NOAA Technical Memorandum NMFS-SEFC-226

PROCEEDINGS OF THE SECOND WESTERN ATLANTIC TURTLE SYMPOSIUM

W.A.T.S. II

S.T.A.O. II

Editorial Committee

Larry Ogren, Editor-in-Chief
Frederick Berry
Karen Bjorndal
Herman Kumpf
Roderic Mast
Glenda Medina
Henri Reichart
Ross Witham

June 1989

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
Panama City Laboratory
3500 Delwood Beach Road
Panama City, FL 32408

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October 12-16, 1987

Mayaguez, Puerto Rico

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The Technical Memorandum series is used for documentation and timely communication of special purpose information. The articles in this issue did not receive complete formal review. Editorial restraint was used in many cases. The National Marine Fisheries Service does not necessarily endorse the managerial, technical, or philosophical opinions and recommendations expressed by the authors. The broad spectrum of views is provided as information only.

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INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
ASSOCIATION FOR THE CARIBBEAN AND ADJACENT REGIONS

Supported by the
UNIVERSITY OF PUERTO RICO
SEA GRANT PROGRAM

Funded by the
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE

and the
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

TABLE OF CONTENTS

Archie Fairly Carr, Jr.
1909 - 1987

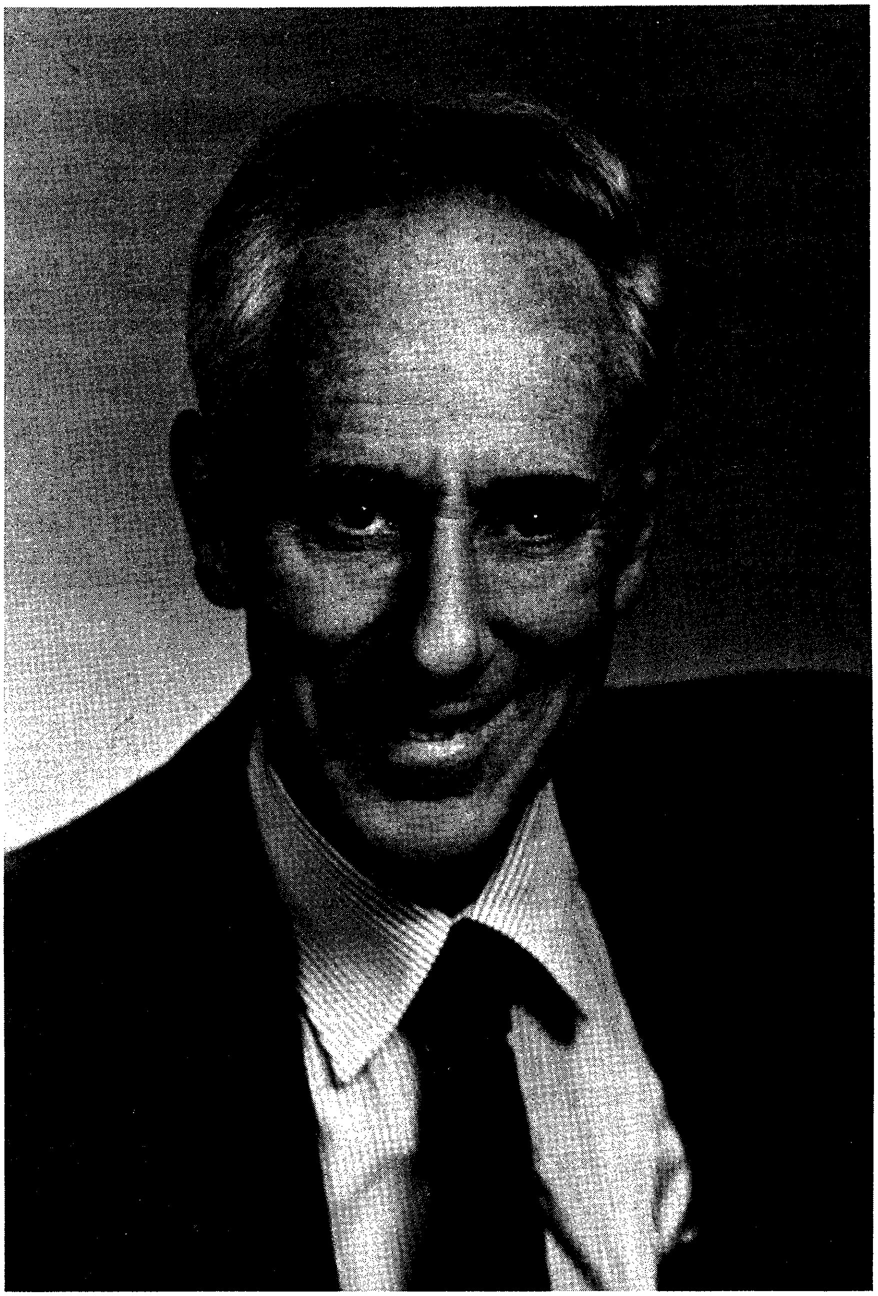
His memory is tinged with the sadness of his loss to us.

What he worked for,
What he wrote about,
What he believed in.

But more than our feeling of loss,
We who knew him and you who know of him
Can be stimulated to dedicate our work to
His goals of conservation and learning more about sea turtles.

The best teacher,
The best leader.

This symposium is dedicated to Dr. Archie Carr.



ACKNOWLEDGMENTS

This symposium was possible because of the participation of hundreds of individuals from dozens of countries who took a personal interest in the conservation and management of sea turtles in their region, and for this reason the symposium was a success and, to all of you we (the editors) are sincerely grateful.

To the personnel at the University of Puerto Rico, Mayaguez campus, we are indebted to you for your support throughout the entire symposium planning and implementation period. In particular, we would like to thank the WATS II staff, especially Laura Acosta, WATS II Secretary from August 1985 to July 1987, Mariblanca Aguet, WATS II Secretary from July 1987 to April 1988, and Kathleen V. Hall, Graduate Student Assistant. Of the Sea Grant staff we would like to thank Evangelina Hernandez, Director, Communications and Publications and Mabel Suarez, Secretary, Communications and Publications, Maria Matos, Secretary, Marine Advisory Services, Enidsa Vasquez, Artist/Illustrator and Guillermo Damiani, Printing and Copying Services. We extend our appreciation to Maritza Pagan, Maribel Gonzalez, and Elba Estevez of the Department of Marine Sciences for their stenographic services.

We are indebted to Charles Karnella, Dean Swanson, and Barbara Schroeder, the rapporteurs for undertaking the demanding task of keeping a written record of all the panel sessions and reviewing the original papers. Thanks to Thane Wibbels for his able assistance with the poster session and collecting the abstracts and to Pedro Gonzales, for all his help throughout the symposium in too many ways to mention. James Richardson and Rebecca Bell generously assisted the editors in reviewing the original papers and Anne Meylan helped in editing the first draft.

Special thanks are due to Iva Walter for the long hours she spent re-typing the many drafts of these proceedings and entering it all on the word processor, Rosalie Vaught for her bibliographic assistance, and to Eugene Nakamura for his expert assistance in editing the final manuscript. All are at the NMFS Panama City Laboratory, Panama City, Florida.

The Western Atlantic Sea Turtle Symposium: Organization and Operation (Frederick Berry)

The History of WATS I

This history was reported by Bullis, Bacon, and Berry in Bacon et al. (1984). The English version of the Proceedings was published in three volumes in April 1984. The Spanish version was published in October 1987. Copies of both the English and Spanish versions of the Proceedings of WATS I are available from: Sea Grant Program RUM/UPR, P.O. Box 5000, Mayaguez, Puerto Rico 00709-5000 and the World Wildlife Fund, 1250 24th St. NW, Suite 500, Washington, DC 20037.

The History of WATS II

Recommendations for conducting WATS II were made by the officials and participants of WATS I. An Executive Committee for WATS II was organized and consisted of: Manuel Murillo, President; Manuel Hernandez Avila, Adminstrator; Robert Lankford, Executive Secretary; Frederick Berry, Secretary; committee members Harvey Bullis, Glenda Medina Cuervo, Jose Ottenwalder, Henri Reichart, Rafael Steer Ruiz, and Horace Walters. This committee, which also served as a Steering Committee, met in Miami, Florida; Castries, St. Lucia; Panama City, Panama; and Mayaguez, Puerto Rico.

WATS II data collection and reporting contracts were placed with more than 20 individuals and organizations within the WATS area. Contracts were awarded to produce biological synopses for the Kemp's ridley, olive ridley and leatherback sea turtles; and preparation of a biological synopsis for the loggerhead sea turtle was endorsed and encouraged. The Loggerhead Biological Synopsis was published by U.S. Fish and Wildlife Service (USFWS) May 1988, Kenneth Dodd, author, and is available through the U.S. Fish and Wildlife Service, P.O. Box 1306, Albuquerque, New Mexico 87103. Plans are in negotiation to publish the other three Biological Synopses through Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. Drafts of all four were available to participants at the 1987 Symposium.

A contract was awarded to prepare a copy of a revised third edition of the Manual of Sea Turtle Research and Conservation Techniques. The English and Spanish versions of editions one and two are out-of-print. Edition three is being edited by Roderic Mast and Frederick Berry with contributions from many colleagues. Edition three should be published during 1989 and should be available for sale through: World Wildlife Fund and the Conservation Foundation, 1250 24th St. N.W., Suite 500, Washington D.C. 20037.

Sea turtle data were collected for WATS II by the Endangered Species Program, National Marine Fisheries Service (NMFS), Southeast Fisheries Center (SEFC), Miami Laboratory, in Miami, Florida, from 1984 until October 1987. These were reports on aerial and beach surveys, position papers and research status reports, poster session abstracts, and National Reports. The titles, authors, and preparation dates, except for the poster session abstracts, are included in Appendix 2 here. Information or questions pertaining to these reports should be obtained from the authors. Ross Witham maintained the listing and copies of the reports during the symposium. Pedro Gonzales coordinated the logistics between the Symposium and the University of Puerto Rico, Mayaquez.

A report on the accomplishments of WATS I and actions of and plans for WATS II were prepared and presented to the 1986 meeting of Intergovernmental Oceanographic Commission Association for the Caribbean and Adjacent Regions (IOCARIBE) by the executive secretary. The principals fully endorsed the continued IOCARIBE sponsorship of WATS.

Letters were sent to the appropriate officials in the 38 countries in the WATS area by the president and the chair of IOCARIBE. These letters requested that each country officially participate in WATS II by 1) designating a national representative who would represent the country at the symposium, 2) collecting sea turtle data on populations and socioeconomics, and 3) preparing a national report and presenting it to the symposium.

The program for the symposium meeting was developed in a planning meeting of the executive committee and other cooperating individuals. Topics were selected. Panel sessions were structured. Speakers, chairs, and panel members were nominated. Karen Bjorndal served as program chairman. The secretary solicited the nominated participants and then additions and replacement for the required positions.

A WATS II mailing list of more than 1,000 individuals and organizations with sea turtle interest was developed. Notices of the symposium meeting were mailed to all.

The Mayaguez International Hilton Hotel was the symposium headquarters. The executive committee met Saturday afternoon, 10 October, and Sunday morning, 11 October and every morning through Friday, 16 October. The national representatives held their first meeting, with the executive committee on Sunday afternoon. Two caucuses were held Monday morning, 12 October--one for the national representatives and the other for panel chairs, speakers, members, rapporteurs, and editors.

The symposium was officially convened at 1100 AM Monday by the administrator and the director of the Department of Marine Science of the University of Puerto Rico.

The symposium was dedicated to Professor Archie Carr.

Karen Bjorndal served as symposium chair, and Henri Reichart served as symposium director.

Symposium Agenda

<u>SATURDAY 10 October</u>

3:00 - 7:00 PM
EXECUTIVE COMMITTEE MEETING
Frederick H. Berry, Secretary
Harvey R. Bullis, Jr.
Manuel L. Hernandez Avila, Administrator
Robert R. Lankford, Executive Secretary
Glenda Medina
Manuel M. Murillo, President
Jose Ottenwalder
Henri Reichart
Rafael Steer
Horace Walters

<u>SUNDAY, 11 October</u>

10:00 AM - 7:00 PM
Registration

10:00 - 12:00 AM
EXECUTIVE COMMITTEE MEETING

4:00 - 6:00 PM
NATIONAL REPRESENTATIVES MEETING WITH EXECUTIVE COMMITTEE

<u>MONDAY 12 October</u>

7:00 - 2:00 PM
Registration

8:00 - 10:30 AM
CAUCUS FOR NATIONAL REPRESENTATIVES

8:00 - 10:30 AM
CAUCUS FOR EACH PANEL: CHAIRS,

SPEAKERS, MEMBERS, RAPPORTEURS, AND EDITORS

10:30 - 11:00 AM Break

11:00 - 12:00 AM

OPENING OF THE SYMPOSIUM

Convenor: Manuel L. Hernandez
Director, Dept. Marine Science, UPR-RUM

Lic. Fernando Agrait,
President, University of Puerto Rico

Hon. Benjamin Cole,
Mayor, Mayaguez
Dr. J. L. Martinez Pico,
Chancellor, UPR-RUM

Symposium Chair:
Karen Bjorndal,
University of Florida

Symposium Director:
Henri Reichart
World Wildlife Fund, Indonesia

12:00 - 1:30 PM Lunch

1:30 - 2:00 PM

BIOLOGICAL SYNOPSES OF SPECIES

Speaker: Peter Pritchard

2:00 - 3:30 PM Panel Session

SOCIOECONOMIC IMPORTANCE OF SEA TURTLES

Chair: Arthur Dammann
Speaker: Frederick Berry on Exploitation
Speaker: Marydele Donnelly on International Trade In Tortoiseshell
Speaker: Michael Weber on Incidental Take

3:30 - 4:00 PM Break

4:00 - 6:30 PM Panel Session (continued)

6:30 - 8:30 PM RECEPTION FOR REGISTRANTS

TUESDAY, 13 October

SUBREGIONAL DATA PRESENTATIONS AND DISCUSSIONS BY THE NATIONAL REPRESENTATIVES

8:00 - 9:45 AM
GROUP I. SUBREGION CENTRAL AMERICA

Chairs: Rafael Steer and Glenda Medina;
Brazil, French Guiana, Surinam, Guyana, Venezuela, Colombia, Trinidad and Tobago, Netherlands Antilles

9:45 - 10:15 Break

10:15 - 11:30 AM
GROUP II. SUBREGION CENTRAL AMERICA
Chair: Manuel Murillo
Panama, Costa Rica, Nicaragua, Honduras, Guatemala, Belize

11:30 - 12:00 AM
GROUP II. SUBREGION NORTH AMERICA
Chair: Herman Kumpf;
Mexico, United States

12:00 - 1:00 PM Lunch

1:00 - 2:45 PM
GROUP IV. SUBREGION GREATER ANTILLES
Chair: Jose Ottenwalder,
Cuba, Cayman Islands, Jamaica, Haiti, Dominican Republic, Puerto Rico, Turks and Caicos, Bahamas, Bermuda

2:45 - 3:15 PM Break

3:15 and 5:00 PM (continued)

7:00 and 8:00 PM
GROUP V. LESSER ANTILLES
Chair: Horace Walters;
U.S. Virgin Islands, British Virgin Islands, Anguilla, St. Kitts and Nevis, Antigua, Montserrat, Guadalupe, Dominica, Martinique, St. Lucis, St. Vincent, Barbados, Grenada.

8:00 - 9:00 PM
SUBREGIONAL STATEMENTS
Chair: Manuel Murillo

WEDNESDAY, 14 October

STATUS REPORTS ON THE SPECIES

8:00 - 10:00 Panel Session
GREEN TURTLE,
Chelonia mydas
Chair: Karen Bjorndal
Speaker: Larry Ogren

10:00 - 10:30 AM Break

10:30 AM - 12:30 PM Panel Session
HAWKSBILL TURTLE,
Eretmochelys imbricata
Chair: Ralf Boulon
Speaker: Anne Meylan (not present) Walter Connley

12:30 - 1:30 PM Lunch

1:30 - 3:30 PM Panel Session
LOGGERHEAD TURTLE,
Caretta caretta
Chair: Sally Murphy
Speaker: Llewellyn Ehrhart

3:30 - 4:00 PM Break

4:00 - 5:30 PM Panel Session
LEATHERBACK TURTLE,
Dermochelys coriacea
Chair: Nicholas Mrosovsky
Speaker: Peter Pritchard

7:00 - 8:00 PM Panel Session
KEMP'S RIDLEY TURTLE,
Lepidochelys kempi
Chair: Jack Woody
Speaker: Rene Marquez

8:00 - 9:00 PM Panel Session
OLIVE RIDLEY TURTLE,
Lepidochelys olivacea
Chair: Johan Schulz
Speaker: Henri Reichart

THURSDAY, 15 October

8:00 - 9:30 AM Panel Session

INTERNATIONAL MANAGEMENT MECHANISMS

Chair: William Gordon

9:30 - 10:00 AM Break

10:00 AM - 12:30 PM Panel Session

MANAGEMENT OPTIONS

Chair: Horace Walters
Speaker: Nathaniel Frazer

12:30 - 1:30 PM Lunch

1:30 - 3:30 PM Panel Session

MANAGEMENT RESEARCH NEEDS

Chair: Frederick Berry
Speaker: Survey - Beach, Thomas Murphy
Speaker: Survey - Water, Nancy Thompson
Speaker: Habitat - Beach, Jeanne Mortimer
Speaker: Habitat - Water, Wayne Witzell
Speaker: Fishing Mortality, Andrew Landry
Speaker: Population Biology, James Richardson

3:30 - 4:00 PM Break

4:00 - 6:00 PM Panel Session
Management Research Needs (continued)

8:00 - 11:00 PM Ad Hoc Discussion

WORLDWIDE SEA TURTLE CONSERVATION AND MANAGEMENT ACTIVITIES

Chair: Colin Limpus

FRIDAY, 16 October

8:00 - 12:00 AM
CAUCUS FOR EDITORS, RAPPORTEURS, ALL PANEL CHAIRS AND SPEAKERS

8:00 - 12:00 am
UNSCHEDULED *AD HOC* DISCUSSIONS

12:00 - 2:00 PM Lunch

2:00 - 5:00 PM

FUTURE ACTIONS

Chair: Manuel Murillo

7:30 PM

BANQUET. CLOSING OF THE SYMPOSIUM

Host: Robert Lankford

SATURDAY, 17 October

FIELD TRIP TO MONA ISLAND

The banquet Friday evening included acknowledgment of all who worked to make the symposium so successful, awarding of certificates of appreciation to the principal participants, kind words of praise for the conceiver of the WATS effort and acronym, Harvey R. Bullis, Jr. (in absentia) by William G. Gordon, and official closing of the symposium meeting by the executive secretary.

Initiation of WATS III

WATS III activities began in early 1988. Sea turtle data acquisition will be requested and compiled from WATS area countries. The Third Symposium will probably be convened in 1992 or 1993.

For information on WATS III, please write:

Frederick Berry
6450 SW 81 St.
Miami, FL 33143 USA

Report of the Opening of the Symposium
11:00-12:00 12 Oct. 87

The Western Atlantic Sea Turtle Symposium II (WATS II - STAO II) was formally opened by the convenor, Dr. Manuel L. Hernandez, Director, Department of Marine Sciences, University of Puerto Rico-Mayaguez Campus.

The convenor expressed his pleasure in welcoming the participants to Mayagüez and extended his wishes for a most successful and productive meeting. He then introduced the individuals primarily responsible for WATS II - STAO II: Mr. Harvey Bullis, Mr. Frederick Berry, Dr. Karen Bjorndal, Dr. J.L. Martinez Pico, Dr. Manuel Murillo, Capt. Rafael Steer Ruiz, Mr. Henri Reichart, and Dr. Robert Lankford.

Dr. Hernandez extended the regrets of both Professor Fernando Agrait, President of the University of Puerto Rico, who was unavoidably detained in Spain and the Honorable Benjamin Cole, Mayor of Mayaguez who was unable to participate in the opening ceremonies due to other committments.

Dr. J.L. Martinez Pico, Chancellor of the University of Puerto Rico, Mayaguez Campus warmly welcomed the national representatives, experts, and interested participants. He briefly described the university and its many campuses and departments and noted the 30 year history of marine science research and education at the Mayaguez Campus. He wished the attendees every success in their work at WATS II.

The symposium chairperson, Dr. Karen Bjorndal, introduced Capt. Rafael Steer Ruiz. Capt. Steer, as president of the co-sponsoring agency, IOCARIBE, thanked the executive committee for their efforts and gave a brief explanation of what IOCARIBE is, how it functions, as well as a chronological overview of WATS I and II.

Next to be introduced was Dr. Manuel Murillo, President of WATS II. Dr. Murillo thanked the previous speakers, organizers, national representatives, scientists, managers and interested participants for their interest and efforts in bringing WATS II to fruition. He further elaborated on the origins of WATS I and stated that few programs within IOC have had the solidarity of goals and outcome as WATS. He voiced the hope that at the conclusion of WATS II there can be a continuation of this great effort so that scientists and managers can work together to manage properly the marine resources. He identified two people that acted as "Fathers" of the WATS effort: Harvey Bullis and Frederick Berry.

Dr. Robert Lankford, Executive Secretary of WATS II, welcomed all participants in WATS and made announcements and gave logistical details regarding the meeting.

Mr. Frederick Berry, Secretary of both WATS I and II warmly greeted all attendees and dedicated the symposium to the memory of Dr. Archie Carr, who passed away earlier this year.

"Those of us who know him will rededicate our efforts to those goals he established."

A moment of silence was observed in the memory of Dr. Archie Carr.

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Biological Synopses of the Species

A Summary of the Distribution and Biology of Sea Turtles in the Western Atlantic (Peter C.H. Pritchard)

Much has been written about the sea turtle species in the western Atlantic and the task of distilling this information into a brief presentation is invidious Despite the remaining gaps in our knowledge of sea turtles, especially in such areas as natal beach imprinting, navigation mechanisms, or population dynamics, an extraordinary amount of sea turtle research, both routine and high technology, has been undertaken in the last decade or two resulting in these fascinating animals becoming among the most intensively studied of all reptiles.

All but one of the living sea turtle species are allocated to the family Cheloniidae. This family includes at least 27 fossil and entirely extinct genera but only five living genera. The living species are almost all of wide distribution, together encompassing the oceans of the world, and were formerly of great abundance. Moreover, they have shown a great ability to persist even in the face of intense exploitation by man. Even though populations of all species have been significantly reduced in the last century or two, no species has become extinct, and most retain at least some large and healthy populations. Most of the extinct sea turtle genera were in fact more specialized--and thus less adaptable--than the living forms. Geographic isolation has fostered much higher levels of speciation and subspeciation among the freshwater and terrestrial chelonians than among the marine forms living in a contiguous environment.

The living sea turtle species include the leatherback (Dermochelys coriacea), which is the only living representative of the family Dermochelyidae; the loggerhead (Caretta caretta); the hawksbill (Eretmochelys imbricata); the olive ridley (Lepidochelys olivacea); Kemp's ridley (Lepidochelys kempi); the green turtle (Chelonia mydas); the black turtle (Chelonia agassizii); and the flatback (Natator depressa). The last seven species are all representatives of the family Cheloniidae; all but the last two are found in the western Atlantic region (the black turtle is confined to the eastern Pacific, and the flatback to the waters of northern Australia).

The Leatherback (Dermochelys coriacea)

Morphology: The leatherback is the largest of all living turtle species, attaining a carapace length of 150-170 cm and a weight that may occasionally exceed 500 kg. The shell structure of this species is unique; instead of the keratinized scutes that cover the shells of most turtles, the shell of the leatherback is covered with a continuous layer of thin, black, often white-spotted skin, overlying a layer of many thousands of irregularly shaped mosaic bones that together form a continuous layer on the carapace. The carapace is raised into a series of longitudinal, slightly wavy or even tubercular ridges, seven in number, beneath which the mosaic bones are significantly enlarged. In the plastron, the mosaic bones are reduced to isolated elements located along the plastral ridges. Below the mosaic bones is a layer of yellowish, oily, tough but non-fibrous tissue that may be 4 cm or more in thickness.

The leatherback has many other distinctive morphological features. Unlike all other turtles, there are no claws, and the skin only bears scales in hatchling and very young specimens. The forelimbs are exceedingly long, with a span that may exceed 2 m. The skeleton is very reduced, or rather is comparable to that of the embryos of other turtles, the bones of the skull not fusing even with maturity, and the ribs and the bones of the plastron remaining splint-like and narrow throughout life. Many of the bones present in the shells of other turtle species, including the neurals, pleurals, peripherals, and entoplastron, are absent in the leatherback; only the nuchal bone could be said to be well-developed.

Distribution: (1) Foraging areas. The leatherback is sometimes seen in coastal waters, occasionally even in small groups, but it appears to be essentially a pelagic form, diving in deep ocean waters to extraordinary depths, sometimes in excess of 475 m. The integument of the leatherback is very delicate, and the species apparently needs to avoid contact with abrasive bottom substrates. The species is rather frequently encountered outside the tropics, and even in latitudes approaching polar waters. Leatherbacks are often reported from the waters of New England and the Maritime Provinces of Canada, for example, and it is possible they even reach as far north as Baffin Island. In the southern hemisphere, records exist from Tasmania, the southern tip of New Zealand, and so on.

(2) Nesting areas. The leatherback nests almost entirely within the tropics, extra-tropical nesting records being essentially confined to low-density nesting in Florida and in South Africa. Nesting is most frequently colonial, and the largest colonies utilize mainland rather than insular beaches. In the western Caribbean, nesting is abundant from northern Costa Rica to western Caribbean Colombia, and in eastern French Guiana and western Surinam. Some nesting also occurs in the central part of the Brazilian coast, and important colonies are found in northwestern Guyana and in Trinidad. In the Antilles, most nesting occurs in the Dominican Republic and on islands close to Puerto Rico, including Culebra and St. Croix (U.S. Virgin

Islands), although a few nests are recorded each year on many of the islands of the Caribbean.

Good leatherback beaches show certain common characteristics. In particular, the absence of a fringing reef appears to be important, and most beaches have high-energy wave action and steep ascent, deep, rock-free sand, and adjacent very deep ocean. However, in the Guianas the adjacent waters are relatively shallow, but the presence of abundant mud and the absence of rocks or coral apparently make these beaches acceptable for nesting.

Food habits: The leatherback is primarily a water-column rather than benthic feeder, and an increasing body of evidence suggests that the principal diet consists of coelenterates. Many species of jellyfish have been found in leatherback stomachs, although the watery nature of this food, resulting in rapid breakdown in the digestive tract, usually requires that the food species be identified by microscopic examination of the nematocysts. The leatherback has numerous adaptations of the head and mouth towards this diet. The jaws, although not nearly as strong as those of, say, loggerheads, are sharp-edged and scissor-like in action. The throat musculature is very highly developed, to generate a powerful inrush of water as the prey is seized. Moreover, the esophagus, which may be nearly two meters in length, is lined with thousands of sharp but flexible spines, all directed towards the stomach, so that, when the water taken in with the prey is expelled, the food itself is retained. Although this would appear to be an unlikely and insubstantial diet for the largest of all turtles, evidence suggests that the species may reach mature size remarkably rapidly.

Reproductive ecology: The leatherback may travel great distances between its feeding and nesting areas, and several instances of the migration of tagged animals from nesting grounds in the southern Caribbean or the Guianas to the waters of New York or New England have been recorded, and in one case a post-nesting female moved from the Guianas to West Africa (Ghana) within a few months.

However, such demanding migrations do not appear to be undertaken annually, and in nearly all cases recorded remigrations of leatherbacks to their nesting grounds have been two or three years after initial tagging. Nevertheless, within a season, productivity may be immense, with up to ten nestings having been recorded, the typical inter-nesting interval being of the order of ten days.

The eggs are large--5.5 or 6 cm in diameter--but are not as numerous as those of other sea turtles. In the Atlantic, the typical nest includes 80-90 normal eggs, with the addition of a variable number of yolkless, undersized eggs, very variable in size and form, whose function, if any, remains speculative. In the eastern Pacific, where adult female leatherbacks are smaller than in the Atlantic, the number of eggs is less--usually less than 60 full-sized eggs per clutch, although sometimes very large numbers of small, yolkless eggs may be present.

The eggs hatch after about 65 days. Hatching success may be close to 100% in an undisturbed natural nest, but on many beaches a significant proportion of nests is lost to erosion, a result of the high-energy beaches favored by this species, and the limited ability of such heavy and cumbersome animals to travel far inland to deposit their eggs. Eggs can be transferred to hatcheries, but they need even more careful handling than those of other sea turtle species if viability is to be maintained during the transfer.

Major threats to survival: The products of the leatherback rarely, if ever, feature in international commerce, and the species as a whole may be less threatened than some of the others. Nevertheless, the frequent belief that this species is inedible is entirely unfounded, and intense beach-slaughter of nesting females occurs in many areas, especially in Guyana, Trinidad, Colombia, and the Pacific coast of Mexico. Moreover, even in areas where the adults are rarely killed, egg collecting may be intense. This is a major threat, for example, to the important nesting populations on both coasts of Costa Rica, and has already decimated the population nesting on the Trengganu coast of Malaysia, once considered to be the largest population in the world by far. On the other hand, beachfront development and directed catch at sea may not be major stresses on this species, the former being limited by the intense erosion occurring on many coasts where leatherbacks nest, and the latter limited by the enormous size and difficulty of capture of leatherbacks except during their vulnerable terrestrial nesting excursions. (Small leatherbacks--less than 1 m or so in length--are extremely rarely encountered. Possibly leatherbacks pass through such growth stages very rapidly, but it is still a major mystery where such animals live.)

The Loggerhead (Caretta caretta)

Morphology: The loggerhead is a relatively large, hard-shelled sea turtle, adults being 80-100 cm in carapace length and about 100-150 kg in weight. Adults of the species are easily identified by the very large head, rather triangular in shape when viewed from above. In old males the width of the head may exceed 25 cm. The shell is somewhat elongate and posteriorly narrowed, with a strong "hump" or thickening near the posterior end; in subadults, there may be a strong pointed tubercle on each of the vertebral scutes, but these disappear with maturity. A row of five costal scutes occurs on each side of the carapace (contrasting with the green turtle and hawksbill, which almost always have four pairs of costals). Adults are dorsally red-brown, and ventrally pale yellowish. However, the hatchlings, which vary from light to dark brown, tend to be comparably pigmented dorsally and ventrally.

Distribution: (1) Foraging areas. The loggerhead occurs in the Indian, Pacific, and Atlantic oceans (including the Mediterranean, Caribbean, and Gulf of Mexico), but is very unevenly distributed. In the western Atlantic, foraging subadults and adults are commonly found in waters of the southeastern United States, as well as Cuba, Yucatan, and associated areas. The immature animals (from hatchling to about 30-35 cm, at least) appear to be open-sea animals, drifting with the Gulf Stream and the north Atlantic gyre up the eastern seaboard of the United States and across the north Atlantic. They may take up residence for a while in the waters of the Canary Islands, Madeira, etc., then re-cross the Atlantic with the Equatorial Current, passing offshore from the Lesser Antilles, and finally reaching waters close to where they originated. This life-history outline is in part hypothetical, but it does account for the observed distribution of the various size-classes of the loggerhead in the north Atlantic.

(2) Nesting areas. The nesting areas of the loggerhead are almost entirely outside of the tropics. In the Atlantic, by far the best nesting grounds are on the eastern coast of Florida, with lesser amounts of nesting north at least to North Carolina, and on the gulf coast of Florida. Some nesting occurs in Cuba and Yucatan also, and also in Caribbean Colombia, especially on the Santa Marta peninsula. Moreover, nesting grounds are found in Brazil, especially in the State of Espirito Santo. However, nesting is extremely rare to non-existent in Central America south of Belize, in the Guianas, and in the Antilles with the exception of Cuba.

In the Mediterranean, nesting occurs in Greece and Turkey and in several countries of North Africa. In the Indian Ocean, the loggerhead is rare in most areas, but it does nest in southern Madagascar and Natal, South Africa, and an extraordinary nesting concentration occurs on Masirah Island, Oman. In the Pacific, the species is all but absent from the central and eastern areas, but significant nesting grounds are found in Japan, and very important ones in Australia.

Food habits: The loggerhead is a carnivore, and its exceedingly powerful jaws, equipped with large, ridgeless crushing plates in adults, are well adapted for a diet of hard-shelled organisms such as molluscs and crabs. On the other hand, the smaller immature individuals are apparently water-column feeders, feeding upon scyphomedusans and pteropods, fish (when they can catch them or find them dead), and, on occasion, plant material.

The loggerhead and the olive ridley have largely complementary and non-overlapping ranges, and this is not entirely (although it is largely) a reflection of the subtropical preferences of the former and the tropical predilections of the latter. Some degree of food competition seems likely between the two species, at least between olive ridleys and immature loggerheads. The mature loggerhead is able to utilize a variety of hard-shelled food species that no olive ridley could crack.

Reproductive ecology: The reproductive habits of the loggerhead are rather unspecialized. It does migrate, but less spectacularly than the green turtle, and sometimes with less accuracy in locating the precise beach area on which it previously nested. Nesting is colonial, although not intensively so, and there is no evidence of coordinated nesting emergences as there are for ridleys. Mainland shores are preferred, and much nesting takes place on beaches partially protected from terrestrial predators by swamps, sounds, or waterways. Some individuals appear to nest only once or twice in a season, but others may nest five or six times. Loggerheads walk with alternating limb movements while on shore, nest exclusively at night, and often show elaborate apparent evaluation of the quality or temperature of the surface sand by means of thrusting actions of the muzzle. The eggs are relatively small (about 4 cm in diameter), and typically number 100-110 per nest. Undersized or yolkless eggs are rarely if ever found, but a surprisingly high frequency of albino embryos with severe cephalic deformities has been found. These usually die around the time of hatching. Incubation takes 55-60 days, and, as with all sea turtles as far as is known, the sex of the hatchlings is to a large extent controlled by the temperature of incubation.

Major threats to survival: The flesh of the loggerhead is less sought-after for human consumption than that of other sea turtle species, and although illegal egg-collection is a problem in some areas (such as Colombia), the majority of nesting grounds are in relatively prosperous temperate-zone nations, where subsistence hunting and food-gathering is generally unnecessary. Nevertheless, the loggerhead is subject to other threats that may be just as effective. In the United States, many of the best nesting grounds are plagued by unnaturally high raccoon populations, which are extraordinarily adept at raiding loggerhead nests, or even stealing the eggs as the female lays them. In addition, beachfront development, with associated levels of artificial illumination and disturbance, is taking place on many of the best nesting areas; and even if lights and direct disturbance are controlled, the necessity of erecting artificial structures, or conducting such operations as "beach renourishment," to combat natural (or unnatural) erosion may disturb the nesting turtles or render the beach unusable by them.

In the Atlantic waters of the United States, the loggerhead is by far the most frequent victim of drowning in shrimp trawls of all the sea turtle species; over 10,000 loggerheads are estimated to be killed annually in this way in waters of the United States alone. This massive loss, principally of subadults, is negating the benefits of the numerous beach protection efforts and hatcheries on southeastern U.S. beaches, and is causing a slow but steady decline of the nesting populations. This loss can be controlled very effectively by utilization of a Turtle Excluder Device (TED) by all trawlers operating within known sea turtle habitat, but such devices are, unfortunately, not yet in widespread use. (Editor's note: Mandatory use of TED in U.S. Federal waters begins May, 1989.)

The Hawksbill (*Eretmochelys imbricata*)

Morphology: The hawksbill is a relatively small sea turtle species, adults rarely exceeding a carapace length of 90 cm or a weight of about 65 kg. This species has a distinctive carapace, the individual scutes being uniquely thick and each overlaps its neighbor to the rear, except in hatchlings or very old adults. There are four pairs of costal scutes. The head is strikingly narrow (except in the very young), and the jaws extend forward into a bird-like beak (although, despite the name "hawksbill," this beak is not hooked, as in the bird of prey). The prefrontal scales, immediately above the nostrils, that form a single pair of elongate elements in the green turtle, are subdivided into four in the hawksbill. Dorsally, the hawksbill is typically reddish-brown to black, usually with attractive irregular, radiating, or flame-like unpigmented areas on the scutes of the carapace. The larger head scales are reddish-brown to black also, with light yellowish borders. The plastral scutes are heavily pigmented (dark brown) in hatchlings, but lighten to light yellow in adults. In some areas, especially in the Indian and Pacific oceans, some plastral markings are black.

Distribution: (1) Foraging areas. The hawksbill is a definite tropical species, whose feeding grounds are most often associated with coral reefs. On such reefs, juveniles of all sizes (except immediately post-hatchling animals) may be seen, although adults are relatively rarely seen. This apparent population structure may simply reflect the accessibility of the juvenile stages of the hawksbill, which in several other species (especially the leatherback and the olive ridley) remain well hidden in unknown habitats. In the western Atlantic, many of the reefs of the Caribbean, the southern Gulf of Mexico, and the Bahamas will have at least a few resident hawksbills. The northernmost area in which the species may be seen regularly is the reef system adjacent to Palm Beach, Florida, where divers have observed certain individuals for several seasons.

(2) Nesting areas. The hawksbill is tropical in its nesting as well as its foraging habits, and almost no nests have been found outside the tropics except for a handful in Florida. Nesting, in contrast to that of most sea turtle species, is not colonial, except perhaps for minor concentrations on the coast of Campeche, Mexico. More typically, individuals nest one-by-one on small island beaches, or sometimes alongside more abundant species on mainland beaches including Tortuguero, Costa Rica, or Almond Beach, Guyana. Nesting is usually nocturnal, although diurnal nesting has been observed in Guyana and is apparently standard in the Seychelles (Indian Ocean).

Food habits: The hawksbill is a rather specialized feeder, individuals in the typical reef habitat utilizing the narrowness of the head and the extended beak to remove sponges, which apparently constitute the preferred food, from niches and crevices. Various species of sponge have been reported in the diet of the hawksbill, but one of the most common is *Geodia gibberosa*. In addition, representatives of a number of other phyla of marine invertebrates may be incorporated in the diet; these include Bryozoa, Coelenterata, Mollusca, Platyhelminthes, and Urochordata.

Post-hatchling hawksbills show a marked preference for *Sargassum*, and possibly this material, which forms huge floating rafts in some areas of the ocean, provides food as well as habitat for neonate hawksbills.

Reproductive ecology: Allusion has already been made to the non-colonial, usually nocturnal nesting habits of the hawksbill turtle. Emerging females are relatively agile and fast-moving on land, progressing by means of alternating movements of the limbs and utilizing the relatively long and flexible neck to search for signs of danger. The beach-track may be long and meandering, and quite often reveals evidence of "trial nestings"--partial, abandoned nesting pits. Quite frequently, the actual nesting site is shaded by dense vegetation, which may have interesting thermal implications; the influence of temperature upon the sex of hatchling hawksbills has not yet been clarified.

Clutch size is high. Nests with more than 200 eggs are found quite frequently, and in extreme cases as many as 250 may be laid. The eggs are about 3.8 to 4.0 cm in diameter. Multiple nesting within a season has been recorded; on occasions, individuals may even nest 4-6 times, but 2-3 appears to be more common. Internesting intervals are most commonly in the 16-20 day range, and in cases where turtles were observed to re-nest after 32 or more days, an intervening nesting emergence was assumed to have occurred but was unwitnessed.

The hawksbill is often assumed to be a non-migratory species, in view of the observed close proximity between known nesting areas and known foraging habitat. However, this assumption is not entirely justified, and many cases are on record of long-distance migration by post-nesting hawksbills. Nevertheless, this species is probably less migratory than most of all other sea turtle species.

Major threats to survival: The diffuse nesting habits of the hawksbill make systematic exploitation of the nesting females difficult, but simultaneously they render conservation patrols not cost-effective in most areas, and even when the nesting turtle escapes, the eggs are commonly taken by man. The hawksbill is edible, and is even the preferred turtle species in a few areas (such as Cayman Brac or Old Providence Island), although in some parts of the range (especially in the Indian Ocean) the occasional hawksbill is virulently poisonous.

While the capture of hawksbills for meat is somewhat desultory, the killing of specimens of almost any size for their commercially valuable scutes is widespread. Possibly the species could tolerate a modest take for the use of specialized artisans, who for centuries have made jewelry and curios out of the thick, decorative scutes of the hawksbill. However, when the new vogue for entire, stuffed, mostly juvenile hawksbills is added to this traditional usage, the results are likely to be catastrophic. The species is now considered endangered throughout its world range, and the single most significant reason for this is the new and extremely widespread waste of turtles for the international tourist trade.

The Olive Ridley (*Lepidochelys olivacea*)

Morphology: The olive ridley is the smallest of the sea turtles, adults being around 60-70 cm in carapace length, and weighing about 40 kg. In shape, the adult is very wide-shelled, the carapace typically having flat, sloping sides and a rather flat top. Hatchlings are uniformly charcoal-gray, and immature individuals are gray dorsally and white ventrally. Immature turtles may show strong, pointed tubercles on each side of the vertebral scutes. The head is of medium size, roughly triangular in shape when viewed from above and the carapace is noteworthy for the unique proliferation of scutes--usually there are six or more pairs of costal scutes, sometimes as many as nine; the vertebrals usually typically number more than five. Each of the enlarged inframarginal scutes in the bridge area (where the plastron connects with the marginal scutes of the carapace) is perforated by a small pore towards its posterior margin. Adult turtles differ in coloration from the hatchlings and subadults, having dark olive or greenish dorsal surfaces and light yellow on the plastron and ventral aspects of the soft parts.

Distribution: (1) Foraging areas. The olive ridley is a strongly tropical species usually found within 100 km or so of mainland shores. Very large populations exist in the eastern Pacific, from Mexico south to Ecuador, and with representation in northern Peru also. On the other hand, the species is scarce in the western Pacific, although known from the Philippines, Malaysia, northern Australia, and New Britain (Papua New Guinea). In the Indian Ocean the largest populations are in the Bay of Bengal. The species occurs widely but apparently not particularly abundantly in west Africa, whilst in the west Atlantic the species is known from northern Brazil to eastern Venezuela, and with occasional individuals extending far into the Caribbean, to Colombia, Puerto Rico, and Cuba.

(2) Nesting areas. In the western Atlantic, the olive ridley nests in small numbers in northwestern Guyana and in eastern Surinam and western French Guiana. The formerly aggregated nesting at Eilanti, Surinam, is greatly diminished, although it may have been replaced by growing numbers nesting near Kourou, French Guiana. In the eastern Atlantic no areas of massively concentrated nesting have been identified, but some degree of nesting probably occurs from Senegal to Angola. In the other oceans, spectacular nesting concentrations or "arribadas" occur in the Bay of Bengal (two sites in Orissa, India), in Oaxaca, Mexico, and at two sites in Pacific Costa Rica, with some lesser concentrations in Nicaragua and Panama. However, very little nesting has been reported on the Pacific coast of South America, although large numbers of individuals (mostly adults) forage off the coast of Ecuador.

Food habits: Rather few data exist on the feeding preferences of the olive ridley, which is surprising in view of the economic importance of the species and the large numbers of individuals taken by man. In the Atlantic and eastern Pacific, the species appears to be carnivorous, feeding upon shrimp, small crabs, fish eggs, and so on. Jellyfish, snails, and tunicates may also be taken. In the Indian Ocean, on the other hand, available information suggests that the species is herbivorous, marine algae featuring extensively in the diet of olive ridleys in Indian and Sri Lankan waters.

Reproductive ecology: The reproductive habits of the olive ridley show many unusual features. The small size and light weight of the species facilitates its utilization of flat wide beaches of the type that may be eschewed by turtles of greater weight. The nesting excursions are usually but not always nocturnal and the terrestrial gait is relatively rapid, involving alternating movements of limbs. A nesting ridley is usually ashore for only 45 to 50 minutes. The nests are rather shallow and contain, on average, about 105 eggs, about 3.7 to 4.0 cm in diameter. After laying the eggs and filling in the nest cavity, the olive ridley thumps the sand over the nesting site by means of a vigorous, side-to-side rocking action of the shell. Nesting may occur two or three times within a season, and, unlike sea turtles of other genera, nesting in successive seasons occurs frequently, and possibly is the norm.

Although olive ridleys often nest in solitary fashion or in small groups, the species is famous for a much more spectacular nesting style. In certain places in the world (see Distribution), nesting occurs in an extraordinarily aggregated fashion, literally tens of thousands of individuals emerging in the course of a single night on the same short stretch of beach. Concentrations of nesting turtles may be so high that many turtles destroy the nests of their predecessors in the course of their own nesting attempts, and the resulting mix of sand, eggshells, spilled egg contents, and ensuing fungi and microorganisms may constitute a very poor incubation medium. The cues to which these large aggregations of turtles are responding when they come ashore are still somewhat mysterious, but in some areas meteorological conditions (especially wind) appear to be important.

The only "arribada," or aggregated nesting effort, in the Atlantic system was a very small one at Eilanti, Surinam, where, during the 1960s, up to 500 turtles might nest in the course of a good night. During the last few years, however, this aggregation has been reduced to perhaps 10 percent of the 1960s' level, prompting great concern for the future of the South Atlantic population of the olive ridley. On the other hand, the collapse of this arribada may possibly be related to the progressive buildup of a mud bank in front of the beach, making access by the turtles increasingly difficult, and informal reports have been received that groups of at least a few hundred olive ridleys may have started to nest to the east, near Kourou, French Guiana.

Major threats to survival: The olive ridley is still the most numerous sea turtle in the world, but it qualifies as an endangered species nonetheless in view of the enormous levels of capture in recent years and to some extent up to the present, at least in Mexico and Ecuador. The primary product in international trade is the skin of the flippers, which is used to make ornamental leather. The shell has no commercial value, and the meat, although edible and suitable for local consumption, has never found much international demand.

In the western Atlantic, the olive ridley has low and possibly fast-disappearing populations. Nesting animals and their eggs are protected in Surinam and French Guiana, but in Guyana the females are often killed and their eggs taken. A more serious source of loss, however, is almost certainly the accidental drowning of individuals in shrimp trawls. The olive ridley frequents the same estuarine and productive marine ecosystems as the shrimp, and it shows no great speed or agility in avoiding trawls. Indeed, the directed catch for this species in the eastern Pacific is, for the most part, based upon animals caught by hand as they float on the surface, seemingly asleep or nearly so. Large numbers of trawlers operate in the waters of the Guianas, Trinidad and eastern Venezuela.

The Kemp's Ridley (*Lepidochelys kempi*)

Morphology: Kemp's ridley may be compared with its congener the olive ridley, from which it differs in being slightly larger and heavier, and with a lower and wider carapace. The carapace width may actually exceed the length in half-grown individuals. The juveniles are of similar coloration to juvenile olive ridleys but the adults are somewhat lighter olive-green on the dorsal surfaces. The head is somewhat larger, and the jaws more strongly ridged and more massive, than those of the olive ridley. The costal scutes almost always number just five pairs, and there are usually five vertebral scutes.

Distribution: (1) Foraging areas. Adult Kemp's ridleys are almost or completely restricted to the Gulf of Mexico, where their principal foraging grounds appear to be off the coasts of Louisiana to Alabama in the north, and off the shores of Campeche, Mexico, to the south. The immatures are found principally in the northern Gulf, but are also found quite regularly in sounds, embayments, and other reasonably protected waters of the Atlantic coast of the United States. Indeed, surprising numbers of immature specimens, around 30 cm in length, may be found as far north as Long Island Sound (New York), and the waters around Cape Cod, where they may be subject to heavy mortality from cold during the winter months. Kemp's ridleys are occasionally found in western Europe also (Ireland, France, etc.), with a single record from Malta (Mediterranean), but some workers feel that such individuals are permanently lost to the breeding population.

(2) Nesting areas. Almost all nesting by Kemp's ridley is concentrated on a few kilometers of beach in southern Tamaulipas, Mexico, in the vicinity of the coastal features of Barra del Tordo, Barra Coma, Barra Calabazas, and Barra San Vicente. However, small numbers nest in the western Gulf of Mexico outside this area, as far north as Padre Island, Texas, and as far south as the coast of central Veracruz.

Food habits: Kemp's ridley is carnivorous, and the diet leans heavily towards crabs of many species. Jellyfish, molluscs (including cephalopods), echinoderms, and fish may also be eaten. This is an aggressive and irascible species, thrashing furiously when caught and turned on its back. In captivity the young show high levels of aggression towards each other and have to be kept separately.

Reproductive ecology: Kemp's ridley show some similarities to the olive ridley in that it lays similar numbers of eggs and also frequently nests in successive seasons, depositing 1-3 clutches during a season. Inter-nesting intervals are very variable, and nesting emergence is usually precipitated by strong on-shore winds. A unique feature is the exclusively diurnal nesting. Other species, including the flatback, the hawksbill, and the olive ridley, may nest by day at certain times or in certain places, but in the case of Kemp's ridley diurnal nesting occurs exclusively.

Primordially, Kemp's ridley nested in enormous "arribadas," a nesting aggregation in 1947 having been estimated to include about 40,000 females. In subsequent years, however, with the abrupt decline of the nesting population, the arribada has lost its integrity, and today most of the few hundred females remaining in the population emerge singly or in small groups, although occasionally an arribada of 100-200 individuals may come ashore over several miles of beach.

Major threats to survival: Kemp's ridley is considered the most endangered of all sea turtle species, and there is little question that this is so. The population of breeding females has been reduced to a few hundred animals producing fewer than 1,000 nests annually. Despite intense patrolling effort on the Tamaulipas nesting beach (and even on the "straggler" nesting beaches of Padre Island and Veracruz), and the annual release of about 50,000 hatchlings, the annual trend in number of breeding females is progressively downward. The species has been completely protected in the United States and in Mexico for many years, and the great majority of the eggs laid annually hatch successfully and the young are either liberated immediately or "headstarted" and released when nearly a year old. Unless the population is undergoing some kind of natural shift away from the Rancho Nuevo beach area, the conclusions seem inescapable that

Kemp's ridley is disappearing as a result of uncontrolled mortality in shrimp trawls, in both Mexico and the United States.

The Green Turtle (Chelonia mydas)

Morphology: The green turtle is the largest of the hard-shelled sea turtle species, although the adult size varies considerably from one colony to another. At Tortuguero, Costa Rica, for example, an unusually large female may measure 105 cm and weigh about 160 kg. In the Guianas or in Surinam, on the other hand, a female may be as much as 125 cm in carapace length, and weigh 250 kg.

The green turtle has a relatively small head, with a short, rounded snout and a single pair of rather elongate prefrontal scales. The shell is broad and smooth, with four pairs of costal scutes; in shape it is nearly oval, but somewhat broader anteriorly than posteriorly. The forelimbs are long and powerful. The green turtle varies greatly in color and markings. Hatchlings are dorsally almost black and ventrally white (the only sea turtle species, apart from Chelonia agassizi, to have a white plastron on hatching). With growth, the carapace becomes brown and usually develops radiating markings on each scute. In mature animals the overall coloration may be brownish or olive, and in some (especially adult males) the radiating markings evolve into spots and blotches. However, the name "green turtle" refers to the color of the fat, not to the external coloration.

Distribution: (1) Foraging areas. The green turtle is primarily a tropical species, and its foraging grounds largely coincide with the huge beds of marine grasses or macroalgae that occur in shallow coastal waters in the tropics. Thus, immature or foraging adult green turtles may occur in shallow waters through the Caribbean, although with conspicuous concentrations in certain areas--for example, off the Caribbean coast of Nicaragua; in Panama and Colombia east to the Gulf of Venezuela; and on the coast of Brazil from Ceara eastward and southward around the "bulge." Outside the tropics, immatures are found in relatively large numbers in some of the protected lagoon systems near Cape Canaveral (Mosquito Lagoon; Indian River), but they are rather scarce north of Florida.

The green turtle also has a wide distribution in the tropical parts of the Indian and Pacific Oceans; this species and the hawksbill are the only two species that are habitually found around remote oceanic islands. Feeding and nesting grounds are often considerably separated, and the migratory habits of the green turtle appear to be more developed, both in terms of distance and of accuracy of making landfalls, than those of any other marine turtle. In some cases these migratory journeys involve the crossing of over 1,000 km of open ocean, as in the case of the turtles that migrate from the coast of Brazil to Ascension Island, or from French Polynesia to Vanuatu and New Caledonia.

(2) Nesting areas. The green turtle is strongly colonial in its nesting habits, although it does not form synchronized "arribadas" as do members of the genus Lepidochelys. In the west Atlantic and the Caribbean, the major nesting grounds are at Tortuguero, Costa Rica; eastern Surinam; and Ascension Island, with smaller but important colonies in Quintana Roo (Mexico), Cuba, northwestern Guyana, Isla Aves (Venezuela), Trinidad and other islands off the coast of Brazil. Small numbers nest in many other places, and the numbers of nesting green turtles in Florida (Atlantic coast)appear to be increasing progressively.

Major nesting grounds are found in the Indian and Pacific oceans also. In the Indian Ocean the most important sites are Europa Island (Mozambique Channel) and other small islands in the Mascarenes, including St. Brandon's; and in western Australia. In the Pacific Ocean, green turtles nest in Hawaii (French Frigate Shoal) in moderate numbers, and in New Caledonia and in Queensland, Australia, in very large numbers. Many other nesting colonies, some of them important but the majority rather small, exist elsewhere.

Food habits: The green turtle is almost entirely vegetarian once it is past the immediate post-hatchling phase, and in the western Caribbean seagrasses of many genera constitute the preferred diet. Small quantities of invertebrates may also be eaten, but in many cases such ingestion may be accidental.

Green turtles from several nesting colonies utilize the same feeding grounds along the coast of Brazil, but there they feed predominantly upon marine algae of the families Rhodophyceae, Chlorophyceae, and Phaeophyceae, rather than upon marine grasses. These turtles have substantially different intestinal floral communities from those typical of the grass-feeding green turtles of the Caribbean, and possibly some of the phenotypic differences between the adult turtles in these different populations may relate to the different diets. The turtles of Isla Aves, the Guianas, and Ascension Island, although presumably reproductively isolated (since copulation occurs in the nesting areas), feed upon similar organisms in the shallow waters off Brazil, and they are similar in adult size and, at least superficially, in form.

Reproductive ecology: As mentioned above, the green turtle has colonial nesting habits, and animals that have dispersed through the waters of several nations may converge back to a small nesting beach every second or third (or fourth) year, when they reach reproductive condition. Thus, nearly all of the green turtles in the western Caribbean converge upon less than 40 km of mainland beach in Caribbean Costa Rica to nest. After depositing several clutches (sometimes as many as eight or nine) at intervals averaging about 14 days, the turtles may migrate to feeding grounds to the north (in Nicaraguan waters) or to the south (Panama to the Gulf of Venezuela), with small numbers of post-nesting females showing up almost anywhere in the Caribbean. Philopatry in the green turtle is good--that is, females usually renest very close to the site of previous nestings. Nesting is almost invariably nocturnal, and the emerging females are very easily disturbed by lights or other unnatural disturbances. The terrestrial gait is slow and ponderous, and involves simultaneous heavings-forward using all four limbs. Having selected a nest site, the turtle excavates a body pit, mainly using the foreflippers, then excavates the egg cavity using only the hind limbs. The eggs usually number over 100, and sometimes as many as 150. They are somewhat larger than the eggs of the hawksbill, loggerhead, and ridleys, about 5.5 cm in diameter, and they hatch after approximately 60 days.

<u>Major threats to survival</u>: Green turtles are still abundant in some parts of the world, notably on the major Atlantic nesting grounds of Costa Rica, Surinam, and Ascension Island, and, in the other oceans, in Australia, New Caledonia, Europa Island. However, they have been severely depleted in most other areas, almost entirely as a result of capture of the turtles as food for man. The green turtle plays a somewhat bimodal role in human nutrition, rarely featuring in the diet of the middle class, but being of importance in a number of subsistence-level coastal communities as well as providing a luxury food for wealthy Europeans and Americans (at least until the provisions of CITES limited international trade).

In addition to demand for the meat of the green turtle, the eggs are highly appreciated by many coastal communities. Where nesting density is low, nearly every nest may be raided, and thus incipient major colonies may be prevented from forming. In Surinam, where large numbers of green turtles nest, the take of eggs for human consumption is controlled, and attempts are made just to harvest those eggs that are judged to correspond to natural wastage--"doomed eggs," laid too near the sea and subject to erosion. On the other hand, in countries such as Malaysia (the Sarawak Turtle Islands in particular), although egg-collection is controlled, the numbers kept back for hatching are so small that the population is already showing evidence of collapse and imminent extinction. Such trends cannot be reversed quickly, since the green turtle takes several decades to reach maturity, and thus, even if total egg protection were to be instigated immediately, such recruitment would not be manifested in the breeding population before the year 2020 or beyond.

Socioeconomic Importance of Sea Turtles

Exploitation (Frederick H. Berry)

Sea turtle exploitation is the capture and killing of sea turtles of all sizes, by whatever methods, when such harvest is intended.

Sea turtle exploitation is the collection of the carapaces of *Eretmochelys imbricata* by the spiny lobster fishermen of the Bay Islands of Honduras. During 1986-1987, an estimated 5,000 hawksbill turtles of all sizes were collected for the Japanese bekko (tortoiseshell) market from the waters of Nicaragua and Honduras by commercial SCUBA divers (Cruz and Espinal, WATS II National Report).

Sea turtle exploitation is the eating of about 300,000 eggs of *Dermochelys coriacea* during March to July of this year along the Caribbean coast of Costa Rica. In one 5-mile area, for example, daily observations during the nesting season revealed that 862 nests out of the 863 that had been recorded were poached. Interviews during this period indicated that most of the leatherback sea turtle eggs were taken to, and sold in, bars (F. Berry, WATS II Report/Data Set and Poster Session).

Sea turtle exploitation is the catch of about 11,000 sea turtles each year by the shrimp fishermen of the Gulf of Mexico and Atlantic coasts of the United States as determined by the NMFS (Henwood and Stuntz 1987). These sea turtles are taken in shrimp trawls. Most are *Caretta caretta*, the loggerhead turtle, but several hundreds of those killed annually are *Lepidochelys kempi*, the Kemp's ridley sea turtle, which is the most endangered of the world's seven sea turtle species.

For WATS I (Bacon et al. 1984), we tried to obtain data on exploitation of the six species for the 38 regional countries where it occurred. Our summary table indicated that five of six species were exploited.

We know now that those records were incomplete and did not adequately represent the quality, nor the quantity of exploitation of the region's sea turtles. For example, a report was not included from Belize of an estimated annual take of about 2,000 subadults and adults of *Caretta caretta* (W. Miller, pers. comm.). Also, the extensive kill of subadult *Eretmochelys imbricata* in Dominican Republic, represented by the extensive collection of mounted heads in Santo Domingo souvenir stores, was not recorded (observed and photographed by F. Berry). The thousands of eggs of *Dermochelys coriacea* that were taken along

Caribbean Costa Rica each year were not mentioned. The often rumored and long term capturing and buying of sea turtles in other countries around the Caribbean Basin by fishermen in vessels from Cayman Islands, from Martinique, and from Guadaloupe were not accounted for. The table for Lepidochelys kempi in WATS I Proceedings (p. 70) had no entries under "Fishery", yet NMFS reasonably estimate that hundreds of these are caught and killed annually by shrimp vessels of the United States and Mexico.

We know now that there are large voids in our data base on exploitation of sea turtles in the western Atlantic. We must continue the efforts to learn and report how many, what species of sea turtles are being killed and where, when and for what purposes. Some examples are given from what we have learned of sea turtle exploitation over the past two years.

Guatemala, on its 50 km of sea turtle nesting beach, records an estimated annual range of 380 to 760 nests of Eretmochelys imbricata, 45 to 90 Chelonia mydas nests, and 25 to 50 Dermochelys coriacea nests. All of these nests were reported to have been exploited (Rosales, WATS II National Report).

Venezuela reports the estimated annual range of exploited nests of Chelonia mydas to be about 1,500 to 4,200, of exploited nests of Eretmochelys imbricata to be about 200 to 2,000, and lesser amounts of exploited nests of Dermochelys coriacea and Caretta caretta. Venezuela estimates a minimum annual harvest of 407 subadults and adults of Chelonia mydas, a minimum of 99 Eretmochelys imbricata, 10 Lepidochelys olivacea, and a few Dermochelys and Caretta (G. Medina, pers. comm.)..

The British Virgin Islands report that the "Sea turtles have played an important role in the cultural and socio-economic development of BVI." Although there has never been an established commercial export of turtles, they have been extensively exploited at the subsistence level. The local turtle fishery has been family or community oriented, and, although there has been a significant decline in the fishery, that trend continues today. More than 10 Chelonia and 10 Dermochelys are estimated to nest there annually and Eretmochelys, Chelonia, and Dermochelys are harvested each year from the nesting beaches (less than 10 each). Between 10 and 100 each of Chelonia and Eretmochelys are harvested each year in the water.

In Costa Rica, during spring and early summer, daily sampling of a five mile section of beach within the Tortuguero National Park recorded 56 nests laid by Chelonia mydas, of which 23 were dug up, and 15 nests laid by Eretmochelys imbricata, of which 7 were dug up and removed. These yield a collective percentage of 42% exploitation, while the percentage of nests of

Dermochelys coriacea that were dug up from the same beach area at this time was only about 16%, indicating a recognition of and prediliction for eggs of Chelonia and Eretmochelys by the diggers.

In 1985, 19 Dermochelys coriacea came ashore to nest on Salisbury Beach in Grenada, and all 19 females were collected for local meat sales by one fisherman we interviewed.

The ad hoc National Report for Haiti states that "official statistics on the amount of turtles and turtle products harvested for human consumption and other uses do not exist." It reports that sea turtle meat and eggs can sometimes be obtained in seafood shops of Port-au-Prince. It estimates the take of hawksbills for trade with Japan alone for the past 27 years at the rate of about 773 hawksbills per year.

In Dominica, approximately 20 Chelonia, 30 Eretmochelys, and 5 Dermochelys nest there each year. Most, if not all, of these nests are being harvested. Of the female sea turtles nesting on the beaches around Dominica, there is an estimated annual kill of about 25 Chelonia, 40 Eretmochelys, and 20 Dermochelys. An estimated 50 other adults and 75 subadults of Chelonia, Eretmochelys, and Dermochelys are taken annually in the water (Lawrence, WATS II National Report).

In St. Lucia, of an estimated annual 25 nests of Chelonia, 15 of Eretmochelys and 8 of Dermochelys, most, if not all, are believed to be harvested. As many as 45 nesting adults of these 3 species may be captured and slaughtered annually for local consumption. As many as 270 adults and subadults of these 3 species may be captured annually in the water.

In Costa Rica, the legal quota of adult Chelonia mydas is 1,800 per year--to be taken only during June, July, and August. For the 5 years 1983-87, the total quota was 9,000 Chelonia. Our survey estimates that 16,492 were taken, exceeding the quota by almost seven thousand five hundred adult Chelonia mydas. By national regulation, all of these animals should be delivered to and processed and recorded in Puerto Limon, but we know that many were slaughtered at other places along the coast. It was reported in 1983-84 that copulating pairs were harpooned to increase harvesting efficiency, but more recently, since harvesting (all presumably of Chelonia in the water) occurs during the nesting season, females are selectively fished (a ratio of 2.4 females to 1 male in 1987), because the ovarian eggs of the females bring the fisherman more profit (F. Berry, WATS II Report/Data Set).

A report on the "Japanese Sea Turtle Trade, 1970-1986" Milliken and Tokunaga (1987) contains some estimates of Eretmochelys imbricata captured to export bekko to Japan. Certain western Atlantic countries that formerly shipped moderate to significant quantities of bekko to Japan have shipped none or very little from about 1983 to 1986. These are Bahamas, Costa Rica, Honduras, Nicaragua, Panama, and St. Lucia. In 1985, Honduras had killed about 2,500 Eretmochelys to supply bekko to Japan. Cayman Islands was estimated to have killed, or at least to have obtained, in excess of 5,000 Eretmochelys in 1984 and 1985 for this purpose, but the estimated kill dropped to about half that amount in 1986. Cuba was estimated to have been the source of 2,000 to 5,000 Eretmochelys annually to supply Japan with bekko from 1970 through 1986. Curiously, 5 Caribbean countries that previously shipped little bekko shipped moderate to significant amounts in 1986: about 400 Eretmochelys each from Antigua and St. Vincent, about 600 from Dominican Republic, about 1,700 from Haiti, and more than 5,000 from Jamaica.

One interesting shift in the market value of Chelonia mydas is contained in the market survey data of the Chelonia mydas adult kill in Costa Rica. During June-August 1986, when an estimated 6,056 Chelonia were butchered, the price per kilogram was only 30 to 50 colones. However, during June-August 1987, when only an estimated 1,817 Chelonia were butchered, the price per kilogram increased to 120 colones. In a report received 11 October 1987 from Costa Rica, in San Jose, Chelonia mydas meat was selling for 160 colones per kilogram (about $1.12 US per pound) and Chelonia mydas eggs were being sold for 120 colones per dozen (about 10 cents US per each).

The National Report for Barbados gives some current values for sea turtle products: sea turtle meat (Chelonia) at $1.40 US per pound; Eretmochelys shell at $7.50 US per pound; and eggs (Dermochelys and Eretmochelys) at $2.00 US per pound. An Eretmochelys imbricata in Barbados of about 160 pounds, the average weight of a breeding female, would currently be worth about $112.00 US in meat, and $50.00 US in shell, for a total of about $168.00 US, plus a few dollars more, if she contained shelled eggs that were sold.

There has been a recent attempt to solicit exploitation data from the Caribbean by James Richardson. A 21-page questionnaire was distributed through the Wider Caribbean Sea Turtle Conservation Network (WIDECAST) requesting information on sea turtle markets, illegal trade, stock assessment, and socioeconomic considerations. The results have been minimal. A 2-page draft questionnaire has been prepared by Marydele Donnelly of the Center for Environmental Education for distribution after the symposium. But, obviously, we do not have nearly enough information on the socioeconomic aspects of sea turtle exploitation.

International Trade in Tortoiseshell (Marydele Donnelly)

The focus of this talk on international trade in hawksbill shell in the Wider Caribbean* is Japanese trade. As the world's largest trader in sea turtle products, Japan has contributed significantly to the depletion of the hawksbill in the Wider Caribbean and around the world. Although other nations have been major markets for Caribbean shell in the past and French trade continues to deplete hawksbills in the Lesser Antilles, the toll which Japan has exacted on the hawksbills of the Wider Caribbean has been unequalled by any other nation.

My primary source of information is a report entitled Japanese Sea Turtle Trade 1970-1986 by Milliken and Tokunaga (1987) of TRAFFIC (JAPAN), the wildlife trade monitoring arm of the World Wildlife Fund. Commissioned earlier this year by the Center for Environmental Education (CEE) in preparation for the sixth biennial meeting of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in July, the major objectives of this report were to determine where exploitation was occurring and estimate the number of turtles that were utilized. Data were obtained from interviews with Japanese dealers of hawksbill shell.

Each year Japan imports approximately 30,000 kg of raw hawksbill shell or bekko from around the world for its traditional shell industry. For over 280 years, Japanese artisans have produced the world's finest quality shell products through a laborious process of heat, pressure, carving and polishing. Beautiful and ornate combs, hair ornaments, and jewelry are expensive and highly prized items. Bekko eyeglass frames are also very popular in Japan.

In many areas of the world, international trade in sea turtle products has been restricted by CITES, the major

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* The Wider Caribbean is a diverse region, and the socioeconomic importance of sea turtles varies widely from one area to another. Historically, sea turtles have been an important resource for Caribbean people, and they have been heavily exploited for local consumption (Bacon et al. 1984) and international trade (Mack et al. 1982; Carr et al. 1982; Roet 1983; Meylan 1984a; Canin and Luxmoore 1985). Populations of all species are declining in the region (Bacon et al. 1984). Because sea turtles are migratory and the waters of many nations are easily accessible to their neighbors, solutions to exploitation must be devised and agreed upon on a regional basis.

international wildlife treaty regulating the trade in endangered species of animals and plants and their products. Under CITES all species of sea turtles are listed on Appendix I which means that trade is prohibited. CITES allows for reservations or exceptions to Appendix I listings, however. When Japan acceded to CITES in 1980, it took reservations on olive ridley, green, and hawksbill turtles (the reservation on green turtles will be dropped in November 1987). At that time the Japanese government set a maximum import quota of 30,000 kg of raw hawksbill shell (between 1970 and 1979 Japan's imports of bekko varied from a low of 34,223 kg to a high of 73,206 kg, with an average of 44,690 kg/year).

Japan is therefore allowed to continue to trade in sea turtle products but only under certain conditions. A country with a reservation cannot trade 1) with other CITES countries without a legal export document (which in most cases should not be given) and 2) with a non-CITES country that prohibits trade in that endangered species. Since acceding to CITES, Japan has frequently violated these restrictions (Weber et al. 1983; Canin and Luxmoore 1985).

The results of the Japanese sea turtle trade survey are staggering in terms of the sheer volume of trade and the volume of illegal trade in the Wider Caribbean. Between 1970-1986 Japan imported 327,000 kg of shell, 51.1% of its total hawksbill shell imports, from the Wider Caribbean. These figures are the equivalent of 251,660 Caribbean hawksbill turtles. During this 16-year period, trade from the region was widely distributed, with 26 countries providing shell. Over time, trading patterns appear to have changed, in large part as a result of CITES restrictions. In some areas there has been an increase in trade; in others a decrease (Figures 1-17). Overall, the Wider Caribbean has continued to provide about 50% of Japan's shell imports.

Four major exporters--Panama, Cuba, the Cayman Islands, and Haiti--have provided three-quarters of Japan's imports from the region. Patterns of trade from these four exporters are very interesting.

Panama (Fig. 15) supplied 15% of Japan's total imports for the 16-year period, the equivalent of 75,906 hawksbill turtles. While many of these turtles were of Panamanian origin, Panama also served as a collecting point for shell harvested in the region. Panama acceded to CITES in November 1978; according to Japanese Trade Statistics, shell imports into Japan continued until 1986. The government of Panama has informed TRAFFIC (JAPAN) that no CITES export documents have been issued in the last ten years.

The Cayman Islands (Fig. 5), a dependent territory of the United Kingdom, was also a regional collecting point. Although there are few resident hawksbills in Cayman waters, the territory is ranked as a major supplier of shell to Japan, providing the equivalent of 27,590 hawksbills to Japan. Although CITES came into force in May 1979, it was not until 1984 that all trade to Japan from the Cayman Islands ceased.

From 1970-1986 Cuba (Fig. 7) supplied 15% of Japan's total shell imports, and today Cuba is the world's major legal exporter of shell to Japan. Cuba is not a member of CITES, but its imports have not increased as CITES restrictions have curtailed exports from other nations in the region. While Cuban trade is carefully regulated, and sea turtles are legally captured only by state controlled fishery cooperatives (Groombridge and Luxmoore 1987), Cuban biologists admit that populations are in decline (M. Weber, pers. comm.). The quality of shell from Cuba is among the world's best; the light color makes it particularly popular for the manufacture of eyeglasses. Presently, annual exports to Japan represent the harvest of about 3,400 animals.

Haiti (Fig. 11) is a non-CITES country which is increasing its exports to Japan as CITES controls have reduced or eliminated trade from other areas of the Wider Caribbean. Most importantly, trade from Haiti has been steadily increasing since 1981. As hawksbills are not abundant in Haitian waters, it is feared that Haiti is serving as an entrepot for shell coming from other areas. In 1986 Haitian exports represented the equivalent of 1,200 hawksbills.

International restrictions on sea turtle trade have affected Japan's importing patterns in recent years because Japan has agreed to reduce or eliminate its trade with CITES nations. Whether this is a genuine effort or a documentary ruse is subject to debate.

It is possible that shipments of hawksbill shell obtained elsewhere are simply being rerouted through non-CITES countries. Prior to 1983, for example, Antigua/Barbuda, a non-CITES nation, did not export hawksbill shell to Japan. Shipments of shell from Antigua/Barbuda have been recorded in the Japanese Customs Statistics since 1983. Antiguan authorities report that no shell has been legally exported and had no idea that their nation was cited in Japanese Customs Statistics until the Milliken and Tokunaga (1987) report was published. It is suspected that Antigua/Barbuda has been cited on Japanese import documents as a cover for trade from a CITES nation. Similarly, although Panamanian exports have ceased recently, it is reported that Japanese dealers are still operating in that country (A. Meylan, pers. comm.). There are other reports of Japanese dealers illegally buying shell in CITES countries in the Wider Caribbean.

Japan's acceptance of shipments of shell from non-CITES nations which prohibit sea turtle trade is also a clear violation of CITES. For example, Japanese Customs Statistics reveal that 6,148 kg of shell, the equivalent of 4,099 hawksbills, have been imported into Japan from Jamaica since 1980. Jamaica prohibits the export of sea turtle products, and no legal export documents have ever been issued (A. Haynes, pers. comm.).

Nations that do not allow the export of sea turtle products should notify Japan's CITES Management Authority, in the Ministry of International Trade and Industry (MITI), that sea turtle exports are prohibited. These letters should ask for Japan's assurance that it will not accept further exports of hawksbill shell from their country.*

There is concern that Japan's volume of trade in the Wider Caribbean will increase as more nations in other parts of the world join CITES and cut off traditional sources. Until all the nations in the Wider Caribbean, including Antigua/Barbuda, Barbados, Cuba, Dominica, Grenada, Haiti, Jamaica, Mexico, St. Kitts and Nevis, and St. Vincent, join CITES, many trading loopholes will be available.

In addition, the weight and quality of Caribbean hawksbill shell make it particularly valuable to Japanese buyers. TRAFFIC researchers found that the weight of shell per animal, including the back, belly and marginal scutes, is higher in the Caribbean than elsewhere in the world. Whether this is a subspecies difference or is related to consumption patterns, i.e., some nations have overfished their hawksbills and are now harvesting smaller animals, is an interesting question. Average shell weights are 1.34 kg in the Caribbean, 0.74 kg in the Indian Ocean/Africa, and 0.88 kg in Oceania.

Individual shell weights also vary within the Wider Caribbean. For example, Cuban turtles produce 1.59 kg/individual while turtles from St. Vincent yield 1.1 kg, and Bahamian turtles produce 0.81 kg. Experienced Japanese dealers report that Bahamian turtles have always been smaller.

Another very interesting fact from the Japanese trade report was the lack of interest shown by Japanese dealers in substituting the shell of ranched green turtles for hawksbill

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* This correspondence should be sent to MITI, International Economic Affairs Division, International Economic Affairs Department, International Trade Policy Bureau, 3-1 Kasumi-ga-seki 1-chome, Chiyodaku, Tokyo 100 Japan and copied to Sr. Obdulio Menghi, CITES Secretariat, 6 rue du Maupas, Case Postale 78, 1000 Lausanne 9 Switzerland.

shell. Because the shell of ranched green turtles is thicker than the shell of wild-caught green turtles, it has been suggested that the shell of ranched specimens could replace hawksbill shell. The following excerpt from the Milliken and Tokunaga (1987) report refutes this possibility:

> "Over the last decade Japanese bekko manufacturers reported extensive experimentation with tortoiseshell (green turtle shell) as a potential substitute for bekko (hawksbill shell). These experiments have proven for the most part unsuccessful. Unlike bekko, several layers of tortoiseshell will not readily adhere together in order to produce a greater thickness more conducive for manufacturing purposes. With time, compressed tortoiseshell invariably separates or cracks."

Today, Japan continues to trade in large volumes of hawksbill shell from the Caribbean. In 1986, 14,544 kg of bekko, the equivalent of more than 10,000 hawksbills, were imported into Japan from the region. While perhaps in time the Japanese can be convinced to lower their annual import quota of 30,000 kg of shell, very substantial numbers of Caribbean hawksbills will continue to be exported to Japan in the foreseeable future. Since WATS I, recorded Japanese imports from the region totalled 61,045 kg of shell (15,004 kg in 1983; 15,207 kg in 1984; 16,290 kg in 1985; and 14,544 kg in 1986).

Although Japanese trade in hawksbill shell is very significant, the effect of French trade in the Caribbean should not be underestimated. For years French fishermen and buyers have heavily exploited sea turtles in Martinique, Guadeloupe, and the Lesser Antilles (Carr et al. 1982; Meylan 1983, 1984a; Pritchard 1984a).

There is a critical need for conservation in the French Antilles as a result of local consumption and the tourist trade in jewelry, shell and other souvenirs (Carr et al. 1982). In Guadeloupe there are limited regulations which protect sea turtles, but they are not enforced and many inhabitants are not even aware of their existence (Carr et al. 1982). Because the extensive reefs of Guadeloupe and Martinique provide excellent developmental and foraging habitat (Carr et al. 1982) this exploitation has also resulted in the depletion of regional populations. Furthermore, French fishermen and buyers have not limited their activities to the waters of the French Antilles. While they have exploited the French islands most intensely, no island in the Lesser Antilles has escaped their attention (Meylan 1984a). France maintains that exports from the French Antilles to metropolitan France are permitted as domestic shipments and are not prohibited by its compliance with CITES regulations. No attempts are made, however, to prevent the sale of sea turtle products to tourists from other nations.

In addition to flaunting the restrictions that prohibit the importation and exportation of sea turtle products, France and its overseas departments violate CITES restrictions by reexporting sea turtle products from Taiwan and the Philippines to meet the demands of the tourist trade (Pritchard 1984a).

France has a well-documented history of failing to comply with international trade restrictions for endangered and economically valuable species such as sea turtles. For example, the CITES Secretariat's Review of Alleged Infractions (1987) cites France for importation of hawksbill shell from CITES and non-CITES nations around the world. Similarly, a preliminary assessment of the implementation of CITES in the European Economic Community (World Wildlife Fund 1986) provides numerous examples of France's trade in hawksbill shell.

International trade in hawksbill shell from the Caribbean is a problem of very substantial proportions, and nations in the Wider Caribbean are going to have to act aggressively to protect their turtles. The solutions include adoption and strict enforcement of regional fisheries legislation and accession to CITES by all Wider Caribbean nations. Countries which prohibit the export of hawksbill shell should notify Japan and France that their activities are undermining regional conservation programs. A moratorium on the taking of hawksbills should also be considered.

If and when sea turtle populations are to be exploited, sustainability will have to be measured in terms of available biological data, trade patterns and other sources of information. There is no doubt that international trade is draining the region of a valuable resource. It is also jeopardizing the continued existence of one of the region's special species.

In summary, Japan is the major international market for Caribbean hawksbill shell. A recent study of the Japanese sea turtle trade reveals that the raw shell of more than 251,000 hawksbills from the Wider Caribbean was exported to Japan from 1970-1986. At present, approximately 10,000 Caribbean hawksbills are harvested annually for the Japanese trade. Japan frequently violates international restrictions on sea turtle trade by accepting imports from Caribbean nations that prohibit trade in sea turtles.

Hawksbills are also heavily exploited in the French islands of Martinique and Guadeloupe. This harvest has been extensive and uncontrolled for years. Although France maintains that trade with its overseas territories is domestic, fishermen and shell buyers from Martinique and Guadeloupe obtain turtles in the waters of neighboring islands. Hawksbill shell and shell products are sold to tourists from France and other nations.

Authorities in the French Caribbean have made no effort to curb this illegal international traffic.

Nations in the Wider Caribbean must act aggressively to stop Japan and France from undermining their conservation efforts to protect sea turtles. Regional solutions are needed, including accession to The Convention on International Trade in Endangered Species (CITES) by all Wider Caribbean countries and adoption of uniform fishery regulations. A moratorium on the harvest of hawksbills in the Wider Caribbean should also be considered.

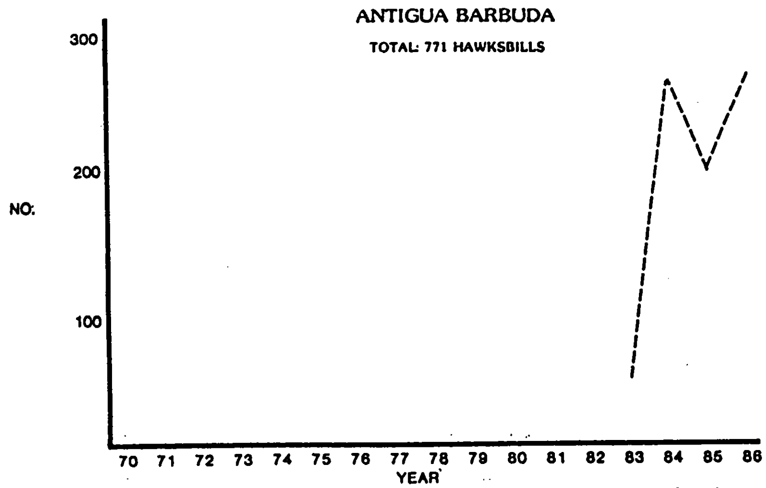


Figure 1. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Antigua Barbuda

Source: Japanese Customs Data Calculated at 1.1kg of Shell per Hawksbill

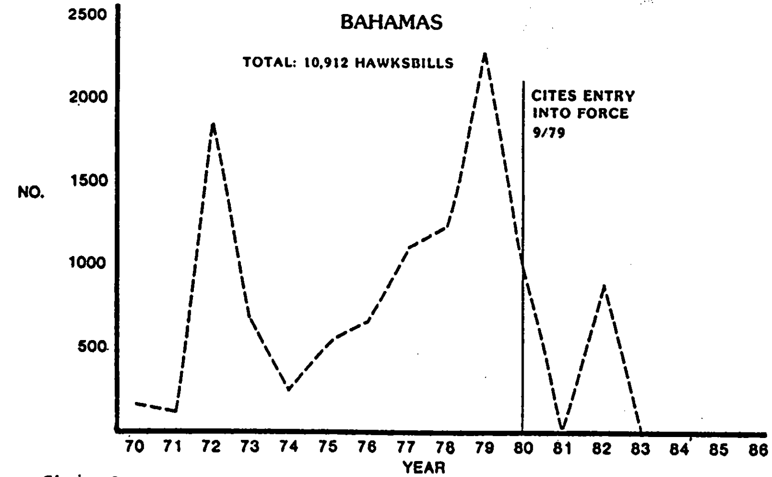


Figure 2. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Bahamas

Source: Japanese Customs Data Calculated at .81kg of Shell per Hawksbill

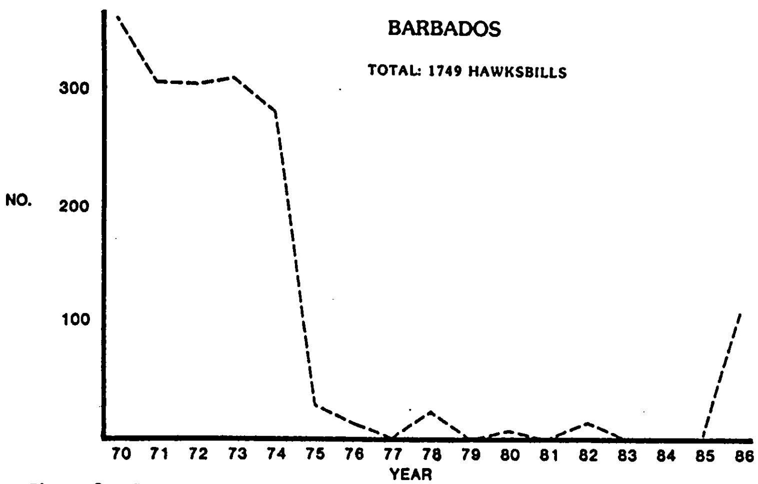


Figure 3. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Barbados

Source: Japanese Customs Data Calculated at 1.1 kg of Shell per Hawksbill

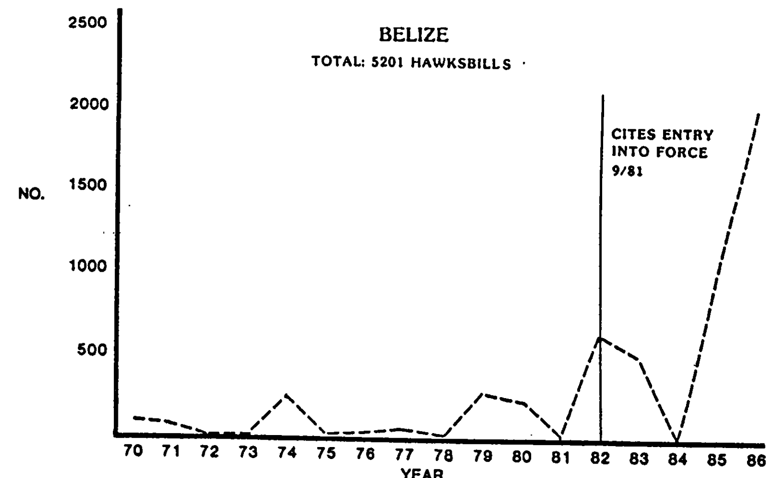


Figure 4. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Belize

Source: Japanese Customs Data Calculated at 1.11 kg of Shell per Hawksbill

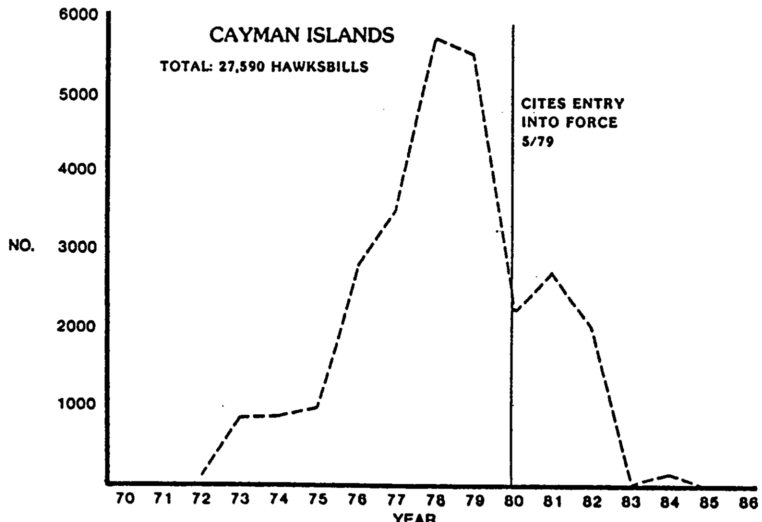


Figure 5. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Cayman Islands

Source: Japanese Customs Data Calculated at 1.1kg of Shell per Hawksbill

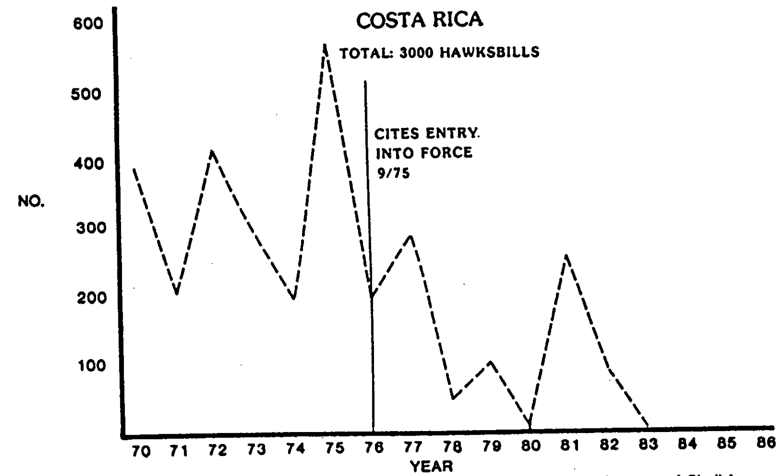


Figure 6. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Costa Rica

Source: Japanese Customs Data Calculated at .925 kg of Shell per Hawksbill

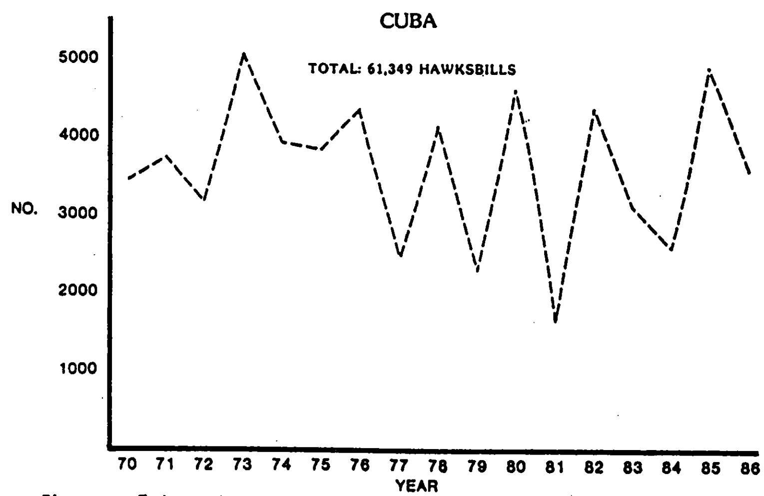


Figure 7. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Cuba

Source: Japanese Customs Data Calculated at 1.595 kg of Shell per Hawksbill

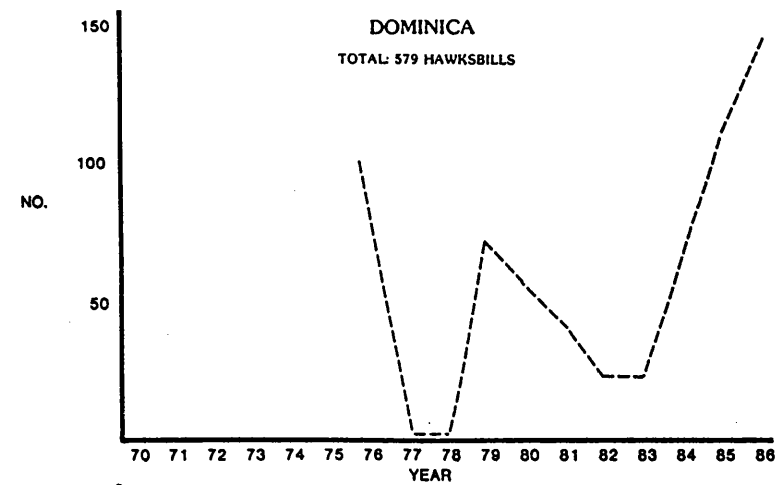


Figure 8. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Dominica

Source: Japanese Customs Data Calculated at 1.5kg of Shell per Hawksbill

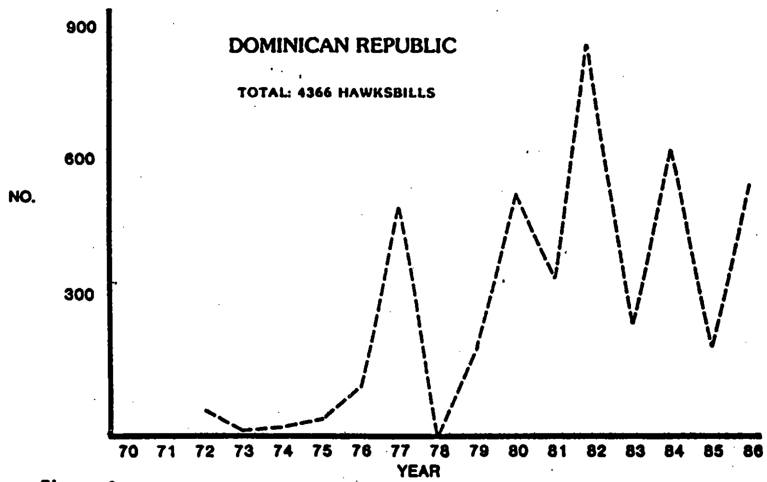


Figure 9. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Dominican Republic

Source: Japanese Customs Data Calculated at 1.0kg of Shell per Hawksbill

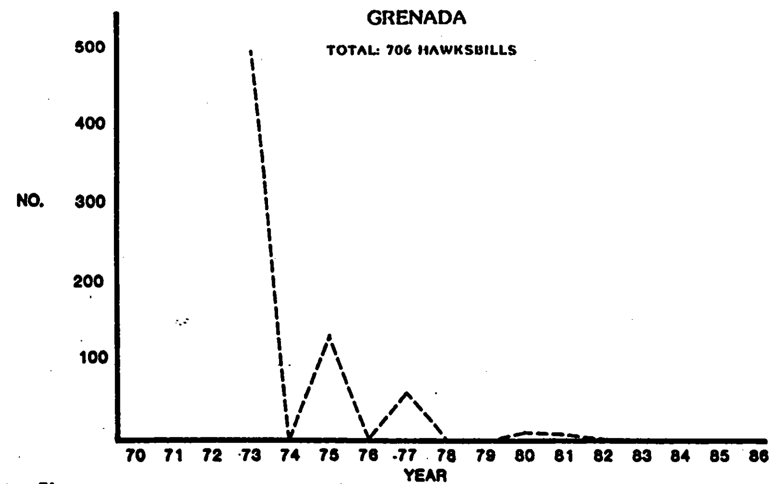


Figure 10. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Grenada

Source: Japanese Customs Data Calculated at 1.0kg of Shell per Hawksbill

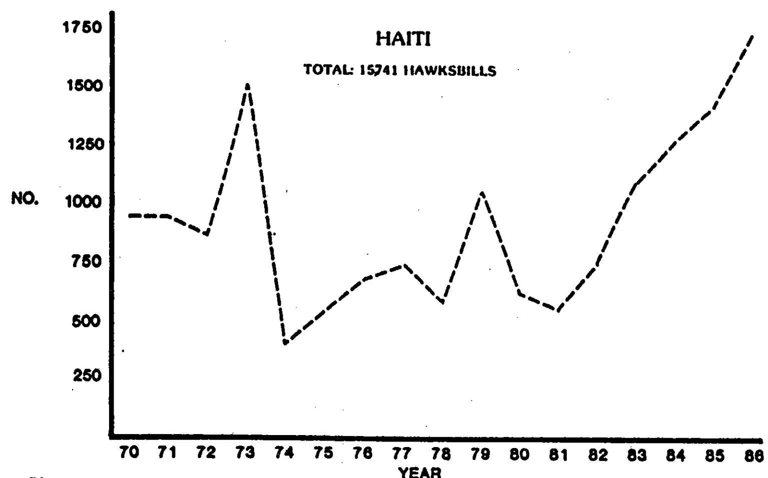


Figure 11. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Haiti

Source: Japanese Customs Data Calculated at 1.575 kg of Shell per Hawksbill

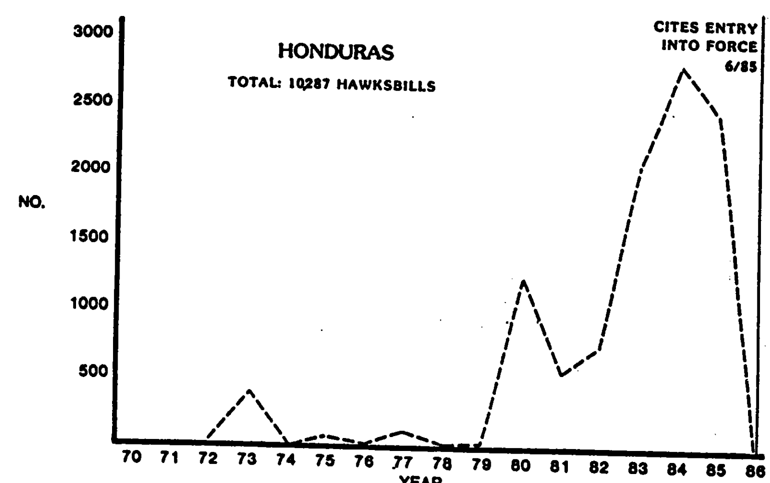


Figure 12. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Honduras

Source: Japanese Customs Data Calculated at .9 kg of Shell per Hawksbill

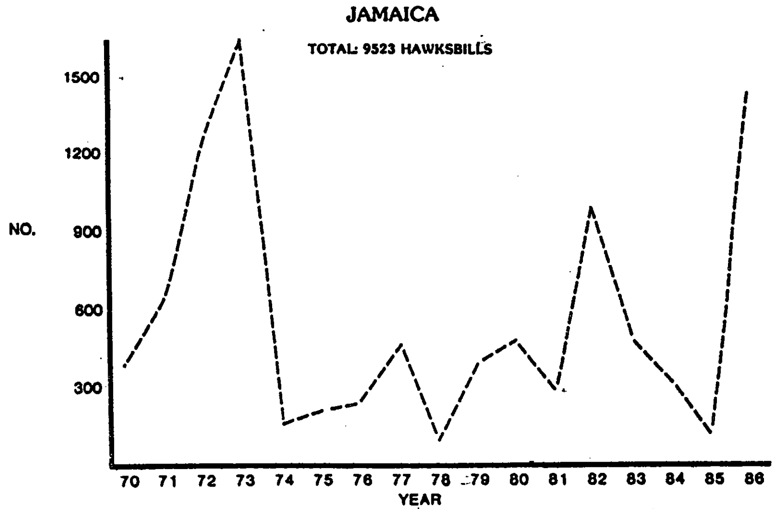


Figure 13. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Jamaica

Source: Japanese Customs Data Calculated at 1.5kg of Shell per Hawksbill

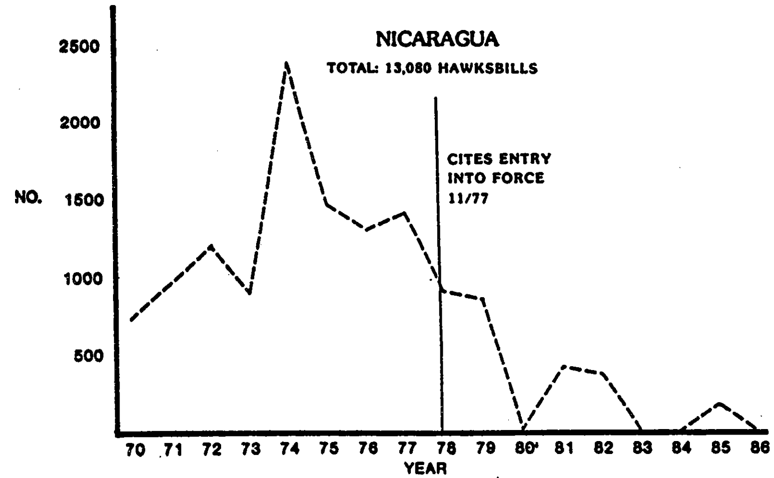


Figure 14. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Nicaragua

Source: Japanese Customs Data Calculated at 1.15 kg of Shell per Hawksbill

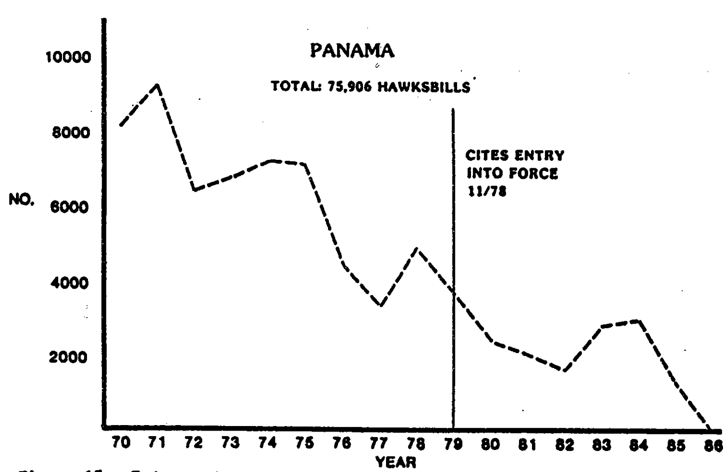


Figure 15. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from Panama

Source: Japanese Customs Data Calculated at 1.3 kg of Shell per Hawksbill

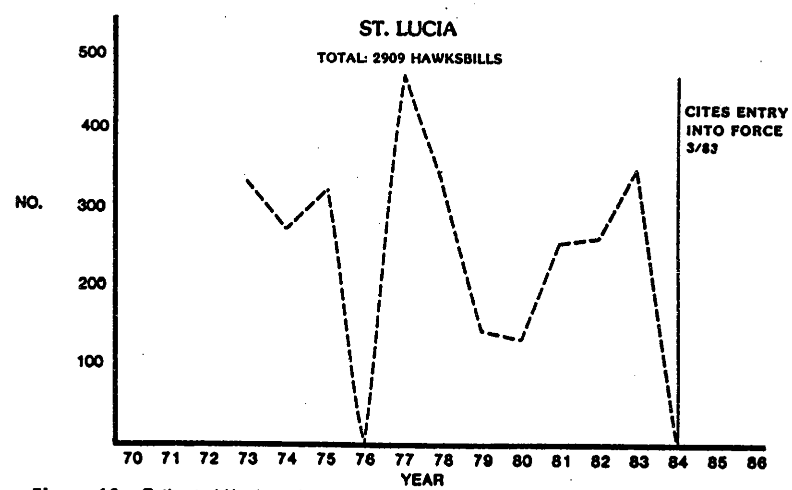


Figure 16. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from St. Lucia

Source: Japanese Customs Data Calculated at 1.03 kg of Shell per Hawksbill

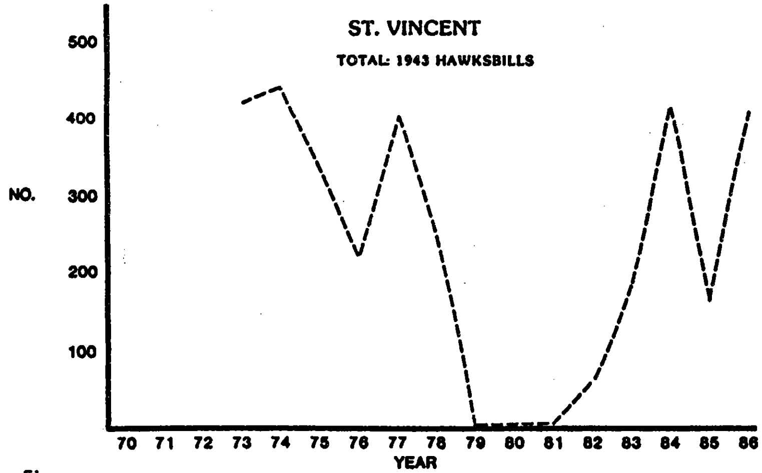


Figure 17. Estimated Number of Hawksbills Represented by Japanese Imports of Shell from St. Vincent

Source: Japanese Customs Data Calculated at 1.15 kg of Shell per Hawksbill

Socioeconomic Importance of Sea Turtles

Incidental Capture (Michael Weber)

Effects of Incidental Catch

As noted at the 1979 World Conference on Sea Turtle Conservation in Washington, D.C., little attention has generally been paid to reducing pressure on wild populations of sea turtles arising from incidental capture and mortality chiefly in connection with fishing activities. Early restrictions on the deployment of gill nets set for sturgeon in North and South Carolina were the exception until recently. The imminent use of Turtle Excluder Devices (TED) in the southeastern shrimp fishery of the United States is clearly only a beginning in reducing shrimp fisheries' capture of sea turtles, particularly endangered sea turtles as the Kemp's ridley.

The relatively low priority accorded incidental capture in sea turtle conservation efforts in the past does not mean that the problem has been unrecognized. In an IUCN monograph Pritchard and Marquez (1973) remarked of the problems confronting the vanishing Kemp's ridley:

> "Probably the most serious problem of all, however, and the hardest to control, is the accidental capture and drowning of ridleys in shrimp trawls, and to a lesser extent, shark nets, particularly as they migrate to and from the nesting grounds. Of the 285 female ridleys tagged by Chavez in 1966, at least 17 had been caught in these ways by August 1967; and at least 6 of the 80 tagged by Pritchard in 1970 have already been caught, and the tags returned." (Pritchard and Marquez, 1973.)

Until the promulgation of TED regulations in the U.S., however, this problem went unaddressed. And the situation only worsened. Despite one of the most intensive recovery efforts ever directed at a species of sea turtle, the Kemp's ridley population has continued to decline at a rate of three percent per year since 1978 (J. Woody, pers. comm.). The TED regulations in the U.S. come not a moment too soon. And we must hope that Mexico continues its recent efforts to address the capture of Kemp's ridleys in its shrimp fishery.

The impact of incidental capture of sea turtles in shrimp trawls and other fishing gear is not limited to Kemp's ridleys. Colin Higgs considered incidental capture in shrimp trawls off Surinam and French Guiana as a primary cause of the decline of olive ridleys in the region (Bacon et al. 1984). Nor can conservationists in the United States be complacent about the more abundant loggerhead sea turtles. Nesting populations in

South Carolina and Georgia have apparently been declining at a rate of at least three percent per year (N. Frazer, pers. comm.). Recent modeling of the population dynamics of U.S. loggerhead populations suggests that the many nesting conservation efforts in the southeastern U.S. will not reverse this decline unless incidental capture in shrimp trawls ends (Crouse et al. 1987).

Our understanding of sea turtle biology and our inability to anticipate problems created by new fishing technology suggest that incidental capture may become the major short-term problem for sea turtle populations even as hunting and commercial trade pressures may be reduced. As well, we are only now coming to recognize the hazards posed to sea turtles by discarded fishing gear and other debris (Balazs 1985). This, too, is a threat that is only now being addressed.

The WATS I panel discussions on management options and conservation identified the reduction of incidental capture of sea turtles as a major element in the conservation of sea turtles and called for the introduction of the TED into the shrimp fisheries of the western Atlantic. I should think a confirmation of this conclusion is in order. We can take some encouragement that several countries, including Mexico, Panama, Honduras, Trinidad and Colombia, have indicated an interest in applying TED technology in their shrimp fisheries.

Incidental Capture of Sea Turtles in Western Atlantic Fisheries

The national reports prepared for the first WATS together with panel discussion during that meeting provide some information on the incidental capture of sea turtles in fisheries (Bacon et al. 1984). Table 13, Incidental Turtle Catch, provides directly relevant information. Other tables also provide useful information: Table 11, Landing Sites for Turtles and Turtle Products, includes information on methods of directed capture. Table 14, Estimated Turtle Catch by Foreign Fishermen, includes several reports of incidental catch of sea turtles in such foreign fisheries as Japanese longlining for tuna and billfish. However, analysis of information presented in these tables is hampered by ambiguities surrounding the definition of incidental catch, as acknowledged in the instructions that accompanied the national reports for WATS I (Bacon et al. 1984).

Some types of gear, such as trawls, are relatively indiscriminate in what they capture, although they may be used in fisheries directed at specific species or groups of species such as shrimps. Non-target species captured in such gear is generally regarded as incidental catch. In many shrimp fisheries, this incidental catch may include dozens of finfish species, sea turtles, crabs, sponges, and undersized shrimp (Tarnas 1986).

The term incidental catch does not differentiate between turtles discarded alive, turtles discarded dead, and turtles slaughtered for consumption. In the United States, best estimates are that of about 48,000 sea turtles captured in shrimp trawls each year from North Carolina to Texas, about 11,000 drown. While the capture of turtles is a cause for concern, the incidental mortality of turtles in this fishery presents a much more serious threat to the affected sea turtle populations. Yet, the term incidental catch does not recognize this difference.

Also, in some countries, some incidental catch is utilized and may be considered a secondary target of a fishery. Thus, a sea turtle caught in a trawl in some shrimp fisheries may be sold as if it had been caught in a fishery directed at turtles and not at shrimp. In another shrimp fishery, however, an incidentally caught turtle may be returned to the water dead. While both turtles have been caught incidentally, the first should probably be reported as a landing and the second as an incidental catch. However, the general use of the term incidental catch, which is followed in the instructions to the WATS I national reports, does not make this distinction.

The distinction is not simply one of narrow semantics. Rather, these differences in the end-use of by-catch demand different conservation measures. In the case of utilized by-catch, one might impose quotas, whereas one might seek to design gear that would reduce by-catch, if the by-catch would otherwise be discarded.

The confusion surrounding the meaning of the term incidental catch is expressed in another manner, also. Several countries reported as incidental catch the capture of sea turtles by spear fishermen who were fishing finfish or lobster. There are few if any types of fishing gear as selective as spearguns. Such captures are intentional, and therefore not incidental.

Finally, as noted above, some types of fishing gear are by design non-selective in the extreme. Such fisheries affect the conservation of species other than sea turtles. In the U.S. Gulf of Mexico shrimp fishery, for instance, more than 1.5 billion pounds of juvenile finfish are captured and discarded each year (Tarnas 1986). I raise this issue to note that sea turtles are but one of the victims of non-selective gear and to urge that in reducing the incidental capture of sea turtles we not ignore the discard of other incidentally captured marine life.

The limitations on the term incidental catch that I have discussed above should be kept in mind in the following summary of the information provided in Tables 11, 13 and 14 of the national reports presented at WATS I. These tables and information from the discussions at WATS I are summarized in Tables I and II of this report.

First, 19 of the 40 national reports prepared for WATS I indicated some level of incidental capture of sea turtles. These countries are: Anguilla, Antigua and Barbuda, Belize, Brazil, British Virgin Islands, Cuba, Dominica, Grenada, Honduras, Jamaica, Martinique, Mexico, Montserrat, Netherlands Antilles, Nicaragua, Surinam, Turks and Caicos, the United States, and Venezuela (see also Bacon et al. 1984, p. 166). Five countries provided estimates of the level of capture, with the United States providing the greatest detail (see below).

The methods of capture included gill nets, pound nets, shrimp trawls, shark nets, fish weirs, beach seines, trammel nets, hook and line fishing, spearguns, and longlines. The various types of net gear dominated reports of incidental catch. This is by no means surprising considering how non-selective such gear is.

Green, loggerhead, and hawksbill sea turtles were listed most frequently as species incidentally captured in the Wider Caribbean region. In the discussion of the olive ridley at WATS I, J. Schulz noted that most of the 59 olive ridleys tagged and released in Surinam were later caught in shrimp trawls off the Guianas, Trinidad, Isla Margarita, and eastern Venezuela (Bacon et al. 1984, p. 107). The British Virgin Islands, Mexico, and the United States also reported captures of leatherbacks.

Few countries presented any information regarding turtle catches by foreign fishermen. Belize, British Virgin Islands, and the United States did report unquantified captures of sea turtles by Japanese longliners fishing for tuna and swordfish.

Twenty-five of the 40 national reports recorded landings of sea turtles, principally of hawksbills, greens, and loggerheads. Interestingly, the most commonly cited method of capture was by nets, including "turtle" nets, set nets, and trammel nets (see Table II). These gear types, which are used in many parts of the world in fisheries for sharks and finfishes, are the very types implicated in the incidental capture of sea turtles in many areas.

Incidental Capture of Sea Turtles in U.S. Fisheries

Although sea turtles are incidentally caught as a result of human activities such as dredging, most incidental captures occur in connection with commercial fishing activities directed at other species of animals, such as shrimp, sturgeon, or tuna. Several authors have reviewed the incidental capture of sea turtles in U.S. commercial fisheries (Murphy and Hopkins-Murphy 1987; Henwood and Stuntz 1987; O'Hara et al. 1986; Crouse 1984). The much higher level of incidental capture of sea turtles in the shrimp fishery has attracted the greatest attention. As a result, information on the capture of sea turtles in other fishing gear and other fisheries is scanty and has not been systematically collected, in general.

Below, I summarize information regarding the different types of gear in which sea turtles are incidentally captured in the U.S. This summary is based principally upon a report prepared by the Center for Environmental Education in 1986 (O'Hara et al. 1986). I intend that the following description of types of gear involved in incidental capture enables others to begin collecting concrete information on the level of incidental captures in similar fisheries in the western Atlantic.

Gill Nets: A gill net is generally a single sheet of webbing suspended vertically from floats (Figure 1). The net may be floated at the surface, in mid-water, or on the bottom. Gill nets may be fixed in position by means of anchors and floats or may be allowed to drift in currents freely or attached to a fishing vessel (Figure 2). They are often deployed perpendicularly to the path of migrating fish, such as sturgeon.

Trammel nets are a type of gill net used for entrapping species that are difficult to catch in a regular gill net (Figure 3). Trammel nets are two or more panels of webbing suspended from a common surface line and attached to a single bottom line. One panel is of a larger mesh (24-32 inches stretched mesh) than the second panel, which may be 8-inch mesh. Fish pass through the larger meshed panel and are caught up in a pocket of the smaller meshed panel.

Delaware Gill Net Fishery: Both set and drift gill nets are used. Fixed gill nets are set in upstream tidal areas for shad and in other nearshore waters for sea trout, striped bass, bluefish, croaker, and white perch. Drift gill nets are set in areas of slow moving water in downstream areas of rivers for weakfish and croaker. There are several records of incidental mortalities of Kemp's ridley and loggerhead sea turtles in this fishery (O'Hara et al. 1986, p. 48-50).

Carolina Gill Net Fishery: From North Carolina to Georgia, gill nets are used to fish for shad, generally in January through April, and for sturgeon or, more recently, shark. Both drift and set gill nets up to 1,200 feet long are deployed in rivers and in nearshore ocean waters. In the past, gill nets set in these waters for sturgeon have been associated with high levels of loggerhead strandings early in the spring. Recent restrictions have substantially reduced this incidental mortality (O'Hara et al. 1986).

Drift Gill Nets for Swordfish: Recently, the use of drift gill nets has been introduced into the fishery for valuable swordfish in the northeast Atlantic. The nets, made of 18-inch stretched mesh, are generally 90 feet deep and one mile long. Nets are deployed at night, 18 feet below the surface, with one end attached to a fishing vessel. The nets are pulled at dawn. This fishery bears close watching. One fisherman reports catching turtles within these gill nets (O'Hara et al. 1986, p. 77-81).

Pound Nets: A pound net is a large stationary trap constructed of netting supported by poles or stakes (Figure 4). A line of netting, generally running perpendicularly from shore, directs fish moving along shore into a series of nets leading to a bag of netting in which the fish are impounded.

New York Pound Net Fishery: The pound net fishery in New York's Long Island area is directed at bluefish, butterfish, Atlantic mackerel, porgy, and sea trout, and lasts from early spring through fall. About 100 fishermen participate in this fishery. Recent interviews of fishermen indicate that these nets annually capture 10 to 20 sea turtles, principally Kemp's ridleys. Most of these turtles are released alive (O'Hara et al. 1986, p. 46-48).

Chesapeake Pound Net Fishery: Pound nets are set out in the Chesapeake Bay and its tributaries from spring through autumn to fish for alewives, bluefish, croaker, spot, shad, butterfish, sea trout, striped bass, and white perch. The Virginia Institute of Marine Science has recorded sea turtle mortalities since 1979. The majority of the mortalities are loggerheads with Kemp's ridleys making up less than five percent of the total. The peak of 80-200 mortalities occurs in early June each year.

Nets in areas of strong tidal currents or in deep water are likely to catch and drown turtles. Likewise, larger mesh nets (12-16 inches stretched mesh) are more likely to entangle and drown turtles than smaller mesh. Also, most turtle mortalities occur when the turtles enter the bay after their taxing migration from the south. Turtles may be attracted to pound nets by the presence of crustaceans that have themselves been attracted by the epibiotic growth on the nets (O'Hara et al. 1986, p. 51-53).

Longlines: Longlining fisheries exploded with the introduction of synthetic monofilament line. In this type of fishery, thousands of baited hooks are suspended from leaders attached to a main fishing line up to 50 miles long (Figure 5). This main fishing line is suspended from floats at depths depending upon the target species, which include tunas and billfishes. The target species also determines the depth at which the hooks are suspended from the main fishing line. In some cases, fishermen attach a "cold light" or cyalume light stick to the line just above the bait to attract animals (O'Hara et al. 1986, p. 77-81).

Longlines may also be used to catch bottom fish, such as snapper and grouper. Reports from Hawaii indicate that sea turtles may become entangled in such gear (O'Hara et al. 1986, p. 144).

<u>Atlantic and Gulf Swordfish Fishery</u>: This fishery is conducted in deeper continental shelf and slope waters. In the New England fishery, up to 40 miles of line with 400-2,000 hooks are set out at a depth of 40 feet for the mainline and another 20 feet for the hooks. Vessels in Florida use shorter mainlines set deeper. A Japanese longline fishery for tuna uses mainlines up to 80 miles in length, with hooks at depths over 150 feet. While the U.S. swordfish fishing effort remained steady or increased since the early 1980s, the Japanese longlining effort in U.S. waters has been increasingly restricted (O'Hara et al. 1986, p. 78-79). Recently, restrictions aimed at reducing fishing effort on swordfish has redirected longlining effort at tuna. During 1978-1981, a period of relatively high effort, it has been estimated that the Japanese longline fishery captured 330 turtles in U.S. waters, of which 204 were captured in the Gulf of Mexico where overall effort was lower compared to the Atlantic. Most of the identified turtles were leatherbacks. Captured turtles were hooked in the mouth or shoulder or entangled in the leader. Mortality ranged from seven percent in the Gulf of Mexico to 30 percent in the Atlantic (O'Hara et al. 1986, p. 79-80). The lack of data from the U.S. swordfishery and the demonstrated catch of sea turtles in the Japanese fishery is a cause for concern.

<u>Seines</u>: Purse seines are floating nets designed to surround fish (Figure 6). These nets can be closed at the bottom by means of a free-running line through one or more rings attached to the bottom (O'Hara et al. 1986, p. 195). In the southeastern United States, where sea turtles are distributed, purse seines are used to capture menhaden. Crouse (1984) noted that sea turtles are reported to be captured in these nets, but documentation is lacking.

Both green and leatherback sea turtles have been reported captured in beach seines in Florida and Georgia (Hillestad et al. 1982, p. 490).

Traps: Traps are portable devices made of wire or wooden slats that are deployed on the bottom. The traps are attached by lines to surface floats that mark the presence of a trap. This type of gear is used principally to fish for lobster and crab.

New England Lobster Fishery: Lobster traps, constructed of wood or plastic-coated wire, plastic or aluminum, are deployed in depths from 120 feet off Maine to New Jersey to depths of 1,900 feet off Cape Hatteras. In inshore areas, traps are set singly or strung in groups along a single line. Traps are left for one to five days inshore and five to ten days offshore. In 1980, 2.4 million traps were used inshore and 25,000 traps offshore. There are anecdotal accounts of leatherbacks becoming entangled in lobster gear, but the frequency of entanglement has not been documented (O'Hara et al. 1986, p. 14-17).

A report exists of a loggerhead caught in a crab trap line in Delaware (O'Hara et al. 1986, p. 49). Also damage done by loggerhead turtles to lobster traps in Florida has been reported(Crouse 1984, p.3).

Trawls: A trawl is a large bag-shaped net towed behind a fishing vessel (Figure 7). Leaving aside for the moment otter trawls utilized in the shrimp fishery (Figure 8), trawls used in the winter flounder fishery off Cape Hatteras have been implicated in the mortality of loggerhead and Kemp's ridley sea turtles leaving the Chesapeake Bay (Crouse 1984, p. 3). The non-selective design of this gear makes it a candidate for incidental capture of turtles in areas of turtle concentration.

The Southeastern U.S. Shrimp Trawl Fisheries

The shrimp trawl fishery conducted in inshore and offshore coastal waters from North Carolina to Texas is the United States' most valuable fishery at $470 million in 1984. While catch has remained more or less the same for many years, the number of participants has increased dramatically as fishing gear and boats have become cheaper and economic opportunities in other areas have decreased. Now up to 40,000 small boats and vessels deploy tens of thousands of shrimp trawls in inshore and offshore waters.

The U.S. National Marine Fisheries Service (NMFS) has estimated that this fishery incidentally captures 47,973 sea turtles each year of which an estimated 11,179 drown (see Table III). These estimates are based upon rates of capture in about 27,000 hours of observation on shrimp trawlers (Henwood and Stuntz 1986).

In 1978, NMFS began a research program to develop modifications to shrimp trawls that would substantially reduce the incidental capture and drowning of sea turtles that were protected under the U.S. Endangered Species Act (ESA). By 1981, NMFS had developed early designs of the TED, which reduced the capture of sea turtles by 97 percent while maintaining the rate of shrimp catch. The NMFS TED is a set of bars held at an angle in the neck of a trawl; large objects such as turtles or sharks are guided by the bars out of the net through a trap door in the top of the device (Figure 9). Other TEDs share the basic feature of a slanting grid of bars (Figures 10, 11, 12).

Further refinements decreased the weight of the NMFS TED to 37 pounds, made the device collapsible so that it takes up less deck space, and devised additional features that allow for the reduction of juvenile finfish by-catch by 50 to 78 percent. Other TEDs, including the Georgia and Texas TEDs (Figures 12 and 14) weigh less and cost less than the NMFS TED; however, they are not as effective in reducing the by-catch of juvenile finfish. A TED made of netting, which is extremely lightweight, has been developed by shrimp fishermen in South Carolina and has excluded larger sea turtles as effectively as the other devices.

On October 1, 1987, regulations phasing in the required use of TEDs in the U.S. shrimp fishery went into effect. These regulations require that fishermen working with boats longer than 25 feet in offshore waters from North Carolina to Texas use TEDs during those months when the conflict between shrimp trawling and sea turtles is highest. In the Canaveral and southwest Florida areas, offshore fishermen must use TEDs year-round, while in the rest of the Atlantic they need only use them from May through August and in the Gulf of Mexico they need use them from March through November (Maps 1 and 3).

Fishermen working inshore waters--generally those waters behind barrier islands or in bays and sounds--must use TEDs or trawl no longer than 90 minutes (Maps 2 and 4). NMFS testing of trawls demonstrated that there is a direct relationship between the percent mortality of sea turtles caught in shrimp trawls and the towing time. Mortality is negligible at towing times up to about 75 minutes. Beyond 90 minutes there is a linear relationship between mortality and towing time; at 330 minutes, mortality is about 53 percent. This requirement, which is difficult to enforce in inshore areas, would be impossible to enforce in offshore areas.

If fully implemented, these regulations will nearly eliminate incidental mortality of sea turtles in the southeastern U.S. shrimp fishery. Shrimp fishermen in some areas are hotly contesting the regulations.

Information Needs

As demonstrated in the review of information on incidental catch presented at WATS I, there is much to be learned about the level, location, and type of incidental capture and mortality of sea turtles in fisheries and other human activities in the western Atlantic. The problem of gathering such information on a regional basis is enormous. A regional view of where sea turtles and fishing activities overlap and where incidental capture may be a significant problem needs to be identified. As a first step we can begin by focusing upon these areas. Several large atlases on the distribution and relative abundance of marine resources have been published and would provide an overview of the scope of the problem.

Several types of information must be gathered beyond general information on incidental capture. I suggest that by gathering the following types of information, countries will be able to identify potential fishery conflicts and how to address them:

- type of gear used in a country's fisheries,
- means and locations of deployment of this gear,
- target species,
- level of fishing effort seasonally,
- incidental catch,
- sea turtle capture and mortality,
    - species, sex and age of captured animals,
    - fate of turtle (e.g., returned alive, returned dead, consumed).

With this information, means of reducing conflicts may be devised that will minimize impacts on the fisheries and on wild turtle populations.

Conclusion

Little work has been done on developing means of assessing the economic implications of the incidental capture of sea turtles. Indeed, most methods of assessing the value of wild populations of animals are very controversial (Tarnas et al. 1987).

In attempting to divine the economic impact of requiring some shrimp fishermen to buy and use TEDs in the U.S. shrimp fishery, the U.S. federal government was only able to measure the cost of investment in TEDs as a portion of the total revenue generated in the fishery. Some fishermen have maintained that TEDs will reduce their catch and thereby reduce their income but have produced no systematically gathered information to support this. Furthermore, the federal government did not attempt to measure benefits that will arise from the conservation of juvenile finfish of economic and recreational value and of sea turtle populations that were once of considerable economic importance in various areas of the southeastern United States (Cato et al. 1978). Without these counterbalancing benefits, any calculation of net costs and benefits arising from requiring TEDs is very questionable.

It is clear that sea turtle populations in the western Atlantic are generally marginal enough that economic and even subsistence dependence upon them is a chancy affair. Maximizing short-term costs associated with reducing incidental capture of sea turtles in commercial fisheries will jeopardize long-term economic and subsistence opportunities. In this sense, the question of the economics of incidental capture must remain open until a choice is made between short-term and long-term gain. No amount of mathematical conjuring will relieve us of that burden.

The author wishes to thank his indefatigable assistant, Andrea Shotkin, and intrepid intern, Nina Burns, for their patient efforts to make this report graphic.

Table 1. Estimated incidental turtle catch

Country	Species	Catch 1980-1982	Type of fishing activity
Anguilla	Ei, Cm		Spearfishermen primarily seeking fish & lobsters
Antigua & Barbuda		Negligible	
Belize	Cm, Ei		Incidental catch of juveniles by divers & fishermen
Brazil	Cm, Ei		Fish weirs & shark nets
British Virgin Islands		(1981)	
	Cm	100	
	Dc	2	
	Ei	100	
Cuba	Cm, Cc, Ei		
Dominica	Ei		Observations of fishermen, little or no data on type
Grenada			
Honduras			Shrimp trawls
Jamaica	Ei	103	Mostly beach seines
	Cm	7	
	Cc	5	
Martinique			
Mexico, Gulf		(1981)	
	Cc	50	Shrimp trawl, trammel
	Cm	50	Shrimp trawl, trammel
	Dc	50	Shrimp trawl, trammel
	Ei	50	Shrimp trawl, trammel and scuba
	Lk	100	Shrimp trawl, trammel
Montserrat			Gill nets

Table 1. (continued)

Country	Species	Catch 1980-1982	Type of fishing activity
Netherlands Antilles			Longlining
Nicaragua	Cm	(1980) 53,144 lbs	Shrimp trawls, nets
		(1982) 710 lbs	Shrimp trawls, nets
Surinam	Lo		Identifies need to reduce incidental catch
Turks & Caicos	Ei		Taken incidentally during lobster season
U.S.A.	Cc	42,868/11,738(a)	Shrimp trawls
	Cm	432 / 97	
	Dc	1,476 / 505	
	Lk	843 / 275	
	Cc, Lk		Boat collision, gill nets, powerplant sea-water intake, trawling, hook & line fishing, channel dredging
Venezuela	Lo	Significant numbers	Trawlers in east Venezuela

Key: Cm = Chelonia mydas, Cc = Caretta caretta, Ei = Eretmochelys imbricata, Lk = Lepidochelys kempi, Lo = Lepidochelys olivacea, Dc = Dermochelys coriacea

Source: Bacon et al. (1984, Vol. 3)

(a) The first number is captures, the second is mortality.

Table 2. Landing sites for turtles and turtle products

Country	Species landed	Methods of capture
Anguilla	Ei, Cm, Cc	Turtle nets, spearguns
Antigua & Barbuda	Dc, Ei, Cm	Nets & boatchase
Bahamas	Cc, Cm, Ei	Nets, diving, spears
Barbados		Trammel nets, 8"-12" mesh, 8-12' deep, 20-150 m long set near surface, on bottom
Belize	Cc, Cm, Ei	Nets
Brazil	Cm, Ei	Floating nets
British Virgin Islands	Cm, Ei	Seine nets & occasional harpooning
Cayman Islands	Cm, Ei, Cc	Nets
Colombia	Cm, Ei, Cc	Large meshed turtle nets set by divers on offshore reefs
Costa Rica		Harpoon and boats
Cuba	Cc, Cm, Ei	Nets, 15-150 yards long
Grenada	Ei, Cc, Cm	Nets and spears
Guatemala	Cc, Cm,	Trammel nets
Haiti	Cc, Cm, Ei	Nets, trammel nets
Jamaica	Ei, Cm, Cc	
Martinique	Ei, Cm, Dc	
Mexico Caribbean	Cm, Cc	Nets and boats

Table 2. (continued)

Country	Species landed	Methods of capture
Mexico, Gulf of Mexico	Lk, Cm, Cc, Ei	Shrimp trawls
Montserrat	Ei, Cm	Spearguns
Nicaragua	Cm	Nets, spear
St. Kitts, Nevis	Ei, Cm	Set nets, spear
St. Lucia	Cm, Ei	Nets, "turtle net"
Trinidad & Tobago	Cm, Ei, Lo	Turtle nets, harpoons
Turks & Caicos	Ei, Cm	Nets & boatchase
Venezuela	Cm, Cc, Ei	Nets

Key: Cm = Chelonia mydas, Cc = Caretta caretta, Ei = Eretmochelys imbricata, Lk = Lepidochelys kempi, Lo = Lepidochelys olivacea, Dc = Dermochelys coriacea

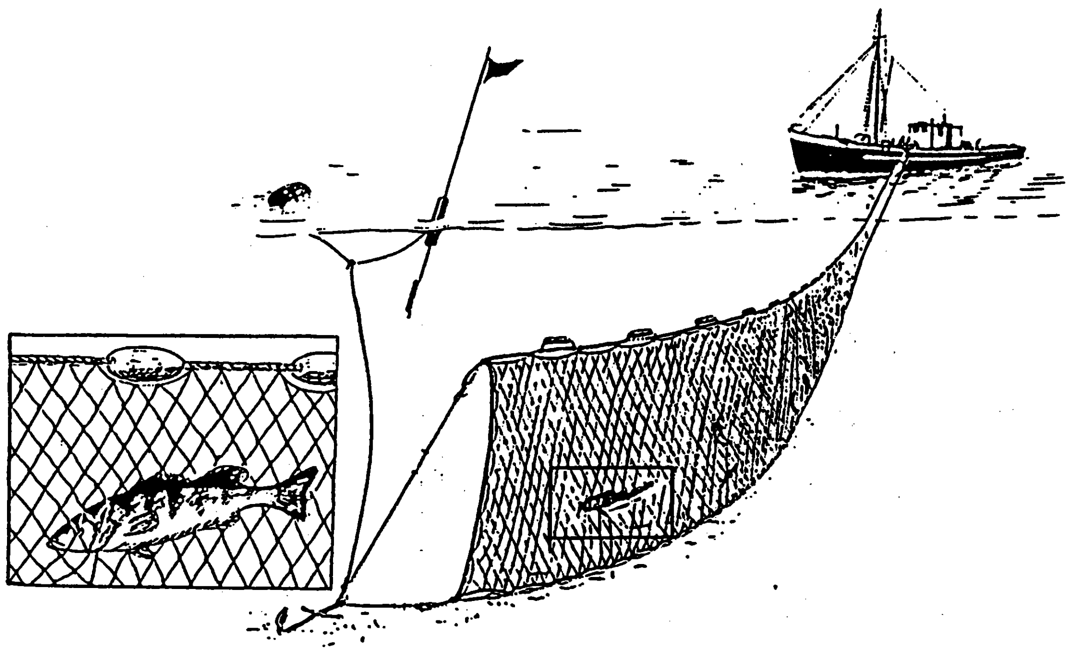
Source: Bacon et al. (1984, Vol. 3)

Table 3. Incidental capture and mortality of sea turtles in the southeastern U.S. shrimp fishery

Species	Capture Atlantic / Gulf	Mortality Atlantic / Gulf
Loggerhead	32,120 / 10,789	6,745 / 3,129
Kemp's ridley	1,268 / 1,726	266 / 501
Green	493 / 432	104 / 125
Hawksbill	70 / 432	15 / 125
Leatherback	211 / 432	44 / 125
TOTAL	34,162 / 13,811	7,174 / 4,005

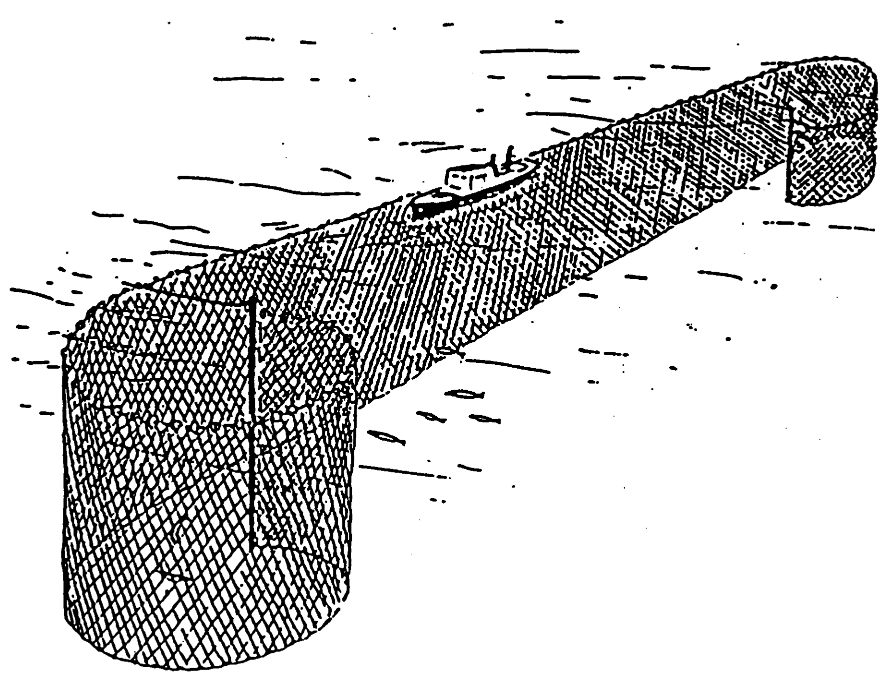
Source: Henwood and Stuntz (1987)

Figure 1



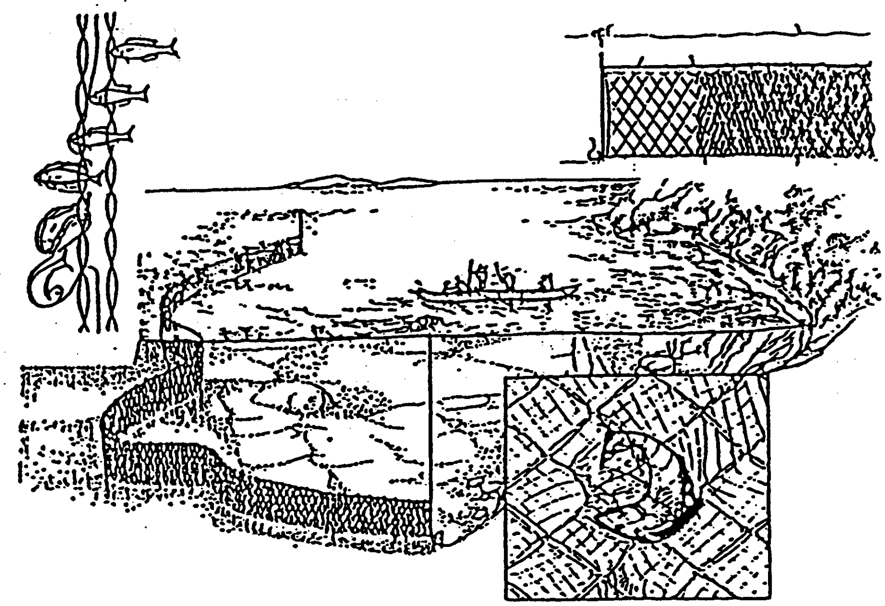
GILL NET

Figure 2



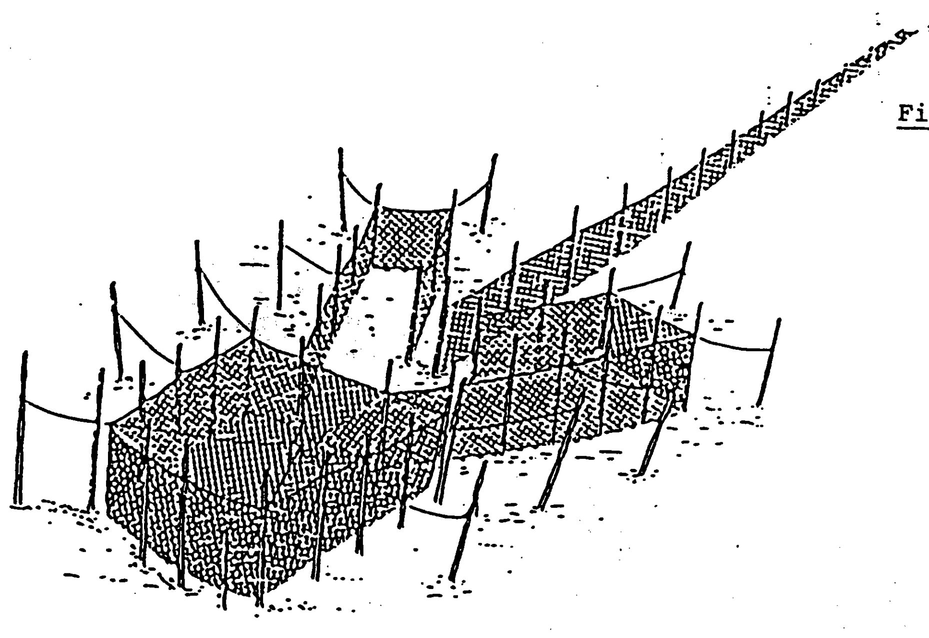
DRIFT NET

Figure 3



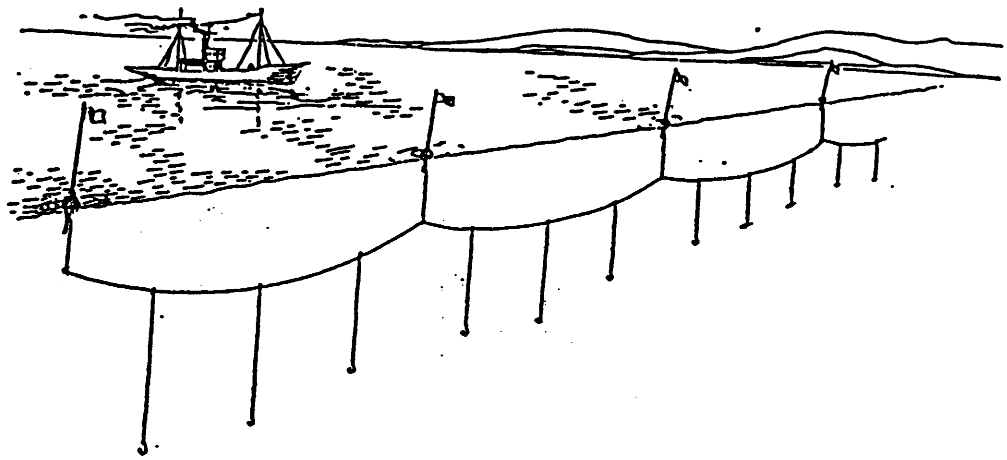
TRAMMEL NET

Figure 4



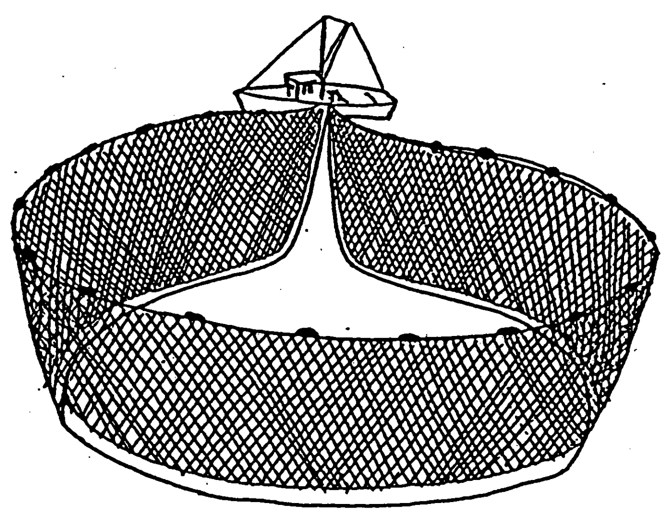
POUND NET

Figure 5



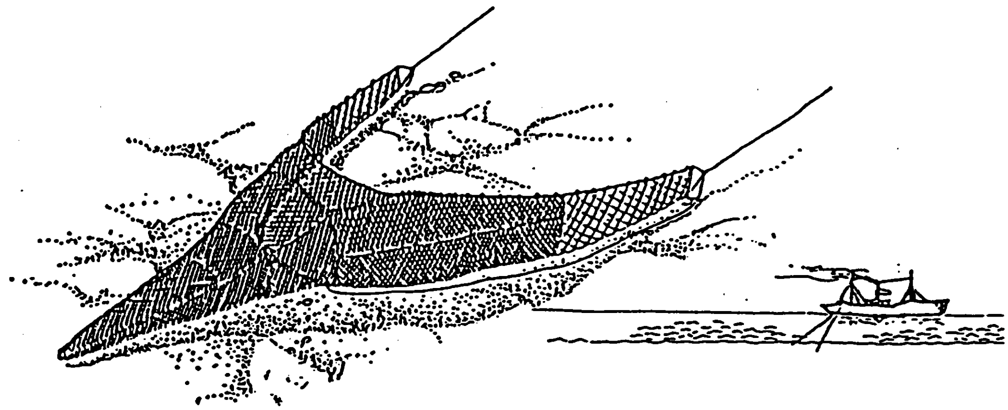
LONGLINE

Figure 6



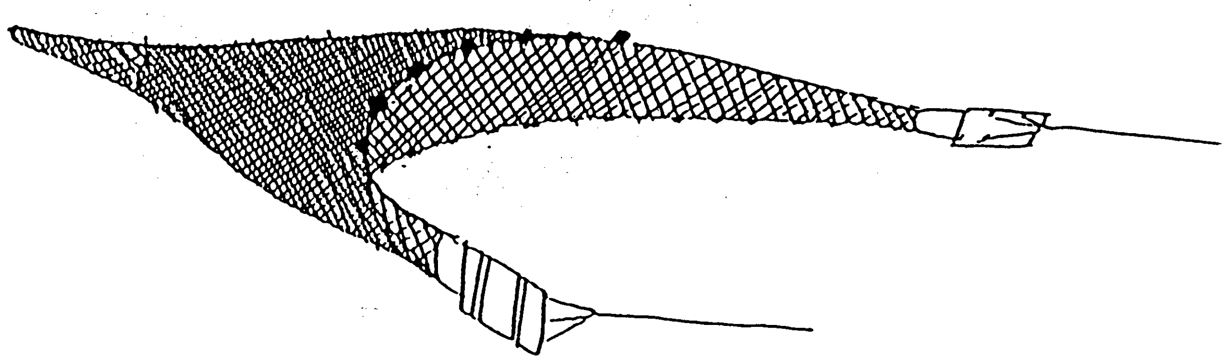
PURSE SEINE

Figure 7



TRAWL

Figure 8



OTTER TRAWL

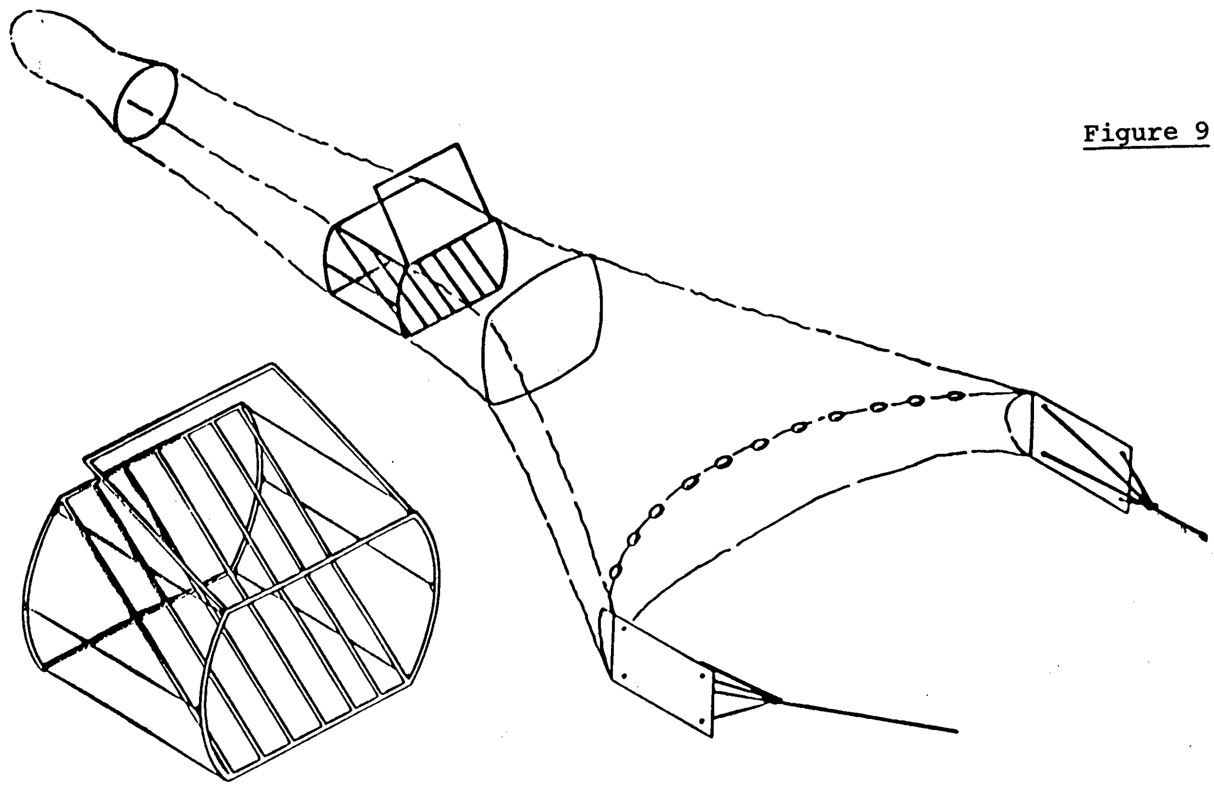


Figure 9

NMFS TED

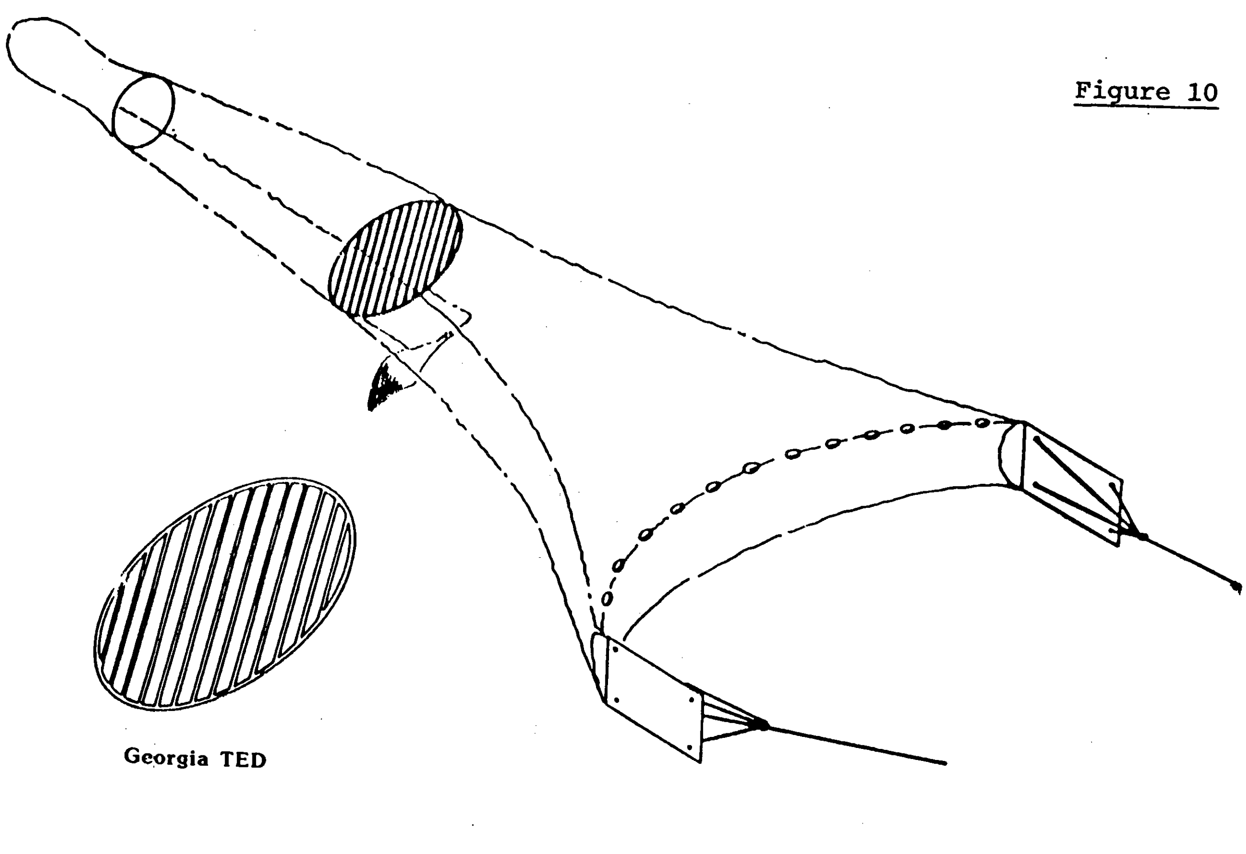
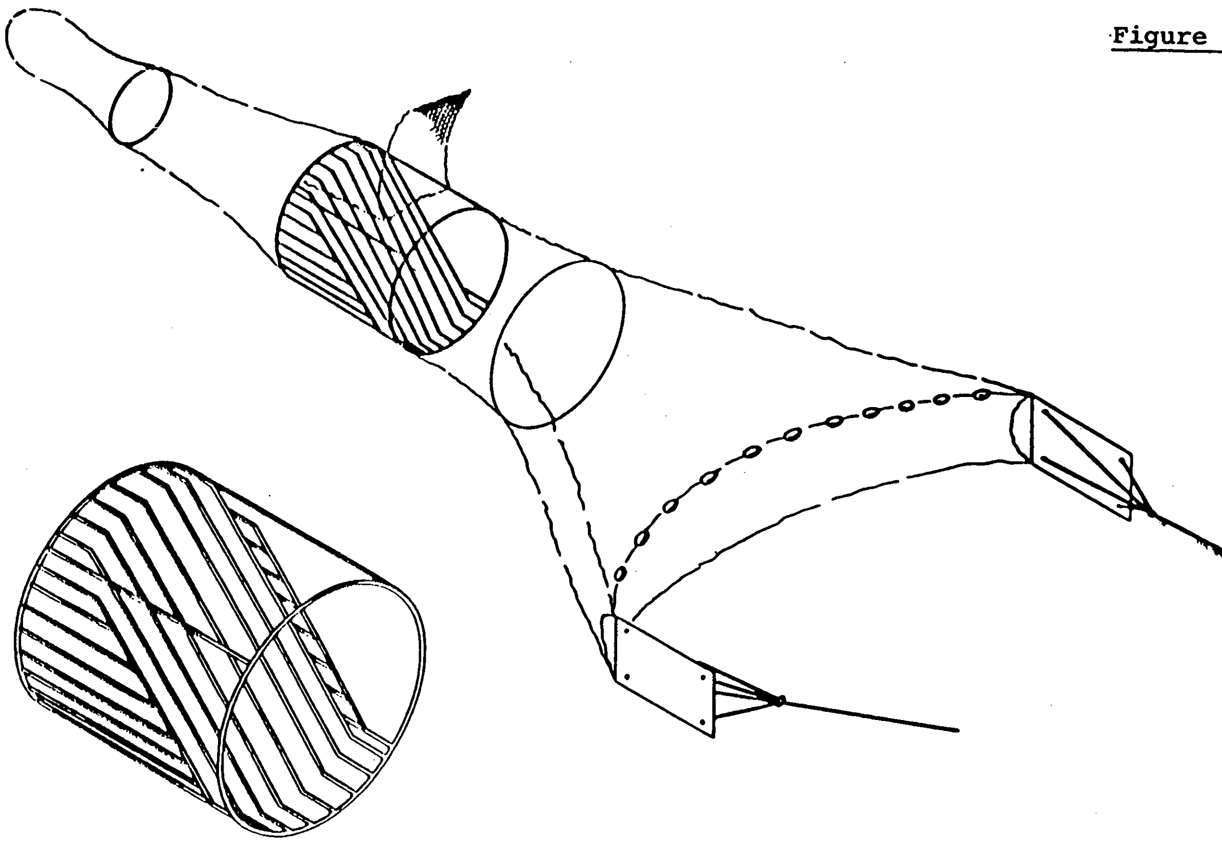


Figure 10

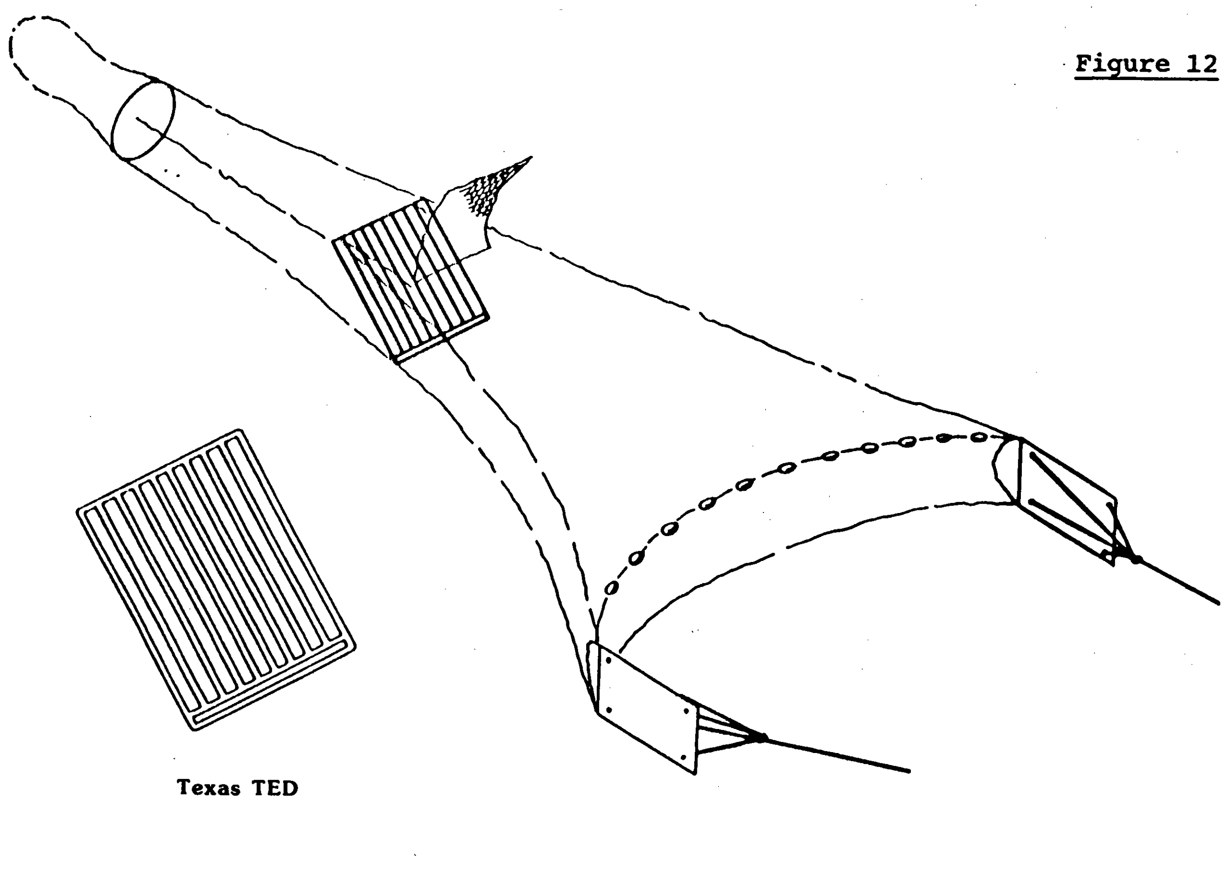
Georgia TED

Figure 11



Louisiana TED

Figure 12



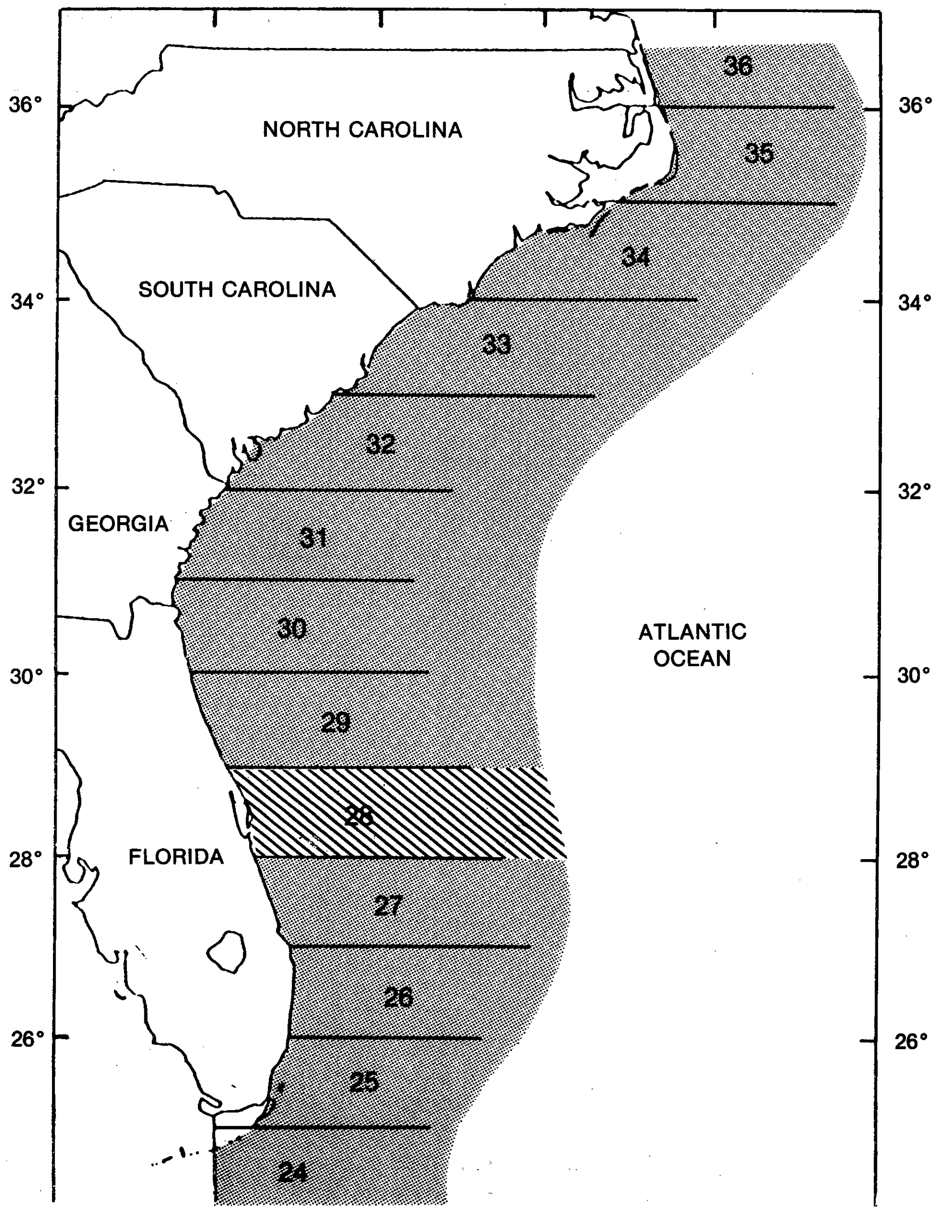
Texas TED

Map 1

OFFSHORE ATLANTIC WATERS WHERE TEDS ARE REQUIRED

Canaveral Area (Zone 28)
ALL WATERS, all year, beginning October 1, 1987.

Atlantic Area (Zone 24 thru NC-VA Border, except Zone 28)
ALL WATERS, May 1-August 31, each year, beginning May 1, 1988.

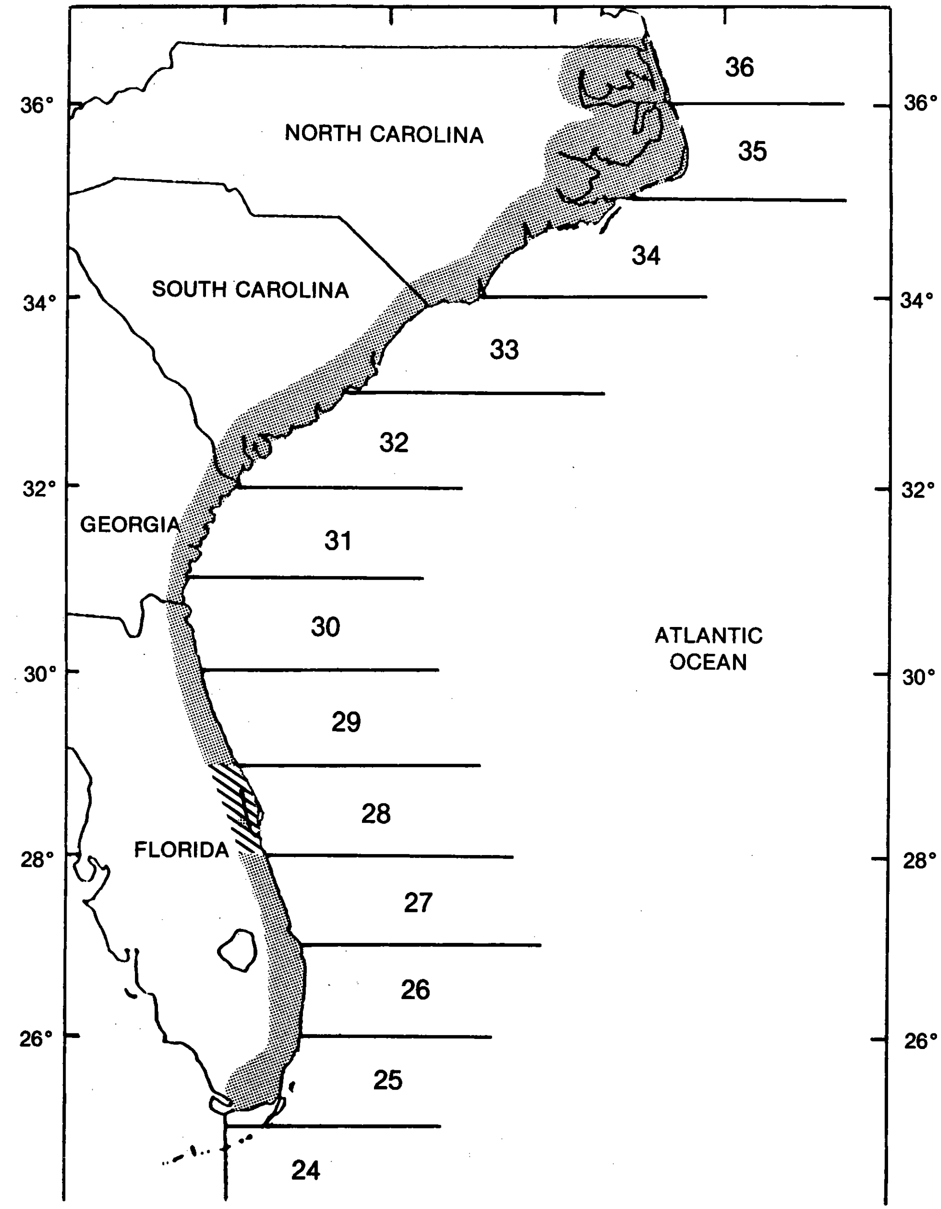


Map 2

INSHORE ATLANTIC WATERS WHERE 90 MINUTE TOW TIMES APPLY

Canaveral Area (Zone 28)
All year, beginning October 1, 1987.

Atlantic Area (Zone 24 thru NC-VA Border, except Zone 28)
May 1-August 31, each year, beginning May 1, 1988.



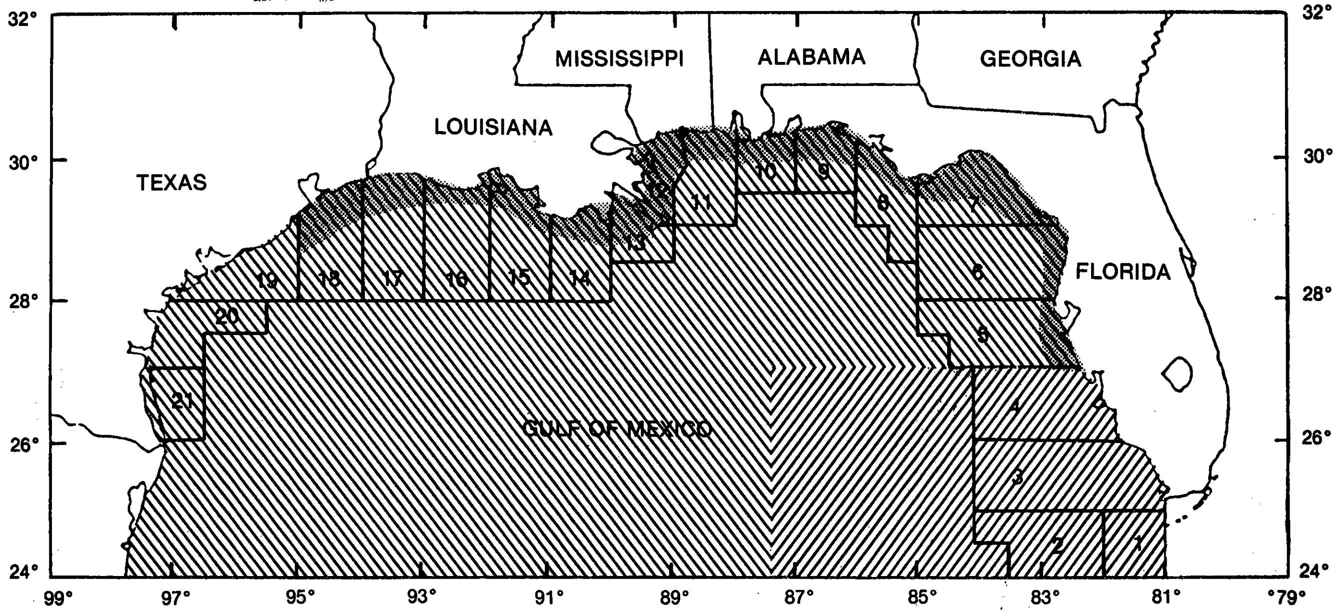
OFFSHORE GULF OF MEXICO WATERS WHERE TEDS ARE REQUIRED **Map 3**

Southwest Florida Area (Zones 1-4)
Shore to 15 miles, all year, beginning January 1, 1988.

Southwest Florida Area (Zones 1-4)
ALL WATERS, all year, beginning January 1, 1989.

Gulf Area (Zones 5-21)
Shore to 15 miles, March 1 to November 30, each year, beginning March 1, 1988.

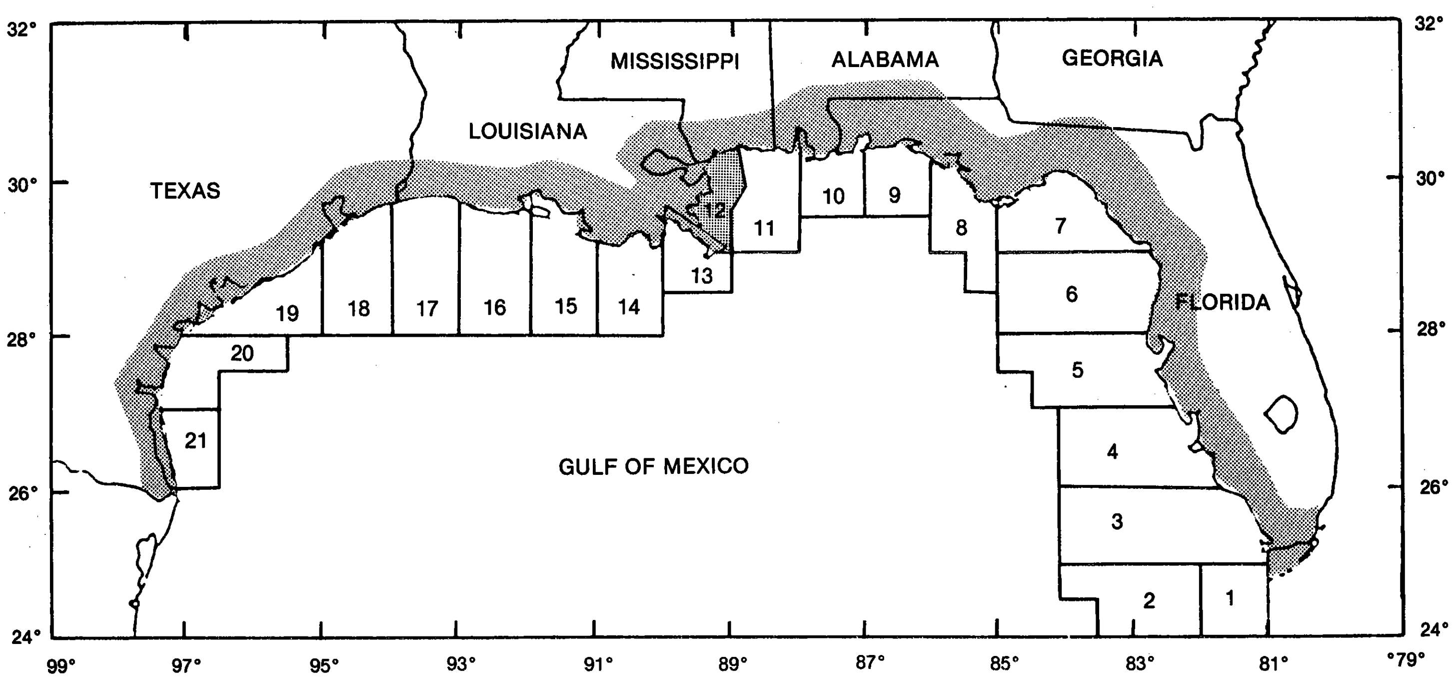
Gulf Area (Zones 5-21)
ALL WATERS, March 1 to November 30, each year, beginning March 1, 1989.



INSHORE GULF OF MEXICO WATERS WHERE 90 MINUTE TOW TIMES APPLY **Map 4**

Southwest Florida Area (Zones 1-4)
All year, beginning January 1, 1988.

Gulf Area (Zones 5-21)
March 1 to November 30, each year, beginning March 1, 1988.



Rapporteur Report of the Panel on the Socioeconomic Importance of Sea Turtles

CHAIR: Arthur Dammann, St. John, US VI

RAPPORTEUR: Dean Swanson, National Marine Fisheries Services, USA

SPEAKERS: Frederick Berry, USA

Marydele Donnelly, Center for Environmental Education, USA

Michael Weber, Center for Environmental Education, USA

Panel: Thomas Carr, Caribbean Conservation Corporation, USA

Ana Chaves, Universidad de Costa Rica, Costa Rica

Gustavo Cruz, Universidad Nacional Autonoma de Honduras, Honduras

Jacques Fretey, Museum National d'Histoire Naturelle, France

Bruce Jaildagian, Greenpeace International, USA

Winston Leonard, U.S. Virgin Islands

Angela Marcovaldi, Instituto Brasileiro Desenvolvimento Forestal, Brazil

Guy Marcovaldi, Instituto Brasileiro Desenvolvimento Forestal, Brazil

Jeanne Mortimer, University of Florida, USA

Jose Ottenwalder, Parque Zoologica Nacional, Dominican Republic

Joe Parsons, Department of Agriculture and Natural Resources, Cayman Islands

Fernando Rosales, Direccion Tecnica de Pesca y Agricultura, Guatemala

Johan Schulz, Netherlands

Wilber Seidel, National Marine Fisheries Service, USA

Hideomi Tokunaga, TRAFFIC, Japan

Berry, Donnelly, and Weber addressed the matters of exploitation, trade in products, and incidental take, respectively.

The chair requested, prior to a break, that all participants consider the possibility and applications of a total moratorium on the taking of sea turtles.

Open to the floor.

MORTIMER: The average weight of hawksbill shells in the Seychelles is 1.5 kg. Variations in these weights are due to the relative sizes of animals rather than shell quality.

DONNELLY: Japanese imports of these products from the Seychelles are relatively modest.

FRETEY: Data sources for Japanese imports of turtle products were questioned. France is trying to limit trade in such products. Attention should be focused on producers as well as consumers.

DONNELLY: Data sources are official Japanese import statistics and some cooperating Japanese dealers.

CHAVES: No law is preferable to an unenforced law. Costa Rica has a new law that in just 2 years has reduced captures significantly.

MROSOVSKY: The use of the word "exploitation" to connote, among other things, the use of turtles to provide money or food to people who need these things was questioned. A more imaginative solution than a moratorium on all taking is required, in part, because some populations of greens are increasing in abundance.

DONNELLY: Although all species are declining in the western Caribbean, this was not the case for all populations.

FULLER: Antigua and Barbuda has made no shipments of turtle products to Japan for the last 10 years, and the Japanese statistics hence show paper transactions by "paper" companies. Officials began tracking this situation a few months ago. Alleged shipments of hawksbill shells from Antigua and Barbuda would exceed the known abundance of the local population.

TOKUNAGA: Access to government documents for private interests is limited. Shipping documents had not been available except from cooperating companies. However, a number of governments report that trade statistics mask transhipment or the activities of "paper" companies which falsely suggest that turtle harvesting by their nationals is going on.

FULLER: Antigua and Barbuda will sign the CITES Treaty this year. U.S. swordfish longliners incidentally catching leatherbacks, greens, and hawksbills are creating a special problem locally in light of a lack of local enforcement capability.

WILKINS: Fishermen claim that transhipment of turtle products to Japan occurs.

WEBER: Japan should be informed officially in all cases in which its import statistics are misleading.

MROSOVSKY: It would be a shame to adopt a total preservation approach in part because turtle populations in Surinam and Costa Rica have grown despite the use by humans of 20-30% of the eggs.

FRETEY: The passage between Surinam and French Guiana has a growing human population and the expanding use of longlines is increasingly involving leatherback turtles. Greenpeace is offering to reimburse fishermen for net damage and to assist in live release of turtles.

PARSONS: Turtle use in the Cayman Islands is traditional, and total protection cannot be considered because many local people have no other source of income. Other means of supplying human needs should be considered, such as ranching.

MAST: The problem of international trade is well documented, but domestic commerce should not be overlooked. Joining CITES is not a complete solution.

CHARLES: Although agreement on a moratorium on taking could be reached, realism calls for a more balanced approach.

FULLER: Few people in the eastern Caribbean have a significant dependence on sea turtles.

LESCURE: The withdrawal of CITES reservations for sea turtles by France and Italy upon their joining the EEC on January 1, 1984 was explained.

FRETEY: Comments, based on personal experience, were given on the importance of trained customs agents in maintaining control and enforcement of trade laws. Spot-checking by agents is too lax.

NATHAY-GYAN: A man in Port of Spain is making aphrodisiacs from the male sex organs of sea turtles.

JEFFERS: A French vessel in Plymouth, Montserrat, had been ordered to release turtles aboard just a few weeks ago. Is a closed season in force on the taking of these animals?

LESCURE: Although there are no reliable estimates of taking of turtles by Guadeloupe fishermen around Montserrat, Dominica, or Antigua and Barbuda, Guadaloupe fishermen would continue to take advantage of the current price of 1,500 FF for turtle meat at home. The period of April 15 - October 15 is closed for taking turtles, but enforcement is a problem.

KERR: Jamaica is not a party to CITES and is a transhipper of turtle products. No residents make a living from turtles because of low numbers, and harvesting and utilization are banned. A balance must be found.

LAWRENCE: Participants were present not to assign guilt but to promote understanding and cooperation.

KAUFMANN: Agreement with the preceding speaker as well as international coordination of national programs and planning was noted. This can be achieved through the Cartagena Convention, whose parties meet beginning on October 21, 1987 and also through WIDECAST.

MARQUEZ: Mexico has adopted and experimented on the use of TEDs in shrimp trawls. Results are varied and require further testing before Mexico can make a decision on their use. The key question is what programs would allow us to conserve turtles without adverse or inadvertent effects.

FOSTER: Before regulations requiring the use of TEDs were implemented, the U.S. performed more than 27,000 hours of observed testing and was satisfied that TEDs exclude turtles 97% of the time without significant loss of shrimp.

<u>MEDINA</u>: Prior to 1978, Venezuelans caught and sent large numbers of turtles to St. Lucia or elsewhere, but increased surveillance capability has since made the activity impossible.

<u>DUTTON</u>: Sea turtles can be "exploited" under a moratorium by deriving value from tourism rather than harvesting.

<u>FULLER</u>: Hawksbill nesting beaches on Antigua and Barbuda have attracted a profitable tourist trade.

<u>CINTRON</u>: Turtles are taken even where prohibited, because enforcement is very expensive.

<u>BOULON</u>: The U.S. Virgin Islands has found that the value of a live turtle is much greater than a dead one.

<u>GILLET</u>: Despite CITES, the Cartagena Convention, and good laws, foreign fishing remains a problem for sea turtles in Belize. More work is needed because sea turtles will continue to be exploited.

<u>WEBER</u>: Promotion of tourism is not enough, especially because not enough is known about sea turtles. Public education and support for necessary action are required.

<u>MORTIMER</u>: Costa Rica promoted foreign tourism and found that sea turtles became an attraction for nationals, as well.

<u>HALL</u>: Tourists can create disruptions on nesting beaches.

<u>FRETEY</u>: The presence of tourists could discourage poaching and promote education, but tourists require facilities. A poor fisherman cannot be compared with a rich hotel owner. French Guiana has used sea turtles as a tourist promotion for the past 10 years.

<u>FINLAY</u>: A moratorium on taking would not work. In Grenada, people depend on sea turtles, and the capacity to monitor and enforce prohibitions would be inadequate. A skillful and sensible educational campaign is the best approach.

MURPHY: The U.S. Fish and Wildlife Service and National Marine Fisheries Service should make available surplus vessels for enforcement purposes to western Atlantic countries.

HORROCKS: Barbados is considering a 5 year moratorium on taking of turtles.

CINTRON: Increased funding for education even in light of enforcement needs should be pursued.

MEDINA: Only 1 of 140 Venezuelan fishermen that were interviewed reported intentionally taking turtles. The prohibition on capture has become effective through enforcement, not education.

BJORNDAL: Costa Rica should be commended on its national program of sea turtle conservation.

The chair thanked all participants and closed the session.

Subregional Data Presentations and Discussions by the National Representatives

Rapporteur Report of Subregional Statements Panel Session

CHAIR: Manuel Murillo, Universidad de Costa Rica, Costa Rica

RAPPORTEUR: Barbara Schroeder, National Marine Fisheries Service, USA

PANEL: Glenda Medina, FUDENA, Venezuela

Herman Kumpf, National Marine Fisheries Service, USA

Jose Ottenwalder, Parque Zoologico Nacional, Dominican Republic

Horace Walters, Ministry of Agriculture, Land, and Fisheries, St. Lucia

MURILLO: Subregional coordinators will have 10 minutes to summarize comments and integrate aspects of the subregional presentations of National Reports of today's session. The National Representatives will then be given an opportunity to comment. The audience will then be given an opportunity to comment.

MEDINA: Subregion South America

The countries of the subregion South America are: Brazil, French Guiana, Surinam, Guyana, Venezuela, Colombia, Trinidad and Tobago, and Netherlands Antilles. Guyana was not represented, and no report was submitted. Areas of greatest nesting activity and their physical characteristics were identified and described. Environmental problems include dredging, construction, tourism, and debris. These factors affect reproductive success of the species and conservation efforts of the countries. There appears to be good data on foraging areas in the subregion. The countries have general information on abundance of the species present in their areas, but whether these populations are increasing, decreasing, or stable is not known. Historical data on population levels are lacking. Catch can be subdivided into incidental and intentional. Little information exists on catch levels by various fisheries. Consumption can be divided into subsistence consumption, local trade, and international trade. This is particularly important with regard to the take of Eretmochelys imbricata, which negatively affects conservation efforts. This trade should be subjected to intense surveillance. The level of legal protection afforded to the species varies from total to none at all. In spite of the existence of legislation, exploitation continues mainly in an incidental way. Community participation in beach protection projects is encouraged to further conservation efforts.

Development plans should be monitored especially in areas important for foraging and nesting. Population levels must be quantified and monitored at the most significant nesting beaches. Catch levels by various fishing methods should be quantified. Trade should be quantified as local, national, or international.

KUMPF: Subregion North America

In the United States, Lepidochelys kempi shows an annual decline of 3%. Incidental capture by shrimping is the major cause of juvenile mortality. Chelonia mydas appears to show an increase in number of nests in Florida but is still far below historical levels. Eretmochelys imbricata nests in low but apparently stable numbers. In certain areas, levels of Caretta caretta are decreasing at 3-5% per year such as in South Carolina and Georgia, but appear stable on the east coast of Florida. The overall data indicate that the population may still be declining. Dermochelys coriacea nesting appears stable in Florida since 1980, but its overall status is unknown.

In Mexico, nesting of Lepidochelys kempi is decreasing at the rate of 3% per year since 1978. The status of Chelonia mydas, Eretmochelys imbricata, Caretta caretta, and Dermochelys coriacea is generally unknown.

In the United States, TED regulations and tow time restrictions are in place offshore and inshore, respectively. Possession of turtles is prohibited, and in certain areas beach development is regulated.

North American Subregion

Species:	U.S.A.	Mexico
Kemp's	Annual average decline: 3%	From 1,200 nests in 1978: 3% decrease per annum
Green	Increase in number of nests in Florida still far from historic levels	Status unknown; some areas lower. Some areas increasing (Tamaulipas coast)
Hawksbill	Nesting in U.S. low (no change)	Unknown Evaluation is beginning
Logger-head	Decrease: 3%-5% in South Carolina and Georgia Stable-Florida east coast	Decreasing in some areas Evaluation incomplete
Leather-back	Nesting in Florida: stable since 1980. Total status unknown	Unknown

North American Subregion

Regulations in Place:

U.S.A.	Mexico
1. TED regulations, offshore	1. No trawling with 4 km of nesting areas.
2. Tow time limits	2. Poaching prohibited
3. Possession prohibited	3. Capture and trade prohibited
4. Habitat regulations	4. 3 Natural preserves: Kemp's, green and hawksbill

Future Country Actions:

U.S.A.	Mexico
1. Short term research, TED evaluations Long term research, mortality sources stock status	1. Continue investigations of conservation measures, academic involvement through a commission
2. TED required	2. Total prohibition continued
3. No harvest	3. No commercial harvest harvest permitted.

In Mexico regulations include trawling restrictions within 4 km of nesting beaches; take and trade are prohibited. Three nature preserves have been established for Lepidochelys kempi, Chelonia mydas, and Eretmochelys imbricata.

Future actions in the United States will focus on evaluation of TED regulations, economic impact of the use of TED to the shrimp fishery, other sources of mortality, and status of stocks.

Future actions in Mexico include increased academic participation in continuing conservation programs.

Both Mexico and the United States have committed funds for continuing research and have demonstrated commendable conservation ethics.

OTTENWALDER: Subregion Greater Antilles

The countries in the subregion are: Cuba, Cayman Islands, Jamaica, Haiti, Dominican Republic, Puerto Rico, Turks & Caicos, Bahamas, and Bermuda. Cuba, Bahamas, and Turks & Caicos were not represented.

The estimates of nesting females for the subregion nesting females in 1986/1987 are:

E. imbricata - 370 (Dominican Republic, Puerto Rico)
C. mydas - 225 (Dominican Republic, Puerto Rico)
D. coriacea - 330 (Dominican Republic, Puerto Rico)
C. caretta - 52 (Dominican Republic, Cayman Islands)

Data are not available on nesting populations in Cuba, Jamaica, Haiti, Turks & Caicos, and the Bahamas.

In the Cayman Islands, the number of nests per year of C. caretta has been reduced to 2-3 nests. No nesting has been recorded in Bermuda for over a decade.

Quantitative information on capture levels is very sparse. Estimated catch in Puerto Rico may be up to 200 individuals per year (all species combined) and in the Dominican Republic possibly 1,000 individuals per year (all species combined).

Poaching of eggs on the nesting beaches seems to be quite high for all islands and may exceed 70% of all nests, except in effectively protected areas of Culebra and Mona Islands.

International trade, as given in the Milliken and Tokunaga report (CEE) for the subregion, shows 161,438 kg of E. imbricata shells exported to Japan between 1970 and 1986. This figure represents 25% of the total Japanese world imports and amounts to approximately 120,476 individual hawksbill turtles or 7,500 hawksbills per year captured for the Japanese trade. Data to estimate catch levels of other species are not available. The origin of hawksbill shells which enter the trade market is difficult to trace, due to interaction between islands and the complications of transshipment.

WALTERS: Subregion Lesser Antilles

The countries in the subregion are: U.S. Virgin Islands, British Virgin Islands, Anguilla, St. Kitts and Nevis, Antigua-Barbuda, Montserrat, Guadaloupe, Dominica, Martinique, St. Lucia, St. Vincent, Barbados, Grenada.

The presentations provided insight into the status of resource conservation measures, legislation, exploitation and future actions that will lead to a healthier resource. In most countries conservation measures have had a positive impact both on the public and the fishing community, and have also contributed to the recovery of turtle populations. Extension of closed seasons extended in many areas, and an increase in size limits of many species was legislated in many areas.

The problems of sand mining, dredging, and mooring were recognized. Nesting beach protection was addressed. Most countries are signatories of CITES, others are aware of the importance of becoming a party to the convention. The need for a moratorium on turtle harvest was discussed by a number of countries in the subregion. The countries, though limited in personnel and financial resources, have an active participation in the recovery of the resource. Continued support from WATS through IOCARIBE would assist these countries in continuing work towards conservation and recovery.

Discussion open to the panel and national representatives.

<u>JAMES</u>: (National Representative of Grenada). *C. caretta* is caught offshore, but does not nest in Grenada.

<u>PARSONS</u>: (National Representative of the Cayman Islands). Data are insufficient to draw conclusions about which species still nest in the Cayman Islands. An unconfirmed *C. mydas* nest was reported in 1987.

<u>OTTENWALDER</u>: Data from 1986/1987 were discussed.

<u>WILKINS</u>: (National Representative of St. Kitts). Main harvest method in St. Kitts is gill netting, not harvesting of nesters.

<u>NATHAI-GYAN</u>: (National Representative of Trinidad and Tobago). *D. coriacea* nesting appears to be increasing in Trinidad.

<u>GILLET</u>: (National Representative of Belize). Enforcement problems are similar between the countries of the Caribbean. Conservation steps taken in one area will not be effective unless other areas will cooperate. A formal format is needed to accomplish this. Existing regulations must be enforced. Assistance from the U.S. and/or Mexico regarding TED technology transfer was requested. They need at least one person trained in their use and installation. Recommendations to the Belize government regarding TED implementation will be considered.

<u>KUMPF</u>: Belize was commended on their interest in use of the TED. N. Foster and W. Seidel of the U.S. should be contacted for assistance. Videotapes and construction plans are available.

<u>MOHADIN</u>: (National Representative of Surinam). Additional information to the Surinam national report was presented. Whether population changes can be determined by comparing annual numbers of nests was questioned.

<u>MURILLO</u>: An opportunity to ask that question of the audience will be provided.

<u>LOPEZ CRUZ</u>: (National Representative of Mexico). Mexico will offer TED assistance to Belize and make available

information on conservation programs. A TED training course supported by WATS was suggested.

MEDINA: Nesting data for Aves Island from 1979-1987 were summarized. Because of the high variation it is difficult to say whether or not the population is recovering; 15-18% of the nesting population are remigrants. Tag loss problems have been experienced.

HALL: (National Representative of Anguilla). St. Vincent and Grenada took the position that a moratorium would be impossible because of food needs of island people. Exclusion for subsistence take only was suggested.

MURILLO: Tomorrow's sessions will be species specific.

CINTRON: (National Representative of Puerto Rico). In his opinion, in Puerto Rico federal and state protective measures have placed turtles in greater danger. Stocks were depleted when legislation was enacted. Few turtles were being intentionally captured. Complaints about regulations were few because turtle fishing was not lucrative. Now the demand has increased for the banned product. Now it is profitable to fish for turtles, and this is extremely harmful to the stock.

MARQUEZ: Tag loss may be difficult to assess. In Michoacan, Mexico, monel tags were frequently lost by the black turtle. Better success was achieved with plastic tags.

Open to the floor.

CHANG: A request was made to add the following very important items to the Panama national report:

1) The impact of herbicides on nests at Bocas del Toro.
2) Oil and water ballast mix dumped every day in Panamanian waters by oil freighters.

MURILLO: These can be incorporated.

GUTIERRE: What is the mechanism used to select the national representatives and what is their role?

MURILLO: WATS consulted with the government agencies responsible for marine species for selection of national representatives. Your comment regarding

Puerto Limon illustrates the need for better internal communication among researchers.

GUADA: An alarming situation exists in Nicaragua in regard to C. mydas. Eggs and adults are being heavily exploited as a food source, especially during the current economic and political crisis.

FRAZER: Concerning numbers of nests to assess population levels, nesting cycles fluctuate up and down and do not necessarily reflect true population changes. Short term observations cannot conclusively demonstrate true increases or decreases. Ten to twenty years may be long enough to begin to draw conclusions about population levels.

FRETEY: (National Representative of French Guiana). N. Frazer was complemented on his statement and an additional explanation was offered. In Surinam increases have been observed in nesting levels of D. coriacea and L. olivacea. Annual variations may be an artifact of movements between nesting areas. Strict nest site fidelity is doubtful. Coordination between French Guiana, Surinam, and Brazil is imperative.

BURNETT-HERKES: (National Representative of Bermuda). Caution was expressed against using only nesting activity as population indicators as this is only a portion of the total population. The need to look at other life history stages was stressed.

MOLERO: Awareness regarding sea turtle conservation in Venezuela is emerging, but a lack of funding for research and conservation and a lack of qualified personnel exist. An American Foundation with signatories to foster education and research was proposed. An international organization may encourage progress.

MURILLO: This will be addressed on Friday. Progress has been made in strengthening the data base. Expansion studies to include water surveys in addition to nesting beach surveys. A lack of data on total population figures exists. Ways to integrate efforts at the regional level and explore intergovernmental mechanisms to continue the efforts initiated by WATS are needed.

Green Turtle (Chelonia mydas)

Status Report of the Green Turtle (Larry H. Ogren)

The green turtle occurs throughout the western Atlantic area from Brazil to northeastern United States and Bermuda, but is most abundant in tropical waters. Intensive exploitation by man since colonial times has greatly reduced many of its former breeding assemblages and extirpated others altogether. There are only three major nesting sites remaining in the Wider Caribbean area today--and they are probably at much lower population levels than formerly existed. They are located in Costa Rica (Tortuguero), Surinam, and Venezuela (Aves Island), as described in the WATS I Proceedings (Bacon et al. 1984).

Many other nesting sites located in 32 circum-Caribbean countries, including North America, have been reported where the numbers of nesting females range from one or two individuals to several hundred per season. These are identified in the WATS I and II National Reports and may be categorized as either remnants of declining populations, incipient colonizers, or naturally rare nesters.

Significant nesting has recently been recorded for Brazil by Chelonia mydas on oceanic island beaches over 100 miles offshore of the mainland (Marcovaldi and Marcovaldi, WATS II National Report). Detailed information on the size of these breeding aggregations was lacking for WATS I. They are important additions to the total breeding population in the Wider Caribbean area, but are probably reproductively isolated from the other three major breeding aggregations and rank as high, or higher, in number of nesting females as the Aves Island rookery.

Other smaller nesting populations exist throughout the region, and for countries such as Mexico, where several hundred turtles nest annually, the nesting beaches are widely distributed along the Gulf of Mexico and Caribbean coasts, and nesting is not as concentrated. Many of these turtles are vulnerable to capture on the beach, and egg poaching is pervasive. This is resulting in declining numbers. Recovery is not likely if adequate beach protection can not be implemented and maintained. Incidental and directed take of the larger and older subadults and adults at sea continues adversely to impact foraging populations everywhere within their range. Statistics on the magnitude of this "extra" mortality are frequently lacking.

Slide Presentation. A historical overview of the Tortuguero green turtle colony, Costa Rica; early days at the tagging camp (1950s); local scenery and project personnel; the commercial fishery at the nesting beach and the feeding grounds of Nicaragua and Colombia; developmental habitats, pelagic and benthic; contemporary scenes at the green turtle station (1980s); the CCC;

Tortuguero National Park; tourists; beach-river development problems--pollution, erosion, poaching, squatters; Dr. Archie Carr's inspiration and legacy--what does the future hold?

A discussion on the current status of the species and trends, if discernible, of the three major rookeries in the Wider Caribbean area follows.

Tortuguero, Costa Rica, Colony

Approximately 30,000 females have been tagged since the project was started in 1955. About 2,000 tags have been returned by turtle fishermen on foraging grounds throughout the Caribbean. The majority of returns are from Nicaragua and Colombia, where extensive seagrass meadows and important artisnal fisheries co-exist. Over 50% of the tags returned either came from remigrants to the nesting beach and fishermen, or were accountable by tag loss estimates. No females have been reported nesting elsewhere. Data from the study area, miles 0-5, is more precise for making population estimates and providing trend information than are data from the entire 22 mile long nesting beach. The estimated number of nesting females recorded in the study area since WATS I are as follows (K. Bjorndal, pers. comm.):

Year	Number of females/season on miles 0-5
1983	1,501
1984	1,580
1985	1,268
1986	4,908
1987	800 (est.)

These results are typical for previous years in that the Tortuguero population continues to fluctuate widely between seasons, or periods of about three years. No statistically significant trends in size have been described for this colony from existing data thus far. The nesting population does not appear to be decreasing or increasing over the last seventeen years. The long-term effects of the earlier intensive exploitation at the nesting beach and on the foraging grounds in Nicaragua remain to be seen, as well as the continuing legal take of breeding adults offshore of the nesting beach. Costa Rica has no choice in selecting maximum size limits--it is either eggs or adults. Placed in the situation of allowing local fishermen some level of take of this seemingly abundant turtle, a seasonal quota of 1,800 turtles has been allowed since 1983. Enforcement has been difficult as it is everywhere, and quotas were exceeded in early years (Chaves, WATS II National Report). Therefore, population assessments may be difficult to determine because of the yearly fluctuations in the size of the nesting assemblage; it continues to be an enigma. Carr et al. (1982) stated in regard to this problem, that a clearer understanding of large magnitude environmental changes that effect the breeding condition and migratory travel of the green turtle needs to be examined. The role of observed shifts in the remigration intervals of individual turtles is not clear either. Limpus (WATS II, this symposium) has suggested that major environmental changes on the foraging grounds caused by global meteorological and oceanographic events are responsible for the observed fluctuations from year to year in the size of Australian green turtle nesting assemblages.

Surinam Colony

The WATS I final assessment of the status of the green turtle nesting assemblage was that despite the great fluctuation in size of the colony between years a slight upward trend was discernible (Bacon et al. 1984). However, Schulz (In: Bacon et al. 1984) did agree that the population was vulnerable and extra mortality in terms of accidental capture by shrimp trawlers was a serious threat to the recovery of the colony. A more recent survey of the nesting beaches by Mohadin and Reichart (WATS II National Report and Report/Data Set) documents that the observed nesting effort has not changed drastically since Schulz's assessment at WATS I, and appears stable.

The average number of nests per female per season (3.5) was used to convert nest counts to number of females for that year. A summary of estimated numbers of nesting females per year from Mohadin (WATS II National Report) follows:

Year	Number of females/season
1983	1,590
1984	2,160
1985	1,464
1986	1,680
1987	1,807

Recoveries of tagged turtles over the years reveal that Surinam females migrate to foraging grounds off the coast of Ceara, Brazil. Remigration intervals range from 1 to 4 years, but the predominant interval is 2 years. To protect and recover this breeding assemblage from mortality occurring away from the nesting beaches, international agreements and support will be necessary and the adoption of turtle excluder devices (TEDs) for the shrimp trawling fleet is strongly recommended.

Aves Island, Venezuela, Colony

In previous years, and up to the time of WATS I, precise data or even estimates of the size of the nesting population were lacking. Our best "guesstimate" was that the size of the total female breeding population was around 800 individuals. The estimated annual number of females for Aves Island was 320 individuals if we use the remigratory interval of 2.5 years for our calculations. Recent and more precise nesting data collected at Aves Island by Glenda Medina and Genaro Sole of FUDENA/WWF (pers. comm.) certainly agrees with the earlier estimate. Their data on estimated numbers of females nesting annually are as follows:

Year	Number of females/season
1984	470
1985	240
1986	479
1987	316

Additional information on the average clutch frequency for Aves Island females was given as 3. The mean number of females nesting per year is estimated to be 365 individuals.

Tag return data from 11 recoveries throughout the Wider Caribbean are interesting, but the data are too few to reach any conclusions on where the important foraging areas are for this breeding assemblage. Returns have come from both the Antilles (Puerto Rico, Cuba, Dominican Republic, St. Kitts, Grenada), North and Central America (Mexico, Nicaragua), and South America (Turtle Island, Venezuela; Guyana).

Besides the undetermined level of mortality of the immature and adult turtles away from Aves Island, the most serious threat to the survival of this nesting assemblage is obviously loss of nesting habitat. With sea levels predicted to rise significantly (in terms of loss of coastal wetlands and low upland areas) in the not too distant future, the question of what the females will do after migrating to this isolated point and not finding a suitable nesting site is intriguing. Hurricane and storm induced flood and erosional damage to nests already in place is a real problem that has and will continue to effect different year-class hatching success. The adverse effects of these meteorological events will continue to occur and be magnified over time due to the incremental rise in sea levels. No long-term management technique has been considered, to our knowledge, that could mitigate these natural perturbations. Our global concern over man's pollution of the atmosphere and the resultant greenhouse effect does have an indirect bearing on a solution to this problem. A logistically difficult nest transplanting effort may be possible if the recovery of this nesting assemblage is determined to be imperative and the rising sea level is no longer a threat.

Other Colonies

The oceanic islands off Brazil's coast have recently been surveyed and significant numbers of green turtles have been recorded nesting on those beaches. The names of the islands and estimated numbers of females, or nests, per season or survey trip are given as follows (Marcovaldi and Marcovaldi, WATS II National Report):

Year	Nesting beach	Distance offshore	Number females or nests
1985/86	Ilha da Trindade	500 miles	385 females
1986/87	Fernando de Noronha	200 miles	37 nests
1982	Atol das Rocas	114 miles	49 nests

Mexico's Gulf of Mexico and Caribbean beaches also host a significant number of green turtles, but like many other localities throughout the Wider Caribbean, the assemblages are not as concentrated for the most part as those mentioned above. A total estimate of nesting females calculated from nest counts, using the value of 2.8 nests per year, and taken from a summary of important nesting beaches in Mexico (Marquez, WATS II National Report) ranged from 283 to 420 females per year.

Florida's green turtle population status has been summarized (Ehrhart and Witherington, WATS II Poster Session). The salient point was that "nesting numbers appear to be increasing." However, according to nesting effort data collected in 1985 and 1986, the numbers of females that nested those two years were estimated to be 263 and 110, respectively. Again, the fluctuating numbers of nesters between years are indicated for Florida's colony.

Conclusion

Mortality levels for the non-breeding portion of these populations are not known. Therefore, the values presented here do not necessarily suggest that recovery (carrying capacity) has occurred or that it will occur in the near future. Because of the length of time required to reach maturity (an estimated 20-30 years or more for the Caribbean green), the effects of this mortality will not be observed for many years. We must keep in mind the biological constraints characteristic of this species mentioned earlier at WATS I. It has been described as "the consequences of herbivory" because of the poor nutritive value of the primary forage item and the long distances between the foraging grounds and the nesting beaches where marine plants are frequently lacking (Bjorndal 1982). These consequences result in: (1) slow growth rates; (2) delayed sexual maturity; and (3) low annual reproductive rate--the modal being 2.5 years.

The status of the adult female population as determined from tagging studies conducted on nesting beaches implies nothing about the status of males or immature turtles. Furthermore, the nesting females may spend 95% (2.8 nests X 14 days - 2.5 yrs. X 365 days) of their adult life away from the protection afforded them at the nesting beach. For the Tortuguero breeding colony, that means many, many miles away on their foraging grounds elsewhere in the Wider Caribbean area. In Colombia, an artisanal level of exploitation continues to operate off the mainland coast from Golfo Moroscillo to the Guajira. In a recent survey of this turtle fishery an estimated 2,500 to 3,500 green turtles were taken annually (Mast, WATS II Report/Data Set). What indirect impact the Nicaraguan revolution had on restricting the entire fishing effort along the Mosquito Coast apparently has been neutralized by economic crisis and expanded fishing in these unprotected waters by Nicaraguans and neighboring countries (Cruz and Espinal, WATS II National Report).

More research on the population characteristics, including mortality rates for the various age groups is needed for both the adults on the foraging grounds as well as the juveniles in their developmental habitats. Directed take of subadults in these habitats continues throughout the Wider Caribbean area from the San Andres Archipelago (Colombia) to Puerto Rico (United States). Frazer's model (WATS II, this proceedings) identifies these age classes as the most valuable in terms of recovery and stabilization of sea turtle populations. They have survived the vulnerable early years and will soon be recruited into the breeding population. The investment in these cohorts is high, and we need to focus our research efforts on the early life history stages at sea for obvious reasons. If we do not obtain this information, the implementation of management plans, either protective or exploitive, could result in serious consequences for the green turtle and a loss of a potentially valuable renewable resource and marine reptile species.

Rapporteur Report of the Green Turtle Status Panel Session

CHAIR: Karen Bjorndal, University of Florida, USA

RAPPORTEUR: Barbara Schroeder, National Marine Fisheries Service, USA

SPEAKER: Larry Ogren, National Marine Fisheries Service, USA

PANEL: James Burnett-Herkes, Department of Agriculture and Fisheries, Bermuda

Ana Chaves, Universidad de Costa Rica, Costa Rica

Llewellyn Ehrhart, University of Central Florida, USA

Jacques Fretey, Museum National d'Histoire Naturelle, France

Reyna Gil, Centro de Investigaciones de Quintana Roo, Mexico

Colin Limpus, Queensland National Parks and Wildlife Service, Australia

Angela Marcovaldi, Instituto Brasileiro Desenvolvimento Forestal, Brazil

Guy Marcovaldi, Instituto Brasileiro Desenvolvimento Forestal, Brazil

Krishnepersad Mohadin, STINASU, Surinam

Jeanne Mortimer, University of Florida, USA

Ross Witham, University of Miami, USA

The chair called the panel members and speaker forward and introduced the speaker. Larry Ogren presented the status report on the green turtle, *Chelonia mydas*, after which there was discussion as follows:

MOHADIN: A summary of *C. mydas* nesting in Surinam was presented. Nest counts compiled since 1967 indicate there is a stable nesting population. The nesting season extends from February to July with peaks during March-May. Hatchling success of wild nests averages 84% with an average of 138 eggs per nest.

FRETEY: Variability of the nesting interval among individuals may affect estimates of annual nesting levels. Firm statements about the size or stability of the nesting population are complicated by shifts in selected nesting beaches. Cooperative tagging programs and exchange of data should be continued.

WITHAM: The Atlantic population was probably once a single population that has been broken up into discrete units by the impact of human activities. Historically scatophagy may have possibly increased feeding efficiency. The inability to find juvenile *C. mydas* may be due to pollution by the oil industry, especially tar ball ingestion.

BJORNDAL: The grave threats of pollution (including petroleum products), especially at convergence zones, were emphasized.

LIMPUS: Fluctuations in Caribbean nesting populations are similar to fluctuations seen in the Pacific. Intensive tagging since 1974 at Heron Island has shown large variations in annual nesting populations. All of the nesting populations along the Great Barrier Reef appear to be similarly fluctuating. There is no indication that changes in take cause or explain changes in nesting population levels. Analyses have shown a strong correlation between the El Nino southern oscillation index and turtle nest densities with a two year lag time. The number of adult females is constant from year to year on the foraging grounds, but the percentage of females that prepare to breed in any year fluctuates. Large fluctuations in nesting densities may be primarily a result of environmental influences on the foraging ground and not an immediate indication of changes in the total population size. Whether the Great Barrier Reef population is increasing, decreasing or stable cannot be answered after 12 years of intense data collection. This emphasizes the need for long term data to assess true population trends.

CHAVES: Greater effort needs to be directed toward determining what is happening to the populations over a long term. Seventeen years of data from Tortuguero show annual fluctuations in nesting density. Both the Tortuguero research team and the Costa Rican team evaluating exploitation should join efforts and request greater control of illegal capture.

G. MARCOVALDI: In Brazil, *C. mydas* is protected by law and is the most abundant species. Large populations of juvenile turtles forage in Brazil. Local common names of turtle species complicate research on distribution and exploitation. Preliminary nesting and tagging data from three Brazilian islands indicated that nesting occurs primarily on distant islands, not on the mainland coast.

BURNETT-HERKES: Witham's comment regarding one Atlantic population was questioned. Further explanation was requested.

WITHAM: A complete explanation was lacking but two suggestions were offered. Site specific nesting may be related more to fidelity to a first nesting area rather than to a natal beach. Published genetic investigations show no genetic variability between Tortuguero and Florida turtles.

BURNETT-HERKES: Disagreement with the hypothesis of one population was expressed

WITHAM: Florida DNR headstarted turtle recaptures are widely distributed. Juvenile turtles foraging in Brazil may not return to Florida to nest when mature. This may support the hypothesis of one population.

BURNETT-HERKES: Long term studies of turtle movements to assess population relationships are needed.

WITHAM: Long term studies are indeed necessary.

BURNETT-HERKES: More work needs to be done on determining how many populations exist. Limpus was questioned about when mating and egg shell formation takes place in the Australian population.

LIMPUS: Fat deposition begins approximately 2 years prior to nesting. Only "very fat" females appear to begin vitellogenesis. Approximately nine months are required to form mature follicles. Therefore, a female nesting (for example) in June/July began vitellogenesis approximately one year prior. Migration occurs, followed by courtship and mating, which occur about one month prior to nesting.

MORTIMER: Age to sexual maturity and its importance in management and conservation were discussed. Protracted age to sexual maturity precludes looking at short term nesting population levels. Total harvest of nesting females can continue for a long time before the nesting population levels will indicate a decline. The example of overexploitation at Assumption Island was provided.

GIL: Studies are preliminary in Mexico. Quintana Roo and Yucatan are the principal nesting and foraging areas. Initial data on tagging and nesting were presented.

EHRHART: Large integumentary tumorous growths occur on Florida green turtles. They do not appear to be invasive but may be secondarily infectious and increase chances of entanglement. In the central east coast of Florida the incidence of tumors has increased from 0% to 55% since the late 1970s. E. Jacobsen at the University of Florida is working on identifying possible viral causes.

CHAVES: An increase in tumors has also been seen on green turtles in Costa Rica.. Meat with tumors is even sold in the markets. Tumors have also been documented on *L. olivacea*.

OGREN: The seriousness of these tumors was stressed. Their effects on vision were noted.

EHRHART: Sixty percent of *C. mydas* with tumors are affected in at least one eye. C. Le Buff on the west coast of Florida and G. Balazs in Hawaii have also documented tumors obscuring vision and apparently causing mortality of green turtles.

WITHAM: Decreases in nesting populations at Ascension Island may be related to the elimination of social facilitation of new recruits in finding the nesting beach.

FRETEY: Movements of tagged nesting females from French Guiana and Ascension Island to the foraging grounds off Brazil were discussed. Radio tracking would be an interesting method for monitoring these movements. Data on the Amazon region were requested of G. Marcovaldi.

G. MARCOVALDI: Efforts have been concentrated on the nesting beaches. They are aware that Brazil is a foraging area, but they are not working intensively on this aspect. No information is available on turtle captures in the Amazon region.

LIMPUS: Many turtles may be concentrated in foraging areas and then move to different nesting beaches. Lengthy movements from foraging areas to nesting beaches (up to 1,500 km), even when a suitable nesting beach is adjacent to a foraging area were noted. Feeding grounds near nesting beaches do not imply that a turtle will nest there.

MORTIMER: Are there exceptions? Do some turtles move from foraging areas to nearby nesting beaches?

LIMPUS: There are a few exceptions. At Heron Island, one individual among 300-400 nested in the same area as its foraging ground.

The chair opened the discussion to national representatives and other participants at this point.

HORROCKS: (National Representative of Barbados) - Are there differences in nest success between high and low density years?

BJORNDAL: It varies from beach to beach. Some high density areas may have lower nest success because of nest destruction by other nesting turtles.

RUEDA: (National Representative of Colombia) - Limpus was asked if reproductive cycles might be related to age?

LIMPUS: The question cannot be answered directly from observations of *C. mydas*. *C. caretta* have been followed from subadult to first nesting, and nesting intervals appear to be unrelated to age. The primary influence appears to be environmental changes.

HALL: (National Representative of Anguilla) - Limpus was questioned on distribution of male turtles. Does mixing occur and if not, could this support the hypothesis of demes?

LIMPUS: Few males have been tagged but recaptures of courting males show strong site fidelity. The male breeding cycle appears to be shorter than that for the female in Australian waters.

HALL: This may support the hypothesis of demes. Two *C. mydas* have been found stranded in Puerto Rico with tumors and one in Antigua. These tumors may be useful as natural tags to determine a turtle's origin, if the tumors are contracted in a restricted locality.

The session was closed.

Hawksbill Turtle (Eretmochelys imbricata)

Status Report of the Hawksbill Turtle (Anne Meylan)

The hawksbill turtle, Eretmochelys imbricata, occurs in tropical and subtropical seas of the Atlantic, Pacific and Indian Oceans. It is widely distributed in the Caribbean and western Atlantic, normally ranging from southern Florida, along the central American mainland south to Brazil, and throughout the Bahamas and the Greater and Lesser Antilles. Biological data on the species have been briefly reviewed at this conference by Peter Pritchard, but in this evaluation of the status of the species, certain relevant points are worth repeating.

Unlike other species of marine turtles, the hawksbill nests diffusely throughout its range, with few known nesting aggregations. This diffuse distribution and the fact that nesting may occur for six or even nine months of the year at some locations make this species one of the most difficult to study. It has been the subject of few intensive studies and consequently, knowledge of key aspects of the reproductive biology, such as the average number of nests per female per season, is poor. With few tagging programs, knowledge of migratory habits and patterns has also remained fragmentary.

In addition to the species' diffuse nesting distribution, other factors make hawksbill populations difficult to census. Hawksbills nest on widely diverse beach types, including habitats that might be considered marginal for other species such as small pocket-beaches, beaches obstructed by coral reefs, and low-energy beaches inside lagoons. These are areas that tend to be undersurveyed. The ephemeral nature of the hawksbill's track also contributes to censusing difficulties, and to underestimation of hawksbill nesting abundance.

Other factors are likely to lead to overestimation. Recent surveys of hawksbill nesting beaches in the Caribbean have shown that a relatively large proportion of crawls does not result in nests. On Mona Island, Puerto Rico, for example, hawksbills make an average of 2.0 emergences per successful nest and females have been recorded to make as many as 11 digging attempts on a single emergence (Kontos 1988). Because the ratio of crawls to nests varies geographically with local conditions, information of this kind on a site-by-site basis is important in order to evaluate accurately aerial survey data.

Whereas population estimates for all marine turtles are fraught with error, those for hawksbills are perhaps the least accurate for the reasons discussed above. In the evaluation of population status that follows, estimates discussed herein are considered to be only rough indicators of the true size of nesting populations. Moreover, extrapolation of these figures to total population sizes is impossible due to lack of knowledge about natural sex ratios and age structures of populations.

The hawksbill is listed as an endangered species in the IUCN Red Data Book (Groombridge 1982), and is included on Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, or CITES. CITES prohibits international trade among member parties, which number 95 countries. With only a few concentrated nesting sites known worldwide, few protected habitats, and centuries of heavy exploitation for tortoiseshell, the hawksbill is considered to be highly endangered throughout its range. It is thought by many to be only second to Kemp's ridley in terms of degree of endangerment.

The status of the hawksbill in the Caribbean as reviewed at WATS I in 1983 (Meylan 1984b), mirrored that of the rest of the world; that is, no large nesting aggregations could be identified and heavy exploitation was reported to be occurring throughout the region. Table 1, reproduced from Table 6 of the WATS I proceedings (Bacon et al. 1984), shows the estimated number of nesting female hawksbills by country for the period 1977 to 1982. Many countries filed no estimate, in some cases because no nesting hawksbills had been recorded, in others because quantitative information on the species was insufficient. Many countries not reporting population estimates did, however, come prepared with good qualitative information, and knowledge of the status of the species as of 1983 is better than the table implies. One correction that should be noted is the number given for Belize, 31, which represents average yearly <u>nests</u>, rather than average number of nesting <u>females</u>. The numbers in this table in some cases represent census data recorded in the field, whereas others are yearly estimates based on census data. Still others are estimates that were based solely on other kinds of data, such as interviews or questionnaires completed by fishermen. Some of the higher figures, including 300 females for Jamaica and 500 for Grenada, fall into this last category. As the national representatives of those countries pointed out at WATS I, these estimates need to be corroborated by actual field investigations. Data gathered for WATS II will probably provide more of this necessary corroboration.

A more recent attempt to evaluate the status of populations of the hawksbill turtle was made by Groombridge and Luxmoore (1987), of the Conservation Monitoring Center in Cambridge, England. Their draft document was circulated in the summer of 1987. These authors made an extensive review of the literature on both hawksbills and green turtles on a worldwide basis, relying heavily on WATS I data for Caribbean countries. They devised a numerical ranking system in which they placed hawksbill nesting populations of each geopolitical unit. They acknowledged in their report the difficulties inherent in censusing populations of this species, and in assigning each to a size category. They stated that considerable uncertainty was associated with many of the estimates. Table 2 was extracted from Table 150 of the Groombridge/Luxmoore document and shows their placement of all hawksbill nesting populations in the Wider Caribbean. The first category, defined as nesting certain or possible, includes countries that they considered impossible to place in a size category, but in most cases were likely to have low or very low nesting levels. Cuba was apparently placed in this category due to the nearly complete lack of information in the literature about nesting levels in that country. Based on evidence that was available when this paper was written, none has significant hawksbill nesting populations.

Bermuda is listed by Groombridge and Luxmoore as the one geopolitical unit within the Wider Caribbean where nesting by hawksbills does not occur on any regular basis, if at all. Immature hawksbills do occur in foraging habitats around the island.

In order to impart greater accuracy to their ranking system, Groombridge and Luxmoore have employed "intermediate" ranks to describe populations that lie between their major groupings. They ranked seven geopolitical units in this first intermediate category. Considerable evidence supported the placement of French Guiana and the United States in this category, and slightly less for Aruba, Barbados, Montserrat and the Windward Netherlands Antilles. New data to be presented at this conference by Venezuela may allow an adjustment of the ranking assigned to the mainland of this country.

Five countries are ranked as having up to 25 nesting hawksbills per year. The parentheses around countries are those of Groombridge and Luxmoore and imply that the estimates are inferred from few data. Seven countries are ranked intermediate between 1-25 and 25-100 nesting females per year, and five countries with between 25-100 females per year. Colombia's numerous islands off the Central American coast, such as San Andres and Providencia, have not been treated separately, and thus this estimate is inclusive. No countries are considered to fall into the next intermediate category.

For large population categories, uncertainty associated with the estimates increases, as does the paucity of hard data. There is considerable doubt about population levels of hawksbills in Brazil. In the ad hoc national report presented for Brazil at WATS I, no population estimate was given, but an estimate of more than 800 annually nesting females was published in a summary table of the proceedings authored by Harvey Bullis. Intensive field investigations on the Brazilian coast carried out since 1983 by Guy Guagni dei Marcovaldi of the Marine Turtles Project (TAMAR) revealed significant hawksbill nesting in only one state of Brazil, Bahia (Groombridge and Luxmoore 1987). Only 10 females per year are known to nest at the main locality, at Prahia do Forte. The placement of Brazil in the category of 100-500 females per year would therefore appear to be incorrect.

Grenada and Jamaica are listed in this same category of 100-500 females nesting annually, on the basis of WATS I data. As mentioned previously, estimates for Grenada were based completely on information from fishermen. This was also the case for Jamaica. Only 40 nesting tracks, unidentified to species, were actually observed in Jamaica during the surveys. These data should be reevaluated at WATS II.

The Turks & Caicos Islands are placed in the category of 100-500 nesting females on the basis of a WATS I estimate developed by John Fletemeyer of 200 ± 75 hawksbills. This estimate should also be in parentheses and evaluated with additional data, as it is based on only a 7-day reconnaissance of the country and relied heavily on fishermen's reports of nesting activity. Only fifteen actual nests were counted in ground surveys and 22 in aerial surveys, including some of the same nests.

The largest known hawksbill nesting population in the entire Wider Caribbean is in Mexico. The WATS I estimates for this country were 480 females nesting annually in the Gulf of Mexico region and 88 for the coast of Quintana Roo. Two significant nesting areas were discovered in Mexico in 1982, during aerial surveys made in preparation for the WATS I conference. Later in this paper, I will present results of recent nesting censuses of these two colonies.

Before leaving Table 2, however, two points should be made. First, the largest number of nesting hawksbills attributed to any single country in the entire Wider Caribbean is less than 600 per year. Second, considerable uncertainty is associated with estimates of many of the largest populations. Nearly all countries in the Wider Caribbean are considered to host fewer than 100 nesting females per year.

Table 3 gives <u>maximum</u> estimates of nesting populations for the entire Wider Caribbean from Table 150 of Groombridge and Luxmoore (1987). The nine unassigned countries do not contribute to this calculation, but with the important exception of Cuba, are not likely to affect significantly the overall estimate owing to their low nesting densities. The maximum number of nesting females in each category is used for the calculations, including that for each intermediate category. The overall total for the Wider Caribbean using the Groombridge/Luxmoore ranking system is 4,975 nesting females. To put this number in perspective, we must consider that some green turtle populations have tens of thousands of turtles nesting annually at a single site.

Table 4 shows census data on hawksbill populations gathered by various investigators around the Caribbean since 1983. These data, combined with those presented in the national reports at this conference, may allow us to refine further the estimates of the size of hawksbill nesting populations in the region. An important point to note in the following discussion is that nearly all the data are reported as number of nests, rather than number of nesting females, as in the previous tables. A rough average of 3 nests per female can be used to convert these figures, but this average is known to vary widely between sites.

Antigua. A previously unknown hawksbill nesting site was discovered on Long Island, off the east coast of Antigua, by John Fuller and Jacques Fretey in the early 1980s. It has been under study now for two consecutive seasons by Lynn Corliss, and Dr. James Richardson. Surveillance did not begin until mid-season in 1986, after which 40-50 nests were recorded. One hundred and three nests were recorded on approximately 1,000 feet of suitable beach from the end of June to the end of November in 1987 (J. Richardson and L. Corliss, pers. comm.).

Belize. A survey of the marine turtle fauna of Belize made by Donald Moll of the Department of Biology, Southwest Missouri State University, in 1983 and 1984 revealed no nesting concentrations of any species (Moll 1985). Eight hawksbill nests were encountered in aerial and ground surveys conducted throughout the country; five of these were in extreme southern Belize in the Sapodilla Keys.

Costa Rica. The hawksbill population nesting at Tortuguero, Costa Rica has been monitored since 1955 by Dr. Archie Carr and associates. Only five miles of the 22-mile beach are surveyed on a daily basis, and coverage is limited to the green turtle nesting season, which is July through mid-September. Four nests were recorded in 1986 and eleven in 1987. Numbers of nesting females for the years beginning with 1983 are as follows: 7, 5, 6, 2 and 9 (K. Bjorndal, pers. comm.).

French Guiana. According to provisional WATS II reports, ground surveys conducted on several beaches in French Guiana under the supervision of Jacques Fretey during the 1987 season revealed only four hawksbill nests. This is consistent with previous observations by Fretey that hawksbills are very rare nesters in that country.

Guyana. Aerial and ground surveys conducted in Guyana by Peter Pritchard in 1984, 1985 and 1986 revealed very low levels of nesting by hawksbills, primarily in the northwest district near Waini Point (WATS II Report/Data Set).

Mexico. Intensive monitoring of the hawksbill nesting population at Isla Aguada in Campeche was carried out in 1985 and

1986 under the direction of Rene Marquez. This is one of two important nesting localities discovered during aerial surveys in 1982. The 40 km beach stretches from the eastern mouth of Laguna de Terminos eastward to the town of Sabancuy. In 1985, 306 nests were recorded on the beach; 191 were observed in 1986 (Marquez et al. 1988). This is currently the largest known nesting population of hawksbills in the entire Wider Caribbean. Assuming an average of 3 nests per female per season, approximately 60 females used this beach in the two years. Isla Aguada is an extremely important nesting site and one that could yield critical data about the reproductive biology of the hawksbill. Its continued study and protection are essential.

A second site of concentrated nesting by hawksbills in Mexico is located between Rio Lagartos and Cuyo, in the state of Yucatan. One hundred-fourteen nests were recorded there in 1985, 82 in 1986, and 97 in 1987 (Castaneda 1987; Marquez et al. 1988; P. Castaneda, pers. comm.) This beach also deserves careful monitoring and protection.

Daily beach surveys were carried out in 1987 on 10 beaches of the state of Quintana Roo, Mexico from the beginning of May through the end of August. During this entire survey period, only one hawksbill nest was recorded (J. Woody, pers. comm.). The primary months of the hawksbill nesting season at both Isla Aguada and Rio Lagartos are June and July, and thus it is likely that monitoring in Quintana Roo spanned the peak of the nesting season.

Panama. A ground survey of the 29 km Chiriqui Beach in Bocas del Toro Province, Panama, on 15 May 1987 revealed only 2 hawksbill tracks. Low density hawksbill nesting has been documented at several other localities in the province since studies began there in 1979 (Meylan 1984a; A. and P. Meylan, unpub. data).

Puerto Rico. The nesting population on Mona Island, Puerto Rico, was monitored in 1984 by Olson (1985) and in 1985, 1986 and 1987 by Kontos (1988). Numbers of nests per season have fluctuated widely with a high of 151 nests recorded in 1984 (see Table 4). Although there is a pronounced peak in nesting in late summer, hawksbills have been recorded nesting on Mona from April through January.

Results of recent nesting censuses on Culebra Island, Puerto Rico, were supplied by Anton Tucker (pers. comm.). Four nests were recorded in 1983, 16 in 1984 and 23 in 1985. The higher number for 1985 is attributed to increased surveillance. There was no coverage in 1986.

United States. Florida is the only state within the United States in which nesting by hawksbills is regularly observed. A single nest each was recorded in 1985 and again in 1986. No verified reports exist for 1987.

U.S. Virgin Islands. The Virgin Islands National Park on St. John has monitored sea turtle nesting activity since 1980. Question marks to the right of the numbers given in Table 4 denote suspected, but not confirmed, nests (Zullo 1986). Buck Island has also been monitored since 1980 and has a significant level of hawksbill nesting. Numbers of nests per year were not available.

The WATS meetings have stimulated the reconnaissance of many miles of Caribbean nesting beaches, and have resulted in the discovery of at least two important sites of nesting by the hawksbill turtle. However, that more sites have not been discovered is discouraging, and that the chances are diminishing for the finding of new major nesting beaches for this species in the Caribbean.

The outline provided to us by the WATS Executive Committee for our status reports asked that we address the issue of nesting beach productivity. Because there are few sites of concentrated hawksbill nesting, few data of this nature are available. No exact figures are available for Tortuguero, Costa Rica, but hatching productivity can be expected to be moderately high at this location. While there is some poaching of nests near both ends of the 22-mile beach, most nesting occurs within Tortuguero National Park, which is vigilantly patrolled. Nearly all losses can be attributed to natural predators and erosion.

At Isla Aguada, Mexico, 52.2% of the nests were lost in 1985, and 54.6% in 1986 (Marquez et al. 1987b). This tremendous loss was due almost exclusively to poaching by humans. Nearly all of the remaining nests are removed from the beach and artificially incubated, with hatching success rates of 58.5% in 1985 and 63.6% in 1986.

Only 26% of the 114 nests at Rio Lagartos, in the Yucatan, were lost in 1985 (Castaneda 1987). This was due to careful surveillance by fisheries personnel. Hatching success of the transplanted eggs was 49%.

Feral pigs represent the primary threat to hawksbill nests on Mona Island, Puerto Rico (Kontos 1988). Nest loss was 17.2% in 1984, 48.2% in 1985, 39.7% in 1986 and 49.3% in 1987. Fencing of important nesting beaches has been recommended since 1974, but has never been carried out.

Another issue that needs to be addressed in the evaluation of the status of a species is the degree of threat that current populations are experiencing. In the case of the hawksbill, trade in tortoiseshell has been identified as the single greatest threat throughout the species' range. This topic will be discussed in detail in another session of this conference, so I will only briefly mention some recent figures on the magnitude of this trade, and point out some significant trends in the Caribbean. A recent report by Milliken and Tokunaga (1987) represents the most comprehensive analysis yet available on the tortoiseshell trade in Japan. Japan accounts for the overwhelming majority of all trade in this product. For their report, the authors analyzed all available statistics from both customs' and dealers' records for the period 1970-1986. They concluded that Japan's trade around the world during this 17-year period represents the utilization of more than 600,000 adult hawksbills. Twenty-six Caribbean countries supplied tortoiseshell to Japan during the period, accounting for over half of the total volume. In terms of number of animals, this represents 251,660 adults. Trade in tortoiseshell is prohibited by CITES between member parties. One promising sign in recent years has been the cessation of trade by many countries within a few years after joining the Convention. Nicaragua is a typical example. CITES came into force there in 1977. Imports to Japan dropped very substantially by 1980. It took considerably longer for trade to drop off in Panama, where CITES became effective at the end of 1978. Exports from this country finally plunged in 1986. Panama was the second largest supplier of tortoiseshell to Japan in the entire world for the 17-year period studied by Milliken and Tokunaga. Exports during this interval totalled 98,679 kg, or 75,906 hawksbills. It is suspected that tortoiseshell from several neighboring countries has been illegally funneled through Panama to Japan. The government of Panama has reported that it has not issued export permits for tortoiseshell for many years, and has protested this illegal trade to Japan's Ministry of International Trade and Industry.

Cuba, the second largest supplier in the Caribbean during the study period, exported 97,852 kg of shell, only slightly less than Panama. Cuba is not a party to CITES and thus this trade is not prohibited by the government.

Two disturbing trends in the tortoiseshell trade are apparent from the Milliken and Tokunaga report. Several Caribbean countries have shown recent increases in the volume of trade. These include Belize, Dominica and Haiti. A second trend is that other countries with no previous record of trade have recently become suppliers, such as Antigua/Barbuda.

The tortoiseshell figures are staggering in light of recent data on the status of nesting populations in the Caribbean. There are two inferences that might be drawn. One is that, somehow, we are greatly underestimating the size of hawksbill populations in the region, and that major colonies exist but have been overlooked. An alternate interpretation is that current low population levels are the result of this massive, long-term exploitation for the tortoiseshell trade. Unfortunately, the latter is more likely to be true.

Trade in tortoiseshell is unquestionably the driving force in the exploitation of the hawksbill. Although the meat of this species is eaten to some extent all around the Caribbean, it is not preferred, and is sometimes even discarded when meat of other species is available. As with all other marine turtles, eggs are highly sought. The skin of hawksbills appears to be of little value as leather, and there is no significant trade in this product, as far as I am aware. There is trade in stuffed juveniles, however; these are sold as curios to tourists. The volume of this trade in the Caribbean is unassessed but is known to be considerable in some areas. There are encouraging signs that effective enforcement of CITES at the point of importation is having some effect on this trade (Meylan 1984a).

The tortoiseshell trade has a long history in the Caribbean, but methods of capturing turtles are constantly evolving. Spearfishing is a relatively new and highly efficient capture technique that is taking a heavy toll. Because hawksbills share the habitat of lobsters and expensive reef fish, divers have ample opportunity to take turtles incidentally, and can afford to continue to do so even when turtle populations are severely depleted (Carr and Meylan 1980b). A report on the lobster fishery off the Caribbean coast of Honduras and Nicaragua by Cruz and Espinal (WATS II National Report) reveals that the annual capture of hawksbills by divers in that country in 1986 may have been 5,000 individuals.

Conservation measures on behalf of the hawksbill have been limited, due in part to the species' diffuse nesting distribution and the consequent difficulty in establishing protected areas. Some of the most ambitious efforts have been made in Mexico, where fisheries personnel have taken great pains to rescue nests from human poachers. Fundacion Los Roques in Venezuela has carried out a headstart project for hawksbills for several years. A number of other countries have small-scale hatcheries on beaches where _in situ_ protection of nests is not possible. The more difficult conservation measures of protecting nesting females and their natural nests, and enforcement of closed fishing seasons, have been undertaken by only a few Caribbean countries, largely because of personnel shortages and financial constraints.

Unquestionably the most effective measure for conserving hawksbill populations has been, and will continue to be, CITES. Through its negative effect on trade in tortoiseshell, it has the greatest chance of bringing relief to the endangered hawksbill. An international campaign to convince Japan to cease trade in this commodity could have more effect on the hawksbill's future than any local management efforts.

Research needs on behalf of the hawksbill are many and costly. Further reconnaissance of nesting and foraging habitats is critical. An analysis of WATS II data should help direct these efforts. At the time of writing of this paper, key areas for exploration within the Caribbean appear to be Jamaica's offshore islands, Mexico's offshore islands in the Gulf of Mexico, the Turks and Caicos Islands, the Bahamas, Haiti, Brazil, the southern coast of Nicaragua, and the Grenadines of St. Vincent and Grenada.

Also needed is an intensive study of the reproductive biology of the hawksbill at the few beaches where nesting concentrations occur. These projects will admittedly have smaller yields than those on major nesting beaches of other species, but they are essential to management efforts.

As with all of the other marine turtle species, the life history of the hawksbill remains poorly known. Studies on the foraging grounds are needed to determine growth rates, dispersal patterns, habitat preferences and population structure.

The survival situation of the hawksbill turtle has probably not changed significantly since 1983, although our knowledge of it has certainly increased. I find the new data reviewed for this report very discouraging, and I suspect now that the hawksbill's status in the Caribbean is far worse than we may have realized in 1983. Heightened interest in marine turtles in the Caribbean since the WATS I meeting and extensive surveys to find new beaches have yielded relatively few rewards. The largest known nesting aggregation consists of, at most, only a few hundred females. Trade in tortoiseshell continues to threaten populations throughout the region, and is even increasing in some countries, abetted by new fishing techniques and markets. It would seem that only a concerted effort at both the national and international level could change the prospects for the hawksbill's future.

I would like to thank Karen Bjorndal, Patricia Castaneda, Lynn Corliss, Anastasia Kontos, James Richardson, Anton Tucker and Jack Woody for contributing information for this report. Pedro Gonzales, of the WATS team, kindly supplied numerous documents.

Table 1. Estimated numbers of hawksbill turtles (*Eretmochelys imbricata*) nesting by country 1977-1982 (from WATS I National Reports, Table 6).

Country	1977	1978	1979	1980	1981	1982	Report cat.
Anguilla							NR
Antigua						76	NR
Bahamas							NR
Barbados						OBS	NR
Belize						31*	DNR
Bermuda							NR
Brazil							AHDR
Br. Virgin Is.					50		NR
Cayman Islands							NR
Colombia							DNR
Costa Rica							NR
Cuba							AHDR
Dominica						3	NR
Dom. Republica				420			NR
Fr. Guiana							NR
Grenada						500	NR
Guadeloupe							NR
Guatemala							NR
Guyana							NR
Haiti							NR
Honduras							NR
Jamaica						300	NR
Martinique							NR
Mexico (Gulf)					480		NR
Mexico (Caribbean)					88		NR
Montserrat							NR
Neth. Antilles(S)							AHDR
Neth. Antilles(N)							AHDR
Nicaragua					25		NR
Panama						10	NR
Puerto Rico	33	2			25	22	NR
St. Kitts/Nevis							NR
St. Lucia						11	NR
St. Vicent							NR
Surinam	OBS	OBS	OBS	OBS	OBS	OBS	NR
Trinidad/Tobago							NR
Turks & Caicos						200	NR
United States					2		NR
U.S. Virgin Is.				21	24	25	NR
Venezuela							NR
Totals	33	2		441	692	1178	

*Estimated yearly average

OBS-Observed only; no quantitative data

NR=National Report; DNR=Draft National Report; AHDR=*ad hoc* Data Report

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Fr. Guiana							NR
Grenada						500	NR
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Guatemala							NR
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Surinam	OBS	OBS	OBS	OBS	OBS	OBS	NR
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Table 2. Size classes of nesting populations (females per year) of hawksbill turtles (<u>Eretmochelys imbricata</u>) in the Wider Caribbean. (From Table 150, Groombridge and Luxmoore, 1987)

	Size	Classes	
Nesting certain or possible (likely to be low or very low)	No nesting known	Intermediate	Up to 25 females/year
Anguilla	Bermuda	Aruba	(Dominica)
Cuba		Barbados	(Guyana)
Guatemala		Fr. Guiana	Neth. Antilles Leewards ?
Guadeloupe		Montserrat	Surinam
Haiti		Neth. Antilles Windward	(St. Lucia)
Honduras		United States	
Martinique		Venezuela mainland	
St. Kitts/Nevis			
Trinidad/Tobago			

Country in parentheses = inferred from few data
Country with ? = marked uncertainty

Table 2 (continued). Size classes of nesting populations (females per year) of hawksbill turtles (*Eretmochelys imbricata*) in the Wider Caribbean. (From Table 150, Groombridge and Luxmoore, 1987)

Size			Classes		
Between 1-25 females per year and 25-100	25-100 females per year	Intermediate	100-500 females females per year	Intermediate	500-1000 females per year
(Costa Rica) (Nicaragua) (Panama) Puerto Rico (St. Vincent) US Virgin Islands (Venezuela) islands ?	Antigua/Barbuda (Bahamas) Belize Br. Virgin Islands (Colombia) ?	none	(Brazil) Dom. Republic (Grenada) ? (Jamaica) ? Turks & Caicos	Mexico	none

Country in parentheses = inferred from few data
Country with ? = marked uncertainty

Table 3. Maximum estimates of number of hawksbills (*Eretmochelys imbricata*) nesting annually in Wider Caribbean (Calculated from Table 150, Groombridge and Luxmoore, 1987)

Size class* of nesting population	Number of geographical areas	Maximum number of hawksbills nesting/year for this size category	Maximum estimates of number of hawksbills nesting/year/category
?	9	-	-
0	1	-	-
0/1	7	25	175
1	4	25	100
1/2	7	100	700
2	5	100	500
2/3	0	500	0
3	5	500	2500
3/4	1	1000	1000
			4975

*Key
? = Nesting certain or possible but impossible to place in size class and likely to be low or very low.
0 = No nesting known.
1 = Up to 25 females nesting/year
2 = 25-100 females nesting/year
3 = 100-500 females nesting/year

Table 4. Number of nests of hawksbill turtles (*Eretmochelys imbricata*) recorded at several monitored beaches in the Wider Caribbean, 1983-1987

Locality	Year 1983	1984	1985	1986	1987
Antigua					
Long Island				(40-50)*	103
Costa Rica					
Tortuguero				(4)	(11)
French Guiana					
several beaches					4
Mexico					
Isla Aguada (Campeche)			306	191	
Rio Lagartos (Yucatan)			114	82	97
Quintana Roo (10 beaches)					(1)
Puerto Rico					
Mona Island		(151)	85	(68)	71
Culebra Island	4	16	23		
Surinam	17	19	31	21	11
United States					
Florida	0	0	1	1	0
US Virgin Islands					
St. John	23(+9?)	8(+2?)	14(+5?)		

*( ) Parentheses indicate beach was not surveyed for entire nesting season.

Rapporteur Report of the Hawksbill Turtle Status Panel Session

CHAIR: Ralf Boulon, Jr., Division of Fish and Wildlife, St. Thomas, U.S. Virgin Islands

SPEAKER: Walter Conley, Florida Department of Natural Resources, USA

RAPPORTEUR: Dean Swanson, National Marine Fisheries Service, USA

PANEL: Patricia Castaneda, Centro Reg. de Investigacion Pesquera, Yucalpeten, Mexico

Lynn Corliss, Jumby Bay Resort, Antigua

Gustavo Cruz, Universidad Nacional Autonoma de Honduras, Honduras

Arthur Dammann, St. John, U.S. Virgin Islands

James Finlay, Ministry of Education and Fisheries, Grenada

Julia Horrocks, Bellairs Research Institute, Barbados

Anastasia Kontos, University of Georgia, USA

Nigel Lawrence, Ministry of Agriculture, St. Lucia

Colin Limpus, Queensland National Parks and Wildlife Service, Australia

Rene Marquez, Proyecto Nacional de Tortugas Marinas, Mexico

Jeanne Mortimer, University of Florida, USA

James Richardson, University of Georgia, USA

Wayne Witzell, National Marine Fisheries Service, USA

Ralph Wilkins, Ministry of Agriculture, St. Kitts

The chair introduced W. Conley who presented an overview of the status of *Eretmochelys imbricata* in the absence of A. Meylan, who had prepared the presentation but was unable at the last minute to attend. The chair then invited comments by panel members on the suggestion made in the Groombridge and Luxmoore report that, due to insufficient data, hawksbills should be considered to be of Indeterminate status rather than Endangered under CITES. The chair thought it would be a grave mistake to do so.

<u>HORROCKS</u>: Comments were requested on hawksbill movements between breeding and feeding grounds, after noting that in Barbados the animals are believed not to be in inshore waters year-round.

<u>MORTIMER</u>: Captures in the Seychelles occur during the breeding season.

<u>LIMPUS</u>: In Australia, there are year-round feeding aggregations of immatures and adults that will not breed in that year, and that breeding grounds may be more than 1,000 km away from feeding grounds. The same scale of movement probably exists in the Caribbean but involves multiple national jurisdictions. A conclusion was drawn that hawksbills shift habitats during their life history.

<u>KONTOS</u>: On Mona Island in Puerto Rico, adults are on the feeding grounds year-round. However, the number declines during the nesting season, but it increases after the nesting season.

<u>MARQUEZ</u>: Mexico has tagged hawksbills and loggerheads for 3 years, and there have been no recoveries outside the tagging area, although every year there are recaptures in the same zone where turtles are tagged.

<u>CHAIR</u>: One major problem given for the lack of nesting studies in the Caribbean has been the diffuse nesting of the species. Recently we have heard of locations with concentrated nesting such as in Antigua. These sites may provide an excellent opportunity to learn more about the nesting biology of the species.

<u>RICHARDSON</u>: Nesting activity on these little pocket beaches need to be measured. Population size may be underestimated if we do not do this. Hawksbills in Antigua and Barbuda seem to return to the same nesting beach. Each country needs to walk its beaches to locate the pockets of nesting. The number of nesting females may be more than presently thought but, because of multiple nestings per female, there are fewer individuals per beach.

DAMMANN: To survey the many small cays found in Grenada, St. Vincent and the Grenadines, the British Virgin Islands, and the U.S. Virgin Islands is not economically feasible. In all these cases, the number of nesting females may be underestimated.

CORLISS: In Antigua and Barbuda people see young hawksbills, and fishermen have reported sightings of adults more in the past than they have in present.

WILKINS: Juveniles are present year-round off St. Kitts-Nevis, where the closed season is June 1 - September 31.

RICHARDSON: It would be wise to shift any taking until after the nesting season. No feasible way exists to protect pocket beaches without substantial private sector support, and when such beaches are found, great care is necessary to avoid disrupting the animals while performing field research.

MARQUEZ: Juvenile hawksbills used to be found with ease in souvenir shops in Mexico. This has changed. Fishermen now cooperate by bringing in hatchlings and juveniles for tagging and then returning them to the water.

KONTOS: Juveniles feed in nearshore waters while older turtles feed in deeper waters.

CHAIR: The tagging project in the U.S. Virgin Islands has shown that of immature and subadult turtles are in the nearshore reefs while adults are believed to be feeding and resting offshore in deeper waters where sponge communities are more developed.

CORLISS: Increasing tourism in Antigua and Barbuda is compatible with field research, with positive spinoff effects in terms of public education.

WILKINS: The Brazilian video tape is an example of a good public education tool. Perhaps it could be made available to western Atlantic states.

The chair opened the discussion to the floor.

G. MARCOVALDI: An offer was made to make available copies of the Brazilian video tape. Current investigation of 50-60 km of a 1,000 km long beach was noted.

__RICHARDSON__: Research on feeding areas such as that conducted on Mona Island was advocated.

__MOHADIN__: Whether or not Puerto Rico has a management plan that addresses the problem of feral animals on Mona Island was asked.

__CINTRON__: Such a program exists and is funded by the U.S. Fish and Wildlife Service, but there are problems in executing it due to distance and conflicting interests of hunters.

__ACKER__: Juveniles are present year-round off the British Virgin Islands. Enforcement personnel could not possibly survey the 30-40 islands, but success had been achieved by providing data sheets to diving companies. Information is useful only if collected consistently in given areas over time.

__FRETEY__: Green turtles may have been confused for hawksbill turtles off French Guiana in nest observations reported prior to 1977-78.

__CHAIR__: Donnelly was asked to address the suggested listing of hawksbills as Indeterminate status under CITES as per Groombridge and Luxmoore's suggestion.

__DONNELLY__: An Indeterminate status would have some significance for the IUCN. For highly migratory species such as sea turtles, there is always the problem that shipments of animal products cannot be identified as to source except by accompanying paperwork.

__MORTIMER__: There is no doubt that hawksbills are endangered and should be listed on CITES Appendix 1.

__LIMPUS__: Despite incomplete information, if the hunting of hawksbills continues, photographs of these animals in the Caribbean will eventually be all that remains.

__ECKERT__: The correct identification of juveniles in the water required proper training and offered to make available the program to do this in the British Virgin Islands.

__MORTIMER__: For countries without complete protection, is it better to protect adults or juveniles? Adults represent the reproductive population while juveniles are more readily available to hunters.

<u>KERR</u>: Jamaica will continue to have problems with data collection. Perhaps the first thing to do is convince fishermen that taking hawksbills is not worth the risk.

<u>FRETEY</u>: Agreement with the preceding speaker was expressed.

<u>WILKINS</u>: Hawksbills are declining. Why not have a worldwide moratorium on their taking?

<u>HALL</u>: If larger hawksbills are to be protected, why have minimum size regulations?

<u>MORTIMER</u>: The Seychelles protects hawksbills whose shells are less than 24 inches long, and this restriction is well enforced.

<u>MARQUEZ</u>: Mexico has been studying hawksbill reproduction for 20 years. In 1966, the population had an increasing proportion of young animals in its age structure. Ten years later, eggs per female had declined 8-10 eggs.

<u>FRETEY</u>: Although one could say protecting juveniles is more important because they are easier to market and are more easily obtained, the adults constitute the reproductive population and are also of key importance. All sizes should be protected.

<u>CINTRON</u>: Is nesting site fidelity observed only within a nesting season, or between seasons as well?

<u>RICHARDSON</u>: Strong nesting site fidelity has been observed only within a nesting season to date. More data are required to answer the between nesting season question.

<u>MORTIMER</u>: The best studied population is perhaps in the Seychelles (since 1972) where about 30 hawksbills nest per year and each turtle nests 3-4 times per year. These turtles are quite site specific from year to year.

<u>HALL</u>: The protection of all turtles would be preferable, but all countries cannot do this. Some countries need more options.

FRAZER: On Richardson's concern that populations might be overestimated, this would mean that every adult female and indeed every adult is more valuable and perhaps such measures as size limits should be re-evaluated. On the matter of shell exports, some countries such as Belize are apparently major new exporters of shell. Stockpiled quantities of shell have been observed in Belize in the past and current exports therefore need not represent new hunting. However, when the stockpiles have been exported, pressure for new hunting can be expected.

CHAIR: Conley was thanked for his presentation as were panel members for their participation. The session was then closed.

Loggerhead Turtle (Caretta caretta)

Status Report of the Loggerhead Turtle (Llewellyn M. Ehrhart)

Introduction

The expressed purpose of WATS II is "to present available data on the status and exploitation of the six sea turtle species in the western Atlantic," and insofar as the loggerhead turtle (Caretta caretta) is concerned, there is a wealth of new information with which to deal. First, the data from the first Western Atlantic Turtle Symposium have been adroitly compiled and summarized by the editors of the Proceedings of WATS I. I intend to draw heavily on that work in this review and, at the outset, acknowledge the useful contribution of those editors (Bacon, Berry, Bjorndal, Hirth, Ogren and Weber). Second, the independent scientific community has produced, in the past four years, research results that constitute significant gains in our understanding of the biology of the loggerhead, and of its conservation and management. In my judgement some of the most useful works are those of Richardson and Richardson (1982); Frazer (1983, 1984, 1986, 1987b); Murphy and Hopkins (1984); Witherington (1986); Henwood (1987); Crouse et al. (1987) and, of course, the late Archie F. Carr (1986a, b; 1987). In several papers published just prior to his passing, and posthumously, Professor Carr brought together a myriad of systematic observations, quantitative data and incandescent insight in a synthesis that furthers our understanding of loggerhead ecologic geography in the western Atlantic by an order of magnitude. Concepts developed by Dr. Carr (1986a, b; 1987), demonstrate the complexity of loggerhead life history and, perhaps, begin to convey the message that there are strategically important stages to which the focus of management and conservation practice should turn.

The complexity that we are now beginning to appreciate in loggerhead life history imputes a necessity to choose among the several life history stages for the one (or ones) most useful in assessing relative population stability, which I take to be the fundamental objective of a status review such as this. Meylan (1982) dealt thoroughly with this issue and concluded that, because of the logistic difficulties presented by seasonal and ontogenetic changes in habitat utilization by other stages, the most practical approach to censusing sea turtles is to enumerate females on nesting beaches. Estimates (and in some cases true censuses) of the number of females emerging annually to nest can be made "without excessive logistical difficulty" (Meylan 1982), and it is reasonable to regard that number as an index to adult survivorship and the culmination of our efforts to manage and conserve. I concur that censusing nesting females continues to provide the best index to population stability and intend to base most of this review on nesting beach survey data. That is not to say, however, that conservation practice should focus on nesting females to the virtual exclusion of turtles in developmental and other habitats. Nesting beach censuses are like a window through which one can view patterns and trends in population size, but the key to recovery and population stability undoubtedly lies with the wise management of immature turtles, as well. This common-sense conclusion is only recently corroborated theoretically by the important new work of Richardson and Richardson (1982), Frazer (1983, 1984, 1986, 1987b) and Crouse et al. (1987), about which more will be said below.

Censusing nesting females directly on beaches where nesting density is relatively high (i.e., greater than ca. 100/km/yr) is generally not feasible . The disturbance to the nesting beach that would result from any census operation large enough in scale to observe and/or tag every emerging female would be self-defeating and prohibitively expensive. It is possible, however, to enumerate fresh nests daily, throughout the season (Witherington 1986), or to derive valid estimates of total nesting from sample censuses carried out on approximately 40% or more of the days in a nesting season (Ehrhart and Raymond 1987). Indeed, most of the available data are in the form of nesting totals, not in the actual number of female turtles comprising any given population or aggregation. Derivation of that number (total individual females) from nesting totals has been a vigorously debated issue and I enter that debate with trepidation, fully aware that I am inviting the criticism of oversimplification. So be it. A number of the conclusions that I come to here will be controversial and I welcome the discussion and constructive criticism that will surely characterize the panel discussion that follows.

At issue here are two fundamental aspects of loggerhead reproduction: 1) the mean number of nests deposited per female per season, and 2) the average multi-annual remigration period length for females of a given population. Loggerheads often lay as many as six clutches per year (Lund 1986; Talbert et al. 1980) and totals of seven (Lenarz et al. 1981) or eight (C. LeBuff, pers. comm.) have been observed. Mean clutch production is apparently much smaller than that, however, throughout the western Atlantic. Talbert et al. (1980) reported that loggerheads usually nest two or three times in South Carolina and Richardson and Richardson (1982) estimated 2.5 nests per female at Little Cumberland Island, Georgia. Other estimates for that same area exhibit considerable annual variation, with Frazer and Richardson (1985) reporting a range of 2.81 to 4.18 over a 10 year period and Stoneburner (1981) estimating only 1.84 to 1.97 nests per female per season. Murphy and Hopkins (1984) also used data from Little Cumberland Island and obtained an estimate of 4.1 nests per female by stochastically manipulating the seasonal distribution of nesting dates. Few estimates exist from elsewhere in the WATS region, but Kaufmann (1975) reported that some Colombian loggerheads nested at least four times. He gave no estimate of the mean. The broad-scale purposes of this review make it necessary to adopt a working hypothesis about mean clutch frequency. Though there is clearly considerable annual variation in this trait, my subjective evaluation of the data cited above has led me to accept Murphy and Hopkins' (1984) 4.1 nests per female as the current "best estimate," and I have adopted that figure for the purposes of this review.

The matter of mean remigration interval is, if anything, even more ambiguous. Meylan (1982) and Hughes (1982) have pointed out the problem of low observed remigration percentages world-wide. A corollary to this involves the impossibility of knowing if a tagged female that fails to reappear has died or is simply nesting unnoticed on some other beach. After all, evidence is abundant that some loggerheads move considerable distances between successive nestings (Bjorndal et al. 1983). Even in the southeastern U.S., beach coverage is so patchy that the probability of observing a female that happens to nest on a beach a few kilometers from any particular research area is far less than 50%. Given this gross imprecision in our ability to assess mean multi-annual cycle length, it seems best to resist the temptation to extrapolate the number of females nesting per year to the total adult female population. Rather, it is more useful to monitor nesting aggregation size each year and analyze the patterns and trends in the variation observed. That can be done, I believe, for very large expanses of nesting beach by the methods pioneered by Carr and Carr (1977), improved by Shoop et al. (1985), and perfected by Murphy and Hopkins (1984).

Should a reason arise to derive an estimate of the total adult population, much evidence exists to show that two and three year cycles clearly predominate in western Atlantic loggerheads (Richardson et al. 1978a; Bjorndal et al. 1983; Ehrhart 1980; Lund 1986). Two year cycles are seen most frequently and intervals of just one year are negligibly few. Observed four year cycles may include turtles that nested elsewhere in two years but the evidence from Little Cumberland Island, Georgia, indicates that some four year cycles are real (Richardson and Richardson 1982). An estimate of 2.6 years is given in that same work, as the mean remigration interval and I believe that to be the current "best estimate." I am aware of Meylan's (1982) warning about annual variation in nesting activity and agree that good estimates must incorporate consideration of that variation. That is, surveys should be done annually over a number of years to establish a baseline against which trends can be based. Loggerhead nesting in the southeastern U.S. can vary by a factor of approximately 2 (Conley and Hoffman 1987), but never to the drastic extent reported by Limpus (1982) for green turtles nesting at Heron Island. I am aware also that any estimation of total adult population size would involve multiplication by a factor reflective of the normal adult sex ratio, so as to include adult males. However, so little is known about adult sex ratios and about adult males, in general, that it seems more reasonable to focus on estimates of adult female population size and assume that trends seen there are reflective of conditions in the adult population as a whole.

Population Size and Stability by Region

Figure 1 attempts to show the foraging and nesting distributions of western Atlantic loggerheads. It includes information from the published WATS I National Reports and verbal presentations at WATS II. A cursory consideration of this map could give one the impression that loggerhead nesting is uniformly distributed through the region, but that is definitely not the case. In the "Summary of Numerical and Other Quantitative Data Derived from Descriptive Materials in the WATS (1) National Reports for Fisheries, Foraging and Nesting, by Species," compiled by Bullis, only two countries, Brazil and the U.S., are seen to have high or very high levels of loggerhead nesting activity, 2,000+ and 28,448 nesting females, respectively. Because the U.S. clearly supports a very high level of nesting activity, and because most of the information developed since WATS I is from the U.S., my review deals predominately with the status of Caretta caretta in the U.S. That is not to say, however, that populations associated with nesting beaches elsewhere in the region are not important. Undoubtedly more nesting occurs in some areas than we know about and loggerheads are exploited to some extent in 18 of the 40 countries/regions that participated in WATS I. They undoubtedly play important, albeit poorly understood, roles in marine and estuarine ecosystems and contribute to region-wide population stasis on geological/evolutionary time scales.

Gulf, Caribbean and South Atlantic Aggregations

Considering Brazil first (please note that the base map does not extend as far south as Brazil), one finds that some loggerhead nesting occurs in the states of Rio Grande do Norte and Bahia. Bullis inferred from the Ad Hoc Data Report to WATS I that in excess of 2,000 females are in the nesting aggregation. That was apparently an over-estimate in light of the National Report of Brazil, given at WATS II, which indicates only about 200. No data are available upon which a trend in population stability can be based, but significantly, sea turtles have been fully protected by law in Brazil since 1978.

Table 1 provides a summary of those countries/regions that support low to moderate loggerhead nesting activity. For a number of them, nesting aggregations are so small or information so sketchy that little needs to be said. Several, however, deserve comment.

In the Bahamas, loggerhead nesting occurs on Great Inagua, Little Inagua, Andros, Abaco (Bacon 1981), Walker's Cay, Grand Bahama, Bimini and Eleuthera (Carr et al. 1982). While quantitative data are apparently lacking, Carr et al. (1982) concluded that the number of nesting loggerheads, and other species, has decreased greatly in the past 50 years, especially in the northern islands.

The level of loggerhead nesting activity in the Dominican Republic is considered to be moderate, in the WATS I summary. Bacon (1981) and Carr et al. (1982) reported "occasional" nesting on the northeast and northwest coasts and the Representative to WATS II from the Dominican Republic said that there are only about 50 nests per year. Information upon which to determine a trend is non-existent, but Carr et al. (1982) noted that "when nesting turtles are encountered, they are regularly killed and their eggs taken."

Bacon (1981) regarded nesting by loggerheads in Jamaica as rare and Carr et al. (1982) said only that it was even more sparse than hawksbill nesting, which occurs only a few times each year. The 210 nesting females given in the WATS I National Report is valuable new information but does not allow for any assessment of stability, and has apparently not been confirmed recently.

A similar situation prevails for Grenada, where loggerhead nesting was formerly thought to be rare (Bacon 1981) or non-existent (Carr et al. 1982), but the WATS National Report reveals that about 100 females nest there each year. Further research is needed to determine any trend that may be developing.

The current status of the loggerhead in Colombia is difficult to decipher. Bacon (1981) considered it to be a common nester there, particularly on the beaches from Cabo San Augustin to Rio Buritaca and on the Islas del Rosario. Carr et al. (1982) found, however, that loggerheads nest there ("on the good beaches...on the mainland between Cartagena and Santa Marta") only occasionally. Data in the National Report for WATS I were, I believe, derived from Kaufmann's reports (1968, 1971a, 1975) and indicate about two loggerhead nests per night and 300 nests per season on a 7.5 km stretch of beach at Rio Buritaca. These numbers are probably obsolete because, as Kaufmann (1975) reported, the number of nesting loggerheads decreased markedly during the 20 year period prior to 1975 due to excessive exploitation. An aerial survey carried out in that area just prior to WATS I (June, 1983) produced no definite evidence of loggerhead nesting, and L. Ogren (pers. comm.) believed at that time that little, if any, nesting occurred on the northern Colombian coast. In the National Report given at WATS II, only

24-31 females were estimated to nest there. Clearly, loggerhead nesting is in great decline on the Caribbean coast of Colombia.

Although consideration of the status of loggerheads in the San Andres Archipelago was not included in the WATS I National Report, the work of Carr et al. (1982), who devoted considerable attention to it is very relevant . That work is readily available so I need not review it extensively. It is worth noting, however, that on San Andres, where loggerheads once nested regularly, nesting is now only "desultory and sporadic." Even so, any turtle found nesting there is always killed, and the eggs always taken. Carr et al. (1982) concluded that, "As nesting territory, San Andres is finished." Similarly, while some loggerhead nesting still occurs on Isla Providencia, the Albuquerque Cays (Bacon 1981) and the Courtown Cays (or East Southeast Cays), evidence indicates that the level of activity has declined markedly since about 1970. Some nesting occurs at the very small Roncador Cay, and some indication exists of greater nesting activity at the most remote atoll, Serrana Bank, although this remains to be quantified. Further information clarifying the status of loggerheads on the mainland coast of Colombia and in the San Andres Archipelago is needed.

I have also encountered some difficulty in assessing the status of nesting aggregations of loggerheads in Mexico. Bacon (1981) regarded the loggerhead as a common nester, primarily I believe, on the basis of nesting activity on the Caribbean coast, especially the beaches of the northeastern Yucatan Peninsula, in Quintana Roo, where Marquez (1976b) estimated 500 nesting females. Sternberg (1981) regarded this region (northern Quintana Roo) as the only major loggerhead nesting area in the western Atlantic other than the southeastern U.S. Carr et al. (1982) also reported frequent nesting by loggerheads, especially at Boca Paila and Isla Contoy. Loggerhead nesting activity in more modest proportions occurs at many points along the gulf coast, west of Quintana Roo, e.g.: the cays off the northern Yucatan coast; the beaches stretching eastward from the Tabasco-Campeche border to Laguna de Terminos; in Vera Cruz, near Cabo Rojo, Montepio, Cerro San Martin and at Punta Gorda; and in Tamaulipas, north of La Pesca. Therefore, the overall impression gained from earlier estimates is that the Caribbean coast, especially northeastern Quintana Roo, may support, or did support at one time, substantial loggerhead nesting activity, while lesser activity characterized the beaches of the gulf coast.

The information in the WATS I National Report suggested a different situation, with only 160 females nesting on the Caribbean side and nearly 50% more (225) nesting on the Gulf coast. These numbers were smaller, in general, than I would have expected and the greater nesting activity on the Gulf was also puzzling. Fortunately, very useful new information concerning loggerhead nesting in Quintana Roo was presented at WATS II by

Reyna Gil Hernandez of the Centro de Investigaciones de Quintana Roo. Though preliminary in nature, these data reveal that 322 nesting female loggerheads were tagged on 10 Caribbean beaches between 1 May and 4 August 1987. This total represented approximately 50% of the turtles nesting on those beaches and provides an overall estimate of about 600 females nesting per year. While this estimate generally agrees with that given 11 years ago by Marquez (1976b), the conclusion that loggerhead nesting activity along most of the Mexican coast is less than it was in the recent past (Carr et al. 1982) is still valid.

Prior to WATS I, information concerning nesting activity of loggerheads (and other species) in Cuba was limited to Bacon's (1981) statement that there is "some nesting all around the island." The local nesting areas that he was aware of were Playa Baracoa and Isla de Pinos (now Isla de la Juventud). The Ad Hoc Data Report for Cuba and the "Informe Nacional Sobre La Actividad Desarrollada Por Cuba En El Estudia Y Conservacion De Las Tortugas Marinas," submitted to the WATS I data base, provided significant new information about loggerhead nesting and foraging in Cuba. The latter document makes it clear that the principal nesting beaches are found on the cays and islands of the southern coast of the Cuban Archipelago, especially at Cayo Largo, Isla de la Juventud, Cabo Corrientes and Jardines de la Reina. This information agrees with that in the Ad Hoc Data Report. Although no quantitative estimates of nesting activity that would permit the delineation of trends are available as yet, clearly, the nesting aggregation on the southern coast of Cuba is an important one. As is the case for virtually every other country involved in WATS, we look forward to further development of a data base for this aggregation.

The United States Aggregation

Before commenting on the size and stability of the aggregation of adult female loggerheads that nest on beaches of southeastern United States, I need to digress briefly to comment on the biological integrity of that aggregation. In one of the few published studies dealing with loggerhead genetics, Smith et al. (1977) showed that when compared to green turtles, loggerheads exhibited less genetic variability. Hendrickson (1980) used this and other information to conclude that there is little evidence of race formation in the western Atlantic. Nevertheless, Stoneburner (1980) and Stoneburner et al. (1980) have found morphological differences and differences in heavy metal content of eggs of loggerheads from South Carolina and Florida that may suggest the formation of demes. Also, several researchers are currently analyzing attributes of the mitochondrial DNA of loggerheads from various localities. Through the methods of modern biochemical genetics, demes, ecotypes or other subunits of the western Atlantic aggregation may eventually be recognized. Whether that happens or not, it seems reasonable to regard the entire group of loggerheads represented by the adult females nesting throughout the southeastern U.S. as a single unit for the purposes of establishing management policy. My reasons for such a conclusion are not very sophisticated, even prosaic. They have to do with the vagility of nesting females. Although most females exhibit considerable site fidelity there are now plenty of records to show that quite a few move long distances up and down the coast between nestings within seasons and between seasons. In 38 records of within-season renesting Bjorndal et al. (1983) observed distance intervals of 26 to 182 km. One loggerhead nested at Cape Island in North Carolina on 9 July, 1979, and then again on 28 July at Cape Canaveral, Florida, a minimum distance of 725 km (Stoneburner and Ehrhart 1981). LeBuff (1974) observed that a loggerhead tagged while nesting on the west coast of Florida in 1968 nested four years later on the Atlantic coast near the center of the peninsula. In light of the vagility demonstrated for loggerheads by records such as these and others too numerous to list, it seems advisable to view the southeastern U.S. loggerhead aggregation as a single functional unit.

The matter of the size of the U.S. population has been under consideration for at least 20 years (Table 2). Earlier studies focused primarily on the state of Florida, where about 90% of all U.S. loggerhead nesting occurs. Nevertheless, important nesting activity occurs in Georgia and the Carolinas and the more recent estimates (the last four on Table 2) take that into account. We have very useful new information, developed since the first Western Atlantic Turtle Symposium, that contributes to our understanding of the size of the U.S. population. As noted above, Murphy and Hopkins (1984) have perfected the methodology of aerial survey that was begun by Carr and Carr (1977) and Shoop et al. (1985). Their careful collection and competent analysis of nesting data gathered during surveillance flights in the summer of 1983 (and their stochastic determination of 4.1 nests per female) have produced an estimate of 14,150 adult females nesting in 1983. As one who has spent each summer since 1976 on the nesting beaches of east Florida, I can attest to the fact that 1983 was an average, or "normal," year. This view is corroborated by data in Conley and Hoffman (1987), as well. As noted, the methodology and analysis that produced the 14,150 estimate was well-conceived and executed, and it conforms well with nesting data available elsewhere (Harris et al. 1984; Hopkins and Richardson 1984; Conley and Hoffman 1987). It is by far the best estimate available, and I would like to go on record as endorsing it, as Mager (1985) did in his loggerhead review. If the 14,150 estimate is approximately correct, it agrees with Ross's (1982) contention that this is the second largest aggregation of loggerheads on earth. His best estimate of the size of the group that nests at Masirah and the nearby Kuria Muria Islands, in Oman, was 30,000 adult females.

The most difficult task that I have is to come to some conclusion about the stability of the U.S. aggregation. It would be easy to say simply that available data, such as those in Table 2, are inadequate as a basis for the detection of a trend, or to agree with Mager (1985), who believed the size of this group was increasing. For a number of somewhat unorthodox reasons I have concluded that the U.S. aggregation is continuing to decline. That statement needs some defending and to do so requires a consideration of fundamental sea turtle zoology, the special consequences it has for sea turtle conservation, and the use of several recent demographic and theoretical treatments of loggerhead population data that, in my opinion, are of salient importance.

One of the most important evolutionary innovations developed by the earliest reptiles was the cleidoic, or shelled egg. It was one of the things that allowed them to colonize the dry land. However, to regard the cleidoic egg as something of a liability for the marine turtles, which returned secondarily to the sea and became thoroughly adapted for life there, is not incorrect. Few terrestrial environments on earth that are more exposed, unstable or dangerous places to deposit eggs than ocean beaches; yet sea turtles, as the only surviving, fully marine reptiles, are obliged, by limitations of limb structure, to deposit their eggs on beaches. Sea turtle life history strategy has adapted to the vicissitudes of meteorology, sea level fluctuation, predator abundance and diversity, and a host of other threatening factors, over geological time. Sea turtles have "weathered the storm" of tremendous loss in the early life history stages by becoming the most fecund of reptiles. For the very small proportion of neonates that survive to juvenile- and subadult-hood, another fundamental aspect of turtle biology comes into play. The shell, which has served to preserve and protect turtles as a group for over 100 million years, together with many other morphological, behavioral and physiological adaptations, has provided, under totally natural conditions, for an exceedingly small loss (mortality) during the long period of growth to maturity. What I refer to as "zoological common sense" tells us that the strategy is resilient to the loss of large numbers of eggs and hatchlings but it is not designed to sustain any substantial loss in the penultimate stages, the juveniles/subadults.

Since WATS I, a series of important papers that provide a solid theoretical foundation for these conclusions has been published. The large body of loggerhead reproductive data gathered over 20 years by Richardson and his associates at Little Cumberland Island, Georgia, has provided for the development of population models (Richardson 1982; Richardson and Richardson 1982; Frazer 1983, 1984, 1987b) and a preliminary life table (Frazer 1983) that are of great usefulness in understanding loggerhead population stability and setting management policy. Richardson and Richardson's (1982) model imputes a turnover of nesting females every six seasons, only a three year mean longevity for nesting adults, and a 39% annual recruitment rate. Their survivorship curve implies that 50% of any given cohort of females is replaced in three years. Significant for my argument also, Frazer (1986) has concluded from these data that the Little Cumberland Island loggerhead population is declining at the rate of 3.0% per year. Also, recently compiled nesting survey data from South Carolina indicate a 5% per year decline in that nesting aggregation (S. Murphy, pers. comm.).

Another very recent and important theoretical product of the Little Cumberland Island work is the development of a Lefkovitch stage-class matrix model of the loggerhead population (Crouse et al. 1987). These authors show clearly that loggerhead population stability is much more sensitive to changes in the "large juvenile" stage (essentially equivalent to subadults) than in earlier stages (eggs and hatchlings). They conclude that "managers need to address the uncomfortable possibility that their current conservation efforts may be focusing on the part of the turtle's life history least likely to produce noticeable, longterm results;" and further that "the key to improving the outlook for these populations lies in reducing mortality in the later stages, particularly the large juveniles."

With all this theory and "zoological common sense" as background, then, one returns to the real world to find that in the southeastern U.S. an estimated 12,600 loggerheads drown each year (Weber 1987) and the great majority of them are subadults (= "large juveniles"). They are drowned in shrimp trawls (Hillestad et al. 1982), pound nets (Lutcavage and Musick 1985) and gill nets (Crouse 1984); crushed and mutilated by dredges (Ehrhart 1987); fatally wounded by boat propellers (ibid); ensnared in discarded nets and line and undoubtedly suffer from ocean pollution in the form of solid wastes and toxic substances.

Considering the estimate of about 14,150 nesting adult females per year, the necessary annual recruitment to that stage implied by the Richardson and Richardson model, the sensitivity of the stage-based population model to loss at the subadult stage, the mortality of about 5,000 subadult females per year, Frazer's estimate of a 3% population decline in Georgia and Murphy's estimate of a 5% loss in South Carolina, I can only conclude that the aggregation of loggerhead turtles represented by adult females that nest in the southeastern U.S. is continuing to decline.

Status of Foraging Populations

Of the 40 countries/regions that participated in WATS I, 29 reported some level of foraging activity by loggerheads. In only 13 of them, judging by information in the national reports, Bacon (1981) and Carr et al. (1982), are foraging loggerheads frequent, common or abundant [these categories are "borrowed" from Bacon (1981)]. Those 13 are listed in Table 3. Having done that, one is reduced mostly to posing questions and problems concerning foraging loggerheads, because little or no quantitative information about size or stability of these populations is available. I have attempted to update the foraging distribution, depicted by light stippling in Figure 1, but this, too, provides more questions than answers. Some of the more important questions are: 1) What are the sizes or densities of foraging populations and how stable are they? 2) What is the stage-class composition of these populations? 3) How contiguous or homogeneous are these populations to which we have arbitrarily given national or regional identities? One of the few ways to answer the latter question is through tagging studies of foraging animals. Only in very few places is this being done, so I have purposely not connected the foraging areas on the map, even though foraging populations must surely be contiguous over large parts of the region.

The only place that I know where the first question is beginning to be addressed is along the east coast of Florida. My students and I have been studying the loggerhead population of the Indian River Lagoon system there for about 10 years. In spite of a respectable rate of recapture of previously tagged animals, however, we are still only able to estimate population size and density for relatively small reaches of the Indian River, but not for the 1,450 km lagoon system as a whole. In the same general area Henwood (1987) has recently described the large aggregation of loggerheads at Port Canaveral, but whether or not that is a "foraging population," as we usually think of that term, is problematic.

Equally puzzling are the results of open-ocean aerial surveys, especially those off the east coast of Florida. Schroeder and Thompson (1987) observed over 2,300 loggerheads over a three year period, with peak sightings during the spring and summer. Most of the loggerheads were seen inside the 40 m isobath and shoreward of the western boundary of the Gulf Stream. Fritts et al. (1983) and Hoffman and Fritts (1982) reported similar results. The marked restriction of the loggerheads to the shallow part of the continental shelf suggests that they were, indeed, foraging there. Whether or not these pelagic aerial surveys are feasible methods for estimating population size and stability in the long run remains to be seen. At this juncture the pelagic survey method constitutes a vantage point from which the loggerhead population on the continental shelf may be viewed, but there is, as yet, no basis for analysis of trends.

Some answers are available to the question about stage composition of foraging populations, but not many. Clearly, in some areas subadults and adults remain completely separate as foraging populations. In the Indian River Lagoon system of east

Florida, a year-round, resident loggerhead population that is composed entirely of subadults occurs. Adults that come to the central Florida coast to breed rarely enter the lagoon system and leave the area after the nesting season. Whether this separation by life history stage is maintained by foraging loggerheads elsewhere in the western Atlantic is unclear. Apparently only about half of the 13 countries/regions that have substantial loggerhead foraging, have populations that include subadults (Table 3). All 13 have adult foragers. The information in Table 3 can be misleading in this regard because, as in the case of the U.S., both adults and subadults do forage in territorial waters but, as noted above, they maintain almost total separation in habitat. The data in Table 3 suggest that the same situation may prevail in other parts of the western Atlantic.

Status of Nesting Beach Management and Production

Virtually all of the information relating to nesting beach management practice and trends in hatchling production is from studies in the southeastern U.S. Descriptions of the procedures are found in Bjorndal and Balazs (1983) and in Hopkins and Richardson (1984). Management techniques that involve moving eggs to artificial hatcheries or protecting nest sites have enjoyed tremendous popularity and governmental support and are employed at many places in Florida, Georgia and the Carolinas. These projects regularly produce hatchlings from 70 to 85% of the incubated eggs (Fletemeyer 1982, 1983, 1984; Hopkins and Murphy 1982) and seem capable of doing so for the foreseeable future. With the advent of a spate of anti-beachfront-lighting ordinances, which promote the transit of emergent hatchlings to the surf the best way to describe this aspect of loggerhead conservation in the U.S. seems to be by the old nautical adage, "Steady as she goes."

I agree wholeheartedly, however, with Pritchard (1980), when he wrote, "lest we get completely carried away by the conviction that our efforts are indeed saving sea turtles, and fail to maintain a constant critical appraisal of our efforts, it is worth reviewing the different things that people try and do to save sea turtles, to judge whether these techniques are indeed as purely beneficial as we might think." In order to assess the success of our beach management techniques we need to compare the results to hatchling production rates in totally natural situations. Such data are not as abundant as one might think, especially if adequate sample size (say, 20+ nests) is considered. Caldwell (1959) reported mean hatching success for 62 nests in South Carolina as 73.4%. Recently, Witherington (1986), in one of the most thorough studies of its kind (N=97 nests), observed a 55.7% natural hatch rate. The latter study was conducted on a heavily nested Florida beach where raccoon predation is unusually low (7-15%), but the results included the loss of almost 25% of the eggs to a late summer storm, which does not happen each year. These few study results suggest that natural hatch rates were generally not far from 50%. In spite of their popularity, labor-intensive hatchery and nest protection programs can only be carried out on a small fraction of the U.S. nesting beaches. While they apparently enhance hatch rates by 20 to 35% in local areas, their overall contribution to population stability may be rather small. That we need to employ such techniques at all is often the direct or indirect consequence of energy-intensive technological alteration of coastal ecosystems. We should not lose sight of the fact that preservation and maintenance of the natural attributes of barrier islands and other sandy shorelines is the ultimate nesting beach management technique.

I am not suggesting that we should abandon management of nesting beaches. Crouse et al. (1987), whose model predicts that, "achieving zero mortality of eggs on nesting beaches would likely be ineffective as a management tool if no concurrent action is taken in the juvenile stage," agree that we should maintain current efforts to protect eggs. The point is, however, that these relatively expensive procedures have not been used very widely on non-U.S. loggerhead nesting beaches in the WATS region. Before we begin to regionalize their use, we should take Pritchard's advice and evaluate their feasibility and effectiveness in the cold, hard light of the scientific method.

Proposals for Recovery Management and Research

The WATS Executive Committee has asked that I list and rank suggestions for promoting recovery, and research needs. I believe that the panel gathered here can handle that task much more thoroughly than I, but I offer the following short lists, which are nothing more than one person's opinion, as "points of departure" for the discussion to follow.

Proposals for recovery management

(1) Go forward with the full program for implementation of the Turtle Excluder Device (TED) that was begun on 1 October 1987 in the U.S.; provide adequate enforcement.

(2) Implement use of the TED in all parts of the region where loggerheads and shrimp trawlers coincide.

(3) Regulate pound nets, gill nets and other fishing devices wherever and to the extent that they are known to kill turtles.

(4) Enact legislation and promulgate regulations to minimize the deposition of solid waste materials, particularly synthetics (plastic containers, wrappings, etc.; monofilament, polyethylene and nylon line), and toxic wastes into the marine environment.

(5) Continue and expand implementation of those nesting beach management practices which prove, with frequent review and reappraisal, to be most effective and feasible.

(6) Carefully regulate and monitor the practice of channel and port dredging to mitigate impacts on sea turtles.

(7) Regulate speed, routes of travel and other aspects of boating/shipping in areas where boat/ship collisions with turtles are concentrated.

(8) Carefully regulate and monitor the process of beach/dune restoration, in accordance with the best available information regarding timing, physical characteristics of materials, etc.

Proposals for research

(1) Investigate patterns and trends in the causes and extent of mortality of subadults and adults, region-wide.

(2) Assess the functional identities, age (stage) structures and relationships among foraging populations of loggerheads, region-wide.

(3) Evaluate currently used (and other) nesting beach management techniques so as to determine which are effective and feasible, and where.

Table 1. Countries/regions with low or moderate levels of loggerhead nesting activity - WATS I Data and Information Summary.

Country/region	No. nesting females (annual)
Bahamas	-
Cayman Islands	5
* Colombia	-
Cuba	-
Dominican Republic	100
Grenada	100
* Guadalupe	-
Guatemala	-
Haiti	-
Honduras	-
Jamaica	210
Mexico (Gulf)	225
Mexico (Caribbean)	160
* Nicaragua	-
Panama	-
* Puerto Rico	-
St. Lucia	2
Turks-Caicos	50
Venezuela	-

* - Added in the "WATS Editors' Summary" on the basis of information in Carr et al (1982).

Table 2. Estimates of the number of adult female loggerheads nesting per year in the southeastern United States

Estimate	Authority
* 9,615 **	Carr and Bass (unpublished)
* 9,615 **	Lund (1974)
8,265 **	Carr and Carr (1977)
6,000-25,000	Ross (1982)
28,448	WATS National Report (1983)
14,150	Murphy and Hopkins (1984)
14,150	Mager (1985)

* - Derived from authors' original using assumptions discussed in text.

** - Estimate restricted to State of Florida

Table 3. Countries/regions where foraging loggerheads are judged to be "frequent" (*), "common" (**), or "abundant" (***); and life history stages present. Sources: WATS I National Reports (<u>In</u>: Bacon et al. 1984, Vol. 3); Bacon (1981); Carr et al. (1982).

Country/region	Foraging activity level	Life history stages Adult	Subadult
Bahamas	*	X	
Belize	**	X	X
Bermuda	*	X	
Colombia	*	X	
Cuba	*	X	
Guatemala	*	X	
Honduras	*	X	X
Martinique	*	X	X
Mexico (Gulf)	*	X	X
Mexico (Caribbean)	**	X	X
Panama	**	X	X
Puerto Rico	*	X	
United States	***	X	X

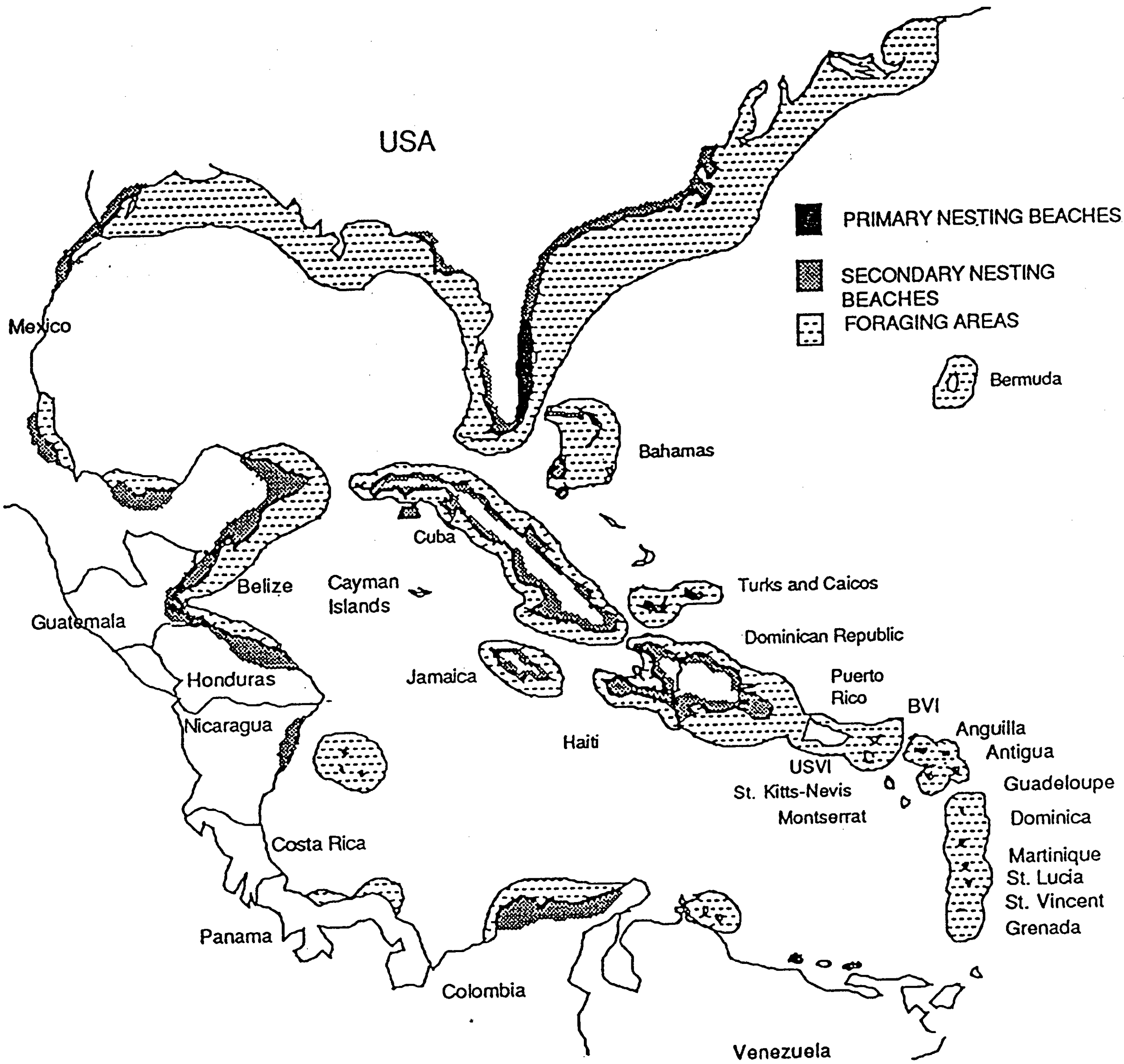


Figure 1. Loggerhead Nesting and Foraging Distributions.

Rapporteur Report of the Loggerhead Turtle Status Panel Session

CHAIR: Sally Murphy, South Carolina Wildlife and Marine Resources Department, USA

RAPPORTEUR: Barbara Schroeder, National Marine Fisheries Service, USA

SPEAKER: Llewelyn Ehrhart, University of Central Florida, USA

PANEL: Rebecca Bell, Little Cumberland Island, Loggerhead Research, USA

Elaine Christens, University of Toronto, Canada

Kenneth Dodd, U.S. Fish and Wildlife Service, USA

Reyna Gil, Cancun, Quintana Roo, Mexico

Vincent Gillet, Department of Fisheries, Belize

Janice Johnson, Greenpeace International, USA

Colin Limpus, Queensland National Parks and Wildlife Service, Australia

Guy Marcovaldi, Instituto Brasileiro Desenvolvimento Forestal, Brazil

Thomas Murphy, South Carolina Wildlife and Marine Resources Department, USA

Larry Ogren, National Marine Fisheries Service, USA

James Richardson, University of Georgia, USA

Perran Ross, Caribbean Conservation Corporation, USA

L. Ehrhart presented the status report on the loggerhead turtle, Caretta caretta, after which there was discussion as follows:

S. MURPHY: The importance of comparisons with other regions was stressed and Ross and Limpus were asked to discuss their regions.

LIMPUS: *C. caretta* in the southern Pacific was discussed. Nesting is restricted to an approximately 200 mile area along the Great Barrier Reef with an estimated 3,000-3,500 breeding females per year. Long term tagging studies have been conducted on several beaches including Mon Repos and Heron Island. Population models developed for southeast U.S. *C. caretta* are generally applicable to the Mon Repos population. Studies on foraging grounds have allowed retagging of adults originally tagged on the nesting beach. Contact with adult females that do not go to the foraging grounds is lost. Population models may not take into account tag loss and therefore may overestimate recruitment; this has serious management implications. Data show that adults have high survivorship and slow turnover in the population. A component of this population has very long internesting intervals. These data are known only because adult females are recaptured on the foraging grounds.

ROSS: Nesting in Oman in the northern Indian Ocean was discussed. Problems arise in applying characteristics of other species to *C. caretta*. Population estimates have a high degree of uncertainty. The high degree of variation in nesting levels from year to year was re-emphasized, and concerns about tag loss were expressed. Titanium tags may solve some tag loss problems. Comments were made on the representation of nesting areas on Ehrhart's distribution map.

LIMPUS: Tag loss was discussed in relation to the following: in 1978 the rate of returning females was 40%, now, after changing methodologies, 75% of nesters are remigrants and this figure is still increasing. Tag loss results in the underestimation of returning females. Tagging studies established for long term data collection must consider durability of tags. Researchers were urged to use the best possible tags.

DODD: The two most highly significant world populations of *C. caretta* are in Masirah Island, Oman and in the southeast United States. Secondarily significant nesting areas, including Australia, South Africa, southern Turkey, and Japan, were discussed.

S. MURPHY: Agreement with Dodd was expressed on the significance of the U.S. population.

OGREN: The available data on early life history stages of C. caretta was discussed. Dr. Carr's research indicated that young turtles may circulate in the North Atlantic gyre 3-5 years before showing up as juveniles greater than 40 cm in carapace length in North American coastal waters.

G. MARCOVALDI: Four nesting beaches of C. caretta in Brazil have been identified. All nesting occurs on the mainland. Little historical data are available on C. caretta in Brazil, although historical population levels are believed to have been much higher than today.

GIL: Nesting at Quintana Roo, Mexico was sporadic except along the central portion of the state, where the most nesting occurs. Figures were presented on nest success, predation rates, hatchery operations, and tagging data.

GILLET: Caution was urged in the use of absolute numbers for turtle populations because of the variability in these populations and in the information sources. Earlier reports of C. caretta in Belize may have overestimated the population.

S. MURPHY: Habitat separation between adults and juveniles described by Ehrhart for the Indian River System, Florida apparently does not occur in South Carolina or Georgia because both size classes are caught in trawl by the shrimping industry.

The chair opened the discussion to the national representatives.

FRETEY: (National Representative of French Guiana) Tagging programs in the Mediterranean Sea and human impacts on sea turtle populations in that area were discussed. Tourism and incidental catch were noted as specific problems. The European community was willing to help solve these problems. Spain and Italy were working together on the fishing problem.

ROSS: Intra-governmental cooperation in Oman has been achieved. This is extremely important to foster.

S. MURPHY: Ross and Limpus were questioned about trawling mortality in their areas and asked if southeast U.S. populations could be gauged against their populations.

LIMPUS: Australia does not have the same mortality pressure from trawlers. He was unsure about how to interpret changes in *C. caretta* nesting levels. The variation may not necessarily reflect real population changes. Research on the foraging grounds is needed to clarify this question.

ROSS: Some trawling mortality occurs in Oman. Migrations are extensive and trawling mortality may occur elsewhere. Research is needed on high density nesting beaches. There are advantages and disadvantages to both. He questioned the panel about number of nests per female per season. In Oman it is estimated at 3.4-3.5 nests/female/season.

T. MURPHY: The stochastic method of determining number of nests per female per year which resulted in the estimation of 4.1 nests/female/season in the southeast U.S. was explained.

Discussion was opened to the other participants.

MROSOVSKY: The differences in the rapid turnover of adult females in Georgia versus longevity described by Limpus were questioned. Can this really be explained by tag loss? Was tag loss factored into the model by J. Richardson?

RICHARDSON: Because of the tag loss problem, multiple tagging of individuals was begun after 1970. Georgia data indicate that approximately two-thirds of the population are Georgia nesters and one-third are nesters coming from other areas and may represent overflow from Florida.

FRAZER: The developed models are based on post-1970 data. Both the Frazer and Crouse work are adjusted for tag loss. Caution should be exercised against applying characteristics of one population to another because of possible differences (e.g., mortality rates). Because loggerheads occur in wealthy countries where more research can be done, the models can be developed for loggerheads and then adapted to the biology of the other species.

DODD: Whenever population estimates are given the methods and limitations must be included.

S. HOPKINS: Comments were made on beach management practices. Predation rates on some of the best nesting beaches are so high that management programs must be utilized. In other areas it may not be as necessary but can help to educate the public and thereby encourage conservation support.

BURNETT-HERKES: The importance of "lost year" habitat was expressed. Inclusion of these areas in the distribution map presented by Ehrhart was urged.

RICHARDSON: The ocean and beach debris problem is a serious threat to turtles. Some of this debris may come all the way from Europe.

EHRHART: Burnett-Herkes was asked if C. caretta "stop over" in Bermuda or if they continue to circulate.

BURNETT-HERKES: Indications that young turtles do become at least semi-resident after "dropping out" of the Sargassum were related.

FINLAY: (National Representative from Grenada) Fishermen catch C. caretta floating at the shelf edge. No nesting occurs on Grenada.

S. MURPHY: What are the sizes of C. caretta caught there?

FINLAY: (Larger subadults and adult-size individuals [Editor])

HALL: (National Representative from Anguilla) Much of the beach debris in the Wider Caribbean region comes from cruise ships. Countries in the region must put pressure on cruise ship companies to stop ocean dumping of their trash.

Leatherback Turtle (*Dermochelys coriacea*)

Status Report of the Leatherback Turtle (Peter C.H. Pritchard)

Until a few years ago, the leatherback turtle was thought to be a great rarity. In reviewing available information on the nesting of this species in the Atlantic, Carr (1952) found only a scattering of old and vague records. For example, Audubon reported leatherback nesting in the Florida Keys in late summer in the 1830s (Proby 1974) . Garman (1883), on the other hand, reported leatherback nesting in Florida from December through January. Today, both of these reports seem flawed: the Florida Keys (and also the Dry Tortugas and the Bahamas, both mentioned as possible nesting areas in some of the old literature) are certainly not nesting areas today, and indeed they appear to be geomorphologically unsuitable for such. Similarly, the months of December and January in Florida are probably too cold for any sea turtles to nest at that time.

Carr also observed that "several old writers mentioned the coast of Brazil" as a leatherback nesting area. We now know that there is indeed some leatherback nesting there, especially in the State of Espirito Santo, although this is nowadays only a minor nesting ground. Wied (1820) reported that leatherbacks, as well as green turtles and loggerheads, nested on the Brazilian coast between the mouths of the Riacho and Mucuri Rivers, and this may be one of the reports to which Carr referred.

Carr was also informed by several local fishermen, presumably in the 1940s, that leatherback nesting occurred from May to August in Honduras and Nicaragua. However, present-day nesting occurs farther south than this, in Costa Rica and Panama, and hardly at all north of Rio San Juan on the southern border of Nicaragua; moreover, the season is earlier than "May to August," and some confusion of species in these reports appears to have been likely.

In the light of all this misinformation, it is reassuring to note at least one old account that corresponds to modern information. Reinhardt and Lutken (1862) reported that leatherbacks nest in the Danish West Indies (now the U.S. Virgin Islands) from March to June, with the islands of Tortola (today in the British Virgin Islands) and St. Croix given special mention.

Carr mentioned a single recent nesting record for the Florida coast, from Flagler Beach, Flagler County, on June 6, 1947. Today nesting on the mid-Atlantic coast of Florida occurs every summer, but is not really frequent; Lund (1978) reported that 10-12 females nested annually in Florida, mainly in Palm Beach and Martin Counties; and Harris et al. (1984) reported 18 nestings in Florida in 1979, 9 in 1980, 39 in 1981, 45 in 1982 and 31 in 1983. Possibly the northernmost record in the western Atlantic, an individual that nested in Flagler County, Florida, about 10 km north of the 1947 record, on May 29, 1983, was reported by Nichols and du Toit (unpub. ms). The specimen reported on a beach near Panama City, Florida, in the summer of 1968 (Pritchard 1971) did not nest; but Yerger (1965) reported hatchlings on the beach in Walton County Florida, and this appears to be the northernmost nesting record for the Gulf of Mexico.

The first report of a major nesting area for Dermochelys in the western Atlantic was that of Carr and Ogren (1959), who identified an area of coast around Matina, Costa Rica, on which the species nested in considerable numbers. Since then, a number of major and minor nesting areas in the western Atlantic and Caribbean have been identified, and our current concept of the nesting distribution of the species in the WATS region is as follows:

> Nesting is scarce on the North American mainland, with only the above-mentioned records for Florida. Nesting is rare to non-existent on the Gulf and Caribbean coasts of Mexico and Belize, but occurs on the short Caribbean coast of Guatemala (J. Richardson, pers. comm.). Elsewhere in Caribbean Central America, there is a zone of concentrated nesting activity extending from north-central Costa Rica (vicinity of Parismina) through Panama to the Golfo de Urabá, Colombia. In Panama, concentrated nesting occurs both in the western sector, in Bocas del Toro (principally on Playa Chiriquí), and also in eastern Panama, at Playa Pito and Bahía Aglatomate (McAlpine 1980; Meylan et al. 1985). Further east in Colombia, nesting has been reported on the Santa Marta Peninsula, in relatively small numbers.

Almost no nesting occurs on the coast of Venezuela (Pritchard and Trebbau 1984), but in Trinidad important nesting is found on both the northern and eastern coasts (Pritchard 1984b). In northwestern Guyana a moderate amount of nesting occurs, mainly at Almond Beach (Pritchard 1987), although in past decades nesting occurred farther to the southeast, mainly on Shell Beach. Nesting is unknown in eastern Guyana or western Surinam, but in eastern Surinam and western French Guiana are found perhaps the highest concentrations of nesting leatherbacks in the hemisphere (Schulz 1975; Fretey and Lescure 1979). Farther to the east and south, in Brazil, nesting is very sparse, and the only beach identified by R. Heimark (in letters to S. Beebe, May 1984) as still showing leatherback nesting activity was a 12 mile beach in Espirito Santo, unfortunately adjacent to a Funai Indian relocation camp.

Nesting occurs on a number of the Antilles. An estimated 300 females nest annually in the Dominican Republic (Ross and Ottenwalder 1983), and nesting is significant on certain Caribbean Islands under U.S. jurisdiction, including Puerto Rico and its associated islands of Culebra and Vieques, and in the U.S. Virgin Islands, principally St. Croix, where they have been exhaustively studied by K. and S. Eckert and Earthwatch volunteers for a number of years. A few nestings occur annually on most of the Lesser Antilles, including St. Kitts, Nevis, Dominica, and St. Lucia, but the aggregate number there is very small compared to mainland populations (Carr et al. 1982; Meylan 1983; Caldwell and Rathjen 1969).

The leatherback turtle is considered endangered by the U.S. Dept. of the Interior and by the International Union for the Conservation of Nature (IUCN), and is listed as Appendix I (i.e., prohibited from international commerce between signatory nations) by the Convention on International Trade in Endangered Species of Flora and Fauna (CITES). These designations may be accurate, but they were for the most part established before many of the now-known nesting beaches were discovered, and discussion of the actual status of the species is appropriate today. For more detailed discussion, see Mrosovsky (1983a) and Pritchard (1982).

The assessment of the status of a species should include discussion of at least four criteria: (1) total geographic distribution, past and present; (2) absolute numbers of individuals in existence; (3) demonstrable population trends, either globally or in specific areas; and (4) identifiable stresses upon populations that may lead to future decline.

Total Geographic Distribution, Past and Present

By this criterion, the leatherback is in no trouble at all. It is probably the most wide-ranging of all vertebrate species, occupying tropical to subartic habitats, both near-shore and pelagic, in the Atlantic, Indian and Pacific Oceans, and in associated seas such as the Mediterranean and the Gulf of Mexico. There is no evidence that the overall range has diminished in any way.

Absolute Numbers of Individuals in Existence

For the leatherback, estimating the world, or even a local population, in its entirety, i.e., including all life stages, is not feasible for several reasons. The number of adults in the population would almost certainly be swamped by the numbers of hatchlings generated during the hatching season each year (the summer months on Atlantic beaches). A very large percentage of these hatchlings (probably over 98%) would be expected to live for only a few hours to a few weeks before succumbing to predators, and their absolute number is thus rather unimportant.

Moreover, the juvenile stages of the leatherback, from post-hatchling to a carapace length of over 100 cm, lead an entirely cryptic existence, and virtually never come before human eyes, to be recorded or counted. The adult males, too, are almost as difficult to count; they may be seen on pelagic surveys or as strandings, but formulae are unavailable to convert numbers seen to numbers in existence.

Thus, the only feasible population estimates will refer to the numbers of nesting females, which may be counted, or at least their numbers estimated, by means of beach patrols or (less accurately) aerial surveys. Different formulae may be utilized to estimate the number of females in a local population from the number seen nesting on an average night. An average inter-nesting interval for individual reproductive females has been established at around ten days for leatherbacks in widely separated populations, but uncertainty enters when one attempts to establish the average number of nestings per female per season. The maximum number is around ten (A. Tucker, pers. comm., Culebra Island; or from Pritchard's work in Surinam in the 1960s), but the average number is surely considerably less, and some females may nest only once or twice in a season. Pritchard (1982) utilized a formula that assumed that the total number of breeding females in a population was about fifty times the number nesting on a typical, mid-season night. This formula incorporated the assumption that individual turtles had a nesting season that was, on average, half the length of that of the population as a whole; and that remigration occurred after an interval averaging 2.5 years. Mrosovsky (1983a) utilized a different formula, still unpublished, but which was based on studies in Surinam in which a complete record was available for at least one season of the number of nests made each night. Since the turtles were always tagged, a relationship between the total nesting population for the season and the average number nesting per night could be established. Tag loss or shift of turtles to other beaches in the course of a season were complicating factors, but Pritchard's and Mrosovsky's formulae still gave rather similar results.

Fitter (1961) estimated that the world population of adult female leatherbacks may be "as few as 1,000," of which 85 percent nested in Trengganu, Malaysia--the only large leatherback rookery known at the time. However, Pritchard (1971) made a much higher estimate of 29,000 to 40,000 breeding females, made up as follows: 15,000 for French Guiana; 8,000 for Pacific Mexico; 4,000 for Trengganu; 1,000 for Matina, Costa Rica; and 200-400 each for Trinidad, Surinam, Tongaland (South Africa) and Sri Lanka (and adjacent parts of south India). The higher-range estimate simply assumed that further nesting grounds would be discovered elsewhere. This estimate, it may be noted, gives a population estimate of 16,400-16,800 for the western Atlantic region.

Pritchard (1982) raised this estimate greatly, to 115,000. The principal new components of this estimate were an estimated 75,000 nesting females in Pacific Mexico, and additional 12,000 estimated for Central America, 4,000 for the Vogelkop Peninsula of Irian Jaya and 3,000 for other parts of Melanesia.

Pritchard (in prep.) gives the following population estimates for the western Atlantic nesting colonies:

Costa Rica through Panama To Colombia: 4,000
Trinidad: 750
Guyana: 500
Surinam/French Guiana: 15,000
Dominican Republic: 300
Other West Indies: 200

Demonstrable Population Trends

The steadily rising population estimates given by Fitter (1961), and Pritchard (1971, 1982, in prep.) may suggest that the leatherback population is increasing rapidly, and it is noteworthy that, while Carr (1952) commented that "the only herpetologist who has had the enviable experience of observing the entire nesting and laying procedure of Dermochelys is Paul Deraniyagala of Ceylon," today we know of dozens of locations in the Western Hemisphere alone where one may predictably see nesting leatherbacks, often dozens and in some cases, even a hundred or two, in a single night.

Nevertheless, separation of the possibility of greatly increasing leatherback populations from the certainty of far more thorough field investigations and more comprehensive knowledge of the breeding range of the species in recent years is not easy. Both factors may well have been at work. In some cases, data are available to demonstrate a spectacularly upward trend; Schulz (1982) documented the following numbers of leatherback nests (not numbers of turtles, but presumably directly related to the numbers of turtles) in Surinam for the years noted:

Year	Number of nests
1964	95
1967	90
1968	200
1969	305
1970	255
1971	285
1972	380
1973	900
1974	785
1975	1,625
1976	670

1977	5,565
1978	2,160
1979	3,900

No statistical test is needed to confirm this upward trend; but it seems probable that a large part of the increase derived from a shift of animals from the very large rookeries immediately to the east, in French Guiana, rather than from an absolute increase. Nevertheless, a real increase appears in some other areas. For example, in Trinidad, the leatherback is nesting in far greater numbers in the 1980s than it did in the 1960s (N. Gyan, pers. comm., and pers. obs.), field patrols now often encounter twenty or more nesting females per night on beaches where only 3-4 may have nested per night in the 1960s. Moreover, the reportedly very small size of many of the turtles today suggests a wave of new nesters resulting from an episode of enhanced recruitment.

Much the same phenomenon is occurring in Guyana. The leatherback was a rare species there in the 1960s; according to personal observations and the reports of the older turtle hunters. Today it is possibly the commonest of the four nesting species in the country, despite heavy persecution on the nesting beach, and 3-4 individuals nesting on Almond Beach, near Waini Point, in a single night is not unusual.

The numbers of strandings of weakened or dead turtles in areas outside the nesting range may also constitute an index to the status of the overall population, although the sum total of factors that control the numbers of stranded animals are undoubtedly complex and variable. Prescott (1988) recorded the following numbers of leatherback strandings around Cape Cod, Massachusetts, USA, for the years in question:

Year	Number of strandings
1976	0
1977	1
1978	1
1979	1
1980	2
1981	5
1982	0
1983	6
1984	10
1985	6
1986	10
1987	14

Again, the upward trend needs no statistical verification.

Nevertheless, there may well have been declines in nesting populations in some of the areas that are now considered minor nesting areas only. For example, in the British Virgin Islands, many coastal features (e.g.,"Trunk Bay" on Virgin Gorda) are named after the leatherback turtle, yet few BVI beaches support leatherback nesting today. Eckert (1988) concluded that an active subsistence fishery for the species in the Virgin Islands had contributed to a substantial decline from historical population levels. Similarly, during the 1987 season, Alfaro et al. (1987) found only one nest on the Buritaca Beach in the Santa Marta Peninsula of Colombia, a zone of intensive exploitation of turtles that is known to have constituted a leatherback nesting beach in former years (Kaufmann 1971b). Furthermore, the nesting beach in Espirito Santo, Brazil, has been under heavy pressure from relocated Kunai Indians in the area, who lack alternative means of sustenance, and this population, too, seems to be significantly reduced (R. Heimark, in letters to S. Beebe, May 1984).

Elsewhere in the world, the populations of southeast Asia have been especially hard hit, almost entirely through excessive collection of eggs, and the vital nesting colony in Trengganu, Malaysia, is seriously depleted and in need of a completely revised management regimen.

Identifiable Stresses upon Leatherback Populations in the Western Atlantic

In the United States, the leatherback is protected by law and nesting animals are reasonably safe; but strandings of dead animals occur quite frequently, especially in areas north of Florida. These may result from entanglement in lobster lines, ingestion of plastics and other anthropogenic causes, and undoubtedly cause some degree of stress to the population as a whole.

In the area from Costa Rica to Colombia, the collection of eggs by local people for food or sale is so intensive that few nests survive, although some conservation efforts have now been initiated in Costa Rica, specifically at Doce Millas beach near Limón (M. Koberg, pers. comm.). In Colombia, Trinidad, and Guyana, a substantial percentage of the nesting animals are killed on the beaches, and the eggs of such turtles are taken also, either from the beach or from the carcasses of the slaughtered turtles. On the other hand, the turtles seem to be well protected in both Surinam and French Guiana, although even here there are some problems, notably civil unrest in Surinam, and heavy tourist use of the Les Hattes nesting beaches, and incidental catch in the nets of local Carib fishermen, in French Guiana.

In the Antilles, direct human take of the turtles may be quite intensive. Meylan et al. (1985) noted that leatherbacks are eaten on almost every island from Anguilla south to Grenada, and this is the preferred meat of many residents of Martinique and Guadeloupe. In Roseau, Dominica, the meat of a single leatherback fetched $532 U.S. in January 1983 -- and sold rapidly. On Nevis, leatherback meat is not only eaten by locals, but is mixed with that of other species and served in hotels. And on St. Lucia, A. Meylan found six leatherback tracks on Grande Anse in May 1982; the remains of slaughtered turtles were present beside four of these six tracks.

In conclusion, the outlook for the leatherback appears to be bleak throughout the Antillean Islands, unless it turns out that the nesting colonies in these islands are able to draw new recruits from the (so far) safe and large mainland nesting colonies in Surinam and French Guiana. The Central American population may decline more slowly, but such a decline may be very difficult to reverse, since it will derive from excessive exploitation of the eggs, with the result of diminished or absent recruitment to the pre-adult age classes. In Trinidad and, especially, Guyana, how nesting populations of leatherbacks have survived there at all, let alone shown the significant increase that has occurred in the last two decades, is hard to understand. We have much yet to learn about the population dynamics of sea turtles.

Rapporteur Report of the Leatherback Turtle Status Panel Session

CHAIR: Nicholas Mrosovsky, University of Toronto, Canada

SPEAKER: Peter Pritchard, Florida Audubon Society, USA

RAPPORTEUR: Herman Kumpf, National Marine Fisheries Service, USA

PANEL: Karen Eckert, University of Georgia, USA

Scott Eckert, University of Georgia, USA

James Finlay, Ministry of Education and Fisheries, Grenada

Jacques Fretey, Museum National d'Histoire Naturelle, France

Kathleen Hall, University of Puerto Rico, USA

Jean Lescure, Museum National d'Histoire Naturelle, France

Krishnepersad Mohadin, STINASU, Surinam

David Nellis, Division of Fish and Wildlife, St. Thomas, U.S. Virgin Islands

Jose Rueda, INDERENA, Colombia

Anton Tucker, University of Georgia, USA

The chair called the panel members to the panel platform and introduced the primary speaker, P. Pritchard, who in turn gave the status address which included a brief review of basic biology and population status of the leatherback, *Dermochelys coriacea*.

The status address presented a background of biological information covering taxonomy, identification, reproduction, distribution, life history features, population estimates and general ecology.

LESCURE: Several experiments conducted by the research team on marine turtles from the Paris Museum were described. One experiment on the effect of incubation temperature on the sex of the hatchling showed the following:

a. All eggs incubated at 29.7°C and above were 100% females.
b. All eggs incubated at 29.5°C and below were 100% males.
c. Eggs incubated at 29.5°C $\pm$ 0.25°C resulted in both sexes.
d. The critical threshold temperature for leatherback turtle eggs was concluded to be 29.5°C. A detailed account of the embryonic development and summary table will be published next year.

Results of a captive rearing experiment were also reported:

a. An egg laid in French Guiana was incubated at the Paris Museum and hatched in September 1984.
b. The female hatchling is being reared at the Liege University Aquarium. The hatchling now is 50 cm long. Swimming activity decreased at 7 weeks, and growth increased. Research on locomotion and skeletal development is planned.

RUEDA: Research on the leatherback nesting colony in Colombia has been conducted. What is the impact of massive egg collection on the population level? The 1987 nesting season in Columbia lasted from March-April up to mid-May. All the nests in one beach section were destroyed by high tide levels. The leatherbacks were nesting all over the beach (low to high). Does this happen elsewhere?

S. ECKERT: A 50-60% loss of nests due to erosion on St. Croix, U.S. Virgin Islands was reported. These turtles average 5-6 nests per season, up to 11 nests, and typically leatherbacks in many areas of the world nest randomly all over the beach. Such behavior patterns may maximize hatchling success in compensation for irregular erosion.

MROSOVSKY: A slide would be shown tomorrow on the comparison of the number of misplaced nests from different areas of the world. How long does it take to reach maturity in the captive rearing experiment?

LESCURE: The captured leatherback is immature now. The turtle is now eating anything it is fed. In the first 3 years the weight increase was 12.5 gms per week. Growth curves will be published.

__FRETEY__: A research project in French Guiana and Panama to investigate the nesting behavior of leatherbacks is desired. Nesting at the waters edge and up to the vegetation line has been observed by him. Even under constant inundation, the female ignored the interruption and continued nesting.

__FINLAY__: Fishermen from Grenada say that the leatherback will cover its dig and flatten the sand over the nest even when they (fishermen) jump on the nester's carapace. He asked why they do not lay their eggs further up the beach?

__HALL__: (In response to a statement by P. Pritchard). Coloration of the hatchlings (speckled and spotted carapace) could be useful in the deeper water environment where bioluminescent plankton occur. Leatherback hatchlings may not have the buoyancy problem of other species and, as they are strong swimmers, allowing deeper diving, may not have a developmental habitat but go directly to the adult habitat.

__CHARLES__: Based on turtle watches in St. Lucia, leatherback nesting takes place over a 10 day cycle during May-June, with peak activity at 2100-0300 hours.

__K. ECKERT__: The leatherback is one of the most unique and misunderstood of all the reptiles. It is a deep, open ocean form with no shell, weighing from 700-1,200 pounds and is 6-8 feet long and is found in the waters of the West Indies from February to July with nesting peaks in May. Relocation of nests to a stable section of the beach, as described in the WATS manual, and demonstrated in Puerto Rico, is the best way to conserve the species.

__MOHADIN__: Leatherbacks are seen on the beach in Surinam in the early morning hours when the sun is rising.

__TUCKER__: Based on leatherback information collected off Culebra, Puerto Rico, the reproductive output (number of eggs) may be underestimated if the mean clutch frequency of 5-7 nests per female is used.

__PRITCHARD__: Although he and Mrosovsky used somewhat different systems, their overall population estimates were not terribly divergent. The formula for making beach female data into population estimates was explained:

A = Average number of females counted on a good mid season night.
B = 10 (mean number of nights of nesting)
C = 2 (overall nesting season lasts longer than that for 1 turtle)
D = 2.5 (mean number of years between returning to nest)
P = Population of nesting turtles
A x B x C x D = P

<u>MROSOVSKY</u>: Based on Surinam research, he multiplied the number of nesting females by the number of nesting nights times a correction factor to obtain the population estimate for nesting females.

<u>PRITCHARD</u>: A break in nesting activities during the cycle may occur and that this interruption could be a complicating factor in estimating population numbers.

<u>MROSOVSKY</u>: The fast, rapid maturation of leatherbacks presents an interesting living model to investigate such things as imprinting, headstarting and a range of alternative management measures.

<u>BOULON</u>: Have stranded turtles been necropsied to see when sexual maturity is attained to determine if reproductive maturity is reached at the same time adult size is first reached?

No answer from panel.

<u>PARSONS</u>: Such rapid growth in the leatherback would make tagging difficult. The usefulness of plugs or "living tags" was questioned.

<u>S. ECKERT</u>: Leatherback tagging is indeed very difficult because of such rapid growth, so that "living tags" would not be feasible. Binary coded wire tags have potential. A preliminary evaluation showed that these were suitable for this species.

<u>K. ECKERT</u>: Rapid growth factors in this species need to be investigated in greater depth and duration. Evaluation of growth studies cited in light of their originating in captive rearing projects is important. Maturity occurs earlier in captive animals and food and feeding are unlike wild, natural conditions. The two referenced captive growth studies where leatherbacks in the two year

studies had weighed 20 Kg and 300 Kg (minimum size at maturity) were cited.

MROSOVSKY: Agreement with the points made by the preceding speaker was expressed.

GYAN: Do marine turtles, in times of stress, nest more times during a nesting season? Observations made in Trinidad showed that only 20-35 hatchlings emerged per nest, but no shells were found. Had predation possibly taken place? Did other Caribbean countries have similar experiences?

PRITCHARD: The nest location was very deep for leatherbacks, the emergence channel was oblique and the nest site covered a broad area. With any hatching, egg shells had to be present.

K. ECKERT: Leatherback eggs are at least 3 feet down and never shallower. Leatherback researchers should have arms at least 72 cm long in order to collect these eggs.

OWENS: Why does a leatherback grow so rapidly, unlike most sea turtle species, and then upon reaching maturity revert to the normal turtle reproductive pattern of multi-annual nesting?

PRITCHARD: Any sea turtle that grows rapidly as well as puts out as many nests as possible would have an advantage. Because of anatomical structures, this species has the potential to reach maturity in 3 or 30 years and because of its size would tie-in ecologically with typical adult temperate/subpolar water species.

MROSOVSKY: Do sea turtles increase their egg production in times of population stress?

PRITCHARD: In his opinion, frequency and numbers of egg production are related to nutrition of the female. In a stressed population, turtles may be fewer and therefore the remaining animals would be less food limited. In Guiana there is a very stressed leatherback population and their behavior is changing in that 50% of the nesting now takes place during the daylight hours. This behavior pattern only started about 10 years ago.

HORROCKS: An immature leatherback, 10-15 cm long, was collected off the east coast of Barbados.

MATOS: He observed that here in Puerto Rico, leatherback nesting had occurred at 2 p.m. after a great rainfall. How common is daytime nesting? Do leatherbacks eat other sea turtles?

PRITCHARD: Records of leatherbacks as carnivores of vertebrates are very scarce . But an old record from Mexico listed an olive ridley found in a leatherback stomach. He also stated that daytime nesting is very rare in Puerto Rico, and the situation in Guiana is unusual. Furthermore, rain falling in the nest should be no problem. He conjectured that some turtles may act in the rain as they would at night because of the cooling effect of the rain.

FRETEY: Daytime nesting in French Guiana is very common and turtles come up on the beach as a function of high tides. Females may go back into the water without laying. If young hatch during the daytime, they die, because their skin cracks, or they are attacked by insects and never make it to the sea.

PRITCHARD: He worked on the same beach as Fretey years ago and found diurnal nesting very rare. Perhaps there is a regional change in nesting activity.

MROVOSKY: Some of the major research projects that need to be done are: systematic study of nesting behavior, more detailed population surveys and estimates, maturation rates, and physiological adaptation studies.

DUTTON: Leatherbacks are perceived to have a lower hatchling success with greater embryonic mortality. Are eggs of this species different?

PRITCHARD: Translocating eggs seems to depress egg fertility. He doesn't believe that an undisturbed nest will have lower hatchling success.

The chair closed the panel session.

Kemp's Ridley Turtle (Lepidochelys kempi)

Status Report of the Kemp's Ridley Turtle (Rene Marquez M.)

Introduction

Lepidochelys kempi is known in Spanish as tortuga lora, in English as Kemp's ridley and in French as Tortue de Kemp's. Morphologically, the adult can be identified by its smaller size: 50-72 cm carapace length and 30 to 50 kg total weight; its carapace is flattened and semicircular in shape; the head is small and its beak strong, similar in a way to that of parrots.

Of all sea turtle species, together with the Australian flatback (Natator depressa), the Kemp's ridley has a more restricted geographic distribution. Kemp's ridley is distributed throughout temperate and subtropical regions of the Gulf of Mexico and North Atlantic. Both are monotypic species, with little morphological variation, due to the isolation of their populations.

The evolution of the population of the Kemp's ridley has been described in detail by many authors (Carr 1963; Hildebrand 1963; Pritchard and Marquez 1973; Marquez 1976a; Marquez et al. 1982). All agree it is the most endangered of the sea turtle species (Bjorndal 1982): from a population of 40,000 female capable of nesting in one "arribada," as seen in 1947 (Carr 1963; Hildebrand 1963), the "arribadas" have diminished to about one percent (between 250-350 congregated turtles nesting in one day, in the most numerous "arribadas" that have taken place in the last three years). This rapid population decrease has been attributed primarily to over-exploitation on the nesting beaches. Nevertheless, as we shall see, this has not been the only cause, but probably until 1965 the most significant. Even though egg extraction from the nest was banned twenty-two years ago, the population has not recovered, which implies that other elements have intervened or are intervening in the non-stability of the population.

This sea turtle only reproduces in the Gulf of Mexico. More than 95% of the adult females nest in only 25 km of beach (Rancho Nuevo, State of Tamaulipas, Mexico). Efficient control exists throughout the nesting season through a national program, and because recently with the participation of specialists from Mexico and other countries, beach surveilance has increased and annual observations and studies on nestings and hatching success have been made. In the last ten years the population has stayed at low levels, even though the presence of juveniles throughout its geographic distribution allows us to believe in a possible future recovery. Since 1966, egg exploitation on the beaches has been controlled and hatchling releases have been constant throughout all these years. Through the U.S. program of headstart (impulso) and imprinting (nemotecnica) more than 10,000 small juveniles have been released. Finally, efforts to decrease the impact by incidental catch also have been carried out. Nevertheless, we still lack control of waste products from oil operations and increasing disposal of garbage, especially plastics which may be contributing factors to reduced populations.

Distribution

The reproduction of the Kemp's ridley takes place in a long, straight sandy beach (Fig. 1) that has a low profile (1-4 m in height) with two berms. The width of the beach that can be used for nesting varies from 20 to 40 m. The area near the water is more prone to inundation and farther away from the water, predation increases. Parts of the beach are filled with driftwood and garbage. In other parts, the tides accumulate great quantities of disk-shaped pebbles, coraline in origin, hampering the nesting, on occasions, throughout long stretches of beach. This zone constitutes a sandy strip limited to the east by the sea and to the west by other wetlands. Here sand dunes are covered mainly by creeping plants, thorny bushes and spots of mangrove. The beach becomes virtually isolated during the rainy season, when reproduction of the turtles takes place (April to September)(Chavez et al. 1967; Marquez 1976a, 1976b and in prep.). This isolation partially reduces predation mainly from coyotes and other mammals, which are abundant in the area.

The nesting beach is located on the west shore of the Gulf of Mexico, State of Tamaulipas, between Barra de Ostionales and Barra del Tordo, (23° 24'45" to 23° 03'10" N and 97° 45'40" to 97° 45'30" W). On this beach more than 90% of all nesting occurs although on some occasions the turtles come onshore outside this area, either to the north or to the south, (Marquez, WATS II National Report). From the time the hatchlings reach the sea until they reach 20 cm mean carapace length, their location is nearly unknown. The juveniles begin to be observed mainly in the littoral, on the northeast coast of the United States, probably dispersed to that area by the Gulf Stream (Pritchard 1969a; Marquez, in prep.). Some have reached European waters, mainly between October and February (Brongersma 1972, 1973) and even to Morocco (Fontaine et al. 1985). When approaching maturity, the subadults and older juveniles are believed to return to the Gulf of Mexico. Historically, this size class was abundant to the west of the Florida peninsula and was a part of the green turtle fishery up to the 1950s (Carr and Caldwell 1956; Carr 1963).

Apparently, the adults do not abandon the Gulf of Mexico and after the nesting season they distribute to the north and south, mainly to the mouth of the Mississippi River and the Banco de

Campeche. In either case, it seems they look for shallower waters, where crustaceans are abundant, especially crabs.

Populations

In the 1950s, the Kemp's ridley was one of the most abundant sea turtles in the Gulf of Mexico as indicated in a 1947 film where more than 40,000 females were estimated by Carr (1963) and Hildebrand (1963) to have come ashore at Rancho Nuevo, in one "arribada." In 1966, the first camp was installed at the nesting beach (Montoya 1969); in that year and the two following years more than 1,000 turtles came ashore during the "arribada." In 1968 Montoya and Vargas (pers. com.) estimated an "arribada" of more than 2,500 females; (Pritchard and Marquez 1973, and pers. obs. by Marquez 1967-1987). Since then, the total number of nesting females has decreased at a constant rate of 3.9% annually (Marquez, in prep.), and during the last five years no "arribada" has had more than 200 females.

The total population (P) is calculated according to the number of nests (N) produced each year at Rancho Nuevo, and multiplied by the nesting cycle (C = 1,724) and considering a 1 to 1 male-female relationship (R), divided by the total fecundity of each female (F = 1,326) (Marquez et al. 1982). The results for 1987 are:

$$P = (N\ C\ R)/F$$
$$P = (854 \times 1{,}724 \times 2)/1{,}326 = 2{,}200 \text{ adults.}$$

According to calculations for the previous ten years, the highest population that nested at Rancho Nuevo was 2,634 turtles in 1979, and the lowest 1,929 in 1985. These figures are estimated to represent 80% of the total nesting population; the rest disperses throughout the coast from South Padre Island, Texas, to Isla Aguada in Campeche, Mexico (Marquez and Fritts 1987). Small nesting concentrations occur at three other sites: Playa Washington, Tamaulipas, a few kilometers from the border with the United States; around Cabo Rojo and between Tecolutla and Boca Lima both in Veracruz. At this last beach, nests are being relocated (10 to 15 nests) by the Fisheries Inspector, Mr. Fernando Manzano (WATS II National Report). Apparently, limited nesting for *L. kempi* occurs at South Padre Island, Texas, and east of Isla Aguada, Campeche, where in some years two or three nests have been recorded.

The abundance of adults, as stated in the previous paragraph, can be evaluated by counting the nests at the main nesting beach. Eggs and hatchlings can also be directly evaluated to measure reproduction that occurs each year. However, other development stages, for example juveniles and pre-adults, can also be assessed by using theoretical models, in which you have to introduce assumptions, based partially on valid observations. One of the most significant parameter is the average age to reach maturity, which we assume is around eight to ten years (Marquez, in prep.). The total mortality from egg to adult can be deduced using the incubation mortality and the total adult mortality assessed by tagging, recapture and consecutively (tagged females) observed at the nesting beaches. This method has its shortcomings but it is the only one available to date. In this way the life cycle and theoretical population changes are truly represented and may be graphed. (Marquez et al. 1982; Marquez, in prep.).

Re-stocking Program

How and when the Kemp's Ridley Program was started has been described previously (Montoya 1966; Chavez et al 1967; Pritchard and Marquez 1973; Marquez 1983, 1984 in prep; Marquez et al. 1985a, b). The main purpose of the program is to restore the species to its maximum possible population levels. For the time being the imminent threat of extinction that hangs over the species has been avoided. To consolidate these results more research and conservation work are needed.

The program has run for 22 consecutive years. During the last ten years, the results have doubled partially as the result of a cooperative program between the Instituto de Pesca, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. The main objective of this effort was to improve the status of the species throughout its geographic distribution, and especially within the Gulf of Mexico, by trying to establish nesting areas on Padre Island, Texas. For the last ten years, this has been conducted under the MEXUS-Golfo Program, and the results of this period are shown in Table 1. These results have doubled those of the 1966-1977 period. During the first period 3,803 nests were protected resulting in 273,614 hatchlings; during the second period from 1978 to 1986, 7,245 nests were protected resulting in 474,723 hatchlings. From the sum total of hatchlings (748,377) more than 97% have been released directly on Rancho Nuevo and up to 1986, 6,327 hatchlings have been used in the Padre Island Project.

The mean number of eggs (Y) per nest has slightly fallen with time (X), and this tendency can be deduced by the following linear regression:

$$Y = 109,554 - 0.433X$$
$$r = - 0.704$$

Older and larger organisms generally lay more eggs than younger ones. This is in agreement with the results from the equation above. In 1966, when the research and conservation was begun we found a Kemp's ridley population made up mostly of aged individuals. On the other hand, one can consider that before 1966, recruitment was near zero as a result of commercial catch, predation and contraband, these being the main causes for the aging of the population and consequently the tendency to produce more eggs per individual. Between 1975 and 1978, a fall in the number of eggs per nest has been observed, even though not very clearly. This could be indicative of recruitment to the population of neophytes, between 10 and 12 years of age, coming from the first years of the program (1966-1968). This situation is more obvious if we use the averages between 1966 to 1977 and from 1977 to 1986: the average was high at 108.3 eggs per nest for the first period versus 102.8 for the second period. Another observation that may be related with the lower fecundity of neophytes can be drawn from the results of individuals tagged in previous years: those without tags would probably be new turtles, since the older ones in 1986 nested 9 to 11.4% more times than those considered as new. This information is being presently analyzed, and these considerations should be taken as preliminary.

Fisheries and Regulations

The commercial exploitation of the species stopped in the first half of the 1960s and the taking of eggs was stopped by establishing the first camp in 1966. A series of laws and regulations has been in effect since 1922 (Marquez, WATS II National Report; Marquez, in prep) that prohibited the taking of eggs. However, the capture of Kemp's ridley was not prohibited until 1971. At that time a regulation was passed that stopped all fishing during 1972. This regulation included all sea turtle species. In July 13, 1973, a complete ban was declared for the Kemp's ridley, the hawksbill and the leatherback (Marquez et al. 1985a) inside Mexican territorial waters. Presently, the capture of the Kemp's ridley throughout its geographic distribution is prohibited. However, Mexican incidental catch of tagged turtles does occur and has been reported, providing information of the capture techniques and the localities within the Gulf of Mexico (Marquez and Fritts 1987). With respect to tagging, the results have provided interesting information as to the behavior of the turtles during nesting and their distribution after the nesting season. This has been deduced from results of 22 years of tagging and recapture. Up to 1986, 3,629 adult female turtles have been tagged at the beaches in Rancho Nuevo and in to that period 142 tagged turtles had been recaptured away from their nesting beaches (Marquez and Fritts 1987).

The preliminary results of the number of tag returns in relation to method of capture shows that the greatest proportion is represented by shrimp trawling (AC in Figure 2). It must be clarified that with the exception, perhaps, of sport fishing (PD) 2.11%, and turning the turtle over on the beach while nesting

(AN) 0.7%, all other methods of capture can be considered incidental: gill nets (AG) 7.04%; shrimp trawlers (AC) 75.35%, fish trawlers (AE) 4.25%; hook and line (AZ) 1%; beach seines (CH) 0.7%; purse seines (RC) 0.7%. Cause of mortality or method of capture cannot be determined for other categories such as drifting dead turtles (MD) 7.04% and unknown (??) 0.7%. A small percentage of animals with unknown capture method are included as unknown (??) 0.7%.

The geographical distribution as related to recapture is as follows:

To the north, along the coast of the U.S.	42.25%
To the south, in Mexico	57.74%

This distribution is detailed in Fig. 3 where it can be seen that Louisiana (LN = 26.76 %), Campeche (CA = 17.61%) and Tamaulipas (TM = 20.42%), have the highest percentage of catch, coinciding with the states where shrimp trawlers in the Gulf of Mexico concentrate. The remaining states include the following percentages: Florida (FL = 2.11%); Alabama (AL = 2.82%); Mississippi (MS = 2.82%), Texas (TX = 7.04%); Quintana Roo (QR = 0.7%); Tabasco (TB = 8.45%) and Veracruz (VR = 10.56%). The only adult captured outside the Gulf of Mexico is from Colombia (CL = 0.7%). This record is very special. According to Chavez and Kaufman (1974), this turtle was found nesting in the Province of Magdalena. No detailed information was given, hence this animal may well have been ill or physically weakened and may have drifted to that beach in a current.

Juveniles and pre-adults, as stated in the beginning, are more frequently found outside the Gulf of Mexico. Along the coast of the United States, records have been kept of turtles that come ashore, dead or alive. Interestingly the frequency of observations of this species has increased lately, especially in the size class between 20 to 55 cm carapace length (Ogren 1985; J. Rudloe, pers. comm.). One of the possible explanations for this is that these turtles are coming from the beaches at Rancho Nuevo, since the great majority of them have not been tagged, in contrast to the ones released after being headstarted at Galveston.

During the last ten years, as a result of the imprinting and headstart project, as described by Klima and McVey (1982) and Woody (1985), more than 15,000 turtles of about 9 months of age have been released. The adaptation of these turtles after release seems to have been successful, according to the results from recaptures. The majority of these turtles have shown normal growth and have been found within the natural distribution of the species, including European waters (Brongersma 1972, 1973) and in Morocco (Fontaine et al. 1985). Besides the headstarted hatchlings, a portion of the hatchlings from Rancho Nuevo (500) and one hundred specimens cultivated during one year at the Galveston Laboratory (Texas), were sent on July 4, 1980 to the Cayman Island Turtle Farm, to make up a reserve reproductive stock. Any hatchling resulting from reproduction by this stock was to be released to the natural environment, as support for the recuperation program. After nearly four years at Grand Cayman, in April 1984, two turtles of the 1979 class nested for the first time and three hatchlings hatched, but died a few days later. In 1985, no nesting occurred but in 1986, five turtles of the same year (1979), laid 535 eggs in eight nests, and 75 hatched. During the present year the results have increased considerably (Wood and Wood, in press; J. Wood, pers. comm.).

A zone of refuge completely protecting the species from exploitation has been created at the nesting beaches of Rancho Nuevo, Tamaulipas. The zone is specifically designed for the development and conservation of the Kemp's ridley. Here, all activities that may negatively affect the turtle population are forbidden, both in the terrestrial area of the littoral zone as well as in the sea, with a perimeter of 4 km from the tidal line to the sea. (Anon. 1977, 1986).

Table 1. Summary of the results of the protection of Kemp's ridleys in Tamaulipas. R.N. = Rancho Nuevo; I.P. = Padre Island.

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Turtles tagged	251	414	272	228	198	225	264	183	204	203
Tags from previous yrs.	29	119	64	53	44	93	106	92	112	92
Number transplanted	834	954	865	897	754	757	798	699	671	712
Eggs, corral 1	63,316	55,401	58,259	34,828	24,138	43,415	52,304	53,433	60,704	51,955
Eggs, corral 2	0	34,131	24,074	50,045	43,559	30,817	18,574	12,989	0	15,948
Eggs in boxes R.N.	18,176	4,814	3,937	5,134	8,383	2,412	6,188	2,946	2,246	2,101
Eggs in boxes I.P.	2,191	2,124	3,000	2,300	2,020	2,000	2,000	2,081	2,011	2,001
Hatchlings, corral 1	36,481	36,017	34,630	22,920	13,689	35,092	42,581	42,885	45,385	32,853
Hatchlings, corral 2	0	24,071	9,330	26,662	26,975	2,728	9,135	10,375	0	11,273
Hatchlings, boxes R.N.	11,528	3,908	2,024	3,678	5,884	950	4,968	705	1,239	1,102
Hatchlings, boxes I.P.	3,127	1,818	2,502	1,894	1,524	230	1,792	1,664	1,776	1,280
Total eggs protected	85,833	96,470	89,270	92,307	78,100	78,644	79,066	71,687	65,260	73,019
Total hatchlings	52,758	65,814	48,486	55,114	48,072	38,883	59,916	55,834	49,268	46,628
Nests "in situ"	46	23	27	26	13	22	19	4	16	10
Eggs on beach	12,773	6,046	6,445	5,105	7,010	6,887	9,607	4,410	9,559	1,014
Hatchlings, beach	2,817	767	890	856	400	708	1,440	205	868	120
Hatchlings freed R.N.	49,631	64,763	46,874	54,076	46,900	39,478	58,124	54,170	47,492	45,348
Nests robbed	79	36	35	23	54	44	75	39	81	26
Eggs robbed	8,072	3,689	3,611	2,366	5,591	4,570	7,666	3,999	7,944	2,638
Eggs laid	98,456	99,999	95,715	97,414	85,110	85,539	88,673	75,409	74,528	75,657

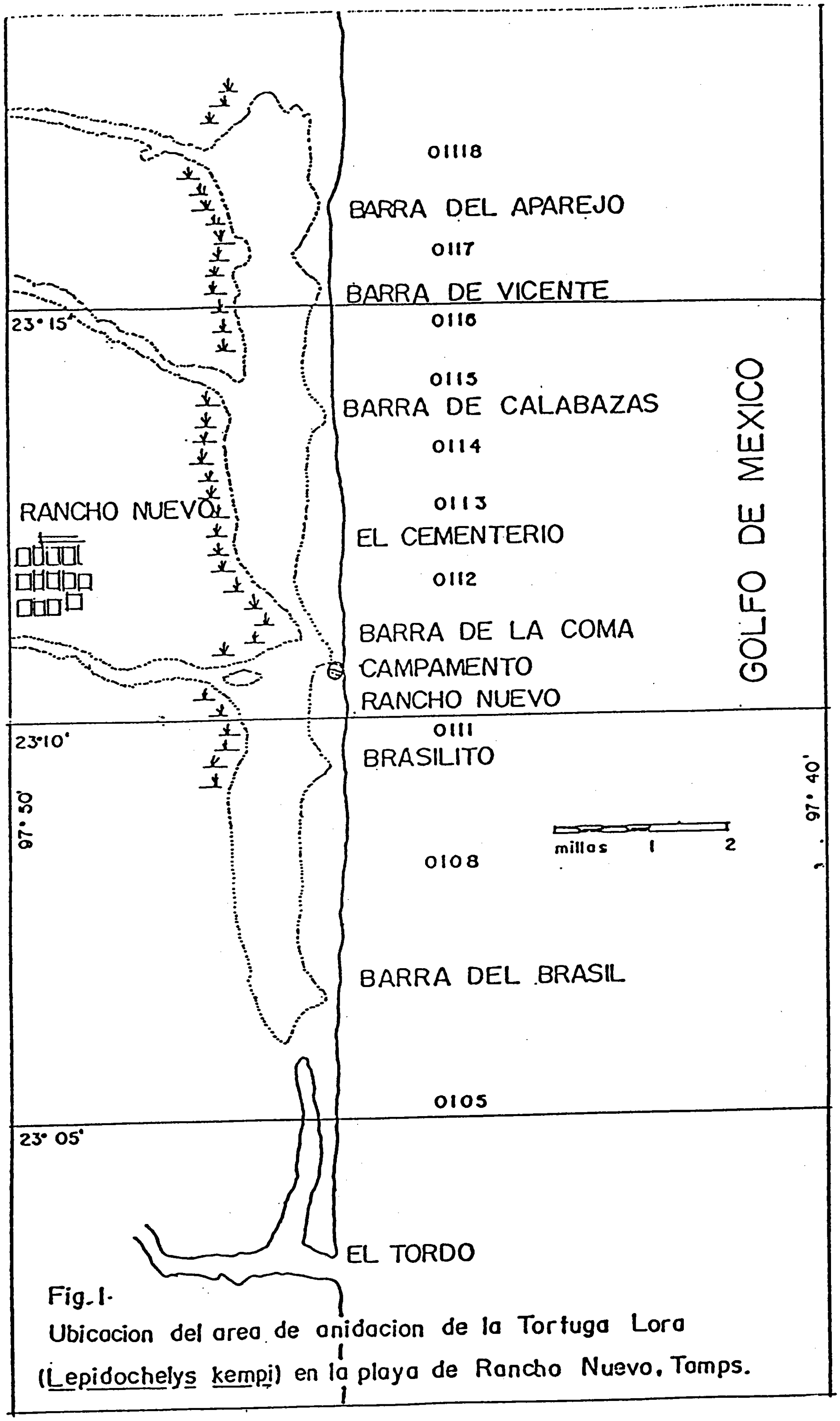


Figure 1. Nesting areas for Kemp's ridleys (Lepidochelys kempi) in Rancho Nuevo, Tamaulipas.

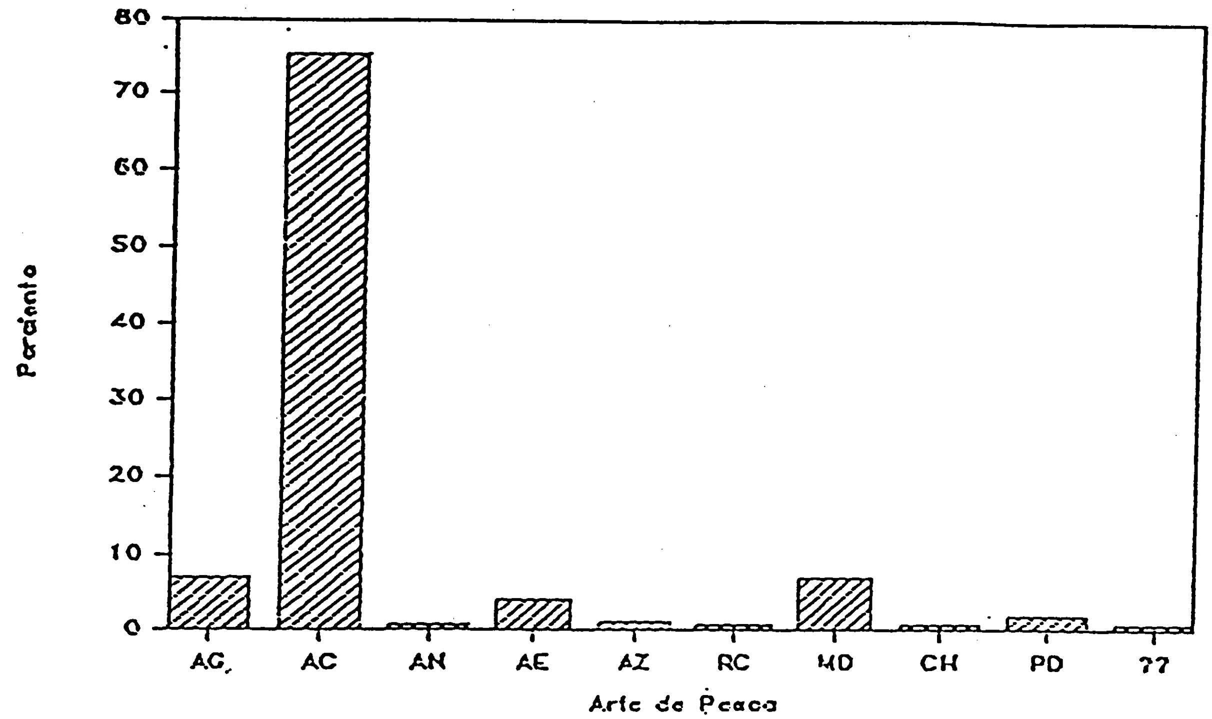


Figure 2. Recapture by capture methods. Kemp's ridley tagged at Rancho Nuevo. See text for abbreviations.

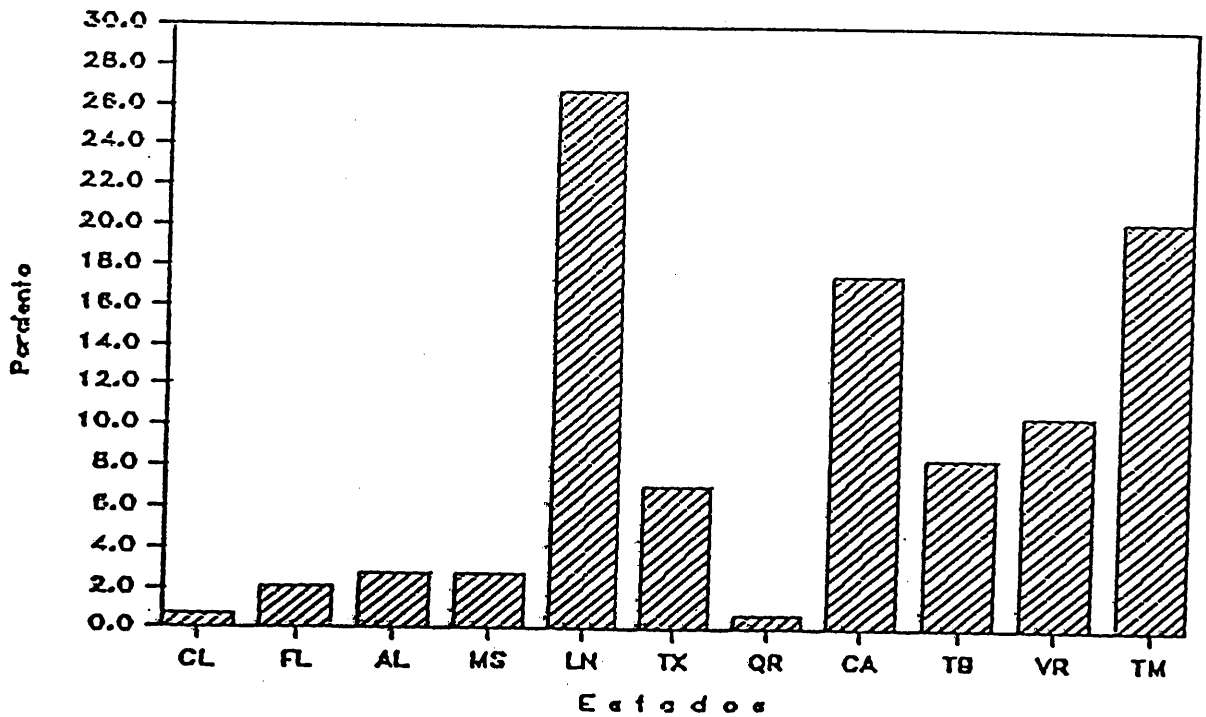


Figure 3. Recapture by state. Kemp's ridleys tagged at Rancho Nuevo. See text for abbreviations.

Rapporteur Report of the Kemp's Ridley Turtle Status Panel Session

CHAIR: Jack Woody, U.S. Fish and Wildlife Service, USA

SPEAKER: Rene Marquez, Proyecto Nacional de Tortugas Marinas, Mexico

RAPPORTEUR: Charles Karnella, National Marine Fisheries Service, USA

PANEL: Carole Allen, HEART, USA

Patrick Burchfield, Gladys Porter Zoo, USA

Richard Byles, U.S. Fish and Wildlife Service, USA

Charles Caillouet, National Marine Fisheries Service, USA

Peter Dutton, San Diego State University, USA

Carlos Hasbun, Gladys Porter Zoo, USA

Larry Ogren, National Marine Fisheries Service, USA

David Owens, Texas A & M University, USA

Robert Shipp, University of South Alabama, USA

The chair introduced the panel and immediately gave the floor to Rene Marquez who provided a status report on *Lepidochelys kempi*. The status report included a lengthy discussion of activities at the principal nesting site, Rancho Nuevo, Tamaulipas, Mexico.

CHAIR: Rene Marquez was thanked and Charles was asked to provide a summary of the headstart program.

CAILLOUET: Each year about 2,000 eggs are taken from Rancho Nuevo to Padre Island. The eggs are transported in Padre Island sand and never touch Rancho Nuevo sand. The U.S. National Park Service incubates these eggs for 50 to 60 days and send 1,500-1,800 hatchlings to the U.S. National Marine Fisheries Service. Hatching success has ranged from 12.5% to 93.2%, with an average of about 76%. The low value was for the 1983 class.

The hatchlings are raised in captivity for 9 to 10 months and released into the wild. To date, 12,837 hatchling Kemp's ridleys have been headstarted from 1978 through the 1986 year class. About 1,200 juveniles are now being raised from the 1987 year class. Survival of these juveniles until release into the wild has ranged from 67% (1978) to nearly 99% (1986).

Generally, multiple tags are applied to these headstarted juveniles. In the early years only monel tags were used. Since 1982, several tags per turtle have been used. Monel tags (on the flipper), internal binary magnetic tags and living tags all were used. Recently, inconel tags were substituted for the monel tags. Of the 16,668 hatchlings received, 12,422 have been tagged and released.

A total of 537 or 4.3%, of these tagged turtles has been recovered. Recovery of the individual year classes ranged from a low of 1.6% for the 1979 class to 11.8% for 1982. In 1982, the headstarted juveniles were released fairly close to shore in sargassum weed. Many of these turtles became coated with oil and died.

Of the 537 recaptures, 353 were from Texas (which is expected), 66 from Louisiana, and 49 from Florida. The remainder have been taken from a number of areas, including the east coast to New York, throughout the northern Gulf of Mexico and Europe. Shrimp trawls account for 23.0% of the recaptures, and dead beach strandings account for 24.8%. There is no information for 24.4% of the recaptures, and the remainder have been recaptured in a variety of ways. Recaptures are highest in spring and decline with the progression of the year. About 62% are recovered alive and released back into the wild.

Growth is estimated by an exponential curve (log of weight [in grams] vs. age). The 1986 class showed the fastest growth and the 1984 class the slowest. Captive stocks are maintained for several purposes. A breeding stock is housed at the Cayman Turtle Farm. The oldest captive stock is maintained at Sea Arama (Texas). Using the latter, a growth curve was generated for the 1978 year class. Captive stocks contain 31 males, 30 females and 46 animals whose sex has not been determined.

<u>MAST</u>: When was the use of binary magnetic tags started and when did looking for the tags on the beach start?

<u>CAILLOUET</u>: The tags were first used in 1982. The program will not be checking the beaches for those tags. Very few nestings have been reported on Padre Island. The National Park Service patrols the beaches at Padre Island for nesting Kemp's ridleys.

<u>DUTTON</u>: There may be an individual with a living tag at Rancho Nuevo. Would it be possible to expect a living tag this year?

<u>CAILLOUET</u>: Anyone finding a turtle with a living tag was urged to report it to NMFS.

<u>CHAIR</u>: How old could a turtle with a living tag be?

<u>CAILLOUET</u>: All headstarted Kemp's ridleys were given living tags from 1982 on. A few living tags were applied before then.

<u>ALLEN</u>: Thoughts were expressed about people and patience, and to consider the Kemp's ridley program as a model. Two great countries are working and learning together. The public should be involved --first by educating them. Once the public is aware of what is happening, they will support the program in other areas. She has worked full time providing a lot of people with information about this program, and asked that all who don't know the mechanisms of the program to find out about it. The program is working beautifully.

<u>OGREN</u>: Reports from Rancho Nuevo haven't been too optimistic lately, so he wished to share a bit of good news at the meeting. For the past two years he has been conducting surveys in the northern Gulf of Mexico for juvenile Kemp's ridleys, and found them almost everywhere. This is believed to be a direct result of the program to protect the eggs at Rancho Nuevo because they were unmarked or

"wild" turtles. When conducting surveys in the 1950s, juveniles couldn't be found. They are also being found along the east coast off Long Island, New York. Now people are beginning to gather data to help us understand the expatriate question in the western Atlantic. These data suggest that they are surviving and are a viable population in the coastal Atlantic states.

CAILLOUET: Attention was drawn to the survival rates on which Rene Marquez reported earlier. Marquez is seeing survival of 40% to 50%, which indicates that extinction will occur in about 22 years.

CHAIR: Comments from another panel member, the National Representative from the Cayman Islands (J. Parsons) were requested. The Cayman Islands are working with the breeding stock and getting some animals to nest.

PARSONS: He apologized for not being up on the podium with the panel and suggested that he would not be missed because of the quality of the group.

BIRCHFIELD: The Gladys Porter Zoo has been providing additional personnel and equipment for the program at Rancho Nuevo.

CHAIR: Someone mentioned TEDs earlier. Discussion on this point was really not needed. TEDs should be used in all waters where shrimping and turtles co-occur at all times.

WIBBELS: Has anyone looked at sex ratios at Rancho Nuevo?

MARQUEZ: About 2,000-3,000 hatchlings have been preserved in formalin. No information at the moment was available, but work was in progress. He also had a number of hawksbills to examine.

MROSOVSKY: The need for patience was expressed. He hoped that the TED will work. In light of the continued decline in nesting numbers at Rancho Nuevo, the panel was asked what thoughts they have given to developing a contingency plan in case these actions don't work.

CHAIR: The captive breeding stock at the Cayman Turtle Farm may be the last resort. The only good news is the finding of juveniles throughout the northern Gulf of Mexico.

<u>MOHADIN</u>: Comments were solicited concerning the effect on hatching success of eggs that were moved; is it the same for all species?

<u>BURCHFIELD</u>: With the Kemp's ridley, mortality is minimal if the eggs are moved carefully and handled within the first day. Others working with different species have had problems, so this may vary with the species.

<u>PARSONS</u>: The Cayman Islands wished to say that they are happy to participate in the Kemp's ridley effort and hope to continue. Elimination of some of the bureaucratic red tape would be nice.

<u>HALL</u>: Are the eggs moved by plane just before they hatch?

<u>BURCHFIELD</u>: The eggs ideally should be moved the first day but in reality are not moved in that way. The eggs are incubated up to 2 1/2 weeks and then moved to Padre Island.

<u>HALL</u>: Does the literature contain anything about this subject?

<u>BURCHFIELD</u>: The information is contained in reports to the Fish and Wildlife Service.

<u>LIMPUS</u>: This is the first time he had heard anything encouraging about the Kemp's ridley. Well done.

<u>CANIN</u>: Are the eggs taken from a certain profile on the beach or at certain times?

<u>MARQUEZ</u>: Nests were left at first in their natural state to see what would happen. If the eggs are not moved, coyotes get them. Now the project takes all of the eggs from the nests.

<u>CANIN</u>: He was referring to the 2,000 eggs sent to Padre Island.

__BURCHFIELD__: The logistics do not allow them to pick and choose as they would like. They cannot randomize their sample as much as they would like.

The chair closed the session with appreciation to all that participated.

Olive Ridley Turtle (Lepidochelys olivacea)

Status Report on the Olive Ridley Turtle (Henri A. Reichart)

Introduction

In all likelihood, the rarest sea turtle inhabiting the western Atlantic Ocean is the olive ridley (*Lepidochelys olivacea*). Data on this species in this region are equally rare. There are only two major, original publications on western Atlantic olive ridleys: Pritchard (1969c), and the classic work by J. Schulz (1975) on sea turtles nesting in Surinam. Both are centered on the Guianas' population. Accurate data on nesting olive ridley females are known only for Surinam, a country which is now in its 20th consecutive year of uninterrupted beach data collection of all species nesting there. This record is second only to that of Tortuguero beach in Costa Rica, which is essentially a two species program, while that of Surinam involves 20 years of data keeping on four species.

Distribution

Historical:

Not until the second half of the 20th century did nesting of olive ridleys in the western Atlantic become known. Up until that time, they were apparently sometimes confused with loggerheads, or the occasional sighting was considered to be that of an errant visitor from the eastern Atlantic olive ridley populations off the coast of west Africa. Therefore, even relatively recent historical distribution of the species in the western Atlantic region is unknown.

P. Pritchard, in his Ph.D. dissertation (1969c), proposes four interesting hypotheses as to the origin of the western Atlantic olive ridleys. These have been summarized in the olive ridley synopsis to be published by WATS II (Reichart, in prep.).

(2) Nesting.

The distribution of nesting beaches in the central western Atlantic is limited to the Guianas. An impeccable source refers to some nesting records for Trinidad (Fig. 1, Table 1), but the actual data on this have not yet appeared in the literature. Reference to olive ridley nesting in other central western Atlantic areas, such as Venezuela, are not known from original, published data, and should be dismissed.

Nesting takes place on the beaches of northwest Guyana. Nesting is mostly diffuse, without any signs of an arribada. From tracks on the beach and evidence of poaching, they are by no means rare nesters. At this time, though, no concerted conservation effort for sea turtles in Guyana exists, and an assessment of population size is not possible.

In Surinam, olive ridley nesting is diffused on all the beaches in the eastern half of the country, but the focus of nesting activities is located on Eilanti Beach at the mouth of the Marowijne River, which separates Surinam from French Guiana. On Eilanti Beach in 1962, the first ever, officially reported, arribada of the ridley genus in the Americas was observed.

In French Guiana, as in Guyana, nesting of olive ridleys is diffused, and there is no evidence of an arribada ever having taken place. Although considerable sea turtle conservation activity takes place in French Guiana, it is mostly concentrated on the leatherbacks. Only recently have olive ridleys been monitored. Conclusions from these data cannot yet be drawn, but tentative records show that olive ridleys nest in reasonable numbers, although not as numerous as in Surinam and Guyana.

Neither the literature nor several personal visits to beaches on the northeast coast of Brazil indicate the presence of olive ridley nesting activity in that region. Moving southward, the first signs of olive ridley nesting were in the state of Bahia. Subsequently, this was verified by research of the dei Marcovaldis, who have reported olive ridley nesting beaches in the states of Bahia and Sergipe.

(3) Foraging.

Olive ridleys have been reported from Cuba, in the north, to Uruguay, in the south (Fig. 1, Table 1). In both locations sightings have been rare. These countries should by no means be considered as part of the normal range. Foraging juveniles and adults have been reported along the coast of Panama, and around some of the eastern Caribbean islands, but the bulk of the central western Atlantic olive ridley population forages near Venezuela and the Guianas. A few Surinam-tagged olive ridleys have been recovered near Natal in the Brazilian state of Rio Grande do Norte, but no indication of a major foraging population has been found there. For the population in the southwestern Atlantic, no specific foraging areas have yet been located, but an educated guess is that these will probably be found near the mouths of the larger rivers, within a radius of some 700-800 km from the nesting beaches.

Conservation Status

(1) Current population numbers.

The only country in the western Atlantic for which a reasonable assessment of population numbers can be made is Surinam (Table 2). For the other countries, which report olive ridley presence, the data are either too few, too short-term, or non-existent.

Fretey and Lescure (1979) report on olive ridley nesting, including beach locations, in French Guiana for the period 1977-1979. J. Fretey (pers. comm.) provided some nesting data for French Guiana for the period 1977 through 1986. Although only some of the beaches were surveyed, and then only during part of the season, his findings confirm olive ridley nesting in French Guiana (Table 3).

The only accurate population dynamics parameter that can be obtained on nesting females is the number of nests laid per year. That in itself is a monumental task, which requires daily beach patrols, starting well before the nesting season, and stopping well after the end of the season. To use this information to obtain population size estimates becomes then largely a matter of number manipulation and personal judgement based on experience.

The next step is counting the number of eggs per nest for a large number of nests. In this manner an average number of eggs per nest is calculated. For Surinam the average olive ridley nest has 116 eggs. With an even greater labor-intensive, multiple-year tagging program, an only marginally accurate estimate can be obtained on the number of times a female comes ashore to nest during a particular season, which in Surinam was found to vary from 1.4 to 2.0 times. With this same tagging program, an equally not-too-accurate estimate is made of the number of years before a particular female returns to nest again in this area (interbreeding period). For Surinam this is 1.4 years. Tagging techniques are notoriously inefficient for population dynamics data because of the high rate of loss of tags, but it is currently the only method available. From the above data, and by extrapolation, an estimate of the female population can be made. Based on these data, the Surinam olive ridley nesting population declined from 2,000-3,000 females in 1967, to 400-500 in 1986 (Table 2).

The highest number of nests recorded in a given year for Surinam was 3,290 in 1968, while the low point was reached in 1986 with only 540 olive ridley nests. Although the number of nests has fluctuated over the years, with a minor upsurge to over one thousand nests per year during the early 1980s, the general trend has been downward.

(2) Rate of change.

By calculating the rate of change of the number of olive ridley nests laid each year, a fair approximation of the rate of change in population numbers of nesting females could be obtained. The Surinam nesting data over the past 20 years should be suitable for a rough regression analysis to obtain this rate, but this has not yet been done. Data for other western Atlantic olive ridley populations are inadequate for such an analysis.

(3) Ability to recover.

With the currently low numbers, how the Surinam olive ridley population can recover is difficult to see. The criteria for a healthy nesting population are present: the beaches are currently in an even better condition than during the late 1960s, when there were greater numbers of olive ridleys, and conservation management in Surinam may be the best in the world. No obvious terrestrial reason explains the precipitous decline of the Surinam population. In the face of overwhelming evidence to the contrary, there is the slight hope that a diffusion of nesting females is taking place to other beaches in French Guiana, or if the hypothesis of west African origin is correct, maybe they are filtering back toward their ancestral home region. Whatever the case, no reason in the past 20 years in Surinam explains the cause for the decline there. The ability to recover must be found in reducing the assumed excessive, man-induced mortality at sea.

<u>Mortality</u>

(1) At sea.

The most devastating damage being done to the olive ridley populations in the western Atlantic is almost certainly caused by the shrimp boats. This is almost self-evident, since they share the same food and foraging grounds--namely crustaceans and their habitat.

Shrimp boats of several nations fish off the coasts of the Guianas and Venezuela. Their cumulative incidental take is not commonly known or available but circumstantial evidence suggests that it must be considerable. In the late 1960s, during experimental trawling exercises along the coast of the Guianas, a single ship caught 39 olive ridleys in a one year period, even though olive ridleys were not the target species, and the ship trawled only periodically.

A rough estimate places some 90-100 shrimp boats of French, German, Japanese and U.S. origin off the coast of French Guiana. An ex-crewmember reported that they usually had a cumulative incidental catch of 2-3 olive ridleys per day. Data are not available on what is being caught on the foraging grounds at the mouth of the Orinoco River, but the large number of tag returns from that area during the studies by Pritchard and Schulz is indicative of a considerable mortality factor there.

Furthermore, and often ignored in mortality analyses, along the Surinam and Guyana coast set nets, often several kilometers long, are used by local fishermen. Olive ridley mortality caused by these lethal barriers is unknown, but it could be considerable.

(2) On the beach.

In Guyana many olive ridleys are killed on the beaches. Carcasses form ample evidence. The full extent of this carnage is unknown, because many olive ridleys are carried off alive and slaughtered elsewhere for local consumption or sale in markets.

In Surinam, olive ridleys are fully protected, and poaching is not evident. Some natural mortality probably occurs among nesting adults; some may be dragged off by jaguars. Finding a dead specimen on the beach or evidence of a kill is rare.

Egg and hatchling mortality is a different matter. From example of 100 olive ridley nests in Surinam, 60 were attacked by ghost crabs within a few days after having been laid, destroying an average of 12% of the eggs, although some nests were completely destroyed.

A major mortality factor in Surinam is beach erosion. Surveys have shown, that about 25% of the nests are destroyed in this manner. For this reason, one of the major activities of the Surinam conservation program is the translocation of such doomed nests to safer beach locations.

Hatchling mortality is speculative for all sea turtle species. Of the newly hatched sea turtles 1% or less is estimated to survive for more than a few weeks. Another pseudo-statistic used is that less than one tenth of one percent of the eggs will ever become an adult turtle. These numbers are often quoted in the popular press as well as in the scientific literature, but no factual basis can be found for this.

A compelling argument to be used in explaining the decline of the Surinam olive ridleys may be the excessive harvest by the local Indians up until the late 1960s. Studies on eastern Pacific olive ridleys have suggested to some researchers that the olive ridleys have a 20-year life span. Indeed the major decline in the Surinam population 20 years after the olive ridley egg harvest was closed to the Indians in 1967 is coincidental. The Indians had been harvesting 90% of the eggs apparently for some time, but when they realized that the harvest would be closed, they collected almost 100% of the eggs for the few years before the closure.

Data on mortality of other olive ridley populations in the western Atlantic are nonexistent.

Management Strategies

Major methods to implement management strategies to conserve olive ridleys consist of:

(1) Modification of shrimp gear.

(2) Protection of nesting beaches.

(3) Hatcheries and headstart procedures.

(4) Legislative regulations.

(5) Public education.

Details and references on these subjects can be found in the WATS II olive ridley synopsis (Reichart, in prep.).

Conclusions

At the outset of this paper it was stated that perhaps the olive ridley was stated to be probably the rarest sea turtle in the western Atlantic. This statement should have been received with considerable concern by the sea turtle conservation community, but it has hardly caused a stir because most of the emphasis is placed on the Kemp's ridley.

This lack of enthusiasm is, no doubt, due to the fact that many turtle workers consider the olive ridley the most abundant sea turtle in the world. One only has to look at the numbers being legally and illegally harvested in the eastern Pacific. This annual take is probably several orders of magnitude greater than the entire olive ridley population in the western Atlantic.

In spite of the ostensibly large numbers of olive ridleys around the globe, this apathy toward the plight of the olive ridley in the western Atlantic should be considered unacceptable.

Extinction implies the disappearance of an entire species, and in that regard no argument about the status of the Kemp's ridley is raised. But population extinction is also a serious matter. In the USA, not so many years ago, a hydro-electric power project was stalled because the population of some "insignificant" little fish called the snaildarter would be wiped out. There are several other populations of this fish, and the species is not about to go extinct. What makes the demise of the western Atlantic olive ridley so different and unimportant? Obviously the reason is that it has no champion coming to the rescue, and that it is apparently far from the sphere of interested persons and pressure from conservationists.

Undoubtedly the shrimp fleets operating on the foraging grounds and off the nesting beaches of the olive ridleys are the primary cause of mortality. Not until pressure is exerted on the owners of the boats to modify their fishing gear will any relief from this mortality factor occur. The situation is critical, and action will have to be taken soon. Otherwise, the presence of olive ridleys in the western Atlantic region will have been a historical event.

I hope that the information given here, and in the olive ridley species synopsis presented at this meeting, will create a change of attitude about the plight of the olive ridley.

Acknowledgments

I would like to acknowledge the contribution to sea turtle conservation, which has been, and still is being made by the fieldworkers in our region.

I cannot, of course, speak for all of my colleagues, but I know that many of us are indebted to those anonymous people in the field, who supply us with day-to-day records that they, on our behalf, collect on the beaches. In addition, those field workers often possess practical, and sometimes quite useful, knowledge about sea turtles, which cannot be found in textbooks. Many researchers have undoubtedly benefited from associations with field personnel. I, for one, have increased my knowledge about sea turtles considerably in this manner.

I would, therefore, like to express my appreciation for the contribution that the fieldworkers have made, and continue to make, to sea turtle conservation, in general. But most of all I want to thank the beach personnel of the Surinam Forest Service, and the fieldworkers of the Foundation for Nature Preservation in Surinam (STINASU). I have walked many miles along the beaches of Surinam myself, but they pale into insignificance when compared to the hundreds of miles of beach each one of the workers walks

in the course of a year. Although these people are too numerous to name individually, I must give special mention to Louis Autar, the beach project foreman, my friend and mentor. Because of their devotion and effort, which go well beyond the call of duty, I respectfully dedicate this paper to Louis Autar and his staff.

Table 1. Nesting and foraging areas with nesting seasons of live olive ridleys for countries of the western Atlantic region (parenthesis indicate reported major nesting months).

Location	Nesting	Foraging	Nesting months	Source
Antigua	---	---	---	Bacon (1975, 1981)
Aruba	n/a	n/a	n/a	" " "
Bahamas	---	---		" " "
Barbados	---	---	---	" " "
Barbuda	n/a	n/a	n/a	" " "
Belize	---	---	---	" " "
Bermuda	---	adults	---	" " "
Bonaire	n/a	n/a	n/a	" " "
Brazil (states: Bahia, Sergipe)	yes	n/a	Oct-Mar	G. Marcovaldi (pers. comm.)
Cayman Islands	---	---	---	Bacon (1975, 1981)
Colombia	unconfirmed	---	---	" " "
Costa Rica	---	---	---	" " "
Cuba	---	*	---	" " "
Curacao	---	---	---	" " "
Dominica	---	---	---	" " "
Dominican Republic	unconfirmed	adults	n/a	Carr et al. (1982)
French Guiana	yes	---	Apr-Sep [1 May-31 Jul]	Fretey (1979)
Grenada	---	---	---	Bacon (1981)
The Grenadines	---	---	---	" "
Guadeloupe	---	---	---	" "
Guatemala	---	---	---	" "
Guyana	yes	---	Apr-Aug [May-Jun]	Pritchard (1969c)
Haiti	---	---	---	Bacon (1981)
Honduras	---	---	---	" "
Jamaica	---	---	---	" "

Table 1. (continued)

Location	Nesting	Foraging	Nesting months	Source
Martinique	---	juvenile (rare)	---	Carr et al. (1982)
Mexico	---	---	---	Bacon (1981)
Nicaragua	---	---	---	" "
Panama	---	adults (unconfirmed)	---	Carr et al. (1982)
Puerto Rico	---	adults	---	Caldwell (1969)
Saba	---	---	---	Bacon (1981)
St. Bartholemew	---	---	---	" "
St. Eustatius	---	---	---	" "
St. Kitts, Nevis, Anguilla	---	---	---	" "
St. Maarten	---	---	---	" "
St. Martin	---	---	---	" "
St. Lucia	---	---	---	" "
St. Vincent	---	---	---	" "
Surinam	yes	---	Apr-Sep (Jun-Jul)	Pritchard (1969c), Schulz (1975)
Trinidad and Tobago	**	adults	---	Bacon (1981), Carr et al. (1982)
Caicos Islands	---	---	---	Bacon (1981)
Uruguay	---	***	---	Frazier (1984)
USA	---	---	---	Bacon (1981)
Venezuela	---	adults	---	Schulz (1975), Pritchard and Trebbau (1984)
Virgin Islands (UK)	---	---	---	Bacon (1981)
Virgin Islands (USA)	---	adults	---	" "

Notes: --- not present

n/a information not available

* This was a rare capture and may only indicate the presence of a "lost" olive ridley.

ble 1. (continued)

** Although Bacon (1975, 1981) indicates that a few olive ridleys are nesting on Trinidad, Carr et al. (1982, p. 27) state that "No olive ridley has been recorded nesting in Trinidad." Gaskin is reported to have olive ridley nesting records for Trinidad (F. Berry, pers. comm.).

*** A rare capture of a subadult; does not necessarily indicate the presence of a foraging population.

Table 2. Nesting records and population estimates for the Surinam olive ridley.

Year	Number of nests*	Number of nesting females**	Female population estimate***	Average female population
1967	2875	1440-2050	2020-2880	2450
1968	3290	1650-2350	2310-3290	2800
1969	1665	830-1190	1160-1670	1420
1970	1750	880-1250	1230-1750	1490
1971	1595	800-1140	1120-1600	1360
1972	1270	640-910	900-1270	1090
1973	890	450-640	630-890	760
1974	1080	540-770	760-1080	920
1975	1070	540-760	760-1070	910
1976	1160	580-830	810-1160	990
1977	1030	520-740	730-1030	880
1978	870	440-620	620-870	750
1979	795	400-570	560-800	680
1980	1020	510-730	710-1020	870
1981	1220	610-870	850-1220	1040
1982	1045	520-750	730-1050	890
1983	1212	610-870	850-1210	1030
1984	940	470-670	660-940	800
1985	670	340-480	480-670	580
1986	540	270-390	380-550	470

* from: Schulz (1975); Reichart (pers. obs.); Mohadin (pers. comm.)

** Number of nesting females was calculated from Schulz (1975) data, which indicates that olive ridleys lay 1.4-2.0 nests per season in Suriname. Numbers rounded off to the nearest multiple of 10.

*** Female population estimate was calculated from Schulz (1975) data, which indicates that the average breeding interval for olive ridleys in Suriname is 1.4 years. Numbers have been rounded off to the nearest multiple of 10.

:able 3. Olive ridley nesting reported in French Guiana.

'ear	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Io. of iests	31	101	33	6	?	?	?	?	?	52

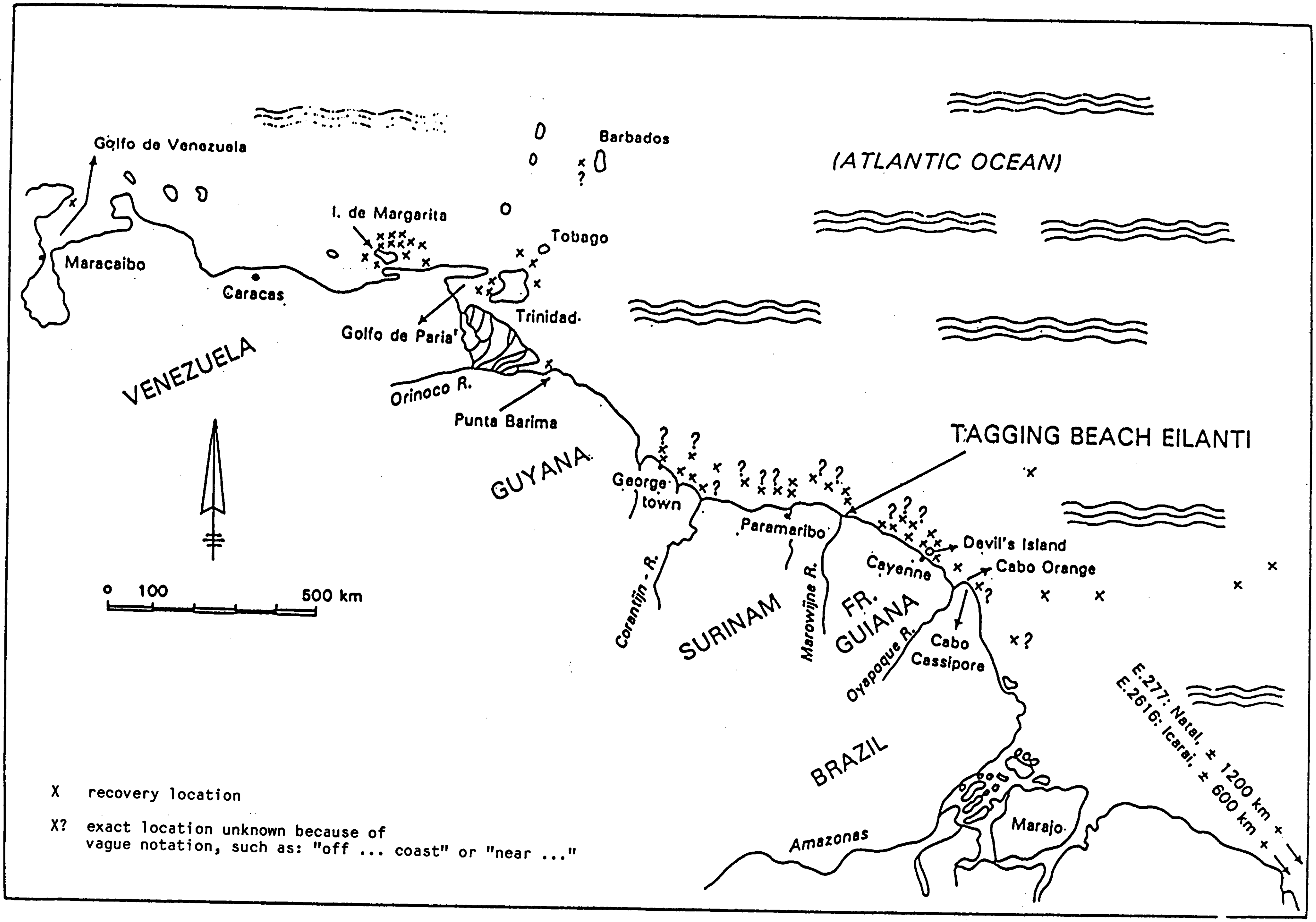


Figure 1. Recaptures of adult olive ridley females, tagged on Eilanti Beach, Surinam (from Schulz, 1975).

Rapporteur Report of the Olive Ridley Turtle Status Panel Session

CHAIR: Johan Schulz, Netherlands

RAPPORTEUR: Dean Swanson, National Marine Fisheries Service, USA

SPEAKER: Henri Reichart, STINASU, Surinam

PANEL: Peter Dutton, San Diego State University, USA

Jacques Fretey, Museum National d'Histoire Naturelle, France

Angela Marcovaldi, Instituto Brasileiro Desenvolvimento Forestal, Brazil

Guy Marcovaldi, Instituto Brasileiro Desenvolvimento Forestal, Brazil

Krishnepersad Mohadin, STINASU, Surinam

Nadra Nathai-Gyan, Ministry of Food Production, Marine Exploitation, Forestry & Environment, Trinidad and Tobago

The chair introduced H. Reichart who presented an overview of the status of *Lepidochelys olivacea*. The Chair then invited comments by panel members.

MOHADIN: All nests in Surinam had been counted from 1967 on, and the number of olive ridley nests had declined steadily until 1987. He supplemented Reichart's data as follows:

1985	670
1986	537
1987	1,651

In reviewing these data, N. Frazer thought the fluctuations over the 20 year period could be considered normal. Tagging started again in 1987, and all countries were requested to report recoveries to the National Marine Fisheries Service, USA.

FRETEY: The best beach in French Guiana for olive ridleys was studied in 1987, and a peak of 27 females per night was observed, with a total for the 1987 season of approximately 400 nests. He agreed with

H. Reichart's concern for the Atlantic population and reported that Indians recall observing 20,000-30,000 specimens per night 25-30 years ago. He expressed interest in the theory noted by Reichart that these animals may be migrating to West Africa.

REICHART: The population might alternatively be migrating south of, or past, Brazil. The Marcovaldis had recently found more olive ridleys in Brazil, but this could be due to more observational effort.

CHAIR: Are reasons for the decline necessary in light of what is known about shrimping?

REICHART: Not enough is known about mortality due to shrimp trawling to be sure, but all indications are that shrimping is the major cause of mortality. The NMFS had offered to Guyana to demonstrate the TED locally and supply several of them in 1982, but there was little interest. Fishermen said they did not want to lose the bycatch.

G. MARCOVALDI: Brazil's turtle populations were compared.. Only 43 olive ridleys were observed in 1987, and 195 of their nests were located.

REICHART: Olive ridleys are solitary nesters, according to the historical record in Brazil.

DUTTON: Should headstarting be considered in Brazil and Surinam?

REICHART: The candidate countries lack sufficient financial resources. Headstarting would be desirable, but the effort would need a champion.

GYAN: Few olive ridleys nest in Trinidad and Tobago, but the animals are commonly caught in offshore fishing nets. In 1986, a carcass was found on a northeast beach, suggesting possible nesting.

FRETEY: Sex ratio studies on olive ridleys are planned. The necessary enclosures are to be named in honor of Archie Carr. He indicated interest in hearing any good ideas concerning headstarting.

CHAIR: What would be the purpose of headstarting except to provide more food for the crews of the shrimp trawlers? All nests in Surinam have been protected for 20 years, but the population continues to decline.

FRETEY: Pressure should be put on the fishermen to get them to use TEDs.

GILLET: If support for the use of TEDs is not available in the short term, could a system be set up whereby shrimping vessels would have to contribute toward implementing a headstarting program as a condition of receiving permission to fish?

FOSTER: H. Reichart was asked if the Government as well as fishermen in Guyana opposed the use of TEDs.

REICHART: Consultations have been held with fishermen, their representatives, and the Minister of Fisheries. All indicated little interest, citing desire to retain bycatch and the belief that shrimp would be lost by using a TED.

The chair opened the discussion to the audience.

S. MURPHY: Five different models of TEDs now exist. All exclude turtles, but they exclude varying amounts of bycatch.

REICHART: The shrimp fleet off Guyana, mostly American, had moved off French Guiana and Benin, rendering these countries as potential sources of a solution to the problem.

S. MURPHY: The use of TEDs would be cheaper than funding a headstarting program.

REICHART: A solution is required as quickly as possible.

CAILLOUET: The similarities between what has happened to the Kemp's ridley and the Atlantic population of the olive ridley are striking. Have strandings of the latter been observed?

CHAIR: Only 12 specimens of all turtle species were observed in Surinam during 1987.

REICHART: Many undamaged stranded leatherbacks were seen but no olive ridleys in 1985/86.

CAILLOUET: If mortalities are due to shrimpers, why were there no strandings?

CHAIR: Olive ridley strandings have not been reported for the past 20 years.

__MORTIMER__: Why, if bycatch is so important, would shrimpers throw olive ridleys overboard to strand subsequently?

__FRETEY__: Congratulations were offered to the directors of STINASU, who were responsible for conservation.

International Management Mechanisms

Rapporteur Report of the International Management Mechanisms Panel Session

CHAIR: William Gordon, New Jersey Sea Grant, USA

RAPPORTEUR: Dean Swanson, National Marine Fisheries Service, USA

PANEL: Karen Bjorndal, University of Florida, USA

James Burnett-Herkes, Department of Agriculture and Fisheries, Bermuda

Rene Chang, Comisionado del Programa de Tortugas Marinas de la Fundacion de Parques Nacionales y Media Ambiente de Panama, Republica de Panama

Alonso Cruz, Direccion General de Asuntos Pesqueros Internacionales, Mexico

Fanny Darroux, OECS, St. Vincent

Bruce Jaildagian, Greenpeace International, USA

Milton Kaufmann, WIDECAST, USA

Colin Limpus, Queensland National Parks and Wildlife Service Australia

Glenda Medina, FUDENA, Venezuela

John Miller, National Park Service, St. Thomas, U.S. Virgin Islands

Horace Walters, Ministry of Agriculture, Land and Fisheries, St. Lucia

The chair opened the session with the comments that follow: Perhaps of all creatures, sea turtles are unique in their evolution, biology, and behavior patterns, yet similar to creatures such as seals in their dependence on returning to specific areas to reproduce. Sea turtles reach the lives of many societies and cultures. Now, they are deeply entrenched in human politics, and it is up to humankind to address the problems it has created for sea turtles.

The chair requested the panel members to address the following relevant management mechanisms as they apply to the international arena:

1. adequate and reliable data acquisition and management systems
2. effective, integrated research programs
3. international protocols or mechanisms for conservation and management throughout the range of sea turtle populations
4. effective habitat protection programs
5. effective, integrated enforcement programs
6. effective public participation
7. international fora for periodic public review
8. full participation in CITES

BJORNDAL: The continued tagging of as many turtles as could be tagged properly with appropriate records was urged. We otherwise will have no way of learning about the shared resource aspects of turtles in the Caribbean. Tagging record clearing house services are available from the NMFS, or the Archie Carr Center for Sea Turtle Research, University of Florida.

BURNETT-HERKES: Education will be a key to effective management. In Bermuda, one-third of all students are reached annually with curricular materials. But the most important targets are user groups--the fishermen--who must receive information on management options and participate in decision making. Forums such as the Gulf and Caribbean Fisheries Institute exist for such purposes and bring users, managers, and conservation interests together.

CHANG: The Foundation of National Parks and Environment in Panama established a commission for sea turtle work in 1985. This includes projects such as a Pacific hatchery for 10,000 olive ridley eggs annually and also work with greens and leatherbacks. It also involves environmental planning by participation in WIDECAST and the Cartagena Convention and efforts to curb the indiscriminate harvesting of eggs, meat, and hawksbill shell. Projects are typically in remote areas and involve much volunteer effort.

CRUZ: The acquisition of reliable data is paramount, because it would facilitate addressing the other needs identified by the chair. The common denominator of all speakers this week has been uncertainty in the data relating to status of stocks, diet, diseases, and behavior. Strengthening these research fields is important. Once this information is available, governments should be able to respond with appropriate management measures.

<u>DARROUX</u>: The Organization of Eastern Caribbean States, particularly its fisheries unit, has been continuing the data base started by WATS. It receives and distributes information, promotes educational programs on a regional basis to fishermen and schools, and is working to prepare a comprehensive, harmonized fisheries ordinance including effective management and conservation of turtles.

<u>JAILDAGIAN</u>: Greenpeace goals are conservation, education, and protection of sea turtles at the grass roots level. Involvement of volunteers in activities such as beach patrols is fulfilling and educational for all concerned. A small project in French Guiana involves volunteers serving for several months at their own expense. Other activities designed to reverse habitat destruction including man-induced beach erosion are meeting with some success.

<u>KAUFMANN</u>: WATS and WIDECAST are complementary in that WATS is a scientific symposium designed to stimulate the collection of necessary information while WIDECAST provides a mechanism for effectively putting the information into practice. WIDECAST is working on the development of 39 sea turtle management recommendations that will be directed, through UNEP, to the western Atlantic national governments. This involves 11 volunteers from 8 countries, 250 network participants, and a task force in each of the 39 countries. Another mechanism at work is the action plan for the Caribbean Environment Program and the Cartagena Convention. The first meeting of the parties to the Cartagena Convention, meeting next week in Guadeloupe, will direct its energies toward developing a protocol on special protected areas which is expected to have an annex focusing on turtles.

<u>MEDINA</u>: Conservation is fundamental and unbroken. The conservation of sea turtles implies the conservation of other species and their habitats, and we are not alone. We should go forward with the IUCN, private conservation groups, and other

existing organizations with conservation mandates and take the larger view and help one another.

<u>MILLER</u>: Conservation of sea turtles in Saudi Arabia is just beginning. The past two years of field work have included tagging, censusing, and interviewing. Shortly, a recommendation will go to the government with the expectation that sea turtles will receive protection in both the Arabian and Red Seas. Neighboring countries are becoming more sensitive to the conservation needs of turtles.

<u>WALTERS</u>: Periodic public review of the role of the WATS is needed. The most important results have been to stimulate basic research work and sensitivity in the field. To continue this dialogue and begin looking at mechanisms for training of field workers is very important. Although WATS has provided technical support, local field skills should be developed. We have come a long way and need to keep it up.

Open to the national representatives.

<u>JAILDAGIAN</u>: Further efforts should be encouraged to enlist the public and promote education, especially concerning beach protection.

<u>CHANG</u>: Pollution problems are of concern, especially a contract that will bring 200,000 tons of ash including 7 tons of heavy metals and other toxic products to Panama for construction of a road.

<u>FOSTER</u>: She mentioned three years of personal involvement in offering assistance to countries in establishing marine sanctuaries. The greatest need had been for advice in setting up educational programs. Materials have been put together on this and on creative financing. These are available on request from the U.S. National Representative.

<u>KAUFMANN</u>: The first meeting of the Parties to the Cartagena Convention will meet next week. All national representatives are urged to ensure that their government's delegation is prepared to address constructively the subject of special protected areas.

<u>CINTRON</u>: We tend to think in a piece meal fashion about sea turtles. We need to think holistically and design

the proper mixtures of legislation, education, and conservation.

<u>HALL</u>: Some national representatives believe that their governments may become concerned at the sheer number of meetings that occur. Perhaps fewer, but longer, meetings with sections devoted to particular species could be an answer.

<u>FINLAY</u>: Education is the way to go on island countries because you can reach the entire population. Despite socio-economic problems, the potential for public interest is strong and people's needs can change. He intended to meet with the USA national representative concerning assistance materials.

<u>BERRY</u>: As we get better at collecting data for management, we will be in a better position to promote public education. WATS sent a sea turtle manual to each of the 70 public schools in St. Lucia. Guatemala has decided to make 8 km of a 50 km long beach a sanctuary and ensure complete protection within the sanctuary.

The chair, in closing, noted that nothing had been said to the effect that the eight needs initially identified were not prerequisites to better sea turtle conservation and management. The chair summarized relevant points made by panel members and closed, noting that our efforts will surely be our legacy to the children of the world.

Management Options

A Philosophical Approach to Population Models
(Nathaniel B. Frazer)

Before I begin my discussion of management options, let me take just a few minutes to put some things into perspective. You've come to this symposium for many different reasons and from many different walks of life. We've spent the last few days discussing virtually every aspect of sea turtle management, biology and conservation. Let me assure you that it is not my intent to review or to repeat all that has been said. But before we decide what our management options are, we must decide what our management objectives are, and why we think it's important to manage sea turtles in the larger context of things.

I will limit my remarks to a consideration of management options only insofar as they relate to developing and caring for sea turtle populations as potentially renewable natural resources, for it seems to me that most of the national representatives gathered here today are looking for guidance concerning this approach to sea turtle management and conservation.

The manager of any natural resource must be concerned with several aspects of management. None of us operates in a vacuum, and each of us attempts to respond to the many, often conflicting, demands of society and of the natural world. The manager's concerns include, but are not limited to, the political, social, and economic needs of people as well as the biological requirements of the resource base.

Natural resource management requires many talents, and managers must display great patience and exercise skilled judgement. It's not a job for the weak-willed or for the faint-hearted. In attempting to manage a resource, we must make rules and regulations that are directed at our fellow human beings. We usually would not attempt to legislate behavioral changes in the resource itself. In the case of sea turtles, I would borrow a phrase from fisheries management and say that "Management plans manage people, not turtles."

Anyone who has been involved in policy analysis or implementation knows clearly that managing people requires compromise.

Fishermen--both artisanal and commercial--perceive that they need to catch fish (or turtles). From the standpoint of the resource manager, fishermen may view that the fish (or turtles) exist only for their use, and that there should be no limit to the degree to which they can utilize the resource. Even when this is not the case, there are other considerations to be faced. A fisherman in Belize, for example, told me that he understood the need for closed seasons on the lobsters and conchs that his government had written, but that these regulations were actually harmful to him if fishermen from neighboring states continued to enter Belizian waters to catch the lobster in the closed season. He perceived his government's regulations as giving someone else an unfair advantage.

To the government resource manager, the environmentalists must, at times, seem to be akin to religious fanatics and to exemplify the most uncompromising aspects of the environmental movement. I know that some of us take very strong stands on these issues--because we believe so firmly in our convictions.

Governmental officials may lean toward resource development and conservation but can find themselves working for a government that has other political interests as well. Sometimes one set of interests conflicts with another, causing internal strife within the government. I have seen this in my own country.

With focus on these social, political and economic concerns, biological realities are often ignored. There is a great danger here, because the resource manager is caught in the middle of a paradox: managing people requires compromise but biological reality defies compromise.

Let me explain what I mean by giving you a somewhat oversimplified example. Let us say that a turtle population produces 3,000 turtles/yr, that the fishermen want to take 6,000/yr and the environmentalists want to limit the catch to 2,000/yr. A political management compromise might be somewhere in between what the fishermen want and what the environmentalists want, say 4,000 turtles/yr. But if this political compromise violates the biological reality, the resource is not sustainable at the compromise level of exploitation.

Of course, economists may tell us that to deplete a potentially renewable resource is sometimes economically justifiable if calculations of short-term monetary profit outweigh the estimated long-term monetary return. However, this kind of reasoning seems to imply that another resource will always take the place of the one depleted. I don't believe that this is always true.

Nevertheless, whatever the political compromises are, clearly the biology of a species cannot be a party to these compromises if the species is to survive. In the time scale in which management decisions are made, biological realities do not change. If the demands we place upon a species are too great, it will not be able to adjust, and we risk losing the resource.

Thus, although we may become preoccupied with political compromise, the wise management of renewable living resources such as sea turtles clearly cannot ignore the basic biology of the species in question. I repeat that the biological realities cannot be compromised without risk of losing the resource for everyone.

In attempting to arrive at a reasonable management plan for the recovery and controlled exploitation of sea turtles, we must do the following: reduce natural mortality; reduce incidental catch and regulate intentional take, which will require us to conduct stock assessment and determine the sustainable yield. That is, we must ask "how many are there?" and "how many can we take?" Much of what you have heard at this symposium thus far concerns various methods which have been proposed to bring about one or more of these objectives. All of them constitute management options that are available to us in our attempts to accomplish these three tasks. In preparing to address these tasks, two points become obvious after a little consideration. First, management options depend upon the biology of the species and second, management decisions are based upon population models.

The first of these is clear from what I have said before. If management options are not derived from biological realities, then all of our political compromises vanish in the wake of resource depletion. The second statement may not be as clear. Note that I have chosen my words very carefully here. I do not say that management decisions should be based on population models. I maintain that management decisions are based on population models. They were based on population models in the past, are now, and will continue to be in the future.

For some of you, this may seem to be a strange thing for me to say. Each of you probably has his or her own favorite management scheme. You may be saying to yourselves right now, "I don't base my management decisions on a population model." I'd like to argue that all of us do base our management decisions on population models, even if those models are hidden, tacit or somewhat inexplicit. I'll use headstarting as an example of what I am talking about, since the general idea is familiar to most of you. Please note that I do not intend to single out headstarting as being in any way especially wrong, misguided or inferior to any other management scheme. I am simply using it to illustrate a point.

If one is an advocate of headstarting, then I maintain that one bases management decisions on a population model, even though the model may not have been developed intentionally as a model or with the degree of explicitness that we usually associate with mathematical demographic computer models. There are several assumptions that are inherent in the underlying headstart model, just as there are in any other model. At some level, the decision for headstarting is based upon the following three mathematical relationships. Survivorship of captive turtles during the first year of life (that is, from the time the eggs are gathered on the beach until the time the yearling headstarted turtles are released) is greater than or equal to the survivorship of wild turtles during the first year of their lives. This is the basis of headstarting programs, and it does express a mathematical relationship even though the survivorship is usually not expressed as any particular quantitative measure. A second assumption is that survivorship of captive turtles after their release is greater than or equal to the survivorship of wild turtles after their first year of life. And finally, the third assumption is that the fecundity of headstarted turtles upon reaching adulthood is equal to the fecundity of wild turtles.

The first of these three model statements, that survivorship from egg to release of yearlings is greater than or equal to survival in the wild, might be easily shown to be true. However, I do not know of any study that has compared natural mortality (from the time eggs are laid to the end of the first year of life) to mortality of headstarted turtles reared from eggs gathered on the same beach.

The third statement, that fecundity of headstarted turtles upon reaching adulthood is equal to the fecundity of natural turtles from the same population, might reasonably be assumed to be true. [Although one must be aware of possible effects of temperature on the incubation of the eggs, imprinting, and other possible, but as yet unknown, effects].

About the relationship expressed in the second statement, that survivorship of headstarted yearlings released into the wild is equal to or greater than survivorship of wild yearling turtles, we know very little. We do know that headstarted turtles can survive in the wild after their release. But do they survive as well or better than their wild counterparts? We do not know. If they do not survive as well, does the presumed increased survival during the first year of life in captivity make up for the decrease in survival later on? Again, we do not know.

Yet those who headstart turtles rely on these mathematical relationships, or some combination of them, when selecting this management option. Even if such mathematical relationships are not stated explicitly when the decision is made to select headstarting as the management option of choice, this population model lies hidden within the assertion that headstarting is better than not headstarting. The important point that I want to make here is that headstarting is based on an underlying mathematical population model whether or not those who headstart turtles are aware of this or are willing to admit it.

As I said, my purpose is not to criticize headstarting projects or those who run them. My purpose is to show that any management effort we are using is based, even if unknowingly, upon a mathematical population model. The same argument could easily be shown to apply to hatcheries, the implementation of TEDs, the setting of size limits on harvests, or any other management decision that has been made.

In the past, when some of us have called for the development and implementation of explicit mathematical population computer models to help determine management options, opponents have said things like: We don't have enough information to develop population models or it's too early to base management on population models.

Well, as I have shown, current management practices are already based on (tacit) population models. To those who say "We don't have enough information to develop population models," I find myself asking "Why do current (tacit) models ignore information that is available?" To those who say, "It's too early to base management on population models," I ask, is it too late to base management decisions on more explicit population models?

Some of the current, informal models guiding our present management decisions may not be based on the best information available, or may be based on only a portion of the information available. We must base our management decisions on explicit population models that incorporate all we know about a particular species. Where specific information is lacking, well constructed models that incorporate general knowledge about sea turtle population attributes can be used to determine just how critical the missing information is and how sensitive the predictions of the model are to inaccurate information.

Inexplicit, vaguely constructed models, put into use by those who do not recognize or admit that they are using models, are potentially counterproductive and will continue to limit our ability to assess which management practices should receive credit for any observed increase in sea turtle populations and which should receive blame for any decline.

It is possible to incorporate all we know about a species or a given population into a model. This is not to say that we now know everything we need to know. But by being explicit in spelling out our models and the values we incorporate into them, we can continue to build better models as more information becomes available.

As I see it, our main decision in addressing the question of management options at this point is this: do we continue to use implicit, unspecified population models in making management decisions, or do we begin to use explicit, clearly-specified population models in attempting to make management decisions?

The formal models require explicit quantitative input values. In order to make mathematical computer models, assumptions must be clarified and stated. Investigators in this field are usually required to state just how the input values were derived so that others who disagree can modify the scheme to incorporate their own methods of assessing the quantitative biology of the species.

Incorporating all known information into a complete model makes it possible to conduct sensitivity analyses to determine how sensitive predictions are to inaccurate or unavailable data. The models generate testable hypotheses in the best scientific tradition. And finally, new information is easily added to such a model.

In short, explicitly constructed mathematical models serve to clarify our thinking. As you can imagine, the explicitness of the formal models and the requirement that we divulge our thoughts about how things fit together and where all the values come from makes them easy to criticize (and easier to correct, I might add). But clear, constructive criticism is not to be shunned or hidden. It is the strength of science, and we should welcome the scrutiny of others.

On the other hand, the implicitness and subjectivity of the current informal models make them more difficult to criticize in any productive way, since builders of this type of model do not have to tell us the specific assumptions they make or the particular values, if any, that they place into the underlying mathematical relationships upon which such models rest.

Two very explicit, carefully constructed formal models of the new type are available. One has been used to carry out stock assessment based on nesting female surveys. K. Eckert provided a modification of the classical Jolley-Sever method for population estimation specifically to incorporate the peculiarities and irregularities of sea turtle reproductive behavior. The other model has been used to assess the probable effects of various management options (hatcheries, TEDs, protecting adult females, protecting subadults, etc.) on a loggerhead population. D. Crouse (also here on the panel) has provided a modification of the classical model of population dynamics. Crouse's model will appear soon in the scientific journal Ecology, after having received constructive critical review by some of the leading ecologists in North America, and I believe that Eckert is preparing her model for publication as well. I know she has presented it at the 50th anniversary meeting of the Association of Southeastern Biologists and has sought constructive criticism and input from colleagues. We must look in the future to investigators like these to achieve any real progress in the assessment of management options for sea turtle conservation.

In closing, let me "get out on a limb" and say that I believe that we know enough about sea turtle biology in general to make certain recommendations concerning management options for their exploitation. For example, we know that all sea turtle species are relatively long-lived, late-maturing animals with high fecundity, high juvenile (and egg) mortality and low (natural) adult mortality. We also know that each of the species is iteroparous both within and between years. (For those of you who don't speak biological Greek, that means they reproduce more than once.) The different sea turtle species may vary somewhat, but all of them exhibit these traits in their basic life histories. For some species, such as loggerheads, we have pretty good data concerning numerical values for each of these aspects of their biology.

I'd like to share with you the results of a population model based on data gathered over the last 25 years on loggerheads off the Atlantic coast of the United States.

In Figure 1, I have attempted to incorporate all we know about loggerhead population biology. I want to stress one thing here and I'm sure that this statement will be controversial and that some (or perhaps all!) of the panel members may disagree. Nevertheless, all I intend to say about Figure 1 and about loggerheads pertains to other sea turtle species as well, because even though their population ecology differs in minor ways, they all have basically the same life history strategy, and this enables us to make certain generalizations about them.

First, I'd like to tell you what this figure says to me about management options, and then I'd like to throw it open to a discussion of management options by the panel.

The figure illustrates a concept called "Reproductive Value," which is a measure of the value to the population of an individual female turtle of a particular age. Reproductive value represents the present value of any future offspring that she is likely to have, given her chances of surviving, and the number of offspring she is likely to have if she does survive.

Simply stated, the V(x) or vertical axis from 0 to 500 represents an index of how valuable an individual is based on her future reproductive contribution to the population. The upper and lower curves represent two different models. The lower curve is for a population that is stationary (that is, neither growing nor declining). The upper curve is for a population that is declining.

For both populations, the figure tells us that an individual of age 5 is not very valuable, whereas an individual of age 30 is very valuable. A five-year old has little chance of surviving to adulthood to reproduce. A thirty-year old has already survived to adulthood and is reproducing. Hence, her value is greater. Also, one egg is not very valuable. An egg has only one chance in 1,000 of surviving to adulthood.

Note how the value increases rapidly for older juveniles just before they become adults, since they've already survived the high juvenile mortality stage and are very likely to achieve adulthood.

The exact values upon which these models are based will change as our knowledge of survival rates, fecundity, and age at maturity improves, but the general shape of the curve is not likely to change. For example, these models are based on an age of maturity of about 23 years old. If it is actually younger than that, the curves will shift to the left, but retain the same shape. If the age is actually older, the curves would shift to the right, but still retain the same shape. That is, older turtles will still be much more valuable than younger turtles.

These curves allow me to make certain recommendations concerning management options for sea turtles. Let's assume for the moment that we are absolutely determined to harvest this resource. What does the slide tell us? It tells us that our management options are limited. We clearly should harvest eggs instead of turtles, since an individual egg is not very valuable to the population. Of course, we would then want to reduce natural mortality of eggs and also reduce any incidental take or accidental destruction of eggs, so that we could maximize the harvest and minimize the impact on the population.

After all, even though an individual egg is not very valuable to the population, turtles can come only from eggs, and more eggs can come only from turtles, so we don't want to overharvest in any case. Since turtles are "designed" for low juvenile and egg survival, we might be able to take eggs without destroying a population by substituting human predation for the natural predation, with which the turtles have evolved to cope. Also, due to environmental effects, there are those "doomed" eggs that N. Mrosovsky keeps talking about -- eggs that are laid in places where they are in danger of being washed away by high tides, etc. We might be able to take all "doomed" eggs, which presumably represent "extra" eggs that would not become turtles anyway.

In terms of the turtles themselves, the slide tells us that we must leave the larger juveniles and adults alone. Each of them is extremely valuable to the population, and every one we remove takes a lot of value from the population. Even if we are headstarting and releasing turtles into the population, we'd better not harvest any large juveniles or adults unless we are absolutely certain that the headstarting is working.

Finally, if we are absolutely unwilling to stop taking the turtles themselves, then the figure directs us to another management option to minimize the impact of our harvesting. We must establish size limits. But the figure tells us that we've been doing this incorrectly for over 350 years. We should not set a minimum size limit to protect small turtles. We should set a maximum size limit to ensure that large turtles are not taken! We must restrict our fishermen to taking the smaller turtles of lesser value to the population. Unfortunately, these small turtles are likely to be of lesser value to our fishermen, as well.

I stress that these answers are based on the biology of sea turtles. The questions assume that we are unwilling or unable to resist harvesting sea turtles or their eggs.

Please do not misunderstand me. I am not advocating any of these harvests. Sea turtles are declining, and if we continue to harvest them and to destroy their habitat, they will disappear, and the potential for the resource will be lost. The wisest move to ensure the presence of the resource base in the future would probably be to institute a moratorium immediately until their populations recover.

If turtles must be harvested then following the dictates of the best models we now have will minimize, although not eliminate, the impact of your harvest on the continued existence of the turtle populations. That is, the models may enable us to destroy the resource base a little more slowly.

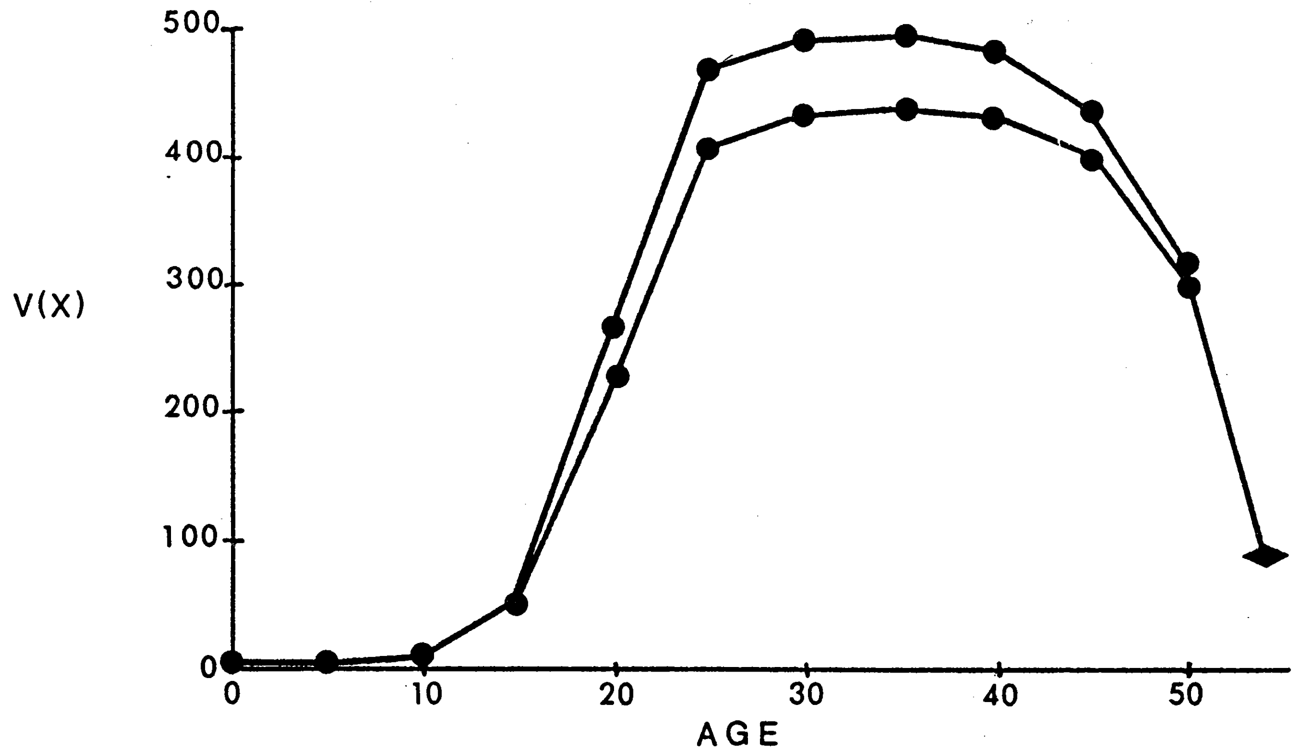


Figure 1. Loggerhead (Caretta caretta) population biology model.

Management Options

Rapporteur Report of the Management Options Panel Session

CHAIR: Horace Walters, Ministry of Agriculture, Land, and Fisheries, St. Lucia

SPEAKER: Nathaniel Frazer, Mercer University, USA

RAPPORTEUR: Charles Karnella, National Marine Fisheries Service, USA

PANEL: Tundi Agardy, Woods Hole Oceanographic Institution, USA

Karen Bjorndal, University of Florida, USA

Jeffrey Canin, Greenpeace International, USA

Deborah Crouse, University of Wisconsin, USA

Arthur Dammann, St. John, U.S. Virgin Islands

Karen Eckert, University of Georgia, USA

Nancy Foster, National Marine Fisheries Service, USA

John Jeffers, Montserrat

Rhema Kerr, Jamaica

Rene Marquez, Proyecto Nacional de Tortugas Marinas, Mexico

Nicholas Mrosovsky, University of Toronto, Canada

Edith Polanco, Directora General de Administracion de Pesquerias, Mexico

Joe Parsons, Department of Agriculture and Natural Resources, Cayman Islands

James Richardson, University of Georgia, USA

Ralph Wilkins, Ministry of Agriculture, St. Kitts

The chair introduced N. Frazer who discussed management options and issues and presented a model for managing sea turtle populations. The chair then asked each of the panel members to provide comments on management options and related topics.

<u>AGARDY</u>: In the northeast United States, sea turtle conservation is perceived to be someone else's problem. In third world countries, sea turtles are harvested for food and other uses, and in the southeastern United States the incidental take of sea turtles in shrimp trawls is a problem. The leatherback is a northeast U.S. problem. Adult mortality is generated in the northeast. Leatherbacks ingest plastic and other pollutants, and interactions with ship traffic are increasing. Strandings are seen as a northeast problem. These losses are having adverse affects on recruitment. We must try and convince everyone that sea turtle conservation is a shared problem, and that we must work together to conserve sea turtles.

<u>BJORNDAL</u>: A commonly proposed management plan for olive ridleys calls for taking the so-called doomed eggs or the eggs from the first arribada because of the damage to the nests from subsequent arribadas. S. Cornelius at Nancite, Costa Rica, has shown that following such a plan would result in harvesting the only eggs that would have hatched. We must be careful to ensure that general management plans are appropriate for the specific locality where they will be implemented.

<u>CROUSE</u>: People are concerned about using models when few data are available. However, the sensitivity of these models with respect to data gaps can be evaluated. This will help us decide which data are needed to make management decisions. Large juvenile sea turtles have reproductive value and are the next breeding stock. If harvesting is absolutely necessary, then it should be confined to smaller juveniles, which have a lower reproductive value.

<u>DAMMANN</u>: He had been trying to select and justify management options for a number of years. If turtles absolutely must be harvested, then this becomes a fishery management problem. Can we tell from available data--i.e., a reproductive decrease--when senility occurs in sea turtles?

Under fishery management and economic concepts, not harvesting post-reproductive individuals is wasteful.

<u>FRAZER</u>: This was an excellent point. No one has presented convincing evidence of senility in sea turtles.

<u>DAMMANN</u>: Most living things appear to undergo senility.

<u>ECKERT</u>: What is the status of the remaining sea turtle populations in the Caribbean? We know that there have been local extinctions. The population trends in this region need to be determined. Are they increasing, stable, decreasing? How can the status of these populations be determined given the existing data? Turtles have varying cycles. What percent of adult females breed in any given year? What effects has harvesting these turtles had on the populations?

Saturation tagging programs must be continued for more than a decade to get reliable information on what is happening in these populations. Despite these data gaps, something must be done to protect sea turtles. Priority must be given to protecting the adult females. If there must be a harvest, then the smaller, less reproductively valuable, sea turtles should be used. Also, any schemes to regulate or control taking of sea turtles should be applied in all the countries in the area.

<u>FOSTER</u>: Based on what was said, there is really only one option. Another category should be added to N. Frazer's list of realities--Management Realities.

The national representatives have said that enforcement already is a problem. A take option based on size will add to these enforcement problems. Decision makers give great weight to economic and social realities. Models should be a real help to them in making hard decisions.

<u>KERR</u>: Support was given to what N. Frazer said. To undertake realistic management options, administrators must have good information. Our scientists and their research must fully be supported. In Jamaica an education program needs to be developed to inform the people about the benefits of conservation programs. This will help reduce the mortality of sea turtles in our area.

A moratorium may be the least complicated way to approach the conservation of sea turtles.

<u>MARQUEZ</u>: Many of us had worked with models, but reliable data on which to base these models are needed. The size at maturation or first breeding for most sea turtle populations is still unknown. Some estimates have been made on the various sources of mortality. This information can be used in models to help determine the most useful management options.

N. Frazer's model is very logical, but how can fishermen be made to understand it? If you were to tell them to take only small turtles, they would laugh. Most fishermen will take a turtle if they come across one. They use the turtles for food. It would be very difficult to apply these models in most of our countries.

In Mexico, people now are more aware of the decline in sea turtle populations. This information appeared on television and radio and in the newspapers. All the fishermen know that taking sea turtles is prohibited, but they still will take one home to eat if they see one.

<u>MROSOVSKY</u>: Emphasis should be on positive actions rather than saying that people can't take turtles. The economic value of the resource should be explained to show people what benefits they will derive from the resource. The scheme in Costa Rica is very practical.

<u>RICHARDSON</u>: Decision makers have an enormous responsibility with turtle conservation. The need for being very conservative at this stage should be stressed. Scientists do not have all the data required to make the models totally predictable. Managers will still have to rely on their intuition somewhat. Other values such as esthetics should be considered in this model as well. Other social values should also be considered.

<u>POLANCO</u>: Implementing fishery management regulations is a conservation technique. Actions should be based on the best available data, and efforts to develop adequate data bases must be continued. Full consideration to new techniques in the area of conservation should be given.

JEFFERS: Industry must be involved.

WILKINS: N. Frazer's model was supported. Not only scientists but fishermen and others who may be affected by this model should be consulted. Training and public education programs must be considered.

PARSONS: He is a manager responsible for making some of these decisions. Information from scientists is needed to help us make these decisions. When we go to them, they tell us that they don't have the information we need. This group should focus on specific management options and fully discuss them, for example, captive breeding programs.

CANIN: He supported what N. Frazer said. The moratorium should stimulate some debate. If the moratorium gains momentum, more control on the taking of turtles will be attained. Even a limited moratorium will give us time to educate people to use smaller sea turtles. High levels of incidental take in certain areas, beach modification and destruction, and ocean debris are also problems. More must be done to stop the killing of adult sea turtles.

BURNETTE-HERKES: N. Frazer's model showed a decline in reproductive value at 50-60 years. Can he give us an explanation for this?

FRAZER: That may be an artifact resulting from assumptions that were made. The data show that adult female loggerheads have a year to year survival rate of 80%. Since turtles do not live "forever," some assumptions were made with regard to when they die. This decline implies nothing about senility.

CHARLES: Fishermen and beach walkers who take sea turtles for food are not dependent on these turtles. These people must be educated as to the importance of sea turtles. A closer look at the moratorium must be taken.

Perhaps this is not the best way for small islands to handle turtle conservation. Shortening the taking season for turtles may be better.

MOHADIN: According to N. Frazer's model, if taking sea turtles is necessary, then eggs should be taken. How many eggs can be safely taken?

FRAZER: First natural destruction would have to be determined and human taking would have to be limited to that level. If eggs and the other stages are harvested, any harvest of eggs is too high. If the other stages are protected then some eggs can be taken. However, under this model any takings will eventually deplete the resource. This will take longer if only the eggs are harvested. He wanted to make it clear that he was not recommending any harvesting.

CINTRON: Basically the more endangered a species is, the fewer the available options other than complete protection. Developing a model and an adequate data base takes time. These resources are near biological depletion. How do we apply here a model that was developed in Woods Hole? This model uses many subjective evaluations, perhaps some are not correct. If the model were applied to a healthy resource, we might be able to recover from any mistakes. However, if the model were applied to a depleted resource, we may end up making the situation worse.

N. Foster's approach was favored. Management realities have to be faced. Models should not take the place of common sense.

FRAZER: Any management scheme has a model. What is important is that the assumptions that are made are specified so that others can see what our mistakes are. Mathematical models will not solve all of our problems.

CRUZ: Highlighting the accuracy of the information is important. the situation must be accurately known. Some turtle mortality is due to shrimp trawling, poaching and pollution. However, the principal cause is not certain.

Extreme measures, such as the moratorium, may do more harm than good. The taking of sea turtles in Mexico was greatest after these takings were prohibited.

Sea turtles are totally different than whales. Anybody can catch a turtle. This is not the case with whales. Enforcing the moratorium for sea turtles would be far more difficult than for whales.

Shrimp trawling may possibly be the principal cause for the decline in sea turtles, but other causes are known. An integrated research plan to address this problem is needed.

<u>GARCIA</u>: Could the take of hatchlings by predators be increased if some eggs were moved to another area? Would predators in the original area take all these remaining hatchlings? For example, say there are 500,000 eggs, and natural predators in the area would take 250,000. If 250,000 eggs were moved to another area, then would the remaining 250,000 be lost to predators? Most of those moved could also be lost to predators in the new area.

<u>FRAZER</u>: This was not an easy question to answer. Some information about predation at the nest is available but none for hatchlings in the water. In general, vertebrate predators tend to react to the availability of prey. Predation usually is thought of in terms of some percent of the prey species. This value may change with prey density. By reducing the number of hatchlings in an area, predators probably wouldn't eat them all.

<u>NATHAI-GYAN</u>: A complete moratorium should be supported, otherwise people will catch the sizes they are not supposed to and this will complicate enforcement. Our enforcement officers already have a morale problem. Something should be done to boost their morale.

<u>HORROCKS</u>: The course shown by N. Frazer is based on a population of known exploitation. If adults have a high reproductive value, an upper size limit on taking might be dangerous. The curve depends on the probability of survival. If juveniles are exploited, then the curve may change because juvenile survival has changed.

FRAZER: If the survival of younger animals is lowered, then the relative reproductive value of adults will increase. Although we worked with a population that was not internationally exploited, almost any reduction in juvenile survival was found to increase the relative reproductive value of adults.

CROUSE: Agreed with N. Frazer. Most changes will not affect the general shape of the curve. It may be higher or lower but the shape is pretty much the same for nearly all changes.

FRAZER: In a declining population, the relative value of adults is higher than in a stable population.

PARSONS: Fishermen don't go strictly by numbers. They will take 10 small turtles in place of one large turtle. Also, enforcement costs are much greater for something like this. The additional costs may come from research funds.

CANIN: The moratorium must be accomplished through public education. The local people must be told what they will miss if they don't conserve the resource.

LAWRENCE: The practicality of using this model must be considered. N. Foster and R. Marquez made good points on this. N. Frazer did not present a complete package. He should try to see how practical it would be to explain this model to someone who uses sea turtles as a source of food. This model may make sense in larger areas, but not on small islands.

BOULON: If the moratorium were put into effect, it would be very good for sea turtle populations in this region. However, all countries would have to support it to make it work.

GILLET: The arguments about the moratorium will go on for a long time. Dr. Frazer's model probably is a good management tool. The countries must work together to decide what the size limits for taking sea turtles will be. This size limit must apply throughout our region if it is to work.

__MARQUEZ__: There are going to be problems implementing it. In Mexico, if we put a size limit on olive ridleys of say 30-40 cm, fishermen will think that we are crazy. This model probably is not applicable to all species.

__FINLAY__: He thanked N. Frazer for presenting his management option to us and agreed with him. Models are used whether we think so or not. With education, the closed season initially could be extended for sea turtles and then a moratorium could be implemented. A dramatic decline of sea turtles has not occurred in some areas. In those areas a moratorium may not be necessary. In Mexico and South America, a moratorium is years away. In Grenada the closed season should be lengthened for two years and then a moratorium should be implemented.

__ECKERT__: That was done 8-9 months ago in the British Virgin Islands, and eventually people may get used to the idea. Why are we afraid of a backlash from fishermen? They already have fisheries regulations that they must live with. The way marine resources are exploited in general may be wrong.

__AGARDY__: The cause of sporadic declines in local areas needs to be determined. Are they natural fluctuations or are they real declines in populations? Tagging and genetic studies can provide valuable information on this.

__CINTRON__: These models are just a series of approximations, and must be applied to sea turtle populations extremely carefully. Our experience should be the basis for determining which management options to implement and for adjusting the models to this experience. The models can also be used to test the effects of management rather than to determine choice of management options.

__BURNETTE-HERKES__: Bermuda has been manipulating sea turtle stocks for 350 years. In 1973 a moratorium was put into place. This has been very expensive to do but it was worth the cost to preserve our sea turtle stocks.

___?___: N. Frazer's presentation was based on population models. This must be put into language that the public can understand. This needs to be done especially for developing countries. What are the effects of long term harvesting of eggs and young?

<u>FRAZER</u>: The long term effects of harvesting eggs, juveniles, and adults would be to deplete the resource very rapidly. Harvesting eggs and juveniles would deplete the resource more slowly. Harvesting only the eggs will deplete the resource more slowly still.

<u>HALL</u>: Some places may choose to impose a size limit on taking sea turtles rather than a moratorium. The national representatives need to understand N. Frazer's reproductive model to explain it to fishermen and other appropriate people when they return home.

<u>MOTERO</u>: N. Frazer's model was supported, but the model must be explained to the people affected by its implementation.

<u>DUTTON</u>: As talk about the moratorium continues, the problems with the incidental take of sea turtles must not be forgotten.

<u>ROSS</u>: Lots of data show sea turtle populations don't shift from one area to another. Local declines cannot be explained. Something to prohibit trade in sea turtles and their products must be done.

<u>OGREN</u>: Green turtles have been tagged at the Tortuguero rookery for over 30 years. About 30,000 sea turtles have been tagged at Tortuguero, and not one has been found nesting elsewhere--a strong case for philopatry.

<u>CHAIR</u>: The chair has been thoroughly educated in management options and now has to evaluate how the various options could apply in his area. How these options could apply in more detail must be discussed with colleagues and other interested parties.

The migratory patterns of sea turtles need to be studied to determine if a world wide moratorium on sea turtles is needed. The political issues and scientific aspects of the various management options must also be discussed. The panel was thanked for a stimulating discussion.

Management Research Needs

An Overview (Frederick H. Berry)

Much more research and data are needed if we are to begin to effectively manage and protect sea turtle populations. Problems exist with obtaining adequate personnel and funding to conduct, compile, and convey this research. Obviously, research needs should be prioritized, existing research plans should be publicized, and research results should be compiled and distributed expeditiously.

One of the best examples of prior lack of research planning relates to research done on sea turtle life history. While the average sea turtle spends perhaps one one-millionth of its life on land, only about one one-thousandth of the past research conducted has been done on sea turtles in the water.

The Executive Committee of WATS II presented the research emphasis for data collection in two important areas:

1) Continue monitoring sea turtle nesting on the major nesting beaches for *Chelonia mydas* (Costa Rica), *Lepidochelys kempi* (Mexico), *Lepidochelys olivacea* (Surinam), *Dermochelys coriacea* (French Guiana and Costa Rica), *Caretta caretta* (Florida), and for *Eretmochelys imbricata* in its more dispersed nesting everywhere it occurs.

2) Documentation of sea turtle mortality, especially exploitation of subadults, adults, and eggs and destruction of nests by any factors.

The Program Planning Committee of WATS II requested the presentation of speeches in six areas of sea turtle management needs:

1) Surveys on the beaches
2) Surveys in the water
3) Beach Habitat
4) Marine Habitat
5) Natural Mortality
6) Population Biology

Management Research Needs

Monitoring Nesting Beaches (Thomas A. Murphy and Sally Hopkins-Murphy)

Introduction

The basic methodology for conducting aerial and ground surveys of nesting beaches is contained in "The WATS Manual of Sea Turtle Research and Conservation Techniques." This paper will augment that chapter since more detailed information has been gained since the manual was published. Much of this information is based on 11 years of ground surveys, 8 years of aerial surveys and 10 years of telemetric monitoring of loggerheads, principally in the state of South Carolina, U.S.A.

Monitoring of beaches will be divided into four survey types. These include: (1) ground surveys conducted to tag nesting turtles, (2) ground surveys to record turtle tracks on the beach, (3) surveys conducted to document hatching success, and (4) aerial surveys of turtle tracks.

Tagging Nesting Turtles

The most traditional beach monitoring has involved the tagging of nesting turtles on the beach. Such surveys provide information on nesting effort and allow the calculation of statistical estimates of a variety of reproductive attributes. The number of nests laid by an individual female per season, the internesting interval, nest site fidelity, as well as recruitment, survivorship and remigration intervals are such attributes. The accuracy of these statistical estimates are greatly influenced by survey efficiency, size of the survey area, seasonal coverage, tag loss, number of survey years, methods used and consistency of data collection. All tagging studies need to be carefully documented and as standardized as possible. After decades of monitoring, many of these statistical estimates need verification using alternate methods such as telemetry.

For example, the number of nests per season for loggerheads is frequently reported between 1.9 and 2.1. This is a minimum number and is related to survey efficiency, size of the study area and the mean distance between nest sites of an individual female. If nesting turtles are missed by survey personnel, if all nights are not surveyed, if the entire nesting season is not monitored or if the size of the study area is too small, the number of nests per female will be underestimated. Except for a few surveys of very isolated islands, there is always an edge effect. This effect is a result of turtles which nest perhaps once within the study area, but nest principally outside the study area. In areas where efficient coverage of extensive areas has been accomplished the number of nests per female per season exceeds three (Richardson 1982; C. Limpus pers. comm.).

In addition to reproductive attributes, movements of tagged females may also be determined by recaptures of tagged turtles. This can provide information on survivorship, feeding areas and migratory routes. In this case sample sizes may be small and may be biased by recoveries from areas where turtles are frequently captured or killed, as opposed to the real proportional use of areas by turtles.

One major disadvantage of a tagging project is that it is labor intensive. For species such as the loggerhead, much of the gathered data will be redundant of information widely available from the literature. Statistical estimates of attributes such as remigration interval usually require several years of surveys to obtain, and information on recruitment may require more than a decade of surveys.

The final aspect of tagging studies which is frequently overlooked is the effects of disturbance on nesting turtles. During 1984, the authors telemetrically monitored the effects of beach disturbance on 11 nesting loggerheads. We repeatedly interrupted the terrestrial emergences of gravid loggerheads. This disturbance resulted in increasing the internesting intervals, poorer nest site selection and extensive nest site relocation. It was also apparent that the farther along in the nesting behavior a female was when disturbed, the greater the level of disturbance that was necessary to cause an abort of the nesting attempt. Thus, much of the effect of beach disturbance on nesting loggerheads occurred while the turtles were still in the ocean and, thus, would go unnoticed by tagging personnel on the beach.

This is not a condemnation of tagging. But before beginning a tagging project, one should carefully determine the project goal, the duration of the project and the allocation of resources to the project. One should also determine if the project will produce the desired information in the time allotted. Experimental results are frequently more interesting and useful to the management and recovery of a species. Alternatives such as telemetry should be considered.

Ground Survey of Tracks

Information on nesting distribution and nesting density may be obtained using morning surveys of turtle tracks. This is relatively inexpensive compared to tagging and results in no disturbance at night to nesting turtles. Morning ground surveys may be easily combined with projects designed to document nest fate and implement or evaluate beach management activities such as predator control. If resources are limited and surveys cannot be made daily to gain a total nest count, several alternative methods are available. First, nests can be marked to obtain a sample of the nesting effort. Second, if nests are marked, then nests laid since the last survey can be determined. Thus, by the second method the beach can be surveyed every other day or every third day depending upon local weather conditions, and a total nest count can still be obtained. In this latter case, track duration under different weather conditions would have to be determined to ensure that the survey schedule was often enough to find all tracks.

Typically, tracks may be evaluated as resulting in egg laying by the presence of a body pit, thrown sand, signs of covering and/or uprooted vegetation. The majority of tracks will either have no body pit and are thus a false crawl (non-nesting emergence), or are stereotypic nesting sites. A small percentage of tracks will have an atypical or unclear body pit and should be carefully probed to determine whether an egg chamber is present.

Some differences between data on turtle tagging surveys and data on ground surveys of tracks should be expected. For example, false crawls which are low on the beach may be washed out prior to the ground track survey. Track signs may also be obliterated by wind or rain, and a few nests may not be located despite extensive probing. In addition, tracks may become impossible to interpret on high density nesting beaches where body pits are disturbed by other nesting turtles. Tracks can also be difficult to read on beaches with extensive rock or on beaches consisting of shells. However, in most cases, careful observation, thorough probing and early morning surveys lead to an accurate appraisal of nesting effort. The major disadvantage of ground surveys of tracks is that they provide limited information on nesting turtles as a group or as individuals. The major research needs of ground surveys is how to standardize surveys and how to compare surveys conducted at different daily frequencies. We need to evaluate the utility of ground surveys for monitoring the status and trends of populations and the value of ground surveys for extrapolating and verifying aerial beach surveys.

Monitoring Hatching Success

Surveys to monitor hatching success may be conducted independently or along with ground surveys of nesting. Nests should be marked so that they can be monitored during the entire incubation interval and located if hatching does not occur in a reasonable time. Factors affecting hatching may be divided into biotic and abiotic. Biotic factors include: poaching, predation, destruction by other turtles, damage by invading root systems, fungal infection, and disturbance associated with a variety of human activities from sand compaction to sand mixing. Abiotic factors include: sand accumulation, inundation by rain or salt water, or erosion.

Monitoring hatching success can identify the type and extent of management required on a nesting beach. These surveys are also important in evaluating the effectiveness of management practices which are currently being used. It should be remembered that when one source of nest mortality is eliminated through beach management, the effect of another factor of nest mortality increases. For example, if 90% of the nests are being depredated by a predator (including man), the removal of the predator or the protection of the nests will not result in a 90% increase in hatching. Other factors such as tidal (salt water) flooding of nests will affect a greater number of nests. This increase in the effects of alternate sources of nest mortality, when one source is controlled, is due to the fact that nests are vulnerable for a longer period of time. Because of this compensatory effect, it is advisable to evaluate beach management practices by continuing to monitor hatching success.

A quantification of hatching success is an important indicator of the status of a sea turtle population. While hatching success is usually calculated during the operation of a hatchery, there is very little quantitative information on hatching success on unmanaged beaches where man is neither a positive nor a negative factor. Thus, we don't know the level of hatching success required to maintain a stable population, although hatching success >50% would appear to be normal on most natural beaches.

Annual hatchling recruitment is also an important statistic in the development of useful, predictive models. Hatchling recruitment may be determined for an individual island or, more importantly, should be estimated for an entire region or population. These models are, or at least may become, important in predicting population trends or in developing management plans. The development of reliable predictive models is particularly important for long-lived species such as sea turtles with characteristic deferred maturity.

<u>Aerial Surveys of Tracks</u>

The principal use of aerial beach surveys has been to locate previously unknown nesting beaches or to survey remote or inaccessible nesting beaches. Aerial surveys also appear to be the most cost effective method of conducting surveys of extensive areas (>100 km). As the flight frequency increases, a documentation of important nesting beaches becomes more complete, and we eventually obtain a relative distribution of nesting. If flights are conducted frequently enough to correct for daily and seasonal fluctuations in daily nesting effort, we can calculate an index to the population which may be used to make comparisons of population trends. These comparisons are frequently used as three-year averages depending on the remigration interval. Quantification of survey samples, information on daily nesting effort for an entire season, and documentation of the number of nests per female per year will allow the calculation of estimates of numbers of nesting females.

To determine the number of nesting turtles during the previous night, the age of tracks is required. Attempts at calculating mean age of a track seen from the air is futile as it varies dramatically from day to day and between areas. In addition, the visibility of old tracks seen from the air varies considerably depending on light conditions, beach substrate and track concentrations. The ability of aerial observers to correctly count only fresh tracks (<24 hrs old) based on track appearance has been consistently shown to be inadequate when subjected to ground verification. With little wind and no rain, fresh tracks are frequently difficult to discern from old tracks when on the ground much less from the air. To resolve the problem of aging fresh tracks correctly, we conduct our aerial beach surveys on a specific tidal cycle. We fly at first light on the morning after the high tide occurs around 2130 hrs. Thus all lower portions (below mean high water) of old tracks have been erased by the tide and all turtles nesting that night will leave tracks between the high tide line and the waterline. Only tracks in this intertidal zone are counted as fresh, and thus during each flight only one 24 hr interval of nesting is monitored. Using this tidal cycle, we could conduct three surveys every two weeks of the season. This tidal technique results in a less than 3% error in the aging of turtle tracks.

Once the flight sample is quantified as to the days surveyed, the daily distribution of nesting will allow estimates of total nesting effort to be calculated. This may be obtained from nesting records which are available from one or more areas where daily ground surveys are conducted. These islands or beaches must be an adequate sample of the total survey area for the extrapolation to be reasonable. In place of single areas or single years of ground truth, which may be much more variable than the daily fluctuations of the extensive aerial survey areas, we have combined daily nesting records for all areas and all years to construct a composite nesting curve which does not show the extensive day to day fluctuations usually seen on a single area. This composite curve currently represents 40,000 nesting events of loggerheads in the southeastern United States. The composite nesting curve also allows an estimate of the expected percent sample using various flight schedules.

Management Research Needs

Research on Sea Turtles in the Water Needed for Management (Nancy B. Thompson)

Introduction

The needs of a manager to manage completely any resource are: (1) the bounds of the unit stock; (2) whether each stock is increasing, decreasing or stable over time; and (3) what is causing any trend or change in abundance. Only with this information can prudent management plans be developed. Various sampling methods applied to collect information on turtles in the water provide information which address each of the three identified management needs.

Turtles are unique aquatic organisms, because they all spend at least a very brief period of time on land. However, except for adult females, the vast majority of turtles never venture onto land, at least on their own. Studies on turtles in the water can be labor intensive or expensive relative to research which focuses on the beaches. The objective of this paper is to review the types of survey methods that have been and are used to study turtles in the water and determine how applicable this information is to the three defined management needs.

Sampling Programs

Two general approaches are available to collect data on turtles in the water and these are via remote and proximal sensing. Remote sensing includes aerial surveys, radio and satellite tracking, while proximal sensing includes vessel surveys and observations.

Aerial surveys remote sensing: Aerial surveys are useful for censusing turtles over a large area. In the U.S., both loggerhead and leatherback turtles are easily visible from the air. The National Marine Fisheries Service, Southeast Fisheries Center (NMFS/SEFC) has supported pelagic surveys from North Carolina to Texas waters targeting both marine turtles and mammals. Surveys were conducted along the Atlantic coast on a seasonal basis from 1982 to 1984 (Figure 1). These surveys, called SETS for Southeast Turtle Surveys, were completed from North Carolina to Key West, Florida in a twin engine Beechcraft AT-11 (Figure 2). This aircraft is equipped with a glass and plexiglass bubble nose observation platform that can accommodate two people who have an unobstructed view of the flight trackline out to the horizon. Flying at an altitude of 500 ft optimizes the sightability of turtles. The study area was divided into 10 sampling units each of which could be flown in one day (Figure 1). Thus, ten flight days were necessary to complete one seasonal survey. Weather always becomes a factor and in this area it took about 2.5 days to sample each area (Schroeder and Thompson 1987).

At the very least, the spatial distribution of turtles can be described over a large area on a seasonal basis (Figure 3). Areas of high turtle density have been defined based on these surveys and future sampling could be reduced in scope to optimize sampling when and where turtles are known to be present in relatively large numbers to reduce costs. Turtle distributions can also be classified by environmental correlates such as sea surface temperature and depth when possible (Figure 4).

Estimates of relative abundance were completed and represent the total number of loggerhead turtles of 2.5 feet or greater of carapace length at the surface. These estimates were derived from using line transect methods to estimate turtle density and then multiplying density by total sampling area to estimate relative abundance (Burnham, Anderson and Laake 1980).

To estimate absolute abundance requires corrections to be made for significant effects of Beaufort Sea State, the obliterating effect of sun glare and the average amount of time a turtle spends at the water's surface. To estimate sea surface time require the use of a radio tag on turtles of all size classes greater than 2.5 feet throughout all seasons throughout a species spatial range. This has yet to be done and therefore, current estimates of abundance from pelagic aerial surveys remain relative.

<u>Radio tracking remote sensing</u>: While several studies have been made on the use of radio and sonic transmitters with turtles, the work conducted by the NMFS/SEFC will be used as an example of the utility of this technique in describing surfacing behavior and short range movements of turtles. Two independent tracking experiments were completed using loggerhead and Kemp's ridley turtles, respectively.

In the first experiment, surfacing and movement characteristics were determined for loggerheads over two four week periods in the Cape Canaveral area off the east coast of Florida. A radio transmitter float was towed by the turtles and emitted standard radio signals while at the surface. A tracking receiver was installed on an airplane and a Loran-C navigation receiver provided positional information. The shape of the transmitter float should be made to minimize drag and therefore not interfere with or alter the animals normal swimming behavior. The life of the transmitter is dependent upon the longevity of the battery; the Cape Canaveral experiment lasted 30-45 days. Twenty turtles were tagged and mean time at the surface was estimated for hourly intervals. To evaluate sea surface time truly, these experiments should be conducted over a species' range throughout the year over all available size classes.

Attaching a sonic tag to the carapace improves the line-of-sight tracking capabilities but requires the use of a directional hydrophone submerged from a vessel. The ability to track a turtle using an acoustic device is dependent upon the amount of ambient noise. In the Cape Canaveral area, constant ship noise reduced the effective detection range to 100 yards (A. Kemmerer, pers. comm.).

A second tracking experiment targeting headstarted Kemp's ridley turtles was conducted in both Florida Bay and off Homosassa, Florida, on the Florida west coast. The tracking transmitter was housed in a pyramidal float to minimize drag (Timko and DeBlanc 1981). Before turtles were released, behavior studies were completed to insure that behavior was not affected by the presence of the transmitter. Turtles were tracked up to 30 days and turtles moved as much as 150 miles from the release point (Timko and DeBlanc 1981).

The ability to obtain information on sea surface time is important in describing the behavior of turtles in the pelagic environment. These data can be used to correct aerial survey counts and therefore absolute abundance, rather than relative abundance, can be estimated. The short range movements of turtles can be defined to provide basic biological information on pelagic activities of turtles such as habitat utilization and residence time.

<u>Satellite tracking remote sensing</u>: The only way to derive direct information on long range movements and migration patterns is through the use of satellite tracking technology. This information can provide insights into population ranges and limits. Thus, the boundaries of a unit stock and migratory routes may ultimately be defined if adequate sample sizes are achieved.

The NMFS/SEFC has been involved with this technology since 1979. The first satellite utilized to track turtles was the NIMBUS system. This system was designed to collect meteorological and oceanographic data from randomly located mobile transmitters. Position of a signal was estimated within five kilometers of the transmitter. A cylindrical transmitter was attached to a loggerhead nicknamed "Dianne" that was obtained from a Mississippi shrimp boat (Timko and Kolz 1982). This turtle was released offshore and both visual and radio contact was immediately lost. Satellite transmissions were received over an eight month period from October 1979 to June 1980. During this period the turtle was tracked from Louisiana south and west to Corpus Christi and back to the Texas-Louisiana border before the transmitter was located in Kansas. Apparently the transmitter was found on a Texas beach and taken to a home in Kansas which was located via satellite transmission. The total tracking distance exceeded 1,400 miles (Timko and Kolz 1982).

More recently, the Argos satellite has been successfully used to track a leatherback turtle off the Guyanas (Fretey and Bretnacher 1984). A transmitter was attached to a nesting female with a harness and provided movement information off the nesting beach. This transmitter could provide valuable time series data on turtle movements over large areas or throughout an entire migratory cycle.

The NMFS/SEFC has applied a smaller version of this transmitter to a loggerhead turtle which towed the cylindrical device (A. Kemmerer, pers. comm.). The primary drawback to this system is its size, which has not been reduced to allow for use with small juvenile turtles. The primary advantage of this system is its longevity which could provide valuable information on stock boundaries.

Habitat studies proximal sensing: In January 1987, the Caribbean Island National Wildlife Refuges initiated an in-water netting study targeting turtles off of Culebra, Puerto Rico (Callazo and Boulon 1987). Netting has been conducted during seven periods from January through August and a total of 62 green and four hawksbill turtles have been caught through this time. An average catch of 1.2 turtles was estimated per set. Turtles were tagged, weighed, measured and released. Growth rates were estimated from nine recaptured turtles. It is apparent that this type of study can yield information on habitat utilization and "residency." The growth of turtles in the wild has yet to be defined and this approach may yield important age and growth information on wild turtles.

Ehrhart (1983) has been able to compare present turtle catch rates in the Indian River complex in east Florida with available historical levels. His long term study has demonstrated that this river system is likely a developmental habitat for juvenile green and loggerhead turtles. The time series data that Ehrhart (1983) is continuing to collect demonstrate how an area of high turtle density can be used to index population trends. This type of study is also being conducted by the NMFS/SEFC, Panama City Laboratory in the Cedar Key, Florida area on the coast of the Gulf of Mexico. A time series of turtle density can be used to evaluate numerical trends by completing these types of netting surveys in an area of relatively high and predictable turtle presence.

All three of these studies utilize gill nets for turtle capture and are labor intensive. However, much information is gained on turtles in localized areas from these efforts. The low cost, at least compared to remote sensing studies, allows for work to continue over several years. Habitats can be evaluated to determine the carrying capacity of, for example, a reef or grass bed for resident or transitory hawksbill or green turtles.

This provides information on the potential impacts of changes in habitat quality and quantity which can cause changes in turtle abundance. Critical habitats can be identified and managed as necessary.

Observer programs proximal sensing: Placing observers on vessels is the only way to obtain unequivocal evidence of turtle catch and mortality either through direct fishery activities or incidental to a non-turtle fishery. For example, Witzell (1984) reported on the capture of sea turtles incidental to the Japanese longline fishery in the U.S. Exclusive Economic Zone (EEZ). These data were provided both by the fishermen who were required to report all incidental catches and by observers placed on these vessels by the National Marine Fisheries Service.

Perhaps the best known NMFS observer program obtained information on the incidental capture of turtles in shrimp trawls. An additional experimental trawling program provided evidence on the capture and mortality of turtles in shrimp trawls. These results led to the promulgation of regulations requiring the use of a Turtle Excluder Device (TED) by shrimpers beginning in the Cape Canaveral, Florida, Oct. 1, 1987.

Entanglement in other types of fishing gear or with other human activities, such as power plant entrainment have been documented. However, quantitative information can only be provided by direct and consistent efforts to collect data. This includes placing observers in the field.

Information Provided

Both remote and proximal sensing techniques provide information on stock boundaries and numerical trends. Direct observations on shipboard provide information on mortality which can be used to project population trends over time. When significant sources of mortality are identified, then management strategies, which mitigate mortality, can be developed .

The quantity of pelagic environment has yet to be determined. However, several existing projects have demonstrated the qualitative importance of specific areas to turtles (Ehrhart 1983; Callazo and Boulon 1987; Ogren 1985). These studies all deal with juvenile turtles that appear to be somewhat resident in localized areas, and will provide information both on the quality and quantity of habitat available to turtles in these areas. These types of studies are of great importance in understanding the habitat requirements of turtles in the pelagic environment. Relative to remote sensing techniques, these types of small scale vessel sampling surveys are inexpensive.

Little work is being done in the offshore pelagic environment. Concerns about the potential impact of plastics, discarded fishing gear, tar and other types of debris are real. The use of satellite imagery may prove useful in defining areas of convergence where weed lines may predictably be discovered. Weed lines are an important habitat for hatchlings and small turtles and also accumulate debris. Once areas of convergence are identified, small vessels are adequate for ground truthing as demonstrated by Bjorndal (K. Bjorndal, pers. comm.). Both the abundance of debris and turtles may be quantified and a risk model developed to examine the probability of impact of debris on small turtles in weed lines as suggested by K. Bjorndal (pers. comm.).

Only through direct sampling whether fishery independent or fishery dependent can the impacts of all the risks facing turtles in the pelagic environment be both qualified and quantified. Only when these results are available can turtles be completely and adequately managed throughout their respective ranges.

Acknowledgments

For the presentation made during the WATS II meeting the following persons loaned me the use of slides: Andrew Kemmerer, Director, Pascagoula Laboratory, Southeast Fisheries Center; Barbara Schroeder, Miami Laboratory, Southeast Fisheries Center; Larry Ogren, Panama City Laboratory, Southeast Fisheries Center. I am particularly grateful to John Mysing, NMFS/SEFC Bay St. Louis Laboratory for the information on satellite and radio tracking of turtles. I appreciate the opportunity that WATS II and Frederick Berry afforded me by allowing me to present this paper during the symposium. I am grateful for the continued support of Walter Nelson, Laboratory Director, Miami Laboratory of the NMFS/SEFC.

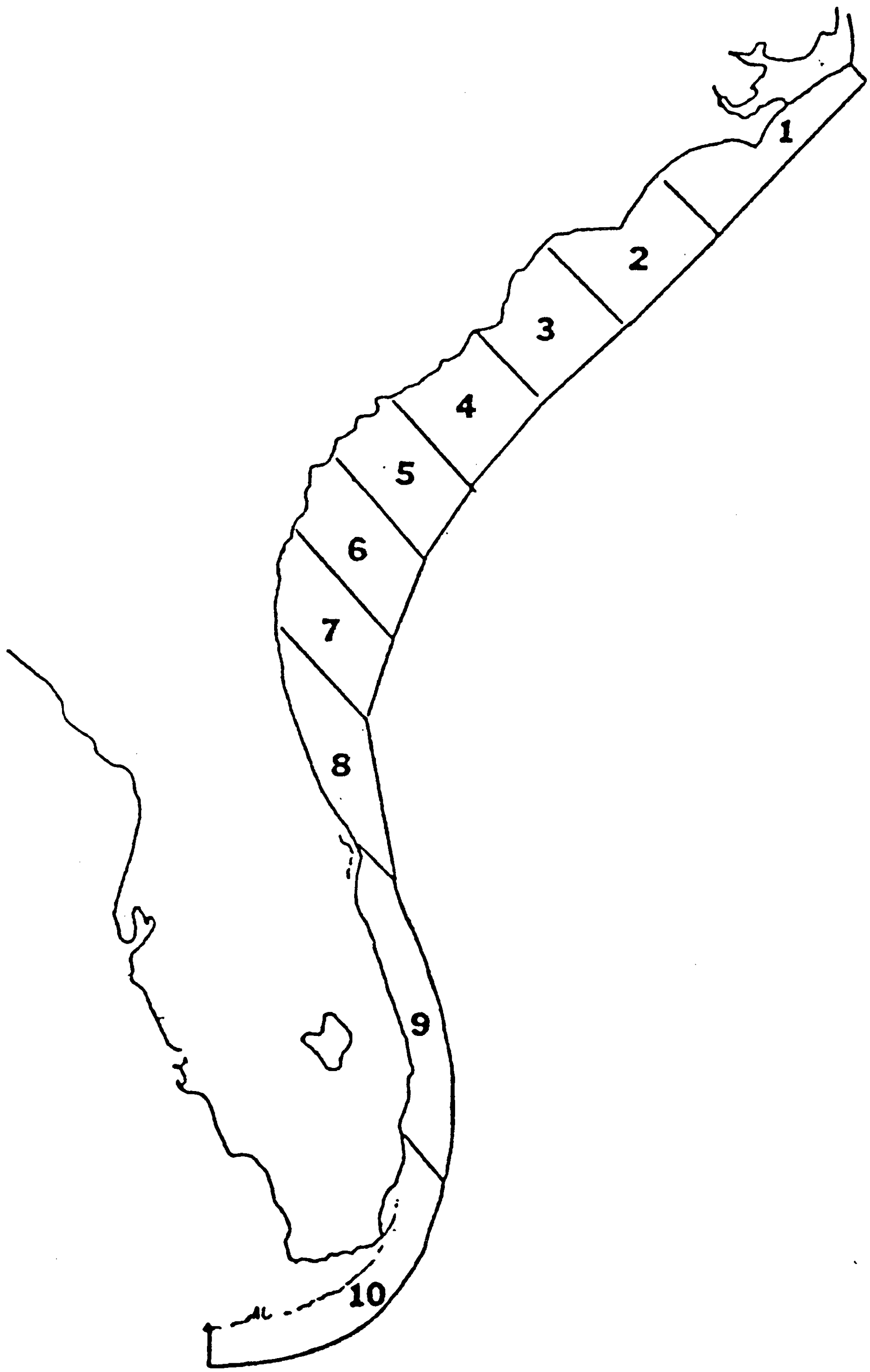


Figure 1. Southeast turtle surveys study area from North Carolina to Key West, Florida. The study area was divided into ten sampling units each about 3,000 sq nm. Each unit could be sampled in a single flight day.

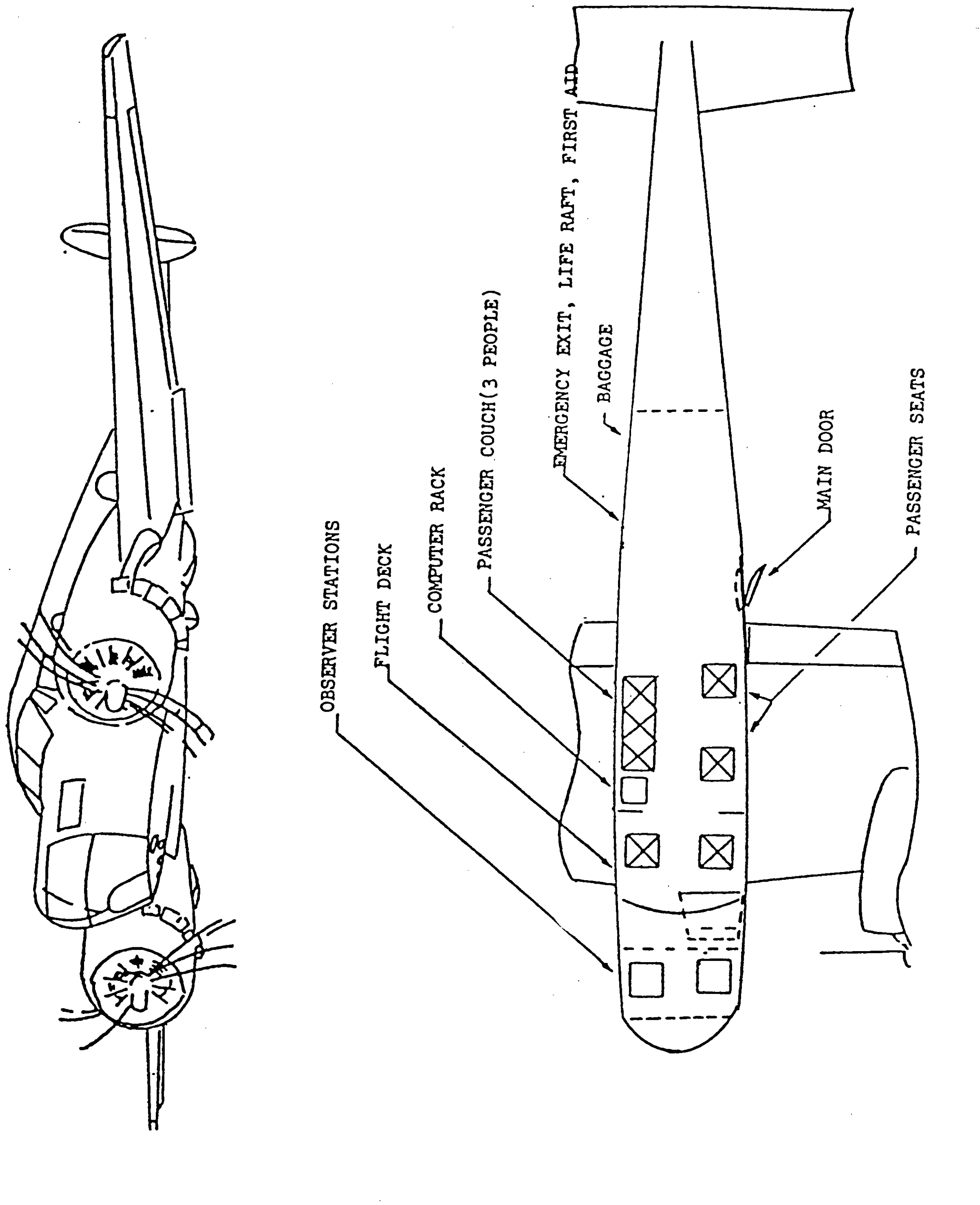


Figure 2. Twin Beechcraft AT-11 which was used to survey the SeTS area. Note the bubble nose which is glass and plexiglass and can accomodate two observers each of whom has an unobstructed view of the flight trackline out to the horizon.

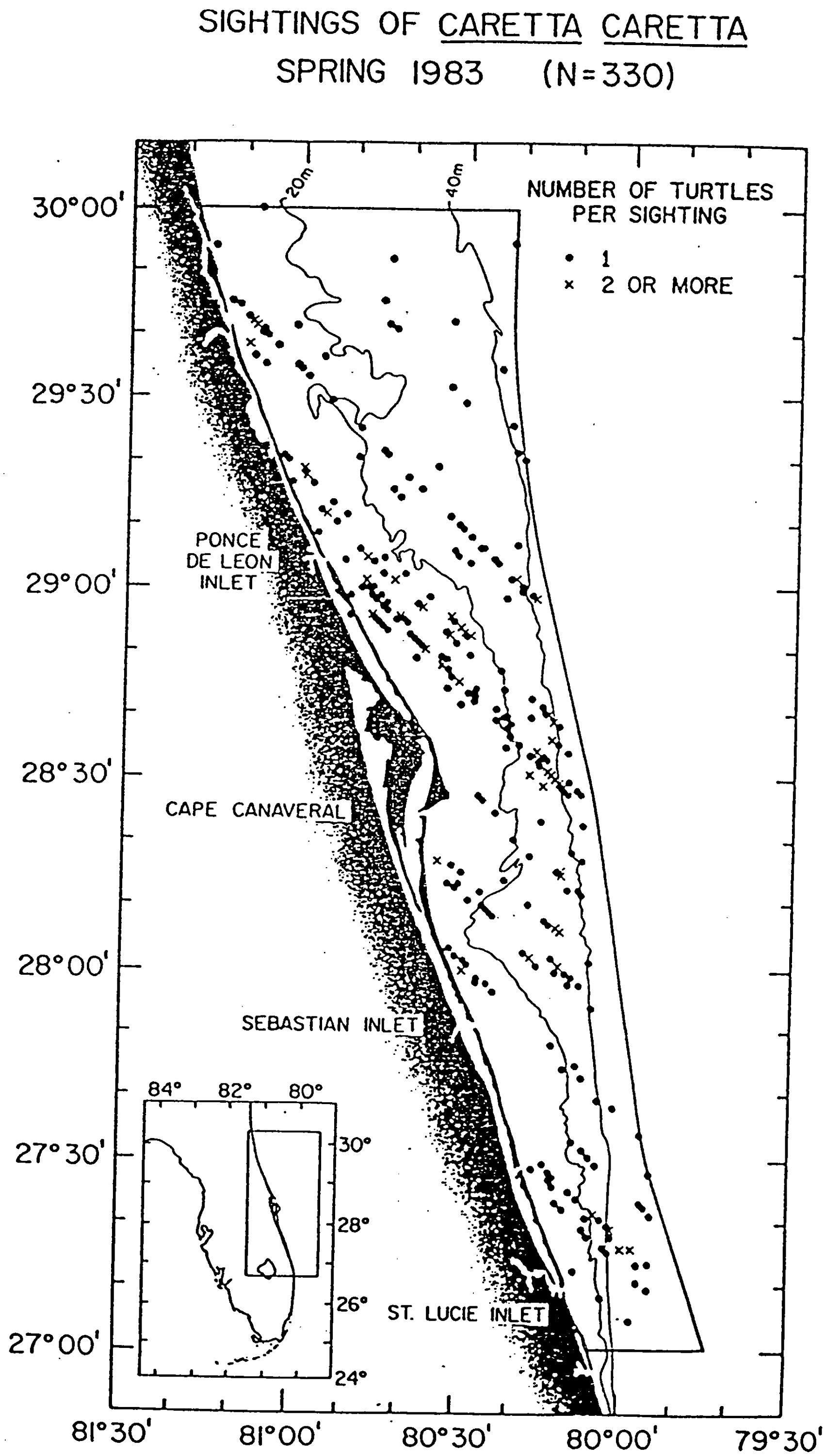


Figure 3. Distribution of loggerhead turtles within one portion of the SeTS area. This distribution is specific to the Cape Canaveral Florida area for the spring 1982 or first survey.

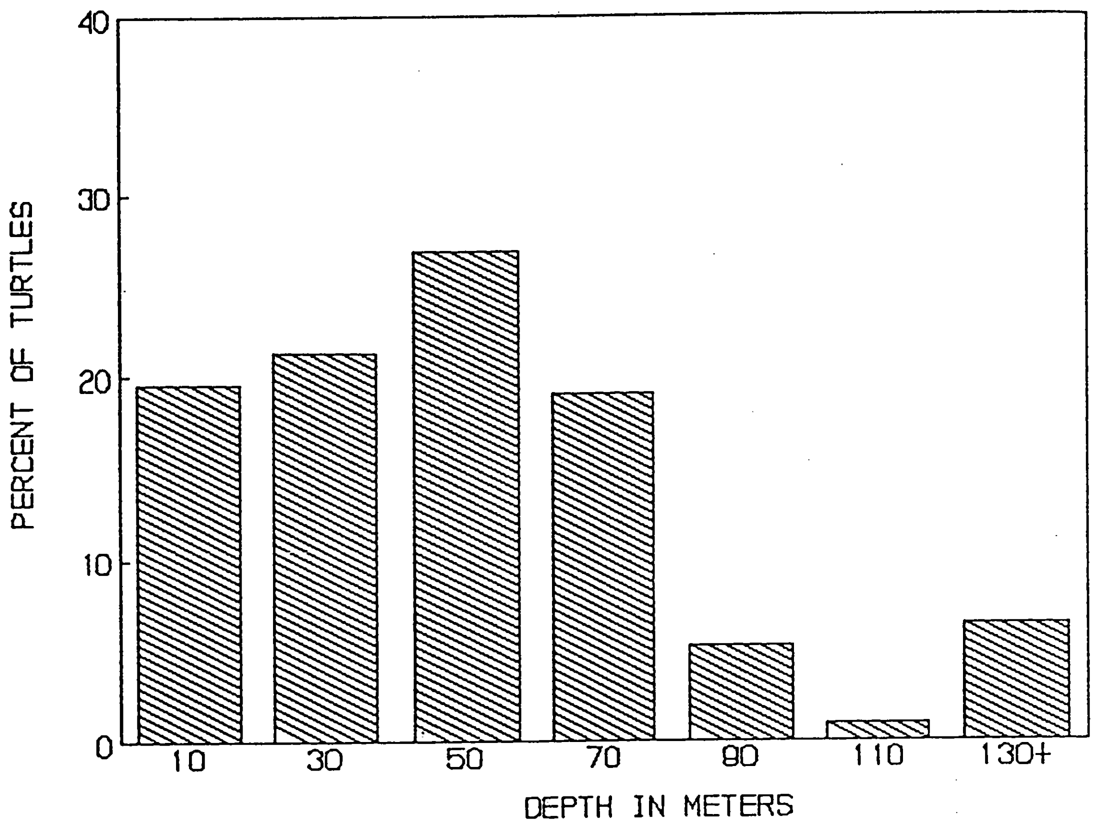


Figure 4. Frequency of turtles classified by depth in twenty meter increments. This distribution represents the percent of turtles, loggerhead, green, leatherback and unidentified, sighted by depth during the spring 1982 or first SeTS sampling survey.

Management Research Needs

Research Needed for Management of the Beach Habitat (Jeanne A. Mortimer)

Introduction

The reproductive success of adult turtles and the survival of their offspring are often diminished by adverse environmental conditions at the nesting beach. Some of these environmental factors occur naturally, but many are induced by human activity. The following is a discussion of some of the most important problems encountered by turtles in their nesting habitat along with suggestions about what sort of research is needed to provide a more complete understanding of these problems so that mitigating steps may be taken.

Disruption Caused by Artificial Lighting

One of the most obvious forms of disturbance at the nesting beach is that caused by the presence of unnatural light sources, either onshore or offshore. It is a problem that is increasing in scope and magnitude as building and road construction proliferate, and as electricity is introduced to remote areas. The village of Tortuguero, Costa Rica, for example, which is situated immediately adjacent to the nesting beach of the largest green turtle breeding colony in the west Atlantic region, will have electricity installed before the start of the 1988 green turtle nesting season.

Artificial light at the nesting beach can affect both nesting females and hatchling turtles. There is evidence that adult turtles may be discouraged from nesting in brightly lit areas (literature reviewed by Raymond 1984a). Hatchling turtles of all species easily become disoriented or misoriented by bright lights (literature reviewed by Raymond 1984a), and then suffer high rates of mortality due to a variety of causes. Unfortunately, even distant sources of illumination--such as the lights of a city located miles from the coast--can produce a disorienting glow, especially on moonless nights.

When hatchlings are distracted by bright lights located directly behind the nesting beach, they may head inland rather than towards the sea. If the light source is located farther down the beach, hatchlings may walk long distances parallel to the shoreline in that direction. Often disoriented hatchlings will circle aimlessly, or wander onto nearby roads and be crushed by traffic. Bright light is apparently so irresistible to hatchlings as to prompt them to run directly into the flames of burning fires. I found the charred carcasses of several hundred green turtle hatchlings in the ashes of a single bonfire behind a nesting beach at Ascension Island, S.A.O. Disoriented hatchlings may spend an entire night trying to crawl up a wall or some other structure in an effort to reach a light source. Others travel so far inland that they are unable to make it back to the sea on their own. Although hatchlings are usually able to reorient towards the sea once the sun rises, many simply become too exhausted or desiccated to do so. Moreover, the longer a hatchling is detained on shore, the more susceptible it becomes to such terrestrial predators as crabs, or birds foraging at dawn. Hatchlings returning to the sea after sunrise are probably subject to higher rates of predation from fish than are those entering the sea at night.

Sometimes illumination from sources onshore remains visible from the surf and may continue to disorient hatchlings even after they enter the sea (Witherington 1986). Under such circumstances hatchlings could be delayed in the shallow waters of the surf-zone, where high concentrations of predatory fish occur, and thus suffer higher than normal levels of predation.

Hatchlings are also thought to be attracted by artificial light sources located offshore--such as lighted ships at anchor, or oil rigs. In addition to attracting young turtles, such lights may also concentrate the predatory fish that then feed upon the disoriented hatchlings (Fletemeyer 1986, and pers. comm.).

More studies are needed to document how much mortality occurs in the presence of varying levels of light pollution, and to quantify exactly what light intensities and color saturations cause the greatest and the least harm. Ways of minimizing the impact must be developed through experimentation with different types of light sources and different ways of shading lights. Such investigations are now underway at the University of Florida (by B. Witherington and K. Bjorndal) and at the University of Illinois (by M. Salmon and J. Wyneken).

Through research we may be able to devise ways to reduce the negative effects of artificial lights at the nesting beach; but research alone will not solve the problem. The ideal nesting beach is one that is completely free of unnatural lighting. To tackle the problem posed by light pollution we must conduct educational campaigns to create public awareness. Laws and ordinances must also be passed that will restrict the placement and proliferation of lights in the vicinity of nesting beaches. Such laws have been passed in Florida and in Australia, and are apparently effective. In Brevard County, Florida, Witherington (1986) found a substantial reduction in hatchling disorientation after enactment of a lighting ordinance there in 1985.

Beach Erosion and Inundation

Virtually all nesting beaches undergo regular cycles of sand erosion and sand replacement (accretion), the magnitude of which varies from one area to another. Along the coast between Guyana and French Guiana, where large numbers of turtles nest, beaches completely disappear and new ones form at frequent, but unpredictable intervals. Barrier islands, such as those along the east coast of the U.S.A., are continuously eroding and accreting, yet provide critical nesting habitat for loggerhead turtles.

Erosion and inundation are popularly perceived as important causes of clutch mortality, but in fact, few studies have been done to test this assumption. Certainly, heavy mortality does occur during storms and hurricanes (Ross and Barwani 1982). A particularly severe storm may remove vast quantities of sand from a beach, sometimes requiring years for the beach to recover.

Investigators in Surinam have estimated that 20-30% of all egg clutches laid each year are probably doomed because they are deposited below the spring high tide line (Schulz 1975; Dutton and Whitmore 1983). On the other hand, studies done at Tortuguero and in Florida, indicate that, barring major storms, mortality caused by erosion can affect less than 6% of the total egg clutches (Fowler 1979; Witherington 1986).

In the past, intolerance of turtle eggs to any inundation by sea water was widely believed. Mounting evidence indicates, however, that moderate wave wash has a relatively innocuous effect on egg survival (McGehee 1979; Mortimer 1981). Witherington (1986) speculated that the primary cause of mortality in clutches affected by surf conditions was not drowning, but the partial exposure or total loss of a clutch to erosion. The tolerance of an egg clutch to inundation seems to vary depending on how long the eggs are immersed in water, and during what stage in their development inundation occurs (C. Limpus, pers. comm.). Also evidence indicates that cold shock, which usually accompanies inundation, may alter the sex ratio within a clutch (Mrosovsky et al. 1984). More research is needed to determine exactly how salt water or fresh water inundation affects the eggs within a clutch when it occurs for varying lengths of time and at various stages during embryonic development.

Translocation of Doomed Egg Clutches as a Management Technique

Ideally, an egg clutch that has been deposited too close to the sea should be translocated to higher ground. If proper procedures are not employed when moving the clutch, however, excessive egg mortality can occur. Eggs can be safely moved only at those times during their development when the delicate extra-embryonic membranes are least likely to be torn--i.e., within the first six hours after they are laid, and during the second month of incubation (C. Limpus, pers. comm.). Even then, the eggs must not be rotated (especially after the first six hours), nor should they be moved quickly in any horizontal direction. Finally, the clutch should be reburied so that its situation approximates as closely as possible a natural nest. Whenever possible, the hatchlings should be allowed to emerge naturally from the nest at night and to make their way to the sea without human interference.

To prevent unnecessary egg mortality resulting from over-manipulation, and to avoid wasting human labor, nests should only be moved when they are in fact "doomed." Unless they will be damaged by other agents, those egg clutches deposited above the spring high tide line are probably best left in situ.

Erosion Made Worse by Human Activity

In recent years coastal erosion seems to be getting worse. Some scientists believe that this is due to a general rise in sea levels. If this is so, and it may well be, many nesting beaches are likely to be in serious trouble and there may not be a great deal that we can do about it.

Some erosion, however, is exacerbated by human activities. When calculating how much distance to put between their property and the sea, developers frequently underestimate the forces of erosion, not considering the prospect of intense storms or hurricanes. They also build in places such as on barrier islands which by nature are unstable. Then when the sea encroaches upon their property they react by constructing sea walls or other beach armoring structures. Unfortunately, such structures can actually worsen erosion by deflecting the waves downward. Eventually, the beach which had once separated the property from the sea disappears and only the barricades remain, until they, too, are destroyed by the sea.

The mining of beach sand for human use can seriously damage nesting habitat and should be prohibited. When too much sand is removed, that which remains may be too shallow to allow nest construction. Often the beach platform is lowered to the point that it floods at high tide or during heavy seas, making it an unsuitable incubating medium.

Beach Renourishment as a Remedy for Beach Erosion

One way to replace lost beach sand is through beach restoration or beach renourishment. Usually, beach renourishment is done by dredging up sand from offshore and then pumping it onto the beach. Alternately, beach fill material may be transported by truck from another locality and redistributed by bulldozer or other heavy equipment onto the beach. Unfortunately, neither method has proved entirely suitable for turtle nesting beaches, primarily because of problems with sand compaction (Raymond 1984b). The sand of high energy nesting beaches is usually well-sorted (i.e., it is composed of sand grains which are fairly uniform in size), and it generally has a low silt-clay component (Mortimer 1981). Sand dredged from offshore is usually poorly sorted and contains large amounts of silt and clay. Even sand transported from elsewhere often contains more fine material than does the native sand. Moreover, the fill material may become artificially compacted by the earth-moving equipment used to redistribute it (Raymond 1984b).

Raymond (1984b) and others in Florida (Fletemeyer 1980) found that the resultant sand compaction can seriously impede the ability of a nesting female to construct a suitable nest. Hatching success may also be reduced if the silt-clay fraction is too high (Mortimer 1981).

The possibility of using aragonite sand as beach fill is currently under investigation (J. Miller, pers. comm.). Aragonite is a calcium carbonate sand, and a by-product from a mining operation at Ocean Key in the Bahamas. Its positive attributes are that it can be transported cheaply and at any time of the year. Its suitability as a nesting medium, however, has not yet been demonstrated. There is concern that because of its small grain size it may become compacted. Also, because its reflective properties differ from those of the native sand which it would replace, the possibility exists that its thermal properties also differ.

More research is needed to determine the cause of compaction during beach restoration, and methods to mitigate it. Alternate ways to renourish beaches need to be developed. Until these problems are solved, nesting beaches should be restored only when absolutely necessary. And then, care must be taken to match the textural characteristics of the fill material as closely as possible to that of the native sand. Obviously, beaches should never be renourished during the turtle nesting season.

Traffic on and near the Beach

Several of the participants at this meeting expressed concern about whether human pedestrian traffic might increase mortality in nests. In fact, some evidence shows that it does, especially on those beaches composed of coarse, smooth-grained sand (Mann 1977; Mortimer 1981). Controlled experimentation is badly needed, however, to determine exactly what effect human footfalls have on both the hatching success of eggs and the emergence success of the hatchlings. Such research should be conducted using a variety of sand types so that the effects of footfalls can be compared between beaches whose sand textures differ.

The findings from such studies would have important implications for the management of recreational areas in which turtle nesting occurs. At the present time, at most nesting beaches, little effort is made to control human foot traffic.

Although documentation is lacking, footfalls of livestock--horses, cows, etc.--most certainly damage eggs and hatchlings on nesting beaches. Studies are needed to determine exactly what effect livestock traffic has on incubating egg clutches. In the meantime, livestock should not be allowed to walk on nesting beaches.

Unquestionably, vehicular traffic, such as off-road vehicles and motorcycles, should be prohibited from driving on nesting beaches. The weight of the vehicles causes sand compaction, and spinning tires can easily injure or kill hatchlings that are making their way up to the surface through the sand column (Mann 1977; Witherington 1986). Ruts produced by such vehicles on the surface of the sand have also been shown to trap hatchlings that are trying to get to the sea, forcing them instead to travel long distances parallel to the water's edge (Hosier et al. 1981; Witherington 1986).

Beach cleaning equipment should not be used on turtle nesting beaches. It crushes hatchlings, and causes sand compaction which in turn interferes with the emergence of hatchling turtles and also impedes the female during nest construction (Mann 1977; Raymond 1984b).

Nearshore boat traffic--recreational speed-boats, water-skiers, etc.--is another form of disturbance present at some nesting beaches. Its effect on turtles at their internesting habitat has never been documented. Nevertheless, boat traffic may interfere with courtship, frighten nesting females away, or cause physical injury or even death should collisions occur with turtles. The possible effect of the low frequency noise it produces also warrants further investigation (Frazier 1980). Probably the worst impact would be felt in those areas where only limited nesting beach is available. Whenever possible, boat traffic should be restricted in the vicinity of nesting beaches during the nesting season. Shrimp trawlers which usually operate close to shore may catch large numbers of turtles in their internesting habitat (Coston-Clements and Hoss 1983).

Chemical Pollution

The most obvious form of chemical pollutant in the nesting habitat is oil. Tar balls can be found on even the most remote beaches of the world (such as at Ascension Island, located mid-way between Brazil and West Africa). Oil pollution is a problem increasing in magnitude, but few studies have been done to quantify how oil affects incubating eggs and hatchlings. Fritts and McGehee (1982) found that fresh crude oil will cause significant mortality and morphological change in the incubating embryos, but that weathered oil may not. In a preliminary study based thus far on few data in the Persian Gulf--where the level of oil pollution is probably the worst in the world--J. Miller (pers. comm.) found no obvious indication that oil mixed into the sand lowers hatching success. Nevertheless, more research is needed to document sublethal or delayed lethal effects of oil pollution. Eggs, embryos, and hatchlings are more vulnerable than adults since volatile and water soluble contaminants can be absorbed into the egg (see review by Coston-Clements and Hoss 1983). Both oil spills and the resulting clean up operations could have harmful effects at the nesting beach (Coston-Clements and Hoss 1983).

Pollution Caused by Physical Debris

Beaches throughout the world are becoming more and more polluted by man-made debris that washes ashore. This debris includes light bulbs, styrofoam, plastics, aerosol cans, tar, wood, glass, cloth, fiberglass, fishing line and other gear, and organic garbage (Hirth 1987). Studies are needed to quantify the extent of this problem and to determine whether the debris interferes with the activities or movements of either the adults or the hatchlings. In 1986, vast quantities of plastic beads carpeted parts of the beach at Tortuguero (A. Meylan, pers. comm.). Small objects like these, if abundant enough, could become incorporated into the beach sand, and ultimately alter its thermal properties or the patterns of gas diffusion within it.

Although debris does float in from far away, in some areas much of it is dumped locally. Large cruise ships and military vessels have frequently been implicated in illegal offshore dumping. Efforts should be made to determine the origin of such trash and, whenever possible, to prosecute the agents responsible for its presence.

Construction may deter or prevent females from coming ashore, as it did on Hutchinson Island, where a cofferdam offshore was a barrier to turtles swimming along the shoreline (Williams-Walls et al. 1983).

Shading of Nesting Beaches

Behind many nesting beaches high buildings or tall trees may cast significant amounts of shade onto the beach (Coston-Clements and Hoss 1983), especially when the shoreline is oriented north and south (as is the case along most of Florida's coastline). In fact, enough shade might be created--especially at those beaches that were originally backed only by low vegetation--to lower sand temperatures to the point where masculinization of hatchlings occurs. This possibility warrants further investigation.

Predation Upon Eggs and Hatchlings

Levels of predation upon eggs and hatchlings vary from one beach to another. Human beings are among the most destructive predators, and in some localities every egg clutch not transferred to a hatchery is poached.

The most destructive non-human predators are generally those species whose presence at the nesting beach is a relatively recent phenomenon, attributable either directly or indirectly to human activity. Man plays an obvious role in the introduction of domesticated animals such as dogs, pigs, cats, etc. But even raccoons, which we think of as "wild" animals, have become abundant in some coastal areas primarily because, in altering the habitat, man has made it more suitable for them.

On the other hand, and contrary to popular opinion, mortality caused by "natural" predators, such as birds, crabs, lizards, etc., is often relatively innocuous at an undisturbed nesting beach (Mortimer 1981, 1984; Witherington 1986). Perhaps this is because most of these predators have co-existed with turtles for a long time and a balance has been reached.

Much more research is needed to quantify what levels of predation occur on nesting beaches, and also in the offshore habitat. More effective methods of predator control also need to be devised for those situations where predation truly is a problem.

Control of Terrestrial Predation

Under some circumstances, such as when poaching is severe, the best policy may be to transfer egg clutches to artificial hatcheries. Such efforts are very labor intensive, however. Another disadvantage of hatcheries is that their rates of hatching success are often lower than are those of undisturbed natural nests on the same beach. Moreover, at nesting beaches where thousands of egg clutches are produced each season, translocation of every clutch is not feasible. The best solution, in such cases, may be to deal directly with the predators.

Ten years ago, at Tortuguero, Costa Rica, feral dogs destroyed as many as 40% of the egg clutches laid on certain parts of the beach (Fowler 1979). The guards of the Tortuguero National Park have since mounted a very successful dog eradication campaign, and feral dogs have been virtually eliminated from the area.

Similarly, at one time, raccoons destroyed almost every egg clutch laid at certain beaches in the United States. After much trial and error, investigators finally devised the following effective method of controlling raccoon predation (Hopkins and Murphy 1983; S. Murphy, pers. comm.). At the beginning of each nesting season, as many raccoons as possible are destroyed--usually they are either trapped or shot. Then each morning during the nesting season, a four or five foot square piece of 2 X 4 inch mesh welded wire is placed over the center of each new nest, anchored at the corners, and covered with a layer of sand. The beauty of this technique is that the egg clutch is not disturbed, and the hatchlings are free to emerge from the nest on their own. Moreover, it is a relatively simple procedure.

Headstarting Turtles

Headstarting is an experimental management measure in which hatchling turtles are raised in captivity until they are large enough to escape the jaws of most predatory fish and birds; then they are released. Headstarting is not yet a proven management measure. We now know that at least some headstarted turtles are able to survive in the sea for a number of years. Unfortunately, we also have numerous documented cases of headstarted turtles that have washed ashore in a moribund condition, have been recovered walking across parking lots in south Florida or have even swum up alongside boats, apparently after having become too habituated to human beings. We still do not know whether survival among headstarted turtles is, in fact, any higher than survival among turtles that enter the sea as hatchlings.

Moreover, until we get proof that headstarted turtles eventually return to the nesting beach and reproduce, headstarting will remain an unproven management measure.

More research is needed to test the effectiveness of head-starting. Preferably such research should be conducted using animals from the larger, more stable nesting populations.

Summary and Conclusions

Anyone working at a turtle nesting beach should watch for clues that may help to answer the sort of questions discussed here. Some problems may never be solved, and others can only be tackled through well-funded research. In general, the more manipulative, experimental research, including the headstarting of hatchling turtles, should not be carried out using animals from small, vulnerable turtle populations.

If one is to manage properly a nesting beach, the first step should be to mount a small scale study of local conditions. The beach and its surroundings should be examined carefully and any factors that pose a threat to the turtles should be identified. Problems caused by artificial lighting, sand mining, or traffic on and near the beach can usually be detected quickly. If poaching of eggs is a serious problem, ideally, steps should be taken to change the behavior of the offenders; but failing that, Removal of egg clutches to a safe place may be necessary.

If you do not detect problems that call for the emergency translocation of eggs, and if you have adequate logistical support, you should determine the natural rates of hatching and emergence success of egg clutches at your beach. The following procedure is recommended.

The study should be conducted using egg clutches that have not been manipulated in any way. To determine the number of eggs in each nest, count the eggs as they fall from the turtle. You can do this by placing your hand inside the nest, just after the turtle finishes digging her egg chamber, and before she starts to lay eggs. Hold your hand, palm up, several inches below her cloaca, and taking care not to touch her tail, count the eggs as they drop onto your hand. Let the eggs fall immediately from your hand into the nest. Allow the turtle to bury the eggs herself. Mark the location of the nest. Check the nest site periodically--daily if possible--to see if erosion, wave-wash, or predation has affected or damaged the nest since your previous visit. Record the dates of all your observations. After hatching occurs (about two months later), dig up the nest and examine its contents. Count the number of empty shells from eggs that hatched normally, the number of unhatched eggs, the number of hatchlings that died while pipping, and the number of dead hatchlings in the nest. Open intact eggs and measure and record the size of the embryos within. Keep complete records of all your observations.

After you have identified what management problems exist at your nesting beach, do what you can to solve them. But do <u>not</u> perform unnecessary manipulations. For example, do not set up a hatchery unless you are quite certain that by doing so, you will, in fact, increase hatching success. Otherwise you may be doing more harm than good.

Management Research Needs

Research Requirements for Management of the Marine Habitat (Wayne N. Witzell)

Introduction

Very little is known about the developmental ecology and population dynamics of western Atlantic sea turtles. Delineating sea turtle habitat research needs, therefore, is difficult due to the lack of basic knowledge concerning habitat utilization by any turtle species. Evidence suggests that the pelagic habitat is contaminated with crude oil pollutants and gear discarded by commercial and recreational fishing operations, dredging, and by industrial and agricultural runoff (Coston-Clements and Hoss 1983; Balazs 1985). The temporal and spatial aspects of this habitat degradation need to be identified as well as the exact nature and extent of the adverse effects on each of the various sea turtle populations. This paper enumerates the research required that are necessary to assess the impacts of pelagic and benthic habitat degradation on sea turtles in the WATS area.

Developmental Habitat Identification

Sea turtle researchers for many years have speculated upon the exact locations of the developmental habitats for hatchling and juvenile turtles. At least some small turtles passively drift along various current boundaries, rips, eddies, and convergence zones, often utilizing floating rafts of sargassum weed as their primary developmental habitat (Caldwell 1968; Witham 1974; Fletemeyer 1978; Carr and Meylan 1980a; Fritts 1981; Carr 1986a; Critchley 1987). These sargassum rafts form extensive weedlines along current boundaries, frequently extending for many kilometers and provide food and shelter for young turtles. Therefore, efforts must first be made to predict and/or locate consistently all major weedline areas before habitat research needs can be effectively addressed. Recent advances in remote sensing equipment and current modeling techniques might prove useful in predicting and locating these drifting habitats.

When juvenile sea turtles leave the pelagic habitats, they move into various estuarine and hard bottom communities. Consequently, detailed surveys should be taken of all local reefs, banks, lagoons, and mangrove tidal creeks to locate possible developmental habitats.

Surface Habitat

The fact that the oceanic environment is rapidly becoming polluted with oil and plastic debris is widely known. This floating material drifts throughout the oceanic zone and collects along current boundaries, frequently with the sargassum weedlines (Carr 1986a). Consequently, many turtles are dying from either ingesting this material (choking, starvation, toxicity) or by becoming entangled (drowning, starvation) according to an extensive survey by Balazs (1985). Balazs (1985) documented that green turtles (Chelonia mydas) were the most commonly found dead turtle species, followed by the loggerhead (Caretta caretta), leatherback (Dermochelys coriacea), hawksbill (Eretmochelys imbricata), and Kemp's ridley (Lepidochelys kempi). With the exception of the leatherbacks, most of the mortalities were small turtles. The problem of possible mass mortalities of hatchlings and juveniles from oil spills collecting in the weedlines (Critchley 1987) and of large migratory leatherbacks from ingesting plastics (Anon 1983) is quite real. Also, the long term, less dramatic effects of petroleum toxicity need to be addressed.

Research is needed in the surface habitat to (1) assess the degree of habitat degradation and (2) identify and quantify associated sea turtle mortality through extensive at-sea surveys and through extensive necropsies of stranded specimens. Conducting the required research, unfortunately, is often very expensive and often unproductive due to the large expanses of oceanic environment. Consequently, few researchers in the Caribbean are willing to attempt such long-term projects, and resource managers will undoubtedly continue to rely on intuitive guesses.

Benthic Habitat

Considerable documentation of coastal benthic habitat degradation throughout the WATS area has been made, and to repeat it here is not necessary. This habitat degradation is caused by a wide variety of factors ranging from commercial and recreational fishing activities, and dredging, to industrial and agricultural run-off. As previously stated, various seagrass beds and hard bottom areas are important developmental habitats for juveniles as well as subadults and adults. The actual impacts of habitat destruction on these turtles is very difficult to assess. The fate of these animals is not as readily apparent as those carcasses that wash up on the beach full of plastic bags and covered with oil. When deprived of their foraging habitat, do sea turtles slowly starve, or do they find suitable alternative areas elsewhere? Will this change eventually alter their migratory patterns and subsequent reproductive success?

Each WATS country must take inventory of all benthic habitats utilized by sea turtles and attempt to assess the impacts of severe habitat destruction on those turtles. For example, in the United States, we need to know what the impacts of possible severe habitat destruction from commercial fishing (trawling) and agricultural and industrial pollution are on: (1)

the adult female loggerheads off Georgia that forage on the isolated hard bottom areas during the internesting interval (Stoneburner 1982), (2) the subadult Kemp's ridleys and loggerheads that return annually to forage in the Chesapeake Bay (Lutcavage and Musick 1985), (3) the juvenile green turtles and loggerheads inhabiting Mosquito Lagoon, Florida (Mendonca and Ehrhart 1982).

Contaminants

The eggs of green and loggerhead turtles have been shown to accumulate potentially dangerous contaminants, particularly pesticides, petroleum, heavy metals, and PCBs (Coston-Clements and Hoss 1983; Nelson 1986). Unfortunately, the minimum tolerance levels before embryonic damage occurs are unknown, and controlled laboratory and field experiments are necessary to determine these levels for all turtle species. Analysis of egg samples from all major turtle rookeries are needed to establish base-line levels of contamination.

Research Recommendations

I. Determine distribution and abundance of sea turtles and identify critical habitats (benthic & pelagic) utilized by each turtle species:

   A. Exact locations
   B. Exact times

II. Determine mortality rates caused by floating pelagic pollution, particularly:

   A. Crude oil
   B. Plastics

III. Determine effects of benthic (seagrass & hard bottom) degradation/destruction on sea turtles by:

   A. Crude oil
   B. Fishing activities (commercial & recreational)
   C. Dredging
   D. Runoff (industrial & agricultural)
   E. Sewage

IV. Determine long-term effects on hatchling success due to petroleum and chemical pollutants in habitat, particularly:

   A. Pesticides
   B. Heavy metals
   C. PCBs
   D. Oils

The problem of conducting such long-term and expensive sea turtle research by the many less-affluent WATS countries could possibly best be addressed by international cooperation. Due to the distributions of sea turtle populations throughout the Caribbean area and the relative closeness of many WATS countries, perhaps a solution to this logistic problem would be for neighboring countries to "pool" available resources and conduct those projects deemed necessary by the participating countries. This consortium would result in considerable savings in aircraft, vessels and equipment, simultaneously providing a pool of expertise and local experience.

Acknowledgments

I would like to thank Ross Witham, Nancy Thompson, and Walter Nelson for reviewing an earlier draft of this manuscript, and to Frederick Berry for his continued support throughout WATS II.

Management Research Needs

Natural Mortality in Sea Turtles: Obstacle or Opportunity? (Nicholas Mrosovsky)

Qualitative Observations

Turtles are subject to natural mortality from the moment the eggs are laid, sometimes even while the eggs are laid, as when raccoons sneak up behind nesting loggerheads, or when leatherbacks lay so close to the surf that the eggs fall with a splash into water at the bottom of the hole. Later crabs and various mammals dig up the eggs (Schulz 1975) and flies crawl in and lay their eggs on the broken turtle eggs; mould spreads and many eggs rot (Cornelius 1986). Roots invade nests dug too far up on the beach: high tides inundate nests dug too low. Rain-compacted soil prevents hatchlings from emerging. In other cases emergence is possible but, nevertheless, hatchlings die in the nest (Whitmore and Dutton 1985). When many females lay on the same beach, they dig up each other's nests. After emergence birds snatch up the hatchlings enroute to the sea, especially when emergence is by day (Mrosovsky 1971; Fretey and Lescure 1981). Once in the water, fish take their toll. Sharks also prey on the larger turtles (Balazs 1979). Even full grown leatherbacks can be eaten by killer whales (Caldwell and Caldwell 1969). On shore jaguar and puma take adults (Schulz 1975; Cornelius 1986). Other turtles become stuck in tangles of branches or wander inland and die of heat stress when the sun comes up the next day (Fretey 1977). Large numbers of green turtles have been stranded on mud flats by cyclones (Limpus and Reed 1985). Lagoonal populations of greens and loggerheads are stunned by cold during cold snaps (Mendonca and Ehrhart 1982). Stancyk's (1982) review gives many other references on predation, but a monograph would be needed even to catalogue all the predators and the abiotic factors contributing to natural mortality of sea turtle species in different parts of the world, and it would not be a particularly profitable exercise. Observations on natural history are a useful start but what is now needed is to progress beyond this initial stage to quantification of the sources of mortality. Unfortunately, this is hard to do. Nevertheless some examples of such attempts will now be given to provide some orders of magnitude as starting points, and to illustrate some of the problems in drawing any general conclusions.

Quantitative Studies

Example 1: Ridley arribadas at Nancite, Costa Rica

A notable study of hatching success, or rather lack of success, has been provided by Cornelius (1986) and his colleagues for the arribadas of olive ridleys at Nancite, Costa Rica. The results are conveniently laid out in a pie diagram (Fig. 1). The findings are surprising. Only about 5% of the eggs produce viable hatchlings, but the most obvious photogenic sources of mortality, the coatis digging up the eggs or the ever present vultures, are not the major sources of low success rate. The invisible predators, the fungi and microorganisms, do more damage. Exactly why so many nests fail to produce hatchlings remains to be determined but enough is clear to say that microbiologists and pathologists rather than zoologists should now be brought in to take this study to the next stage. Destruction of nests by the turtles themselves is also as great or greater than the toll taken by obvious predators.

We hope that the full details of methods and data of this study will be published in the archival peer-reviewed literature. Despite the numerous positive things that could be said of this work, as conservationists and managers, we should also note its limitations.

The study covers the fate of eggs up to the time of hatching. Considerable natural mortality still occurs at later stages of the life cycle, especially during movement from the nest to the water and in the immediate offshore zone, but how great this is, we do not know.

The loss of eggs to erosion varies widely from year to year. If estuaries behind the beach open up and flood the nesting areas, as many as 30% of the eggs can be destroyed. On other occasions only 2% are lost to erosion. Predicting mortality for any particular arribada remains beset with uncertainties.

Finally, and this will apply equally to the other examples discussed below, one cannot generalize from this beach to other nesting beaches. Nancite is an unusual arribada site in that the extent of nesting space is severely limited by large rock masses at each end of the beach. Even at other ridley arribada sites in Costa Rica, for example, Ostional, where the beach is larger, rotting of eggs is far less frequent.

<u>Example 2: Green and leatherback turtles in Surinam</u>

A detailed and methodologically explicit study of the fate of eggs of two species of sea turtles nesting in Surinam has been carried out by Whitmore and Dutton (1985). Although the hatch rates of successful green turtle nests are relatively high (80.4%), because 21% of their nests are laid below the spring high tide line, the overall hatch rate is estimated at 63.5% (Table 1). In addition to nests laid below the spring high tide line (judged to be doomed eggs and often relocated), nests laid above this line are nevertheless washed over by exceptionally high seas without being totally destroyed. Whitmore and Dutton (1985) kept records of such washovers and found that they were associated with higher embryonic mortality. The greater embryonic mortality and lower overall hatch rate (35.8%) of leatherbacks is partly attributable to their tendency to nest closer to the water than green turtles and so leave their eggs more liable to wetting by exceptionally high seas; 40% of leatherback nests laid above the high tide mark are nevertheless washed over. The idea that greater infertility is an important cause for lower success of leatherback nests is refuted. Once again, the obvious predators such as the numerous ghost crabs are not the main agent of destruction. The apparently imperfect nest site selection by the turtles themselves results in a hatching failure of more than twice the number of eggs that predators take.

The Whitmore and Dutton study cited above contains a wealth of other information, including data on incubation in styrofoam boxes (greater embryonic mortality than natural nests laid above the high tide lines) and on nests reburied higher up on the beach (lower predation, cf. Stancyk et al. 1980). Some potential problems are that determining fate of eggs by counts of emerged hatchlings do not always match up with those obtained by examining the broken eggshells, and whether or not sampling of nests was random is unclear. However, the more serious limitations of such studies are that they stop at hatching, and that they cannot be generalized to other beaches, as comparison of the green turtle data to those in the nest example will illustrate (Tables 1 and 2).

<u>Example 3: Green turtles at Tortuguero, Costa Rica</u>

A useful study by Fowler (1979) shows the fate of 350 green turtle nests at Tortuguero, Costa Rica (Table 2). Fowler also gives the hatching rate for the undisturbed successful nests, 83.1%. Since only 42.6% of the nests were in this category, with another 4.9% of the nests giving some lesser hatch rates, a hatching percent for the total sample of all nests, whatever their fate, is <40%. This means that an artificial hatchery removing predation by humans and animals, and loss to tides, only has to achieve a 40% hatch rate to be more successful in terms of hatchling production than leaving the eggs where they were laid. Of course other considerations, such as sex ratios in artificial hatcheries (Dutton et al. 1985), also have to be taken into account.

A potential problem with this study is that the sample may not have been representative. In addition to the 350 nests whose fate was followed, a further 86 nest sites originally marked were excluded because of failure to locate the eggs. Some of these may have been false crawls but eggs may have been missed in other cases.

Another difficulty in using these data to assess natural mortality is that although Tortuguero beach is protected, it is not completely natural. Human predators could perhaps be considered as natural, but the large number of accompanying dogs do the most damage. The study area was near a village and may not have been representative of the whole beach.

Example 4: Loggerheads in South Carolina

The fate of 458 loggerhead nests was determined for four island beaches in South Carolina (Hopkins et al. 1978). The overall hatch rate of 6.1% was almost as low as for the Nancite ridleys, but for very different reasons. Raccoons dug up 56% of the nests in South Carolina (Table 3). Losses to raccoons were highest on the night the eggs were laid. Other interesting details were that the chances of a nest being found by raccoons did not depend on its location on the beach. Rather, raccoon predation paralleled the density of nests. Such detailed studies not just of predation levels but of the temporal and spatial predisposing factors are helpful in controlling particular threats. Indeed transplanting loggerhead clutches the night they are laid greatly increases their chances of escaping detection by raccoons (Stancyk et al. 1980). But, again, there are difficulties in arriving at theoretical or practical generalizations.

Should raccoons be considered as natural predators? At Cape Sable in the Everglades, predation by raccoons averaged 76% for years in which no raccoons were removed (Davis and Whiting 1977). Despite these high levels Davis and Whiting (1977) considered that predators of raccoons such as alligators, owls and bobcats were sufficiently common and that the numerous raccoons were not a result of human actions removing their predators. Nevertheless, perhaps access to some turtle beaches has been made easier for raccoons. The South Carolina beaches studied by Hopkins et al. (1978), although relatively unspoiled, cannot be considered completely natural. Water diversion schemes have altered the erosion patterns, especially for Cape Island (note 17.9% egg loss, Table 3).

The Hopkins et al. (1978) work brings out inter-beach differences in a striking way. All the areas they studied were relatively similar barrier islands, fairly close to each other, yet large differences in the fate of nests were found, both in losses to erosion and in type of predator. The low figures for predation by raccoons for Sand Island may partly be because people got to the eggs first on this relatively accessible beach. This leads to consideration of an important point about the interaction between the various factors contributing to mortality.

Removal of one source of mortality does not mean that all or even a majority of those eggs will automatically go into the percent hatched rows of balance sheets such as those shown in Tables 1-3. Stopping poaching on Sand Island also leaves more eggs for raccoons. Eliminating raccoons leave more clutches to be washed away by hurricanes at the end of the season. Saving eggs from tides early in the season again leaves more for predators. The great attraction of artificial hatcheries is that eggs can be saved from a variety of threats. More research on optimal hatchery procedures should be undertaken.

Example 5: Doomed eggs of leatherbacks

Various patterns of mortality on different beaches have been mentioned repeatedly. One way to arrive at valid generalizations is to compare the contribution of a particular factor to natural mortality on a number of beaches and try to discern some explanatory principle. This approach has been tried for the doomed eggs of leatherbacks (Mrosovsky 1983a). It seems remarkable that after long migrations these turtles so often fail to move the few extra meters up the beach necessary so that their eggs are not washed over. Obstructions are not a sufficient explanation. Table 4 compares the frequency of nesting below the high tide lines in a number of different leatherback rookeries. The great variation between beaches is as striking as the high levels for misplaced nests in the Guianas. On the basis of information on beach topography, nesting below the high tide line has been suggested to be more frequent in places where the vegetation on the landward side of the beach is relatively sparse. Without dark masses on the landward side, the danger of hatchlings becoming disoriented and wandering inland increases. The pressures not to lay too far inland result in a proportion of the eggs being laid too near the sea. The behavior of leatherbacks at Culebra, Puerto Rico, fits nicely into this. The females almost always move well clear of the seas on this beach, which is backed by cliffs and hillsides sufficiently large to provide excellent cues for sea finding.

Nevertheless, some conditions appear to be inconsistent with this formulation. In South Africa, nesting below the high tide line is common, yet the beaches there often lie at the base of tree-covered hills.

A methodological problem is that the data were mostly derived from predictions about loss of the nest to the seas. These were made on the basis of previous tidelines; actual destruction of these nests was not verified. This introduces imprecision into the study but does not invalidate it altogether. Laying below the high tide line is clearly far more common in the Guianas than in Malaysia (Table 4).

Limitations of Quantitative Studies

Careful studies, such as those outlined above, provide valuable information for particular rookeries. But they do not permit generalizations because of the marked differences between beaches. Another problem is that the line between natural and unnatural mortality is often blurred, as few really natural beaches are left. Furthermore, taking measures to reduce particular sources of natural mortality does not necessarily result in corresponding increases in the overall hatch rate, because they may simply provide opportunities for other sources of natural mortality to increase. At present no alternative to a step by step approach is evident. Studies of particular beaches should ideally extend over several seasons to take account of year to year variability. Even then, until quantitative work on attrition in the aquatic phase of the life cycle is undertaken, estimating survivorship to maturity will not be possible by such an approach. In Frick's (1976) study, 2 out of 26 green hatchlings were taken by fish as they swam out to sea off Bermuda; this was within just a few hours and <6.5 km from shore but was by day. More extensive studies of this kind, even if telemetry rather than swimming behind the hatchlings were used, could probably be faulted as looking at predation in a situation into which the experimenter had introduced artificialities, but might nevertheless provide some interesting information.

Some estimates of survivorship can be made from a combination of information on age (derived with some assumptions from size) and frequency of catching turtles in these different age classes (Frazer 1987b). These could be useful for comparing survivorship in different places or at different times, but they do not distinguish between natural and unnatural mortality, and they only apply to particular age classes. Thus, for example, an estimated 70% of the juvenile loggerheads off the southeast United States survive each year (Frazer 1987b); much of the mortality is from drowning in shrimping nets.

Natural Mortality Estimated from Reproductive Output

Nevertheless, one overriding generality provides some guidance: natural mortality is very high. Moreover some order-of- magnitude estimates can be obtained without studying predation and destruction by abiotic factors directly. In a stable population (if there is such a thing for turtles!) each female must produce 2 successful offspring, assuming a 1:1 sex ratio. According to Fowler (1979) "estimating from past records, each female that nests on the Tortuguero beach lays several thousand eggs, perhaps as many as 10,000 or more, during her reproductive life time." Two successful breeding survivors out of 10,000 give an attrition of 99.98% before breeding. Suppose Fowler's figure for reproductive output is ten times too high. If 1,000 eggs are laid in a lifetime, the mortality is 99.8%.

Even if one takes the pessimistic position that an average female manages to lay only a single clutch (ca. 100 eggs), pre-breeding attrition would still be 98%. More sophisticated models, incorporating more data but also more assumptions, have been elaborated for various species in various parts of the world (review in Frazer 1986). All of these give >98% mortality from egg to maturity; in fact most give >99.5%.

Much of this attrition takes place on the beaches. One may quibble about some of the details and limitations in the quantitative studies outlined above, but they all show high mortality at these initial stages in the life cycle. In the particular examples discussed above, 63.5% is the highest survival to hatching to be found. Most of the survival rates are <50% with some <10% (Fig. 1, Tables 1-3). This means that by protecting eggs (and hatchlings) on the beach one can exert some leverage on the population. Exactly how much will depend on the complex interactions between the various sources of mortality. Saving 20% of the eggs from tides provides more for predators on the beach. Putting more hatchlings into the water provides more food for the fishes. But no reason exists to assume that predation from such sources would become proportionally worse the more eggs and hatchlings were being produced (one assumes one is operating at a level past that where a specific search image could be activated). Therefore, the very high levels of natural mortality which at first may seem yet one more obstacle to overcome in conserving sea turtles, in fact, offer a splendid opportunity for increasing turtle populations. Exactly how such an opportunity should be used will depend on the levels of unnatural mortality and one's conservation philosophy.

Natural and Unnatural Mortality and Options for Utilization

Natural and unnatural mortality (e.g., incidental catch), have to be considered together in formulating management policies. If a particular population is at perilously low levels, and subject to high unnatural mortality (e.g., Kemp's ridley, incidental catch) every effort should be used to reduce natural mortality until unnatural mortality can be attenuated. But there are also turtle populations that are clearly not on their last stand. Thousands of green turtles nest each year in Surinam and Costa Rica and the numbers are not declining (see Mrosovsky 1983b). Olive ridleys in Costa Rica destroy vast numbers of eggs of their own species. In India at Gahirmatha, Orissa, when a ridley arribada came ashore on the same stretch of beach used by the previous arribada "the beach became littered with broken shells and dead hatchlings" (Mohanty-Hejmadi 1987). The same thing occurred on another occasion and the beach "resembled a turtle graveyard" (Bhaskar 1984).

What if anything, should one do in such cases about natural mortality? At the last WATS meeting, a distinguished conservationist asserted that to leave doomed eggs in the ground to rot would be better than to remove them if doing so stimulated any international trade in turtle products. Others find this attitude appalling. Not only do they regret the loss of protein but, taking a resource oriented approach to conservation more in line with the World Conservation Strategy, they feel that governments will be more likely to spend money on wildlife if some financial incentives are provided, especially if foreign exchange, which is desperately needed by third world countries is involved. Natural mortality offers an opportunity to generate such exchange, and to produce funds for conservation. In the case of turtles, I have suggested elsewhere (Mrosovsky 1983b) that one third of doomed eggs be collected for consumption while the other two thirds be protected. The eggs to be taken for consumption should be handled in a way that generates as much revenue as possible, as much as possible for covering the costs of the whole scheme and the protection of the beaches and the other eggs, or, perhaps better, for protection at some later stage of the life cycle. Some imagination and marketing skills could be helpful. Suppose, for example, that just as a limited number of permits are issued to trophy hunters for game in Africa or for polar bears in Canada, so a limited number of permits were sold to tourists in the Caribbean for egg collecting. There will be those who will find this idea quite as appalling as others find the suggestion of leaving doomed eggs in the ground to be washed away by the seas. But let managers and fisheries officials be asked which of the following two approaches will result in more turtles being saved: designating parks and reserves for which so often there are inadequate funds for enforcement, or obtaining funds from controlled commercialization and using those funds to protect other turtles? With the huge natural mortality, compensatory actions for the taking of eggs can easily be provided through hatcheries or other measures. These activities will have the added advantage of putting government personnel on the beaches; this in itself can discourage poachers. Some of the experienced poachers could be employed as guides, boatmen and wardens.

The particular suggestion of licensed egg hunting is just a hypothetical example. The general point is that there are only limited funds for conservation. In the long run governments may be more disposed to support wildlife departments that attract tourists or bring in some money on their own in other ways. The huge natural mortality of sea turtles is sometimes seen simply as just one more pressure pushing these species toward extinction. For example, a recent poster from the Belize Audubon Society states "... the mortality of young turtles is naturally very high. Therefore, turtle eggs are completely protected and their harvesting is prohibited." But sea turtles have been designed to withstand much natural mortality. This also offers an opportunity for conservation schemes that are more imaginative than total bans on harvesting.

Conservation Practices and the Gene Pool

Some interesting technical objections may be raised. If one saves eggs or hatchlings that would have otherwise been destroyed by predators, is one distorting the genetic constitution of the population? If one reburies doomed eggs in a hatchery, is one also reburying genes for poor nest-site selection? If one saves eggs from raccoons, is one relaxing selective pressures against anti-predator disguises? Let us consider the matter of doomed eggs as an example. Sea turtles have been here for a very long time. If a nest-site selection strategy that included laying eggs below the high tide line was non-adaptive, such misplacement of about a third of the nests in the Guianas today seems unlikely. Sufficient generations would have passed for this behavior to be selected out. The overall nesting strategy of laying eggs in a variety of places, some of which will be successful, and of accepting the risk of having some eggs washed away rather than laying all one's eggs too high up the beach where later the hatchlings will encounter difficulties reaching the sea seems more likely. Eckert (1987) found that there was considerable variance in the distance individual leatherbacks moved inland on different occasions before nesting. Her data support a scatter nesting strategy. This implies that allowing doomed eggs to contribute to the gene pool would not be harmful. Further thought and research on this topic certainly are desirable.

However, suppose that despite these considerations, doomed eggs were believed to have bad genes. Then what could be the objections to taking the eggs and selling them? One cannot have it both ways. Either these eggs are a source of valuable recruits to the population, in which case protecting them can be used to compensate for limited utilization, or, on the bad genes argument, they are all available for use by people.

One way or another high natural mortality means that turtle eggs, or ranched turtles produced by these eggs, are available for people. Unless the particular turtle population is perilously low, the sooner these realities are incorporated into management schemes, the safer turtles will be.

Acknowledgment

Support came from the Natural Sciences and Engineering Research Council of Canada.

Table 1. Fate of eggs (percentages) of green and leatherback turtles at Krofajapasi, Surinam, based on data in Dutton and Whitmore (1983) and Whitmore and Dutton (1985). Some approximations result from reading values from histograms and because infertility values come from a smaller data set.

	Green	Leatherback
Hatched	63.5	35.8
Laid below high tide	21.0	31.6
Predated (ruptured eggs)[a]	9.2	13.2
Embryonic mortality	4.1	14.4
Infertile	1.6	4.2
Undetermined	0.5	0.5

a includes some cases with eggs pierced by roots

Table 2. Fates of marked green turtle nests at Tortuguero. Percentages are based on 350 nests (adapted from Fowler 1979).

Nest fate	Percent of total
Undisturbed, young emerged	42.6
Disturbed, some young emerged	4.9
Destroyed by animal predators	34.8
Lost to human predators	6.6
Destroyed by the sea	5.7
Dead although undisturbed	5.4

Table 3. Fates of loggerhead nests on four barrier islands in South Carolina in 1977. Data expressed as percentages (adapted from Hopkins et al. 1978).

Island sample size (n)	North 79	Sand 158	South 87	Cape 134	Total 458
Beach erosion	3.8	17.1	1.1	17.9	12.0
Saltwater inundation	1.4	2.5	2.3	2.2	2.2
Raccoons	69.5	16.4	86.3	75.4	56.1
Raccoons or crabs[a]	8.9	6.3	1.1	1.5	4.4
Ghost crabs	2.5	3.2	4.6	0.0	2.4
Human beings	2.5	47.5	0.0	0.0	16.8
Hatched	11.4	7.0	4.6	3.0	6.1

[a] not known if crabs or raccoons reached the nest first

Table 4. Percentage of leatherback nests estimated to be below the high tide line on different beaches (from Mrosovsky, 1983a with additions).

Country and beach	Nests poorly sited	n (of nests unless specified)	Reference
Surinam, Baboensanti, 1982	78%	9	Mrosovsky (unpublished)
Surinam, Bigisanti	ca. 50%	many	Schulz, J. (pers. comm.)
Surinam beaches, 1971[a]	46%	24,000 eggs	Schulz (1975)
Surinam beaches, 1972[a]	44%	36,000 eggs	Schulz (1975)
Surinam beaches, 1973[a]	37%	75,000 eggs	Schulz (1975)
Surinam, Krofajapasi, 1980	36%	39	Mrosovsky (1983)
Surinam, Krofajapasi, 1982	32%	196	Dutton & Whitmore (1983)
French Guiana, Point Isere, 1970	39%	33	Mrosovsky & Shettleworth (1975)
French Guiana, Kawana	high	many	Lescure, J. (pers. comm.)
U.S. Virgin Islands, Sandy Point, 1982	31%[b]	86	Eckert & Eckert (1983)
South Africa Tongaland, 1968-69	30%	56	Hughes (1970)
Mexico, Tierra Colorada, 1978	22%	32	Mrosovsky & Marquez (unpublished); Mrosovsky (1983a)

Table 4. Continued

Country and beach	Nests poorly sited	n (of nests unless specified)	Reference
Puerto Rico, Isla de Culebra	2.5%	156	Tucker & Hall (1984)
Malaysia, Rantau Abang	<2.5%	>100 old tracks	Mrosovsky (1983a)
Malaysia, Rantau Abang	very low	many	Siow, K. (pers. comm.)

a Calculations based on data on disposition of eggs from Schulz (1975), assuming equal clutch sizes in poorly and well sited nests.

b These nests were thought to be in danger of being destroyed by tides and beach erosion and were therefore moved. In the event, an additional 30%, which were not moved, were lost during storms and high seas.

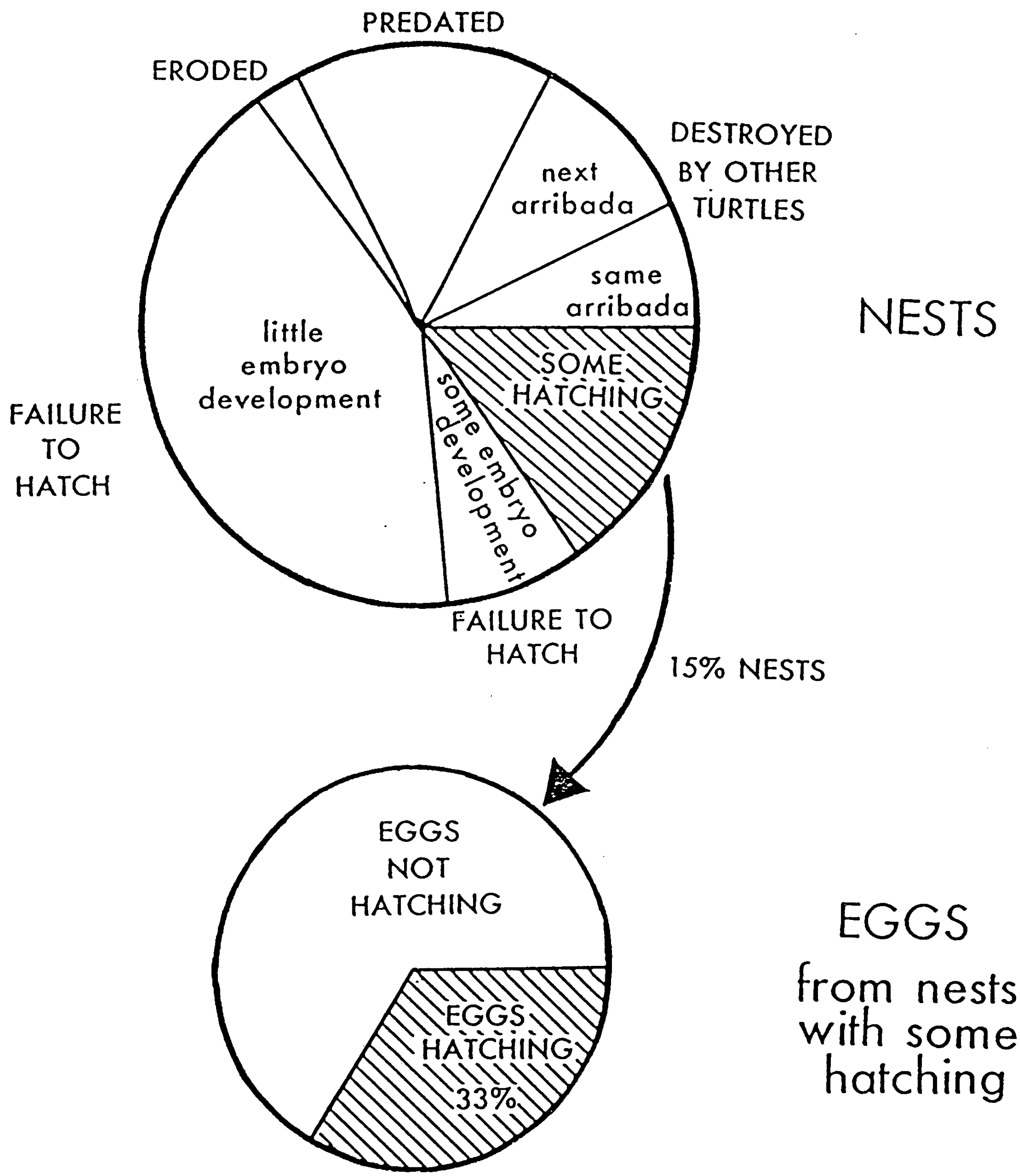


Figure 1. Fate of olive ridley nests & eggs at Nancite (Adapted from Cornelius, 1986).

Management Research Needs

Fishing Mortality in Sea Turtle Stocks (Andre M. Landry, Jr.)

Introduction

Current sea turtle management policies must take into account biological, socioeconomic, cultural and political factors which impact these stocks and their survival. Exploitation of sea turtles for subsistence and commerce is of primary concern to policy makers (Hopkins and Richardson 1984) because of the potential for endangerment and extinction of these stocks created by overharvesting, whether by directed fisheries or incidental take. Both directed and incidental harvests of sea turtles continue today--often at alarming rates and upon stocks near extinction (Frazer 1987). Although stopping exploitation of sea turtles is a long range ideal of many conservation strategies, today's management policies realistically can only strive to return these stocks to their former abundance while permitting controlled harvest for the socioeconomic welfare of human generations to come.

Continuation of directed and/or incidental sea turtle harvest necessitates sound conservation policies developed from research on impacts of fishing-induced mortality (or what is referred to in mortality analysis as F) and the overriding results these losses have on population recovery and viability. Management research needed to characterize fishing mortality is extremely varied in its approach and often difficult to conduct. Nevertheless, the future of many sea turtle stocks depends upon management recommendations developed from this research. This paper identifies management research needs as they apply to sea turtle harvest and suggests ways in which these needs can be met.

Management Research Assumptions

An underlying theme of the managment research approach presented herein is conservation of those wild stocks which collectively constitute a species through simple, conservative and low risk techniques. This approach is mandated by our inadequate knowledge of these stocks, their long migrations across international boundaries and the associated jurisdictional concerns which result and the exceedingly long maturation time characteristic of sea turtle stocks (Ehrenfeld 1982). Long life history cycles of sea turtles, wherein species such as the loggerhead (*Caretta caretta*) may take 15 to 30 years to reach sexual maturity, constitute a complex management problem because stock recovery and/or response time to management measures is so long. As an example, very effective and intensive efforts by Mexico since the mid 1960s to eliminate Kemp's ridley (*Lepidochelys kempi*) egg harvest at the Rancho Nuevo nesting beach has yet to result in an increase in size of the primary nesting stock. Should we increase our estimates of 6 to 13 years to maturity for Kemp's ridley, or should we look elsewhere to determine what is happening to the hundreds of thousands of turtles released as hatchlings during the history of beach protection at Rancho Nuevo? Conservation efforts like these should bear fruit but, in the case of the Kemp's ridley, it may take another 10 years before visible evidence is forthcoming as to whether or not management strategies that have been in place for two decades are effective (J. Woody, pers. comm.).

A prerequisite and explicit assumption of the following discussion on management research methods is that major sources of turtle losses due to fishing (F) can be identified. The problem is more easily studied in directed fisheries, where knowledge of turtle catch and fishing effort can be used in the estimation of F within a stock. An implicit assumption is the expectation by managers and conservationists that there is some reasonable chance of controlling the fishing effort responsible for identified major losses due to fishing. Complications to such a control arise when stocks cross one or more international boundaries (Dodd 1982). A case in point is that Mexico's efforts to protect Kemp's ridley eggs and nesters on beaches may be severely compromised by incidental capture of this species within the U.S. and Mexican shrimp industries (Hopkins and Richardson 1984). These problems can only be solved through international cooperation among countries having management jurisdiction over the stock(s) in question.

Life History Approach to Estimating Fishing Mortality

Stocks exploited directly as eggs, juveniles and adults, as well as taken incidentally in other fisheries, are subject to more than one instantaneous rate of fishing mortality (F) during their life cycle. This statement also probably applies to the instantaneous rate of natural mortality (M). In attempting to arrive at a framework for measuring these rates, we must divide life history of the species in question into a sequence of fairly homogeneous stages, within which the rates of fishing mortality from specific causes are assumed constant. Just how the life span is divided is a question that must occupy turtle biologists. The question addressed herein is to develop a life history model framework to guide investigations of fishing mortality. Once defined, this framework can become the basis for data collection and parameter estimation within directed fisheries and in sea turtle stocks impacted by incidental takes. This first step in the process is the main purpose of the present communication. However, recommendations presented herein need discussion and clarification by turtle researchers before field studies are planned for further data collection and analysis.

The objective of this approach is to develop a life table for sea turtles whereby life history is partitioned into meaningful phases (of non-uniform duration) within which impact(s) of fishing mortality can be determined. This approach to identifying management research needs assumes that defining impacts of harvesting on stock replenishment is the key question to consider for overexploited and potentially endangered resources such as sea turtles. Questions related to optimal yield should be deferred until such time as stocks recover to the point where they can be safely exploited, <u>if ever</u>. A second overriding assumption is that characterizing impacts of turtle harvest by estimating fishing mortality (F) assumes that there exists a real potential for management (i.e., fishing effort is or can be controlled). Complete prohibitions on fishing and incidental take are two extreme kinds of management controls of fishing effort, but more moderate controls are also possible.

<u>Partitioning sea turtle life history</u>: All sea turtle life history stages subject to fishing mortality are addressed herein; but, by necessity, females are the only component considered for the breeding population sector. At any one stage (i) of the life cycle the various causes of mortality expressed as exponential rates are additive (i.e., total mortality equals fishing mortality plus natural mortality, or $Z_i = F_i + M_i$), but this does not apply to comparable mortality rates experienced by successive stages in the life history. For the sake of argument, sea turtle life histories are divided into arbitrary stages i = 1, 2, 3..k (Fig. 1), to each of which we attribute annual mortality rates ($F_i + M_i$) and duration (t_i, where t is measured in years) as follows:

<u>Stage</u>	<u>Description</u>	<u>Parameters</u>
I	Egg survival from oviposition to hatching	F_I, M_I, Δt_I
II	Migration of hatchlings from nest to beyond littoral zone	F_{II}, M_{II}, Δt_{II}
III	'Juvenile' stage (until sexual maturity)	F_{III}, M_{III}, Δt_{III}
IV*	Migration of adults (females only)	F_{IV}, M_{IV}, Δt_{IV}
V	Time spent at sea as mature adults	F_V, M_V, Δt_V

* It is desirable to distinguish repeated egg laying events (in the life history model) for organisms that show multiple nestings. This is achieved by a superscript--e.g., F_{IV}, denoting fishing mortality experienced during the first egg laying migration.

A Model for estimation of fishing mortality: Parameter estimation (F) in a population life history model for sea turtles must be approached "piece meal," with initial emphasis on those mortality rates that are most accessible to estimation; other rates become the subject of informed speculation or are assigned orders of magnitude derived from a consideration of the life history, age structure, and longevity of the stock as a whole. Fishing mortality parameters for the various life history components and general comments pertinent to estimation of F within these components are presented below.

Parameter	Estimation
$F_I \ \Delta t_I$	Egg harvesting mortality might be estimated in terms of the number of eggs harvested as a proportion of the mean number of eggs present during the season: i.e., Number of eggs harvested seasonally / Mean number of eggs on beach during nesting season
$F_{II} \Delta t_{II}$	Are hatchlings susceptible to harvest on the beach or in the littoral zone? (if not, set $F_{II} \Delta t_{II} = 0$)
$F_{III} \Delta t_{III}$ and $F_V \Delta t_V$	Included here are 'directed' fisheries on juvenile and adult turtles at sea, as well as incidental deaths due to capture in fishing gear. Estimates of number of deaths caused by these two impacts should be made separately, as well as estimates of the population size of adults at sea, and these adjusted for number of females using available information on sex ratio. A rough estimate of number of mature females at sea might be: # of females = Number nesting annually X Mean time interval between successive egg laying
$F_{IV} \Delta t_{IV}$	Harvest of females onshore would be documented. A rough estimate of mortality might be:

$$F_{IV}\Delta t_{IV} = \frac{\text{Harvest of nesting females}}{\text{Number of females nesting annually and returning to sea}}$$

Management Research Needs

The research needs outlined below are in keeping with a conservative, simple and low-risk approach to sea turtle management. Consequently, many of these needs will share a common philosophy--that is, employ research methodologies which promote accessibility to critical data under conditions which permit the investigator as much experimental control as possible. Meylan (1982) recommended that nesting beaches were the only practical place to conduct censuses of sea turtles. Data collection programs staged on a nesting beach permit characterization of egg harvest, exploitation of hatchlings (if any), and adult harvest for use in estimating F for each of these stages as well as recording other life history information (i.e., sex ratio, nesting frequency, nesting fidelity, etc.). Research needs identified herein will be more easily met at major, well studied and well established nesting beaches that exhibit increased potential for yielding accessible data. Beaches such as those at Rancho Nuevo, Cumberland Island and Tortuguero are prime examples where research programs have been able to collect large quantities of data from readily accessible turtles and nests. Continued research on beaches such as these and the identification of others suitable for study are critical to estimating loss rates of sea turtles and eggs on nesting beaches. Other shore-based collection programs such as stranding and salvage networks may operate on and away from nesting beaches to provide relatively inexpensive information on sea turtle mortality (both F and M).

Specific research needs quantifying fishing mortality on sea turtle stocks are presented below. These needs are addressed by life history stage and the estimation of F_i.

Egg mortality: The ultimate research need pertinent to sound management at the egg stage and stages thereafter is identifying the number of hatchlings needed to produce one nesting female under conditions of no exploitation (whether directed or incidental) and under various levels of exploitation. This assumes the untested hypothesis that hatchlings produced on a given beach return there to reproduce as adults through some homing instinct. If true, management strategy becomes one of determining optimum size of the nesting stock needed to assure stability and renewal of the sea turtle subpopulation that reproduces on a given beach. At present, this research need probably cannot be met with available information and technology because the stocks are already depressed by overexploitation. However, the impact of exploitation of eggs (F_I) on generating a sexually mature female from a stock's reproductive products should be addressed initially. Estimating F_I may be accomplished by the method outlined earlier (see earlier section on Fishing Mortality Model) as long as appropriate data are available. Most realistic estimates of F_I will be generated at beaches that are well studied or where egg harvest is controlled. For example, Rancho Nuevo is patrolled for the majority of the nesting season and the number of Kemp's ridley eggs produced by the breeding stock is known. Because egg production depends on number and size of nesters, it can be measured or estimated. These data and the relatively controlled conditions under which they are collected are conducive to research determining the role of F_I in stock dynamics as well as providing useful information on nesting frequency, clutch size and natural mortality.

F_I also can be determined at nesting beaches with or having the potential for, controlled egg harvest. Costa Rica's Ostional beach is a federally protected site of large olive ridley (Lepidochelys olivacea) arribadas and subsequent egg harvest (Cornelius 1986). Recent legislation will permit legal exploitation of these eggs under controlled monitoring by Costa Rican federal and university personnel during very early phases of an arribada (S. Cornelius, pers. comm.). Monitoring programs such as this are needed to provide data for F_I estimation and to determine how it affects hatchling production. Subsequent management recommendations can then be guided by these results and, perhaps, applied to other sea turtle stocks as well. This is particularly true for nesting beaches with limited or controlled access, where monitoring stations could be established to quantify egg harvest.

Hatching mortality: Little attention has been focused on the need to estimate fishing mortality among hatchlings (F_{II}). For the most part, many researchers see little cause for concern about loss of hatchlings to exploitation and would probably agree with setting $F_{II}\Delta t_{II}=0$. This philosophy is often based on the theory that the hatchling's "lost-year" or years is spent in association with Sargassum or other flotsam (Carr 1985) where susceptability to harvest by most fishing gears is minimal. In any case, estimates of F_{II} at sea would be difficult to obtain unless at sea observer programs were implemented for this purpose. Such programs obviously would receive little priority in view of much more critical research needs for this life history stage such as quantifying at sea mortality among hatchlings due to ingestion of tar, oil clots, paper, plastics and nylon line (Carr 1986a).

A recent sea turtle management concern is impact of exploitation of hatchlings by "ranching" operations. Mariculture activities such as those on Reunion Island off Madagascar remove hatchlings from the nesting beach, rear them under conditions promoting accelerated growth and harvest them for commercial enterprises (Bonnet et al. 1985). Research assessing the impact from this source of F_{II} could be conducted through approaches similar to those outlined for estimation of F_I. Research to develop a permanent tag suitable for hatchlings is probably one of the most critical needs of sea turtle management. Such technology would not only shed information on impact from fishing mortality but also would help answer the evasive management question of how many hatchlings are needed to produce one nesting female within respective stocks. The ramifications of having suitable tag technology for the hatchling life history stage are enormous in understanding sea turtle population dynamics in general, and during the "at sea" stage in particular.

<u>"At sea" mortality of juveniles and adults</u>: "At sea" life history stages are very difficult to study and, consequently are those in most need of management attention. Opportunities to conduct research on juvenile and adult sea turtles at sea are unlike those for their onshore cohorts for whom data on F_I, F_{II} and F_{IV} can be generated on the nesting beach where access to eggs, hatchlings and nesters is more readily available and the ability to control or characterize harvest substantially greater. "At sea" stages constitute the longest and most inaccessible (to the researcher) of all constituent life history stages. Furthermore, a lack of information on sea turtles in these offshore stages and their tendency to migrate across international boundaries pose severe managerial problems. Research to solve this management dilemma should be initially focused on exploited stocks where access to valuable information on stocks at sea is inherent in the fishery. Examples of exploited stocks with tremendous research potential are the directed olive ridley fishery operating out of Oaxaca, Mexico and the incidental harvest of Kemp's ridleys by U.S. and Mexican shrimp fleets.

Research programs identifying rates of fishing mortality for sea turtles at sea (F_{III} and F_V) must be developed for directed fisheries as well as incidental catch. Several research alternatives appear applicable for generating at sea data on directed and incidental fishing mortality among juvenile and adult sea turtles. Among traditional methods deployed in finfish fisheries which are transferable to exploited sea turtle stock management are "fishing success" methods using catch and fishing effort data (DeLury 1951). These can be improved with tag-recapture data (Leslie and Davis 1939). Such data can be used to construct catch curves (if age is known), estimate exploitation rates, and calculate catchability coefficients as well as to identify changes in stock abundance and size composition through analysis of time series of catch and effort statistics.

Data collection programs which incorporate onboard observers have proven successful in estimating incidental sea turtle losses in the southeastern U.S. shrimp fishery. Similar programs appear feasible for directed fisheries such as those operating on olive ridleys in Mexico and Surinam and green turtles in Costa Rica. Intercept programs wherein port agents interview fishermen at the dock could yield data on sea turtle catch (bycatch) and fishing effort leading to estimates of F_{III} and F_V at less expense than those deploying onboard observers.

Additional data on fishing mortality among sea turtle stocks at sea can be gained through stranding survey techniques. Systematic beach surveys provide spatial and temporal mortality statistics, permit comparisons between stranding rates and measured fishing pressure, and enable collection of other valuable life history data such as species distribution and size compostion. The National Marine Fisheries Service is currently deploying an extensive stranding survey program to quantify sea turtles mortality along the Atlantic and Gulf of Mexico coasts of the U.S. and to identify probably causes of these deaths (E. Klima, pers. comm.). Similar methodology has been used to investigate the relationship between turtle mortality and fishing along Cumberland Island, Georgia, and to evaluate the impact of these losses on stock dynamics (Ruckdeschel and Zug 1982). Stranding surveys also quantify incidental fishing mortality through the documentation of turtle carcasses entangled in lost or discarded fishing nets, pot gears and monofilament line.

Use of stranding data to estimate F_{III} and F_V may create controversy because of the difficulty in distinguishing between fishing and natural mortality. Questions also arise as to the applicability of using stranding surveys in countries where fishermen utilize bycatch, especially sea turtles. Despite these drawbacks, stranding surveys provide the only source of information other than that from incidental catch data on intermediate life history stages and their associated fishing mortality (F_{III}). At sea observer programs provide excellent research opportunities to test the validity of using stranding data to estimate F_{III} and F_V within incidental sea turtle catches. Tagging and releasing all incidentally caught turtles (both live and dead) would allow the observer to generate data (from stranding surveys) on percentage of live-tagged and dead-tagged turtles which subsequently strand, range of times required for dead-tagged carcasses to reach shore and percent composition of incidentally caught turtles within the stranding population. Size composition data from stranded carcasses could be used to estimate age composition, based on growth curves; thence producing "catch curves" for strandings as a means of estimating total mortality rates (C. Caillouet, pers. comm.).

Transfer of turtle excluder device technology (i.e., TEDs) to shrimp fisheries inside and outside the U.S. will permit additional research quantifying reductions in incidental fishing mortality rates among sea turtle stocks. Not only should implementation of this technology lessen incidental sea turtle harvest, but research then becomes warranted to evaluate impact of this reduced exploitation on constituent stocks. Development of turtle exclusion technology in fisheries incidentally capturing turtles by means other than trawling is another critical research need for those stocks subject to F_{III} and F_V. For example, it is known that sea turtles are captured incidentally in pound nets and crab pots.

Nesting female mortality: Research needs associated with estimating fishing mortality on females at the nesting beach (F_{IV}), like those for F_I, are fairly well documented and the approach straightforward for well studied beaches. Emphasis should be placed on collecting mortality data along nesting beaches that are patrolled and which have the potential for controlled human access. This is particularly true in fisheries like that for green turtles in Costa Rica where a permitted harvest on females and males occurs on the Tortuguero nesting beach (K. Bjorndal, pers. comm.). These circumstances allow impact of harvest on prenesting (off the beach) and nesting females (on the nesting beach) to be determined. Mortality statistics must be supplemented with tag return data and traditional nesting information (i.e., number of nesting females, nesting frequency, nesting site fidelity, etc.) to assess better the impact of F_{IV} and other sources of F on stock viability.

A major research need related to F_{IV} estimation is establishing validity of nesting and natal beach fidelity within sea turtle stocks. Several workers (Richardson et al. 1978b; Shoop et al. 1985) have documented this trait in loggerheads. Mark and recapture research (especially the development of tagging technology for hatchlings) together with aerial tracking via radio receivers and observations from surface vessels are needed to validate this concept and monitor any change in spatial nesting patterns over time which results from human activities such as fishing.

Population Model

Satisfying research needs for estimating fishing mortality within sea turtle stocks will enable managers to develop population models for conserving these endangered resources. A population model that could be used for sea turtle stock management has been referred to as a "gantlet" model (Paulik and Greenough 1966). This model has been employed for marine mammals and can be expressed in matrix form (Vaughan and Saila 1976) for segmented life histories such as those exhibited by sea turtles.

The equation that needs solving to determine if harvesting at all stages allows enough survivals to a successive generation would resemble the following:

A. Number of females surviving to nest = Number of eggs produced per mature female $\times P_F \, e^{-(F_I + M_I)\Delta t_I} \, e^{-(F_{II} + M_{II})\Delta t_{II}} \ldots e^{-(F_V + M_V)\Delta t_V}$

(P_F = proportion of eggs that become females)

The eggs produced by these survivors may then be expressed by:

B. Number of eggs produced in next generation = Number females surviving to nest X fecundity X nesting frequency

It would be necessary then that:

$B \geq A$, otherwise population decline would occur.

One simplifying and conservative approach to management is to manage in such a way that at least nesting stock size is stabilized. With this being the minimum level of protection, the next step is to manage so that nesting stock size increases. Assuming that there is some optimum size for the nesting stock at a given beach, it would follow that more nesters may have detrimental effects on egg and hatchling production. In other words, a stock-recruitment approach is suggested, whereby the recruitment in question is that of nesting females. This simplifying assumption of course becomes more realistic as F decreases.

Conclusion

The research needs presented herein may at least provide a framework for discussion among turtle biologists, resource managers, and population modelers. Meeting these needs should generate new approaches to field data collection, fill critical information gaps, enable more realistic models to be developed and enhance implementation of sound management strategies.

Acknowledgments

I wish to thank John Caddy, FAO Rome, for concepts leading to development of the life history approach to modeling sea turtle mortality due to fishing. Charles Caillouet, Jr., National Marine Fisheries Service in Galveston, Texas, provided valuable management research recommendations and constructive criticism. Clara Surber and Mollye Wenglar assisted with manuscript preparation.

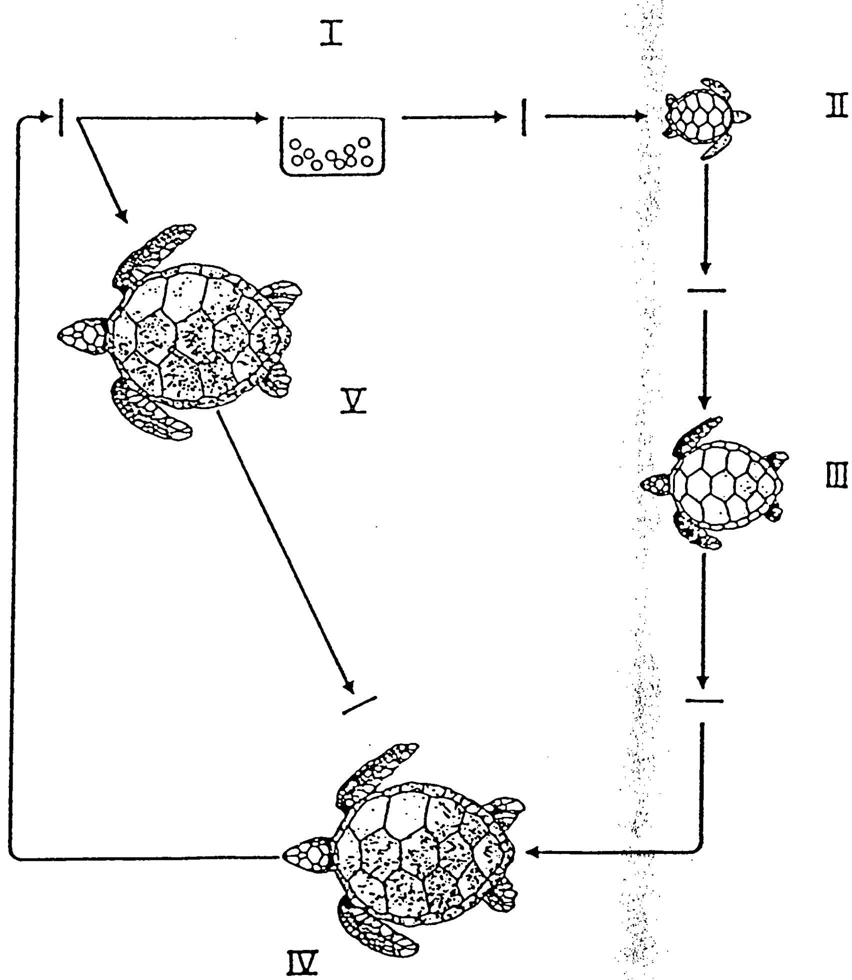


Figure 1. Sea turtle life history stages where fishing mortality occurs.

Management Research Needs

Research Needs for Population Biology (James I. Richardson)

My comments today will focus quite narrowly on my assigned topic: Research needs to understand better the population biology of sea turtles and, in so doing, to enhance our ability to recover and manage sea turtle stocks in the Wider Caribbean. What do we not know about the behavior of these creatures that we absolutely must know to enable the fisheries officers and resource managers of the WATS II region to carry out their responsibilities? When can we begin to know that a management decision is wise? When can we stop guessing?

Several exciting avenues of research will not be covered in my talk. These research areas are near and dear to some of my colleagues who may become unhappy that I have not drawn attention to their interests. For this I apologize, but I am determined to talk about short term (5 years or less), inexpensive research needs with maximum value for recovering and managing sea turtle populations in the Caribbean. What can we do now, with limited funds?

Reproductive Behavior

How many eggs can one female turtle produce in a single season? The other side of this coin would be ... how many female turtles produce the number of eggs or nests on the beach? The average number of seasonal nests per turtle continues to climb (greater than four for *Caretta*, six for *Dermochelys*, and possibly as many as five for *Eretmochelys*), but we are still guessing. The experts continue to argue. If the average sea turtle proves ultimately to lay five or more clutches of eggs in a nesting season, as I suspect it does, then we have been badly overestimating the number of adult females calculated from nest surveys. Overestimating numbers is not wise when dealing with a dwindling species.

For how many seasons can a female turtle return to nest during her adult lifetime? Six nesting seasons in twelve years? Eight seasons in 25 years? How many adult female turtles that disappear from the nesting beaches are not dead but, in fact, have just quit nesting, as C. Limpus has discovered for his Australian loggerheads? We simply do not know. Our estimates of survivorship are biased by the attrition of nesting females from incidental and directed take, by the uncertainty with which we locate our female turtles in subsequent seasons, and by tag loss.

If an adult female can live for many years, as I suspect it can, then our laws that persist in allowing the take of adult females on and off the nesting beach are truly misguided. If, on the other hand, sea turtles most often nest just one season in a lifetime, as was suggested at WATS I, then we could harvest the adults at the end of the nesting season and not affect our population replacement rate, as was also suggested at WATS I. Such idle speculation is dangerous, for it can become the foundation for counterproductive laws. We are the scientists, but we still do not know how many nesting seasons are contained in the lifetime of an average sea turtle.

I have been pleased to hear from most of the national representatives at this WATS II gathering a desire for conservative fisheries laws where the adequate supporting data are not yet available. I sense a desire to protect the eggs, to protect the adults, and, if necessary, to harvest a few young animals that appear to offer the shortest replacement time. This is a good conservation management plan to set in place, while the research needs are being met. We must move forward with the research so that a management schedule can be maintained.

There are other facts associated with nesting behavior about which we have more to learn. How many times on the average must a turtle visit a beach before she nests successfully? Does this average remain constant for a given beach or for a given species? These questions are directly related to stock assessment questions.

Research needed to perfect stock assessment methodology for sea turtles of all species is always a high priority. Surprisingly, we still have much to learn about the nesting season itself. By this, I do not mean when nesting occurs, for an occasional hawksbill or other species may appear at any time of the year. I mean how much nesting, or what proportion of the season's nesting females are active at a given time. Much is said about turtles shifting their nesting season, but no one has quantified such a shift. Let me give you an example of the value of accurate seasonal nesting data. Antigua and Barbuda fisheries law permits the taking of adult turtles after 30 September. Based on our studies this year, we predict that 75 percent of this season's hawksbills nesting at Pasture Bay, Antigua, will have appeared during the first ten days of October. Virtually all of these animals could be taken legally in front of the nesting beach with tangle nets during this short period of time. Certainly, we must have knowledge of nesting rates and nesting seasons with considerable accuracy to support needed changes in harvest seasons and harvest rate regulations.

Before I move on, I would like to digress for a moment on the subject of tagging. The research needs that I have been discussing require the tagging of adult females on the nesting beach. Several of us are convinced that aggressive tagging programs can and already have, in some instances, affected the behavior and, hence, our understanding of the population biology of nesting loggerheads along the southeastern U.S. For this reason we observed the hawksbills at Pasture Bay, Antigua, for an entire nesting season before we selected a tagging methodology. Today, we are tagging our animals in three different ways, and we are confident that the turtles are not being adversely affected by our presence on the nesting beach. Given that the number of safe nesting beaches are few and becoming more scarce with each passing day throughout the Caribbean, we would be irresponsible if, in our quest for knowledge, we drove turtles to nest on a less protected beach and thereby to their destruction. Please deal gently with nesting sea turtles, particularly while they are ascending and descending the beach. Do not initiate tagging programs on beaches unless you have specific goals in mind and you are very careful about what you are doing. If you are going to tag, use the best available tagging technology, so you don't have to harass your turtles on subsequent nesting visits. Research on better tag technology is always needed.

Reproductive Success

We know now many eggs are in an average clutch, but we know very little about the proportion of hatchlings that emerge from a given clutch or the proportion of emerged hatchlings that successfully reach the water. We count nests and nesting crawls, but all too often we do not follow the fate of those nests. Some or most will be destroyed before they hatch. We know many reasons for the losses (predators, erosion, excessive rainfall, etc.), but rarely do we know how many nests are lost or what proportion are associated with a particularly lethal factor. If a nest does escape destruction, hatching success is rarely 100 percent, more usually 50 to 95 percent, depending on the species of turtle involved and the beach conditions affecting the nest. Reproductive success of natural nests is a most important aspect of population biology and resource management, but the data are generally not available. Research on reproductive success is inexpensive and accessible to anyone with an active nesting beach. Much more research is needed in this area.

Temperature Modulated Sex Ratios

No topic has captured the attention of the sea turtle research community quite like Mrosovsky and Yntema's temperature modulated sex ratio paper of several years ago. For those of us brought up on the "birds and bees" school of sex education, the lack of deterministic sex chromosomes in the fertilized egg of sea turtles was an amazing revelation. Since then, the pivotal temperatures for several species of sea turtles have been determined, and the association of the phenomenon with natural nests has been verified. However, ambient sand temperatures fluctuate on the beach, and the relationship between these fluctuating temperatures and sex determination remains poorly understood.

I bring all this up to caution against overreaction in management efforts. We are manipulators at heart and confident of our skills. We love hatcheries and buckets of baby turtles to carry to the sea. There are even those of us who believe that the goal of temperature modulated sex ratio research is to manipulate the hatchling sex ratios of local populations and, thereby, enhance recovery rates. This should not be so. We must not allow natural nesting beach conditions to be replaced in our management plans with manipulative hatching programs, unless absolutely necessary. For most of us in the WATS area with a sea turtle recovery job to perform, further temperature studies are not needed. Instead, we should protect natural nesting beaches. If hawksbills want bushes under which to nest, then leave the bushes for the purpose. If nests must be relocated, then relocate to a site as similar to natural conditions as possible. For those of us with a zest for curiosity, temperature profiles of the nesting beach provide insight into sea turtle nesting behavior, and we can check to see if our hatchery sites simulate natural thermal conditions as closely as possible. Beyond that, I believe management will be better served in the long run by allowing the sea turtle to make her own choice as to where a nest should be placed and spending our time making sure that her options for choosing a site remain open and not compromised.

<u>Population Research</u>

For those of us who work with life tables and predictive population models of sea turtles, the past several decades have been frustrating. Dealing with population models is not easy when bits and pieces of the life history are unknown. Our colleagues who work with more accessible organisms tend to put down our modeling efforts with sea turtles, because we cannot find those elusive hatchlings during Dr. Carr's missing year and, therefore, cannot track their fate from egg to death. However, we know a great deal about many segments of sea turtle life history, and those segments offer much of value for management. Knowledge of certain other segments of the life cycle still elude us but are within our grasp if we initiate vigorous research efforts in their direction. For example, growth rate is probably the parameter of population behavior most urgently needed for management. Growth rates tell us how long it takes a turtle to grow up, how long we must wait for this year's hatchlings to become tomorrow's nesting females, how long it may take to put turtles back into certain Caribbean waters where turtles once roamed but now are no longer found. We know how fast adult female turtles grow; they don't grow at all, or at least not significantly within the lifetime of the researcher taking the measurements. On the other hand, we do not know even a fraction of what we should know about growth rates of juvenile turtles in the wild. My recommendation: tag as many juveniles as possible. Collect growth rates over time as recapture data accumulates. One of these days, a tagged juvenile will crawl up on a beach to nest, and we will have taken a giant step in understanding the management task that lies before us. If fishermen want to bring live, tagged turtles to a local research center set up to gather growth and distribution data, I say encourage them to do so. Such an exercise may produce some very valuable research data and could even be supported with research funds.

Much is said about tagging hatchlings, but, if a couple of hatchlings could later be recognized as 30 cm juvenile turtles, then we will have taken another giant step forward toward modeling and predicting population response and recovery rate. One method being discussed for tagging hatchlings is the use of implanted, coded chips called PITs, an acronym which stands for passive integrated transponders. Years later, a unique identification number can be read from the turtle by passing a wand over the carapace or flipper containing the PIT. A tagging project of this kind would be a major effort, requiring tens of thousands of hatchlings, a commitment of time over many years by resource management agencies and lots of money. Should such a massive experiment succeed, the results for management would be unbelieveably valuable. The whole idea is fascinating but needs a great deal more debate and careful thought before action should be taken. I am not sure we can afford such an effort, and I am concerned that the disturbance associated with implanting the tag will reduce survival potential of the hatchlings and compromise the experiment.

Population sex ratios of juvenile and adult sea turtles in the wild represent another life cycle parameter about which we know very little. The methodology is technical, requiring an internal inspection of the gonads with a laparoscope. The value of the exercise depends on how well the researcher has sampled the population. That is to say, is he looking at a random sample of a whole population or at a biased gathering of turtles drawn non-randomly from the real population? I don't know anywhere in the Caribbean where you can test this point. I suggest that sex ratios are fascinating bits of information but not a management research priority in the WATS area; we may have to depend on C. Limpus' Australian work for our answers. I suggest that we gather such data whenever and wherever they are available, such as from slaughterhouses or indigenous take on beaches or from animals killed by trawl nets. However, I do not think we can afford to set sex ratio studies as a priority management need in the Caribbean.

Other avenues of investigation into the population biology of sea turtles are fascinating, particularly the endocrine or internal hormone system that drives sea turtle behavior and the way in which the internal system of the turtle interacts with physical parameters of the outside environment. This is very exciting work, with much potential value for management needs. However, in terms of a WATS priority, I think we should leave this work to the experts and focus within the Caribbean more on research needed for developing short-term management options and recovery of sea turtles.

Home Range and the Movement of Turtles

We must know where turtles go, where they spend their time. We need to know the areal requirements of foraging territory for a species, a population, an individual. We need to know the routes taken by individuals between foraging and nesting/mating habitat. The classic work with tagged Chelonia mydas by Dr. Carr over the last three decades has shown us what can be done and how useful for management are the results. We still have much to learn along these lines (for all the sea turtle species) by tagging juveniles and non-nesting adults in the water and by tagging nesting females on large, remote beaches. However, please remember my word of caution about driving local groups of nesting turtles from safe beaches into adjacent areas where the turtle and their eggs will be taken.

What about alternative tagging methods? The PIT tag mentioned earlier may have a more immediate application for the larger turtles. The coded chip, inserted into the leading edge of the carapace, could permit the shell of a butchered turtle to be traced to its origin.

There is a wide variety of remote sensing devices, most of them costly and very difficult to follow at sea. The documented wandering of a few turtles does not tell us much about the population, so be prepared to tag and follow a lot of turtles. Perhaps the international travels of a single turtle might prove useful for stimulating cooperative efforts among nations. Whatever your choice of research might be, please remember this: tags of any kind and remote sensing devices, in particular, are tools for answering questions. The act of tagging a sea turtle must not become an end in and of itself. If we do not have a specific, well-considered question in mind which requires tags for an answer, then perhaps the tagging project is not in the best interest of the endangered turtle species or the individual animal that was persuaded to carry the device.

Biochemical Identification of Stocks

If I am not mistaken, we promised among ouselves at the termination of WATS I to work toward defining sea turtle populations. I don't think we have achieved much on this task. Should we consider Montserrat and Guadeloupe juvenile hawksbills to be from the same population? Are U. S. Virgin Islands (USVI) and Trinidad leatherbacks from the same population? If the Aves Island green turtles are lost, does it really matter for the Wider Caribbean, so long as the green turtles at Tortuguero, Costa Rica, continue to nest in good numbers? If we have 28,000 loggerheads along the southeastern U.S., can Yucatan loggerheads be considered endangered or the Colombian loggerheads extinct? I think we must continue to grapple with these technical/emotional issues, for we must continue to assign priorities to Caribbean conservation efforts.

There are ways to identify species, local populations, even individual animals by characteristics of the genetic material (genotypic tags) or the body protein (phenotypic tags). Efforts to identify sea turtle stocks have been partially successful. We can tell a Chelonia hamburger from a Caretta hamburger, but we have not yet been able to separate a Tortuguero, Costa Rica, Chelonia from an Aves Island, Venezuela, Chelonia. Many people are working on this research challenge. The payoff to management, if the research succeeds, is so great that we must continue to support this work. Even if the chances for success are not great, we still need to keep trying.

Impact Assessment Mitigation

I would like to conclude with a discussion on impact assessment. If recovery and management of sea turtle populations in the Caribbean represent our primary objectives, then this is where the research is needed. This is the war in the trenches. In the United States, an enormous amount of money and human energy are being spent on behalf of loggerheads and Kemp's ridleys being impacted by beach lights, sea walls, and trawl nets. The number of volunteers working on these projects must number in the thousands. The U.S. government spends millions of dollars on the personnel and project expenses it dedicates to sea turtle conservation in its territorial waters. Throughout the Caribbean, there are many problems that need research assistance, but there are few funds and not enough people to help.

Degradation of foraging habitat and its effect on turtle populations would be one example of a Caribbean management need requiring research assistance. Development of nesting beaches for the tourist industry would be another. There are thousands of beaches on hundreds of islands threatened by resort development, and if a beach is not used for tourism, it may be used for sand mining. I have heard it said by a dozen speakers in the last few days that sea turtles of all species have disappeared from many historical nesting beaches because of development, but I cannot find out why. Loggerheads nest successfully on heavily developed Florida beaches, given proper protection. Leatherbacks seem to do well on Sandy Point, USVI, where groups of 20-100 people are not uncommon at night. We urge guests at Pasture Bay, Antigua, to come out and witness the nesting hawksbills. As far as we can tell, the noise, light, and general commotion of the visitors do not adversely affect the hawksbills, at least not yet.

If all of the above are true, then how does development drive turtles away? I personally believe that properly regulated development can be partially compatible with nesting turtles. The intended development at Pasture Bay will provide us with an invaluable research opportunity to measure the before-and-after development stress on the turtles. We had better be successful, because the development will not stop. If something has to go, it will be the turtles. There must be a serious research effort initiated throughout the Caribbean to identify and mitigate disturbance associated with resort development. Is it lights, habitat disturbance, human harassment, noise, presence of dogs, taking of eggs by resort staff, something else, or all of the above? If the turtles must leave, will they go somewhere else, and how far? Research is needed <u>now</u> to answer these questions.

Acknowledgments

I wish to thank IOCARIBE and the U.S. National Marine Fisheries Service for causing this amazing series of meetings (WATS I and WATS II) to happen. The positive effect on research and conservation of Caribbean sea turtles has already been dramatic and will continue to guide recovery and management efforts for years to come. Please do it again! There are many of us standing in the wings to help, if you can use our services.

I also want to thank Peter Pritchard and Scott and Karen Eckert who have provided me with most of the magnificent slides I have used in this presentation.

Management Research Needs

Rapporteur Report of Management Research Needs Panel Session

CHAIR: Frederick Berry, USA

RAPPORTEUR: Barbara Schroeder, National Marine Fisheries Service, USA

SPEAKERS: Thomas Murphy, South Carolina Wildlife and Marine Resources Department, USA

Jeanne Mortimer, University of Florida, USA

Wayne Witzell, National Marine Fisheries Service, USA

Nicholas Mrosovsky, University of Toronto, Canada

Nancy Thompson, National Marine Fisheries Service, USA

Andre Landry, Texas A & M University at Galveston, USA

James Richardson, University of Georgia, USA

Each speaker presented a paper on his or her assigned topics: Beach Habitat (Mortimer), Beach Surveys (Murphy), Water Habitat (Witzell), Sea Turtle Natural (Mrosovsky), Water Surveys (Thompson), Fishing Mortality (Landry), and Population Biology (Richardson). The Chair opened the discussion to the panel members.

MORTIMER: In areas of high density nesting, hatcheries handle a very insignificant percentage of all nests laid on the beach. Protecting nests *in situ* may be a better alternative. Aerial surveys may be biased if the day selected for nest counts is not representative of the season.

Open to the floor.

WILKINS: (National representative of St. Kitts). Are previously laid nests destroyed by subsequent nesters on high density nesting beaches?

RICHARDSON: Yes, this does happen. Nesting can be density dependent; loss of habitat can also concentrate nesting and cause problems.

FRETEY: (National representative of French Guiana). Screening nests is not possible on high density nesting beaches, because screens are destroyed by subsequent nesters. It is also difficult to obtain temperature profiles from high density beaches because the probes cannot be protected from the turtles. He asked about the accuracy of the mathematical equations used to estimate nesting populations.

T. MURPHY: Arrival survey methodology was reviewed. The estimate of nesting females has not been extrapolated to the total population. This aspect is under study.

FRETEY: Headlamps operating off solar power are used in French Guiana. Further information is available through him.

FOSTER: (National representative of U.S.). Mrosovsky's point about moratorium regulations causing enforcement problems exists also with seasonal closures or size limitations. She asked Murphy if aerial nesting surveys are conducted comparably in other states.

T. MURPHY: No.

MROSOVSKY: He agreed with Foster about enforcement. Commercialism can generate funds for enforcement while non-exploitation cannot.

GOMEZ: (National representative of Venezuela). He commented on Mrosovsky's comments on harvesting "doomed" eggs subject to tidal inundation or erosion representing negative genes. Observations on Aves Island seem to indicate randomization of nest site selection on the nesting beach. Eggs laid in poor sites at one nesting are not necessarily negative genes. It is dangerous to utilize these eggs at the commercial level and may be much better to translocate these eggs.

MROSOVSKY: Urged publication of these data. What is done with eggs deposited in poorly selected nests sites is part of one's conservation philosophy. You must do what you think is best.

LAWRENCE: (National representative of Dominica). Has any work been done on fishing mortality by the swordfish fishery? Our knowledge indicates heavy mortality especially in regard to *D. coriacea*.

Shouldn't we look at this? Can we obtain data at the ports where catch is off loaded? Puerto Rico, Miami, British Virgin Islands?

WEBER: Information on the Japanese swordfish fishery in the Gulf of Mexico indicated that 204 turtles were taken between 1978-1981. There is no information on the U.S. swordfish fishery, and an observer program is needed.

THOMPSON: A limited observer program is conducted by the University of Puerto Rico Sea Grant. The paper on Japanese long line catch was authored by W. Witzell.

LANDRY: An intercept (interview) program at landing ports may be an alternative to an observer program. He asked about catch per effort data in countries allowing harvest. These data should be collected from fishermen and possibly utilized to monitor populations, as catch is density dependent.

LAWRENCE: Swordfish fishing is conducted by U.S. and Japanese boats. This needs to be addressed.

FULLER: (National representative of Antigua). Longliners in the eastern Caribbean are small fiberglass boats: turtles are caught and thrown overboard. An intercept (interview) program will not work, the fishermen will not tell you what they caught. He was unable to understand the "bad gene" hypothesis discussed by Mrosovsky.

FRETEY: Saving doomed eggs through translocation sends a greater public education message about conservation. He asked Mrosovsky how we intervene in terms of "bad gene" nests without playing with witchcraft.

MROSOVSKY: There is a problem in choosing which is better to do.

GOMEZ: Two recent reports (unpublished) show two turtles tagged at Aves Island were recaptured nesting at a different locality. One female nested 11 days later on Mona Island, and one female nested 9 days later on St. Kitt's.

LAWRENCE: There is no need for research on ocean debris; there is a need for immediate action to stop this pollution.

PARSONS: (National representative of Cayman Islands). He believed turtles could adapt and move elsewhere to nest if previously selected nest sites are not available. Headstarting has shown that turtles can reproduce in captivity.

MORTIMER: Extensive tagging of thousands of nesting females at Ascension Island, Aves Island, and Tortuguero has not produced any records of females nesting at a different nesting beach than the one where it was tagged.

BOULON: (National representative of U.S. Virgin Islands). Nest relocation at Sandy Point, USVI (poor nest sites to suitable nest sites) increased production. This is not propagating "bad" genetic material,because females nest site selection is random there. Tagging projects targeting juveniles and sub-adults is important. He offered to assist other Caribbean countries in establishing a juvenile tagging project.

GILLET: (National representative of Belize) As sea turtles are very ancient reptiles, are we witnessing a natural extinction? Are we trying to conserve a species which is naturally headed for extinction? He supported the need for additional research in the Caribbean region.

EHRHART: Legislation is currently pending in the U.S. Congress regarding the dumping of debris.

SHIPP: From an evolutionary standpoint, it is esoteric to worry about "bad or good" genes at this point. Perhaps 5,000 years from now we should worry about this.

Worldwide Sea Turtle Conservation and Management Activities

Rapporteur Report of the Ad Hoc Worldwide Sea Turtle Conservation and Management Activities Panel Session

CHAIR: Colin Limpus, Queensland National Parks and Wildlife Service, Australia

RAPPORTEURS: Roderic Mast, World Wildlife Fund, USA

Herman Kumpf, National Marine Fisheries Service, USA

PANEL: Alfredo Figueroa, Universidad de Michoacan, Mexico

Rene Marquez, Instituto Nacional de la Pesca, Mexico

Jeffrey Miller, Queensland National Parks and Wildlife Service, Australia

Jeanne Mortimer, University of Florida, USA

Perran Ross, Caribbean Conservation Corporation, USA

Georgita Ruiz, Universidad Veracruzana, Mexico

Johan Schulz, Netherlands

The chairman announced that he was pleased, as an outsider, to be able to expand his horizons to the Caribbean.

LIMPUS: The intention of this session is to give you some idea of sea turtle activities that are taking place outside the Caribbean, the species and the issues.

MARQUEZ: The leatherback is one of the most widely distributed species; it travels the greatest distance from its nesting zone. These animals are very special; they maintain a temperature above that of the sea. Scientific information on this species is new. They are well known to Pacific fishermen and have a different common name in each region (tinglada, chalupa, etc.).

Until recently we did not know all the nesting areas. Their discovery is an interesting story. Lots of eggs were seen in markets in Mexico City, but their origin was unknown. After tailing one of the trucks which carried the contraband eggs, we were led to Punta Maldonado, once an isolated spot near the border of Oaxaca where hundreds of leatherbacks nest. Families walk the beaches, marking the nests and returning to remove the eggs; they respect each other's territory. Commercial traffic in eggs and take of turtles has been banned in Mexico since 1966. We found a nesting beach in Michoacan with hundreds of turtles; later, Pritchard did a reassessment of leatherbacks worldwide. We have no organized fishery, only contraband (illegal).

<u>FRAZER</u>: Do you think there are undiscovered leatherback nesting areas?

<u>MARQUEZ</u>: Yes, there are. Leaving Acapulco near the airport there is a coastal strip which has turtles. Also at Playa Colorado, and at Bahia Achacagua and farther north, as well as near the Chiapas border. Leatherback turtle nesting in Mexico has not been fully quantified. There should be some more nesting beaches farther south, also.

<u>RUIZ</u>: We had 3,000 nests in 1982, and in the period from 1983-86 this collapsed down to 500/year. Has this type of fluctuation been seen elsewhere?

<u>MARQUEZ</u>: Often we blame the El Nino phenomenon when we cannot explain something. This has been seen elsewhere.

<u>ROSS</u>: I'd like to draw your attention to what was said by Frazer. In Oman we are dealing with a situation where we must manage the people associated with sea turtles. Oman is a very small country with a modest income from oil. Sea turtle populations are large and management in Oman is not necessarily applicable to other areas. I have worked in Oman for 10 years. The Oman authorities consider turtles to be a fisheries resource from which there must be an economic return. We have not developed our own population model for their management, but have utilized those of Frazer and Richardson. We have four species (<u>Chelonia mydas</u>, <u>Caretta caretta</u>, <u>Eretmochelys imbricata</u> and <u>Lepidochelys olivacea</u>) for which we have used a management plan based on protection of all species concentrating on major nesting beaches; we do not regulate the taking of eggs because too small a number are taken. We have tried to protect habitat as well (used example of a large clinic

which was built in the middle of a nesting beach and cast light which disoriented hatchlings).

Artisanal fishing as a management option is a gamble because we don't know stock size. Several thousands of hawksbills are taken by harpooning, etc. We can proceed with the information available using best guesses to manage the population.

FOSTER: Since you allow the taking of eggs, do you then manage the remainder?

ROSS: We have lots of turtles and are letting nature take its course.

MROSOVSKY: At Azira you had a 60% loss of eggs. Why don't you do something about that?

ROSS: The volume of nesting beaches precludes any logical action. Eggs are measured in metric tons; we have so many, we are letting nature take its course. I'm not suggesting that these methods would be appropriate everywhere.

RUIZ: Eastern Pacific Olive Ridley: These comments are personal, as I do not represent Mexico at WATS II. In the American Pacific we have the second largest nesting in the world after Orissa, India. Extremely high numbers of turtles nest in arribadas in many locations. The species is very vulnerable and some populations have already collapsed. We have learned migratory routes and have learned that olive ridleys are a very migratory species, nesting in Mexico and feeding in Ecuadorian waters. They are a very gregarious species and are easy prey, thus they are subjected to intense capture and are traded extensively.

Playa Escobilla produces 7.5 million hatchlings, more than all other beaches combined. There is evidence that Costa Rican and Mexican turtles are going to Ecuador. In Mexico, management focuses on eggs. The Ostional nesting beaches have put a very interesting egg management plan into effect; this will be talked about tomorrow. It contains all the aspects of proper conservation.

I would like to close by reiterating a point made earlier that the only thing non-negotiable is the biological reality of the species.

MOHADIN: Do you have any data regarding how many nests a turtle can lay in one season, and what the remigration interval is?

RUIZ: 1.5 to 3 nests per season, and they can return yearly.

CHAVES: We won't be able to discuss Ostional tomorrow. If you could mention more now, it would be appreciated.

RUIZ: Egg harvesting is allowed on the first night of the arribada, but not at all on the following nights. The collected eggs are washed, packed, labelled and distributed to places where illegally gathered eggs are eaten in Costa Rica. This drives down the price of illegally taken eggs, thus discouraging that activity. Environmental education is also a part of the program. The income obtained from the sale of these eggs goes 60% to the community and 40% to the project.

REP. PANAMA: In Panama, olive ridleys were abundant at Isla de Canas until 1960. They declined a great deal in numbers, and we began to protect them. By 1980 there was a notable increase, in 1981 there was an arribada of 2,000-10,000 in 3 nights and by Sept. 1984 there were 33 consecutive days of nesting with 18,000-30,000 turtles. Can you explain this rapid recovery?

RUIZ: This is difficult to explain. Possibly, this is a result of conservation, but not likely. These are probably nesters from another population. Do you agree, Rene Marquez?

MARQUEZ: Yes.

CHAVES: Similar things have happened at Ostional. Olive ridleys are susceptible to cyclical fluctuations.

FIGUEROA: The following summarizes the work done by the University of Michoacan at the nesting site of the black turtle (*Chelonia agassizi*) in Pacific Mexico. Work is directed by Javier Alvarado and supported by the U.S. Fish and Wildlife Service and World Wildlife Fund. The project covers approximately 20 km of beach and nests are translocated to hatcheries; 80% of the eggs are of *Chelonia agassizi*, and the peak nesting season is Sept. to Dec. We have been working for six years and want to continue in order to develop a better model. We believe we are working with two major sub-populations, and though there was increased nesting in 1986, we believe this to be a result of natural fluctuations. We tag with monel and plastic, and have received returns from the Sea of Cortez, as well as many from Costa Rica. Clutch size is 60-69. Studies show that the pivotal temperature for sex determination is 31°C, less than 27°C during the 2nd third of incubation produces all males, and over 31°C produces all females.

LIMPUS: Chelonia depressa is now known as Natator depressa: The flatback is no longer a green turtle. This change is based on electrophoretic studies and skeletal features. The flatback has greater affinities with Lepidochelys.

It possesses 2 prefrontals (like hawksbills), but one pre-ocular scale not found in other species. It is carnivorous and eats sea pens, soft corals and crustaceans. The hatchlings are large and have a disruptive color and shape with white borders on the flippers. They weigh approximately 40 gms. The carapace edges are upturned. Their skin is very similar to Dermochelys.

Flatbacks are known to nest only in Australia, but sub-adults do migrate and have been captured in Indonesian waters. Major nesting beaches are limited. Crab Island is a 5 km sand island with 2,000 nesting turtles/year which peak in August and September. Peak Island has 400-500 turtles/year, and it is a preservation zone with a length of 500 meters. Wild Duck Island National Park also has 400-500 turtles/year.

Crab Island is an aboriginal reserve where harvesting takes place. There are a few other major nesting sites, as well, and they nest sporadically on all the beaches of northern Australia in small numbers. They nest both day and night. Hatchling predation is low (less than 2% to crabs, and 0.2% to birds, though nocturnal birds take 30% at Crab Island).

Flatbacks are found in inshore waters where there is a muddy bottom. This coincides exactly with the areas where shrimp are fished. Australian shrimpers do not tow long, however, thus mortality is low. This could be a potential problem for the future.

Large numbers of juvenile flatbacks are being found beneath the feeding stations of fish eagles. Young turtles do not appear to have an oceanic developmental stage, but stay on the Australian continental shelf.

The flatback is the turtle I'm in love with!

<u>FRETEY</u>: How is flatback skin like <u>Dermochelys</u>?

<u>LIMPUS</u>: The keratinized exterior layer is very thin. Scratching it with your fingernail can draw blood.

<u>MARQUEZ</u>: Does this turtle suffer any commercial capture? Is it known by any other name besides Kikila?

<u>LIMPUS</u>: It is known to the Indonesians, but is very infrequently seen. Any exploitation is minor. It has <u>no</u> commercial use in Australia, though aborigines are allowed to take them for their own use. In some areas, 100% of the eggs are lost to pigs (Queensland), but overall this loss amounts to only 10% for all of Queensland.

The main threat, which is potential, comes from shrimp trawlers. Their only other serious predator, the salt water crocodile, is so rare that it poses no serious threat.

<u>CANIN</u>: Is the population increasing, decreasing or stable?

<u>LIMPUS</u>: The major nesting beaches were unknown to us until quite recently; most have been discovered since 1968. We really haven't got enough data to answer that question yet.

<u>SCHULZ</u>: Lessons are to be learned from the turtle situation in Indonesia, concerning the last four decades during which egg harvests and turtle catches have risen to excess to such an extent, that the turtle problem is now considered as constituting possibly the most urgent single conservation challenge facing the Indonesian conservation authorities. In Indonesia, like in many other countries in the world, the previous levels of subsistence and commercial exploitation have risen to excess as local cultures declined,

modern technology spread and--the principal cause --human population explosively increased.

Turtle eggs of all types (including those of the three non-commercial types protected by law) are collected throughout Indonesia for local and distant markets. And it is not only in the areas of intensive harvest (that is on the main green turtle nesting beaches that are all rented out to concessionaires), but also on the remotest islands of the archipelago (which consists of 13,560 islands!) that virtually every green turtle, hawksbill and leatherback egg is taken. The egg collectors don't miss an egg. This constitutes an annual harvest which I very roughly estimated between 6 and 8 million eggs/year (80% green turtle?).

You will look in vain for the bucolic scene of happy islanders collecting eggs and meat only for their own daily consumption. What they do not need for themselves is to be commercially exploited for nearby and distant markets.

There is a prolific domestic and also an export trade in turtle products. Green turtles are collected all over Indonesia to supply some 10-15,000 turtles annually to Bali alone, which makes Bali the center of the world's largest trade in live green turtles and the island of ill-fame in conservationist's circles. The most dramatic example of the consequence of over-exploitation is the extinction of the green turtle population that formerly nested on Bali Island and the depletion, and near-extinction, of nearby turtle stocks. This results in turtle fishing shifting from one area to another as each stock in turn is depleted. The turtle boats now travel to the farthest corners of Indonesia.

In many areas, local governments regulate fishing. However, Buginese/Macassar turtle hunters that provide the bulk for the Bali slaughter houses make their own laws. Their activities are not restricted to turtle fishing, but include destructive activities like the killing of nesting turtles plus dynamiting for fish on coral reefs. This applies particularly to the waters in East Java. Consumption of green turtle is not restricted to Bali. The assumption seems warranted that in Indonesian waters annually over

25,000 green turtles (adults and subadults) are slaughtered for domestic consumption alone.

Indonesia has also become a major supplier of turtle products in the world market: stuffed turtles appear to form the bulk of exports (partly by-products of Bali slaughter houses). Turtle shell, as rough scutes and as worked tortoiseshell, are exported in smaller quantities.

The outlook for the hawksbill is not less grim. The take of young plus large hawksbills has been estimated at between 20 and 30,000 annually.

Going into detail once more about the export of tortoiseshell and other turtle products to Japan and other countries would be superfluous.

Turtle populations are also affected in indirect ways, such as by siltation of feeding habitats. Let me limit myself to one example: in the Celebes Sea, mass extinction of some 20 km of sea weeds in the green turtle foraging grounds has occurred. I blame the siltation caused by the destruction of the West Borneo forests.

And now some good news: Although in serious decline, large populations of green turtle, hawksbill and leatherback still exist in Indonesia. For the last few years, increasing concern has been shown in Indonesia about the sea turtle problem and the first significant steps toward conservation measures have already been taken or are proposed. One interesting conservation management measure should be mentioned here: the establishment of multiple use reserves with special management areas among them that provide local resources for local people. In Indonesia the largest and least disturbed reef areas are often far from the larger islands, and have small populations of people living on small sand keys. Not residents but rather visiting fishermen are the ones who threaten the reef resources. These vast reef areas offer a good opportunity for the establishment of large multiple use reserves, which can be zoned to accommodate strict protection of valuable areas, appropriate tourist development plus continued fishing by residents. Management would be largely entrusted to the heads of local villages with a low level of supervision by the conservation authorities.

LIMPUS: In Australia, we are very concerned about turtle exploitation in Indonesia, because these are our turtles being killed.

CANIN: Who is behind the trade in Bali?

SCHULZ: Between 15 and 20 rich boat owners are behind the trade there, but these Balinese are not fishing them, but rather buying up the turtles from other fishermen.

FRAZER: We have heard that there are thousands of Turtle Excluder Devices (TED) in use in Indonesia. Do you have any knowledge of this?

SCHULZ: Fisheries authorities and USAID people say that there are no TEDs in use.

CALDWELL: Are there laws to protect Indonesian turtles?

SCHULZ: Indonesian laws protect Chelonia mydas, Caretta caretta, and Eretmochelys imbricata.

REICHART: TEDs are not used in Indonesia or Malaysia, as TEDs are believed to lose shrimp.

MILLER: Eggs are a most manageable life stage. Reproduction begins at the feeding grounds where the female follicles begin to function. Females go to the mating area and are responsive to several males. Sperm is stored and as the follicles ovulate the ova become fertilized. True infertility is very low in sea turtles.

The fertilized egg moves into the oviduct and is covered with albumin and shelling commences. Eight to nine days are required for the turtle to metabolize calcium out of the bones and onto the shell membrane.

The embryo begins division while the egg shell is being laid down. The egg is ready to be laid a day or two before nesting. Eggs are held at constant temperature within the female's body. Once oviposited, development goes forward.

Effects of temperature are well known: eggs fail to hatch below 23°C, and above 33°C malformation and/or death occurs. The range of temperature tolerance is 10°C.

Wet/dry beach variation tolerance is broad but if the substrate is too dry, the hatchlings are undersized, and if too wet, then they come out of the egg swollen. The gaseous environment of the egg is not well known. We do know that oxygen consumption and carbon dioxide production increase as development continues. Egg manipulation may be necessitated because of high water, predation or public education, but well intentioned movements may increase mortality. (Internal egg development and embryology were described in detail.)

BURNETT-HERKES: What should be done if the turtle drops her eggs in the water prior to nesting?

MILLER: Remove them from the water as quickly as possible.

MROSOVSKY: In laboratory studies embryonic mortality is sometimes late. What could cause this?

MILLER: As oxygen demand increases during development, any oxygen deprivation may cause mortalities.

RUIZ: What is the effect of postponing or interrupting egg laying during nesting behavior?

MILLER: In experiments where turtles have been interrupted in nesting, the female postpones development internally and development continues at the next oviposition.

MORTIMER: The title of this presentation is: "Recovery of a Turtle Population, Seychelle Island Case Study."

Aldabra Atoll in the Seychelle Islands is one of the most remote, 700 miles from the main island group and 50 km long. It has 50 nesting beaches and is famous for its Aldabra tortoises (150,000 in number).

The green turtle was the target of a fishery from 1906-1968. From 1968 to the present, marine turtles have had 100% protection, and 1,000 green turtles were nesting on Aldabra. Based on seven years of data (1981-1987) 2,000 green turtles are now estimated to be nesting.

Management measures included regulations on the nesting beach and a closed season. Since major harvest was stopped 20 years ago (1968), if there is an actual increase in numbers, we can conclude that the management of the nesting beach was effective.

<u>LIMPUS</u>: The interaction between turtle workers and the development of a data base through WATS I and II has been impressive. Could something like WATS be developed for the Indian or Pacific Ocean or on a worldwide basis?

<u>ROSS</u>: Such an extension would be invaluable.

<u>CHAVES</u>: A worldwide conference is in order but socio-economic questions are more regional.

<u>MORTIMER</u>: In the Seychelles area, regional meetings have been held and these could continue.

A number of effective by-products of WATS has been produced. This includes the rejuvenation of workers, important, rich exchange of ideas and the establishment of networks.

<u>LIMPUS</u>: Interested subgroups were encouraged to meet with panel members to discuss areas of mutual interest. Meeting/session was adjourned.

Future Actions

Rapporteur Report of the Future Action Panel Session

CHAIR: Manuel Murillo

RAPPORTEUR: Dean Swanson

The chair convened the session and referred to discussions that had occurred earlier in the day among national representatives. He reported that there had been a feeling of consensus on the possibilities of ensuring the continuity of the WATS concept. He then requested proposals from the national representatives.

The national representatives adopted by consensus the proposal put forward by the representative of the Dominican Republic which follows.

A resolution by the National Representative participants in WATS II:

Recalling the support provided by IOCARIBE and WECAF to accomplish WATS I and WATS II,

Recognizing that both symposia have been important fora to promote the exchange of experiences and knowledge between marine resource managers, scientists and non-governmental groups, with a view to make possible the conservation and recovery of marine turtle populations,

Recognizing also that the two symposia, WATS I and WATS II, constitute excellent examples of regional cooperation to:

1. Assemble an adequate data base on biological and socio-economic aspects relative to western Atlantic turtles, derived from national reports,

2. Conduct discussions of this information to validate the data base, identify critical areas, and examine potential directions for future action,

3. Consider the establishment of appropriate mechanisms to facilitate the continuation of WATS' efforts, and of actions aimed to assure the participation of all states in the region in marine turtle conservation and recovery programs,

Taking into account that IOCARIBE has reached the status of a permanent Subcommission of the Intergovernmental Oceanographic Commission (IOC), for the Caribbean and Adjacent Regions, *Being interested* in assuring the continuity of the objectives of the WATS,

Therefore, the National Representative participants in WATS II resolve to:

Express their desire to facilitate the continuation and strengthening of WATS,

Decide to express their interest in having IOCARIBE, in its Third Assembly (IOCARIBE III), to adopt and ratify the concept of WATS as part of its Program on Living Resources, this adoption of WATS by IOCARIBE should result from a concerted action of its member states.

Decide to establish an interim steering committee (ISC) with the responsibility of keeping active the WATS concept until formally adopted by IOCARIBE III,

Decide also to request the cooperation of Frederick Berry, Harvey Bullis, Herman Kumpf, Glenda Medina, Manuel Murillo, Jose Ottenwalder, Henri Reichart and Horace Walters, to integrate this ISC,

Request IOCARIBE to convene WATS III no later than three years after IOCARIBE III.

Abstracts of Poster Presentations

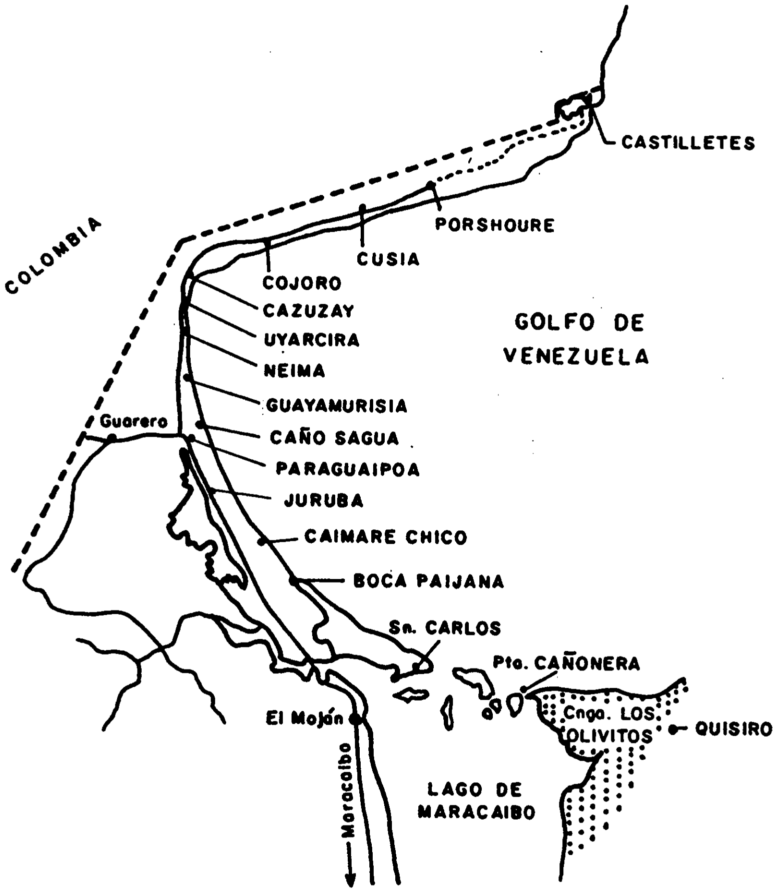
Acuna, Alexander, Leyda Gonzalez, Maria Guerrero, Harold Molero
Daria Pirela, Rincon Jose and Luz Sideregts

Preliminary Report on the status of Sea Turtles on the Western Coast of the Golfo de Venezuela, Zulia State

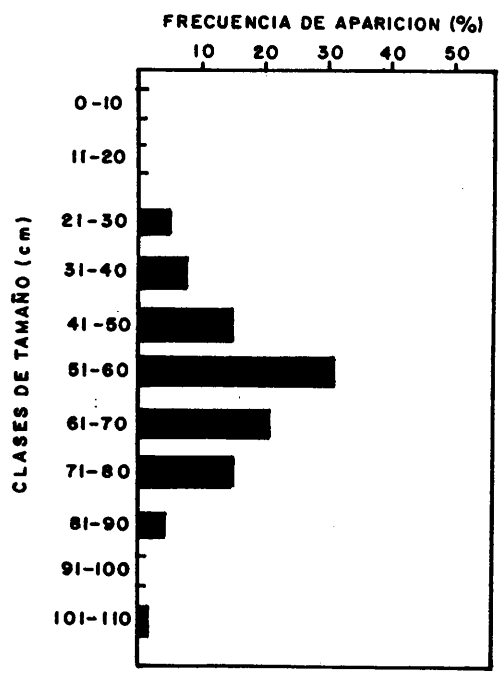
Museo de Biologia, Departamento de Biologia
Facultad Experimental de Ciencias
Universidad del Zulia, Maracaibo, Venezuela

The present study presents the first information on sea turtles on the western coast of the Golfo de Venezuela and includes information on the species present in the area, nesting, human predation and commercialization. The study area is located between 10°59' and 11°51'N; 71°19' and 72°28'W. The research includes: interviews with fishermen, beach surveys (diurnal and nocturnal) and data from specimens (remains and live individuals) in the areas of: Castilletes, Poshoure, Cusia, Cojoro, Casuzay, Vyarcira, Neima, Guayamurazay, Cano Sagua, Caimare Chico and San Carlos in the Paez and Mara districts in the state of Zulia. Four of the five species present in Venezuela were recorded (Chelonia mydas, Caretta caretta, Dermochelys coriacea and Eretmochelys imbricata). The total number of specimens observed was 135. The number of specimens identified was 96; ninety two (92) were identified as Chelonia mydas. The most frequent carapace length was between 51 to 60 cm. No information was gathered on seasonality, distribution, migration or nesting, even though favorable beaches are present (e.g., Cusia). The sea turtle population has decreased in recent years. Human exploitation for subsistence and trade is evident. Nevertheless, it takes place at a low scale. Maicao and Puerto Lopez in the Republic of Colombia are the main market. Puerto Cojoro and Casuzay are important trading posts. Of the registered specimens, 87% come from the hamlets of Vyarcira, Neima, Casuzay, Cojoro and Cusia.

The present work was sponsored by STAO/WATS II through FUDENA (Fundacion para la Defense de la Naturaleza) and received collaboration from the Zulia Development Corporation and the II Infantry Brigade, Maracaibo.



MAPA INDICANDO SITIOS DE TRABAJO



FRECUENCIA DE APARICION DE LAS CLASES DE TAMAÑO DE *Chelonia mydas*.

Alvarado, Javier and Alfredo Figueroa

The East Pacific Chelonia Population of Michoacan, Mexico: Status, Post-Nesting Movements, and Aspects of Reproductive Biology.

Escuela de Biologia, Universidad de Michoacan,
Morelia, 5800, Michoacan, Mexico

The beaches of Colola and Maruata on the Michoacan coast are the only remaining important nesting sites of the endangered black turtle (*Chelonia agassizii*) in North America. Because of heavy exploitation for meat and eggs, a drastic decline in numbers has occurred in the last decade. Since 1982, the Escuela de Biologia of the Universidad de Michoacan has been carrying out a field conservation-research program (financed mainly by World Wildlife Fund-US and U.S. Fish and Wildlife Service) on behalf of the black turtle. In this paper a summary of the results of the project from the previous five years is presented.

Conservation

Through relocation of nests to protected hatcheries approximately 900,000 sea turtle hatchlings (80% *Chelonia*) have been released into the East Pacific. Although the poaching rate of adult turtles has been lowered, illegal hunting and incidental capture remain the most serious threats to the recovery of *Chelonia* in the East Pacific.

Nesting season

Although females nest year round in Michoacan, most of the nesting occurs from September through December with the peak in October and November.

Trends in Nesting Numbers

The maximum number of recorded nesting females was 4,483 in 1982. In 1983 the estimate was 1,000 nesting females. In the 1984 season, 940 females were estimated. In the 1985 season 1,200 females were estimated. In 1986, 3,334 females was the number calculated. The decline in 1983, 1984 and 1985 could be ascribed to El Nino which swept through the Pacific in 1983, perhaps disrupting the food-chains in some of the main chelonian foraging grounds in Central America.

Although the overriding trend is of a drastic long-term decline (in 1970 about 25,000 females nested in Michoacan) the slight recovery shown in 1986 is encouraging.

Post-Nesting Movements

Tagging returns from turtles marked in Michoacan indicate that there may be two subpopulations nesting here; one feeding in the Gulf of California and adjacent waters and the other foraging south off Central America. As of April 1987, of the 35 Chelonia tagged in Michoacan, and recovered and reported away from the nesting grounds, 23 were recovered from Central America: 16 from El Salvador, 4 from Guatemala, 1 from Nicaragua, 1 from Costa Rica, 1 from Colombia; and 12 from waters off Mexico (5 from sites north of Michoacan and 7 south of Michoacan).

Breeding Cycles

Considering all the remigrants detected since 1982, 54 (57.5%) have shown a three-year breeding cycle, 25 (26.5%) a one-year cycle and 15 (16%) have shown a two-year breeding cycle.

Clutch Size

Clutch size of 1,935 Chelonia nests analyzed in 1986, varied from 1-128 ($\bar{X}$ = 64.9) eggs. The average number of clutches laid throughout the season was 2.2 (range = 1-7). The average seasonal total was 152 eggs per turtle. The analysis of the relation between body size and clutch size in 447 nests analyzed in 1986, showed no correlation ($r = 0.095$). To assess possible seasonal trends in clutch size, the number of eggs was reported for 21 turtles that laid four known nests in 1986. A decrease in the number of eggs was found as the season progressed. An analysis of variance failed, however, to reveal any significant differences in mean clutch size values ($P>0.01$).

Renesting

Organized into four-day groups, intervals of 11-15 days were the most common (n = 2,500; 1982-1986).

Temperature and Sex Determination

Data from 47 nests monitored on the beach in 1984-1985 indicate that C. agassizii exhibits TSD. Average temperatures below 27°C during the middle third of incubation resulted in 100% males. Average temperature between 27.5° and 31°C resulted in mixed sex ratios. Average temperatures above 31°C resulted in 100% females.

Berry, Frederick

Aerial and Ground Surveys of *Dermochelys coriacea* Nesting in Caribbean Costa Rica, 1987

6450 SW 81 Street
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Aerial beach surveys along the Caribbean coast of Costa Rica during the period March-June of 1983-1986 had recorded a significant number of nests of *Dermochelys coriacea* spread along the entire coast and concentrated in the northern portion. They had also recorded, along with a few visits to the beaches, relatively heavy destruction of nests by mammals, primarily *Homo sapiens*.

During 1987, a two phase survey was made. Four aerial beach surveys were flown over most of the coast near the middle of March, April, May and June. Two ground truth surveys were made almost daily, at two five-mile beach sections, south of Boca de Matina (March 5-June 30) and north of Laguna Jalova (April 1-June 15). The original survey records are archived in the WATS II Reports/Data Set series.

The great majority of the tracks and nests recorded were by *Dermochelys coriacea*. Records of *Eretmochelys imbricata* and *Chelonia mydas* are preserved in the original data records.

Because the tracks of leatherbacks (also greens and hawksbills) are often short or short-lived, and the nest body-pits are more durable, the aerial counts concentrated on body-pits for nesting estimates (after distinguishing 1987 leatherback body-pits from those of greens laid late in 1986).

Ground survey records were made the morning after nightly nesting in one-half mile sections over the five-mile subzone. They recorded fresh events: false crawls, and tracks with nests as either dug-up or not dug. The old marks recorded tracks separately and nests (as body-pits) as either dug-up or obviously/apparently not dug.

GROUND SURVEYS

Matina Subzone: The daily surveys (3/1-7/4) recorded 865 nests (Fig. 1), and 886 nests were estimated for the season (2/4-8/29). The majority of nesting was between 4/11-6/6 (75%). The peaks of nesting were from 5/16-6/6. The most fresh nests recorded in one day was 23 (5/23). False crawls were rare in March and July, accounted for 24.4% of the fresh tracks during April-June, with an estimated 280 false crawls for the season (Subzone 9A).

Jalova Subzone: The daily surveys 4/1-6/15) recorded 376 nests (Fig. 1). The peak of nesting was 5/2-6/1. The most fresh nests recorded on a single day was 12 (5/2, 5/9, 5/11). False crawls were 20.0% of the total fresh tracks (Subzone 4B).

NEST LIFE AND TRACK LIFE

It has been obvious that sea turtle tracks and body-pits are erased, after some variable time period, by the forceful effects of tide, wind, and rain (and sometimes man and other factors).

In the Matina and Jalova subzones we had a cumulative daily record of the number of nests that had been laid, and we maintained daily records of residual tracks and body-pits that were visible. The following sample indicates the percent of nests (body-pits) and tracks that are obliterated during a season:

	NESTS			TRACK		
Date	Visible	Laid	% Obliterated	Visible	Laid	% Obliterated
4/15	90	122	26	14	147	90
4/30	219	306	28	40	355	89
5/14	298	407	27	27	436	94
5/30	402	615	35	42	709	94
6/14	338	770	56	11	836	99
6/30	327	848	61	19	869	98

AERIAL SURVEYS

Nesting occurs all along the coast. We flew north of Rio Colorado only once in 1987 because of safety precautions. On three of the four flights we surveyed into Panama to Boca del Drago and recorded dozens of leatherback tracks there. On one flight (4/17) we were able to survey Playa Chiriqui, Panama, and recorded 235 leatherback body-pits between Rio Canaveral and Rio Chiriqui.

In Costa Rica, about 8 to 15% of the total leatherback nesting occurs to the south of Puerto Limon.

From prior years we had determined that the number of leatherback body-pits counted from the air was less than those more reliably recorded from beach surveys. The error increased both as the season progressed and from north to south in the Tortuguero to Moin area (the latter for reasons remaining to be verified). I estimated correction factors by zone and subzone from the ground truth surveys and multiplied these to give estimates of number of nests along the entire coast at mid-month periods.

The estimated number of nests by zone varied during the season. In percent of total estimated nests from Rio Colorado to Moin, the zone and subzone estimates were:

Zone	3/17	4/17	5/12	6/13
2	15	5	4	3
3-4A	27	10	21	12
4B	9	9	8	11
5	2	4	4	2
6	16	8	14	9
7	4	21	16	12
8	12	20	14	26
9A	10	17	12	18
9B	5	6	6	7

The heaviest nesting by zone in March was along Tortuguero, shifting south to Pacuare-Matina in April, more spread out in May and most concentrated at Urpiano-Matino (zone 8) in June.

TOTAL NEST ESTIMATE FOR 1987

The total nest estimate from ground surveys at Jalova (4B) was 445 and at Matina (9A) was 886.

To obtain estimates for the entire coast from the aerial surveys, factors were calculated for 1) the number of body-pits counted at the Jalova and Matina subzones on 6/13 compared to the number of nests known to have been laid in each section until then, and 2) the number of nests estimated to have been laid from 6/13 to the end of the nesting season. These factors with the aerial survey results for 6/13 gave an estimated total number of leatherback nests during 1987 for Caribbean Costa Rica of 4,987 -- rounded for discussion purposes to, 5,000 nests.

NEST DESTRUCTION

The preponderant cause of leatherback sea turtle nest destruction along Caribbean Costa Rica is by human predators (Figure 1). Human destruction of leatherback nests along Caribbean Costa Rica has been recorded as increasing since my first aerial beach survey there in March 1983. This is nest destruction for the alleged purpose of taking the large eggs to sell in bars with the premise that eating them will increase male libido. This leatherback nest destruction has been increasing both in percent of nests destroyed along the entire coast and in the number of nests destroyed northward into the Totuguero National Park.

Based on records obtained and familiarity with the area, I estimate, conservatively, that 3,867 *Dermochelys* nests were removed by man along Caribbean Costa Rica during 1987 (about 78% of the total nests). Assuming 80 fertile eggs per nest, the guess is that 309,360 embryos of leatherback turtles never had a chance--because of the existing attitudes, education, and enforcement that prevails now along this wonderful but decaying coast.

I respectfully petition the government and the people of Costa Rica to stop this slaughter during 1988 and to protect and manage wisely their sea turtle resources in the future.

ACKNOWLEDGMENTS

I am grateful to many who assisted in this survey effort. Some of these are acknowledged here: Robert Carlson, Anne Meylan, Roxanne Diaz, David Carr, Michael Kaye, Douglas Robinson, Darrell Berry, Eduardo Herrera, Ross Witham, Pedro Gonzales, Robert Lankford, Arthur Dammann, Antionette Marchfelder, Larry Ogren, and the pilots who flew us with variable results and reliability but with safety.

Special acknowledgement is awarded to Franklin Cole for walking the Matina Subzone, to Victor Tato Coto for the Jalova subzone results, and to John M. Hall III, whose help, perseverance, dedication, facilitation, and friendship were great.

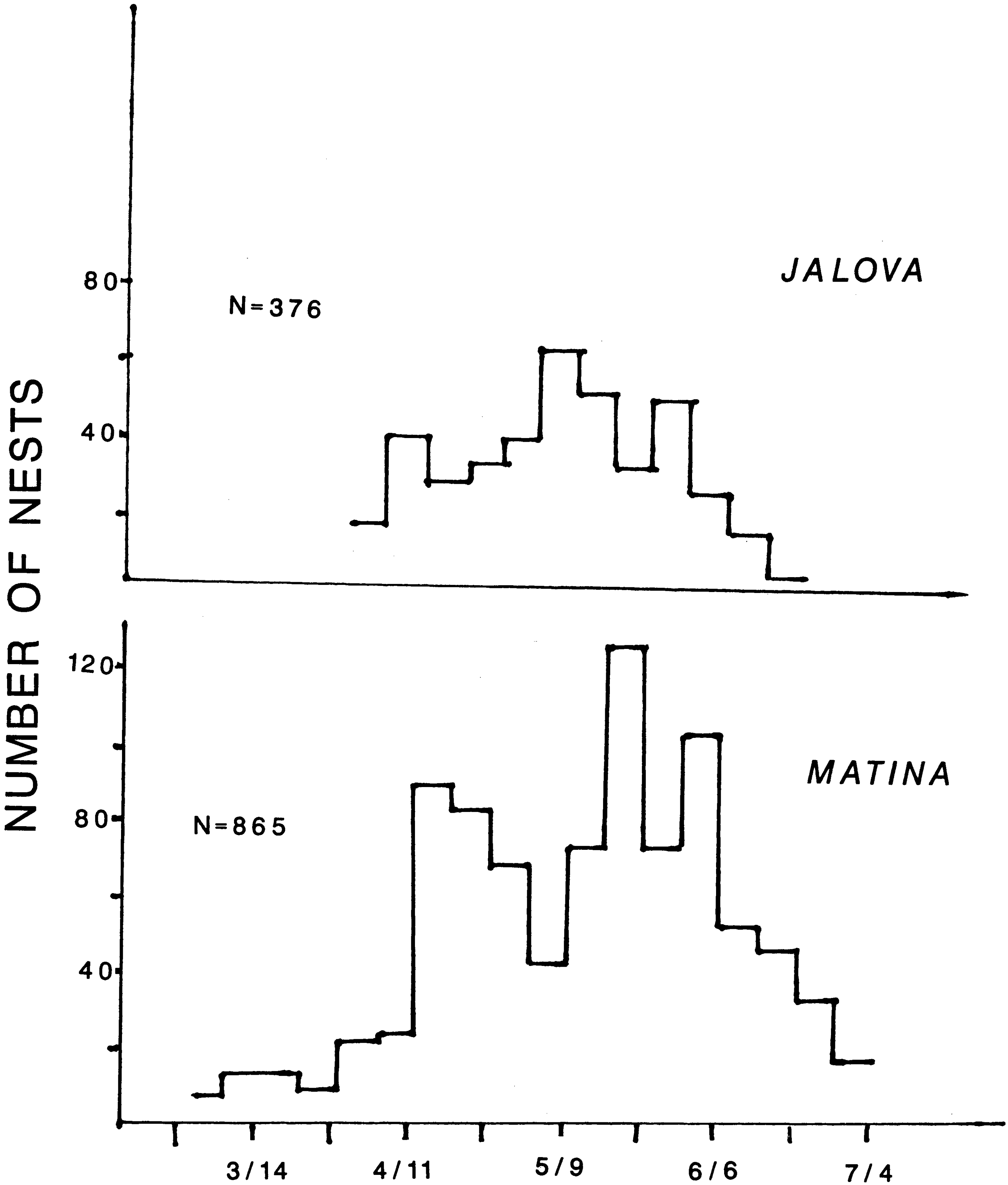

Figure 1. Dermochelys coriacea nests on two beaches of Caribbean Costa Rica, 1987: Number of nests dug by week for each five-mile survey zone.

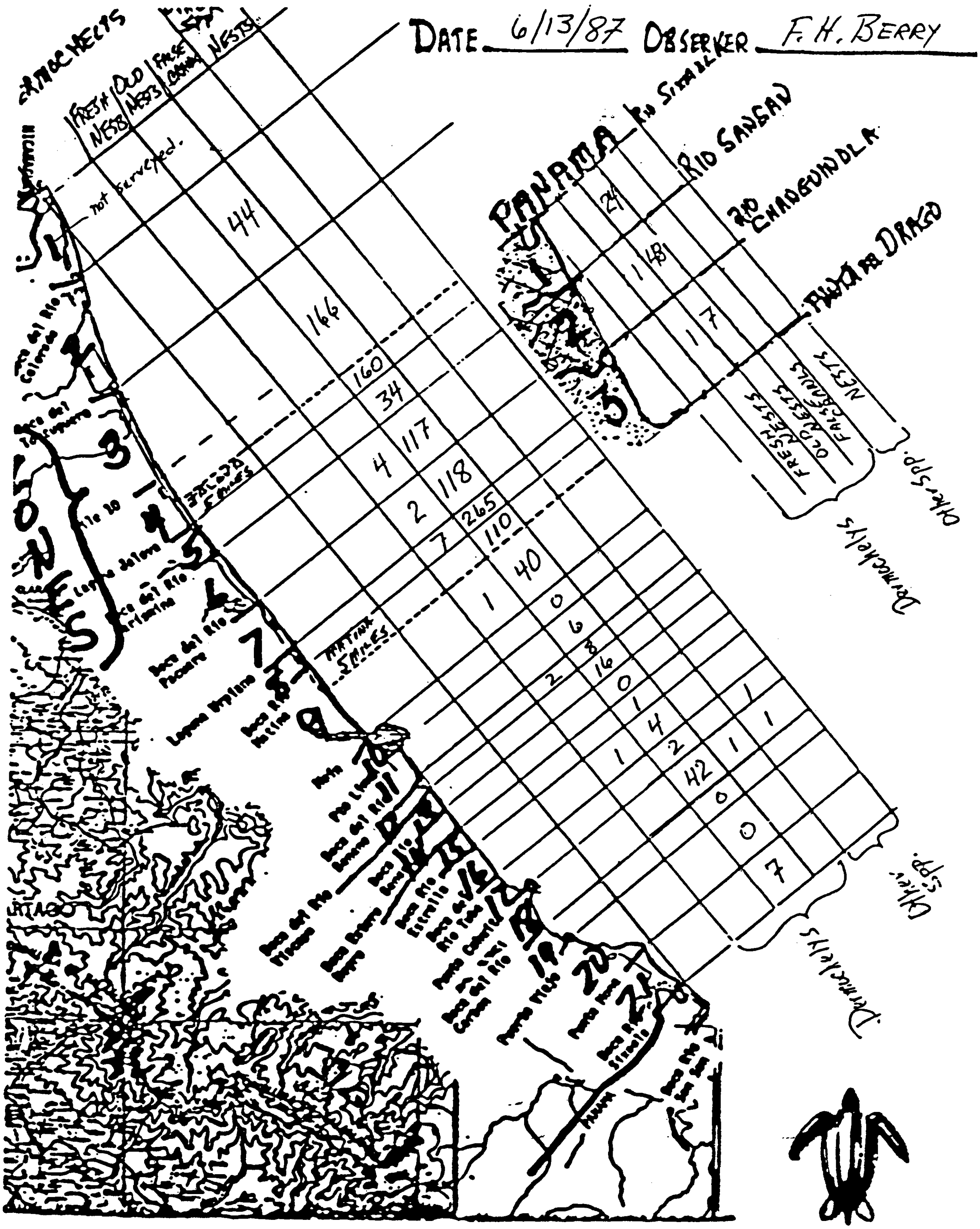

Figure 2. Sea turtle aerial beach survey for June 1987 along the Caribbean coast of Costa Rica and northern Panama: Records of Dermochelys coriacea nests (1,157 nests in Costa Rica and 81 in Panama).

Byles, Richard

Development of a Sea Turtle Satellite Biotelemetry System

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A location and data gathering system has been developed for use with free-ranging sea turtles utilizing System Argos. Previous satellite tracking experiments were basically limited to locations of individual turtles. The present system transmits a record of the number and mean duration of dives over the prior twelve hours, the duration of the last dive and the current sea water temperature. Prototype transmitters have been deployed on loggerhead (*Caretta caretta*) sea turtles in the western mid-Atlantic and Kemp's ridley (*Lepidochelys kempi*) sea turtles in the Gulf of Mexico. Locations for an individual turtle are obtained from System Argos on an average of only every eight to ten days due to mismatches between the turtle's surface and submergence cycle and satellite passes. However, data are usually obtained on a daily basis from surface transmissions of insufficient duration for location calculations. Preliminary data from two ridleys indicate submergences from less than one minute to eight hours, with an average of 32.2 minutes, (std. dev. 34.6, n = 71). Four loggerheads in the Chesapeake Bay and Mid-Atlantic Bight were telemetered with earlier versions of the PTT that did not sample submergence times. Two of these transmitters were detached from the animals after limited migration tracking and became drift buoys, tracking currents and temperatures. The attachment system is currently being refined and the housing is being re-designed for use with various species of sea turtles. A depth sensor is currently being tested with the PTT to add mean and maximum depths to the data stream. Another loggerhead from Chesapeake Bay and a black turtle (*Chelonia agassizii*) from Pacific Mexico will be telemetered in the late summer and fall of 1987. Twenty *L. kempi* will be telemetered with transmitters during the 1988 nesting season and monitored throughout an annual cycle.

Castaneda Alvarado, Patricia

Nesting of the Hawksbill Turtle (Eretmochelys imbricata) on the Yucatan Coast (1985-1986)

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The hawksbill turtle is an over-exploited resource. Therefore, the Mexican Government has established regulations for its protection. Management activities started in 1979 and, at first, consisted of the collection and transplantion of eggs.

In 1984, the Instituto Nacional de la Pesca started a research program to enhance the protection of these animals. The program includes: collection of biological data; observation on hatching success under natural conditions, as well as in transplanted nests; and tagging of juveniles and adults. The survey area is northeast of the Yucatan Peninsula between Rio Lagartos and El Cuyo along 60 km of beaches where 14 sampling sites were established.

Methodology

Night searches along the beach were carried out through the nesting season. Searching effort was increased in June and July. The beach was also covered during the morning.

All observed turtles were measured and tagged. Egg clutches were transplanted to a reserve area. The same procedure was applied to all nests that were found.

Hatchlings that emerged inside the protected area were released at sunset to reduce predation. In addition, the work with the juveniles was limited to measuring size and tagging. Most of the results presented here were obtained in 1985 and 1986.

Results

After two years of sampling, the most frequently chosen area was the middle part of the study area, from #7 to #11 sampling sites. The total number of nests found was 116 in 1985 and 82 in 1986.

Hawksbill turtles nest from April through September in the survey area. The highest frequency of nesting females was observed in May, June and the first two weeks of July.

No significant differences in the nesting period were found between the two years of observation ($t = .977$; $p = 0.05$).

However, a slight lag in the nesting period was evident in the 1985 nesting season.

The number of eggs per clutch ranged from 93 through 223. The frequency distribution of clutch size was about the same for the two years; modal values were 145 and 155 eggs per clutch in 1985 and 1986, respectively. A scatter diagram was constructed with the aim of establishing the possible relationship between clutch size and body size. Hirth (1980) and Witzell (1983) stated that fecundity depends upon female body size in a direct relationship. However, McKeown (1977) and Garnett (1978) were not able to confirm the statement. In many species there is a direct relationship between these two variables, and the difficulties of identifying all nests for each single female may be why this relationship has not been shown.

A total of 233 individual juveniles was measured during 1985, 1986 and 1987, as well as 17 (1985), 30 (1986) and 15 (1987) adults. The juveniles ranged from 120 to 640 mm; the adults were between 900 and 1,140 mm.

Taking care of eggs has been the main activity for the protection of this resource. In 1985, 23,357 eggs were collected, while in 1986, 11,721 eggs were collected.

Donnelly, Marydele

Japanese Trade in Hawksbill Shell from the Wider Caribbean 1970 - 1986

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A recent report produced by TRAFFIC (JAPAN) at the request of the Center for Environmental Education (CEE) reveals that Japanese imports of hawksbill shell (bekko) from the Wider Caribbean totalled 327,938 kg from 1970-1986. These figures represent an estimated 251,660 hawksbill turtles. The Wider Caribbean provided 51.1% of Japan's hawksbill shell imports during the 16-year period.

The Japanese trade in sea turtles has been unequalled anywhere in the world. In 1980, in response to international pressure to protect diminished sea turtle populations, Japan imposed an annual limit of 30,000 kg (approximately 28,000 turtles) on its hawksbill imports when it acceded to The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Under CITES, sea turtles are listed on Appendix I which prohibits commercial trade. CITES, however, allows countries to take reservations or exceptions to Appendix I listings. A country with a reservation can continue to trade in an Appendix I species with non-CITES countries or CITES countries holding similar reservations. In 1980 Japan took a reservation for green, olive ridley, and hawksbill turtles (the reservation on the green turtle was dropped in 1987). Since 1980, Japan has violated CITES resolutions by trading with other CITES nations and by importing sea turtle products from non-CITES nations which prohibit this trade.

Sea turtle populations in the Wider Caribbean will continue to be jeopardized by Japanese trade not only because many nations in the region are not CITES members but because Japanese trade in the Wider Caribbean could increase. In 1985 and 1986, for example, Cuba exported more shell to Japan than any other country in the world. Continued high levels of Japanese imports and changes in sources of imports will place additional burdens on sea turtles in the region. Japan is now making an effort not to import sea turtle products from other CITES nations. Japanese imports from non-CITES nations in the Caribbean are expected to increase as Japan moves away from traditional CITES sources such as Indonesia. In the last year, imports from Haiti and Jamaica, nations which have not joined CITES, have increased.

CEE's posters present individual data for Wider Caribbean countries on the estimated number of hawksbills harvested each year for the Japanese trade from 1970-1986, from The Japanese Sea Turtle Trade 1970-1986 by Thomas Milliken and Hideomi Tokunaga, TRAFFIC (JAPAN).

Eckert, Scott A., Karen L. Eckert and James I. Richardson

Tagging Sea Turtles

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Most tags currently being used for sea turtles were designed for livestock. Consequently problems with corrosion, retention, and quality control are inherent. Limiting the effect of these problems has long been the focus of sea turtle biologists. Three important lessons have been learned over the last 20+ years of tagging experience: 1) one tag style does not work for all species in all areas; consequently, you should experiment until you find a satisfactory combination; 2) quality control is not always consistent in all batches of tags, particularly considering the extraordinary stress placed on these tags when used on sea turtles; consequently, you should monitor tag retention closely and take remedial action, if needed; 3) always double tag your turtles with a tag of known retention qualities; not only does this increase the chance of the turtle remaining marked, it gives the means to monitor (or calculate) tag retention.

Tagging is not a magical solution to all management/research goals and should never be carried out without clear purpose. It is only useful for population analysis when combined with rigorous beach patrols to mark all the turtles in a nesting population. Otherwise its prime function is to elucidate portions of the migratory pathways and geographical range of the turtles. Without the monetary and personnel commitment to rigorous beach patrols, more efficient methods are available for monitoring population status such as daily crawl counts.

Finally, sea turtle biologists and managers need to keep each other informed of advances in marking technology. Places where such information is available are publications such as the Marine Turtle Newsletter and Nicholas Mrosovsky's book Conserving Sea Turtles.

Fretey, Jacques and Bruce Jaildagian

Kawana 87: A Campaign for the Study and Protection of Sea Turtles in French Guiana

Laboratoire de Reptiles et de Amphibiens
Museum National d'Histoire Naturelle
Paris, France 75700

Greenpeace International
New Smyrna Beach, Florida 32070 USA

Greenpeace has been committed for the last three years to a campaign for the study and protection of sea turtles (particularly the leatherback). Greenpeace came to French Guyana, because this country has the most important leatherback beach in the Atlantic. The name of the campaign is Kawana, a Caribe-Amerindian word for the leatherback.

The main objective of the campaign for this year was surveillance of about 200 km of nesting beaches between April and August. The access to these beaches is difficult and only possible by sea, except for the base camp in the town of Ya:Lima:Po, which is accessible by an airstrip. The team consists of five local people and close to 100 volunteers from 15 countries. Without a doubt this infrastructure is the most important for saving sea turtles. The different activities of the Kawana campaign can be summarized as follows:

Saving Adult Females

Dead trees and clay banks fill the beach with lethal traps for leatherbacks. Only a few turtles were harmed by the trees, but many were trapped in the clay. The team had to work hard to save a hundred turtles.

The present nesting concentration on the beaches near the estuary of Maroni poses an increasing problem since the fishermen are also concentrated there. Sometimes, accidentally, leatherbacks can be caught in a fishing net. We have answered the fishermen's call for help to aid them in releasing the turtles, dead or alive, from their nets, while attempting not to damage the nets. The fishermen will be reimbursed for the damage to nets, under the condition that they will give priority to the turtle's safety. Regular night beach patrols reduce the kill of turtles.

Saving Eggs

The patrols prevent any illegal egg collecting for commercial purposes. Some Indian families are allowed to collect some eggs for home consumption.

Special efforts were made with respect to incubation in Ya:Lima:Po with the aim of building two thermoregulated rooms which work on solar power.

Saving Hatchlings

In the last two years a team of veterinarians has made efforts to decrease the number of dogs in the town of Ya:Lima:Po and Awa:La. To date, 900 dogs live in the area and a single dog can eat up to 200 hatchlings in one night. Those dogs showing signs of disease are euthanised with the approval of the local people, and many other dogs are sterilized.

Identification and Censuses

The teams patrol the beaches nightly with the objective of counting and identifying those turtles that come to nest. This information is then incorporated into the data bank at the base camp.

Education

Total protection of the sea turtles will be impossible without changes in Guianese mentality. For this reason, the educational activities with the schools carried out at the hatchery are very important, as is the education of the tourists who come to see the nesting of turtles, and for whom we provide written material.

Fretey, Jacques and Peter Puetschel

The Solar Hatchery of Les Hattes - Ya:Lima:Po (French Guiana): Possible Control of Sex in Artificial Incubation.

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Museum National d'Histoire Naturelle
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The Hattes-Ya:Lima:Po hatchery created in 1981 (Fretey and Lescure 1982) works entirely on solar energy. Its non-commercial aim is to create a substitute for the leatherback turtles' natural nesting beach where a series of factors (erosion, excess humidity in the sand, destruction of the eggs by the turtles) interfere with successful incubation (Fretey et al. 1986).

For two years, considerable work has been done to transform the hatchery so as to hatch the eggs according to sex. The sex ratio to be attained is copied from the one which would normally occur on the beach. Two incubating rooms were built in 1987, one for males, the other for females.

The male room is maintained at a temperature of 28° to 29° C by forced ventilation and is thermostatically controlled.

The room temperature for females has to be kept within 30° to 32° C. This is why a room with an entry-sluice was built.

The room is heated by warm air. The air is heated inside of a specially built solar-collector. The warm air is slowly pulled out of the collector (by ventilator 1) on the two highest corners. Ventilator 1 is activated by a temperature drop below 30.5° to 31° C (thermostat 1). The air is blown inside the room and distributed by a pipe system installed below the shelves.

To have a closed air-circle but still a constant temperature, the cold air is pulled out of the sluice (separated from the hatchery room by an isolating curtain) and blown inside the collector on the deepest level in the middle (ventilator 2 starts through thermostat 2 at temperatures below 30° to 30.5° C). The solar-collector itself is filled with collecting material (cement stones and water-filled bottles, partly black painted, which are arranged in a special manner to have the air circulating around most material and getting heated before entering back into the room) and covered by a special UV-stabilized foil.

Ventilator 3 will be activated by thermostat 3 when the temperature goes above 32.5° to 33.0° C.

At the end of the incubation period the eggs are put in sand tanks from which the baby turtles reach the surface as in a natural nest.

Problems

To arrange constant temperature in all parts of the room, the pipe system has to be carefully designed. Therefore,we installed thermometers in seven specific points in the room, readable from outside. To run the hatchery without technical problems non-electronic equipmentmust be chosen. The biggest problem may be the humidity inside the room and the collector (humidity is high in French Guiana--up to 95%). So both must be dried out and all nests kept inside isolating boxes. Boxes have the advantages of keeping a steady temperature and humidity for every nest separately and makes moving easy.

Philosophy

To build a hatchery allowing to "the making" of males or females as we wish would be perfect. But how many females or how many males should we produce?

Should we copy natural sex-ratio? Should we produce 50% of each sex? Should we increase the number of females, that experience a high mortality rate and are responsible for the species reproduction? Who can say?

Fritts, Thomas H. and M. Angela McGehee

Effects of Petroleum on the Development and Survival of Marine Turtle Embryos

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The vulnerability of marine turtle progeny in the event of a petroleum spill in waters adjacent to a nesting beach was investigated at the nesting beach of Kemp's ridley sea turtle (Lepidochelys kempi) near Rancho Nuevo in Tamaulipas, Mexico. Petroleum from the IXTOC oil well washed up on this beach after the nesting season was completed in 1979. Oil was still evident on the beach in the form of tar during the nesting season in 1980. Nine clutches of eggs were collected from nesting ridley turtles in 1980 for comparative incubation experiments. Half of each clutch was incubated in contaminated sand taken from areas of the beach where turtles usually nest and half in clean sand collected from the dune areas of the beach. The results indicated no significant differences in hatching success, incubation time or hatchling morphology between the two groups. The quantity and weathered state of oil remaining on the beach one year after the IXTOC spill did not appear to affect incubating sea turtle embryos.

Laboratory experiments were conducted with five clutches of eggs collected from nesting loggerhead sea turtles (Caretta caretta) on Merritt Island, Florida in 1980. Ninety eggs were selected randomly from each clutch, divided into six subsamples of 15 eggs each and incubated in buckets containing 4 kg of sand. Subsamples were subjected to the following treatments:

A. Control--no oil added

B. Light dosage--7.5 ml of crude oil (0.5 ml per egg) mixed with the sand at the initiation of incubation

C. Medium dosage--15.0 ml of crude oil (1.0 ml per egg) mixed with the sand at the initiation of incubation

D. Heavy dosage--30.0 ml of crude oil (2.0 ml per egg) mixed with the sand at the initiation of incubation

E. Half-time--30.0 ml of crude oil added for the last half of the incubation period (poured on top of the sand after 28 days)

F. Quarter-time--30.0 ml of crude oil added for the last quarter of the incubation period (poured on top of the sand after 42 days)

Groups receiving different dosages of oil did not differ significantly in hatching success, embryonic survival or incubation time. Hatchlings were significantly smaller in light dosage subsamples than in other dosage groups. These results suggest that if turtle eggs are deposited in sand after oil contamination has occurred, significant mortality is not likely, but hatchlings may be smaller than normal.

Addition of 30 ml of oil to subsamples during the last half or last quarter of incubation resulted in significantly lower hatching success than controls or subsamples exposed to oil at the initiation of incubation. Significant mortality of embryos in the half-time and quarter-time subsamples occurred shortly after exposure to oil. No significant differences occurred in incubation times between these groups. Hatchlings were smaller in the half-time and quarter-time subsamples than in other groups. Thus, sensitivity to oil appears to vary with the age of the embryos.

The results of this study indicate that if oil washes up on a sea turtle nesting beach outside of the nesting season, even if it is only a short time before the season begins, it will probably be weathered to a nontoxic state (i.e., tar) by the time nesting turtles arrive. However, if oil washes up on a nesting beach while eggs are incubating in the sand, significant mortality may occur if the oil washes up on the beach to the level where the nests are buried. Apparently, the effects of a one-time oil spill on hatching are relatively short-lived and would threaten at worst a single year's reproductive effort.

Gil Hernandez, Reyna A. and Pedro Viveros Leon

Sea Turtle Conservation in Quintana Roo, Mexico During 1987

Centro de Investigaciones de Quintana Roo
Cancun, Quintana Roo, Mexico

During 1987 the Quintana Roo Research Center carried out a research and conservation program, sponsored by the U.S. Fish and Wildlife Service, of the nesting sea turtles at Quintana Roo. The littoral extends about 900 km, and it is characterized by numerous beaches, bays and coral reefs.

Ten beaches make up the study area (Fatima, Xpu-ha, Kantenah, Aventuras, Xca-tel, Tankah, Ojo de Agua, Santa Rita and Estacion San Juan), located to the south of Cancun (20°29' to 19°51'N and 87°13' to 87°16' W).

Night censuses were carried out on the beaches mentioned above. Sea turtles were tagged and measured in the following order of abundance: loggerhead (*Caretta caretta*), green turtle (*Chelonia mydas*), occasionally the hawksbill (*Eretmochleys imbricata*) and the leatherback (*Dermochelys coriacea*). At the same time some nests were transplanted to protected areas; morphometric data as well as number of released hatchlings were recorded.

The nesting season for the loggerhead spans from May to August and for the green turtle from June to September; in the cases of the hawksbill and the leatherback, only one individual came ashore throughout the nesting season. None nested, but they were tagged.

Results

Description	Loggerhead (*Caretta caretta*)	Green turtle (*Chelonia mydas*)	Total
Tagged turtles	322	92	414
Recaptures	63	13	76
Other tags	23	4	27
Nests in corral	620	153	773
Natural nests	221	42	263
Predated nests	90	23	113
Released hatchlings	56,941	11,779	68,720

Data are incomplete, since the nesting season had only recently ended in September, and have not been fully analyzed.

Gutierrez, Walter

Experiences in the Captive Management of Hawksbill Turtles (Eretmochelys imbricata) at Isla Uvita, Puerto Limon, Costa Rica

Junta Administracion Portuaria y Desarrollo Vertiente Atlantica
Limon, Costa Rica

Location: Isla Uvita, Limon, Costa Rica
Area: Six hectares
Average Annual Precipitation: 3,567 mm
Average Annual Temperature: 24.5°C
The island is accessible only by boat and is 5 minutes from the national pier.

The program was initiated with 143 turtles hatched at Isla Uvita under natural conditions; they were maintained in two 21 cubic meter cement tanks, each one housing 60 turtles (3 turtles/cubic meter).

Twice daily the water in the tanks is changed to flush out feces and food residues; once each eight days the pools are disinfected with chlorine and soap to eliminate pathogens.

The food consists of *Tilapia*, and it is provided twice daily. The *Tilapia* is entire and unprocessed; this fish is raised at the Estacion Piscicola, owned by JAPDEVA on the outskirts of the city of Limon.

The ambient air temperature is measured twice daily as is the sea temperature, once in the morning and once in the afternoon.

Regarding diseases, no drastic effects have been reported, but injuries as a result of aggression between turtles over food have occurred. Nevertheless, these circumstances have not produced mortality in the population. The decrease in individuals has resulted from the removal of the specimens from the pools during the night.

Results

Table 1 presents the most pertinent aspects of the activity such as weight, length (growth) and feeding of the turtles during the first year in captivity.

Discussion or Comment

This annual study has permitted us to gain experience in the management of animals in captivity, and it has opened the field not only within the institution but also at a national level to continue research of this sort not only with the hawksbill, but also with the green turtle, following a conservationist theme. The primary objective is raising the critical levels of their natural populations as well as the accumulation of technical scientific information.

Data from the second year's activities will be utilized by me for the presentation of an undergraduate thesis for the completion of a degree in tropical biology.

Table 1. The outstanding aspects of captive management of hawksbills such as weight, growth and feeding, during the first year in captivity.

Month	Year	Number of turtles	Total weight (kg)	Average weight (gm)	Average length (cm)	Average width (cm)	Food/Feed (kg)
Beginning of October	1985	137	2.1	15.6	4.0	3.0	---
End of October	1985	137	4.4	32.0	5.8	4.8	4.5
November	1985	135	10.8	80.0	7.8	5.9	18.2
December	1985	134	18.4	137.0	9.2	7.0	26.2
January	1986	134	28.0	209.2	10.7	8.1	36.5
February	1986	134	41.6	310.0	12.7	9.6	49.5
March	1986	134	61.3	458.0	14.7	11.0	73.0
April	1986	130	74.1	570.4	16.4	11.9	90.2
May	1986	130	100.0	769.0	18.2	13.1	114.0
June	1986	130	114.3	879.0	19.0	13.2	127.0
July	1986	130	148.6	1,143.0	20.6	15.0	172.0
August	1986	130	173.4	1,334.0	22.0	15.8	149.0
September	1986	130	207.0	1,592.0	24.2	17.6	178.0

Hasbun, Carlos Roberto

Kemp's Ridley Turtle (*Lepidochelys kempi*)

U.S. Fish and Wildlife Service
Gladys Porter Zoo
Brownsville, Texas USA

This poster provides basic and general information about the protection program for the Kemp's ridley (*Lepidochelys kempi*) at Rancho Nuevo, Tamaulipas, Mexico.

By means of two graphics showing the numbers of relocated nests per season, the numbers of hatchlings released per season and the percentage of hatch per season, an attempt is made to present the course being taken by this species.

Despite having relocated fewer nests per season from 1978 to 1986, the number of released hatchlings has remained relatively constant. The hatch rate has increased over time, especially in the last three years.

The photographs illustrate the various activities that have been undertaken to conserve this species.

Horikoshi, Kazuo

Egg Survivorship and Primary Sex Ratio of Green Turtles (*Chelonia mydas*) at Tortuguero, Costa Rica

Center for Sea Turtle Research
Department of Zoology
University of Florida
Gainesville, Florida 32611 USA

Number and position (either vegetation/border zone or open sand zone) of green turtle nests in the central part of Tortuguero Beach, Costa Rica, were recorded from 15 July - 9 November 1986. The number of nests was the highest recorded for 16 years at Tortuguero. Over 3,700 clutches per kilometer were deposited in the high density areas from July to October. The proportion of the nests in the vegetation/border zone and in the open sand zone were 51.4% and 48.6%, respectively. These values are not significantly different (chi-square test, alpha = 0.05).

Egg survivorship was measured for 74 marked nests. In 1986, hatching success rate was 46.3% ± 39.0 (n = 32) in the vegetation/border zone and 57.3% ± 37.5 (n = 42) in the open sand zone. These values are not significantly different (Mann-Whitney test, alpha = 0.05). Flooding and high ground water caused by sporadic heavy rains (>100mm per day) and erosion by waves were major causes of mortality for clutches. Animal predation, mainly by coatis (*Nasua narica*), and digging up of nests by adult female turtles also reduced the survivorship of eggs.

Sand temperature at the depth of the nest (60 cm deep) in the different zones was monitored during the incubation period from 1 July - 10 December 1986. At Tortuguero, Morreale (1983) found that nests with temperatures below 28.5°C during the middle third portion of development would produce nearly 100% males, while nests with temperatures exceeding 30.3° C would produce 100% females. For intermediate temperatures, a mixed sex ratio would result. Because the sand temperature, regardless of the position on the beach, remained below 28.5° C for most of the season, the sex ratio of hatchlings that emerged in 1986 was probably strongly male-biased. In the open sand zone, although the sand temperature from September to December intermittently rose to the level of producing both sexes, these periods were too short to produce many females.

Numerous rainy days and especially, sporadic heavy rain, produced the low sand temperatures for the entire season. Rainfall records revealed that rainfall in August (846 mm) and in September 1986 (514 mm) were the highest recorded for the last nine years. Rainfall for 1980, when Morreale (1983) found differences in sex ratios depending on nest position on the beach, was much lower than that in 1986. Since rainfall at

Tortuguero can be extremely variable from year to year, local climate conditions, particularly rainfall, may play an important role in determining the primary sex ratio of the Tortuguero green turtle population.

These reproductive parameters, egg survivorship and primary sex ratios, are not only necessary for improving conservation practices but also will increase our understanding of the dynamics of the largest population of green turtles in the Caribbean Sea.

Lescure, Jean, Frederique Rimblot-Baly, Claude Pieau
and Jacques Fretey

Effect of Temperature on Sex Differentiation in *Dermochelys coriacea*: Sex Determination of Hatchlings.

Laboratoire de Zoologie (Reptiles & Amphibiens)
Museum National d'Histoire Naturelle
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Effect of Temperature on Sex Differentiation

This effect was discovered by C. Pieau (1972) in European turtles, *Emys orbicularis* and *Testudo graeca*. Sex differentiation is temperature sensitive in two species of lizards, two species of crocodiles and twenty species of turtles, of which five are living species of marine turtles studied up to now.

In *Dermochelys coriacea*, incubation of eggs at 29.25°C and below leads to 100% phenotypic males at hatching, whereas at 29.75°C and above, all individuals are feminized. Since the ovaries are only beginning to differentiate, these individuals have been classified as potential females (Rimblot et al. 1985).

The phenotypic males and potential phenotypic females are obtained from the same clutch at 29.5°C. Therefore, 29.5°C is the threshold temperature ("temperature critique") for sexual differentiation of the gonads in *D. coriacea* (Rimblot-Baly et al., 1987).

Sex Determination of Hatchlings: Gross Morphology or Histology?

In order to find criteria allowing rapid and reliable identification of sexual phenotype and avoiding histological study, we have measured the length, width and thickness of the gonads in neonates issued from eggs incubated at 27°C, 28.7°C and 30.5°C. At 30.5°C, gonads are somewhat but not significantly longer than at 27°C, 28.75°C. However, they are significantly thinner, and the bidimensional study of the three variables shows a correlation between width and thickness. Therefore, measurement of one of these variables is sufficient to identify the sexual phenotype of an individual. Width can be easily measured under a dissecting microscope. After fixation, width in the middle part of the gonads is less than 1.1 mm in phenotypic females, whereas it is greater than 1.1 mm in phenotypic males. Since the shape of gonads is not very regular, we recommend a histological study if the width is between 1.0 and 1.2 mm. This width is observed only in 6.6-7.5% of neonates.

The length measurement of the gonad is not a good determinate of sex phenotype, because it is between 9.0 and 12.5 mm when the temperature of egg incubation is between 28.75° C and 30.5° C.

The method is only reliable for Dermochelys coriacea and cannot be applied to other marine turtle species, because the ovaries are more differentiated than in Dermochelys coriacea and are as wide or slightly wider than the testes.

These data have been used to diagnose the sexual phenotype of emerged neonates from 34 different nests on a beach in French Guiana in 1981, 1983, 1984 and 1985. A total of 647 individuals, 8 to 40 per nest, has been studied. The sex-ratios in nests have been interpreted as a function of the temperature of the sand, at the same depth (60-80 cm) as the nests, during the periods that are thermosensitive for sexual differentiation. In French Guiana, the nesting period of marine turtles generally begins in February and includes the rainy season (April to the beginning of July) during which the sand temperature is lower than 29° C, and the dry season (end of July to October) during which the sand temperature is often higher than 30° C. Mature females of Dermochelys coriacea deposit 4 to 7 clutches of 50 to 148 eggs, at 9 to 11 day intervals, during the nesting period. In earlier nests, the hatchling sex-ratio is generally biased in favor of males, whereas, in later nests it is biased in favor of females.

Marcovaldi, Maria Angela and Guy Guagni dei Marcovaldi

The Brazilian Sea Turtle Program

Instituto Brasileiro Desenvolvimento Forestal
Salvador, Brazil 40.000

Until 1979, few things were known about Brazilian sea turtles, and almost nothing was done to assure the preservation of these animals threatened by extinction.

Some foreign surveys had described, but not very precisely, the occurrence of nesting areas on our coast, and also had recorded turtles that had been tagged in other countries or oceanic islands, such as Surinam and Ascencion Island.

In 1980, the Marine Turtles Project (TAMAR) was created by Instituto Brasileiro de Desenvolvimento Forestal; and Fundacao Brasileira para a Conservacao de Naturesa, to evaluate the real situation of these animals in Brasil.

For years, a detailed survey was conducted, in which 8,000 km of coastline were studied, and thousands of interviews and scientific observations were made by TAMAR employees.

The main problem that threatens the marine turtles is the killing of females on the beach and the poaching of eggs. On most Brazilian beaches, very few turtles that come up to nest succeed in their aim.

As a result of this survey, eight areas were selected and considered essential to marine turtle survival. Other beaches were recognized as being of secondary importance.

Considered essential:

1) Lencors Maranhenses, state of Maranhao;
2) Biological Reserve of Atol das Roces; state of Rio Grande do Norte;
3) Trindade Island; state of Espirito Santo;
4) Fernando de Noronha Archipelago;
5) Biological Reserve of Santa Isabel; state of Sergipe
6) Praia do Forle and Vicinity; state of Bahia
7) Praia de Santa Maria (Interlagos); state of Bahia
8) Biological Reserve of Comboios, state of Bahia

The number of turtles that used to nest in Brazil was higher than presently. On many beaches they are now non-existent, and on other beaches few turtles remain.

In the five last stations described above, almost 150 km, successful reproduction is being reestablished.

For lack of funds and personnel, TAMAR chose to transfer the eggs to beach hatcheries with the conditions as close as possible to the natural ones. Since 1986, because of more education and popular participation in the regions, the project decided to keep part of the nests (30%) in their original places. No human predation occurred.

Martin, R. Erik, Robert G. Ernest, Nancy W. Walls
and J. Ross Wilcox

<u>Size Distribution and Seasonal Abundance of Loggerhead and Green Turtles in Nearshore Waters off Hutchinson Island, Florida</u>

Applied Biology, Inc.
Jensen Beach, Florida 34958 USA

Florida Power & Light Company
Juno Beach, Florida 33408 USA

The St. Lucie Power Plant is located on Hutchinson Island in southeast Florida. The plant draws its condenser cooling water through an enclosed intake canal connected with the Atlantic Ocean via submerged pipes. Sea turtles, which are apparently attracted to the offshore structures housing the intake pipes, are often entrained with cooling water and become trapped in the intake canal. Since the plant began operating, entrapped sea turtles have been systematically captured, measured, weighed, tagged and returned to the ocean.

From May 1976 through December 1986, 1,322 loggerhead and 192 green turtles were removed from the St. Lucie Plant intake canal. Loggerheads ranged in size from 41.5 to 112.0 cm (mean = 64.9 ± 11.9 cm; minimum SLCL). Seventy-five percent of these were classified as immature (SLCL<70 cm) with the majority in the 50-70 cm size classes. Adults (SLCL>80 cm) constituted 12.5 percent of total loggerhead captures. A transitional size class (70-80 cm SLCL) containing both immature and mature animals accounted for the remaining 12.5 percent.

Green turtles removed from the intake canal ranged in size from 20 to 108 cm (mean = 36.9 ± 15.1 cm; minimum SLCL). Ninety-six percent were classified as immature, and 74 percent were 40 cm or less in length.

Immature loggerhead and green turtles were captured with greatest frequency during the winter (January-March). However, the proportion of juveniles captured during winter was much greater for green turtles than for loggerheads. Adult loggerheads (n = 161) were most abundant during the summer, and adult captures were predominated by females (n = 131). Five of the six adult green turtles captured were males; all were collected between June and October.

Size-frequency distributions of loggerhead and green turtles captured at the St. Lucie Plant were compared with those from other locations along the east coast of Florida, Georgia and South Carolina. Collectively these data suggest that:

1) A relatively uniform population structure exists for loggerheads inhabiting coastal waters of the southeastern United States;

2) Loggerheads do not leave the pelagic environment to enter coastal waters until they are at least 40 cm in length,

3) Pelagic-stage green turtles are recruited into Florida coastal waters at a smaller size than are loggerheads,

4) Florida coastal waters serve as an intermediate habitat for green turtles leaving the pelagic environment to enter lagoonal feeding grounds, and

5) Maturing sub-adult green turtles (70-90 cm SLCL) are generally absent from Florida coastal waters.

Seasonal data from the St. Lucie Plant suggests that movements of immature loggerhead and green turtles increase during the winter, probably in response to changing environmental conditions and/or environmental requirements. Increased captures of adult loggerheads during the summer presumably reflect increased movements of adult females en route to nesting beaches on Hutchinson Island and adjacent barrier islands.

Menzies, R.A.

Sea Turtle Nesting on Testigo Grande Island, Venezuela.

St. George's University
Grenada, West Indies

Testigo Grande Island is located at latitude 11°24'N and longitude 62°10'W or about 50 nautical miles North of Carupano and 50 nautical miles N.E. of Pampatar, Margarita, Venezuela and 84 nautical miles S.W. of Grenada (see Figure 1).

On 22 July 1987 a recent hatch of sea turtles was discovered on the northeast shore of the island. About 45 egg shells were observed, although some might have blown away. Most were still pliable, indicating that the hatch was recent. Considering the ambient temperature and continual breeze which would have promoted drying, the hatch most likely occurred within a day or two. No unsuccessful hatchlings were found. Because of the size of the egg shells, the species was believed to be Dermochelys coriacea, the leatherback turtle. Portions of egg shells were collected for later identification, possibly by chemical methods.

The nest was above the high water mark and back about 10 meters and on the first dune rise which had about 3-4 meters of elevation. The rise was abrupt, the grade being about 25-35. The sand here was white, soft and powdery and alternated from rock rubble or pebble to sand. The intertidal zones appeared to reflect this pattern. The beach immediately in front of the hatch was mostly sand as was the intertidal zone.

Sea turtle nesting in the Testigos is not surprising when the many sandy beaches are seen. The fact that this location was not recorded in the Venezuela report to WATS I (Bacon et al. 1984) is probably due to its remoteness.

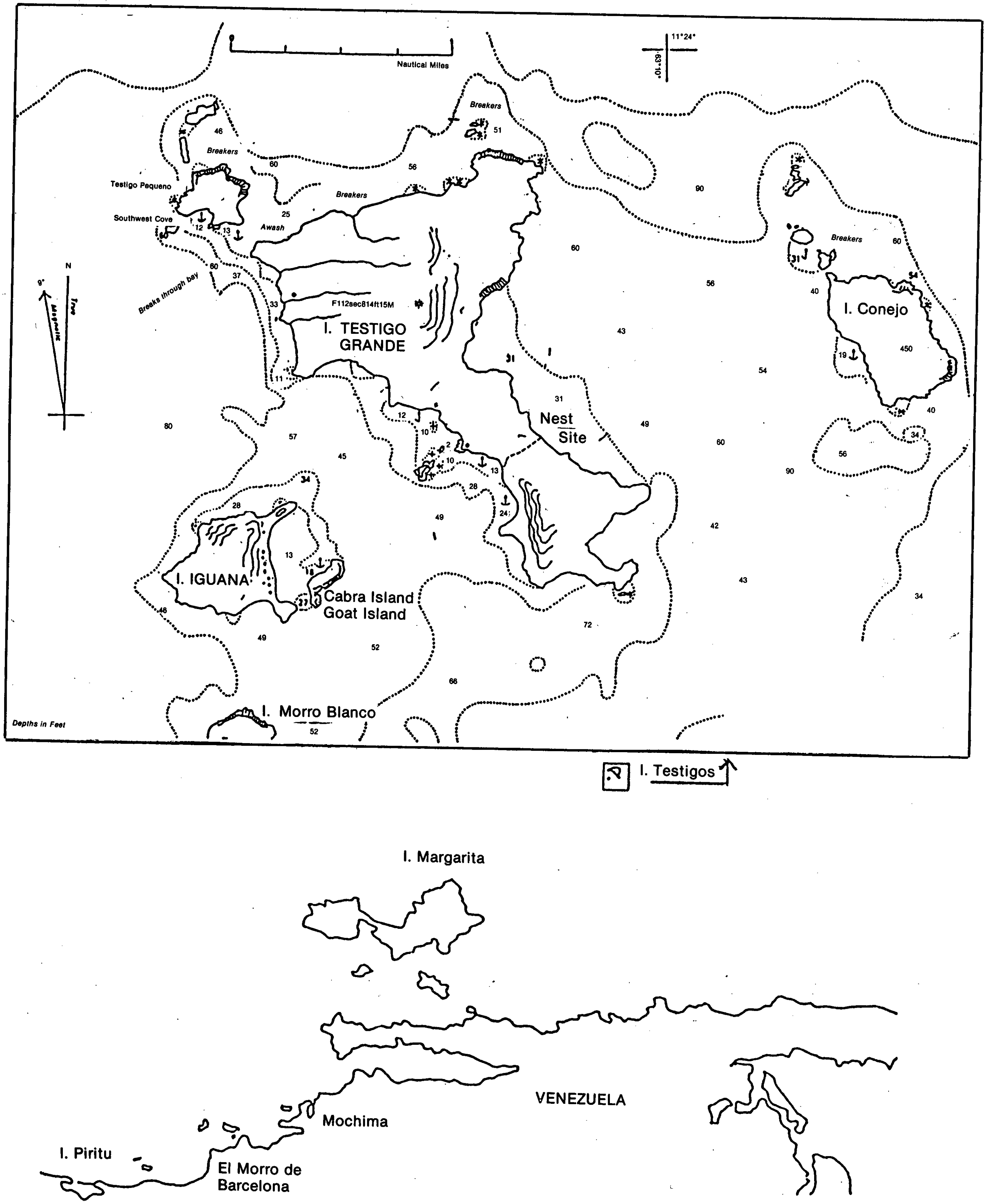

Figure 1. Testigo Grande Island, Venezuela.

Owens, David, Thane Wibbels, Diana Comuzzie, David Rostal
Mark Grassman, Robert Figler and Colin Limpus*

Reproductive Behavior and Physiology of Marine Turtles: Results of Recent Research

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Imprinting studies

Grassman conducted laboratory protocols in which hatchlings of *Chelonia mydas*, *Caretta caretta* or *Lepidochelys kempi* were exposed to natural beach sands and solutions of artificial media and chemicals. Chemical exposures were either: A) nest only, B) holding tank water only, or C) nest and tank. The turtles were less than one year of age when their responses to these same chemicals were evaluated in a multiple choice arena. The following conclusions were derived from this work:

1. Sea turtles can orient to specific chemical cues learned early in life without formal conditioning.

2. They can distinguish between low concentrations of solutions prepared from natural beaches.

3. In our apparatus, immature turtles appear to show imprinting (Lorenzian definition) to chemicals to which they have been exposed early in life.

4. Exposure *both* in the nest and the tank water was necessary for any consistent responses in our system. This amounts to a prolonged exposure of several weeks.

We intend to test a similar protocol with adult turtles in the near future.

Reproductive behavior studies

Comuzzie has worked with James and Fern Wood at Cayman Turtle Farm and developed an ethogram of adult *C. mydas* behaviors observed in captivity. Specific described behaviors include checks, nuzzels, bites, circling, chases, attempted mounts, mounts, escorts, following, gapes, cloacal checks, faces and pushes. Bites, circling and biting, chasing and mounts were also seen in a wild population in Australia. Males did not discriminate between reproductively active and inactive females when giving cloacal checks and may use this behavior to evaluate active females. Females conducted cloacal checks of other females but not males. Females appear to have a series of mating avoidance behaviors as a way of selecting the fittest males. Females are active in escorting but not once they have been mated.

Rostal has undertaken a similar study with captive reared L. kempi at the Cayman Turtle Farm. These smaller, quicker animals have a less diverse and possibly more subtle behavioral repertoire. Much of the mating occurs at night in these turtles, and they appear very secretive. Endocrine levels are being determined for comparisons with wild ridleys and other sea turtle species.

Reproductive hormone studies

Several studies are being compiled by Wibbels on work with Limpus in Australia, NMFS in Florida and Marquez in Mexico. Testosterone and spermatogenesis peak prior to mating and decrease through a distinct mating season. Some males appear to be multi-annual, like females. A softened medial plastron patch is characteristic of reproductively active males in several species. In females, estrogen is secreted at fairly low levels over the non-nesting years to drive a slow follicle enlargement phase. A peak in estrogen occurs in spring prior to migration and during maturation of subsequent clutches. Thyroxin (T_4) peaks in early spring prior to a testosterone surge which appears to initiate migratory behavior.

Figler has studied the hormone arginine vasotocin in sea turtles. He found a steep peak in the circulating level of this molecule coincident with oviposition. This hormone may be of use when nesters have difficulty in dropping eggs. This work was supported by Sea Grant #NA83AA-D-00061, NSF grant #BNF-8418538, Cayman Turtle Farm and by Sea Turtles, Inc.

Richardson, James, Lynn Corliss, Rebecca Bell and John Fuller

Antigua and Barbuda Hawksbill Project

University of Georgia
Institute of Ecology
Athens, GA 30602 USA

Lord Nelson Club,
St. John, Antigua, WI

The nesting behavior of the hawksbill sea turtle (*Eretmochelys imbricata*) is poorly known because the species disperses its nesting on many small remote beaches. However, Pasture Bay Beach on Long Island, Antigua, has a relatively high concentration of nesting hawksbills, perhaps one of the highest accessible concentrations known in the Caribbean.

WIDECAST - Antigua and Barbuda and the University of Georgia have initiated a program to study the biology of these turtles on the nesting beach. Hourly patrols are run nightly, and each turtle is identified by three methods: a self-locking tag in the flipper, a drill hole in the marginal scutes of the carapace, and a photograph. Nests are marked, and nest success is checked after the hatchlings have emerged.

Resource management is an important part of this program. Long Island is owned by a resort development company. Construction on the resort is still underway. Because of the owners' new awareness of the importance of the hawksbill nesting beach, they have agreed to leave several selected sites undeveloped and to design houses with shielded lighting. Parts of Pasture Bay Beach are not good nesting beach. Plans are being made to modify this area by adding dune and seagrape habitat to enhance nesting possibilities on a crowded beach.

Environmental education is another important aspect of this program. Guests at the resort are encouraged to observe the nesting turtles, thus demonstrating that sea turtles can be an important part of the tourist's Caribbean experience. Educational programs have been introduced into the schools. The potential for environmental education in Antigua is very good.

To date, (midseason-Sept. 20), 19 nesting females have been tagged. They have produced 53 nests. By the end of the season in December about 25 turtles are anticipated to have produced well over 100 nests. The nest site fidelity exhibited by returning females at this time appears to be equal to or greater than that of any other species of sea turtle investigated to date.

Rosales-Loessener, Fernando

Nesting Beach Sanctuary on the Atlantic Coast of Guatemala

Direccion Tecnica de Pesca y Acuicultura
Ministerio de Agricultura, Guatemala

1. INTRODUCTION

Guatemala possesses 148 km of Caribbean coastline, of which 50 km constitute suitable marine turtle nesting beaches. The species which nest on these beaches in order of their abundance are: hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), and the leatherback (*Dermochelys coriacea*). The nesting activities of these three species occur throughout the year.

2. OBJECTIVES

2.1 To establish a sanctuary of 8 km of nesting beach which will permit the effective protection of the three species of turtles which nest there, as well as their nests, eggs and hatchlings.

2.2 To initiate and maintain a program of environmental education directed toward the neighboring residents which will permit them to acquire consciousness of the need to protect this resource for their own benefit.

2.3 To serve as a model for the establishment of similar sanctuaries in other areas.

3. LOCATION OF THE PROJECT

(see map)

4. METHODS/PLAN OF ACTION

4.1 PHASE ONE (3 months)

Measurement, demarcation and placement of signs marking the 8 km sanctuary.

Announcement of the project's objectives in the local community.

Initiation of the project.

4.2 PHASE TWO (Permanent Operation)

Night patrols within the sanctuary for the collection of biological data to be undertaken by DITEPESCA.

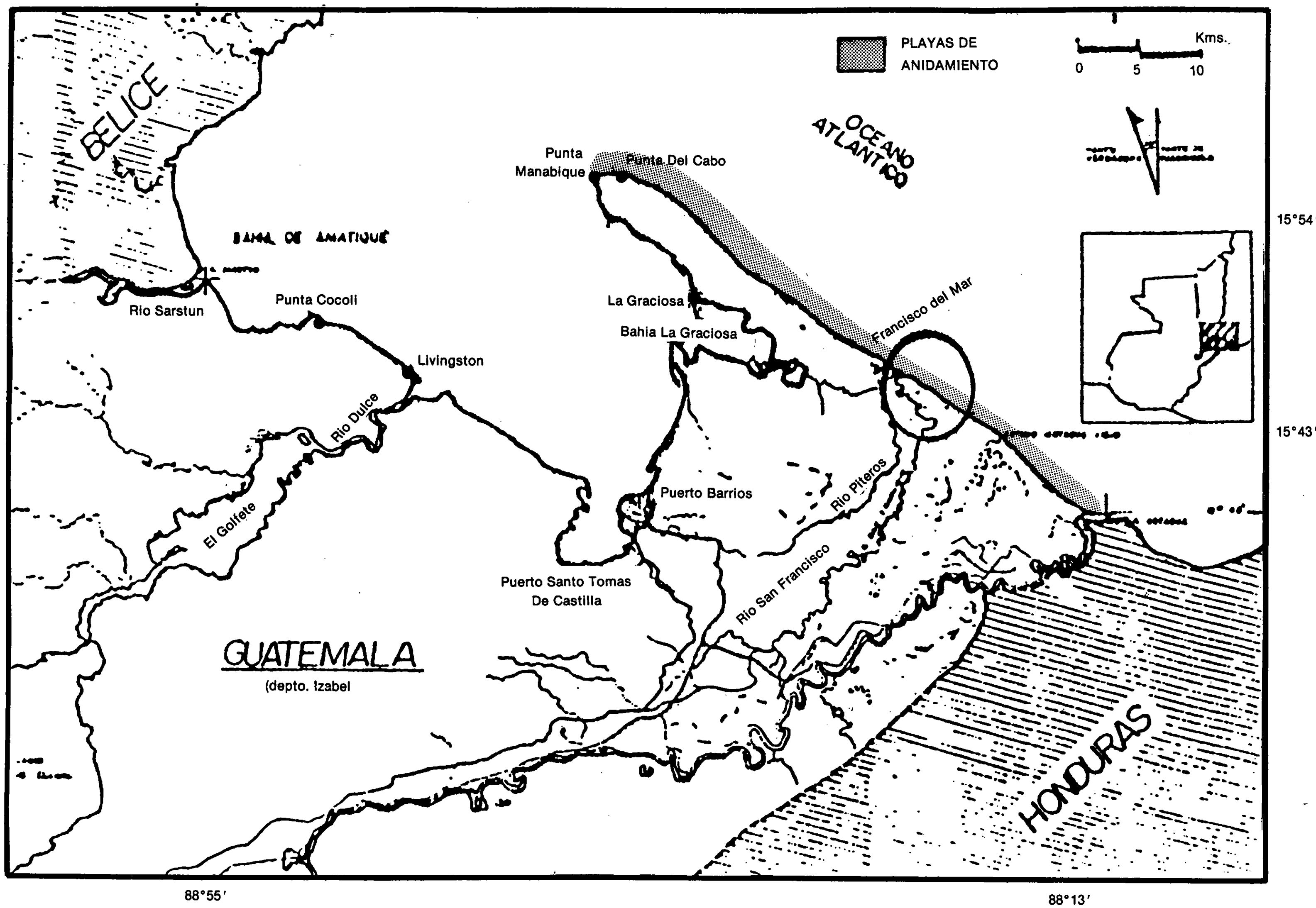
Day and night patrols by the Marina Nacional to guarantee the effectiveness of the sanctuary.

Environmental education undertaken by DITEPESCA and other conservation entities directed toward the local resident's protection of in situ nests.

5. COMMENTS

Since 1981, a law which prohibits the capture and commercialization of marine turtles and their eggs has existed in Guatemala. Nevertheless, severe over-exploitation of turtle eggs by humans on both coasts of the country has placed sea turtle populations in great danger.

The creation and management of this sanctuary provide absolute protection for nesting turtles and also provide a viable option for the conservation of these resources.



MAPA DEL LITORAL ATLANTICO DE QUATEMALA
Y PLAYAS DE ANIDAMIENTO

Suganuma, Hiroyuki

The Green Turtle (*Chelonia mydas*) in Ogasawara Islands, Japan

Ogasawara Marine Center
Ogasawara, Tokyo, Japan

Ogasawara Islands are located about 1,000 km south of Tokyo, Japan. Green turtles breed in Ogasawara Island, one of the most northern rookeries of this species in the western Pacific Ocean.

Green turtles are caught by fishermen during mating season (March-May), and the annual catch records suggest 100-200 turtles were taken in the past ten years. More than 90% of the catch comes from Hahajima Island, although this population is expected to diminish in the near future. Fishing for green turtles is closed during June and July. Egg collection and capture of turtles smaller than 75 cm (curved carapace length) are prohibited.

An experimental hatchery program was conducted from 1910 to 1939, and 38,971 hatchlings were released in those 30 years. In 1975, the hatchery program was started again, and 114,534 hatchlings have been released during the last 12 years.

A tagging study of green turtles has been carried out for the last 14 years. Recapture rates are: 1.3% for headstarted turtles released as yearlings, 10.1% for headstarted turtles released as 2-year-olds, 16.7% for headstarted turtles released as 3-year-olds turtles, 13.4% for subadults, 9.9% for adults on the feeding ground, and 10.7% for adults on the nesting ground (remigration). The feeding ground is located along the Pacific coast of Japan, ranging from 26 N to 38 N latitude. However, it may extend to the East China Sea and near Taiwan.

The period of remigration ranges from 2 to 7 years. A 4-year interval accounts for 42.5% of the remigration records, and 25.0% with a 3-year interval.

Japan removed the green turtle from its reservation list at the 1987 CITES meeting. A report about the situation will be made after the enforcement of the regulations.

Tucker, Anton D.

Revised Estimate of Annual Reproductive Capacity for Leatherback Sea Turtles (*Dermochelys coriacea*) Based on Intraseasonal Clutch Frequency

Georgia Marine Turtle Cooperative Program
Institute of Ecology
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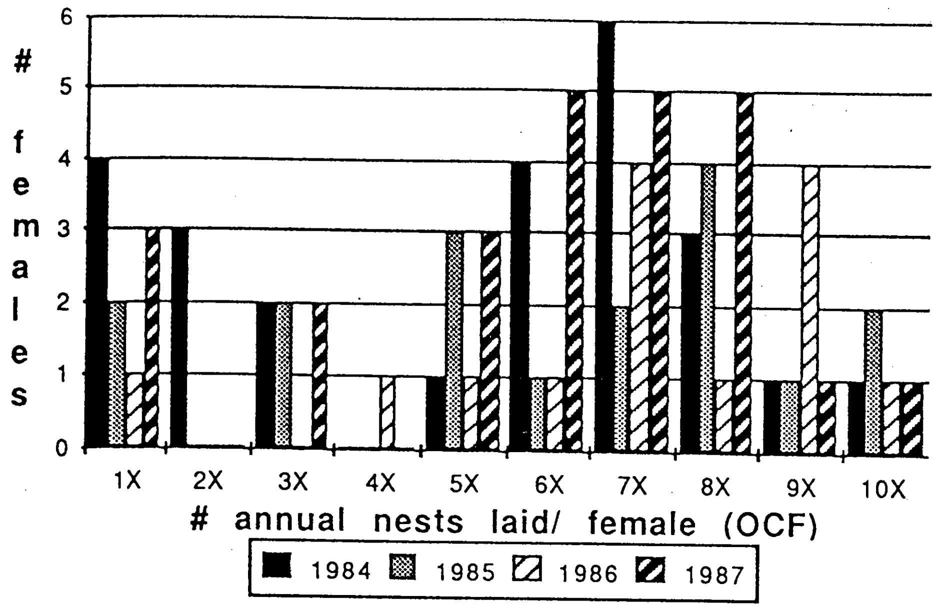
Athens, Georgia 30602 USA

Nesting of leatherback sea turtles has been intensively monitored by a saturation tagging project at Culebra National Wildlife Refuge, Puerto Rico, from 1984 to 1987. The rookery is considered to be a minor Caribbean nesting assemblage but is unique in being patrolled frequently enough to insure that all nesting females are tagged and are subsequently recorded at all other intraseasonal nestings within the study site. The short lengths of the study beaches, lack of alternative nesting habitats outside the study sites, and intense coverage of the study sites result in a very high probability of encountering each female to verify all nesting events within a season. The opportunity to study a relatively complete annual nesting history for each female in the nesting aggregate has not previously been available. Data recorded for annual observed clutch frequency (OCF) and estimated clutch frequency (ECF) exceed published accounts for *Dermochelys*. OCFs of ten nests within a season have been documented. These revised estimates of annual reproductive output indicate that current world population estimates for leatherbacks derived from basing species abundance on more moderate estimates of annual reproductive output may be significantly overestimating true population levels.

Nesting frequency of individual leatherbacks nesting at Culebra, P.R. 1984-1987.

Year	# Turtles	OCF	ECF
1984	n=27*	5.2 (SD=2.79,range 1-10)	5.8 (SD=2.80,range 1-10)
1985	n=17	6.1 (SD=2.80,range 1-10)	6.9 (SD=3.00,range 1-11)
1986	n=14	7.0 (SD=2.33,range 1-10)	7.5 (SD-2.16,range 2-10)
1987	n=25	5.9 (SD=2.47,range 1-10)	6.7 (SD=2.91,range 1-11)

* OCF and ECF for 1984 calculated for 25 nesting females. Two additional females were tagged but did not nest on the study site.



Annual number of nests per female (OCF=Observed Clutch Frequency) for leatherbacks at Culebra, P.R. in 1984-1987.

Wershoven, Robert

Assessment of Utilization of Sleeping Habitat by Juvenile Turtles off Broward County, Florida

Broward County Audubon Society
Deerfield Beach, Florida 33442 USA

Juvenile green turtles are frequently sighted by divers over the hardbottom, first reef area of Broward County, Florida. The range, feeding habits, and growth rates of this population are unknown. Adult green turtles are rarely observed in this habitat, even though there is a small nesting population. In addition to observation by divers, juvenile green turtles frequently strand along the beaches of Broward County.

A study was implemented to gather more information about this population. Dives were conducted along a mile-stretch of hardbottom known to harbor sleeping animals during the nighttime hours. The reef area consists of scattered coral heads with limestone ledges at depths of three to six meters. Animals were captured by hand, brought to the surface, measured, observed, tagged with #681 Inconel tags, and released.

Data were supplemented by necropsies performed on 10 juvenile green turtles after stranding. Stomach contents were removed for analysis, and the intestinal tract and pre-stomach were examined for obstruction.

The diving survey has resulted in 72 green turtles and 3 hawksbills captured and tagged between March 1986 and September 1987. Twenty of these turtles were recaptured, with four green turtles showing multiple recaptures. One hawksbill was recaptured seven times. Curved carapace lengths range from 27.4 cm to 67 cm at time of initial capture.

Turtles have not been observed feeding on any occasion. Examination of the stomach contents through the cooperation of George Balazs and NMFS indicate the consumption of the algae Gelidium crinale in five turtles, and Gracilaria cylindrica and Codium isthmocladum in one.

Analysis of capture frequencies indicates seasonal variability in utilization of the study area, with the peak period during the month of June. Further study will be needed to verify this. The area appears to be primarily sleeping habitat. Surveys conducted during the day to observe feeding turtles or to locate sources of the identified Gelidium crinale or Gracilaria cylindrica have not been successful. Stranded animals may thus reflect a migratory juvenile population which may, or may not, be representative of that population currently being captured and tagged. The study will continue as long as the collection of additional data is feasible.

Wibbels, Thane, David W. Owens, Colin J. Limpus*, and Max S. Amoss

Field Testing of a Sexing Technique for Immature Sea Turtles

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Past research indicates that sea turtles possess an environment-dependent sex determination system. As such, sea turtle population sex ratios are of conservation and evolutionary interest. The sex ratio within a population may possibly vary between size classes of turtles due to such factors as seasonal and yearly variations in hatchling production, sex-specific mortality, etc. Therefore, sex ratios should be examined in the various size classes within a population. We hypothesize that an effective initial step is to examine the sex ratio in the post "lost-year"-through-pubescent portion of the population. This portion of the population represents the condensation of many years of hatchling production. Therefore a study of its sex ratio may be free from some of the logistical problems associated with the study of hatchling and adult sex ratios. However, a prerequisite for studying the post "lost-year"-through-pubescent portion of the population is the development of an accurate sexing technique. We have recently completed a field evaluation of a serum testosterone sexing technique for sea turtles.

Our initial study was conducted in the Cape Canaveral ship channel in collaboration with the National Marine Fisheries Service. During that study, loggerhead turtles were captured by trawling. We collected blood samples from large numbers of turtles via their bilateral cervical sinus. This blood sampling technique is quick, nonharmful, and easily learned. We also laparoscopically examined 21 of those turtles (sex ratio = 2.5F:1.0M). This surgical technique facilitates the direct viewing of the gonad and thus a means of positively sexing individual turtles. However, this technique requires surgical training and is logistically difficult to perform in the field. The serum testosterone titers of the male turtles were all greater than those of the females.

We further evaluated this sexing technique during a six month field project on Heron Atoll in collaboration with the Sea Turtle Research Group of the Queensland National Parks and Wildlife Service. Heron Atoll is located on the southern end of Australia's Great Barrier Reef and it harbors populations of green, loggerhead, and hawksbill turtles. The clear, shallow, and calm waters of the atoll facilitated the use of a "turtle rodeo" technique for capturing sea turtles. Turtles were bled immediately after capture and were then taken to Heron Island where they were laparoscopically examined. During that study, we laparoscopically examined 60 immature loggerheads (sex ratio = 3.6 M:1.OF), 26 immature hawksbills (sex ratio = 4.2F:1.0M), and 200 greens (sex ratio = 2.0F:1.0M). In each of the species examined (with the exception of one male green turtle) the serum testosterone titers of the males were always higher than those of the females. Therefore, these data indicate that serum testosterone is an accurate indicator of a sea turtle's sex and it could be used as a conservation tool for studying population sex ratios. However, to use this technique effectively one must 1) be capable of processing blood samples in the field (i.e., centrifuging and freezing) and 2) have access to a sensitive radioimmunoassay for testosterone (sensitive down to approximately 5 picograms).

Witherington, Blair E. and Llewellyn M. Ehrhart

Status and Reproductive Characteristics of Green Turtles (*Chelonia mydas*) Nesting in Florida

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From 1973 to 1981, a 40 km stretch of beach north of Cape Canaveral on the east coast of Florida was monitored intermittently for sea turtle nesting activity. Beginning in 1981 this effort shifted south, to a 21 km stretch of beach near the town of Melbourne Beach, Florida, and is continuing. On 160 occasions at both sites, 91 green turtles were observed The number of nests made by green turtles has been monitored systematically at Melbourne Beach from 1982 to 1987 and has been cyclic, varying between 1.5 and 13.4 nests/km/yr. Nesting numbers appear to be increasing. Though small in comparison to the number of loggerhead turtles that nest at Melbourne Beach, this accounts for a large part of this species' reproductive activity in Florida. Green turtles nest from early June to late September, with peak nesting occurring in July and August.

The sizes of nesting female green turtles ranged from 83.2 to 116.7 cm standard straight-line carapace length (SCL; n = 90, mean = 101.5 cm, SD = 5.83). Total straight-line carapace length (TCL), used for comparisons with other areas, averaged 102.4 cm (n = 89, SD = 5.61). Body mass ranged from 104.3 to 176.8 kg (n = 15, mean = 136.1 kg, SD = 17.7). The absence of values for variation accompanying size data from Costa Rican green turtles (Carr and Hirth, 1962, mean = 100 cm TCL; Bjorndal 1982, mean = 126 kg) precludes statistical comparisons. A comparison with green turtles nesting in Surinam (Pritchard 1969; mean = 107 cm TCL) indicates that Florida green turtles are significantly smaller (t' test, t statistic adjusted for unequal variances and sample sizes, P<0.01). Growth rates in SCL of adult female green turtles recovered in Florida were small (n = 15, mean = 0.5 cm/yr, SD = 0.6).

Clutch sizes of Florida green turtles ranged from 90 to 199 eggs (n = 130, mean = 136 eggs, SD = 21.2). Mean clutch size of Florida green turtles exceeded that of Costa Rican green turtles (K. Bjorndal pers. comm.; mean = 112 eggs, t' test, P<0.01) and Ascension Island green turtles (Mortimer and Carr, 1987; mean = 121 eggs, t' test, P<0.01). Clutch size in Florida green turtles appears similar to that reported for Surinam green turtles (Schulz 1975; mean = 138 eggs, the absence of values of variation precludes a statistical test). SCL of Florida green turtles correlated well with clutch size (R^2 = 35%, n = 53, P<0.005, Spearman rho correlation).

Florida green turtle clutches left in situ incubated a mean of 54 days (n = 20, SD = 3.2), with a mode of two hatchling emergences per clutch. Hatching success of natural nests not protected from predation was 61.6% (n = 25, SD = 33.9) at Melbourne Beach.

Internesting intervals of Florida green turtles displayed a mode of 14 days. An estimate of the number of intraseasonal nestings per individual lies between two and three. A distinct, two-year remigratory period prevailed, with 15 of 18 recoveries occurring after two years.

Using values of 2.8 nests/female/yr (Carr et al., 1978) and a two year remigration interval, applied to data on the number of nests deposited on major Florida beaches in 1985 and 1986 (n = 736 and 308 nests, respectively, Conley and Hoffman 1987), an estimate for the number of reproductively active females nesting in Florida is approximately 375.

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*U.S. GOVERNMENT PRINTING OFFICE:1989-657-713