairs in the vicinity of islands (i.e., Galapagos; Revillagigedos, Mexico). A pair mating adjacent to the sheer, beachless cliffs of Wenman Is., Galapagos, was 170 km from the nearest possible nesting beach.

**Hawksbill** (Eretmochelys imbricata) (Figure 6). There were 4 identified individuals, of which 2 were 20 cm or less. This is undoubtedly the rarest marine turtle in the ETP where its breeding status seems unclear.

**Association with Flotsam.** Sea turtles on the open ocean, with the exception of leatherbacks, readily associated with flotsam. Turtles associated with everything from plastic bags and buckets, fish nets, logs, bottles and coconuts, to dead sea lions. Of the 187 records of turtles with flotsam, 26 were olive ridleys, 3 greens, 2 loggerheads, 1 hawksbill and 154 unidentified; no leatherbacks were found near flotsam. Protection is one explanation for this behavior; in the open ocean a floating object may be an important refuge from large predators. For example, at the approach of a vessel, turtles often tried to climb out on top of large drifting objects. Secondly, flotsam may provide feeding opportunities for associated turtles. Drifting objects in the ocean act as fish aggregators and substrate for sessile organisms (Hunter and Mitchell 1966, Gooding and Magnuson 1967). Drifting fish nets in the pelagic ocean are especially deadly for turtles because they often have large crab communities associated with them which may lure hungry turtles to their death.

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Hunter, J.R., and C.T. Mitchell. 1966. Association of fishes with flotsam in the offshore waters of Central America. Fish. Bull. 66:13-29.

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Figure 1. Distribution of all identified and unidentified hardshell turtles showing maximum number sighted per day, per 2 degree square (n = 2,742 turtles). Dots show noon vessel positions for days when no turtles were seen.

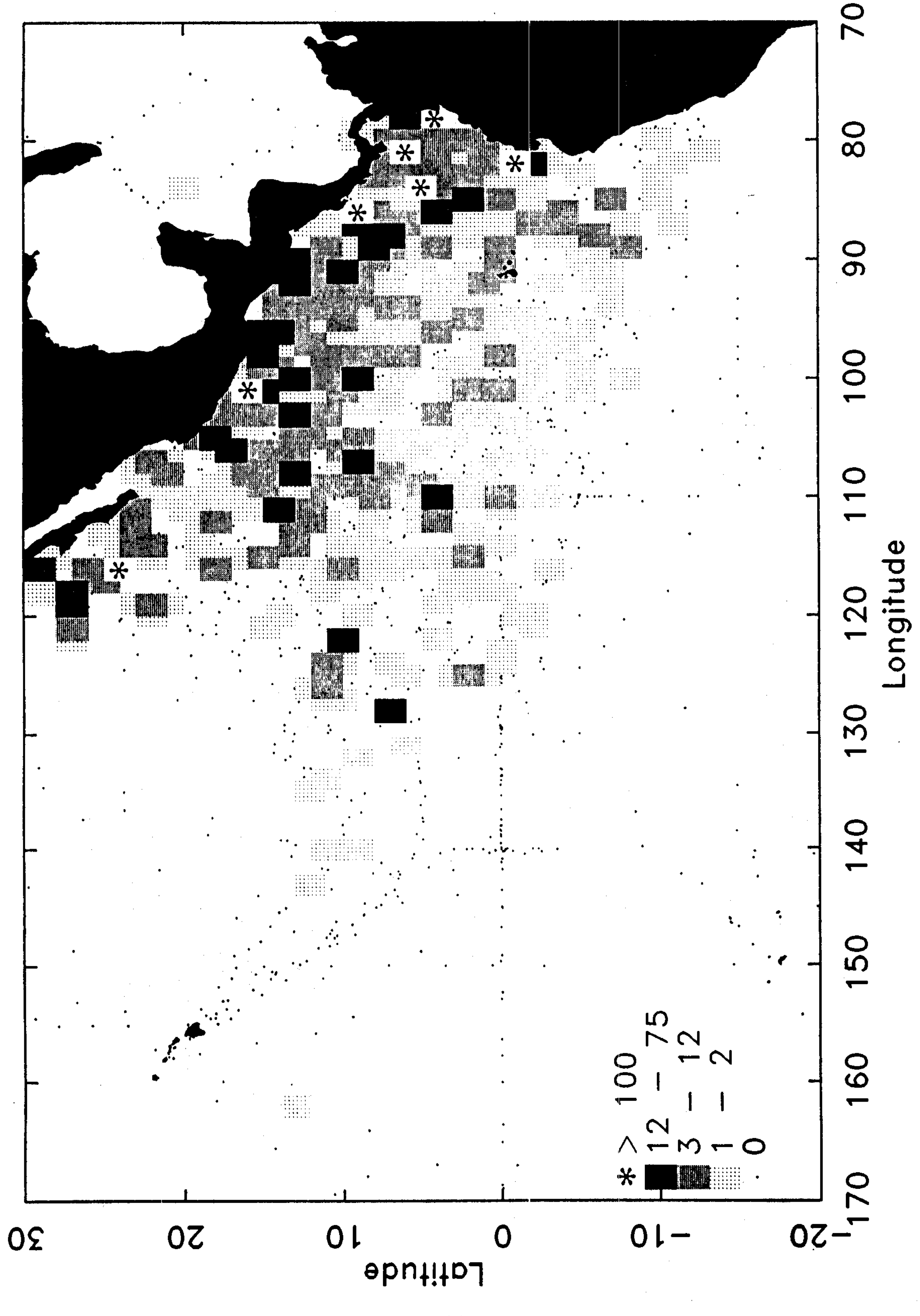


Figure 2. Sightings of loggerhead (n = 19) and olive ridley (n = 247) turtles.

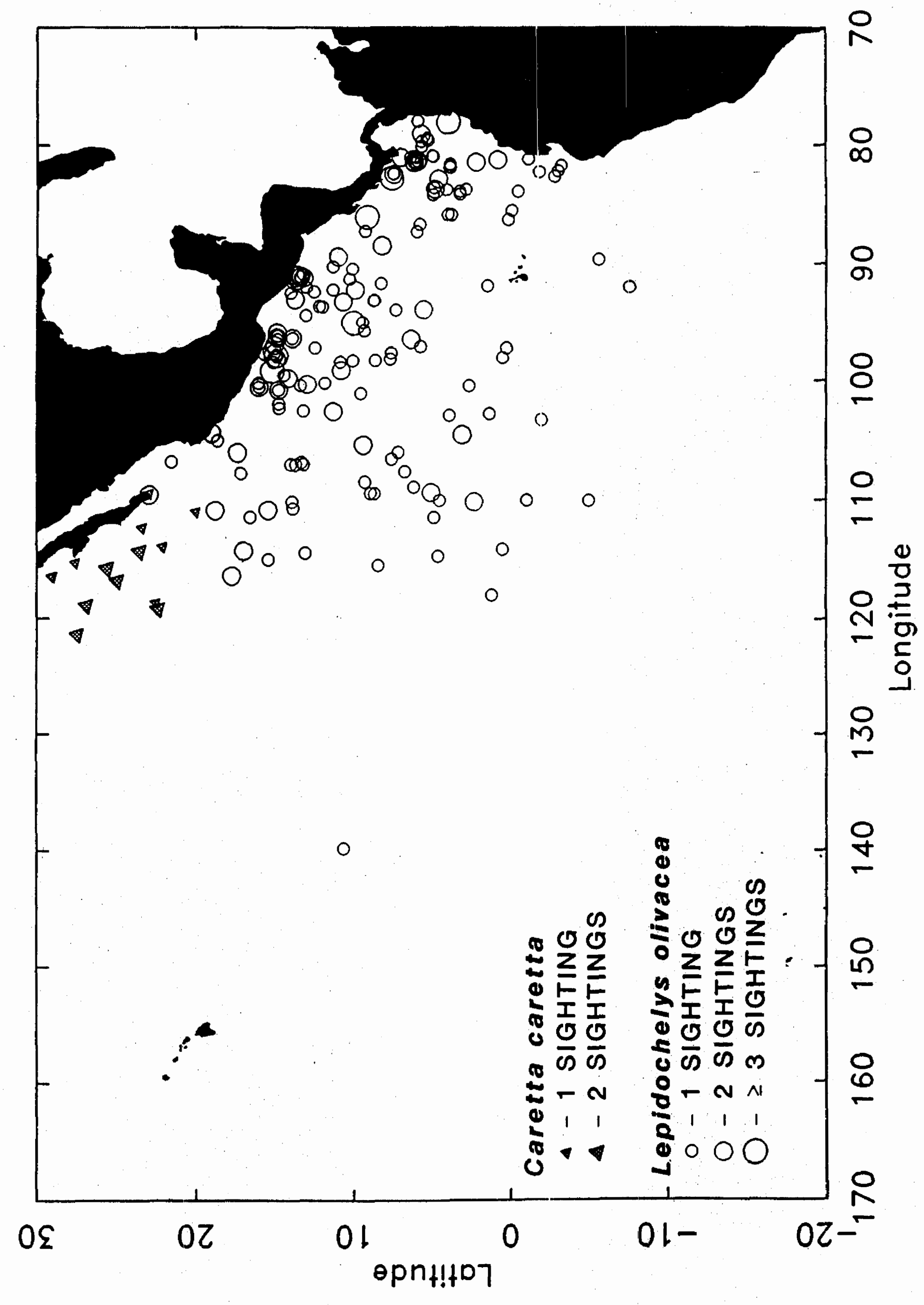


Figure 3. Sightings of mating pairs of olive ridley (n = 29) and unidentified (n = 30) turtles.

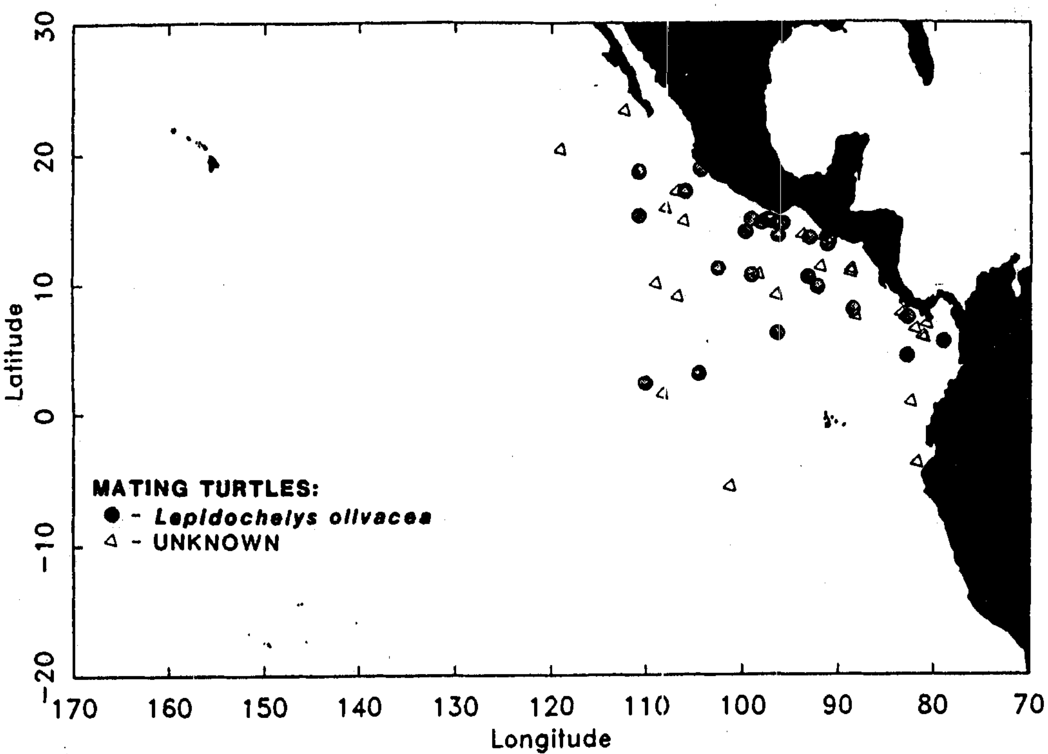


Figure 4. Distribution of red crab, Pleuroncodes planipes, in the ETP; hatching shows area of primary occurrence (from Boyd 1967).

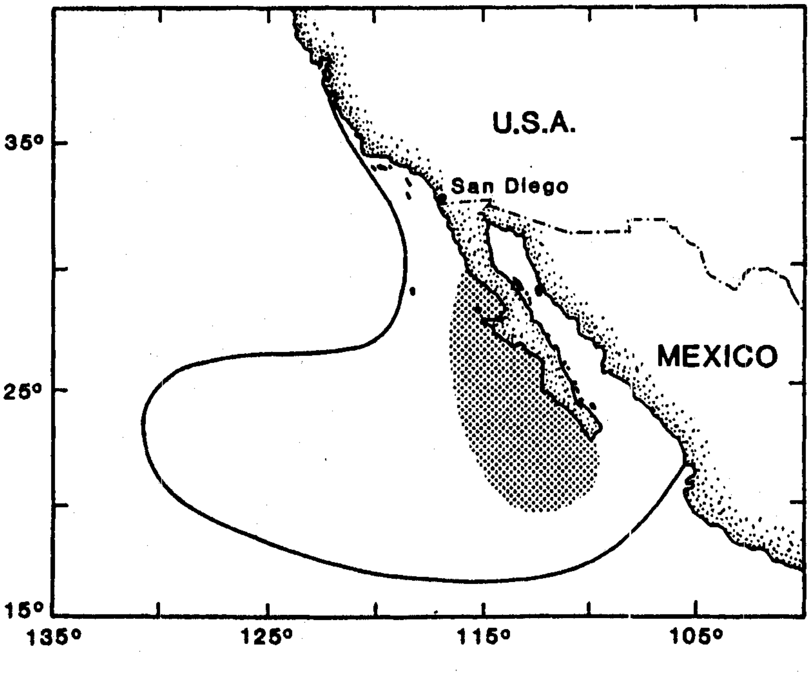


Figure 5. Sightings of leatherbacks (n = 39).

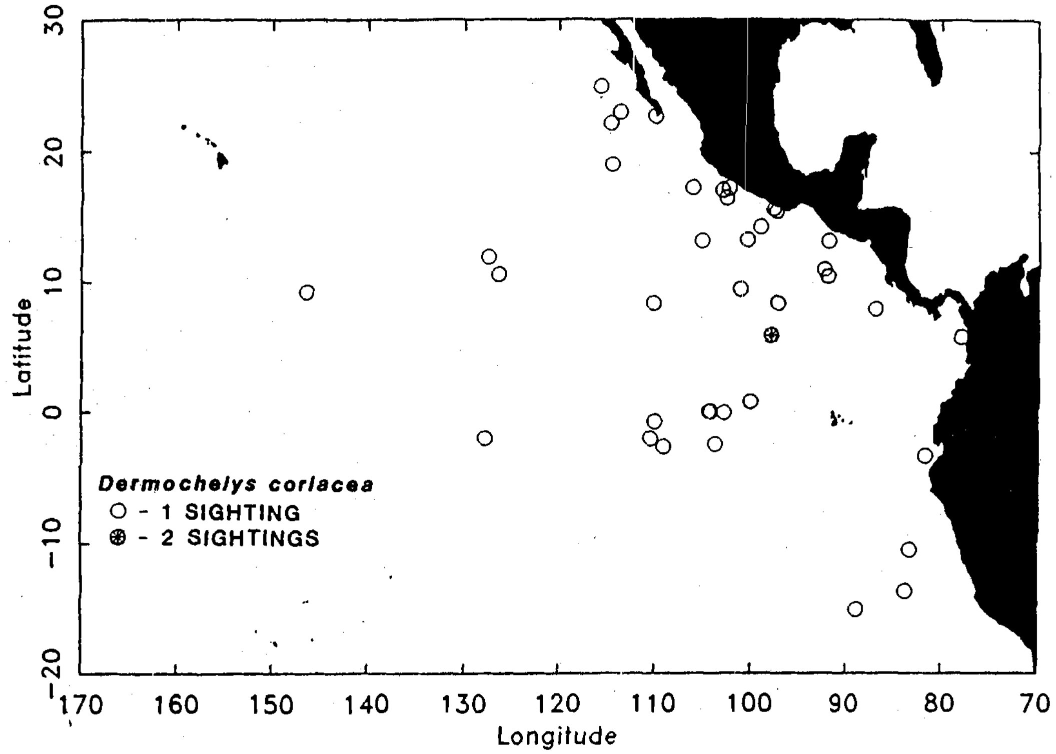
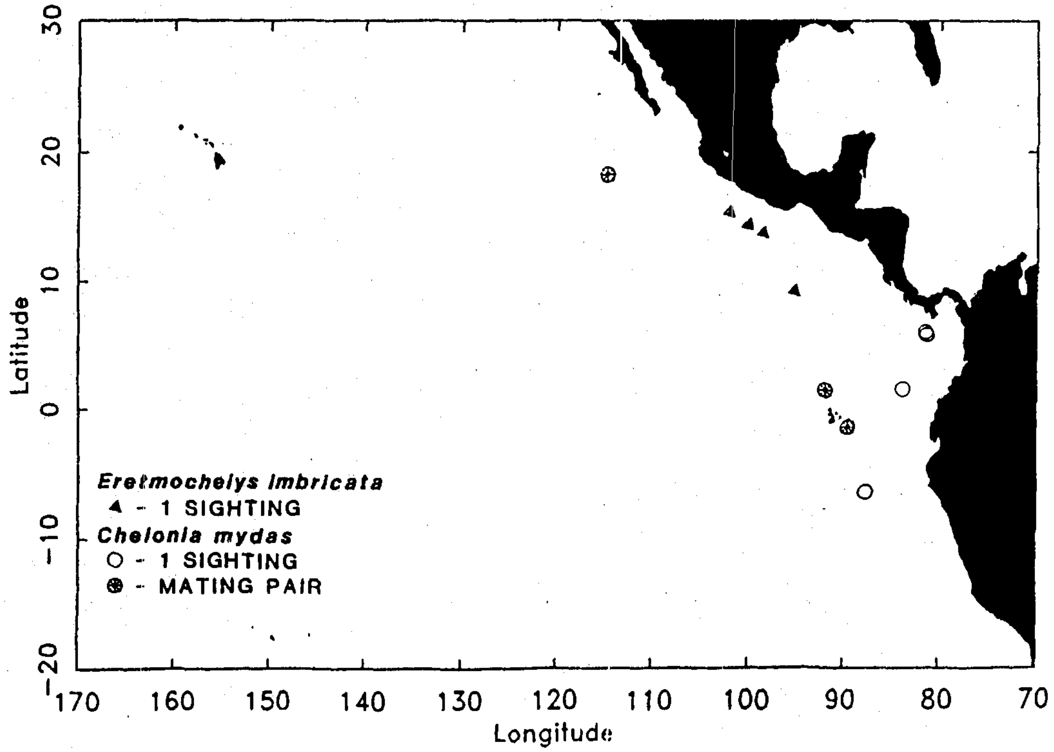


Figure 6. Sightings of green (black) (n = 7) and hawksbill (n = 4) turtles.



(Balazs 1980). However, Kualoa was not a site where this phenomenon had been previously recorded. Park maintenance personnel, life guards, and other people long familiar with Kualoa Beach unanimously agreed that fecal wash-ups of this nature had never taken place there.

No unusual seasonal weather conditions, or notable activity by turtles immediately off Kualoa, occurred that might help to explain the acute fecal wash-up event. A review of available data for tidal cycles, moon phase, wind speed and direction, and surf conditions failed to identify any consistent correlation with the irratic fluctuations in daily fecal counts recorded (Figure 1). Southeasterly winds prevailed on 28-29 August, which partly coincided with counts of 335 pellets per day for 2 days. However, no such relationship was apparent for any of the other days studied. It should be noted that green turtles are only occasionally sighted directly off Kualoa, where they have become entangled in fishing lines or their carcasses have stranded ashore.

## CONCLUSIONS

The most plausible area for the fecal pellets to have originated appears to be Kaneohe Bay, which extends for some 13 km immediately to the southeast of Kualoa Beach. A comparatively large aggregation of green turtles, mainly composed of immature size classes, is known to reside in this bay for foraging and resting purposes. No sudden increase is known to have occurred during 1989 (or any previous year) in the number of turtles inhabiting the bay, as might happen from high juvenile recruitment and seasonal migrations, the latter of which has never been recorded in Hawaii for immature size classes. However, for the past 2 years, special attention has been focused on the turtles in Kaneohe Bay because of the continuing documented increase in fibropapillomas, a debilitating and life-threatening tumor disease of unknown etiology. During 1989, 49.6% of the 113 green turtles reported stranded throughout the Hawaiian Islands had these tumors. Furthermore, at least half of the turtles sighted during diving surveys in Kaneohe Bay now have tumors. A similarly high level also exists for turtles that are hand-captured in benthic resting habitats in Kaneohe Bay for the purpose of tagging and related research.

It is suspected that the acute fecal wash-up on Kualoa Beach may be related to the tumor epidemic in Kaneohe Bay. However, the manner in which this might be mediated is unknown, and open to speculation. Perhaps the disease reduces a turtle's ability to adequately digest algae, possibly by changes in intestinal microbes, thereby causing the fecal pellets to be more buoyant and resistant to breaking apart. Another tenable hypothesis is that certain turtles feeding exclusively on Halophila hawaiiana, a sea grass that grows in Kaneohe Bay, shifted to algal foraging habitats during the summer of 1989. Such a change could be related to the tumors and/or the considerable increase in tourist-related activities and possible disturbances to foraging turtles at certain sites in Kaneohe Bay. Bjorndal (1980) has pointed out that a change of diet by the green turtle, from sea grass to one of algae, would likely require radical changes in gut microflora resulting in a lowered digestive efficiency, at least for a period of time. Whatever the cause, the amazing fecal wash-up phenomenon documented at Kualoa Beach warrants additional investigation. The site will continue to be monitored for a reoccurrence, and the small number of pellets still coming ashore will receive further bacteriological and other analyses. This work with feces in Hawaii appears to be unique, considering that no other reports are known of pellets of the green turtle, or any other species of sea turtle, washing ashore at any location outside of the Hawaiian Islands.

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# SOME ASPECTS OF THE GREEN TURTLE FECAL WASH-UP PHENOMENON ON HAWAIIAN BEACHES

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## INTRODUCTION

During July 1989, a phenomenal wash-up of buoyant fecal pellets occurred on Oahu at Kualoa Beach Park located at the northwestern end of Kaneohe Bay, the largest bay in the Hawaiian Islands. As a precautionary measure, the State of Hawaii's Department of Health closed this 1 km stretch of beach to public use, while trying to determine the source of the pellets and their possible health hazard. Wastes from domestic pigs were initially suspected, and the possibility of human origin was also suggested in the news media. However, after we became involved in the investigation, the droppings were correctly identified as originating from the green turtle, Chelonia mydas. The pellets ranged from 0.5 to 2 cm in diameter and up to 5 cm long. They were found to consist almost entirely of partially digested benthic algae, mainly Codium edule and Amansia glomerata, which are commonly eaten by green turtles in Hawaii. Algal particles were clearly discernible with the naked eye after the pellets were broken open. In addition, ova in the feces were determined to be non-mammalian and most likely those of flukes that parasitize green turtles in Hawaii and elsewhere. The pellets were green to brownish in color. They had a distinctly different and somewhat less objectionable odor than mammalian feces, and appeared to be less attractive to flies and other insects.

Kualoa Beach was reopened after a 40-day closure (11 August- 22 September) when the daily number of pellets declined and health risks to humans were judged to be minimal, if any. During the extreme periods, over 300 pellets per day, and 1 day of 470 pellets, were counted and picked up for disposal by park maintenance personnel (Figure 1). A total of nearly 5,500 pellets were removed during the 40 days. Even after the beach was reopened, pellets have continued to float ashore, but only in small numbers of a few dozen per day.

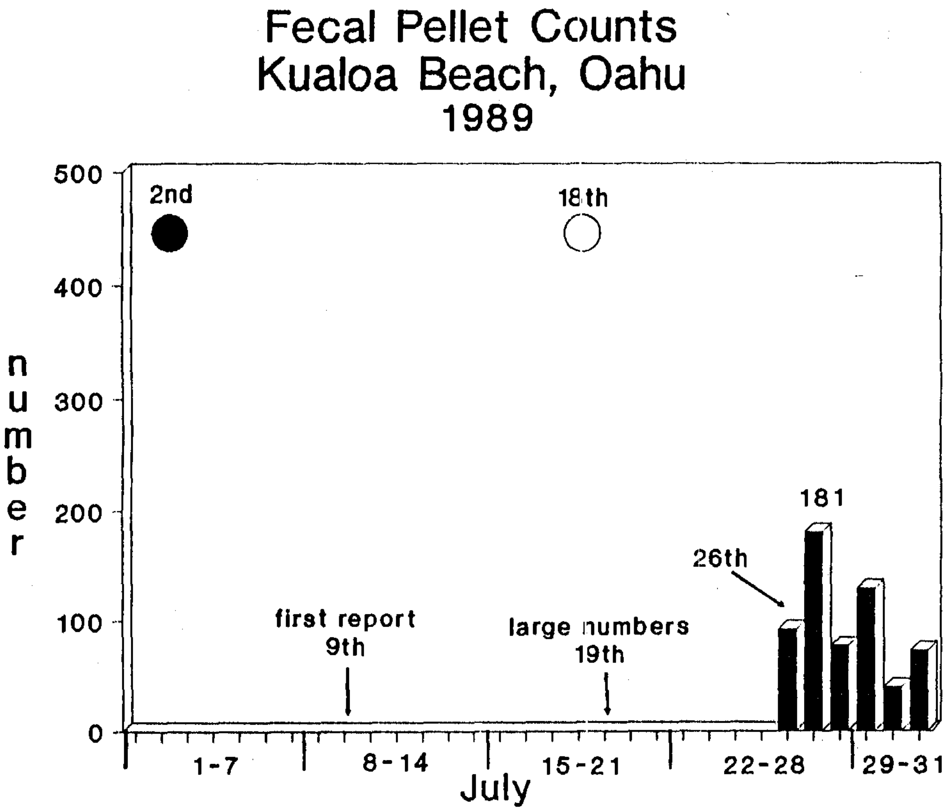
### Bacteriological Analyses

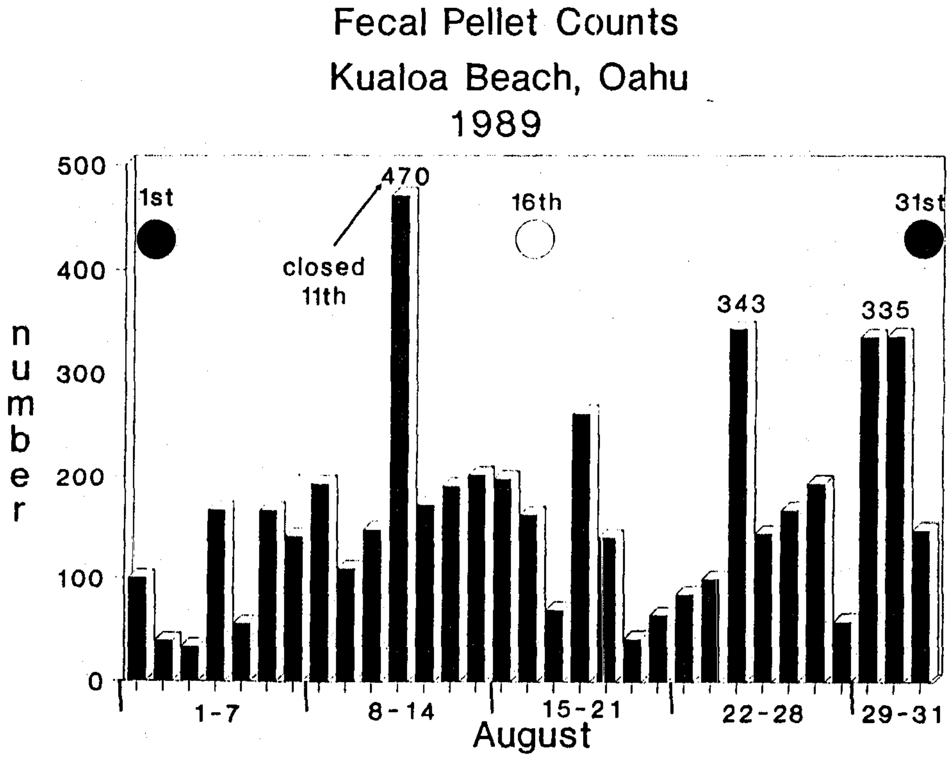
Despite the magnitude of fecal pellets seen during the 40 days, nearshore water samples analyzed by the Department of Health did not exceed indicator bacterial limits set by the Environmental Protection Agency for ocean recreational waters (i.e., <33 Colony Forming Units of fecal enterococci per 100 ml of seawater). To measure bacteriological aspects of the feces, something that had never been done for green turtles in Hawaii, a preliminary follow-up study was conducted. Fecal coliforms and fecal enterococci from turtle pellets freshly collected at Kualoa were found to be low (Most Probable Number (MPN) 3-43 per gram of feces), compared with mammalian and avian feces (MPN $10^6$-$10^8$ per gram of feces). In addition, turtle pellets held at laboratory room temperature (21.5 -25.5$^\circ$ C) showed no multiplication of fecal coliforms or enterococci. Pellets placed in beakers of seawater continued to remain intact, and mostly buoyant, for 15 days with no bacterial growth in the water. Breaking the feces into small pieces after 15 days also failed to result in the isolation of fecal coliforms or enterococci (Fujioka 1990). Cultures from fresh pellets performed by a private hospital laboratory, as well as the State of Hawaii's Department of Agriculture, were found to be negative for Salmonella.

## DISCUSSION

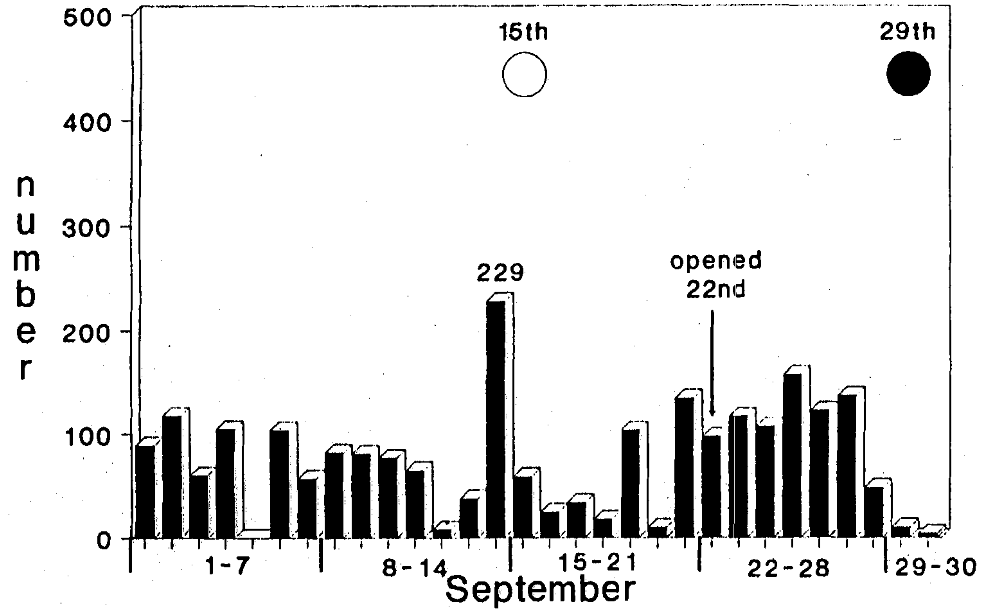
Fecal pellets of the green turtle have been known for at least the past 12 years to sometimes wash ashore in small numbers on certain beaches in the Hawaiian Islands. The opportunity to easily collect this material has provided a simple method of identifing food sources exploited by the turtles in their nearshore foraging pastures

Figure 1. Four graphs: Fecal pellet counts during July, August, September, and October 1989 at Kualoa Beach, Oahu.

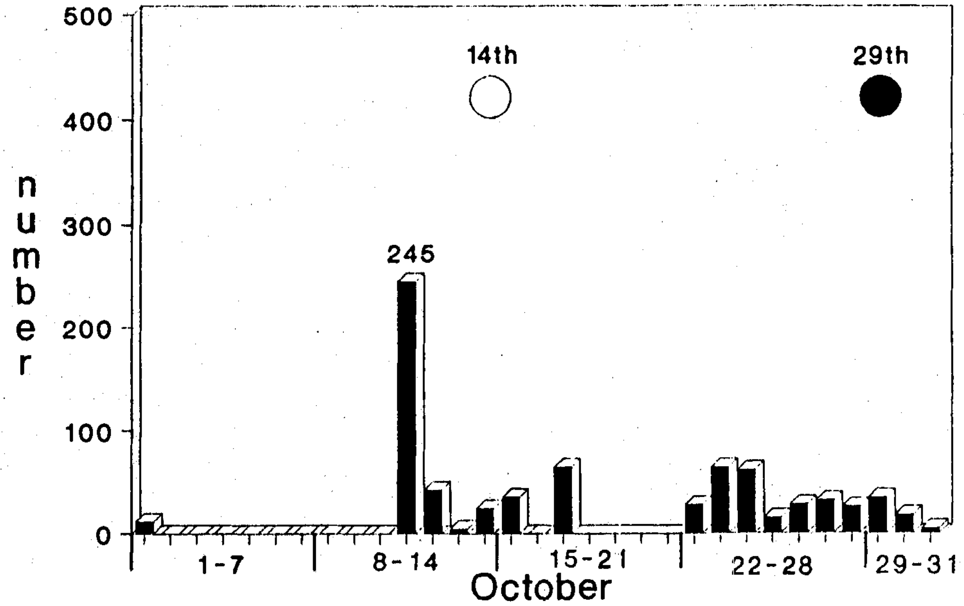




Fecal Pellet Counts
Kualoa Beach, Oahu
1989



Fecal Pellet Counts
Kualoa Beach, Oahu
1989



# INFLUENCE OF BEACH SAND CHARACTERISTICS ON NESTING BEHAVIOR AND CLUTCH SURVIVAL IN GREEN TURTLES

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The sands of sea turtle nesting beaches vary considerably from one locality to another, but few studies have examined how substrate characteristics influence the biology of nesting females and incubating eggs. During the past 12 years I have gathered information on this subject from around the world--especially from Ascension Island in the South Atlantic Ocean and Aldabra Atoll in the Seychelles. At both these sites the nesting beach is dissected into numerous cove head beaches varying greatly in sand type. The following information is presented in far more detail in a paper soon to appear in Copeia (Mortimer, in press).

At both Ascension and Aldabra, where green turtles typically dig multiple body pits before laying eggs, I found a positive correlation between the average number of trial nest holes dug per nesting emergence at each beach, and the mean particle size of the sand at the beach. Because sand characteristics affect the behavior of nesting females, one might predict reproductive success to be best on the finer-grained beaches where the risk is lower that a turtle's eggs would be accidentally dug up during subsequent nesting attempts by turtles.

At Ascension, I also found that hatching success of eggs and the emergence success of hatchlings were better at some beaches than at others--but the reasons are more complicated. Laboratory studies have shown that there are three main factors influencing the survival of reptile eggs--temperature, gas diffusion, and available moisture. But these factors are complicated by the physical characteristics of the substrate.

Figure 1 shows the interrelationship of physical characteristics of beach sand, one of the most important of which is the particle size distribution. Two parameters of particle size distribution are mean particle diameter and sorting coefficient. Sorting is a measure of the uniformity of particle size. (Well sorted substrates are composed of uniform sized particles, while poorly sorted substrates are composed of particles having a wide range of sizes--i.e. gravel.) Particle shape can be described as spherical vs. angular and as smooth vs. rough. Particle size distribution and particle shape interact to determine characteristics of the pore spaces between the sand grains. The amount of pore space and the shape of the pores in the sand affect both gas diffusion and water conductivity. Very small pores can have a capillary effect and retain water. The amount of water in the sand affects gas diffusion, while the rate of gas diffusion, in turn, affects water availability. In fact, too much gas diffusion can cause desiccation, since water can be removed in its gaseous phase. Chemical properties of the sand can also affect gas exchange and availability of moisture. Some minerals are hydrophilic and water adheres to the surface of the particles. Such minerals can make water less available to the eggs. Hydrophobic minerals repel water. Finally, depending on the geographic locality, rates of precipitation and characteristics of the water table can have a tremendous effect on both water availability and gas diffusion.

At Ascension, I found that overall, the worst hatching success was found in the volcanic sand. Among the calcium carbonate beach sands, the best emergence success was found in the finer-grained sand, and the worst in the coarser sand. Because much of the observed mortality occurred prior to pipping, it is reasonable to assume a physiological cause based on either temperature, gas exchange or water availability. For reasons too complicated to deal with here, I ruled out temperature as a factor. Since gas exchange would probably be highest in coarse grained sand, survival would not be limited by gas exchange. This leaves water availability as the most likely limiting factor.

In fact, when I compared the water potential (which is a measure of water availability) at each beach with hatching success, I found a tendency for the hatching success to be best at the "wettest" beaches. I also found that the lowest rates of hatching success occurred at beaches with the greatest amount of air-filled pore space in the sand. This provides further evidence that gas exchange does not limit clutch survival at the coarse grained beaches. It also suggests that excessive rates of gas exchange might be causing desiccation of the eggs. The theory that water is a limiting factor at Ascension is reasonable when you consider that annual rainfall at sea level averages only about 19 cm (Mortimer and Carr, 1987). Other evidence that water availability is the limiting factor at Ascension is that hatching success was best in the deepest nests, where sand is more moist. Also, the worst hatching success occurred in the saltiest substrates which could bind the water, making it unavailable to the eggs.

Considering that the quality of the beach sand can so strongly influence reproductive success, one would expect the turtles to use sand texture as a criteria in their choice of beach. But, data gathered at Ascension suggest otherwise. There was no correlation between percent hatching success and nesting density (Mortimer, 1982). Since sand texture and hatching success are related, this suggests that sand texture is not a criteria in beach choice. Some turtles even lay eggs in sand that produces 0% hatching success. Another point to consider is that when a turtle fails in her effort to construct a nest, she usually tries again only a few meters away from her her aborted nest hole. The turtles do not generally return to the sea and look for a new beach. In fact, Ascension turtles show particularly strong site fidelity to the same nesting beach when they return to nest on the night after an aborted nesting emergence (Mortimer and Portier, 1989).

A look at the variation found in green turtle nesting beaches elsewhere in the world provides further evidence that green turtles do not use sand texture as a criteria in their choice of nesting beach. Figure 2 shows the relationship between mean particle diameter and sorting coefficient of green turtle beaches from sites in the Atlantic, Indian and Pacific Oceans. Clearly, green turtles nest in sands having a wide variety of textures. The Ascension beach sands that produced the highest rates of hatching success and which were also the easiest for the females to construct nests in are shown in Figure 2 by points indicating mean particle diameters ranging from 0.4 to 1.0 mm and sorting coefficients between 0.5 and 1.1. Spire Beach, Pebbly East and Pebbly West beaches (Figure 2) are the Ascension beaches with the poorest hatching success. Based on this, one might expect the outlying beaches in Figure 2 to have very poor hatching success--especially the Hawaiian and Samoan beaches. But, according to G. Balazs (pers. comm.) hatching success there is good.

At Ascension, it was possible to identify an "optimal particle size distribution" because other factors at the island were uniform. But what constitutes "optimal particle size distribution" varies greatly from one locality to another depending on patterns of precipitation, characteristics of the water table, mineral composition and shape of the particles. I suggest that because the situation is so complex, turtles can not use sand texture as a criteria in their choice of nesting beach. There is no such thing as an "ideal sand texture." Texture is just one of many characteristics of sand that means little when considered alone.

We can, however, make some general statements about what constitutes "good" sand. Good sand must be of the proper temperature, must allow adequate gas exchange, and must provide the eggs with sufficient (but not too much) moisture. My world survey of green turtle nesting beaches suggests that most (though not all) good green turtle beaches share certain characteristics including: 1) low levels of silt/clay; 2) low salinity; 3) low levels of organic carbon; 4) moderate sorting; 5) mean particle diameters ranging from 0.2 to 1.0 mm; and 6) high sphericity. Turtles would use beaches with these characteristics because such substrates tend to produce an environment having favorable levels of gas exchange and moisture availability.

The hatching success data from Ascension Island also suggest that characteristics of beach sand that are undesirable at a nesting beach include: 1) a large silt/clay component; 2) high salinity; and 3) poor sorting. These characteristics typify much of the sand that is used for beach renourishment projects. Clearly, much more work is needed to determine the physiological requirements of sea turtle eggs and to learn how these requirements are related to conditions in the field--especially relative to beach renourishment.

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Figure 1. Interrelationship between physical characteristics of soils.

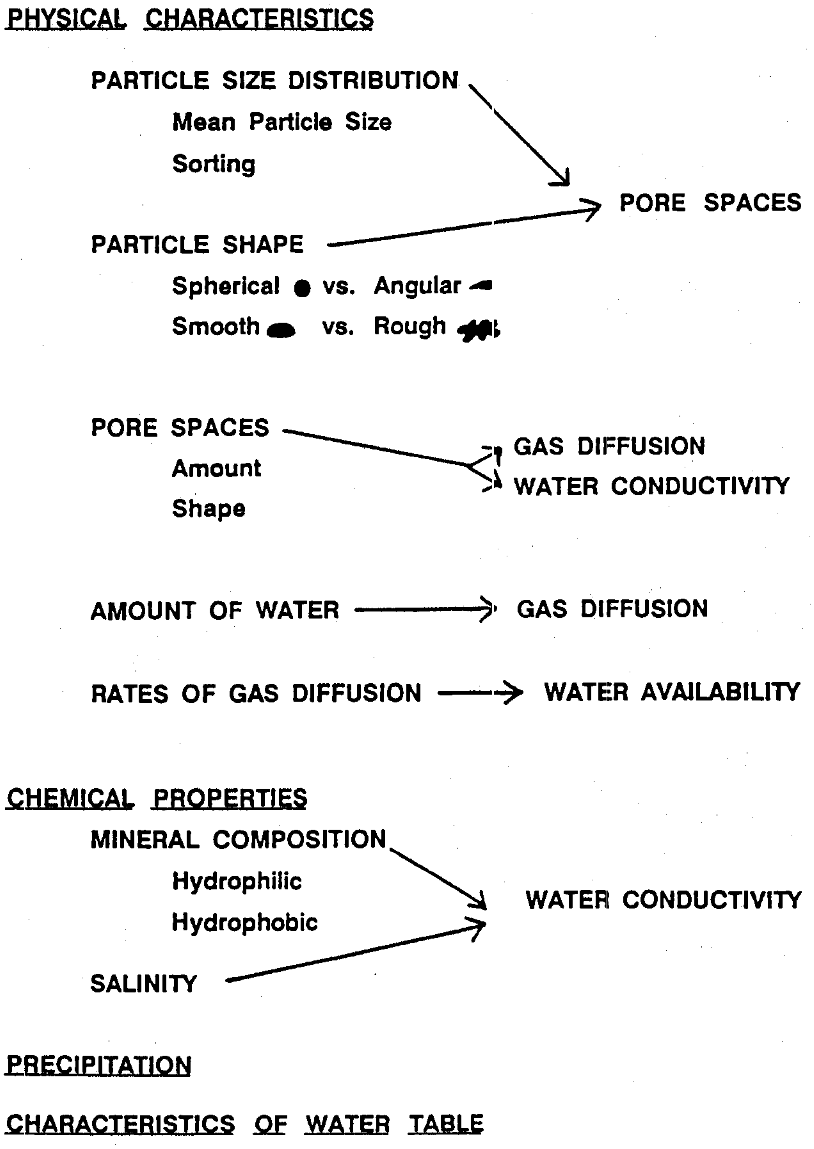
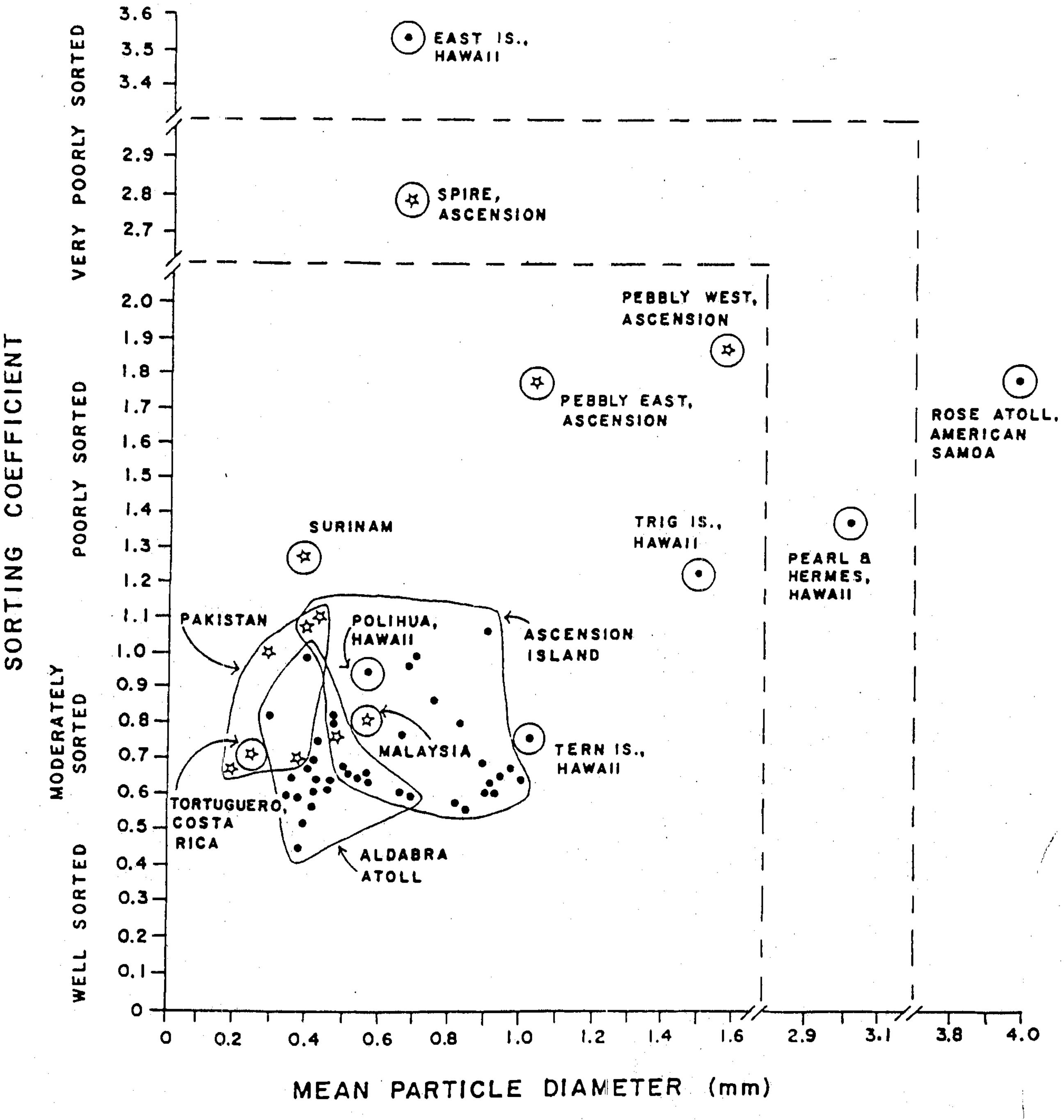


Figure 2. Relationship between sorting coefficients and mean particle diameters (mm) at each of 65 green turtle nesting beaches examined. Calcium carbonate beaches are indicated by closed circles and volcanic (or pyrogenic) beaches by open stars. (Taken from Mortimer, in press, Copeia.)



# A CASE REPORT ON BEACH EROSION, BEACH NOURISHMENT AND SEA TURTLE NESTING

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There is considerable concern by some conservationists and the management personnel of some agencies about the possible long-term effects of beach nourishment on sea turtle nesting. This paper reports on the status of sea turtle nesting on the beach of the Town of Jupiter Island.

Erosion has long been a serious problem on this coastal island in southern Martin County, Florida, and efforts to protect upland property began in 1945. Between 1945 and 1955, 8,000 feet of steel sheet seawalls were installed (Lund, 1986). Beach nourishment began in 1957 and 1958 when more than 250,000 cu yds of sand were pumped from the intracoastal waterway. During 1961-1962 an additional 366,000 cu yds from the intracoastal waterway was pumped to the beach. As erosion continued, more than 7,000 feet of a waffle pattern, sloped revetment was built during 1961 and 1962. This revetment failed, and beach nourishment using a dragline bucket rig to scrape sand from nearshore onto the beach was begun in 1964. This method was used until 1968. And during the interim, in 1966, groins were constructed at 100 ft intervals along three miles of the beach. During 1970 and 1972 an additional 280,000 cu yds of sand from the intracoastal waterway were placed on the beach. Nourishment with hydraulically placed sand from offshore borrow pits began in 1973-1974 and was repeated in 1977-1978, 1983, and 1987.

While it was common knowledge among local residents that sea turtles nested within the eroding area of the Town of Jupiter Island's beach, systematic surveys of such nesting did not begin until 1969 (Lund, 1986). Lund provided a graph of annual nesting activity data and reported that nesting on the filled area of the island increased more than 120% during the 1979-1982 period when compared with the 1969-1972 period. Comparisons of nesting increases for the same times in the unfilled areas north and south of the fill zone were less than 20% and approximately 40%, respectively. For the filled area Lund's graph shows approximately 75 nests per mile in 1969 and more than 250 nests in 1983. By way of comparison, nesting per mile in the natural sand north area was about 275 in 1969 and about 325 in 1983. For the natural sand south area, nesting per mile was approximately 300 in 1969 and about 375 in 1983.

In 1987, the erosion impacted beach from the Hobe Sound National Wildlife Refuge south to the Blowing Rocks area was divided into 30 quadrats by the field survey personnel (Fig. 1). Fill was placed on all, or parts, of northern quadrats 1, 2 and 3, central quadrats 9 through 17, and southern quadrats 22, 23 and 24. During 1988, nesting in the filled area included loggerheads, greens and leatherbacks. Loggerhead nesting activity (nests and false crawls) in the various quadrats during 1988 is given in Fig. 2. Reduced nesting activity in quadrats 2, 15, 16 and 17 resulted from severe erosion, which left those quadrats unsuitable for nesting. Within the 7.5 mi (12.1 km) survey area (Levasseur, 1987) during the 1988 season, there were 4,413 nests and 3,854 false crawls for loggerheads, 45 nests and 49 false crawls for greens, and 10 nests and one false crawl for leatherbacks.

There has been much speculation about the shoreline erosion related to sea level rise. However, the strongest evidence is that major erosion along Jupiter Island has resulted from the St. Lucie inlet and its jetty system (Douglas and Dean, 1989; Clark, 1989).

Efforts to protect upland property in the developed segment of Jupiter Island south of the St. Lucie inlet could have resulted in most of this part of the island being hardened with various types of revetments such that, most likely, very limited sea turtle nesting could have taken place. Fortunately for the turtles, the Town of Jupiter Island opted for beach nourishment.

While there are as of yet not well understood effects of the various types of sand used for such beach nourishment, it is unquestionable that sea turtles effectively use this and other nourished beaches. In the case of the Town of Jupiter Island, nesting activity on the impacted segment of the beach is on a par with other high density nesting areas. During 1988 the loggerhead nesting density within the town was 588/mi (354/km). During the same year, there were approximately 138 loggerhead nest/km on Hutchinson Island, the island immediately north of Jupiter Island [ABI (Applied Biology, Inc.), 1989]. While Jupiter Island has experienced a long history of erosion and various erosion control methodologies, the impacted beach within the town has had a loggerhead nesting density 2.6 times that of Hutchinson Island.

Loggerhead hatch success in the study area during 1988 ranged from 0-100%. The nest that failed to hatch was in an area considered to have natural sand, while the nest with 100% hatch was in a nourished part of the beach. Forty nine nests from nourished areas had an average hatch success of 91%, and 44 nests from "natural" sand areas averaged 90%. These observations are consistent with the findings of others (e.g., Raymond, 1984) that hatch success on restored beaches was not significantly different from hatch success on natural beaches.

I suggest that we encourage regulatory agencies to require appropriate studies (Witham, 1989) in order to better understand the effects of beach nourishment on nesting sea turtles.

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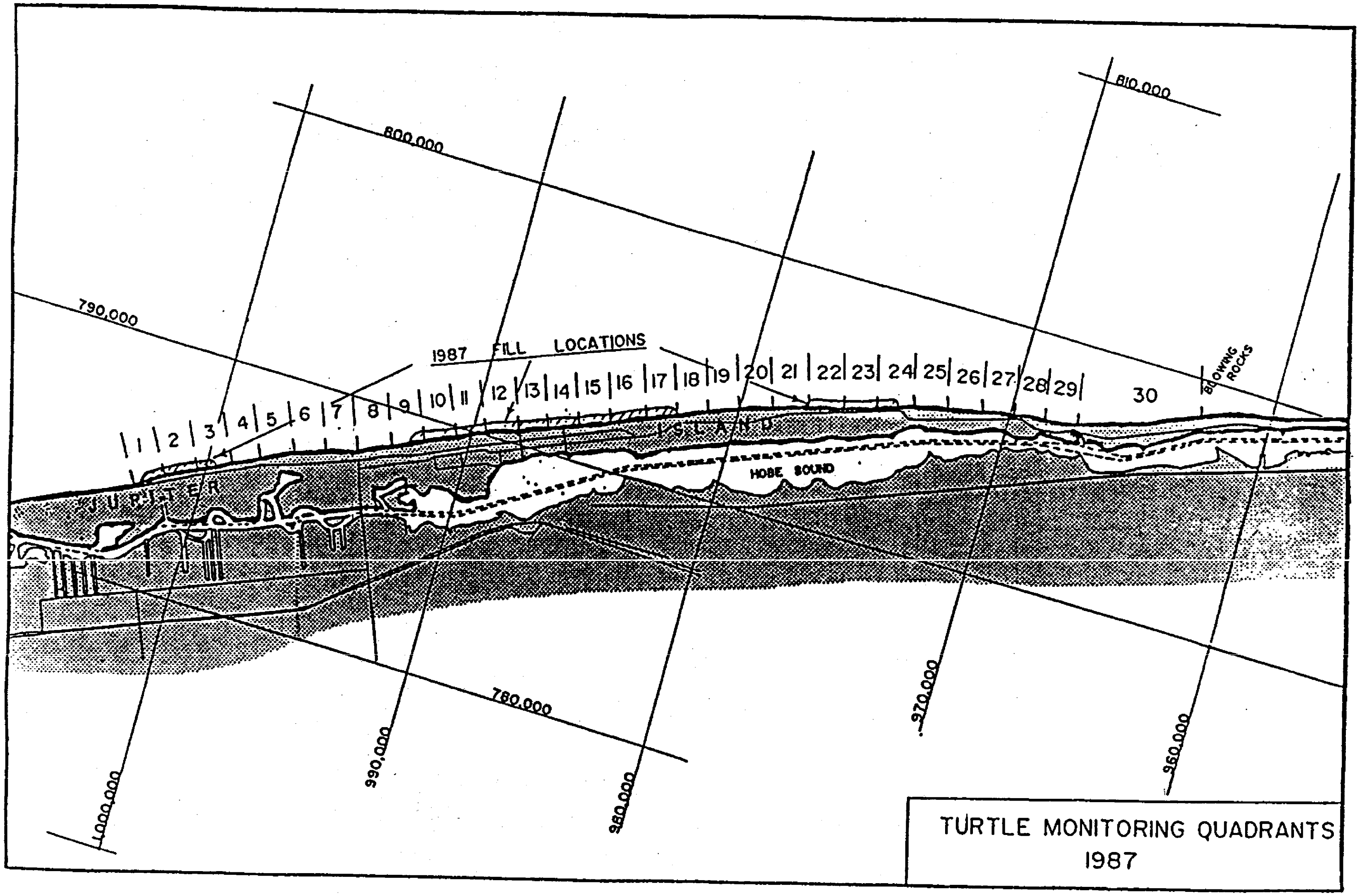
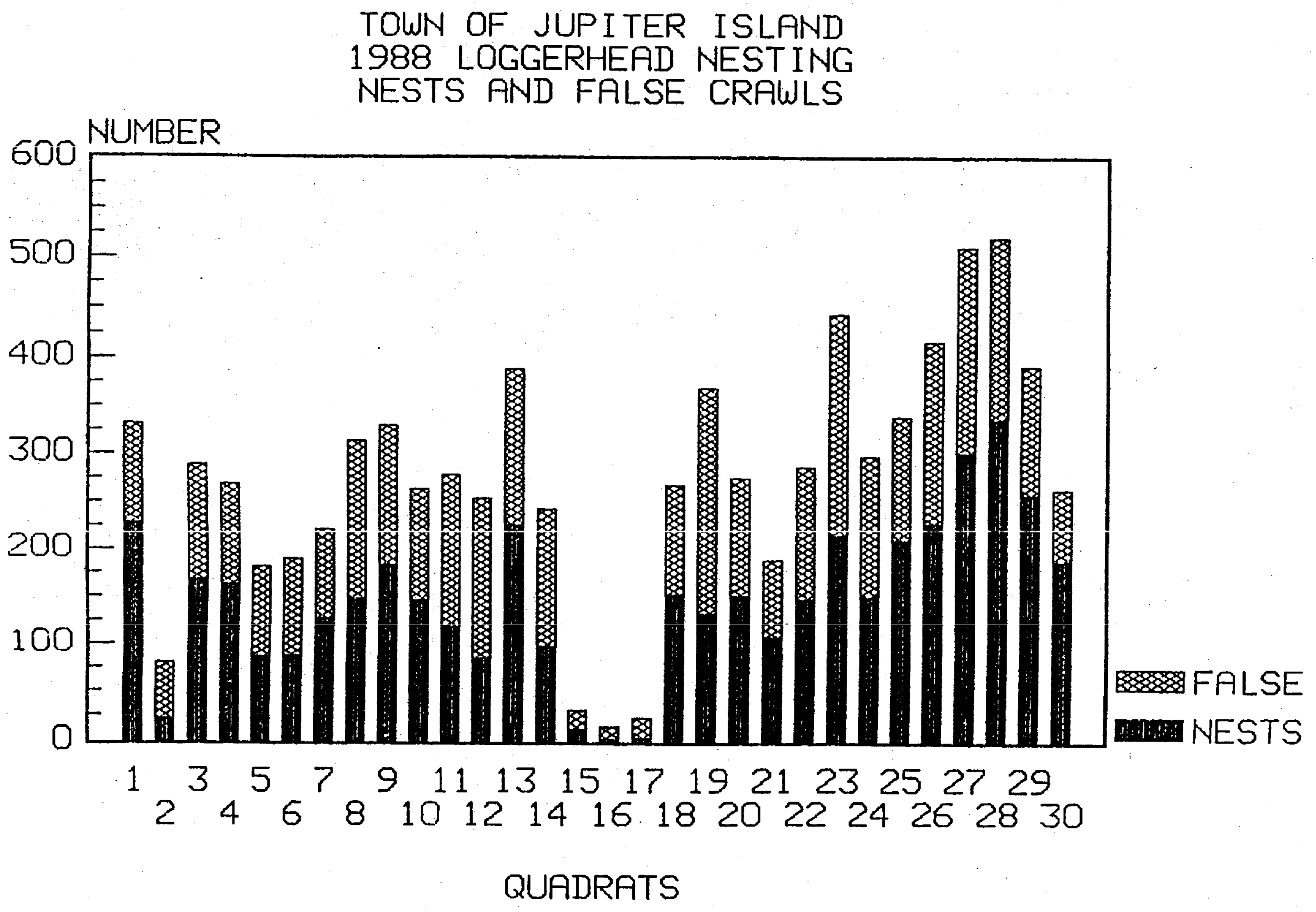
FIGURE 1



TURTLE MONITORING QUADRANTS
1987

FIGURE 2


TOWN OF JUPITER ISLAND
1988 LOGGERHEAD NESTING
NESTS AND FALSE CRAWLS
NUMBER
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
QUADRATS
FALSE
NESTS

# THE RELATIONSHIP OF LOGGERHEAD NESTING PATTERNS AND MOON PHASE IN BROWARD COUNTY, FLORIDA

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Several authors have attempted to relate sea turtle nesting patterns with lunar or tidal phases. Some have reported that no such relationships exist (Baldwin and Lofton, 1959; Davis and Whiting, 1977). Talbert et al. (1980) found higher loggerhead nesting densities near the times of the new and full moons (spring tides) during one year, but not the following season. Fretey and Girondot (1989) reported a similar visual correlation of moon phase and leatherback nesting densities on one part of Ya:lima:po beach (French Guiana) but not on other sections. Certainly, factors including (but not limited to) tidal and nontidal currents, offshore beach obstructions, beach slope, weather conditions and human disturbance could account for some of this lack of consensus. Inconsistent methods of data analysis may also play a role. This report outlines the data analysis used to reveal a statistically significant relationship between moon phase and nightly loggerhead nesting densities in Broward County.

Sunrise surveys of five beach sections spanning the county (38.6 km) were conducted daily from 21 April to 15 September, 1989 during the Broward County Sea Turtle Conservation Project (Burney et al., 1989). Counts of nests and false crawls were recorded. The raw nesting data were plotted (Figure 1, squares) and smoothed with a three-point centered moving average, which revealed peaks, roughly corresponding to the times of the new and full moons (Figure 1, curve.a). The seasonal trend in this parameter was described with a 10th order polynomial regression (Figure 1, curve b).

Moon phase (M) was quantified using a linear transformation of the moon age. The untransformed moon age parameter, derived from Kepler, a public domain astronomy program, varies from 0 to 1, with 0, .25, .5, .75 and 1 corresponding to the new, first quarter, full, third quarter and new (last waning) moon phases, respectively. M was derived by first multiplying the moon age for each day by 4. The integer portion of each number was subtracted from values with even integers, and 1 plus the integer value was subtracted from values with odd integers. The absolute value of each result was taken. M has a value of 0 on the new and full moons and 1 on the first and third quarter moons, and varies linearly between phases. Burney et al. (1989) used a different transformation based on a sine function of moon age. The current transformation is superior because it varies linearly between moon phases. M was scaled by a factor of 10 for plotting (Figure 1, curve c), but not for correlation analysis. Figure 1 shows a striking inverse visual correlation between the smoothed nesting data (moving average) and M (curves a and c) during peak season (19 May to 6 August).

To quantify this correlation, the polynomial regression value was subtracted from the three-point moving average nest count for each day of the study, to remove the seasonal trend from the latter data. The detrended moving average nesting data were compared to M by linear correlation analysis (Figure 2). Positive points on the ordinate indicate average nesting densities greater than the seasonal trend defined by the polynomial regression. Near the full or new moons (M <.15), all points are positive. Conversely, near the quarter moons (M > .85), all points are negative, indicating average nesting below the seasonal trend. The correlation coefficient (r) was highly significant, confirming the statistical association of moon phase and fluctuations in loggerhead nesting densities in the combined 1989 Broward County data.

The same analyses were conducted on data from the five separate beaches. Correlation coefficients (n=80) and significance levels (P) for one-tailed comparisons of M versus three-point average nesting, as well as total nest for each beach, are given below.

| Beach | Total Nests | r | P |
|---|---|---|---|
| Hillsboro | 522 | -.597 | <<.001 |
| Pompano | 423 | -.253 | .012 |
| Ft.Lauderdale | 479 | -.389 | <.001 |
| Lloyd Park | 130 | -.239 | .016 |
| Hollywood | 141 | -.012 | n/s |

The relationships were significant at all beaches except Hollywood (including Dania and Hallandale) which had the lowest nesting density (0.103 nests/km/day). The differences in the significance of the relationships may be related to the degree of beach-front development, lighting and nocturnal human disturbance, but this is difficult to quantify. All areas except Hillsboro and Lloyd Park are heavily developed with high-rise buildings and beach-front businesses. A beach renourishment project was in progress at Lloyd Park.

The finding of a statistically significant relationship between moon phase and nightly nesting densities is important for sea turtle conservation program in Broward County (and possibly elsewhere) because intense beach-front lighting and heavy beach use require that most nests (82.1% this year) be relocated. Future coordinators of these very labor intensive projects can anticipate heavier nesting near full and new moons, and allocate personnel and equipment resources more efficiently.

The influence of the moon on sea turtle nesting patterns must operate via the tides. Moon light is clearly not the causative agent because increased nesting also associated with new moons. However, the correlation of the heights of the nocturnal high tides with the smoothed nesting data was not as significant as the moon relationships. We are currently working on a multivariate model involving tide heights, ranges, times and possibly tidal currents.

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Figure 1: The seasonal pattern of the number of daily sea turtle nests (squares) in Broward County, showing the three-point centered moving average (a), and tenth-order polynomial regression trend line (b), compared to M, the moon phase parameter (c). Maxima in M fall on quarter moons; minima indicate full or new moons.

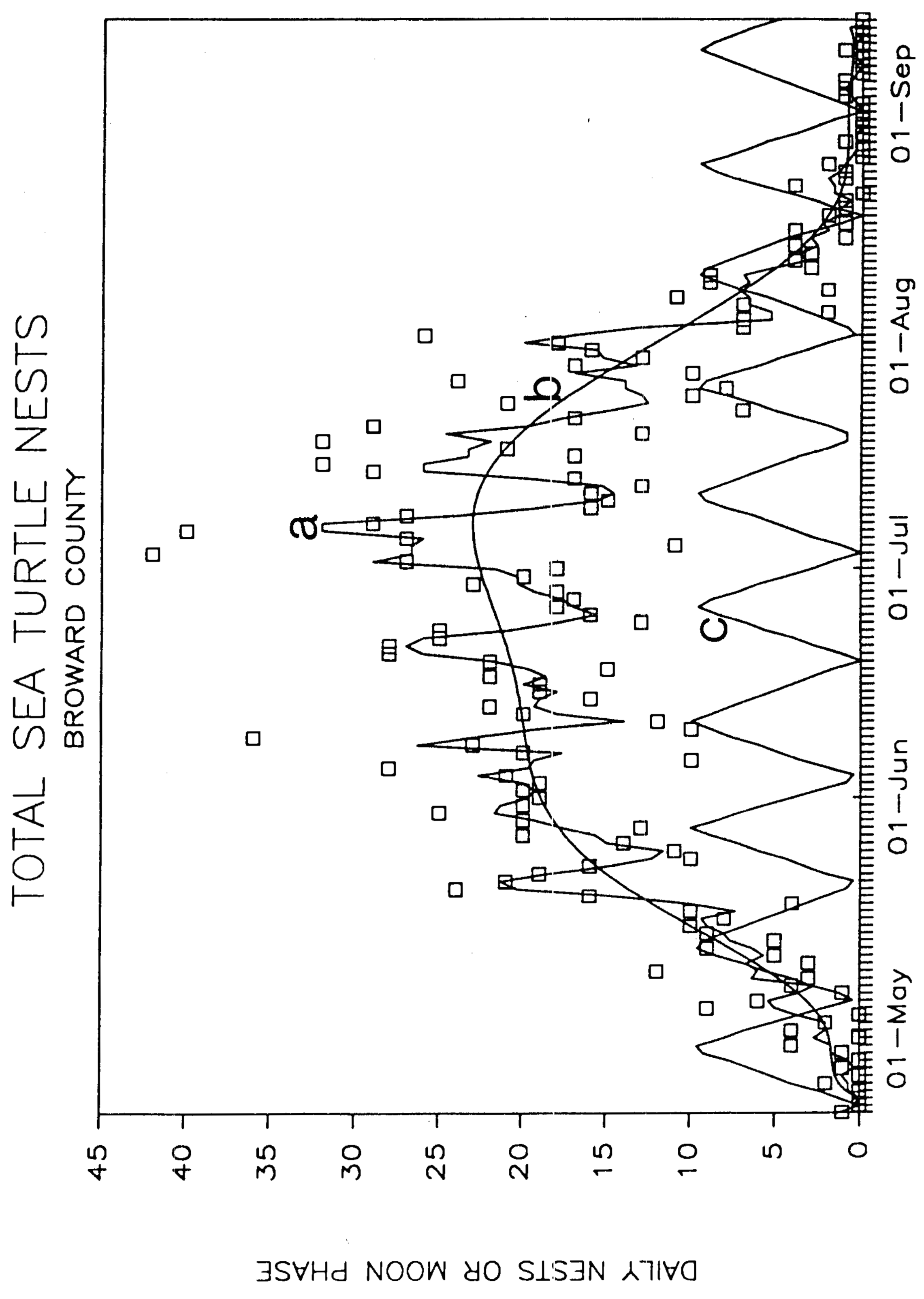
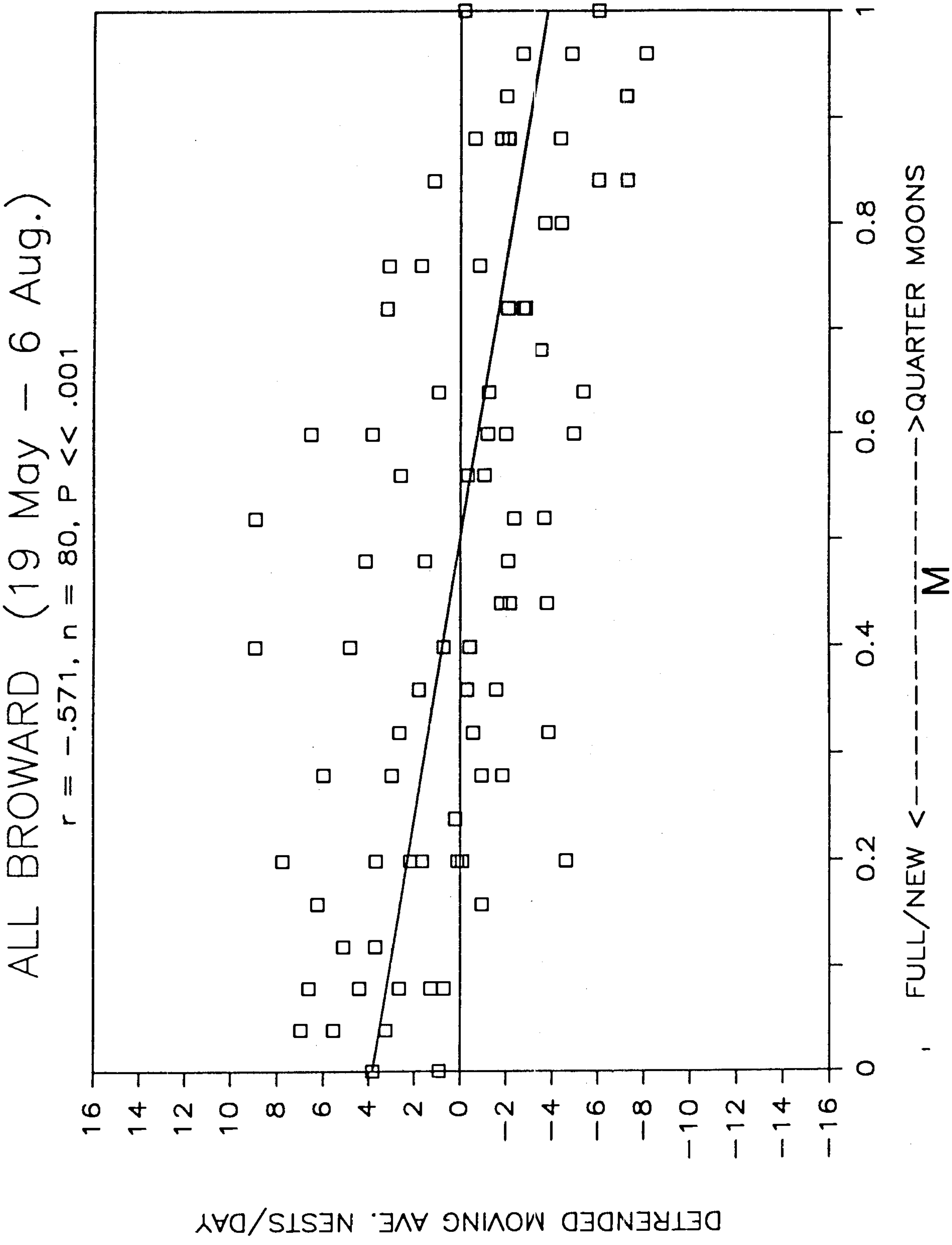


Figure 2: The statistical relationship between the detrended moving average nesting pattern and the moon phase parameter (M), with the linear regression line, correlation coefficient (r), number of data (n) and significance level (P).



# SEA TURTLE NESTING AND HATCHING SUCCESS IN BROWARD COUNTY, FLORIDA, 1989

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Six beach areas spanning Broward County were patrolled daily at sunrise from 21 April to 15 September, 1989 during the Broward County Sea Turtle Conservation Project. Nests and false crawls were counted. Endangered nests were relocated to hatcheries or safe beach areas. Relocated nests and 99 natural nests were excavated after hatching for hatching success determinations. The data collected were compiled, analyzed and plotted primarily with Lotus 123. Full results of the project are found in Burney et al. (1989).

A total of 1695 sea turtle nests were surveyed county-wide. Of these, 1670 were *C. caretta*, 21 were *C. mydas*, and 4 were *D. coriacea* nests. The density of sea turtle nesting has increased in Broward County since 1981 (Figure 1), but the slope of the trend line is significantly greater than zero at only the 93.7 percent confidence level. There were no significant long term trends in *C. mydas* and *D. coriacea* nesting patterns, only considerable interannual variability. The seasonal nesting pattern is presented in Burney et al. (1989, 1990).

Total nests per km and per km per day are shown in Table 1. A 1-way ANOVA and a SNK test (Zar, 1974) showed that Hollywood-Hallandale was significantly lowest and Hillsboro clearly highest in terms of mean daily nesting per kilometer. Both these groups were statistically distinct from all the others. The higher nesting densities at Hillsboro beach are possibly related to its predominately single-family residential development, but it is difficult to relate the degree of development to nesting densities in the rest of the county. Lloyd Park is undeveloped but was the site of an ongoing beach renourishment project. Although Lloyd Park had the second lowest nesting density (Table 1), it was not statistically different from Fort Lauderdale North.

Total and mean daily nesting success is shown in Table 2. Lloyd park had the lowest nesting success, but it was not statistically different from that at Pompano Beach. If the renourishment project impacted nesting at Lloyd Park, the effect was not statistically different than that caused by heavy beach development at Pompano. Nesting success at the other beaches was statistically higher than for Lloyd Park and Pompano.

Mean loggerhead clutch size varied from 103.6 at Pompano to 118.3 at South Fort Lauderdale (county mean = 108.7). Clutch size at Pompano was significantly smaller than at all other beaches. Clutch size also declined over the season, county wide. This trend has been reported previously (Caldwell, 1959; Lebuff and Beatty, 1971).

A total of 1392 nests (82.1 percent of total nests) were relocated to hatcheries or safer beach locations. Most of the relocations were due to beach lighting which would have disoriented many of the hatchlings. A total of 104,622 hatchlings were released, a 41 percent increase over 1988. With only one exception, there has been an increasing number of hatchlings released each year since 1978. This indicates an increasing emphasis on hatchery operations rather than increased nesting.

Hatching success (live hatchlings / total eggs) of relocated nests was 69.9 percent which compares favorably to the 66.7 percent success for natural nests. Although hatching success for both relocated and natural nests was down from 1988, it was similar to several other years since hatchery operations commenced in 1981. The source of the great interannual variability is unknown, but may be related to weather conditions. The summer of 1989 was unusually hot and dry.

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Table 1: Total sea turtle nests, nests per kilometer and mean daily nests per kilometer for the six Broward Co. beaches.

| Beach | Total Nests | Beach Length (km) | Nests per km | Mean Nests/km per day |
|---|---|---|---|---|
| Hollywood-Hall. | 141 | 9.4 | 15.0 | .103 |
| Lloyd Park | 130 | 3.9 | 33.3 | .228 |
| Ft. Laud. North | 359 | 8.6 | 41.7 | .286 |
| Pompano | 423 | 7.7 | 54.9 | .376 |
| Ft. Laud.South | 120 | 2.0 | 60.0 | .411 |
| Hillsboro | 522 | 7.0 | 74.6 | .511 |
| Overall | 1695 | 38.6 | 43.7 | .318 |

Table 2: Total and Mean Daily nesting success expressed as percentages. Total nesting success is total nests/total crawls. Mean daily nesting success is the average of daily nests/daily crawls calculated for each day of the survey.

| Beach | Total Nesting Success | Mean Daily Nesting Success |
|---|---|---|
| Lloyd Park | 42.3 | 45.1 |
| Pompano | 50.9 | 50.1 |
| Hillsboro | 53.4 | 59.4 |
| Ft. Laud. South | 56.3 | 61.1 |
| Ft. Laud. North | 61.7 | 64.6 |
| Hollywood-Hall. | 81.6 | 84.9 |
| Overall | 55.0 | 56.2 |

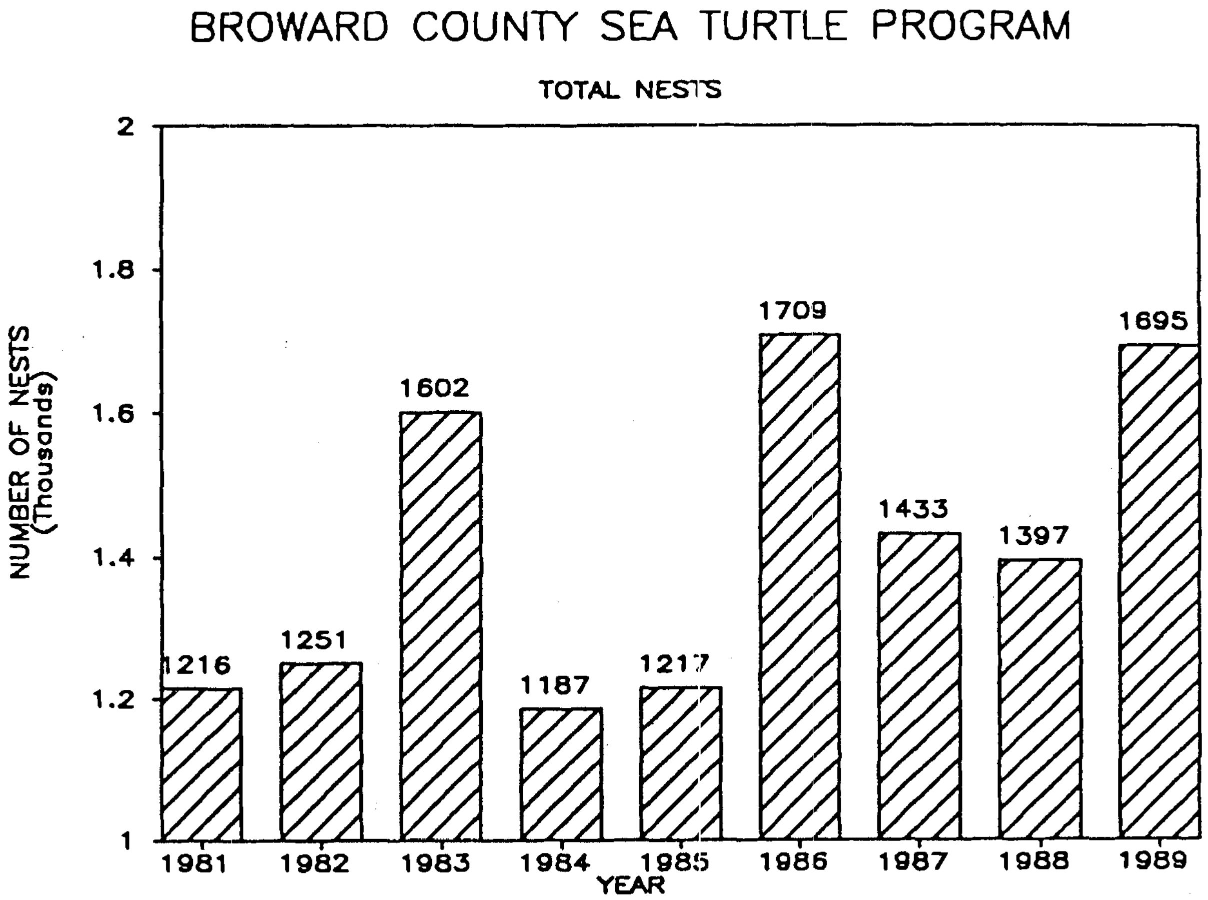

Figure 1: The historical pattern of total yearly sea turtle nesting in Broward County since full surveys began in 1981.

# THE DEVELOPMENT OF A REGIONAL SEA TURTLE PROGRAM IN THE SOUTH PACIFIC

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## INTRODUCTION

Of the seven species of sea turtles, six occur in the South Pacific region. The most widespread and frequently seen are the hawksbill and green turtle, although the leatherback, loggerhead and olive ridley also occur. The flatback has a range restricted to northern Australia and southern Papua New Guinea waters. Tag recoveries to date show clearly that many sea turtles, particularly green turtles and hawksbills, travel widely thoughout the South Pacific region between their nesting and feeding grounds. In recognition of the migratory nature of sea turtles, South Pacific nations have recently moved to develop a regional marine turtle conservation and management program under the direction of the South Pacific Regional Environment Programme (SPREP).

### Exploitation and Trade in the Pacific

Pacific peoples have been hunting sea turtles for subsistence purposes for thousands of years, and the taking of limited numbers of turtles for food and traditional local use continues today. Most hunting has focused on the green turtle and hawksbill which in many areas still help supply the basic needs of the community for food, tools, decorations, and items for trade. Turtle hunting has also helped pass on a traditional knowledge of the turtle, such as where and when it can be found, its habits, and the most efficient methods of hunting it. In some places, traditional knowledge has formed the basis of rituals, taboos and ownership rights which have helped to regulate exploitation and prevent overhunting in the past.

However, as in other regions throughout the South Pacific, traditional hunting is being transformed by the advent of modern forms of transport and the introduction of cash economies. In recent times, the hunting of turtles in some areas has become more commercially motivated. This is no doubt largely due to the fact that tortoiseshell, in particular, has become a highly sought after commodity in Japan.

Unfortunately, there is little information available from most Pacific nations on the extent of sea turtle product exports, although it appears that only tortoiseshell is currently traded internationally. Some Pacific countries list turtle shell in their export statistics, but the most reliable information on tortoiseshell exports from the Pacific comes from Japanese Customs statistics. These show that in the last five years Japan imported significant quantities from both the Solomon Islands and Fiji (neither of which is a CITES party). The statistics reflect an upward trend in kgs of tortoiseshell exports, as follows:

| Year | Solomon Islands kgs | Fiji kgs |
|---|---|---|
| 1985 | 1556 | 294 |
| 1986 | 1793 | 497 |
| 1987 | 4723 | 1859 |
| 1988 | 3911 | 817 |
| 1989 (Jan-Nov) | 3387 | 1765 |

As in other parts of the Pacific, recent information on turtle populations in these countries is unavailable. Even so, the 1988 figures represent tortoiseshell derived from approximately 4,250 adult hawksbills in the Solomon Islands and 888 adult hawksbills in Fiji (average is 0.92 kg = 1 adult hawksbill in the Pacific region; C. Limpus, pers. comm.) Whether the populations of hawksbills existing in these areas can sustain this level of exploitation is currently unknown. Limited surveys of nesting beaches are currently underway in the Solomon

Islands, and there are also plans for some surveys in Fiji. Hopefully, further information on the status of sea turtles in these countries will be available by the end of this year.

While the tortoiseshell trade is most likely the major threat to hawksbill populations, in some areas the numbers of green turtles being traditionally hunted for food may be cause for concern. For example, there is a large harvest of green turtles occurring in the Torres Strait (the narrow body of water between the northern tip of Australia and Papua New Guinea). It is estimated that in the order of 10,000 adult green turtles are killed each year in this area. Of these, around 4,000 per year are taken for food by the islanders who live in Torres Strait, and the remainder are taken by Papua New Guineans for sale in their coastal markets. As Australia and Papua New Guinea have concluded a bi-lateral treaty covering the Torres Strait area, it is hoped that this will provide a useful forum for the conservation of sea turtles in this area.

### The SPREP Regional Program

While some individual South Pacific nations have taken steps over the years to protect sea turtles, it is now generally accepted that a regional approach is required to ensure the long term survival of turtles in the region. As a result, at the Second Intergovernmental Meeting of the South Pacific Regional Environment Programme or SPREP (which is one of the UNEP Regional Seas Programs) held in New Caledonia in 1988, an agreement was made that "...a project for the coordination and integration of regional marine turtle management initiatives be developed..."

The SPREP proposal was subsequently made a major agenda item for the IVth South Pacific Conference on Nature Conservation and Protected Areas held in Vanuatu in September, 1989. This conference, also organized by SPREP, was the fourth in a series of conferences held once every four years to promote nature conservation and the establishment of protected areas in the South Pacific. Along with a large number of representatives from governments and NGOs throughout the region, I attended this conference on behalf of Greenpeace. Prior to the conference, a draft outline of the turtle program was prepared by Sylvia Spring from the Australian National Parks and Wildlife Service. During the conference, a working group was set up to revise and amend this document which was subsequently adopted by the conference. A sea turtle resolution was also passed, which among other things called for the UNEP East Asia Regional Seas Program to consider developing a similar turtle program.

The overall aim of the adopted SPREP turtle program is:

> To conserve marine turtles and their cultural, economic and nutritional values for the coastal peoples of countries served by the South Pacific Regional Environment Program (SPREP)

In summary, the SPREP program comprises the following elements:

**Information Gathering:**

- developing a regional database on marine turtles;
- reviewing all past work on turtles in the region to identify current status of research;
- identifying government agencies with responsibility for turtles and addressing where management is presently lacking.

**Institution Building:**

- providing countries with legal, policy and administrative advice to assist them to develop national conservation programs for turtles;
- providing training and education opportunities for personnel involved with turtle conservation in the region.

**Research Management:**

- gathering data on the population status and distribution of sea turtles in the region and marine turtle activity in isolated areas;
- encouraging further research into turtle biology and effective conservation management techniques.

**Traditional Knowledge:**

- documenting traditional/cultural knowledge of turtles and turtle hunting;
- including traditional ecological knowledge where relevant in conservation/management strategies for turtles;
- involving traditional landowners and resource users in turtle management;
- including traditional ecological information in appropriate curricula for schools/education institutions.

**Conservation Measures:**

- Identifying and encouraging countries to protect important turtle habitat such as breeding and feeding sites;
- developing realistic guidelines for the management of turtle harvesting for incorporation into national legislation.

**Education/Publicity Programs:**

- developing an educational program for use in individual countries using local languages;
- involving local communities, NGO's, church groups, etc. in community based turtle conservation projects.

**International Efforts:**

- supporting South Pacific countries to accede to international and regional conservation agreements, especially CITES;
- encouraging neighboring range countries to enter into bilateral agreements for the conservation of turtles and other marine resources.

At the present time, the SPREP Secretariat is still seeking funding from aid agencies to employ a Project Coordinator and establish a Project Team based in the South Pacific to begin implementing the regional program. Greenpeace has offered to assist SPREP by funding certain aspects of the regional turtle program and by offering the use of our new ship, Rainbow Warrior, as a base for turtle research in the South Pacific. However, further financial assistance is needed this year to get this important program going. (If anyone at this workshop is aware of possible sources of funding for the SPREP program, I'd be happy to hear from you).

## CONCLUSION

Once in place, the SPREP regional sea turtle program will no doubt ensure the effective coordination of turtle conservation efforts throughout the South Pacific. With the continuing rapid declines in sea turtle populations around the world, efforts in the South Pacific region could well prove to be crucial to the future survival of sea turtles on a global basis.

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# WATS--PAST, PRESENT, AND THE FUTURE

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The WESTERN ATLANTIC TURTLE SYMPOSIUM supplies data and communication on sea turtles, primarily of the western Atlantic area. It is a unique (and working) effort that involves officials of the 38 governments of the area and individuals from all over the world. It has been responsible for the publication of the "Sea Turtle Manual" and the "Proceedings of WATS I" and the "Proceedings of WATS II" [see below].

## THE PAST

About 1977, Archie Carr voiced the need to get the countries of the western Atlantic together to deal with sea turtle problems. In 1978, Harvey Bullis conceived the idea of what was to be WATS I and assigned me to effect it. We formed an international Steering Committee and a Technical Team, and we proceeded to do it.

We were dealing with six species of sea turtles and a broad area of more than 38 countries. For WATS I we tried to deal with all important sea turtle factors. We distributed a National Report form with 24 tables for data entry.

We promoted the publication of THE SEA TURTLE MANUAL to assist in collecting and coordinating data on sea turtles.

We worked. We communicated, coordinated, and cooperated, and we stressed these actions throughout the area. A prodigious amount of data on sea turtles, albeit incomplete, was collected and assembled.

WATS I was conducted 17-22 July 1983 in San Jose, Costa Rica. The PROCEEDINGS OF WATS I were published April 1984. At the conclusion of the Symposium in the plenary session, the delegates recommended that the WATS effort be continued.

WATS II was modified to concentrate on obtaining comprehensive data on the major sea turtle nesting beaches in the western Atlantic area and, most importantly, to determine exploitation of sea turtles, as completely as possible.

WATS II was conducted 12-16 October 1987 in Mayaguez, Puerto Rico. The PROCEEDINGS OF WATS II were published June 1989. At the conclusion in plenary session, the delegates again recommended that the WATS efforts continue.

The successes of WATS I and WATS II were due to the people involved. Of the hundreds of people participating, the following made significant and special contributions: Peter Bacon, George Balazs, Karen Bjorndal, Ralf Boulon, Harvey Bullis, Jim Burnett-Herkes, the late Archie Carr to whom WATS II was dedicated, Jorge Carranza, Patricia Castaneda, Anny Chavez, Franklin Cole, Victor Cotto, Gustavo Cruz, Jack Dammann, Ken Dodd, Marydell Donnelly, Karen and Scott Eckert, Lew Ehrhart, James Finlay, John Fletemeyer, Bill Fox, Nat Frazer, Jacques Fretey, Pedro Gonzalez, Bill Gordon, Argelis Ruiz Guevara, Kathy Hall, John Hall, Manuel Hernandez, Colin Higgs, Harold Hirth, Julia Horrocks, Rhema Kerr, Maria Teresa Koberg, Herb Kumpf, Andy Landry, Bob Lankford, Nigel Lawrence, Colin Limpus, Guy and Angela Marcovaldi, Mirna Marin, Rene Marquez, Rod and Angela Mast, Anne Meylan, Kerwin Morris, Jeanne Mortimer, Nicholas Mrosovsky, Manuel Murillo, Sally and Tom Murphy, Bernard Nietschmann, Larry Ogren, Jose Ottenwalder, Joe Parsons, Peter Pritchard, Hank Reichart, Jim Richardson, Emily Roet, Fernando Rosales, Barbara Schroeder, Joop Schultz, Rafael Steer, Nancy Thompson, Horace Walters, Mike Weber, Amy Webster, Rakph Wilkins, Ross Witham, Wayne Witzell, and last but certainly far from least, Jack Woody.

## THE PRESENT

WATS III is activating its Steering Committee. I am serving again as Secretary. We are looking for volunteers for the Technical Team. We are establishing a mailing list of key personnel and will issue a periodical update of plans, activities, and accomplishments.

For copies of PROCEEDINGS OF WATS I (in English or Spanish) and PROCEEDINGS OF WATS II write: Larry Ogren, Editor, NMFS, 3500 Delwood Beach Road, Panama City FL 32407 USA.

## THE FUTURE

The Sea Turtle Manual, Edition 2, is out-of-print. The Third Edition is being revised for printing by Rod Mast, Fred Berry, and others.

WATS III will collect data and reports. The Third Symposium will be conducted at a time and a place to be determined later by the Steering Committee.

# THE RESULTS OF MORE THAN TWO YEARS OF TURTLE EGG HARVESTS AT OSTIONAL, COSTA RICA

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## INTRODUCTION

In October 1987 a legal harvest of olive ridley (L. olivacea) turtle eggs was begun by the Development Association of Ostional This was permitted due to the following circumstances:

1. In 1984, the Costa Rican government created the National Wildlife Refuge of Ostional with the idea of protecting one of the most important areas of the world for the reproduction and conservation of this species. However, this was in name only, and to date no assistance has been offered nor the minimal protection given that is required for a wildlife refuge.

2. Within the area of the refuge are located most of the 350 townspeople of Ostional who have previously taken part in the illegal sale of the turtle eggs.

3. A large portion of the nests are destroyed by the large quantities of turtles which arrive to nest in the small principal beach, only 1/2 mile long, during the arribadas.

4. Actual studies demonstrated that a pilot plan to market the eggs on a small scale would not be harmful to the nesting population (Alvarado, 1985; Castro, 1986; Cornelius et al., 1987; Pritchard, 1984).

5. The existing Community Development Association was legally formed and contracted to watch over the turtle species that arrived to nest and to follow the scientifically based management plan (Alvarado, 1987-1989.) This paper evaluates the actual situation of Ostional after more than two years of rational management of this resource. This management is a sample of a conservation alternative for a wildlife area.

## RESULTS

**Size of the Arribadas:** One of the requirements of the legal harvest of eggs is the monitoring of the size of the arribadas. In Figure 1, we observe the behavior of the population from 1982 to 1989 during January to July, the time of least nesting. In 1982 and 1984 there are only data as to whether or not there was an arribada during certain months, but there are no estimations of the size. During the months of April to July in 1988, the average of the months is 4,261 turtles per arribada (ranging from 0 to 16,243). During these same months in 1989, it is 15,376 (ranging from 6,817 to 30,517). Observations show a 1989 increase of 3.6 times the numbers of turtles in arribadas from earlier years.

In Figure 2, we show the size of the arribadas for the peak nesting months of August to December, from 1982 to 1989. At a quick glance it is difficult to observe increasing or decreasing trends. When we analyze the averages of the arribadas, we see that there is no difference between the averages of August and September of 1982, 1984, and 1989, but there is a difference for 1988 with respect to the other years. There are no obvious differences for the averages of the arribadas of October, November, and December in the years of 1987, 1988, and 1989. Starting with the few data that we have for the moment, it is possible to determine a slight tendency to increase the number and size of the arribadas in relation to 1989.

**Success Rate of Hatchlings:** The success rate of hatchlings is calculated for the months of August 1984 (n=159), 1988 (n=191) and 1989, (n=214). The principal cause of nest destruction during these three years was by the turtles themselves (15.4%), and especially for those turtles in the following arribada (7.9%). A large quantity of nests (34.6%) never developed an embryo, and 31.9% of the nests produced neonates. The arribada of

August 1984 presented a normal condition, even though the nests deposited in the beach suffered destruction by the turtles of the same arribada and by turtles of the following arribada; those in 1988 suffered minimal impact by the turtles of the following arribada, even though it occurred to the north of the principal beach. In 1989 an abnormal condition also occurred, because nesting suffered the impact of a third arribada.

Table 1 shows the success rate of the hatchlings of the aforementioned arribadas. The lowest corresponds to the arribadas of August 1989 with 4.3%. In August 1984 there was a 7.9% success rate, and for August 1988 there was a higher rate of 12.6%

Table 1. Details of the estimation of the rate of production of neonates based on studies of marked nests in Ostional Beach for the arribadas of August 1984, 1988, and 1989.

| | 1984(+) | 1988 | 1989 |
|---|---|---|---|
| Nests (Sample) | 159 | 191 | 214 |
| Complete Incub. | 115 | 157 | 150 |
| With Neonates | 53 | 90 | 38 |
| With Complete Data | 35 | 90 | 33 |
| Neonates Obtained | 1174 | 2578 | 970 |
| Hatchling Percentage | | | |
| Total Nests (*) | 7.9 (n=141) | 12.6 (n=191) | 4.3 (n=209) |
| Incub. Nests Completed | 11.3 (n=97) | 15.3 (n=157) | 6.0 (n=150) |
| Successful Nests (*) | 31.2 (n=35) | 26.7 (n=90) | 27.4 (n=33) |
| Average of Hatchlings | | | |
| Successful Nests(*) | 33.5 ± 9.6 (n=35) | 28.6 ± 3.3 (n=90) | 29.3 ± 4.4 (n=33) |
| Range | 1-108 | 1-99 | 1-83 |

The hatching percentage is based on the average of 107.4 ± 4.2 (n=66) for the size of the nests. (*) Nests with complete data of the neonates number produced.

(+) Cornelius et al., (in Press).

Success rate is calculated for the months of December 1984 and November 1987; the results are very low. During the December arribada, the principal cause of destruction was by humans (12.3%) followed by the turtles of the same arribada (7%). A large quantity of nests had no embryonic development (63.1%) and only in 4 nests (7%) were there neonates. In the month of November 1987 there were more dramatic results. The principal cause of destruction was the turtles of the same and following arribadas (9.2%) and the destuction by humans (4.6%). The percentage of nests without any embryonic development was the highest (82.4%), and no marked nests had neonates.

It is important to mention that in both arribadas the lack of precipitation was a determining factor in the success rate of the hatchlings in December 1984 (0.8%) and in November 1987 (0%).

**Arribadas and Egg Harvest** The percent of egg harvest during an arribada is inversely proportional to the size of that arribada, (3.7% for 1987, 5.1% for 1988, and 6.7% for 1989, with a total of 5.6% for the 3 years.) Evidence shows that when the arribadas are small, there is actually a larger percentage of the eggs not destroyed by the turtles themselves and thus, a greater success rate of hatchlings. When the arribadas are large many of the eggs are destroyed by the turtles themselves.

**Financial Report**: From October 1987 to December 1989 the members of the Association received $228,282. Most of the money (61.4%) was divided between the 160 members of the Association, 16.3% for various expenses such as administration, transportation and per diem, 7.2% was deposited in the Association's account, 6.7% was invested in conservation and investigation expenses, 6.6% was for the Guards' salaries and 1.8% for the Fishing Direction account. Each associate received monthly shares for working the arribada between $27.60 to $83.40 for August, October and December; for the months of the highest dividends, the average share was $48.70.

## CONCLUSIONS

The actual data affirms that the size of the arribadas at Ostional could maintain their normal level, with the slight possibility of increasing in number and size.

The success rate of hatchlings is maintained at an acceptable level if we compare it with other arribada beaches like Nancite Beach (2.2%). However, hatching success depends on the various environmental factors like the magnitude of the destructive impact by the turtles themselves, the increase in temperature and the lack of rain during the dry season.

Another important aspect of the function of the project is the maintenance of the harmony between conservation, research and members of the community. The income from egg sales permits a way to maintain that balance, which would otherwise not be achieved.

Even though the Costa Rican government, universities and other institutions in charge of the conservation of the species have not coordinated with the work of Ostional, the Association or the biologists, much has been accomplished. However, it is urgent to get outside help on behalf of these institutions, to realize more investigation projects in the area that offers the greatest natural facility for investigation of sea turtles.

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Figure 1. Size of arribadas at Ostional during the time of low density nesting, 1982-1989. (ND= no data ; ? = no size estimation)

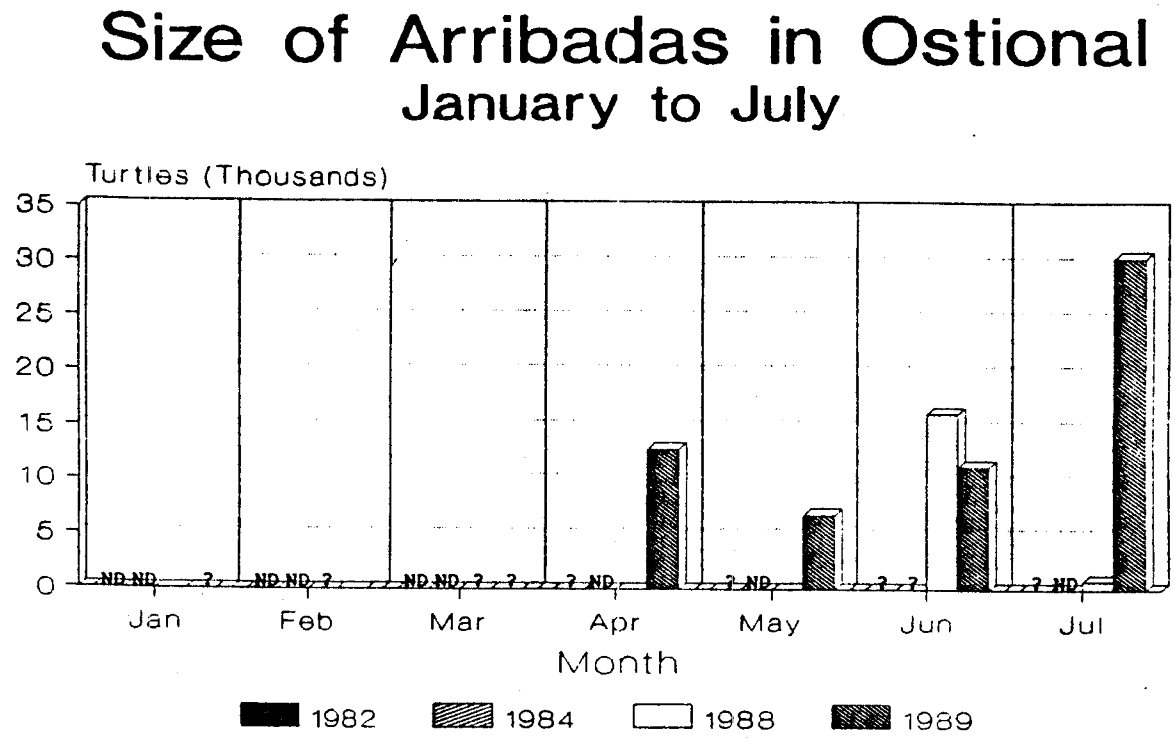
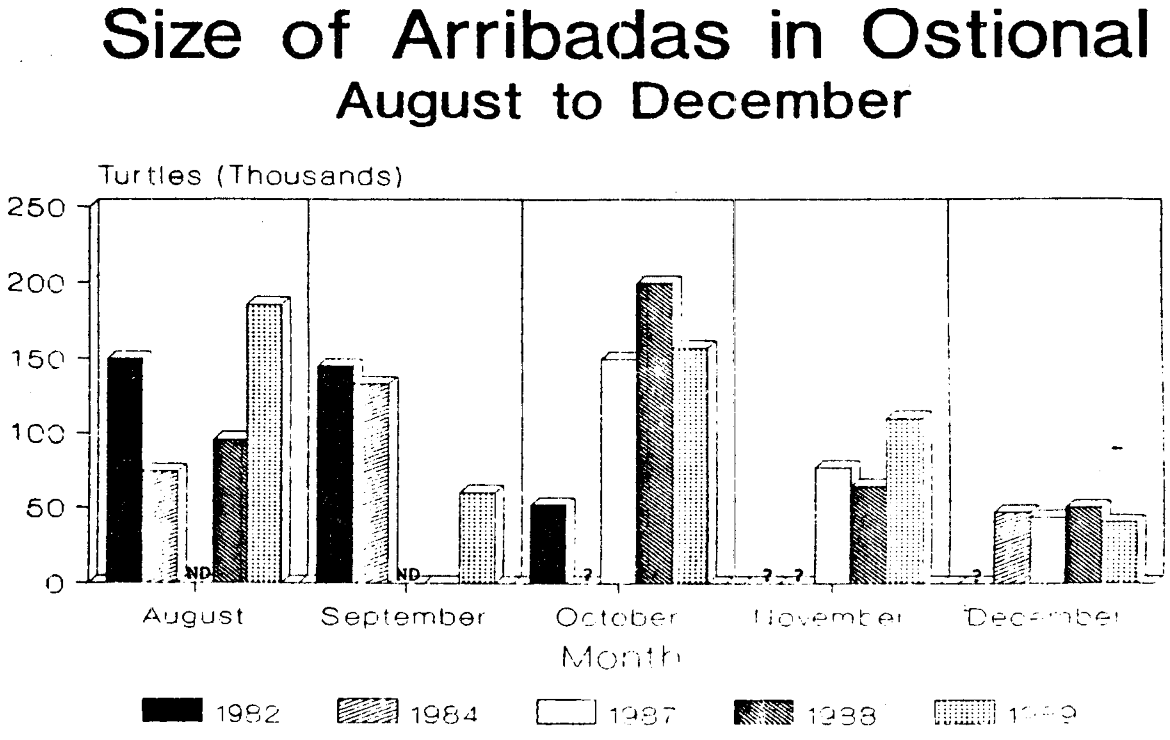


Figure 2. Size of arribadas at Ostional during the time of high density nesting, 1982-1989. (ND=no data; ? = no size estimation)



# MORPHOMETRIC COMPARISON OF THE CHELONIA POPULATIONS OF MICHOACAN, MEXICO, AND TORTUGUERO, COSTA RICA

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The morphological analysis of sea turtles is an important element in clarifying taxonomic problems. The genus Chelonia has been considered for many years as a single species, C. mydas, comprising two distinct suspecies. The first, C. m. agassizi (Bocourt, 1868), is found in the eastern Pacific, with a range of distribution from Baja California south to Peru and west to the Galapagos, Hawaii, and the Marshall Islands. The second subspecies, C. m. mydas (Linneaus, 1758), is found throughout the rest of the Chelonia range (Carr, 1975).

Although C. agassizi was initially described by Bocourt in 1868 in the binomial form, Carr claimed it had a subspecific rank in 1952. Later, he revoked this proposition (Carr, 1972). Furthermore, in 1975, Carr considered that the mydas complex had not been adequately studied from the taxonomic point of view; he recommended the use of C. m. japonica (Thunberg, 1878) for the Indian Ocean and western tropical Pacific forms and suggested that Caribbean populations might eventually be recognized as C. m. viridis (Schneider, 1783). Pritchard (1979) remarked that the only group of populations whose differentiation as a separate subspecies had been generally accepted is the East Pacific form of C. m. agassizi, excluding Hawaii and the Marshall Islands.

The present study is based on a mutivariate analysis using comparative morphometric characters between the Chelonia populations of the Mexican East Pacific and the Costa Rican West Atlantic. The study areas were located at the beaches of Colola and Maruata, Michoacan, Mexico, and Tortuguero, Costa Rica. These areas are the main nesting sites of the black turtle (C. agassizi) and the green turtle (C. mydas), respectively. The Mexican beaches were decreed natural reserves in 1986.

A total of eight morphometeric characters were taken: straight-line carapace length (LRC), curve-line carapace length (LCC), head width (AC), body depth (ALC), infra-anal scute (EIA), straight-line carapace width (ARC), curve-line carapace width (ACC), and plastron length (LP). Linear measurements were obtained to the nearest 0.1 cm using caliper and measurement tape according to Frazier (1983) and Pritchard et al. (1983).

A sample of 100 nesting black turtle females and 10 green turtle females was taken. All the analysed specimens were adults, first, because of the difficulty of gathering juveniles and sub-adults, and second, to reduce size variation due to age. A principal component analysis (PCA) for morphometric characters was carried out. Interpretation of PCA results focused on the first two principal components.

PCA showed a clear distinction between the two populations of Chelonia. The first two PCs accounted for 91.96% of the variation. As might be expected, loadings for all characters were relatively similar on PCI, except for infra anal scute, and all of the signs were positive. Nevertheless, the character of infra-anal scute was heavily loaded on PCII.

In addition to PCA, size frequency histograms were made based on the eight morphometric characters. The fact of larger body size in the Chelonia Atlantic population is especially evident in some characters, such as carapace length, carapace width and plastron length. The Atlantic population is also larger for head width, body depth, and infra-anal scute, even though there is some overlapping.

With respect to straight carapace length, the East Pacific population, when compared with other populations from Hawaii, Ogasawara Island, Sarawak, South Yemen, Costa Rica, Ascension Island and Surinam, is on average the smallest of all.

In a principal component analysis, scores on PCI and PCII separate C. agassizi from C. mydas. The morphological differentiation between both sea turtle populations could be a result of a long period of geographical separation. Consequently, they probably exist as relatively isolated units with no extant gene flow among them.

The question is: What is the possibility of contact among populations in the world. The answer is complex, but, in theory, contact zones between all populations could exist. But in the particular case of the western Atlantic green turtle and the East Pacific black turtle, they are probably more islolated than other Chelonia populations due to geographical barriers. Furthermore, the information on black turtles tagged in Michoacan, Mexico, and recaptures away from the nesting area, especially from Central America and the Gulf of California, confirms the likelihood that this population is confined to East Pacific coastal areas. This geographical separation may account for the notable morphological differences between the two populations found in the present study.

For the formulation of efficient conservation and management plans, it is essential to clarify the taxonomic status of the Chelonia mydas complex. Mutivariate analysis of morphometry among geographic samples, including males, juveniles and sub-adults, biochemical analysis, and studies of breeding systems and behavior should be pursued as a matter of urgency.

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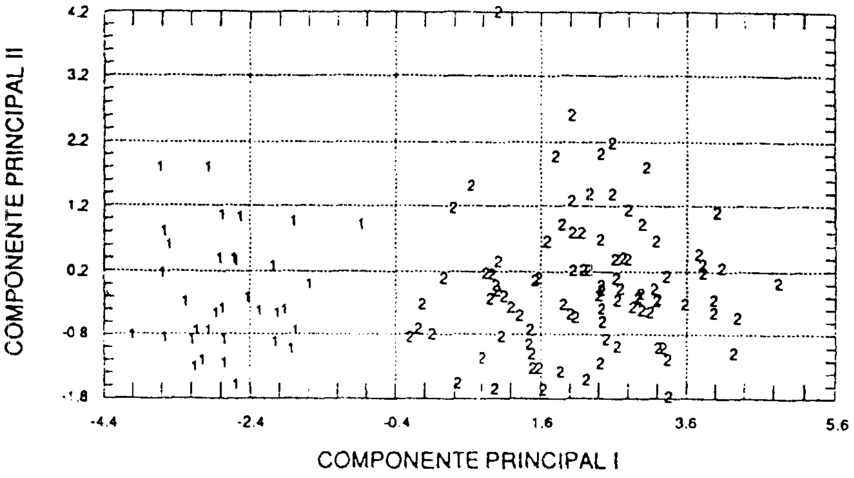

Fig. 1. Principal components ( I and II) of the two populations of *Chelonia* of Michoacan, Mexico and Tortuguero, Costa Rica.

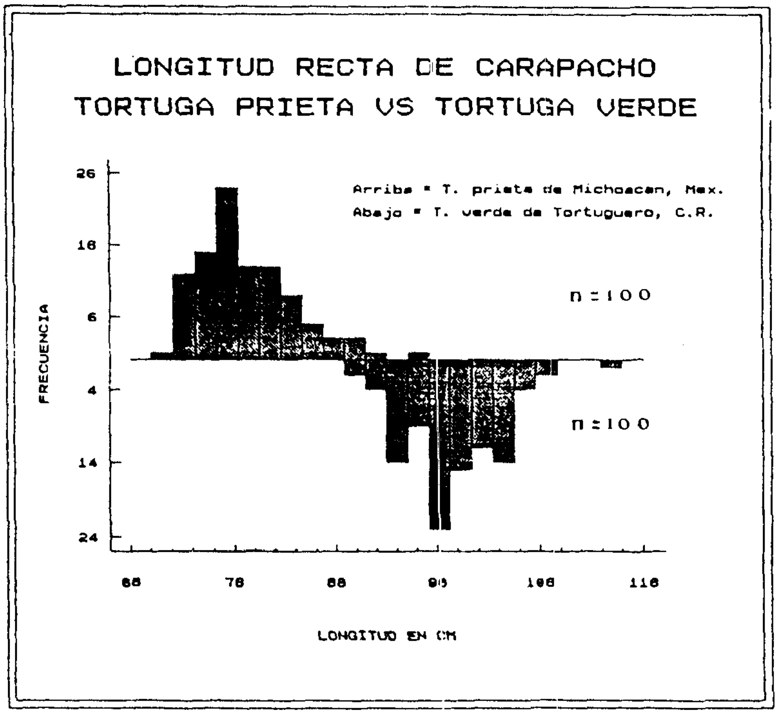

Fig. 2. Size-frequency histogram of straight carapace length of Black Turtle (up) and Green Turtle (down).

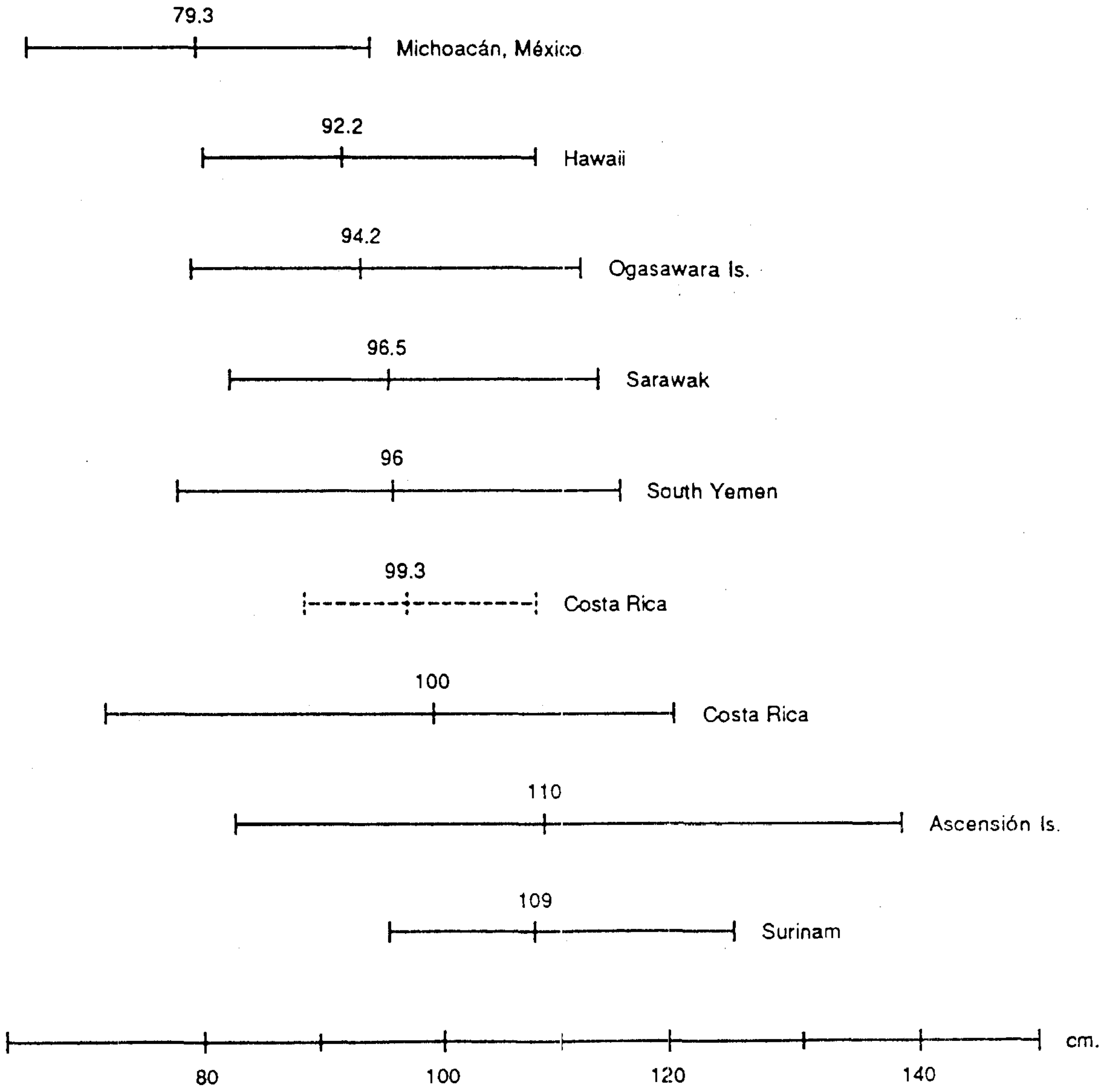

Fig. 3. Straight carapace lenght of Green Turtle females from different locations vs. Black Turtle of Michoacan, Mexico.

# ALTERNATIVE CONSERVATION METHODS USED FOR MARINE TURTLES IN MICHOACAN, MEXICO

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The most important nesting and breeding grounds for the black turtle Chelonia agassizi on any mainland shore are the east Pacific areas of Maruata Bay and Colola in Michoacan, Mexico. Numbers of nesting turtles, however, have been seriously reduced due to over-exploitation of both adults and eggs. Since 1982 the Universidad de Michoacan, with the assistance of the U.S. Fish and Wildlife Service and World Wildlife Fund, has been carrying out a conservation-research project for the recovery of sea turtles in that area. This project was initiated by Kim Cliffton in the late 1970s.

The black turtle shares geographical boundaries with the Nahual indigenous people in Michoacan. Accounts from the 15th and 16th centuries referred to the great numbers of black turtles along the Michoacan coast, especially at Maruata Bay. After the Spanish conquest, coastal settlements were abandoned in favor of higher settlements in the coastal Sierra. Nature reclaimed abandoned villages, and in the nineteenth century and early twentieth century, the thick vegetation surrounding Maruata, along with the malaria-transmitting mosquitos, prevented the resettlement of this area.

As late as the 1950s, there were no settlements at Maruata and Colola. The Nahual people would make sporadic trips from their pueblos in the Sierra to the black turtle nesting beaches to collect eggs. The eggs were transported by mule and burro back to the villages, where they were eaten fresh or hard boiled and dried for storage to supplement the meager diet of beans, corn, squash and chile. For many years the Nahual people collected their limited harvest of eggs without affecting the black turtle population.

The expansion of international markets for sea turtle leather as a substitute for crocodile skin in the 1960s initiated the hunting pressure upon the sea turtle populations of the Mexican Pacific. In the same decade the Nahual increased their population, and settlements were established on the coastal plain encompassing the black turtle breeding and nesting grounds. When a market for sea turtle products was introduced to the Nahual in the early 1970s, settlements in Colola and Maruata grew rapidly.

The heavy exploitation of black turtles at both their breeding grounds in Michoacan and their feeding grounds in the Sea of Cortes resulted in a population collapse. It is estimated that as recently as the 1960s the number of black turtle breeding individuals in the eastern Pacific was about 150,000. By the late 1980s, there remained only 7 to 10 thousand adults in the breeding population.

Although black turtle fishing has been prohibited in Mexico since 1984, trying to stop the illegal hunting of turtles remains our most immediate and difficult challenge. The turtles' high commercial value in the Mexican marketplace exposes them to intensive exploitation. Sea turtle poaching will continue as long as socio-economic conditions are not included in conservation strategies. Economic pressures to support families make sea turtles a prime target, since they are easy to catch and bring a high price. Therefore, environmental education and economic alternatives are of high priority in the black turtle conservation project in Michoacan. For that reason, in addition to the basic conservation and research, we have designated four areas of special concern.

A. **Basic Education**: Since 1983, during every nesting season, various communication media have been used to present a diversity of environmental issues to the local communities. The effort has been mainly directed at elementary school children. Audio-visuals films, posters, publications, talks and workshops have been utilized. The main objective is to promote local awareness of the need to conserve regional natural resources including the sea turtle.

B. **Economic Alternatives:** The Michoacan black turtle recovery program has worked with the people of Colola to begin pilot operations in the winter of 1989 for the establishment of a low profile, limited ecological tourism enterprise in which turtles are the main attraction. The objective is to demonstrate to the local people that turtles can be more profitable alive than dead. Groups of 10 people join the sea turtle biologists for seven days as part of the conservation team. Rustic, clean, safe accomodations on Colola beach are provided. At night the participants work with the conservation team in the collection and transportation of clutches to the hatchery, in the measurement and tagging of nesting turtles, and in the release of hatchlings into the sea. By day they participate with the research team in the recording of turtle behavior at sea. The tourists can also explore the beautiful reefs and beaches and observe the rich variety of tropical wildlife found in the surrounding lush Pacific foothills.

An additional economic alternative which is being encouraged is a snail that lives on the rocky shores of the Mexican Pacific. The snail "caracol purpura" (purple snail) has traditionally been utilized by Indian groups, mainly in Oaxaca for the dyeing of cloth. Some of the elders of the Michoacan Nahual group still remember the use of this dye by their ancestors. A cooperative of 25 people was formed in Maruata for the production and marketing of traditional cloth, dyed with the purple snail. This group works with a cooperative of artisans that was established in 1986 for the production and marketing of local native crafts.

C. **Alternative Sources For Food:**

1. Iguana Culture: In 1988, a pilot management plan for the rational utilization of the green iguana in the area was initiated. The iguana has been traditionally hunted by local people for meat and eggs and is now fast disappearing from this region. Repopulation with juveniles produced and raised under protected conditions will help restore the wild iguana populations. The surplus will be utilized by local people for subsistence consumption. It is expected that this alternative source of food will help diminsh the dependence of local people on sea turtle egg and meat consumption.

2. Vegetable Gardens: In 1985, to supplement the income and diet of local people, the Recovery Program initiated a family vegetable garden program. Elementary school children and their teachers were the first participants, and now vegetable gardens are seen in the yards of many families in Colola and Maruata.

D. **Rational Utilization of Local Ecosystems:** The tropical forest in the main natural system from which the local Nahual people obtain resources to cover their most basic subsistence needs. With the destruction of the forest, peripheral existing resources, such as the sea turtle, will be under increasing exploitative pressure. Because of population increase and economic pressures at the present time, large areas of forest are being felled at a rapid rate, and cultivated fields are given less time to recover. The traditional slash and burn agricultural practice is not ecologically sound under these conditions. The destruction of the forest is also resulting in the loss of potentially important genetic resources and a general ecological deterioration of the region. To conserve the area's tropical forest, the recovery program is working in several areas; first, in agricultural practices that lead to a more efficient utilization of cultivated fields; second, in the diversification of forest utilization. The commerce of forest products, such as gums, perfumes, pharmaceutical products, dyes, and tourism, that traditionally have not been commercially utilized, could be a major incentive in local forest conservation. The utilization of gallery forests for iguana farming could also be an important motivation in forest conservation.

For the conservation of the black turtle in Michoacan, we will have to continue our efforts to protect the turtle population through intensive vigilance in its nesting and breeding habitat and through the relocation of its nests to protected hatcheries. However, we are also aware that for our conservation efforts to be effective in the long run, the need and aspirations of the local people have to be incorporated into the conservation efforts.

# MEXICAN WAR TO PROTECT SEA TURTLES

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**Yuri Blanco-Casillo**
Greenpeace International

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## INTRODUCTION

Mexico is home to more species of sea turtles than any other country in the world.

For many years, sea turtles nesting in Mexico have been struggling to survive due to heavy slaughter and nest poaching occurring in the country. Despite protective laws, little protection has actually been achieved, and the problems have in fact increased. Recently some Mexican conservationists, being fed up with the situation, made a public denunciation of the country's pathetic turtle situation.

## THE DENUNCIATION

In late January a report written by Homero Aridjis, President of the Group of One Hundred, a collective of the most important artists and intellectuals in Mexico, appeared in the newspaper LA JORNADA. His facts were based on studies and information given to him by at least 15 specialists who worked directly in the areas where the facts occurred.

In this report, the most gruesome facts of Mexico's treatment to turtles were exposed. For instance, he reported that since 1987 at the protected beach of Rancho Nuevo, the major nesting beach in the world for Kemp's ridley, a cooperative of red snapper fishermen moved in, causing great impact on the nesting area; also these fishermen have been slaughtering some turtles from time to time. To add to the problem, a highway has been planned to cross the protected area, but the Mexican authorities, knowing the problems and even working in the area, have completely ignored the situation.

In the meanwhile on the other side of Mexico's coast in San Agustinillo, Oaxaca, a nightmarish place for all those who dedicate their lives to sea turtle conservation, thousands of olive ridleys are being slaughtered. A legal quaota, with no biological criteria, has been established by the authorities every year, and every year the quota has been exceeded. In many cases, the legal take is exceeded by up to 70 to 80%.

According to the report, "officially, SEPESCA (Secretary of Fisheries) fixed a quota of 20,000 ridley turtles for 8 fishing cooperatives during the 1989-1990 season, one sixth of the estimated nesting population for a season. The legal capture began 15 August, two weeks after the first arribada. During the following three months, 25,000 turtles were captured, mostly females, exceeding the quota by 25%. The capture continued off of Escobilla and Morro Ayuta, a beach nearby, because, although the official quota had been met by the end of October, the season lasts until April of the following year."

In addition, the illegal take on the same coast has been estimated to represent a number of turtles equal in size to the "legal" take. In this respect, the report denounced that "in the year 1989 at the beginning of October, anywhere from 2 to 12 pirate boats could be seen fishing day and night in front of the Escobilla beach sanctuary taking from 40 to 50 turtles each trip; an average of 80 to 600 turtles per day. The pirate boats operate next to the cooperative boats without interference of the marine patrols to prevent what is plainly visible to all."

The biggest illegal trade takes place in Cacalotepec, Oaxaca, where the authorities are rarely seen. Here an illegal slaughter house operates with a forged permit issued by the authorities of Puerto Angel. All the fishermen of the locality are involved, and a truck comes every third day to collect the skins that are illegally sent to Mexico City and then distributed elsewhere. However, the final buyer is almost always Japan. Milliken et al. (1987) reported that in the decade of 1976-86, 98.7% of the Olive ridley skins (including raw and tanned) legally imported by Japan came from Mexico alone.

The skin trade is seldom mentioned, if ever, by the Mexican authorities. This is a very profitable market, and somebody is getting filthy rich, but this is not precisely the fishermen. Their actual legal income for one turtle is $13 US. However, the prices paid to the fishermen in the black market tend to be higher. In Cacalotepec, for instance, a fisherman receives between $11 and $15 US for two pairs of flippers and over $3.70 US more for the womb eggs.

What makes the black market more profitable for the fishermen is not the prices themselves but the fact that this market is not controlled and, therefore, provides an unlimited take. What is striking is that in a Mexico City shopping mall one small handbag made out of turtle shin is sold for $200 US alone, and at least two handbags, if not more, could be made out of a single pair of flippers.

The denunciation gives many examples of how the slaughtering of olive ridleys is out of control and how the contraband system in the state of Oaxaca is so endemic, that it is very difficult to irradicate because of the involvement of people in the government.

Turtle production in Mexico has been neglected. Poaching, slaughtering, corruption and other illegal activities are denounced all along the Mexican coasts. The victims are not only the olive ridleys but also leatherbacks, hawksbills, greens, blacks, kemps and loggerheads, yet all have been protected by the Presidential Decree on 13 July 1973.

The three states in the Yucatan Peninsula have, for instance, heavily exploited hawksbills, and all of them work and sell tortoise-shell in every tourist shop or market; furthermore, some bekko has also been exported despite national and international regulations against it.

"During the month of July of 1989 alone, Mexico exported to Japan 259 kg of bekko worth $6,483 US, while in August a sum of 265 kg worth $10,585 US was exported. Mexico is competing with Jamaica, Haiti, and the Solomon and Fiji islands in this miserable business. In order to obtain these kilograms of bekko, around 500 hawksbills were slaughtered. During 1973 only 8 kg were exported, and 36 kg in 1983. As can be shown, the exports of bekko have increased this last year, regardless of the fact that both the capture and commercialization of hawksbills is strictly forbidden by national law in Mexico."

Only a few turtle camps have been able to protect some of the turtle adults and nests, and these camps are 90% of the times being run by universities or conservationists with the "help" of several Mexican authorities, whose protectionist involvement is rather dubious.

## THE CONSERVATIONISTS' REACTION

The day after this release, four of the main umbrella organizations in the country sent a letter to the newspapers, addressed to the President, supporting the Group of One Hundred's denunciation and demanding immediate protection and real enforcement of the existing laws.

In the United Kingdom, the President of Mexico, Carlos Salinas de Gortari, was paying an official visit; he was not entirely ignorant to what was happening in his country. Nevertheless, Greenpeace UK had a press release exposing the situation and supporting the demands of the Group of One Hundred and the other Mexican umbrella organizations.

In the next days, newspapers around the country published stories complementing Mr. Aridjis' denunciation, and, on the other hand, several government offices in charge seemed to become very active.

## THE RESPONSE OF AUTHORITIES

This is not the first time that the gruesome facts of Escobilla have been denounced. Previously, in the late 70s, Tim Cahill wrote an article entitled "The Shame of Escobillia". The article generated little positive action on behalf of the turtles. Perhaps the reason why this denunciation did not prosper was due to the fact that it was published abroad. The slaughter continued, and the government's reaction, as is usual in these cases, was to use it as an attack on the national sovereignty and to attempt to hide the turtle situation even more. All research was banned in the area, and no turtle experts could even come near for over 5 years, until Pronatura (a Mexican NGO) and the Universidad Autonoma Benito Juarez of Oaxaca were allowed to enter the "protected" area in 1982.

This time, the govemement's reaction was not so different.

The Secretary's declarations basically deny everything and try to focus the public attention to the US government's shrimp embargo planned for 1st March 1991, in case Mexican shrimpers do not use TEDs. They accuse the American NGOs of serving commercial interests and not having a real concern for the turtles' welfare. Again, the sovereignty over Mexican natural resources is used to accomplish a nationalistic feeling over the accusations.

Furthermore, the Mexican authorities give ransom figures of the reproductive turtle populations in the country. They state that turtles are by no means endangered or becoming extinct and talk about all the conservation work they have been doing. Finally, Mr. Aridjis is also accused of serving foreign interests.

In the following days, newspapers continued to reveal more evidence but also publish the new arrests and confiscations undertaken by the authorities.

## THE UNIVERSITY RESPONSE

A day after the Secretary's declarations, the newspapers wrote to a University spokesman, representing 15 universities working with sea turtles, supporting the denunciation and revealing new evidence. The spokesman also accused the ministries involved in the protection of sea turtles of "closing one eye in front of facts" and confirmed that sea turtles are in fact becoming extinct.

On the other hand, Aridjis responded to the government, reaffirming his accusations which were based on the declarations of 15 turtle experts, and accused the government of misleading the public by trying to focus the attention to what is being said abroad, while the denunciation was made in Mexico, by Mexicans. Aridjis also pointed out that the statement "mentioning that the quotas are given because fishermen are starving" is absolutely immoral, since he exposed in his denunciation how the fishermen are not the ones to obtain the profit from the lucrative turtle business.

## THE PRESENT SITUATION.

After this counter attack, the position of the government changed, what seems rather drastically, and declared to the press that "SEPESCA will try to eliminate the commercialization of turtles;" SEPESCA denies being non-ecological and promises to intensify the protection of the species.

By February 1, delegates of the Fisheries Secretary all around the country were summoned to Mexico City's headquarters to elaborate a working plan, in view of the national and international pressure. A day after they called the inter-universities commission who was meeting in Mexico City, as well, and proposed to have a meeting with them.

As a result of this meeting, both parties agreed to have a 2-day workshop on March 6 and 7 where the problems could be further discussed.

However, Pesca, at present, has not yet agreed to stop the quotas, regardless of the fact that Japan has agreed to stop importing olive ridley skin by early 1991 and that Japan has promised as well to stop all imports of turtle products from countries that at least nationally protect sea turtles.

The outcome of this turtle war in Mexico is still unknown, but one thing is sure; all turtle lovers and experts should continue the fight until the survival of these friendly and millinery species is assured.

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# RECENT UNITED STATES LEGISLATION FOR THE PROTECTION OF SEA TURTLES: PROMISING BEGINNINGS OR FALSE START?

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The purpose of this paper is twofold; first, to explain a recent federal law dealing with international sea turtle conservation and protection, and second, to offer a possible strategy for modifying this law, taking into account what I consider to be a substantial gap between a nobel objective and what can be reasonably accomplished in the immediate future.

The sea turtle measure was introduced by Senator Breaux (D. La.), and became law as part of the Departments of Commerce, Justice, and State, the Judiciary, and Related Agencies Appropriation Act of 1990 on November 21, 1989 (Public Law 101-162). Section 609, Subsection (a) of the law states that, "the Secretary of State in consultation with the Secretary of Commerce shall with respect to those species of sea turtles the conservation of which is the subject of regulations promulgated by the Secretary of Commerce on June 29, 1987 initiate negotiations as soon as possible with other nations for the protection and conservation of such species of sea turtles." (The regulations of June 29, 1987 target the kemp's ridley, hawksbill, loggerhead, leatherback and green turtles for domestic conservation and protection.[2]) The Subsection continues to state that negotiations are to be initiated concerning commercial fishing techniques that may adversely affect such species of sea turtles, and encourage other agreements for the protection of specific land and ocean regions. Other requirements under this subsection are to amend certain treaties, and to provide a report to the Congress.

Subsection (b) states that, "the importation of shrimp or products from shrimp which have been harvested with commercial fishing technology which may affect adversely such species of sea turtles shall be prohibited not later than May 1, 1991 except if the President determines and certifies to the Congress not later than May 1, 1991, and annually thereafter that:

(A) the government of the harvesting nation has provided documentary evidence of the adoption of a regulatory program governing the incidental taking of such sea turtles in the course of such harvesting that is comparable to that of the United States, and

(B) the average rate of that incidental taking by the vessel of the harvesting nation is comparable to the average rate of incidental take of sea turtles by United States vessels in the course of such harvesting, or

(C) the particular fishing environment of the harvesting nation does not pose a threat of the incidental taking of such sea turtles in the course of such harvesting."

Despite the support this legislation may have from the shrimp industry and the environmental community, a closer look reveals several serious implementation problems with the law. The first of these difficulties arises from the broad scope of the law. Approximately 150 countries are affected by the general negotiation directives of Subsection (a). This number is the result of the statute's use of the term "species" of sea turtles, and the collective distribution of these sea turtles in all ocean waters. No deadline or sanctions are specified in Subsection (a) if negotiations are not concluded, but considering that no additional funds were appropriated to support such negotiations, it is unlikely that any tangible results can be expected in the near future.

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[1] Formerly with the United States Department of State, Office of Fisheries Affairs. The views expressed are the personal views of the author and are not to be attributed to the Department of State.

[2] 52 Fed. Reg. 24244 (to be codified at 50 C.F.R. Parts 217, 222, and 227).

Significant difficulty can also to be expected under the requirement of Subsection (a) Paragraph 2. Here the United States Government is directed to initiate negotiations with all foreign governments engaged in commercial fishing operations which may adversely affect sea turtles. By using the term "commercial fishing operations," the legislation includes shrimp trawling, and all other trawling operations, plus driftnet, gillnet, longline, trolling, purse seining, and indigenous fishing operations. While these other fishing activities may adversely affect sea turtles, the United States Government currently does not regulate the impact of these other fishing operations on sea turtles in United States waters. The question that arises under this context is whether the United States is justified in asking other countries to do more than it is willing to do itself?

The more immediate area of interest concerns the possibility of shrimp embargoes beginning May 1, 1991. Currently, about 80-90 countries export approximately 500 million pounds of shrimp to the United States worth over 1.7 billion dollars.[3] Based on sea turtle distribution data, it appears that nearly all of these countries could face an embargo of their shrimp exports. To avoid such embargoes these countries must provide comparable data as described earlier. Few countries, however, will be able to satisfy the requirements of Subsection (b) Paragraphs (A) and (B), or (C) as described above by May 1, 1991. The United States will then be faced with the challenge of enforcing an embargo that must differentiate between wild and cultured shrimp, since the latter is not affected by the legislation.

Another point concerns the deadline for imposing shrimp embargoes as specified by the statue. Subsection (b) gives foreign governments only 17 months to develop comparable regulatory programs, and incidental capture rates of sea turtles in the course of commercial shrimp harvesting operations. This compares to the nearly 20-year campaign in the United States between the time the Kemp's ridley was listed as an endangered species, to when turtle excluder devices were actively enforced in United States waters.

I would now like to offer an alternative within the framework of P.L. 101-162, Section 609, which I believe could lead to attainable goals and result in a significant improvement in international sea turtle protection. This alternative calls for a two-track policy approach.

The first track recognizes the seriousness of sea turtle conservation throughout the world. Subsection (a), as currently written, reflects this problem and should be retained except for the part which discusses negotiations concerning commercial fishing operations. This language should be amended to address only commercial shrimp fishing operations. Consistency with current United States regulations is the objective of this change.

The second track addresses the scope of potential United States shrimp embargo action. The change I propose would adopt a regional sea turtle stock or population approach for such embargo action. I believe that our strongest sea turtle protection efforts should be directed towards those nations that share the same stocks of sea turtles that inhabit or migrate through U.S. waters where domestic sea turtle protection regulations are in place. Such a plan is no doubt a compromise, but I believe it provides the economic parity that U.S. shrimpers and certain members of Congress demand, yet also seriously advances sea turtle conservation. If implemented, the United States Government's international sea turtle conservation efforts would be concentrated among those governments bordering the Gulf of Mexico, Caribbean Sea and certain portions of the South Atlantic. Although the legislative history is brief, and largely unclear, it appears that several members of the Senate intended the law to have a limited geographic impact. Focusing our efforts in this region would also take advantage of the extensive national and international initiatives already undertaken in the Wider Caribbean region to promote sea turtle conservation such as WIDECAST, the UNEP Caribbean Environment Programme, the Caribbean Conservation Association, and the Western Atlantic Turtle Symposium. (If supported by scientific evidence, i.e. tag returns, this approach should be extended to certain portions of the Eastern Atlantic.)

The proposal also includes a later deadline when embargoes would go into effect, the allocation of resources to the Departments of State and Commerce to support their work in this area, foreign assistance to support sea

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[3] Fisheries of the United States, 1988, National Marine Fisheries Service, Washington, DC.

turtle conservation programs in other countries, and the initiation of multilateral negotiations for the development of an international conservation, protection and management regime for sea turtles.

Any attempt to redress Section 609, however, will be complicated by several other developments. First, in response to the sea turtle legislation, President Bush has stated that "...Under our Constitution it is the President who articulates the Nation's foreign policy and who determines the timing and subject matter of our negotiations with foreign nations. Accordingly, keeping with past practice, I shall treat these (sea turtle negotiation) provisions as advisory, not mandatory."[4] Another development is House bill H.R. 3442. The bill contains language that would amend the Endangered Species Act by prohibiting the importation of shrimp from any nation a) whose shrimp fishing vessels are not required to use National Marine Fisheries Service (NMFS) approved turtle excluder devices, b) which allow the taking of eggs on its beaches, or c) which engage in other activities which adversely affect the ability of the sea turtle to survive or reproduce. Finally, House bill 2061 would amend the Fisheries Management Conservation Act by adding a section requiring the President to initiate negotiations for sea turtle conservation and protection.

In closing, I believe PL 101-162, Section 609 is both a promising beginning and a false start. While the United States now has legislation which addresses international sea turtle conservation and protection, it's implementation is uncertain. Furthermore, the danger with legislation such as Section 609 is that in attempting to implement the law, government agencies can be compelled not to choose strategies that maximize environmental protection, but rather strategies that minimize the likelihood of being sued, or which maintain the status quo.

I would like to leave you with three points. First, despite passage of this legislation, the United States does not have a clear or consistent international sea turtle policy. Second, there is a group of dedicated professionals at the Fish and Wildlife Service, the National Oceanic and Atmospheric Administration, NMFS and the Department of State who need support and encouragement in developing such a policy. Third, I call upon this body of experts on sea turtle biology and conservation, to draft a position statement regarding Section 609 of PL 101-162, and to send it to appropriate members of the Congress, Secretary of Commerce Mosbacher, and Secretary of State Baker. Your input is critical because at this moment there exists a unique window of opportunity to help shape this country's international sea turtle conservation policy. This opportunity will either be lost, or it will be used to further protect these magnificent creatures who are delegates of the global commons and ambassadors from the sea.

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[4] President's statement to Congress on signing the Departments of Commerce, Justice, and State, the Judiciary, and Related Agencies Appropriation Act, 1990, 25 Weekly Comp. Pres. Doc. 1808 (Nov. 21, 1989).

# THE NEW CARIBBEAN ENVIRONMENT PROGRAMME PROTOCOL CONCERNING SPECIALLY PROTECTED AREAS AND WILDLIFE (SPAW) AND THE ASSOCIATED NEW REGIONAL PROGRAMME FOR PROTECTED AREAS AND WILDLIFE

**Milton M. Kaufmann**
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An important Protocol (international agreement) on the conservation of wildlife, habitat and natural areas, potentially of great importance for sea turtle survival and conservation in the Gulf of Mexico and Caribbean, was signed and adopted by 13 Caribbean Environment Programme governments[1] on January 18, 1990, at Kingston, Jamaica. The Protocol is a UNEP sponsored sub-agreement of the 1983 Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region[2], otherwise known as the Cartagena Convention. Of comparable importance, the Governments agreed to immediately establish a program which will become the operational arm of the Protocol, called the Regional Programme for Protected Areas and Wildlife as well as immediately establishing an interim Scientific and Technical Advisory Committee on Protected Areas and Wildlife to be called the "Ad hoc group of Experts" until the Protocol comes into force.

Formal negotiations on the SPAW Protocol began in October 1988. However, work on a treaty to protect wildlife and habitat in the Wider Caribbean began in 1981 when Thomas Garrett, funded by the Center for Marine Conservation under a contract with Monitor International, drafted a comprehensive wildlife and habitat treaty with explanatory notes. He attempted to get two Wider Caribbean countries to convene a negotiating conference of Wider Caribbean countries. When this was unsuccessful, Garrett and Monitor International conformed the draft to the new 1983 Cartagena Convention as an NGO draft of a SPAW Protocol to the Convention and began collaborating with Party governments encouraging them (1) to reach a Caribbean Environment Programme intergovernmental decision to develop a SPAW Protocol negotiating text and (2) then negotiate and adopt the Protocol. Such an intergovernmental decision was made in early 1987. Following an intergovernmental SPAW Workshop convened and hosted by the Government of Antigua and Barbuda and a second Workshop convened and hosted by the Government of Panama, both in mid 1988, in which NGOs played an active role, UNEP convened two meetings of Government experts to develop the SPAW Negotiating Text. These meetings led to the successful January 1990 Negotiating Conference at Kingston.

The SPAW will come into force as international law when 9 of the signing countries formally ratify the Protocol. As many as 27 countries can ultimately become eligible to accede to the Protocol.

The following is a summary of some of the Protocol's major provisions:

1. General obligations of Parties to the SPAW Protocol:

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[1] The 13 signatories of the protocol were Antigua and Barbuda, Columbia, Cuba, France, Guatemala, Jamaica, Mexico, the Netherlands, St. Lucia, Trindad and Tobago, the United Kingdom, the United States and Venezuela.

[2] Wider Caribbean Region: The marine and estuarine environment of countries having Caribbean or Gulf of Mexico coasts including the Bahamas (27 countries). This is a definition of the inter-governmental Caribbean Environment Programme, one of the UNEP sponsored Regional Seas programs which has two closely related parts: the Cartagena Convention and the Action Plan.

a. Each country will take necessary measures (1) to establish and manage marine and estuarine protected areas (and, optionally, related terrestrial areas to include watersheds) that require protection to safeguard their special values, (2) and to protect endangered and threatened species of fauna and flora.

b. Each country will cooperate internationally in the enforcement of protection measures.

c. Each country will manage fauna and flora with the objective of preventing species from becoming endangered or threatened.

2. Each country will undertake to expand its present system of protected areas, or to establish such a system if it does not exist. Protected areas are to include areas of special biological, ecological, educational, scientific, historic, and cultural value. The Protocol commits the countries to conserve, maintain and restore representative coastal and marine ecosystems, habitats, and associated ecosystems critical to the survival and recovery of endangered and threatened species of flora or fauna. Protection of these areas will include prohibiting the dumping or discharge of wastes, monitoring of coastal disposal or discharges causing pollution, and controlling the passage of ships.

3. Each country is required to establish a system for assessing environmental impact of projects in the planning stage that would have a negative environmental impact on areas or species that are protected under the Protocol.

4. The core of the wildlife provisions of the Protocol is the requirement for annexes listing endangered and threatened species and other species requiring protection. These annexes as part of the Protocol will share with the Protocol the status of international law and, accordingly, the obligation of countries to protect and manage wildlife in accordance with the provisions of the Protocol.

In addition, lists of protected areas will be maintained consisting of protected areas that fulfill guidelines and criteria established by the Parties. Countries are then obligated to manage and take enforcement measures consistent with the relevant Protocol articles.

5. The Protocol requires the establishment of a Scientific and Technical Advisory Committee to advise the Parties and the Secretariat on scientific and technical matters relating to the SPAW Protocol.

6. Parties are obligated to carry out species recovery planning and management for protected species within their countries and to coordinate their efforts through bilateral or multi-lateral actions including, if necessary, any treaties for the protection and recovery of migratory species whose range extends into their area.

7. The Parties are required to establish cooperation programs to assist with the management and conservation of protected areas and protected species. WIDECAST and the evolving WIDECAST sponsored Sea Turtle Regional Activity Center are examples of the cooperation programmes called for in the Protocol.

The eight-day period of negotiations was intense but highly successful. The opinion was expressed by two heads of government delegations at the conclusion of the Meetings that the adopted SPAW Protocol may be one of the most specific and one of the strongest wildlife and protected areas treaties in the world.

However, due to administrative difficulties, Species Annexes I, II and III to the Protocol, which were scheduled to be adopted as a part of and simultaneously with the Protocol, were not adopted. Accordingly, a tight schedule has been set up for the remainder of 1990, culminating in an Interim Scientific and Technical Advisory Committee (Ad Hoc Group of Experts) meeting not later than October 1990 to prepare the draft lists required for the Annexes. The Annexes are tentatively scheduled to be adopted at a Conference of Plenipotentiaries in February 1991. Non-governmental organizations will be making recommendations to governments and at the Conference on placing sea turtles in a protected status on Annex II.

Even though the Protocol Concerning Specially Protected Areas and Wildlife and its three annexes will not become international law for an estimated three to five years, its momentum is already clearly in evidence. The Governments, at the Kingston meetings approved the creation of a Regional Programme for Protected Areas and Wildlife within the framework of the 1981 CEP Action Plan. This Programme, which is just five weeks old, having been approved on 18 February 1990, has already been funded to provide for the 1990 and 1991 meetings of the Interim Scientific and Technical Advisory Committee, and funding for a West Indian manatee conservation project. This Regional Programme will have the responsibility of offering project coordination and facilitation for all protected areas and species scientific and conservation projects in the Wider Caribbean. This capability, relating to sea turtle work will be significantly increased by the activation of a Sea Turtle Regional Activity Center (STRAC). WIDECAST and the Sea Turtle Regional Activity Center (if activated) will probably come within this Regional Programme, as well as a black coral conservation project and other protected areas and species projects in the future. For further information on the STRAC, see Dr. Karen L. Eckert.

A new NGO Coalition called the Wider Caribbean Coalition for Protected Areas and Wildlife (CPAW) has been active over the past three years, collaborating with Governments and UNEP on development of the Protocol. It will continue to be active in supporting UNEP in the development of the new Regional Program for Protected Areas and Wildlife. If you or your organization would like more information on CPAW, kindly contact the author.

The following organizations have provided support for CPAW Protocol activities or actively participated themselves in the SPAW Protocol development work:

> The Center for Marine Conservation, Chelonia Institute, Chelonia Society, Greenpeace International, The Humane Society of the United States, International Wildlife Coalition, Monitor International, National Wildlife Federation, Non-Governmental Environment Trust, Pro-Vita Animalium, Sea World, Sierra Club, WIDECAST and World Society for the Protection of Animals.

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# HATCHING SUCCESS OF LEATHERBACK TURTLE (DERMOCHELYS CORIACEA) CLUTCHES IN RELATION TO BIOTIC AND ABIOTIC FACTORS

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The study site was located at Culebra Island, Puerto Rico, and consisted of two adjacent beaches, with medium-grained sand consisting primarily of broken shell. At oviposition in 1984 and 1985, egg diameter, nest depth, and nest distances from vegetation and recent high water mark (HWM) were determined. Additionally in 1985, sand dryness, shape of nest chamber, number of cave-ins, and amount of sand between eggs were ranked subjectively. After hatchling emergence, nests were excavated, and number of yolked and yolkless eggs were estimated. Hatchlings were examined for deformities, and percent fertility, hatching success, emergence success, and exit success were calculated. Hatching success was defined as number of hatchlings divided by yolked egg number, emergence success as number of hatchlings emerging nest divided by yolked egg number, and exit success as number of hatchlings emerging nest divided by hatchling number. Pearson product-moment correlations are represented by r, and Spearman rank correlations by rho.

Over 30% of total clutch size consisted of yolkless eggs (Table 1); however, at St. Croix they accounted for approximately 12% of clutch mass (Eckert et al. 1989). All leatherback populations and three populations of hawksbills in the Middle East lay high percentages of yolkless eggs. Both species usually lay them towards the end of the clutch; therefore they overlay the yolked eggs. Leatherbacks lay less yolked eggs than any other marine turtle species (Table 1), with the exception of the flatback turtle, which lays approximately 50 eggs. Variability was high for both yolked and yolkless eggs (Table 1).

## BIOTIC FACTORS

Previous reports of biotic influences on egg mortality have usually referred to predators; however, predation was very low at Culebra, and intrinsic factors such as number of yolked and yolkless eggs were more important in determining hatching success. Yolked egg number was very significantly negatively correlated with hatching success and number of yolkless eggs (also percent yolkless eggs) was highly positively correlated (Table 2). Yolked egg number and yolkless egg number were not significantly correlated with each other ($r = -0.110$, $n = 211$). Egg size was not significantly correlated with hatching success, and percent fertility was highly positively correlated with percent hatch, as would be expected (Table 2).

By examining a curvilinear regression of hatching success and yolked egg number, it was determined that hatching success was best around 52-56 eggs, which was below the mean of 70 eggs. Balasingam (1967) found similar empirical results for translocated leatherback clutches in Malaysia, with hatching success best around 46 - 60 eggs, which was below the average clutch size of 85-90 eggs. Why might hatching success be lower in larger clutches? Several people have hypothesized about this phenomenon for different turtle species. Balasingam (1967) believed metabolic heating produced detrimentally high temperatures in the center of the clutch. Ackerman (1980) thought gaseous exchange might be lower in the center, while Packard et al. (1980) felt that eggs at the center may lose a disproportionate amount of moisture to the nest environment. Low moisture or water potential has been shown to decrease hatching success in many turtle species.

Yolked egg number was also related to other forms of mortality. There was a significant positive relationship between percent hatchling deformities and yolked egg number ($rho = 0.320$, $n = 211$, $p \leq 0.001$), and most deformed hatchlings probably do not survive to maturity. No deformed hatchlings were found in clutches of less than 50 yolked eggs. Additionally, larger clutches had lower emergence success ($rho = -0.417$, $n = 197$, $p \leq 0.001$). However, emergence success implicitly includes hatching success, and hatching success was already negatively correlated with yolked egg number. Therefore, to test the ability of hatchlings to exit the nest, independent of hatching success, exit success and number of hatchlings were tested for correlation -- which was also significant (rho = -0.228, n = 196, $p \leq 0.001$). Perhaps high numbers of hatchlings caused the impedence of some hatchlings by trampling or depletion of oxygen in the nest.

There are many selective pressures acting to optimize clutch size temporally and spatially, and equal pressures in both directions will have a tendency to maintain current clutch size. At least three factors may be working to lower clutch size at Culebra, and depending on how long they have been in operation, may help explain why clutch size is already so low for this population, and perhaps for other leatherback populations as well. The high variability in clutch size (Table 1) allows turtles the plasticity to adapt clutch size to environmental changes. A tradeoff may have taken place between clutch size and clutch frequency, in that small clutch size has been compensated for by a high clutch frequency of approximately six nests per season (Table 1).

Yolkless egg number was positively correlated with hatching success, and therefore yolkless eggs may in some way be beneficial to hatching success. Three explanations for the possible adaptive value of yolkless eggs have been set forth. Hirth (1980) proposed predator divergence, Frazier and Salas (1984) thermal buffering, and Pritchard and Trebbau (1984) and Frazier and Salas (1984) suggested they may prevent sand from falling between the eggs, which would permit more space for gaseous exchange. A fourth theory presented here is that they could provide moisture to the nest, and possibly store moisture after rainfall.

Predator divergence was found at Culebra. One or more yolkless eggs in seven nests were attacked by ghost crabs; however no yolked eggs were harmed. This was probably due to their position on top of the clutch, where ghost crabs may first encounter eggs. Thermal buffering was not tested, but may be more important in the shallow nests of hawksbills. Sand between eggs may not be too important at Culebra, and will be discussed with abiotic factors.

There are two lines of evidence which give credence to yolkless eggs providing moisture to the nest environment. One is that egg chamber sand moisture was very low at Culebra (2.78% + 0.96, n = 9) when compared to beaches of other species of sea turtles, and was probably low at the three hawksbill beaches mentioned earlier, due to their desert localities. Sand moisture data were not available for other leatherback beaches. However, they may also have low sand moisture regardless of rainfall, due to their characteristically steeper slopes and coarser grained sands, which are more permeable to water, and therefore less likely to hold water. Secondly, yolkless eggs were usually found partially or fully collapsed upon nest excavation. In 1985, this was quantified, and 89% of yolkless eggs had lost some or all of their net moisture by hatching time. It is possible that some of this moisture was made available either directly or indirectly to yolked eggs, or that it helped stabilize sand moisture at the top of the nest. The possibility exists that these collapsed eggs could also absorb and store water that would normally drain away after a rainstorm.

## ABIOTIC FACTORS

The majority of abiotic factors tested did not significantly correlate with hatching success (Table 2). Distance of nest from vegetation and nest above HWM may not have been significant because very few nests were placed in vegetation (3.28%) or below the HWM (3.33%), and therefore, nesting sites were relatively uniform in nature. Also, the low variation in sand moisture, may have precluded differences in hatching success due to a lack of substantial differences in sand dryness. Since amount of sand between eggs was not correlated with hatching success, it was probably not important for yolkless eggs to prevent sand from falling between eggs at Culebra.

Only one abiotic factor -- nest depth -- was slightly negatively correlated with hatching success (Table 2). In contrast, Mortimer and Carr (1984) found a positive correlation between nest depth and percent hatch at Ascension Island, and thought it might be due to higher moisture in deeper nests. At Culebra, there was no significant difference in sand dryness at depth; however, there was a trend towards deeper nests being moister. An explanation for lower hatch at depth, if truly significant, was not readily evident.

A stepwise multiple regression analysis indicated that approximately 25% of variation in hatching success could be explained by number of yolked eggs and yolkless eggs ($r2 = 0.254$, $F = 13.419$, $p \leq 0.0001$). The standard equation was: y' = -0.388 + 0.323 (for yolked and yolkless respectively), with yolked eggs explaining approximately 15.5%, and yolkless eggs 9.5% of the variation. Doubtlessly other factors not tested were also important to hatching success at Culebra.

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Table 1. Descriptive statistics for reproductive variables of Culebra leatherback population for 1984 and 1985 combined. CV = coefficient of variation (SD x 100 / x).

| | mean | SD | range | n | CV |
|---|---|---|---|---|---|
| Carapace length, curved (cm) | 155.3 | 6.6 | 140.0-167.8 | 42 | 4.2 |
| No. Yolked eggs/clutch* | 70.0 | 16.3 | 30-115 | 212 | 23.3 |
| No. Yolkless eggs/clutch | 35.9 | 14.5 | 5-75 | 211 | 40.4 |
| Yolked egg diameter (mm) | 54.0 | 2.0 | 48.1-59.9 | 1356 | 3.7 |
| Estimated clutch frequency (clutches/turtle/season) | 6.4 | 3.0 | 1-11 | 42 | 49.2 |

* Split clutches not included

Table 2. Correlations of hatching success to various biotic and abiotic factors for leatherback clutches at Culebra, PR. in 1984 and 1985. Correlations are Pearson product-moment unless otherwise indicated.

| | r | P | n |
|---|---|---|---|
| Biotic Factors: | | | |
| No. yolked eggs | -0.339 | ≤0.0001 | 208 |
| No. yolkless eggs | 0.281 | ≤0.0001 | 205 |
| % yolkless eggs | 0.377 | ≤0.0001 | 206 |
| Egg diameter (mm) | 0.100 | NS | 115 |
| % fertility (arcsin transformed) | 0.100 | ≤0.0001 | 203 |
| Abiotc Factors: | | | |
| Date laid (Julian date) | 0.000 | NS | 203 |
| Incubation time (days)* | 0.001 | NS | 187 |
| Distance nest from vegetation (m)* | 0.128 | NS | 196 |
| Distance nest from HWM (m) | -0.078 | NS | 193 |
| Nest depth (cm) | -0.195 | ≤0.05 | 101 |
| Sand dryness at oviposition* | 0.065 | NS | 75 |
| Shape of nest chamber* | 0.112 | NS | 72 |
| No. of cave-ins during nesting* | 0.042 | NS | 68 |
| Amount of sand between eggs* | 0.173 | NS | 69 |

* Spearman rank correlations, r represents rho.

# NUMBERING AND TAGGING OF LEATHERBACKS FOR FOUR YEARS ON FRENCH GUIANA BEACHES

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French Guiana is an overseas department of France located on the South American continent in the Wider Caribbean region. In French Guiana are found the main beaches of the Atlantic Ocean for leatherback turtles, Dermochelys coriacea. Pritchard in 1971 and then Fretey and Lescure in 1979 have estimated the total number of females nesting in French Guiana to be 15,000 animals. The work of four years presented here provides a new estimation of this number. Financing for this work was provided by GREENPEACE, the World Wildlife Fund, and the European Economic Community.

Results have been obtained by several workers; 17 countries have been represented during these four years. In 1987 more than 100 volunteers patrolled the beaches for public information and to gather data on numbers of clutches and nesting turtles.

Females were counted directly with a nighttime beach survey, or tracks were counted in the morning. Intensive tagging was carried out in 1987 and 1988. In 1986, 1987 and 1988, camps were set up on different beaches along the coast of French Guiana to record turtle populations, principally the olive ridley turtles, Lepidochelys olivacea. The main nesting beach for leatherbacks is the Ya:limapo-Les Hattes beach on the estuary of the Maroni and Mana rivers on the Surinam border. Figures presented in this paper deal only with leatherback turtles.

In 1986, 196 turtles were tagged with titanium tags, and the feasibility of branding was tried. In 1987, 1207 turtles were tagged with Monel tags, and 5502 were tagged in 1988. In 1989 no tagging was done. Tagging is mostly useful if turtles return within the same year. In 1988, out of 5502 tagged females, 4031 were recaptured the same year. Observed Clutch Frequency (OCF) and Estimated Clutch Frequency (ECF) were calculated from these within-season recapture values. Maximum OCF was 9 and maximum ECF was 12. Mean value of ECF was estimated at 7.52 clutches per season.

Efforts to obtain remigration records for tagged leatherbacks returning after one year are very unrewarding. Perhaps the cause of the low recovery rates is due to the placement of the tag. So as to be easily read during the patrols, the preferred tag site on the flipper is also the site most vulnerable to tag loss. In previous seasons, only 8 tagged remigrant nesting turtles have been seen with their original tags (Fig. 1):

4 tagged turtles in 1985 were recaptured in 1988 (3 years);
1 tagged turtle in 1985 was recaptured in 1989 (4 years);
3 tagged turtles in 1987 were recaptured in 1989 (2 years).

From such small tag return numbers, a remigration pattern for leatherbacks cannot be worked out.

Two tagged turtles from 1987 have been caught in a net during the tagging year, one in Cuba and the other in Newfoundland. The latter is the most northeasterly record ever observed for a turtle nesting in Guiana. It confirms the rapid journey of turtles within the Gulf Stream system, as proposed by Carr in 1980.

One tagged female from 1987 was caught in a net offshore of Long Island, New York, in February 1989. Another female, first tagged when nesting in 1985 and again when nesting in 1988, was found at Jekyll Island, Georgia, in August 1989. A necropsy report prepared by Scott Eckert and Jane Fleetwood indicated that death may have been caused by a boat propeller.

In 1986, 11,577 nests of leatherbacks were counted, 33,740 in 1987, 52,923 in 1988, and approximatly 20,000 in 1989. The highest number of turtles seen in one night was 333 in 1986, 648 in 1987, 1032 in 1988 and 487 in 1989 (Fig. 2).

The total number of nesting females could not be precisely computed from 1988 data. Two previous estimates of total nesting females were 14,700 (Pritchard 1971) and 15,300 (Fretey and Lescure 1979) individuals, respectively. The factor used by these authors to convert annual numbers to total numbers was an average remigration interval of 2.5 years, with 6000 turtles nesting each year. The total estimated population is then 15,000 nesting females. It appears now that this number must be reconsidered, because in 1988, 15,000 different turtles were estimated to be nesting in French Guiana in a single season.

Since the French Guiana nesting leatherback population is one of the main components of the Atlantic population, it is important to reestimate the actual population of Atlantic leatherbacks. Given the great annual variation in numbers of nesting turtles each year and the poorly understood remigration cycle of leatherbacks in French Guiana and the "Typical, but not cycles" observation by Nat Frazer (1989) concerning remigration values, we don't want to propose a new estimation of the global population nesting in French Guiana. Moreover, since turtles nesting in Surinam and in French Guiana are certainly the same animals, it is important to group our data with those of the STINASU fundation for the protection of nature in Surinam.

Several observations indicate that some female leatherbacks might alternatively nest on either South American beaches or on West African beaches, which goes against the well known theory of nest beach fidelity. Specifically:

- a leatherback tagged in French Guiana was discovered off Ghana (Pritchard, 1973);
- females most likely tagged in French Guiana were seen nesting on Gabon beaches in 1984 (Fretey and Girardin, 1989);
- more recently, a female showing tagging injuries has been captured by fishermen along the coast of Guinea-Conakry (Fretey, unpubl.), bearing in mind that no tagging is done in West Africa.

Thus, it is very difficult at this time to integrate these data into a global number of Atlantic leatherbacks.

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**Figure 1**

Return of the tagged turtles from 1985 to 1989

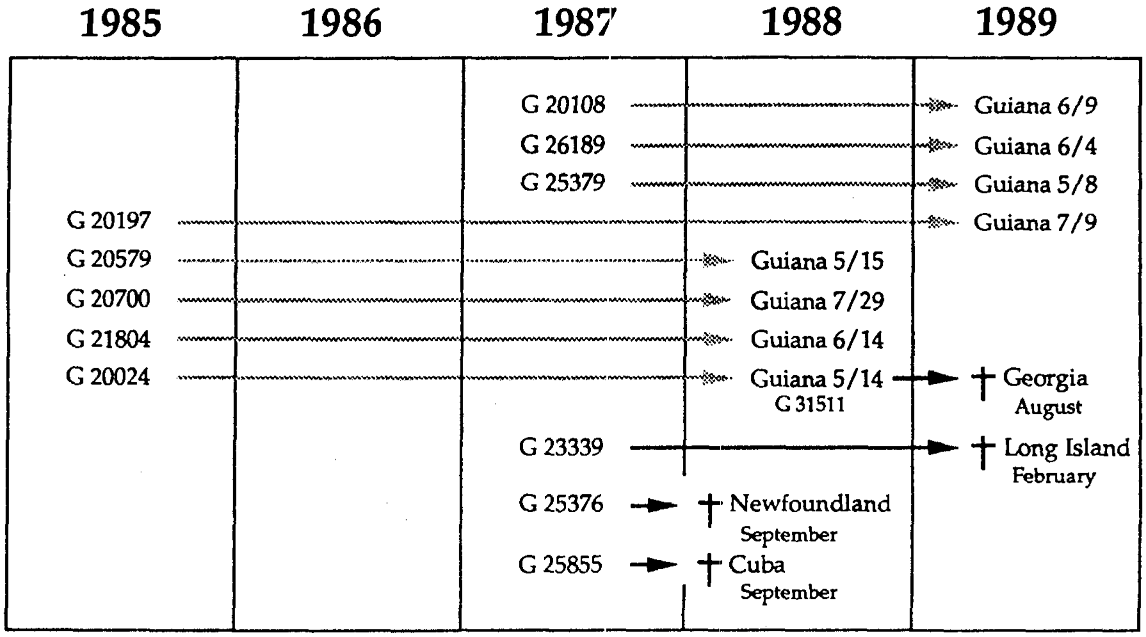
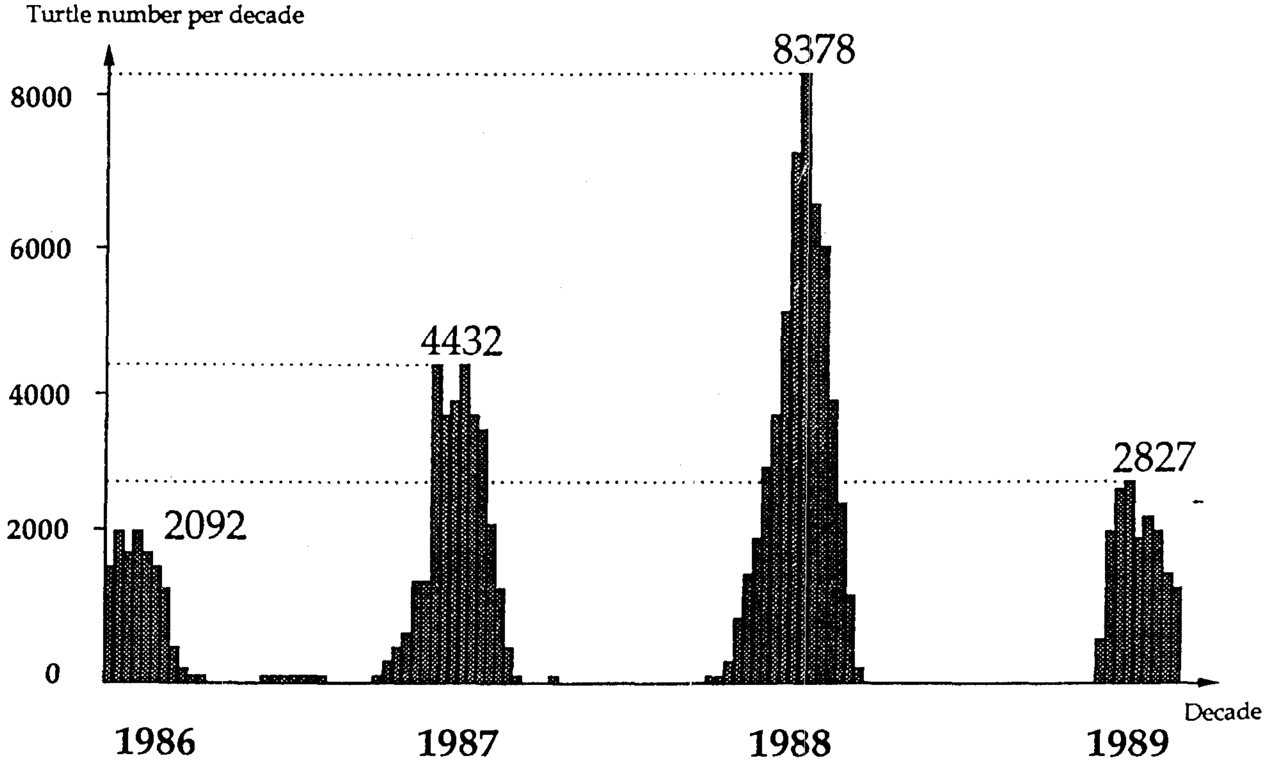


**Figure 2**

Turtle number per decade in French Guiana during four years : 1986-1989



# CHEMICAL AND BIOCHEMICAL ANALYSES OF THE TISSUES OF A BEACHED LEATHERBACK TURTLE (DERMOCHELYS CORIACEA L.)

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## INTRODUCTION

In September 1988 a male specimen of Dermochelys coriacea, currently the largest leatherback ever caught anywhere in the world (Eckert and Luginbuhl, 1988) was beached at Harlech, North Wales, U.K. It was rapidly transferred to a freezer store at the National Museum of Wales, Cardiff, and so represented an unusual opportunity to examine the chemical and biochemical characteristics of fresh tissue samples. Three main objectives were set. Firstly, as an air breathing, ocean-going medusivore, the leatherback is the top predator of a poorly studied food chain; it seemed appropriate to determine whether this food chain had been contaminated with pollutants to the extent that signs of such pollution were evident in the tissues of the turtle. Accordingly, analyses were carried out to measure heavy metal and polychlorobiphenyl (PCB) concentrations.

Secondly, unlike other living sea turtles, the leatherback Dermochelys coriacea forages widely in temperate waters during summer and dives to abyssal depths (Eckert et al. 1984, 1986) where temperatures are low (c. 5°C). There is strong anatomical plus limited physiological evidence in favour of at least facultative endothermy (Pritchard, 1969; Frair et al., 1972; Greer et al., 1973; Mrosovsky, 1980). Unlike other extant sea turtles, leatherbacks possess extensive peripheral blubber beneath the leathery skin of the carapace and plastron. Blubber can have several functions (eg. energy reserve, shaping material, buoyancy), but is well known to be insulative material, provided that the blood supply to the blubber is relatively sparse and under neurohumoral control to maintain peripheral vasoconstriction under cold conditions. The tissue samples were studied to test the following hypotheses which rely heavily on the work of Irving et al. (1957):

1. That an endothermic reptile capable of penetrating temperate waters in summer should have blubber which would freeze at a lower temperature than the fat of tropical reptiles.
2. Given an effective countercurrent heat exchanger vascular arrangement at the flipper roots, any adipose tissue in the flippers of leatherbacks should have a lower melting/freezing point than blubber lining the carapace and plastron.

To test these hypotheses, the thermal and biochemical characteristics of adipose tissues collected from various parts of the turtle were determined and compared with adipose tissues taken from spectacled caiman Caiman crocodilus (L.), domestic sheep Ovis sp. and grey seal Halichoerus grypus (Fabricius).

Finally, the remarkable diet of leatherback turtles (dominated by medusae and other coelenterates throughout life) invites study of trophic relationships. Of particular interest was the relationship between lipids of the leatherback and the lipids of its coelenterate prey. Accordingly, samples of Rhizostoma octopus, Cyanea lamarcki, Chrysaora isoceles and Aurelia aurita, known to be part of the diet of leatherbacks, was collected in July 1989 and fatty acid analyses performed for comparison with the leatherback data.

## MATERIALS AND METHODS

The methods used in the collection, preparation and analysis of samples have been described thoroughly in papers to be published elsewhere (Davenport et al., In Press 1, 2; Davenport and Wrench, In Press: Holland et al., In Press; McEvoy et al., In Press).

## RESULTS

### Metal analyses

*Metal analysis is now complete (Table 1). For several of the heavy metals (Hg, Cd, Zn, Ni) the liver appears to* contain the highest concentrations; this observation is in line with the trend in other marine animals. None of the values reported here could be regarded as elevated above the "normal" background levels seen in other organisms (see Bryan, 1984 for review). In most cases the subcutaneous blubber of the leatherback contained low levels of metals. However, arsenic was more concentrated in the blubber than in liver or muscle. This observation is consistent with previous reports that arsenic may associate with polar lipids in organisms at lower trophic levels and be transferred to organisms at higher trophic levels as "arsenolipid" complexes (Wrench and Addison, 1981).

TABLE 1. Trace metal concentrations (mg. metal Kg. dry wt-1) in tissues of an adult male leatherback turtle, Dermochelys coriaceus, stranded on the coast of Wales, U. K.

| | TISSUE | | |
|---|---|---|---|
| **METAL** | **LIVER** | **PECTORAL MUSCLE** | **BLUBBER** |
| **Hg** (Mercury) | 0.39 ± 0.04 | 0.12 ± 0.06 | 0.11 ± 0.02 |
| **Cd** (Cadmium) | 0.22 ± 0.02 | 0.06 ± 0.01 | < 0.01 |
| **Cu** (Copper) | 0.15 ± 0.04 | 0.26 ± 0.05 | 0.06 ± 0.02 |
| **Ni** (Nickel) | 2.13 ± 0.16 | 1.62 ± 0.21 | 0.07 ± 0.02 |
| **Pb** (Lead) | 0.12 ± 0.02 | 0.31 ± 0.03 | 0.04 ± 0.03 |
| **Se** (Selenium) | 1.41 ± 0.02 | 3.61 ± 0.48 | < 0.05 |
| **As** (Arsenic) | 0.58 ± 0.11 | 0.21 ± 0.07 | 1.28 ± 0.18 |
| **Zn** (Zinc) | 2.62 ± 0.15 | 1.89 ± 0.10 | 0.08 ± 0.01 |

### PCB analyses

Total PCB concentrations in the blubber have been determined at about 1.8 ppm. PCB fingerprinting (McEvoy et al., In Press) revealed the presence of more than 20 PCB congeners, all at low concentration, but with a preponderance of highly chlorinated components. The PCB fingerprint was consistent with contamination by commercial formulations (such as Arochlor 1254 and Arochlor 1260).

### Anatomical, thermal and biochemical characteristics of lipid deposits

The lipids of leatherbacks exhibit features which are consistent with maintenance of a core temperature above ambient levels when in cool waters. The heart, lungs and gut are surrounded by a blubber capsule at least 2 cm thick. The trachea and great vessels of the neck are protected by a thick pad of fat. The lipid of flipper adipose tissue freezes at a lower temperature (+11.4°C) than lipids extracted from the blubber lining carapace and plastron (+16.5 to +18.3°C). Lipid freezing points in leatherbacks are lower than for tropical caimans or terrestrial sheep (+39.1 to 42.5°C), but higher than for lipids taken from the blubber of a grey seal (-4.0°C). Leatherback adipose tissues show levels of unsaturation in neutral lipid fractions intermediate between those of seals and sheep.

### Comparison of lipids of leatherback and medusae

The major difference between lipids extracted from leatherback blubber and lipids collected from pinnipeds and cetaceans lies in the high concentrations of the polyunsaturated fatty acid 20:4 w 6 (arachidonic acid) found in Dermochelys. This is a long chain member of the linoleic family and makes up 1.8 - 41.1% of the total fatty acid of leatherback adipose tissues (c.f. < 1% in a range of whale, seal and fish oils). Pectoral muscle tissue was particularly rich in arachidonic acid (10.9% of neutral lipid fatty acids; 15.5% of phospholipid fatty acids). Analysis of jellyfish showed high levels of 20:4 w too (9.7 - 20% of total fatty acids).

## CONCLUSIONS

1. There is no evidence of heavy metal accumulation in the leatherback turtle. All of the values are within expected background levels.

2. The PCB data indicate contamination of the oceanic food web and accumulation of PCBs by leatherbacks. Open ocean surface water PCB levels are about $1 \times 10^{-3}$ ppb, while oceanic plankton have a concentration of around 1 ppb. This suggests that the planktonic food of leatherbacks concentrates PCBs by a factor of $10^3$ , and that leatherbacks provide a further bioaccumulation factor of $10^3$. Despite this finding, the blubber PCB levels are an order of magnitude below those found in seal blubber from relatively clean coastal waters, and two orders of magnitude below those found in seals from more polluted areas (Pertillä et al., 1986; Laws et al., 1989).

3. The thermal and biochemical characteristics of the lipids of Dermochelys provide further evidence for the hypothesis that leatherbacks are endothermic, at least when in temperate waters during the summer. Leatherbacks have been caught in areas where surface water temperatures are in the range of 6-15°C. Assuming that blubber lipids remain fluid at these temperatures, it seems probable that the core body temperature of Dermochelys must be in the region of 25°C.

4. The fatty acid analysis of leatherback tissues confirms the unusual nature of the species' diet. High levels of arachidonic acid are present in blubber and the membranes of a range of tissues. This acid occurs only in trace levels in the zooplankton/fish/marine mammal food chain. However, 20:4 w 6 is characteristic of all of the medusae studied and is probably incorporated directly into the tissues of leatherbacks (rather than being synthesized *de novo*).

## ACKNOWLEDGMENTS

The authors wish to thank The Vincent Wildlife Trust for providing funds to support this study. They also thank Mr Peter Morgan of the National Museum of Wales (Cardiff) for inviting them to collect samples from the giant male leatherback beached at Harlech. The authors are also grateful to the Sea Mammal Research Unit, Cambridge, for kindly donating a seal blubber sample. V. C-I. wishes to thank CONACYT (Mexico) for a studentship grant.

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# GALA BANQUET

# A HISTORY OF THE SEA TURTLE WORKSHOP

**Fred Berry**
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The Sea Turtle Workshop on Biology and Conservation started in 1980 when Bob Shoop walked into my office at the Southeast Fisheries Center and said " We need a sea turtle meeting." This was after the 1979 World Conference on Sea Turtles in Washington DC and before WATS I.

Bob and I discussed the idea, and then he went back North and left the idea simmering in my office. Thank you, Bob. I pushed some buttons, pulled some strings, and involved Ross Witham, and it started. Thank you Ross.

What has evolved over the intervening 10 years is an unregimented, loosely organized group that has kept on and grown and become better and remained unfettered. We have become an annual rallying force for sea turtle ideas and research results and care and concern. We have met and remet each other and become friends and generally enjoyed ourselves greatly at these annual meetings.

One thing that used to concern me was that I could not find too much public charisma from sea turtles. Now I know that a good part of the charisma to fuel public concern for sea turtles comes from this almost amorphous group of us that belong to the Sea Turtle Workshop.

The Workshops have been held prior to the sea turtle nesting season each year since. Although many people and organizations have helped in the success of each one, at the end of each Workshop a Coordinator is picked by the group to pull off the next Workshop--always along the U.S. South Atlantic seaboard. We note now with great appreciation and satisfaction the sites and the Coordinators for our first 10 Workshops:

| | | |
|---|---|---|
| 1981 | Jacksonville, Florida | Ross Witham |
| 1982 | St. Simons Island, Georgia | Chuck Cowman |
| 1983 | Charleston, South Carolina | Sally Ray Hopkins |
| 1984 | Oveido, Florida | Lew Ehrhart |
| 1985 | Dover Bluff, Georgia | Jim Richardson |
| 1986 | Dover Bluff, Georgia | Sally Hopkins Murphy |
| 1987 | Wekiva, Florida | Jamie Serino and Walt Conley |
| 1988 | Cape Fear, North Carolina | Tom Henson |
| 1989 | Jekyll Island, Georgia | Jim Richardson |
| 1990 | Hilton Head, South Carolina | Sally Murphy. |

Thank you Ross, Chuck, Sally, Lew, Jim, Jamie, Walt, and Tom. Thanks again to Jim who doubled and to Sally, who tripled.

# CHALLENGES OF THE DECADE OF THE ENVIRONMENT
## Sea Turtle Conservation and Earth Day 1990

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**Dr. Jay D. Hair**
President, National Wildlife Federation, Washington, DC USA

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10th Annual Sea Turtle Workshop
February 23, 1990
Hilton Head Island, South Carolina

Ladies and gentlemen...

It is indeed a pleasure to have the opportunity to share my thoughts with such a dedicated group of sea turtle scientists and conservationists. As one who faces the "slings and arrows" of criticism and controversy each day, I feel a special kinship with those of you who face similar, daunting challenges with your sea turtle work.

I wish to talk tonight about my thoughts on the challenges of sea turtle conservation in the new decade. But I also want to discuss the importance of a national event, Earth Day 1990, and the urgent importance of dealing with the global environmental challenges we face in the 1990s. I think I would have to go a long way to find a group more intimately aware of the intensity of the environmental challenges we face than the one to which I speak tonight.

For in 1989 we saw an unprecedented level of controversy erupt over sea turtle conservation, and specifically, the requirement for many shrimpers to use turtle excluder devices (TEDs). It was a year of roller-coaster emotions for many of us who were involved. Frustration, despair, hope, relief...all of these and more were caused by the TEDs controversy. As you well know, some of the dramatic emotional changes came days, even hours, apart.

Looking back over the tumultuous events of the past year, it is a wonder to me that you all had the energy to plan, and carry-out this conference. But your presence here is testament to your thirst to keep learning how to do things better, to keep a group of incredible animals, sea turtles, from going extinct, and to try to make this world a better place for us and our children in which to live.

Sea turtle protection in 1990. What a monumentally important time it is for this endeavor! What a pivotal time for the work you folks do.

But to put this exciting time into perspective, we need to first look back down the path from which we have come. Clearly, it is not a pretty view.

In his book A Sand County Almanac, the famous conservationist Aldo Leopold preached to us about protecting the integrity of biological communities and the importance of individual parts to the health of the community. In summary, he said "the land is one organism." I'm sure Leopold would have agreed to carry his analogy one step further: The Ocean is one organism...and as you and I know, sea turtles are important components.

Yet in 1989, Leopold's sermon continued to fall on deaf ears. In the midst of the TEDs controversy, then-governor of Louisiana Edwin Edwards was quoted as saying "If it comes down to shrimpers or turtles, it's bye-bye turtles."

And for much of this century, when it came down to sea turtles getting in the way of human activities, it was bye-bye turtles. When the hard choices had to be made on sea turtle conservation, it was bye-bye turtles.

When shrimpers were faced with the hard choice of voluntarily using TEDs or risk having regulations requiring TEDs forced on them, they failed to use TEDs.

When the Department of Commerce faced a situation where it had no recourse but to establish TED regulations, the Department had to be threatened with a lawsuit to spur it on. And when Secretary Mosbacher had to face mobs of angry shrimpers in the Gulf of Mexico this past summer to defend the TED regulation, which had taken over ten years of sweat and blood to achieve, it was bye-bye turtles.

The failure of Secretary Mosbacher to carry-out the congressionally-mandated TED regulations had to be one of the darkest hours in the history of the Endangered Species Act and of wildlife conservation. I can clearly recall the intense anger and frustration felt by us at the National Wildlife Federation, by many in Congress who had taken major political risks to defend TEDs, and by many conservationists around the country. It was a decision that required the most immediate, strongest possible rebuke. The National Wildlife Federation filed suit against the Secretary the following day.

Thankfully, through the legal pressure brought to bear, the incredible outpouring of criticism levelled against the decision, and the hard work of many of you in this room, the decision was reversed, and once again, use of TEDs is the law of this land.

I would like to publicly acknowledge some of those who gave of themselves so unselfishly through this controversial time: the state and federal marine agency personnel involved with the issue were incredibly courageous; the Center for Marine Conservation, the Environmental Defense Fund, the group called Help Endangered Animals Ridley Turtles (HEART), and many others who have fought for sea turtle conservation for so many years; and the more than 3000 private citizens who wrote to the Department in support of the TEDs regulation over the course of a very short comment period this past summer.

But as I'm sure you all know, the TEDs requirement is a tenuous one. So many times before conservationists have been heartbroken by failed leadership in the face of harsh political pressure. Even now we know that TEDs opponents are gearing up for another attempt to wipe out this critical measure. And so, 1990 is a critical year for sea turtle conservation.

Let us make a pact together, you and I, that in 1990 we move forward on sea turtle conservation. No more delays, and no more backsliding. Let us move forward with our sea turtle research, let us do a better job of protecting nesting beaches, let us reinvigorate our sea turtle work with our international friends, and most of all, let us vigorously enforce the TEDs requirement. Preventing the extinction of the Kemp's ridley, and the other sea turtle species, will require nothing less. And lest anyone leave this room tonight not knowing where we stand, the National Wildlife Federation will do everything in its power to ensure that sea turtle conservation moves forward, and that TEDs requirements are fully implemented, this year.

1990 is a critical year in another way. It is the first year of the last decade of this century. And it is the first year of what must be a dramatically heightened effort to protect the life support systems of this Planet Earth. That is why we are proclaiming the 1990's "THE DECADE OF THE ENVIRONMENT," and that is why we are pushing so hard on the celebration of Earth Day 1990.

Earth Day, 1990. What a monumentally important day this will be for our country! You and I, who toil in the trenches of resource conservation, will be there! Together, we will make it happen!

But this critical event, too, must be put in proper perspective to be fully appreciated.

Where were you...in the spring of 1970? Americans were packing the theaters to see "Butch Cassidy and the Sundance Kid." Watergate was just an apartment complex. A "watt" was just a measure of electrical power! "TED" was still just an abbreviated version of "Theodore."

Something else happened that spring. It began with a spark of imagination, and spread like wildfire. Wisconsin Senator Gaylord Nelson suggested that all Americans set aside April 22nd as a day for serious discussions of environmental problems. Considering everything we had on our minds that spring, the response was nothing short of phenomenal. 20 million Americans turned a simple idea into a sociological event. It was an idea whose time had come! As one commentator noted in response to this new environmental awareness, "Not since the Japanese attack on Pearl Harbor has any public issue received such massive support in all the news media, local, as well as national."

In that glorious spring of 1970, the seeds of a new environmental ethic began to sprout. Planted earlier by visionaries like Aldo Leopold and Rachel Carson, these seeds would soon grow...into the Clean Water Act and the Clean Air Act. They would bloom into laws like the Endangered Species Act, and lead to the creation of the Environmental Protection Agency. Today, that environmental ethic is still growing, still branching...and all from those first tiny seeds!

Of course, not all the seeds flourished. Our nation is losing its extremely valuable wetlands at an intolerable rate of about a half million acres per year. Loss of habitat in coastal Louisiana, which includes some of our most valuable wetlands, is estimated to be an astounding 50 square miles per year. With figures like this, is it any wonder that our waterfowl populations are at or near all time low levels?

The land is one organism. The planet is one organism. The time has come for us to address the challenges of the 1990's and nurture the growing seedlings of our new environmental ethic.

The political climate is right for this. A recent New York Times poll showed 80% of Americans believe environmental protection standards cannot be "too high"...that improvements should be made regardless of the cost! Back in 1969, only 1% of those responding to a similar poll thought the environment was even an issue!

Individual citizens, community groups, business and government officials are making changes...in the way they think, and in the way they act. You folks have seen this with your own eyes. Here in the Southeast we have an enthusiastic group of hundreds of people who are working with government biologists to protect sea turtle nesting beaches and document sea turtle strandings. The North American Wetlands Conservation Act was recently signed into law. This bill should provide about $25 million a year for wetlands acquisition and restoration, much of it being matched by private donations of money and labor.

But this Earth Day must be more than a re-run of the original. We have reached a critical point where demonstrations and litter pick-ups are simply not enough. What was once a "quality of life" issue, is now a matter of survival. We must move the issues associated with environmental protection from the margins to the mainstream of public attention.

The effort will require both individual sacrifices, and international cooperation. No nation, including the United States, has a right to disregard the global impacts of its own environmental degradation.

America must play a leading role...financially, technologically, and ethically. This nation may be the most productive on earth, but it is also the most wasteful. We consume a disproportionate amount of the world's resources, and inflict more than our share of environmental damage. It is America's moral responsibility to lead this new effort.

What can America, as a nation, do? First we need to set new priorities. Sustainable development, in order to be successful, will require funding. And don't let anybody tell you we don't have the money!

A global arms reduction and control program could save up to $500 billion annually for expenditures on sustainable development, the environment, health, population control and human welfare! All the guns, all the bombs, all the armies in the world will not protect us unless these problems are addressed now! Restoring and protecting our global environment is the national security issue of our time!

And I would especially like to see our young people start learning the "Four R's"...reading, 'riting, 'rithmetic...and resources! We're working to institute an "Environmental Education for the 21st Century" project, with the goal of creating an environmentally literate society. I think every school in America should include environmental sciences in the curriculum at every grade level. And that every student should demonstrate competency in these areas before graduating from high school.

And so I ask you to join us in achieving these goals, and in celebrating Earth Day, 1990.

I think that it is fitting that the National Wildlife's slogan for Earth Day 1990 is "Earth Day, Every Day", you can make a world of difference! You in this audience tonight -- many of you who have spent much of your careers working on various aspects of sea turtle science and conservation, some having risked careers, and in some cases even your lives -- you are making a world of difference. You are keeping these magnificent creatures from dropping from the face of this earth.

Today, I'm asking you to renew the vigor in which you sow the seeds of a new environmental renaissance. I'm asking you, each in your own way, to create a force that will move governments and change our world for the better!

Whatever each of you decides to do...remember...that our welfare is tied together, inseparably, with that of the Kemp's ridley, and all of the other creatures of the sea and of land.

For you see, it's no longer "us", against "them". It's just us. All dependent on one earth...each of us a thread in a magnificent global tapestry. Your contribution, however large or small, united with others on Earth Day, 1990, and every day, will generate the only force I know strong enough to save our planet.

Thank you.

# PART II: POSTER PRESENTATIONS and ADDITIONAL PAPERS

# MARINE TURTLE POSTAGE STAMPS OF THE WORLD--PROMOTING CONSERVATION

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**George H. Balazs**[1]
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**Nancy B. Linsley**[1]
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Postage stamps offer an excellent and novel means to promote the conservation of sea turtles and stimulate an interest in their biology. The following list shows the 285 stamps and souvenir sheets featuring sea turtles that have been issued by some 77 countries and territories worldwide. The popularity of issuing stamps depicting sea turtles has increased considerably during recent years. When the first comprehensive list of sea turtle stamps was published a few years ago by Gomez and Balazs (1983), there were known to be 176 stamps from 56 countries.

The updated and revised list which follows is arranged alphabetically by country, chronologically within each issuing authority, and by Scott (1990) catalog. A more detailed and annotated list of these stamps, available upon request from George H. Balazs, includes the Stanley Gibbons (British) catalog number, denomination of the stamp, description given in Scott, relevant description printed on the stamp, and/or the authors' own descriptive notes.

With only modest expense and effort, it is now possible for the amateur philatelist and sea turtle enthusiast to assemble a substantial collection of attractive and interesting stamps. It is hoped that even more such stamps showing sea turtles will be issued during coming years, including ones from the United States, Australia, and other nations not yet featuring this topic on their postage.

The authors acknowledge the valuable assistance of Judy Hornaday, Frank Lopez, Donald Riemer, and Walter Allen in the preparation and updating of this list.

## LITERATURE CITED

Gomez, E. D., and G. H. Balazs. 1983. Marine turtle stamps--promoting conservation. Chelonian Documentation Center Newsletter, 2(2-4):15-22.

Scott Publishing Co. 1990. Scott standard postage stamp catalogue. Four vol. New York.

| Country | Date issued | Scott no. |
|---|---|---|
| Anguilla | 20 May 1975 | 160 |
| | 7 1976 | 246 |
| | 10 Aug 1983 | 537 |
| | " | 538 |
| | " | 539 |
| | " | 540 |
| | " | 541 |
| Ascension | 2 July 1934 | 24 |
| | " | 26 |
| | " | 29 |
| | " | 31 |
| | 19 Nov 1956 | 70 |
| | 28 Aug 1973 | 170 |
| | " | 171 |
| | 28 Aug 1973 | 172 |
| | 21 May 1978 | 229c |
| | 8 Jan 1979 | 237 |
| | 19 Apr 1982 | 305 |
| | " | 306 |
| | " | 307 |
| | " | 308 |
| | June 1984 | 357 |
| | 17 Nov 1989 | |
| Bahamas | 1971 | 316 |
| | 21 Sep 1971 | 318 |
| | 2 Nov 1976 | 400 |
| | June 1978 | 439 |
| | 1979 | |
| | 15 Aug 1984 | 567 |
| | " | 567a |
| | " | 568d |
| Barbados | 26 Feb 1985 | 657 |
| | " | 657b |
| Bermuda | 19 Feb 1979 | 378 |
| | 4 Dec 1986 | 509 |
| Brazil | 5 June 1987 | 2103 |
| Caicos Island | 6 June 1983 | |
| Cayman Islands | 5 Dec 1932 | 69 |
| | " | 70 |
| | " | 71 |
| Cayman Islands (continued) | " | 72 |
| | " | 73 |
| | " | 74 |
| | " | 75 |
| | " | 76 |
| | " | 77 |
| | " | 78 |
| | " | 79 |
| | " | 80 |
| | 1935-1936 | 90 |
| | " | 92 |
| | " | 95 |
| | 5 May 1938 | 104a |
| | " | 107a |
| | " | 111 |
| | 16 July 1943 | 104 |
| | " | 107 |
| | " | 111a |
| | 8 July 1947 | |
| | 2 Oct 1950 | 124 |
| | " | 131 |
| | 7 July 1954 | 137 |
| | 21 Feb 1955 | 145 |
| | 6 Jan 1959 | 149 |
| | 4 July 1959 | 151 |
| | | 152 |
| | 28 Nov 1962 | 159 |
| | | 166 |
| | 1 Dec 1967 | 194 |
| | 5 June 1969 | 223 |
| | 8 Sep 1969 | 240 |
| | 8 Sep 1970 | 275 |
| | 28 Jan 1971 | 284 |
| | " | 285 |
| | " | 286 |
| | 10 Jan 1972 | 297 |
| | " | 298 |
| | " | 299 |
| | 20 Nov 1972 | 304 |
| | " | 305 |
| | 15 Jan 1973 | 308 |
| | " | 309a |
| | 1974-75 | 335 |
| | 19 Oct 1977 | 344 |
| | | 344a |
| | 30 July 1989 | |
| | 5 Feb 1979 | 423 |
| | " | 425 |

| | | |
|---|---|---|
| | 15 Aug 1979 | 428 |
| | 19 Dec 1980 | 461 |
| | 1982 | |
| | 9 Nov 1982 | 498 |
| | " | 500 |
| | 14 Mar 1983 | 511 |
| Chile | 5 Sep 1974 | 452a |
| Christmas Island | 30 Sep 1986 | 190 |
| | 25 Mar 1987 | 211 |
| | " | 211a |
| Columbia | 25 Apr 1980 | 879a |
| Comoro Islands | 20 Dec 1965 | 65 |
| Costa Rica | 1 Feb 1988 | 397 |
| Cuba | 1967 | Not listed |
| | 15 Nov 1983 | " |
| | " | " |
| | " | " |
| | " | " |
| | " | " |
| Dahlak Islands (part of Ethiopia) | 30 Dec 1969 | Not listed |
| Djibouti | 14 Sep 1977 | 467 |
| Dominica | 10 Mar 1969 | 253 |
| | 6 Sep 1970 | 297 |
| | " | 300a |
| | | 1146 |
| Dominican Republic | 30 Aug 1980 | C317 |
| Ethiopia | 14 Nov 1978 | 900 |
| Falkland Islands | 19 Apr 1982 | 344 |
| | " | 345 |
| | " | 346 |
| | " | 347 |
| Fiji | 3 Dec 1962 | 164 |
| | 14 Jan 1964 | 176 |
| French Polynesia | 24 June 1976 | 289 |
| | 19 Feb 1986 | 432 |
| | 13 May 1987 | 461 |

| | | |
|---|---|---|
| Gambia | 27 Nov 1984 | 535 |
| Gilbert Islands (now Kiribati) | 15 Jan 1979 | 322 |
| Grenada | 20 Jan 1976 | 694 |
| Grenadines of Grenada | 15 Apr 1985 | |
| Grenadines of St. Vincent | 20 July 1978 | Not listed |
| | " | |
| | " | |
| | " | |
| Guyana | 15 Feb 1978 | 268 |
| | 15 Nov 1983 | |
| Indonesia | 20 Dec. 1966 | B206 |
| | 17 Oct 1979 | 1066 |
| | 17 Oct 1979 | 1066a |
| Italy | 3 Apr 1978 | 1318 |
| Jamaica | 25 Feb 1980 | 487 |
| Japan | 28 Jan 1975 | 1204 |
| Jugoslavia | 24 May 1980 | 1474 |
| Kenya | 27 June 1980 | 174 |
| Kiribati (formerly Gilbert Islands) | 14 Feb 1984 | 437 |
| | 21 Nov 1984 | 448 |
| Lesotho | 14 Dec 1987 | 614 |
| Malaysia | 31 Jan 1972 | 95a |
| 4 Jan 1979 | 179 | |
| | 14 Apr 1986 | 324a |
| | | 324b |
| | | 324c |
| | | 325a |
| | | 325b |
| | | 325c |
| Maldives | 17 Feb 1980 | 841 |
| | " | 842 |
| | " | 843 |
| | " | 844 |

| | | |
|---|---|---|
| | " | 845 |
| | " | 846 |
| | " | 847 |
| | 29 Dec 1980 | 897 |
| | 21 Sep 1984 | 1030 |
| | 22 Sep 1986 | 1192 |
| Malta | 10 Oct 1979 | 564 |
| Mauritania | 21 Dec 1981 | 509 |
| | " | 510 |
| | " | 511 |
| Mauritius | 19 Apr 1982 | 544 |
| | " | 545 |
| | " | 546 |
| | " | 547 |
| Mexico | 3 July 1982 | 1281 |
| Mozambique | 3 Mar 1981 | 735 |
| New Caledonia | 20 May 1978 | 437 |
| | 1980 | 452 |
| New Hebrides (British) | 11 Feb 1974 | 185 |
| New Hebrides (French) | 11 Feb 1974 | 204 |
| Nicaragua | 1979 | Not listed |
| | " | " |
| | " | " |
| | " | " |
| | " | " |
| | " | " |
| | 1980 | " |
| | 10 Dec 1982 | C1034 |
| Niua'ou'fou (part of Tonga) | 7 May 1984 | |
| Pakistan | 20 Jun 1981 | 547 |
| Palau | 1983-84 | 12 |
| | 11 Jun 1985 | 80 |
| | 22 May 1986 | 103 |
| | 28 Oct 1986 | 116 |
| Papua New Guinea | 8 Feb 1984 | 592 |
| | " | 593 |
| | " | 594 |
| | " | 595 |
| | " | 596 |
| | " | 597 |
| | 13 Sep 1987 | |
| Philippines | 5 Jun 1982 | 1590 |
| | 11 Jul 1988 | 1933 |
| Pitcairn Island | 29 Sep 1980 | 194 |
| | 12 Feb 1986 | 266 |
| | " | 267 |
| | " | 268 |
| | " | 269 |
| Redonda (dependency of Antigua) | 1980 | Not listed |
| Ryukyu Islands | 20 Jan 1966 | 137 |
| St. Helena | 19 Apr 1982 | 368 |
| | " | 369 |
| | " | 370 |
| | " | 371 |
| St. Vincent | 31 Aug 1989 | |
| El Salvador | 20 Mar 1981 | C488 |
| Samoa (Western Samoa) | 18 Jun 1973 | 378a |
| | 14 Apr 1978 | 471 |
| Sarawak | 1 Oct 1957 | 204 |
| | 17 Aug 1965 | 220 |
| Senegal | 31 Jan 1981 | 543 |
| | " | 545c |
| Seychelles | 6 Feb 1978 | 389 |
| | 14 Mar 1980 | |
| | 16 Oct 1978 | 420 |
| | 22 Apr 1988 | 638 |
| | " | 639 |
| | | 640 |
| | " | 641 |
| Seychelles Outer Islands-(Zil Eloigne Sesel) | 20 Jun 1980 | |
| Solomon Islands | 5 Nov 1958 | 105 |
| | 15 Jun 1970 | 208 |
| | 16 Dec 1974 | 276 |
| | " | 279 |
| | " | 279a |

| | | |
|---|---|---|
| | 7 Jul 1978 | 372 |
| | 16 Aug 1979 | 395 |
| | 1 Jul 1982 | 471 |
| | 1982 | 412a |
| | 5 Jan 1983 | 489 |
| | " | 490 |
| | " | 491 |
| | " | 492 |
| Spanish Guinea | 23 Nov 1954 | 335 |
| | | B31 |
| Surinam | 17 Feb 1982 | 591 |
| | " | 592 |
| | " | 593 |
| Surinam (continued) | " | 594 |
| | " | 595 |
| Tanzania | 20 Aug 1986 | 330 |
| Thailand | 8 Jan 1986 | 1139 |
| | " | 1140 |
| | " | 1141 |
| | " | 1142 |
| Tokelau | 3 Dec 1986 | 135 |
| Tonga | 15 Dec 1978 | 446 |
| | " | C251 |
| | " | C0152 |
| | 1989 | 705 |
| Trinidad and Tobago | 7 Jul 1981 | 346 |
| | | 347a |
| Turkey | 1989 | 2456 |
| | " | 2457 |
| | " | 2457a |
| Turks and Caicos Islands | 14 Dec 1948 | 98 |
| | " | 99 |
| | " | 100 |
| | 29 May 1979 | 381 |
| | 2 Nov 1979 | 402 |
| Tuvalu | 21 Apr 1976 | 22 |
| | 1 July 1976 | 23 |
| | Sep 1977 | 58 |
| Vietnam | 1965 | Not listed |
| | 1975 | " |
| | 1988 | " |
| | " | " |
| | " | " |
| | " | " |
| | " | " |
| Virgin Islands (British) | 10 Feb 1979 | 348 |
| | " | 348a |
| | 15 Jan 1985 | 484 |
| | " | |
| | 15 Nov 1988 | 627 |
| | " | 630 |
| Yemen (People's Republic of Southern Yemen) | 2 Sep 1972 | 120 |

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Addendum.--Issues in which marine turtles appear only in the border of stamps (rather than on the actual stamp).

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| | | |
|---|---|---|
| Antigua and Barbuda | 28 Jun 1982 | 662 |
| Turks and Caicos Islands | 17 May 1979 | 385 |

# AERIAL SURVEYS FOR SEA TURTLES IN CORE AND PAMLICO SOUNDS, NORTH CAROLINA

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**Sheryan P. Epperly**
**Alexander J. Chester**
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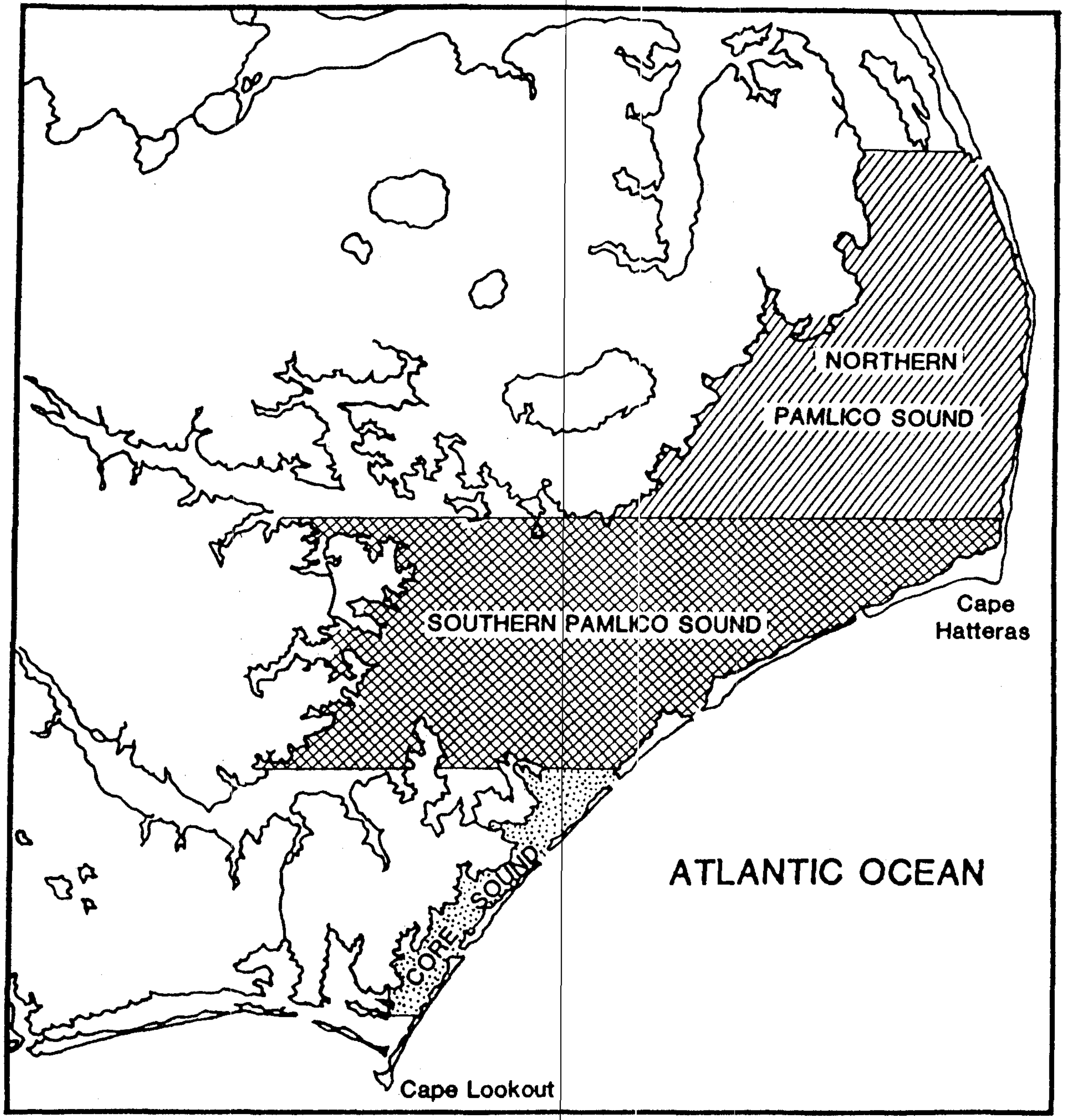
The National Marine Fisheries Service, Beaufort Laboratory, has been conducting research since the summer of 1988 on the seasonality and species distribution of sea turtles in the Pamlico-Albemarle estuarine complex of North Carolina. This study employs four methodologies, including aerial surveys of selected estuarine waters of North Carolina (Epperly and Veishlow, 1989; Epperly et al., in press). Aerial surveys of Core and Pamlico Sounds were conducted monthly from May 1989 through December 1989 (except June). The sounds were divided into three areas: Core Sound (34° 41' to 35° N), southern Pamlico Sound (35° to 35° 20'N) and northern Pamlico Sound (35° 20' to 35° 48'N) (Figure 1); however, all three areas were not surveyed every month. In Core Sound, transect lines were spaced to survey about 40% of the sound; for the southern and northern Pamlico Sound areas, transect lines were spaced to survey approximately 10% of those areas. We flew in a Cessna 172 at 130 km/hr and an altitude of 152m. Spring surveys yielded 45 sea turtle sightings distributed mainly along the eastern edges of Core and southern Pamlico Sounds. Summer and fall surveys yielded 53 and 39 turtle sightings, respectively, distributed throughout all of Core and Pamlico Sounds. The winter survey yielded 5 sea turtle sightings (including 3 leatherbacks) in Core Sound - too small a number to indicate any distribution patterns. The number of sea turtles on the surface was estimated and surface densities were calculated for each survey and area. Density within the northern areas was initially less than in southern areas, but increased as waters warmed and then decreased in the fall. Emigration was complete by January.

## LITERATURE CITED

Epperly, S. P. and A. Veishlow. 1989. Description of sea turtle distribution research in North Carolina, p. 53-55. In S. A. Eckert, K. L. Eckert and T. H. Richardson, compilers. Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology, 7-11 February 1989, Jekyll Island, Georgia. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS SEFC-232, 305p.

Epperly, S. P., J. Braun and A. Veishlow. In press. Distribution and species composition of sea turtles in North Carolina. In T. H. Richardson, J. I. Richardson and M. Donnely, compilers. Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation, 20-24 February 1990, Hilton Head, South Carolina.

Figure 1.


NORTHERN
PAMLICO SOUND
SOUTHERN PAMLICO SOUND
Cape
Hatteras
ATLANTIC OCEAN
CORE SOUND
Cape Lookout

# THE DEATH OF UNHATCHED EMBRYOS

**Orville D. Clayton**
Longboat Key Turtle Watch, 696 Marbury Lane, Longboat Key, FL 34228 USA

Ten years ago, questioning the premise that all unhatched eggs were infertile, I started to analyze all unhatched eggs from each nest. In trying to clarify what I was looking at, I hunted through various publications and found in one of the books by H.R. Bustard of Australia a scale by which he had classified unhatched embryos.

They were classified, as follows: 2 to 10 days, in which the eye spots were clearly visible after 2 days; 10 to 20 days, in which the head has started to take shape and body form is distinguishable; 20 to 30 days, scutes are well remarked and eyes greatly enlarged and flippers and body well defined; 38 days to maturity, the carapace takes on color and the head, lower jaw, and flippers move at will. I also classified dessicated and infertile.

To avoid classing an egg as infertile when the nucleus might be hidden by the yolk, I turn the egg out into a watch glass. Maybe I should say clock glass since my watch glass is the crystal of an old Seth Thomas mantle clock. By using this glass I am able to see the hidden side of the egg.

This 2- to 10-day period is the one that concerns me the most. Up through 1986 the death rate of the embryos in this period ran from 1 to 3% of all unhatched eggs. In 1987 it was 3%. Then in 1988 it rose to 7% and in 1989 it soared to 24%. This drastic increase is what alarms me. The death rate in all other stages of incubation remained fairly constant.

My reason for bringing this situation before you today is seeking answers. I am certain that there are some of you here who are much more knowledgeable than I in the study of embryology. So I am asking any of you who may analyze eggs if you have come across a similar situation.

I know that in 2 or 3 years it is impossible to draw any definite conclusions, and I shall continue to closely examine all unhatched eggs. It may be that this condition only exists in our area. However, I feel that it is not too soon to be on the lookout for something that could develop into a serious problem.

Maybe I'm like a hound barking "treed" when there is no "coon," but any suggestions or advice will be greatly appreciated.

# REMIGRATION AND HATCH SUCCESS OF THE JUMBY BAY HAWKSBILLS, ANTIGUA, W.I.

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**Lynn A. Corliss**
**James I. Richardson**
**Anna L. Bass**
**Rebecca Bell**
**Thelma H. Richardson**
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Jumby Bay is a 300 acre island of limestone, flint rock and small trees located 3 km northeast of Antigua, West Indies. The hawksbill sea turtle (Eretmochelys imbricata) nests on the windward side of the island at Pasture Bay, a small cove beach of about 500 m in length.

In the past four years, the hawksbill project's main objectives have been: 1) nesting behavior, 2) beach management and 3) environmental education. This year's emphasis was focused on tagging and nest success. The 1989 season was perhaps the most exciting year because of the return of tagged remigrants and because of Hurricane Hugo.

## METHODS

The research season is from June to November, a period of 150 days during the peak nesting season. Nightly foot patrols are conducted along the length of Pasture Bay beach between 8:00 pm and 5:00 am on hourly intervals. Turtle nesting behavior is recorded and timed. Each individual receives replicate tags through the proximal pad on the left and right front flippers with a self-locking Inconel tag and also a diagnostic drill hole pattern on the trailing edge of the supracaudal scutes. Tagging is done only while the eggs are being laid. Once the nesting individual begins covering, all marking and measuring activities are terminated so as not to disturb the animal, and a false crawl turtle is never disturbed. Nest locations are marked with a yellow rope and a laminated/numbered index card. During the predicted hatching dates, nests are checked intermittently throughout the night. All emerged nests are cleaned and the contents tabulated to determine hatch success.

## RESULTS

During the 1989 season, 30 turtles nested at Pasture Bay. Of these, 16 were remigrants from the cohort of 29 turtles (51%) that nested during the 1987 season. Fourteen of the 16 remigrants (88%) carried both original tags and diagnostic drill holes from 1987, and at least one identifying mark was present on every animal. The system of drill holes and tags did exceptionally well.

There were 129 nests laid during the study season. Seven nests were inundated by high waves from hurricanes Gabriel and Hugo (Table 1), and Antigua took a near direct hit when the eye of Hugo passed only 40 miles to the southwest of the island. Four out of seven of the inundated nests were completely destroyed. The average hatch rate was 79% for the season, including all nests. The average hatch rate calculated without inundated nests was 84%. Five clutches laid too close to the water were relocated during the season; hatching success (82%) was calculated for three of these nests. The natural hatch rate on Pasture Bay, without relocation or manipulation of any nests, would have been 79%. Because of the sheltered nature of Pasture Bay and the resistence of beach vegetation to high winds, nesting success for 1989 was scarcely affected by the severity of the hurricane season.

## DISCUSSION

Sixteen individuals returned in 1989 from the 1987 season, indicating a significant if not predominant two-year remigration cycle. Thirteen individuals arrived this year without tags; we expect them to be on a three-year cycle, representing individuals from the 1986 season when no tagging was done. Also, it was noted that the drill holes from 1987 had drifted approximately 5 mm toward the edge of the scute over the two-year period. This observation may provide some indication of scute growth rates on wild adult females in Antiguan waters. With triple tagging, the Jumby Bay project looks forward to 100% of remigrants carrying identifiable marks in the future.

Knowledge of hatching success and the capability for successful relocation of threatened nests promise better management for hawksbill nesting beaches. Clutches on Pasture Bay have been moved primarily to prevent tidal inundation of nests positioned at or below the high tide line. There has not been a need for a hatchery. If a hawksbill nesting beach is in need of using a hatchery due to poaching or predation, there is risk of skewing sex ratios on a turtle that nests under vegetation. An on-going study is being conducted at Pasture Bay on beach temperature profiles and the pivotal temperature of the hawksbills. It is hopeful that this study will provide necessary information for sound management decisions concerning the future of the hawksbill sea turtle in the Caribbean.

Table 1. Development success of seven nests washed over by high waves from hurricanes, Pasture Bay, Antigua, W.I., 1989.

| Nest No. | Location | Condition |
|---|---|---|
| 13 | 14-15 | 119 hatchlings dead |
| 24* | 14-15 | 26 rotten; 72% hatch rate |
| 35 | 8-9 | destroyed; no trace of nest |
| 38 | 30-31 | destroyed; no trace of nest |
| 50 | 8-9 | 93% hatch rate |
| 57* | 13-14 | all rotten on top |
| 66 | 26-27 | destroyed; no trace of nest |

* Attempted to relocate nests during high waves. Eggs inundated with water.

# SEA TURTLE CONSERVATION AND EDUCATION PROGRAMS IN ANTIGUA, WEST INDIES

**Lynn A. Corliss**
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Antigua is one of the few islands in the Caribbean where the hawksbill sea turtle (Eretmochelys imbricata) exists in "significant" numbers. There may be more hawksbill sea turtles in the waters of Antigua than most neighboring islands, and fewer and fewer fishermen set nets. The older Antigians tell of a time when hawksbill sea turtles were abundant.

Today, turtle soup in Antigua seems to be eaten only on rare occasion. The eggs, on the other hand, are especially sought after for their supposed aphrodisiacal qualities. There does not seem to be much necessity for hawksbill meat as a source of protein, and yet 8-10 hawksbills can still be seen at one time in the St. Johns meat market.

Conservation for the endangered hawksbill in Antigua is on a small scale. Most of the effort was started by John and Sarah Fuller, residents of the island. They have purchased many a captured sea turtle from fishermen in order to release the animal. The "word" about sea turtle conservation has travelled far and wide across Antigua and Barbuda due to the efforts of these two people.

Other environmental interest groups have contributed to sea turtle conservation in Antigua. The local museum, directed by Desmond Nicholson, supports a local conservation group that meets once a month to discuss a wide range of local conservation issues. They have invited guest speakers to talk about issues such as coral reefs and sea turtle conservation. The Jumby Bay Hawksbill Project has designed a dive sheet for SCUBA groups and other interested divers, so that participants can record underwater observations on hawksbills. The dive sheet was designed in hopes that much needed information on underwater behavior of hawksbills can be obtained. Many people are interested and want to become involved.

There is a great need for more educational programs on sea turtles and conservation in Antigua. Since the establishment of the Jumby Bay Hawksbill Project, many slide shows have been shown in both public and private schools throughout the country. All science teachers in the public school system are required to teach the basic concepts of ecological and conservation but do not have the knowledge or background to teach correctly. The Jumby Bay project has coordinated workshops for science teachers on seashore ecology and sea turtles. Both the workshops and slide shows have been an immense success.

There is a need to look beyond education. Tourism is on a rapid increase and is the major source of income in Antigua. Ecotourism promotes local conservation and supports the local economy. If Antigua chooses to focus on ecotourism, they will not only be promoting conservation and attracting a wider range of tourists but also be saving their future. It is vital that Antigians have a sense of pride in the natural beauty of their island now, so that there will be something left for future generations to come.

The future of the Antigua hawksbills is now in the hands of the business establishment; historic attitudes of the Antigians towards conservation have not been good. If ecotourism cannot play a role in the future economy of Antigua, the picture looks bleak. If Antiguans can find ways to attract tourists to their natural areas with conservation in mind, then there may be hope. Antigua, Mona Island (Puerto Rico) and Buck Island (U.S. Virgin Islands) are some of the last refuges in the Caribbean for the hawksbill.

# HATCHLING SUCCESS FOR DERMOCHELYS CORIACEA IN A FRENCH GUIANA HATCHERY

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Figure 1. Hatching successful results in the hatchery of Les Hattes - Ya:lima:po in 1986, 1988 and 1989.
Figure 2. Death of embryos during the incubation: two most sensitive stages.
Figure 3. Influence of the beginning incubation time: most significant results.
Figure 4. Description of the experiments in 1989: results of experiments.
Figure 5. Analysis of the 1989 experiments: some information about the best conditions of incubation.

## Germs found on rotten eggs or eggs with dead embryos

| Familly of Micrococcaceae | Name of experiment |
|---|---|
| *Streptococcus sp.* | |
| *Diplococcus sp.* | |
| Family of Enterobacteriaceae | |
| *Escherichia coli* | |
| *Proteus vulgaris* | |
| *Citrobacter diversus* | B |
| *Enterobacter sakazakii* | B |
| *Enterobacter cloacae* | |
| *Enterobacter gergoviae* | B |
| *Proteus (Morganella) morganii* | |
| *Aeromonas sobria* | B G |
| *Aeromonas hydrophila* | |
| Family of Pseudomonadaceae | |
| *Pseudomonas aeruginosa* | B G |
| *Pseudomonas stutzeri* | B |
| *Pseudomonas putida* | B |
| *Acinetobacter calcoaceticus* | |
| Not classified | |
| *Xantomonas maltophila* | G |
| *Sphingosum spiritovarum* | |

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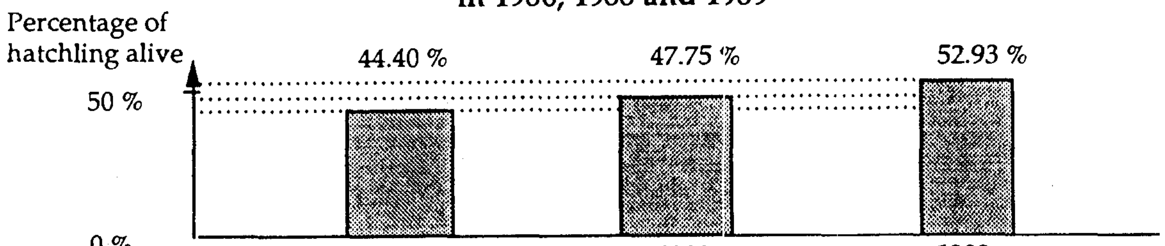
McFadden, T.W. 1969. Effective disinfection of trout eggs to prevent transmission of Acromonas liquefaciens. J. Fish. Res. Bd Canada. 26(9): 2311-2318.

**Figure 1**

Hatching successful results in the hatchery of Les Hattes-Ya:lima:po in 1986, 1988 and 1989

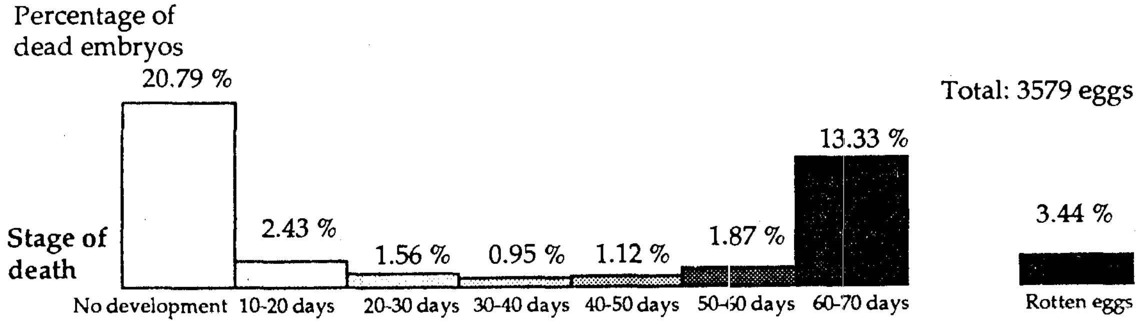


| | 1986 | 1988 | 1989 |
|---|---|---|---|
| Number of eggs | 4595 | 3106 | 3579 |
| Number of boxes | 70 | 69 | 63 |

In 1987 two rooms were built within the hatchery and no incubation could be done.

**Figure 2**

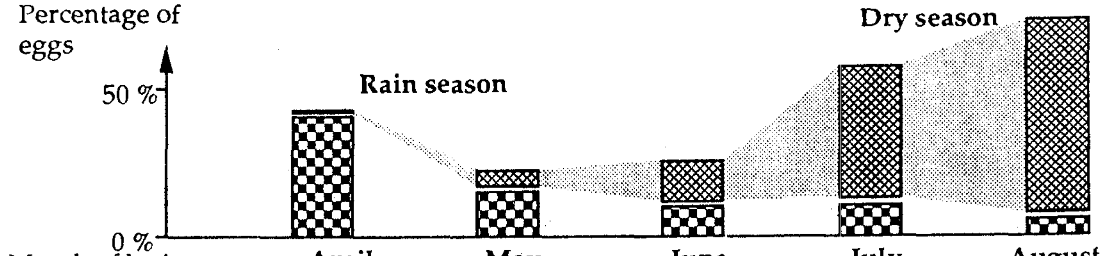
Death of embryos during the incubation : Two most sensitive stages



The embryos at the stages "No development" and "60-70 days" appear to be the most sensitive. The stage "No development" include unfertilized eggs and embryos dead between 0 and 10 days. These data are from the 1989 experiments but the same proportions have been obtained in 1986 and 1988.

**Figure 3**

Influence of the beginning incubation time : Most significant results (from 1986)



| Month of laying | April | May | June | July | August |
|---|---|---|---|---|---|
| Total of eggs | 235 | 949 | 1303 | 1384 | 724 |
| ▨ Rotten eggs | 0.43 % | 5.27 % | 13.35 % | 44.29 % | 63.54 % |
| ▦ Death at the end of incubation | 40.42 % | 15.18 % | 10.05 % | 10.26 % | 4.97 % |

We can forward two reasons to explain those differences of mortality in function of the laying month, but we don't have any information to confirm any of them :

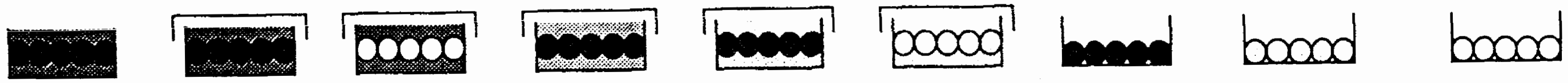
- The gradient of humidity and temperature along the months (rain season to dry season) ,
- The females laying in August are probably at the end of their laying period by that time.

**Figure 4**

## DESCRIPTION OF THE EXPERIMENTS IN 1989

| A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|
| ▨ Unwashed sand | ▨ Unwashed sand | ▨ Unwashed sand | ▨ Sand washed with Phagosept 0,02% | Sand washed with Phagosept 0,04% | | No sand | No sand | No sand |
| ● Unwashed eggs | ● Unwashed eggs | ○ Eggs washed with Bétadine 0,4% | ● Unwashed eggs | ● Unwashed eggs | ○ Eggs washed with Bétadine 0,4% | ● Unwashed eggs | ○ Eggs washed with unboiled water | ○ Eggs washed with Bétadine 0,4% |
| No cover | Cover | Cover | Cover | Cover | Cover | No cover | No cover | No cover |

## RESULTS OF EXPERIMENTS



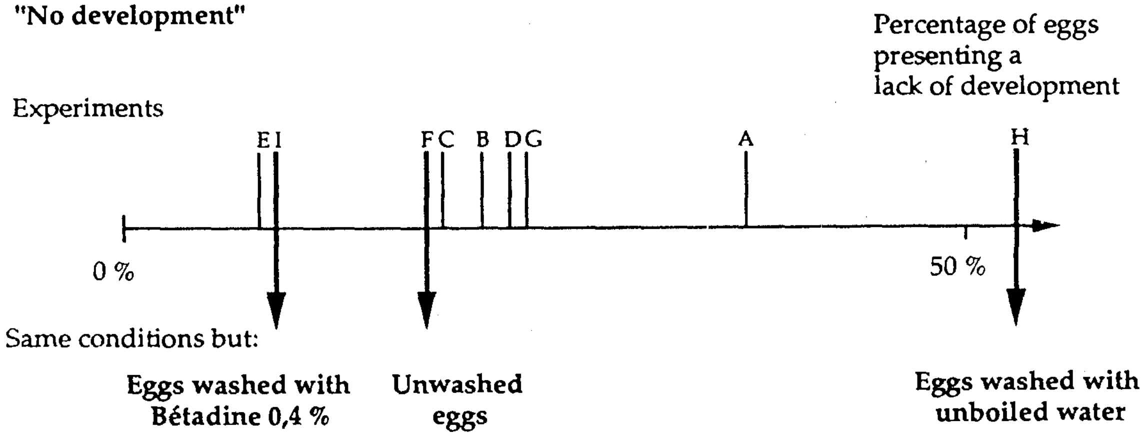
| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| Number of boxes | 5 | 17 | 6 | 6 | 9 | 5 | 7 | 3 | 3 |
| Number of eggs | 182 | 1005 | 307 | 395 | 395 | 237 | 531 | 169 | 214 |
| Percentage of hatchling alive | 19.54 % | 58.63 % | 75.58 % | 65.17 % | 62.03 % | 73.62 % | 29.01 % | 16.87 % | 48.06 % |

**Figure 5**

## Analysis of the results of the 1989 experiments: some information about the best conditions of incubation

To explain the two main causes of death in 1989 "No development of the embryo" and "Embryo dead at the end of the incubation", the different experiments are sorted along a line in function of the percentage of eggs dead at this stage. The percentage of "Dead at the end of incubation" is computed from a total number of eggs equal to the number of embryos alive at this stage ("Hatchling alive" + "Dead at the end of incubation").

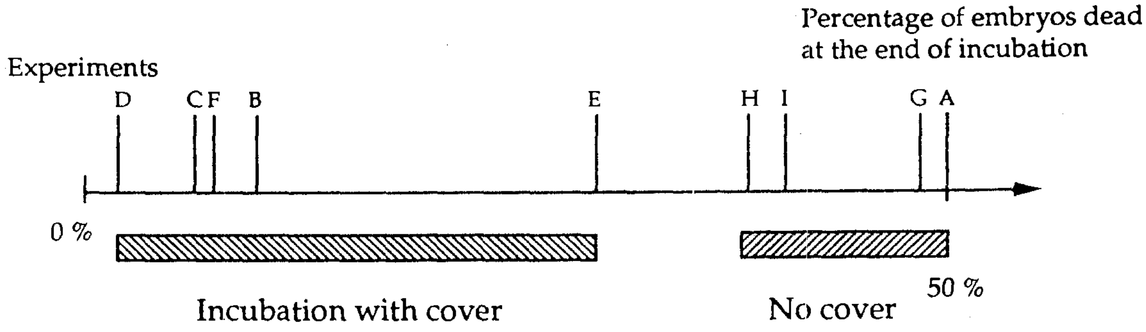
**"No development"**



Bétadine is iodinated polyvinylpyrolidone or PVP-I

Egg washing with Bétadine 0.4 % seems to be a good treatment against the lack of development of eggs. The same conclusion is obtained with other experiments, but it seems that the egg washing can be replaced by sand washing with the same result. Egg washing and/or sand washing is particulary active against rotting of eggs.

**"Dead at the end of incubation"**



Absence of cover on the box seems to be an important factor in the death of the embryo at the end of incubation.
The addition of sand does not seem to be determinant for successful incubation.

# SEA TURTLE MONITORING AT OFFSHORE OIL AND GAS PLATFORMS

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Sea turtle monitoring by observers from the Naitonal Marine Fisheries Service (NMFS) Galveston Laboratory is conducted during the explosive removal of oil and gas structures in state and federal waters of the Gulf of Mexico. Collection of data began in 1986. Through December 1989, 187 offshore removals were monitored.

Opportunistic monitoring was also conducted at various offshore structures that are still intact. In the fall of 1989, 170 turtle sightings were made during 30 hours of monitoring at a single platform located 30 miles from Galveston, Texas. At least 11 loggerhead turtles were identified over a 10-day period. During a 30-hour period, 3 NMFS divers logged a total of 165 minutes to a depth of 70 feet. Divers captured 6 loggerhead turtles as they lay sleeping or resting on the sea bottom next to the legs of the platfom. One turtle was equipped with a satellite tag to monitor its movements. Remaining turtles were painted with identifying letters to facilitate short-term identification. Three additional loggerhead turtles were identified at each of two platforms near Galveston. Up to 20 turtles were reported at a platform 5 miles from Aransas Pass, Texas, but this has not yet been confirmed.

These data indicate more turtle activity around offshore platforms than was previously thought. Research is being planned to investigate the relationship between turtles and offshore structures.

# HEMATOLOGY STUDY ON THE BLACK TURTLE, CHELONIA AGASSIZI, AT PLAYA COLOLA, MICHOACAN, MEXICO

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## INTRODUCTION

Limited information is available concerning sea turtle blood cytology and hematology (Frair, 1977a,b; Bashtar, 1979; Bachere, 1980; Wood and Ebanks, 1984). These data are based primarily on captive populations. In addition, there is variability and confusion as to the morphological characteristics of circulating blood cells among species of sea turtles as well as reptiles in general. We report the red and white blood cell counts, packed cell volumes, and differential white blood cell counts of wild black turtles (Chelonia agassizi) during nesting and captures at sea. It is our purpose to present parameters seen in a healthy wild population of sea turtle in order to determine "normal" values for captive populations. We also compare the results obtained from using two types of anti-coagulants (EDTA and Lithium heparin) in order to clarify which is more suitable for sea turtle hematology studies.

## MATERIALS AND METHODS

### 1) Hematology study of the black turtles

Four ml Lithium heparin Vacutainers were used to collect blood samples from the cervical sinus of 24 nesting turtles, 6 females captured at sea, and 8 males captured at sea during November 1989 at Playa Colola, Michoacan, Mexico. Blood smears were made at collection and air dried for staining.

Packed cell determinations (PCV), blood counts (RBC and WBC), and blood smear staining were done within 1-12 hours of collection. Determinations were done in duplicate or triplicate for each parameter. PCV determinations were done using heparinized microhematocrit tubes in a modified Junior angle centrifuge. Blood cell counts were done manually using white and red cell diluting pipettes and a hemocytometer counting chamber. The diluent used was 0.85% saline with 5% formalin for WBC counts and the same solution with 1% Wright's stain added for RBC counts (Wood and Ebanks, 1984). Differential white cell counts were made using modified Wright-Giemsa (Neat Stain, Accura Labs) stained preparations by counting 100 white cells in adjacent areas on a slide and listing them by cell types according to the nomenclature of Frye, 1981.

### 2) Anti-coagulant comparisons

A 4 ml Lithium heparin and a 7 ml EDTA blood sample were collected from the cervical sinus of 10 immature, captive green turtles (Chelonia mydas) in January 1990. PCV and blood cell counts were done on each sample and the results compared. Differential blood cell counts could not be done on the EDTA samples, as the white blood cell morphology was extremely distorted.

### 3) Statistical analysis

Paired t tests and one-way analysis of variance (Bruning and Kintz, 1977) were done to test statistical significance ($p < 0.05$).

## RESULTS AND DISCUSSION

### 1) Hematological parameters of the black turtles

The following results were obtained on the wild population of black turtles at Playa Colola (Fig. 1):

1) Packed cell volumes were not significantly different between males and females (Fig. 1A). The packed cell volumes were 31.1 ± 6.7; mean ± SD, range 17.7 -40.0 for nesting females; 32.3 ± 3.3; mean ± SD, range 28.0 - 36.5 for females at sea; and 29.1 ± 10.3; mean ± SD, range 10.0 - 38.0 for males at sea.

2) Red blood cell counts were not significantly different between males and females (Fig. 1B). Red cell counts were 483 X $10^3$ ± 119; mean ± SD, range 200 - 720 X $10^3$ for nesting females; 429 X $10^3$ ± 113; mean ± SD, range 270 - 598 X $10^3$ for females at sea; and 465 X $10^3$ ± 109; mean ± SD, range 255 - 655 X $10^3$ for males at sea.

3) White blood cell counts were significantly lower ($F = 7.18$; df = 2,35; $p < 0.05$) for males than females (Fig. 1C). White blood cell counts were 2,396 ± 1233; mean ± SD, range 1,325 - 5,250 for males at sea; 5,330 ± 2,208; mean ± SD, range 2,000 -12,250 for nesting females and 4,208 ± 1,656; mean ± SD, range 1,500 - 6,000 for females at sea. The difference in white cell counts was in the percentage of eosinophils. The percentage of eosinophils was lower in males at sea (mean = 17.3% ± 17.9 SD, range 7 - 44%) than in all females combined (mean = 34.8% ± 17.6 SD, range 3 - 61).

These results represent parameters from healthy, wild sea turtles and may be beneficial in the interpretation of hematological values obtained from captive sea turtles when trying to assess their state of health.

### 2) Hematology parameters of EDTA versus Lithium heparin

The following results were obtained on the captive green turtles held at Texas A&M (Fig. 2):

1) The packed cell volume of heparinized blood was significantly lower ($t = 4.85$; df = 9; $p < 0.001$) than EDTA blood (34.5% ± 3.8 versus 44.0% ± 4.9; mean ± SD) even though 7 of 10 EDTA blood samples were hemolyzed (Fig. 2A). This difference is thought to be due to the incomplete separation of the blood components in EDTA (i.e., blood components never settled out even after 24 hours).

2) EDTA red blood cell counts were significantly higher ($t = 3.01$; df = 9; $p<0.01$) than heparin counts (501 X $10^3$ ± 44 vs. 433 X $10^3$ ± 57; mean ± SD; Fig. 2B).

3) There was no significant difference in white blood cell counts of heparinized versus EDTA blood (2,357 ± 474 vs. 2,330 ± 528; mean ± SD; Fig. 2B).

From the results of this study, it is evident that Lithium heparin is the anti-coagulant of choice for sea turtle hematology studies.

## ACKNOWLEDGMENTS

We would like to thank the students and workers at Playa Colola, Michoacan, Mexico, for all their help and support with this study. Support was provided by Texas A&M University Sea Grant College Program NA85AA-D-SG128, U.S. Fish and Wildlife Service, and Sea Turtles Inc.

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**Figure 1.** Hematological parameters of the black turtles at Playa Colola. A) Packed cell volumes and B) red blood cell counts were not significantly different between nesting females, females at sea, and males at sea. C) White blood cell counts were significantly lower for males at sea than nesting females or females at sea (F = 7.18; df = 2,35; $p < 0.05$).

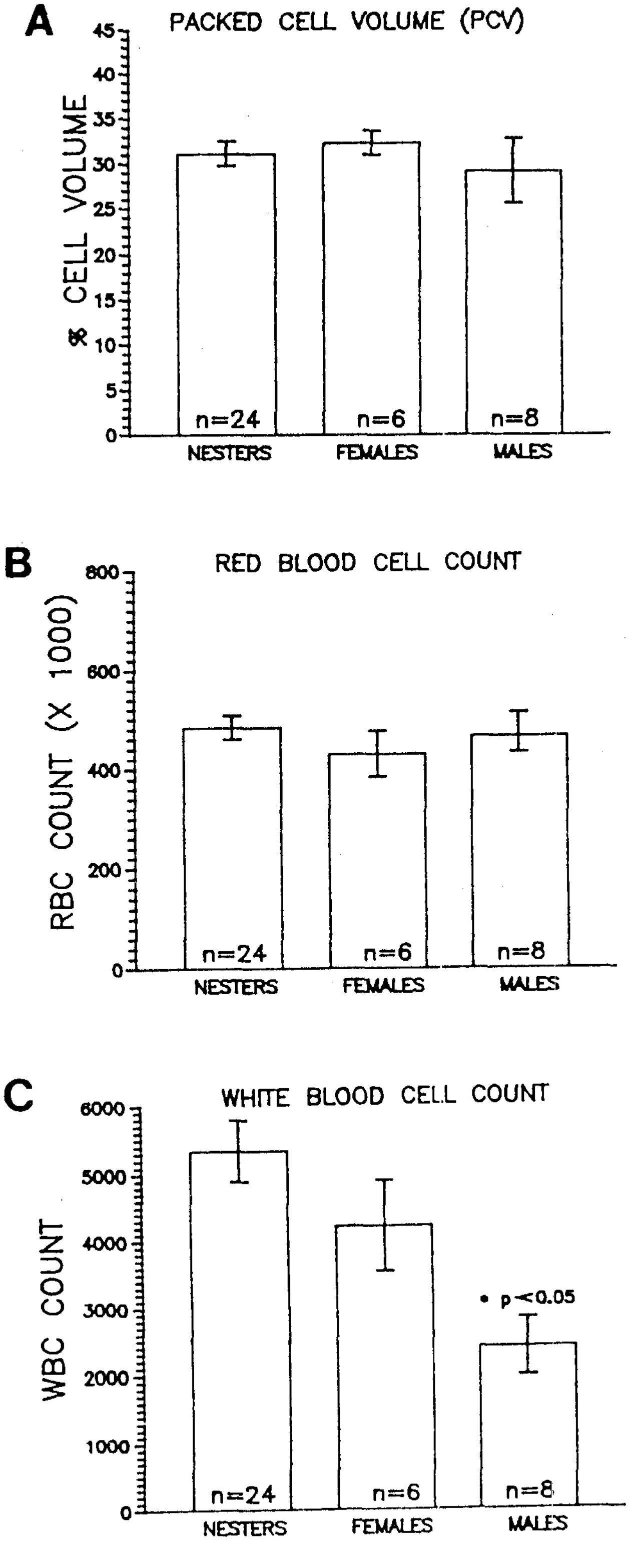
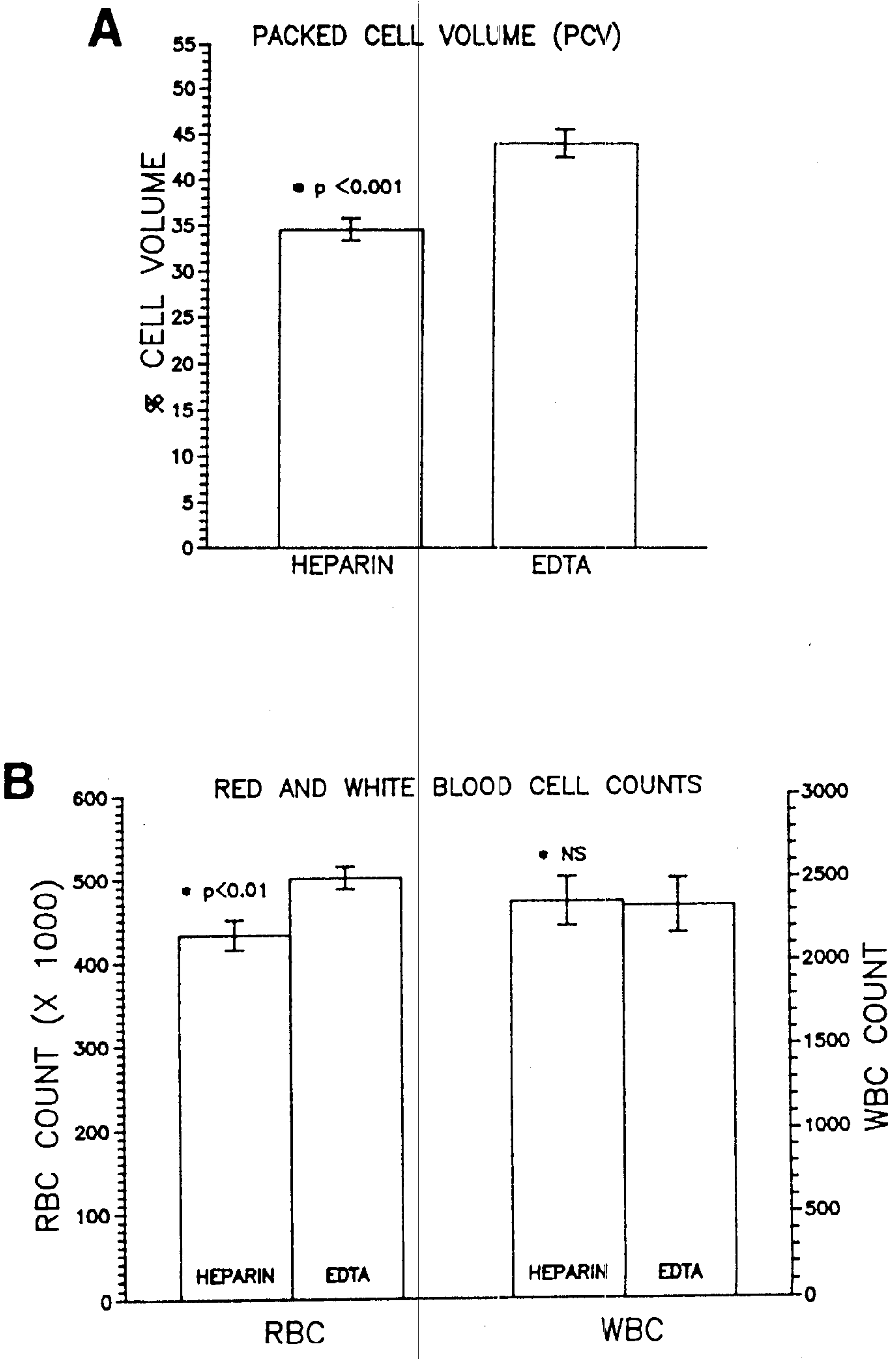


**Figure 2.** Hematology parameters of EDTA versus Lithium heparin in captive green turtles. **A)** The packed cell volume of heparinized blood was significantly lower than EDTA blood ($t = 4.85$; $df = 9$; $p<0.001$). **B)** EDTA red blood cell counts were significantly higher than heparin counts ($t = 3.01$; $df = 9$; $p <0.01$) but there was no significant difference in white blood cell counts of heparinized versus EDTA blood.



# BUCK ISLAND REEF NATIONAL MONUMENT SEA TURTLE PROGRAM, 1989

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**Jane Fleetwood**
**Kevin McIntyre**
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The program objectives were to collect basic biological information on hawksbill sea turtles (Eretmochelys imbricata) nesting on Buck Island Reef National Monument (BUIS), continued long-term population study, and monitor nesting beach management concerns, i.e., impact of recreation, erosion and beach debris, predation, and poaching. In addition, impacts of hurricane HUGO, September 17-18, 1989, on nesting beach success are discussed.

There are three principal sea turtle nesting areas; the North Shore, West Beach, and the South Shore/Turtle Bay (Figure 1). The North and South Shores are typical hawksbill nesting habitat (beach forest, low berms, cobble or sand beaches, offshore coral reefs), while West Beach has a wide, exposed beach with no offshore reefs.

Day beach surveys are conducted before and after the nocturnal research program recording all nesting sea turtle activities. With the aid of local and visiting volunteers, technicians were able to patrol the nesting beaches 6 nights per week. Nesting sea turtles were located by their crawls in the sand or the presence of fallen "knockdowns," wire survey markers spaced 24 inches apart on the berm crest. All morphometric data were recorded, nesting behaviors timed, and during covering sea turtles were tagged with NMFS Inconel tags. Three animals were tagged with inconel and flexible plastic Rotoriese tags. Nest excavations were conducted 60 days after laying to determine hatching success.

**Effects of Hurricane Hugo on Buck Island Nesting**: On September 17-18, 1989, Hurricane Hugo, a meteorological event of phenomenal proportions disrupted the sea turtle nesting season at Buck Island. The hurricane passed directly over the island of St. Croix effecting Buck Island nesting beaches. For over 12 hours, winds gusting to 200 mph battered the islands. The slow passage and extreme duration of the storm were the causes of extensive damage to shorelines and vegetation.

Several changes in normal, non-hurricane, nesting patterns were observed. In 1988, monthly nesting distribution on the three nesting beaches shows less than 15% of hawksbill activities on West Beach (Figure 2). In 1989, post-hurricane, nesting activities on West Beach were 40% higher than 1988 and double that prior to the storm. Increased nesting activity on West Beach, an atypical hawksbill nesting habitat, was due to storm erosion, fallen trees and extensive root tangles which had effectly closed the beach forest nesting areas along the North and South Shores (Figure 3). In addition, the false crawl ratio doubled after the hurricane from 31% up to 59% (Figure 4).

**1989 Nesting Results**: The hawksbill nesting season spanned 7 months peaking July through October (Figure 5). During the 47 nights on the nesting beaches, 34 hawksbill activities were observed and 16 females tagged (Table 1). There were 171 hawksbill nesting activities recorded; 71 confirmed nests, 50 false crawls, and 50 unconfirmable activities (Figure 4). Each nesting area showed its own peak in activities within the nesting season; this was also observed in 1988. The North Shore supported 34% (58) of the hawksbill activities, West Beach 22% (37), and South Shore 44% (76) of the annual nesting activities. Figures 6 and 7 of nesting activity distribution show clumping on both North and South Shore. Average inter-nesting interval for 17 observed activities was 14 days (SD = .707). Nesting site fidelity was frequently observed. Tagged individuals nested repeatedly within a few meters of their previous nest sites (See Table 1 in paper section). Whole beach success was 53.7%, lowered by 3 nests whose poor success was not attributed to erosion, predation, or poaching. For nests surviving to term, hatching success was 83.7% (N = 45, SD = 23.87, and range was 62 - 212 eggs).

Several of the management concerns identified in 1988, i.e., harrassment, disorientation of nesting adults and hatchlings, beach traffic/recreation, and beach fires have been effectively reduced or eliminated. However, erosion and beach debris, a management concern prior to the hurricane, has become more extensive since the storm. Fallen trees and extensive root tangles along the North Shore nesting area will have to be reduced prior to the 1990 season to prevent potential entanglement of nesting adults and provide access to stable beach forest for successful nesting. Several incidents of predation occurred on the South Shore in 1989; although trapping efforts removed several black rats, the identity of the"predator" remains in question. There were no confirmed incidents of poaching on BUIS in 1989, however, several well-covered nest holes which did not contain eggs were excavated 60 days after a successful nesting attempt was recorded in these areas.

The results of the 1989 BUIS hawksbill research program have met all the program objectives. Nocturnal research and tagging has continued to add to the data base on nesting hawksbill turtles in the Caribbean, providing information on nest site fidelity, population size, remigration interval, fecundity, tag loss, and species habitat use and requirements. The several management concerns addressed by the program have increased the park's understanding of impacts on nesting which is assisting in the development of a sea turtle nesting and habitat management plan for BUIS. With the continued support from the National Park Service, 1990 will be the third year of the program.

Table 1. Tagging information on female hawksbill sea turtles nesting on Buck Island Reef NM, U. S. Virgin Islands, 1989.

| Riese Type 2 NPS/BUIS[1] | NMFS Tag[2] | Date Tagged | Tagging Location[3] | Other Dates Observed |
|---|---|---|---|---|
| | LFF/RFF[4] | | | |
| - | 835/826 | 6/21/89 | SS/16 | 7/21 |
| - | 837/836 | 6/25/89 | NS/01 | 7/10;7/25;8/08 |
| - | 839/838 | 626/89 | NS/01 | 7/11;7/25;8/08 |
| - | 841/842 | 7/16/89 | SS/17 | 7/31;8/16 |
| - | 844/845 | 7/17/89 | NS/04 | 8/01;8/15 |
| - | 829/834 | 7/23/89 | SS/17 | 8/08;8/22 |
| - | 852/851 | 7/25/89 | NS/04 | 8/09 |
| BI 006 | 847/ | 7/27/89 | SS/13 | 8/10 |
| BI 007 | 853/ | 8/04/89 | WB/10 | 8/20 |
| BI 001 | /857 | 8/06/89 | NS/2A | 8/22 |
| - | 833/828 | 8/06/89 | NS/2A | 8/22 |
| - | 859/858 | 8/06/89 | NS/02 | - |
| BI 008 | 840/ | 8/10/89 | SS/14A | - |
| - | 865/860 | 8/14/89 | NS/01 | - |
| - | /864 | 8/16/89 | NS/01 | - |
| - | 846/855 | 8/18/89 | TB/19 | - |

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[1] Dalton Rotoriese Type 2 Flexible Pastic Tag. Yellow. "BI 000" Inscription: Return Send NPS/BUIS, C'STED; STX, USVI, 00821

[2] National Marine FIsheries Service, Inconel Tags, Series PPW.

[3] Nesting area (SS = south shore; NS = North shore; WB = West Beach; TB Turtle Bay) and corresponding "Marker" number see Figure.

[4] Left Front Flipper/ Right Front Flipper - tag position.

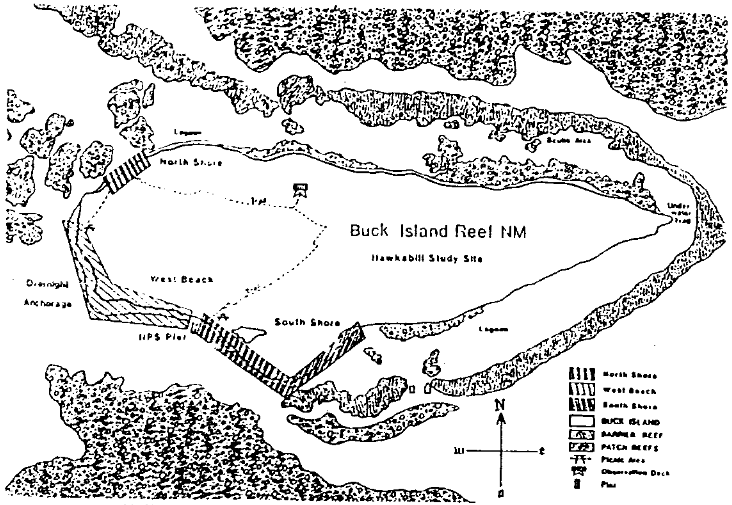
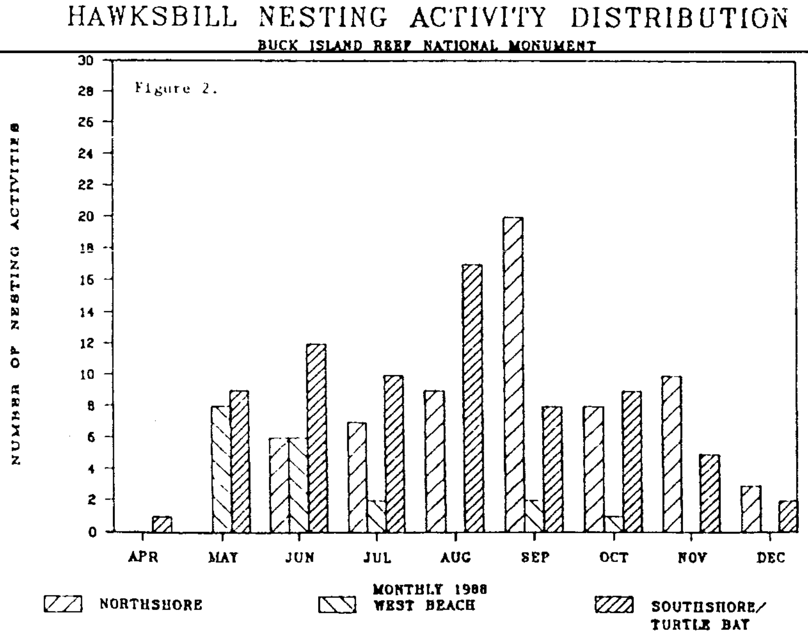
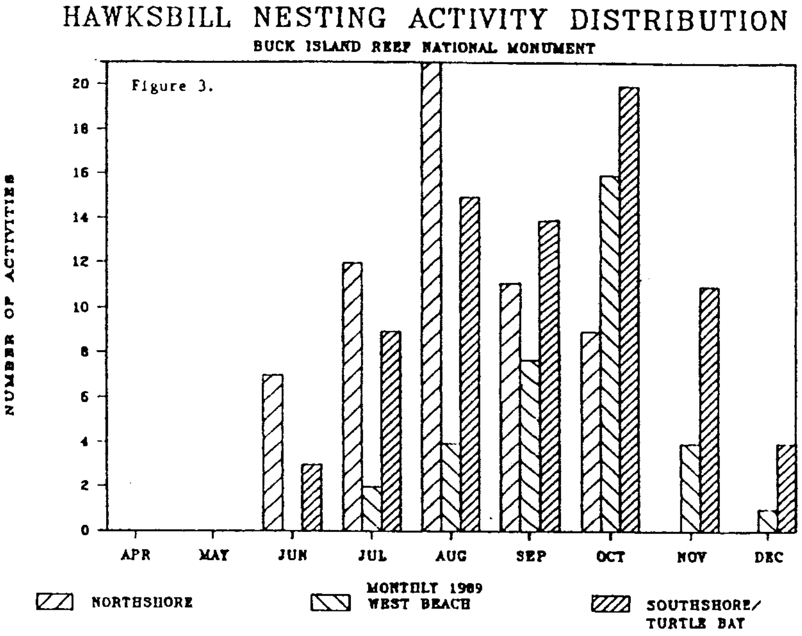
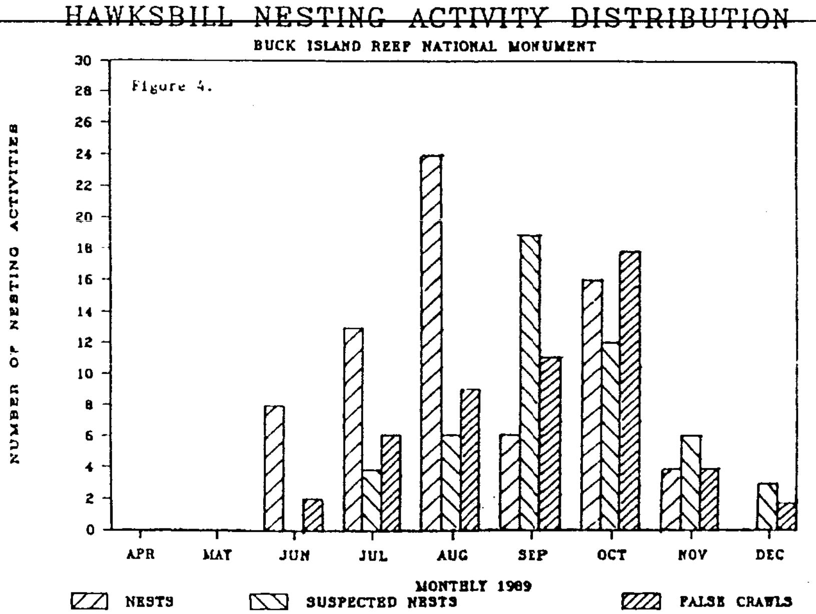


Figure 1. Buck Island Reef NM Study Site. Predominant sea turtle nesting area; North shore, West Beach, and South shore. 1989.

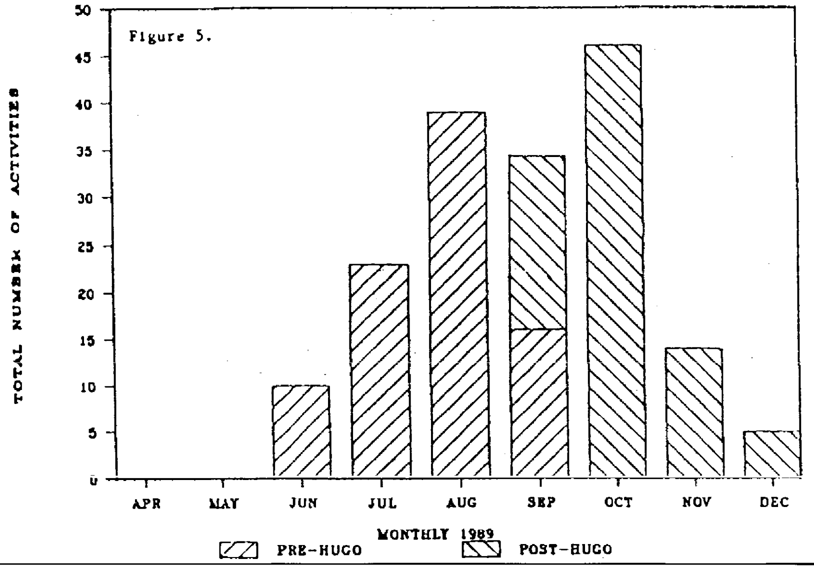






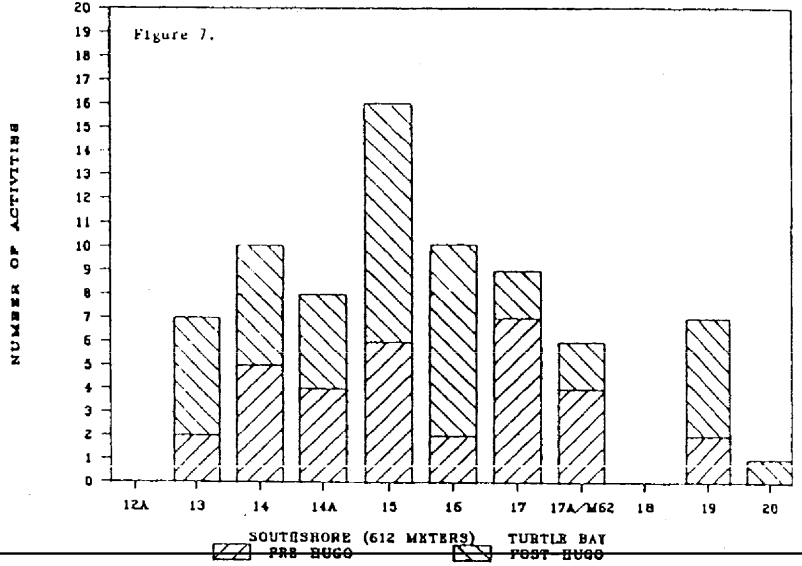
## HAWKSBILL SEA TURTLE ACTIVITY

**BUCK ISLAND REEF NATIONAL MONUMENT**



## HAWKSBILL NESTING ACTIVITES 1989

**BUCK ISLAND REEF NATIONAL MONUMENT**



## HAWKSBILL NESTING ACTIVITES 1989

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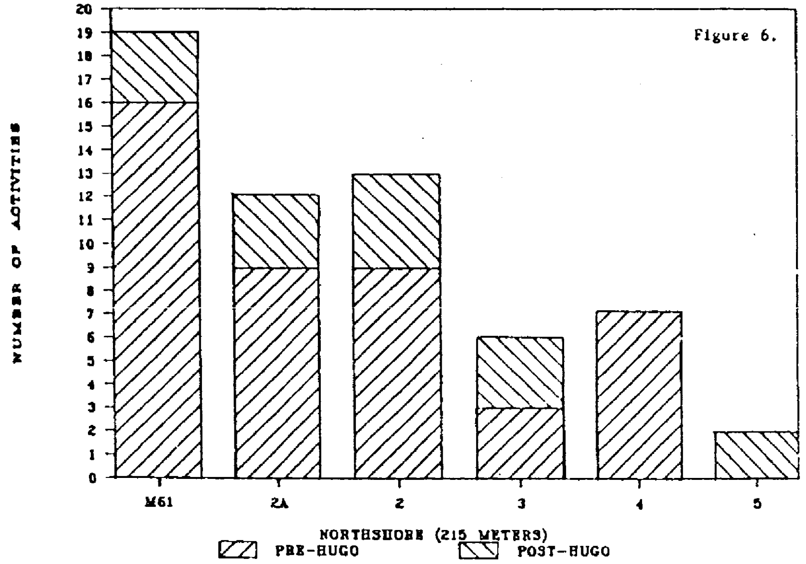

# NEST SITE LOCATION AND NEST SUCCESS IN THE HAWKSBILL TURTLE (ERETMOCHELYS IMBRICATA) IN BARBADOS, WEST INDIES

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The locations of hawksbill nest sites in Barbados were recorded over a three-year period (1987-1989). Most nesting activity took place on the leeward west coast beaches of the island, fewer on the more exposed south coast beaches, and fewest on the fully exposed Atlantic east coast beaches of the island.

A sample of 32 nests were monitored until hatching; nest contents were dug up and examined. Unhatched eggs were opened and categorized as undeveloped (died prior to embryo formation) or as dead embryos (died during development). The number of trapped hatchlings was also recorded. Indices of nest success were calculated and are shown in Table 1. Four environmental characteristics of nest sites were recorded; the profile (slope) of the beach, the distance inland from the high tide mark to the nest site, the elevation of the nest above mean sea level and the presence of vegetation. Four edaphic factors were measured at nest depths; % water content, % organic content, temperature (°C) and % sand particle size <425 microns. The compaction of sand at each nest site was recorded using an Eijkelkamp-Giesbeek penetrometer which measures penetration resistance through a semi-solid medium in $N/cm^2$.

Overall emergence success (% of eggs laid that emerged from the nest) is low in Barbados (75.5%, Table 1) compared to hawksbills in Costa Rica (91.6%, Bjorndal et al., 1985) and the Virgin Islands (90.1, Small 1982). The primary reason for the low emergence in Barbados is that the % undeveloped eggs is high (11.1%) compared to that in Costa Rica (3.8%, Bjorndal et al., 1985), and that escape success (% of hatchlings that escaped from the nest) is low (Table 1).

The beach profile, distance inland from the high tide mark to the nest, and the elevation of nests are shown separately for west, south and east coasts in Table 2. The elevation of nests above mean sea level does not differ between coasts (Kruskall-Wallis, $P>0.05$), because hawksbills adjust for differences in beach slope by changing the distance they go above the high tide mark before nesting (Table 2). On steeper sloping beaches, females travel less far above the high tide mark (Kruskall-Wallis $P<0.05$, Table 2). These results suggest that controlling for elevation above mean sea level may be an important aspect of nest site selection by hawksbills.

The costs, measured in terms of energy expenditure by gravid hawksbills and in terms of levels of hatchling predation, may be greatest on the east coast, less on the south coast and least on the west coast, both because of higher wave energy and because gravid females and hatchlings must travel further to and from nest sites on the east coast than on the south and on the west coasts. This is consistent with the observation that nesting is more common on the protected west coast than on the exposed east coast.

Indices of nest success by coast are shown in Table 3. Emergence success from nests is highest on the west coast and lowest on the east coast, primarily because hatching success is low (72.1%) on the east coast and % undeveloped eggs is high (26.1%). These results indicate that nest success is highest on the coast preferred by hawksbills (west coast), and lowest on the coast least often used by hawksbills (east coast).

West, south and east coast nest sites differed significantly in all edaphic factors measured (Table 4), but statistical analysis revealed that none of these factors were significantly correlated with emergence success (Table 5).

Emergence success was negatively correlated with compaction (Table 5). This is because escape success was lowest from most compacted nests (Table 5). This suggests that sand compaction is a major factor influencing nest success of hawksbills in Barbados. Notably, nest sites at which vegetation was present were significantly less compacted (mean 76.9% N/cm$^2$) than non-vegetated sites (mean 174.3 N/cm$^2$; Mann-Whitney U=93, $P<0.05$); and escape success was significantly higher from vegetated than non-vegetated nests (Mann-Whitney U=74.5, $P<0.05$). Vegetation may strongly influence hawksbill nest success through its effect on reducing compaction. On beaches where gravid females were able to choose between vegetated and non-vegetated sites, significantly more chose to place their nests amidst vegetation ($X^2_c=5.3$, $P<0.05$). Nests made below the mean islandwide elevation had higher % dead embryos than those above the mean elevation (Mann-Whitney U=74, $P<0.05$).

The results suggest that, both at the level of coast and on a given beach with respect to elevation and vegetation, hawksbills show active nest site preference and the preference displayed is adaptive.

Increasing coastal development in Barbados will continue to remove vegetation, restrict elevation choice and increase sand compaction on beaches, and these changes will negatively affect nest success of hawksbills.

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TABLE 1

CLUTCH SIZE AND INDICES OF NEST SUCCESS OF HAWKSBILL NESTS AROUND BARBADOS

| | N | MEAN | SD |
|---|---|---|---|
| CLUTCH SIZE | 32 | 127.0 | 30.27 |
| % EMERGENCE[1] | 32 | 75.5 | 29.00 |
| % HATCHING[2] | 32 | 84.5 | 19.80 |
| % UNDEVELOPED[3] | 32 | 11.9 | 17.20 |
| % DEAD EMBRYOS[4] | 32 | 4.4 | 11.2 |
| % ESCAPE[5] | 32 | 86.5 | 29.6 |

1. % laid that emerged from the nest
2. % laid that hatched
3. % laid that were undeveloped
4. % laid that died as embryos
5. % hatched that escaped from the nest

## TABLE 2.

NEST SITE CHARACTERISTICS ON THE WEST, SOUTH AND EAST COASTS (MEANS; STANDARD DEVIATIONS IN PARENTHESIS).

| | WEST COAST | SOUTH COAST | EAST COAST |
|---|---|---|---|
| BEACH PROFILE | 32.8(5.55) | 24.3(7.55) | 19.8(4.75) * |
| DISTANCE OF NEST ABOVE THE HIGH TIDE MARK (M) | 6.15(4.28) | 8.55(5.2) | 10.8(7.0) * |
| ELEVATION OF NEST ABOVE MEAN SEA LEVEL (M) | 1.05(0.29) | 1.18(0.17) | 1.08(0.46) |

* INDICATES SIGNIFICANT DIFFERENCES BETWEEN THE THREE COASTS (KRUSKAL-WALLIS; $p<0.05$)

## TABLE 3.

INDICES OF NEST SUCCESS BY COAST (MEANS; STANDARD DEVIATIONS IN PARENTHESIS)

| | WEST COAST | SOUTH COAST | EAST COAST |
|---|---|---|---|
| % EMERGENCE | 79.1(25.4) | 73.9(31.5) | 70.9(35.5) |
| % HATCHING | 89.1(6.4) | 85.6(18.7) | 72.1(35.2) |
| % UNDEVELOPED | 8.2(5.9) | 9.2(8.3) | 26.1(35.9) |
| % DEAD EMBRYO | 3.2(4.3) | 6.6(17.1) | 2.4(2.7) |
| % ESCAPE | 89.1(27.4) | 85.9(28.5) | 85.3(34.6) |

TABLE 4.

EDAPHIC FACTORS AT WEST, SOUTH AND EAST COAST NEST SITES (MEANS; STANDARD DEVIATIONS IN PARENTHESIS)

| | WEST COAST | SOUTH COAST | EAST COAST |
|---|---|---|---|
| % WATER | 4.54(1.87) | 5.98(1.14) | 5.63(2.97)* |
| % ORGANIC | 1.39(0.26) | 1.61(0.24) | 1.26(0.26)* |
| TEMPERATURE | 32.4(2.2) | 30.3(1.81) | 30.5(0.4)* |
| PARTICLE SIZE (%<425microns) | 70.4(10.8) | 26.5(19.9) | 79.1(11.4)* |

* INDICATES SIGNIFICANT DIFFERENCES BETWEEN THE THREE COASTS (KRUSKAL-WALLIS; $P<0.05$).

TABLE 5.

SPEARMAN'S RANK CORRELATION COEFFICIENTS BETWEEN INDICES OF NEST SUCCESS AND EDAPHIC CHARACTERISTICS OF NEST SITES.

| | % EMERGE | % HATCH | % UNDEVELOPED | % DEAD EMBRYOS | % ESCAPE |
|---|---|---|---|---|---|
| % WATER | .11 | .14 | .19 | -.11 | -.08 |
| % ORGANIC | .19 | .41* | -.24 | -.32 | .12 |
| TEMPERATURE | -.16 | -.13 | .007 | .39* | -.17 |
| PARTICLE SIZE | -.04 | -.12 | .09 | .08 | .008 |
| COMPACTION | -.45* | .04 | -.04 | .16 | -.78* |

* INDICATES A SIGNIFICANT CORRELATION BETWEEN THE TWO VARIABLES ($P<0.05$).

# ARE FUNGI AND BACTERIA RESPONSIBLE FOR OLIVE RIDLEY'S EGG LOSS?

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## INTRODUCTION

The genus Lepidochelys is the only sea turtle genus that has the unique reproductive strategy in which several thousand, up to 100,000, turtles emerge to nest in 3-7 consecutive nights. This phenomenon is known as "arribada", and it occurs on 2 beaches on the Pacific coast of Costa Rica: Nancite and Ostional. Despite such impressive numbers of nesting females, successful nests are very rare: only 4% in Nancite and 8% in Ostional produce any neonates. The main cause of nest loss is attributed to microorganism contamination.

Up to 150-300 tons of organic matter, represented by broken eggs, can be added in each arribada to the beach. This accumulation of organic matter creates an optimum media for fungal and bacterial growth. Cornelius and Robinson (1985) found a differential hatching success along both the length and the width of Nancite beach. The most productive area was in the middle zone of the center part of this 1.1-km long beach, where an estuary opens up during heavy rains or very high tides. It is believed that the sand in this area is "cleaner" than in the rest of Nancite, since all the old nests are washed away by the water when the estuary opens up. If microorganism levels in the sand are directly related to hatching success, Cornelius and Robinson's results would corroborate this hypothesis.

This study has the following objectives:

1. To determine the microflora present in nest sand, eggs, and olive ridley cloacas on Nancite beach.
2. To compare the levels and diversity of microorganisms throughout the year and in different parts of the beach.
3. To establish a correlation between levels and diversity of microorganisms and the hatching success of natural and artificial nests.
4. To determine the pathogenicity of isolated bacteria and fungi in experimentally infected eggs under artificial incubation.
5. To study the interrelationship between biotic and physical factors (humidity and temperature) which may cause embryo death and subsequent invasion of the egg by bacteria and fungi.

## METHODOLOGY

1. We marked and protected natural nests with wire mesh on Nancite beach between May and December 1987.
2. From each of these nests, we collected a sand sample at the time eggs were laid, and after incubation (45-55 days), for bacterial and mycotic culture. We also cultivated eggs that failed to hatch, eggshells, and cloacal swabs from females.

3. Artificial incubation with different substrates was done in styrofoam boxes in the lab. Treatments were as follows:

   a) polystyrene foam pad;
   b) Nancite sand, in front of estuary, high tide zone;
   c) Nancite sand, in front of estuary, vegetation zone;
   d) Nancite sand, outside estuary, high tide zone;
   e) Nancite sand, outside estuary, vegetation zone;
   f) Naranjo beach sand, high tide zone;
   g) Nancite sand, autoclaved.

4. Bacterial cultures were done in marine agar, except for cloacal swabs (on blood agar). Fungi were grown on Saboraud agar with 1% chloramphenicol. Identification was done to genus or species whenever possible, according to Lenette et al. (1985) and Buchanan and Gibbons (1974).

5. Eggs have been experimentally infected with fungi and bacteria isolated in the first part of this study, and incubated on foam pads, under different levels of temperature and humidity.

6. Eggshells of viable eggs incubated for 2, 4, 6, and 8 weeks are submitted to scannon electron microscopy. Eggshells of eggs that failed to hatch are also examined by scanning electron microscope.

## RESULTS AND DISCUSSION

Hatching success in natural nests was very low as expected: only 1 out of 21 was successful (4.8%). This result coincides with Cornelius and Robinson's (1985) findings. Seven of a total of 28 marked nests were lost due to erosion, vertebrate predation or marker loss. Due to the low number of successful nests, we could not correlate bacterial levels or microorganism diversity to hatching success. The number of bacterial colonies per gram of sand did not vary significantly during the nesting season, but a comparison with sand from the adjacent beach, Naranjo, where only occasional olive ridleys and leatherbacks nest, showed at least 6 orders of magnitude difference between the levels of Nancite and Naranjo (Fig.1). There was no spatial pattern of microorganism distribution along Nancite beach either.

Table 1. Identified bacteria and fungi, found in nest sand, eggs, and turtle cloaca.

| BACTERIA | NS | EG | CL |
|---|---|---|---|
| Enterobacter sp | X | X | X |
| Serratia sp |  | X | X |
| Acinetobacter sp | X | X | X |
| Staphylococcus sp |  | X | X |
| Alcaligenes sp |  | X | X |
| Vibrio sp | X | X |  |
| Citrobacter sp | X | X |  |
| Pseudomonas sp | X | X |  |
| P. aeruginosa | X | X | X |
| Bacillus sp |  | X |  |
| Micrococcus sp | X |  |  |
| Achromobacter sp | X | X |  |
| Klebsiella sp | X |  |  |
| Proteus sp | X |  |  |
| Aeromonas sp |  | X |  |

Table 1. (continued)

| FUNGI | NS | EG | CL |
|---|---|---|---|
| *Fusarium sp* |  | X | X |
| *Hormodendrum sp* | X | X |  |
| *Aspergillus spp* | X | X |  |
| *Allescheria sp* | X | X |  |
| *Saksenaea vasiformis* | X | X |  |
| *Crisosporium sp* | X |  |  |
| *Gliocladiopsis sp* |  | X |  |
| *Cunninghamella sp* |  | X |  |
| *Acremonium sp* | X |  |  |
| *Paecilomyces sp* | X |  |  |
| *Absidia sp* | X |  |  |
| *Mucor sp* | X |  |  |
| *Penicillium sp* | X |  |  |

NS=nest sand; EG= eggs; CL= cloaca.

4. Artificial nests proved to be a good method to compare hatching rates with different substrates. The highest rate was achieved with foam pad (68.7%). Other hatching rates were: Nancite, out of estuary, high tide zone (50.0%); Nancite, in front of estuary, high tide zone (30.2%); Nancite, autoclaved sand (30.2%); Naranjo (6.7%); and Nancite, in front of, and outside estuary, vegetation zone (0.0%). These results imply that biotic factors may not be as important as physical ones to determine hatching success, as the autoclaved sand treatment did not produce a high number of neonates.

5. Experimental infection with bacteria and fungi has shown that several of these are secondary agents: *Alcaligenes*, *Klebsiella*, *Citrobacter*, *Achromobacter*, and *Proteus* did not significantly reduced hatching rates compared to controls. *Aspergillus sp* was consistently found in successful nests.

6. Experimental infection with other isolated bacteria and fungi, under different temperature and humidity, is under way.

7. Electron microscopy examination of eggshells, both from healthy and unhealthy eggs is also in progress.

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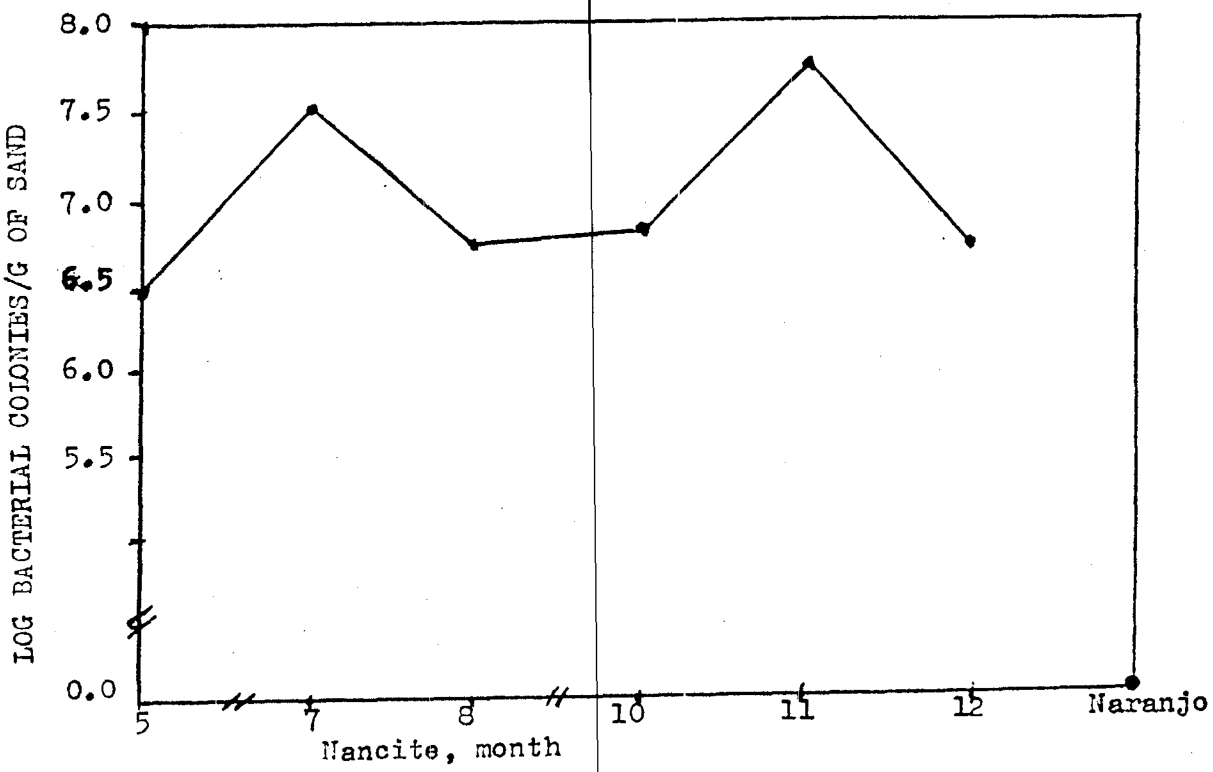
Figure 1. Number of bacterial colonies (log/g of sand) in Playa Nancite from May through December of 1987, and in Playa Naranjo.



# SERUM THYROID HORMONES IN SEA TURTLES

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## INTRODUCTION

In vertebrates, it has been proposed that thyroid hormones regulate energy demanding processes such as growth, development, and reproduction. Although many experiments have been conducted to describe thyroid function in snakes and lizards, the function of thyroid hormones in other reptilian species, such as sea turtle species, has rarely been investigated. Thyroid hormone measurements in sea turtles were made only by Licht et al. (1985), in which the annual thyroxine levels for male green sea turtles in captivity were described. The purpose of this paper is to describe the seasonal or annual variation of the hormones in additional sea turtle species of both sexes, with the objective of identifying periods of possible metabolic activation.

## METHODS

Blood samples were taken at regular intervals from the following sea turtles:

a. Wild immature green (Chelonia mydas) and loggerhead (Caretta caretta) sea turtles, captured in the water off coral reefs at Heron Island, Australia, were sampled monthly from July to November 1985 (n=2-9, n=5-9, respectively). The water temperature during the study period ranged approximately from 19 °C in July to 27 °C in November.

b. Captive adult Kemp's ridley (Lepidochelys kempi) sea turtles at Sea Arama Marineworld in Galveston, Texas, U. S. A., were sampled monthly from March 1987 to February 1988 (n=5 for females and n=3 for males). Animals were maintained in indoor tanks individually under controlled temperature and were fed a diet of squid, capelin, herring and smelt. The water temperature during sampling time ranged from 21 °C in winter to 29 °C in summer.

Turtles were bled from the cervical sinus into vacutainer tubes. The serum was separated and kept frozen until it was assayed by thyroxine ($T_4$) and triiodothyronine ($T_3$) radioimmunoassay (RIA) (MacKenzie et al., 1977, with modification described by Denver and Licht, 1988).

## RESULTS

The thyroxine levels of wild immature green sea turtles over the 5 month sampling period were low and constant, ranging from 1.6 ng/ ml to 3.1 ng/ml in females and 1.9 ng/ ml to 3.0 ng/ ml in males. Wild immature loggerhead sea turtles also showed low and constant levels of thyroxine which ranged from about 0.8 ng/ ml to 1.5 ng/ ml in females and 0.9 ng/ ml to 1.4 ng/ ml in males. No significant variations in immature animals were observed during the sampling periods. $T_3$ was non-detectable in both species. Captive adult Kemp's ridley sea turtles at Sea Arama appeared to have a seasonal cycle of thyroxine in females but not in males (Fig. 1). Females displayed higher levels of thyroxine in spring (12 to 13 ng/ml) and winter (9.5 to 11 ng/ml) than in summer and fall (4.5 to 7ng/ml). Males showed relatively constant levels of thyroxine which ranged from 3 to 6.5 ng/ml. $T_3$ was non-detectable in both male and female Kemp's ridleys.

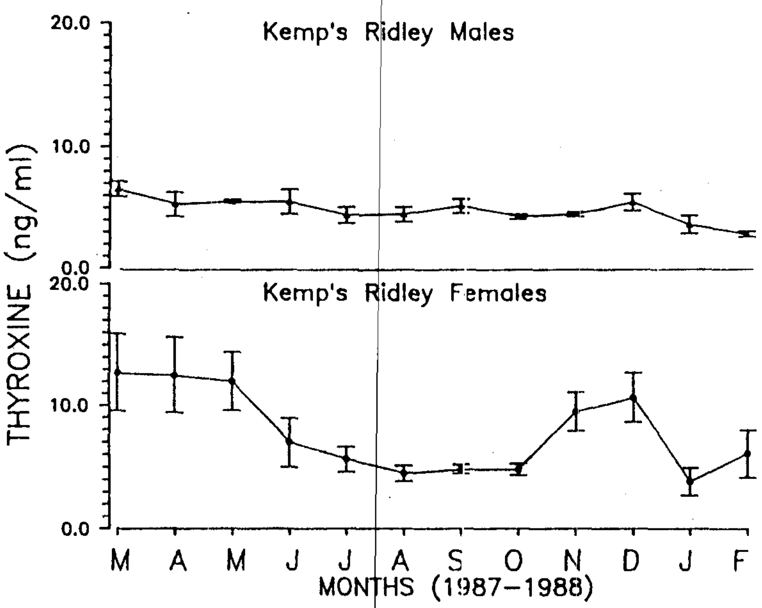

Figure 1. Mean thyroxine levels from captive male and female Kemp's ridley sea turtles sampled monthly from March 1987 to February 1988. Vertical bars represent standard errors (n=3 for males and n=5 for females).

## DISCUSSION

1. Thyroid hormone cycles were found in groups of captive female Kemp's ridleys, but not in males, indicating a possible activation of thyroid hormone secretion associated with ovarian development (Rostal et al., 1988). According to Rostal et al. (1988), female Kemp's ridleys were observed by laparascopy to have follicles yolking up during fall and winter when thyroxine increases, but no follicles were observed yolking up during summer when thyroid levels were low.

2. The investment of thyroid hormone in female reproduction is supported by observed lack of thyroxine elevations in immature animals. However, a number of differences between wild immature and captive adult animals were observed. Sampling over relatively brief periods may not show the increase of thyroid hormone. Either food availability or temperature or both may also influence thyroid state.

3. $T_3$ was non-detectable, indicating a low rate of $T_4$ to $T_3$ conversion or high clearance rate of $T_3$.

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# OBSERVATIONS ON THE REPRODUCTIVE BIOLOGY OF THE BLACK TURTLE, *CHELONIA AGASSIZI*, AT PLAYA COLOLA, MICHOACAN, MEXICO

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## INTRODUCTION

The general chronology for sea turtle reproduction was recently outlined by Owens et al., 1989. The suggested chronology of events involves a distinct mating period prior to the nesting period when multiple nests are produced. Fertilization of subsequent nests is thought to result from sperm stored in the albumen gland region of the oviduct. Behavioral variations in this chronology, however, have been observed in natural populations of both the green turtle (*Chelonia mydas*; Carr and Hirth, 1962) and the black turtle (*Chelonia agassizi*; Alvarado and Figueroa, 1989). Multiple matings were reported for females which had already begun nesting. It has been suggested that multiple breeding scenarios may exist among sea turtles (Alvarado and Figueroa, 1989). The behavioral and physiological factors involved are unclear. During the 1989 season, a pilot study was conducted at Playa Colola, Michoacan to investigate the reproductive biology of the black turtle (*C. agassizi*).

## METHODS

Behavioral and physiological data were collected from Nov. 10 to Nov. 25, 1989 during the late mating/mid-nesting season. Blood samples were collected from 33 adult black turtles (14 nesters, 6 false crawls, 6 mating females and 7 mating males). Mean curved carapace length was 79.6 ± 0.9 cm (SE, n = 7) for males and 85.3 ± 1.2 cm (SE, n = 26) for females. Turtles were captured at sea by hand from a motor boat (Alvarado and Figueroa, 1989). Behavior of the turtle (mating, escorting, nesting or false crawl) was recorded at the time of sampling. Evidence and location of mating scars were also recorded. Serum testosterone levels were measured using radio-immunoassay (Wibbels et al., 1987). For males, 10 to 100 ul of serum was extracted. For females, 250 ul of serum was extracted. Extraction efficiency was 75.8% (n = 4), inter-assay coefficient of variation was 22.7% and intra-assay coefficient of variation was 12.5%.

## OBSERVATIONS AND RESULTS

Extensive mating scars were observed on the neck, shoulder and carapace of all adult female black turtles (n = 26) captured at sea while mating and sampled on the nesting beach. Scarring was also observed on the flippers and base of the tail of mating male black turtles captured at sea (n = 6). These scars appear to result from biting by escort males. Nesting chronologies for females originally tagged at sea fit the general model as suggested (Fig. 1A). Females captured while mating were tagged and released and later observed nesting (n = 4). Several females (n = 7) originally tagged while nesting were later recaptured at sea being mounted by males (Fig. 1B). The function of these mounts remains unclear. The time intervals between nesting and mounting is highly variable (4 to 19 days) and two females (#A1322 and #A1541) were not observed nesting again following observed mounting at sea. The mean nesting interval observed for the black turtle at Playa Colola was 15.7 ± 1.7 days (SE, n = 18).

Serum testosterone levels of female black turtles sampled ranged from 28.5 pg/ml to 321.6 pg/ml (mean ± SE = 122.7 ± 17.4 pg/ml, n = 26). Mean serum testosterone levels were not significantly different for mating, nesting, or false crawls (Fig. 2A). Male serum testosterone levels ranged from 1.33 ng/ml to 10.32 ng/ml (mean ± SE = 5.08 ± 1.33 ng/ml, n = 7). Female serum testosterone levels were observed to decline with subsequent nestings (Fig. 2B). Female testosterone levels during nesting ranged from 30.7 pg/ml to 239.5 pg/ml (mean ± SE = 128.2 ± 23.3 pg/ml, n = 14).

## DISCUSSION

The reproductive biology of the black turtle does display some distinct variations from the general chronology model. The physiological and behavioral function of mating following nesting is difficult to determine. Females observed mating following nesting had variable serum testosterone levels (range 47.2 pg/ml to 232.4 pg/ml, n = 6) which appear more directly relatable to their nesting history (number of nests laid that season). Male serum testosterone levels were representative of reproductively active males. The intensity of mating aggression in this population is well evidenced in the mating scars observed on both male and females. The one escort male captured displayed virtually no scaring and the highest serum testosterone level (10.32 ng/ml) suggesting that he may be a new arrival on the mating grounds. A final observation that may influence the behavioral variations observed here is the spatial location of the mating grounds to the nesting grounds. The role of the multiple matings following nesting is unclear. At Playa Colola, the mating grounds are directly offshore from the nesting beach and mating pairs can sometimes be observed directly from the beach. Further behavioral and physiological data is required for the determination of the actual functional significance of these multiple matings during the nesting season.

## ACKNOWLEDGMENTS

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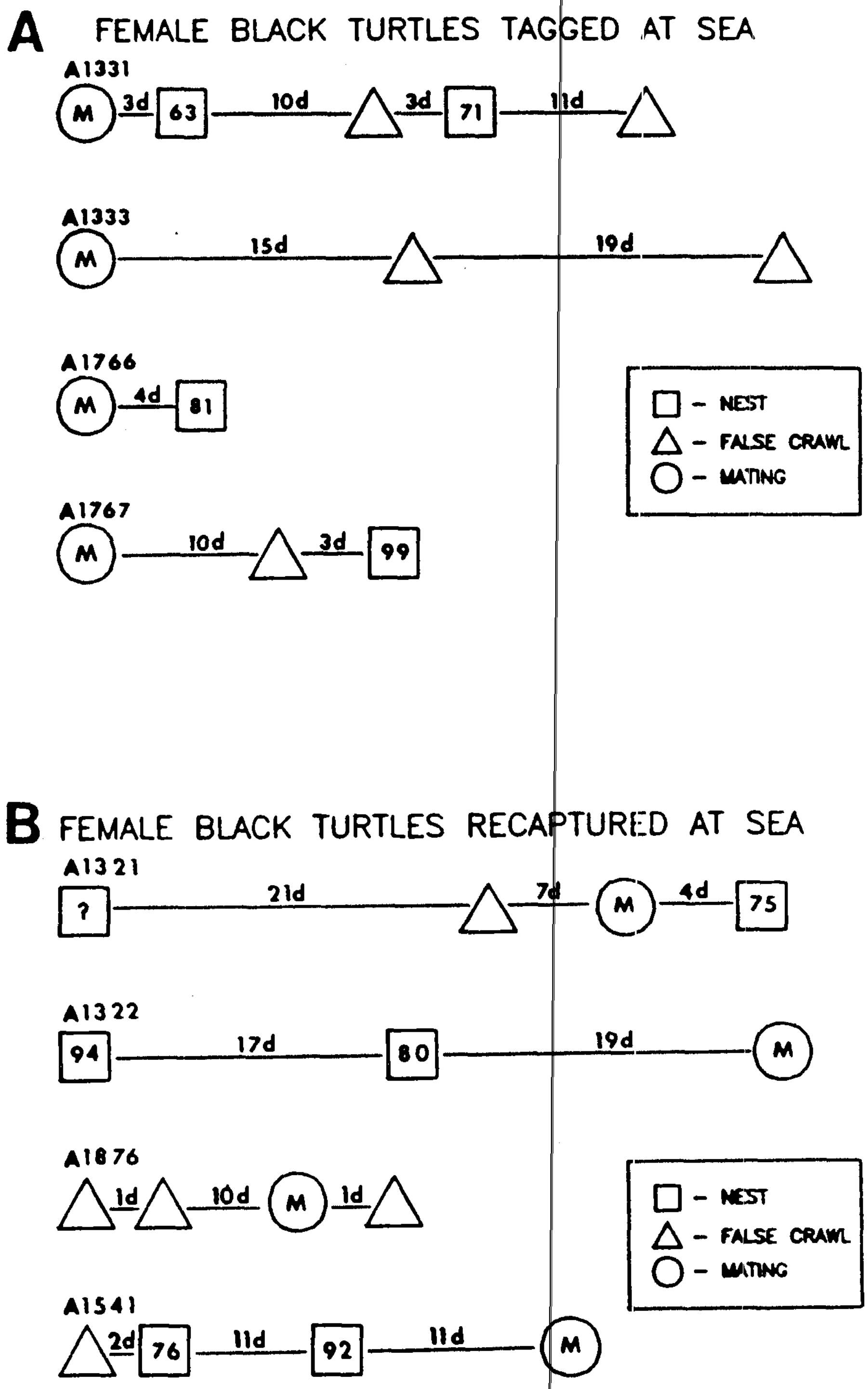

Figure 1. Mating and nesting chronology for female black sea turtles (Chelonia agassizi). (A) Females originally tagged at sea, and (B) females tagged on the beach and later recaptured at sea.

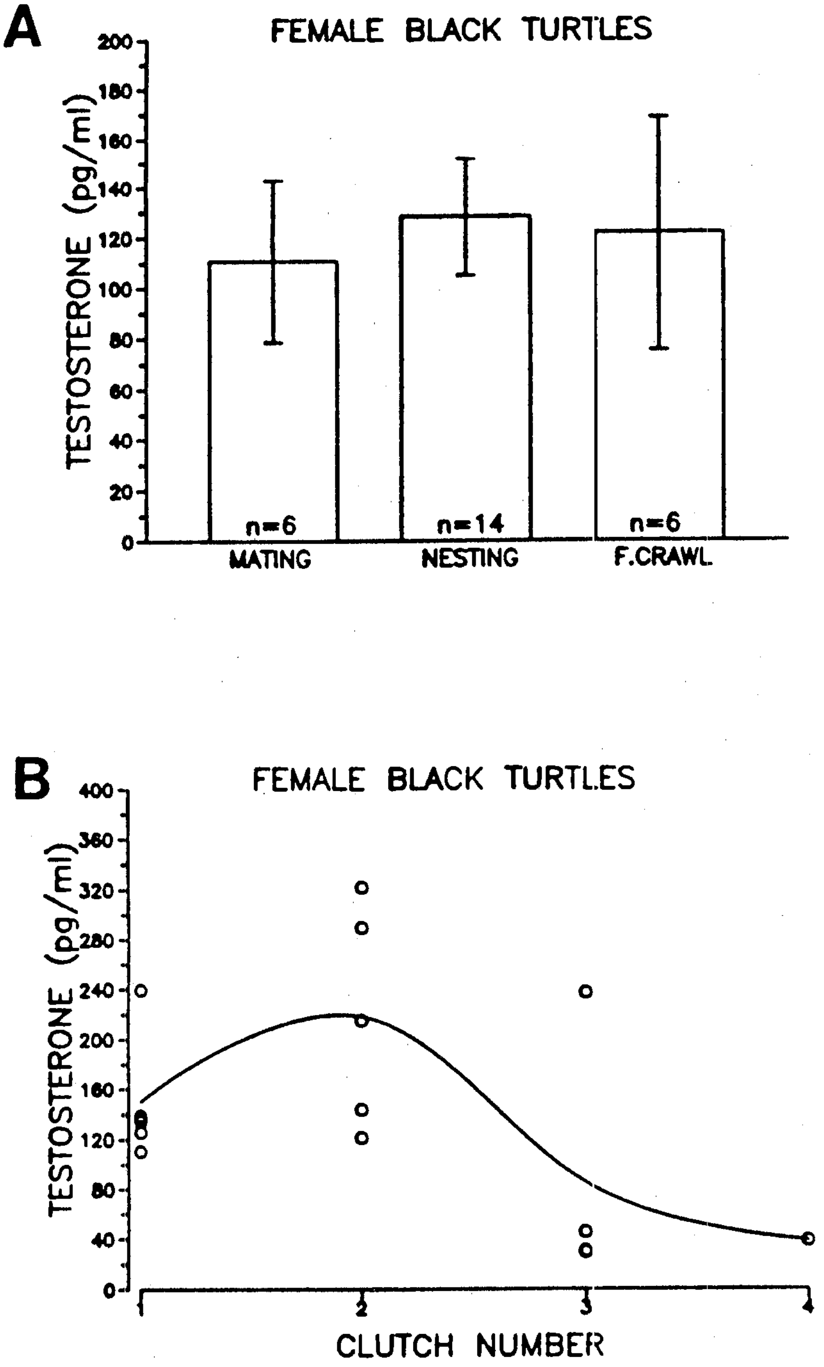

Figure 2. Serum testosterone levels (pg/ml) for female black sea turtle (Chelonia agassizi). (A) Mean serum testosterone levels for females sampled during mating, nesting, and false crawl. (B) Individual female serum testosterone levels relative to number of clutches.

# THE CURRENT SITUATION CONCERNING SEA TURTLE POPULATIONS AND THE CONSERVATION AND RESEARCH PROGRAM WITH PACIFIC RIDLEY (LEPIDOCHELYS OLIVACEA) AND LEATHERBACK (DERMOCHELYS CORIACEA) SEA TURTLES IN THE SOUTHERN RANGE OF THE STATE OF MICHOACAN

**A. Laura Sarti M.**
National Autonomous University of Mexico (UNAM)

The 1989-1990 season at the Sea Turtle Campground of "El Farito" will end on March 30, 1990. There has been much satisfaction and many good results, despite all the problems. Activities started on July 17, 1989, with the Pacific ridley (Lepidochelys olivacea), the species in our area that is commercially exploited. The Secretaria de Pesca (Fisheries Secretary) grants shares (quotas) to fishermen who are organized in "cooperativas" during the capture season (July - October 1989). Three out of four cooperatives that participated in the program this year did not complete their shares during any of the 4 months, because there were no profits and the economic loss was high. As a result, the cooperatives could not meet their payrolls owed to egg collectors and guards from the various campgrounds located on different beaches in the southern area of Michoacan. This condition of debt in turn caused the workers to abandon their jobs, leaving the nurseries and beaches exposed to abusive practices.

The Bahia de Bufadero Cooperativa, with whom we share the nursery, was one of the three that did not make a profit, even though it is the one with the largest number of available nests. We assisted them financially by taking care of them, providing the labor necessary to guard the beach.

The sad part of it all is that the smugglers of skin and turtle meat are among the "cooperativiastas," members of the cooperatives. The other members of the cooperatives can do nothing out of fear of getting into trouble. The law abiding members also say that the authorities know who are the smugglers, where the illicit products are delivered, to whom the products are delivered, and what quantity is delivered. It is said that there are alarming numbers of turtles captured in trammel nets as well as in other nets placed along the coast. I become discouraged when I see all of the problems, because I am unable to do anything substantial to correct the problems; I do not have adequate institutional support, and it is risky for me to become involved in these problems. I coordinate too many students and volunteers in a very hostile environment among the poachers and smugglers. For this reason, I choose to do nothing that might provoke violence against our research group, even though this lack of action on my part does not mean that I do not care about the situation.

I do not have the precise numbers of sea turtles taken legally and illegally, but I am certain that since 1985 the number of nesting females has diminished in our area. During this season (1989-1990), the highest number of nesting females was not more that 18 individuals along the 7-8 km beach during September, when in previous years there were up to 40 turtles nesting along a four kilometer stretch of beach.

I have personally verified the reduction in population numbers by means of surveys at sea, during which we used to see hundreds of sea turtles floating in certain area. During 1989, this past season, we did not see more that two sea turtles. I am willing to predict that the same losses are occurring at other beaches in the southern area of Michoacan, because there have been no nesting tracks report during recent censuses in those areas. I have three possible explanations for this lack of observed nesting activity:

- sea turtles have been displaced (not killed) for some unknown reason;
- what we are observing are normal populations fluctuations;
- the number of Pacific ridleys in the southern area of Michoacan is diminishing at an alarming rate.

The 1989-1990 leatherback nesting season was a poor one, with just a few individuals nesting (approximately 400 females this season). We tagged nearly 95% of the females present, obtaining good results from our double tagging project.

The problems that we encountered at the beginning of the season with embryo development and survival of hatchlings in the nests were solved satisfactorily by incubating the clutches in polyurethane boxes.

We have in captivity hatchlings of 20 Pacific ridleys, 20 leatherbacks, and 10 black turtles (Chelonia agassizi). The Pacific ridleys are a little over 3 months old, the leatherbacks are nearly two months old, and the black turtles are one month old, as of Februray 1990. The majority of the hatchlings are growing very well, mortality has been low, and we have learned interesting things about care of sea turtles in captivity. Care of the turtles has not been easy, since we do not have proper facilities for changing the water or for preparing food of crabs and fish.

Lack of budget and institutional support is a problem, as usual. However, my students from the National Autonomous University of Mexico (UNAM) have done an excellent job in the field, collecting money, equipment and food. They have also solicited the help of other students and the cooperation of the Sea Turtle Center and it's director, Michael Rugge, whose moral support and assistance with equipment have been a great help. Assistance from such sources has allowed us to complete the season satisfactorily. I would also like to express my appreciation to the Foundation for Field Research for their assistance with labor and equipment during the season.

# WITHOUT YOUR HELP THE OLIVE RIDLEY SEA TURTLES OF MEXICO ARE ON A RENDEZVOUS WITH EXTINCTION

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**Todd Steiner**
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Mexico is allowing the "legal" harvest of 23,000 olive ridley sea turtles this year along its Pacific coast (Loaeza, pers. comm.). The largest harvest occurs in the state of Oaxaca at the Mexican government slaughterhouse in San Augustinillo (Figure 1) where the 1989-90 quota has been set at 20,000. By mid-December, the quota had already been exceeded by more than 10,000 turtles, according to U.S. government sources (Anon., pers. comm.) and Mexican conservationists (Aridjis, 1990). The Mexican government has denied that the quota has been exceeded and the slaughter continues (Aridjis, pers. comm.).

U.S. government officials and Mexican conservationists estimate that when the illegal killing and legal harvest are combined, the true mortality exceeds 75,000 olive ridleys each year (Aridjeis, pers. comm.; Anon., pers. comm). Mexican conservationists have provided Mexican government officials with the names of individuals, corporations and government officials involved in the illegal slaughter and cover-up (Aridjis, 1990; Aridjis, pers. comm.), but no action has been taken.

**Is this a sustainable harvest?** Incomplete knowledge of the population biology of sea turtles remains a fact for most populations of sea turtles, even those that have been studied intensively for many years. In comparison to long-term studies of sea turtles of the Atlantic and Caribbean regions, the sea turtles of the Pacific are poorly understood.

Due to the mysterious life-history of sea turtles, our knowledge of their biology is unlikely to change dramatically in the future. Ehrenfeld (1981) concludes this dictates the need for a "very conservative conservation strategy."

Olive ridley turtles nest in massive near-synchronous arrivals (known as arribadas or arribazones in Spanish). Only twelve beaches worldwide are reported to have populations exceeding 10,000 females (Ross, 1981). This makes the adult female population extremely vulnerable to commercial exploitation.

At the beach known as Escobilla in Oaxaca, Mexico, the site of the present exploitation of olive ridleys processed for the San Augustinillo slaughterhouse, recent nestings have varied between 202,470 nests laid during six arribadas in 1987 (Ruiz and Marin, 1988) and 55,000 nests during four arribadas in 1989 (Ruiz and Marin, 1988).

U.S. government sources report that more than 99 percent of all turtles killed at San Augustinillo are gravid females, and that more than a million eggs are poached off the Escobilla beach each year.

Three other important nesting populations in Mexico: El Playon de Mismaloya, Jalisco; El Playon de Tlacoyunque, Guerro; and Bahia Chacahua, Oaxaca; each with female olive ridley nestings once estimated between 20,000-50,000 per year have collapsed from commercial exploitation (Kliffton et al., 1981; Ross, 1981; Ruiz and Marin, 1988).

The present level of exploitation in the state of Oaxaca, Mexico cannot be considered a conservative conservation strategy. The consensus of the sea turtle conservation community is that it is not sustainable and is likely to lead to the collapse of the population.

**Why slaughter sea turtles?** Olive ridley sea turtles in Oaxaca are mainly being slaughtered for their skin (Figure 2) which is used for exotic leather fashion apparel in international markets in Asia, primarily Japan.

Not surprisingly, the poor sea turtle "fishermen" of Mexico are not getting rich, and in fact a resource that has been utilized for centuries by coastal communities is being destroyed. This continued level of exploitation is deleterious to sea turtles, the Pacific Ocean ecosystem and coastal people throughout Latin America. Sustainable programs of egg harvesting by communities in Nicaragua (Steiner, 1988) and Costa Rica may be negatively impacted by the Mexican slaughter.

**What you can do!** Environmental and ecological organizations in Mexico have asked for the support of international environmentalists and biologists to pressure the Mexican government to stop the slaughter of sea turtles in Mexico.

**In solidarity with our colleagues in Mexico we urge you to support their demands:**

1. Immediately stop the legal and illegal slaughter of olive ridleys.
2. Mexico join the Convention on International Trade in Endangered Species (CITES).
3. Mexico provide alternative employment opportunities for local turtle hunters.
4. Mexico stop the illegal commerce of all turtle products including eggs, meat and leather.

Write to: President Carlos Salinas de Gortari, Palaceo Nacional, Mexico, DF 06066;

Secretary of Fisheries Maria de los Angeles Moreno, Av. Alvaro Obregon, No. 269, Mexico, DF 06700; and

Patricio Chirinos Calero, Secreatria de Desarollo Urbano y Ecologia, Av. Constituyentes No. 947, Edificio B Planta Alta, Col. Belen de las Flores, 01110 Mexico.

Please contact the Sea Turtle Restoration Project for more information.

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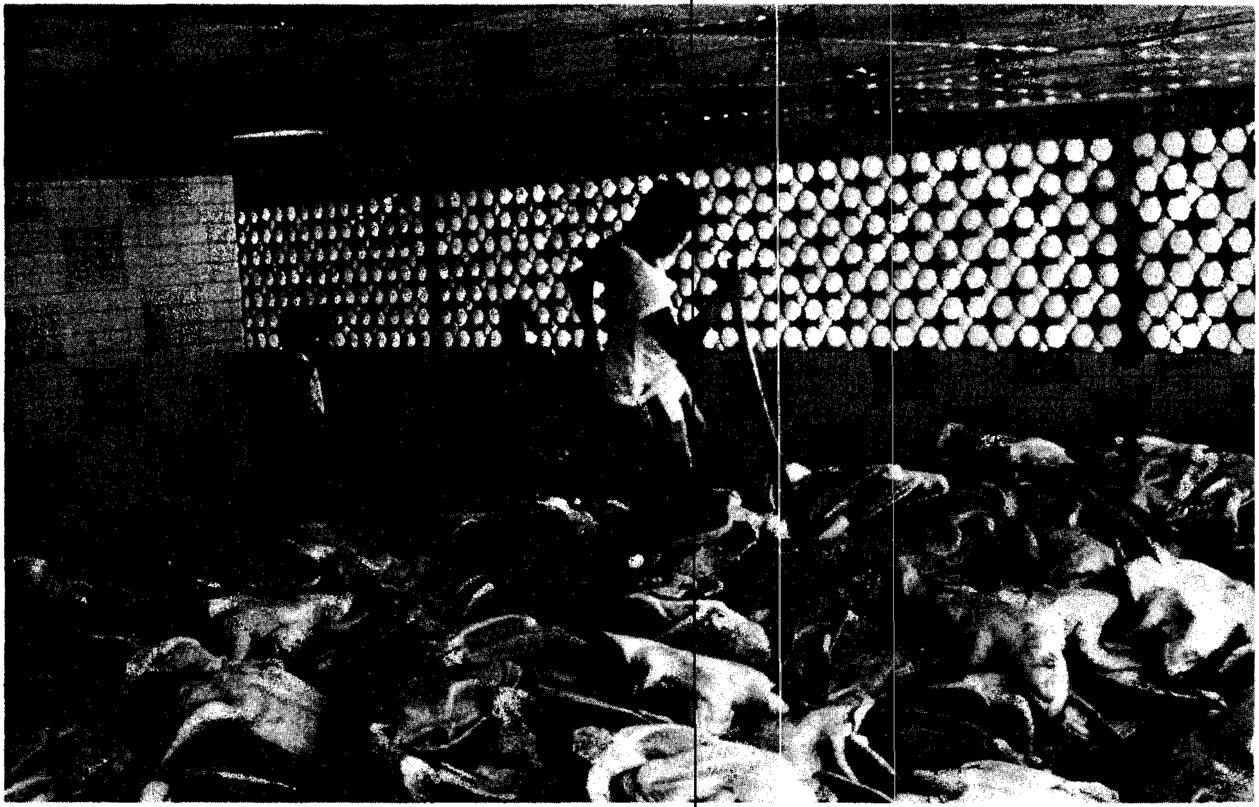

Figure 1. San Augustinillo slaughterhouse, Oaxaca Mexico. Thirty five thousand ridleys were killed in the first 4 months of the 1989-90 season. The "legal" kill for the 1989-90 season is 20,000.

Figure 2. The turtles are being killed for a small piece of skin that is exported to Japan to be made into exotic turtle-leather fashion apparel.

# SEA TURTLE BIOLOGY AND CONSERVATION ON MONA ISLAND, PUERTO RICO

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## INTRODUCTION

Mona Island, which lies between Puerto Rico and the Dominican Republic in the Caribbean, supports significant numbers of hawksbill (Eretmochelys imbricata) and green (Chelonia mydas) sea turtles in its surrounding waters. The many beaches of the island (Figure 1) are used for nesting by these species and, occasionally, by the leatherback (Dermochelys coriacea). In recognition of the island's importance as a nesting ground for sea turtles of the region, beach surveys and studies of nesting behavior were made in 1974 by Jean Thurston, in 1984 by Molly Olson, and from 1985 to 1987 by Anastasia Kontos. The current project, initiated in 1989, aims at continuing research efforts of these previous studies while introducing several conservation elements.

## OBJECTIVES AND METHODS

Ongoing research objectives are the quantification of sea turtle nesting, the determination of factors influencing reproductive success, and the observation of nesting and non-nesting behavior. Management objectives are the protection of sea turtles both on land and in the waters surrounding the island, and the maximization of reproductive output.

To meet these objectives, a schedule of activities is made consisting of:

- night patrols along the most accessible beaches;
- daytime censuses of all remaining nesting beaches;
- observation of sea turtles from the cliff-top.

The reproductive success of sea turtles on Mona Island not being maximal has a number of natural and man-induced causes. Nests are lost to beach erosion, feral pig predation, and because of ovi-position in areas subject to inundation. Hatchlings are often trapped by roots or unable to escape from the bottom of partially hatched nests.

The methods selected to minimize the effects of these causes are:

- the prompt moving of nests considered in danger of inundation to a safer, more suitable location;
- the protection of nests with wire fencing when threatened by predation;
- the excavation of hatched nests.

## RESULTS

During the research period from 24 July to 3 October 89, a total of 128 sea turtle nests was counted, 126 of which were attributed to the hawksbill (Eretmochelys imbricata). Two nests were laid by the green turtle (Chelonia mydas). No activity of leatherbacks (Dermochelys coriacae) was noted.

Action to prevent nest loss by predation and/or flooding was taken for 24 nests. However, another 24 nests (19% of total) were destroyed by feral pigs, notably along the Uvero and U-beaches.

Ten hawksbills encountered on beach patrols were tagged on both flippers with small Monel tags. Two of these carried tags applied during previous studies on Mona Island; one was tagged in 1984 by M. Olson, the other in 1987 by A. Kontos.

## DISCUSSION

Mona Island lies in a region where (illegal) trade in sea turtle products continues. This project is pursuing two strategies to assist in the conservation of these species:

- the maximization of reproductive output of those sea turtles nesting on Mona Island;
- the education of local people, enabling them to recognize problems facing sea turtles.

The continuing destruction by feral pigs of large amounts of turtle nests on Mona Island is intolerable. Through efforts such as implemented this year, only about half of the nests under threat can be saved. Therefore, we strongly encourage the taking of more efficient measures, such as putting up fencing.

The involvement of Sociedad CHELONIA in the project has meant that Puerto Rican volunteers are participating in the research and conservation efforts. Also, it enabled the generation of a substantial amount of publicity in the local press.

## PROJECT SUPPORT

This project was made possible by contributions from:

Stichting tot Bevordering van de Herpetologie (Foundation for the Advancement of Herpetology), Amsterdam, The Netherlands;

CHELONIA, Sociedad Herpetologica de Puerto Rico (Puerto Rican Herpetological Society), Rio Piedras, Puerto Rico;

Departamento de Recursos Naturales (Department of Natural Resources), San Juan, Puerto Rico;

G.J. van Dam, Amsterdam, The Netherlands.

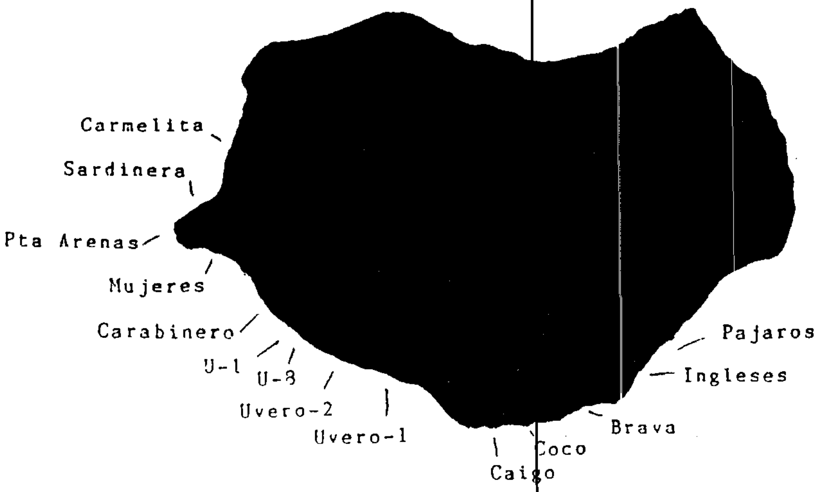

Figure 1. The sea turtle nesting beaches of Mona Island, Puerto Rico.

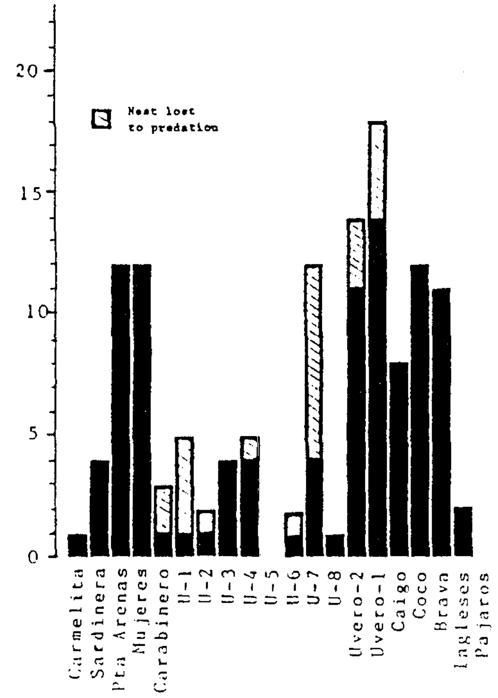

Figure 2. Number of sea turtle nests laid per beach from 24-JUL to 3-OCT-89. Total is 128 nests.

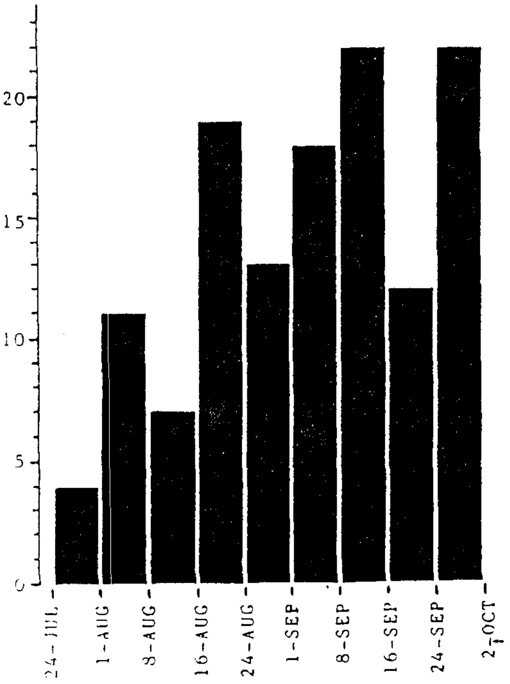

Figure 3. Number of nests laid per interval of time from 24-JUL to 3-OCT-89. Total is 128 nests.

# SEA TURTLE SIGHTINGS IN NORTH CAROLINA REPORTED BY PUBLIC AND FERRY BOAT SURVEYS

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**Allison Veishlow**
**Joanne Braun**
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The NMFS Beaufort Laboratory has been conducting research, since the summer of 1988, to determine what species of sea turtles are inhabiting what waters in North Carolina. This study uses four methodologies (Epperly and Veishlow 1989; Epperly et al., in press), including a public sighting program and ferry boat survey.

The public sighting program used a poster (Figure 1), which asked the public to report sightings of sea turtles. Attached to the poster was a gummed pad of prepaid, addressed postcards that asked for the date, location, species sighted, and whether the turtle was dead or alive. About 450 posters have been placed along the North Carolina coast at a variety of locations including marinas, commercial fish houses, dive shops, etc. In 1989 a question asking fishermen if they saw a sea turtles during their fishing trip was added to the North Carolina portion of the National Recreational Fishery Statistics Survey, supplementing the data from the public sighting program.

Public sightings have reported 621 live turtles in 1989. The majority of these were in offshore waters (the waters extending seaward from the COLREGS Demarcation line) during the spring and summer months. A few sightings were reported in January, February, and March, but it was not until April, when water activities increased, that sightings were consistently reported. Most species identifications were unconfirmed, thus emphasis in this method is on the number and location of turtles sighted rather than the species. The majority of the returned cards came from residents of coastal North Carolina followed by non-coastal North Carolina residents, and out-of-state residents.

The ferry boat survey placed sighting logs on each North Carolina public ferry. Vessel personnel recorded the number of passages made daily and the location of any turtle sighted, alive or dead. The ferries cross the mouth of the Cape Fear River, Pamlico Sound, the lower Neuse and Pamlico Rivers, Hatteras Inlet and Currituck Sound (Figure 2). Few live turtles were sighted: 20 over an 18-month period (August 1988 - December 1989). The majority of sightings were in Pamlico Sound, specifically from the Hatteras Inlet ferry, during the summer and fall months of 1988. Since the number of turtles reported was too low to warrant the continuation of keeping full-time logs on the ferry boats, the ferry personnel now fill out a sighting card each time a turtle is seen similar to the public sighting program.

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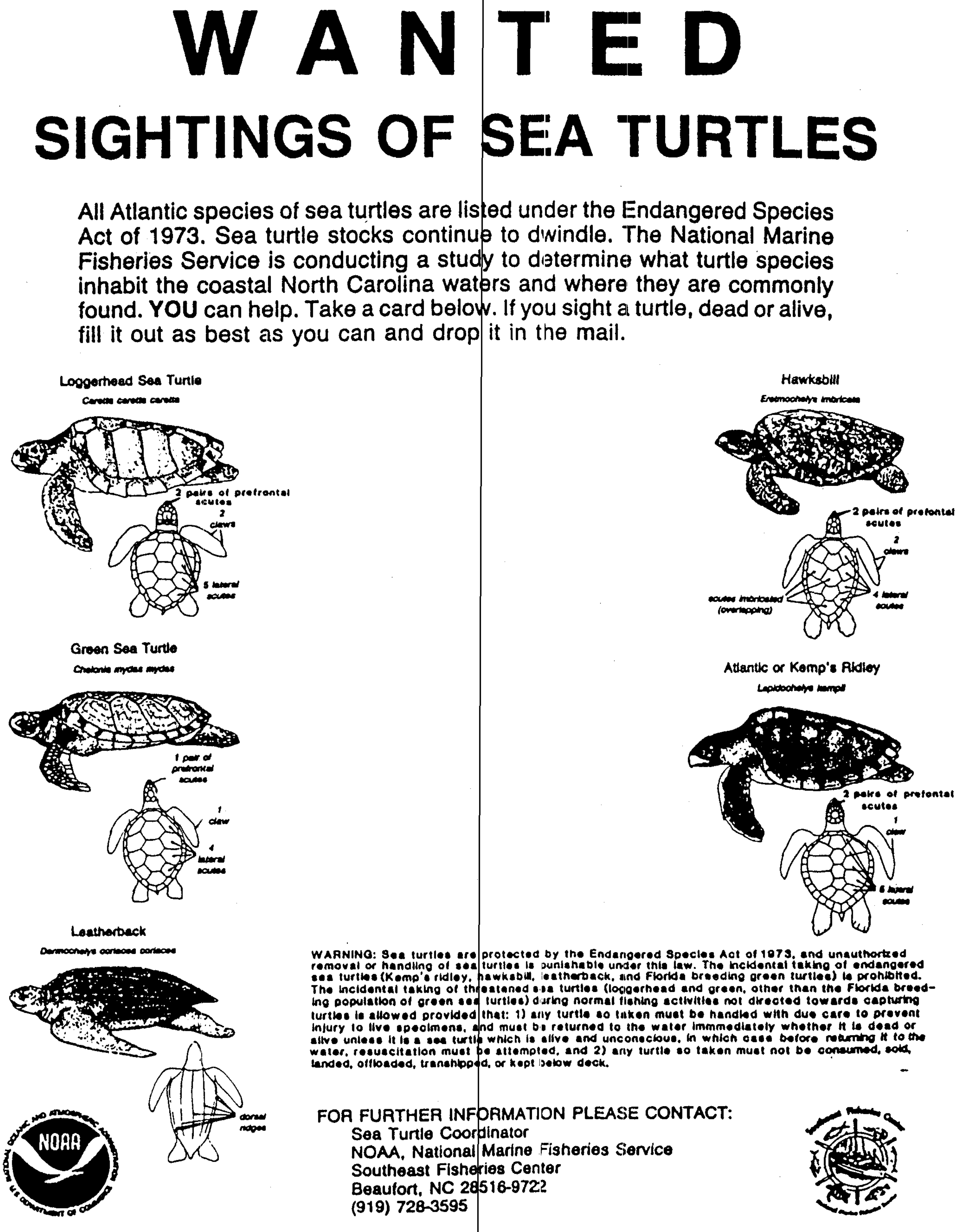

# WANTED

## SIGHTINGS OF SEA TURTLES

All Atlantic species of sea turtles are listed under the Endangered Species Act of 1973. Sea turtle stocks continue to dwindle. The National Marine Fisheries Service is conducting a study to determine what turtle species inhabit the coastal North Carolina waters and where they are commonly found. **YOU** can help. Take a card below. If you sight a turtle, dead or alive, fill it out as best as you can and drop it in the mail.

WARNING: Sea turtles are protected by the Endangered Species Act of 1973, and unauthorized removal or handling of sea turtles is punishable under this law. The incidental taking of endangered sea turtles (Kemp's ridley, hawksbill, leatherback, and Florida breeding green turtles) is prohibited. The incidental taking of threatened sea turtles (loggerhead and green, other than the Florida breeding population of green sea turtles) during normal fishing activities not directed towards capturing turtles is allowed provided that: 1) any turtle so taken must be handled with due care to prevent injury to live specimens, and must be returned to the water immmediately whether it is dead or alive unless it is a sea turtle which is alive and unconscious, in which case before returning it to the water, resuscitation must be attempted, and 2) any turtle so taken must not be consumed, sold, landed, offloaded, transhipped, or kept below deck.

FOR FURTHER INFORMATION PLEASE CONTACT:
Sea Turtle Coordinator
NOAA, National Marine Fisheries Service
Southeast Fisheries Center
Beaufort, NC 28516-9722
(919) 728-3595

FIGURE 1. SEA TURTLE SIGHTING POSTER

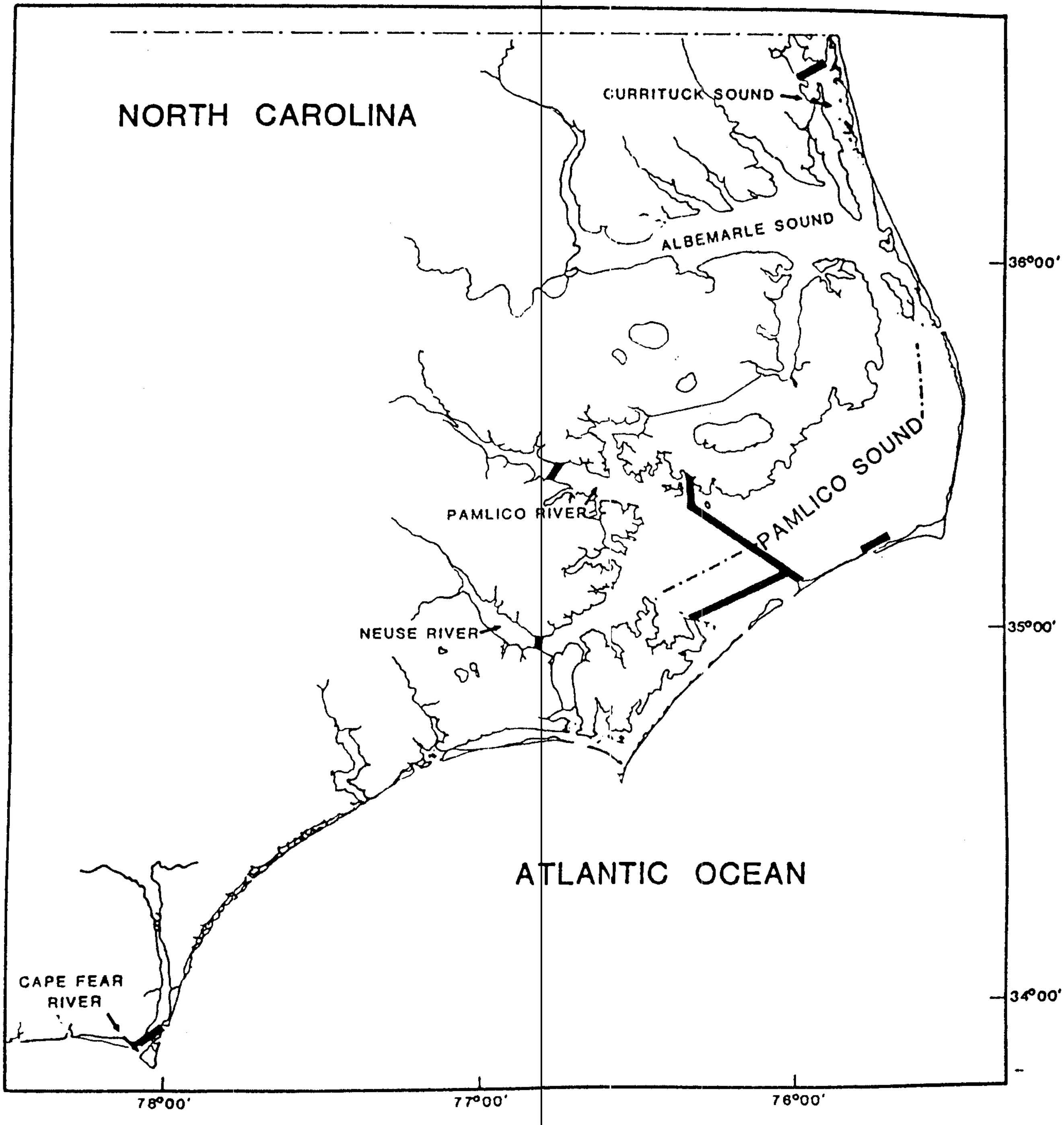

FIGURE 2. N.C. FERRY ROUTE SYSTEM

# MEDASSET

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**Lily E. Venizelos**
MEDASSET, 1 (c) Licavitou St., 10672 Athens, Greece

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There can now be little doubt that the situation facing sea turtles, these ancient animals of the Mediterrranean, is grave in the extreme; yet, despite the various research programmes, political debates, and paper protection measures of the 1980s, their plight continues to worsen year by year.

The sole purpose of MEDASSET is to rationalise and update the conservation requirements for Marine Turtles in the Mediterranean, and to assess and advise on the considered priorities to all funding and involved bodies. We are presently concerned over the numbers of overlapping "research projects", their poor compatibility, the parochial nature of their reports and conclusions, and the rather repetitious meetings and symposia which serve more to publicise these researches than to apply their results to the obvious conservation need. This risks wasting scarce conservation resources and has tended to confuse the whole picture of Marine Turtle conservation. Our aims are thus to maximise efficiency in this field by updating, pursuing, and publicising the conservation priorities including all sound projects on applied research. We are confident that the expertise within our small but specialised group will enable an objective view to be achieved in assessing these conservation priorities, and that our efforts will continue to make a positive contribution for Marine Turtle conservation.

MEDASSET was founded in October 1988. We hereby present a preliminary progress report covering the period upto February 1990:

**Projects achieved:**

1. Accidental captures at sea: Interaction between loggerhead turtles (Caretta caretta) and the commercial sword-fish fleets operating in the Ionian Sea.
2. Nesting beaches: Conservation assessment of the southwest Peloponnese coastline.

**Current projects:**

1. A full survey of all potential nesting beaches on the mainland and islands of the North Aegean Sea. and as requested by the E.E.C.
2. A nesting beach assessment of Southeast Sardinia, with an emphasis on the Gulf of Orosei, and also covering reported exploitation of loggerheads in this region. This project has a major potential for the future of nesting in the western Mediterranean from where this species has declined the most dramatically. Substantial funding has been promised for both of these projects from the E.E.C., providing that MEDASSET can raise a core sum (see below).
3. Continuation on accidental capture in the Ionian and including tagging.
4. Catalysing inter-governmental actions (at Ministery of Fishery levels ) on the problems of accidental captures, which now involve many fleets, European, North African, and Asian.
5. Participation in all relevant international meetings and symposia in order to ensure that a common and justified set of priorities are recognised and adopted.

6. Assuring publicity via the various media a) for the general problems, and b) the specific and important cases, eg. Patara beach (Turkey) and Laganas Bay (Zakynthos in Greece).

7. Fund raising to support these conservation activities. At the moment, £3500 is urgently needed to supplement E.E.C.'s conditional funding of 1. and 2. above.

**Participation in:**

Seminar on Nature Conservation and Sustainable Development - the Role of Europe. Sevilla (Spain), 9-11 February 89. European NGOs.

Conservation of Marine Turtles in the Mediterranean. Paphos (Cyprus), 4-6 July 89. UNEP inter-governmental forum.

Seminar on Environmental Policy of the European Community and its Application to Greece. Athens (Greece), 16 September 89. IEEP.

Expert Committee on Marine Turtles. Strasbourg (France), 2-3 October 89. Council of Europe/Berne Convemtion.

Sixth Ordinary Meeting of the Contracting Parties to the Barcelona Convention. Athens (Greece), 3-6 October 89. UNEP inter-governmentnal.

Second International Colloquy on Mediterranean Coasts and Environmental Protection. Izmir (Turkey), 19-20 October 89. Council Of Europe - Centre Naturopa.

Conference on the Mediterranean in the 1990s. Antalya (Turkey), 23-26 October 89.

**Actions, Publicity, etc.:**

MEDASSET's Athens office now opened, inconjunction with a conservation stamp issue.

National and international pressure to improve the conservation situation of Laganas Bay, Zakynthos, the Mediterranean's largest concentration of nesting loggerheads.

Save Patara - an international campaign to save this important nesting beach and archeological site from tourist development.

# PRESSURE ON THE ENDANGERED MEDITERRANEAN SEA TURTLE IS INCREASING DUE TO THE GROWING IMPACT OF TOURISM ON IMPORTANT NESTING BEACHES BOTH IN GREECE AND IN TURKEY (TWO EXAMPLES)

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The last few known remaining important nesting beaches of endangered marine turtles in the Mediterranean are threatened with development, tourist invasion, and pollution. Destruction of their coastal environment is also unavoidable. In Greece and in Turkey sensitive ecosystems adjacent to important nesting beaches have already been destroyed in order to build hotels, airports, golf courses, etc. In Greece, laws protecting nesting sites and the turtle are not being implemented. Turkey needs stronger legislation for their protection. A survey of incidental captures by fishermen in both countries is imminent.

The impact of uncontrolled tourism and coastal development has been responsible for the total destruction of nesting beaches in several Mediterranean countries. Human greed accelerates with growing tourism. Destruction of nesting beaches does not only affect turtle reproduction, it also affects "Man the Developer," as his greed cannot be sustained forever. A "broken" ecosystem could soon drive away another species, the tourist! Research in the Mediterranean on the impact of tourism on the Environment has not yet been very extensive, and most of it has been undertaken <u>after</u>, rather than <u>before</u>, damage has occured. The process of "change" related to tourism development has yet to be studied. For example:

1. Turkey has taken considerable effort to minimize effects of development in some breeding areas (Dalyan 1988). On the other hand one of the important nesting beaches, Patara (Antalya), is in imminent danger of major tourism development (1989). A Lycian temple has already been bulldozed to make way for a road. Another road has been built to carry the construction vehicles. The 200-strong population of the village of Patara has raised a petition, counting over 2500 signatures against tourist development in that area. Turkey set an example in 1988 by stopping tourist development on Dalyan nesting beach, a gesture greatly admired in Europe and applauded at the Council of Europe's meeting (Standing Committee), December 88.

2. In Greece the island of Zakynthos has in Laganas Bay the largest known single concentration of nesting loggerhead sea turtles (<u>Caretta caretta</u>) in the Mediterranean. Presidential Decrees (1984), Ministerial Decisions (1987-88), Council of Europe's Recommendations (1988), International Conventions, and campaigns by several International Organizations (1986-89) have met with indifference and inactivity from Government and Local Administration. As a result, illegal buildings and walls, sun umbrellas, deck chairs, tables, boats and pedalloas mushroom on nesting beaches and prevent turtles from nesting. Horses, mopeds, cars, bicycles and bulldozers abuse "protected" beaches. At night noise and light from discotheques, hotels and night flights disorient and frighten turtles. Zones regulating sea traffic are being violated daily by fast speedboats, jet skies and private yachts. Researchers, partly financed by the Government, are being intimidated and driven away from nesting beaches by local, affected landowners and by illegal sun umbrella "operators." These endangered Mediterranean turtles are caught accidentaly (Spain, Malta, etc.) or deliberately at sea (Tunisia). This action coupled with the destruction of their habitat will prove to be fatal for the species. "Conservation is not merely a consideration, but an urgent imperative." Dalyan and Laganas Bay should become National Parks as soon as possible.

# SEA TURTLE SIGHTING SIGNS ON THE TEXAS GULF COAST

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## INTRODUCTION

The National Marine Fisheries Service (NMFS) Galveston Laboratory maintains a data file of sea turtle sightings. A sighting is described as an event in which a sea turtle is seen, usually swimming at the surface. Sightings are reported by divers, oil companies who are cooperating with the Lab, NMFS observers on oil rig removals and salvage operations, boat operators, fishermen, and the general public. Reports have indicated that sea turtles are frequently seen in association with jetties that occur along the Texas Gulf Coast. Because the same people frequently utilize the jetties, the general public can be a valuable source of information. Through public reports, data on the frequency, species, and size classes of sea turtle sightings associated with the jetties can be collected by NMFS with a minimum investment of funds, time, and personnel.

In order to encourage public participation, "sea turtle sighting signs" were placed at the north and south Fish Pass jetties in Mustang Island State Park near Port Aransas in the summer of 1989 and at the north jetty of the Brazos Santiago Pass on South Padre Island in the fall of 1989. Data collected from these two sights is summarized.

## MATERIALS AND METHODS

The sighting signs contain descriptions and colored illustrations of the five species of sea turtles that occur in the Gulf of Mexico and explain that turtles are often seen near the jetties. Also attached to each sign is a box holding sighting cards to be filled out and a box for the deposition of completed cards. Data are collected on the date and time of sighting, species, color, carapace length and shape, and location of the turtle in respect to the jetties.

The Fish Pass jetties consist of two rock (granite) groins extending approximately 92 meters southeastward into the Gulf of Mexico at a distance of approximately 92 meters apart. Constructed in 1972, the Fish Pass once connected the Gulf with Corpus Christi Bay, but gradually filled in over time. Located within Mustang Island State Park, the jetties are highly utilized by fishermen, surfers, and beach goers. Signs were erected at both the north and south jetties on 28 June 1989. Texas Parks and Wildlife Department personnel monitor the boxes, retrieve any completed cards and forward them to the NMFS Galveston Lab on a regular basis.

Constructed in the mid-1930s, the Brazos Santiago Pass jetties extend eastward into the Gulf of Mexico for approximately 1.5 km and border a channel that is 92 m wide and 12 m deep leading into the lower Laguna Madre. The ports of Brownsville and Port Isabel and the Intracoastal Waterway are accessed through this pass. The north jetty is located within Isla Blanca Park and is frequented by beach goers and fishermen. A sighting sign was placed at the north jetty on 9 November 1989. A sign was not placed at the south jetty, located on Brazos Island, due to logistical problems associated with the collection of completed cards. The sign at Brazos Santiago Pass is maintained by a NMFS Sea Turtle Stranding and Salvage Network employee. Respondents from both data collection sights are sent a packet of sea turtle information and a letter of acknowledgment for their assistance.

## RESULTS AND DISCUSSION

As of 1 January 1990, 80 sightings have been reported from the Fish Pass jetties and 13 sightings from the Brazos Santiago Pass north jetty. Three additional reports were also received for areas not associated with the jetties. The number of turtles sighted from each jetty and the orientation of the turtle in respect to the jetties is shown in Figure 1. At the Fish Pass jetties, the largest percentage of turtles was seen at the north side of the north jetty, an area relatively protected from the prevailing wind-driven waves. This may not necessarily reflect a preference by the turtles for this area, but rather the possibility of sighting a turtle may be increased by the calmer waters. Relatively few turtles were seen in the area between the jetties at Fish Pass, while over 69% of the sightings at the Brazos Santiago Pass were reported from this area. As with all data presented, any variation in the location and times of sightings may not reflect actual turtle occurrences, but rather different degrees of utilization of the jetties by the public. For example, sightings were only reported for daylight hours in which the turtles would be more visible and the public would most likely be present at the jetties.

Monthly variation (Figure 2) in the number of sightings reflects the co-occurrence of turtles and the people who report them. Attendance at Mustang Island State Park in 1989 dropped from approximately 100,000 people in July to less than 14,000 in December. The low number of sightings in June at the Fish Pass jetties and in October at Brazos Santiago is due to the reporting of a few sightings prior to the installation of the signs.

Species determination (Figure 3) may be difficult due to both inexperience by the observer and short surfacing times by the turtle. The data from the sighting cards suggests that sightings are equally distributed among four species: *C. mydas*, *E. imbricata*, *C. caretta*, and *L. kempi*. At this time the species identification cannot be verified, but observations by NMFS personnel indicate that the majority of turtles sighted are juvenile *C. mydas*. As a number of the sightings are reported by the same people, perhaps further education of these individuals will increase the reliability of their observations. Data is also collected on color and carapace shape in order to aid in the identification of the species. Estimated carapace lengths (Figure 4) indicate that most of the turtles are of a juvenile to subadult size.

The response to the signs has been positive; all respondents have indicated a great deal of interest and only one "prank" card and one negative response have been received. One response reported the sighting of a 3000 centimeter pink turtle; the other informed us that we didn't know what was going on, and if we really wanted to learn anything about sea turtles we should talk to a shrimper. Initially, plans were to capture and paint-mark the carapace of turtles found at the jetties in order to determine if the same turtles are present at the jetties over a long period of time or if there is a constant turnover of individuals; however, this was prevented due to weather conditions. Paint-marking of the turtles could aid in the positive identification of the species. Meanwhile, the sighting signs and cards have served quite well to educate the public and to collect data with a minimum of resources.

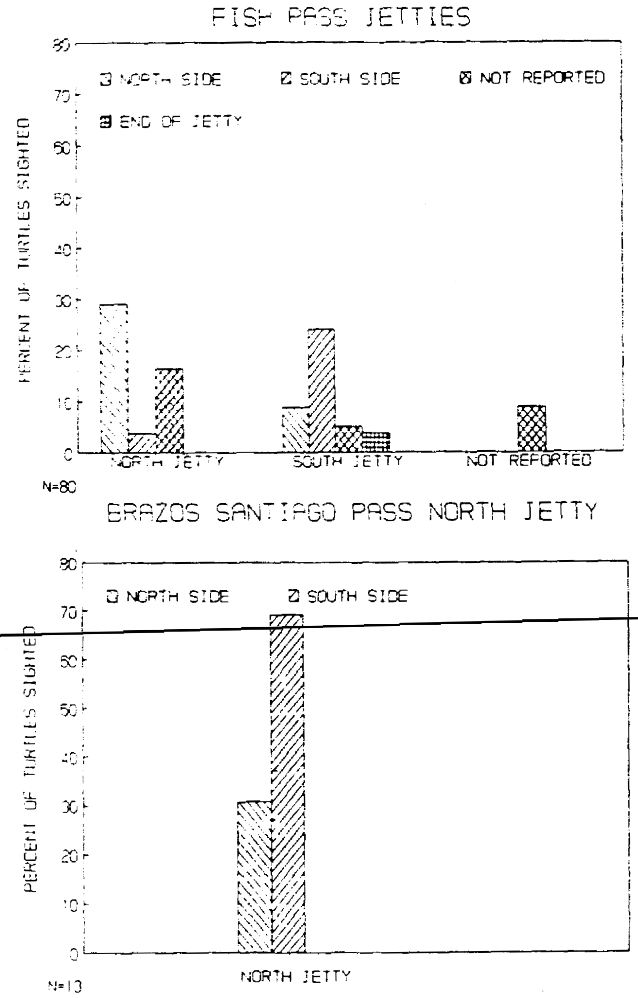

Figure 1. Location of sea turtle sightings in respect to the jetties at Fish Pass and Brazos Santiago Pass.

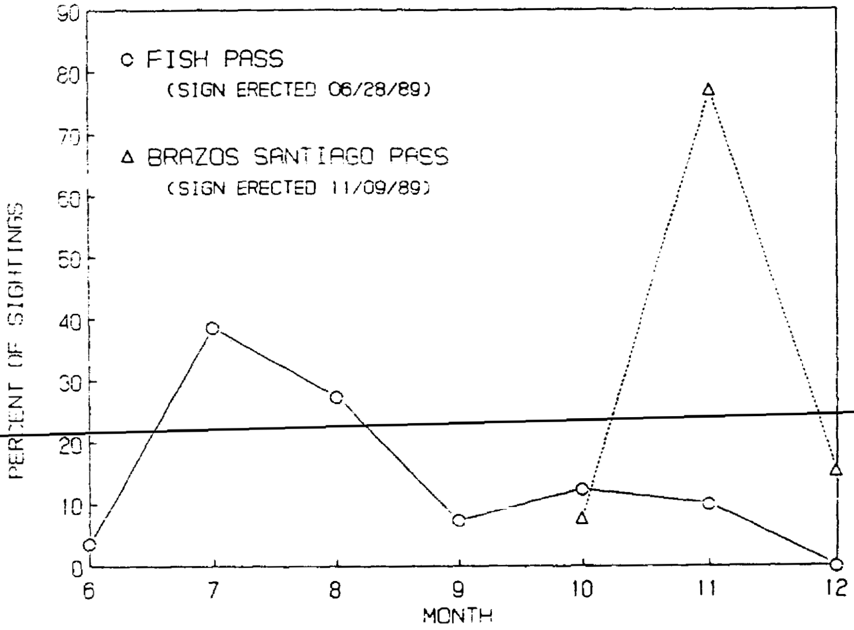

Figure 2. Sea turtle sightings reported by month at Fish Pass and Brazos Santiago Pass in 1989.

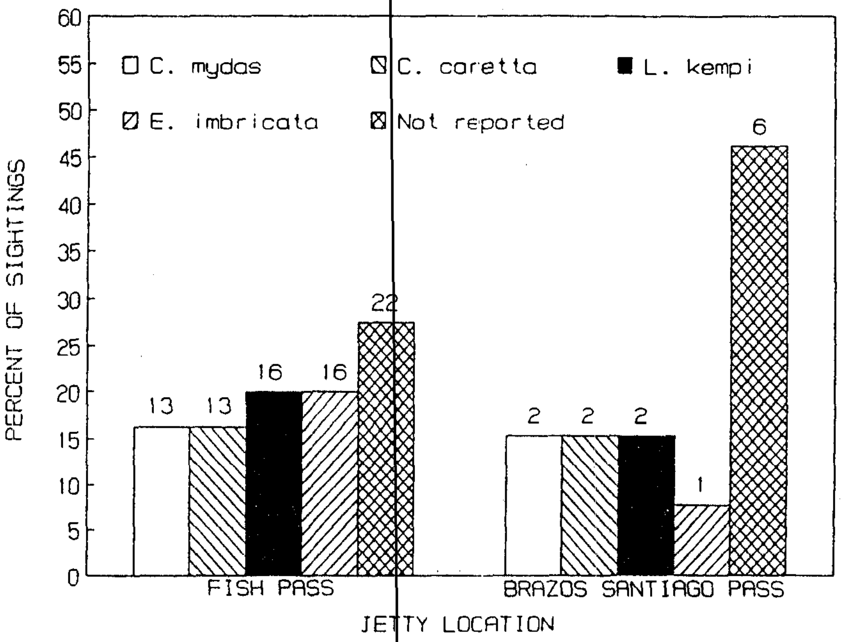

Figure 3. Species composition of sea turtle sightings reported by the public at Fish Pass and Brazos Santiago Pass jetties. Figures at top of vertical bars represent actual number of sightings for each species.

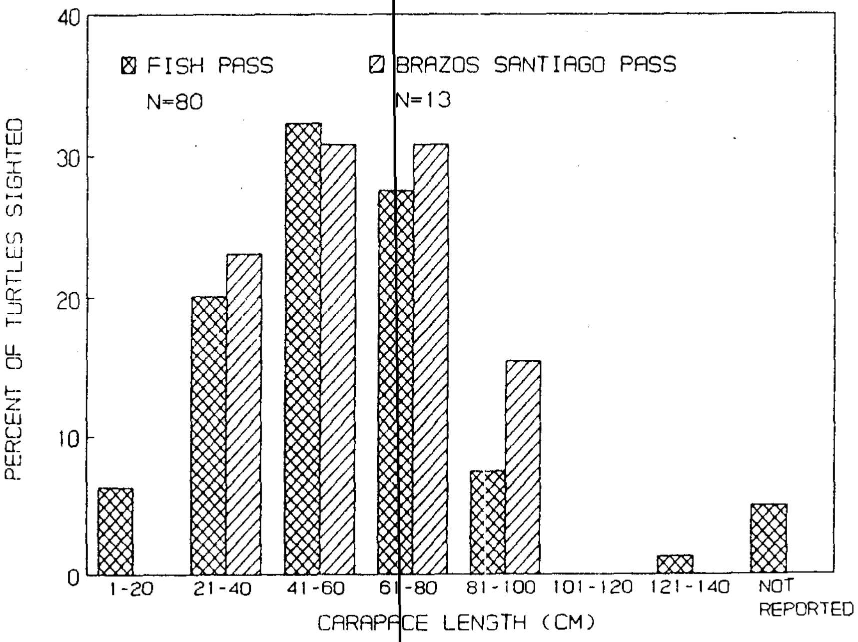

Figure 4. Estimated carapace lengths of sea turtles sighted by the public at Fish Pass and Brazos Santiago Pass.

# SUCCESSFUL PRODUCTION OF CAPTIVE F2 GENERATION OF THE GREEN SEA TURTLE

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During the 1989 reproductive season at Cayman Turtle Farm, three F1 female green sea turtles produced viable hatchlings as a result of captive mating. One of these females was hatched at the Farm in 1973. The other two females were from the 1974 year class. All three females had nested in two previous years, but without producing hatchlings. A total of 199 hatchlings were hatched from the 980 eggs set from 12 nests laid by these three females. Table 1 shows the composition of the F1 breeding herd for the 1989 reproductive season. Table 2 presents individual nesting data for F1 females on the Farm. Of the 31 F1 females in the breeding herd, 10 have begun nesting.

An unusual winter storm on Christmas Eve 1989 resulted in damage to some of the Farm's tanks and the loss of several thousand hatchlings and yearlings which were washed from their tanks. The F2 hatchlings were also swept into the melee and as a result are not now distinguishable from among the remaining 3,700 turtles of the 1989 year class. The Farm is currently completing rebuilding and preparing for the 1990 breeding season.

Table 1. Composition of the F1 breeding herd for the 1989 reproductive season.

| Age | # of Females | # of Males |
|---|---|---|
| 16 | 6(2) | 5 |
| 15 | 12(6) | 2 |
| 14 | 3(1) | 3 |
| 11 | 2(0) | 2 |
| 10 | 8(1) | 0 |
| 9 | 0 | 3 |
| Total | 31 | 18 |

The number of females that have begun nesting for each age class is given in parentheses.

Table 2. Individual nesting information for F1 females.

| Turtle | Recruitment | | Number of Nests Laid | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Age (Yrs) | Wt (Kgs) | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
| 161 | 11 | 159 | | | 1 | | | 3 | 3 |
| 162 | 15 | 143 | | | | | | | 1 |
| 168 | 9 | 123 | 3 | 2 | | | | | 2* |
| 172 | 14 | 130 | | | | | | 1 | |
| 173 | 11 | 161 | | | 4 | | | 4 | 4* |
| 175 | 14 | 140 | | | | | | 1 | |
| 400 | 9 | 141 | | 4 | | 5 | | | 4 |
| 490 | 8 | 116 | | | | | 2 | | 4 |
| 939 | 10 | 173 | 4 | | | 3 | | | 6* |
| 945 | 12 | 191 | | | 1 | | | | |

*Female 168 produced 16 hatchlings from 120 eggs set; female 173, 20 hatchlings from 301 eggs set; and female 939, 163 hatchlings from 559 eggs set.

# ECOTOURISM AND CONSERVATION OF SEA TURTLES IN MICHOACAN, MEXICO

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The most important nesting and breeding grounds for the black turtle Chelonia agassizi on any mainland shore are the east Pacific areas of Maruata Bay and Colola in Michoacan, Mexico. Numbers of nesting turtles, however, have been seriously reduced due to over-exploitation of both adults and eggs. Since 1982 the Universidad de Michoacan, with the assistance of the U.S. Fish and Wildlife Service and World Wildlife Fund, has been carrying out a conservation-research project for the recovery of sea turtles in that area. This project was initiated by Kim Cliffton in the late 1970s.

The black turtle shares geographical boundaries with the Nahual indigenous people in Michoacan. Accounts from the 15th and 16th centuries referred to the great numbers of black turtles along the Michoacan coast, especially at Maruata Bay. After the Spanish conquest, coastal settlements were abandoned in favor of higher settlements in the coastal Sierra. Nature reclaimed abandoned villages, and in the nineteenth century and early twentieth century, the thick vegetation surrounding Maruata, along with the malaria-transmitting mosquitos, prevented the resettlement of this area.

As late as the 1950s, there were no settlements at Maruata and Colola. The Nahual people would make sporadic trips from their pueblos in the Sierra to the black turtle nesting beaches to collect eggs. The eggs were transported by mule and burro back to the villages, where they were eaten fresh or hard boiled and dried for storage to supplement the meager diet of beans, corn, squash and chile. For many years the Nahual people collected their limited harvest of eggs without affecting the black turtle population.

The expansion of international markets for sea turtle leather as a substitute for crocodile skin in the 1960s initiated the hunting pressure upon the sea turtle populations of the Mexican Pacific. In the same decade the Nahual increased their population, and settlements were established on the coastal plain encompassing the black turtle breeding and nesting grounds. When a market for sea turtle products was introduced to the Nahual in the early 1970s, settlements in Colola and Maruata grew rapidly.

The heavy exploitation of black turtles at both their breeding grounds in Michoacan and their feeding grounds in the Sea of Cortes resulted in a population collapse. It is estimated that as recently as the 1960s the number of black turtle breeding individuals in the eastern Pacific was about 150,000. By the late 1980s, there remained only 7 to 10 thousand adults in the breeding population.

Although black turtle fishing has been prohibited in Mexico since 1984, trying to stop the illegal hunting of turtles remains our most immediate and difficult challenge. The turtles' high commercial value in the Mexican marketplace exposes them to intensive exploitation. Sea turtle poaching will continue as long as socio-economic conditions are not included in conservation strategies. Economic pressures to support families make sea turtles a prime target, since they are easy to catch and bring a high price. Therefore, environmental education and economic alternatives are of high priority in the black turtle conservation project in Michoacan. For that reason, in addition to the basic conservation and research, we have designated four areas of special concern.

One such area is the promotion of economic alternatives for local people. The Michoacan black turtle recovery program has worked with the people of Colola to begin pilot operations in the winter of 1989 for the establishment of a low profile, limited ecological tourism enterprise in which turtles are the main attraction. The objective is to demonstrate to the local people that turtles can be more profitable alive than dead. Groups of 10 people join the sea turtle biologists for seven days as part of the conservation team. Rustic, clean, safe accomodations on Colola beach are provided. At night the participants work with the conservation team in the collection and transportation of clutches to the hatchery, in the measurement and tagging of nesting turtles, and in the release of hatchlings into the sea. By day they participate with the research team in the recording of turtle behavior at sea. The tourists can also explore the beautiful reefs and beaches and observe the rich variety of tropical wildlife found in the surrounding lush Pacific foothills.

In the winter of 1989, operations were initiated with the participation of two pilot groups of ecotourists. Profits were utilized by the village of Colola for the purchase of an electric generator for the local school. For the first time local people are begining to realize that live turtles can be profitable. It is hoped that, by working with the villagers to create alternative sources of income, the pressure on sea turtles and other reources will be significantly reduced. To this end, a range of other economic alternatives are now being examined.

# ESTIMATES OF AGE AND GROWTH IN <u>LEPIDOCHELYS KEMPII</u> FROM SKELETOCHRONOLOGICAL DATA

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How old are the first-time nesting females? Age estimates for <u>Lepidochelys kempii</u> have ranged from 5-9 years to grow from a 40 mm hatchling to a 650 mm sexually mature female. A preliminary skeletochronological analysis (Zug and Kalb 1989) suggested that the preceding estimates were too optimistic. The original sample, however, was comprised of small to medium-sized juveniles (241 - 436 mm sCL, straight carapace length), hence the growth equations calculated from this sample did not yield realistic growth curves. The addition of larger specimens to the skeletochronological sample yields more realistic, although tentative, growth curves.

## MATERIALS AND METHODS

The skeletochronological estimates derive from thin (ca. 0.5 mm) cross-sections of bone removed from the middle of the right humerus, just distal to the deltopectoral crest, of 44 Kemp's ridleys (241 - 615 mm sCL). A series of long (ab- to adaxial) axis measurements were recorded for the diameters of the resorption core, each periosteal growth layer, and the exterior. A ranking protocol was used to assign the periosteal diameters of each bone to age classes, and the class containing the exterior bone diameter equals the turtle's age. The protocol is outlined in Zug (1990), along with the protocol's conceptual basis, advantages, and disadvantages. Growth curves were calculated from these estimated ages using the nonlinear curve fitting module of SYSTAT (Wilkinson 1988).

## RESULTS AND DISCUSSION

The addition of larger turtles to the skeletochronological sample has improved the biological reality of the growth equations, although most still do not provide an asymptote that approaches the mean carapace length of nesting females (640 - 650 mm). The asymptotes are 561 (logistic), 585 (von Bertalanffy without beta), and 581 (Gompertz); only the von Bertalanffy with beta equation yields an appropriate asymptote of 640 mm (Fig. 1). This curve indicates that at least 11-12 years are required for the Kemp's ridley females to attain the minimum size of nesting females. However, the new data set with larger juveniles is still too small to accept this age estimate of sexual maturity as totally reliable.

## ACKNOWLEDGMENTS

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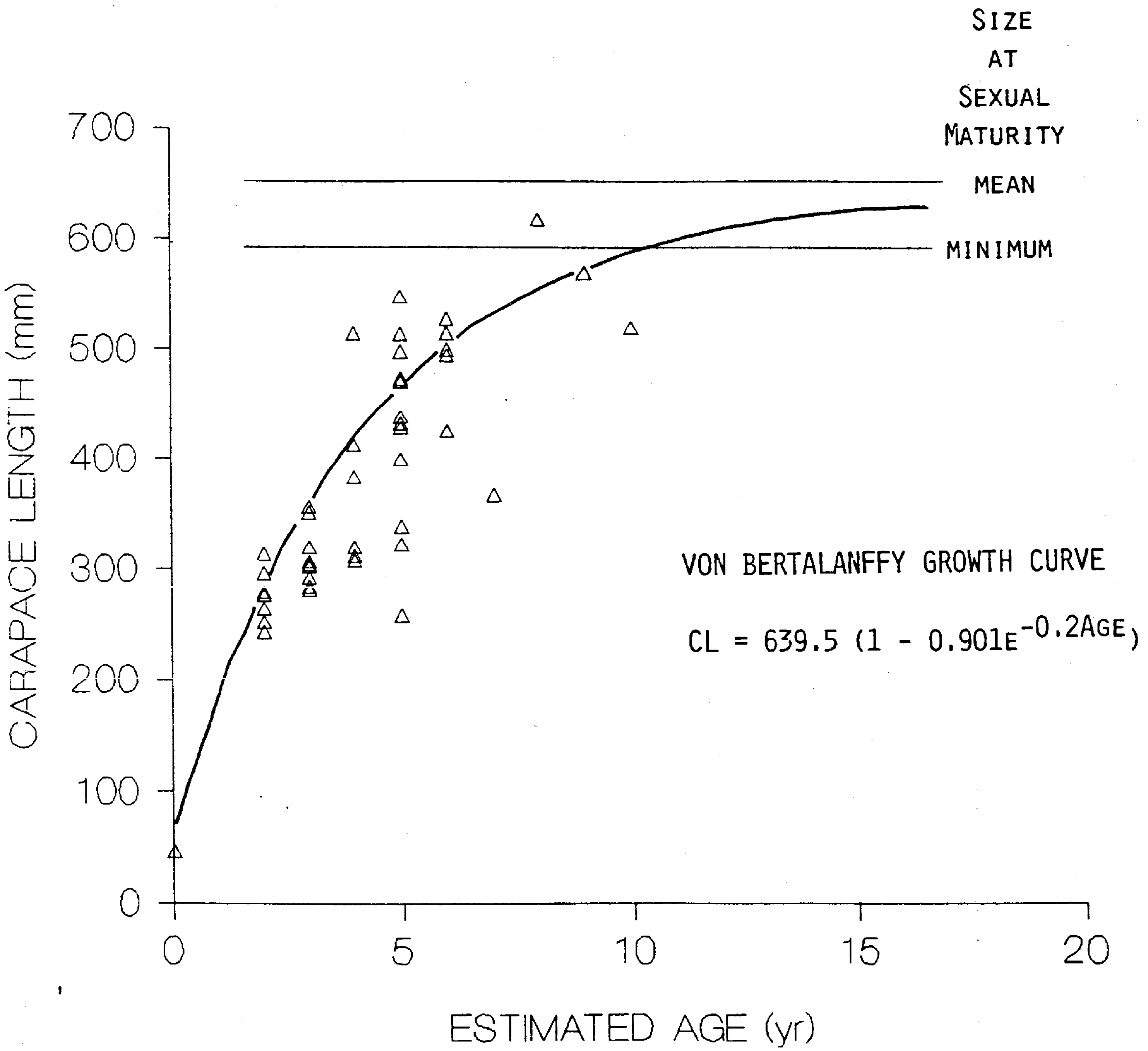
SIZE
AT
SEXUAL
MATURITY
MEAN
MINIMUM
CARAPACE LENGTH (mm)
700
600
500
400
300
200
100
0
0
5
10
15
20
ESTIMATED AGE (yr)
VON BERTALANFFY GROWTH CURVE
CL = 639.5 (1 - 0.901E^-0.2AGE)