NOAA Technical Memorandum NMFS

JUNE 1994

RESEARCH PLAN TO ASSESS MARINE TURTLE HOOKING MORTALITY: RESULTS OF AN EXPERT WORKSHOP HELD IN HONOLULU, HAWAII NOVEMBER 16-18, 1993

George H. Balazs
Samuel G. Pooley

In collaboration with 14 workshop participants

NOAA-TM-NMFS-SWFSC-201

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

NOAA Technical Memorandum NMFS

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National Marine Fisheries Service
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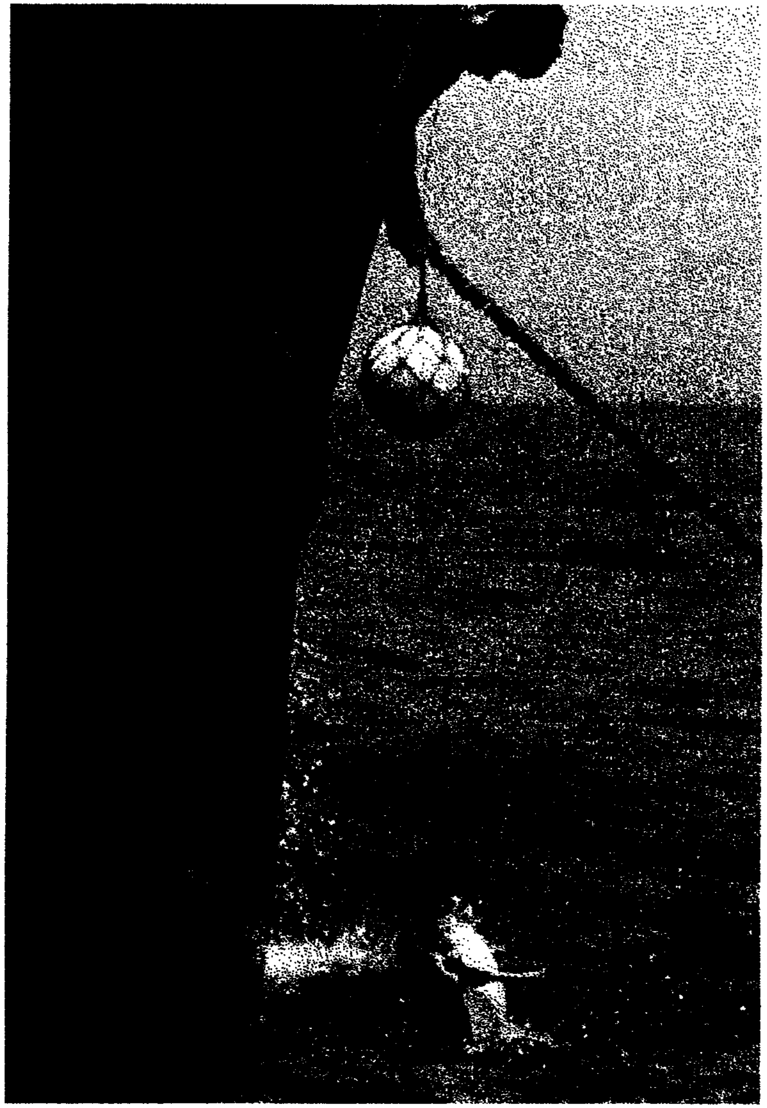
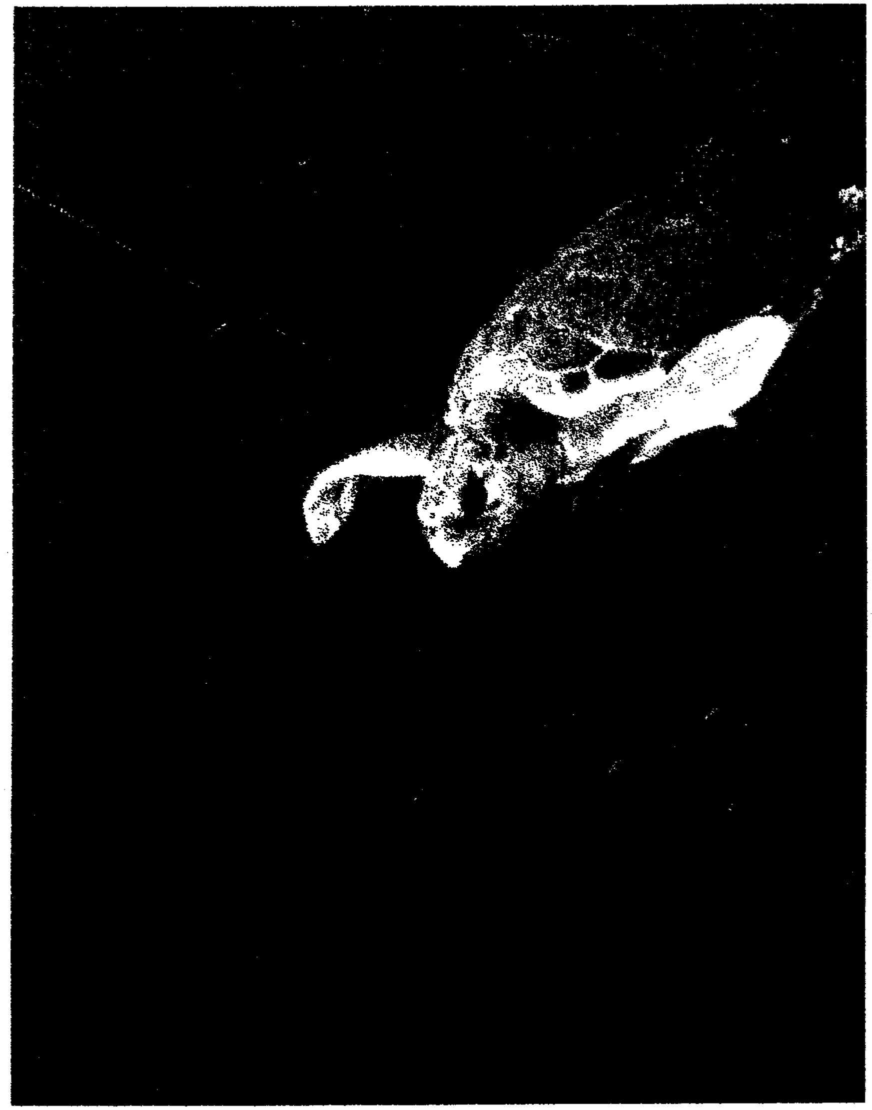
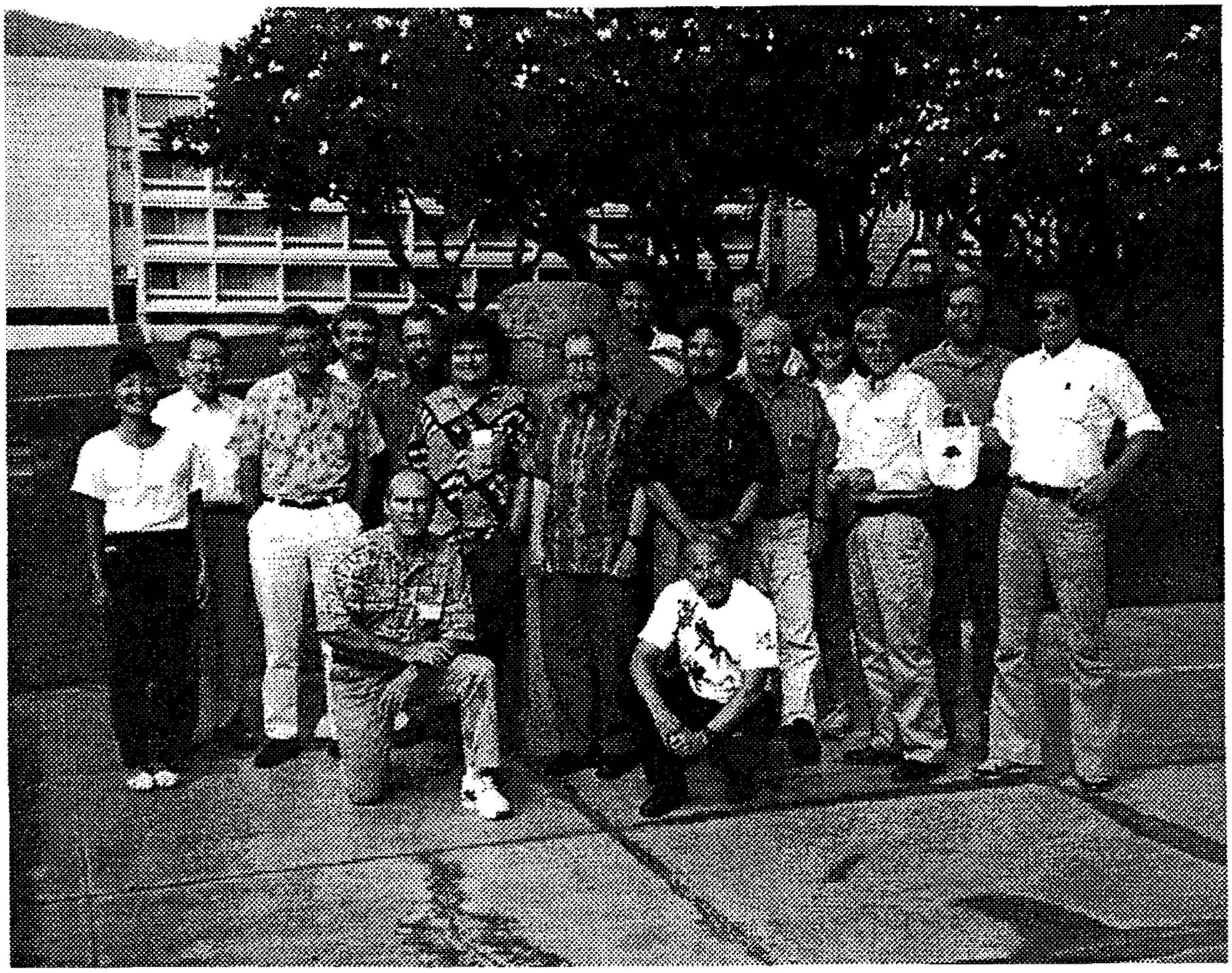




Loggerhead turtles (*Caretta caretta*) hooked by the Spanish longline swordfish fishery in the Mediterranean. (Photos courtesy of Ricardo Aguilar, Green Peace International.)

ACKNOWLEDGMENTS

For the successful conduction of the workshop we appreciate the valuable assistance and contributions of Shawn Koga, Thomas Shearer, Fredrick Dowdell, Russell Ito, Bryan Winton, and Russell Miya. Jerry Wetherall prepared the Marine Turtle Population Dynamics section of the report. For editorial assistance, we thank Judy Kendig, Deborah Yamaguchi, and Francine Fiust.



Participants at the Marine Turtle Hooking Mortality Workshop held in Honolulu, Hawaii, on 16-18 November 1993. Front row (from left to right): Charles Caillouet and Elliott Jacobson. Back rows (from left to right): Shawn Koga, Itaru Uchida, Jerry Wetherall, George Balazs, Jeffrey Miller, Christofer Boggs, Frederick White, Samuel Pooley, Scott Eckert, Thomas Shearer, Larry Ogren, Pamela Yochem, Alan Bolten, Phil Williams, and Kiyoshi Katsuyama (Bernard Thoulag not available for photo),

EXECUTIVE SUMMARY

Problem

Sea turtles (Cheloniidae and Dermochelyidae) are known to ingest baited hooks or become entangled and hooked externally in association with longline fishing. All sea turtles under U.S. jurisdiction are listed and protected under the U.S. Endangered Species Act of 1973. However, the number of turtles captured in longlining, the level of mortality and injury caused by these interactions, and the resulting impact to the affected stocks, are currently unknown. Mortality and injury of sea turtles from incidental capture in certain other fisheries are already recognized as important issues to the conservation and recovery of these threatened and endangered species. Recently there has been increased concern by the National Marine Fisheries Service over reports of turtles hooked in the North Pacific by the Hawaii-based longline fishery. The limited information available on this subject has been summarized in a formal Section 7 Biological Opinion prepared by the National Marine Fisheries Service.

Objective

This research plan identifies a coordinated series of research activities to estimate mortality and physiological impacts on marine turtles hooked and/or entangled by Hawaii's domestic longline fishery.

Planning Framework

The Marine Turtle Hooking Mortality Workshop held in November 1993 was sponsored by the Honolulu Laboratory, Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA. Scientists from across the U.S.A., as well as from three foreign nations, met to propose and discuss activities that can be used to estimate mortality and injury to turtles from longlining. Using an interactive planning methodology, a research plan was prepared as a first step in developing a comprehensive research strategy on marine turtle impacts from longlining. No formal organization of the participating scientists exists, but individual researchers and their agencies may use this research plan as the framework for research coordination.

Recommendations

The research plan recommends a schedule of activities ranging from 1.5 to 5 years in duration that would result in substantial progress in determining the level of mortality and physiological impact to turtles from longline hooking. The estimated cost of this research program is $2.6 million in specific research activities and a minimum of $640,000 in ship time for field work. It is assumed that much of the required research will take advantage of existing programs where ship time is available at no additional cost.

The major activities in the research plan consist of studies which relate to the following:

(1) mortality models;
(2) hooking mechanics;
(3) clinicopathology of hooked turtles;
(4) hooking physiology;
(5) impact assessment of hooked turtles in captivity;
(6) biotelemetry of hooked turtles;
(7) live turtle collection;
(8) pelagic turtle ecology; and
(9) predation of hooked turtles.

At present, there is very little research being conducted on longline hooking mortality of turtles. The research plan lays out the logical sequence of steps and conceptual roadwork for success, but funding sources are not identified. The proposed work must be balanced against competing and important research interests within the same issue, such as hooking mitigation and turtle treatment measures. However, it is apparent that much needs to be learned about hooking mortality which will be applicable not only in the North Pacific but also to sea turtles on a worldwide basis.

INTRODUCTION

BACKGROUND AND RATIONALE

Mortality and injury of sea turtles associated with incidental capture in various fisheries are widely recognized as important issues to the conservation and recovery of these threatened and endangered species (NMFS/FWS 1991a, 1991b, 1992). All sea turtles under U.S. jurisdiction are currently listed and protected under the Endangered Species Act of 1973 (ESA). Forced submergence in shrimp trawls in the southeastern United States, and elsewhere worldwide, has been a focus of research and mitigation efforts during recent years. However, the urgent need has also been emphasized to closely examine the bycatch of sea turtles by other fishing gear, such as coastal set nets, high-seas driftnets, purse seines, and longlines (National Research Council, 1990).

Cases of sea turtles ingesting baited longline hooks or becoming entangled and hooked externally have been known to the scientific community for more than a decade (Hillestad et al., 1982; Balazs, 1982). The most thoroughly documented case involves the hooking of a large leatherback (*Dermochelys coriacea*) that swallowed squid bait on swordfish longline ganging during research fishing in the North Pacific (Skillman and Balazs, 1992).

Only limited quantitative data exist on the number of turtles caught by longline, and the immediate or consequent injury and mortality that take place. Turtles may be either dead or alive when hauled aboard or alongside a fishing vessel during gear retrieval. Further injury may occur during the hauling process. Death may result from forced submergence, or from the hook penetrating a major blood vessel or internal organ. Live turtles with hooks deep in their throat may be cut free by the fishermen and released with varying lengths of line trailing from the mouth. In other cases, the hook may only be superficially imbedded in the mouth or flipper, hence easy to remove if the turtle is brought on deck. However, hauling a turtle aboard may not always be possible or practical, especially when large adult animals like leatherbacks are involved. It should also be noted that in some foreign longline fisheries hooked sea turtles may not always be released but rather kept for food, taxidermy, or other purposes.

There is clearly an array of unknown and incomplete information concerning the number of turtles caught by longline, and how many of them are alive or dead at the time of capture. Also unknown are how many of those hooked are able to survive if released and, of the survivors, how debilitating their injuries may be during the post-release recovery period. These important questions form the basis for the research plan contained in the present report.

The limited information available on incidence of longline hooking and mortality of turtles has been outlined in a recent ESA Section 7 biological opinion by the National Marine Fisheries Service (NMFS, 1993). NMFS concluded that the Hawaii-based longline fishery adversely affects the survival of listed sea turtles, and that "..the authorized level of take established by this biological opinion may not likely be sustained by these species on a continuing basis without the risk of jeopardizing their continued existence". It was estimated that in 1991 the total projected incidental take (capture) by the Hawaii longline fishery was 752 turtles with 148 immediate mortalities. One of the resulting recommendations by NMFS was to evaluate methods and experimental designs that can be utilized to determine the fate of turtles released alive after being incidentally caught in the Hawaii longline fishery. The present report has been prepared in response to that recommendation.

The NMFS biological opinion noted the following information. Incidental take from 1978-81 by Japanese tuna longlining in the U.S. Atlantic and Gulf of Mexico was estimated by Witzell (1984) to be 330 turtles, involving leatherbacks, green turtles (*Chelonia mydas*), Kemp's ridleys (*Lepidochelys kempii*), and loggerheads (*Caretta caretta*). Catch rates per 1000 hooks deployed equalled 0.007 turtles in the Atlantic and 0.018 turtles in the Gulf of Mexico, as derived from logbooks and shipboard observers opportunistically recording turtle capture data. The percentage of dead turtles upon capture was 29.5% in the Atlantic and 7% in the Gulf of Mexico.

Similarly, incidental capture by the Japanese tuna longlining fleet worldwide was estimated by Nishemura and Nakahigashi (1990) to be 0.1 turtles per 1000 hooks, with 42% dead upon retrieval. The overall estimated take in the Western Pacific and South China Sea by Japanese longliners was 21,200 turtles, with 12,300 retrieved dead annually. Commercial logbooks, research vessel data, and questionnaires were used to make these estimates.

For the Spanish swordfish longline fleet in the Western Mediterranean involving 30-60 vessels, Aguilar et al. (1992) using observer data estimated a catch rate of 4.5 turtles per 1000 hooks, or 20,000 turtles a year, nearly all of which were loggerheads. Most of the turtles were reported released alive with the hook lodged internally. Mortality rates of 20-30% were estimated based on a sample of hooked turtles subsequently held in captivity. A more recent report by Aguilar et al. (1993) that has become available estimates a 25% mortality rate for hooked turtles held in captivity. For captive turtles that survived, 22% of them passed hooks out the cloaca in times ranging from 53-393 days. According to Bentivegna et al. (1993) turtles held at the Naples Aquarium rarely survived after ingesting longline hooks in the wild.

Some additional information on the incidence of hooked turtles in fisheries of different geographical areas is presented in the workshop papers found in Appendix A.

A comprehensive review of the known biology and population status of sea turtles in the North Pacific has recently been compiled by Eckert (1993). In addition, Wetherall et al. (1993) have prepared an analysis of the bycatch of turtles in foreign driftnet fisheries that formerly operated in distant pelagic waters to the north and west of Hawaii outside the U.S. Exclusive Economic Zone (EEZ). The loggerhead was by far the most commonly captured turtle in this fishery. The only known nesting areas for loggerheads of any magnitude throughout the North Pacific occur in the southern part of Japan. Loggerheads do not nest in Hawaii, nor do they normally occur in the waters immediately surrounding the archipelago. The Hawaii-based longline fishery extends into areas that were formerly fished by the foreign driftnet fleets. It can therefore be assumed that loggerheads may be the principal species of turtle involved in hooking, although additional observer data are needed to confirm this point.

STATUS OF THE HAWAII LONGLINE FISHERY

The Hawaii longline fishery has been active since 1917.[1] Until the last five years, its primary target was yellowfin (*Thunnus albacares*) and bigeye (*T. Obesus*) tuna for a fresh fish market. It operated relatively near the main Hawaiian Islands (MHI) and used a rope mainline set relatively deep (down to 350 m), with 650 to 1,700 hooks per vessel set daily. Recently the fishery has grown dramatically, from 37 vessels in 1987 to 123 active vessels in 1992. Coincident with this growth has been an almost total change in technology, with gear now consisting of monofilament mainlines. This has allowed more flexible gear configurations, including more shallow sets (as little as 70 m at its deepest point). Additional changes include both day and night sets and the use of chemical lightsticks as attractants. Furthermore, there has been greater targeting of swordfish (*Xiphias gladius*) and a much broader range to the fishery. Vessels now travel as much as 1,500 miles from Honolulu (Figure 1). Fishing effort remains, however, relatively stable in terms of the average number of hooks per vessel set daily (1,016 hooks in 1992). It also remains a fresh fish fishery, with swordfish

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[1]Information on the Hawaii longline fishery is compiled in Kawamoto, Ito, Clarke, and Chun 1987; Dollar, 1991; and Dollar, 1993.

exported to the mainland U.S., and substantial quantities of bigeye tuna exported to Japan from Hawaii.

Total Hawaii longline landings in 1992 were 21.2 million pounds ($44.7 million). Of this, swordfish was 12.6 million pounds ($24.3 million) and bigeye tuna was 3.3 million pounds ($11.9 million). Total fishing effort in 1992 was 11.7 million hooks set, of which 4.7 million were in the MHI, 680,000 in the Northwestern Hawaiian Islands (NWHI), 6.1 million outside the U.S. EEZ, and less than 200,000 in other areas of the U.S. EEZ.

The Hawaii longline fishery is regulated by the Western Pacific Regional Fishery Management Council which at present exercises a moratorium on new entry into the fishery (the number of permitted longliners is fixed at 166) and which restricts longlining to seasonally-adjusted areas 25-75 miles around the MHI and the NWHI. Domestic longline fishing outside the Hawaii 200-mile EEZ by vessels not home-ported in Hawaii is unregulated (e.g., vessels operating out of Alaska or Seattle).

The Hawaii longline fishery is a small part of Pacific-wide pelagic fisheries. In the North Pacific, the Japanese, South Korean, and Taiwanese longline fleets remain active for both fresh bigeye and yellowfin tuna, and albacore tuna for canneries in distant-water areas outside the U.S. EEZ in the western Pacific (Figure 2). Table 1 provides an estimate of the relationship between total Hawaii landings of key target species (including landings by non-longline vessels) and the estimated total catch of these species (WPRFMC, 1993).

Marine mammal and sea turtle interactions with the traditional Hawaii longline fishery were known but apparently uncommon. However, with the growth of the monofilament longline fishery in the late 1980s, interactions with the endangered Hawaiian monk seal (*Monachus schauinslandi*) in the NWHI were suspected. NMFS fielded a voluntary observer program in 1990 but recorded very few interactions throughout the range of the fishery (observer trips were not limited to the NWHI). Table 2 summarizes these interactions.

Interaction data are also required on the daily logbook reports from Hawaii-based longline fishing boats. Table 3 summarizes that information for 1992, but the NMFS monitoring staff noted in its annual report that the number of interactions are not necessarily an accurate indication of the actual number due to underreporting. Dollar (1992) noted: "These data raise concerns that many vessels may be underreporting their interactions with endangered and protected species.... The general consensus among shoreside monitoring personnel, as well as observers returning from trips aboard vessels fishing in the NWHI and mid-Pacific, is that more accurate reporting of interactions should be emphasized." NMFS Southwest Region prepared protected species identification cards which were given to longline vessel captains by NMFS Honolulu Laboratory staff. Recently, the NMFS Southwest Region (Long Beach, California) has reinitiated a voluntary observer program on Hawaii-based longline fishing vessels, and a mandatory observer program with partial fleet coverage is expected in 1994.

EXPERT WORKSHOP

In response to the biological opinion (NMFS, 1993), the Honolulu Laboratory convened a workshop on the issue of turtle mortality and injury caused by hooking and entangling in the Hawaii-based domestic longline fishery. The overall objective of the workshop was:

> **To develop a coordinated research plan identifying research activities to estimate mortality and physiological impacts on marine turtles hooked and/or entangled by Hawaii's North Pacific longline fishery.**

Fifteen experts in the field of marine turtle biology, fishery interactions, protected species management, veterinary medicine, and physiology participated in the workshop (see Appendix B). Four professionals from outside the U.S.A. were among the participants. Included were two from Japan, one from Australia, and one from the Federated States of Micronesia. In addition, invitations to attend the workshop were sent to a number of longline fishermen, industry representatives, and staff of the Western Pacific Regional Fishery Management Council. The workshop was held in Honolulu on November 16-18, 1993 and was convened by George Balazs, zoologist and program leader of the NMFS Honolulu Laboratory's Marine Turtle Research Program. The workshop was moderated by Samuel Pooley, industry economist at the Honolulu Laboratory, who also acted as the facilitator for the planning process. The workshop used an interactive strategic management planning model used for over 10 years in the Southwest Fisheries Science Center and recently used to prepare a research plan for marine turtle fibropapilloma (Balazs and Pooley, 1991).

The marine turtle hooking mortality workshop began with technical presentations by the fifteen participants on scientific and operational knowledge concerning this subject (Appendix A). In addition, a presentation including an at-sea video outlining the basics of fishing with monofilament longline gear was presented by a longline vessel owner, Mr. Sean Martin of Pacific Ocean Producers.

The remainder of the workshop followed a sequence of strategic planning questions used to identify the primary research objectives and research activities, to identify the interrelationships between research activities, and to develop a well-rounded research program by preparing research project outlines. The planning exercise consisted of a number of talents of the workshop participants to identify the basic building blocks of the research plan. The results of these exercises have been utilized by the workshop convener to develop the research program recommended in this report.

The first planning exercise consisted of responses to a "trigger" question concerning the **general goals** that a research program concerning marine turtle mortality in a longline fishery should consider. Some of the goals proposed were broader than the specific topic of the workshop (research on marine turtle hooking mortality), but were germane to the general issue. These goals addressed 4 supplementary issues:

- Mitigation measures
- Animal welfare
- Marine turtle population dynamics
- Observer protocols

Little time was spent on these goals during the workshop. However participants were asked to provide some guidance to NMFS on these issues, and that guidance is summarized in the following section. A full list of the general goals is provided in Appendix C.

The next day focused on marine turtle hooking mortality research activities and avoided research activities focused on supplementary issues (mitigation, population dynamics, etc.). The participants responded to a trigger question concerning the **most important research activities** required for identifying the causes and magnitude of mortality, and other physiological impacts, of turtles hooked or entangled by longline fishing gear. This session was divided into two sets of responses: research activities which were essentially **sea-based** (i.e., to be initiated on-board research or commercial fishing vessels) and **land-based** (i.e., to be conducted in shoreside laboratories). These two lists form the basis of the research activities identified later in the report (Appendixes D and E).

These research activities were then "linked" into a logical mapping of interrelationships through the use of the Interpretive Structural Modeling technique which queried which research activities significantly affected the accomplishment of other research activities. These responses are the basis for the "critical path" diagram used later in this report (Figure 3).

On the final day of the workshop, the participants selected individual research topics (i.e., groups of interlinked activities) on which to prepare research outlines. These outlines are included later in the report and provided the basic information for identifying the timeline and budgetary requirements for carrying out this research.

SUPPLEMENTARY ISSUES

Mitigation

The handling and treatment of turtles hooked or entangled by the longline fishery, and means to avoid or minimize such interactions, need to be determined. Because of the limited scope of the research planning workshop and the time available for considering other issues, detailed recommendations on "mitigation" were not provided. Therefore, this report does not focus on measures or research which could modify fishing gear or turtle handling procedures which might reduce the incidental capture, mortality, or harm of sea turtles. However, workshop participants unanimously recommended that a workshop be convened to address specifically questions of mitigation. Research in such mitigation effects should be a high priority, whether it be "TEDs"[2] for longliners or simple resuscitation procedures for turtles to be implemented by longline crews. It may be the case that research on mitigation--particularly avoidance of hooking and entangling--will have a greater salience than research on turtle mortality, fishery management, or fisheries enforcement, per se. A brief list of potential mitigation measures was generated by the workshop participants and is attached as Appendix F. The activities on this list were **not ranked** in terms of importance or likely success.

Animal Welfare

The issue of the care and treatment of turtles to minimize or prevent pain and suffering from hooking and entanglement by the longline fishery, and as subjects of scientific research at-sea and in laboratories, is extremely important. Participants of the workshop were concerned that adequate standards be in place to guide this research to insure that turtles are handled in a humane manner. The consensus of the planning workshop[3] was to make the following recommendation to NMFS:

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[2]TED = Turtle Excluder Device. A device successfully used in shrimp trawling to allow sea turtles to escape from the net thereby preventing their death from forced submergence.

[3]Notwithstanding a general consensus on this recommendation, no individual participant in the workshop should be identified with or considered responsible for any particular research activity identified in this report. This research plan represents a proposal by the NMFS Honolulu Laboratory to NMFS headquarters for internal review.

The workshop participants strongly recommended that all research involving hooked sea turtles follow the spirit as well as the letter of relevant legislation and guidelines for animal care.

For example, the number of experimental animals should be the minimum necessary to provide statistically valid results. All projects should be reviewed by an Institutional Animal Care and Use Committee, and researchers should refer to existing guidelines on the use of live amphibians and reptiles in research (cf. American Society of Ichthyologists and Herpetologists, 1987; Schaeffer, D. O., K. M. Kleinow, and L. Krulisch (eds.), 1992. The care and use of amphibians, reptiles and fish in research. Scientists Center for Animal Welfare, Bethesda, Maryland; Association for the Study of Animal Behavior, 1993).

Specific concerns and proposed measures on the animal care issue have been sent separately to the appropriate branches within NMFS.

Marine Turtle Population Dynamics

Workshop participants recognized the urgent need to better understand the dynamics of sea turtle populations in order to ascertain impacts of mortality due to Hawaii longline fishing. The effects of incidental turtle mortality in fishing gear depend on the sizes of the turtle populations and the magnitude of mortality from all sources. Uncertainty about all of these factors was clearly underlined in the NMFS Biological Opinion. It will do little good to accurately assess the probability of survival of turtles released after hooking or entanglement in longline gear if the other factors remain poorly understood.

Critical elements of turtle population research include the identification of stock origins and stock structure of turtles in the Hawaii longline fishing area, assessment of turtle population sizes, and estimation of reproductive rates, component mortality rates, and net rates of change in population size. Progress is being made in identification of stock origins of turtles taken in the Hawaii longline fishery, through genetic analyses, and more progress can be expected as an adjunct to the Hawaii longline fishery observer program. In the area of population assessment, significant strides are being made with Hawaii green turtles. Statistically rigorous methods have been developed to estimate the nesting population at French Frigate Shoals and work will soon begin to estimate the abundance of juvenile and subadult turtles in inshore waters through tag-and-recapture methods. Recent progress in ageing of Hawaii green turtles and loggerheads from the Hawaii longline fishing area will allow more realistic age-dependent modeling of population dynamics. But in general the knowledge of the populations that are being affected by the Hawaii longline fishing is meager.

Most turtles affected by the Hawaii longline fishery do not originate in Hawaii or other areas of U.S. jurisdiction and are subject to mortality risks beyond U.S. control, including other sources of fishing mortality. Comprehensive assessments of the affected populations and development of successful recovery strategies will require multilateral cooperative research.

Observer Protocol

The NMFS Southwest Region will be fielding Federal observers on Hawaii-based domestic longline fishing vessels under regulations pertinent to the fishing permits required of these vessels under the Pelagic Species fishery management plan of the Western Pacific Regional Fishery Management Council. The workshop participants made a number of suggestions on observer protocol concerning the handling of turtles, configuration of fishing gear, interactions and the condition of the turtles, sampling of turtles (alive and dead), and experimentation on turtles hooked or entangled in the longline fishery.

Two participants prepared a preliminary observer data collection form (attached as Appendix G). It consists of a number of logical choices depending on the condition of the turtle and the research design. Some of these selections include:

- Hooked or entangled
- Alive or dead
- Hauled aboard or cut free in the water
- Treated or not treated
- Retained, transferred, discarded or released
- Tagged or not tagged

Participants also volunteered a wide array of individual data elements and sampling/handling protocols which are included as a collated list in Appendix G. Statistical guidelines for an observer program to estimate turtle take in the Hawaii longline fishery have recently been developed by DiNardo (1993).

RESEARCH OBJECTIVES

The general objectives for a coordinated research plan identifying research activities to estimate mortality and physiological impacts on marine turtles hooked and/or entangled by longline fishing are:

- To develop methods for estimating mortality caused by the fishery

- To identify the physiological impacts of hooking and entangling on marine turtles

- To estimate the population impacts of hooking and entangling on marine turtles

- To determine the effect of fishing gear on take rates

Greater detail on the sub-objectives which comprise these primary objectives is given in Table 4 (p. 22) and Appendix C. The activities necessary to meet these objectives and to implement the research plan are the subject of the following section.

RESEARCH ACTIVITIES

The basic activities (Appendixes D and E) which need to be covered by this research can be grouped into the following categories. These activities also sometimes address the supplementary issues (i.e., mitigation, population dynamics) as well as the primary issue of bycatch mortality. Detailed research into outlines are attached as Appendix H.

- Mortality and population models

  Construct mathematical models of bycatch mortality and population dynamics for sea turtles; compile data on mortality sources; and develop procedures to study sensitivity of incidental take to model components.

- Mechanics of hooking and hook ingestation

  Determine anatomical hooking sites by shipboard observers; study mechanics of ingestion to ascertain effect of bait type on hooking site. X-ray turtles to follow hook through the gut; and measure transit time of food through gut.

- Clinical and pathological effects of hooking

  Develop detailed protocol for data collection from hooked turtles; establish a database for normal blood values; develop criteria for health assessment of hooked turtles both in the field and lab; develop techniques to determine location of hooks and categorize lesions; and determine effects of hooking and hauling turtles on board vessels.

- Physiological effects of hooking and entanglement

  Determine blood variables and heart rates of hooked turtles; study blood variables during mechanical ventilation for resuscitation; study lung morphology and dynamics; and develop surgical methods of removing hooks from the gut.

- Assessment of hooking impact through captive animal research

  Monitor changes in the location of the hook, along with changes in the health of the turtles; study the effects of temperature on hook movement; document physical damage at hooking site; and develop practical methods of hook removal and medical treatment aboard ship.

- Biotelemetry of hooked turtles at sea

  Identify optimum satellite hardware technologies and appropriate geographic region for study; deploy transmitters on turtles and access data; characterize data for survival and integrate results with outcome of captive turtle studies.

- Collection of live turtle bycatch for research

  Develop practical methods for maintaining live hooked turtles aboard ship; develop turtle tethering protocols for research vessel pick-up; design fishing methods to maximize turtle bycatch for research vessel fishing; and deploy research vessel to collect live bycatch from commercial fleet.

- Alternate methods for capturing live sea turtles to study their pelagic ecology.

  Conduct fishery-independent surveys and tagging of pelagic turtles; and develop data base on distribution, life stages, environmental correlations and stock identification (mtDNA).

- Predation of hooked turtles

  Examine stomach contents of hooked sharks for predation on hooked turtles; mimic predation on hooked turtles using salvaged carcasses; model results to accurately estimate overall mortality from hooking.

- Research information data base

  Identify and utilize all available literature sources and other existing information relevant to the successful conduction of research as outlined and set forth in this report (each research effort is independently responsible for this activity).

- Research design

  Formulate statistically valid designs for the research being undertaken (each research effort is independently responsible for this activity).

RESEARCH INTERRELATIONSHIPS

It is difficult to identify all of the interrelationships which exist between research activities (Appendixes D and E), but Figure 3 (p. 33) identifies a number of key linkages between the important groups (see also Table 5). These activities were categorized and the relationships simplified for the purpose of this report. The activities parallel those identified in the previous section but are categorized into slightly different groupings.

RESEARCH BUDGET AND TIMELINE

The overall estimated budget for carrying out a full program of research on marine turtle hooking mortality is $3.2 million. This includes $2.6 million in specific research activities and a minimum of $640,000 in ship time for various types of field work. It is assumed that this research will "piggy-back" to the extent possible on existing research programs, including any observer programs which exist in the commercial fishery.

The detailed research budget, broken down by research topic, follows:

Research topic	Duration in months	Activity cost $k	Ship time cost $k	Total $k
Mortality models	18	150	-	150
Hooking mechanics	24	115	-	115
Hooking mechanics (Japan)	24	30	-	30
Clinicopathology of hooked turtles	60	540	600	1,140
Hooking physiology	24	165	-	165
Impact assessment of hooked turtles in captivity	18	275	-	275

Research topic	Duration in months	Activity cost $k	Ship time cost $k	Total $k
Biotelemetry of hooked turtles	26	825	TBD[4]	825
Live turtle collection	12	180	TBD	180
Pelagic turtle ecology	24	300	TBD	300
Predation of hooked turtles	18	23	40	63
Total		**$2,603k**	**$640k**	**$3,243k**

CONCLUSIONS

It is clear that to meet all the identified research objectives, the research budget and levels of activity will have to be substantial. The proposed work must be balanced by NMFS against competing interests, even within the same field, such as hooking mitigation and turtle treatment measures. However, it is apparent that much needs to be learned about hooking mortality which will be applicable not only in the North Pacific but also to sea turtles on a worldwide basis. With the accomplishment of this expert workshop, now is an opportune time to initiate research that will provide answers to important questions on sea turtle hooking mortality. Concomitantly, it is possible to implement measures to mitigate the impacts of longline fishing on marine turtles as a critical component step in addressing the overall hooking mortality issue. Both avenues urgently need to be pursued.

[4]TBD = To be determined. In preparing the research outlines, several participants declined to estimate vessel costs due to insufficient information. Numerous variables and uncertainties exist at this preliminary stage. Ship time in some cases may be shared, or available at no cost.

CITATIONS

Aguilar, R., J. Mas, and X. Pastor.
1992. Impact of Spanish swordfish longline fisheries on the loggerhead sea turtle *Caretta caretta* population in the Western Mediterranean. Presented at the 12th Annual Workshop on Sea Turtle Biology and Conservation. February 25-29, 1992, Jekyll Island, Georgia, 9 p.

1993. Las tortugas marinas y la pesca con palangre de superficie en el Mediterraneo. Draft English translation of unpublished report, Greenpeace Internacional, Proyecto Mediterrano, Palma de Mallorca, Islas Baleares. August, 1993, 72 p.

American Society of Ichthyologists and Herpetologists.
1987. Guidelines for use of live amphibians and reptiles in field research. J. Herp., Supplement No. 4, p. 1-14.

Association for the Study of Animal Behavior.
1993. Guidelines for the use of animals in research. Anim. Behav., 1993, 45, 209-212.

Balazs, G. H.
1982. Annotated bibliography of sea turtles taken by longline fishing gear. NOAA, NMFS, Southwest Fisheries Center, Honolulu Laboratory. Unpubl. rep., 4 p.

Balazs, G. H. and S. G. Pooley (editors).
1991. Research plan for marine turtle fibropapilloma. Results of a December 1990 workshop. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-156, 113 p.

Bentivegna, F., P. Cirino, and A. Toscano.
1993. Care and treatment of loggerhead sea turtles from the Gulf of Naples, Italy. Marine Turtle Newsletter, 61:6-7.

DiNardo, G. T.
1993. Statistical guidelines for a pilot observer program to estimate turtle takes in the Hawaii longline fishery. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-190, 40 p.

Dollar, Robert A.
1991. Summary of swordfish longline observations in Hawaii, July 1990-March 1991. Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-91-09, 13 p.

1992. Annual report of the 1991 Western Pacific longline fishery. Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-92-11, 26 p.

1993. Annual report of the 1992 Western Pacific longline fishery. Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-93-12, 25 p.

Eckert, K. L.
1993. The biology and population status of marine turtles in the North Pacific Ocean. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-186, 156 p.

Hillestad, H. O., J. I. Richardson, C. McVea, Jr., and J. M. Watson, Jr.
1982. Worldwide incidental capture of sea turtles. *In*: K. A. Bjorndal (editor), Biology and conservation of sea turtles, p. 489-502. Smithson. Inst. Press.

Kawamoto, Kurt E., Russell Y. Ito, Raymond P. Clarke, and Allison Chun.
1989. Status of the tuna longline fishery in Hawaii, 1987-88. Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-89-10, 34 p.

National Marine Fisheries Service (NMFS).
1993. Endangered Species Act Section 7 Consultation Biological Opinion: Impacts of the Hawaii longline fishery on listed sea turtles. National Marine Fisheries Service, June 10, 1993, 18 p.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (FWS).
1991a. Recovery plan for U.S. population of loggerhead turtle. National Marine Fisheries Service, Washington, D.C., 64 p.

1991b. Recovery plan for U.S. population of Atlantic green turtle. National Marine Fisheries Service, Washington, D.C., 52 p.

1992. Recovery plan for leatherback turtles in the U.S. Caribbean, Atlantic and Gulf of Mexico. National Marine Fisheries Service, Washington, D.C., 65 p.

National Research Council.
1990. Decline of the sea turtles: Causes and prevention. National Academy Press, Washington, D.C., 259 p.

Nishemura, W. and S. Nakahigashi.
1990. Incidental capture of sea turtles by Japanese research and training vessels: results of a questionnaire. Mar. Turt. Newsl., 51:1-4.

Schaeffer, D. O., K. M. Kleinow, and L. Krulisch (editors).
1992. The care and use of amphibians and reptiles and fish in research. Scientists Center for Animal Welfare, Bethesda, Maryland.

Skillman, R. A., and G. H. Balazs.
1992. Leatherback turtle captured by ingestion of squid bait on swordfish longline. Fish. Bull., 90:807-808.

Skillman, R. A., C. H. Boggs, and S. G. Pooley.
1993. Fishery interaction between the tuna longline and other pelagic fisheries in Hawaii. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-189, 46 p.

Western Pacific Regional Fishery Management Council (WPRFMC).
1993. Draft amendment 7 to the fishery management plan for the pelagic fisheries of the Western Pacific Region, Honolulu, Hawaii.

Wetherall, J. A., G. H. Balazs, R. A. Tokunaga, and M. Y. Y. Yong.
1993. Bycatch of marine turtles in North Pacific high-seas driftnet fisheries and impacts on the stocks. *In*: Ito, J. et al. (editors), INPFC Symposium on biology, distribution, and stock assessment of species caught in the high seas driftnet fisheries in the North Pacific Ocean, Bulletin Number 53 (III), p. 519-538. Int. North Pac. Fish. Comm., Vancouver, Canada.

Witzell, W. N.
1984. The incidental capture of sea turtles in the Atlantic U.S. Fishery Conservation Zone by the Japanese tuna longline fleet, 1978-81. Mar. Fish. Rev. 46(3):56-58.

TABLES

Table 1.--Stock-wide catch (in metric tons, t) of tuna and billfish species by areas of interest (areas encompassing putative stocks) compared with the Hawaii catch (t). Areas as defined by source (given in Skillman et al. 1993). Stock-wide catches area for 1990 except for source 3 (1986-89 average).

Species	Area stock (?)	Catch (t)	Source[a]	Hawaii[b] (t)	Hawaii (%)[c]
Swordfish	Pacific	29,000	1		14.0%
	Northwest Pacific	9,200	1		
	Eastern central Pacific	8,900	1	4,490	39.0%
Blue marlin	Pacific	22,000	1	590	2.7%
Striped marlin	North Pacific	10,000	2	730	7.3%
Yellowfin tuna	Eastern Pacific	290,000	3		
	Central & western Pacific	375,000	4	1,270	0.4%
Bigeye tuna	Pacific	152,000	1	1,900	1.3%
Albacore	North Pacific	59,000	5	320	0.5%

[a]Sources are: 1-FAO (FAO 1990, and unpublished data), 2-approximation based on FAO areas 61 and 71 (FAO 1990, FAO unpublished data), 3-Wild (1993), 4-Suzuki (1993a), 5-NOAA (1991). See Skillman et al. 1993 for citations.

[b]Hawaii data for 1991.

[c]Hawaii 1991 catch as a percentage of the total for each area or stock. Percentage based on the assumption that total catch stayed relatively stable from 1990-91 except for swordfish. The large 1990-91 increase in the Hawaii swordfish catch (2,590 t) was added to the area totals before calculating Hawaii's percentage of the swordfish catch.

Table 2.--Number and type of trips and number of interactions occurring in and out of a study area in the Northwestern Hawaiian Islands. "Inside" indicates sets made in the study area (50-mile zone); "outside" indicates sets made out of study area.

					Interactions (observed or actual)						Actual Interactions with birds	
					Monk seals		Turtles		Whales/Porpoise			
Month out	Type	Month in	Inside[a]	Outside[a]	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
						1990						
Jul	LL-V[b]	Jul	5	5	0	0	2	0	8	0	0	0
Jul	LL-V	Jul	0	10	0	0	0	0	0	0	0	0
Jul	LL-V	Aug	0	14	0	0	0	0	0	0	0	0
Sep	LL-V	Sep	(trip aborted due to death in family of crew member)									
Sep	LL-V	Oct	0	10	0	0	0	0	0	1	0	0
Sep	LL-V	Oct	0	10	0	0	0	0	0	0	0	0
Sep	LL-V	Oct	0	7	0	0	0	0	0	0	0	0
Oct	BF-V[c]	Oct	93	0	2	0	0	0	50	0	0	0
						1991						
Jan	BF-V	--	(exempted)									
Jan	BF-V	Jan	(trip aborted in Kauai due to mechanical problems)									
Jan	LL-M[d]	Feb	3	5	0	0	0	1	3	0	0	9
Feb	LL-M	Feb	3	3	0	0	0	0	0	0	2	0
Feb	LL-M	Mar	9	0	0	0	0	0	1	0	6	0
Feb	LL-M	--	(cancelled 2/91)									
Feb	LL-M	--	(cancelled 2/91)									
Mar	LL-M	Mar	0	6	0	0	0	0	0	0	0	0
Mar	LL-M	--	(cancelled 3/91)									
Mar	LL-M	--	(cancelled 3/91)									
Mar	LL-M	--	(cancelled 3/91)									
Mar	BF-M	Apr	79	0	1	0	0	0	1	0	2	0
Apr	BF-M[e]	May	164	0	0	0	0	0	0	0	1	0

[a]Numbers for longline vessels indicate sets; numbers for bottomfish vessels indicate drifts and anchor stations.
[b]LL-V = Longline-voluntary.
[c]BF-V = Bottomfish-voluntary.
[d]LL-M = Longline-mandatory.
[e]BF-M = Bottomfish-mandatory.

Table 3.--Number of interactions with endangered and protected species reported by Hawaii's domestic longline fleet January-December 1992. Numbers indicate animal count, not sets with interactions.[1]

Endangered/protected species	No. released alive	No. released injured	No. released dead
Turtle:			
Green turtle	29		
Leatherback	32		
Loggerhead	2		
Olive ridley	1		
Dolphin:	1		1
False killer whale:	2		
Seabird:			
Albatross	18	8	65
Booby		3	6
Other: Unidentified species	7	2	3
TOTAL:	92	13	75

Table 3A.--Location of protected species interactions.

Endangered/protected species	Inside the EEZ (No.)	Outside the EEZ (No.)
Turtle	11	53
Dolphin	0	2
False killer whale	2	0
Seabird	15	85
Other species	1	11
TOTAL:	29	151

[1]All data in these tables are unedited.

Table 4.--Primary research objectives and sub-objectives.

- Develop methods for **estimating mortality** caused by the fishery.

  Specific objectives:

  Decision information: Acquire and present scientific information for decision-making on turtle bycatch and fishery management regulations.

  Mortality model: Integrate research information to develop a multi-faceted model predicting the fate of turtles hooked or entangled.

- Identify the **physiological impacts** of hooking and entangling on marine turtles.

  Specific objectives:

  Document physical effects of hooking: Characterize injuries, lesions, and other pathological impacts associated with hooking and with hauling turtles up to vessels and on-board.

  Sub-lethal or chronic effects: Determine what percentage of hooked and released turtles have reduced growth rates, abnormal migratory behavior, reduced reproductive capacity, etc.

  Criteria for health assessment: Develop criteria for conducting a health assessment of marine turtles for evaluation in the field and under laboratory conditions.

  Hook location: Develop practical methods for determining the anatomical location of hooks in the turtle.

  Fate of released turtles: Document the fate of released turtles. Determine if hooked turtles released alive are able to survive and continue to be functioning members of their populations.

  Shark take: Determine prevalence of incidental take by sharks on turtles hooked by longline gear.

- To estimate the **population impacts** of hooking and entangling on marine turtles.

  Specific objectives:

  Population impacts: Determine if longline fishing threatens turtle populations.

Table 4.--Continued.

Turtle population information: Determine boundaries and size of impacted populations of turtles.

Determine "tolerable" mortality: Determine what level of turtle take is acceptable, if any, given conservation goals.

Total mortality: Judge relative impact of U.S. fishery bycatch of sea turtles to total sea turtle take involving fishing fleets of all involved nations.

Other factors: Find out how to deal with other factors affecting turtle populations, e.g., shoreside development in nesting areas, marine pollution, etc.

- To determine the effect of **fishing gear** on take rates.

Specific objectives:

Gear effects on take rate: Quantify effects of different longline gear configurations and fishing operations on rate of hooking sea turtles.

Incidence of take: Quantify incidence of take--how hooking occurred and where in turtles the hook has penetrated or was lodged.

Observer program: Implement observer program and protocols on longline vessels to facilitate necessary research data.

Table 5.--Research activity groupings by topic. The activities are also listed in Appendixes D and E (number in parentheses).

- **Mortality models**

  Mortality model: Develop model for predicting mortality of turtles hooked or entangled in fishing gear.

- **Research information data base**

  Informational database: Assemble into a computerized data base all applicable research and observer data collected on turtle hooking and mortality.

- **Hook damage**

  For dead turtles: Determine damage caused by hooking and hauling up on-board vessel by studying dead turtles through rigorous necropsy.

  For live turtles: Determine damage through surgical interventions.

  Categorize injuries and effects: Differentiate animals by location of hook, type of hook removal, cuts caused by fishing leaders, etc. through experimental (laboratory) means. Differentiate turtle condition by physical condition (e.g., fatness).

  Tissue analysis: Tissue taken from dead turtles and samples taken of live turtles by on-board observers to be analyzed.

  Cause of death: Identify cause of death, particularly submergence vs. hooking injury.

  Health assessment: Assess health of hooked turtles (health index, physical profile, and blood sample).

  Categorize hooked turtles: Develop a ranking of hooking types which will assign turtles to categories based on initial location of hook and circumstance of hauling on-board.

- **Turtle movement**

  Biotelemetry: Satellite track hooked turtles after release to monitor their movements and if possible their condition (including all categories of turtles: alive and apparently healthy, alive and physiologically stressed, or dead).

Table 5.--Continued.

Fate of released turtles: Implement proven biotelemetry and other methodologies (e.g., tagging) to determine survival and adverse physiological impact of hooking.

Tagging: Design and implement a tagging program (external flipper tags and internal PIT tags) aimed at all live (and, perhaps on occasion, dead) sea turtles, both those taken in the fishery and those captured by a research vessel.

Directed recapture: Implement a tag-recapture program. Design program to collect, process and analyze tag returns from the longline fishery, as well as dedicated recapture and experimental cruises (government or private), and general public recaptures (strandings, etc.). Distribution information on the tagging program and solicit returns with date/location of recapture.

Dead turtle telemetry: Monitor movement of dead turtles through satellite telemetry as part of a controlled study for assessing the post-release status of live turtles.

Remote sensing technology (biotelemetry): Develop and test sensors, attachment methods, and other aspects of remote sensing, tracking, and monitoring devices, including satellite and archival tags.

- **Shark predation**

Large predators: Investigate the impact of large predators (e.g., sharks) on turtles hooked or entangled by longline gear through investigation of their stomachs and experimental means.

- **Hooking/swallowing mechanism**

Hook progression: Monitor progression of hook through the turtle gut **as well as** the health of hooked turtles. Measure the rate and manner of hook sloughing, as well as the health of the turtle during the sloughing process.

Hooking mechanism: Conduct experiments to understand the mechanism of hooking in order to minimize or eliminate hooking or its impacts (linked to mitigation activities).

Feeding trials: Determine passage of food through gut through feeding trials to develop standard of comparison in hook progression research.

Table 5.--Continued.

Digestive milieu: Characterize internal digestive milieu (environment) to understand what conditions the hooks are subject to for evaluation of hook impacts and for later development of biodegradable hooks.

Bait studies: Determine the impact of different baits through the type of bites taken by turtles and the eventual location of the hook in the turtle.

- **At-sea turtle research and information**

Record hooking details: Record gear configuration and physical location of hooking when turtles are taken.

Vessel environmental data: Record basic oceanographic data, related environmental factors, time and location, and gear configuration for each set (whether turtles taken or not).

Location of hook in turtle: Identify the physical location of hook in turtle.

Tissue sampling: At-sea blood and tissue sampling from live turtles, necropsy of dead turtles (when it is absolutely impossible to bring dead turtles back to land).

Collect live turtles: Obtain, transport, and hold hooked turtles for scientific research purposes at land-based research facilities.

Retain all dead turtles: Salvage and properly store and transport all dead turtles to land-based research facilities for comprehensive necropsy and other studies.

Practical medical evaluation: Determine what kind of health assessment on hooked turtles can be practically conducted at-sea, either on research vessels, by observers on commercial fishing vessels, or by fishing crews.

Collect turtles: Utilize other fishing methods, such as short tangle nets, to capture turtles at-sea for research purposes (tagging, bio-telemetry, behavioral studies, and baseline parameters).

Photo/video: Use video and still photography to document all aspects of fishing operations, sea turtle capture, sea turtle handling by crew and observers (hauling, decking, hook removal, and resuscitation or cutting lines and release), and processing on-board (icing, freezing, necropsy, and tissue sampling).

Table 5.--Continued.

- **Captive studies and laboratory analysis**

  Captive holding: Holding turtles in a controlled environment to conduct all relevant research necessary to ascertain the fate of hooked turtles.

  Temperature effects: Effect of temperature on turtle holding and eventual fate of bycatch turtles (captive or released). Maintain captive turtles at various temperatures to evaluate impact on turtle physiology.

  Biological analysis: Analyze all relevant biological samples (blood, tissues, etc.) taken by benign means from live turtles, as well as those collected through necropsy on dead turtles.

  Stomach contents: Investigate natural turtle diet in order to duplicate diet in captive studies so that protein levels and other nutritional aspects will be equivalent.

  At-sea evaluation: Techniques for evaluating turtles health and condition at sea (e.g., endoscopy, portable x-ray).

  Annotated bibliography: Generate an annotated bibliography and literature review on sea turtle anatomy, physiology, and fishery interactions.

  Identify high-take areas: Analyze information on turtle take world-wide to identify location for experiments.

  Natural captive diet: Determine how natural diet can be mimicked for captive turtles.

- **Observer protocol**

  Observer protocol: Develop a detailed protocol on the information to be collected by observers and design the field sheets for collecting data on hooked sea turtles, as well as instructions on how to handle hooked turtles at-sea.

- **Research vessel**

  Use vessels not involved in the commercial fishery in order to conduct at-sea research, including the transport of live turtles and non-satellite tracking.

- **Research design**

  Sample size: Design experimental sample size for appropriate confidence levels for both land and sea-based research.

FIGURES

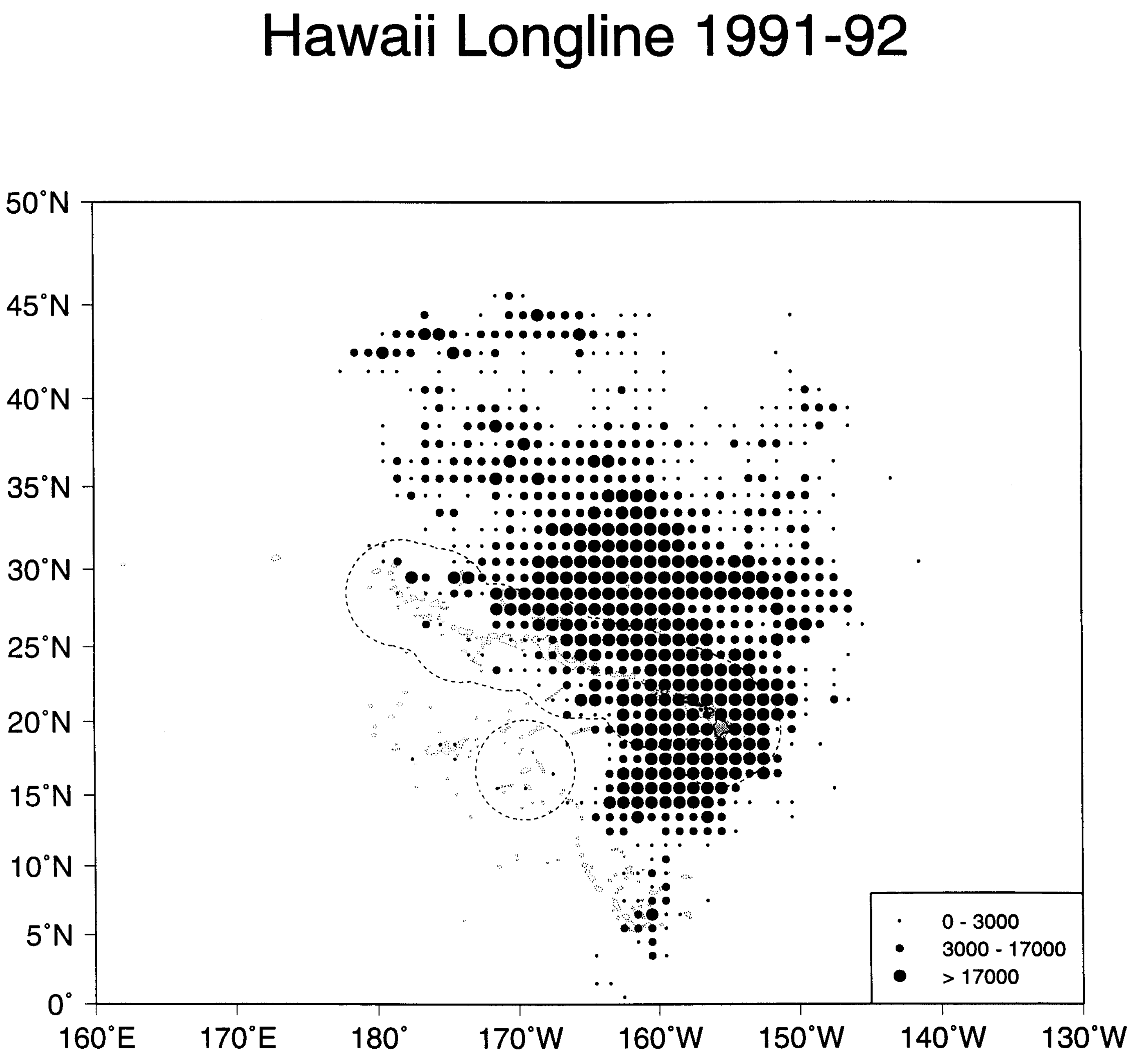

Figure 1. Distribution of reported fishing effort (number of hooks) in the Hawaii longline fishery, 1991 and 1992 combined.

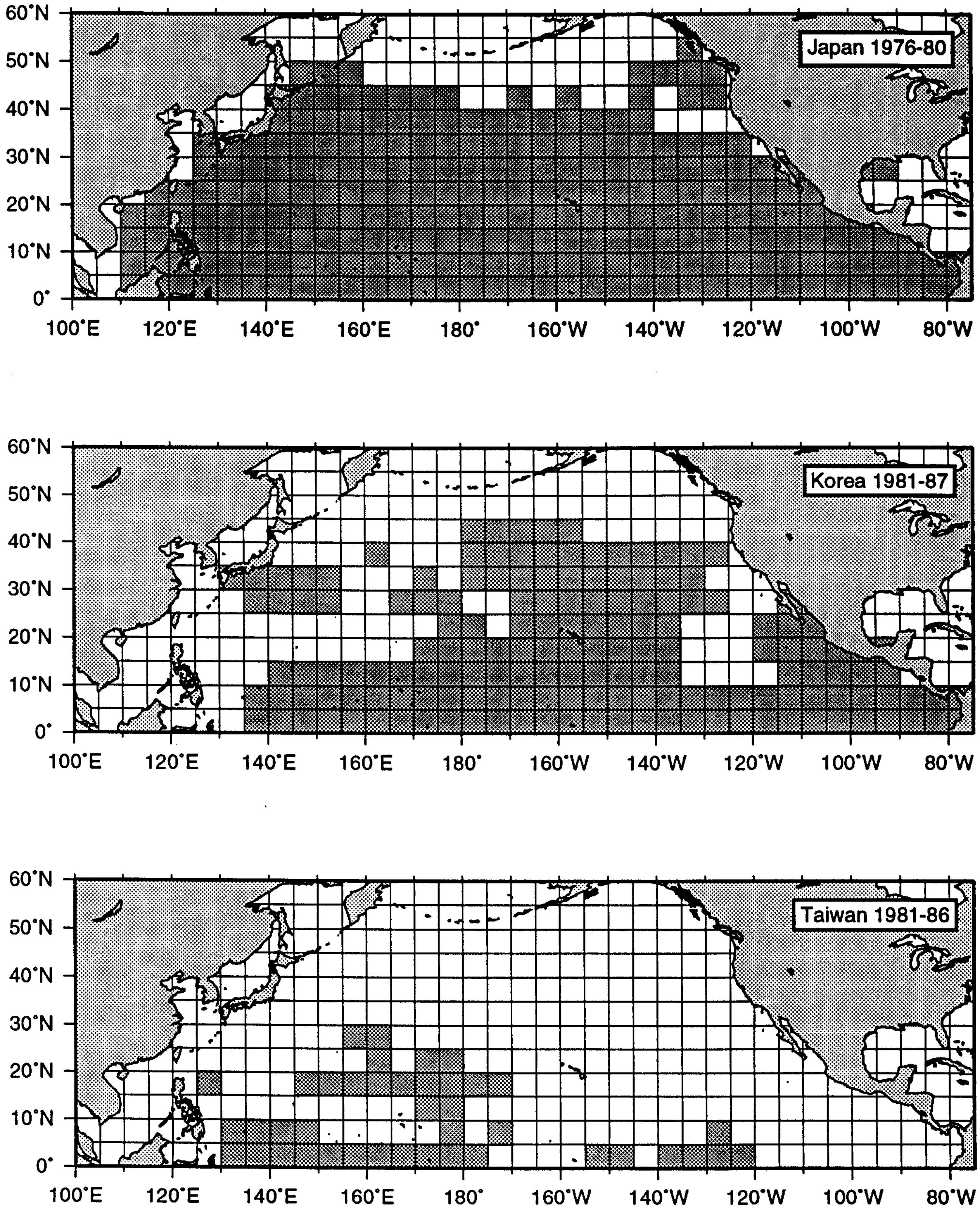

Figure 2.--North Pacific longline fishing areas for Japan, Korea, and Taiwan

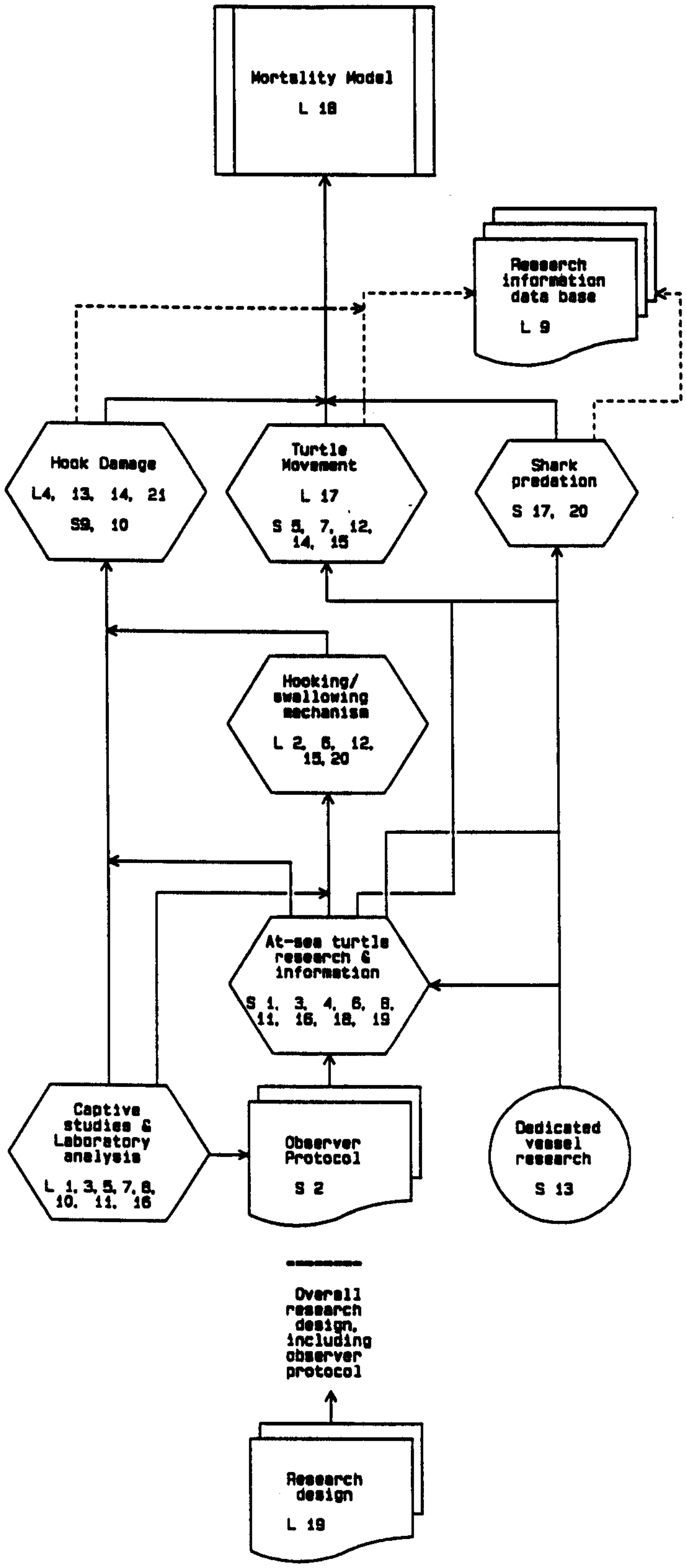

Figure 3.--Interpretive structural modeling (IMS) flow chart showing interrelationships of research activities

APPENDIXES

Appendix A.--Presentations by workshop participants.

NATIONAL MARINE FISHERIES SERVICE RESPONSIBILITIES FOR MARINE TURTLES UNDER THE ENDANGERED SPECIES ACT OF 1973

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INTRODUCTION

The convening of a workshop to evaluate methods and develop research techniques to determine the fate of turtles released alive after being incidentally caught in the longline fishery is a very interesting scientific endeavor. However, it is also a practical requirement for the National Marine Fisheries Service (NMFS), which is charged with managing America's fisheries for optimal sustainable yields and with protecting endangered and threatened species that may interact with those fisheries. This workshop is a requirement of a Section 7 Endangered Species Act (ESA) consultation and was identified as one of several measures necessary to monitor and minimize impacts by the Hawaii longline fishery on endangered and threatened sea turtles. This paper provides a summary of the legal and policy basis for this action.

BACKGROUND

Species Status

All marine turtle species that occur in United States waters are listed as either endangered or threatened under the ESA. Leatherback (*Dermochelys coriacea*), Kemp's ridley (*Lepidochelys Kempii*) and hawksbill (*Eretmochelys imbricata*) turtles are listed as endangered. Loggerhead (*Caretta caretta*), olive ridley (*Lepidochelys olivacea*) and green (*Chelonia mydas*) are listed as threatened, except for breeding populations of green turtles in Florida and on the Pacific coast of Mexico, and the breeding population of olive ridley turtles on the Pacific coast of Mexico, which are listed as endangered. The ESA defines an endangered species as being in danger of extinction throughout all or a significant portion of its range. A threatened species means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Taking Prohibitions

Section 9 of the ESA prohibits the taking of endangered turtles, except under limited circumstances. These include incidental take authorized by regulation, take under the terms of a scientific research permit, or an incidental take authorization issued pursuant to section 7 of the ESA. "Take," as defined by the ESA, means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in such conduct. There is currently no prohibition on the take of threatened turtles incidental to fishing operations. However, green turtles occurring in the Atlantic U.S.A. and Pacific, and olive ridley turtles occurring in the Pacific are assumed to have come from the Florida or Mexico breeding populations. Therefore, because of the similarity of appearance, the geographic proximity of the nesting beaches, and their highly migratory nature, these species are considered to be endangered, unless proven otherwise.

Consultation Requirements

Section 7 of the ESA requires that each Federal agency shall insure that any action authorized, funded, or carried out is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the NMFS to be critical. In fulfilling the requirements of Section 7, NMFS is required to use the best scientific and commercial data available.

Section 7 requires that when a proposed agency action is found to be consistent with the ESA and the proposed action may incidentally take individuals of listed species, NMFS will issue a statement that specifies the impact of such incidental taking. It also states that reasonable and prudent measures be provided that are necessary to minimize such impacts. Incidental taking that complies with the reasonable and prudent measures of the incidental take statement is authorized and exempt from the taking prohibition of the ESA.

HAWAII LONGLINE FISHERY

NMFS reinitiated consultation under section 7 of the ESA for Hawaii longline fishing activities managed under the Fishery Management Plan for Pelagic Fisheries in the Western Pacific Region, to address higher-than-anticipated levels of incidental take of listed sea turtles specified in a May 1991 biological opinion. NMFS concluded that the activities of the Hawaii longline fishery adversely affect green, leatherback, loggerhead, olive ridley, and hawksbill turtles. The current estimates of incidental take, if accurate, may not be sustained by marine turtles on a continuing basis without the risk of jeopardizing their continued existence.

Because of the uncertainties of the actual level of incidental take, NMFS required an observer program to document the incidental capture of sea turtles and to verify logbook data submitted by fishermen. NMFS will reinitiate ESA section 7 consultation no later than June 10, 1994. At that time NMFS will assess the results of the observer program to measure the incidental capture of turtles in this fishery. These requirements, and others, as well as conservation recommendations were detailed in the biological opinion assessing the impacts of the fishery on listed sea turtles and issued by NMFS on June 10, 1993.

In addition to a lack of knowledge of actual incidental take levels, NMFS knows little about the fate of turtles released alive by the longline fishery. Based on very limited information, NMFS estimated, for purposes of its consultation, that 25 percent of all turtles released alive would die of their wounds. To try to determine actual survivability of released turtles, NMFS has required an evaluation of methods and experimental designs that can be utilized to determine the fate of turtles released alive after being incidentally caught in the Hawaii longline fishery. In addition, NMFS has recommended that research be undertaken to determine the fate of turtles released alive after being incidentally caught in the Hawaii longline fishery.

CONCLUSION

NMFS is committed to determining the impacts of the Hawaii longline fishery on endangered and threatened sea turtles and to eliminating or minimizing incidental take. The problems this fishery faces are similar to U.S.A. longline fisheries in the Atlantic and Gulf of Mexico and foreign fisheries also operating in the Pacific and elsewhere. Therefore, this workshop, with a necessary commitment to fund the identified research and monitoring of any incidental take, will help meet NMFS' goal of continuing U.S.A. fishing activities in a manner that is compatible with the protection of listed sea turtles. Our actions will also provide a basis for resolving the problems of incidental take of migratory sea turtles by longline fisheries of other nations.

PELAGIC DISTRIBUTION AND SIZE COMPOSITION OF TURTLES IN THE HAWAII LONGLINE FISHING AREA

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Abstract

Information on the species composition, distribution, and size composition of turtles in the region of the Hawaii pelagic longline fishery is meager. The fishery ranges over 2,000 nm of latitude from waters well south of the Hawaiian Archipelago to waters north of the islands in the North Pacific Transition Zone (NPTZ). Daily logbooks submitted by longline captains and data collected by scientific observers deployed on longliners indicate that turtles occur throughout the longline fishing grounds but suggest provisionally that hooking and entanglement rates may be highest in the Subtropical Convergence Zone, a region of relatively high biological aggregation and productivity at the southern margin of the NPTZ. Data collected by observers on high-seas driftnet vessels of Japan, Korea, and Taiwan during 1990-91 show that turtles are widely distributed in the NPTZ. Driftnet data show that leatherbacks, loggerheads, and green turtles have somewhat different pelagic distributions in the NPTZ but that all three species are found in the area fished by Hawaii longliners. Olive ridleys and hawksbills also occur in the area. Driftnet fishery data indicate that the majority of leatherbacks encountered in the NPTZ are adults, whereas most loggerheads and green turtles are immature. A more complete understanding of turtle species composition, distribution and size structure will emerge from a mandatory observer program on Hawaii longliners to be implemented soon by NMFS.

SEA TURTLE INTERACTIONS WITH THE LONGLINE FISHERY IN THE GULF OF MEXICO

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INTRODUCTION

In the last decade observer reports of sea turtles hooked or entangled by the pelagic longline fishery for swordfish and tuna in the Gulf of Mexico indicated that some low level of take and mortality occurred. This low incidental capture rate as recorded may have been a result of the opportunistically way it was collected. The observers were directed to collect the requisite data on the commercially important fish for statistical analysis of the stocks. Reporting the incidental take of sea turtles was secondary to their mission. These large turtles were not usually decked and as a consequence, were not closely examined. And any injury incurred by the gear was not noted nor was their viability determined. Therefore, the mortality rate recorded most likely was underestimated because the observer could not accurately predict the survivorship of the turtles released with internal hooking injuries or the stress of being forcibly submerged and in a physiologically imbalanced state. Death would or could occur days or weeks later if the turtles were released under these conditions.

The following discussion briefly describes the major oceanic and biological features of the Gulf of Mexico as it relates to the problem of hooking of sea turtles by the longline fishery. Some observer data collected from the foreign and domestic fisheries is presented, as well as anecdotal information on the magnitude of the problem from conversations with fishermen.

OCEANIC FEATURES AND SEA TURTLE POPULATIONS

The Gulf of Mexico receives its major source of water through the Yucatan Straits from the Caribbean Sea. This stream of water becomes the Gulf of Mexico Loop Current whose meanders and eddies form the ocean basin circulation of the Eastern Gulf. Anticyclonic eddies shed periodically from the Loop Current migrate into and across the western Gulf of Mexico, which results in an overall clockwise circulation pattern in the western Gulf (Figure 1). The frequency of ring shedding by the Loop Current is variable from year to year, and the circulation pattern in the eastern and western basins are coupled (Figure 1). Mean circulation in the western basin is largely determines by Loop Current events (Collard and Ogren, 1990).

Aggregations of sea turtles, primarily the pelagic leatherback, *Dermochelys coriacea*, assemble along the fronts or boundary waters of these current systems. Large numbers of this highly migratory species move north from their Caribbean breeding grounds through the Yucatan Strait. They forage on the masses of jellyfish that accumulate along these frontal systems (Collard 1990; Hirth and Ogren 1987; Leary 1957; Yerger 1965). These are the same oceanic features where the longline fishermen typically set their hooks.

FISHERY DEPENDENT OBSERVER DATA

Observer data from the Japanese longline fishery for the period 1978-81 was summarized by Witzell (1984). The total effort recorded for the Gulf as number of hooks for those years was 1,662,273. The catch per unit effort (CPUE) per 100 hooks was .0018, and the total number of turtles captured was reported to be 30. Twelve of these turtles were identified as leatherbacks (the remainder were unidentified), and mortality was estimated to be 7%.

The turtle capture data from the foreign fishery for one of those years (1979) reported an estimated mortality rate of 30%, but only 12 turtles (2 leatherbacks; 10 unidentified) were captured for an effort of 451,902 hooks; CPUE per 100 hooks was .0026 (Thompson, 1982). In another report for the year 1980 the estimated mortality was zero, but only eight turtles were captured. Seven were leatherbacks, one was unidentified. That year's total effort was 294,297 hooks, with a CPUE per 100 hooks estimated at .0027 (Reese, 1983).

In the domestic longline fishery observer report for 1987, total fishing effort reported was 48,941 hooks with a CPUE per 100 hooks of .020 (NMFS, 1988). Ten leatherbacks were captured and the mortality rate was 10%. The domestic longline fishery observer report for 1989-92 (Russell, 1992) reported an effort of 197,498 hooks resulted in a CPUE per 100 hooks of .003 and a mortality rate of zero. Six unidentified turtles were reported.

ANECDOTAL INFORMATION FROM THE DOMESTIC LONGLINE FISHERY

Conversations with captains and crew members of the domestic longline fishery about their encounters with sea turtles, primarily the leatherback (and some lesser number of loggerheads, *Caretta caretta*) took place mostly in the early years of the fishery. At that time they were more inclined to talk freely about their experiences with turtles on the northern Gulf of Mexico grounds. The information we obtained was believed to be factual and not exaggerated or biased.

In a report to the NMFS (Hildebrand, 1980) the new swordfish fishery in the western Gulf was catching an unusually large number of leatherbacks. There was no way to verify the information, however, and for that reason it was with some reluctance Hildebrand related this event in his report. From January to July, 1980, 135 trips by converted trawlers were made to the swordfish grounds offshore Texas. Most of these occurred in the winter and spring. The catch per effort was estimated to be slightly less than one turtle per night per 20-mile set, for a total estimated catch of 1,500 turtles. Most turtles were reported to have been entangled in the gangions (branch lines). Only one was reported to have been hooked in the mouth, and only one turtle was reported dead in the Texas Fishery.

Anecdotal accounts form the Florida based longline fishery were obtained in the mid-1980s from three vessel captains. They frequently set in the area around the Desota Canyon, approximately 90 nm south of Mobile, Alabama, or around the Mississippi Delta. The Loop boundary current was the major oceanic feature in the area fished, as well as the irregular occurring eddies from the Loop. Late winter and early spring were good months for observing lots of leatherbacks, was the general agreement among those questioned. This was especially so when sets were made in the "rip" zones containing an abundance of jellyfish. Two or three leatherbacks were hooked or entangled each set. Turtles were observed all along the set line--hundreds of them on many occasions. Schools of squid were also abundant in the water column. The yellowfin tuna were landed with their mouths and throats crammed full of squid. Most of the leatherback caught were entangled in the drop lines and main line and had to be cut free from the heavy monofilament lines. Some of the turtles, however, were hooked in the mouth (Skillman and Balazs, 1992). The fate of the released turtles was unknown--all were too heavy to be brought on deck. Some had tags on their flippers but the numbers could not be seen from the rail. These turtles were most probably females that had been tagged on their nesting beaches in the circum-Caribbean area (Hirth and Ogren, 1987).

DISCUSSION

The low hook and mortality rates recorded by the observers may have been due to under reporting because of the opportunistic way the program was conducted, especially in the treatment of incidentally captured turtles. Certainly no one can be certain of the fate of the turtles if they were forced underwater during the set and hopelessly entangled when released. Hooked turtles may have swam away when released, apparently alive, but only to die later from ingesting the hook. Conversations with the longline fishermen confirm that leatherbacks do occur coincidentally with the tuna and swordfish and that the fishery does have an impact on turtles. We can relate to other activities such as the recreational surf fishing along the Texas coast, to understand how the severe trauma of hooking effects the Kemp's ridley sea turtle (*Lepidochelys kempii*). Forced submergence of sea turtles in trawls is known to cause death by drowning and/or suffocation in many species of sea turtles. The problem of incidental capture of sea turtles by other fisheries is world wide. Longlines are only one example, and as in the shrimp fishery, this adverse impact on endangered species needs to be addressed.

CITATIONS

Collard, S. B.
1990. Leatherback turtles feeding near a watermass boundary in the eastern Gulf of Mexico. Marine Turtle Newsletter (July). No. 50:12-14.

Collard, S. B. and L. H. Ogren.
1990. Dispersal scenarios for pelagic post-hatchling sea turtles. Bull. Mar. Sci. 47(1):233-243.

Hildebrand, H.
1980. Report on the incidental capture, harassment and mortality of sea turtles in Texas. NMFS-SEFC Contract Report No. NA80-66-A-00160, p. 34.

Hirth, H. F. and L. H. Ogren.
1987. Some aspects of the leatherback turtle *Dermochelys coriacea* at Laguna Jalova, Costa Rica. NOAA Tech. Rep. NMFS 56, Jul 1987, 14 p.

Leary, T. R.
1957. A schooling of leatherback turtles, *Dermochelys coriacea*, on the Texas Coast. Copeia. Copeia, No. 3:232.

Thompson, P. A., Jr.
1982. Japanese longline fishing: comparisons between observer data and Japanese quarterly reports for 1979 in the Atlantic and Gulf of Mexico. NOAA Tech. Memo. NMFS-SEFC-64, p. 30.

Reese, G. B.
1983. Japanese longline fishing: comparisons between 1980 observer and Japanese report data and between 1979 and 1980 fishing activity and catch rates for the Atlantic and Gulf of Mexico. NOAA Tech. Memo. NMFS-SEFC-125, p. 42.

National Marine Fisheries Service (NMFS).
1988. Southeast Fisheries Center domestic longline observer project. Annual Proj. Rep., March-December 1987, p. 10.

Russell, S. J.
1992. Biological and catch/effort sampling of the domestic tuna and shark longline fisheries in the northern Gulf of Mexico. MARFIN, Fifth Marfin Conf. Oct. 28-29 1992, Corpus Christi, Texas.

Skillman, R. A. and G. H. Balazs.
1992. Leatherback turtle captured by ingestion of squid bait on swordfish line. Fish. Bull. U.S. 90:807-808.

Witzell, W. N.
1984. The incidental capture of sea turtles in the Atlantic U.S. Fishery Conservation Zone by the Japanese tuna longline fleet, 1978-81. Mar. Fish. Rev. 46(3):56-58.

Yerger, R. W.
1965. The leatherback on the Gulf Coast of Florida. Copeia, 1965, No. 3:365-366.

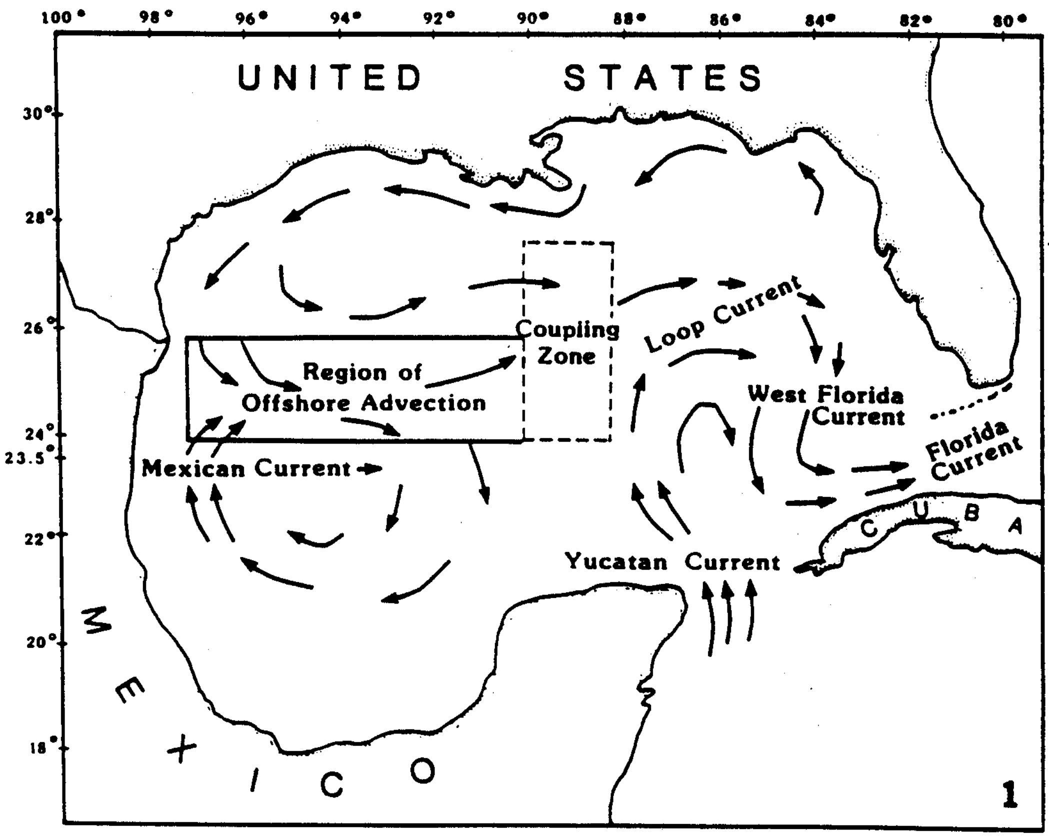

Figure 1. Major current systems in the Gulf of Mexico.

LIFE HISTORY MODEL FOR THE LOGGERHEAD SEA TURTLE (*CARETTA CARETTA*) POPULATION IN THE ATLANTIC: POTENTIAL IMPACTS OF A LONGLINE FISHERY

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To address the workshop objective to develop a coordinated research plan to estimate mortality of and physiological impact on marine turtles by longline fisheries, we present a description of the biology of a pelagic sea turtle population and data on the impact of longline fisheries on that sea turtle population in the Azores.

BIOLOGY OF A PELAGIC SEA TURTLE POPULATION

Approximately 50,000 to 70,000 loggerhead sea turtle (*Caretta caretta*) nests are deposited on southeastern U.S.A. beaches each year (National Marine Fisheries Service and U.S. Fish and Wildlife Service, in press). After approximately 50-60 days of incubation, the hatchlings emerge, run down the beach and enter the ocean. These hatchlings, which are approximately 4.5 cm carapace length, are not seen again in the western Atlantic until they reach approximately 50-55 cm, at which size they appear in the coastal, benthic feeding grounds of the southeastern U.S.A. We believe that when the hatchlings leave the nesting beach, they become incorporated into the Gulf Stream Current. Those post-hatchlings that, by chance, are in the easternmost portion of the Gulf Stream, become incorporated in the Azorean Current, and eventually the North Atlantic Gyre System (Carr, 1986; 1987). This gyre system would carry the turtles from the southeastern U.S.A. waters past the Azores, Madeira, Canary Islands and possibly Cape Verde Islands before returning them to the western Atlantic. During this period, the turtles are often associated with sargassum weed lines in regions of convergences, driftlines or frontal zones in which they find food and shelter. Sea turtles between 5 and 50 cm occupy the pelagic habitat--the "lost year" life stage described by Carr (1986, 1987).

To study the loggerhead pelagic life stage, we have established a network of collaborators in the eastern Atlantic to tag and measure sea turtles in order to document size distributions and movement patterns. The collaborating institutions are Archie Carr Center for Sea Turtle Research, University of Florida; Department of Oceanography and Fisheries, University of the Azores; Secretariat of Agriculture and Fisheries, Azores; Secretariat of Agriculture and Fisheries, Madeira; Municipal Museum of Funchal, Madeira; University of Madeira; Center for Oceanography, Canary Islands; and Center for Oceanography, Malaga, Spain.

In 1990 a collaborative tagging effort was established with the commercial tuna fleet in the Azores. The primary method for fishing tuna in the Azores is visually searching for shearwater (Aves: Procellariidae) feeding activity and then using pole and line in the area observed. Turtles are not caught incidental to this fishing method. Because the tuna crews are constantly searching the surface for tuna feeding activity, they are excellent observers of sea turtles. When not busy with fishing activities, the fishermen capture turtles off the ocean's surface with dipnets. Since the program began in 1990, over 800 loggerheads have been caught, measured, tagged, and released. Analysis of these data demonstrates that there is no significant difference in mean size and size class distribution among years (Bolten et al. 1993). From this we can conclude that the eastern Atlantic loggerhead population is a dynamic population with small, post-hatchlings entering the population each year and with large juveniles (approximately 50-55 cm) leaving each year.

Figure 1 presents the size frequency distribution of loggerheads in the western Atlantic and in the Azores. This figure illustrates how the loggerhead population in the Azores represents the missing size classes in the western Atlantic (Bolten et al., 1993). This was the first evidence that the eastern and western Atlantic loggerhead populations are related. Preliminary analysis of mitochondrial DNA (mtDNA) using restriction fragment length polymorphism (RFLP) data has provided initial confirmation (Bolten, Bjorndal, Bowen, and Martins, unpubl. data). We are now evaluating mtDNA sequence patterns to confirm the relationship of these populations.

Based on our hypothesis of the movement pattern of the eastern Atlantic loggerheads, we would predict that as the turtles move in the North Atlantic Gyre, the carapace length of the smallest size class in the population would increase. Preliminary data from Madeira indicate that this prediction may be correct (Bolten et al. 1993). This prediction needs to be rigorously tested and evaluated for other regions, e.g., Canary Islands and Cape Verde Islands.

Our collaborative tagging efforts in the eastern Atlantic have not only provided size-class information but also have been the basis for the study of movements and growth within the pelagic habitat by recapture of tagged individuals. Recaptures of tagged loggerheads have confirmed our hypothesis of loggerhead movements in the North Atlantic Gyre (Eckert and Martins, 1989; Bolten et al., 1992a and b; Bjorndal, et al., in press).

In their analysis of growth rates of loggerheads in the western Atlantic, Frazer and Ehrhart (1985) were limited by the absence of individuals less than 55 cm. They were not able to distinguish between the von Bertalanffy and logistic growth models because the characteristic lag phase of the logistic curve for smaller size classes could not be evaluated. Analysis of the growth of loggerheads recaptured in the eastern Atlantic demonstrates that the growth data fit the von Bertalanffy model and that the pelagic period is 10-12 years (Bjorndal, Bolten, and Martins, in prep.). Previous demographic models for loggerheads (e.g., Crouse et al., 1987) should now be modified to incorporate the longer duration of the pelagic stage.

IMPACT OF LONGLINE FISHERIES ON SEA TURTLES IN THE AZORES

There are two longline fisheries in the Azores. The fishery that targets demersal fish species apparently does not capture sea turtles incidental to the target species because of the depths (200-700 m) at which the lines are set. The fishery that targets swordfish (*Xiphias gladius*) catches sea turtles incidental to the target species. For the swordfish fishery, hooks are generally set at depths of 5-50 m and primarily baited with squid and mackerel. Both loggerheads and leatherbacks (*Dermochelys coriacea*) are captured on the baited hooks as well as entangled in lines. Figure 2 presents our preliminary data on the size frequency of loggerheads caught in this fishery in the Azores. The frequency distributions are significantly different (Kolmogorov-Smirnov two-sample test, $P < 0.001$). As can be seen, the largest size classes of loggerheads present in the eastern Atlantic are impacted by this fishery. This additional source of mortality could have major demographic implications as indicated by Crouse et al. (1987).

Turtles are usually released alive by the longline fishermen. In general, the line is cut as close to the turtle's mouth as possible, and the hook is left in the turtle. The fate of released turtles is not known. However, ingestion of even small quantities of monofilament line can kill sea turtles (Bjorndal, Bolten and Lagueux, in press).

One of the longline fishermen who is collaborating with us is a careful observer and is willing to make the effort to remove hooks whenever possible. One of the 28 loggerheads for which he recorded data was dead (Fig. 3). Nineteen had been hooked in the mouth and were released alive after the hooks were removed. Eight were hooked distal to the oral cavity and were released alive with the hooks still embedded. In addition, the fisherman reported five leatherbacks had been captured but were not brought on board because of their size. The turtles were released by cutting the line at a distance from the turtle. It is likely that turtles that have swallowed the hook and have the hooks still embedded when released and turtles that are released trailing a length of line will suffer the greatest mortality.

ACKNOWLEDGMENTS

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CITATIONS

Bjorndal, K. A., A. B. Bolten, J. Gordon and J. A. Caminas.
In press. *Caretta caretta* (loggerhead) growth and pelagic movement. Herpetol. Rev.

Bjorndal, K. A., A. B. Bolten and C. J. Lagueux.
In press. Ingestion of marine debris by juvenile sea turtles in coastal Florida habitats. Mar. Pollut. Bull.

Bolten, A. B., H. R. Martins, K. A. Bjorndal, M. Cocco and G. Gerosa.
1992a. *Caretta caretta* (loggerhead) pelagic movement and growth. Herpetol. Rev. 23:116.

Bolten, A. B., J. C. Santana and K. A. Bjorndal.
1992b. Transatlantic crossing by a loggerhead turtle. Marine Turtle Newsletter 59:7-8.

Bolten, A. B., H. R. Martins, K. A. Bjorndal and J. Gordon.
1993. Size distribution of pelagic-stage loggerhead sea turtles (*Caretta caretta*) in the waters around the Azores and Madeira. Arquipelago 11A:49-54.

Carr, A.
1986. Rips, FADS, and little loggerheads. BioScience 36:92-100.

Carr, A.
1987. New perspectives on the pelagic stage of sea turtle development. Conservation Biology 1:103-121.

Crouse, D. T., L. B. Crowder and H. Caswell.
1987. A stage-based population model for loggerhead sea turtles and implications for conservation. Ecology 68:1412-1423.

Eckert, S. A. and H. R. Martins.
1989. Transatlantic travel by juvenile loggerhead turtle. Marine Turtle Newsletter 45:15.

Frazer, N. B. and L. M. Ehrhart.
1985. Preliminary growth models for green, *Chelonia mydas*, and loggerhead, *Caretta caretta*, turtles in the wild. Copeia 1985:73-79.

National Marine Fisheries Service and U.S. Fish and Wildlife Service.
In press. Recovery plan for U.S.A. population of loggerhead turtle. National Marine Fisheries Service, Washington, D.C.

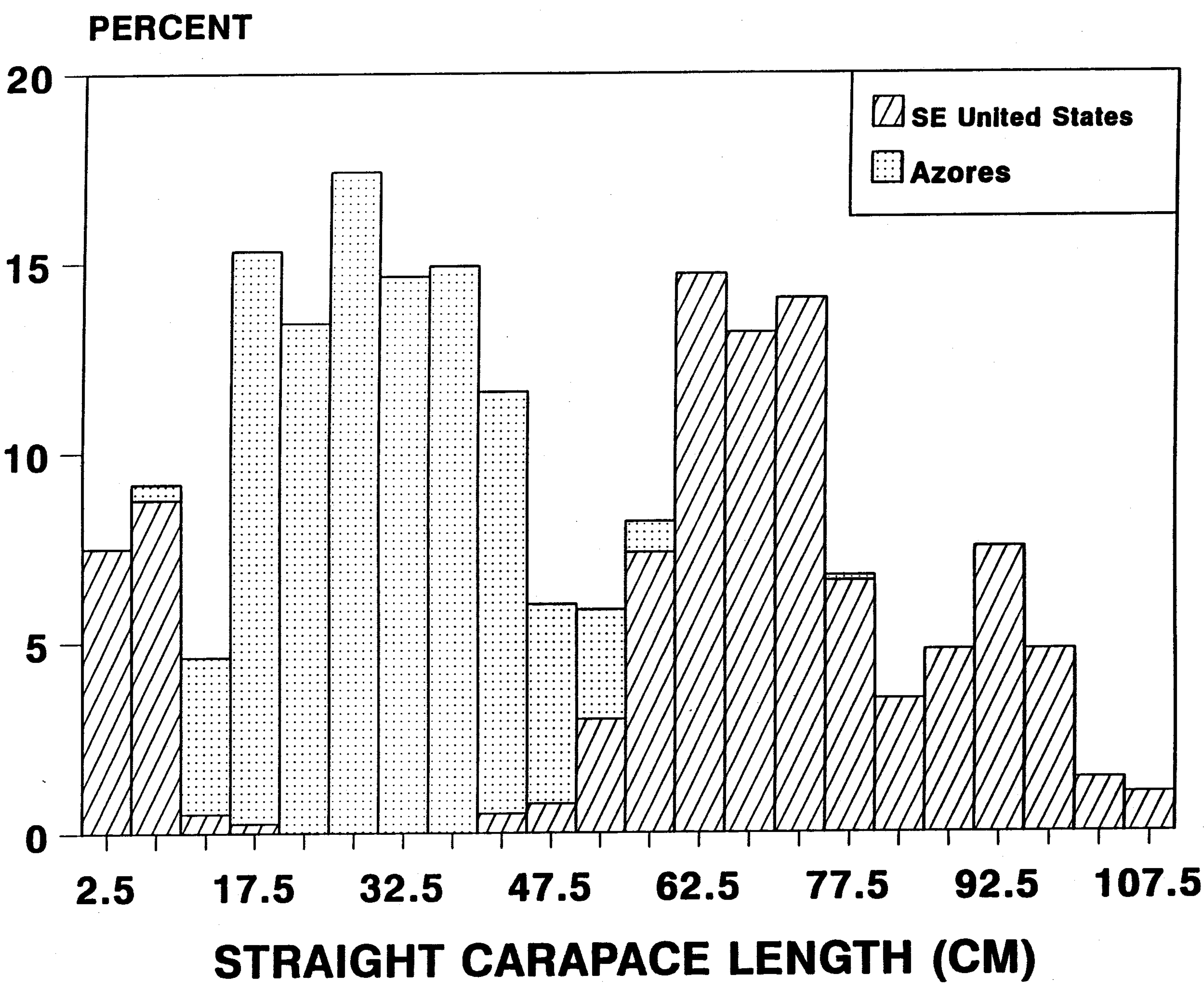

Figure 1.--Size distributions of loggerheads around the Azores and the southeastern U.S.A. (Bolten et al., 1993).

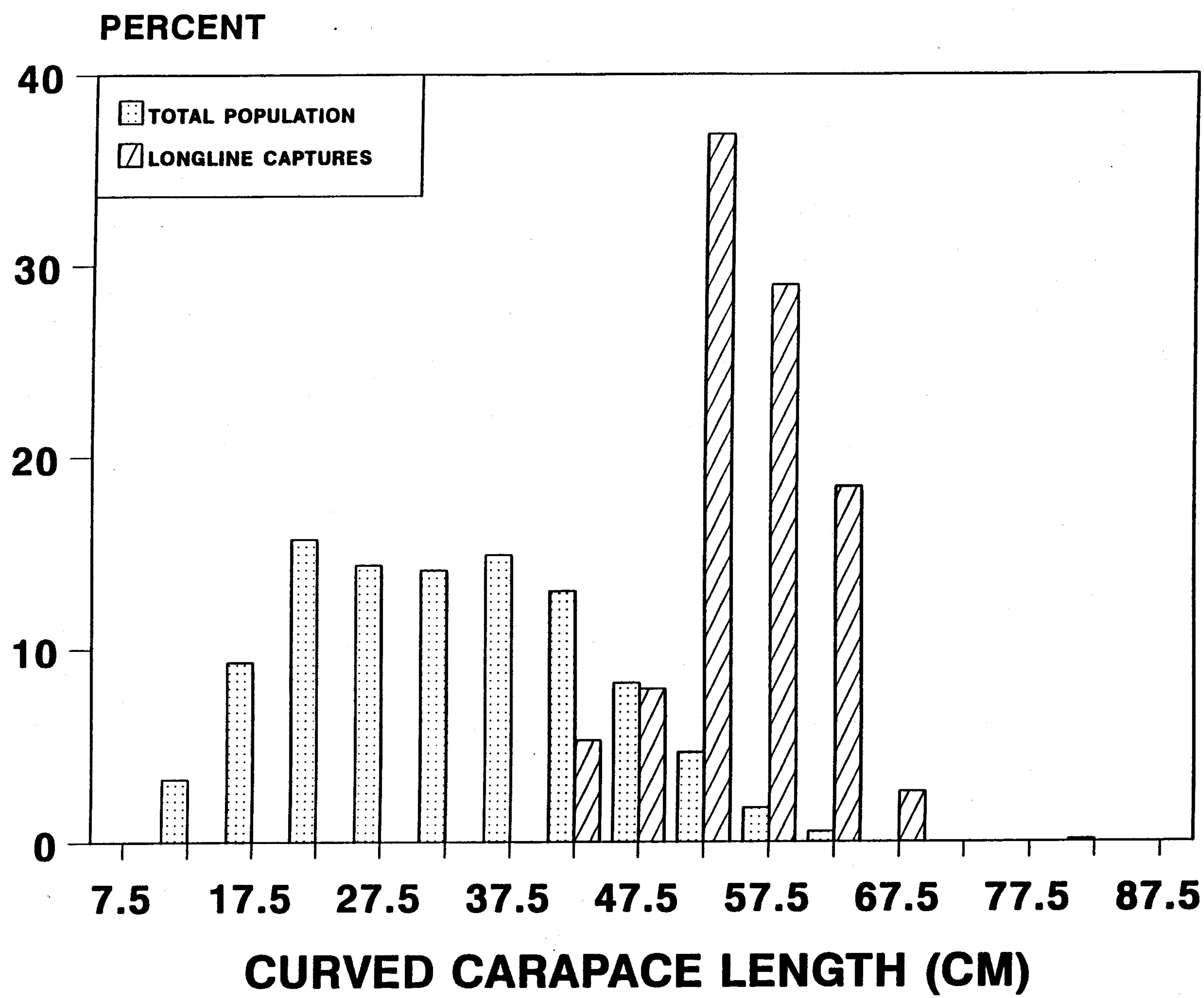

Figure 2.--Comparison of the size distributions of all loggerheads in the waters around the Azores (n = 731) and those captured by the longline fishery in the Azores (n = 38). The frequency distributions are significantly different (Kolmogorov-Smirnov two-sample test, $P < 0.001$).

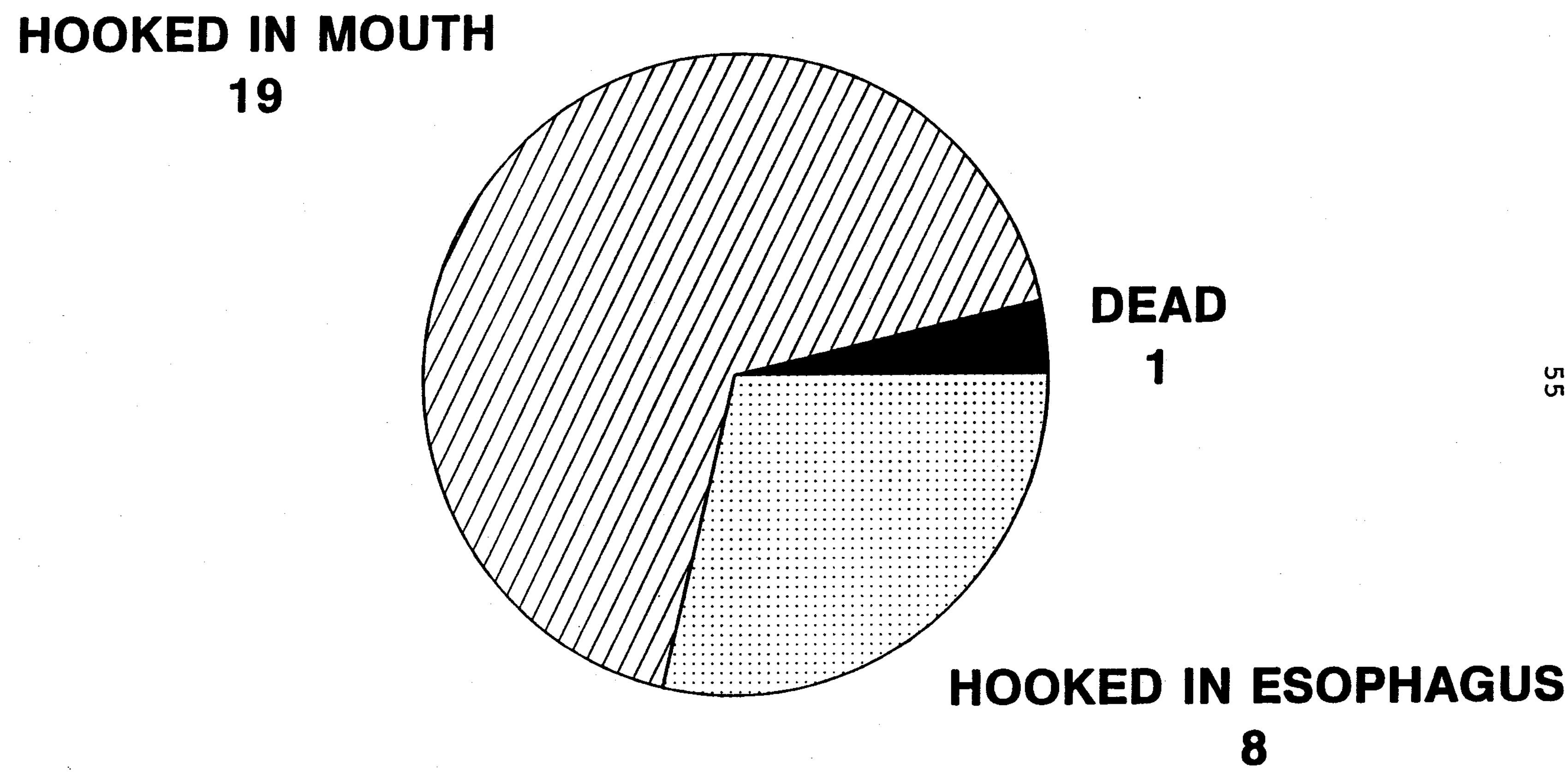

Figure 3.--Observations made by a longline fisherman on 28 loggerheads captured on swordfish longline sets.

MICRONESIAN MARITIME AUTHORITY FISHERIES OBSERVER PROGRAM: INCIDENTAL CATCH OF MARINE TURTLES BY FOREIGN FISHING VESSELS

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INTRODUCTION

Since 1979 the Micronesian Maritime Authority (MMA) has established and maintained a Fisheries Observer Program (FOP) aimed at collecting qualitative and quantitative data on the various fishing fleets operating in the Exclusive Economic Zone (EEZ) of the Federated States of Micronesia (FSM).

This observer program is the largest of its kind in the region and covers all gear types and all fleets licensed to fish in the FSM EEZ, except for the United States purse seine fleet which falls under the observer jurisdiction of the Forum Fisheries Agency (FFA). Many of the MMA fisheries observers are also trained FFA fisheries observers and occasionally are called to monitor one of the United States purse seine vessels.

The MMA FOP is not a surveillance-oriented program but rather a scientific-oriented program with the objective to collect real time fisheries data that is otherwise omitted or poorly reported on the mandatory catch reports of the foreign fleets submitted to the MMA. The data sought after includes information on bycatch and discards for the various gear types (longline, purse seine, pole and line) and basic catch and effort information for validation of mandatory catch reports.

The MMA FOP workforce currently stands at eight observers. These observers receive training in filling out standardized data collection forms and in the identification of commonly captured target and bycatch species (see Appendix A for copies of the forms). The observers go through a detailed debriefing process upon their return from sea duty at which time the data is error-checked and species identifications are verified. When the debriefing process is completed, a trip summary report is prepared and submitted to the Executive Director for review.

The observer data is held in strict confidence and is used mainly by the MMA staff. There has been limited release of certain portions of the data (e.g., bycatch and discard information shared with the TBAP staff at the SPC) but always in aggregate form that does not reveal any sensitive fishing information by vessel or by flag of origin.

MMA FOP--THE EARLY YEARS

From the program's inception during 1979-80 until mid 1992, the majority of the observer trips have been on Japanese fishing vessels, the predominant fleet for that era in the FSM EEZ. The data gathered was both qualitative and quantitative in nature with more emphasis put on observing the "trends" of the different fisheries (i.e., unique gear types, fishing areas by fleet). The early data include some limited length frequency data on the target species, but the data on bycatch and discards is limited for the most part to anecdotal observations. Another compounding factor for some of these trips is the lack of information on the effective time of monitoring (i.e., observed portion versus non-observed portion of trip, especially for longline trips). This makes extrapolation of the data dubious at best and calls for caution when making assumptions about the "applicability" of the data to the overall picture (e.g., hooking rate for various target and bycatch species in the longline fishery).

MMA FOP--1992 TILL THE PRESENT

The MMA FOP has undergone an expansion in scope and depth of coverage. Emphasis is now placed on monitoring a percentage of all the fleets operating in the FSM EEZ. Currently, the MMA FOP places observers on Japanese, Taiwanese, Korean, Australian, and FSM flag purse seine vessels along with Japanese, Taiwanese, Mainland Chinese, and FSM flag longliners. The Japanese pole and line fishery is also covered but on a limited basis due to the rapid reduction of this fleet during the past few years and the relative "clean" nature of the fishery (i.e., very little bycatch and discards).

Given the current worldwide concerns on the effect that uncontrolled bycatch and discards may be having on the various fisheries, observer programs have become vital tools in the effort to accurately quantify these and other concerns. New bycatch and discard forms have been instituted in the MMA FOP with additional training given to the observers on the identification of the various species involved (see Appendix A). As a result, the reporting of this information has increased significantly over the previous years. More accurate information on turtle captures is one example of the increased importance given to the collection of this data by the MMA observers (54% of the observer reported turtle captures in the longline fleet, 1980-93, have come after mid 1992).

MMA OBSERVER TURTLE SAMPLING PROTOCOL

When a turtle species has been captured, the MMA observers are instructed to collect the following specifics in addition to the general catch information (date, position, time):

1. Species identification
2. Carapace length
3. Carapace width
4. Gear specifications (depth of set, bait used)
5. Condition of Animal (injuries, hooks in mouth, diseases)
6. Fate (released alive, discarded dead)
7. Photograph and label with vessel-catch information

All of the MMA observers have seen the documentary video on cases of fibropapilloma that have been affecting the green sea turtles in the Pacific and in the Atlantic Oceans and the Caribbean Sea. Our observers are on the lookout for any signs of tumors and other abnormalities. All the turtles are checked for tags.

INCIDENTAL CATCH OF TURTLES BY LONGLINE VESSELS

Table 1 lists the MMA FOP records on turtle captures by FSM-licensed foreign longline vessels. Vessel name and flag of origin have been omitted to preserve the confidentiality of the data. As previously mentioned, the early observer sampling design did not place a high priority on the quantification of bycatch and discards; however, some qualitative records on turtle captures were noted. Fortunately, all of the records on turtle catches at least had some mention as to the fate of the captured animal. With the exception of one animal (olive ridley-Record No. 12), the captured turtles were noted as being released alive. Record Nos. 1-6 are listed as unidentified turtles and cover captures made prior to 1992 before training on species identification of bycatch and discard species (including turtles) was instituted. In addition, to the training on identifying the most commonly encountered turtle species, MMA observers now carry instamatic flash cameras with them and are instructed to photograph all turtles that are captured. Record Nos. 10, 11, and 13 have photographic verifications of species identifications. Record No. 12 did not have photographic verification, and the species identification was made by the observer.

A total of 38 longline observer trips were reviewed for turtle captures out of a possible 54 completed trips (1980-93). Sixteen observer trips were not included in the analysis because of suspect data or missing data points (the majority of these rejected trips were in the early years of the MMA FOP, prior to 1992) of the more recent trips (11 trips, from mid 1992 to the present), a total of 280,110 hooks were monitored with a catch of seven turtles. The species breakdown are one hawksbill, two leatherbacks, three olive ridleys and one unidentified turtle. This gives us a rough estimate of 0.025 turtles captured for every 1,000 hooks set. In other words, every 40,000 hooks set will result in one incidental turtle bycatch.

Obviously, a data set of only 11 trips (280,110 hooks) is quite small, compared to the current longline effort in the FSM EEZ, to draw definitive conclusions that apply on a fleetwide basis. We can, however, use this estimate as a baseline indicator of the hooking rate for discussion purposes. More information will be needed to finetune this hooking rate estimate, and the MMA FOP is working toward obtaining this information on future observer longline trips.

INCIDENTAL CATCH OF TURTLES BY PURSE SEINE VESSELS

Table 2 lists the MMA FOP turtle captures by FSM-licensed foreign purse seine vessels. You will notice that only one record, out of the seven recorded turtle captures, was made during the time period 1980-92. The other six records are for the current period (1992-93) and reflect a more accurate picture of purse seine turtle bycatch given the current level of fishing effort in the region.

One of the turtles captured was a confirmed mortality (Record No. 3) and another was released injured and the observer listed the animal as "injured and discarded" (Record No. 7). The remainder of the animals were released alive and unharmed (Record No. 1 from 1980 condition status was not apparent from data set but interview with observer indicated that animal was released alive and unharmed).

FUTURE RESEARCH OBJECTIVES

The MMA FOP will begin a turtle tagging program in December 1993. We have been in contact with Ms. Adrienne Farago of SPREP and with Mr. George Balazs of NMFS, Honolulu in regard to securing the necessary equipment and expertise to implement the tagging program. Five applicators and a few hundred tags are on order from SPREP, and our tuna biologist will train the observers in the proper tagging procedures and data collection methods.

Tagging will take place on both purse seine and longline vessels. It is anticipated that the MMA FOP will place observers on 45-50 vessels during the 1994 calendar year. Posters and educational materials will be printed and passed out to the participating fleets asking for assistance in recording recaptured turtles.

The data gathered from this tagging program should provide useful insights in fundamental areas such as growth, migration, and distribution and abundance of turtles throughout the available fishing grounds. The recapture information can possibly be tied in with regional oceanographic data to provide some insight into the environmental parameters that affect the distribution of turtles throughout the region.

Our observers may also be in a position to collect data and/or samples for other research objectives formulated during this workshop. We are open to suggestions.

CONCLUSION

The data presented in this document is viewed as a starting point for what is hoped to be an ongoing effort by the MMA FOP to accurately quantify the incidental catch of turtle species by foreign fishing vessels operating in the FSM EEZ and surrounding high seas areas. Sound scientific data will be vital to any ancillary attempts to institute gear and time/area conservation measures to preserve threatened or endangered stocks of turtles.

Given the importance of turtles in traditional Micronesian cultures, the MMA is keen to work hand in hand with our government and business partners to ensure that this national treasure is preserved for the benefit of future generations of Micronesians.

The MMA is pleased to be a participant in this regional effort to plot out the necessary research goals aimed at understanding the life history and stock structure of marine turtles. We offer our services in assisting in the implementation of these research goals and our capable observer force stands ready to cooperate in this endeavour.

Table 1. Incidental Catch of Turtles by Foreign Flag Longline Vessels Carrying MMA Fisheries Observers. 1980-1993.

Record No.1	Species	Date of Capture (d/m/y)	Position of Capture	Carapace Length (cm.)	Carapace Width (cm.)	Condition	SST (°C)	Type of Bait	Depth of set (m)	No. Hooks / set	No. of sets	Total Hooks set
1	Unid. Turtle	14/05/80	03°52' N 148°56' E	not taken	not taken	Released alive	29	scad	n/a	2110	40	84,400
2	Unid. Turtle	03/01/86	not available	not taken	not taken	Released alive	29	mackerel	150	2,500	28	70,000
3	Unid. Turtle	09/02/86	03°10' N 146° 02' E	not taken	not taken	Released alive	29	scad	100	2,500	29	72,500
4	Unid. Turtle	26/02/86	09° 33' N 150° 36' E	not taken	not taken	Released alive	28	scad	100	2,500	29	72,500
5	Unid. Turtle	17/08/88	02° 45' N 150° 39' E	not taken	not taken	Released alive	29	scad	n/a	2,660	26	69,160
6	Unid. Turtle	01/05/90	05° 09' N 161° 20' E	not taken	not taken	Released alive	29	scad	n/a	2,300	25	57,500
7	Hawksbill	11/11/92	05° 48' N 136° 35' E	46.5	21.8	Released alive	28	squid	75	800	12	9,600
8	Unid. Turtle	12/03/93	06° 40' N 144° 46' E	n/a, crew cut line	n/a, crew cut line	Line cut, alive with hook in	n/a	squid	75	700	8	5,600
9	Leather-back	28/04/93	04° 16' N 147° 26' E	n/a, crew cut line	n/a, crew cut line	Line cut, alive with hook in	27	scad	75	2,400	35	84,000
10	Leather-back	13/05/93	02° 21' N 158° 27' E	120	72	Released alive, hook in mouth	28	scad	100	2,400	35	84,000
11	Olive Ridley	07/08/93	06° 17' N 159° 08' E	50	48	Released alive, crew removed hook	27	squid	75	950	7	4,550
12	Olive Ridley	17/08/93	02° 22' N 160° 27' E	68	46	Discarded dead	29	scad	150	2,470	18	44,460
13	Olive Ridley	01/10/93	09° 33' N 140° 39' E	40	36	Released alive, crew removed hook	28	squid	60	750	11	8,250

Footnote: Beginning August 1992 all observers carried cameras with them in the field. As a result, records 9, 10, 11, and 13 include photographs for verification of species identifications.

Table 2. Incidental Catch of Turtles by Foreign Flag Purse Seine Vessels Carrying MMA Fisheries Observers. 1980-1993.

Record No.1	Species	Date of Capture (d/m/y)	Position of Capture	Carapace Length (cm.)	Carapace Width (cm.)	Condition	SST (°C)	Type of Set	Tons Captured	Total Sets / trip	Total Catch / trip
1	Unid. Turtle	08/08/80	01° 50' N 141° 13' E	not taken	not taken	unknown	28	log	12 SKJ 8 YFT	24	247 SKJ 103 YFT
2	Unid. Turtle	08/03/93	01° 02' S 148° 57' E	not taken	not taken	Released alive	30	surface	32 SKJ	32	85 SKJ 168 YFT
3	Olive Ridley	04/07/93	04° 29' N 144° 16' E	41.4	41.5	Released alive	29	log	25 SKJ 11 YFT	20	170 SKJ 481 YFT
4	Hawksbill	13/07/93	05° 10' N 148° 44' E	36	29	Released alive	29	FAD	500 kg. SKJ	20	170 SKJ 481 YFT
5	Unid. Turtle	03/09/93	02° 18 N 150° 54' E	n/a, escaped during sacking	n/a, escaped during sacking	Alive, escaped	29	log	400 kg. SKJ 100 kg. YFT	18	310 SKJ 462 YFT 20 BET
6	Hawksbill	17/09/93	00° 18' N 152° 12' E	not taken	not taken	Dead, discarded	27	log	2 SKJ 3 YFT	18	310 SKJ 462 YFT 20 BET
7	Olive Ridley	25/09/93	05° 37' N 157° 31' E	35	29	Injured, shell broken by power block, discarded.	29	surface	67 YFT	27	427 SKJ 455 YFT 4 BET

Records No. 3, 4, 6 and 7 have photographs for verification of species identification.

APPENDIX A

STANDARDISED FORMS FOR MMA FISHERIES OBSERVER PROGRAM

1. LONGLINE CATCH MONITORING FORM
2. LONGLINE CATCH MONITORING CODES
3. LONG LINE SETTING AND HAULING FORM
4. SPECIES CODES
5. PURSE SEINE BYCATCH AND DISCARDS CODE

MMA OBSERVER - LONGLINE CATCH MONITORING FORM

Observer Name ____________________ **Date** __________________ **Pg.** ____ **of** ____ .

Vessel Name ______________________ **Begin Time** __________ **End Time** ___________

Time	Basket No.	Hook No.	Species Code	Cond. Code	Fate Code	Length (cm.)	Length Code	Wt. (kg.)	Wt. Code	Sex (M/F)	Comments

Species Codes

Species Code		Common name
	Tuna	
YFT		Yellowfin
BET		Bigeye
ALB		Albacore
SBT		Bluefin (Southern)
SKJ		Skipjack
KAW		Kawakawa
MAK		Unidentified mackerel
WAH		Wahoo
DOG		Dogtooth tuna
BUL		Bullet tuna
FGT		Frigate tuna
TUN		Unidentified tuna
	Billfish	
MLS		Striped Marlin
BLZ		Blue Marlin
BLM		Black Marlin
SWO		Swordfish
SAI		Sailfish
SBS		Short-billed Spearfish
MAR		Unidentified Marlin

Species Codes (continued)

Species Code		Common Name
	Sharks and Rays	
MAK		Mako sharks
CRS		Crocodile Shark
OWT		Oceanic White-tip
THR		Thresher sharks
WTR		White-tip reef shark
BTR		Black-tip reef shark
GRS		Grey Reef shark
BSH		Blue Shark
STS		Silver-tip shark
HAM		Hammerhead shark
TIG		Tiger shark
SHK		Unidentified sharks
RAY		Pelagic Sting-ray (other rays)

	Others	
BRM		Breams
FLY		Flying Fishes
LAT		Lancetfishes
OFH		Oilfish
SUN		Sunfishes
MAH		Mahi Mahi
OPH		Opah
BAR		Barracudas
DEF		Dealfish
LEP		Snake mackerel
ESC		Escolar
FSH		Unidentified Fish
MAM		Marine Mammal
TUR		Marine Turtle

Species Condition Codes

Code	Description
A	Alive
D	Dead
U	Condition Unknown

Species Processing Codes

Code	Description
GG	Gilled and gutted (retained for sale)
CW	Whole or gilled/gutted for crew consumption
FI	Filletted for crew consumption
T	Trunk only retained
F	Fins removed and trunk discarded
FT	Fins removed and trunk retained
DG	Discarded - Gear damage
DS	Discarded - Shark damage
DW	Discarded - Whale damage
DU	Discarded - Undesirable species
DF	Discarded - No space in freezer
DL	Discarded - Difficult to land
DR	Discarded - rejected (struck off before landing)
DT	Discarded - too small
DQ	Discarded - poor quality

Length Measurement Codes

Code	Description
TL	Total length - tip of snout to end of tail
FL	Upper jaw to caudal fork (Fork Length)
EO	Posterior Eye orbital to caudal fork
PF	Anterior base of pectoral to caudal fork
LF	Lower jaw to caudal fork

Weight Measurement Codes

Code	Description
WW	Whole weight
GW	Gilled and Gutted
FW	Filletted
TW	Trunk Weight
CW	Captains Estimate
OW	Observers Estimate

MMA LONGLINE OBSERVER MANUAL - Setting and Hauling Form

Observer Name: ______________________________
Vessel : ______________________________
Date : ______________________________

Start set position : Time :
1st change direction : Time :
2nd change direction : Time :
3rd change direction : Time :
End set position : Time :

Setting pattern : Vessel speed of setting :

Number of hooks/basket : Length of branchline :
Number of baskets : Length of floatline :
Total number of hooks : Line setting speed :
Estimated depth (range) :
Distance between branchlines :

Bait used (1) : Weight : Bait sequence in basket :
(2) : Weight :
(3) : Weight :
(4) : Weight :
Reasons for bait selection :

Wind direction : - strength :
Current direction : - strength :
Air temperature : Water temperature : Cloud cover :

Start haul position : Date : Time :
1st change direction : Time :
2nd change direction : Time :
3rd change direction : Time :
End haul position : Time :

Wind direction : - strength :
Current direction : - strength :
Air temperature : Water temperature : Cloud cover :

Any other details of particular fishing strategy, problem(s) with gear, etc. during this set/haul.

SPECIES CODES

I. Scombrids (Tuna Family)

Code Category	*Common name*
YFT	Yellowfin
BET	Bigeye
ALB	Albacore
SBT	Bluefin (Southern)
SKJ	Skipjack
KAW	Kawakawa
MAK	Unidentified mackerel
WAH	Wahoo
BUL	Bullet tuna
FGT	Frigate tuna
TUN	Unidentified tuna

II. Billfish

MLS	Striped Marlin
BLZ	Blue Marlin
BLM	Black Marlin
SWO	Swordfish
SAI	Sailfish
SBS	Short-billed Spearfish
MAR	Unidentified Marlin

III. Sharks and Rays

SLK	Silky shark
MAK	Mako sharks
OWT	Oceanic White-tip shark
THR	Thresher sharks
BSH	Blue shark
HAM	Hammerhead shark
TIG	Tiger shark
SHK	Unidentified sharks
RAY	Pelagic Sting-ray (other rays)

SPECIES CODES

IV. Fishes

Code Category	*Common name*
TRF	Oceanic Triggerfish
RBR	Rainbow Runner
RUD	Rudder Fish
SCD	Mackerel Scad
REM	Remora Fishes
SUN	Sunfishes
MAH	Mahi Mahi (Dolphinfish)
OPH	Opah
BAR	Barracudas
FSH	Unidentified Bony Fishes

V. Marine Turtles & Mammals

HAW	Hawksbill
GRN	Green
LTB	Leatherback
OLR	Olive Ridley
LOG	Loggerhead
TUR	Unidentified Turtle
DOL	Dolphin/Porpoise
WHL	Whale
MAM	Unidentified Marine Mammal

VI. Species Condition codes

Code	*Description*
A	Alive
D	Dead
U	Condition Unknown

MMA Observer - Purse Seine Bycatch and Discards Form

Name ______________ Vessel ________________ Flag/Gear ________

Date ______________ Position __________N/S__________E/W

Set Type ____________ Time of Set __________ hrs.

Tuna Catch (m/t):

YFT __________ SKJ ___________ BET ___________

Tuna Discards:

Species Code	Amount (m/t or kgs)	Size Range (kgs.)	Discard Code	Comments

Bycatch Discards:

Species Code	Amount (kgs. or pcs)	Size Range (kgs.)	Discard (Y/N)	Discard Code	Comments

Footnote: Note down in the Comments section the condition (alive, dead, unknown) for billfish, turtles, marine mammals, and whale sharks. Include information on any injuries to the species in question.

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HOOK AND LINE BYCATCH OF KEMP'S RIDLEY SEA TURTLES (*LEPIDOCHELYS KEMPII*) ALONG THE TEXAS COAST, 1980-1992

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Kemp's ridley sea turtles (*Lepidochelys kempii*) have been reported as bycatch in a variety of commercial and recreational marine fisheries (Manzella et al., 1988; Fontaine et al., 1989; Magnuson et al., 1990; Caillouet et al., 1991; Cannon et al., in press). This overview of Kemp's ridleys caught, snagged or entangled by hook and line along the Texas coast during 1980-92 was excerpted from Cannon et al. (in press).

Data were obtained from files archived by the Sea Turtle Stranding and Salvage Network (STSSN) headquartered at the National Marine Fisheries Service (NMFS), Southeast Fisheries Science Center, Miami Laboratory, Miami, Florida, and the NMFS Galveston Laboratory. All observations of wild and head started Kemp's ridleys reported alive or dead were included. The original reports were provided by STSSN participants, various agencies and the general public, and in some cases were supplemented by x-rays and necropsies.

Reports were grouped into two coastal zones, the Upper Texas Coast (UTC) and the rest of the Texas coast, separated at latitude 29°20'N by Bolivar Roads ship channel between Bolivar and Galveston Island, Texas. The UTC extends northward from the channel to Sabine Pass, Texas and the rest of the coast extends southward from the channel to the Texas-Mexico border. Out of 118 hook-and-line-associated Kemp's ridley sea turtle reports along the Texas coast, most were reported from the UTC.

Curved carapace length (CCL, cm) was the length most often reported. When only straight carapace length (SCL, cm) was reported, SCL was multiplied by 1.06 to convert it to CCL (Manzella and Williams, 1992). Only one report for a Kemp's ridley smaller than 20.1 cm CCL was associated with hook and line. The rest of the reports were grouped into four CCL class intervals: 20.1-30.0, 30.1-40.0, 40.1-50.0 and ≥ 50.1 cm. The size class most often associated with hook and line was 30.1-40.0 cm.

Most turtles reported as hook and line encounters were also reported as unharmed and released alive after removal of the hook by the fisherman. Eleven were held for veterinary care instead of being released. One of the 11 was a revealing case. It was a wild Kemp's ridley with a hook in the left side of its mouth. X-ray detected two more hooks in its esophagus. The turtle was anesthetized, the three hooks were surgically removed by a qualified veterinarian, and the turtle was released after 51 days of post-surgery rehabilitation. Six of the hook and line encounters were from turtles found stranded dead, but the hooks were not discovered until carcasses were necropsied.

The year 1992 contained an unusually high incidence of Kemp's ridley hook and line encounters on the UTC. There were higher proportions of hook and line encounters reported for head-started Kemp's ridleys than for wild ones. All head-started ridleys reported in association with hook and line had been in the wild for at least 1 year, a period considered more than adequate for their adaptation to the wild. Eckert et al. (1992) suggested that head-started Kemp's ridleys, which bear foreflipper tags, are more likely to be reported than nontagged wild ridleys. Cannon et al. (in press) agreed, adding that the larger number of reported hook and line encounters by head-started Kemp's ridleys did not indicate they were more vulnerable than wild ridleys to capture on hook and line.

In her study of feeding ecology of Kemp's ridleys on the Texas coast, Shaver (1991) suggested that the fish found in the digestive tracts of turtles 20-60 cm CCL originated as shrimp trawl bycatch. She believed the fish were probably dead when ingested. The preferred baits used by recreational surf fishermen on the UTC are cut mullet (*Mugil* spp.) and shrimp (*Penaeus* spp.). Mullet and shrimp are naturally abundant species on the Texas coast. Such species used as bait may be particularly attractive to juvenile Kemp's ridleys, thus increasing vulnerability to capture on hook and line.

No concomitant studies were conducted to determine cause(s) of the apparent increase in number of Kemp's ridleys encounters with hook and line on the UTC in 1992. However, Cannon et al. (in press) speculated that adverse environmental conditions (low salinities) in 1992 forced ridley prey species from coastal bays into the surf zone, thus attracting the ridleys to areas where they were vulnerable to hook and line capture. They also speculated that use of turtle excluder devices (TEDs) by commercial shrimpers may have increased survival and therefore numbers of juvenile Kemp's ridleys on the UTC. It has been known for years that the UTC is an area of abundance of Kemp's ridleys, so the high incidence of hook and line encounters in this zone may simply reflect Kemp's ridley availability.

Results of the study by Cannon et al. (in press) suggest that Kemp's ridley hook and line encounters are underreported in the existing data base. It is obvious that external examinations alone are inadequate. Internal examination of Kemp's ridley carcasses (necropsy) and live turtles (esophageal examination and gastrointestinal x-ray) will be required to evaluate incidence of hook and line encounters. Kemp's ridleys released by fishermen after capture by hook and line may suffer ill effects of hooks lodged in the mouth, esophagus or stomach. Surgical removal of deeply embedded hooks by qualified veterinarians may be necessary to assure survival of hooked turtles. In this regard, Moon and Stabenau (unpublished data) suggested that inhalant anesthetics may be superior to injectable anesthetics during sea turtle surgery, since they reduce post-surgery recovery from anesthesia. Finally, an improved resuscitation technique (Stabenau and Heming, 1993) is available for turtles submerged on hook and line for nonlethal periods of time.

CITATIONS

Caillouet, C. W., Jr., M. J. Duronslet, A. M. Landry, Jr., D. B. Revera, D. J. Shaver, K. M. Stanley, R. W. Heinly, and E. K. Stabenau.
1991. Sea turtle strandings and shrimp fishing effort in the northwestern Gulf of Mexico, 1986-89. Fish. Bull., U.S. 89:712-718.

Cannon, A. C., C. T. Fontaine, T. D. Williams, D. B. Revera, and C. W. Caillouet, Jr.
In press. Incidental catch of Kemp's ridley sea turtles (*Lepidochelys kempi*), by hook and line, along the Texas coast, 1980-1992. *In*: Proceedings of the Thirteenth Annual Workshop on Sea Turtle Biology and Conservation, Jekyll Island, GA, February 1993.

Fontaine, C. T., S. A. Manzella, T. D. Williams, R. M. Harris, and W. J. Browning.
1989. Distribution, growth and survival of head started, tagged and released Kemp's ridley sea turtles (*Lepidochelys kempi*) from year-classes 1978-1983, p. 124-144. *In*: Caillouet, C. W., Jr. and A. M. Landry, Jr. (Editors), Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, Texas A&M University, Sea Grant College Program, TAMU-SG-89-105, VI plus 260 p.

Eckert, S. A., D. Crouse, L. B. Crowder, M. Maceina, and A. Shah.
1992. Review of the Kemp's ridley turtle headstart experiment, 22-23 September 1992, Galveston, Texas. Report to the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami Florida, 9 p.

Magnuson, J. J., K. A. Bjorndal, W. D. DuPaul, G. L. Graham, D. W. Owens, C. H. Peterson, P. C. H. Pritchard, J. I. Richardson, G. E. Saul, and C. W. West.
1990. Decline of the sea turtles: causes and prevention. National Research Council, National Academy of Sciences Press, Washington, D.C., 190 p.

Manzella, S. A., C. W. Caillouet, Jr., and C. T. Fontaine.
1988. Kemp's ridley, *Lepidochelys kempi*, sea turtle head start tag recoveries: distribution, habitat, and method of recovery. Mar. Fish. Rev. 50(3):24-32.

Manzella, S. A., and J. A. Williams.
1992. The distribution of Kemp's ridley sea turtles (*Lepidochelys kempi*) along the Texas coast: an atlas. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-110, 52 p.

Shaver, D.
1991. Feeding ecology of wild and head-started Kemp's ridley sea turtles in South Texas waters. J. Herpetol. 25(3):327-334.

Stabenau, E. K., and T. A. Heming.
1993. Resuscitation of sea turtles. Mar. Turt. Newsl. No. 62, pp. 3-5.

LONGLINE FISHERY INTERACTIONS WITH SEA TURTLES IN AUSTRALIA: A BRIEF OVERVIEW

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INTRODUCTION

The interactions between sea turtles and fishing are determined by the distribution and biology of the turtles in the context of the distribution, gear, and operational practices of the fishing industry.

DISTRIBUTION AND BIOLOGY OF SEA TURTLES

There is a great deal of information available concerning the distribution and biology of marine turtles (see review by Eckert 1993); however, the long-term survival of marine turtles remains in doubt. Worldwide, marine turtles migrate between foraging areas and nesting sites (Limpus, et al., 1992); some migrations are long and others are not. In the South Pacific region, some turtles that nest in the Great Barrier Reef (GBR) province come from foraging areas located in neighboring countries (including the Trobriand Islands, the Solomon Islands, Vanuatu, New Caledonia and Fiji to the East and southern Papua New Guinea, Irian Jaya, and Indonesia to the West) (Limpus, et al., 1992). Some of the nesting turtles return to foraging areas in the GBR while others move to distant areas in Australian territory (e.g., Arnhem Land, 2600+ km) (Limpus, et al., 1992). Other data indicate that some turtles forage in the GBR and migrate to nest at sites outside Australian territory (Limpus, unpubl. data; Miller, unpubl. data). During these migrations, in their foraging areas and in internesting habitat, marine turtles are subject to several types of interaction with fishing operations including being hooked, becoming entangled in lines, colliding with gear, and being trawled.

In Australia, the loggerhead turtle is classified as endangered; the other species are classified as threatened except the flatback which is listed as vulnerable. Limpus and Reimer (1994) summarized the ecology and biology of loggerhead turtles in the southern Pacific and made the following points (among others). (1) Breeding by loggerhead turtles in the southern Pacific Ocean region is almost entirely restricted to the southern GBR and adjacent coastal areas of Queensland. (2) The nesting populations of loggerhead turtles in the northern and southern Pacific Oceans have little or no genetic interchange as determined by mtDNA analysis (B. Bowen pers. comm. to C.J. Limpus). (3) After leaving the nesting beach little loggerheads disappear from Australian continental shelf waters and may require 2 decades before they reappear in the foraging areas at approximately 70-80 cm in carapace length (Limpus & Reimer 1994). (4) In a declining population, adult and large immature turtles make the greatest contribution to the survival of the population.

TYPES AND DISTRIBUTION OF FISHING

A wide variety of commercial fishing methods are used in Australia, including entanglement nets (e.g., gill nets), surrounding and seine nets, trawling, hook-and-line, and longline. Each type is used to target a particular species (or group of species) of fish or prawn in a particular habitat. For example, longline fishing zones have been defined around the entire country (Cropp, 1993; ABARE, 1991), but bilateral agreement on the areas to be fished, seasonal closures of some areas as well as limits on the number of boats and the tonnage of southern bluefin tuna to be caught help to control the fishery (ABARE, 1991).

The Japanese tuna longline industry has negotiated access agreements to fish within the exclusive economic zones surrounding many of the nations in the South Pacific region, including the Federated States of Micronesia, Kiribati, the Marshall Islands, the Solomon Islands and Australia (ABARE, 1991). These agreements typically require reporting of information such as number of hooks set and details of the catch; however, details of the bycatch may or may not be reported. The Japanese tuna longline industry also fishes in the high seas outside the controlled areas (ABARE, 1991).

LONGLINE EFFORT

The number of hooks set in 1989 in the Australian Fishing Zone (AFZ) was reported to be 4,749,000, and in selected South Pacific Commission (SPC) areas the number of hooks was reported to be 8,992,000 (ABARE, 1991). In 1990 the number of hooks set had increased to 5,521,000 in the AFZ and decreased to 8,790,000 in the SPC areas. The total number of hooks used in both areas had increased by 570,000. Between November 1, 1992 and July 31, 1993 in the longline areas around Australia (AFZ), the total number of hooks set was 13,297,353 which is more than twice the number set in the AFZ in 1990 and close to the total number of hooks set in the combined areas in 1989. The majority of the fishing effort (51%) was concentrated in the Tasmanian Winter Season (6,784,362 hooks); a further 29.7% of the effort (3,955,884 hooks) occurred in the Tasmanian Summer Season. The West Coast and Great Australian Bight area had 9.3% of the effort (1,235,930 hooks); 9.9% of the effort occurred in the East Coast area (1,321,176 hooks) (Cropp, 1993). Hooks were set between 21 and 230m; in the East Coast hook depth was 50-182m. Each set averaged 2,867 hooks (Cropp, 1993).

BYCATCH

Although detailed statistics are maintained concerning the catch in most Australian fisheries (including longline (e.g., Cropp 1993) and prawn fisheries), there is a paucity of information on the composition and quantity of the bycatch (Harris and Poiner, 1990).

Based on the 1993 data from 57 observer cruises of the Japanese longline fleet working in the Australian Fishing Zone, only one turtle was caught in the east coast area (3 cruises, 47,432 hooks); no turtles were caught in the other areas (Cropp, 1993). The turtle was hooked "under the shell but cut free before landing and was observed swimming strongly away from the vessel" (Cropp, 1993). Given that the majority of the observer reports on longline fishing effort came from vessels working in the southern latitudes, the interaction between the fishery and marine turtles remains undefined.

The current agreement between Australia and the Tuna Longline Development Corporation contains five conservation measures which direct the company to comply with "all fishing or other measures specified and required by the Commonwealth of Australia" to protect whales and "to protect and conserve protected or endangered species of marine life and sea birds" (CoA 1993, p 14, Article 25, Items 1-5). Article 25 also requires cooperation in "testing and developing and applying methods and devices intended to protect" nontarget marine life including marlin and sharks; sea turtles are not mentioned directly but are obviously contained in the wording of items 2 & 3. The impetus for closer monitoring of the situation lies with the Commonwealth of Australia.

COMMENTS

Available data from the longline fishery operating in the southwestern Pacific region indicate that some turtles are captured but given the paucity of capture data, the situation must be monitored closely to avoid damage to the populations of sea turtles in the region.

A similar situation existed in the prawn fishery several years ago. Today, following detailed studies to assess the impact of trawling on marine turtles, data from the prawn fishery indicate that several thousand marine turtles are captured each year in eastern and northern Australia (actual catch depends on location, fishing effort, depth and season); species-specific mortality occurs among those captured (e.g., 19.2% of 844 loggerhead turtles drown but only 7.7% of 2,964 flatback turtles drown; these figures do not account for post release mortality) (Poiner et al., 1990; Poiner and Harris, 1994).

Other nearshore fisheries also catch turtles; Limpus (pers. comm.) examined data from sharkline fishing and interviewed many of the contractors; he concluded that it was common for marine turtles to be hooked on sharklines. One such turtle was hooked through the mouth and out the orbit; the turtle was treated and eventually released. Antidotal reports by recreational fishermen usually describe the turtle actually taking the bait or being hooked on a flipper (or infrequently on the neck) as the bait was retrieved. Reports such as these document the occurrence of interactions between marine turtles and fishing operations but provide little information on subsequent survival and cannot be placed into the context of a population because of the lack of a designed sampling protocol.

The recent comment by Brian Bowen (pers. comm. to C. J. Limpus) that there is a distinct possibility that the Queensland loggerheads are involved in the North Pacific drift net fishery is particularly disturbing. He stated that 5 of 20+ specimens examined appear to exhibit the Qld. *Caretta* genetic sequence. Given the paucity of data on the distribution of little loggerhead turtles in the Pacific, it is possible that loggerheads from the southern Pacific are at risk in fishery operation outside the region.

Although the impact of longline fishing operations in the southwestern Pacific region on marine turtles cannot be assessed in detail on the available data, it is clear that turtles are hooked, and it is essential that appropriate data be gathered to evaluate the situation. Given that (1) longline fishing occurs throughout the South Pacific Commission area and in specific areas around Australia, (2) the bycatch of marine turtles in the longline fishery is largely unquantified, and (3) bilateral and multilateral agreements require record keeping, it appears that the assessment of the impact of longline fishing on marine turtles can be accomplished, if governmental agencies are presented with a workable scheme that augments data being collected in the existing observer programs.

CITATIONS

ABARE (Australian Bureau of Agriculture and Resource Economics). 1991. Japanese access to the Australian fishing zone. A report to the Australian Fisheries Service. Australian Bureau of Agriculture and Resource Economics Project 9357.102, p 23.

CoA (Commonwealth of Australia). 1993. Agreement between the Commonwealth of Australia and Tuna Longline Development Cooperation PTY LTD November 1993 (reprinted November 1993--including amendments). Commonwealth Government Printing Office, Canberra.

Cropp, D.
1993. Summary of AFZ observer program cruise reports: Japanese style longline tuna fishing in the Australian Fishing Zone. 1 November 1992-31 July 1993. Prepared for the Australian Fisheries Management Authority (AFMA) Report: AA93(1) 45 p.

Eckert, K.
1993. The biology and population status of marine turtles in the North Pacific Ocean. Final Report to NOAA/NMFS 123 p.

Harris, A., and I. Poiner.
1990. Bycatch of the prawn fishery of Torres Strait: composition and partitioning of the discards in to components that float or sink. pp 37-52. IN The Effects of Fishing (W. Craik, J. Glaister & I Poiner, eds.). CSIRO Australia. (Reprinted from the Australian Journal of Marine and Freshwater Research 41(1), 1990).

Limpus, C. J., J. D. Miller, C. J. Parmenter, D. Reimer, N. McLachlan, and R. Webb.
1992. Migration of green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles to and from eastern Australian rookeries. Wildl. Res. 19:347-358.

Limpus, C. J., and D. Reimer.
1994. The loggerhead turtle *Caretta caretta*, in Queensland: a population in decline. pp 34-54. IN Proceedings of the Australian Marine Turtle Conservation Workshop 14-17 November 1990. Queensland Department of Environment & Heritage & Australian National Parks & Wildlife Service (now Australian Nature Conservation Agency).

Poiner, I., and A. Harris.
1994. The incidental capture and mortality of sea turtles in Australia's northern prawn fishery. pp 115-123. IN Proceedings of the Australian Marine Turtle Conservation Workshop 14-17 November 1990. Queensland Department of Environment & Heritage & Australian National Parks & Wildlife Service (now Australian Nature Conservation Agency).

Poiner, I., R. Buckworth, and A. Harris.
1990. Incidental capture and mortality of sea turtles in Australia's northern prawn fishery, pp 97-110. IN The Effects of Fishing (W. Craik, J. Glaister & I Poiner, eds.). CSIRO Australia. (Reprinted from the Australian Journal of Marine and Freshwater Research 41(1), 1990).

SOME ASPECTS OF SEA TURTLES IN JAPAN

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There are five species of marine turtles found in the Japanese Archipelago. These are loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretomochelys imbricata*), pacific ridley turtle (*Lepidochelys olivacea*), and the leatherback turtle (*Dermochelys coriacea*).

Three species of sea turtles, loggerhead, green, and hawksbill, nest along the coast of Japan. The pacific ridley and the leatherback turtle have been recorded, but only as rear visitors. Nesting by these two species is never found on the coast of Japan.

The loggerhead turtle, the most common and important sea turtle occurring in this area, breeds along the coast south of the Fukushima Prefecture, lat. 37°N, at the site of the Pacific Ocean. While on the coast of the Sea of Japan, the loggerhead occasionally nests as far south as the Ishikawa Prefecture, also at lat. 37°N. The peak of the loggerhead nesting season is in the summer. These nesting sites can be considered one of the largest in the northwestern Pacific Ocean. There is no intensive field research of loggerhead nesting around the eastern coast of China, including North and South Korea and Formosa (Taiwan).

The green turtle migrates to the southern coast of Japan, but its nesting areas are restricted in the Islands of Nansei Shoto at about lat. 30.5°N. Yakushima Prefecture is the northern tip of the nesting site recorded in Japan.

The Bonin Islands are situated at about lat. 27.44° to 20.25°N, and long. 153.58° to 136.05°E., famous as a site of green turtle reproduction and distribution. According to the records of tagging release, green turtle migrate in the Bonin Islands along the coast of the Izu Islands, the mainland of Japan, and the Nansei Shoto. Their migration behavior is similar to that of the green turtles in the Hawaiian Archipelago.

There are no surveys of the green turtle population in Japan. This population is estimated to be small because the Japanese Islands are the northern nesting site of green turtles in the Pacific Ocean.

The small hawksbill turtle (30-40 cm carapace length) is the most common sea turtle in the southern islands of Japan, especially at Nansei Shoto. Hawksbill nests are located in the south from the Tokara group of islands at about lat. 30°N. The

Japanese Islands only provide minor nesting sites for hawksbills in the northwestern Pacific Ocean.

In our tagging release experiment of loggerhead turtles, the migration behavior of hatchlings and adult females in the waters adjacent to Japan were studied (Table 1). The general tendency of loggerhead hatchlings is to swim first to the north. Usually they remain there until autumn, after which they move south. The most southern record of recaptured tagged females was at the southern part of the East China Sea. The southern portion of the South China Sea is one of the most successful foraging and reproductive areas for loggerheads in Japan.

Little is known about the migration of loggerhead hatchlings in Japan, mainly because of the absence of suitable tags for this size category.

Studies are conducted with natural hatchlings released into the wild or with turtles which have been reared in captivity for a period of from 1 to 4 years. All released loggerhead turtles have been recaptured north of their release point. The most northern recapture record is the southern part of the Kurill Islands. It is possible to estimate that the loggerhead hatchlings which originated on the coast of Japan are driven northward by the Kuroshio Current.

Table 1.--Record of tagged adult loggerhead turtles in Japan.

Tag No.	Date of release	Release location	Sex	Date of recapture	Recapture location	Release/recapture No. days
V48	7/15/71	Gamouda	F	4/25/72	Nagasaki	285
B13	7/18/72	Gamouda	F	4/3/75	East China Sea	989
D100	7/26/72	Gamouda	F	12/5/92	Wakayama	102
D29	11/18/72	Oshima, Izu	?	12/30/72	Okitsu, Kouchi	42
				1/3/72	Tosashimizu	4
D108	7/25/73	Gamouda	F	9/4/75	Odawara	771
D70	10/16/73	Hyogo	M	10/25/73	Kouchi	8
DO	8/12/72	Muroto	?	4/16/82	Izuhara, Tsushima	247

STATEMENT BY MR. KIYOSHI KATSUYAMA

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The Japan Fishery Agency requests research budget to the Ministry of Finance for purposes of conserving wildlife dependent on the sea, including sea turtles, and we conduct research activities in this field.

With respect to loggerhead sea turtles in particular, since their spawning grounds are distributing in the Japanese coast, we have been promoting seashore preservation and conservation of spawning sea turtles, and in appropriate cases, artificial hatching and release.

In addition, we are now examining an effective tagging program to solve the behavior and ecology of sea turtles (for example, such as the introduction of the archival tag).

In the seas around Japan, there have been several reports on accidental damage of wildlife involving sea turtles. For example, while swimming, their carapaces have been broken by boat screws, while plastic materials flowing into the sea from land base have caused death by occlusion by clogging their digestive organs. In addition, turtles are sometimes seen straying into set nets.

With the cooperation of fishermen and volunteer groups, we are striving to collect as much information as possible on cases involving turtle casualties, but it is exceedingly difficult to develop an accurate picture of the true situation, since, for example, spawning areas also extend to uninhabited islands. These same circumstances stand in the way of gaining accurate knowledge of sea turtle populations as well. Accordingly, at the present time, as one approach to monitoring changes in the stock level, countings are being made on the number of sea turtles coming ashore to spawn. However, a key premise of this method is continuous preservation of the spawning beaches. Thus, we are making a particular effort in our public relations activities to gain the understanding and cooperation of the citizens in this respect.

Turning next to incidental takes of sea turtles by fisheries, some reports occurred in the coastal zone not caused by longline but caused by set net fishery. Also, with regard to the distant longline tuna fishery operating mainly in high-seas waters at the present time, we are still in the process of collecting and analyzing information from a variety of vantage points, including the existence of significant incidental takes or not by these vessels. And so, regretfully, I cannot provide this meeting with any scientific data in this area.

With the exception of particular or peculiar water areas, our general feeling is that estimating on the basis of the high densities in and around islands and shoals, the likelihood of incidental takes in a high-seas area is quite small.

In any event, in order to promote scientific research and the conservation of sea turtles, it is essential to set clear objectives and determine the various measures that would be realistic and reasonable.

I am, therefore, confident that the research reports presented at this meeting by my fellow scientists will provide us with valuable clues as to the direction of future investigations in this field. Thank you very much for your kind attention.

HEALTH ASSESSMENT OF SEA TURTLES

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Health assessment has become an important issue in the conservation biology of a wide variety of vertebrates. While populations can be assessed by changes in density, reproductive rates, and recruitment and replacement, understanding the dynamics of a population is ultimately dependent upon understanding the biology and condition of individuals within a population. Evaluating individuals in free-ranging populations is no easy matter, with the methods utilized varying with the species being studied.

As a group, chelonians are difficult animals to medically evaluate. The shell imposes certain limitations on the ability of the examiner to do a thorough assessment. For some chelonians such as tortoises, once pulled within the margins of the shell, the animal becomes a virtual black box. While sea turtles are limited in their ability to withdraw into their shell, the shell still limits the ease at which the internal relief can be assessed. Examining the oral cavity of large sea turtles, without inflicting injury to the turtle and examiner, is a challenge. In performing a complete medical examination of a large sea turtle, chemical restraint or anesthesia is a prerequisite.

In health-assessing sea turtles at sea, field sheets are essentially the animal's medical record. These sheets need to be formatted so that all relevant information can be collected in a systematic and organized fashion. Clinically relevant information should be incorporated into the sheet. The exact origin of the turtle, water conditions, and air conditions should be recorded. Any human activity in the vicinity of the origin of the turtle needs to be noted. Photographs of the turtle, including both plastron and carapace, should be taken and eventually attached to the field sheet.

At some point in the health assessment process, the animal's behavior needs to be noted. This includes alertness and ability to swim and dive. A thorough physical examination begins with collecting weight and dimensional data. Weight vs. carapace length in the midline (MCL) relationships may provide some information on the condition or health status of the turtle. Next, the exterior of the turtle should be examined in detail. The quality of the shell and skin including rough estimates of the symbiont-ectoparasite burdens should be noted. The limbs should be palpated for any obvious fractures. Any external lesions or evidence of old injuries should be recorded. An eye examination should be performed using an ophthalmoscope. If it can be opened without use of chemical restraint agents, the oral cavity should be inspected. Finally, the vent should be examined; in large turtles, a cloacal palpation can be performed. A fecal specimen should be collected for parasite ova determinations.

Any significant lesions should be biopsied for histopathology and microbial isolation attempts. Blood samples should be collected, placed in lithium-heparin microtainer tubes and properly handled for complete blood counts and plasma biochemical profiles. Blood films should be immediately prepared and fixed in alcohol for determining the white blood cell differential count. For plasma biochemical determinations, the plasma should be separated from the blood cells as soon after collection as possible, removed, transferred to cryotubes, and stored either in liquid nitrogen or on dry ice until the tests are performed. In order to properly assess the blood profiles of the turtle being evaluated, a normative blood data base needs to be established.

The assessment of the internal condition of the sea turtle will be dependent on the availability of specialized equipment. Portable x ray machines are available for radiographic evaluation of sea turtles in the field. While the quality of radiographs produced from portable machines are generally not as good as fixed machines, still some good information can be obtained. Foreign bodies such as fish hooks will be easy to identify using conventional techniques. For determining patency of the gastrointestinal tract, contrast studies can be performed.

Endoscopy utilizing flexible endoscopes is the preferred technique for directly visualizing the upper and lower gastrointestinal tracts and the pulmonary system. Endoscoping these systems will require general anesthesia. For evaluating visceral structures, rigid endoscopes can be used. The preferred cannulation site is the soft tissue adjacent to the hindlimbs. Most endoscopes can be fitted with cameras, allowing a permanent recording of the viewed area. Using biopsy devices, lesions can be sampled for histopathology and microbial isolation attempts.

Ultrasonography is a noninvasive technique which can be used for evaluating certain coelomic structures. Turtles can be manually restrained and the ultrasound machine's probe applied to the soft tissue area adjacent to the hindlimbs. Appreciating findings will be dependent upon a thorough understanding of the ultrasonographic anatomy of the sea turtle. Ultrasound-guided biopsy of visceral organs/masses can be taken through cutaneous incisions.

SWALLOWING DYNAMICS OF SEA TURTLES

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While hand feeding squid to captive sea turtles it can be observed that food is sucked into the mouth after the fashion of fresh water snapping turtles, *Chelydra serpentina* (Lauder, 1985). Following the entrance of a food bolus into the mouth, turtles feeding at the water surface may eject a series of dual streams of water via the nostrils for up to a meter through the air (Fig. 1). This periodic ejection of water accompanies the swallowing process. When removed from the water a green turtle, *Chelonia mydas,* made attempts to eat squid pieces but was unable to take food into the mouth. It appears that submergence in water is a necessary precondition to ingestion of food. These observations suggest that deglutition involves a hydraulic process for acquisition of food which is suspended in water and for the propulsion of the food bolus from mouth to stomach.

The esophagus of sea turtles is remarkable among vertebrates in that the lumen is densely lined with strong conical papillae, the apexes of which are directed toward the stomach (Fig. 2). These structures were described for *Chelonia sp.* in the last century (Bronn, 1890). In a 15.4 cm *Dermochelys* the papillae were up to 15.4 cm in length and with a surface layer of heavily keratinized squamous epithelium covering a rather insubstantial core of loose myxomatous tissue (Dunlap, 1955). *Chelonia mydas* and *Lepidochelys kempi* have strongly developed esophageal papillae (personal observations) while John Steinbeck (1941) described the papillae in *Eretmochelys imbricata* where they were conjectured to affect the maceration of small ingested crustaceans. Much smaller papillae, similar in structure and appearance to those in the esophagus, may be observed along the margins of the internal choanae in *Chelonia mydas,* a location and arrangement which led Parsons (1958) to suggest the possibility that their function is to prevent pieces of food from entering the nasal cavities of this species.

In order to gain knowledge of the pressure magnitudes, transitions, and distributions between the oropharynx and the esophagus during deglutition of squid, turtles (*Lepidochelys kempi* and *Chelonia mydas)* were intubated via a single nostril with either a sea water filled catheter of polyethylene (PE-90) or, a double lumen modified 7 French Swan-Gans catheter which had been shortened so that the end pressure point was 15 cm distal to the side pressure point. The turtles ate voraciously and appeared oblivious of their nasal catheters.

Pressure traces in the pharynx alone, or, taken simultaneously in the pharynx and deep in the esophagus are exhibited in Figure 3. Intake of food into the mouth and pharynx is associated with several sub-ambient pressure pulses followed by primarily super-ambient pressure pulses which decay into the slightly sub-ambient range (Fig. 3a). In Figure 3b it can be seen that deep esophageal pressure is maintained at near ambient levels until, in this case, the occurrence of the 4th major super-ambient pharyngeal pulse. At this point the ensuing esophageal pressure pulses are synchronized with those of the pharynx. These events indicate a temporal progression of pressure penetrance to deeper levels of the esophagus as the food bolus moves toward the stomach (see also Fig. 4). It is not clear whether or not the transition of pressure levels between the early food intake period of ingestion to the largely super-ambient pressures of food passage through the esophagus is associated with differences in the distribution of water flow between mouth and nostrils. It seems likely that the transition to super-ambient pressure pulses is associated with a higher resistance to the exiting water flow, perhaps due to a more tightly closed mouth during the compressive phase of the pressure cycle (see Fig. 4).

The above mode of acquiring food may be viewed as an analogue to that in baleen whales in the limited sense that it involves a device (esophageal papillae; the baleen) which retains food extracted from an aqueous environment while at the same time minimizing the coincident ingestion of excessive amounts of sea water. In both cases, a major biological consequence of these modes of feeding is the avoidance of heavy electrolyte loads in vertebrates of fresh water ancestry and limited urinary concentrating capacity. While sea turtles utilize lachrymal salt secreting glands which produce a solution of electrolytes which is hyper osmotic to plasma (Holmes and McBean, 1964), it is probable that by far the most effective mode of osmoregulation is the avoidance of ingesting large amounts of sea water by the filtration mechanism of esophageal papillae in conjunction with the periodic intake and expulsion of sea water during deglutition.

Aguilar, et al. (1992) estimated that during July and August, 1990, the approximately sixty boats of the Spanish western Mediterranean longline fleet had an incidental catch of 23,520 loggerhead turtles. Of 1,094 living loggerheads caught by fishermen and examined by observers, the removal of the hook was possible in only 171 cases. This suggests that approximately 84% of the incidental catch had the hook in the esophagus or stomach. Observers of captive turtles, hooked in the esophagus or lower digestive tract, found that 29% died while 16% expelled their hooks. These observations suggest that turtle mortality attributed to the Spanish fishery in the western Mediterranean was around 6,000 animals during the July-August, 1990, period.

The high percentage of turtles which are hooked in the esophagus or stomach is likely to be due to the bolting of food as described in Figure 4. When hook+bait is passed through the esophagus it seems probable that penetration of the hook into the wall of the esophagus, or the stomach, would occur primarily at the time that tension of the longline develops to pull the hook in a cephalic direction.

Conservation measures would logically seek to preserve the longline fisheries while, at the same time, significantly reduce sea turtle mortality. Major internal damage to sea turtles is likely to occur during hauling in the lines, and especially when turtles are pulled from the sea surface to the deck by the longline. Once a turtle is brought to the surface, further injury would be avoided by guiding a net pallet, supported by a frame attached to a long pole, under the turtle and conveying it, supported on the pallet, to the deck of the ship.

A simple modification of hooks may also be beneficial. While untried, a hook with a flexible guard which covers the pointed end of the hook may deserve attention (see Fig. 5). Such hooks are manufactured commercially and, the flexible wire serves as a weed guard. Questions regarding the use of a guard at the tip of the hook are: (1) Will the hook catch swordfish? (2) Will the guard protect the esophagus and stomach at the time of ingestion? (3) When tension is applied to the longline while the guarded hook is in the esophagus, will he guard provide protection and the possibility of extraction as the hook is pulled forward? (4) If the guarded hook has entered the stomach, what effect will the pull of the longline have? And, how will the guard behave at the pyloric region of the stomach when the longline is pulled forward?

Sea trials, using such guarded hooks, would be required to determine whether the hooks are effective in catching fish. The outcome would be crucial to the attitude of the fishermen.

Radiological studies of dedicated sea turtles, during ingestion of food laden hooks, would be useful in answering questions regarding the behavior of the hook following its swallowing.

CITATIONS

Aguilar, R., J. Mas and X. Pastor.
1992. Impact of Spanish swordfish longline fisheries on the loggerhead sea turtle *Caretta caretta* population in the western Mediterranean. 12th Ann. Workshop on Sea Turtle Biology and conservation. Jekyll Island, GA (USA).

Bronn, H. G.
1890. Kalssen und ordnungen des Thier-Reichs. VI (3) Reptilien. 1. Schildkroten. Leipzig.

Dunlap, C. E.
1955. Notes on the visceral anatomy of the giant leatherback turtle. The Bull. of the Tulane University Medical Faculty 14(2),55-69.

Holmes, W. N. and McBean, R. L.
1964. Some aspects of electrolyte excretion in the green turtle, *Chelonia mydas mydas*. J. Exp. Biol. 41, 81-90.

Lauder, G. V.
1985. Aquatic Feeding, *In*: Hildebrand, M., Bramble, D. M., Liem, K. F., and Wake, D. B. (editors), Functional Vertebrate Morphology, p. 210-229. The Belknap Press of Harvard University Press, Cambridge.

Parsons, T. S.
1958. The choanal papillae of the Cheloniidae. Breviora, No. 85, 1-5.

Steinbeck, John.
1941. The log from the Sea of Cortez, p. 45-46. Penguin Books, New York.

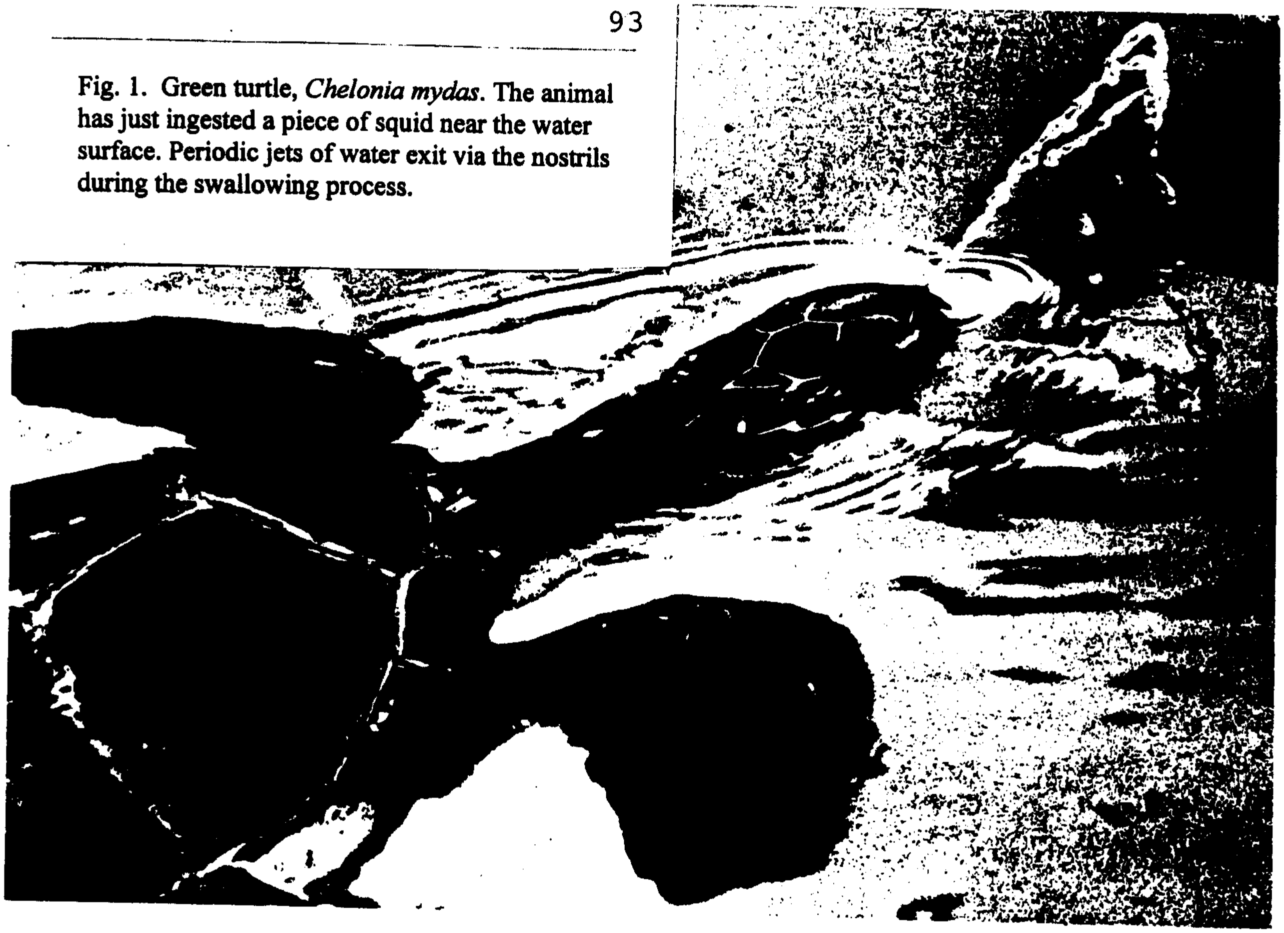


Fig. 1. Green turtle, *Chelonia mydas*. The animal has just ingested a piece of squid near the water surface. Periodic jets of water exit via the nostrils during the swallowing process.

Fig 2. Interior of the esophagus (left) and stomach (right) of a small (2.5 kg) pacific ridley. Note the dense lining of conical papillae, the tips of which "point" toward the stomach.

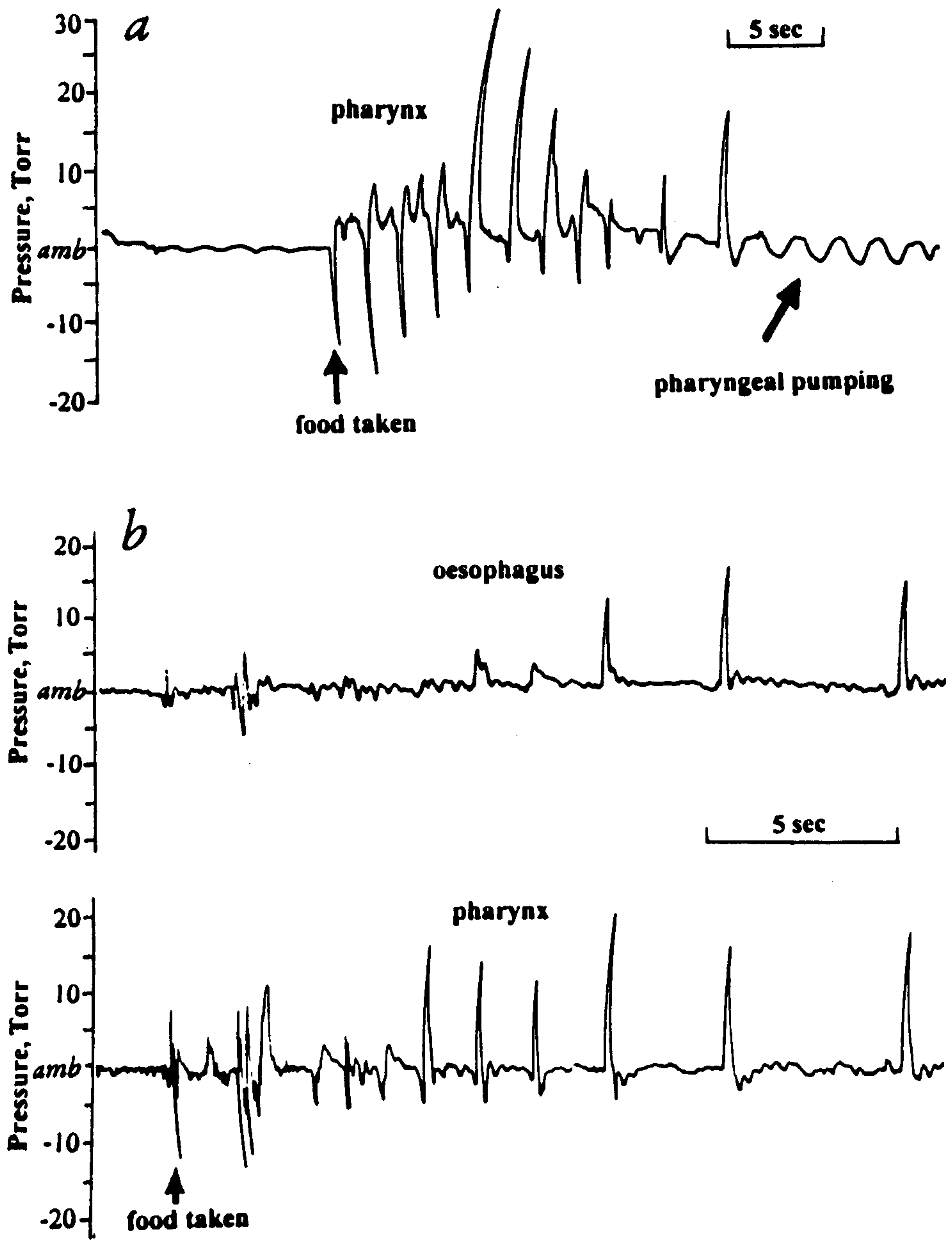


Figure 3. Pharyngeal and oesophageal pressures during food ingestion in sea turtles.
In a - note that the initial intake of food is accompanied by a series of sub-ambient presure pulses as the food is literally sucked in. The positive pressure pulses represent the sequence of pressure events which aid in propelling the food bolus toward the stomach. During transit through the esophagus the food bolus is prevented from refluxing mouthward by the esophageal papillae.

b - Simultaneous pressures in the pharynx and esophagus. The esophageal pressure pulses, which are located at 15 cm below the pharyngeal pressure point, indicate a progression of penetration of the pressure wave to deeper portions of the esophagus as the food bolus travels.
Simultaneous pressures from the two points were obtained from a modified double lumen Swan-Gans catheter. The subject was a Green Turtle of 12 kg mass.

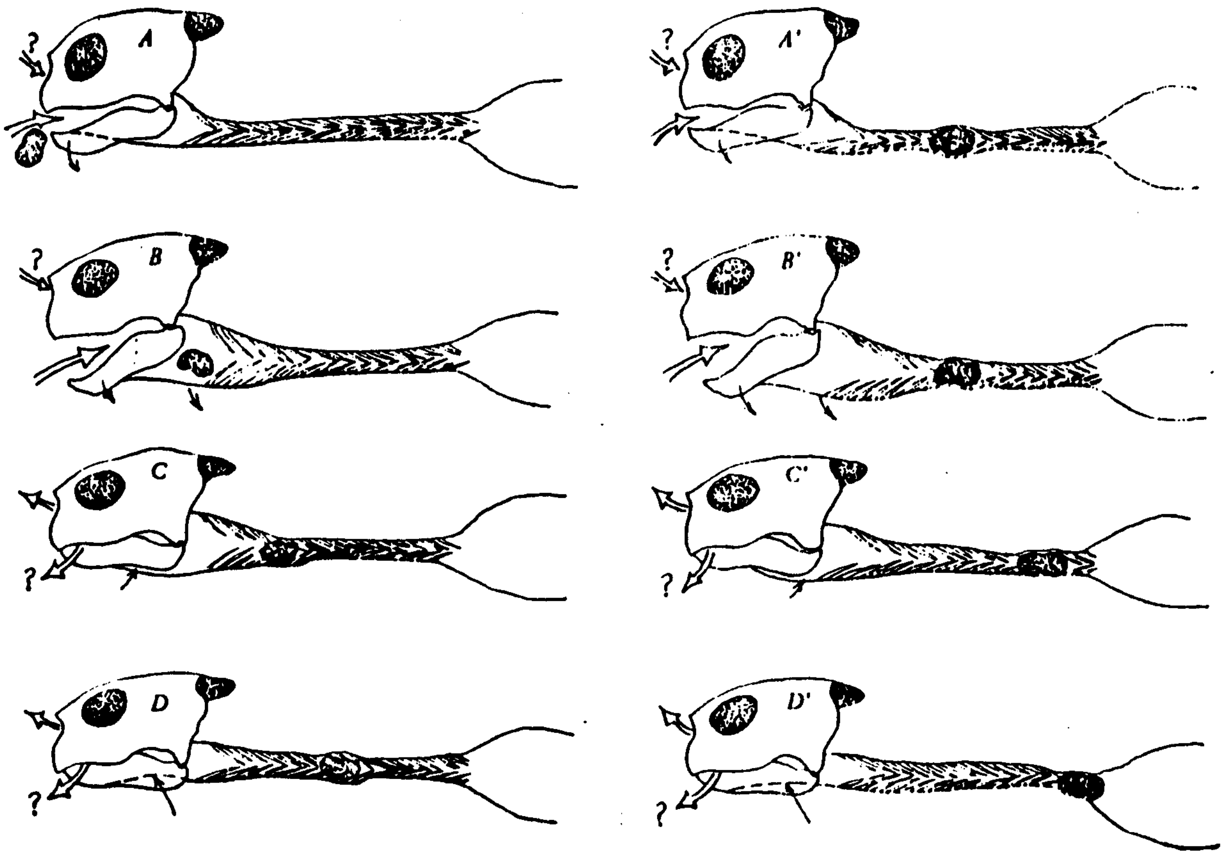
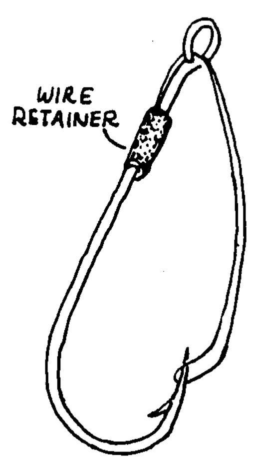


Figure 4. Phases of swallowing in sea trutles. A-D represent successive stages in the initial aquisition of a suspended piece of food and its introduction into the esophagus. A' - D' are later phases in the passage of food to the stomach. Open arrows indicate direction of water flow. Solid arrows indicate jaw and gular movements, the latter probably involving the hyoid apparatus.

Figure 5. Hook fitted with a wire point guard. "Weedless" hooks of this type are manufactured by: *Eagle Claw* Wright & McGill Co. 4245 E. 46th Ave. Denver, CO 80216 (USA)



RESEARCH METHODS FOR STUDIES OF PELAGIC LONGLINE BYCATCH AND HOOKED LONGEVITY

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Many methods developed to study longline bycatch of fish, hooked longevity, and to tether longline-caught fish for behavioral experiments may be applicable to the study of turtle bycatch. Some of these methods are best suited for research vessels (RVs) and others may be utilized by fishery observers (FOs), or used in analyses of logbook data. The fish bycatch studies (Boggs 1990, 1992) suggest modifications of fishing gear and operations to reduce the catch of some species and increase the catch of others, and may provide a model for mitigating the take of turtles in longline fisheries, and for increasing the take of turtles for research purposes (see proposal for turtle collection in this report).

Hook depth is an important factor affecting catch rates of pelagic fish. Because of the arrangement of longline gear (Figure 1) an approximation of hook depth can be obtained by recording the position (in sequence) of branch lines that catch fish or turtles. Many billfish and other species important to sport fishermen are caught on hooks near the surface, whereas some target species such as bigeye tuna *Thunnus obesus* tend to be caught on deeper hooks (Figure 2). The FO program is attempting to record hook position when turtles are taken. The one turtle taken by NMFS research longline cruises was hooked on a branch line adjacent to a float line, and closest to the surface (Skillman and Balazs, 1992). Other factors, such as the float itself, or the squid and chemical light-sticks used in longline fishing for swordfish *Xiphias gladius*, may be attractive to turtles and it is important that logbooks and FOs report the number of floats and lights deployed, and type of bait. The swordfish longline configuration employs fewer hooks between floats (3-5) and is nearer the surface (generally <70 m) than the tuna longline configuration (Figure 1) which uses 11-25 hooks between floats and reaches depths up to 350 m.

Estimates of hook depth are improved when the depth of the longline are recorded using time-depth recorders (TDRs). The FO program is attempting to use TDRs to record depths fished by commercial vessels. Even a single TDR can greatly improve estimates of hook depth, which are otherwise based only on the length of line or number of hooks deployed between floats.

Hook timers (Somerton et al. 1988, Boggs 1992) record the time when fish are hooked, which may be anytime over 6-24 hours while the gear is in the water. Such data shows that shallow-dwelling fish are often caught on deep-position branch lines as the lines are pulled up towards the surface. Time of day may also be an important factor affecting the take of shallow-dwelling animals, which may not be taken as often while hooks are retrieved in darkness. Much of the recovery of tuna longline gear takes place after dark but swordfish longlines are recovered in daylight. Most research with hook timers requires a research vessel but adaptation of this technology to commercial operations is underway. Even without hook timers, important information on time of gear recovery is present in logbook and FO data may help show the circumstances under which turtles are most frequently taken.

Hook timer data also indicate hooked longevity (Figure 3). Comparing the condition of animals to the length of time they have been on the line may help explain the degree of damage or cause of death. It was surprising to discover that tuna often survive more than 8 hours on the gear. Tethering of a dozen tuna for experimental work showed that they could survive even longer. Other species tended to die sooner (Figure 3).

Tethering was developed to retain animals too large to deck without injury, or to hold aboard the vessel. Behavioral experiments such as sonic telemetry, that would otherwise have required the vessel to cease longline haulback operations, were thus postponed. Radio beacons were attached by 100-200 m of line to the branch line on which the fish were caught. The tethered animals were left behind as the ship finished the haulback, and could be recovered from as much as 50 miles away. Of the dozen fish tethered on research cruises, none have shown evidence of attack by sharks. This method is proposed as a means of fishery observers providing live, bycaught turtles to a research vessel operating in the vicinity.

CITATIONS

Boggs, C. H.
1990. Longline research on tuna and marlin. *In* Relatorio, X Semana das Pescas dos Acores, March 12-16 1990, p. 249-252. Sec. Reg. Agric. Pescas, Dir. Reg. Pescas, Horta, Faial, Azores.

Boggs, C. H.
1992. Depth, capture time, and hooked longevity of longline-caught pelagic fish: timing bites of fish with chips. Fish. Bull., U.S. 90:642-658.

Kawamoto, K. E., R. Y. Ito, R. P. Clarke, and A. E. Chun.
1989. Status of the tuna longline fishery in Hawaii, 1987-1988. Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-89-10, 34 p.

Skillman, R. A., and G. H. Balazs.
1992. Leatherback turtle captured by ingestion of squid bait on swordfish longline. Fish. Bull., U.S. 90:807-808.

Somerton, D. A., B. S. Kikkawa, and C. D. Wilson.
1988. Hook timers to measure capture time of individual fish. Mar. Fish. Rev. 50(2):1-5.

Suzuki, Z., and Y. Warashina.
1977. The comparison of catches made by regular and deep-fishing longline gear in the central and western equatorial Pacific Ocean. Transl. No. 20; available Southwest Fish. Sci. Cent. Honolulu Lab., NMFS, NOAA, Honolulu HI 96822-2396.

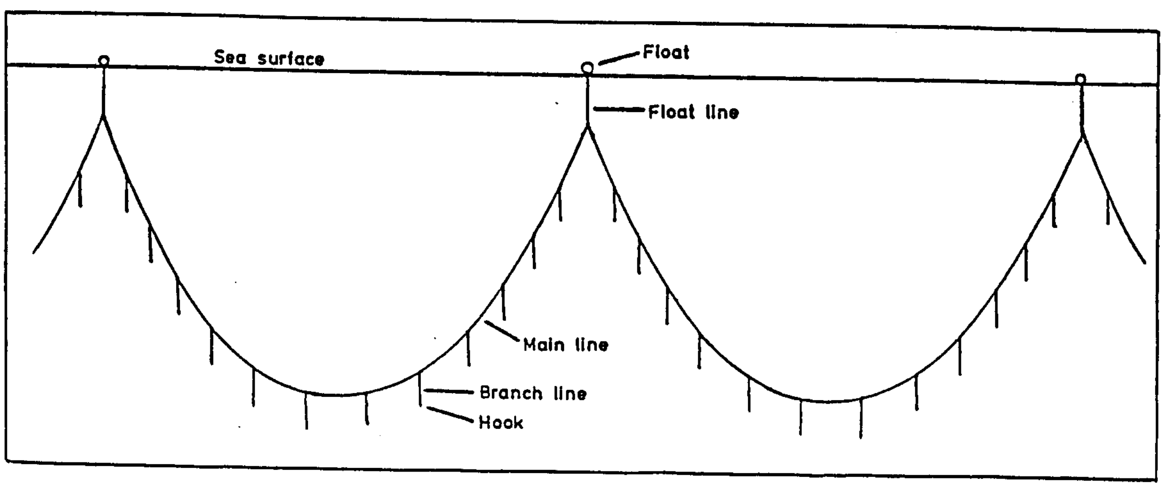

Figure 1.--Section of the tuna longline with catenary formed by the sag between floats (from Kawamoto et al. 1989, adapted from Suzuki and Warashina 1977).

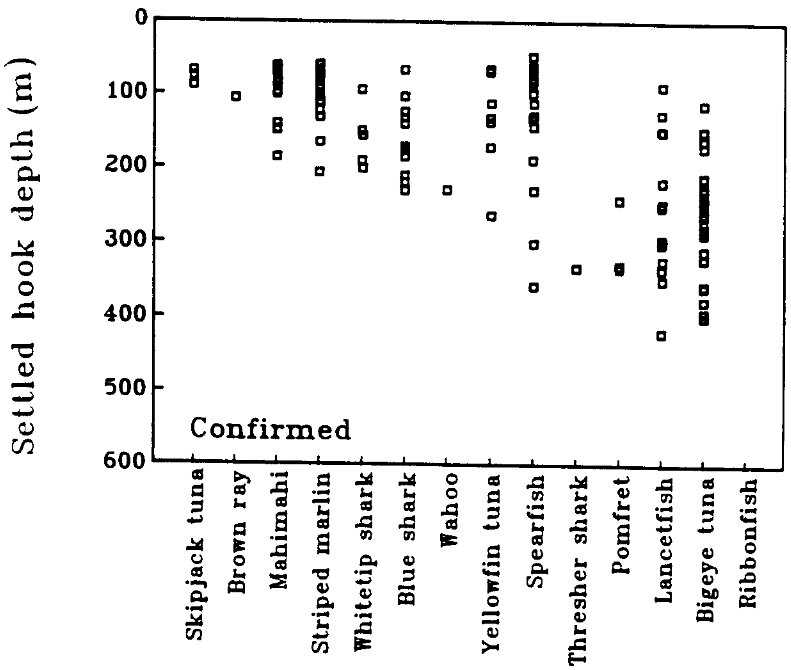

Figure 2.--Tuna longline hook depths for catches of 14 frequently-caught taxa in a study off Hawaii in winter, 1989 and 1990. Depths are for settled hooks, and do not reflect capture depth when fish were caught while hooks were sinking or being pulled back up (from Boggs 1992).

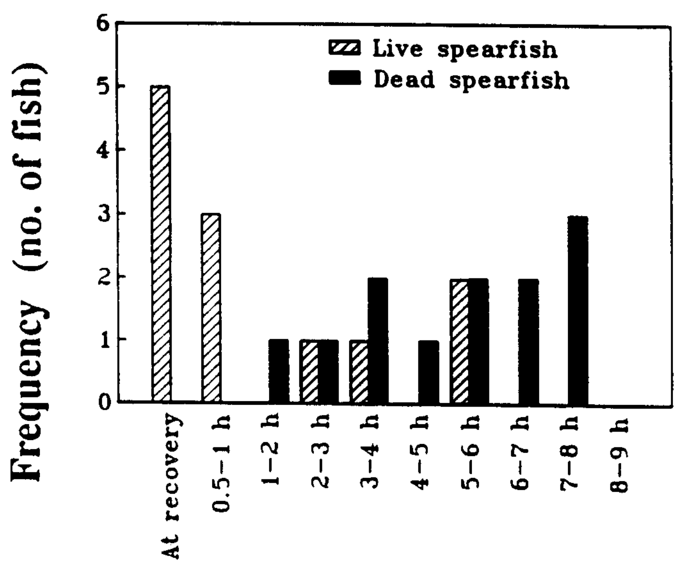

Figure 3.--Condition (alive or dead) of shortbill spearfish *Tetrapterus angustirostris* in relation to the elapsed time between capture and recovery as indicated by hook timers (from Boggs 1992).

SATELLITE MONITORING: A POTENTIAL METHOD FOR EVALUATING POST-RELEASE SURVIVAL OF HOOKED SEA TURTLES IN PELAGIC HABITATS

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Polar-orbiting NOAA satellites in the Argos system have been used since 1979 to study the movements and behavior of sea turtles in the marine environment (Stoneburner, 1982; Timko and Kolz, 1982; Byles and Keinath, 1990; Renaud, 1990). Because of their relatively large size and configuration, the transmitters initially used in this research required positively buoyant housings that had to be towed by the turtle. This methodology imposed a number of significant disadvantages, including limitations for use on smaller species and size classes of sea turtles.

Transmitters currently available are of an improved design and much reduced size. Recent satellite telemetry of sea turtles both in Hawaii and elsewhere has successfully incorporated the ST-3, a backpack-mounted transmitter developed by Telonics Inc. in collaboration with Richard Byles of the U.S. Fish and Wildlife Service. This compact unit weighs only 765 g with overall dimensions of 10 by 17 by 3.5 cm. A small plastic-sheathed antenna projects 13 cm from the top of the transmitter. Power-saving innovations extend transmissions to 5 months or longer, depending upon the turtle's diving pattern and the amount of time spent at the surface where greater battery drain occurs. The basic ST-3 transmitter costs about $3,400. When the transmitters are successfully deployed, information is relayed to the user on a daily basis via computer modem from the Argos Global Processing Centers. Data transmitted by the ST-3 include 1) the location of the turtle (often to within 1 km accuracy), 2) the number of dives and average dive time over the proceeding 12-hour period, 3) the duration of the last dive, and 4) the temperature of the transmitter as an indication of seawater temperature. Modifications to the transmitter are possible at additional cost in order to record diving depths.

ATTACHMENT TECHNIQUE

The method of attachment to safely and securely deploy ST-3 units on adult (>100 kg) green turtles, *Chelonia mydas*, in Hawaii has been patterned after procedures used by Byles and Keinath (1990), Renaud et al. (1992), and Beavers et al. (1992). A significant improvement to these earlier techniques has been the use of Silicon Elastomer, a product that can be used to quickly and effectively form a mounting area so the flat bottom of the transmitter will rest firmly against the curvature of the turtle's carapace. This two-part substance, used as a splinting agent in human medicine, produces absolutely no heat during its quick curing process. A customized transmitter platform for each turtle can therefore be easily molded under field conditions, with no risk of thermal damage to underlying tissue resulting from catalytic action.

The remainder of the attachment process involves the application of several thin coats of polyester resin and strips of fiberglass cloth laid over the transmitter and the top of the carapace. The entire procedure takes about 2 hours, after which the turtle can be immediately released back into the sea. The innovative use of Silicon Elastomer in combination with fiberglass was conceived by Sally Beavers of Oregon State University. The system was first tested in a collaborative study with the author using two green turtles in captivity at Sea Life Park Hawaii. The imitation transmitters remained attached to both captive turtles for 12 months, at which time they were intentionally removed. The area of the carapace under the transmitter where the Silicon Elastomer had been applied was found to be in perfect condition. It is believed that transmitters attached in such a manner will eventually fall off because of normal cellular shedding of the external surface of carapacial scutes. Premature detachment and loss (sinking) of the transmitter does not appear to be a problem.

RESULTS

During 1992 three mature green turtles nesting at French Frigate Shoals in the Northwestern Hawaiian Islands were equipped with ST-3 transmitters and tracked during high-seas migrations to resident foraging pastures (Balazs, 1994). Two of the turtles traveled over 1100 km to the southeast, taking 23 and 26 days, respectively, to reach their destination goal--Kaneohe Bay on the Island of Oahu. The third turtle traveled 800 km to the south, taking 22 days to reach the isolated foraging area of Johnston Atoll. From the time of transmitter deployment, data transmissions were received from these three turtles over a 5-10 month period. During August 1993, two more green turtles were fitted with ST-3 transmitters at French Frigate Shoals. Both were tracked to Kaneohe Bay over a 26-day period. Diving and other data are still being received (as of 12/93). In addition, using the same proven attachment technique, ST-3 transmitters were deployed in early November 1993 and are functioning perfectly on three nesting green turtles at Rose Atoll in American Samoa (Balazs et al. in press).

RECOMMENDATIONS

Except for a single turtle in the eastern tropical Pacific (Owens 1993), satellite transmitters have thus far not been used on sea turtles captured from and released back into pelagic habitats, such as those where longlining occurs in the North

Pacific. Except for funding and logistical problems in deployment, there is no reason why this technology cannot be successfully utilized. Overall, the subadults and smaller size classes of Cheloniidae (hard shelled family of sea turtles) are the ones expected to be encountered and hooked most often in the fishing region. The use of satellite telemetry patterned after the work described here is a plausible means of evaluating post-hooking behavior and survival. In fact, there may be few other options for carrying out such an evaluation using live turtles returned to the wild on the high seas.

Leatherback turtles, *Dermochelys coriacea*, (family Dermochelyidae) usually of large size are also known to be hooked in the longlining area. However, because of the divergent shape and soft composition of the carapace, transmitter attachment is not suited for leatherbacks. Instead, simple harnesses have been employed on this species (Eckert and Eckert 1986), a method which may be applicable in telemetry research of post-hooking survival.

A preliminary feasibility study involving a few animals is needed to determine the efficacy of satellite transmitters deployed on pelagic-phase turtles. A comprehensive, full-scale research program would have to include telemetry of both healthy non-hooked turtles, as well as dead ones, to provide controls for the accurate evaluation of behavioral and movement data received through the Argos system.

CITATIONS

Balazs, G. H., P. Craig, B. R. Winton, and R. K. Miya.
In press. Satellite telemetry of green turtles nesting at Rose Atoll, American Samoa, and French Frigate Shoals, Hawaii. Proceedings of the 14th Annual Symposium on Sea Turtle Biology and Conservation.

Balazs, G. H.
1994. Homeward bound: satellite tracking of Hawaiian green turtles from nesting beaches to foraging pastures. Proceedings of the 13th Annual Symposium on Sea Turtle Biology and Conservation. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-341, p. 205-208.

Beavers, S. C., E. R. Cassano, and R. A. Byles.
1992. Stuck on turtles: preliminary results from adhesive studies with satellite transmitter. Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SEFSC-302, p. 135-138.

Byles, R. A., and J. A. Keinath.
1990. Satellite monitoring sea turtles. Proceedings of the 10th Annual Workshop on Sea Turtle Biology and Conservation. U.S. Dep. Commer., NOAA Tech. Memo. NMFS. NOAA-TM-NMFS-SEFSC-278, p. 73-75.

Eckert, S. A. and K. L. Eckert.
1986. Harnessing leatherbacks. Mar. Turt. Newsl. 37:1-3.

Owens, D. W.
1993. The research vessel *Gyre* cruise in the eastern tropical Pacific. Mar. Turt. Newsl. 62:8-9.

Renaud, M. L.
1990. Sea turtles and satellite tags: movements and dive patterns. Proceedings of the 10th Annual Workshop on Sea Turtle Biology and Conservation. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SEFSC-278, p. 121.

Renaud, M. L., G. R. Gitschlag, and J. K. Hale.
1993. Retention of imitation satellite transmitters fiberglassed to the carapace of sea turtles. Herpetol. Rev. 24 (3):94-96.

Stoneburner, D. L.
1982. Satellite telemetry of loggerhead sea turtle movement in the Georgia Bight. Copeia 1982 (2):400-408.

Timko, R. E., and A. L. Kolz.
1982. Satellite sea turtle tracking. Mar. Fish. Rev. 44(4):19-24.

EVALUATING THE POST-RELEASE MORTALITY OF SEA TURTLES INCIDENTALLY CAUGHT IN PELAGIC LONGLINE FISHERIES

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The worldwide decline of sea turtle populations has been of great concern since the early 1970's. Evidence of this concern can be found in the classification of all sea turtle populations as "threatened" or "endangered" by the U.S. Endangered Species Act of 1973 and similar classification by the IUCN. In virtually all cases, declines in turtle populations are measured by the annual monitoring of numbers of nesting turtles. Since sea turtles can easily be encountered when on the beach, and because of the existence of large numbers of nesting beach monitoring programs, both conservation efforts and research tend to focus on nesting turtles and their eggs. Thus, there has been a historical bias toward conserving this important but relatively limited part of sea turtle life history.

With the application of modern population modelling techniques to sea turtle populations, in particular those of Frazer (1983) and Crouse et al. (1987), and more recently the use of Population Viability Analysis (PVA), the central importance of accounting for mortality in other portions of the life history of marine turtles has become apparent. These new analysis techniques have demonstrated that the relative "value" of large juvenile and subadult sea turtles is extraordinarily high, much higher than the relative value of nests and eggs. Thus, these models suggest that the preservation of nesting turtles and their nests is not enough. Without increased protection of turtles at sea, nesting beach protection can have only minimal effect. This new awareness has required the scientific and conservation communities to increase efforts to monitor and reduce or prevent significant sources of mortality for turtles while at sea. Development of the Turtle Excluder Devices (TED) and subsequent passage of Public Law 101-162 requiring foreign nations to use TEDS if they wish to export shrimp to the U.S. are relevant examples. In addition evidence of the mortality of turtles killed or injured in the high-seas driftnet fisheries played a part in the international prohibition of this fishery.

It is increasingly clear that sea turtles are incidentally caught in longline fisheries in the Pacific, Atlantic and Caribbean (Balazs, 1982, Nishemura and Nakahigashi, 1990, Witzell, 1984, Tobias, 1992). One report (Nishemura and Nakahigashi, 1990) described the incidental catch of turtles by the Japanese longline fleets and concluded that this fishery may be responsible for the annual mortality of 12,200 turtles in the Western Pacific and South China Sea. Such high take levels could represent a significant threat to Pacific Ocean marine turtle populations. However, only a few such studies have been undertaken, most reports are limited to anecdotal information or general catch rates. Determining the impacts these fisheries have on sea turtle populations requires a more accurate determination of mortality rates than has been attempted to date. In partial response to this need the U.S. National Marine Fisheries Service has instituted a Federal Fisheries Observer Program in the Hawaiian-based longline fishery (NMFS Endangered Species Act Section 7 Consultation, June 10, 1993). This program seeks to determine the incidental catch rates on turtle populations around the Hawaiian Islands. Such a program will record the composition of turtle species caught, and the condition of those turtles at capture and release. However, as it is currently designed, the program will not be capable of monitoring the fate of the turtles post-release.

The need for understanding the fate of incidentally hooked turtles after release is significant to longline fisheries. Incidentally hooked turtles are usually released with the hook and leader embedded in the esophagus or stomach. The adverse impact of releasing a turtle with a hook still embedded can be significant. One study (Aguilar et al., 1992) estimated post-release mortality rates of 20 to 30 percent in the Mediterranean by the Spanish swordfish fishery. Their data was based on results of captive rearing incidentally hooked turtles. Any program seeking to estimate fishery mortality based only on condition-at-release will probably yield low estimates. Nishemura and Nakahigashi (1990) estimated turtle mortality at 42% in the Japanese longline fleet, but their information addressed only the condition of the turtle at capture. If we combine the results of the Mediterranean assessment to the Japanese study, it appears that the mortality rate of turtles caught in Pacific longlines could be in excess of 50%.

Determining the effects of longline fishing on turtle populations will likely require two investigation techniques.

Instantaneous effects

Essentially this approach monitors the condition of the turtles as they are retrieved with the catch. Data collection is already underway as part of the NMFS Federal Observer Program.

Post-Release effects

To determine how well the turtles survive after release will take a two different approaches.

Field-Based

To monitor the post-release mortality of the turtle in situ will require remote monitoring, most likely by satellite transmission. Such a study is not without problems and must consider the following:

(1) Condition of animal

Some means to monitor the condition of the animal will be important. For example, dive behavior (depth and duration for which equipment is currently available) should be monitored. Such data can be compared to behavior of uninjured turtles to indicate if the turtle is behaving normally.

(2) Transmitter longevity

Considering the long period required for turtles to die, or to shed the hook (according to Aguilar's study it can take in excess of 6 months), transmitters and attachment should be designed accordingly.

(3) Sample Size

Sample size must be large enough to account for the equipment failure and individual variation in turtle behavior. A control group will have to be established consisting of turtles in comparable size classes in the same general region.

Lab-Based

It will be very important to retain some of the turtles to study the effects of embedded hooks. Optimally, turtles should be taken directly from the fishery in the same condition as they would normally be released. Health should be monitored until it can be determined that the turtle will die, or until it is apparent the hook will not incapacitate the turtle. The following variables should be measured:

(1) Radiographs--to document position of hooks, damage to internal organs, and presence or absence of diseases such as pneumonia.

(2) Endoscopy--to document position of hooks and condition of gastrointestinal mucosa.

(3) Complete blood counts--to monitor for presence of infection or anemia.

(4) Serum chemistries--to monitor electrolyte balance and renal and hepatic function.

(5) Fecal exam or cloacal wash--to diagnose parasitic disease if present.

(6) Microbiological samples (e.g., tracheal culture, blood culture, fecal culture) where indicated, to determine cause of infection.

(7) Food intake, weight gain or loss, and swimming ability--general indicators of health and ability to survive once released.

(8) Finally, complete necropsies should be performed on any turtles that die during the course of the project.

Further projects on the captive turtles should center around development of simplified hook removal techniques.

Prevention of Incidental Capture

In tandem with research just outlined, work should proceed on means to minimize turtle hooking altogether. This may involve developing techniques to make turtles less susceptive to capture, such as changes in bait, the removal of cyalume sticks as fish attractors etc. Also important could be the development of bio-degradable hooks, or collapsible hooks that can easily be removed from marine turtles and other non-target species.

CITATIONS

Aguilar, R., J. Mas, and X. Pastor.
1992. Impact of Spanish swordfish longline fisheries on the loggerhead sea turtle *Caretta caretta* population in the western Mediterranean. Presented at the 12th Annual Workshop on Sea Turtle Biology and Conservation. Feb. 25-29, 1992. Jekyll Island, GA.

Balazs, G. H.
1982. Annotated bibliography of sea turtles taken by longline fishing gear. NOAA, NMFS, Southwest Fisheries Center, Honolulu Laboratory. Unpubl. rep. 4 p.

Crouse, D. T., Crowder, L. B. and Caswell, H.
1987. A stage-based population model for loggerhead sea turtles and implications for conservation. Ecology 68(5):1412-1423.

Frazer, N.
1983. Survivorship of adult female loggerhead sea turtles, *Caretta caretta*, nesting on Little Cumberland Island, GA, USA. Herpetologica 39(4):436-447.

Nishemura, W., and S. Nakahigashi.
1990. Incidental capture of sea turtles by Japanese research and training vessels: results of a questionnaire. Marine Turtle Newsletter 51:1-4.

Tobias, W.
1991. Turtles caught in Caribbean swordfish net fishery. Marine Turtle Newsletter 53:10-12.

Witzell, W. N.
1984. The incidental capture of sea turtles in the Atlantic U.S. Fishery Conservation Zone by the Japanese tuna longline fleet, 1978-81. Mar. Fish. Rev. 46(3):56-58.

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Appendix C.--General objectives for marine turtle hooking mortality research (including some broader objectives that address mitigation, population dynamics, observer protocols, etc.).

Trigger question:

Brainstorming (sequential) response to:

"What are the **most important objectives** required for dealing with the possible impact of longline fishing gear on turtles?"

The following are the **unranked responses** to the trigger question:

1. Minimize turtle distress & mortality

   Develop on-board techniques to minimize and/or eliminate physiological distress and mortality for turtles already taken by longline gear.

   (see also: 32. Develop practical methods for treating hooked turtles)

2. Document physical effects of hooking

   Characterize injuries, lesions, and other pathological impacts associated with hooking and with hauling turtles up to vessels and on-board

   (see also: 6. Document physiological impact of hooking and 38. Determine location of hooks and categorize lesions)

3. Identify non-attractive bait

   Test and identify alternative baits (or bait additives) with captive turtles that will successfully catch fish **without** catching turtles

4. Sub-lethal or chronic effects

   Determine what percentage of hooked and released turtles have reduced growth rates, abnormal migratory behavior, reduced reproductive capacity, etc.

Appendix C.--Continued.

5. Gear effects on take rate

   Quantify effects of different longline gear configurations and fishing operations on rate of hooking sea turtles

6. Document physiological impact of hooking (merged with 2.)

7. Decision information

   Acquire and present scientific information for decision-making on turtle bycatch and fishery management regulations

8. Handling live bycatch turtles

   Develop methods for handling live bycatch turtles on-board commercial fishing boats

9. Population impacts

   Determine if longline fishing threatens turtle populations

10. Incidence of take

    Quantify incidence of take--how hooking occurred and where in turtles the hook has penetrated or was lodged.

    (see also: 15. Obtain more intensive scientific information on hooking incidence)

11. Turtle population information

    Determine boundaries and size of impacted populations of turtles

    (see also: 14. Determine population levels of sea turtles)

12. Modify gear for mitigation

    Modification of longline gear to minimize and avoid hooking

13. Determine "tolerable" mortality

    Determine what level of turtle take is tolerable, if any, given conservation goals

Appendix C.--Continued.

14. Determine population levels (merged with 11.)

15. Hooking incidence

    Obtain more intensive scientific information on hooking incidence (merged with 10.)

16. Satisfy ESA

    Fulfill the requirements of the U.S. Endangered Species Act in terms of protecting and recovering sea turtles to former levels of abundance so that protective measures of the ESA will not longer be required

17. Criteria for health assessment

    Develop criteria for conducting a health assessment of marine turtles for evaluation in the field and under laboratory conditions

18. Mitigation trials

    Conduct trials to test alternative methods for avoiding or minimizing turtle take by longline gear

19. Total mortality

    Judge relative impact of U.S. fishery bycatch of sea turtles to total sea turtle take involving fishing fleets of all involved nations

20. Hook location

    Develop practical methods for determining the anatomical location of hooks in the turtle

    (see also: 38. Determine location of hooks and categorize lesions)

21. Continuation of fisheries

    Determine if it is possible to maintain fisheries and still protect turtles

22. "Landing" large turtles

    Determine how to "land" a large turtle (whether hooked or for experimental purposes) on a relatively small boat (the size of Hawaii longline vessels)

Appendix C.--Continued.

23. Turtle repellents

    Develop devices or chemicals for repelling sea turtles from longline gear

24. Fate of released turtles

    Document the fate of released turtles. Determine if hooked turtles released alive are able to survive and continue to be functioning members of their populations

25. Mitigation in other fisheries

    Apply plan beyond Hawaii fisheries (i.e., multiple fisheries)

    (see also: 33. Include all fisherman, i.e., non-U.S.)

26. Observer program

    Implement observer program and protocols on longline vessels to facilitate necessary research data

27. Reduce mortality

    Find means to reduce mortality of hooked or entangled turtles

28. Other factors

    Find out how to deal with other factors affecting turtle populations, e.g., shoreside development in nesting areas, marine pollution, etc.

29. Monitor nesting places

    Conduct long-term monitoring of nesting places to determine population status

30. Alternative fishing methods

    Develop non-longline fishing methods (i.e., methods which do not hook or entangle turtles)

Appendix C.--Continued.

31. Fish bycatch

    Identify scope and magnitude of other bycatch (fish)

32. Develop practical methods for treating hooked turtles (merged with 1.)

33. Include all fisherman (i.e., non-U.S. fisheries (merged with 25.)

34. Temporal mitigation

    Quantify and develop temporal fishing strategies to reduce hooking (e.g., season or area closures)

35. Stock enhancement

    Develop stock enhancement for threatened and endangered sea turtles taken by fisheries to compensate for bycatch mortality

36. Alternative fish products

    Develop alternatives to fresh tuna and swordfish which would reduce prevalence of longline fishing in areas of turtle abundance

37. Shark take

    Determine prevalence of incidental take by sharks on turtles hooked by longline gear

38. Determine location of hooks and categorize lesions (merged with 20.)

39. Physiological database

    Develop a normal-state data base of hematology, plasma biochemistries, blood gasses, etc. for use in health assessments

40. Recreational impacts

    Evaluate impact of hooking of turtles in recreational fisheries

Appendix D.--Land-based research activities on marine turtle hooking mortality.

Trigger question:

"What are the **most important research activities** required for identifying the causes and magnitude of mortality, and other physiological impacts, of turtles hooked or entangled by longline fishing gear?"

The following are the **unranked responses** to the trigger question, categorized for **land-based** research activities.

L1. Captive holding

Holding turtles in a controlled environment to conduct all relevant research necessary to ascertain the fate of hooked turtles

L2. Hook progression

Monitor progression of hook through the turtle gut **as well as** the health of hooked turtles

Measure the rate and manner of hook sloughing, as well as the health of the turtle during the sloughing process

L3. Temperature effects

Effect of temperature on turtle holding and eventual fate of bycatch turtles (captive or released)

Maintain captive turtles at various temperatures to evaluate impact on turtle physiology

L4. Damage assessment

For dead turtles: Determine damage caused by hooking and hauling up on-board vessel by studying dead turtles through rigorous necropsy

For live turtles: Determine damage through surgical interventions

L5. Biological analysis

Analyze all relevant biological samples (blood, tissues, etc.) taken by benign means from live turtles, as well as those collected through necropsy on dead turtles

Appendix D.--Continued.

L6. Hooking mechanism

Conduct experiments to understand the mechanism of hooking in order to minimize or eliminate hooking or its impacts (linked to mitigation activities)

L7. Stomach contents

Investigate natural turtle diet in order to duplicate diet in captive studies so that protein levels and other nutritional aspects will be equivalent

L8. At-sea evaluation

Techniques for evaluating turtles health and condition at sea (e.g., endoscopy, portable x-ray)

L9. Informational database

Assemble into a computerized data base all applicable research and observer data collected on turtle hooking and mortality

L10. Annotated bibliography

Generate an annotated bibliography and literature review on sea turtle anatomy, physiology, and fishery interactions

L11. Identify high-take areas

Analyze information on turtle take world-wide to identify location for experiments

L12. Feeding trials

Determine passage of food through gut through feeding trials to develop standard of comparison in hook progression research

L13. Categorize injuries and effects

Differentiate animals by location of hook, type of hook removal, cuts caused by fishing leaders, etc. through experimental (laboratory) means Differentiate turtle condition by physical condition (e.g., fatness)

Appendix D.--Continued.

L14. Tissue analysis

Tissue taken from dead turtles and samples taken of live turtles by on-board observers to be analyzed

L15. Digestive milieu

Characterize internal digestive milieu (environment) to understand what conditions the hooks are subject to for evaluation of hook impacts and for later development of biodegradable hooks

L16. Natural captive diet

Determine how natural diet can be mimicked for captive turtles

L17. Remote sensing technology (biotelemetry)

Develop and test sensors, attachment methods, and other aspects of remote sensing, tracking, and monitoring devices, including satellite and archival tags

L18. Mortality model

Develop model for predicting mortality of turtles hooked or entangled in fishing gear

L19. Sample size

Design experimental sample size for appropriate confidence levels for both land and sea-based research

L20. Bait studies

Determine the impact of different baits through the type of bites taken by turtles and the eventual location of the hook in the turtle

L21. Cause of death

Identify cause of death, particularly submergence vs. hooking injury

Appendix E.--Sea-based research activities on marine turtle hooking mortality.

Trigger question:

"What are the **most important research activities** required for identifying the causes and magnitude of mortality, and other physiological impacts, of turtles hooked or entangled by longline fishing gear?"

The following are the **unranked responses** to the trigger question, categorized for **sea-based** research activities.

S1. Record hooking details

Record gear configuration and physical location of hooking when turtles are taken

S2. Observer protocol

Develop a detailed protocol on the information to be collected by observers and design the field sheets for collecting data on hooked sea turtles, as well as instructions on how to handle hooked turtles at-sea

S3. Vessel environmental data

Record basic oceanographic data, related environmental factors, time and location, and gear configuration for each set (whether turtles taken or not)

S4. Location of hook in turtle

Identify the physical location of hook in turtle

S5. Biotelemetry

Satellite track hooked turtles after release to monitor their movements and if possible their condition (including all categories of turtles: alive and apparently healthy, alive and physiologically challenged, or dead)

S6. Tissue sampling

At-sea blood and tissue sampling from live turtles, necropsy of dead turtles (when it is absolutely impossible to bring dead turtles back to land)

Appendix E.--Continued.

S7. Fate of released turtles

Implement proven biotelemetry and other methodologies (e.g., tagging) to determine survival and adverse physiological impact of hooking

S8. Collect live turtles

Obtain, transport, and hold hooked turtles for scientific research purposes at land-based research facilities

S9. Health assessment

Assess health of hooked turtles (health index, physical profile, and blood sample)

S10. Categorize hooked turtles

Develop a ranking of hooking types which will assign turtles to categories based on initial location of hook and circumstance of hauling on-board

S11. Retain all dead turtles

Salvage and properly store and transport all dead turtles to land-based research facilities for comprehensive necropsy and other studies

S12. Tagging

Design and implement a tagging program (external flipper tags and internal PIT tags) aimed at all live (and, perhaps on occasion, dead) sea turtles, both those taken in the fishery and those captured by a research vessel

S13. Dedicated vessel research

Use vessels not involved in the commercial fishery in order to conduct at-sea research, including the transport of live turtles and non-satellite tracking

Appendix E.--Continued.

S14. Directed recapture

Implement a tag-recapture program

Design program to collect, process and analyze tag returns from the longline fishery, as well as dedicated recapture and experimental cruises (government or private), and general public recaptures (strandings, etc.)

Distribution information on the tagging program and solicit returns with date/location of recapture

S15. Dead turtle telemetry

Monitor movement of dead turtles through satellite telemetry as part of a controlled study for assessing the post-release status of live turtles

S16. Practical medical evaluation

Determine what kind of health assessment on hooked turtles can be practically conducted at-sea, either on research vessels, by observers on commercial fishing vessels, or by fishing crews

S17. Shark predation

Conduct trials on the predation of hooked turtles by sharks

S18. Collect turtles

Utilize other fishing methods, such as short tangle nets, to capture turtles at-sea for research purposes (tagging, biotelemetry, behavioral studies, and baseline parameters)

S19. Photo/video

Use video and still photography to document all aspects of fishing operations, sea turtle capture, sea turtle handling by crew and observers (hauling, decking, hook removal, and resuscitation or cutting lines and release), and processing on-board (icing, freezing, necropsy, and tissue sampling)

Appendix E.--Continued.

S20. Large predators

Investigate the impact of large predators (e.g., sharks) on turtles hooked or entangled by longline gear through investigation of their stomachs and experimental means

Appendix F.--List of potential mitigation measures.

The following responses were given to this trigger question:

> What measures might be taken to mitigate or prevent the hooking or entangling of sea turtles, and what measures might be taken to improve their treatment if taken?

Responses were grouped into Research activities (R) and in short-term mitigation activities (A):

Short and long-term research activities:

R1. Explore hook removal alternatives

R2. Develop experimental hooks (which would avoid hooking or damage if swallowed)

R3. Analyze take rate as a function of various types of vessel operations in order to identify safer fishing methods

R4. Explore bait attractiveness and develop detractors

R5. Record how turtles take bait and then investigate changes in bait

R6. Create "repellents" on "attractiveness" of baits

R7. Develop workable resuscitation techniques

R8. Explore new fishing methods

R9. Promote acceptable substitutes for tuna and swordfish as fresh seafood products

R10. Investigate measure on how to open a turtle's mouth to improve removal of hook

R11. Explore drug alternatives to reduce impact of hooking

Immediate mitigation activities:

A1. Develop a "landing" platform (a means to bring turtles on-board without hauling them in by the fishing leader)

A2. Develop longline area closures to reduce fishing in areas of high turtle availability

A3. Stock enhancement to increase the population of sea turtles

Appendix F.--Continued.

A4. Limit the number of longline hooks set or the level of fishing effort

A5. Implement a simplified shipboard triage for hooked turtles

A6. Delist turtles from the ESA via enhancement activities

A7. Build turtle "resorts" or sanctuaries where their development would be protected

A8. Retain turtles on-board to ventilate fully to a level where they could be safely returned to the sea

A9. Identify a "shotgun" of drugs which could be administered to reduce infection from hooking or entangling

A10. Negotiate controls on other sources of turtle mortality (including other fisheries and other ocean and shore-based non-fishing activities (e.g., habitat destruction)

A11. Transfer and exchange mitigation research and knowledge with other nations

A12. Develop observer protocols for safely handling hooked turtles

A13. Conduct an industry workshop on turtle handling

A14. Conduct enhanced enforcement of turtle regulations

Appendix G.--Preliminary Observer Data Collection Form and Observer Protocol List of Activities, Supplies, and Data Needs.

Field data form
- Date of capture
- Time of capture
- Water temperature
- Depth of capture--position in hook set
- Latitude, longitude
- Observer
- Vessel
- Bait type and light stick proximity
- Tags present--tag no., location of tag, type of tag
- New tags--no., location, type
- Weight
- Dimensions--curved and straight carapace length and width; straight plastron length

Physical examination (should have a dorsal and ventral drawing of a turtle for noting lesions)
- Carapace
- Plastron
- Soft tissue
- Limbs
- Eyes
- Nares
- Oral cavity
- Vent
- Body condition (emaciated or robust)
- Ectoparasite/symbiont burden (including skin scrapings)
- Evidence of pollutants (oil, etc.)
- Behavior (alert, mildly depressed, moderately depressed, severely depressed, dead)
- Heart rate (Doppler ultrasound)
- Entangled (extent and location)
- Hooked (external, mouth, beyond oral cavity)
- How was turtle hauled on board
- How was turtle transported
- Photographs taken of dorsal, ventral, and frontal view
- Videotape of animal being captured, of animal's behavior (for health assessment--locomotion, character of respiration, food intake--if animal held on board)
- Samples collected from live turtles
- Blood (site of collection, amount, anticoagulant, blood films, packed cell volume, plasma removal and packed cell volume storage; requires special training and supplies)
    - Blood samples
    - Blood gases
        - Hematology
        - Chemistry
        - Genetics

Appendix G.--Continued.

- Viral assays
- Blood culture

Micro samples
- Tracheal swab
- Cloacal swab/flush/fecal sample

Feces
Cultures of lesions
Biopsies (of tissue where hook imbedded)
Treatment (resuscitation if needed)
Release (hook still in turtle or hook removed; monofilament still present)
Return to port (essential for all dead to be iced and brought back for professional study)
Transport live turtles (off-load to research vessel, tether with float, and VHF tag for pickup by research vessel)

Equipment and supplies list
- Necropsy instruments (kit)
- Jars of neutral buffered formalin
- Pathology checklist
- Cotton swabs
- Transport media
- X-ray unit (portable)
- Cryotubes
- Liquid nitrogen tank
- Centrifuge
- Hematocrit and hematocele
- Lithium-heparin microtainer tubes
- Glass slides
- Methanol (100%)
- Sample jars
- Caliper
- Flexible measuring tape
- Marking pens
- Tacklebox--syringes, needles, suture material, etc.
- Biopsy punches
- Ketamine
- Camera/electronic flash/35 mm slide film/videocam
- Ruler, mm
- Scale--electronic/spring loaded

Tagging equipment (tags, applicators)

Telephone numbers
- Federal contact people
- Research scientists
- Disposition of turtle

Sea Turtle Interaction Form

Video Record? (Y / N)
TDR Record? (Y / N)

Capture Type
Hooked: Float#___ Hook#___
Tangled: Float#___ Other____________

Species: Green Hawksbill LoggerheadLeatherback Ridley

Landed? (Y / N) Method: Line Haul Net Haul Rope Haul

GPS Info Latitude Longitude ______________________________

Sea Temp. __________
Time __________

Tags? (Y / N) Number____________ Location____________ Type____________

New Tag Info: Number____________ Location____________ Type____________

Condition: Dead Comatose Live

If Dead...
Disposition Retained Discarded Transferred

Samples Taken

Gut	Blood	Other organs
Stomach	Brain	
Gonads	Head	

If Comatose:
Determined by what method?

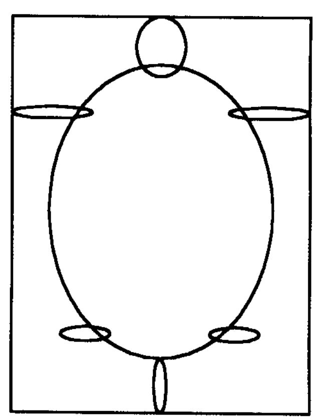
Treatment Regime?

Results?

If Live:
Samples Taken
Blood
(???)

Health Assessment
Treatment/Handling
(METHODOLOGY TO BE DETERMINED)

Damage:
Carapace
Flippers
Plastron
Malformation
Fibropapilloma



Disposition:

Retained

Released to: Sea Research Vessel Other

Date: Time:

GPS Info Latitude Longitude ______________________________

Attachments:
Sattelite __________
Radio __________
Sonar __________

PACIFIC AREA LONGLINE OBSERVER PROGRAM FISHING LOG

Page ____ of ____

Vessel ______________ / No. ________ Observer Trip No. ________ Set No. ______

Begin Set: ______________ (Date / Time) Position: ____° ____.____' ___ Lat. ____° ____.____' ___ Long.

End Set: ______________ (Date / Time) Position: ____° ____.____' ___ Lat. ____° ____.____' ___ Long.

Begin Haul: ______________ (Date / Time) Position: ____° ____.____' ___ Lat. ____° ____.____' ___ Long.

End Haul: ______________ (Date / Time) Position: ____° ____.____' ___ Lat. ____° ____.____' ___ Long.

Longline (Lgth) ________ nmi Droppers (Lgth) ________ m Floatline (Lgth) ________ m Shooter Yes / No

Hooks ________ (Total No.) Hooks Between Floats ________ (No.) Hook Style & Size ______________

Sinkers ________ (Wt.) Wire Leader Yes / No Target Depth ________ m Setting Shooter Speed ________ kts

Lightsticks ________ (No.) / ______________ (Color & Size) Kind & Size of Bait ______________

No.	Species	Length (cm)	Sex	Wt (kg)	G	Gonad Wt	O	Sp	St	DNA	Remarks

[illegible]

Appendix H.--Detailed marine turtle hooking mortality research outlines.

RESEARCH ACTIVITY TITLE **PAGE**

MARINE TURTLE HOOKING MORTALITY RESEARCH OUTLINE

A. RESEARCH ACTIVITY TITLE:

Models to assess impacts of sea turtle takes in the Hawaii longline fishery

B. RESEARCH SYNOPSIS:

Models will be developed to provide a rigorous framework for evaluating the impact of Hawaii longline fishery on turtle stocks. The models will identify how information on the magnitude of turtle takes in the Hawaii fishery, the survival rate of released turtles, stock size, and demographic factors, including other sources of mortality, can be combined to assess the impacts of the Hawaii fishery. The model will incorporate measures of uncertainty and risk. The model will provide a basis for judging the sensitivity of turtle take decisions (e.g., take limits) to various components of information and associated levels of uncertainty. Therefore, it will provide guidance for allocation of research funds.

C. PRIMARY RESEARCH OBJECTIVE(s):

1. Produce quantitative and logical framework for decision on incidental turtle take levels in the Hawaii longline fishery.

2. To integrate information on key components of a broad research and jointly assess their contributions to decision uncertainty and risk.

3. To provide a basis for decision on research strategy and funding allocation.

D. BACKGROUND STATEMENT:

Decision on incidental take levels in the Hawaii longline fishery may have significant repercussions with respect to economic output of the fishery and the recovery of protected and endangered turtle populations. Methods and models are needed to establish take levels and to weigh the uncertainty about key components of information and how it impacts decision risk. A comprehensive model is needed that incorporates turtle population dynamics, fishery take levels, and survival rates of turtles taken alive and released. The model will provide a means of assessing where research can be focused for the greatest benefit in terms of reducing decision risk.

E. MAJOR RESEARCH ACTIVITIES:

1. Construct provisional models of population dynamics for key turtle species using best available data on age- or stage-specific abundance, growth rates,

maturation rates, survivorship, and reproductive biology. Incorporate provisional information on migration and distribution dynamics.

2. Compile best information on sources of mortality, including mortalities in various fisheries.

3. Apply models to assess current status of turtle populations relative to recovery goals and criteria.

4. Develop procedures to study the sensitivity of incidental take decision risk to model information components and uncertainty.

5. Use results of (4) to help in research planning.

F. OTHER ACTIVITIES/LINKAGES WITH OTHER PROJECTS:

The model will explicitly include as an information component the probability of survival for a turtle released in the Hawaii longline fishery. In particular, it includes L18 and L19.

G. PROJECT WORK PRODUCTS:

1. Description of further stocks and population parameters (largely estimations).

2. Best estimates of fishery takes and other mortality sources.

3. Integrated numerical computer simulation models of each affected stock.

4. Guidelines for NMFS management decision.

H. PROJECT TIME FRAME:

TOTAL DURATION (Chronological Months): 18

ACTIVITY NO.	STARTING MONTH	DURATION (MONTHS)
1	1	6
2	1	12
3	6	6
4	6	6
5	12	6

I. PERSONNEL AND OTHER RESOURCES:

PERSONNEL:

Turtle population dynamics/fisheries specialist with modeling skills.

Computer programmer (assistant)

EQUIPMENT, SUPPLIES, ETC.:

Computer
Software
Supplies

J. LOCATION OF RESEARCH:

Southwest Fisheries Science Center
Honolulu Laboratory

WHY?

The Honolulu Laboratory has access to data and people with the required skills.

K. ESTIMATED BUDGET:

PROJECT TOTAL: $150k

BUDGET DETAIL:

Salaries	$85k
Computer, etc.	$ 5k
Travel	$10k

Total $100k/year x 1.5 year = $150k

MARINE TURTLE HOOKING MORTALITY RESEARCH OUTLINE

A. RESEARCH ACTIVITY TITLE:

Hooking sites, mechanics, and progression of hooks in gut of captive sea turtles

B. RESEARCH SYNOPSIS:

Collection of shipboard data on hook locations in turtles will indicate frequencies of hook sites at time of catch. Hooked turtles in a laboratory setting will be monitored by radiology to determine, through time, the location and possible passage of hook in gut. Effects of hooking on passage time of ingested food will be compared with normal animals. Bait type (fish vs. squid) and hook types will be evaluated in the laboratory and, if indicated, at sea as determinants of hooking sites (mouth vs. esophagus or stomach).

C. PRIMARY RESEARCH OBJECTIVE(s):

1. Determine frequency of hooking in various sites (external, mouth, site in gut) at sea.

2. Determine mortality of hooked animals in holding tanks.

3. Evaluate hook sites by radiology and possible progress of hooks through gut.

4. Determine effects of internal hooking on time for passage of food through gut.

5. Ascertain influence of types of bait (fish vs. squid) on mechanics of hooking and hooking sites in turtles.

D. BACKGROUND STATEMENT:

Swallowing dynamics in sea turtles is a hydrolic process which results in the bolting of food which might explain the high frequency of hooking in the esophagus or stomach reported in the western Mediterranean where squid are utilized as bait. Another report indicates a high frequency of hooking in the mouth in a circumstance where fish were used as bait. Evaluation of these bait types (using congenitally deformed turtles) as determinants of hooking mechanics and site of hooking (in the laboratory) should indicate value of bait selection at sea as a means of governing frequency of mouth vs. gut-hooked turtles.

Temporal analysis of ingested hooks by x-ray should provide information regarding hook sloughing and possible passage of hook in feces (reported for captives from the

Western Mediterranean). This information should be useful in predicting mortality and survival rates of hooked turtles released at sea or held in rehabilitation programs.

E. MAJOR RESEARCH ACTIVITIES:

1. Observer determination of hook site. Using standard leaders, marked at known distances above hook, observer determines approximate hook location in turtle (also, carapace length).

2. Effect of bait type on hooking site. Observe mechanics of ingestion of squid vs. fish and site at which hooking occurs. Use of animals which cannot be released (genetic aberrant animals; loss of limbs).

3. Radiology of hook locations. This activity follows, through time, the fate of ingested hooks and their possible passage through gut. Requires access to "simple" x-ray machine.

4. Transit time of food through gut. Normal transit times, determined by collection of fecal non-absorbable marker, will provide comparison for transit times in internally hooked animals. Long transit times may be associated with putrification and pathology.

F. OTHER ACTIVITIES/LINKAGES WITH OTHER PROJECTS:

1. Pathology: tissues preserved from hooked animals which die--passed on to pathology program.

2. Collection of feces: relates to previous diet and possibility of containing hook or hook fragment. (Samples preserved for nutrition and diet observations)

G. PROJECT WORK PRODUCTS:

1. Annual reports

2. Journal publications

H. PROJECT TIME FRAME:

TOTAL DURATION (Chronological Months): 24

ACTIVITY NO.	STARTING MONTH	DURATION (MONTHS)
1		24
2		24
3		24
4		24
5		24

I. PERSONNEL AND OTHER RESOURCES:

PERSONNEL:

Part-time x-ray technician

Veterinarian services

Animal care technician

Principal investigator

EQUIPMENT, SUPPLIES, ETC.:

X-ray machine, film, processing (rental, if not available for loan).

J. LOCATION OF RESEARCH:

NMFS Galveston Laboratory

WHY?

Holding facilities available; have genetically deformed animals for hooking experiments. These animals cannot be returned to the wild.

K. ESTIMATED BUDGET:

PROJECT TOTAL: $115k

BUDGET DETAIL:

Salaries and benefits	$60k
Equipment (x-ray machine)	$30k
Supplies and food	$10k
Travel and per diem	$10k
Publications, reports, meetings	$ 5k

MARINE TURTLE HOOKING MORTALITY RESEARCH OUTLINE

A. RESEARCH ACTIVITY TITLE:

Hooking mechanism in sea turtles

B. RESEARCH SYNOPSIS:

Collection of data on captive turtles using various techniques will increase the understanding of hooking and how best to lessen its effect.

C. PRIMARY RESEARCH OBJECTIVE(s):

1. To develop a safe swallowing device (gear) for experimentation of hooking mechanisms.

2. To improve hook shape.

3. To safely lift sea turtles out of the water once they are hooked.

D. BACKGROUND STATEMENT:

Sometimes loggerhead turtles can recognize solid materials from bait. When turtles chew the bait, sometimes they spit out the solid materials in the water. If we can reveal this taste inclination of turtles, it can help to improve shape of hooks.

The life of the hooked turtles may be saved by lighter gear. This is proposed as a way to improve fishing gear.

E. MAJOR RESEARCH ACTIVITIES:

F. OTHER ACTIVITIES/LINKAGES WITH OTHER PROJECTS:

G. PROJECT WORK PRODUCTS:

1. Annual reports

2. Journal publications

H. PROJECT TIME FRAME:

TOTAL DURATION (Chronological Months): 24

ACTIVITY NO.	STARTING MONTH	DURATION (MONTHS)
1	Apr 1994	Mar 1996
2	Apr 1994	Mar 1996
3	Apr 1994	Mar 1997

I. PERSONNEL AND OTHER RESOURCES:

PERSONNEL:

Two for video recording

Five for preparation and recording of experiment

EQUIPMENT, SUPPLIES, ETC.:

Infrared video camera
Lux meter

J. LOCATION OF RESEARCH:

Port of Nagoya Public Aquarium, Nagoya, Japan

WHY?

Suitable facility and turtles available

K. ESTIMATED BUDGET:

PROJECT TOTAL: $30k

BUDGET DETAIL:

1. Labor
2. Preparation of experimental gear
3. Miscellaneous supplies

MARINE TURTLE HOOKING MORTALITY RESEARCH OUTLINE

A. RESEARCH ACTIVITY TITLE:

Clinicopathological investigations on hooked sea turtle

B. RESEARCH SYNOPSIS:

Clinical and pathological effects of hooking in sea turtles will be investigated. Criteria for health assessment of sea turtles will be identified and a normative data base established for clinically healthy sea turtles. An observer field sheet will be developed so that all pertinent data/biological samples will be collected. A group of live hooked sea turtles will be transported to a land-based research facility for (1) developing practical techniques of hook location (2) assessing the injuries sustained by the turtles (3) collecting further biomedical samples, and (4) ultimately treating injured turtles prior to release. Dead turtles will be pathologically sampled for determining the cause of death.

C. PRIMARY RESEARCH OBJECTIVE(s):

1. Establish normative data base on clinically healthy turtles.
2. Develop proper methods for collecting and processing samples.
3. Develop a detailed field sheet for collecting data at sea.
4. Develop criteria for health assessment.
5. Identify equipment and methods for determining hook location in sea turtles.
6. Determine the impact of hooking on the health of sea turtles.
7. Investigate pathology of dead turtles in order to determine cause(s) of death.

D. BACKGROUND STATEMENT:

Longline fisheries have surfaced as a potentially important human activity having a negative impact on the long-term survival of multiple populations of sea turtles worldwide. In the western Mediterranean, approximately 15,000 to 30,000 turtles are estimated to have been captured by the Spanish Fleet. In a recent study by Aguilar et al. (1993) in the western Mediterranean Sea, for the summers of 1990, 1991 and summer and autumn of 1992, 1,127 turtles were captured on 30 longline boats; 4 of these were dead. Of a group of hooked turtles which were maintained in captivity, 25% mortality was recorded. A similar mortality rate has been seen by other investigators.

In 1993, the U.S. National Marine Fisheries Service reinitiated a consultation under section 7 of the ESA for Hawaii longline fishing actuates managed under the Pelagics FMP to address the issue of incidental take of sea turtles. While NMFS concluded that the Hawaii longline fishery is not likely to jeopardize the continued existence of listed sea turtles, it did conclude that the fishery is adversely affecting green, leatherback, olive ridley, loggerhead, and hawksbill turtles.

In an attempt to better understand the impact of longline fishing on sea turtle mortality, a series of research activities is proposed to provide clinicopathological information on hooked sea turtles.

E. MAJOR RESEARCH ACTIVITIES:

1. Observer protocol field sheet. To develop a detailed protocol and field sheet for standardizing data collection from hooked sea turtles.

2. Hematology and plasma biochemistry. To develop a normal database for blood cellular and biochemical values for health assessment of hooked sea turtles.

3. Health assessment. To develop a list of criteria for health assessment of hooked sea turtles for both evaluation in the field and under laboratory conditions.

4. Hooking location. To develop practical techniques to be used in determining location of hooks in sea turtles and categorizing lesions.

5. Hooking/hauling morbidity and mortality. To determine the physiological and pathological effects of hooking and hauling sea turtles onboard.

F. OTHER ACTIVITIES/LINKAGES WITH OTHER PROJECTS:

1. Objective 2; Activities L4, L14, L21; S6.

2. Objective 17; Activity S9.

3. Objectives 20, 38; Activities L8, S4; S16.

4. Objective 39.

5. Activities S2; S19.

G. PROJECT WORK PRODUCTS:

1. Annual reports for a 3-5 year project.
2. Normative hematological and plasma biochemical database.
3. Database on blood values of hooked sea turtles.
4. Development of a videotape covering sampling methods.
5. Possibility of 3-5 journal publications.

H. PROJECT TIME FRAME:

TOTAL DURATION (Chronological Years): 3-5 years

ACTIVITY NO.	STARTING MONTH	DURATION (MONTHS)
1	July 1, 1994	12 months
2	July 1, 1994	3-5 years
3	July 1, 1994	12 months
4	July 1, 1994	3-5 years
5	July 1, 1994	3-5 years

I. PERSONNEL AND OTHER RESOURCES:

PERSONNEL:

1 Ph.D. level graduate student	100% time
1 full-time technician	100% time
1 Advisor/faculty	25% time

EQUIPMENT, SUPPLIES, ETC.:

Endoscope--light source, camera, film
Liquid nitrogen tank
Portable blood gas machine
Centrifuge
Generator
Portable x-ray machine
Ultrasound machine
Miscellaneous--tackle box, medical supplies (syringes, needles, etc.)

J. LOCATION OF RESEARCH:

Azores and Hawaii

WHY?

A good database already exists for turtles at these sites and hooked turtles can be rescued and transported to land based facilities for further studies.

K. ESTIMATED BUDGET:

PROJECT TOTAL: $1,140k for 5 years

BUDGET DETAIL:

Graduate student	$22k/yr for 5 yrs	$ 110k
Technician	$30k/yr for 5 yrs	$ 150k
Advisor (25% time)	$15k/yr for 5 yrs	$ 75k
Equipment and supplies	1st year $75k-$100k	$ 85k
	2nd year-5th yrs @ $20k/yr	$ 80k
Travel	$ 7k/yr for 5 yrs	$ 35k
Shipping	$ 1k/yr for 5 yrs	$ 5k
Boat rental	$ 2k/day for 60 days for 5 yrs	$ 600k

MARINE TURTLE HOOKING MORTALITY RESEARCH OUTLINE

A. RESEARCH ACTIVITY TITLE:

Physiological effects of longline hooking and entanglement on sea turtles

B. RESEARCH SYNOPSIS:

The proposed research will assess the physiological effects of stresses associated with hooking or entanglement of sea turtles by longlines and develop methods to increase survival through resuscitation and surgical removal of hooks.

C. PRIMARY RESEARCH OBJECTIVE(s):

1. To determine physiological effects (respiratory/metabolic) of longline hooking/entanglement on sea turtles.

2. To determine time required for recovery of longline-hooked or entangled sea turtles prior to release (for turtles not deeply hooked or hook-damaged).

3. To develop and evaluate resuscitation techniques aimed at speeding time to recovery of longline-hooked or entangled sea turtles.

4. To develop improved methods of surgical removal of hooks (under anesthesia).

5. To develop improved methods of serially blood-sampling sea turtles under field conditions.

D. BACKGROUND STATEMENT:

It has been established that sea turtles forcefully submerged by fishing gear (e.g., shrimp trawls) undergo respiratory/metabolic stress leading to severe disturbance of blood respiratory, acid-base and ionic status. Such stress is correlated with the duration of submergence, sea water temperature and size of the sea turtles, and species differences in response are possible (related to their physiological-ecological adaptations to their environment). Similar studies are required to evaluate physiological effects of stresses experienced by sea turtles hooked or entangled on longlines. The proposed research not only will determine physiological impact of longline bycatch on sea turtles but will provide information of value in reducing stresses on by-caught turtles and for resuscitating comatose turtles at sea.

E. MAJOR RESEARCH ACTIVITIES:

1. Blood sampling--Blood samples must be taken and processed/analyzed or stored in specific ways to assure accuracy/precision of various whole blood and plasma constituents. Standard methods and equipment are available, but modifications may be needed to adapt them for observer use.

2. Blood variables--The following blood variables must be monitored (e.g., by serial sampling) in longline-hooked/entangled sea turtles alive when caught: blood pH, gases (PO_2, PCO_2,), ion concentrations (lactate, Cl^-, Na^+, K^+, Ca^{2+}, Mg^2, osmolarity, glucose, catecholamines, (epinephrine, norepinephrine).

3. Heart beat and heart rate--Doppler ultrasound instruments will be used to measure heart beat and rate to determine whether or not caught sea turtles are alive (if comatose or moribund) and at what stage of recovery as determined by blood variables and ventilation.

4. Resuscitation--Comatose turtles will be mechanically ventilated while blood variables and heart rate are monitored to provide speedier recovery (hyperventilation) as compared to turtles not ventilated after capture, to determine differences in survival.

5. Lung morphology and dynamics--Lung morphology and dynamics, pulmonary gas exchange and pH equilibration, and cellular-medicated processes involved in carbon dioxide excretion will be examined in freshly dead sea turtles via lung perfusion studies.

6. Blood sampling methods--Develop and test improved blood sampling methods to obtain arterial blood (e.g., cannulation of a carotid). Dorsal cervical sinuses provide venous blood, and can be unreliable sources (due to collapse, shunting, pooling) of blood, as well as being unacceptable for respiratory studies. Recently developed cannulation methods involving carotid arteries have been used on captive, congenitally deformed sea turtles, but the method is invasive and requires permanent ligation of the carotid following serial blood sampling procedures. Alternate sampling sites, apparatus, and methods need to be developed for serial sampling of arterial blood of sea turtles.

7. Hook removal surgery and recovery--Develop improved methods of surgical removal of hooks from the gastrointestinal tracts of sea turtles hooked on longlines.

F. OTHER ACTIVITIES/LINKAGES WITH OTHER PROJECTS:

L1, L14, S6, S9, S11, S16, S8, S18

G. PROJECT WORK PRODUCTS:

1. Improved resuscitation technique.

2. Improved serial blood sampling technique (arterial).

3. Impacts of longline hooking/entanglement on blood respiratory and acid-base balance in sea turtles.

4. Methods to improve recovery of longline-hooked or entangled sea turtles.

5. Lung morphology and dynamics in longline-hooked or entangled sea turtles.

6. Improved surgical techniques for hook removal in sea turtles.

H. PROJECT TIME FRAME:

TOTAL DURATION (Chronological Months): 24 months

ACTIVITY NO.	STARTING MONTH	DURATION (MONTHS)
1	1	24
2	1	24
3	1	24
4	1	24
5	1	24
6	1	12
7	1	24

All activities start when turtles can be made available (caught on longlines)

I. PERSONNEL AND OTHER RESOURCES:

PERSONNEL:

1. Professional physiologist (Ph.D. candidate or Ph.D.)

2. Laboratory technicians

3. Veterinary surgeon/anesthesiologist

EQUIPMENT, SUPPLIES, ETC.:

Portable blood gas machine
Disposable syringes
Portable blood pH meter/electrodes
Liquid nitrogen & Dewar
Portable centrifuge
Chemicals
Blood analysis kits (glucose, lactate, etc.)
Blood ion analyzer (flame photometry, ion exchange electrodes)
Cannulae
Surgical equipment
Anesthesia equipment
Mechanical ventilators
Doppler ultrasound equipment

J. LOCATION OF RESEARCH:

NMFS Galveston Laboratory/University of Texas Medical Branch

WHY?

These laboratories have the expertise, equipment and experience (plus record of peer-reviewed publication) in such physiological studies related to impacts of trawling on sea turtles.

K. ESTIMATED BUDGET:

PROJECT TOTAL: $165k

BUDGET DETAIL:

Salaries/benefits	$100k
Equipment	$ 20k
Supplies	$ 20k
Travel/per diem	$ 15k
Publication/reports/meetings	$ 10k

L. OTHER SIGNIFICANT INFORMATION:

NOAA Technical Memorandum NMFS-SEFC-328 listing publications/reports by the NMFS Galveston Laboratory on sea turtle research.

MARINE TURTLE HOOKING MORTALITY RESEARCH OUTLINE

A. RESEARCH ACTIVITY TITLE:

Determination of fate of hooked sea turtles released alive using captive assessment

B. RESEARCH SYNOPSIS:

This project will provide an estimate of the mortality rate of hooked sea turtles released alive. Hooked turtles will be brought into the laboratory and the following will be documented: progression of ingested hooks through the gastrointestinal tract (including effects of environmental temperature and diet); effects of initial starting conditions (e.g., location of hook, physical condition of turtle at time of capture) on progression of hook and fate of turtle; effect of hook removal techniques on turtle survival.

C. PRIMARY RESEARCH OBJECTIVE(s):

1. Assess the impact of longline hooks on health and survival of individual sea turtles.

2. Develop models to predict morbidity and mortality of hooked sea turtles given certain conditions (e.g., initial location of hook).

3. Develop and evaluate practical ship-board hook removal techniques.

D. BACKGROUND STATEMENT:

Determining the fate of turtles hooked incidentally to longline fishing operations must be approached by monitoring hooked turtles in a controlled laboratory setting as well as in the wild. The physiological effects of longline hooks can be studied using captive turtles, and these data can then be used to predict the fate of hooked turtles released alive from longline fishing vessels. This will allow a more accurate assessment of the impact of the longline fishery on sea turtle populations.

E. MAJOR RESEARCH ACTIVITIES:

1. Monitor changes in physical location of hook with time using radiography (including contrast radiography), endoscopy, and possibly exploratory surgery, track the movement (if any) of the hook(s) in the animal's body until the hook is sloughed/expelled or until medical intervention is attempted.[1]

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[1]Veterinarians will intervene when turtles' injuries are severe enough to result in certain death without medical or surgical treatment.

2. Monitor changes in health of turtle with hook progression using standard veterinary clinical techniques, monitor the health (or disease progression) of the turtle as hook is sloughed/expelled or until medical intervention is attempted; document time to recovery post-sloughing (e.g., when do parameters return to baseline).

3. Evaluate effect of environmental temperature on 1 and 2 and 4. Monitor hook progression and health of turtles held at various temperatures to allow extrapolation of results among seasons and geographical locations of fishery.

4. Document physical damage caused by hooking using standard veterinary clinical techniques (e.g., radiography, ultrasonic- or endoscopic-guided biopsy). Document physical tissue damage, tissue reaction, and healing.

5. Develop model for predicting mortality of hooked turtles. Describe likelihood of survival of hooked sea turtles, given certain starting conditions (e.g., hook location, initial condition of turtle, temperature). Describe/quantify sublethal or chronic effects (e.g., decreased growth rate).

6. Develop practical hook-removal techniques using techniques already employed in other settings (e.g., hooked sea birds), test feasibility in turtles--monitor effects on turtle (e.g., faster recovery, lower mortality).

7. Develop practical medical treatment of hooked turtles. Test simple medical intervention (e.g., hold turtles onboard for several days, antibiotics, anti-inflammatories, fluid therapy, analgesics) that could be implemented on vessels--monitor effects on turtle (e.g., faster recovery, lower mortality). Categories of turtles to be studied:

    a. Hooked turtles (subcategories--if sample size permits--to include number of hooks present and location of hook, e.g., mouth vs. esophagus, leader cut short or left long).

    b. Turtles with hook removed by fisherman with currently used techniques and by devices in use elsewhere (e.g., removal of hook and line from pelican esophagus).

    c. Control animals--collected by other means.

F. OTHER ACTIVITIES/LINKAGES WITH OTHER PROJECTS:

L1, L2, L3, L4, L5, L9, L10, L12, L13, L16, L18, L19, L21, S4, S6, S8, S9, S10, S13, S16, S18, S19

G. PROJECT WORK PRODUCTS:

1. Model to predict mortality of hooked turtles.
2. Model to predict morbidity of hooked turtles.
3. Database on health and disease in normal and hooked turtles.
4. Presentation of results (reports, conference presentations, publications).

H. PROJECT TIME FRAME:

TOTAL DURATION (Chronological Months): 18

ACTIVITY NO.	STARTING MONTH[2]	DURATION (MONTHS)
1	1	12
2	1	12
3	1	12
4	1	12
5	12	3-6
6	1	12
7	1	12

I. PERSONNEL AND OTHER RESOURCES:

PERSONNEL:

Veterinarian

Ph.D. turtle biologist

2 research technicians/animal care (1 full-time, 1 part-time)

EQUIPMENT, SUPPLIES, ETC.:

Dedicated pools with temperature control and water quality control
Veterinary medical laboratory
Endoscope, x-ray machine, ultrasound machine, surgery, necropsy facilities
Lab analysis
Supplies (blood samples, etc.)
Turtle food

[2]as soon as turtles are obtained

J. LOCATION OF RESEARCH:

Research facility associated with oceanarium

WHY?

Facilities and experience in maintaining and rehabilitating sea turtles, full veterinary medical facilities (lab, surgery, necropsy facilities, monitoring equipment)

K. ESTIMATED BUDGET:

PROJECT TOTAL: $275k

BUDGET DETAIL:

Salaries	$125k
Travel	$ 10k
Equipment (will vary w/research location)	$100k
Supplies	$ 30k
Publication/presentations	$ 10k

L. OTHER SIGNIFICANT INFORMATION:

Ethical considerations. Animal care and use committee and attending veterinarian must evaluate the benefit of the proposed research (to conservation of turtle populations) relative to the cost to an individual animal (e.g., if turtle will experience more than minor/transient pain and suffering). These considerations are especially critical in light of the threatened/endangered status of sea turtles. It is emphasized that the smallest possible sample will be used, that animals will be under constant veterinary care and supervision, that criteria for medical intervention will be established, and that the data are of critical (not trivial) importance to sea turtle conservation.

MARINE TURTLE HOOKING MORTALITY RESEARCH OUTLINE

A. RESEARCH ACTIVITY TITLE:

Biotelemetry of behavior and survivorship of hooked sea turtles from longline fisheries

B. RESEARCH SYNOPSIS:

Biotelemetry technologies will be used to determine the fate of post-released turtles that have been hooked in longline fisheries. Behavior patterns (e.g., dive depth and dive duration) of previously hooked turtles will be compared with control turtles to determine survivorship patterns. The primary technology used will be satellite telemetry. The research will be conducted in a geographic region where a sufficient number of turtles can be obtained to insure adequate samples to accomplish stated objectives.

C. PRIMARY RESEARCH OBJECTIVE(s):

1. Estimate post-release mortality of hooked turtles and incorporate results in a model to predict mortality from longline fisheries.

2. Estimate sublethal effects of post-released hooked turtles.

3. Modify and enhance existing biotelemetry technologies for application for the study of behavior and survivorship of hooked turtles.

D. BACKGROUND STATEMENT:

Determining the fate of turtles hooked incidentally to longline fishing operations must be approached by monitoring hooked turtles in both captive and wild or free ranging conditions. Captive studies of hooked turtles will be useful for understanding how hooking affects the turtle physiologically and can lead to predicting what may occur when hooked turtles are released from longline fishing vessels. However, it will still be critical to measure the fate or survival of turtles in the wild, as captive situations may induce artifacts in the results by their very nature. Satellite telemetry has reached a point, technologically, where it can answer the question of post-release mortality very accurately. Instruments are available today that are capable of transmitting location and behavior (which can, by interpretation, diagnose the health of the turtle) for up to one year. These instruments transmit data and location directly to polar orbiting satellites which are linked to an investigator's computer through the Argos Service downlink system. For this project, it will be important to monitor the post-release behavior, particularly dive depths and durations of injured (hooked) and noninjured (control) turtles in the same geographic region during the same time periods. Dive behavior is a direct reflection of the health of a turtle. Sick or incapacitated turtles exhibit erratic or short diving periodicity which will contrast directly to a control group of turtles in the same area. Because turtles, as poikilotherms will exhibit behavioral modifications due to temperature, it will be important to control these factors by transmitting temperature by satellite as well. Most satellite transmitters available today are capable of temperature transmission as well as dive durations, and in some cases, dive depths. The latter units, which will also transmit depth, are preferable for this project.

E. MAJOR RESEARCH ACTIVITIES:

1. Identify and test appropriate satellite technologies. Contact companies to determine availability of equipment to effectively measure the following variables (dive depth and duration, geographic position, environmental temperature). Battery life of transmitters and size class of turtles to be instrumented will be considered.

2. Identify geographic region that can provide sufficient numbers (sample size) of turtles to accomplish stated objectives. Also, determine appropriate season to conduct field aspects.

3. Develop experimental design. The following components will be incorporated into design: formulation of deployment strategy; determination of sample size for each treatment group by species of turtle, size class, and hooked location. Experimental design will include both non-hooked, healthy turtles and fresh dead turtles.

4. Deploy satellite transmitters on turtles.

5. Access data as relayed by satellite link into appropriate computer database.

6. Characterize behavior and mortality of hooked and control turtles.

7. Integrate results of biotelemetry project with results of captive studies described elsewhere in this report.

F. OTHER ACTIVITIES/LINKAGES WITH OTHER PROJECTS:

1. Incorporate results into a model to predict mortality.

2. Integrate results with captive studies described elsewhere in this report.

G. PROJECT WORK PRODUCTS:

1. Estimation of mortality of post-released hooked turtles.
2. Final report to include methods, results, discussions and conclusions.
3. Database of all data collected from project.
4. Protocol to study behavior and survivalship of hooked turtles that can be applied to other fisheries and geographic regions.
5. Recommendations for follow-up studies, if needed, and mitigation activities to reduce mortality.
6. Publication of results in scientific journals.

H. PROJECT TIME FRAME:

TOTAL DURATION (Chronological Months): 26 months

ACTIVITY NO.	STARTING MONTH	DURATION (MONTHS)
1	1	4
2	1	1
3	1	4
4	4	8
5	4	14
6	4	20
7	24	2

I. PERSONNEL AND OTHER RESOURCES:

PERSONNEL:

1 Project Leader, 26 months

1 Senior Biologist, 26 months

1 Junior Biologist, 26 months

2 Field Assistants, 9 months

EQUIPMENT, SUPPLIES, ETC.:

Equipment: satellite transmitters, satellite time, Argos data charges, notebook computer; CTD, GPS
Supplies: transmitter attachment and peripheral supplies; miscellaneous supplies (phone, Fax, photocopy, film, video, etc.)
Travel and per diem

J. LOCATION OF RESEARCH:

If possible, project to be done in N. Pacific. However, may need to be conducted in other ocean basins in order to accomplish stated objectives.

WHY?

Geographic region where sufficient sample size available

K. ESTIMATED BUDGET: $825k

PROJECT TOTAL: *NB: Does not include research vessel charter costs.

BUDGET DETAIL:

Personnel:	$330k
Equipment and Supplies:	$470k
Travel:	$ 25k

MARINE TURTLE HOOKING MORTALITY RESEARCH OUTLINE

A. RESEARCH ACTIVITY TITLE:

Collection of live sea turtles as bycatch for experimentation

B. RESEARCH SYNOPSIS:

Using observers on fishing vessels, and possibly non-observer fishing vessels, to retain live bycatch of turtles and to provide them to researchers for telemetry and other experiments. Methods would include tethering turtles for recovery by a research vessel simultaneously conducting directed fishing for turtles, and also "decking" and maintaining live turtles on fishing vessels for later delivery to researchers.

C. PRIMARY RESEARCH OBJECTIVE(s):

1. Obtain sufficient numbers of live, by caught turtles to perform meaningful experiments and long-term observations.

2. Reduce post-bycatch injury due to handling prior to the initiation of experiments and long-term observations.

3. Provide a fishing methodology to increase the rate of bycatch.

4. Provide a vessel to initiate experiments and long-term observations.

5. Determine the incidence of predation on live, tethered, by-caught turtles as a model of the incidence of predation on live by-caught turtles (by sharks, while attached to the gear).

D. BACKGROUND STATEMENT:

Turtle bycatch may be a relatively rare event that could make obtaining substantial numbers difficult. The validity of any experiments or long-term observations on the longevity of turtles released from longline gear may be compromised by a small samples size (n). Although turtle bycatch may be high in some fisheries in some parts of the world, it may be important to conduct at least some experiments and observations on turtles collected from the Hawaii-based fishery. Work in this fishery will be expedited by the presence of an observer program largely dedicated to turtle research. Beginning early in 1994, 20 observers will be active in this fleet. Incidence of turtle bycatch is on the order of 1 per 17,000 hooks (NMFS Biological Opinion) and might be higher or lower. The annual take in this fishery might be 700 turtles and number taken on observer trips might be about 100 (30 to 300 depending on observer coverage and catch rates) some of which may be dead. Experiments such as telemetry or long-term observation may be enhanced if they can be initiated by professional scientists rather than by fishery observers. Thus, it would be desirable to have a method by which a large number of live, by-caught turtles could be provided as soon as possible, with as little additional stress or injury as possible, to scientists. Fielding a research vessel to collect turtles from a group of commercial vessels in an area of concentrated fishing effort would allow those researchers to initiate telemetry experiments and to conduct the tests and detailed observations need to document initial conditions for other long-term observations or experiments.

During each month that the research vessel was fielded, it might be able to deploy about 25,000 hooks, or enough to catch less than 2 turtles, while during this same period 20 observers might encounter 10-20 more assuming the average incidence (NMFS Biological Opinion). By choosing optional areas and grounds, a higher incidence (3x?) might be achieved. By collecting live bycatch from other commercial vessels, the opportunity of doubling the collection might be possible. If we assume that a successful experiment might require 50 animals, and that scientists (not observers) must initiate the experiments, then some method of increasing the catch during the time window of the research vessel must be achieved. Certain techniques may be identified which increase the take of turtles and these might be employed by the research vessel, and also the observer vessels or fishing vessels under special permits.

E. MAJOR RESEARCH ACTIVITIES:

1. "Decking" live bycatch. Develop and implement practical methods for observers, or fishermen, to "deck" and maintain live turtles without additional injury. [supports S8]

   Decking will be accomplished by large dipnets with removable handles and yokes suitable for attachment to block and tackle or similar hoist. Turtles will be kept wet in collapsible (for storage) bins covered with wet foam rubber.

2. Tethering live bycatch--Develop and implement protocols of observers, and perhaps fishermen, to tether live turtles for pick-up by a research vessel in range. [supports S8, S17]

   Tethering is conducted with a long (200-400 m) leader attached to the turtle by the line that entangles or hooks the turtle (without decking). All other recovery operations then take place on the nearby (less than 50 miles) research vessel which finds the turtle by a radio beacon attached to the end of the tether by the observer (or fisherman).

3. Analyze the circumstances of bycatch (gear configuration, hook position on the line, time-area strata, bait, etc.) to design a fishing method, season, and fishing ground to maximize the rate of bycatch by a research fishing vessel, or cooperating vessels. [supports S8]

   Certain circumstances (shallow gears, lots of floats, lights, areas, or seasons may increase take rates. Gear would be altered in these respects and the research cruise scheduled for the appropriate time (changing the time frame).

4. Field a research vessel to collect live turtle bycatch from the fleet, and by directed fishing, and to initiate observations and experiments (especially telemetry) on those animals. [supports S13]

F. OTHER ACTIVITIES/LINKAGES WITH OTHER PROJECTS:

1. Telemetry, more so than any of the other experiments described in this report. Telemetry may require initiation by scientists as soon as possible after capture. Other experiments might more easily make use of turtles brought to port on fishing vessels or by observers). [S5, S7]

2. Other live-animal research. [S12, L1-4, L6, L8, L12, L13, L15, L20]

3. Predation on turtle by sharks effectively "hiding" some take and mortality. [S17]

4. Directed recapture. [S14] (via directed fishing--slight)

G. PROJECT WORK PRODUCTS:

1. Instructions to observers on recovery and transfer of live turtles (document).

2. Scientific publication (note) on the incidence of prey on tethered turtles.

3. Delivery of less than 50 live turtles to research vessel.

4. Delivery of less than 50 more live turtles to shore-based researchers.

H. PROJECT TIME FRAME:

TOTAL DURATION (Chronological Months): 12

ACTIVITY NO.	STARTING MONTH	DURATION (MONTHS)
1	1	12+
2	3	1-2
3	1	5+
4	3	1-2

I. PERSONNEL AND OTHER RESOURCES:

PERSONNEL:

Project coordinator

Observers covered under other projects

Researcher covered under other projects

EQUIPMENT, SUPPLIES, ETC.:

Radio beacons for tethering
Vessel time (30-60 days)
Stipends to alter commercial vessel operations for 1 trip each $100k
Nets for decking turtles 2k
Collapsible bins for turtles 2k

J. LOCATION OF RESEARCH:

In the Hawaii-based longline fishery, or similar fishery.

WHY?

Hawaii is preferred if fishery-specific aspects of research are essential. Otherwise, another fishery with a higher bycatch would be more cost effective.

K. ESTIMATED BUDGET:

PROJECT TOTAL: $180k (plus vessel time)

BUDGET DETAIL:

Salaries/benefits	$25k
Equipment and supplies	$55k
Stipends	$100k
Vessel time	(to be determined)

MARINE TURTLE HOOKING MORTALITY RESEARCH OUTLINE

A. RESEARCH ACTIVITY TITLE:

Alternative fishing methods for the capture of sea turtles: Distribution and relative abundance in the pelagic environment

B. RESEARCH SYNOPSIS:

Research is proposed to conduct independent studies on the population characteristics, developmental life stages, distribution in time and space, epipelagic habitat of marine turtles. The goal is to develop sufficient information on the ecology and behavior of sea turtles that will ultimately result in reduction of the man-induced mortality incurred by the longline fishery (an action mandated by the ESA) necessary to recover the species.

C. PRIMARY RESEARCH OBJECTIVE(s):

1. Conduct fishery-independent surveys of marine turtles in the pelagic environment in order to determine their distribution, biological characteristics, and ecological (habitat preference) relationships.

2. Conduct tag-recapture studies to determine movements within the sampling area, growth rates, and fortuitous recoveries over the long term and by other fisheries.

3. Develop data base on marine turtle populations (demographics): Distribution in marine environment, life stages, relationship with frontal systems, mtDNA/stock identification.

D. BACKGROUND STATEMENT:

Knowledge of the distribution, migration, and relative abundance of sea turtles in the pelagic environment is poorly understood. Limited information has been obtained from the incidental capture of turtles by other fishery-dependent activities employing driftnets and longlines directed toward the capture of commercially important finfish such as tunas and swordfish. Background references include the following reports:

1. Bycatch data collected by observers on foreign longline vessels operating in U.S. jurisdictional waters: NOAA Technical Memorandum NMFS-SEFC-64, 125 (and others).

2. Bycatch data in domestic (U.S.) longline fishery as identified in fisheries initiative (MARFIN) annual reports, as well as contract reports submitted to NMFS laboratories from state agencies/institutions.

3. Witzell, 1984. The incidental capture of sea turtles in the Atlantic U.S. fishery conservation zone by the Japanese tuna longline fleet, 1978-81. Mar. Fish. Rev. 46(3):56-58.

E. MAJOR RESEARCH ACTIVITIES:

1. Develop suitable collecting gear/methods to capture turtles that will not result in mortality/injury. Primary gear will be surface entangling nets of various mesh sizes (8 to 10 inch bar minimum), depths, and lengths. Nets will be monitored closely to avoid drowning turtles. Soak times are to be of short duration (< 30 min) if nets cannot be visually inspected and turtles cannot be removed with gear in place.

2. Selected sets--Sets will be made in areas predetermined to be locations of turtle activity, or areas representing typical oceanographic features where turtles are usually observed; i.e., zones of advection (fronts), "weed" lines, rips.

3. Random sets--Other sets will be randomly made in areas not exhibiting frontal system conditions to offset bias resulting from method employed in 2.

4. Data collection/environmental--Collect standard oceanographic data, especially characteristics of frontal systems, for each set. Include description of flotsam, sargassum/algal communities entrained in advection currents, or drifting in adjacent area. Spatial/temporal data will be recorded for each sampling effort/set.

5. Biological data--Species, carapace length-width, weight, sex, injuries/scars, photograph. Stomach contents (flushing) and a blood sample are minimum data to be collected.

6. Movements/growth determined by tag/recapture method. Tag/internal PIT-external flipper (metal or plastic) will be applied to all turtles released. Biotelemetry is optional activity.

F. OTHER ACTIVITIES/LINKAGES WITH OTHER PROJECTS:

S5, S12, S13, S14, L7, L8, L9, L17, L19, S8

G. PROJECT WORK PRODUCTS:

1. Knowledge of the distribution and relative abundance of marine turtles in the pelagic environment.

2. Ecological relationships of marine turtles in the pelagic environment.

3. Migrations of marine turtles.

4. Food habitats.

5. Life stages, size (age) of marine turtles occupying marine habitat-demographic information.

6. Origins of pelagic populations--reproductive affinities (nesting beaches).

7. Genetic relationships (mtDNA) between populations.

H. PROJECT TIME FRAME:

TOTAL DURATION (Chronological Months): 24 minimum with seasonal collecting/sampling*

ACTIVITY NO.	STARTING MONTH	DURATION (MONTHS)
1	12/1/2	3 (x 2)
2	3/4/5	3 (x 2)
3	6/7/8	3 (x 2)
4	9/10/11	3 (x 2)

*Dec Jan Feb - Mar Apr - Jun July Aug - Sep Oct Nov

I. PERSONNEL AND OTHER RESOURCES:

PERSONNEL:

Vessel/crew (vessel contract costs includes vessel, fuel, food, crew)

Biologist GS 9/11

Bio Techs (2)

Gear man (FMES) (1)

EQUIPMENT, SUPPLIES, ETC.:

Nets, entangling, 8-10" bar mesh--various lengths/depths
Tags, external and applicators
Tags, internal pit and xmtr/recorder "wand"
Blood sampling equipment (centrifuge, liquid nitrogen freezer, etc.)
Photographic equipment
Binoculars, wide angle 7x50s

J. LOCATION OF RESEARCH:

Longline fisheries under U.S. jurisdiction in the Atlantic, Pacific, and Gulf of Mexico--Caribbean.

WHY?

Incidental capture of sea turtles has been reported for all of the above-mentioned areas.

K. ESTIMATED BUDGET:

PROJECT TOTAL: $300k (excluding vessel charter)

BUDGET DETAIL:

Salaries	$240k
Equipment and supplies	$ 45k
Travel	$ 15k

Vessel cost related to geographic area. The major cost is driven by vessel costs. A survey of vessel owners/captains in order before realistic budget can be made.

L. OTHER SIGNIFICANT INFORMATION:

Scientific personnel--GS level determined on training level necessary to accomplish at sea sampling; i.e., salary costs can be reduced with degree of training and careful selection. Data analysis could be done by supervisory biologist.

MARINE TURTLE HOOKING MORTALITY RESEARCH OUTLINE

A. RESEARCH ACTIVITY TITLE:

Assessment of possible underestimation of hooked sea turtles by longlining as the result of shark predation

B. RESEARCH SYNOPSIS:

The number of turtles hooked in longline fisheries may be undercounted due to predation by large sharks prior to retrieval of fishing gear. Assessment techniques will involve the examination of stomach contents of hooked sharks, and the use of surrogate hooked turtle carcasses to estimate loss from predation. Resulting data will be incorporated into a model to predict overall mortality of hooked turtles.

C. PRIMARY RESEARCH OBJECTIVE(s):

1. To determine the level of loss of hooked turtles due to predation by large sharks, which are in turn hooked and discarded as bycatch in longline fisheries.

2. To experimentally measure the susceptibility of hooked turtles to shark predation and other loss factors using turtle carcasses salvaged from other sources.

3. To utilize the resulting estimated losses by predation in a model for predicting overall mortality of hooked turtles.

D. BACKGROUND STATEMENT:

A determination of the scope and magnitude of turtle bycatch in longlining is presently limited to the number of turtles observed and counted when the fishing gear is retrieved. However, this may be an underestimation of the true number of turtles hooked. Oceanic sharks, including some large species, are commonly caught and discarded by longline fisheries. Sea turtles, especially young juveniles residing in oceanic habitats, are susceptible to predation by sharks. Hooked turtles may be exposed to increased predation due to their tethered status, and the attraction of sharks resulting from squid and fish (and lite sticks) used as longline bait. The number of turtles hooked and then preyed upon, with nothing left on the hook to count, needs to be estimated in order to judge overall turtle mortality in the fishery.

E. MAJOR RESEARCH ACTIVITIES:

1. Examine stomach contents of hooked sharks. A statistically valid sample of sharks taken as bycatch will be decked and dissected to identify, quantify, and salvage turtles and turtle parts that were hooked and subsequently preyed upon.

2. Mimic predation using salvaged turtle carcasses. A statistically valid number of intact turtle carcasses obtained elsewhere will be experimentally set out on longline hooks to measure loss during standardized fishing sets.

3. Model results to estimate overall mortality. Estimates of mortality derived from examining shark bycatch and using surrogate hooked turtles will be incorporated into a mathematical model, designed to estimate overall mortality of turtles hooked by longlining.

F. OTHER ACTIVITIES/LINKAGES WITH OTHER PROJECTS:

This project links with observer protocol and supports all other research activities involving the salvage and study of hooked turtles found dead. It also significantly contributes to the overall objective of predicting (modeling) turtle mortality resulting from longline hooking.

G. PROJECT WORK PRODUCTS:

1. Data base of hooked turtles recovered from hooked sharks by species, size class, geographical location, and position on fishing gear.

2. Data base elucidating the level of loss of surrogate hooked turtle carcasses experimentally used in longline fishing.

3. Journal publication.

H. PROJECT TIME FRAME:

TOTAL DURATION (Chronological Months): 18

ACTIVITY NO.		STARTING MONTH	DURATION (MONTHS)
1.	Design sampling protocol.	1-2	2
2.	Sample shark stomachs.	3-14	12

3.	Experimental baiting with dead turtles.	3-14	12
4.	Data analysis and report preparation.	15-16	2
5.	Integrate data into prediction model of mortality.	17-18	2

I. PERSONNEL AND OTHER RESOURCES:

PERSONNEL:

1 Senior researcher, 4 months

20 Shipboard observers

EQUIPMENT, SUPPLIES, ETC.:

Dissection and sampling studies.
Time and space aboard longline fishing vessels.
Transport of turtle carcasses dead from natural causes for use as bait.
Dedicated research vessel or chartered fishing vessel.

J. LOCATION OF RESEARCH:

North Pacific longline fishing area

WHY?

Area of immediate concern for turtle mortality. Mandatory observer program will be in effect that can facilitate this research.

K. ESTIMATED BUDGET:

PROJECT TOTAL: $63k

BUDGET DETAIL:

Senior biologist	$15k
Supplies	$ 3k
Procure and transport carcasses	$ 5k
Research vessel or charter	$40k (or platform of opportunity with other projects)

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NOAA-TM-NMFS-SWFSC-191 The Hawaiian monk seal on Laysan Island.
D.J. ALCORN and R.L. WESTLAKE
(December 1993)

192 Techniques for the preparation and examination of reproductive samples collected from dolphins in the eastern tropical Pacific.
P.A. AKIN, K.M. PELTIER, and R.B. MILLER
(December 1993)

193 A comparison of the recreational and commercial fisheries for lingcod (*Ophiodon elongatus*) off the Pacific coast of the United States, and a description of the recreational lingcod fishery.
K.R. SILBERBERG and P.B. ADAMS
(December 1993)

194 Economic effects of the United Nations moratorium on high seas driftnet fishing.
D.D. HUPPERT and T.W. MITTLEMAN
(December 1993)

195 Report on cetacean aerial survey data collected between the years of 1974 and 1982.
T. LEE
(January 1994)

196 A test of two photogrammetric measuring instruments used to determine dolphin lengths from vertical aerial photographs.
J.W. GILPATRICK, JR. and M.S. LYNN
(January 1994)

197 Hook-and-line fishing study at Cordell Bank, California, 1986-1991.
M.B. ELDRIDGE
(February 1994)

198 Small cetacean dissection and sampling: A field guide.
T.A. JEFFERSON, A.C. MYRICK, JR., and S.J. CHIVERS
(April 1994)

199 A recharacterization of the age-length and growth relationships of Hawaiian snapper, *Pristipomoides filamentosus.*
E.E. DEMARTINI, K.C. LANDGRAF, and S. RALSTON
(May 1994)

200 Report on cetacean sightings during a marine mammal survey in the eastern tropical pacific ocean aboard the NOAA ships *McArthur* and *David Starr Jordan.*
K.F. MANGELS and T. GERRODETTE
(May 1994)