ENDANGERED SPECIES ACT SECTION 7 CONSULTATION
BIOLOGICAL OPINION

Action Agency: National Marine Fisheries Service, Office of Protected Resources, Endangered Species Division

Activity: Issuance of Scientific Research Permit #1303 Under Section 10(a)(1)(A) of the Endangered Species Act to Take Sea Turtles while Conducting Experiments on Methods for Reducing Sea Turtle Take by Longline Fisheries and Determining Target Species Catch Per Unit Effort Viability and to Transport Deeply Hooked Hard-shelled Turtles for Rehabilitation

Consulting Agency: National Marine Fisheries Service, Office of Protected Resources, Permits, Conservation, and Education Division

Approved By: ________________________________

Date Issued: ____**January 2002**____________________________

Introduction

Section 7(a)(2) of the Endangered Species Act (ESA) (16 U.S.C. § 1531 et seq.) requires that each federal agency "shall ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species." When the action of a federal agency may affect a listed species, that agency is required to consult with either National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the protected species that may be affected. For the actions described in this document, the action agency (applicant) is the Southwest Fisheries Science Center (SWFSC)-Honolulu Laboratory of NMFS. The consulting agency is the Endangered Species Division, also of NMFS. Section 7(b) of the ESA requires that the consultation be summarized in a biological opinion detailing how the action may affect protected species.

This document represents the NMFS' biological opinion (Opinion) based on our review of the proposed issuance of scientific research permit application #1303 and the effects of this action on green turtles (*Chelonia mydas*), leatherback turtles (*Dermochelys coriacea*), loggerhead turtles (*Caretta caretta*), and olive ridley turtles (*Lepidochelys olivacea*), in accordance with section 7 of the ESA.

This Opinion is based on information provided in the permit application, sea turtle recovery plans, past and current research, and biological opinions for this and other relevant fisheries.

Under section 10(a)(1)(A) of the ESA, individuals and organizations may apply for permits from NMFS to take ESA-listed species under the jurisdiction of NMFS if such taking is for scientific purposes or to enhance the propagation or survival of the affected species. In determining whether to issue a scientific research permit, the Assistant Administrator shall specifically consider, among other application criteria, the following relevant measures: (1) whether the permit, if granted and exercised, will not operate to the disadvantage of the endangered species; (2) whether the permit would be consistent with the purposes and policy set forth in section 2 of the ESA[1]: (3) whether the permit would further a bona fide and necessary or desirable scientific purpose or enhance the propagation or survival of the endangered species, taking into account the benefits anticipated to be derived on behalf of the endangered species; and (4) the status of the population of the requested species and the effect of the proposed action on the population, both direct and indirect (Code of Federal Regulations (CFR) Section 222.308).

On May 1, 2001, NMFS' Office of Protected Resources (OPR) received a complete application for a scientific research permit from NMFS-SWFSC - Honolulu. The purpose of the application is to request a permit to (1) take sea turtles while conducting experiments in the Pacific Ocean on methods for reducing sea turtle take by longline fisheries and on testing target species catch per unit effort (CPUE) viability; and (2) transport living, deeply hooked hard-shelled sea turtles for treatment to alleviate hooking damage and to monitor the progression of ingested hooks. In order to fulfill its requirements under the National Environmental Policy Act, OPR is currently in the process of completing an Environmental Assessment for this action.

Background

This permit action was precipitated by a larger action undertaken by NMFS, beginning in 1999, when an environmental impact statement (EIS) for the implementation of the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region (Pelagics FMP) was prepared. The final EIS (FEIS) was completed on March 30, 2001. This Pelagics FMP has been the subject of litigation. A complete history of the recent litigation and EIS development can be found in Section 1.2 of the FEIS entitled "Need for the Proposed Action."

In a May 18, 2000, memo to the Director of the NMFS Pacific Islands Area Office (PIAO), the SWFSC, which is responsible for calculating the estimates of incidental take occurring in the Hawaii-based longline fishery, noted that the Hawaii-based longline fishery had likely exceeded anticipated incidental take levels of olive ridley turtles (NMFS, 2000a). On June 7, 2000, the

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[1]The purposes of the ESA are to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, to provide a program for the conservation of such endangered and threatened species, and to take such steps as may be appropriate to achieve the purposes of treaties and conventions. (16 U.S.C. 1531 *et seq.*)

Southwest Region reinitiated consultation on the fishery (NMFS, 2000b). On March 29, 2001, NMFS issued the "Biological Opinion on the Authorization of Pelagic Fisheries under the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region" (NMFS, 2001a). A complete administrative record for the March 29, 2001, opinion is available in the Southwest Regional Office, Long Beach, California.

After reviewing the best available scientific and commercial data, the current status of Pacific Ocean sea turtles, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, NMFS concluded that the continued authorization of pelagic fisheries in the Western Pacific Region under the Pelagics FMP was likely to jeopardize the continued existence of green, leatherback, and loggerhead sea turtles. In order to avoid jeopardy for these three species, NMFS developed a reasonable and prudent alternative (RPA) comprised of five elements.

Because a significant number of sea turtle takes appeared to be related to how the longline gear is set, NMFS prohibited longline fishing practices targeting swordfish or a mixture of targets north of the equator, by vessels operating under the Pelagics FMP. By eliminating swordfish-style fishing, NMFS expected that the incidental capture of loggerhead turtles would be virtually eliminated and there would be a significant reduction in the takes of leatherback, green, and olive ridley turtles. Second, NMFS implemented time and area closures to prohibit all longline fishing south of 15^{o} N latitude, north of the equator (0^{o}), west of the 145^{o}W and east of the 180^{o} longitude between April 1st through May 31st. The implementation of both RPA elements was expected to reduce interactions between the Hawaii-based longline fishery by an estimated 100% for loggerheads, 82% for leatherbacks, 85% for greens, and 52% for olive ridleys (point estimates).

The Hawaii-based longline fishery is a small segment of the total amount of longline fishing that occurs in the Pacific Ocean compared to the international fleet (e.g., Japan, Korea, and Taiwan), Recommendations to address sea turtle interactions with longline fisheries and to develop or modify gear technologies and fishing strategies for reducing sea turtle capture rates in fisheries have been suggested (Balazs and Pooley, 1994; Williams et al.1996; Hoey, 1998; Hoey and Moore, 1999; Kleiber and Boggs, 2000). In order to increase the likelihood of survival and recovery of these sea turtle populations, a Conservation Recommendation of the March 29, 2001, biological opinion recommended that NMFS research modifications to existing gear that (1) reduce the likelihood of gear interactions and (2) dramatically reduce the immediate and/or delayed mortality rates of captured turtles (e.g., visual or acoustic cues, dyed bait, hook type). In addition, all research funded and/or implemented by NMFS must be covered by a research and enhancement permit pursuant to section 10(a)(1)(a) of the ESA. The goal of any research would be to develop a technology or method, via a robust experimental assessment, which would achieve the above two goals and remain economically and technically feasible for fishermen to implement. By exploring these research needs, NMFS believed that it would be in a better position to lead the development and cultivation of open and collaborative dialogue between international fishing communities towards creating solutions to this world wide problem.

Examples of such efforts to reduce international takes of protected species include the adoption of dolphin-safe fishing methods in foreign tuna purse-seine fisheries, the export of turtle excluder devices (TEDs) to foreign trawl fisheries, and the use of trade sanctions to encourage foreign nations to adopt such methods. The proposed research permit under consultation in this Opinion responds to this Conservation Recommendation.

On March 30, 2001, after receiving the FEIS and the biological opinion on the Pelagics FMP, the U.S. District Court of Hawaii (Court) issued an Order making effective the preferred alternative in the FEIS (equivalent to the RPAs contained in the biological opinion) that intended to mitigate the Hawaii-based longline fishery interactions with turtles.

On June 12, 2001, NMFS published an emergency interim rule which would codify the aforementioned Order, effective from June 12, 2001 through December 10, 2001 which, among other requirements: (1) prohibits the targeting of swordfish north of the equator by Hawaii longline vessels (includes certain gear requirements to ensure swordfish-style fishing is not possible); (2) prohibits longline fishing by Hawaii longline vessels in waters south of the Hawaiian Islands (from 15°N latitude to the equator, and from 145°W longitude to 180° longitude) during the months of April and May.

On December 12, 2001, the NMFS Acting Regional Administrator, Southwest Region, Rodney McInnis, signed a memorandum to Donald Knowles, the Director of the NMFS Office of Protected Resources, reinitiating consultation on the effects of the Western Pelagic Fisheries on sea turtles under section 7(b) of the Endangered Species Act, 16 U.S.C. ' 1536(b). NMFS reinitiated the March 29, 2001, consultation because new information is available which may improve NMFS' ability to quantify and evaluate the effects of the pelagic fisheries under the Fishery Management Plan (FMP) for the Pelagic Fisheries of the Western Pacific Region and the reasonable and prudent alternative in the Biological Opinion on listed sea turtle populations. The new information available consists of an improved sex- and age- class structured stochastic simulation model of leatherback sea turtle population dynamics, recent eastern Pacific leatherback population censuses for the 2000/2001 season, fewer vessels are operating than what was anticipated under the March 29, 2001 Reasonable and Prudent Alternative, new observer data collected since 1999, and correction of a minor error to the anticipated take in the incidental take statement. If the evaluation of this new information and conclusions drawn as a result of this reinitiation of the March 29, 2001, biological opinion constitute significant new information that would change the evaluation and conclusions of this opinion, NMFS will reinitiate this biological opinion on the issuance of research permit # 1303.

I. CONSULTATION HISTORY

The applicant for scientific research permit #1303 is NMFS-SWFSC, Honolulu Hawaii. On May 1, 2001, OPR received a complete application for a scientific research permit from NMFS-SWFSC. After making a preliminary determination that the application was complete, and as required by 50 CFR 222.303(b), NMFS published a notice of receipt in the Federal Register on May 10, 2001, (66 FR 23882). The 30-day public comment period closed on June 11, 2001. On June 18, 2001, the comments were sent to the applicant, and were responded to on July 5, 2001.

In their permit application, NMFS-SWFSC stated that tissue sampling, disposition of samples and turtle tagging would be covered under two separate permits (Permits #1190 and #1296) held by the Honolulu Laboratory and NMFS - Southwest Regional Office (SWRO). Consultation history for these two permits and related research is described below. This is the first time that the testing of modified longline gear to determine effectiveness at reducing sea turtle interactions and determine target species catch per unit effort viability has been conducted in the Pacific Ocean.

On July 2, 2001, this applicant received a five year scientific research permit (#1296) authorizing trained longline captains and crewmembers to perform sea turtle research activities at sea to help NMFS better fulfill its ESA responsibilities to recover sea turtles. The purpose of the research is to document and evaluate the incidental take of sea turtles in the Hawaii-based longline fishery, and the permit authorizes specific individuals to examine, tag, weigh, measure, resuscitate, take tissue samples, and release incidentally-captured turtles. Maximum authorized annual takes under this permit are: 13 green turtles, 61 leatherbacks, 122 loggerheads, and 42 olive ridleys.

The SWR's second permit (#1190) was originally issued on March 8, 1999, authorizing observers to continue to handle, measure, photograph, and flipper tag up to 10 green sea turtles, 25 leatherbacks, 150 loggerheads, 10 olive ridleys and 10 hawksbills annually in the Eastern Tropical Pacific Ocean in association with the Hawaii longline fishery. This observer program was required as a term and condition of a reinitiated biological opinion on this fishery issued on November 3, 1998. Permit #1190 also authorized up to 15 of the hard-shell turtles to have transmitters attached to them for tracking purposes.

Modification #1 to Permit #1190 was issued on September 21, 2000. The modification increased the authorized take of olive ridley turtles from 10 to 25 annually due to an increase in the coverage of the fleet as a result of a court order. The permit was also amended by NMFS to clarify the permit holder as the NMFS-SWRO and to clarify that transmitters can only be attached to hard-shelled turtles using the techniques laid out in the observer field manual included as part of the application. No other changes to the permit were issued.

On August 21, 2000, NMFS received a request from the SWRO to increase the authorized take of turtles under permit #1190. The modification request asked for an increase in the authorized take of all five listed turtle species. The increases were necessary due to higher numbers of observed takes expected under court mandated requirements. On August 4, 2000, a court order was issued and filed in U.S. District Court, District of Hawaii, requiring NMFS to increase its observer coverage to over 20% for the Hawaii longline fishery (historically, NMFS had a 3%-5% coverage level for the fishery).

Modification #2 to Permit #1190 was issued on February 20, 2001. The permit was modified to authorize maximum takes (i.e. examined, tagged, weighed, measured, resuscitated, using approved techniques, have tissue samples taken, and released) per year of the following: up to 40 green turtles, up to 100 leatherback turtles, up to 600 loggerhead turtles, up to 100 olive ridley turtles, and up to 40 hawksbill turtles. In addition, under Modification #2 to Permit #1190, NMFS-SWRO was authorized to attach transmitters on up to 50 of the above-listed hard-shelled turtles.

II. DESCRIPTION OF THE PROPOSED ACTION

The National Marine Fisheries Service's Office of Protected Resources proposes to issue a scientific research permit (#1303) under Section 10(a)(1)(A) of the ESA to the SWFSC, Honolulu, Hawaii, to: (1) take sea turtles while conducting experiments on fishing gear modifications for reducing sea turtle take by longline fisheries; (2) take sea turtles while conducting experiments to test the viability of fishing gear modifications for catching targeted fish species; and (3) import live, deeply hooked, hard-shelled sea turtles for treatment to alleviate hooking damage and to monitor the progression of ingested hooks. The goal of the Minor Gear Modification of the experiment (1) is to test modifications to fishing gear that evidence suggests should reduce sea turtle take by longliners, and which evidence also suggests will maintain viable fishing performance. This experiment will only begin if the results and analysis from ongoing experiments, expected by spring 2002, provide evidence that further experimentation is warranted. The goal of the "Stealth" Gear and Deep Set Day Time Fishing and Hook Timer and Hook Type part of the experiment (2) is to see if more radical gear modifications have viable fishing performance, without which there is no point in exposing turtle populations to further testing of those modifications. The ultimate purpose of these first two parts of the experiment is (a) to develop less expensive and more effective sea turtle protection measures for the domestic longline fishery that will be superior to the time and area closures we use now, and (b) foreign longline fisheries worldwide can be encouraged to adopt these fishing methods. Gear modification measures are believed to be the most easily and consistently adopted measures throughout the domestic and international longline fleets and therefore are expected to achieve the greatest conservation benefit for sea turtles. The research is in response to a Conservation Recommendation placed on NMFS in the March 29, 2001, biological opinion for the Pelagics FMP (NMFS, 2001) a recommendation that was similar to other (Williams et al.1996; Hoey, 1998; Hoey and Moore, 1999; Kleiber and Boggs, 2000).

The following description of the proposed research is taken from the May 1, 2001, permit application.

All research activity under this permit will be conducted by fishery biologists, biological technicians, fishery observers, vessel operators and crew of Hawaii-based longline fishing vessels. Fishery observers working for NMFS PIAO will supervise most of the experiments which will be conducted on contracted fishing vessels. The principal investigator and principal field supervisor may also recruit fishery technicians to supervise some of the experiments. No experiments will be conducted by vessel operators without supervision by a NMFS employee or contracted fishery biologist, biological technician, or fishery observer. Handling and treatment of sea turtles (except transportation), collection of information, biopsies taken or radio transmitters or tags that are applied to a captured sea turtle will be covered by research permits #1190 and #1296.

Under the scientific research permit, fishing vessel operators will be contracted to use their fishing vessels to conduct the fishing experiment under the direction of field supervisors. Catch of target species will be sold to reduce the cost of the contracted fishing operations. In addition, catch sales data will be used to demonstrate the relative economic viability of modified fishing operations in comparison with unmodified fishing operations. Vessel operators will be chosen through an interview process conducted by NMFS that will focus on aptitude, adherence to rules, understanding of technical requirements, and motivation. Vessel operators under consideration will participate in a workshop covering the fishing technology and contract requirements of the experiments and will be tested on their comprehension to ensure understanding of the experiment, the terms and conditions of their contracts, and the role of their field supervisor. Field supervisors working for NMFS (fishery biologists, biological technicians, or fishery observers trained in turtle handling procedures) will oversee all turtle takes by each fishing vessel and terminate participation by any vessel operator or crew member who does not adhere to research protocols and turtle handling procedures. Furthermore, all measures that have been implemented by regulations in the commercial fishery to reduce the mortality of the bycatch will be used in the experiments (50 CFR 223.206(d)(1)), including the handling and release of turtles captured, resuscitation, etc. In addition, takes of sea turtles in the experiments will be reported to NMFS on a real-time basis using single sideband radio or the satellite vessel monitoring system. If at any time NMFS determines that the take levels for the experiment have been exceeded or are likely to be exceeded in the control and treatment fishing operations required by the experimental design, then NMFS will cease the experiment.

Vessels contracted for this experiment will fish in typical fishing areas and will strictly adhere to the general parameters presented in Table II-1 for experiments with swordfish-style and tuna-style of fishing, respectively. As explained further below, the only experiment that is planned for both styles of fishing is the testing of stealth fishing gear for the viability of target species CPUE. Experiments will be conducted throughout the year, depending on the availability of contracted vessels. Tuna style fishing may occur during April and May, but will avoid the closed area established to protect sea turtles (50 CFR 660.34(c)).

Table II-1. Average of fishing gear parameters for the Hawaii-based longline fishery using two styles of fishing: Swordfish-style fishing and tuna-style fishing.

Gear/Trip Type	Swordfish Fishing	Tuna Fishing
Area Fished	North of Hawaiian Islands	South of Hawaiian Islands
Main line Length	42 miles	34 miles
Shooter Used	No	Yes
Vessel Speed	7.8 knots	6.8
Lightsticks Used	Yes	No
Branch Line Length	17 meters	13 meters
Float Line Length	8 meters	22 meters
Number of Hooks per Set	820 hooks	1,690 hooks
Number of Hooks per Float	4 hooks	27 hooks
Number of Floats	189 floats	66 floats
Type of Hook	J-shaped	Tuna
Type of Bait	Squid	Saury
Target Depth	28 meters	167 meters
Gear Soaks	Night	Day
Soak Time	20 hours	19 hours

A. Gear modification (test use of blue-dyed bait and moving branch line)

Two modifications to fishing practices which have been determined to have promise for reducing turtle takes while having only minor impacts (if any) on fishing performance (target species CPUE) are the use of squid bait dyed blue with food coloring and the removal of branch lines attached to the main line closest to the float line attachment points. Similar field work is being conducted in the Atlantic Pelagic longline fishery under Permit # 1324. This experiment will only begin if the results and analysis from this and other ongoing experiments, expected by spring 2002, provide evidence that further experimentation is warranted.

The first portion of the proposed research would simultaneously test a combination of these two experimental gear modifications as a single experimental fishing treatment against a control. The experiment would test the effect of longlining for swordfish using blue-dyed bait and moving the nearest branchlines to at least 40 fathoms from the nearest floatline and comparing this method to standard (i.e. control) fishing operations. Data analyses and results would determine the efficacy of the combined method for reducing sea turtle bycatch, compared to normal fishing operations. This portion of the experiment will involve the majority of time and effort (3 years) and will also have the most impact to turtles (i.e. higher turtle take than other portions of the experiment).

A limiting condition of the proposed experiment is the need to minimize the take of endangered and threatened sea turtles while retaining the statistical power necessary to detect a significant effect of the bycatch reduction treatment. Turtle takes are rare events in the Hawaii-based fishery and they have the statistical power of a Poisson distribution, in which the standard deviation is as large as the mean. In such circumstances, the statistical power of a controlled experiment depends on the number of turtles taken in control and treatment operations (see attachment 1 to the May 1, 2001, permit application) and not on the number of fishing operations (sets). Therefore, to increase the power of the experimental tests, it is best to use the fishing style with the greatest turtle take rate, which, in the Hawaii-based longline fishery, is swordfish-style fishing. This type of fishing is the best for testing sea turtle take reduction measures because, based on historical data, it will have a higher take rate and will provide more rapid statistical confirmation of bycatch reduction by contrasting control and treatment operations.

The objective of the experiment will be to test whether a treatment reduces turtle takes versus a control. The experiment will continue until a fixed number of turtles are caught, often referred to as a "sequential" experiment. Because alternating treatments with controls along a single longline will not result in independence between control and treatment if the control sections (e.g. highly visible undyed squid) attract turtles to the adjacent treatment sections, full sets will serve as the experimental unit for testing any treatment that involves the attractiveness of the longline to turtles or to target species. The applicants have assumed that turtle takes come from two distributions (in the statistical, not the biological sense), a treatment group and a control group, and that within each group, turtle takes at the set level are independent identically distributed Poisson variates.

A power analysis was conducted to scope out a variety of sample sizes required to detect a bycatch method that has different degrees of effectiveness in comparison with the control fishing method (see attachment 1 in the May 1, 2001, permit application). Because leatherback turtles "arguably the species for which results are needed most badly due to the presumed dire status of the population," (application p. 20) the applicants chose this species to focus on for the experimental design. Take numbers required to detect a 25% effective treatment are much higher than those required to detect a 50% effective treatment because of the lower signal-to-noise ratio when the treatment is closer to the control method (Table 4 in the permit application). The higher the type I (alpha, attachment 1 in the application) and type II (beta, attachment 1 in the application) error rates that can be accepted, the lower the sample sizes required.

The applicants have proposed a one-sided composite test where the null hypothesis is that the treatment reduces turtle takes by 50% or more versus the alternative hypothesis that the treatment reduces turtle takes by less than 50%. Using the highest level of type I and II error rates that the investigators can accept, and anticipating that the treatment will be at least 50% effective in reducing take of leatherbacks, the preferred design will take a total of 36 leatherbacks spread out over 3 years (Table II-2). If the treatment is 50% effective, 12 of these turtles will be caught by treatment fishing operations and 24 will be caught by control operations and the results will be statistically significant at the alpha = 0.10 level and beta = 0.20 level . The required take is 12 leatherbacks per year (36 leatherbacks in 3 years), the number given in the summary of designs (Table II-5). Fractional numbers are raised to the nearest whole integer in summarizing annual takes (Table II-5).

Table II-2. Sea turtle takes/mortalities per year in minor gear modification experiment, with significant (50% effective*) leatherback findings in 3 years.

				Concomitant takes per year (other species)					
Error Levels		Leatherbacks/year		Loggerheads/year		Olive ridleys/ year		Greens/year	
Alpha	Beta	Takes	Morts	Takes	Morts	Takes	Morts	Takes	Morts
0.10	0.20	12	4	65	24	6	2	4	1

*treatment reduces leatherback take by 50% compared with control

Equal numbers of treatment and control operations (sets) will be conducted but the total number of sets listed is just an estimate based on historical capture rates of turtles by swordfish style fishing gear (leatherbacks - 0.0154/set; loggerheads - 0.0829/set; olive ridley - 0.0078/set; green - 0.0044/set). Again, the statistical properties of Poisson-distributed data are such that the number of sets is not critical to the test, and the experiment will be limited to the number of turtle takes required, not the number of sets estimated. If more sets are needed to reach the required number of observed turtle interactions, additional fishing operations will be contracted. The estimated total number of sets per year for this portion of the experiment will be 1,039, a third of the 3,117 sets that may be required over three years (Table II-5).

The estimated number of fishing operations required for finding a statistically significant effect of a bycatch reduction measure that is 50% effective for leatherback turtles will have a concomitant take of other turtle species, based on the historical rate of interactions with those species by the type of fishing operations that will be used in the experiment. The requisite number of operations for the preferred leatherback experimental design will probably result in a take of loggerhead turtles (65 per year, Table II-2) sufficient at an alpha level of 0.05 and a beta level of 0.10 to find a significant effect of a 50% effective bycatch reduction method in only 1 year (61 per year, Table 5 in the permit application). If the experiment is conducted for the full three-year estimated time period, this take will reach 195 loggerhead turtles which is enough to find a significant effect of a treatment that is only 30% effective at a lower, but acceptable error level. Since this design dovetails so well with the leatherback design it is incorporated in the preferred design for leatherbacks (Table II-5).

B. Testing "stealth gear" and deep-set daytime fishing for CPUE viability

Because of sea turtles' association with floating objects[2] and possible attraction to anomalies in what otherwise is a featureless ocean, the applicant proposes to test the use of "stealth" gear - longline gear that has been camouflaged in order to be less visible to sea turtles. Before determining whether this major gear modification may reduce sea turtle interactions, the applicants first want to ensure that CPUE of target species using these modifications is still comparable to standard longline fishing. Therefore, reducing the visibility of longline gear to sea turtles by using "stealth" longlines with major gear modifications is proposed for testing viability in maintaining target species CPUE in both swordfish-style (shallow set, nighttime) and tuna-style (deep-set, daytime) fishing operations and comparing to standard (i.e. controlled) swordfish- and tuna-style operations. Should the results indicate that CPUE remains comparable between the treatment and control then an experiment that tests whether the gear reduces sea turtle bycatch will be developed.

The treatment sets will utilize floats that are blue on the bottom and orange on top, and control sets will utilize typical floats that are orange all over. The treatment sets will also use dark grey monofilament for main line, float lines, and branch lines, while the control sets will use typical longline gear (i.e. visible). Battery powered, narrow-frequency, yellow light emitting diode-(LED) based, down-welling (shaded on the upper half) light sticks will be used on stealth gear (treatment), and regular yellow chemical light sticks will be used on standard gear (control). Lastly, for stealth gear (treatment), the metallic shine of the branch line and float line snaps will be removed or they will be painted, and the bait will be dyed blue, while controls will use natural (i.e. un-dyed) squid and longline gear used by typical Hawaii-based longline fishers. The applicants have stated that they need at least 3 fishing trips (i.e. 30 sets) with controls for a credible demonstration in both types of fishing operations. Therefore, there will be 30 control sets and 30 treatment sets each for swordfish-style and for tuna-style fishing operations (120 sets total).

Based on the number of sets needed to test CPUE viability, and on historical catch rates of the four species of turtles likely to be encountered by both swordfish-style[3] and tuna-style[4] fishing, the applicants have estimated the number and species taken (and killed) during this portion of the experiment (Table II-3).

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[2] see for example Hall, M.A. 1998. An ecological view of the tuna-dolphin problem: impacts and trade-offs REVIEWS IN FISH BIOLOGY AND FISHERIES; v. 8, no. 1, p. 1-34

[3]Applicants have used the following sea turtle interaction rate based on historical takes in the Hawaii-based longline fishery using swordfish-style fishing: 0.0044 greens/set; 0.0154 leatherbacks/set; 0.0829 loggerheads/set; and 0.0078 olive ridleys/set.

[4]Applicants have used the following sea turtle interaction rate based on historical takes in the Hawaii-based longline fishery using tuna-style fishing: 0.0025 greens/set; 0.0055 leatherbacks/set; 0 loggerheads/set; and 0.0153 olive ridleys/set

Similar testing of target species CPUE is proposed for deep-set daytime swordfish fishing. This proposed method would target swordfish deep, where they descend during the day, using swordfish-type bait and lightsticks in areas where near-surface nighttime swordfish abundance is high. Deep daytime fishing operations for swordfish will use a depth configuration comparable to that of tuna gear, which will be modified based upon results expected within the next few months from swordfish recently tagged with pop-up satellite transmitting archival tags (PSATs). These tags will report the typical daytime depth distribution of swordfish. Target depth will be achieved using a main line shooter and a much greater length of main line and greater number of hooks between floats while maintaining the standard swordfish-style number of branch lines per set. Depth will be measured with time-depth recorders to ensure target depths are achieved. The applicants have stated that 30 sets will be needed to demonstrate target species CPUE viability.

Based on the number of sets needed to test CPUE viability, and on historical catch rates of the four species of turtles likely to be encountered by swordfish-style fishing, the applicants have estimated the number and species taken (and killed) during this portion of the experiment. These take levels have been combined with the estimates for the "stealth" gear experiment and are presented in Table II-3. However, NMFS in its permit has authorized, for this experiment in combination with the Hook Timer and Hook Type experiment, observed and estimated post-hooking mortality of one leatherback on four loggerheads only. Should there be more mortalities, this experiment will cease and consultation will be reinitiated.

Every effort would be made to avoid taking any turtles in the stealth and deep swordfish fishing tests for target species CPUE. This will be accomplished by trying to schedule direct experimental fishing effort to times and areas where the target fish species CPUE was historically high and the turtle take rates were low. To demonstrate CPUE, some loggerheads, a few leatherbacks, olive ridleys, and green turtle takes are anticipated, based on historical interaction rates in the Hawaii-based longline fishery.

The stealth and deep day swordfish experiments will be conducted at the same time, and in the same area, with three vessels: one conducting control operations to demonstrate high near-surface abundance of target species, another conducting stealth tests, and the third conducting deep daytime fishing for swordfish. Thus there will be some economizing of the control operations to serve two purposes. In testing the stealth gear with tuna style fishing there will be only two vessels, as both stealth and control fishing operations will be conducted deep during the day. The vessels would fish south of the Hawaiian Islands, in areas currently open to Hawaii-based tuna fishing operations. This portion of the experiment is estimated to last no longer than one year. In addition, with a low number of sets, these experiments are expected to have low levels of sea turtle take. However, NMFS in its permit has authorized, for this experiment in combination with the Hook Timer and Hook Type experiment, observed and estimated post-hooking mortality of one leatherback on four loggerheads only. Should there be more mortalities, this experiment will cease and consultation will be reinitiated.

Table II-3. Stealth gear and deep daytime swordfishing tests to demonstrate CPUE viability

Number of sets			Synoptic Vessels	Total Turtle Takes/Mortalities (one year experiment)							
Control	Stealth	Deep Day		Leatherback		Loggerhead		Olive ridley		Green	
60	60	30	3	2	1	8	3	2	1	1	1

C. Testing use of hook timers and hook type

Measuring trends in the time and depth of sea turtle captures could reveal particular time intervals or depths of longline operations for which sea turtles are most vulnerable, revealing possible modifications to fishing operations for future testing. The use of hook timers, in conjunction with time-depth recorders (Boggs, 1992) is proposed for this purpose. Hook timer experiments will be conducted using standard swordfish style gear fitted with hook timers as described by Boggs (1992). No controls are used, and the comparison is between different times and depths within the combined fishing operations. Based on research conducted on fish (Boggs, 1992), the applicants anticipate that 30 hook timer readers (i.e. 30 observations of a sea turtle species taken by longline) are needed in order to detect trends in turtle capture time or depth. Based on historical take levels in the swordfish fishery, the applicants anticipate that two years are needed for this portion of the experiment.

The testing of large (18/0) circle hooks for the viability of target species CPUE is proposed as a piggyback project during the hook timer measurements. Therefore, this experiment will utilize alternating “J” and 18/0 circle hooks on all hook timer operations. The applicants anticipate that this portion of the experiment will only require one year to demonstrate credible results. Experiments comparing 16/0 circle and J hooks in the Azores (Bolton and Bjorndal, 1999) and in the North Pacific (LaGrange, 2001) reduced the severity of injury of a hooked turtle; however the target species CPUE was reduced by 30-50%. Both Bolton (personal communication) and LaGrange (personal communication) have suggested that larger (18/0) circle hooks could increase the viability of target species CPUE. Therefore testing larger circle hooks is proposed for this purpose. Because testing of different hook types differs only in their mechanical effects after a target species (or turtle, in the hook timer portion of the experiment) interacts with the hook, treatment and controls can be applied independently on the same set without pseudo-replication. If the 18/0 circle hooks are as effective at catching target species as the standard J hook, then the implementation of this gear modification in longline fisheries may reduce the severity of sea turtle injuries, thereby increasing post-release survivability.

Table II-4 shows the number of sets anticipated per year to detect trends in loggerhead capture time or depth. Loggerheads have been chosen since, based on historical capture records, this is the species most likely to interact with the swordfish fishery north of the Hawaiian Islands. Other sea turtle species will be taken concomitantly with loggerheads, as shown in the table.

Table II-4. Hook timer and hook type experiments, estimated effort, turtle take/mortality per year.

Total Years	Sets/ year	# Full-time vessels	Loggerheads/yr		Leatherbacks/yr		Olive ridleys/yr		Greens/yr	
			Takes	Morts	Takes	Morts	Takes	Morts	Takes	Morts
2	181	2	15	6	3	1	2	1	1	1

D. Annual Evaluation

Permit #1303 is proposed to be issued for up to three years. However, based on evaluation of data collected in this proposal, as well as results of the Atlantic NED Pelagic Longline Fishery Experiment and other lab or field experiments, the permit may be modified or not reauthorized beyond the first year evaluation. At the end of the first year of the Minor Gear Modification experiment, an evaluation, in consultation with the OPR, on whether or not to continue the experiment will be based upon all results, including the results of a risk assessment to determine the costs and benefits of revising the experimental design to incorporate newly discovered or developed take reduction measures. The applicants have stated that they would be able to determine success for loggerheads within the first year due to the high interaction rates loggerheads have had with swordfish sets and the number of sets needed to obtain first-year results for leatherback interactions. If the applicants determine that the experiment has not successfully reduced interactions with loggerheads by 50%, they may re-evaluate their experiment and, based on the results of other lab or field experiments, request a modification to their permit. If no other information is available, the experiment will cease in order to avoid unnecessary takes of turtles. This Opinion will assume that the results and analysis from ongoing experiments, expected by spring 2002, provide evidence that warrants further experimentation and will evaluate the effects of issuing a 3-year permit for the experiment as it is currently proposed. However, any takes that are anticipated for a modified experiment will not exceed anticipated takes identified in this initial Permit #1303.

If after one year the applicants show that minor gear modifications have had a 50% or greater reduction in loggerhead interactions, the OPR will evaluate whether or not the experiment should continue another year in order to evaluate success for leatherbacks. Their determination will be based on: 1) the status of loggerheads; and 2) initial results with leatherbacks during the first year of testing. Continuing the experiments for another 2 years in order to prove effectiveness for leatherbacks might unnecessarily affect loggerheads after the point when the effectiveness of a measure has been determined for these species. Therefore, it is important to re-evaluate the status of loggerhead populations in order to determine whether or not they can withstand additional takes and possible mortalities. It is also important to determine whether results from the first year of testing show any positive results for leatherbacks.

If the initial results are anywhere within a fairly broad range, they might still average out to show 50% effectiveness after the full three year experiment due to the very high variance in turtle take rate. Therefore statistical analyses conducted at an interim point in the experiment will have to indicate a very unsuccessful preliminary result (e.g. bycatch increase using the modified gear) to be almost certain that a continued experiment would not eventually show 50% successful bycatch reduction at acceptable confidence levels. A lack of interim positive results will have to be detected at a very high probability (e.g. $p< 0.05$) to be conclusive. For example, assuming Poisson distributed data, after 12 leatherback turtle takes the distribution would have to be 5 in the control treatment and 7 in the modified gear treatment to conclude with 95% confidence that the treatment was not having a 50% reducing effect on bycatch.

Without conclusive findings that the results are negative, and in the absence of other considerations, the leatherback experiment would continue in order to reach significant conclusions within the general levels of statistical confidence selected in the original power analysis. Also, interim testing will alter the power analysis. All tests and probabilities after the first year will have to be re-derived conditional on the experiment continuing to the year of interest.

If the OPR determines that the modified gear experiments show initial success with leatherbacks and that loggerhead status has not declined, the experiment will continue for a second year. If the status of loggerheads has declined below the status of the species reviewed in this opinion (e.g. if additional information indicates new threats, higher rates of decline, or a worsening population structure), NMFS must either take measures to improve the baseline such that positive benefits will offset the negative consequences of the experiment, or the experiment must be discontinued. If the experiment does not show initial success for leatherbacks, the applicants will need to re-evaluate potential changes to the experiment (e.g. use of stealth gear, deep daytime sets, use of 18/0 circle hooks) that might prove successful for reducing leatherback interactions before continuing with the experiment. If the OPR determines that one year of modified gear experiments have not shown success for leatherbacks and the status of loggerheads is worse than anticipated in the Opinion (i.e. baseline conditions have worsened), then methods will have to be revised and improvements to the baseline of loggerheads will have to be implemented if the experiments are to continue.

If the experiments continue for a second year, another risk assessment and evaluation as described above will take place after the second year before the final year of experiments can proceed.

E. Total estimated turtle take from experiments

The applicant has applied for a three year scientific research permit. However, with the implementation of a risk assessment and evaluation to be conducted after each year of the experiment, the experiment may last only one or two years. Table II-5 shows the total anticipated take and mortality of sea turtles with a three year experiment. The anticipated take levels for Year 2 and Year 3 are less than Year 1 because the second (stealth and deep set daytime fishing tests) and third portions (hook timer and hook type test) of the experiment are only expected to take one and two years, respectively.

The annual estimated maximum incidental mortality is calculated by adding the 1) immediate mortality (multiplying annual estimated maximum incidental take by the immediate mortality rate for that species of sea turtle in the swordfish-style component of the fishery) and 2) delayed mortality (multiplying the remaining live animals by the delayed mortality rate of 27 to 42 percent based on rates of deep and light hooking for the species in the swordfish-style gear segment of the fishery). The deeply hooked turtles that are returned to Honolulu for observation and potential rehabilitation may have a reduced rate of delayed mortality, which could reduce the number of mortalities below these estimates.

Table II-5. Preferred Experimental Designs

Experiment	Years to complete	Leatherbacks/ year		Loggerheads/ year		Olive Ridleys/ year		Greens/ year	
		Takes	Morts	Takes	Morts	Takes	Morts	Takes	Morts
Minor gear modification	3	12	4	65	24	6	2	4	1
"Stealth" gear and deep-set daytime fishing	1	2	1	8	3	2	1	1	1
Hook timers/ alternative hooks	2	3	1	15	6	2	1	1	1
Totals by year	Year 1	17	6	88	33	10	4	6	3
	Year 2	15	5	80	30	8	3	5	2
	Year 3	12	4	65	24	6	2	4	1
Grand Total		**44**	**15**	**233**	**87**	**24**	**9**	**15**	**6**

Some of the turtles taken and released alive during these experiments may be biopsied and tagged with flipper tags, passive induced transponder tags, radio transmitters, or pop-up satellite transmitting archival tags, but only if these activities are conducted by authorized personnel using techniques approved for these activities by other permits (Permits #1190 and 1296). Section 7 consultations have already been completed by NMFS for these permits. The applicant has requested that fishery biologists and biological technicians contracted or employed by NMFS as field supervisors in this experiment be authorized to handle, tag, biopsy and release sea turtles using techniques authorized by permits #1190 and #1290 after training as described in those permits.

F. Returning deeply hooked turtles to port for rehabilitation and monitoring

The applicants propose to transport deeply hooked (defined as hook ingested past the mouth cavity - in esophagus or deeper) hard-shelled turtles taken in the experiments back to holding facilities for treatment and monitoring of hook progression. Permitting the development of treatments and rehabilitations for hooked turtles will also provide an opportunity to better understand the mode of injury and prognosis for recovery of deeply hooked turtles (i.e. mortality rate). Only hard shelled sea turtles of less than 70 cm straight carapace length will be transported, and only if they are captured within an estimated 72 hours return time to Honolulu.

Based on the raw observer data for sea turtles caught by shallow set swordfish and mixed target longline sets, the percentage of turtle species that are deeply hooked and alive, and caught within 72 hours of Honolulu (at a vessel speed of 8 knots) are: about 7% for loggerhead turtles, 53% for olive ridley turtles, and 20% for green turtles. The data on all turtle takes that have been measured by observers indicates that about 82% of loggerheads, 100% of olive ridleys, and 87% of greens are under 70 cm straight carapace length (attachment 4 in permit application). These percentages and the estimated number of turtles which may be taken in the experiments were used to estimate the number of turtles which might be transported to Honolulu (Table II-6). These estimates are likely to be higher than the number actually transported as the vessel may not always be prepared to depart immediately for Honolulu from the capture location. However, if more turtles of the appropriate size or condition for transport happen to be captured, the applicants state that there is no reason why they also should not also be returned to port, and therefore, the numbers in Table II-6 are not intended to be a limit. The upper limit will be the total annual take shown in Table II-5.

Table II-6. Estimated annual number of deeply hooked but alive hard-shelled turtles less than 70 cm straight carapace length captured during the experiments within 72 hours of Honolulu that could be transported to Honolulu for treatment and monitoring of hook progression.

Species	Annual Estimated Turtles Transported		
	Year 1	Year 2	Year 3
Green	1	1	1
Loggerhead	5	5	4
Olive Ridley	5	4	3

1. Transportation of a Listed Species

a. The NMFS Honolulu Laboratory has been transporting injured and diseased turtles for many years as part of the Sea Turtle Stranding Network. Transportation from vessels to the veterinary clinic on Oahu by motor vehicle will follow the same procedure used in the Stranding Program to transport injured or diseased turtles on Oahu. Transportation at sea will be provided by captains of fishing vessels participating in the research under the supervision of on-board fishery observers, fishery biologists, or biological technicians.

b. Turtles must be caught within an estimated 72 hours from the port of Honolulu and will be brought to port within 8 hours of this estimated time or else they will be released at sea. The Protocol for Sea Turtle Stranding Response (attachment 5 in the permit application) calls for turtle transportation 24 hours a day 7 days a week with a typical response time of a few hours for remote Oahu locations during weekends and after hours. With the advantage of real time reporting from participating vessels and with a veterinarian contracted specifically for this project it should take no more than an hour to transport the turtles from the vessel to the veterinarian. Depending on the turtles condition and any necessary surgery or other treatment turtles will be kept at the clinic for as long as necessary and then be moved again to NMFS holding facility at Kewalo Basin. Turtles which appear to be rehabilitated will be released to the wild (1c, below) and some turtles may be euthanized when necessary in the opinion of the attending veterinarian (Section 3, below)

c. Turtles which eliminate hooks or have had them removed by surgery or other means developed by the veterinary work in this project, and which appear to be fully recovered may be transported back to a vessel and taken to sea for release within a 72 hour radius of Honolulu.

d. Turtles will be transported at sea and in Honolulu using Petmate Vari Kennels, giant size (48 inches long x 32 inches wide x 35 inches high) which will be supplied to each vessel participating in the research. These kennels are wide enough for the largest turtles that will be transported (70 cm straight carapace length = 28 inches).

e. Captured deeply-hooked turtles that will be returned to Honolulu will be handled according to the guidelines developed in NMFS workshops (*see* Guidelines for Handling Marine Turtles Hooked or Entangled in the Hawaii Long line Fishery, Balazs *et al.*, 1995). These include specified procedures for how to haul the main line, retrieve branch lines which catch turtles, assess turtle condition and hook location, removing lines, resuscitation, and care of turtles on board the vessel. The procedures are those mandated for use by all Hawaii-based longline captains and crew by court order and/or reasonable and prudent measures or conservation measures stated in relevant biological opinions, to de-hook and disentangle, and resuscitate turtles, as appropriate and possible. In this study the field supervisor (fishery observer, fishery biologist, or biological technician) will oversee or conduct these procedures, and instead of returning a recovering deeply-hooked turtle to the sea after 24 hours, the turtle will be retained on board, covered in a moist cloth in the pet carrier in a shaded area for the 72 hour transit period to Honolulu.

Treatment by the veterinarian in Honolulu will include all measures possible at a fully equipped clinical facility including x-rays, surgery, anesthetics, antibiotics, etc. as deemed best by the project veterinarian (to be named). The veterinarian contracted for the project will have a minimum of 5 years experience in the first hand assessment and treatment of injured and diseased sea turtles and will operate from a clinic provided with complete veterinary instrumentation required to treat injured and diseased sea turtles. When a turtle's condition has stabilized and/or all treatments which may improve its chances for survival have been carried out, it will be moved to NMFS holding facility at Kewalo Basin. If the turtle is to be returned to the sea for release, the release procedure will again be as specified in the "Guidelines for Handling Marine Turtles Hooked or Entangled in the Hawaii Long line Fishery" (Balazs et al., 1995).

2. Holding of a Listed Species:

a. Dimensions of pools used to hold sea turtles at NMFS Kewalo Facility and water supply:

2 fiberglass tanks, 2 m diameter, 1 m deep, 20 gal/h, 2 turtles/tank maximum.

2 fiberglass tanks, 2 m diameter, 1.5 m deep, 20 gal/h, 2 turtles/tank maximum

3 fiberglass tanks, 7 m diameter 2 m deep, 200-300 gal/h, 10 turtles/tank maximum

Turtles will be less than 70 cm straight carapace length, of both sexes, and unknown age. Within these broad categories, the size and species of individuals held at any given time will vary and cannot be predicted since incidental captures are involved. The maximum number of turtles per tank listed above is based on assuming a 70 cm carapace length, whereas a larger number of smaller turtles could be kept. Assuming 70 cm carapace length, the capacity of the 7 tanks is 38 turtles. The total number and mix of species may be as estimated in Table II-5, with a maximum of 11 turtles in the first year, but it would be extremely unlikely that such numbers of turtles would need to be held at one time. Delayed mortality of the deeply hooked turtles is assumed in the Western Pelagics FMP biological opinion (NMFS, 2001a) to be 42% so it would be unlikely that even the total annual numbers estimated to be transported (8 to 11 turtles) would ever need to be maintained at one time.

b. Water quality. Water supply is from a filtered sea water well, no temperature control is needed since ambient temperature is maintained at 25 ± 1°C. Oxygen levels are irrelevant as turtles are air breathers.

c. Frozen squid (*Loligo*), and or herring (*Clupea*) packed for human consumption, is maintained frozen until day of use, then thawed and fed to turtles once a day *add libitum* (Protocol for care and feeding of Kewalo turtles, attachment 6 in the permit application). Depending on appetite and size feeding turtles are fed 1-15 squid or fish weighing around 100 grams apiece per day.

d. Sanitation practices include regular tank cleaning and quarantine of diseased turtles (Protocol for care and feeding of Kewalo turtles, attachment 6 in the permit application). Green sea turtles affected by fibropapilloma tumors are held in separate tanks, fed and cared for after non-tumored turtles have been fed and cared for, and are cleaned with separate brushes. Tanks and brushes used with tumored turtles are disinfected prior to use with non-tumored turtles.

3. Emergency contingencies

Euthanasia will be used when necessary according to the procedure given under University of Hawaii - Institutional Animal Care permits (attachment 7 in the permit application).

NMFS Kewalo Facility has a second sea water well with its own pump as a backup to the primary seawater supply. The facility also has an automated alarm system that notifies key personnel in case of fire or power failure. Emergency power generation and saltwater pumping equipment is available.

G. Description of The Action Area

The action area includes all areas that will be affected directly or indirectly by the fisheries operating under the scientific research permit. The applicant proposes to conduct all swordfish-style fishing experiments north of 28°N latitude, in the Pacific Ocean. The portions of the experiment involving tuna-style fishing will be conducted where the Hawaii-based longline fishery is currently authorized to fish using tuna-style methods. Therefore, the experiment will not be conducted in the area closed to tuna fishing during April and May.

The experiment will also not occur in the following protected areas that have been closed to longlining. Longline fishing is prohibited inside the protected species zone surrounding the Northwestern Hawaiian Islands (50 nautical miles from the center geographical positions of Nihoa Island, Necker Island, French Frigate Shoals, Gardner Pinnacles, Maro Reef, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Island, and Kure Island) to protect monk seals. The area closed around the main Hawaiian Islands varies from 25 to 75 nautical miles seaward of the shore depending on the season, island, and direction of the facing shore. These closures are in place to alleviate potential gear conflicts among small boat handline/troll fishers, charter boat operators, recreational fishers, and longline fishers. From February 1 through September 30 each year, longline fishing is prohibited up to 75 nautical miles around the main Hawaiian Islands in the portion of the exclusive economic zone (EEZ) seaward of Hawaii bounded by straight lines. From October 1 through the following January 31 each year, longline fishing is prohibited further inshore around the main Hawaiian Islands in the portion of the EEZ seaward of Hawaii.

III. STATUS OF AFFECTED SPECIES AND ENVIRONMENTAL BASELINE

The following endangered and threatened species occur in the action area and may be affected by the issuance of a scientific research permit to conduct experiments on methods for reducing sea turtle take by longline fisheries in the Pacific Ocean:

Marine Mammals	**Status**
Blue whale (*Balaenoptera musculus*)	Endangered
Fin whale (*Balaenoptera physalus*)	Endangered
Hawaiian monk seal (*Monachus schauinslandi*)	Endangered
Humpback whale (*Megaptera novaeangliae*)	Endangered
Northern right whale (*Eubalaena glacialis*)	Endangered
Sei whale (*Balaenoptera borealis*)	Endangered
Sperm whale (*Physeter macrocephalus*)	Endangered

Sea turtles	**Status**
Green turtle (*Chelonia mydas*)	Endangered/Threatened
Hawksbill turtle (*Eretmochelys imbricata*)	Endangered

Leatherback turtle (*Dermochelys coriacea*)	Endangered
Loggerhead turtle (*Caretta caretta*)	Threatened
Olive ridley turtle (*Lepidochelys olivacea*)	Endangered/Threatened

Critical habitat for all of the above-listed species in the Pacific Ocean has not been designated or proposed within the action area. Therefore, the proposed action is not likely to adversely affect critical habitat of any listed species.

Although blue whales, fin whales, northern right whales, and sei whales are found within the action area and could potentially interact with the longline vessels involved in the experiment, there have been no reported or observed incidental takes of these species in the Hawaii-based longline fisheries. Therefore, the proposed action is not likely to adversely affect blue whales, fin whales, northern right whales, or sei whales, and these species will not be considered further in this Opinion.

In 1991, one humpback was reported by an observer entangled in the mainline of a Hawaii-based longline vessel. The animal was released with trailing gear (Dollar, 1991). The interaction occurred inside what is now the protected species zone (50 nautical miles) of the islands and atolls of the Northwestern Hawaiian Islands (Bob Harman, NMFS, personal communication, November, 2000). Another humpback whale was reported entangled in longline gear off Lanai (Nitta and Henderson, 1993) and by whalewatch operators off Maui in 1993 (Hill and DeMaster, 1999). Confirmation was not made as to whether the gear type was pelagic longline gear, and it is believed to be the same whale.

Humpback whales favor waters less than 100 fathoms (183 meters) around the main Hawaiian Islands. The highest densities of humpback whales occur in the shallow-water, inter-island channels of the four-island region (Maui, Lāna'i, Moloka'i, and Kaho'olawe) and Penguin Bank (Hudnall, 1978, Baker and Herman, 1981, Mobley and Bauer, 1991 *in* Mazzuca *et al*., 1998). The 1991 interaction occurred inside the 50 nautical mile area now closed to longline fishing, and vessels fishing under the scientific research permit will be fishing far north of where humpbacks are normally concentrated. Therefore, NMFS considers the likelihood of an interaction to be very low, and does not expect that longliners fishing under the scientific research permit will interact with a humpback whale. Therefore, NMFS has determined that the proposed action is not likely to adversely affect humpback whales.

NMFS has observed one sperm whale interaction by the Hawaii-based longline fishery. The event occurred in May, 1999 inside the Northwestern Hawaiian Islands EEZ (about 140 nautical miles north of Raita Bank), and the vessel was targeting swordfish (gear was set at night, lightsticks were used, and no line shooter was used). According to the observer report, the sperm whale's pectoral fin was entangled in the mainline. The captain stopped the boat, let out more mainline, and then backed up until he could reach the other end of the mainline. At this point, both ends of the mainline, on each side of the sperm whale, were secured on the vessel. During this time, the whale broke the mainline and swam away without trailing gear. This is the first reported interaction by the observer program since the Hawaii-based longline fleet has been monitored (1991). In addition, there have been no reported sperm whale interactions by fishers in their logbook submissions.

NMFS has observed 3,251 sets, representing approximately 3,874,635 hooks (data from February 1994 through December 31, 1999), since the implementation of the mandatory observer program. Based on this information, the observed entanglement rate for sperm whales would equal approximately 0.31 whales per 1,000 sets. However, with only one sperm whale entanglement, NMFS believes that this estimated entanglement rate does not represent the actual entanglement rate. One whale entanglement cannot provide a reliable estimate of the true entanglement rate with any certainty. At this time, there is insufficient data to suggest that a sperm whale interaction with longline gear is anything more than a one time random event. Nevertheless, NMFS recognizes the potential that sperm whales could interact with longline gear set in the open water but without more accurate data is unable to predict with any level of confidence the likelihood of an interaction. Therefore, without additional information to support the frequency of entanglements, NMFS does not anticipate that there will be a sperm whale interaction in the foreseeable future by longliners fishing under the scientific research permit. Therefore, NMFS has determined that the proposed action is not likely to adversely affect sperm whales.

The endangered Hawaiian monk seal is currently found throughout the northwestern Hawaiian Islands (NWHI), specifically: Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianki Island, Laysan Island, French Frigate Shoals, Gardner Pinnacles, Necker Island and Nihoa Island. These islands form a chain approximately 1,840 km long. Hawaiian monk seals are also occasionally found in the main Hawaiian Islands. The longline area closure around the NWHI instituted in 1991 (longline fishing prohibited within 50 nm of the NWHI and in 100 nm closed corridors connecting the non-contiguous closed circles) appears to have eliminated monk seal interactions with the Hawaii-based longline fleet, as there have been no observed or reported interactions with this fishery since then. Therefore, NMFS has determined that the proposed action is not likely to adversely affect the Hawaiian monk seal.

Although hawksbill turtles are known to nest on the Main Hawaiian Islands (MHI) (Molokai and Hawaii), they are not known to interact with the Hawaii-based longline fishery, as there have been no reported or observed interactions between these pelagic longliners and hawksbills. As hawksbills become adults, evidence suggests that they switch foraging behaviors from pelagic surface feeding to benthic reef feeding. The maturing turtle establishes foraging territory and will remain in this territory until it is displaced. If Hawaiian hawksbills forage close to their known nesting sites, they are probably benefitting from the protected species zone instituted by the Council in 1991, where longliners are prohibited from fishing within 50 nm of the NWHI and within 100 nm closed corridors connecting the non-contiguous closed circles. Further longline exclusion zones prohibit longline fishing in specific areas around the MHI (depending on the time of year and location, the exclusion zones around the MHI range from 25-75 nm). Because adult hawksbills are most likely foraging primarily in nearshore waters, and the majority of the experiments will take place north of 28°N, the likelihood of an interaction with a longliner fishing under the scientific research permit is very low. Therefore, NMFS has determined that the proposed action is not likely to adversely affect hawksbill turtles.

Based on observed and reported interactions between the Hawaii-based longline fishery (including both swordfish-style, mixed-style, and tuna-style sets) and four species of sea turtles, NMFS has determined that the proposed experiments are likely to adversely affect green, leatherback, loggerhead, and olive ridley turtles. Therefore, formal consultation is required in order to analyze the effects of the proposed action on these listed species.

The following subsections are synopses of the current state of knowledge on the life history, distribution, and population trends of these sea turtle species and that NMFS expects may be incidentally taken as a result of the proposed action. In addition, the Status of the Species and the Environmental Baseline, typically two separate sections in a Biological Opinion, are combined here because the status of the species and the factors affecting them are similar both within the action area and throughout their range in the Pacific Ocean.

Status of Listed Sea Turtles

All stocks/populations of sea turtles adversely affected by the proposed action are in decline, except for olive ridleys and Hawaiian green turtles, which appear to be increasing. Impacts to sea turtles in the Pacific Ocean are primarily due to the composite effect of human activities which include: the legal harvest and illegal poaching of adults, immatures, and eggs; incidental capture in fisheries (coastal and high-seas); and loss and degradation of nesting and foraging habitat as a result of coastal development, including predation by domestic dogs and pigs foraging on nesting beaches (associated with human settlement). Increased environmental contaminants (e.g. sewage, industrial discharge) and marine debris, which adversely impact nearshore ecosystems that turtles depend on for food and shelter, including sea grass and coral reef communities, also contribute to the overall decline. While it is generally accepted by turtle biologists and others that these factors are the primary cause of turtle population declines, in many cases there is little quantitative data on the magnitude of human-caused mortality. These four species of sea turtles are highly migratory or have a highly migratory phase in their life history, which makes them susceptible to being incidentally caught by fisheries operating throughout the Pacific Ocean. Because this experiment will take place in an area where the Hawaii-based longline fishery typically fishes, using standard fishing gear and strategy, and using typical longline vessels, this proposed action is anticipated to interact with all four species of sea turtles. In addition to anthropogenic factors, natural threats to the nesting beaches and pelagic-phase turtles such as coastal erosion, seasonal storms, predators, temperature variations, and phenomena such as El Niño also affect the survival and recovery of sea turtle populations. More information on the status of these species along with an assessment of overall impacts are found in this section as well as the Pacific Sea Turtle Recovery Plans (NMFS and USFWS, 1998a-d) and are reviewed extensively in Eckert (1993). NMFS will also be conducting additional analysis on the status of these species through the reinitiation of the March 29, 2001 biological opinion on the Western Pelagic FMP. The analysis will include, in part, new information an improved sex- and age- class structured stochastic simulation model of leatherback sea turtle population dynamics, recent eastern Pacific leatherback population censuses for the 2000/2001 season, and new observer data from the Hawaii-based longline fishery collected since 1999.

a. *Green Turtles*

Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawaii, as a direct consequence of a historical combination of overexploitation and habitat loss (Eckert, 1993). The species is listed as threatened under the ESA, except for breeding populations found in Florida and the Pacific coast of Mexico, which are listed as endangered. The International Union for Conservation of Nature and Natural Resources (IUCN) has classified the green turtle as "endangered"[5] due to an "observed, estimated, inferred or suspected reduction of at least 50% over the last 10 years or three generations, whichever is longer," based on: (a) direct observation; (b) an index of abundance appropriate for the species; and (c) actual or potential levels of exploitation.

The genus *Chelonia* is composed of two taxonomic units at the population level, the eastern Pacific green turtle (referred to by some as "black turtle," *C. mydas agassizii*), which ranges (including nesting) from Baja California south to Peru and west to the Galapagos Islands, and the nominate *C. m. mydas* in the rest of the range (insular tropical Pacific, including Hawaii).

Green turtles are distinguished from other sea turtles by their smooth carapace with four pairs of lateral scutes, a single pair of prefrontal scutes, and a lower jaw-edge that is coarsely serrated. Adult green turtles have a light to dark brown carapace, sometimes shaded with olive, and can exceed one meter in carapace length and 100 kilograms (kg) in body mass. Females nesting in Hawaii averaged 92 cm in straight carapace length (SCL), while at the Olimarao Atoll in Yap, females averaged 104 cm in curved carapace length (CCL) and approximately 140 kg. In the rookeries of Michoacán, Mexico, females averaged 82 cm in CCL, while males averaged 77 cm CCL (*in* NMFS and USFWS, 1998a).

Green turtles are a circumglobal and highly migratory species, nesting mainly in tropical and subtropical regions. Based on growth rates observed in wild green turtles, skeletochronological studies, and capture-recapture studies, all in Hawaii, it is estimated that green turtles attain sexual maturity at an average age of at least 25 years (*in* Eckert, 1993). Growth rates and age to first reproduction in other north Pacific populations remain unquantified (Eckert, 1993). In Hawaii, green turtles lay up to six clutches of eggs per year (mean of 3.7), and clutches consist of about 100 eggs each. Females migrate to breed only once every two or possibly many more years. Eastern Pacific green turtles have reported nesting between two and six times during a season, laying a mean of between 65 and 86 eggs per clutch, depending on the area studied (Michoacan, Mexico and Playa Naranjo, Costa Rica (*in* Eckert, 1993 and NMFS and USFWS, 1998a).

The nonbreeding range of green turtles is generally tropical, and can extend approximately 500-800 miles from shore in certain regions (Eckert, 1993). They appear to prefer waters that usually remain around 20°C in the coldest month; for example, during warm spells (e.g., El Niño), green turtles may be found considerably north of their normal distribution. Stinson (1984) found green turtles to appear most frequently in U.S. coastal waters with temperatures exceeding 18°C. An east Pacific green turtle equipped with a satellite transmitter was tracked along the California coast and showed a distinct preference for waters with temperatures above 20°C (Eckert, unpublished data). Hawaiian green turtles monitored through satellite transmitters were found to travel more than 1,100 km from their nesting beach in the French Frigate Shoals, south and southwest against prevailing currents to numerous distant foraging grounds within the 2,400 kilometer span of the archipelago (Balazs, 1994; Balazs, *et al.*, 1994; Balazs and Ellis, 1996).

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[5]Under the IUCN, taxa are classified as endangered when they are not "critically endangered, but are facing a very high risk of extinction in the wild in the near future.

Three green turtles outfitted with satellite tags on the Rose Atoll (the easternmost island at the Samoan Archipelago) traveled on a southwesterly course to Fiji, approximately 1,500 km distance (Balazs, *et al*., 1994).

Tag returns of eastern Pacific green turtles establish that these turtles travel long distances between foraging and nesting grounds. In fact, 75 percent of tag recoveries from 1982-90 were from turtles that had traveled more than 1,000 kilometers from Michoacán, Mexico. Even though these turtles were found in coastal waters, the species is not confined to these areas, as indicated by 1990 sightings records from a NOAA research ship. Observers documented green turtles 1,000-2,000 statute miles from shore (Eckert, 1993). The east Pacific green is also the second-most sighted turtle in the east Pacific during tuna fishing cruises; they are frequent along a north-south band from 15°N to 5°S along 90°W, and between the Galapagos Islands and Central American Coast (NMFS and USFWS, 1998a). In a review of sea turtle sighting records from northern Baja California to Alaska, Stinson (1984) determined that the green turtle was the most commonly observed sea turtle on the U.S. Pacific Coast, with 62% reported in a band from southern California and southward. The northernmost reported resident population of green turtles occurs in San Diego Bay, where about 50-60 mature and immature turtles concentrate in the warm water effluent discharged by a power plant (McDonald, *et al*., 1994). These turtles appear to have originated from east Pacific nesting beaches, based on morphology and preliminary genetic analysis (*in* NMFS and USFWS, 1998a); however, the possibility exists that some are from Hawaii (P. Dutton, NMFS, personal communication, January, 2001). Stranding reports from the Hawaiian Islands from 1982-1999 indicate that the green turtle is the most commonly stranded sea turtle (96.5 percent, compared to other species), averaging around 150 per year (2,689 total/18 years).

Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, it is presumed that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (NMFS and USFWS, 1998a). The maximum recorded dive depth for an adult green turtle was 110 meters (Berkson, 1967, *in* Lutcavage and Lutz, 1997), while subadults routinely dive 20 meters for 9-23 minutes, with a maximum recorded dive of 66 minutes (Brill, *et al*., 1995, *in* Lutcavage and Lutz, 1997). Additionally, it is presumed that drift lines or surface current convergences are preferential zones due to increased densities of likely food items. In the western Atlantic, drift lines commonly contain floating *Sargassum* capable of providing small turtles with shelter and sufficient buoyancy to raft upon (NMFS and USFWS, 1998a). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance from natural predators and humans. In the MHI these foraging and resting areas for adults usually occur at depths greater than 10 meters, but probably not normally exceeding 40 meters. Available information indicates that green turtle resting areas are in proximity to their feeding pastures (NMFS, 2000e). Immature Hawaiian green turtles have been found in increasing numbers residing in "foraging pastures" around the eight main Hawaiian Islands. These pastures consist of a narrow band of shallow water around these islands and "accounts for 96% of the benthic habitat potentially available for recruitment by post-pelagic green turtles" (Balazs, 1996).

Although most green turtles appear to have a nearly exclusive herbivorous diet, consisting primarily of sea grass and algae (Wetherall *et al.*, 1993), those along the East Pacific coast seem to have a more carnivorous diet. Analysis of stomach contents of green turtles found off Peru revealed a large percentage of molluscs and polychaetes, while fish and fish eggs, and jellyfish and commensal amphipods comprised a lesser percentage (Bjorndal, 1997). In the Hawaiian Islands, green turtles are site-specific and consistently feed in the same areas on preferred substrates, which vary by location and between islands (*in* Landsberg, *et al.*, 1999).

In the western Pacific, the only major (> 2,000 nesting females) populations of green turtles occur in Australia and Malaysia. Pulau Redang, a coral fringed island located approximately 45 kilometers off the coast of Terengganu, Malaysia contains one of the largest green turtle rookeries in peninsular Malaysia, and a 1 nautical mile no-fishing zone has been established around the island to prevent interactions between fishing gear and internesting females (Liew and Chan, 1994). Smaller colonies occur in the insular Pacific islands of Polynesia, Micronesia, and Malaysia (Wetherall *et al.*, 1993). In Taiwan, Cheng and Chen (1996) report that between 1992 and 1994, green turtles were found nesting on 9 of 11 beaches on Wan-Am Island (Peng-Hu Archipelago). The numbers, however, were small, between 8 and 14 females nested during each of these 3 years.

In Japan, the Ogasawara Islands, located approximately 1,000 km south of Tokyo, serve as the northern edge of green turtles rookeries. In the late 1800s, when Japan first colonized the islands, the government encouraged a sea turtle fishery. Declines in catch were steady from 1880-1890s (1,000-1,800 adults taken annually) through the mid-1920s (250 taken annually). Data from 1945-1972 (American occupation) indicate that 20-80 turtles were taken annually, and since then, annual harvests have fluctuated from 45-225 turtles per year (Horikoshi, *et al.*, 1994) (Suganuma, *et al.* (1996) estimates 100 mating adults are speared by fishermen annually). Beach census data from 1985-93 indicate that 170-649 clutches were deposited each year (43 to 162 nesting females, assuming a female deposited 4 clutches during a nesting season). The Ogasawara population has declined in part due to past commercial exploitation, and it is likely to continue if fishery effort continues (Horikoshi, *et al.*, 1994).

Thousands of islands comprise the eight U.S.-affiliated Pacific island groups, and of the sea turtle species, greens and hawksbills make up most of the composition. Unfortunately, there is a serious shortage of information on the population sizes, distribution, and migration patterns of these turtles, which can hamper recovery efforts. Based on limited data, green turtle populations in the Pacific islands have declined dramatically, due foremost to harvest of eggs and adults by humans. In the green turtle recovery plans, directed take of eggs and turtles was identified as a "major problem" in the American Samoa, Guam, Palau, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Republic of the Marshall Islands, and the Unincorporated Islands (Wake, Johnston, Kingman, Palmyra, Jarvis, Howland, Baker, and Midway). Severe overharvests have resulted in modern times from a number of factors: 1) the loss of traditional restrictions limiting the number of turtles taken by island residents; 2) modernized hunting gear; 3) easier boat access to remote islands; 4) extensive commercial exploitation for turtle products in both domestic markets and international trade; 5) loss of the spiritual significance of turtles; 6) inadequate regulations; and 7) lack of enforcement (NMFS and USFWS, 1998a).

In Hawaii, green turtles nest on six small sand islands at French Frigate Shoals, a long atoll situated in the middle of the Hawaiian Archipelago (Balazs, 1995). Unlike any other regional sea turtle populations, green turtles in Hawaii are genetically distinct and geographically isolated. Ninety percent of the nesting and breeding activity of the Hawaiian green turtle occurs at the French Frigate Shoals, where 200-700 females are estimated to nest annually (NMFS and USFWS, 1998a). Important resident areas have been identified and are being monitored along the coastlines of Oahu, Molokai, Maui, Lanai, Hawaii, and at large nesting areas in the reefs surrounding the French Frigate Shoals, Lisianski Island, and Pearl and Hermes Reef (Balazs, 1982; Balazs *et al*., 1987). Since the establishment of the ESA in 1973, and following years of exploitation, the nesting population of Hawaiian green turtles has shown a gradual but definite increase (Balazs, 1996). For example, the number of green turtles nesting at an index study site at East Island has tripled since systematic monitoring began in 1973 (NMFS and USFWS, 1998a). However, the green turtle population in this area is afflicted with a tumor disease, fibropapilloma, which is of an unknown etiology and often fatal, as well as spirochidiasis, both of which are the major causes of strandings of this species (G. Balazs, NMFS, personal communication, 2000). The presence of fibropapillomatosis among stranded turtles has increased significantly over the past 17 years, ranging from 47-69 percent during the past decade (Murakawa, *et al*., 2000). Green turtles captured off Molokai from 1982-96 showed a massive increase in the disease over this period, peaking at 61% prevalence in 1995 (Balazs, *et al*., 1998). Preliminary evidence suggests that there is an association between the distribution of fibropapillomatosis in the Hawaiian Islands and the distribution of toxic benthic dinoflagellates (*Prorocentrum* spp.) known to produce a tumor promoter, okadaic acid (Landsberg, *et al*., 1999). Fibropapillomatosis is considered an inhibiting factor to the full recovery of the Hawaiian green turtle populations, and the incidence of decreased growth rates in afflicted turtles is a minimum estimate of the impact of the disease (Balazs, *et al*., 1998).

The primary green turtle nesting grounds in the eastern Pacific are located in Michoacán, Mexico, and the Galapagos Islands, Ecuador (NMFS and USFWS, 1998a). Here, green turtles were widespread and abundant prior to commercial exploitation and uncontrolled subsistence harvest of nesters and eggs. More than 165,000 turtles were harvested from 1965 to 1977 in the Mexican Pacific. In the early 1970s nearly 100,000 eggs per night were collected from these nesting beaches (*in* NMFS and USFWS, 1998a). The nesting population at the two main nesting beaches in Michoacán (Colola, responsible for 70% of total green turtle nesting in Michoacán (Delgado and Alverado, 1999) and Maruata) decreased from 5,585 females in 1982 to 940 in 1984. Despite long-term protection of females and their eggs at these sites since 1990, the population continues to decline, and it is believed that adverse impacts (including incidental take in various coastal fisheries as well as illegal directed take at forage areas) continue to prevent recovery of endangered populations (P. Dutton, NMFS, personal communication, 1999; W. Nichols, Wildcoast, personal communication, 2000). In addition, the black market for sea turtle eggs in Mexico has remained as brisk as before the ban (Delgado and Alvarado, 1999). On Colola, an estimated 500-1,000 females nested nightly in the late 1960s. In the 1990s, that number dropped to 60-100 per night, or about 800-1,000 turtles per year (Eckert, 1993). During the 1998-99 season, based on a comparison of nest counts and egg collection data, an estimated 600 greens nested at Colola. Although only about 5% of the nests were poached at Colola during this season, approximately 50% of the nests at Maruata were poached, primarily because of difficulties in providing protections as a result of political infighting (Delgado and Alvarado, 1999).

There are few historical records of abundance of green turtles from the Galapagos - only residents are allowed to harvest turtles for subsistence, and egg poaching occurs only occasionally. An annual average of 1,400 nesting females was estimated for the period 1976-1982 in the Galapagos Islands (NMFS and USFWS, 1998a).

Green turtles encountered by vessels participating in the experiments may originate from a number of known proximal, or even distant, breeding colonies in the region. Genetic sampling of green turtles taken by the Hawaii-based longline fishery indicates representation from nesting beaches on Hawaii (French Frigate Shoals) and the Pacific coast of Mexico population. Preliminary genetic analysis revealed that of eight greens caught by the Hawaii-based longline fishery, four were of eastern Pacific (Mexico) origin, three were of eastern Pacific or Hawaiian origin, and one was of Hawaiian origin (P. Dutton, NMFS, personal communication, January, 2001).

b. *Leatherback Turtles*

The leatherback turtle is listed as endangered under the ESA throughout its global range. Furthermore, the Red List 2000 of the IUCN has classified the leatherback as "critically endangered"[6] due to "an observed, estimated, inferred or suspected reduction of at least 80% over the last 10 years or three generations, whichever is the longer," based on: (a) direct observation; (b) an index of abundance appropriate for the taxon; and (c) actual or potential levels of exploitation. Increases in the number of nesting females have been noted at some sites *in the Atlantic*. Florida and the U.S. Caribbean nesting populations have been increasing at about 10.3% and 7.5%, respectively, per year since the early 1980's but the magnitude of nesting is much smaller than that along the French Guiana coast (see NMFS SEFSC 2001). The nesting aggregation in French Guiana has been declining at about 15% per year since 1987. From the period 1979-1986, the number of nests was increasing at about 15% annually.

Genetic analyses of leatherbacks to date indicate that within the Atlantic basin significant genetic differences occur among St. Croix, U.S. Virgin Islands, and mainland Caribbean populations (Florida, Costa Rica, Suriname/French Guiana) and between Trinidad and the same mainland populations, (Dutton *et al*. 1999) leading to the conclusion that there are at least 3 separate subpopulations of leatherbacks in the Atlantic. Much of the genetic diversity is in the relatively small insular subpopulations. The analysis of mitochondrial DNA (mtDNA) indicate that the loss of the nesting populations from the St. Croix region and Trinidad would essentially eliminate most of the detected mtDNA variation throughout the Atlantic (Dutton *et al*. 1999). The Trinidad nesting population may be at a high risk. An estimated 1,000 mature female leatherback sea turtles are caught annually off of Trinidad and Tobago with mortality estimated to be between 50-95% (Eckert and Lien 1999). To date, no studies have been published on the genetic make-up of pelagic or benthic leatherbacks in the Atlantic. Compared to current

[6]Taxa are categorized as critically endangered when they are facing an extremely high risk of extinction in the wild in the immediate future.

knowledge regarding loggerhead populations, the genetic distinctness of leatherback populations is less clear and populations or subpopulations of leatherback sea turtles have not been formally recognized based on genetic studies. This Opinion, therefore, considers the status of the various nesting populations, as well as the Atlantic and worldwide populations.

The demise of once large populations *throughout the Pacific*, such as in Malaysia and Mexico. Spotila *et al.* (1996) estimated the global population of female leatherback turtles to be only 34,500 (confidence limits: 26,200 to 42,900) nesting females; however, the eastern Pacific population has continued to decline since that estimate, leading some researchers to conclude that the leatherback is now on the verge of extinction in the Pacific Ocean (e.g. Spotila, *et al*., 1996; Spotila, *et al*., 2000). The loss of the Pacific nesting aggregations in addition to losses of key nesting aggregations in the Atlantic would appreciably reduce population viability buy severely reducing genetic diversity, reproduction, distribution, and numbers.

Leatherback turtles are the largest of the marine turtles, with a CCL often exceeding 150 cm and front flippers that are proportionately larger than in other sea turtles and may span 270 cm in an adult (NMFS and USFWS, 1998b). In view of its unusual ecology, the leatherback is morphologically and physiologically distinct from other sea turtles. Its streamlined body, with a smooth, dermis-sheathed carapace and dorso-longitudinal ridges may improve laminar flow of this highly pelagic species. Adult females nesting in Michoacán, Mexico averaged 145 cm CCL (L. Sarti, Universidad Naçional Autonoma de Mexico, unpublished data, *in* NMFS and USFWS, 1998b), while adult female leatherback turtles nesting in eastern Australia averaged 162 cm CCL (Limpus, *et al*., 1984, *in* NMFS and USFWS, 1998b).

Leatherback turtles have the most extensive range of any living reptile and have been reported circumglobally from 71°N to 42°S latitude in the pelagic Pacific and in all other major pelagic ocean habitats (NMFS and USFWS, 1998b). For this reason, however, studies of their abundance, life history and ecology, and pelagic distribution are exceedingly difficult. Similar to the olive ridley turtle, leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Males are only rarely observed near nesting areas, and it has been proposed that mating most likely takes place outside of the tropical waters, before females move to their nesting beaches (Eckert and Eckert, 1988). They are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Morreale, *et al*., 1994; Eckert, 1998; Eckert, 1999a). In a single year, a leatherback may swim more than 10,000 kilometers (Eckert, 1998).

Recent satellite telemetry studies indicate that adult leatherback turtles follow bathymetric contours over their long pelagic migrations and typically feed on cnidarians (jellyfish and siphonophores) and tunicates (pyrosomas and salps), and their commensals, parasites and prey (NMFS and USFWS, 1998b). Because of the low nutritive value of jellyfish and tunicates, it has been estimated that an adult leatherback would need to eat about 50 large jellyfish (equivalent to approximately 200 liters) per day to maintain its nutritional needs (Duron, 1978, *in* Bjorndal, 1997). Compared to greens and loggerheads, who consume approximately 3-5% of their body weight per day, leatherback turtles may consume perhaps 20-30% of their body weight per day (Davenport and Balazs, 1991). Surface feeding has been reported in U.S. waters, especially off the west coast (Eisenberg and Frazier, 1983), but foraging may also occur at depth. Based on offshore studies of diving by adult females nesting on St. Croix, U.S. Virgin Islands, Eckert *et al.* (1989) proposed that observed internesting[7] dive behavior reflected nocturnal feeding within the deep scattering layer (strata comprised primarily of vertically migrating zooplankton, chiefly siphonophore and salp colonies, as well as medusae). Hartog (1980, *in* NMFS and USFWS, 1998b) also speculated that foraging may occur at depth, when nematocysts from deep water siphonophores were found in leatherback stomach samples. Davenport (1988, *in* Davenport and Balazs, 1991) speculated that leatherback turtles may locate pyrosomas at night due to their bioluminescence; however direct evidence is lacking.

Leatherback turtles also appear to spend almost the entire portion of each dive traveling to and from maximum depth, suggesting that maximum exploitation of the water column is of paramount importance to the leatherback (Eckert, *et al*., 1989). Maximum dive depths for post-nesting females in the Carribean have been recorded at 475 meters and over 1,000 meters, with routine dives recorded at between 50 and 84 meters. The maximum dive length recorded for such female leatherback turtles was 37.4 minutes, while routine dives ranged from 4-14.5 minutes (*in* Lutcavage and Lutz, 1997). A total of six adult female leatherback turtles from Playa Grande, Costa Rica were monitored at sea during their internesting intervals and during the 1995 through 1998 nesting seasons. The turtles dived continuously for the majority of their time at sea, spending 57-68% of their time submerged. Mean dive depth was 19 ± 1 meters and the mean dive duration was 7.4 ± 0.6 minutes (Southwood, *et al*., 1999). Migrating leatherback turtles also spend a majority of time at sea submerged, and they display a pattern of continual diving (Standora, *et al*., 1984, *in* Southwood, *et al*., 1999). Eckert (1999a) placed transmitters on nine leatherback females nesting at Mexiquillo Beach and recorded dive behavior during the nesting season. The majority of the dives were less than 150 meters depth, although maximum depths ranged from 132 meters to over 750 meters. Although the dive durations varied between individuals, the majority of them made a large proportion of very short dives (less than two minutes), although Eckert speculates that the short duration dives most likely represent surfacing activity after each dives. Excluding these short dives, five of the turtles preferred dive durations greater than 24 minutes, while three others preferred dive durations between 12-16 minutes.

On the Pacific coast of Mexico, female leatherback turtles lay an average of 4 clutches per season with clutch size averaging 64 yolked eggs per clutch (García and Sarti, 2000) (each clutch contains a complement of yolkless eggs, sometimes comprising as much as 50 percent of total clutch size, a unique phenomenon among leatherback turtles and some hawksbills (Hirth and Ogren, 1987)). Each clutch is laid within a 9.3 day interval (García and Sarti, 2000). Clutch sizes in Terengganu, Malaysia, and in Pacific Australia were larger, averaging around 85-95 yolked eggs and 83 yolked eggs, respectively (*in* Eckert, 1993). Females are believed to migrate long distances between foraging and breeding grounds, at intervals of typically two or three years (García and Sarti, 2000). Spotila *et al*. (2000), found the mean re-nesting interval of females on Playa Grande, Costa Rica to be 3.7 years, while in Mexico, 3 years was the typical reported interval (L. Sarti, personal communication, 2000). In Mexico, the nesting season generally extends from November to February, although some females arrive as early as August (Sarti *et*

[7]Internesting – time spent between laying clutches of eggs during a single nesting season.

al., 1989). In the western Pacific, nesting peaks on Jamursba-Medi Beach (Irian Jaya) from May to August, on War Mon Beach (also Irian Jaya) from November to January (Starbird and Suarez, 1994), in peninsular Malaysia in June and July (Chan and Liew, 1989), and in Queensland, Australia in December and January (Limpus and Riemer, 1994).

Using skeletochronological analysis of a small sample size of leatherback sclerotic ossicles, Zug and Parham (1996) suggested that mean age at sexual maturity for leatherback turtles is around 13 to 14 years, giving them the highest juvenile growth rate of all sea turtle species. Zug and Parham (1996) concluded that for conservation and management purposes, 9 years is a likely minimum age for maturity of leatherback turtles, based on the youngest adult in their sample. The natural longevity of leatherback turtles has not been determined (NMFS and USFWS, 1998b), although there are recorded documentations of post-maturation survival on the order of about 20 years (Pritchard, 1996).

Migratory routes of leatherback turtles originating from eastern and western Pacific nesting beaches are not entirely known. However, satellite tracking of post-nesting females and genetic analyses of leatherback turtles caught in U.S. Pacific fisheries or stranded on the west coast of the U.S. present some strong insight into at least a portion of their routes and the importance of particular foraging areas. Current data from genetic research suggest that Pacific leatherback stock structure (natal origins) may vary by region. Because leatherback turtles are highly migratory and stocks mix in high seas foraging areas, and based on genetic analyses of samples collected by Hawaii-based longline observers, leatherback turtles inhabiting the action area are comprised of individuals originating from nesting assemblages located south of the equator in Indonesia and in the eastern Pacific along the Americas (e.g., Mexico, Costa Rica) (Dutton, *et al*., 2000).

For female leatherback turtles nesting at Mexiquillo Beach, Mexico, the eastern Pacific region has been shown to be a critical migratory route. Nine females outfitted with satellite transmitters in 1997 traveled along almost identical pathways away from the nesting beach. These individuals moved south and, upon encountering the North Equatorial Current at about 8°N, diverted west for approximately 800 km and then moved east/southeast towards the waters off Peru and Chile (Eckert, 1999a). In addition, four leatherback turtles recovered from Chilean fishing vessels from 1988-91 had been tagged on nesting beaches in Costa Rica and Mexico (Brito-Montero, 1995, *in* Donoso, *et al*., 2000).

Morreale *et al*. (1994) demonstrated that satellite tagged, post-nesting leatherback turtles leaving Costa Rica followed precisely defined, long-distance migratory pathways after nesting. Despite differences in dates of departure from the nesting areas, nesting cohorts followed along nearly identical pathways. All 6 leatherback turtles' (from the Pacific and Carribean coasts of Costa Rica) movements paralleled deepwater bathymetric contours ranging from 200-3,500 meters. When a turtle's path intersected an abyssal plain, it veered along the outer slope, and when an abyssal plain was unavoidable, the turtle crossed it at its narrowest point. These studies underscore the importance of this offshore habitat and migratory corridors and the likelihood that sea turtles are present on fishing grounds, particularly for large commercial fishing fleets south of the equator (Eckert, 1997). Eckert (1999a) speculates that leatherback turtles leaving the nesting areas of Mexico and Costa Rica may be resource-stressed by a long reproductive season with limited food and the high energetic requirements brought about by the demands of reproduction, elevated water temperatures, or both. When they leave, their greatest need is to replenish energy stores (e.g. fat) and they must move to areas where food is concentrated (e.g. upwelling areas). These eastern Pacific nesting stocks may also move northwest, as genetic samples from two leatherback turtles caught south of the main Hawaiian islands by the Hawaii-based longline fishery indicated representation from eastern Pacific nesting beaches (Dutton *et al*., in press, and unpublished).

Migratory corridors of leatherback turtles originating from western Pacific nesting beaches most likely exist along the eastern seaboards of Australia, Asia and the former Soviet Union (NMFS and USFWS, 1998b). Genetic markers in 12 of 14 leatherback turtles sampled to date from the central North Pacific (captured in the Hawaii-based longline fishery) have identified those turtles as originating from nesting populations in the southwestern Pacific; the other 2 specimens, taken in the southern range of the Hawaii fishery, were from nesting beaches in the eastern Pacific (P. Dutton, NMFS, personal communication, January, 2001). Stranding records from 1982-99 indicate that the leatherback rarely strands in the Hawaiian Islands; only five leatherback turtles have been recorded stranded in 18 years (G. Balazs, NMFS, personal communication, 2000).

Leatherback turtles originating from western Pacific beaches have also been found along the U.S. mainland. Here, leatherback turtles have been sighted and reported stranded as far north as Alaska (60°N) and as far south as San Diego, California (NMFS and USFWS, 1998b). Of the stranded leatherback turtles that have been sampled to date from the U.S. mainland, all have been of western Pacific nesting stock origin (P. Dutton, NMFS, personal communication, 2000). Genetic analysis of samples from two leatherback turtles taken off California and Oregon by the California/Oregon (CA/OR) drift gillnet fishery revealed that they both originated from western Pacific nesting beaches (i.e. Indonesia/Solomon Islands/Malaysia) (P. Dutton, NMFS, personal communication, March, 2000). In addition, two female leatherback turtles were recently captured and tagged in Monterey Bay, California, on September 7-8, 2000 and fitted with transmitters. One of these individuals was of a size normally associated with the western Pacific nesting stock, which are, on average, 10-20 centimeters larger than eastern Pacific nesting stocks (Zug and Parham, 1996). As of 9/21/00, both were on a southwest migratory path and appeared to be heading to the western Pacific nesting beaches. On 11/17/00, the larger female stopped transmitting when it entered an area southeast of the Hawaiian Islands (145°W longitude, 15°N latitude). The other leatherback continues to travel west along the North Equatorial Current towards Indonesia, and as of mid-June, it was located around 147°E longitude, 8°N latitude, north of Indonesia (Dutton and Eckert, unpublished).

Lastly, genetic analyses of two leatherback turtles taken by fishing vessels in Chilean waters suggest that one is from a western Pacific or Indian Pacific nesting population and the other is of eastern Pacific origin. This is the first evidence that leatherback turtles from western Pacific nesting beaches occur in Chilean waters, confirming transoceanic migration to eastern Pacific forage areas in the southern hemisphere (Donoso, *et al*., 2000).

Hawaiian fishermen in offshore waters have seen leatherback turtles generally beyond 100 fathoms, but within sight of land. Two areas where sightings have taken place are off the north coast of Oahu and the west coast of the Island of Hawaii. The pelagic zone surrounding the

Hawaiian Islands apparently is regularly used as foraging habitat and migratory pathways for this species (NMFS, 1991).

The distribution of juvenile leatherback turtles has long been a mystery. However, a recent compilation and analysis of sighting and stranding data for the species has yielded some interesting insight into the developmental habitats of this species at earlier life stages. It appears that young leatherback turtles (carapace length <100cm) reside only in waters warmer than 26°C, which should generally place them outside of areas in which longline swordfish fleets operate (Eckert, 1999b; Eckert, submitted manuscript). However, as discussed further in the Effects of the Action section, the Hawaii-based longline fishery has been observed to take a few subadult leatherback turtles (straight carapace length < 100 cm).

Based on published estimates of nesting female abundance, leatherback populations are declining at all major Pacific basin nesting beaches, particularly in the last two decades (Spotila *et al.*, 1996; NMFS and USFWS, 1998b; Spotila, *et al.*, 2000). Declines in nesting populations have been documented through systematic beach counts or surveys in Malaysia (Rantau Abang, Terengganu), Mexico and Costa Rica. In other leatherback nesting areas, such as Irian Jaya and the Solomon Islands, there have been no systematic consistent nesting surveys, so it is difficult to assess the status and trends of leatherback turtles at these beaches. In all areas where leatherback nesting has been documented, however, current nesting populations are reported by scientists, government officials, and local observers to be well below abundance levels of several decades ago. The collapse of these nesting populations was most likely precipitated by a tremendous overharvest of eggs coupled with incidental mortality from fishing (Sarti *et al.*, 1996; Eckert, 1997).

Eastern Pacific nesting populations of leatherback turtles

Leatherback nesting populations are declining at a rapid rate along the Pacific coast of Mexico and Costa Rica (see Appendix B, Table 1). At Las Baulas National Park, Costa Rica, the number of nesting leatherback turtles has declined from 1,500 in 1988-1989 to 193 in 1993-1994 (Steyermark *et al.*, 1996). Leatherback turtles have been studied at Playa Grande (in Las Baulas), the fourth largest leatherback nesting colony in the world, since 1988. During the 1988-89 season (July-June), 1,367 leatherback turtles nested on this beach, and by the 1998-99 season, only 117 leatherback turtles nested (Spotila*et al.*, 2000). The 1999-2000 season showed a slight increase in the number of adult females nesting here, with slightly over 200 nesting (preliminary data presented on the Las Baulas leatherback conservation project website[8]). During the last three nesting seasons (1996 through 1999), an average of only 25% of the turtles were remigrants (turtles returning to nest that were observed nesting in previous nesting seasons). Less than 20% of the turtles tagged in 1993 through 1995 returned to nest in the next five years (Spotila, *et al.*, 2000). Remigration intervals for leatherback turtles at nesting beaches in South Africa and the U.S. Caribbean have been documented as over 91% returning within 5 years or less (Hughes, 1996 and Boulon, *et al.* 1996 *in* Spotila, *et al.*, 2000). Comparatively few leatherback turtles are returning to nest on east Pacific nesting beaches and it is likely that leatherback turtles are experiencing abnormally high mortalities during non-nesting years. Since 1993, environmental

[8]http://www.leatherback.org/lasbaulas/costa-rica/Las_Baulas/Results_progress/1999_00/Index.html

education and conservation efforts through active law enforcement has greatly reduced egg poaching in Costa Rica (Chaves, *et al*., 1996). For example, during the 1993-94 nesting season, poaching accounted for only 1.3 percent of the loss of nests on Playa Grande. Other losses were due to predation, tidal effects and failure in egg development or infestation by maggots (Schwandt, *et al*., 1996).

The decline of leatherback subpopulations is even more dramatic off Mexico. According to reports from the late 1970s and early 1980s, three beaches located on the Pacific coast of Mexico sustained a large portion of all global nesting of leatherback turtles, perhaps as much as one-half. Since the early 1980s, the eastern Pacific Mexican population of adult female leatherback turtles has declined from 70,000[9] in 1982 (Pritchard, 1982, *in* Spotila *et al*., 1996) to slightly more than 200 adult females during the last two seasons (1997-98 and 1998-1999 (Sarti *et al*., 2000). Monitoring of the nesting assemblage at Mexiquillo, Mexico has been continuous since 1983-84. According to Sarti *et al.* (1996), nesting declined at this location at an annual rate of over 22 percent from 1984 to 1995. Sarti *et al*. (1998) reports:

> "While reporting the results for the 1995-96 nesting season (Sarti *et al*., 1996), we regarded beaches having densities higher than 50 nests per kilometer as the most important. In the present season [1997-98] no beach reached such density values: the main beaches had 5 or more nests per kilometer, and none were higher than 25. This is evidence of the large decrement witnessed from the start of the aerial surveys, and may indicate that the nesting population still has a declining trend despite the protection efforts in the major beaches."

Furthermore, Sarti, *et al*. (2000) notes that during the 1980s, 30% of the nesting females per season were remigrants, but since the mid-1990s, there has been no evidence of remigration, even with more efficient tagging methods.

Although the causes of the decline in the nesting populations are not entirely clear, Sarti *et al.* (1998) surmises that the decline could be a result of intensive egg poaching in the nesting areas, incidental capture of adults or juveniles in high seas fisheries, and natural fluctuations due to changing environmental conditions. Although leatherback turtles are not generally captured for their meat or skin in Mexico, the slaughter of female leatherback turtles has been detected on beaches such as Píedra de Tiacoyunque, Guerrero (Sarti, *et al*., 2000). In addition, there is little information on incidental capture of adults due to coastal fisheries off Mexico, but entanglement in longlines and driftnets probably account for some mortality of leatherback turtles. Eckert (1997) speculates that the swordfish gillnet fisheries in Peru and Chile have contributed to the decline of the leatherback in the eastern Pacific. The decline in the nesting population at Mexiquillo, Mexico occurred at the same time that effort doubled in the Chilean driftnet fishery.

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[9] This estimate of 70,000 adult female leatherback turtles comes from a brief aerial survey of beaches by Pritchard (1982), who has commented: "I probably chanced to hit an unusually good nesting year during my 1980 flight along the Mexican Pacific coast, the population estimates derived from which (Pritchard, 1982) have possibly been used as baseline data for subsequent estimates to a greater degree than the quality of the data would justify" (Pritchard, 1996).

Most conservation programs aimed at protecting nesting sea turtles in Mexico have continued since the early 1980s, and there is little information on the degree of poaching prior to the establishment of these programs. However, Sarti *et al.* (1998) estimates that as much as 100% of the clutches were taken from the Mexican beaches. Since protective measures have been in place, particularly emergency measures recommended by a joint U.S./Mexico leatherback working group meeting in 1999, there has been greater nest protection and nest success (Table III-1). Mexican military personnel were present during the 1999-2000 season at three of the primary nesting beaches in Mexico (Llano Grande, Mexiquillo, and Tierra Colorado), responsible for approximately 34% of all nesting activity in Mexico. Of 1,294 nests documented, 736 were protected (57%), resulting in a total of 25,802 hatchlings. Monitoring and protection measures at two secondary nesting beaches resulted in the protection of 67% and 10% at Barra de la Cruz and Playa Ventura, respectively. Currently, the primary management objective is to protect over 95% of nests laid at the three index beaches (includes protecting nesting females, eliminating illegal egg harvest, and relocating nests to protected hatcheries) and to maximize protection of all the secondary nesting beaches over the next three years. NMFS has committed funding for the next three years to help implement these objectives (minutes from joint U.S./Mexico Leatherback Working Group meeting, 23-24 May, 2000).

Table III-1. Nest protection at index beaches on the Pacific coast of Mexico (Source: Sarti *et al.*, personal communication, 2000)

Season	Number of clutches laid	Number of clutches protected	Percentage of clutches protected
1996-97	445	86	19.3%
1997-98	508	101	19.9%
1998-99	442	150	33.9%
1999-00	1590	943	58.7%

From tagging and aerial surveys, Spotila *et al.* (2000) have estimated that there are currently 687 adult females and 518 subadults comprising the Central American population of leatherback turtles. With an estimated Mexican population of 1,000 adults and 750 subadults (by Spotila *et al.*, 2000), the entire east Pacific leatherback population has been estimated by Spotila *et al.* (2000) to contain approximately 2,955 females (1,687 adults and 1,268 subadults); however, insufficient foundation was given for these estimates (i.e. derivation of estimates are unclear, and models rely on theoretical assumptions that need further evaluation and testing).

Western Pacific Populations of Leatherback Turtles

Similar to their eastern Pacific counterparts, leatherback turtles originating from the western Pacific are also threatened by poaching of eggs, killing of nesting females, human encroachment on nesting beaches, incidental capture in fishing gear, beach erosion, and egg predation by animals. Little is known about the status of the western Pacific leatherback nesting populations but once major leatherback nesting assemblages are declining along the coasts of Malaysia, Indonesia and the Solomon Islands. Low density and scattered nesting of leatherback turtles occurs in Fiji, Thailand, Australia (primarily western and to a lesser extent, eastern), and Papua New Guinea. In the Solomon Islands, the rookery size is estimated to be less than 100 females nesting per year (D. Broderick, personal communication, *in* Dutton, *et al*., 1999). In Indonesia, low density nesting occurs along western Sumatra (200 females nesting annually) and in southeastern Java (50 females nesting annually), although the last known information is from the early 1980s (*in* Suarez and Starbird, 1996a). The largest extant leatherback rookery in the Indo-Pacific lies on the north Vogelkop coast of Irian Jaya (Suárez *et al.*, in press), with over 1,000 females nesting during the 1996 season (Suárez *et al*., in press (see Table III-3)).

As with the eastern Pacific nesting populations, the decline of leatherback turtles is severe at one of the most significant nesting sites in the region - Terengganu, Malaysia, with current nesting representing less than 2 percent of the levels recorded in the 1950s, and the decline is continuing. The nesting population at this location has declined from 3,103 females estimated nesting in 1968 to 2 nesting females in 1994 (Chan and Liew, 1996) (Table III-2). With one or two females reportedly nesting each year, this population has essentially been eradicated (P. Dutton, personal communication, 2000). Years of excessive egg harvest, egg poaching, the direct harvest of adults in this area, as well as incidental capture in various fisheries in territorial and international waters, have impacted the Malaysian population of leatherback turtles. There were two periods in which there were sharp declines in nesting leatherback turtles at this location: 1972-74 and 1978-80. Between 1972 and 1974, the number of females nesting declined 21% and coincided with a period of rapid development in the fishing industry, particularly trawling, in Terengganu (Chan *et al*., 1988 *in* Chan and Liew, 1996). Between 1978 and 1980, nestings dropped an average of 31% annually, and coincided directly with the introduction of the Japanese high seas squid fishery of the North Pacific in 1978 (Yatsu *et al*., 1991, *in* Chan and Liew, 1996). Because tagged individuals from Rantau Abang have been recovered from as far away as Taiwan, Japan and Hawaii, this fishery, as well as fisheries operating within the South China Sea, may have impacted the Malaysian leatherback population (Chan and Liew, 1996). After 1980, rates of decline averaged 16% annually, suggesting continuing threats from fisheries (Chan and Liew, 1996).

Table III-2. Number of nesting females per year in Terengganu, Malaysia (summarized in Spotila, *et al.*, 1996)

1968	1970	1972	1974	1976	1978	1980	1984	1987	1988	1993	1994
3,103	1,760	2,926	1,377	1,067	600	200	100	84	62	20	2

The nesting populations of leatherback turtles in Irian Jaya, Indonesia appear to be steady, although without systematic consistent surveys of nesting beaches, an reliable assessment of the trends and status of leatherback turtles here is difficult. However, there has yet been no evidence of the collapse documented in Malaysia or the in the eastern Pacific. Leatherback nesting generally takes place on two major beaches, located 30 km apart, on the north Vogelkop coast of Irian Jaya, Jamursba-Medi (18 km) and War-Mon beach (4.5 km) (Starbird and Suarez, 1994). As shown in Table III-3, Suarez, *et al*. (in press) has compiled, re-analyzed, and standardized data collected from leatherback nesting surveys in the 1980s and 1990s. In addition, Suarez *et al*. (in press) has included information on the estimated number of nests lost due to both natural and anthropogenic causes. For example, during 1984 and 1985, on Jamursba-Medi, 40-60% of nests were lost to inundation and erosion, while 90% of those nests not taken by poachers[10] or by the sea were destroyed by feral pigs (*Sus scrofa*). Eggs from poached nests were commercially harvested for sale in the Sarong markets until 1993, when the beaches first received protection by the Indonesian government (J. Bakarbessy, personal communication, *in* Suarez and Starbird, 1996a). During the 1993-96 seasons, environmental education activities in nearby villages and protection measures on this same beach were put into place, with unreported results. Again, approximately 90% of those nests not taken by poachers or the sea[11] were destroyed by pigs (Suarez *et al.* in press). War-Mon beach supports a lower percentage of nesting females, yet egg poaching for subsistence accounted for over 60% of total nest loss during 1993-94, and total loss of nests due to pig predation was 40% (because there are more people in this region, there is more pig hunting; hence less pig predation of leatherback eggs (Starbird and Suarez, 1994)).

[10]Suarez, *et al.* (in press) provided no information on the estimated percentage of nests lost to poachers.

[11]No information on percentage of nests lost to poachers of the sea or were given, except that it was "noted."

Table III-3. Estimated numbers of female leatherback turtles nesting along the north coast of Irian Jaya (Summarized by Suarez, *et al.*, in press.)

Survey Period	# of Nests	Adjusted # Nests	Estimated # of Females[3]
Jamursba-Medi Beach:			
September, 1981	4,000+	7,173[1]	1,232-1,623
April - Oct. 1984	13,360	13,360	2,303-3036
April - Oct. 1985	3,000	3,000	[(658)-731]
June - Sept. 1993	3,247	4,329[2]	746-984
June - Sept. 1994	3,298	4,397[2]	758-999
June - Sept. 1995	3,382	4,509[2]	777-1025
June - Sept., 1996	5,058	6,744[2]	1,163-1,533
War-Mon Beach:			
Nov. 1984 - Jan. 1985	1,012	N/A	175-230
Dec. 1993	406	653	128 - 169

[1]The total number of nests reported during aerial surveys were adjusted to account for loss of nests prior to the survey. Based on data from other surveys on Jamursba-Medi, on average 44% of all nests are lost by the end of August.

[2]The total number of nests have been adjusted based on data from Bhaskar's surveys from 1984-85 from which it was determined that 25% of the total number of nests laid during the season (4/1-10/1) are laid between April and May.

[3]Based on Bhaskar's tagging data, an average number of nests laid by leatherback turtles on Jamursba-Medi in 1985 was 4.4 nests per female. This is consistent with estimates for the average number of nests by leatherback turtles during a season on beaches in Pacific Mexico, which range from 4.4 to 5.8 nests per female (Sarti *et al.*, unpub. report). The range of the number of females is estimated using these data.

Recently, monitoring of leatherback turtles nesting at Jamursba Medi revealed that a total of 3,408 adult female nesting activities were recorded between May and October, 1999, and of these, 3,244 resulted in egg laying. Peak nesting occurred in July, 1999, when approximately 30 leatherback nests were recorded nightly (Putrawidjaja, 2000). Given this, without adjusting the total observed to include the month of April (see footnote 2 in Table III-3) and assuming that the average number of nests per female ranged between 4.4 to 5.8 (see footnote 3 in Table III-3), the number of females nesting during 1999 was between 586 and 775 leatherback turtles, approximately half of the number observed nesting during 1996.

In the Kai Islands (also spelled "Kei Islands"), located approximately 1,000 kilometers southwest of the Irian Jaya nesting beaches, adult leatherback turtles are traditionally hunted and captured at sea by local people. Villagers hunt leatherback turtles only for ritual and subsistence purposes, and, according to their beliefs (known as *adat*), they are forbidden to sell or trade the meat. However, due to population increase and deforestation of the area which has lead to the loss of forest resources such as deer, pigs, and birds, villagers are taking leatherback turtles more for their increased need for meat for subsistence than for traditional purposes (Suarez and Starbird, 1996b). The carapace is rendered for oil, and the meat from the plastron is shared among villagers (Starbird and Suarez, 1994). Based on a study conducted during October-November, 1994, Suarez and Starbird (1996a) estimated that approximately 87 leatherback turtles were taken annually by villagers in the Kai Islands, and this estimate did not include incidental take by local gill and shark nets. Locals report that sea turtle populations in the area have declined dramatically (Suarez, 1999). Overall, approximately 200 leatherback turtles, both adult males and females, are killed per year in these traditional fisheries southwest of Kai Kecil during October-April (*in* Chan and Liew, 1996) (the Kai Islands take is assumed included in this estimate), and these takes are most likely continuing (C. Starbird, personal communication, 1998, *in* Clever Magazine, Issue No. 6).

As shown in Table III-3, since the early-to-mid 1980s, the number of female leatherback turtles nesting annually on the two primary beaches of Irian Jaya appear to be stable. However, given the current, serious threats to all life stages of the Indonesian leatherback populations, this trend may not be sustained and this population could collapse, similar to what occurred in Terrengganu, Malaysia. As human populations in Indonesia increase, the need for meat and competition between the expanding human population and turtles for space increases, all leading to more direct takes of leatherback turtles or incidental take by local fisheries. There is no evidence to indicate that the preceding threats are not continuing today, as problems with nest destruction by feral pigs, beach erosion, and harvest of adults in local waters have been reported (Suarez et al., unpublished report). In addition, local Indonesian villagers report dramatic declines in local sea turtle populations (Suarez, 1999); without adequate protection of nesting beaches, emerging hatchlings, and adults, this population will continue to decline.

Regarding the status of the Irian Jaya population of nesting leatherback turtles, Suarez *et al*. (in press) comment: "Given the high nest loss which has occurred along this coast for over thirty years it is not unlikely that this population may also suddenly collapse. Nesting activity must also continue to be monitored along this coast, and nest mortality must be minimized in order to prevent this population of leatherback turtles from declining in the future."

Conclusion on status of eastern and western Pacific leatherback turtles
Although quantitative data on human-caused mortality are scarce, available information suggests that leatherback mortality on many nesting beaches remains at unsustainable levels (Tillman, 2000). In addition, except for elimination of fishing mortality in the now-defunct high-seas driftnet fisheries in the North and South Pacific, and reductions of effort in a few other fisheries, risks of mortality in fisheries generally have not been reduced.

Conservation efforts during the last few years at nesting beaches in Mexico and Costa Rica have led to increased survival of eggs, and therefore greater hatchling production per nesting female. Nesting surveys of the eastern Pacific population showed an increase in 2000/2001. This has the potential for increasing future recruitment if post-hatchling survival is not further reduced; however, since numbers of nests are so low, and post-hatchling and juvenile natural mortality are assumed to be high, this increase in hatchling production may only result in the addition of a few adults annually. In western Pacific populations, particularly Irian Jaya, nest destruction by beach erosion and feral pig predation is widespread, and hatchling production is likely to be low relative to the numbers of nests laid. Overall, both eastern and western Pacific populations appear to have low female abundance as a result of legal harvest of eggs and nesting females, poaching, and incidental take in fisheries. Representation in the various age classes of female leatherback turtles is most likely unbalanced as a result of losses of adult females, juveniles and eggs and sub-adults and adults as a result of on-going fisheries and the now-defunct high seas driftnet fisheries. Gaps in age structure may cause sudden collapse of nesting populations when age classes with few individuals recruit into the reproductive population as older individuals die or are removed.

c. *Loggerhead Turtles*

The loggerhead turtle is listed as threatened under the ESA throughout its range, primarily due to direct take, incidental capture in various fisheries, and the alteration and destruction of its habitat. The loggerhead is categorized as Endangered, by the IUCN where taxa so classified are considered to be facing a very high risk of extinction in the wild in the near future. Loggerheads are a cosmopolitan species, found in temperate and subtropical waters and inhabiting pelagic waters, continental shelves, bays, estuaries and lagoons. In the Pacific Ocean, major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics (*in* NMFS and USFWS, 1998c).

The loggerhead is characterized by a reddish brown, bony carapace, with a comparatively large head, up to 25 cm wide in some adults. Adults typically weigh between 80 and 150 kg, with average CCL measurements for adult females worldwide between 95-100 cm CCL (*in* Dodd, 1988) and adult males in Australia averaging around 97 cm CCL (Limpus, 1985, *in* Eckert, 1993). Juveniles found off California and Mexico measured between 20 and 80 cm (average 60 cm) in length (Bartlett, 1989, *in* Eckert, 1993). Skeletochronological age estimates and growth rates were derived from small loggerheads caught in the high-seas driftnet fishery. Loggerheads less than 20 cm were estimated to be 3 years or less, while those greater than 36 cm were estimated to be 6 years or more. Age-specific growth rates for the first 10 years were estimated to be 4.2 cm/year (Zug, *et al*., 1995).

In the Atlantic, from a global perspective, the southeastern U.S. nesting aggregation is a critical component of this species. It is second in size only to the nesting aggregations in the Oman and represents about 35 and 40 % of the nesting of this species globally. The western Atlantic is composed of distinct genetic subpopulations: (1) a northern nesting subpopulation, occurring from North Carolina to northeast Florida at about 29º N (approximately 7,500 nests in 1998); (2) a south Florida nesting subpopulation, occurring from 29º N on the east coast to Sarasota on the west coast (approximately 83,400 nests in 1998); (3) a Florida panhandle nesting subpopulation, occurring at Eglin Air Force Base and the beaches near Panama City, Florida (approximately 1,200 nests in 1998); (4) a Yucatán nesting subpopulation, occurring on the eastern Yucatán Peninsula, Mexico (Márquez 1990) (approximately 1,000 nests in 1998); and (5) a Dry Tortugas nesting subpopulation, occurring in the islands of the Dry Tortugas, near Key West, Florida (approximately 200 nests per year) (NMFS SEFSC 2001). The northern subpopulation of loggerheads is declining or stable at best.

Nesting of loggerheads in the Pacific Basin are restricted to the western and southern region (Japan and Australia, primarily); there are no reported loggerhead nesting sites in the eastern or central Pacific. Upon reaching maturity, adult females migrate long distances from resident foraging grounds to their preferred nesting beaches. The average re-migration interval is between

2.6 and 3.5 years, in Queensland, Australia (*in* NMFS and USFWS, 1998c). Nesting is preceded by offshore courting, and individuals return faithfully to the same nesting area over many years. Clutch size averages 110 to 130 eggs, and one to six clutches of eggs are deposited during the nesting season (Dodd, 1988). Based on skeletochronological and mark-recapture studies, mean age at sexual maturity for loggerheads ranges between 25 to 35 years of age, depending on the stock (*in* Chaloupka and Musick, 1997), although Frazer *et al*. (1994 *in* NMFS and USFWS, 1998c) determined that maturity of loggerheads in Australia occurs between 34.3 and 37.4 years of age.

The transition from hatchling to young juvenile occurs in the open sea, and evidence is accumulating that this part of the loggerhead life cycle may involve trans-Pacific developmental migration (Bowen, *et al*., 1995). The size structure of loggerheads in coastal and nearshore waters of the eastern and western Pacific suggest that Pacific loggerheads have a pelagic stage similar to the Atlantic. This is supported by the fact that the high seas driftnet fishery, which operated in the Central North Pacific in the 1980s and early 1990s, incidentally caught juvenile loggerheads (mostly 40-70 cm in length) (Wetherall, *et al*., 1993). In addition, large aggregations of mainly juveniles and subadult loggerheads, numbering in the thousands, are found off the southwestern coast of Baja California, over 10,000 km from the nearest significant nesting beaches (Pitman, 1990; Nichols, *et al*., 2000a). Genetic studies have shown these animals originate from Japanese nesting stock (Bowen *et al*., 1995), and their presence reflects a migration pattern probably related to their feeding habits (Cruz, *et al*., 1991, *in* Eckert, 1993). These loggerheads are primarily juveniles, although carapace length measurements indicate that some of them are 10 years old or older. Loggerheads tagged in Mexico and California with flipper and/or satellite transmitters have been monitored returning to Japanese waters (Resendiz, *et al*., 1998a-b).

Tagging programs to study migration and movement of sea turtles provide evidence that loggerhead turtles are highly migratory and capable of trans-Pacific movement. Satellite telemetry studies show that loggerhead turtles tend to follow 17° and 20°C sea surface isotherms north of the Hawaiian islands (Polovina, *et al*., 2000; Eckert, unpublished data). Relationships between other turtle species and sea surface temperatures have also been demonstrated, with most species preferring distinct thermal regimes (Stinson, 1984). After capture in the Hawaii-based longline fishery, six satellite transmitter-equipped loggerheads traveled westward along two convergent oceanic fronts, against prevailing currents and associated with a "cool" front characterized by sea surface temperature (17°C), surface chlorophyll and an eastward geostrophic current of about 4 centimeters/second (cm/sec). Three others were associated with a warmer front (20°C), lower chlorophyll levels, and an eastward geostrophic flow of about 7 cm/sec. This study supports a theory that fronts are important juvenile habitat (Polovina, *et al*., 2000). Genetic analyses of 124 loggerheads caught in the Hawaii-based longline fishery indicated that the majority (nearly 100 percent) originated from Japanese nesting stock (P. Dutton, NMFS, personal communication, January, 2001). Loggerheads are not commonly found in U.S. Pacific waters, and there have been no documented strandings of loggerheads off the Hawaiian Islands in nearly 20 years (1982-1999 stranding data, G. Balazs, NMFS, personal communication, 2000).

For their first years of life, loggerheads forage in open ocean pelagic habitats. Both juvenile and subadult loggerheads feed on pelagic crustaceans, mollusks, fish, and algae. The large aggregations of juveniles off Baja California have been observed foraging on dense concentrations of the pelagic red crab, *Pleuronocodes planipes* (Pitman, 1990; Nichols, *et al*., 2000b). Data collected from stomach samples of turtles captured in North Pacific driftnets indicate a diet of gastropods (*Janthina* sp.), heteropods (*Carinaria* sp.), gooseneck barnacles (*Lepas* sp.), pelagic purple snails (*Janthina* sp.), medusae (*Vellela* sp.), and pyrosomas (tunicate zooids). Other common components include fish eggs, amphipods, and plastics (Parker, *et al*., in press). These loggerheads in the north Pacific are opportunistic feeders that target items floating at or near the surface, and if high densities of prey are present, they will actively forage at depth (Parker, *et al*., in press). As they age, some loggerheads begin to move into shallower waters, where, as adults, they forage over a variety of benthic hard- and soft-bottom habitats (reviewed *in* Dodd, 1988). Subadults and adults are found in nearshore benthic habitats around southern Japan, in the East China Sea and the South China Sea (e.g. Philippines, Taiwan, and Viet Nam).

Studies of loggerhead diving behavior indicate varying mean depths and surface intervals, depending on whether they were located in shallow coastal areas (short surface intervals) or in deeper, offshore areas (longer surface intervals). Loggerheads appear to spend a longer portion of their dive time on the bottom (or suspended at depth), which may be related to foraging and refuge. Unlike the leatherback, to the loggerhead foraging in the benthos, bottom time may be more important than absolute depth (Eckert, *et al*., 1989). The maximum recorded dive depth for a post-nesting female was 211-233 meters, while mean dive depths for both a post-nesting female and a subadult were 9-22 meters. Routine dive times for a post-nesting female were between 15 and 30 minutes, and for a subadult, between 19 and 30 minutes (Sakamoto, *et al*., 1990 *in* Lutcavage and Lutz, 1997).

Loggerhead nesting in the Pacific basin is restricted to the western region, primarily Japan and Australia. In the western Pacific the only major nesting beaches are in the southern part of Japan (Dodd, 1988), but the population status of the loggerhead nesting colonies here and the surrounding region are less clear. Balazs and Wetherall (1991) speculated that 2,000 to 3,000 female loggerheads may nest annually in all of Japan; however, more recent data suggest that only approximately 1,000 female loggerhead turtles may nest there (Bolten *et al*. 1996). Nesting beach monitoring at Gamoda (Tokushima Prefecture) has been ongoing since 1954. Surveys at this site showed a marked decline in the number of nests between 1960 and the mid-1970s. Since then, the number of nests has fluctuated, but has been downward since 1985 (Bolten *et al*., 1996). Recent information from the Sea Turtle Association of Japan (N. Kamezaki, personal communication, August, 2001) indicates that the number of nests at Gamoda is still very low, fluctuating between near zero (1999) to near 50 (1996 and 1998). Monitoring on several other nesting beaches, surveyed since the mid-1970s, revealed increased nesting during the 1980s before declining during the early 1990s. Recent data reflect a continuing decline (see Table 2 in Appendix B) (N. Kamezaki, Sea Turtle Association of Japan, personal communication, August, 2001). Nesting of loggerheads may also occur along the south China Sea, but it is a rare occurrence (Marquez, 1990, *in* Eckert, 1993).

In the south Pacific, Limpus (1982) reported an estimated 3,000 loggerheads nesting annually in Queensland, Australia during the late 1970s. However, long-term trend data from Queensland indicate a 50 percent decline in nesting by 1988-89, due to incidental mortality of turtles in the coastal prawn fishery. This decline is corroborated by studies of breeding females at adjacent feeding grounds (Limpus and Reimer, 1994). By 1997, the number of females nesting annually in Queensland was thought to be as low as 300 (1998 Draft Recovery Plan for Marine Turtles in Australia). Survey data are not available for other nesting assemblages in the south Pacific. Scattered nesting has also been reported on Papua New Guinea, New Zealand, Indonesia, and New Caledonia; however, population sizes on these islands have not been ascertained (NMFS and USFWS, 1998c).

There are no records of nesting loggerheads in the Hawaiian islands (Balazs, 1982), or in any of the islands of Guam, Palau, the Northern Mariana Islands (Thomas, 1989), the Federated States of Micronesia (Pritchard, 1982), or American Samoa (Tuato'o-Bartley, *et al*., 1993). There are very few records of loggerheads nesting on any of the many islands of the central Pacific, and the species is considered rare or vagrant on islands in this region (NMFS and USFWS, 1998c).

As mentioned, aggregations of juvenile loggerheads off Baja California Mexico have been reported, although their status with regard to increasing or declining abundance has not been determined. NMFS and USFWS (1998c) report "foraging populations ... range from 'thousands, if not tens of thousands' (Pitman, 1990) to 'at least 300,000 turtles' (Bartlett, 1989). Extrapolating from 1988 offshore census data, Ramirez-Cruz *et al.* (1991) estimated approximately 4,000 turtles in March, with a maximum in July of nearly 10,000 turtles."

Loggerhead mortality from human activities is not well-documented, except for estimates based on NMFS observer data in the Hawaii-based longline fishery and the CA/OR drift gillnet fishery and recent ongoing studies in Baja California, Mexico (Nichols, *et al*., 2000b; W. Nichols, Wildcoast, personal communication, 2000). A high mortality in the North Pacific high-seas driftnet fisheries of Japan, Republic of Korea, and Taiwan was estimated in the 1990s, but those fisheries no longer operate. Mortality of loggerheads in the East China Sea and other benthic habitats of this population are a concern and thought to be "high," but have not been quantified (Kamezaki, personal communication, *in* Tillman, 2000).

d. *Olive Ridley Turtle*

Although the olive ridley is regarded as the most abundant sea turtle in the world, olive ridley populations on the Pacific coast of Mexico are listed as endangered under the ESA; all other populations are listed as threatened. The olive ridley is categorized as endangered by the IUCN, where taxa so classified are considered to be facing a very high risk of extinction in the wild in the near future (IUCN Red List, 2000). They are the smallest living sea turtle, with an adult carapace length between 60 and 70 cm, and rarely weighing over 50 kg. They are olive or grayish green above, with a greenish white underpart, and adults are moderately sexually dimorphic (NMFS and USFWS, 1998d).

Like leatherback turtles, most olive ridley turtles lead a primarily pelagic existence (Plotkin *et al*., 1993), migrating throughout the Pacific, from their nesting grounds in Mexico and Central America to the north Pacific. While olive ridleys generally have a tropical range, with a distribution from Baja California, Mexico to Chile (Silva-Batiz, *et al*., 1996), individuals do occasionally venture north, some as far as the Gulf of Alaska (Hodge and Wing, 2000). Surprisingly little is known of their oceanic distribution and critical foraging areas, despite being the most populous of north Pacific sea turtles. The post-nesting migration routes of olive ridleys tracked via satellite from Costa Rica traversed thousands of kilometers of deep oceanic waters, ranging from Mexico to Peru, and more than 3,000 kilometers out into the central Pacific (Plotkin, *et al.*, 1993). The turtles appeared to occupy a series of foraging areas geographically distributed over a very broad range within their oceanic habitat (Plotkin, *et al.*, 1994). The species appears to forage throughout the eastern tropical Pacific Ocean, often in large groups, or flotillas, and are occasionally found entangled in scraps of net or other floating debris. In a three year study of communities associated with floating objects in the eastern tropical Pacific, Arenas and Hall (1992) found sea turtles, present in 15 percent of observations and suggested that flotsam may provide the turtles with food, shelter, and/or orientation cues in an otherwise featureless landscape. Olive ridleys comprised the vast majority (75%) of these sea turtle sightings. Small crabs, barnacles and other marine life often reside on the debris and likely serve as food attractants to turtles. Thus, it is possible that young turtles move offshore and occupy areas of surface current convergences to find food and shelter among aggregated floating objects until they are large enough to recruit to benthic feeding grounds of the adults. Olive ridleys feed on tunicates, salps, crustaceans, other invertebrates and small fish. Although they are generally thought to be surface feeders, olive ridleys have been caught in trawls at depths of 80-110 meters (NMFS and USFWS, 1998d), and a post-nesting female reportedly dove to a maximum depth of 290 meters. The average dive length for an adult female and adult male is reported to be 54.3 and 28.5 minutes, respectively (Plotkin, 1994, *in* Lutcavage and Lutz, 1997).

Olive ridley turtles begin to aggregate near the nesting beach two months before the nesting season, and most mating is generally assumed to occur in the vicinity of the nesting beaches, although copulating pairs have been reported over 100 km from the nearest nesting beach. Olive ridleys are considered to reach sexual maturity between 8 and 10 years of age, and approximately 3 percent of the number of hatchlings recruit to the reproductive population (Marquez, 1982 and Marquez, 1992, *in* Salazar, *et al.*, 1998). The mean clutch size for females nesting on Mexican beaches is 105.3 eggs, in Costa Rica, clutch size averages between 100 and 107 eggs (*in* NMFS and USFWS, 1998d). Females generally lay 1.6 clutches of eggs per season by Mexico (Salazar, *et al.*, 1998) and two clutches of eggs per season in Costa Rica (Eckert, 1993). Data on the remigration intervals of olive ridleys in the eastern Pacific are scarce; however, in the western Pacific (Orissa, India), females showed an annual mean remigration interval of 1.1 years. Reproductive span in females of this area was shown to be up to 21 years (Pandav and Kar, 2000).

Historically, an estimated 10 million olive ridleys inhabited the waters in the eastern Pacific off Mexico (Cliffton, *et al.*, 1982 *in* NMFS and USFWS, 1998d). However, human-induced mortality led to declines in this population. Beginning in the 1960s, and lasting over the next 15 years, several million adult olive ridleys were harvested by Mexico for commercial trade with Europe and Japan. (NMFS and USFWS, 1998d). Although olive ridley meat is palatable, it was not widely sought after; its eggs, however, are considered a delicacy. Fisheries for olive ridley turtles were also established in Ecuador during the 1960s and 1970s to supply Europe with leather. (Green and Ortiz-Crespo, 1982).

In the eastern Pacific, nesting occurs all along the Mexico and Central American coast, with large nesting aggregations occurring at a few select beaches located in Mexico and Costa Rica. Few turtles nest as far north as southern Baja California, Mexico (Fritts, *et al*., 1982) or as far south as Peru (Brown and Brown, 1982). A single olive ridley reportedly nested in 1985 on the island of Maui, Hawaii, but the eggs did not hatch (Balazs and Hau, 1986), and the event was most likely an anomaly. Where population densities are high enough, nesting takes place in synchronized aggregations known as *arribadas*. The largest known *arribadas* in the eastern Pacific are off the coast of Costa Rica (~475,000 - 650,000 females estimated nesting annually) and in southern Mexico (~800,000+ nests/year at La Escobilla, in Oaxaca (Millán, 2000).

The nationwide ban on commercial harvest of sea turtles in Mexico, enacted in 1990, has improved the situation for the olive ridley. Surveys of important olive ridley nesting beaches in Mexico indicate increasing numbers of nesting females in recent years (Marquez, *et al*., 1995; Arenas, *et al*., 2000). Annual nesting at the principal beach, Escobilla Beach, Oaxaca, Mexico, averaged 138,000 nests prior to the ban, and since the ban on harvest in 1990, annual nesting has increased to an average of 525,000 nests (Salazar, *et al*., in press). At a smaller olive ridley nesting beach in central Mexico, Playon de Mismalayo, nest and egg protection efforts have resulted in more hatchlings, but the population is still "seriously decremented and is threatened with extinction" (Silva-Batiz, *et al*., 1996). Still, there is some discussion in Mexico that the species should be considered recovered (Arenas, *et al*., 2000).

In Costa Rica, 25,000 to 50,000 olive ridleys nest at Playa Nancite and 450,000 to 600,000 turtles nest at Playa Ostional each year (NMFS and USFWS, 1998d). In an 11-year review of the nesting at Playa Ostional, (Ballestero, *et al*., 2000) report that the data on numbers of nests deposited is too limited for a statistically valid determination of a trend; however, there does appear to be a six-year decrease in the number of nesting turtles. At Playa Nancite, concern has been raised about the vulnerability of offshore aggregations of reproductive individuals to "trawlers, longliners, turtle fishermen, collisions with boats, and the rapidly developing tourist industry" (Kalb, *et al*., 1996). The greatest single cause of olive ridley egg loss comes from the nesting activity of conspecifics on *arribada* beaches, where nesting turtles destroy eggs by inadvertently digging up previously laid nests or causing them to become contaminated by bacteria and other pathogens from rotting nests nearby. At a nesting site in Costa Rica, an estimated 0.2 percent of 11.5 million eggs laid during a single *arribada* produced hatchlings (*in* NMFS and USFWS, 1998d). In addition, some female olive ridleys nesting in Costa Rica have been found afflicted with the fibropapilloma disease (Aguirre, *et al*., 1999).

At Playa La Flor, the second most important nesting beach for olive ridleys on Nicaragua, Ruiz (1994) documented 6 *arribadas* (defined as 50 or more females resting simultaneously). The main egg predators were domestic dogs and vultures (*Coragyps atratus* and *Cathartes aura*).

Although olive ridley *arribadas* in Orissa, India are among the largest such sites in the world, in the western Pacific, olive ridleys are not as well documented as in the eastern Pacific, nor do they appear to be recovering as well (with the exception of Orissa, India, only in recent years). There are a few sightings of olive ridleys from Japan, but no report of egg-laying. Similarly, there are no nesting records from China, Korea, the Philippines, or Taiwan. No information is available from Viet Nam or Kampuchea (*in* Eckert, 1993). In Thailand, olive ridleys occur along the southwest coast, on the Surin and Similan islands, and in the Andaman Sea. On Phra Thong Island, on the west coast of Thailand, the number of nesting turtles have declined markedly from 1979 to 1990. During the 1996-97 survey, only six olive ridley nests were recorded, and of these, half were poached, and one was predated by feral dogs. During the 1997-98 survey, only three nests were recorded. The main threats to turtles in Thailand include egg poaching, harvest and subsequent consumption or trade of adults or their parts (i.e. carapace), indirect capture in fishing gear, and loss of nesting beaches through development (Aureggi, *et al*., 1999).

Indonesia and its associated waters also provides habitat for olive ridleys, and there are some recently documented nesting sites. On Jamursba-Medi beach, on the northern coast of Irian Jaya, 77 olive ridley nests were documented from May to October, 1999 (Teguh, 2000 *in* Putrawidjaja, 2000). However, as mentioned in the leatherback subsection, extensive hunting and egg collection, in addition to rapid rural and urban development, have reduced nesting activities in this area. In Jayapura Bay, olive ridleys were often seen feeding, and in June, 1999, an estimated several hundred ridleys were observed nesting on Hamadi beach, despite heavy human population in the nearby area. Locals report daily trading and selling of sea turtles and their eggs in the local fish markets (Putrawidjaja, 2000). At Alas Purwo National Park, located at the eastern-most tip of East Java, olive ridley nesting was documented from 1992-96. Recorded nests were as follows: from September, 1993 to August, 1993, 101 nests; between March and October, 1995, 162 nests; and between April and June, 1996, 169 nests. From this limited data, no conclusions could be reached regarding population trends (Suwelo, 1999).

Olive ridleys nest on the eastern and western coasts of peninsular Malaysia; however, nesting has declined rapidly in the past decade. The highest density of nesting was reported to be in Terengganu, Malaysia, and at one time yielded 240,000 *eggs* (2,400 nests, with approximately 100 eggs per nest) (Siow and Moll, 1982, *in* Eckert, 1993), while only 187 *nests* were reported from the area in 1990 (Eckert, 1993). In eastern Malaysia, olive ridleys nest very rarely in Sabah and only a few records are available from Sarak (*in* Eckert, 1993).

Olive ridleys are the most common species found along the east coast of India, migrating every winter to nest en-masse at three major rookeries in the state of Orissa, Gahirmatha, Robert Island, and Rushikulya (*in* Pandav and Choudhury, 1999). The Gahirmatha rookery, located along the northern coast of Orissa, hosts the largest known nesting concentration of olive ridleys. Unfortunately, uncontrolled mechanized fishing in areas of high sea turtle concentration, primarily illegally operated trawl fisheries, has resulted in large scale mortality of adults during the last two decades. Records of stranded sea turtles have been kept since 1993. Since that time, over 50,000 strandings of olive ridleys have been documented (*in* Shanker and Mohanty, 1999), and much of it is believed to be due to near-shore shrimp trawling. Fishing in coastal waters off Gahirmatha was restricted in 1993 and completely banned in 1997 with the formation of a marine sanctuary around the rookery. However, mortality due to shrimp trawling reached a record high of 13,575 ridleys during the 1997-98 season, and none of the approximately 3,000 trawlers operating off the Orissa coast use turtle excluder devices in their nets (Pandav and Choudhury, 1999), despite mandatory requirements passed in 1997. "Operation Kachhapa" was developed in the late 1990s to protect sea turtles and their habitat by enabling strict enforcement of the 5 km non-mechanized fishing zone limit, as well as putting forward efforts to monitor nestings and educate local inhabitants and fishermen (Shanker and Mohanty, 1999). However, shrimp boats continue to fish close to shore within this protected zone and continue to not use turtle excluder devices. Threats to these sea turtles also include artificial illumination and unsuitable beach conditions, including reduction in beach width due to erosion (Pandav and Choudhury, 1999).

According to Pandav and Choudhury (1999), the number of nesting females at Gahirmatha has declined in recent years, although after three years of low nestings, the 1998-99 season showed an increasing trend (Noronha, Environmental News Service, April 14, 1999), and the 1999-2000 season had the largest recorded number of olive ridleys nesting in 15 years (The Hindu, March 27, 2000; The Times of India, November 15, 2000). During the 1996-97 and 1997-98 seasons, there were no mass nestings of olive ridleys. During the 1998-99 nesting season, around 230,000 females nested during the first arribada, lasting approximately a week (Pandav and Kar, 2000); unfortunately, 80% of the eggs were lost due to inundation and erosion (B. Pandav, personal communication, *in* Shanker and Mohanty, 1999). During 1999-2000, over 700,000 olive ridleys nested at Nasi islands and Babubali island, in the Gahirmatha coast. It is not known how many eggs and nests were lost to high winds and strong waves, predicted to cause erosion on the islands (The Hindu, March 27, 2000), and an estimated 6,000 turtles were killed during this period due to illegal mechanized trawlers and non-use of the prohibited turtle excluder devices (S. Sahoo, January, 2001 in rediff.com[12]).

There are no records of nesting on the unincorporated U.S. territories in the North Pacific. In the central Pacific, a single nesting was reported in September, 1985 on the island of Maui, Hawaii (*in* Eckert, 1993).

While olive ridleys generally have a tropical to subtropical range, individuals do occasionally venture north, some as far as the Gulf of Alaska. The post-nesting migration routes of olive ridleys, tracked via satellite from Costa Rica, traversed thousands of kilometers of deep oceanic waters ranging from Mexico to Peru and more than 3,000 kilometers out into the central Pacific (Plotkin *et al*. 1993). Stranding records since 1982 indicate that the olive ridley is the third most often stranded sea turtle in the Hawaiian Islands, averaging 2 per year (20 strandings from 1982-99) (G. Balazs, NMFS, personal communication, 2000).

Recent genetic information analyzed from 20 olive ridleys taken in the Hawaii-based longline fishery indicate that 60% of the turtles (n=12) originated from the eastern Pacific (Mexico and Costa Rica) and 40% of the turtles (n=8) were from the Indian and western Pacific rookeries (P. Dutton, NMFS, personal communication, January, 2001), indicating the animals from both sides of the Pacific converge in the north Pacific pelagic environment. An olive ridley taken in the CA/OR drift gillnet fishery originated from an eastern Pacific stock (i.e. Costa Rica or Mexico) (P.Dutton, NMFS, personal communication, September, 2000).

2. Factors Affecting Sea Turtles in the Pacific Ocean

[12]http://www.rediff.com/news/2001/jan/22oris.htm

Because impacts to sea turtles in the Pacific Ocean are generally non-discriminatory insofar as the different species are concerned, the following is a description of fisheries and non-fisheries-related threats to all sea turtles in the Pacific Ocean.

a. *Fisheries impacts*

Very few fisheries in the Pacific Ocean are observed or monitored for bycatch. Rough estimates can be made of the impacts of coastal, offshore, and distant water fisheries on sea turtle populations in the Pacific Ocean by extrapolating data collected on fisheries with known effort that have been observed to incidentally take sea turtles. However, the point needs to made that a straight extrapolation of this data contains a large degree of uncertainty and variability. Sea turtles are not uniformly distributed, either by area, or by time of year. In addition, observer coverage of a fishery may be very low, observers may not always be randomly distributed on vessels, or they may be placed on vessels that use fishing strategy that may be uncharacteristic of the fleet. Also, surveys and logbooks may contain biased or incomplete information. Lastly, such take estimates are also hampered by a lack of data on pelagic distribution of sea turtles.

This section will summarize known fisheries that have been observed or reported to incidentally or intentionally take sea turtles. Appendix A provides a summary of current trends in fishing effort in the eastern and western Pacific Ocean, by year, and country. Estimates of total fishing effort are complicated by the fact that not all active vessels fish equivalent number of days per trip or annually, or use the same number of hooks, length of net, or mesh size, or have the same carrying capacity. However, even with minimum effort estimates, it is apparent that there is significant fishing effort in the Pacific Ocean for which NMFS has no bycatch information for sea turtles.

(i) North Pacific Driftnet Fisheries (before December 1992)

Foreign high-seas driftnet fishing in the north Pacific Ocean for squid, tuna and billfish ended with a United Nations moratorium in December, 1992. Except for observer data collected in 1990-1991, there is virtually no information on the incidental take of sea turtle species by the driftnet fisheries prior to the moratorium. Tables 1 and 2 in Appendix A provide a summary of the number of active Japanese, Korean, and Taiwanese vessels fishing mainly for tuna in the Central Western Pacific Ocean from 1990-99.

The high seas squid driftnet fishery in the North Pacific was observed in Japan, Korea, and Taiwan, while the large-mesh fisheries targeting tuna and billfish were observed in the Japanese fleet (1990-91) and the Taiwanese fleet (1990). A combination of observer data and fleet effort statistics indicate that 4,373 turtles, mostly loggerheads and leatherback turtles, were entangled by the combined fleets of Japan, Korea and Taiwan during June, 1990 through May, 1991, when all fleets were monitored (Table III-4). Of these incidental entanglements, an estimated 1,011 turtles were killed (77 percent survival rate).

Table III-4. Estimated annual bycatch and mortality of sea turtles in the North Pacific high-seas driftnet fishery for squid, tuna & billfish in 1990-91 (Wetherall, 1997).

Species	Estimated Annual Take	Estimated Annual Mortality
green	378	93
leatherback	1,002	111
loggerhead	2,986	805
TOTAL	4,366	1,009

Data on size composition of the turtles caught in the high-seas driftnet fisheries were also collected by observers. Green turtles and the majority of loggerheads measured by observers were immature, and most of the actual measured leatherback turtles were immature, although the size of leatherback turtles that were too large to bring on board were only estimated, and are therefore unreliable (Wetherall, 1997).

These rough mortality estimates for a single fishing season provide only a narrow glimpse of the impacts of the driftnet fishery on sea turtles, and a full assessment of impacts would consider the turtle mortality generated by the driftnet fleets over their entire history and geographical range. Unfortunately, comprehensive data are lacking, but the observer data does indicate the possible magnitude of turtle mortality given the best information available. Wetherall *et al*. (1993) speculate that "the minimum total turtle mortality in the North Pacific high-seas driftnet fisheries may have been on the order of 2,500 turtles per year during the late 1980s. The actual mortality was probably greater than this, but less than the estimated total driftnet bycatch of perhaps 9,000 turtles per year. Based on 1990 observer data, most of the mortalities would have been loggerheads taken in the Japanese and Taiwanese large-mesh fisheries."

While a comprehensive, quantitative assessment of the impacts of the North Pacific driftnet fishery on turtles is impossible without a better understanding of turtle population abundance, stock origins, exploitation history and population dynamics, it is likely that the mortality inflicted by the driftnet fisheries in 1990 and in prior years was significant (Wetherall *et al*. 1993), and the effects may still be evident in sea turtle populations today. The high mortality of juvenile, pre-reproductive adults, and reproductive adults in the high-seas driftnet fishery has probably altered the current age structure (especially if certain age groups were more vulnerable to driftnet fisheries) and therefore diminished or limited the reproductive potential of affected sea turtle populations.

(ii) Japanese tuna longliners in the Western Pacific Ocean and South China Sea

Based on turtle sightings and capture rates reported in a survey of fisheries research and training vessels and extrapolated to total longline fleet effort by the Japanese fleet in 1978, Nishimura and Nakahigashi (1990) estimated that 21,200 turtles, including greens, leatherback turtles, loggerheads, olive ridleys and hawksbills, were captured annually by Japanese tuna longliners in the Western Pacific and South China Sea, with a reported mortality of approximately 12,300 turtles per year. Using commercial tuna longline logbooks, research vessel data and questionnaires, Nishimura and Nakahigashi (1990) estimated that for every 10,000 hooks in the Western Pacific and South China Sea, one turtle is captured, with a mortality rate of 42 percent. Although species-specific information is not available, vessels reported sightings of turtles in locations which overlap with commercial fishing grounds in the following proportions: loggerhead - 36 percent, green turtle - 19 percent, hawksbill - 10.3 percent, olive ridley - 1.7 percent, leatherback - 13.7 percent, and unknown - 19 percent.

Caution should be used in interpreting the results of Nishimura and Nakahigashi (1990), including estimates of sea turtle take rate (per thousand hooks) and resultant mortality rate, and estimates of annual take by the fishery, for the following reasons: (1) the data collected was based on observations by training and research vessels, logbooks and a questionnaire (i.e. hypothetical), and do not represent actual, substantiated logged or observed catch of sea turtles by the fishery; (2) the authors assumed that turtles were distributed homogeneously; and (3) the authors used only one year (1978) to estimate total effort and distribution of the Japanese tuna longline fleet. Although the data and analyses provided by Nishimura and Nakahigashi (1990) are conjectural, longliners fishing in the Pacific have had, and (with the current level of effort) probably continue to have significant impacts on sea turtle populations. Unfortunately, current bycatch information is not available for these fisheries, and NMFS is unaware of any follow-up studies since 1990. Future investigations into the level of sea turtle bycatch in these fisheries would allow a more complete assessment of cumulative effects on pelagic sea turtles in the Pacific Ocean.

(iii) South American fisheries

Chile

Although data on the incidental take of sea turtles in the Chilean swordfish fisheries are sparse, both green and leatherback turtles have been confirmed taken and killed, and olive ridleys and loggerheads may also be taken incidentally by the fishery (Weidner and Serrano, 1997). As described further in Appendix A, the Chilean swordfish fishery is comprised primarily of artisanal fishermen, averaging 500 boats (mainly driftnetters) from 1989 to 1991, and decreasing in numbers after 1991. Since 1991, approximately 20 large industrial (i.e. commercial) boats have fished swordfish in Chile, the effort is comprised of gillnets (27%), pelagic longliners (72%) and boats that switch gear. Effort by the artisanal fishery (including the driftnet fleet) increased from 5,265 days-at-sea in 1987 to 41,315 days-at-sea in 1994 (Barbieri, *et al*., 1998).

Adult female leatherback turtles tagged in Mexico have been taken in Chilean waters by gillnet *and* purse seine fisheries (Marquez and Villanueva, 1993). In addition, data were recorded opportunistically from the artisanal swordfish fishery (driftnetters primarily) for a single port (San Antonio) over a two year period. This partial record documented leatherback captures and sightings totaling 9 in 1988 and 21 in 1989. A rough estimate of 250 leatherback takes per year without differentiating between kills and total takes for vessels operating out of San Antonio was provided (Frazier and Brito Montero, 1990). A more recent estimated annual take of 500 leatherback turtles was provided by Montero (personal communication, 1997, *in* Eckert, 1997) which was not unreasonable, given the nearly ten-fold increase in fishing effort from 1987 to

1994.[13] As shown in Table III-5, the take of sea turtles by the artisanal driftnet fishery in the late 1980s appeared to be comprised primarily of leatherback turtles.

Effort by the artisanal driftnet fishery for swordfish appears to be relatively constant through 1996, as shown in Table III-6. Given the total sea turtle take estimate from the 1988-89 season, and combining it with the total effort (days-at-sea) data from 1988-1996, and assuming effort was constant and in the same general area during all years, a simple calculation can be made to estimate the incidental take of turtles by the Chilean artisanal driftnet fishery for swordfish during subsequent years (third column in Table III-6). Turtles reportedly began appearing in Chilean markets in 1987, just as the swordfish driftnet fishery was expanding, and Chilean observers have reported occasional individual sets with leatherback mortalities of from 3-13 (*in* Weidner and Serrano, 1997). Assuming the current artisanal driftnet fishing effort is equivalent to 1996 and assuming the proportion of species taken is equivalent to data collected from the 1988-89 fishing season, this fishery would currently take an estimated 39 greens, 76 leatherback turtles, 4 loggerheads, and 29 olive ridleys annually.

During 1996, there was a substantial expansion of Chilean longline fishing in offshore areas, but there has been no collection of data on this fishery as of 1997 (Weidner and Serrano, 1997), the anticipated effects on sea turtle stocks as a result in this change in fishing strategy are not known. Since effort for swordfish in the Chilean fishery or throughout the Pacific has declined significantly overall since 1994 (as a result of concerns about overfishing swordfish stocks) the bycatch of sea turtles in this fishery has likely declined as well, although the extent of this decrease is currently unknown. There is very little information on lethal and non-lethal incidental catch per unit effort. In addition to the swordfish fishery, Chile also has a substantial purse seine fleet, which has recently shifted from a reliance on coastal anchovy and sardines to a substantial take of jack mackerel further offshore, where turtle interactions may be more common (Weidner and Serrano, 1997). The extent of the impact of the Chilean purse seine fishery on sea turtles is unknown.

Table III-5. Chile – turtle bycatch of artisanal driftnet fishermen, 1988-89.

Species	Number	Percentage of Total
Green turtle	42	28%
Leatherback	82	55%
Loggerhead	5	3%
Olive ridley	21	14%
Total	150	100%

[13]Based on all information from Chile and Peru, Eckert (1997) estimated that a minimum of 2,000 leatherback turtles are killed annually by Peruvian and Chilean swordfish operations, representing a major source of mortality for leatherback turtles originating from and returning to nesting beaches in Costa Rica and Mexico. Because swordfish fishing effort has declined significantly since the early 1990s, incidental take has most likely declined as well, although the current estimate is unknown.

Source: José Brito-Montero, personal communication, 3/3/97, *in* Weidner and Serrano, 1997

Table III-6. Chile - artisanal (driftnet) swordfish effort, by year, from 1989-1996 and calculated (not actual or known) turtle take [note assumptions used in this Opinion].

Year	Effort (Days-at-sea)	Calculated Turtle Take*
1989	7,579	150*
1990	6,226	123
1991	11,450	227
1992	11,209	222
1993	10,755	213
1994	8,393	166
1995	8,152	161
1996	7,041	139

*Calculated turtle take was estimated by comparing effort for 1989 (7,579 days-at-sea) and a known turtle take of 150 (1988-89 season) with subsequent years for which effort was known, but turtle take is not known.

**Estimated take of turtles by Brito-Montero, for the 1988-89 season, and assuming 1989 data is equivalent in effort to 1988-89 effort, for the purpose of comparing year-to-year calculations of estimated turtle take. Source: Weidner and Serrano, 1997.

Colombia

A description of known Colombian commercial fisheries is provided in Appendix A and summarized in Table 5 of the Appendix. No information is available on the sea turtle bycatch levels in the shrimp trawl fisheries and other fisheries operating out of Colombia. However, a turtle excluder device program has been initiated in the shrimp trawl fishery to reduce incidental catch. Artisanal fisheries in the past targeted turtles (Weidner and Serrano, 1997); however, no recent information on directed take is available.

Ecuador

Appendix A contains a description of known current commercial and artisanal fisheries in Ecuador. Unfortunately, the composition of turtle species incidentally taken by Ecuadoran commercial and artisanal fisheries is unavailable. Prior to a ban on the commercial harvest for olive ridleys in 1986, artisanal fishermen prosecuted a directed turtle fishery as well as taking them incidentally. During 1985 and 1986, 124 and 715 metric tons of turtles, respectively, were reportedly taken (Table III-7). In 1990, the Ecuadoran government permanently ended the directed fishery, prohibiting the catch as well as domestic and export marketing. Incidental catches of sea turtles by tuna and swordfish longliners are reportedly very rare, but they do occur, and Ecuadoran authorities have seized turtle skins from Japanese longliners (*in* Weidner and Serrano, 1997).

Peru

Appendix A contains a description of known domestic and foreign fisheries in Peru. Peruvian commercial longline fleets have had limited success in fishing for swordfish, so there is probably very little incidental catch of sea turtles in this fishery. Peruvian artisanal fishermen, however, also target fish species normally taken in commercial longline fisheries (especially shark) and have been more successful than the commercial longline fleet, so more turtles may be caught incidental to these artisanal fisheries. Foreign longline fleets are also active and extensive off Peru and the bycatch of sea turtles in these foreign fisheries has been considered significant (Weidner and Serrano, 1997).

Peru conducted directed commercial turtle harvests throughout the 1980s, and, as recently as 1990, over 100 metric tons of turtles were taken (Table III-7) (Food and Agriculture Organization , Yearbook of Fishery Statistics, 1994, *in* Weidner and Serrano, 1997). Species-specific information was not available. Based on a sighting of 167 leatherback carapaces in a canyon near the port of Pucusana in 1978, Brown and Brown (1982) estimated a minimum of 200 leatherback turtles killed per year at that time. Furthermore, central Peru was known to have had the largest leatherback fishery in the world, taking what appeared to be adults and subadults, thus representing a considerable number of reproductive and near reproductive individuals (*in* Brown and Brown, 1982). The Ministerio de Pesqueria (MIPE), which is the Peruvian agency responsible for fisheries, prohibited the taking of all leatherback turtles and green turtles less than or equal to 80 cm in length through a resolution in January, 1977, although observers report that regulations are rarely enforced. Other species were not protected and were still unprotected as of 1989, although catches appear to have declined to negligible levels (Weidner and Serrano, 1997). Specific take levels remain unknown.

Table III-7. Ecuador and Peru - turtle catch in metric tons, 1985-95.

Year	Catch - Ecuador (metric tons)	Catch - Peru (metric tons)
1985	124	36
1986	715	9
1987	–	305
1988	–	32
1989	–	79
1990	–	101
1991	–	9
1992	–	30
1993	–	28
1994	–	6
1995	10*	4*

Source: FAO, Yearbook of Fishery Statistics, 1994, *in* Weidner and Serrano (1997)
*1995 data would not be found in the above source, yet Weidner and Serrano (1997) provide data for this year.

(iv) Distant Water Fishing Nations Longline Fishing in the EEZ around the Federated States of Micronesia

Heberer (1997) summarized the results of 51 distant-water fishing nation (DWFN) longline trips observed by Micronesian Maritime Authority fisheries observers from 1993 through 1995. Vessels from China, Taiwan, and Japan captured a total of 34 sea turtles. These turtles were reported as 15 olive ridleys, 8 green turtles, and 11 unidentified sea turtles. Thirty of the 34 turtles were released alive and the remainder were dead when landed (11.8% mortality rate). Data on hooking location or entanglement was not reported, nor was the condition of each turtle by species.

The Micronesia Fisheries Authority (previously Micronesian Maritime Authority) places observers aboard distant water fishing vessels fishing by longline in their EEZ. Table III-8 shows the observed catch of sea turtles by these vessels from January 1, 1990 through December, 2000. While the overall data set represents a significant amount of effort - 971 sets and 1,272,000 hooks observed over a 10 year period, the rate of observer coverage is extremely low. From 1990 through 1997, observer coverage ranged from 1 to 3%.

Table III-8. Observed captures of sea turtles aboard distant water longline vessels, January 1990 through December 2000. Source: Micronesian Fisheries Authority

Species	Number	Condition	
		% Alive	% Dead
Green	4	100	0
Hawksbill	1	100	0
Loggerhead	1	100	0
Olive ridley	8	100	0
Unidentified turtle	33	79	21
Total	47		

The information presented above is from two separate data sets, which may not have been coordinated. The study done by Heberer (1997) utilized observers specifically trained and directed to record bycatch information, whereas observers in this fishery typically prioritize the collection of target catch data over bycatch information. This information represents the best available information on bycatch in this fishery. Appendix A provides additional information on fishing effort. However, the above data cannot be compared or used to extrapolate expected rates of turtle bycatch based on small sample sizes, low rates of observer coverage, and prioritization of catch data.

(v) U.S. tuna purse seine fishery in the eastern tropical Pacific Ocean (ETP)

The vast majority of the U.S. western and central Pacific purse seine activity occurs in the highly productive fishing grounds of the equatorial western Pacific (principally in the EEZs surrounding

Papua New Guinea, the Federated States of Micronesia and Kiribati) under a multilateral agreement entitled *Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America* or the South Pacific Tuna Treaty (SPTT). The treaty was signed by the United States and 16 Pacific Island Parties belonging to the Forum Fisheries Agency (FFA), and provides U.S. tuna purse seiners access to tunas in a 25.9 million km^2 area of the central-western Pacific Ocean in exchange for fishing fees and adherence to rules related to closed area, etc (Coan, *et al*., 1997). The treaty was renegotiated in 1992 for an additional 10 years.

Between 1988 and 1999, the number of licensed U.S. tuna purse seiners ranged from 35 to 51, although only between 31 and 49 vessels fished during those years. Between 71 and 241 trips were made during each calendar year (Coan, *et al*., 2000), and most of the fishing was conducted in the equatorial belt, extending from around 155°W to 140°E longitude, the traditional fishing zone for the U.S. fleet (Coan, *et al*., 1997). The U.S. fleet primarily lands their catch in American Samoa (Coan, *et al*, 1997, 2000). From 1988 to 1995, the fleet primarily set on free-swimming school sets and less on log sets; however, beginning in 1996, sets were increasingly made on floating aggregation devices (FADs), and in 1999, nearly 100 % of sets were on FADs (Coan, *et al*., 2000). Because turtles tend to congregate around floating objects in the open ocean, this change in fishing strategy may increase the likelihood of sea turtle interactions.

The number of large (>400 short tons carrying capacity) ETP tuna purse seine vessels has remained steady since 1992, varying between 5 and 7 vessels, and the number of smaller (≤400 st) vessels has also remained steady, averaging 18 vessels between 1993 and 1997 (NMFS, 1998). Although all large tuna purse seine vessels fishing in the ETP for tuna have been required to carry observers since 1989 (100 percent coverage), smaller purse seine vessels are not required to carry observers. Most smaller tuna vessels fishing off southern California fish on tuna schools because the vessels are old, slow, and lack the resources (e.g. helicopters) needed to place and find floating objects (B. Jacobson, NMFS, personal communication, 1999). Based on observer data from the large vessels, the chances of incidentally capturing a sea turtle during a school set are much less than incidentally capturing a sea turtle during floating object sets; therefore, the incidental take of sea turtles by the small vessel fleet is likely to be less than that of the larger purse seine vessels. However, with no observer coverage, data on sea turtle bycatch are not available for the small tuna purse seine vessels in the ETP.

The U.S. fleet is required to take FFA observers on a minimum of 20 percent of their fishing trips, and captains are responsible for recording catch and bycatch data in logbooks. Logbooks are verified by observers, if possible, and are sent to the FFA no later than 14 days after returning to port (K. Staisch, FFA, personal communication, February, 2001). Between 1997 and 1999, there was approximately 20-23% observer coverage (FFA, 1998; A. Coan, personal communication, February, 2001). Collecting data on target species (i.e. tuna) is a priority for observers; however, if possible, and when time permits, observers do collect bycatch data. Observers receive limited training on sea turtle identification and are trained to look for tags, but they do not collect information on length or take biopsies, as the turtles are generally released immediately from the net. The incidental catch of sea turtles is a "rare occurrence," and any turtles observed taken have been released alive. Purse seine techniques normally allow turtles to surface for air during the pursing period, and based on observer reports, any turtles caught in nets are usually released as soon as possible. In addition, there have been no reports of turtles caught in the power block (K. Staisch, FFA, personal communication, February, 2001).

Table III-9. Sea turtle interactions by U.S. tuna purse seine fleet (1990 - 1997) - large vessels only [Note: there is some discrepancy between the numbers in the two parts of the table because previously dead turtles were not included in species estimates and hawksbill turtles were not included in the top part of the table and not accounted for it in the lower part]

Set Summary / by calendar year 1/1 - 12/30

Cruise Year	1990[1]	1991	1992	1993	1994	1995	1996	1997	Total
Number of sea turtles taken (mortality in parentheses) by species[2]									**Annual Average**
Olive ridley	113(2)	104	132	133(1)	69	69(1)	45(1)	95(1)	**96**
Green turtle	4	8	21	35	28	29	17	11	**19**
Leatherback	3	0	0	2	1	0	0	0	**0.8**
Loggerhead	0	1	0	0	3	0	0	2	**0.8**
Unidentified	36	37	25(1)	21	19	3	25	8	**22**
Totals	**156**	**150**	**178**	**191**	**120**	**101**	**87**	**116**	**137**
Condition of sea turtle when released (injury/mortality due to set)									**Annual Average**
Prev. dead	0	0	2	1	4	2	0	2	**1.4**
Released unharmed	126	137	168	181	115	92	73	110	**127**
Released slightly injured	13	5	7	1	3	6	5	2	**5.3**
Kill accidentally	2	0	1	1	0	1	1	1	**0.9**
Escaped net	11	5	3	6	2	0	7	3	**4.7**
Other/unknown	3	3	0	2	0	4	1	2	**1.9**
Totals	**156**	**150**	**181**	**192**	**124**	**105**	**87**	**120**	**141.1**

[1]First year of sea turtle data collection, did not began until 3/20. Summary reflects cruises from 3/20/90 - 12/30/90, when data was collected. 1,629 sets out of 1,814 for 1990 were observed for sea turtles.
[2]Mortalities are a subset of total incidental take.

In addition to collecting tuna life history and marine mammal and bycatch data during a set, observers on large U.S. purse seiners in the ETP complete a sea turtle life history form when a sea turtle is taken in a set (i.e., sea turtle was captured or at any time entangled in the net). Table III-9 shows sea turtle interactions in the large U.S. tuna purse seine fleet from 1990 to 1997. Data for 1998 and most of 1999 has not been entered into a database and is therefore currently unavailable. The 1990-1997 data include 174 turtles taken in the fishery that were not identified to species, although only 1 of these unidentified turtles is listed as accidentally killed (as discussed earlier, these estimates may underestimate the number of sea turtles killed in the fishery because some turtles that were lethargic when they were released, which were considered "alive" when they were released, probably died from their injuries subsequent to their release).

Most of unidentified sea turtles probably never came on board, but escaped after being encircled or captured, and the observer was not close enough to identify the turtle as it swam away. Assuming that these unidentified turtle interactions occurred in the same proportions as the identified sea turtle interactions, these 174 turtles would most likely be comprised of 143 olive ridleys, 28 green turtles, and 1 to 3 leatherback, hawksbill or loggerhead turtles, in unknown proportion. It is likely that most of these 174 unidentified turtles were uninjured by their capture or encirclement if they did release themselves from the net and swim away.

In its December 8, 1999, biological opinion on the effects of the interim final rule for the continued authorization of the ETP U.S. tuna purse seine fishery on listed species, NMFS estimated the maximum annual incidental takes and mortalities of sea turtles for 2000-2010: green - 35 taken, 2 killed; leatherback turtles - 2 taken, 1 killed every 10 years; loggerheads - 3 taken, 1 killed every 7 years; olive ridleys - 133 taken, 7 killed (NMFS, 1999).

(vi) Foreign tuna purse seine fishery in the ETP

The international fleet represents the majority of the fishing effort and carrying capacity in the ETP tuna fishery, with most of the total capacity consisting of purse seiners greater than 400 st. These large vessels comprised about 87 percent of the total fishing capacity operating in the ETP in 1996 (IATTC, 1998). An average of 107 foreign vessels with a carrying capacity greater than 400 st fished in the ETP during 1993 to 1997. In addition to these larger vessels, the foreign fleet contains smaller vessels less than 400 st that target tuna in the ETP. From 1993 to 1997, an average of 63 foreign vessels ranging from 45 to 400 st carrying capacity fished in the ETP each year.

Data from observers on both U.S. and foreign tuna purse seine vessels have been gathered collectively by the IATTC since the early 1990s (Table III-10; data are in addition to Table III-9). The most recent data from the IATTC indicate that an average of 172 sea turtles per year were killed by vessels over 400 st in the entire ETP purse seine fishery (U.S. included) from 1993-97 (IATTC, 1999).

The 1993-1997 data indicate that 168 turtles killed by the entire tuna purse seine fishery were "unidentified," although the reasons for this were not given. Assuming that these unidentified turtle mortalities occurred in the same proportions as the identified turtle mortalities, these 168 turtles would be 140 olive ridleys, 20 green turtles, 7 loggerhead turtles and one would be either a leatherback or hawksbill.

Table III-10. Estimated sea turtle mortality by species for the entire ETP tuna purse seine fishery (U.S. and foreign) from 1993-1997[1]

Species/Year	1993	1994	1995	1996	1997
Olive ridley	197	103	94	83	99
Loggerhead	5	10	2	3	7
Green/black	39	8	12	7	19

Leatherback	0	0	0	1	0
Unidentified	46	36	32	29	25
TOTAL	287	157	140	123	150

[1] (M. Hall, IATTC, personal communication, 1999)

(vii) Mexican (Baja California) fisheries and direct harvest

Based on a combination of analyses of stranding data, tag-recapture studies and extensive interviews, all carried out between 1994 and 1999, Nichols (Wildcoast, personal communication, October 2000) has conservative estimates of the annual take of green turtles and loggerhead turtles by various fisheries and through direct harvest in the Baja California, Mexico region. Even though direct killing of turtles has been prohibited by Mexican law since 1990, Nichols and his affiliates estimated the annual mortality of green turtles in this region to be *greater* than 7,800 turtles, impacting both immature and adult turtles. Nichols (Wildcoast personal communication, July, 2001) estimates that between 10 and 25 percent of turtles on the feeding grounds are harvested. Large scale poaching has been reported in the B. Kino, Desemboque, and Punta Chueca (Sonora) areas, and a recent survey on Isla Magdalena found 70 new carapaces (estimated 210 turtles taken annually by this community). The primary causes for mortality are the incidental take in a variety of fishing gears and direct harvest for consumption and [illegal] trade. More recently, based on a massive survey of fishing communities, scientists at the Autonomous University of Baja California estimate that poachers kill as many as 30,000 green turtles annually in Baja. According to the study, much of the demand for turtles is from the government sector, including politicians, teachers, and the military; i.e. those that have the cash to pay for the turtles and those with the political clout to escape legal repercussions for their actions (Scientific American, August, 2001). Based on collection and genetic analyses of tissue samples from green turtles on the foraging grounds off Baja, the majority of the animals (80% of samples) originate from Michoacan, while the rest may originate from Hawaii or the Islas Revillagigedos, a small archipelago off the coast of Colima, Mexico (Nichols, *et al*., 2000a).

Mortality of loggerhead turtles in Baja California, based on stranding and harvest rates, is estimated at 1,950 annually, and affects primarily immature size classes. Based on stranding patterns, Nichols, *et al*. (2000b) speculate that mortality of loggerheads due to local fishing may primarily be due to a net-based fishery. None of the stranded turtles showed signs of hooking; therefore the halibut fishery, which reports regular loggerhead bycatch and coincides with the movement of pelagic red crab into the shallower continental shelf, may interact with loggerheads as they enter coastal waters in the spring and summer.

(viii) California/Oregon drift gillnet fishery

The California/Oregon (CA/OR) drift gillnet fishery targets swordfish and thresher shark. The fishery has been observed by NMFS since July 1990, and observer coverage has ranged from 4.4 percent in 1990 to an estimated 21.0 percent in 1999. Between July 1990 and December 31, 1999, NMFS has observed 5,529 sets (NMFS unpublished data). The fishery occurs primarily within 200 nautical miles (nm) of the California coastline and to a lesser extent off the coast of Oregon. Under California state regulations, the fishery is restricted to waters outside 200 nm from February 1 through April 30 and outside 75 nm from May 1 through August 14. Fishing is allowed inside 75 nm from August 15 through January 31. Because of these restrictions, the fishery is not active during February, March, and April. In addition, very little fishing effort occurs during the months of May, June, and July since CA/OR drift gillnet vessels targeting swordfish tend to set on warm ocean water temperature breaks which don't appear along the California coast until late summer. Currently, approximately 90 percent of the fishing effort occurs between August 15 and December 31. On average, about 9 percent of the fishing effort occurs during the month of January, 0 percent occurs February through April, and slightly more than 1 percent occurs between May 1 and August 14 (California Department of Fish and Game (CDFG), unpublished data).

Fishers use nets constructed from 3-strand twisted nylon, tied to form meshes. The meshes range from 16 to 22 inches stretched, and average 19 inches stretched. Although termed "gillnets," the nets actually entangle fish, rather than trap them by the gills. Net length ranges from 750 to 1000 fathoms, averaging 960 fathoms. The top of the net is attached to a float line by hanging lines laced through several meshes and tied at intervals of 8 to 24 inches. The number of meshes per hanging determines the slack or tautness of the net. The bottom of the net is attached to a weighted lead line. The number of meshes between the float line and the lead line determines the depth of the net, which ranges from 100 to 150 meshes. The depth at which the float line is suspended in the water column is determined by the length of the buoy line (extender length). Nets are often set perpendicular to currents, or across temperature, salinity, or turbidity fronts. Nets are typically set in the evening, allowed to soak overnight, then retrieved in the morning. The average soak time is 10.5 hours (NMFS 1997). The vessel remains attached to one end of the net during the soak period, drifting with the net.

The CA/OR drift gillnet fishery has been subject to the Pacific Offshore Cetacean Take Reduction Plan (PCTRP) since October 1997 (62 Federal Register (FR) 51805). The PCTRP requires that nets be fished at a minimum depth of 36 feet below the water surface, that acoustic warning devices ("pingers") be used during all sets, and that skipper workshops be held to educate fishers about the take reduction plan requirements and solicit input on additional ways to possibly reduce marine mammal take. Based on a comparison of observer data collected prior to and since the implementation of the PCTRP, there does not appear to be a significant difference in sea turtle entanglement rates, although interactions are rare events in this fishery.

Green and olive ridley turtles are rarely taken by the CA/OR drift gillnet fishery; in fact, only one green and one olive ridley turtle have been observed since NMFS began observing the fishery in 1990. Both of these observed takes occurred in 1999. The green turtle was returned dead and the olive ridley was released alive. In addition, there have been 23 leatherback turtles observed taken by this fishery since 1990. Almost all of these interactions occurred north of Point Conception (34° 25' N), and 78% of these interactions occurred during the months of August, September, and October with the majority of the interactions occurring during October (61%). There have been 14 loggerhead sea turtle interactions observed in the CA/OR drift gillnet fishery. All of these interactions were south of Point Conception and occurred during El Niño events. Table III-11 shows the annual estimated mortality of sea turtles incidentally taken by the CA/OR drift gillnet fishery, based on extrapolated observer data. Animals released alive or injured are not included in the table.

Table III-11. Estimated mortality (and coefficients of variation) of sea turtles by the CA/OR drift gillnet fishery based on observer data.

Species	1990[1]	1991[1]	1992[1]	1993[1]	1994[1]	1995[1]	1996[2]	1997[3]	1998[3]	1999[4]
Green	0	0	0	0	0	0	0	0	0	5 (0.90)
Loggerhead	0	0	7 (0.93)	0	0	0	0	6 (0.95)	5 (0.89)	0
Leatherback	23 (0.97)	0	15 (0.65)	15 (0.66)	0	26 (0.55)	24 (0.64)	7 (0.95)	0	0
Olive Ridley	0	0	0	0	0	0	0	0	0	0
Unidentified Turtle	0	0		7 (0.93)	0	0	0	0	0	0

[1] Julian and Beeson, 1998.
[2] Julian 1997.
[3] Cameron and Forney, 1999.
[4] Cameron and Forney, 2000.

On October 23, 2000, NMFS issued a biological opinion on the issuance of a permit under section 101(a)(5)(E) of the Marine Mammal Protection Act (MMPA) for the incidental taking of marine mammal species listed under the ESA during commercial fishing operations. After reviewing the available scientific and commercial data, current status of Pacific leatherback and loggerhead sea turtles, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, the opinion found that the issuance of section 101(a)(5)(E) permits and the associated continued operation of the CA/OR drift gillnet fishery, as regulated under the PCTRP, was likely to jeopardize the continued existence of Pacific leatherback and loggerhead sea turtles. Based on this opinion, NMFS implemented regulations on August 24, 2001, prohibiting drift gillnet fishing from August 15 through November 15 in an area bounded by straight lines from Point Sur, California to 34°27'N 123°35'W, west to 129°W, north to 45°N, then east to the Oregon coast to reduce the likelihood of interactions with leatherback turtles. In addition, fishing effort south of Point Conception will be eliminated during El Niño events in August and January to reduce the likelihood of an interaction with loggerhead turtles. As a result of these closures, NMFS expects there to be at least a 78% reduction in the overall leatherback interactions and 92% reduction in loggerhead interactions.

(ix) California-based longline fishery

Longline vessels which fish on the high seas (i.e. outside of EEZ waters) and unload their catch and re-provision in California ports comprise the California-based longline fishery. This fishery targets swordfish and tuna, especially bigeye tuna. From 1991 to late 1993, three vessels participated in the fishery. Then in late August, 1993, longliners from the Gulf of Mexico began arriving in southern California, and by 1994, 31 vessels landed swordfish and tuna in California. By 1995, most of the Gulf of Mexico vessels left, and only 4 to 6 vessels made more than one trip from a California port, although 22 vessels made at least one longline landing. By the end of

1995, 5 vessels from the Hawaii-based fleet began operations in California due to the higher prices paid there for their fish, and in 1999, a large group of Hawaii-based longliners established operations in Los Angeles harbor. In general, however, a core group of 4 long-term California-based longliners are in this fishery (Draft Pacific Highly Migratory Species Fisheries Management Plan, June, 2001).

Preliminary and unedited data from fisher logbooks submitted to the CDFG show that the California-based longline fishery does interact with sea turtles. Between August 1, 1995 through December 31, 1999, 33 different vessels fished a total of 2,090 days and deployed 7,071,745 hooks. Although some of the vessels began and ended their fishing trips in California, others may have begun their trip in Hawaii and ended in California. The data have not been standardized for effort, seasonality, size, or any other variables. Furthermore the data represent a subset of the results of an unknown amount of fishing effort expended in the areas of the ocean in which the reporting captains fished (CDFG, 2000). Given those caveats, Table III-12 is a summary of reported sea turtle by catch in the California-based longline fishery.

Table III-12. Sea turtle bycatch, August, 1995 - December, 1999 in California-based longline fishery, reported logbook data

Species	Animals Released		
	Alive	Injured	Dead
Green turtle	12	0	0
Leatherback	33	2	0
Loggerhead	21	0	0
Olive ridley	19	0	0
Unidentified Turtle	7	0	0

Source: unedited data from high-seas longline logbooks submitted to CDFG, and reported by M. Vojkovich (CDFG) on 9/29/00.

(ix) Hawaii-based longline fishery

The Hawaii-based longline fishery is a limited access fishery with up to 164 permitted vessels (114 active), all 101 ft or less in length. These vessels participate in an international fishery for tuna on fishing grounds which extend beyond the U.S. EEZ. The fishery is open all year except for an area closure south of the Hawaiian Islands during the months of April and May. The fleet can be separated into three trip types, based on target species, fishing grounds, and operational characteristics: tuna, swordfish, and mixed target. A complete description of the fishery can be found in the March 29, 2001 biological opinion (NMFS, 2001a).

As described in Section I, Consultation History, NMFS recently completed a Section 7 consultation on the effects of the Hawaii-based longline fishery as it is managed under the Pelagics FMP. Based on the analysis in the March 29, 2001 biological opinion, NMFS concluded that the operation of the fishery jeopardized the continued existence of the green, leatherback and loggerhead sea turtles. Reasonable and prudent alternatives included a closure north of the equator to all swordfish, mixed trip style fishing and a time and area closure to all longline fishing south of 15°N latitude, north of the equator (0°), west of 145°W latitude and east of the 180° longitude between April 1st and May 31st.

Based on a "worst case" analysis, NMFS estimated the annual capture and mortality levels in the Hawaii-based longline fishery after the reasonable and prudent alternatives were implemented (Table III-13).

Table III-13. Estimated annual capture and mortality levels in the Hawaii-based longline fishery after implementation of the RPA measures for this fishery based on a worse case analysis (see above discussion). Numbers in parentheses are estimates based on the 95% confidence intervals for the point estimates [1].

Species	Annual Estimated Incidental Take	Annual Estimated Incidental Mortality
Green	14 (0-41)	9 (0-27)
Leatherback	26 (0-59)	14 (0-32)
Loggerhead	0-5	0-2
Olive Ridley	67 (1-137)	59 (1-121)

[1] Where numbers represented fractions of turtles, the number was rounded up to represent a whole turtle.

(x) Other pelagic fisheries authorized under the Pelagics FMP

All four species of sea turtles may be taken in fisheries other than the Hawaii-based longline fishery and authorized by the Pelagics FMP. The known level of effort and the selectivity of the gear used in these fisheries led NMFS in its March 29, 2001 to conclude that few takes, if any, occur in these other fisheries, although NMFS had limited data to confirm this assumption. Therefore, based on the limited information available, NMFS quantified the amount of incidental take of sea turtles that may occur during operations of these other fisheries. The resulting numbers (Table III-14) are possible minimums that must be re-evaluated after one year of data has been gathered on these fisheries. Subsequent years' information will be used to further refine expected levels of incidental take and evaluate their impacts on listed species.

Table III-14. Estimated annual capture and mortality levels in the pelagic fisheries under the Pelagics FMP other than the Hawaii-based longline fishery.

Fishery	Annual Estimated Incidental Take (All Species Combined)	Annual Estimated Incidental Mortality (All Species Combined)
All handline fisheries	1	0
All troll fisheries	1	0
Pole and line	1	0
American Samoa longline	3 hardshell turtles, 1 leatherback	1 hardshell turtle
Guam longline	3 hardshell turtles, 1 leatherback	1 hardshell turtle
CNMI longline	3 hardshell turtles, 1 leatherback	1 hardshell turtle

b. *Other impacts*

Threats to sea turtles vary among the species, depending on their distribution and behavior. The value of their meat, eggs, shell or other parts plays an important role in the extent of directed harvest. All sea turtle life stages are vulnerable to human-induced mortality. On nesting beaches, direct exploitation of turtles for meat, eggs, skin or shell, and other products takes place for both commercial markets and local utilization, and to a much lesser degree for traditional ceremonies. Nesting beach and in-water habitat degradation and destruction have occurred due to many factors, including coastal development, dredging, vessel traffic, erosion control, sand mining, vehicular traffic on beaches, and artificial lighting, which repels the adults and disorients the hatchlings. Human alteration of terrestrial habitats can also change the feeding patterns of natural predators, thereby increasing predation on marine turtle nests and eggs.

Petroleum and other forms of chemical pollution affect turtles throughout their marine and terrestrial habitats. Poisoning, as well as blockage of the gastrointestinal tract by ingested tar balls, has been reported. Low level chemical pollution, possibly causing immunosuppression has been suggested as one factor in the epidemic outbreak of a tumor disease (fibropapilloma) in green turtles. Plastics and other persistent debris discharged into the ocean are also recognized as harmful pollutants in the pelagic environment. Marine turtles such as leatherback turtles actively feed on jellyfish, and plastic bags floating in the water potentially resemble such prey in form, color and texture. Ingested plastics can occlude the gut, preventing or hampering feeding, and causing malnutrition or starvation. Both the entanglement in, and ingestion of, this synthetic debris have been documented (*in* NMFS and USFWS, 1998a-d).

3. Status Summary of Sea Turtle Species

All listed sea turtle populations affected by the proposed action have been impacted by human-induced factors such as commercial fisheries, direct harvest of turtles, and modification or degradation of the turtle's terrestrial and marine habitats. Nesting beach habitat impacts have resulted in the loss of eggs and hatchlings as well as the deterrence of nesting females resulting in decreased nesting success. In the marine environment, a significant anthropogenic impact is the incidental capture and mortality of subadult and adult sea turtles in various commercial fisheries. Mortality resulting from the effects of marine pollution are important but much less significant. Increased mortality at the egg and early life history stages has impacted the species' ability to maintain or increase its numbers by limiting the number of individuals that survive to sexual maturity. In addition, the mortality of adult females results in the loss of their future reproductive output. The age at sexual maturity of loggerheads may be as high as 35 years, while green turtles may not reach maturity until 30-60 years (*in* Crouse, 1999). Upon reaching maturity, female sea turtles generally lay between 100-130 eggs per clutch, minimally 2-3 clutches per year, every 2-4 years. Thus, in general, a female sea turtle will lay between 200-390 eggs per season over an average of 2-4 years.

The potential for an egg to develop into a hatchling, into a juvenile, and finally into a sexually mature adult sea turtle will vary among species, populations, and the degree of threats faced during each life stage. Females killed prior to their first successful nesting will have contributed nothing to the overall maintenance or improvement of the species' status. Anthropogenic mortality to females (or males, for that matter) prior to the end of their reproductive life results in a serious loss of reproductive potential to the population. While quantitative data do not yet exist to provide a precise understanding of the effects of this loss of reproductive potential, the status and trends of the turtles themselves are the best evidence that sea turtle populations cannot withstand current mortality rates. In the face of current levels of mortality and extent of habitat degradation, nesting assemblages of green, leatherback, and loggerhead turtles have declined to levels that place them at a very high risk of extinction within the foreseeable future. Of the sea turtles considered in this Opinion, only olive ridley turtle nesting assemblages seem to be somewhat stable or increasing slightly.

IV. EFFECTS OF THE ACTION

Pursuant to Section 7(a)(2) of the ESA (16 U.S.C. §1536), federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This biological opinion assesses the effects of NMFS Endangered Species Division's proposal to issue a scientific research permit (#1303) to the SWFSC, Honolulu, Hawaii, on threatened and endangered species and critical habitat that has been designated for these species. The permit would authorize research to be conducted on longline vessels in the Pacific Ocean. This proposed action is likely to adversely affect listed species through gear interactions, primarily entanglement and hooking, which may injure or kill individual animals. In the *Description of the Action* section of this Opinion, NMFS provided an overview of the scientific research to be conducted under the permit, including the anticipated number of threatened and endangered species that may be taken. In the *Status of the Species* (which is also the *Environmental Baseline*) section of this Opinion, NMFS provided an overview of the threatened and endangered species that are likely to be adversely affected by issuance of the scientific research permit.

Under section 10(a)(1)(A) of the ESA (16 U.S.C. § 1539(a)(1)(A)), individuals and organizations may apply for permits from NMFS to take ESA-listed species under the jurisdiction of NMFS if such taking is for scientific purposes or to enhance the propagation or survival of the affected species. In determining whether to issue a scientific research permit, the Assistant Administrator shall specifically consider, among other application criteria, the following relevant measures: (1) whether the permit, if granted and exercised, will not operate to the disadvantage of the endangered species; (2) whether the permit would be consistent with the purposes and policy set forth in section 2 of the ESA; (3) whether the permit would further a bona fide and necessary or desirable scientific purpose or enhance the propagation or survival of the endangered species, taking into account the benefits anticipated to be derived on behalf of the endangered species; and (4) the status of the population of the requested species and the effect of the proposed action on the population, both direct and indirect (CFR Section 222.308).

In this section of a biological opinion, NMFS assesses the probable direct and indirect effects of the issuance of this scientific research permit on threatened and endangered species and designated critical habitat. The purpose of this assessment is to determine if it is reasonable to expect that the proposed action would have direct or indirect effects on threatened and endangered species that appreciably reduce their likelihood of surviving and recovering in the wild or appreciably diminish the value of designated critical habitat for both the survival and recovery of threatened and endangered species in the wild. Before beginning our analyses, we will discuss our approach to the assessment, the evidence available for our assessment, and assumptions we had to make to overcome limits in our knowledge.

A. Approach to the Assessment

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of federal actions to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the ESA and it implementing regulations also require biological opinions to determine if federal actions would appreciably diminish the value of critical habitat for the survival and recovery of listed species (16 U.S.C. §1536; 50 CFR 402.02). Since the proposed action is not likely to affect designated critical habitat, this Opinion will focus only on the jeopardy analysis.

We approach jeopardy analyses in three steps. First, we identify the probable direct and indirect effects of an action on the physical, chemical, and biotic environment of the action area. The second step of our analysis determines if we would reasonably expect threatened or endangered species to experience reductions in reproduction, numbers, or distribution in response to these effects. In the third step of our analyses, we determine if any reductions in a species' reproduction, numbers, or distribution (identified in the second step of our analysis) can be expected to appreciably reduce a listed species' likelihood of surviving and recovering in the wild.

Human activities can reduce a species' reproduction by reducing the number of adults that reproduce in a population, reducing the number of young an adult will produce in a time interval or a lifetime, increasing the time it takes for an adult to reproduce, increasing the number of years that pass before an adult females returns to breed, reducing the survival of young, or decreasing the number of young that recruit into the adult population (Andrewartha and Birch, 1954; Ebert, 1999; Caughley and Gunn, 1996). Human activities can reduce a species' numbers by killing them immediately or over time, reducing the numbers of individuals born into a population, reducing the number of individuals that immigrate into a population, or increasing the number of individuals that emigrate from a population (Burgman *et al.*, 1993, Caughley and Gunn, 1996). Human activities can reduce a species' distribution by reducing its population size or density in ways that cause the species to abandon parts of its range (Fowler and Baker, 1991). A species' reproduction, numbers, and distribution are interdependent: reducing a species' reproduction will reduce its population size; reducing a species' population size will usually reduce its reproduction, particularly if those reductions decrease the number of adult females or the number of young that recruit into the breeding population; and reductions in a species' reproduction and population size normally precede reductions in a species' distribution.

The final step in our analysis — relating reductions in a species' reproduction, numbers, or distribution to reductions in the species' likelihood of surviving and recovering in the wild — is the most difficult step because (a) the relationship is not linear; (b) to persist over geologic time, most species' have evolved to withstand some level of variation in their birth and death rates without a corresponding change in their likelihood of surviving and recovering in the wild; (c) our knowledge of the population dynamics of other species and their response to human perturbation is usually too limited to support anything more than rough estimates. Nevertheless, our analysis must distinguish between anthropogenic reductions in a species' reproduction, numbers, and distribution that can reasonably be expected to affect the species' likelihood of survival and recovery in the wild from other (natural) declines.

Error

As scientists, we have two points of reference available when we consider data, information, or other evidence to support our analyses: (1) we can analyze the information available to avoid concluding that an action had an effect on listed species or critical habitat, when, in fact, it did not or (2) we can analyze the information available to avoid concluding that an action had no effect on listed species or critical habitat when, in fact, the action had an effect. In statistics, these two points of reference are called "errors": the first point of reference is designed to avoid what is called Type I error while the latter is designed to avoid what is called Type II error (see Cohen,1987). Although analyses that minimize either type of error are statistically valid, most biologists and ecologists still focus on minimizing the risk of concluding that there was an effect when, in fact, there was no effect (Type I error) and tend to ignore Type II error.

To comply with direction from the U.S. Congress to provide the "benefit of the doubt" to threatened and endangered species [House of Representatives Conference Report No. 697, 96th Congress, Second Session, 12 (1979)], our analyses are designed to avoid concluding that actions had no effect on listed species or critical habitat when, in fact, there was an effect (Type II error). This approach to error may lead us to different conclusions than scientists who take more traditional approaches to avoiding error, but we believe our approach is more consistent with the purposes of the ESA and direction from Congress.

Jeopardy analyses must look into the future to identify the effects of activities conducted today on the future of threatened and endangered species. Some human activities have delayed effects on plant and animal populations, either because a species' population takes time to respond to an effect, because the population only responds when effects accumulate, or a combination of these two. The classic example of a combined response is the bald eagle population's response to DDT, which became apparent only after many years of population declines. These responses pose the challenge of choosing how far into the future we must look to (1) detect a population's response to an effect or (2) detect a change in a species' likelihood of surviving and recovering in the wild (Crouse, 1999). If we do not look far enough into the future, our analyses will not detect a population's response to a human activities and we are more likely to falsely conclude there was no effect when, in fact, an effect occurred (which means, in the case of fisheries, adult and subadult turtles will have been captured and killed for a period of years). If we look too far into the future, our analyses can mask short-term collapses in a population and, again, we increase our likelihood of falsely concluding there was no effect when, in fact, an effect occurred.

Because the proposed issuance of scientific research permit #1303 is for a maximum of three years, we will analyze the effects of the action for a three year period. Within the experiment, NMFS has designed a "check" system, whereby after each year of the experiment, a risk assessment will be conducted in order to determine the effectiveness of the experiment and the risks to the species affected. Therefore, based on the results of the assessment after each year, this experiment may last one year, two years, or three years. Based on a "worst-case" scenario, this experiment will last three years; therefore, we must analyze effects to the species over three years. In addition, the applicants have anticipated take and mortality levels of listed species based on a worst case scenario; therefore, the anticipated take and mortality levels are maximum numbers, and in reality, mortality may be lower.

Evidence Available for the Assessment

Detailed background information on the status of these species and critical habitat has been published in a number of documents including status reviews of sea turtles (Eckert, 1993); recovery plans for the eastern Pacific green turtle (NMFS and USFWS, 1998a), U.S. Pacific populations of leatherback sea turtle (NMFS and USFWS, 1998b) loggerhead sea turtle (NMFS and USFWS, 1998c), and olive-ridley sea turtles (NMFS and USFWS, 1998d); and reports on interactions between sea turtles and gear used in pelagic fisheries (Bolten *et al*., 1996). In addition, Crouse *et al*. (1987), Crowder *et al*. (1995), Heppell (1998), Heppell and Crowder (1996), Heppell *et al*. (2000a and 2000b) published results from population models, sensitivity analyses, and elasticity analyses for various species of marine turtles, although most models are based on data on loggerhead sea turtles in the Atlantic Ocean.

Despite this published information, our knowledge of the biology and ecology of sea turtles, including their life history, population dynamics, and their response to environmental and other variation is still rudimentary. The National Research Council (NRC; 1990) identified many of these limits and recommended research on a wide array of variables, including age at reproductive maturity, age-specific rates of survivorship and fecundity, distribution, and migration. Wetherall (1996, *in* Bolten *et al.* 1996) further described limitations in our understanding and, consequently, concluded that even the results of population models would be little more than guesses with untested critical assumptions. Bolten *et al*. (1996) concluded that developing analytical tools to support assessments like the one we must conduct in this Opinion requires much more information than is currently available. Pritchard (1996) concluded that we do not currently have enough life history data on sea turtles to construct models that can be used for predictive purposes. As a result of these limits, we cannot quantify the effects of changes in abundance, reproductive success, and other vital rates on a sea turtle's likelihood of surviving and recovering in the wild.

Assumptions Made to Overcome Limits in our Knowledge

While the limits in our understanding we discussed in the preceding section remain, and while models undergo further development, we will use a conceptual life history and population model to conduct our effects analysis. In the absence of specific information on the likelihood of threatened and endangered sea turtles surviving and recovering in the wild, we used the extensive body of information on the population dynamics of small and declining populations (for example, see summaries presented in Soulé, 1986, Burgman *et al*., 1993, Caughley, 1994, Meffe and Carroll, 1997, Primack, 1993, and Caughley and Gunn, 1996). These authors identify general patterns that small and declining populations follow, which we will use to make inferences about the effects of the proposed action on listed species or the species' response to those effects. In particular, we rely on these patterns to make inferences about the sea turtles' likelihood of surviving and recovering in the wild.

In general, a species' response to human actions will depend on several variables, including the number of populations that comprise the species; the distribution and size of these populations; the number, size, and distribution of sub-populations in each population; the structure (distribution of ages or stages in a population), composition (gender relationships), and vital rates (rates of birth, death, immigration, and emigration) of each population; and the ecological and social relationships between individual members of the species and their environment (Andrewartha and Birch, 1954; Lawton, 1995).

The status and trends of most populations are usually discussed in terms of their vital rates: rates of birth, death, immigration, and emigration (Burgman *et al*., 1993; Caughley, 1994; Lawton, 1995). Populations whose average birth (or immigration) rates are higher than or equal to their average death (or emigration) rates will remain stable over time. Populations whose average birth rates are lower than or equal to their average death rates will decline. The rate of these declines will reflect the difference between the birth and death rates; the greater the difference between their birth and death rates, the faster the rate of decline. If a population's mean death rate consistently exceeds its mean birth rate, the population will not survive over any long period of time (Mangel and Tier, 1994; Caswell, 2001).

Many species that are currently listed as threatened or endangered experienced two kinds of population processes on their path to endangerment: (1) population processes that caused the species' total abundance to decline until it was a percentage of historic abundance and (2) population processes that affected the species once its population was small which can cause the species' to become extinct without any new human threats (Caughley, 1994; Lawton, 1995). Once populations become small, they become more susceptible to (a) changes in birth rates, death rates, and emigration rates, that further reduce their population size; and (b) genetic factors that increase their risk of inbreeding depression or reduce their ability to adapt to environmental change, which combine to (c) increase the ability of environmental variation to cause the population to decrease (Shafer and Samson, 1985; Gilpin and Soulé, 1986; Primack, 1993; Caughley, 1994). Small populations are also vulnerable to population declines caused by low population densities, changes in sex ratios, and changes in the annual production of young. In small populations, small changes in birth, death, immigration, and emigration have increasingly significant effects on a population's status and trend (Caughley 1994). For example, small reductions in reproduction and numbers can significantly reduce a species' reproduction, numbers, distribution, and its likelihood of surviving or recovering in the wild. Finally, small populations face a high risk of extinction caused by catastrophic events, which can be more significant than any other threat (Mangel and Tier 1994).

Because of these characteristics, small populations are less likely to survive (that is, they have much higher risks of extinction) than other populations and are less able to recover from further declines caused by natural or human-related phenomena. Additional human activities that reduce a species reproduction, numbers, or distribution usually decrease the species' likelihood of surviving and recovering in the wild.

To assess the potential effects of reductions in sea turtle reproduction, numbers, or distribution on the turtles' likelihood of surviving and recovering in the wild, we used a conceptual model of sea turtle life history. To compensate for a high mortality rate of eggs, hatchlings, and small juveniles each year, sea turtles have evolved a life history strategy that requires adults to produce large numbers of eggs each year, live for many years, and breed repeatedly (NRC, 1990). Through this life history strategy, the long lives of adults turtles buffers the turtles from dramatic fluctuations caused by large fluctuations in egg, hatchling, and juvenile survival (Crouse 1999). Now that these species of sea turtles are endangered, however, we assume that the long lives of adult turtles *mask* the effect of previous losses of eggs, hatchlings, and juveniles on the turtle populations (see Crouse 1999). As a result, we allow that sea turtles probably face a higher risk of extinction than our knowledge allows us to recognize and allow that our assessment probably underestimates the effects of the fisheries on turtles (see Ludwig *et al*. 1993).

Application of this Approach to the Species Considered in this Opinion

We begin these analyses with an implicit understanding that the sea turtles considered in this Opinion are threatened with global extinction by a wide array of human activities and natural phenomena; we have outlined many of those activities in the *Status of the Species* section of this Opinion. We also recognize that some of these other human activities and natural phenomena pose a much larger and more serious threat to the survival and recovery of sea turtles (and other flora and fauna) than the proposed action. Further, we recognize that we will not be able to recover sea turtles without addressing the full range of human activities and natural phenomena that could cause these animals to become extinct in the foreseeable future. Nevertheless, this Opinion focuses solely on the issuance of a scientific research permit (#1303) on threatened and endangered sea turtles.

We will treat sea turtle populations in the Pacific Oceans as distinct populations from the Atlantic Ocean populations for the purposes of this consultation (except the olive ridley turtle, which is limited to the Pacific basin). This approach is allowable based on interagency policy on the recognition of distinct vertebrate populations (Federal Register 61: 4722-4725). To address specific criteria outlined in that policy, sea turtle populations in the Pacific basin are geographically discrete from populations in the Atlantic basin, with limited genetic exchange. The loss of sea turtle populations in the Pacific basin would result in a significant gap in the distribution of each turtle species, which makes these populations biologically significant. Finally, the loss of these sea turtle populations in the Pacific basin would dramatically reduce the distribution and abundance of these species and would, by itself, appreciably reduce the entire species' likelihood of surviving and recovering in the wild.

To conduct our jeopardy analyses, we will evaluate the information provided by the applicant on the numbers of sea turtles anticipated to be captured, injured, or killed during the three years anticipated to conduct this research in order to determine if these injuries or deaths can be expected to reduce a species' reproduction, numbers, or distribution. As part of these analyses, we made assumptions about the number of adult, female sea turtles that might be captured, injured, or killed as a result of the proposed action.

We consider these reductions within the context of the species' status and trend. We estimate the relative abundance of sea turtle populations based on the numbers of adult females, usually as they return to their nesting beaches. As a result, our population estimates will generally change only in response to changes in (1) the death rate of adult females, (2) the recruitment rate of sub-adult females, (3) the interval between a female's return to nesting beaches, and (4) migration patterns that might cause females to nest on other, uncensused, beaches (given the strong tendency of female turtles to return to the beach of their birth, we discount this latter phenomenon as having minimal effect on population trends). Over any five-ten year interval, the size of sea turtle populations will only change in response to changes in death rates and changes in recruitment rates (this time interval should be long enough to mask differences in re-nesting intervals). Therefore, if a turtle population is increasing, we can infer that the average number of females that recruit into the adult population is greater than the average number of adults that die in the population. If a turtle population is stable, we can infer that the average number of females that recruit into the adult population equals the average number of adults that die in the population. If a turtle population is decreasing, we can infer that the average number of females that recruit into the adult population is less than the average number of adults that die in the population.

If we conclude that the number of turtles captured, injured, or killed as a result of the issuance of scientific research permit #1303 would reduce the species' reproduction, numbers, or distribution, we will consider the effects of those reductions on the species' likelihood of surviving and recovering in the wild. We will conduct this inquiry by considering the probable effects on those reductions on the species' population structure, the status and trends of the various populations, the vital rates, and the relationship between vital rates and the population's status and trend (that is, the population's rate of increase). Specifically, we will consider whether additional, human-related mortalities associated with the proposed action are a significant or chronic source of reduced fecundity in the adult population or decreased rates of survival in one or more life history stages of these sea turtles. If the proposed action can be expected to have significant, adverse effects on a life history stage that would translate into reduced numbers of breeding sea turtles, we will assume this will reduce the numbers of eggs and hatchlings over the next breeding cycle, which would be expected to reduce the size of these turtle populations in subsequent generations.

B. Effects of the Action

Determining the scope and magnitude of impacts of any action on sea turtle populations, particularly in the marine environment, is complicated by the fact that all of these species lead an oceanic existence during most of their life history. There are broad gaps in our knowledge of sea turtles in the marine environment due to the difficulties in studying them away from their nesting beaches. Recent technological developments in satellite telemetry and genetic analyses are rapidly expanding our knowledge on the movements and habits of sea turtles in the marine environment, but much remains unknown. In contrast, at certain nesting beaches, reasonably good ecological data exist for the breeding phase when adult females, eggs, and hatchlings are accessible. The leatherbacks and olive ridleys are the most pelagic species, living well offshore from the time they leave the beach as hatchlings until they return to breed as adults. Others, such as the green and the loggerhead, inhabit coastal waters as adults, but spend varying segments of their immature life in the open ocean. Even then, the adults regularly undertake breeding migrations over deep water.

The proposed action involves the issuance of a scientific research permit to test longline gear modifications in order to determine whether such modifications are effective at reducing interactions with sea turtles and/or whether or not target species CPUE viability is compromised. Because the proposed research also involves longline fishing (i.e. standard method of fishing normally used by the Hawaii-based longline fishery), many of the effects to sea turtles that were summarized and analyzed in the March 29, 2001, biological opinion still apply. NMFS has reinitiated the March 29, 2001, biological opinion as a result of new information consisting of an improved sex- and age- class structured stochastic simulation model of leatherback sea turtle population dynamics, recent eastern Pacific leatherback population censuses for the 2000/2001 season, fewer vessels are operating than what was anticipated under the March 29, 2001 Reasonable and Prudent Alternative, new observer data collected since 1999, and correction of a minor error to the anticipated take in the incidental take statement. If the evaluation of this new information and conclusions drawn as a result of this reinitiation of the March 29, 2001, biological opinion constitute significant new information that would change the evaluation and conclusions of this opinion, NMFS will reinitiate this biological opinion on the issuance of research permit # 1303

1. Purpose and Need for the Experiment

As shown in Table 1 of Appendix A, in 1999, there were approximately 4,800 longliners fishing for pelagic species (e.g. swordfish and tuna) in the Central Pacific Ocean, with representation from 22 countries. Of the total number of vessels, the U.S. comprised about 2.5 % of the vessels for that year. Japan and Taiwan (offshore) have clearly dominated this fishery from 1990-99, fishing coastally, in distant water and offshore[14]. According to data compiled by Sonu (1997), Japan captured an average of 37 percent of the world's swordfish catche during 1985-1995, and approximately 87 percent of their swordfish catch was made by longliners. Countries such as Japan also import swordfish caught by countries such as Taiwan, Korea, Indonesia, and others. With demand for swordfish and tuna products expected to continue, longline fisheries for swordfish and tuna in all oceans of the world are also expected to continue. Although we are beginning to learn and collect more information about sea turtle bycatch in eastern Pacific longline fisheries (e.g. South and Central America), little is known about the sea turtle bycatch in western Pacfic longline fisheries. However, based on what we know about sea turtle abundance and distribution and the incidental take and mortality in our domestic fishery, we can assume that many turtles are being taken by foreign longliners. This undocumented take is likely contributing to the steady and even precipitous decline of some sea turtle populations in the Pacific basin.

[14] In reference to the Japanese tuna longline fleet, "offshore" refers to vessels that fish outside Japan's EEZ but closer to Japan, while "distant water" refers to vessels which fish in other areas throughout the Pacific Ocean (A. Coan, NMFS, personal communication, August, 2000).

Through the implementation of an observer program for the Hawaii-based longline fishery from 1994 through the present, NMFS has been able to learn a great deal about the effects of longlining on sea turtles, including interaction rates with various species, mortality rate estimates for lightly and deeply hooked turtles, and possible patterns in fishing gear and strategies which may increase or decrease interaction rates. In addition, through workshops, collaborations with scientists worldwide, symposia presentations, and the promulgation of regulations, NMFS has served as a leader in helping to reduce mortality rates of sea turtles hooked or entangled by domestic longline through improved sea turtle handling guidelines, resuscitation techniques, and education (e.g. skipper workshops).

On March 29, 2001, NMFS completed a biological opinion which summarized the effects of the Hawaii-based longline fishery (among other fisheries managed under the Pelagics FMP) on sea turtles. In that Opinion, NMFS analyzed data collected through the observer program and reviewed the most recent information regarding the status and baseline for sea turtles in the Pacific Ocean. Given the threats to sea turtle species throughout their range and the expected takes and mortalities in the Hawaii-based longline fishery, NMFS determined that the operation of the fishery would jeopardize the continued existence of leatherback, loggerhead, and green sea turtles. NMFS also determined that the swordfish and mixed-style fishing styles tended to have a much higher interaction rate with all species of sea turtles. Although NMFS had information from ongoing lab experiments and field experiments in other oceans regarding possible gear modifications that could reduce sea turtle interactions, a rigorous test of these modifications had not been performed. Without the confidence necessary to implement gear modifications in the Hawaii-based longline fishery, in order to avoid the likelihood of jeopardy, NMFS instead developed a reasonable and prudent alternative which included the closure of areas of the Pacific Ocean to swordfish and mixed-style fishing.

Through this drastic closure, NMFS expects the sea turtle interaction rate with the Hawaii-based longline fishery to be significantly reduced. In its March 29, 2001 biological opinion, NMFS recognized that alternative gear strategies should be tested. Discovery of alternate methods to avoid or reduce sea turtle interactions with longline gear would help to implement recovery efforts for the listed turtles. The resulting conservation recommendations of the opinion include: "(1) NMFS should research modifications to existing gear that (a) reduce the likelihood of gear interactions and (b) dramatically reduce the immediate and/or delayed mortality rates of captured sea turtles (e.g. visual or acoustic cues, dyed bait, hook type) ... (8) NMFS should provide technical and financial assistance necessary to export advances in knowledge of techniques and gear modifications that reduce interactions with sea turtles..."

Without methods to reduce longline fishery bycatch of turtles in the U.S. and foreign fleets, the survival and recovery of endangered and threatened sea turtles may not be possible. In order to achieve comprehensive sea turtle take reductions in pelagic longline fisheries that will have a long-term significant effect on sea turtle survival and recovery, measures must be found that can be implemented by the large, international fleets that fish the entire Pacific Ocean. Fishing tactics and modified gear configurations – technical solutions – that allow longline vessels from all fleets to continue to catch target species effectively are likely to be exportable solutions that meet that requirement (Williams et al.1996; Hoey, 1998; Hoey and Moore, 1999; Kleiber and Boggs, 2000).

The purpose of the proposed research is to develop such technical solutions to reduce sea turtle bycatch in commercial longline fisheries while still maintaining the ability to catch target species. Very little research has been accomplished to date to address this issue. The proposed research addresses one of the most pressing conservation research questions facing sea turtles worldwide. Although the proposed research will itself take sea turtles, it is occurring against a background of much greater levels of turtle take in commercial longline fishing fleets. The rapid and promising results expected from this research will provide greater benefit to sea turtle survival and recovery, before population declines continue even further.

In addition to the expected benefits towards the conservation of sea turtles, NMFS also expects to gain invaluable information about sea turtles from these experiments. Trained biologists will collect information on the species caught, how they were hooked/entangled, where they were captured, degree of injury (if any), and other important demographic information. NMFS expects that this information will help determine a more accurate post-hooking survival rate estimate, establish a clearer picture of loggerhead and leatherback distribution in the Pacific Ocean, and increase the available information on sea turtle life history and population demographics.

2. Overview of the Experiment

The NMFS-SWFSC, Honolulu, Hawaii has applied for a scientific research permit (#1303) in order to conduct research in the Pacific Ocean on several modifications to longline gear to determine whether interactions with sea turtles can be reduced and/or target species CPUE viability will be affected, and to transport live, deeply hooked, hard-shelled turtles to the Honolulu laboratory for monitoring and rehabilitation.

The proposed scientific research involving longline vessels fishing in the Pacific Ocean consists of three different experiments. One experiment will test two modifications to normal longline fishing gear (dyeing squid bait blue and moving the branchline normally attached nearest to the float to 40 fathoms) in order to determine whether or not the treatment reduces sea turtle interactions by 50%, compared to standard (i.e. controlled) fishing operations. Because this experiment has been designed to test effectiveness on leatherbacks, a species that has not historically interacted as frequently with the Hawaii-based longline fishery but for which information is most need to conserve the species, it is anticipated to last three years. The second experiment is designed to test whether the use of “stealth” gear (i.e. gear that has been camouflaged to become less visible to species such as turtles) and deep-set, daytime fishing for swordfish, can effectively catch target species comparable to standard fishing practices. This second experiment will last one year. Should these tests prove that such modified gear and fishing strategy will not compromise CPUE of target species, then they may possibly be tested to determine reduction in sea turtle interactions in following years. Through the use of hook timers, the third experiment is designed to test where and when sea turtles become hooked on the longline and will take two years. A piggyback experiment with the hook-timer experiment is the simultaneous testing of 18/0 circle hooks versus “J” hooks to determine target species CPUE viability. This portion of the third experiment will only take one year to complete.

The last portion of the scientific research permit involves the transportation and rehabilitation of deeply hooked, hard-shelled turtles. This activity is intended to provide researchers the opportunity to better understand the mode of injury and the prognosis for recovery of deeply hooked turtles.

3. Factors contributing to sea turtle interactions with the longline fishery

The following subsections describe aspects of longline fishing, including gear characteristics as well as environmental conditions, that may contribute to the likelihood of sea turtle interactions with this fishery. A review of longline gear components and their possible attractiveness to sea turtles in the ocean is particularly important to understanding the importance of testing modifications to gear to reduce sea turtle interactions (i.e. meeting the goals and objectives of the scientific research permit).

a. Gear

(1) Floats: Sea turtles may be attracted to the floats used on longline gear. Sea turtles have been observed associating with manmade floating objects significantly more frequently than with natural objects, perhaps related to turtles' affinity for three-dimensional objects. In addition, flotsam may provide turtles with food, shelter, and/or orientation cues in an otherwise featureless landscape. Turtles also show a preference for objects floating horizontally and nearly submerged and are strongly attracted to brightly colored objects (Arenas and Hall, 1992). Floats typically used during swordfish-style sets are bright orange, bullet-shaped, and slightly submerged. Tuna-style sets generally use larger cylindrical inflatable or rigid spherical buoys and floats, and these also are typically orange in color (L. Enriquez, NMFS, personal communication, January, 2001; e.g. www.lindgren-pitman.com/floats.htm).

(2) Bait: Sea turtles may also be attracted to the bait used on longline gear. Four olive ridleys necropsied after being taken dead by Hawaii-based longliners were found with bait in their stomachs (Work, 2000). In addition, a leatherback has been documented ingesting squid bait on swordfish longline gear. The authors speculate that the lightsticks may initially have attracted the turtle, by simulating natural prey (Skillman and Balazs, 1992).

(3) Lightsticks: Sea turtles foraging at night may be attracted to the lightsticks, confusing them for prey. Lightsticks are often used by longliners targeting swordfish in order to attract the swordfish to the bait. Whether lightsticks attract swordfish directly or whether they attract baitfish, which in turn attract the swordfish, is not entirely clear; however, fishermen report higher takes of swordfish when they use lightsticks. Lightsticks are generally attached to every other branchline, approximately a meter above the hook. Researchers studying the prey and foraging habits of sea turtles have reported the ingestion of pyrosomas, the so-called "fiery bodies," by leatherbacks, loggerheads, and olive ridleys; however, there is little information on the actual ingestion of lightsticks by sea turtles. In addition, statisticians have not been able to find any correlation between sea turtle take and the proximity of a lightstick to the hook or branchline that the turtle was hooked on or entangled in.

b. Environmental conditions: Environmental conditions may also play a large part in whether or not a sea turtle interacts with longline gear. Sea turtles in the open ocean are often found associated with oceanographic discontinuities such as fronts and driftlines, areas often indicating high productivity. In addition, sea turtles also appear to associate with particular sea surface temperatures . As mentioned in more detail later, species such as the loggerheads have been tracked moving along convergent ocean fronts, in waters with sea surface temperatures of 17° C and 20° C (Polovina, *et al*., 2000). Swordfish are caught by longliners in association with frontal zones where ocean currents or water masses meet to create turbulence and sharp gradients of temperature and salinity. Swordfish also make vertical migrations through the water column, rising near to the surface at night from deep waters. Thus, while searching for concentrations of swordfish, longliners set their gear across these temperature gradients ("breaks") indicative of intersecting water masses, and when sea turtles are associated with these fronts, interactions are more likely.

4. Expected success of proposed experiments

A variety of pelagic longline fishing gear and fishing operation modifications have been suggested to reduce the take and mortality of sea turtles (Balazs and Pooley, 1994; Hoey, 1998; Hoey and Moore, 1999; Kleiber and Boggs, 2000). Ideas for modifications to longline gear and strategy to reduce turtle takes have come from fishermen, from logical consideration of fishing mechanics and turtle behavior, and from analysis of observer data on sea turtle takes. The choices of initial take reduction measures for testing in the proposed experiments are based on these documents and on reviews by three expert working groups including scientists, commercial fishermen, and conservationists (Anon. 2000, 2001a, 2001b).

a. Blue-dyed bait and branchline re-positioning

Modified baits and properly designed fishing gear used in longline fisheries have significant potential to reduce catch rates of sea turtles without reducing the catch rates of the targeted species (tunas and swordfish). Based on data collected by observers in the Hawaii-based longline fishery, experimentation with captive turtles, and field studies, two modifications to fishing strategy show evidence of efficacy in reducing sea turtle bycatch while retaining viability in target species catch rates.

One modification to longlining which has been determined to have great promise for reducing sea turtle takes while having only minor impacts (if any) on fishing performance (target species CPUE) is the use of squid dyed blue with food coloring. One of the first food preference studies involving the use of colored bait was conducted at NMFS - Southeast Fisheries Science Center (SEFSC), in Galveston, Texas, where researchers observed strong reactions by young Kemp's ridley (*Lepidochelys kempi*) sea turtles to red, orange, yellow and white colors, and less reaction to darker colors. When presented with fresh abdominal muscle of shrimp dyed red, yellow, blue, green, and non-dyed, the turtles preferred the blue-dyed food least and were strongly attracted to the red-dyed bait (Fontaine, *et al*., 1985). Under water, the blue color may make the baits less visible to turtles. Preliminary results from the Honolulu Laboratory show actively feeding green turtles reject blue-dyed bait for up to 10 days. The experiment was conducted on "naive" green turtles that had not started feeding in captivity and focused on food color preference/aversion. Turtles were fed both treated (e.g. blue) and untreated squid for their initial feeding. While the green turtles actively fed on untreated squid, they rejected blue-dyed squid for 8-10 days (65-80 presentations). The colored bait experiment is also planned to be tested on "naive" juvenile loggerhead turtles (Swimmer, *et al.*, in press). Furthermore, in field testing the use of blue-dyed bait on seabirds, no sea turtles were taken on blue-dyed bait, yet turtles were caught in the same tests with regular (un-dyed) bait. Squid bait that has been dyed blue has also been shown to reduce the bycatch of seabirds and possibly increase the catch of swordfish (Kleiber and Boggs, 2000).

These laboratory results show that blue-dyed bait may be very effective at reducing sea turtle-longline interactions, especially since wild turtles would not encounter blue-dyed bait as often, sea turtles tested in the lab. Therefore, individual wild sea turtles may take a long time, if ever, to discover that blue-dyed bait is edible. Furthermore, if the bait is less visible to a turtle, they are less likely to become attracted to it, which would also reduce encounters with longline gear. This most likely holds true with leatherbacks, who do not normally target the bait on a longline, but do get entangled in various parts of the gear, perhaps due to an attraction to anomalous features in the ocean.

NMFS' SEFSC, under # Permit 1324, is conducting an experiment in the Atlantic pelagic longline fishery to tests the effectiveness of blue-dyed bait in reducing sea turtle bycatch. When the results of this experiment are analyzed in conjunction with the results of the experiment planned for this permit, NMFS will evaluate, as specified in the Annual Evaluation and Reauthorization for this permit, whether to reinitiate consultation and/or terminate the testing of blue-dyed bait.

The second modification to longline gear that shows promise at reducing sea turtle interactions involves the removal of branchlines attached to the mainline closest to the floatline attachment points. A typical distance between branchlines on a set of longline gear targeting swordfish is 37 fathoms, but one branchline is usually attached much closer (i.e. adjacent) to the floats than this. Observers in the Hawaii-based longline fishery record the position of sea turtles taken in relation to the floatline. Such data offer the opportunity to test whether the proximity to floatlines affects the chances of a turtle take. Statistical analyses of turtle take rates in this fishery reveal that a higher proportion of loggerhead and leatherback turtles were taken on the branchline closest to floats than on other branchlines (P. Kleiber, 2000; Kleiber and Boggs, 2000). With the null hypothesis that all hooks are equally likely to catch a turtle ("expected turtles taken" field in the tables), Kleiber (2000) analyzed only those sets in the Hawaii-based longline fishery in which a turtle was observed caught (swordfish and tuna sets). Tables IV-1 and IV-2 show floatline contingency tables for loggerheads and leatherbacks, respectively. In these tables, "0" refers to branchlines adjacent to the floatline, "1" refers to the next branchline after or before "0," and so on. There are few instances of hooks placed further than 3 hooks away from a floatline in the fishery, because most sets that catch turtles involve swordfish-style sets. For both loggerheads and leatherbacks, the probabilities are low (0.0 and $<10^{-5}$, respectively) that the observed distributions could have arisen by chance alone. Therefore, the null hypothesis could be rejected for both these species.

As shown in Table IV-1, loggerheads are over twice as likely (58 observed hooked versus 25.3 expected hooked) to be caught on hooks that have been placed adjacent to the floatline ("0" position) and over five times less likely (9 observed hooked versus 53.2 expected hooked) to be caught on hooks that are 2 or more branchlines away from the floatline.

Table IV-1. Loggerhead-floatline proximity test.

	Distance from nearest floatline		
	0	**1**	**2+**
All hooks	25,660	51,054	53,898
Observed turtles taken on hooks	58	62	9
Expected turtles taken on hooks	25.3	50.4	53.2

$P(X^2)$ = the probability of the contingency table under the null hypothesis = ~0.0.

As shown in Table IV-2, leatherbacks are also more than twice as likely (17 observed versus 5.8 expected) to be taken on hooks that are adjacent to the floatline, and over four times less likely (4 observed versus 17.7 expected) to be caught on hooks that are 2 or more branchlines away from the floatline.

Table IV-2. Leatherback-floatline proximity test.

	Distance from nearest floatline		
	0	**1**	**2+**
All hooks	6,692	13,308	20,490
Observed turtles taken on hooks	17	14	4
Expected turtles taken on hooks	5.8	11.5	17.7

$P(X^2)$ = probability of the contingency table under the null hypothesis = $<10^{-5}$

Kleiber (2000) notes that hooks placed closest to the floatlines tend to be shallower than those placed further away and that therefore, turtles may simply be more likely to be taken on a shallower hook because it is more accessible. However, as described below, turtles may be initially attracted to the float and the floatline, and subsequently follow the floatline down and attack the nearest baited hook. Kleiber posits that by avoiding the placement of hooks close to the floatline, it may be possible to reduce takes by approximately one half.

Looking at observer data, Kleiber (NMFS, personal communication, February, 2001) also evaluated whether or not swordfish were more apt to be captured on hooks nearest the float. Kleiber concluded that the distribution of hooks that caught swordfish was not much different than the distribution of all hooks available to the swordfish, implying that swordfish are not very discriminating about hook position.

By combining these two gear modifications into one experiment, both of which show promise at reducing sea turtle interactions, the applicants hope to demonstrate a 50% reduction in turtle take.

b. Stealth gear and deep daytime sets

Lab experiments, anecdotal observations, and analyses of observer data show that sea turtles may be attracted to longline gear because of the brightly colored floats, the line gear (i.e. mainline, branchline, floatline), the bait, or a combination of all three, sequentially. For example, sea turtles may initially become attracted to the brightly colored float, then to the floatline, down to the mainline, and eventually to the branchline and to the bait. Sea turtles, especially leatherbacks, have been observed entangled in all parts of the gear. If gear is made less visible to sea turtles through camouflage, it may be less of an attractant, and interactions may decrease. This experiment would test whether or not the use of "stealth" gear can effectively catch target species. If the use of stealth gear proves effective at catching target species, there would be interest in future experiments to test this major gear modification on its effectiveness at reducing sea turtle interactions.

Based on an analysis of data collected on sea turtles' association with floating objects in the eastern tropical Pacific, Arenas and Hall (1992) concluded that sea turtles associated with man-made objects significantly more frequently than with natural objects, perhaps due to their affinity for three-dimensional objects. Sea turtles showed a preference for objects floating horizontally and nearly submerged and were strongly attracted to brightly colored objects. As described in the food preference studies, sea turtles prefer bright colors (i.e. red and yellow) over dull or darker colors (i.e. black, green or blue) (e.g. Fontaine, *et al*., 1985). In the Southeast, controlled experiments and qualitative evaluations were conducted using captive reared sea turtles to evaluate their responses to various components of pelagic longlining gear and other stimuli. One experiment tested the attraction of sea turtles to orange and white colored longline floats in a 80' x 35' pen enclosure. Sea turtles were introduced into the pen with a single float treatment. Preliminary analysis of the results indicate that the test turtles may have been more attracted to orange colored floats than to white colored floats (J. Watson, SEFSC, personal communication, July, 2001).

The SEFSC also conducted evaluations at their Panama City Laboratory which involved placing longline gear in open water pens with captive reared loggerhead turtles to investigate turtle entanglement with various longline gear components. During these experiments, scientists observed turtles tracking along the mainline and biting at the hardware (snaps). Turtles that were placed in a pool without longline gear (i.e. control) tended to track along the outside edges of the pool. These observations and observations of longline gear at sea by divers and remotely operated vehicles indicate that the standard mainline used by the fishing industry is highly visible and that turtles may be attracted to the mainline and hardware and may follow the mainline. Such observations suggest that using mainline and hardware that is less visible (i.e. stealth gear) may reduce turtle interactions (J. Watson, SEFSC, personal communication, August, 2001).

The applicant also proposes to test swordfish CPUE viability by fishing during the daytime, using deeply set gear, similar to tuna-style fishing. Longlining for swordfish in the Hawaii-based longline fishery generally takes place at night, using lightsticks, with gear set shallow, north of the Hawaiian Islands. In this fishery, swordfish-style sets have consistently shown a higher interaction rate with all species of sea turtles compared to tuna-style sets, either because of fishing strategy or a higher occurrence of sea turtles north of Hawaii. With regards to the first scenario, routine dives for sea turtles range from 9-22 meters (loggerhead) to 50-84 meters (leatherback) (*in* Lutcavage and Lutz, 1997), and foraging often takes place at night in order to target vertically migrating zooplankton (e.g. Eckert *et al*., 1989). In addition, there is speculation that sea turtles are able to target some species due to their bioluminescence (e.g. pyrosomas).

Therefore, a longline set at more shallow depths, at night, using lightsticks appears to be more likely to take turtles than one set deeper during the day. If deep set daytime fishing north of the Hawaiian Islands proves effective at catching target species (swordfish), there would be interest in future experiments to test this fishing strategy on its effectiveness at reducing sea turtle interactions.

c. Hook timer and hook type

In the Hawaii-based longline fishery, when a turtle is hooked, observers record the hook number (the sequential number of the hook after a floatline) and the float number (the sequential float number, along the mainline, associated with the hook number), and they also collect information on the set, such as the gear deployment, target depth fished, etc. This information gives scientists a sense of where turtles are taken on longline gear in relationship to the floatline or the vessel, and what general depth in the water column they are hooked. Such information is limited, however, in providing clues as to when during the set turtles are caught, or what the exact depth of water was when they were caught.

In order to resolve the uncertainty in estimating the depths and times of fish captured on pelagic longline gear, experiments were conducted in which electronic microchip hook timers were attached to branchlines to record when bites occurred, and time-depth recorders (TDRs) were attached to longline gear. Boggs (1992) found large discrepancies in reported depth of capture (unconfirmed skipper estimates of the target depth of the capture) compared to the actual (confirmed) depths of capture. In addition, the use of hook timers and TDRs were able to provide information regarding capture incidences in relation to gear that is sinking, settled, or rising (i.e. setting, soaking, or hauled back). Information on the actual time of capture of a sea turtle (i.e. relative to the time and duration of the set and relative to the time of day) and the actual depth of capture would be extremely useful in developing modifications to gear and fishing strategy that may reduce sea turtle interactions.

The use of circle hooks instead of the more typical "J" hooks used in swordfish-style longline operations may reduce the severity of turtle injury from longline hooking. Experiments comparing 16/0 circle and J hooks in the Azores (Bolton and Bjorndal, 1999) and in the North Pacific (LaGrange, 2001) indicate a much lower frequency of deep hooking (defined as a hook ingested past the mouth cavity, in the esophagus or deeper), as opposed to hooking in the mouth. Presumably, delayed mortality of turtles that have been hooked in the mouth is much lower than that of deeply hooked turtles. Although the use of 16/0 circle hooks did not decrease the turtle take rate in these experiments, it did reduce the target species CPUE by 30-50%. Researchers have suggested that larger (18/0) circle hooks could increase the viability of target species CPUE. Therefore testing larger circle hooks is proposed for this purpose. If the 18/0 circle hooks are as effective at catching target species as the standard J hook, then the implementation of this gear modification in longline fisheries may reduce the severity of sea turtle injuries, thereby increasing post-hooking survivability.

5. General effects of longlining

Potential impacts from longlining on sea turtles will generally be related to injury or mortality, although the entanglement or hooking episode, whether or not it develops into an injury or mortality, may also impact sea turtles. Injury or mortality of turtles hooked by a long-soaking longline may result from drowning due to forced submergence, and/or impairment or wounds suffered as a result of hooking, either externally or internally. Long-term effects from the hooking or entanglement incident could include reduced locomotive or foraging capability or interruption of migration, breeding and reproduction patterns. Although survivability studies have been conducted on sea turtles taken by the Hawaii-based longline fishery, such long-term effects are nearly impossible to monitor; therefore a quantitative measure of the effect of longlining on sea turtle populations is very difficult. The following subsections detail the general effects to sea turtles interacting with longline gear.

a. Effects of forcible submergence

Sea turtles can be forcibly submerged by longline gear either through a hooking or entanglement event, where the turtle is unable to reach the surface to breathe. This can occur at any time during the set, including the setting and hauling of the gear, and generally occurs when the sea turtle encounters a line that is too short to reach the surface or is too heavy to be brought up to the surface by a swimming sea turtle. For example, a sea turtle that is hooked on a 3 meter branchline attached to a mainline set at depth by a 6 meter floatline will generally not be able to swim to the surface unless it has the strength to drag the mainline approximately 3 more meters (discussed further below).

Turtles hooked by longline gear will sometimes drag the clip, attached to the branch line, along the main line. If this happens, the potential exists for a turtle to become entangled in an adjacent branch line which may have another species hooked such as a shark, swordfish, or tuna. According to observer reports, most of the sharks and some of the larger tuna such as bigeye are still alive when the are retrieved aboard the vessel, whereas most of the swordfish are dead. If a turtle were to drag the branch line up against a branch line with a live shark or bigeye tuna attached, the likelihood of the turtle becoming entangled in the branch line is greater. If the turtle becomes entangled in the gear, then the turtle may be prevented from reaching the surface. The potential also exists, that if a turtle drags the dropper line next to a float line, the turtle may wrap itself around the float line and become entangled.

Sea turtles that are forcibly submerged by longline gear undergo respiratory and metabolic stress that can lead to severe disturbance of their acid-base balance. While most voluntary dives by sea turtles appear to be aerobic, showing little if any increases in blood lactate and only minor changes in acid-base status (pH level of the blood), sea turtles that are stressed as a result of being forcibly submerged through hooking or entanglement in a line rapidly consume oxygen stores, triggering an activation of anaerobic glycolysis, and subsequently disturbing their acid-base balance, sometimes to lethal levels. It is likely that the rapidity and extent of the physiological changes that occur during forced submergence are functions of the intensity of struggling as well as the length of submergence (Lutcavage and Lutz, 1997). In a field study examining the effects of shrimp trawl tow times and sea turtle deaths, there was a strong positive correlation between the length of time of the tow and sea turtle deaths (Henwood and Stuntz, 1987, *in* Lutcavage and Lutz, 1997).

Sea turtles forcibly submerged for extended periods of time show marked, even severe, metabolic acidosis as a result of high blood lactate levels. With such increased lactate levels, lactate recovery times are long (even as much as 20 hours), indicating that turtles are probably more susceptible to lethal metabolic acidosis if they experience multiple captures in a short period of time, because they would not have had time to process lactic acid loads (*in* Lutcavage and Lutz, 1997). Presumably, however, a sea turtle recovering from a forced submergence would most likely remain resting on the surface (given that it had the energy stores to do so), which would reduce the likelihood of being recaptured by a submerged longline. Recapture would also depend on the condition of the turtle and the intensity of fishing pressure in the area. NMFS has no information on the likelihood of recapture of sea turtles by the Hawaii-based longline fishery or other fisheries. However, in the Atlantic Ocean, turtles have been reported as captured more than once by longliners (on subsequent days), as observers reported clean hooks already in the jaw of captured turtles. Such multiple captures were thought to be most likely on three or four trips that had the highest number of interactions (Hoey, 1998).

Respiratory and metabolic stress due to forcible submergence is also correlated with additional factors such as size and activity of the sea turtle (including dive limits), water temperature, and biological and behavioral differences between species and will therefore also affect the survivability on a longline. For example, larger sea turtles are capable of longer voluntary dives than small turtles, so juveniles may be more vulnerable to the stress of forced submergence than adults. During the warmer months, routine metabolic rates are higher, so the impacts of the stress due to entanglement or hooking may be magnified. In addition, disease factors and hormonal status may also play a role in anoxic survival during forced submergence. Any disease that causes a reduction in the blood oxygen transport capacity could severely reduce a sea turtle's endurance on a longline, and since thyroid hormones appear to have a role in setting metabolic rate, they may also play a role in increasing or reducing the survival rate of an entangled sea turtle (*in* Lutz and Lutcavage, 1997). Turtles necropsied following capture (and subsequent death) by longliners in the Hawaii-based longline fishery were found to have pathologic lesions. Two of the seven turtles (both leatherbacks) had lesions severe enough to cause probable organ dysfunction, although whether or not the lesions predisposed these turtles to being hooked could not be determined (Work, 2000). As discussed further in the leatherback and loggerhead subsections below, some sea turtle species are better equipped to deal with forced submergence.

Although a low percentage of turtles that are captured by longliners actually are reported dead, sea turtles can drown from being forcibly submerged. Such drowning may be either "wet" or "dry." In the case of dry drowning, a reflex spasm seals the lungs from both air and water. With wet drowning, water enters the lungs, causing damage to the organs and/or causing asphyxiation, leading to death. Before death due to drowning occurs, sea turtles may become comatose or unconscious. Studies have shown that sea turtles that are allowed time to stabilize after being forcibly submerged have a higher survival rate. This of course depends on the physiological condition of the turtle (e.g. overall health, age, size), time of last breath, time of submergence, environmental conditions (e.g. sea surface temperature, wave action, etc.), and the nature of any sustained injuries at the time of submergence (NRC, 1990).

b. Effects of entanglement

Sea turtles are particularly prone to entanglement as a result of their body configuration and behavior. Records of stranded or entangled sea turtles reveal that fishing debris can wrap around the neck or flipper, or body of a sea turtle and severely restrict swimming or feeding. Over time, if the sea turtle is entangled when young, the fishing line will become tighter and more constricting as the sea turtle grows, cutting off blood flow, causing deep gashes, some severe enough to remove an appendage. Sea turtles have also been found trailing gear that has been snagged on the bottom, thus causing them to be anchored in place (Balazs, 1985).

Sea turtles have been found entangled in branchlines (gangions), mainlines and float lines. Longline gear is fluid and can move according to oceanographic conditions determined by wind and waves, surface and subsurface currents, etc.; therefore, depending on both sea turtle behavior, environmental conditions, and location of the set, turtles could be entangled in longline gear. Entanglement in monofilament line (mainline or gangion) or polypropylene (float line) could result in substantial wounds, including cuts, constriction, or bleeding on any body part. In addition entanglement could directly or indirectly interfere with mobility, causing impairment in feeding, breeding, or migration. Sea turtles entangled by longline gear are most often entangled around their neck and foreflippers, and, often in the case of leatherback entanglements, turtles have been found snarled in the mainline, floatline, and the branchline.

c. Effects of hooking

In addition to being entangled in a longline, sea turtles are also injured and killed by being hooked. Hooking can occur as a result of a variety of scenarios, some of which will depend on foraging strategies and diving and swimming behavior of the various species of sea turtles. For example, olive ridleys that were killed by the Hawaii-based longline fishery and were necropsied have been found with bait in their stomachs after being hooked; therefore, they most likely were attracted to the bait and attacked the hook. In addition, leatherbacks, loggerheads and olive ridleys have all been found foraging on pyrosomas which bioluminesce at night. If lightsticks are used on a swordfish set at night to attract the target species, the turtles could mistake the lightsticks for their preferred prey and get hooked externally or internally by a nearby hook. Similarly, a turtle could concurrently be foraging in or migrating through an area where the longline is set and could be hooked at any time during the setting, hauling, or soaking process.

Sea turtles are either hooked externally - generally in the flippers, head, beak, or mouth - or internally, where the animal has attempted to forage on the bait, and the hook is ingested into the gastro-intestinal tract, often a major site of hooking (E. Jacobson, *in* Balazs, *et al*., 1995). Even if the hook is removed, which is often possible with a lightly hooked (i.e. externally hooked) turtle, the hooking interaction is believed to be a significant event. Like most vertebrates, the digestive tract of the sea turtle begins in the mouth, through the esophagus, and then dilates into the stomach. The esophagus is lined by strong conical papillae, which are directed caudally towards the stomach (White, 1994). The existence of these papillae, coupled with the fact that the esophagus snakes into an s-shaped bend further towards the tail make it difficult to see hooks, especially when deeply ingested. Not surprisingly, and for those same reasons, a deeply ingested hook is also very difficult to remove from a turtle's mouth without significant injury to the animal. The esophagus is attached fairly firmly to underlying tissue; therefore, when a hook is ingested, the process of movement, either by the turtle's attempt to get free of the hook or by being hauled in by the vessel, can traumatize the internal organs of the turtle, either by piercing the esophagus, stomach, or other organs, or by pulling the organs from their connective tissue. Once the hook is set and pierces an organ, infection may ensue, which may result in death to the animal.

If a hook does not become lodged or pierce an organ, it can pass through to the colon, or even expelled through the turtle (E. Jacobson *in* Balazs, *et al*., 1995). In such cases, sea turtles are able to pass hooks through the digestive track with little damage (Work, 2000). Of 38 loggerheads deeply hooked by the Spanish Mediterranean longline fleet and subsequently held in captivity, six loggerheads expelled hooks after 53 to 285 days (average 118 days) (Aguilar, *et al*., 1995) . If a hook passes through a turtle's digestive tract without getting lodged, the chances are good that less damage has been done. Tissue necrosis that may have developed around the hook may also get passed along through the turtle as a foreign body (E. Jacobson, *in* Balazs, *et al*., 1995).

d. Effects of trailing gear

Trailing line (i.e. line that is left on a turtle after it has been captured and released), particularly line trailing from an ingested hook, poses a serious risk to sea turtles. Line trailing from an ingested hook is likely to be swallowed, which may occlude the gastrointestinal tract, preventing or hampering foraging, leading to eventual death. Trailing line may also become snagged on a floating or fixed object, resulting in further entanglement, with potential loss of appendages, which may affect mobility, feeding, predator evasion, or reproduction. For the scientific research conducted under this permit, all sets will be supervised by NMFS employees or contracted biologists, technicians, or fishery observers. In the event that a hook cannot be removed from a turtle, these personnel will be responsible for and are directed to clip the line as close to the hook as possible in order to minimize the amount of trailing gear. This is difficult with larger turtles, such as the leatherback, which often cannot practicably be brought on board the vessel, or in inclement weather, when such action might place the observer or the vessel and its crew at risk. Clipping and/or removing the trailing gear should reduce effects to sea turtles.

6. Effects of transportation of turtles

After capture, some deeply-hooked hard-shelled turtles will be brought onboard fishing vessels contracted for this experiment and transported to the dock (those captured within a 72 hour journey to port). The turtles will be treated in accordance with conditions outlined in the permit (also described in the *Description of the Proposed Action* section) and in accordance with CFR §223.206(d)(1) - NMFS handling and resuscitation requirements for incidentally taken sea turtles. The applicants anticipate that a total of 3 greens, 14 loggerheads, and 12 olive ridleys will be transported to a facility in Honolulu.

Turtles are to be transported via a climate-controlled environment, protected from temperature extremes of heat and cold, and kept moist. The turtle will be placed on pads for cushioning and the area surrounding the turtle will be free of any materials that could be accidentally ingested. Turtles have been transported using these methods for 30 years by stranding network participants without any adverse effect to the turtles.

Turtles transported to a facility for rehabilitation will be maintained and cared for under the "Care and Maintenance Guidelines for Sea Turtles Held in Captivity" issued by the U.S. Fish and Wildlife Service dated August 1997. While held at the facility, turtles will have plentiful food, shelter, and antibiotics. In addition, if necessary, turtles will be fed supplements and vitamins to take care of any deficiencies (Walsh, 1999).

Based on past experience with stranding and salvage network participants using these transport and holding techniques, NMFS does not expect that the transport and holding of sea turtles, in accordance with the special conditions of the permit, will cause any additional stress or discomfort to the turtle. In fact, because of the close care, treatment, and supervision the turtles will receive once they arrive at the facility, NMFS believes that the survival rate of the deeply hooked turtles will be higher than if the turtles had been released into the ocean soon after being captured.

7. Mortality rate estimates

a. NMFS estimates of mortality rates

Given the potential for organ and tissue damage and subsequent infection, total mortalities may likely have been underestimated previously if lightly hooked animals were assigned a zero mortality rate. NMFS has reviewed past studies on post-hooking survival and developed an estimate, described below, which takes into account the possible levels of post-interaction mortality based on these studies. This estimate was used to calculate anticipated mortality of turtles taken as a result of the proposed action.

For estimating possible future mortality, NMFS reviewed the results of several post-hooking survival studies. In a January 4, 2001, memorandum to the Southeast Regional Office, the Office of Protected Resources recommended that 50% of longline interactions with all species of sea turtles be classified as lethal, and 50% be classified as non-lethal. This finding was based on a review of several post-hooking studies in Hawaii, the eastern Atlantic, and the Mediterranean (i.e. Aguilar *et al*. (1995), Parker and Balazs (personal communication, 2000), Bjorndal, *et al*. (1999), Riewald, *et al*, (2000)), as well as analyses of input from veterinarians and scientists with expertise in sea turtle biology and/or longline gear impacts. Knowles (2001) concluded that, based on the range of mortality reported in the various studies and adopting a "risk-averse approach that provides the benefit of doubt to the species where there are gaps in the information base," post-interaction mortality rates of sea turtles released in the wild, under actual fishing conditions, are likely higher than those observed in scientific studies.

Upon review of this memo and the studies upon which the recommendations were based, NMFS' Office of Sustainable Fisheries and NMFS' SWFSC, Honolulu Laboratory recommended that post-hooking mortality rates applied to turtles captured by longlines reflect the differences in post-interaction survival between seriously and non-seriously injured animals found in these studies rather than apply one mortality rate across the board (Morehead, 2001; Laurs, 2001). In addition, the Honolulu Laboratory stated, "(e)stimates of turtle mortality, or any other quantity, should be the best estimates that we can muster and should not contain internal buffers or fudge factors of any kind. It is at the point that estimated quantities enter into making management decisions that consideration should be given to the uncertainty inherent in those estimates" (NMFS-SWFSC, 2001). After reviewing information summarized in the Knowles (2001) and Morehead (2001) memos, NMFS derived a consensus approach for estimating sea turtle mortalities (Morehead, 2001; NMFS 2001b). NMFS' final adopted approach apportions mortality in a manner consistent with the best scientific information in lieu of applying one standard across the board, while still providing the precautionary approach required for evaluating effects to listed species (NMFS, 2001b). Table IV-3 details the estimated mortality rates for sea turtles captured on longline gear based on their condition.

Table IV-3. Sea turtle mortality rates based on level and type of interaction with longline fishing gear.

Interaction	Response	Injury	Mortality Rate
Entangled / no hook	Disentangled	No injury	0%
Entangled / external hook	Disentangled, no gear	Minor	27%
	Disentangled, trailing gear	Moderate	27%
	Dehooked, no gear	Minor	27%
Hooked in beak or mouth	Hook left, no gear	Moderate	27%
	Hook left, trailing gear	Serious	42%
	Dehooked, no gear	Moderate	27%
Hook swallowed	Hook left, no gear	Serious	42%
	Hook left, trailing gear	Serious	42%
Turtle Retrieved Dead	- - -	Lethal	100%

Source: Morehead, 2001; NMFS, 2001b

b. Mortality rate estimates used in this Opinion

Based on these latter recommendations, which take into account the best available scientific and commercial data, the applicant applied the mortality rates in Table IV-3 to its estimates of impacts to sea turtles captured by longline gear used during the proposed experiments. In analyzing effects to turtles captured during the experiments, NMFS will also use the mortality rate estimates contained in Table IV-3, taking into account data collected by observers in the Hawaii-based longline fishery regarding the fate of captured sea turtle species (summarized in a later section on individual sea turtle species).

Given the presence of trained biologists on board the longline vessels contracted for this experiment, and the expected treatment of captured turtles, the mortality rate estimates contained in Table IV-3 may be overestimates. The implementing regulations of the Pelagics FMP requires fishermen to dehook and untangle any turtles incidentally taken in these fisheries; however, NMFS has no independent verification that this is occurring, and believes that having trained observers onboard is a direct benefit to the species. The February 16, 2001, policy memorandum specifically considered "reduced compliance rates with mitigation measures...when observers were not present" as part of the basis for precautionary choices in developing the post-hooking mortality estimates. Since the memorandum gave no guidance on how to account for the presence of observers, this Opinion will not attempt to quantify the benefit of their presence, but does consider that the post-hooking mortality estimate, as applied to this experiment, is conservative.

8. Expected maximum take/mortality in experiment

The maximum number of turtles by species anticipated to be taken and killed under the proposed issuance of scientific research permit #1303 during the three years of experiments is presented in Table IV-4. Under 100% observer coverage and with real-time reporting of the results to NMFS, the experiments will be terminated when the three year take limits (the total take numbers) for any one species are reached.

Table IV-4. Estimated maximum sea turtle take and mortality levels in the proposed scientific research experiment.

	Annual Estimated Take			Total Take	Estimated Mortality			Total Mortality
Species	Year 1	Year 2	Year 3	All years	Year 1	Year 2	Year 3	All years
Green	6	5	4	**15**	3	2	1	**6**
Leatherback	17	15	12	**44**	6	5	4	**15**
Loggerhead	88	80	65	**233**	33	30	24	**87**
Olive Ridley	10	8	6	**24**	4	3	2	**9**

As mentioned, the applicant calculated expected annual mortality by applying the post-interaction mortality rates (described in Morehead (2001) and NMFS (2001b) and presented in Table IV-3) to the proportion of animals externally hooked, deeply hooked, or retrieved dead based on past observations. For example, of the 8 green turtles observed taken in the swordfish-style component of the Hawaii-based longline fishery, 87.5% were externally hooked (broadly estimated as 27% mortality rate), and 12.5% were deeply hooked (42% mortality rate). Applying these percentages and their associated mortality rate to the interaction rate of green turtles (given the number of estimated swordfish sets per year during the experiment), the applicant calculated the number of green turtles that would be expected to killed during the first year of the experiment involving swordfish-style fishing. The same methodology was used to estimate the number of sea turtle species that would be taken and killed during the tuna-style fishing component of the experiment.

Because the abundance and distribution, migration and foraging patterns, and physiology vary so significantly between the four species of sea turtles that may be encountered during the experiment in the Pacific Ocean, their vulnerability to the longline fishing component of the scientific research permit also varies. The following sections review the expected impacts of the proposed issuance of scientific research permit #1303 on each of the sea turtle species.

a. Effects on green turtles

The proposed issuance of scientific research permit #1303 is anticipated to capture up to 6 green sea turtles during the first year, 5 greens during the second year, and 4 greens during the third year, for a total of up to 15 green turtles captured during the three year experiment (Table IV-5). Since a major portion of the experiments was designed to detect a 50% or greater reduction in leatherback capture, the number of incidentally captured green turtles is the maximum number anticipated. Similarly, because the latter two portions of the experiment were designed to test target species CPUE viability and to collect information on the depth and time of capture of loggerheads, the number of incidentally captured green turtles is the maximum number anticipated. The estimated number of green sea turtles captured during the entire experiment is based on the observed interaction rate of green sea turtles with the Hawaii-based longline fishery (including proportional takes in swordfish-style sets and tuna-style sets), taking into account the expected number of sets per year, and the anticipated effects of all portions of the experiment, where applicable.

Given the anticipated number of green turtles captured by the experiment and applying the mortality rate estimates contained in Table IV-3 to the fate of green turtles observed taken in the Hawaii-based longline fishery (described below), with proportional number of swordfish-style sets and tuna-style sets planned for the experiment, the applicants anticipate the following green turtle mortalities: 3 greens killed during the first year, 2 greens killed during the second year, and 1 green killed during the third year, for a total of 6 green turtles killed during the proposed three year experiment (Table IV-5).

Because the control sets in the experiment will be fished in the same manner in which the Hawaii-based longline fishery fished prior to the court-ordered closure, a summary of documented green sea turtle interactions with this fishery is warranted. Most of the experiments will be conducted north of 28°N, using swordfish style gear. The Hawaii-based longline fishery primarily interacted with green sea turtles south of 28°N (approximately 1/3 of the observed green turtle takes occurred near or north of 28°N). Therefore, it is likely that the actual take and mortality of green turtles will be much lower than anticipated.

The incidental take of green turtles by the Hawaii-based longline fishery has been rare. Observers have recorded the incidental take of 10 green turtles by the fishery from 1994-1999. All of these turtles were hooked either externally (9), or internally (1), and only one was observed dead, the rest were injured. Green turtles have been observed taken in this fishery during the months of February through July only. The turtles were caught in the area bounded by 155°W and approximately 180° longitude and between 5°N and 30°N latitude. Six out of the ten turtles were caught in an area around the Hawaiian island chain between 155°W and 160°W longitude and between 15°N and 30°N latitude. The remaining four were caught either far south of the Hawaiian islands (n=1), or to the northwest of the MHI (n=3). In addition, more green turtles were observed taken in swordfish-style sets compared to tuna-style sets. Eight out of the ten turtles caught were taken in sets with less than 10 hooks per float, indicative of swordfish-style, shallow-set gear. The one mortality observed was on a deep, tuna-style set; therefore, it is likely that the turtle died as a result of its inability to reach the surface. Subadult green turtles reportedly perform routine dives of 20 meters (Brill, *et al*., 1995, *in* Lutcavage and Lutz, 1997); therefore, it is not surprising that they are more likely to encounter a swordfish longline versus a tuna longline, which is often set below 100 meters.

Based on observer data, green turtles appear to be more likely to be hooked externally than to be entangled or hooked internally. Therefore, it is likely that green turtles may not be attracted to the baited hook or even to the lightsticks typically used during swordfish sets. The principal food sources for the green turtle are benthic marine algae. These algae are restricted to shallow depths where sunlight, substrate, and nutrients are conducive to plant growth. As a consequence, the feeding pastures used by green turtles are usually less than 10 meters deep and frequently not more than 3 meters deep, often right up to the shoreline. Because of these foraging strategies and food preferences, interactions between green turtles and the Hawaii-based longline fishery are rare.

Green turtles encountered during longline fishing may originate from a number of known proximal, or even distant, breeding colonies in the region. However the most likely candidates would include those from Hawaii (French Frigate Shoals) and the Pacific coast of Mexico population. This is based on limited genetic sampling conducted within the NMFS observer program for the Hawaii-based longline fishery. Of eight greens caught by the fishery and genetically tested, four were of eastern Pacific (Mexico) origin, while three were either of Hawaiian origin or eastern Pacific origin, and one was of Hawaiian origin (P. Dutton, NMFS, personal communication, January, 2001). At the time of this writing, information was not available regarding which of these sampled turtles had been taken in tuna-style sets and which had been taken by swordfish-style sets. Based on life history information collected by observers, green turtles encountered by the Hawaii-based longline fishery represented both subadult and adult stages. Straight carapace lengths ranged from 28.5 cm to 73.5 cm (average 51.5 cm).

b. Effects on leatherback turtles

The proposed issuance of scientific research permit #1303 is anticipated to capture 17 leatherbacks during the first year, 15 during the second year, and 12 during the third year, for a total of up to 44 leatherbacks (Table IV-4). Because the minor gear modification experiment (testing blue-dyed bait and re-positioning floatlines) has been designed to test a 50% or greater reduction in leatherback take, this portion of the experiment must take exactly 36 leatherbacks (24 in control, and 12 in experiment) over the three year period (Table II-2) to detect a 50% or greater reduction. Based on the number of sets needed for the two experiments testing for CPUE viability (stealth/deep daytime swordfish and hooktimer/hook type), a maximum of 6 leatherbacks are anticipated to be captured. This is based on the observed interaction rate of leatherbacks with the Hawaii-based longline fishery (including swordfish-style sets and tuna-style sets), and taking into account the expected number of sets per year, and the anticipated effects of these latter two portions of the experiment.

Given the anticipated number of leatherback turtles captured by the experiment and applying the mortality rate estimates contained in Table IV-3 to the fate of leatherbacks observed taken in the Hawaii-based longline fishery (described below), with proportional number of swordfish-style sets and tuna-style sets planned for the experiment, the applicants anticipate the following leatherback turtle mortalities: 6 leatherbacks killed during the first year, 5 leatherbacks killed during the second year, and 4 leatherbacks killed during the third year, for a total of 15 leatherbacks killed during the three year experiment (Table IV-4).

Because the control sets in the experiment will be fished in the same manner in which the Hawaii-based longline fishery fished prior to the court-ordered closure, a summary of documented leatherback interactions with this fishery is warranted. Since the Hawaii-based longline fishery for swordfish primarily interacted with leatherbacks north of 28°N, we would expect a similar number of interactions to occur during the experiment.

Observers recorded the incidental take of 40 leatherback turtles in the Hawaii-based longline fishery. Of these, 3 were entangled, released alive and uninjured (7.5%), 31 were injured (77.5% – comprised of 3 entanglements, 23 hooked externally, 1 hooked internally, and 4 hooked in an unknown location), 3 died as a result of the interaction (7.5% - comprised of 2 that were entangled, and 1 that was hooked externally), and for 3 leatherbacks taken, there were no records (i.e. the observer was unable to identify the fate or condition of the turtle). Of 34 leatherbacks that had life history forms recorded by observers, only five leatherbacks were measured. Straight carapace lengths were 71, 80, 87.5, 110, and 130 centimeters. Four of these measured leatherbacks were subadults, representing early pelagic stage (n=1), and late pelagic stage (n=3), based on stage structure parameters assumed for Malaysian turtles presented in Bolten, *et al.* (1996). If the larger (130 cm) leatherback originated from the eastern Pacific, it could be an adult; otherwise, if it originated from the western Pacific, it would be a subadult (P. Dutton, NMFS, personal communication, January, 2001). Those leatherbacks that were not measured may have been too large to be safely brought on board; therefore they may have been adults.

Leatherback turtles have been observed taken in all months of the year, except August. The leatherbacks were caught in the area bounded by 170°E and 133°W longitude and between 5°N and 41°N latitude. Leatherbacks caught in sets above 20°N latitude (34 out of 40 leatherbacks observed) were caught in sets with less than 10 hooks per float, indicative of swordfish-style, shallow-set gear and also indicative of the general area in which swordfish-style fishing methods are used. Leatherback takes in these sets occurred primarily between 165°W and 130°W longitude and 20°N and 40°N latitude. The remaining leatherbacks observed taken (6 out of 40), were taken in sets with more than 10 hooks per float, indicative of tuna-style, deep-set gear. Leatherback takes in these sets occurred between 157°W and 167°W longitude and between 5°N and 15°N latitude.

Leatherbacks in general appear to be very vulnerable to entanglement in fishing gear. Of 11 sea turtles examined port-mortem after being taken by a Hawaii-based longline, the only two turtles with entanglements of leaders around body parts were leatherbacks (Work, 2000). Their long pectoral flippers and their active behavior make them particularly vulnerable to any ocean debris. Studies of daily swimming patterns over time yielded a very small percentage (0-7%) of time in which the leatherback was not swimming (S. Eckert, manuscript in prep. May, 2000). Leatherback hatchlings studied in captivity for almost 2 years swam persistently without ever recognizing the tank sides as a barrier (Deraniyagala, 1939, *in* Wyneken, 1997). Individual leatherbacks have been known to continue swimming while entangled in crab pot lines (Rudloe, 1979, *in* Witzell, 1984). Turtles could be captured while feeding or swimming at the surface when the longline is being set or hauled back, or when the longline is fishing at depth. A leatherback entangled by a longline will most likely continue trying to swim, expending valuable amounts of energy and oxygen. As available oxygen diminishes, anaerobic glycolysis takes over, producing high levels of lactic acid in the blood. In addition, leatherbacks store an enormous amount of oxygen in their tissues, similar to marine mammals, which is efficient for such a deep-diving turtle but means that they have relatively less oxygen available for submergence. Maximum dive duration for the species is substantially less than that of other turtles (*in* Lutcavage and Lutz, 1997). The disadvantage of this is that they are not able to hold their breath as long and are probably more vulnerable to drowning in long, longline sets.

Based on observations of all sea turtles taken by the Hawaii-based longline fishery, it appears that leatherbacks in particular tend more to get hooked externally or entangled rather than ingesting the hook. This is most likely due to their foraging strategy as well as their physiology. Whereas some hard-shelled turtle species (e.g. loggerheads) are piscivores and will forage on the bait (e.g. squid) used on longlines and therefore become hooked internally, leatherbacks tend to target cnidarians (e.g. medusae and siphonophores), so they may also be attracted to the lightsticks used on the longlines at night to attract squid and subsequently are hooked externally or entangled.

Hawaii fishermen in offshore waters see leatherbacks turtles generally beyond the 100-fathom curve but within sight of land. Two areas where sightings take place are off the north coast of Oahu and the west coast of the Island of Hawaii, and in the area of the seamounts above the Northwestern Hawaiian Islands (*in* Skillman and Balazs, 1992). The pelagic zone surrounding the Hawaiian Islands apparently is regularly used as foraging habitat and migratory pathways for this species. Further to the north of the Hawaiian Islands, a high seas aggregation of leatherbacks is known to occur at 35°N latitude, between 175°W and 180° longitudes (NMFS, 1991).

Based on genetic analysis of mitochondrial DNA (mtDNA), leatherback stocks encountered in the Hawaii-based longline fishery derived from two Pacific stocks: 1) the eastern Pacific region (Mexico and Costa Rica), and 2) the western Pacific region (Malaysia, Indonesia and Solomon Islands). To date mtDNA analyses indicated that 12 of 14 leatherbacks captured in the Hawaii-based longline fishery originated from nesting populations in the southwestern Pacific; the other 2 specimens, taken in the southern range of the Hawaii fishery, were from nesting beaches in the eastern Pacific (P. Dutton, *et al*., in press, and P. Dutton, NMFS, personal communication, May, 2000). Because the majority of the sets during the experiments conducted under this scientific research permit will take place north of the Hawaiian Islands, any leatherbacks taken will most likely have originated from western Pacific nesting beaches.

c. Effects on loggerhead turtles

The proposed issuance of scientific research permit #1303 is anticipated to capture 88 loggerheads during the first year, 80 loggerheads during the second year, and 65 loggerheads during the third year, for a total of 233 loggerheads taken (Table IV-4). Since a major portion of the experiments was designed to detect a 50% or greater reduction in leatherback capture (minor gear modification experiment - blue-dyed bait and repositioning floatlines), the number of incidentally captured loggerheads during this experiment is the maximum number anticipated (Table II-2). Similarly, since the stealth-deep set/daytime experiment is designed to test for target species CPUE viability, the number of incidentally captured loggerheads during this experiment is the maximum number anticipated (Table II-3). The estimated take of loggerheads for both the minor gear modification experiment and the stealth-deep set/daytime experiment is based on the observed interaction rate of loggerheads with the Hawaii-based longline fishery (including proportional takes in swordfish-style sets and tuna-style sets), taking into account the expected number of sets per year, and the anticipated effects of these portions of the experiment. For the hook timer-hook type experiment, the applicant has stated that the take of 15 loggerheads per year for two years is necessary to detect trends in depth and time of capture. Therefore, the capture of exactly 30 loggerheads is anticipated for this portion of the experiment (Table II-4).

Given the anticipated number of loggerhead turtles captured by the experiment and applying the mortality rate estimates contained in Table IV-3 to the fate of loggerheads observed taken in the Hawaii-based longline fishery (described below), with proportional number of swordfish-style sets and tuna-style sets planned for the experiment, the applicants anticipate the following loggerhead mortalities: 33 loggerheads killed during the first year, 30 loggerheads killed during the second year, and 24 loggerheads killed during the third year, for a total of 87 loggerheads killed during the proposed three year experiment (Table IV-4).

Because the control sets in the experiment will be fished in the same manner in which the Hawaii-based longline fishery fished prior to the court-ordered closure, a summary of documented loggerhead interactions with this fishery is warranted. Since the Hawaii-based longline fishery for swordfish primarily interacted with loggerheads north of 28°N, we would expect a similar number of interactions to occur during the experiment.

Of all marine turtles, loggerheads are the species most often taken by the Hawaii-based longline fishery. From 1994-99, observers recorded the incidental take of 147 loggerheads. Of these, 3 were released alive and uninjured (2%), 139 were injured by hooking (94.5%) (56 hooked externally, 83 hooked internally), and 4 died as a result of the interaction (3%) (1 hooked internally and 3 hooked in an unknown location). For one loggerhead interaction, there was no record of its condition. From life history data collected by observers, it appears that the Hawaii-based longline fishery primarily interacts with juvenile loggerheads. Straight carapace lengths ranged from 38.4 cm to 90 cm (average 56.9 cm); however, approximately 75% of the captured loggerheads were less than 65 cm SCL (G. Balazs, NMFS, personal communication, January, 2001).

Genetic analyses of 124 loggerheads caught in the Hawaii-based longline fishery indicated that the majority (nearly 100 percent) originated from Japanese nesting stock (Dutton, *et al*., 1998) and the rest derived from Australia (P. Dutton, NMFS, personal communication, January, 2001). Based on this, we expect that the loggerheads taken by the proposed action will have originated from Japanese nesting beaches.

All of the 147 loggerheads observed taken by the Hawaii-based longline fishery from 1994-1999 were captured by longliners targeting swordfish (i.e. target depth less than 100 meters, using less than 10 hooks per float, fishing at night, using lightsticks). Two factors, the location of swordfishing effort and the overlap between loggerhead dive depths and typical swordfish set depths, may influence the high interaction rates loggerheads have historically had with the Hawaii-based longline fishery.

Loggerheads tend to congregate in areas typically fished by longliners targeting swordfish, taking advantage of high productivity associated with particular oceanographic features. Recent satellite tracking by Polovina *et al*. (2000) indicates that loggerheads of all life stages are active migrators, swimming against weak geostrophic currents along two convergent fronts as they travel from east to west across the Pacific. Of nine juvenile loggerheads tracked in the central North Pacific, six associated with a front characterized by 17°C sea surface temperature (SST) (termed "cool group") and the other three associated with a front with a sea surface temperature of 20°C ("warm group"). Seasonally, these 17°C and 20°C isotherms move north and south over 10 degrees of latitude, and as the turtles moved westward, they also appeared to move north and south coincident with these isotherms. During the first quarter, the distribution of surface longline sets (targeting swordfish) is largely between the 17°C and 20°C SST fronts used by loggerheads. Swordfish are believed to move south through the fronts, perhaps following squid, so during the second quarter, the fishery is well to the south of the 17°C SST front but overlapping the 20°C SST front. Sea turtles tracked during the first quarter of the years (1997 and 1998) occupied waters with a mean of 17°C SST, with considerable overlap with the SST occupied by the fishery in the northern portion of the fishing grounds. As the fishery moves south in the second quarter, those "warm group" turtles following the 20°C front may be well within the fishing ground, while the "cool group" will likely be well north of the fishing ground (Polovina, *et al*., 2000). Observer data shows that the interaction rate (turtles per longline set) is substantially greater at 17°C SST than at 20°C SST (P. Kleiber, NMFS, personal communication *in* Polovina, *et al*., 2000).

Loggerheads in north Pacific pelagic habitats are opportunistic feeders that generally forage on items floating near or at the surface, although they will actively feed at depth if there are high densities of prey available. Loggerheads captured and killed by the international high-seas driftnet fishery in the Pacific Ocean, were opportunistically necropsied to determine stomach contents. Based on the results from 52 turtles, it appears that loggerheads are omnivorous predators of the surface layer, feeding both by swallowing floating prey whole and/or biting off prey items from larger floating objects. In samples that contained pyrosomas, the prey items often comprised a high percent of the total gut content, indicating that the turtles were encountering dense patches of this prey item. In addition, prey items normally found in the upper photic zone (within 100 meters of the surface) but not the surface layer were also found in the gut, indicating that the loggerheads actively hunted for these species (Parker, *et al*., in press). With 57 percent of loggerheads observed hooked internally in the Hawaii-based longline fishery, it is likely that they are foraging at depth and may have been confusing lightsticks for prey items or were attracted to the baited hooks. In addition, the presence of an orange float in the water may have caused the initial interest and attraction to the gear.

Polovina, *et al.* (in review), monitored the temporal distribution and depth of dives of two loggerheads caught in the Hawaii-based longline fishery. Their analyses indicate that the loggerheads spent about 40 percent of their time at the surface and nearly all of their dive time at depths shallower than 100 meters. Typical swordfish sets in the Hawaii-based longline fishery are shallower than 100 meters, as well. The overlap in geographic location and depth between swordfish sets and loggerheads could be a primary factor in the high loggerhead interaction rates seen in the swordfish component of the Hawaii-based longline fishery. Given this overlap, if proposed experiments to test CPUE of swordfish using deep sets during the daytime are successful (that is, if they indicate a viable method to catch swordfish or big-eye tuna), a simple method to reduce or avoid loggerhead interactions in areas where the geographic overlap occurs would be available.

d. Effects on olive ridley turtles

The proposed issuance of scientific research permit #1303 is anticipated to capture 10 olive ridleys during the first year, 8 olive ridleys during the second year, and 6 olive ridleys during the third year, for a total of 24 olive ridleys during the proposed three year experiment (Table IV-4). Since a major portion of the experiments was designed to detect a 50% or greater reduction in leatherback capture, the number of incidentally captured olive ridley turtles is the maximum number anticipated. Similarly, because the latter two portions of the experiment were designed to test target species CPUE viability and to collect information on the depth and time of capture of loggerheads, the number of incidentally captured olive ridley turtles is also the maximum number anticipated. The estimated number of olive ridleys captured during the entire experiment is based on the observed interaction rate of olive ridleys with the Hawaii-based longline fishery (including proportional takes in swordfish-style sets and tuna-style sets), taking into account the expected number of sets per year, and the anticipated effects of all portions of the experiment, where applicable.

Given the anticipated number of olive ridley turtles captured by the experiment and applying the mortality rate estimates contained in Table IV-3 to the fate of olive ridleys observed taken in the Hawaii-based longline fishery (described below), with proportional number of swordfish-style sets and tuna-style sets planned for the experiment, the applicants anticipate the following olive ridley mortalities: 4 olive ridleys killed during the first year, 3 olive ridleys killed during the second year, and 2 olive ridleys killed during the third year, for a total of 9 olive ridleys killed during the proposed three year experiment (Table IV-4).

Because the control sets in the experiment will be fished in the same manner in which the Hawaii-based longline fishery fished prior to the court-ordered closure, a summary of documented olive ridley interactions with this fishery is warranted. Most of the experiments will be conducted north of 28°N, using swordfish style gear. The Hawaii-based longline fishery primarily interacted with olive ridleys south of 28°N (approximately 1/8 of the observed takes were near or north of 28°N). Therefore, it is likely that the actual take and mortality of olive ridley turtles will be much lower than anticipated.

From 1994-1999, observers recorded the incidental take of 32 olive ridleys by the Hawaii-based longline fishery. Of the 32 olive ridleys observed taken, 26 were captured in swordfish-style sets, and 6 were caught in tuna-style sets. Out of these 26 taken in swordfish-style sets, 25 were injured, all by hooking incidents (9 hooked externally and 16 hooked internally) and 1 died as a result of the interaction. Based on life history data collected by observers, it appears that the fishery interacts with both subadult and adult life stages of olive ridleys. For those olive ridleys brought on board and measured (n=29), straight carapace length ranged from 44.5 cm to 66.5 cm (average 55.43 cm).

In the Hawaii-based longline fishery (including both swordfish-style and tuna-style sets), none of the olive ridleys observed taken were entangled - all were hooked, therefore, it is likely that the olive ridleys may be attracted to the baited hook or to the lightsticks, which may be confused for pyrosomas by the turtles. While the habitat of juvenile olive ridleys is not well-known, adults use a wide range of foraging habitats, feeding pelagically in deep water as well as in shallow benthic waters. They feed on a wide variety of items, ranging from jellyfish, to crabs, molluscs and algae (*in* NMFS and USFWS, 1998d). Stomach contents of 7 olive ridleys captured by the fishery were found to contain salps, cowfish and pyrosomas. Four of the olive ridleys examined had bait in their esophagus. One of these four turtles was found with three fish used as longline bait, indicating that it had ingested from more than one hook (Work and Balazs, draft manuscript, January, 2001).

From 1994 to 1999, olive ridleys were observed taken by the Hawaii-based longline fishery during all months of the year except February, with most of the take occurring during the warmer months (May-August). In addition, the fishery interacted with olive ridleys throughout the fishing grounds, with observed takes ranging from as far north as 33°N to as far south as 7°N latitude, and from longitudes 143°W, west to 175°W. Sea surface temperatures, latitude, and the distance to the approximate 17°C and 19°C isotherms were associated with the takes, but there was a high degree of collinearity between these variables. There was a clear distinction between the proportion of takes between the two categories of sea surface temperature, but over latitude, the pattern was less clear (McCracken, 2000).

Based on observer data, olive ridleys had the highest mortality rate of all sea turtles taken by the Hawaii-based longline fishery, most likely because more olive ridleys were captured and killed in tuna-style sets than any other species of sea turtle. The turtles that died as a result of the interaction most likely drowned, suffocated, or succumbed to injuries suffered as a result of their being hooked. Of the 6 taken by tuna-style sets, 5 died. This high mortality rate is most likely as a result of the turtles' inability to reach the surface, due to the deep sets.

Results from genetic analyses suggest that olive ridley stocks involved in the Hawaii-based longline fishery may originate from nesting beaches in both the western and Indian Pacific, and in the eastern Pacific. Although haplotypes for olive ridley rookeries have not been identified due to small sampling sizes, there is a current effort underway to expand the rookery database. Thus far, genetic analyses suggest that of the 20 sampled olive ridleys taken by the Hawaii-based longline fishery, 40 % (n=8) originate from the Indian/western Pacific and 60% (n=12) originate from the eastern Pacific (P. Dutton, NMFS, personal communication, January, 2001). Some areas of large relative take of olive ridleys indicated representation from both eastern and western Pacific beaches, signifying that ridleys from both sides of the Pacific converge in the north Pacific pelagic environment. Since the majority of the experiment will take place north of 28°N, and olive ridleys characteristically occupy areas south, well in the center of the a subtropical gyre (Polovina, *et al.*, in review), few olive ridleys are anticipated to be captured, and the one sample taken from an olive ridley north of 28°N showed that the turtle had originated from a western Pacific beach.

9. Measures to minimize the effects of the experiment on sea turtles

Turtles that are hooked during the experiment, line/hook cutters or de-hookers will be used to remove longline gear. Based on observer data from the Hawaii-based longline fishery, sea turtles that are taken during the swordfish-style portion of the experiment will most likely be alive and will be either entangled or hooked in longline gear. During normal fishing operations in the Hawaii-based longline fishery, one observer is present to collect vast amounts of information during a set, including oceanic conditions, gear used, number of target species caught, number and identification of bycatch species caught, etc. Meanwhile, the crew's primary focus is on landing, dressing, and storing fish. Although both observer and crew have guidelines for the handling of turtles caught in longline gear, treating and resuscitating turtles may be a secondary duty or may not get the prompt or focused attention the event deserves. On the other hand, the primary purpose of the majority of the proposed experiments under scientific research permit #1303 is to take and treat turtles, not land fish. Therefore, turtles taken during the experiments should get better treatment and thus have a higher survival rate compared to normal fishing operations. The presence of biologists aboard every vessel in the experiment will provide trained handlers for removing lines, hooks and nets, and resuscitation (if needed).

NMFS expects that turtles that are eventually released after capture will be in better condition than when they were first brought aboard because they will have entangling gear and/or hooks removed, and will have additional recovery time before release.

10. Likelihood of success of experiment

Based on results of laboratory experiments, anecdotal reports, and analyses of data collected on sea turtle interactions and longline fishing, NMFS believes there is a high likelihood that the proposed gear modification experiment will reduce sea turtle interactions. The applicants anticipate that sea turtle interactions would be reduced by greater than 50%. If after the first year, the minor gear modifications have not reduced loggerhead interactions by greater than 50%, the applicants will have already conducted concurrent experiments to determine target species CPUE viability using alternative strategies and modifications to longline fishing. If such experiments prove that target species CPUE is not compromised, changes to the original proposed experiment can be made after the first year, so that continuing experiments can take place.

An evaluation and risk assessment following the first year will also ensure that sea turtle species such as the leatherback and the loggerhead are not unduly compromised by experiments that have not shown success. If results of the first year indicate that loggerhead interaction rates have not been reduced by 50%, continuation of the original experiment to test leatherback interaction rates would cause unnecessary harm to all species concerned. Much of the support for the probable success of the minor gear experiment comes from data on hardshell turtles. Should the experiment prove unsuccessful for a hardshelled turtle, the likelihood of success for the leatherback would be very low. Discontinuation of the experiments prior to the full 3 year period would reduce the impact on the species. However, NMFS has analyzed the full impact of the take on the assumption that the experiment will continue for the full three years.

Should the minor gear modifications prove successful for loggerheads, and annual evaluations of the ongoing experiment and status of the species prove positive, there is still some concern over the ability of the experiment to produce reliable results. First, current power analysis indicates that NMFS faces a 20 percent chance of falsely concluding the minor gear modifications are 50% or more effective for leatherbacks. This is a very high probability when the conservation of a listed species is at stake. Unfortunately, in order to achieve a lower probability that we have reached a false conclusion, more turtles would have to be taken. Rather than cause this additional harm to the species, NMFS has chosen to accept the higher risk of a false conclusion. Adoption of a method somewhat less effective than 50% by longline fisheries in the Pacific Ocean would still reduce significant impacts to this species and provide some benefits towards their conservation.

a. Expected Benefits of the Experiment Techniques

Without methods to reduce longline fishery bycatch of turtles in the U.S. and foreign fleets, the survival and recovery of endangered and threatened sea turtles may not be possible. In order to achieve comprehensive sea turtle take reductions in pelagic longline fisheries that will have a long-term significant effect on sea turtle survival and recovery, measures must be found that can be implemented by the large, international fleets that fish the entire Pacific Ocean. Fishing tactics and modified gear configurations – technical solutions – that allow longline vessels from all fleets to continue to catch target species effectively are likely to be exportable solutions that meet that requirement.

The purpose of the proposed research is to develop such technical solutions to reduce sea turtle bycatch in commercial longline fisheries while still maintaining the ability to catch target species. Very little research has been accomplished to date to address this issue. The proposed research addresses one of the most pressing conservation research questions facing sea turtles worldwide. The rapid and promising results expected from this research will provide greater benefit to sea turtle survival and recovery, before population declines continue even further.

In addition to the expected benefits towards the conservation os sea turtles, NMFS also expects to gain invaluable information about sea turtles from these experiments. NMFS expects that this information will help determine a more accurate post-hooking survival rate estimate, establish a clearer picture of loggerhead and leatherback distribution in the Pacific Ocean, and increase the available information on sea turtle life history and population demographics.

In order to determine the likelihood that conservation measures developed by these experiments will be adopted in domestic and foreign longline fleets, NMFS reviewed case studies of protected species conservation techniques that had been adopted by other fisheries. NMFS expects that adoption of these types of techniques in domestic fisheries will be a relatively quick process once the results are available. NMFS and the United States (U.S.) have no direct influence over foreign fleets, therefore NMFS' review of the adoption of conservation measures focused on adoption by foreign nations.

b. Evidence of Adoption of Other Species Conservation Measures by Foreign Nations

The reduction in the mortality of protected species caused by unintentional capture in fisheries can be attained by limiting fishing effort at some times and places, closing a fishery, reducing tow times or soak times, or modifying fishing gear to either exclude animals or prevent injuries and mortalities. Two programs that have shown success in significantly reducing injury and mortality of protected species through adoption of alternative techniques and gear by domestic and international fisheries include the dolphin conservation program in the eastern tropical Pacific purse seine fishery for tuna and the development and use of turtle excluder devices in bottom trawl fisheries.

(1) *Dolphin protection measures in the Eastern Tropical Pacific tuna purse seine fishery*

For a variety of reasons, schools of large, mature yellowfin tuna regularly congregate and swim beneath schools of dolphins in the eastern tropical Pacific Ocean (ETP). U.S. fishermen began to exploit this association in the late 1950s by encircling the dolphin schools with large purse seine nets to capture the yellowfin tuna swimming beneath the dolphins. Despite efforts to release the entrapped dolphins while landing the tuna, dolphins became entangled in the nets and died by asphyxiation

Tuna seiners took early action to reduce dolphin mortalities. In 1957, acting on suggestions from experienced European purse seine fishermen, tuna seiners modified procedures to back-down vessels so as to release dolphins over the top of the purse seine net. In 1971, tuna seiner Harold Medina developed and introduced a special panel for seine nets that further reduced dolphin entanglement. These two methods were improved further after passage of the MMPA in 1972.

Since the enaction of the MMPA in 1972, the U.S. has made great strides in reducing the incidental mortality of dolphins by purse seiners in the ETP. The ETP tuna fishery was dominated by U.S. vessels during the 1960s and the early 1970s. In 1972, U.S. vessels were responsible for the mortality of an estimated 368,600 dolphins, while foreign vessels killed an estimated 55,078 dolphins. In the late 1970s and early 1980s, the U.S. fleet declined while the number of foreign vessels participating in the fishery increased; along with these shifts in the fishery came changes in the associated mortality of dolphins. Furthermore, as progress was made by the U.S. to reduce dolphin mortality, foreign vessels continued to kill dolphins, offsetting any beneficial effects to dolphin populations through U.S efforts (Marine Mammal Commission, 2001).

The 1988 amendments to the MMPA established standards for U.S. vessels purse seining for tuna in the ETP and established comparability requirements for nations seeking to export tuna into the U.S. in 1988. Under the amendments, in order to be found comparable to the U.S. program, a foreign program was required to include by the beginning of the 1990 fishing season: 1) prohibitions on conducting sundown sets and such other activities as were applicable to U.S. vessels; 2) monitoring by observers; and 3) observer coverage equivalent to that for U.S. vessels.

Lastly, the 1988 amendments added Pelly certification[15] to the embargo process for those nations not meeting the comparability requirements of the MMPA (NMFS, 1999).

As a result of the 1988 amendments to the MMPA, dolphin mortality declined by more than 95 percent between 1988 and 1993. Although part of this decline was attributable to fewer sets being made on dolphins, the primary factor in reducing the incidental dolphin mortality was a marked reduction in the average number of dolphins killed per set, due to modifications such as backing down (Marine Mammal Commission, 2001).

Through various international agreements and U.S. Acts (e.g. the La Jolla Agreement in 1992, the Panama Declaration in 1995, the International Dolphin Conservation Program Act (1997) and The Agreement on the International Dolphin Conservation Program (1998)) the incidental mortality of dolphins has been reduced to less than 5,000 animals per year (domestic and international combined) since 1993 (Marine Mammal Commission, 2001).

(2) *Turtle Excluder Devices*

Prior to the development of a gear modification to trawling, one of the major threats to turtles in the United States, and around the world, was mortality through drowning in shrimp fishing trawls. Instead of swimming away from an approaching net, turtles tried to outswim the trawl but got caught in the net as they tired. Without a means of escape, they became trapped in the net for as long as it was towed underwater and sometimes drowned before being brought aboard. The problem is analogous to the purse seining of tuna fish, where thousands of dolphins drowned every year during the 1970s and 80s because they did not have a means of escaping the net.

The drowning of sea turtles in shrimp trawls was identified as a serious problem in the late 1960s. At that time, tens of thousands of turtles were being caught in shrimp trawl nets in U.S. waters alone (Fox, 1990, *in* Bache, 2001). Since gear modifications were much preferred by shrimpers to the alternative of time and area closures, the initial reaction to the problem was to devise a technical solution (Bache, 2001). After ten years of studying this problem and at a cost of millions of dollars, NMFS developed the Turtle Excluder Device (TED) for use by commercial fishermen.

In June, 1987, NMFS published a final rule requiring all shrimpers to begin using TEDs by May 1988. The National Academy of Sciences estimated that, without the use of TEDs, as many as 55,000 threatened and endangered sea turtles would have drowned annually in American shrimp nets. By 1989, six TED designs had been shown to exlude 97% of the sea turtles that would have been caught in nets without TEDs (NRC, 1990).

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[15]Under the terms of the Pelly Amendment to the Fisherman's Protective Act of 1967, the Secretary of the Interior is required to issue a certification to the President when it has been determined that nationals of a foreign country are engaged in trade that can diminish the effectiveness of any international conservation program for endangered or threatened species. Upon receipt of a Pelly certification, the President can impose trade sanctions on the offending country.

In 1989, Congress enacted a law that required foreign nations be certified as having sea turtle conservation standards equivalent to those of the U.S. as a condition for the importation of shrimp (Public Law No. 101-162 § 609 - Conservation of Sea Turtles: Importation of Shrimp Law.) (Bache, 2001). Since then, NMFS and the State Department have been working closely with shrimp supplying nations throughout the world to help them develop comparable TED programs in their shrimp fisheries. These programs are now in place in about forty countries. For example, in 1997, Thailand manufactured and distributed 2,900 TEDs to fishermen in Thailand, and a law was enacted there requiring the use of TEDs. Sea trials experimenting with and demonstrating the use of TEDs and the education of fishermen has also commenced in Malaysia, the Phillipines, and Indonesia (Chokesanguan, 2001). In addition, NMFS participates in the negotiations & development of the International Sea Turtle Convention to further promote TED programs in other countries.

c. Likelihood of Adoption

Given past success in the development of gear modification and alternative fishing strategies to reduce interactions and mortalities with marine mammals and sea turtles, and with growing worldwide concern for the conservation of endangered and threatened sea turtles, NMFS expects that, should these proposed experiments provide an economically and technically feasible alternative to longline fishing that would reduce sea turtle interactions, foreign countries would likely be very open to adoption.

Although at this time there are no comparability requirements on the importation of swordfish or tuna caught on longline gear, the U.S. has shown willingness in the past to adopt these types of requirements. For example, section 8 of the ESA allows the Secretaries of State and Commerce to use various methods, including provision of funds, with foreign nations to ensure the conservation of listed species. Therefore, the tools are available to NMFS and the U.S. to promote the use of viable conservation measures for sea turtles. Adoption of these measures in domestic and foreign fisheries should significantly reduce a worldwide source of juvenile, sub-adult, and adult sea turtle mortality. Such a reduction should reduce the threats these turtles face and potentially increase their likelihood of survival and recovery in the wild.

V. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Most of the fisheries described as occurring within the action area (Section III. Status of the Species and Environmental Baseline), are expected to continue as described into the foreseeable future. Therefore, NMFS is not aware of any proposed or anticipated changes in most of these fisheries that would substantially change the impacts each fishery has on the sea turtles covered by this Opinion. Numbers of vessels participating in the California longline fishery, however, appear to be increasing due to an influx of Hawaii-based longliners targeting swordfish in waters beyond 200 nm off the California coast; some of these vessels have de-registered from their Hawaii limited entry permits. Longline vessels began landing swordfish at San Pedro/Terminal Island, California in 1999. That year, 1.5 million pounds of swordfish were landed by drift gillnet and longline vessels, compared with approximately 340,000 pounds landed by just drift gillnet vessels the previous year. Longline and drift gill net vessels landed a total of 2.6 million pounds of swordfish at San Pedro/Terminal Island, California in 2000 (D. Petersen, NMFS, personal communication, February, 2001). As a result of this increased effort off of California, interactions between listed species commonly found in northeastern portions of the action area and the California longline fishery may increase. Based on observer data in the Hawaii-based longline fishery and the California drift gillnet fishery, both leatherback and loggerhead sea turtles are commonly found in this area. Because the California longline fishery is not observed, the current level of incidental take of listed sea turtles is unknown, but may increase as a result of increased effort.

In addition to fisheries, NMFS is not aware of any proposed or anticipated changes in other human-related actions (e.g. poaching, habitat degradation) or natural conditions (e.g. over-abundance of land or sea predators, changes in oceanic conditions, etc.) that would substantially change the impacts that each threat has on the sea turtles covered by this Opinion. Therefore, NMFS expects that the levels of take of sea turtles described for each of the fisheries, except the California longline fishery, and non-fisheries will continue at similar levels into the foreseeable future.

VI. SPECIES RESPONSE TO THE ACTION

The *Approach to the Assessment* section of this Opinion stated that we approach jeopardy analyses in three steps. First, we identify the probable direct and indirect effects of an action on the physical, chemical, and biotic environment of the action area. The second step of our analysis determines if we would reasonably expect threatened or endangered species to experience reductions in reproduction, numbers, or distribution in response to these effects. In the third step of our analyses, we determine if any reductions in a species' reproduction, numbers, or distribution (identified in the second step of our analysis) can be expected to appreciably reduce a listed species' likelihood of surviving and recovering in the wild.

In the *Status of the Species and Environmental Baseline* sections of this Opinion, we discussed the various natural and human-related phenomena that caused populations of the various sea turtle species to become threatened or endangered and continue to keep their populations suppressed.

This section of an Opinion examines the physical, chemical, and biotic effects of the experiments authorized by the proposed issuance of scientific research permit #1303 to determine: (a) if those effects can be expected to reduce the reproduction, numbers, or distribution of threatened or endangered species in the action area; (b) if any reductions in reproduction, numbers, or distribution would be expected to reduce the species' likelihood of surviving and recovering in the wild, and (c) if a reductions in a species' likelihood of surviving and recovering in the wild would be appreciable. For the purposes of this analysis, we will assume that anything that places sea turtle populations in the Pacific Ocean at greater risk of extinction also places the entire species at a greater risk of extinction.

A. Green Turtles

The proposed issuance of scientific research permit #1303 is anticipated to incidentally capture, injure, or kill adult and subadult green sea turtles. Based on past patterns of green turtles captured in the longline fishery, turtles would be taken throughout the year. Based on observer data from the Hawaii-based longline fishery, most of these turtles will probably be hooked, rather than entangled, with most of them hooked externally; external hooking is expected to kill fewer turtles than internal hooking. Based on past interaction rates in the Hawaii-based longline fishery, the applicants anticipate that up to 6 green turtles will be taken during the first year, 5 will be taken during the second year, and 4 will be taken during the third year, for a total of 15 green sea turtles. Of these 15 green turtles taken, the applicants expect that not more than 6 would die as a result of the interactions.

If the experiments affect green turtle populations proportional to their relative abundance in the action area, about half of the green turtles that are captured, injured, or killed by the experiment would come from the eastern Pacific population that nests in Mexico. Another 35 percent of the affected turtles would represent either the eastern Pacific population or the Hawaiian population, and the remaining 12 percent would represent the Hawaiian population. Using this assumption, it is reasonable to expect between 3 and 5 adult or sub-adult green turtles from the eastern Pacific population and between 1 and 3 adult or sub-adult green turtles from the Hawaiian population each year would be killed by the proposed experiments.

Based on the location of much of the proposed experiments (north of 28°N), however, NMFS expects that fewer green turtles will actually be taken during the course of the experiment. Based on past observed interactions with the Hawaii-based longline fishery, most green turtle interactions occurred south of 28°N (one-third of the observed takes occurred near or north of 28°N). Therefore, it is very likely that fewer green turtles may be taken during the experiment than anticipated. Based on expectation of this reduced captures, NMFS anticipates that fewer green turtles will die as a result of the experiments, as well.

We believe it is reasonable to expect that killing adult or sub-adult green turtles would reduce the numbers of individuals in the species, particularly since population estimates for this species are based on estimated numbers of adult turtles. Assuming that some of these turtles would be female, we would also conclude that these deaths would reduce the population fecundity in addition to reducing their population size. If all of the green turtles killed are females, the resulting loss of production could be up to 600 eggs per female, per nesting season. The annual loss of these eggs would reduce the fecundity of these nesting populations for the would extend into subsequent generations.

In the *Environmental Baseline* section of this Opinion, we noted that green turtles are captured, injured, or killed in numerous Pacific fisheries including Japanese longline fisheries in the western Pacific Ocean and South China Seas; longline fisheries off the Federated States of Micronesia; commercial and artisanal swordfish fisheries off Chile, Columbia, Ecuador, and

Peru; purse seine fisheries for tuna in the eastern tropical Pacific Ocean, and CA/OR drift gillnet fisheries. Because of limited available data, we cannot accurately estimate the number of green turtles captured, injured, or killed through interactions with these fisheries. However, an estimated 85 green turtles were estimated to have died between 1993 and 1997 in interactions with the tuna purse seine fishery in the eastern tropical Pacific Ocean; more than 7,800 green turtles are estimated to die annually in fisheries and direct harvest off of Baja, California[16]; and before 1992, the North Pacific driftnet fisheries for squid, tuna, and billfish captured an estimated 378 green turtles each year, killing about 93 of them each year. Little data on the life stage or sex of captured animals is available; however, it is reasonable to expect that both incidental and intentional takes affect the older turtle life stages, sub-adults and adults.

In Mexico, green turtles were widespread and abundant prior to commercial exploitation and uncontrolled subsistence harvest of nesters and eggs. More than 165,000 turtles were harvested from 1965 to 1977 in the Mexican Pacific. In the early 1970s nearly 100,000 eggs per night were collected from these nesting beaches (NMFS and USFWS, 1998a). Although the number of adult female green turtles killed by poachers in Mexico has been reduced dramatically, the number of nests destroyed for the black market for sea turtle eggs has not changed significantly since the ban (Delgado and Alvarado, 1999). Recent information suggests that as many as 30,000 green turtles are killed each year by poachers in Mexico.

Despite attempts at long-term protection of females and their eggs at nesting sites since 1990, the population continues to decline. At Colola, the beach responsible for 70% of the green turtles that nest in Michoacán (Delgado and Alvarado, 1999), counts in the early 1990s found an estimated 60-100 females nesting per night, or about 800-1,000 turtles per year (Eckert, 1993). During the 1998-99 season, an estimated 600 greens nested at Colola (Delgado and Alvarado, 1999). Previously, the nesting population at the two main nesting beaches in Michoacán, Mexico, was estimated as 5,585 females in 1982 and 940 in 1984. Then, during the 1990s, Delgado and Alvarado (1999) estimated female nester abundance at Michoacán as ranging between approximately 250 and 1,200 female turtles per year, suggesting that the population is experiencing dramatic swings in abundance which, over time, has and could continue to result in extremely small or even extirpated populations in some years. Researchers believe the numbers of adult green turtles incidentally captured and killed in various coastal fisheries and those intentionally killed in coastal foraging areas prevents this population from increasing (P. Dutton, NMFS, personal communication, 1999; W. Nichols, Wildcoast, personal communication, 2000).

The green turtles in Hawaii are genetically-distinct and geographically isolated from other green turtle populations; therefore, they can be treated as a discrete subpopulation. Ninety percent of the nesting and breeding activity of the Hawaiian green turtle occurs at French Frigate Shoals, where 200-700 females were estimated to nest annually (NMFS and USFWS, 1998a). Since the green turtles in Hawaii were first protected in the early 1970s, ending years of exploitation, the nesting population of green turtles in Hawaii has shown a gradual but definite increase (Balazs, 1996). For example, the number of green turtles nesting at an index study site at East Island has tripled since systematic monitoring began in 1973 (NMFS and USFWS, 1998a). Nevertheless,

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[16]Researchers have recently estimated that poachers kill as many as 30,000 green turtles annually in Baja California (Scientific America, August, 2001.

the small size and geographic isolation of this population makes it vulnerable to changes caused by reduced birth rates, increased death rates, or both. The incidence of diseases such as fibropapilloma, and spirochidiasis, which are major causes of strandings of green turtles suggests that future declines in this population could reverse or eliminate the increases of recent decades (Murakawa *et al.*, 2000).

As discussed previously, the eastern Pacific population of green turtles is declining due to a combination of high egg mortalities on nesting beaches and high adult and sub-adult deaths in coastal fisheries and direct harvests. In effect, this population is declining because the number of sub-adults that survive to recruit into the adult population does not offset the number of adults that die in the same time interval. The loss of an additional adult or sub-adult, green turtles from this population would reduce the number of adult turtles that reproduce each year which, in turn, would have long-term effects on the size of this green turtle population.

Based on the lower likelihood of green turtle interactions with the experiments north of 28°N however, NMFS expects that no more than one or two green turtles will die as a result of the proposed action,. NMFS does not believe it is reasonable to expect that the loss of these turtles and their future progeny will have a detectable effect on the likelihood of survival and recovery of either the eastern Pacific or Hawaiian green turtle populations. Therefore, since we do not expect an increase in the likelihood that these populations will become extinct, we do not expect the impacts of the proposed experiments to reduce appreciably the likelihood of both the survival and recovery of the green turtle in the wild.

B. Leatherback Turtles

The proposed issuance of scientific research permit #1303 will capture, injure, or kill adult and subadult leatherback sea turtles. Based on past patterns of leatherback turtles captured in the longline fishery, turtles may be taken throughout the year, primarily between 130°W and 165°W longitude and between 20°N and 40°N latitude.

Based on interaction rates with the swordfish-style fishing component of the Hawaii-based longline fishery, the applicants anticipate that they will capture 17 adult or sub-adult leatherback turtles during the first year, 15 leatherback turtles during the second year, and 12 leatherback turtles during the third year of the experiments, for a total of 44 leatherback turtles. Based on past observed interactions, most of these turtles will probably be hooked, rather than entangled, with most of them being hooked externally (external hooking is expected to kill fewer turtles than internal hooking). Given this, the applicants estimate that 15 of the leatherback turtles captured in this experiment will die.

The limited genetic sampling from leatherback turtles caught by the Hawaii-based longline fishery north of 28°N latitude, where the majority of the experiment will take place, indicates that 100% of the leatherbacks (12 out of 14 genetic samples) originated from western Pacific nesting beaches (P. Dutton *et al.*, 2000; P. Dutton, NMFS, personal communication, January, 2001). Because the majority of the experiments will be conducted in this area, and if the experiments affect leatherback turtle populations proportional to their relative abundance in the action area, about 100 percent of the leatherback turtles that are captured, injured, or killed by the experiment would come from the western Pacific populations. Because of the very low number of sets anticipated south of the Hawaiian Islands (where leatherbacks originating from the eastern Pacific have been observed taken by the Hawaii-based longline fishery using tuna-style gear), NMFS does not anticipate leatherbacks to be taken that have originated from eastern Pacific nesting beaches. Assuming proportionality, 15adult or sub-adult leatherback turtles from the western Pacific population would be killed in the experiments.

We believe it is reasonable to expect that killing up to 15 adult or sub-adult leatherback turtles would reduce the numbers of individuals in the species, particularly since population estimates for this species are based on estimated numbers of adult turtles. Assuming that some of these turtles would be female, we would also conclude that these deaths would reduce the species' reproduction potential in addition to reducing their numbers. Assuming that turtles captured and killed in the experiment are proportional to their relative abundance in the action area, the western Pacific population of leatherback turtles would experience the larger reduction in reproduction and numbers.

We also believe it is reasonable to expect that these mortalities will appreciably reduce the leatherback sea turtles' likelihood of surviving and recovering in the wild, particularly given the status and trend of leatherback turtle populations in the Pacific basin. Based on published estimates of nesting female abundance, leatherback populations have collapsed or have been declining at all major Pacific basin nesting beaches for the last two decades (Spotila *et al*., 1996; NMFS and USFWS, 1998b; Sarti, *et al.,* 2000; Spotila, *et al*., 2000). Leatherback turtles had disappeared from India before 1930, have been virtually extinct in Sri Lanka since 1994, and appear to be approaching extinction in Malaysia (Spotila *et al*. 2000).

In the western Pacific Ocean, declines in leatherback nesting assemblages have been documented by systematic beach counts or surveys in Rantau Abang, Terengganu (Malaysia). The nesting assemblage in Terengganu, which was one of the most significant nesting sites in the western Pacific Ocean, has declined severely from an estimated 3,103 females in 1968 to 2 nesting females in 1994 (Chan and Liew, 1996; see also Table III-2). The size of the current nesting assemblage represents less than 2 percent of the size of the assemblage reported from the 1950s, with one or two females nesting in this area each year (P. Dutton, personal communication, 2000). Nesting assemblages of leatherback turtles along the coasts of the Solomon Islands, which supported important nesting assemblages historically, are also reported to be declining (D. Broderick, personal communication, *in* Dutton *et al*. 1999). In Fiji, Thailand, Australia, and Papua-New Guinea (East Papua), leatherback turtles have only been known to nest in low densities and scattered colonies.

Only an Indonesian nesting assemblage has remained relatively abundant in the Pacific basin. The largest, extant leatherback nesting assemblage in the Indo-Pacific lies on the north Vogelkop coast of Irian Jaya (West Papua), Indonesia, with over 1,000 nesting females during the 1996 season (Suarez *et al*., in press; see Table III-3). During the early-to-mid 1980s, the number of female leatherback turtles nesting on the two primary beaches of Irian Jaya appeared to be stable. More recently, however, this population has come under increasing threats that could cause this population to experience a collapse that is similar to what occurred at Terengganu, Malaysia. In

1999, for example, local Indonesian villagers started reporting dramatic declines in sea turtle populations near their villages (Suarez, 1999); unless hatchling and adult turtles on nesting beaches receive more protection, this population will continue to decline. Declines in nesting assemblages of leatherback turtles have been reported throughout the western Pacific region where observers report that nesting assemblages are well below abundance levels that were observed several decades ago (e.g., Suarez 1999).

In the western Pacific Ocean and South China Seas, leatherback turtles are captured, injured, or killed in numerous fisheries. Leatherback turtles in the western Pacific are also threatened by poaching of eggs, killing of nesting females and adults found near the breeding areas, human encroachment on nesting beaches, incidental capture in fishing gear, beach erosion, and egg predation by animals.

In the eastern Pacific Ocean, nesting populations of leatherback turtles are declining along the Pacific coast of Mexico and Costa Rica. According to reports from the late 1970s and early 1980s, three beaches located on the Pacific coast of Mexico support as many as half of all leatherback turtle nests. Since the early 1980s, the eastern Pacific Mexican population of adult female leatherback turtles has declined to slightly more than 200 during 1998-99 and 1999-2000 (Sarti *et al*. 2000). Spotila *et al*. (2000) reported the decline of the leatherback turtle population at Playa Grande, Costa Rica, which had been the fourth largest nesting colony in the world. Between 1988 and 1999, the nesting colony declined from 1,367 to 117 female leatherback turtles. Based on their models, Spotila *et al*. (2000) estimated that the colony could fall to less than 50 females by 2003-2004.

Although all causes of the declines in leatherback turtle colonies have not been documented, Sarti *et al*. (1998) suggest that the decline is likely caused by egg poaching, directed harvest of adults, adult and sub-adult mortalities incidental to high seas fisheries, and natural fluctuations due to changing environmental conditions. Some published reports support this suggestion: Sarti, *et al*. (2000) reported that female leatherback turtles have been killed for meat on nesting beaches such as Píedra de Tiacoyunque, Guerrero, Mexico. Eckert (1997) reported that swordfish gillnet fisheries in Peru and Chile likely contributed to the decline of leatherback turtles in the eastern Pacific; the decline in the nesting population at Mexiquillo, Mexico occurred at the same time that effort doubled in the Chilean driftnet fishery. In response to these effects, the eastern Pacific population has continued to decline, leading some researchers to conclude that the leatherback are on the verge of extinction in the Pacific Ocean (e.g. Spotila *et al*. 1996; Spotila, *et al*. 2000).

In the Pacific Ocean, leatherback turtles are captured, injured, or killed in commercial and artisanal fisheries and killed by direct harvest. . Because of the limited available data, we cannot accurately estimate the number of leatherback turtles captured, injured, or killed through interactions with these fisheries. However, between 8 and 17 leatherback turtles were estimated to have died annually between 1990 and 2000 in interactions with the California/ Oregon drift gillnet fishery; 500 leatherback turtles are estimated to die annually in Chilean and Peruvian fisheries; 200 leatherback turtles are estimated to die in direct harvests in Indonesia; and before 1992, the North Pacific driftnet fisheries for squid, tuna, and billfish captured an estimated 1,002 leatherback turtles each year, killing about 111 of them each year. Little data on the life stage or sex of animals captured in these fisheries are available; however, the fisheries probably affect the more mature turtle life stages, sub-adults and adults because of their distribution in the ocean and the size of the animals that interact with the gear used in the fisheries.

In summary, the abundance of leatherback turtles on nesting colonies throughout the Pacific basin have declined dramatically over the past 10 to 20 years. Leatherback turtle colonies throughout the eastern and western Pacific Ocean have been reduced to a fraction of their former abundance by the combined effects of human activities that have reduced the number of nesting females and reduced the reproductive success of females that manage to nest (for example, egg poaching). At current rates of decline, leatherback turtles in the Pacific basin are a critically endangered species with a low probability of surviving and recovering in the wild.

As we discussed in the *Status of the Species* and *Approach to the Assessment* sections of this Opinion, changes in the survival of adult and sub-adult stages of leatherback turtles can have the most significant, short-term effects on the status and trend of these turtle populations (Crouse, 1999; Heppell, 1998; Caswell, 2001). From the decline of the western Pacific population of leatherback turtles we infer that the rate at which sub-adult females are recruiting into the adult, breeding population is lower than the death rate of breeding, adult females (that is, adult females are dying without replacing themselves). In areas like Terengganu, the difference between recruitment rates and adult death rates would have to be dramatic to explain the declines of nesting colonies. The loss of an additional 15 adult or sub-adult, leatherback turtles from the western Pacific population would exacerbate the decline of this population by reducing the number of adult turtles that reproduce each year which, in turn, reduces the number of young the population can produce in a year. The loss of these adult turtles would have a short-term effect on the number of breeding adults in this leatherback population (which is already declining) and short- and long-term effects on the birth rates of this population, which will have longer-term effects on the number of recruits into the breeding population .

The cumulative effect of the loss of 15 adult or sub-adult leatherback turtles is the loss of future progeny from these individuals, which will affect the viability of subsequent generations. For example, for each female leatherback that is killed, approximately 250 eggs per nesting season will be lost. While not all of these eggs will survive to hatch, due to natural factors, this indicates a possible maximum loss of 2,500 eggs per female with a reproductive span of 20 years and a 2 year remigration interval. This increases the importance of reducing anthropogenic pressure on the remaining eggs and juveniles. Loss of these future individuals (and their progeny) will reduce the resilience of local populations to the negative effects of natural catastrophes, environmental perturbations , and human-caused mortality.

If the 15 western Pacific adult or sub-adult leatherback turtles captured and killed in the experiment *are* replaced in the same time interval by equal or greater numbers of maturing turtles, then the mortalities caused by the experiment should not appreciably affect the leatherback turtle's likelihood of surviving or recovering in the wild. On the other hand, if the 15 western Pacific adult or sub-adult leatherback turtles captured and killed in the experiment *are not* replaced in the same time interval by equal or greater numbers of maturing turtles, then the mortalities caused by the experiment could threaten this population's likelihood of surviving and recovering in the wild. The declining status and trend of this population, as a result of high mortalities in all life stages from poaching, habitat development, and incidental and intentional mortality in fisheries, suggests that dying adults and sub-adults in this population are not currently being replaced by equal numbers of maturing juveniles and sub-adults.

Therefore, if the 15 western Pacific adult or sub-adult leatherback turtles captured and killed in the experiment *are not* replaced in the same time interval by equal or greater numbers of maturing turtles, as many as 2,500 juvenile leatherback turtles *per female killed in the experiment* will have been permanently removed from the western Pacific population within the next 20 years. Removing these numbers of juveniles from this declining population, would be expected to reduce the numbers and reproductive success of the western Pacific populations, which would, in turn, reduce or eliminate this population's ability to withstand ongoing threats, new threats, and the impacts of environmental variation. This would appreciably diminish this population's likelihood of surviving and recovering in the wild, although we cannot quantify the exact magnitude of this effect. Given the small size of this population, this is an appreciable reduction in the population size and reproductive capacity that would be expected to appreciably increase this population's risk of extinction.

The eastern Pacific population of leatherback turtles may be affected, but to a much lesser degree. The collapse of leatherback turtle nesting colonies along the Pacific coast of Mexico and Costa Rica over the past decade also suggests that adult, female leatherback turtles are not replacing themselves and the mortality rate of adult females is significantly higher than the recruitment rate of sub-adults. With an estimated population of about 3,000 adult females that are threatened by poaching and death in numerous fisheries, the additional loss of more adults would represent a source of mortality and subsequent reduced population abundance and fecundity that can be expected to reduce the population's likelihood of surviving and recovering in the wild.

However, the negative population effects of the loss of adult female leatherbacks are expected to be offset by the reductions in fishery mortality expected in the years following the experiment. As discussed in the *Effects of the Action* section, NMFS anticipates that the successful techniques to reduce or avoid turtle interactions will be adopted (or required) in domestic longline fisheries shortly after the experiments conclude. NMFS also anticipates that foreign longline fleets will adopt these methods as well. Adoption of these methods in both domestic and foreign longline fleets will result in Pacific-wide, if not worldwide, reductions in longline fisheries mortality of leatherbacks. If the techniques are shown to be 50 percent or more effective, we would expect a concomitant reduction in leatherback takes in longline fisheries that have adopted the measures. Thus, even though the experiments may result in a short-term reduction in the likelihood of survival and recovery of leatherbacks, reductions in leatherback capture and mortality in domestic longline fisheries are expected to more than replace the 15 leatherbacks expected to die in the experiments. As a result of this long-term increase in survival rates, the proposed experiments are not expected to reduce appreciably the likelihood of survival and recovery of the leatherback turtle in the wild.

C. Loggerhead Turtles

The proposed issuance of scientific research permit #1303 will capture, injure, or kill juvenile and subadult loggerhead sea turtles. Based on past patterns of loggerheads captured in the Hawaii-based longline fishery, these turtles may be taken throughout the year, although most interactions have occurred during the fall and winter months, especially in January and February. Geographical distribution appears to significantly affect the probability of loggerhead take; for example, there were no observed loggerhead takes south of 22°N (1,263 sets observed below this latitude had zero takes) (McCracken, 2000), and this pattern is likely to continue. In addition, loggerhead takes also appear to be correlated with sea surface temperatures (SST) as satellite telemetry data indicate that loggerheads are following 17°and 20°C temperature fronts which swordfish also utilize. Observer data shows that the interaction rate (turtles per longline set) is substantially greater at 17°C SST than at 20°C SST (P. Kleiber, NMFS, personal communication *in* Polovina, *et al*., 2000).

Based on interaction rates with the swordfish-style fishing component of the Hawaii-based longline fishery, the applicants anticipate that they will capture 88 juvenile or sub-adult loggerhead turtles during the first year, 80 loggerhead turtles during the second year, and 65 loggerhead turtles during the third year of the experiments, for a total of 233 loggerhead turtles. Based on past observed takes, captured turtles are more likely to be internally hooked, which is assumed to have a lower survival rate than turtles hooked externally. Given this, the applicants have estimated s that 87 of the loggerhead turtles captured in this experiment will die. If the experiments affect loggerhead turtle populations proportional to their relative abundance in the action area, virtually all of the loggerhead turtles that are captured, injured, or killed by the experiment will have originated from the Japanese nesting population. Genetic analyses of 124 loggerheads caught in the Hawaii-based longline fishery indicated thatnearly 100 percent originated from Japanese nesting population (Dutton, *et al*., 2000; P. Dutton, NMFS, personal communication, January, 2001). The representation of loggerhead turtles in the longline fisheries is roughly proportional to patterns of loggerhead abundance in the Pacific basin. Therefore, it is reasonable to expect 87 juvenile and sub-adult loggerhead turtles from the Japanese nesting stock will be killed by the proposed experiments.

We believe it is reasonable to expect that killing up to 87 juvenile and subadult loggerhead turtles would reduce the numbers of individuals in the species. Assuming that some of these turtles would be female, we would also conclude that these deaths would reduce the species' reproduction in addition to reducing their numbers. Assuming that turtles captured and killed in the experiment are proportional to their relative abundance in the action area, the Japanese nesting population of loggerhead turtles would experience this reduction in reproduction and numbers.

We also believe it is reasonable to expect that these mortalities will appreciably reduce the loggerhead sea turtles' likelihood of surviving and recovering in the wild, particularly given the status and trend of loggerhead turtle populations in the Pacific basin. Loggerhead turtles only nest in the western Pacific basin, primarily Japan and Australia. The only major nesting beaches for this species are in the southern part of Japan (Dodd, 1988). Balazs and Wetherall (1991) speculated that 2,000 to 3,000 female loggerheads may nest annually in all of Japan; however, more recent data suggested that this nesting colony current consists of about 1,000 female loggerhead turtles (Bolten *et al*. 1996). Even more updated information on the number of female loggerhead turtles returning to this colony suggest that this colony continues to decline (e.g. see Table 2, Appendix B; N. Kamezaki, personal communication, August, 2001). Loggerhead turtles may also nest along the south China Sea, but it is a rare occurrence (Marquez, 1990, *in* Eckert, 1993).

In the south Pacific, Limpus (1982) reported an estimated 3,000 loggerheads nesting annually in Queensland, Australia during the late 1970s. However, long-term trend data from Queensland indicate a 50 percent decline in nesting by 1988-89, due to incidental mortality of turtles in the coastal prawn fishery. This decline is corroborated by studies of breeding females at adjacent feeding grounds (Limpus and Reimer, 1994). By 1997, the number of females nesting annually in Queensland was thought to be as low as 300 (1998 Draft Recovery Plan for Marine Turtles in Australia). Survey data are not available for other nesting assemblages in the south Pacific. Scattered nesting has also been reported on Papua New Guinea, New Zealand, Indonesia, and New Caledonia; however, population sizes on these islands remain unknown (NMFS and USFWS, 1998c).

In the *Environmental Baseline* section of this Opinion, we noted that loggerhead turtles are captured, injured, or killed in numerous Pacific fisheries including Japanese longline fisheries in the western Pacific Ocean and South China Seas; direct harvest and commercial fisheries off Baja California, Mexico, commercial and artisanal swordfish fisheries off Chile, Columbia, Ecuador, and Peru; purse seine fisheries for tuna in the eastern tropical Pacific Ocean, and California/Oregon drift gillnet fisheries. Because of limits in the available data, we cannot accurately estimate the number of loggerhead turtles captured, injured, or killed through interactions with these fisheries. However, between 3 and 11 loggerhead turtles were estimated to have died annually between 1990 and 2000 in interactions with the California/Oregon drift gillnet fishery; approximately 1,950 loggerhead turtles are estimated to die annually in fisheries and direct harvest off of Baja, California; and before 1992, the North Pacific driftnet fisheries for squid, tuna, and billfish captured an estimated 2,986 loggerhead turtles each year, killing about 805 of them each year. Little data on the life stage or sex of captured animals are available; however, it is reasonable to expect that both incidental and intentional takes affect the larger pelagic juveniles and sub-adult life stages of this species. The annual loss of 805 juvenile and subadult loggerhead turtles would be expected to reduce the survive rates of this species, reduce the number of turtles recruiting into the adult, breeding population, and reduce the number of breeding sea turtles.

In summary, the abundance of loggerhead turtles on nesting colonies throughout the Pacific basin have declined dramatically over the past 10 to 20 years. Loggerhead turtle colonies in the western Pacific Ocean have been reduced to a fraction of their former abundance by the combined effects of human activities that have reduced the number of nesting females and reduced the reproductive success of females that manage to nest. The combination of juvenile and adult deaths at sea over this period would appreciably reduce the number of eggs produced by this population, which would reduce the number of individuals in the population. When added to other human activities – such as poaching eggs – that reduce the reproductive success of nesting female turtles (as measured by the number of eggs that survive to become hatchlings or early pelagic juveniles), the total effect of these activities would be expected to appreciably reduce the reproduction and numbers of loggerhead sea turtles in the Pacific Basin.

Changes in the survival of juvenile and sub-adult stages of loggerhead turtles can have the most significant, short-term effects on the status and trend of these turtle populations. Crouse *et al*. (1987), Crouse (1999), Heppell (1998), Ebert (1999), and Caswell (2001) constructed population models of loggerhead sea turtles and conducted what are called elasticity analyses (which, this case, represent the relative contribution of different life stages to the long-term trend of the species). All of these analyses suggest that changes in the survival of early pelagic juveniles and breeding adults would have the largest effect on the the growth of loggerhead turtle populations, followed by benthic immature and late pelagic juvenile sea turtles. The additional mortalities of early and late pelagic loggerhead turtles resulting from the experiments would reduce the number of juvenile loggerhead turtles in multiple stage for up to three years. When added to the baseline mortality rates for these classes, this reduction would be expected to appreciably reduce the population's ability to sustain its size.

As discussed previously, the Japanese population of loggerheads is declining. Given this, we infer that the rate at which sub-adult females are recruiting into the adult, breeding population is lower that the death rate of breeding, adult females (that is, adult females are dying without replacing themselves). The loss of an additional 87 juvenile or subadult loggerhead turtles from this population would reduce the number of animals that recruit into the adult population to replace adults that die, which, in turn, reduces the future number of young the population can produce. The loss of these juvenile turtles would have a short-term effect on the number of breeding adults in this population (which is already declining) and short- and long-term effects on the birth rates of this population, which will have longer-term effects on the number of turtles recruiting into the breeding population . This would be expected to increase the population's rate of decline, which would increase the population's risk of extinction.

The cumulative effect of these deaths is the loss of future reproductive output from these turtles, which will affect the viability of subsequent generations. For example, for each juvenile, female, loggerhead turtles that is killed in the experiments (and would have survived to recruit into the breeding population), approximately 300 eggs per nesting season are lost as well. While not all of these eggs would survive to hatch, due to natural factors, this indicates a maximum loss of 3,000 eggs per female with a reproductive span of 30 years and a 3 year remigration interval. This increases both the importance of reducing anthropogenic pressure on the remaining eggs and juveniles. Loss of these future individuals (and their progeny) will reduce the resilience of local populations to the negative effects of natural catastrophes, environmental perturbations , and human-caused mortality.

If the 87 loggerhead turtles captured and killed in the experiment *are* replaced in the same time interval by equal or greater numbers of maturing turtles, then the mortalities caused by the experiment should not appreciably affect the loggerhead turtle's likelihood of surviving or recovering in the wild. On the other hand, if the 87 loggerhead turtles captured and killed in the experiment *are not* replaced in the same time interval by equal or greater numbers of maturing turtles, then the mortalities caused by the experiment could threaten this population's likelihood of surviving and recovering in the wild. Unfortunately, we do not have enough information on the age structure of this population or age-specific survival rates to determine which of these two scenarios is more likely. However, the declining status and trend of this population suggests that dying adults and sub-adults in this population are not being replaced by equal numbers of maturing juveniles and sub-adults.

Therefore, if the 87 loggerhead turtles captured and killed in the experiment *are not* replaced in the same time interval by equal or greater numbers of maturing turtles, as many as 3,000 juvenile loggerhead turtles per female killed in the experiment will have been permanently removed from the Japanese nesting stock within the next 30 years. Removing these numbers of juveniles from this declining population would be expected to reduce the reproductive success of the Japanese nesting stock, which would, in turn, reduce or eliminate this population's ability to withstand ongoing threats, new threats, and the impacts of environmental variation. This would appreciably diminish this population's likelihood of surviving and recovering in the wild, although we cannot quantify the exact magnitude of this effect. Given the small size of this population, this is an appreciable reduction in the population size and reproductive capacity that would be expected to appreciably increase this population's risk of extinction.

Additional reductions in the likelihood of persistence of Japanese loggerhead stocks are likely to affect the overall persistence of the entire Pacific Ocean loggerhead population by reducing genetic diversity and viability, representation of critical life stages, total population abundance, and resilience as sub-populations are extirpated. These effects would be expected to appreciably reduce the likelihood of both the survival and recovery of the loggerhead turtle.

However, the negative population effects of the loss of adult or sub-adult female loggerheads are expected to be offset by the reductions in fishery mortality expected in the years following the experiment. As discussed in the *Effects of the Action* section, NMFS anticipates that the successful techniques to reduce or avoid turtle interactions will be adopted (or required) in domestic longline fisheries shortly after the experiments conclude. NMFS also anticipates that foreign longline fleets will adopt these methods as well. Adoption of these methods in both domestic and foreign longline fleets will result in Pacific-wide, if not worldwide, reductions in longline fisheries mortality of loggerheads. If the techniques are shown to be 50 percent or more effective, we would expect a concomitant reduction in loggerhead takes in longline fisheries that have adopted the measures. Thus, even though the experiments may result in a short-term reduction in the likelihood of survival and recovery of loggerheads, reductions in loggerhead capture and mortality in domestic longline fisheries are expected to more than replace the 87 loggerheads expected to die in the experiments. As a result of this long-term increase in survival rates, the proposed experiments are not expected to reduce appreciably the likelihood of survival and recovery of the loggerhead turtle in the wild.

D. Olive Ridley Turtle

The proposed issuance of scientific research permit #1303 is anticipated to incidentally capture, injure, or kill adult and subadult olive ridley sea turtles. Based on past patterns of olive ridley turtles captured in the Hawaii-based longline fishery, turtles would be taken throughout the year, with most of the take occurring during the warmer months. In addition, given observed interactions of this species, past takes have been primarily concentrated in areas surrounding the Hawaiian Island chain. Most of these turtles will probably be hooked, rather than entangled, with slightly more of them being hooked internally. Internal hooking is expected to kill more turtles than external hooking. In addition, the applicants anticipate that up to 10 olive ridley turtles will be taken during the first year, 8 will be taken during the second year, and 6 will be taken during the third year, for a total of 24 olive ridley sea turtles. Of these 24, the applicants expect that not more than 9 would die as a result of the interactions.

Recent genetic information analyzed from 20 olive ridleys taken in the Hawaii-based longline fishery indicate that 60% of the turtles originated from the eastern Pacific (Mexico and Costa Rica) and 40% of the turtles were from the Indian and western Pacific beaches, indicating the animals from both sides of the Pacific converge in the north Pacific pelagic environment and may be equally affected by the proposed action. As mentioned in the *Description of the Action Area*, the applicant proposes to conduct the majority of the experiments in an area north of 28°N latitude. Only one olive ridley observed taken north of 28°N has been genetically analyzed to determine its origin; it had originated from a western Pacific nesting beach (P. Dutton, NMFS, personal communication, January, 2001). However, because olive ridleys observed taken by the Hawaii-based longline fishery north of the Hawaiian Islands originated from both eastern and western Pacific beaches in nearly equivalent representations, we will use results from all genetic samples collected from olive ridleys taken by the Hawaii-based longline fishery.

If the experiments affect olive ridley turtle populations proportional to their relative abundance in the action area, 60 percent of the olive ridley turtles that are captured, injured, or killed by the experiment would come from the eastern Pacific population. The remaining 40 percent would represent the western Pacific population. Using this assumption, it is reasonable to expect 5 or 6 adult or sub-adult olive ridley turtles from the eastern Pacific population and 3 or 4 adult or sub-adult olive ridley turtles from the western Pacific population each year would be killed by the proposed experiments.

However, based on the location of much of the proposed experiments (north of 28°N), NMFS expects that fewer olive ridley turtles will actually be taken during the course of the experiment. Based on past interactions with the Hawaii-based longline fishery, most olive ridley turtle interactions occurred south of 28°N (1/8 of the observed takes occurred north of 28°N) . Therefore, it is very likely that fewer olive ridley turtles may be taken during the experiment. Based on this expectation of reduced captures, NMFS anticipates that fewer olive ridley turtles will die as a result of the experiments as well.

We believe it is reasonable to expect that killing up to 9 adult or sub-adult olive ridley turtles would reduce the numbers of individuals in the species, particularly since population estimates for this species are based on estimated numbers of adult turtles. Assuming that some of these turtles would be female, we would also conclude that these deaths would reduce the species' reproduction in addition to reducing their numbers. Assuming that turtles captured and killed in the experiments are proportional to their relative abundance in the action area, the eastern Pacific population of olive ridley turtles would experience the larger reduction in reproduction and numbers.

We do not believe it is reasonable to expect that these mortalities will appreciably reduce the olive ridley sea turtles' likelihood of surviving and recovering in the wild, because of the status and trend of olive ridley turtle populations in the Pacific basin. Historically, an estimated 10 million olive ridleys inhabited the waters in the eastern Pacific off Mexico (Cliffton, *et al*., 1982 *in* NMFS and USFWS, 1998d). However, human-induced mortality led to declines in this population. Beginning in the 1960s, and lasting over the next 15 years, several million adult olive ridleys were harvested by Mexico for commercial trade with Europe and Japan. (NMFS and USFWS, 1998d). Fisheries for olive ridley turtles were also established in Ecuador during the 1960s and 1970s to supply Europe with leather (Green and Ortiz-Crespo, 1982).

In the eastern Pacific, nesting occurs all along the Mexico and Central American coast, with large nesting aggregations occurring at a few select beaches located in Mexico and Costa Rica. The largest known *arribadas* in the eastern Pacific are off the coast of Costa Rica (about 475,000 to 650,000 females estimated nesting annually) and in southern Mexico (about 800,000 or more nests per year at La Escobilla, in Oaxaca; Millán, 2000). The greatest single cause of olive ridley egg loss comes from the nesting activity of conspecifics on *arribada* beaches, where nesting turtles destroy eggs by inadvertently digging up previously laid nests or causing them to become contaminated by bacteria and other pathogens from rotting nests nearby.

The nationwide ban on commercial harvest of sea turtles in Mexico, enacted in 1990, appears to have improved the situation for the olive ridley. Surveys of important olive ridley nesting beaches in Mexico indicate increasing numbers of nesting females in recent years (Marquez, *et al*., 1995; Arenas, *et al*., 2000). Annual nesting at the principal beach, Escobilla Beach, Oaxaca, Mexico, averaged 138,000 nests prior to the ban, and since the ban on harvest in 1990, annual nesting has increased to an average of 525,000 nests (Salazar, *et al*., in press).

Olive ridleys are not as well documented in the western Pacific as in the eastern Pacific, nor do they appear to be recovering as well (with the exception of Orissa, India in recent years). There are a few sightings of olive ridleys from Japan, but no report of egg-laying. Nesting information from Thailand indicates a marked decline in olive ridley numbers primarily due to egg poaching, harvest and subsequent consumption or trade of adults or their parts (i.e. carapace), indirect capture in fishing gear, and loss of nesting beaches through urban development (Aureggi, *et al*., 1999). Extensive hunting and egg collection, in addition to rapid rural and urban development, have reduced nesting activities in Indonesia as well.

Olive ridley nesting is known to occur on the eastern and western coasts of Malaysia; however, nesting has declined rapidly in the past decade. The highest density of nesting was reported to be in Terengganu, Malaysia, and at one time yielded 240,000 eggs (2,400 nests, with approximately 100 eggs per nest) (Siow and Moll, 1982, *in* Eckert, 1993), while only 187 nests were reported from the area in 1990 (Eckert, 1993).

In contrast, olive ridleys are the most common species found along the east coast of India, migrating every winter to nest en-masse at three major rookeries in the state of Orissa, Gahirmatha, Robert Island, and Rushikulya (*in* Pandav and Choudhury, 1999). The Gahirmatha rookery, located along the northern coast of Orissa, hosts the largest known nesting concentration of olive ridleys. Unfortunately, uncontrolled mechanized fishing in areas of high sea turtle concentration, primarily illegally operated trawl fisheries, has resulted in large scale mortality of adults during the last two decades. Fishing in coastal waters off Gahirmatha was restricted in 1993 and completely banned in 1997 with the formation of a marine sanctuary around the rookery. Threats to these sea turtles also include artificial illumination and unsuitable beach conditions, including reduction in beach width due to erosion (Pandav and Choudhury, 1999). According to Pandav and Choudhury (1999), the number of nesting females at Gahirmatha has declined in recent years, although after three years of low nestings, the 1998-99 season showed an increasing trend, and the 1999-2000 season had the largest recorded number of olive ridleys nesting in 15 years when over 700,000 olive ridleys nested at Nasi islands and Babubali island, on the Gahirmatha coast.

Given initial population sizes and increases in the Mexican and Costa Rican populations in recent years, the mortalities and loss of future production associated with the proposed experiments are not likely to halt or reverse the increasing trend of those populations.

Population trends in the western Pacific are more difficult to discern, although it is clear that there are still large populations of olive ridleys nesting in India. Killing adult and sub-adult turtles in the western Pacific population could have more serious consequences, since this population continues to be affected by ongoing factors such as incidental take in fisheries, the harvest of eggs on nesting beaches, and inundation and erosion of beaches. By removing reproductive adults and pre-reproductive sub-adults from this declining population, the proposed action could adversely affect the future persistence of the population, although it is unknown how much, or to what degree, this might impact the population's survival in light of the other factors currently affecting this population.

Because the majority of the experiment will take place north of 28°N latitude, where few olive ridleys have been observed taken in the Hawaii-based longline fishery, NMFS anticipates that fewer olive ridleys than anticipated will be captured and killed by the action. In addition, the major populations of olive ridley turtles in the Pacific Ocean appear to be increasing, despite some residual, adverse effects of fishery-related mortalities and harvest of adults and eggs. Because of the population size, number of reproductive females, and the rates at which sub-adults are recruiting into the adult population, we believe this population can withstand the few mortalities and reduced reproductive rates associated with the proposed experiments without appreciable reductions in the olive ridley turtle's likelihood of surviving and recovering in the wild.

VII. CONCLUSION

After reviewing the available scientific and commercial data, current status of Pacific green turtles, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the NMFS' biological opinion that the issuance of permit #1303 to research gear modifications to reduce sea turtle interactions with longline fishing gear is not likely to jeopardize the continued existence of green turtles.

After reviewing the available scientific and commercial data, current status of Pacific leatherback turtles, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the NMFS' biological opinion that the issuance of permit

#1303 to research gear modifications to reduce sea turtle interactions with longline fishing gear is not likely to jeopardize the continued existence of leatherback turtles.

After reviewing the available scientific and commercial data, current status of Pacific loggerhead turtles, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the NMFS' biological opinion that the issuance of permit #1303 to research gear modifications to reduce sea turtle interactions with longline fishing gear is not likely to jeopardize the continued existence of loggerhead turtles.

After reviewing the available scientific and commercial data, current status of Pacific olive ridley turtles, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the NMFS' biological opinion that the issuance of permit #1303 to research gear modifications to reduce sea turtle interactions with longline fishing gear is not likely to jeopardize the continued existence of olive ridley turtles.

VIII. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Harm is further defined to include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and 7(o)(2), taking that is incidental to and not intended as part of the proposed action is not considered to be prohibited taking under the Act provided that such taking is in compliance with this Incidental Take Statement.

The application for Permit 1303 is for the intentional take of listed sea turtles associated with scientific research. Incidental take of endangered or threatened species is not anticipated. This opinion does not authorize any taking of a listed species under section 10(a) or immunize any actions from the prohibitions of section 9(a) of the ESA.

IX. REINITIATION OF CONSULTATION

This concludes formal consultation on the issuance of Permit 1303. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in the biological opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, NMFS must immediately reinitiate consultation.

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