
Endangered Species Act – Section 7 Consultation

Biological Opinion

Action Agency:	National Marine Fisheries Service, Pacific Islands Region, Sustainable Fisheries Division
Activity:	Measures to Reduce Interactions between Green Sea Turtles and the American Samoa-based Longline Fishery – Implementation of an Amendment to the Fishery Ecosystem Plan for Pelagic Fisheries of the Western Pacific Region.
Consulting Agency:	National Marine Fisheries Service, Pacific Islands Region, Protected Resources Division
Approved By:	Michael D. Tosatto Acting Regional Administrator, Pacific Islands Region
Date Issued:	16 SEP 2010

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1 Introduction

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (ESA; 16 U.S.C. 1539(a)(2)) requires each federal agency to ensure that any action they authorize, fund, or carry out 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 a federal agency's action "may affect" an ESA-listed species, that agency is required to consult formally with the National Marine Fisheries Service (for marine species or their designated critical habitat) or the U.S. Fish and Wildlife Service (for terrestrial and freshwater species or their designated critical habitat). Federal agencies are exempt from this formal consultation requirement if they have concluded that an action "may affect, but is not likely to adversely affect" ESA-listed species or their designated critical habitat, and the National Marine Fisheries Service (NMFS or NOAA Fisheries) or the U.S. Fish and Wildlife Service (USFWS) concur with that conclusion (see ESA Section 7 Implementing Regulations; 50 CFR 402).

If an action is likely to adversely affect a listed species, the appropriate agency (either NMFS or USFWS) must provide a biological opinion to determine if the proposed action is likely to jeopardize the continued existence of listed species (50 CFR 402.02). "Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

The proposed federal action addressed by this biological opinion is implementation of the Fishery Ecosystem Plan for Pelagic Fisheries of the Western Pacific Region (Pelagics FEP) as amended, which includes a modification of the management program for the American Samoa longline fishery. All other fisheries under this FEP are addressed by separate ESA consultations, as explained below in Section 3. The amendment is designed to reduce interactions[1] between green turtles and the American Samoa longline fishery, and was developed by the Western Pacific Fishery Management Council (Council or WPFMC; WPFMC 2010). The Secretary of Commerce may approve, disapprove or partially approve FEPs and their amendments under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act). If approved, NMFS implements the plan or amendment through federal regulations. NMFS also has responsibility under the ESA for conducting Section 7 consultations on federal actions affecting ESA-listed marine species. Therefore, this biological opinion is an intra-service Section 7 consultation, as described in the Endangered Species Consultation Handbook (USFWS & NMFS 1998).

2 Consultation History

The following sequence of events led to the development of the proposed action, and the subsequent consultation that resulted in this biological opinion.

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[1] 'Interaction' is defined as being hooked or entangled by fishing gear, thus encompassing all hookings, entanglements, captures, and mortalities, whether the turtle is brought on board the vessel or not.

NMFS previously issued a biological opinion on proposed regulatory amendments to the Pelagics Fisheries Management Plan (Pelagics FMP) on February 23, 2004 (2004 BiOp) (NMFS 2004), which included the Hawaii shallow-set longline, the Hawaii deep-set longline, the American Samoa longline, and the regional non-longline pelagic fisheries. The 2004 BiOp (NMFS 2004) included an Incidental Take Statement (ITS) estimating that six sea turtle interactions (cumulatively resulting in one mortality) for all hardshell sea turtle species combined would occur annually in the American Samoa longline fishery and the regional non-longline pelagic fisheries combined. Between April and December, 2006, three juvenile green sea turtle interactions (all mortalities) were observed in the American Samoa longline fishery, which had eight percent observer coverage that year (NMFS 2007 - observer program annual report). In 2007 and 2008, one juvenile green sea turtle interaction was observed each year in the fishery (both mortalities), which had seven and six percent observer coverage during those two years, respectively (NMFS 2008 - observer program annual report). In 2009, there were three interactions with juvenile green turtles, all mortalities, and eight percent observer coverage for the year (NMFS 2009 - observer program annual report). As of August 2010, five observed interactions with juvenile green turtles had been reported in this fishery in 2010 by the Observer Program (four mortalities), with observer coverage having increased this year to 17.50 percent through the end of August 2010.

The interactions observed since April 2006 indicate that this fishery is resulting in higher levels of sea turtle incidental take than anticipated in the 2004 BiOp. As a result, the Pacific Islands Regional Office (PIRO) recommended several potential measures to reduce sea turtle interactions in the fishery in a March 20, 2008, letter to WPFMC. These potential measures included requiring hooks to be set at least 100 m deep, requiring use of 45 g or heavier weights on branch lines within 1 meter from each hook, requiring use of longer float lines, restricting hook deployment to an appropriate distance away from either side of floats, requiring use of the largest practical whole fish bait with the hook point covered, and requiring use of 16/0 or larger circle hooks with <10 degree offset. Also as a result of the higher level of sea turtle incidental take than anticipated in the 2004 BiOp, the NMFS Pacific Islands Regional Office's (PIRO) Sustainable Fisheries Division (PIRO/SFD) requested reinitiation of consultation under Section 7 of the ESA in a July 31, 2008, letter to PIRO's Protected Species Division (PIRO/PRD).

In response to the recommendations in the March 20, 2008, letter, the WPFMC took initial action at the 142nd WPFMC meeting in June 2008 by directing its staff to develop and analyze a range of alternatives for mitigating sea turtle interactions with the American Samoa longline fishery. WPFMC staff then held a public scoping meeting in Pago Pago on July 21, 2008, to present information on sea turtle interactions in this fishery, and to solicit feedback on methods to reduce interactions. At its 144th meeting held in March 2009 in Pago Pago, American Samoa, the WPFMC took final action to recommend a minimum 100 m hook depth requirement as a means of reducing sea turtle interactions in the fishery. WPFMC drafted a proposed amendment to the Pelagics FEP (developed in 2009 when the Council began moving towards an ecosystem-based approach to fisheries management and restructuring its management framework from species-based FMPs to place-based FEPs) that would implement the hook depth requirement, and provided the proposed amendment to PIRO/SFD in July 2009. The proposed amendment was reviewed and commented on by PIRO/SFD and PIRO/PRD; then PIRO/SFD amended its July 31, 2008, consultation request with a new request for formal consultation using the proposed amendment (WPFMC 2010) as the Biological Assessment (BA), and resubmitted the revised consultation request to PIRO/PRD on May 12, 2010. The May 12, 2010 consultation request constitutes a reinitiation of formal consultation.

This biological opinion is the response to the formal consultation request. PIRO/SFD determined in its July 31, 2008, letter that the proposed action would have no effect on blue, fin, or sei whales, thus no response from PIRO/PRD is necessary with regard to these three species. On August 27, 2008, PIRO/PRD responded to PIRO/SFD's July 31, 2008, consultation request memo by concurring that sperm whales and loggerhead turtles are not likely to be adversely affected by the proposed action. In the May 12, 2010, amended request for consultation, PIRO/SFD determined that humpback whales are not likely to be adversely affected by the proposed action and on July 27, 2010, PIRO/PRD concurred regarding humpbacks. Therefore, this opinion addresses only the four sea turtle species that are likely to be adversely affected by the proposed action: green, hawksbill, leatherback, and olive ridley. A draft opinion was provided by PIRO/PRD to PIRO/SFD on July 9 and August 27, 2010. Comments were received from PIRO/SFD on draft opinions on July 23 and September 7, 2010. PIRO SFD held an informational meeting on August 20, 2010, with PIRO PRD, Council staff, PIFSC, and the PIRO Observer Program to discuss technical aspects of the proposed action.

3 Description of the Proposed Action

The proposed action addressed by this biological opinion is the continued implementation of the Pelagics FEP as amended to incorporate management changes to the American Samoa-based longline[2] fishery (WPFMC 2010). The Pelagics FEP was developed in 2009 when the Council began moving towards an ecosystem-based approach to fisheries management and restructuring its management framework from species-based FMPs to place-based FEPs; it did not, at that time, establish any new fishery management regulations. This FEP, in conjunction with the Council's American Samoa Archipelago, Hawaii Archipelago, Mariana Archipelago, and Pacific Remote Island Areas FEPs, replaces the Council's existing Bottomfish and Seamount Groundfish, Coral Reef Ecosystems, Crustaceans, Precious Corals and Pelagic Fishery Management Plans and reorganizes their associated regulations into a place-based structure aligned with FEPs. The Pelagics FEP manages longline, troll, handline, purse seine, and pole and line fisheries based out of Guam, Hawaii, the Commonwealth of the Northern Mariana Islands (CNMI), Pacific Remote Island Areas, and American Samoa. The proposed management measures apply only to American Samoa longline fishery permit holders within specific vessel size classes; all other measures currently applicable to this and other fisheries under the Pelagics FEP would remain unchanged. All other fisheries and their associated regulations under the

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[2] Longline fishing gear consists of a mainline that exceeds one nautical mile (nm, 6,076 ft; 50 CFR 665.800) in length that is suspended horizontally in the water column at a preferred depth using floats spaced at regular intervals. Branchlines, each with a single baited hook, are attached to the mainline spaced at regular intervals between floats. This gear allows a vessel to distribute effort over a large area to harvest fish that are not concentrated in great numbers. Mainline depth is typically less than 100 m for swordfish (e.g., Hawaii shallow-set longline fishery; NMFS 2008A), about 150 – 400 m for bigeye and yellowfin tuna (e.g., Hawaii deep-set longline fishery), and about 75 – 200 m for albacore (e.g., the American Samoa longline fishery). Mainlines are typically 30 to 100 km (18 to 60 nm) long, and after the mainline is completely deployed, the gear is allowed to "soak" for several hours before being retrieved ("hauled"). In longlining, a "set" is a discrete unbroken section of line, floats, and branchlines. Usually, only one set is fished per day (NMFS 2005, 2008a).

Pelagics FEP have existing biological opinions (BiOps) that remain valid (NMFS 2005 – Hawaii-based deep-set longline fishery BiOp, NMFS 2008a – Hawaii-based shallow-set longline fishery BiOp, NMFS 2009a – Western Pacific non-longline pelagic fisheries BiOp). Therefore, this biological opinion will focus solely on anticipated impacts to protected species resulting from modifications to management measures proposed in the amendment to the American Samoa longline fishery under the Pelagics FEP (WPFMC 2010). The purpose of the new amendment is to reduce sea turtle interactions in the American Samoa-based longline fishery by requiring hooks to be set at a minimum depth of 100 m (WPFMC 2010), as described below. All other measures currently applicable to the American Samoa fishery would remain unchanged. The regulations for this fishery are set forth in the Code of Federal Regulation (50 CFR, Part 665) and summarized in a NMFS compliance guide (NMFS 2010 – regulations summary).

The American Samoa longline fishery limited entry program was established under Amendment 11 to the Pelagics FMP implemented in 2005. The primary purpose of Amendment 11 was to limit pelagic fishing in what had become a rapidly growing but unregulated fishery (WPFMC 2004). The fishery began in the late 1990s with a few locally-built catamarans (*alia*) less than 40 ft in length, then expanded rapidly in 2001 as several dozen conventional monohulls greater than 50 ft in length joined the fleet. The primary target species of the fishery is albacore, although bigeye, yellowfin, and skipjack tuna are also caught. Amendment 11 established a maximum of 60 permits for the fishery based on four vessel size classes: 17 permits in Class A (≤ 40 ft), 6 in Class B (> 40-50 ft), 11 in Class C (≥ 50-70 ft), and 26 in Class D (> 70 ft). Vessels 50 ft or greater in length (i.e., Classes C and D) are defined as large vessels. Large vessels are prohibited from fishing within about 50 nm from shore in two large vessel closed areas that surround the islands and atolls of American Samoa.

Because this fishery targets albacore, setting is done at intermediate depths, and is neither "shallow-setting" (like in the Hawaii shallow-set longline fishery for swordfish) nor "deep-setting" (like in the Hawaii deep-set longline fishery for bigeye and yellowfin tuna). Although observer coverage was less than 10 percent in this fishery from 2006 – 2009 (and increased to 17.50% for Jan-Aug 2010), a total of 13 green turtles have been observed caught in this fishery between April 2006 and August 2010, 12 of which resulted in fishery-caused mortalities. Current information indicates that the green turtle interaction rate is higher in the American Samoa longline fishery than in the Hawaii deep-set longline fishery. Bigelow and Fletcher (2009) posit that shallower hook depth in the American Samoa longline fishery compared to the Hawaii deep-set longline fishery (Bigelow et al 2006; Beverly et al 2009) may be contributing to higher green turtle interaction rates in the American Samoa fishery. The preferred alternative in the proposed amendment is to require all hooks to fish deeper than 100 m (WPFMC 2010).

The 100 m minimum hook depth requirement would apply to Class B, C, and D vessels (> 40 ft length). A 100 m minimum hook depth would be accomplished by requiring a minimum float line length of 30 m, together with a minimum of 70 m of blank mainline (no hooks) between each float line and the first branchline in either direction along the mainline (WPFMC 2010). Since each branchline is at least several meters in length, the minimum of 100 m from the float to the beginning of the branchline, plus the length of the branchline itself, would enable the shallowest hooks (i.e., those closest to the float line) to fish below 100 m depth (Fig. 1).

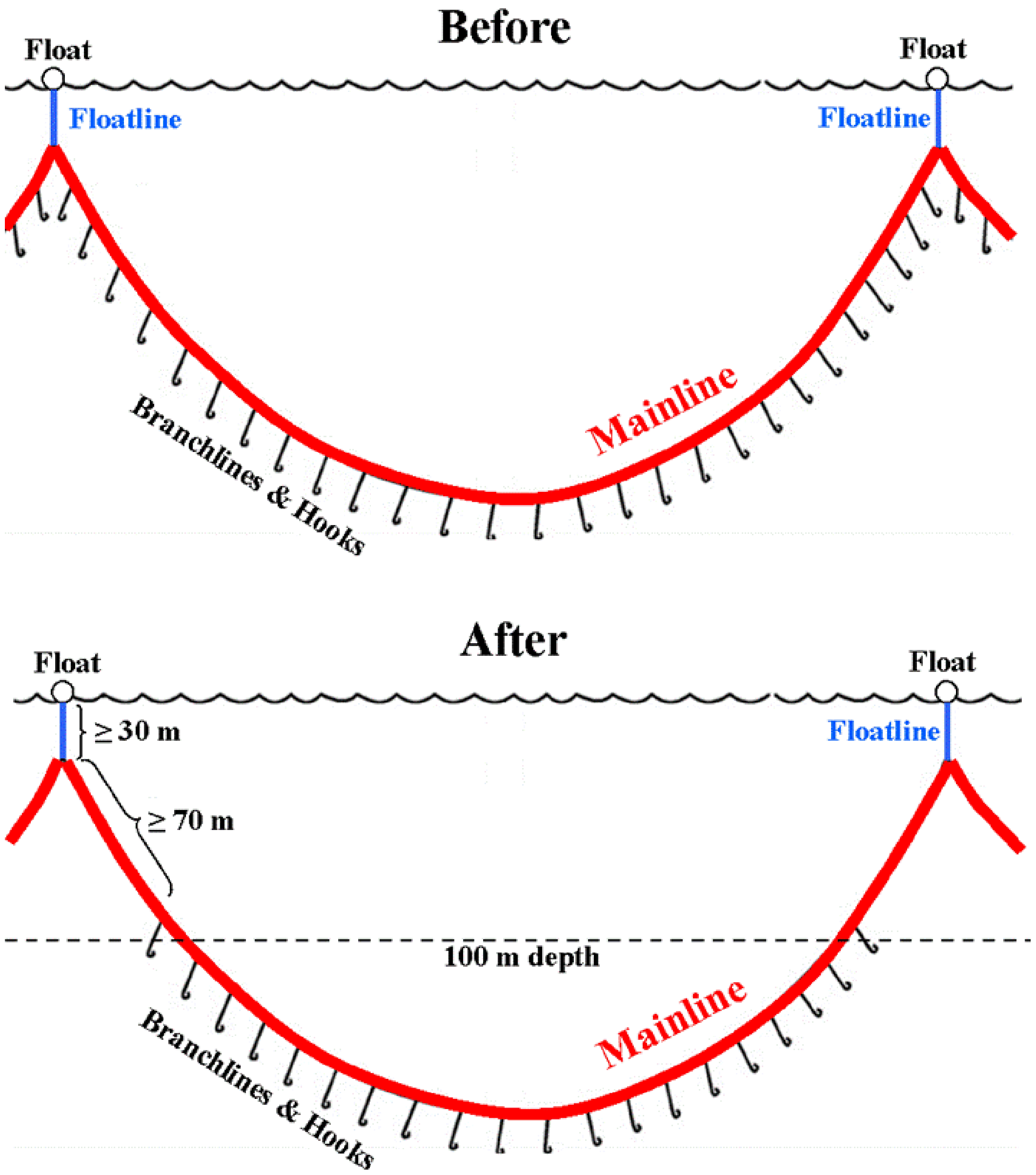

Figure 1. Longline gear configuration in the American Samoa longline fishery before (above) and after (below) the proposed action.

Additional details of the proposed action for Class B, C, and D vessels in this fishery intended to increase the likelihood of all hooks being set to fish deeper than 100 m are: (1) a requirement for a minimum of 15 branchlines between floats, to provide the weight needed to ensure that the basket (i.e., section of gear between floats) sinks down to the desired depth; and (2) a prohibition against landing or possessing more than 10 swordfish during a fishing trip (WPFMC 2010). The swordfish trip limit is intended to discourage fishing targeted at shallower depths commonly used to harvest swordfish.

4 Action Area

The action area for this proposed action includes all areas where vessels permitted by the American Samoa longline fishery operate fishing gear, and areas that such vessels travel through on their fishing trips. American Samoa longline fishing in 2005-09 all occurred in the area bounded by 180° and 155° W longitude, and 3° S - 32° S latitude, hence this rectangle is the action area (Figure 2 – the fishery made <20 sets annually between 3° and 5° S and 20° and 32° S; confidentiality restrictions prevent the locations from being shown in the figure). The action area includes the U.S. Exclusive Economic Zone (EEZ) around American Samoa, but portions of this EEZ around the islands and atolls of American Samoa are closed to large (≥50 ft in length) domestic fishing vessels (50 CFR 665.817). These areas are included in the action area because longline vessels travel through them on fishing trips. Since 2001, American Samoa-based longline vessels have fished in several foreign EEZ waters such as Samoa, Tokelau, and others. Fishing effort in these countries ranges from a couple thousand hooks per year to over 2.7 million hooks set in the Cook Islands in 2006. Three green turtle interactions that resulted in mortalities have occurred in Cook Islands waters, two of them in 2010. As such, some foreign EEZs are included in the action area because longline vessels travel through them on fishing trips as well as actively fish in these areas (Fig. 2).

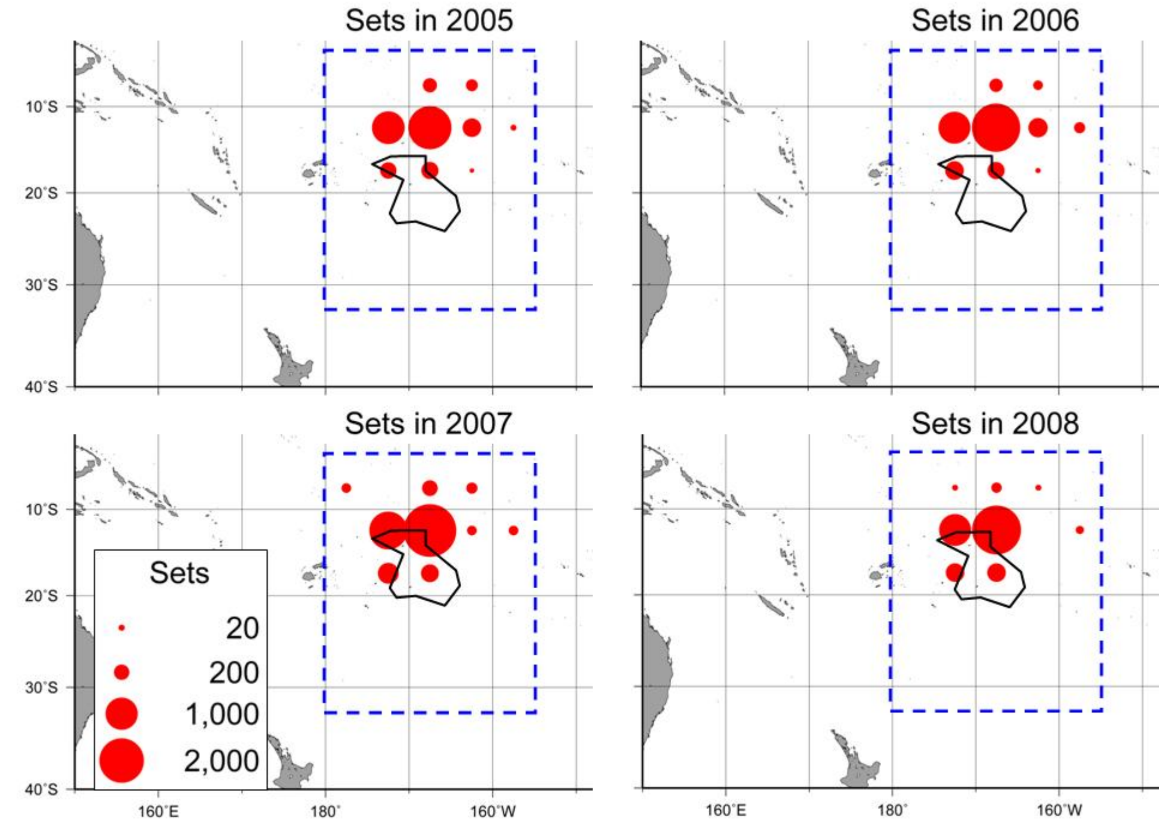

Figure 2. American Samoa EEZ (black line), the action area for this biological opinion (blue rectangle), and annual sets (2005-08) for the American Samoa longline fishery (maps provided by Karen Sender, PIFSC, 7-1-09). Fishing in 2009 also occurred within the area bounded by the blue rectangle. The fishery made <20 sets annually between 3° and 5° S and 20° and 32° S so confidentiality restrictions prevent their locations from being shown in the figure.

5 Status of Listed Species

As described above in Section 2 (Consultation History), four species shown in Table 1 below (green, hawksbill, leatherback, and olive ridley sea turtles) are likely to be adversely affected by the proposed action, and the remainder of this biological opinion deals exclusively with these four species.

Table 1. ESA-listed marine species that may be affected by the proposed action.

Species	Scientific Name	ESA Status	Listing Date	Federal Register Reference
Table 1a. Species not likely to be adversely affected by the proposed action.				
Sperm Whale	*Physeter macrocephalus*	Endangered	12/02/1970	35 FR 18319
Loggerhead Sea Turtle	*Caretta caretta*	Threatened	7/28/1978	43 FR 32800
Humpback Whale	*Megaptera novaeangliae*	Endangered	12/02/1970	35 FR 18319
Table 1b. Species likely to be adversely affected by the proposed action.				
Green Sea Turtle	*Chelonia mydas*		7/28/1978	43 FR 32800
Nesting aggregations, west coast Mexico, Florida		Endangered	7/28/1978	43 FR 32800
All other Green turtles		Threatened	7/28/1978	43 FR 32800
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered	7/28/1978	43 FR 32800
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered	06/02/1970	35 FR 8491
Olive Ridley Sea Turtle	*Lepidochelys olivacea*			
Nesting aggregations on west coast of Mexico		Endangered	7/28/1978	43 FR 32800
All other Olive Ridley turtles		Threatened	7/28/1978	43 FR 32800

This section presents biological or ecological information for green, hawksbill, leatherback, and olive ridley sea turtles affected by the proposed action relevant to formulating the biological opinion including species-specific descriptions of distribution and abundance, life history characteristics (especially those affecting vulnerability to the proposed action), threats to the species, major conservation efforts, and other relevant information (USFWS & NMFS 1998). Factors affecting those species within the action area are described in more detail in the Environmental Baseline. No critical habitat has been designated for any of these listed species in the Pacific Ocean, although on January 5, 2010, NMFS published a proposed rule in the Federal Register to revise leatherback critical habitat to include two marine areas totaling approximately 46,100 square miles within the west coast U.S. EEZ east of a line approximating the 2,000 meter depth contour: one area along the California coast from Point Arena to Point Vincente; and one area from Cape Flattery, Washington to Winchester Bay at the mouth of the Umpqua River, Oregon (75 FR 319, January 5, 2010). These areas are not within the action area and therefore are not considered in this analysis. The four species addressed by this biological opinion have global distributions, and are listed globally at the species level (Table 1).

To date, 11 of the 13 green turtles incidentally caught in the American Samoa longline fishery from April 2006-August 2010 were sampled for genetic analysis in an effort to identify stock origin of sea turtle interactions. Results of mitochondrial DNA sequencing are available for nine of the sampled animals (the most recent two have yet to be sent to the lab for analysis at the time of writing) and reveal the following: (1) one individual with a haplotype (CmP80) representing nesting aggregations of the Great Barrier Reef area, the Coral Sea, and New Caledonia; (2) two individuals with a haplotype (CmP22) representing nesting aggregations of the Marshall Islands, Yap and American Samoa; (3) two individuals with a rare haplotype (CmP65) only found so far in the nesting aggregation in the Marshall Islands, (4) two individuals with haplotypes (CmP31

& CmP33) of unknown nesting stock only found so far in foraging green turtles around Fiji , (5) one individual with a haplotype (CmP20) commonly found in nesting aggregations in Guam, Palau, Marshall Islands, Yap, Northern Mariana Islands, Taiwan and Papua New Guinea, and (6) one individual (CmP47) with a haplotype found in nesting aggregations in Yap, northern and southern GBR, New Caledonia, Coral Sea, Timor Sea, and east Indian Ocean (Peter Dutton, NMFS, pers. comm.). Work is ongoing to sufficiently characterize all the Pacific green turtle nesting stocks with informative genetic markers in order to improve the ability to assign stock origin of individual animals.

The Observer Program has no records of other turtle species interacting with the American Samoa longline fishery. Additional non-observed interactions have been recorded in vessel logbooks over the course of the Federal logbook program (since 1996) in this fishery; however, the accuracy of these reports is unable to be independently verified. Fishermen have had access to some informational tools, such as sea turtle identification guides from NMFS protected species workshops, but incidental catch, including protected species, is typically not an area of high priority or focus for fishermen. In addition, most protected species data contained in logbooks is confidential due to the limited number of reports. As such, only observed interactions are considered in this analysis. There is one published report of an interaction with a small juvenile leatherback (39.3cm straight carapace length (SCL)) south of Swains Island in 1993 (Grant 1994). This report does not appear in observer data since regular observer coverage did not begin in this fishery until April of 2006. Genetic analysis indicates that this individual originated from nesting beaches in the western Pacific (Peter Dutton, pers. comm.). Species distribution data and anecdotal information suggest that hawksbill, leatherback, and olive ridley turtles may occasionally interact with the fishery. Similar to green turtles, hawksbill turtles in the action area may originate from several nesting sites spread across a broad area of the western and southern Pacific (NMFS & USFWS 2007b). Little genetic work has been done to determine the stock structure of Pacific hawksbills. However, preliminary results based on 47 samples indicate that hawksbills nesting in Hawaii are likely a discrete genetic stock (similar to green turtles) although more samples are required to determine this conclusively (Dutton and Leroux, 2008). Similar to green turtles, hawksbills in the action area most likely originate from nesting sites in Oceania.

There is little known nesting of leatherback and olive ridley turtles within the action area. Migratory patterns suggest that leatherback (Shillinger *et al*. 2008; NMFS & USFWS 2007c) and olive ridley (Eguchi *et al*. 2007; NMFS & USFWS 2007d) turtles originating from Eastern Pacific nesting beaches do not enter the action area, thus only the Western Pacific nesting aggregations of these two species are considered in this opinion.

5.1 Green Turtles

Information in this section is summarized from gray literature, the most recent green turtle 5-year status review (NMFS & USFWS 2007a), the PIFSC draft green and hawksbill turtle research plan (Snover *et al*. 2007), the proposed amendment (WPFMC 2010), and the other sources cited below.

5.2.1 Distribution and Abundance

Green turtles (*Chelonia mydas*) occur in the western, central, and eastern Atlantic, the Mediterranean, the western, northern, and eastern Indian Ocean, southeast Asia, and the western, central, and eastern Pacific (NMFS & USFWS 2007a). The Eastern Pacific nesting aggregation likely includes turtles that nest on the west coast of Mexico, which are listed under the ESA as endangered. The Western Atlantic nesting aggregation includes turtles that nest in Florida, which are listed under the ESA as endangered. All other green turtles (including those in the Eastern Pacific that nest outside of Mexico, and those in the Western Atlantic that nest outside of Florida) are listed as threatened (see Table 1 above).

Based on the genetic results described above, the proposed action is expected to directly affect green turtles originating from many nesting aggregations in Oceania (here defined as Polynesia, Micronesia, Melanesia, eastern Australia). Within this area, green turtles are known to nest at nearly 200 sites (and likely hundreds more yet to be surveyed; Figure 3). Limited information is available on numbers of nesting females, nesting trends, or genetic relationships between turtles from various nesting sites. However, a study of turtles sampled from 13 nesting sites on the western fringe of this region revealed six genetically distinct breeding stocks (Dethmers et al. 2006) or Management Units (MUs; Moritz 1994). The study also examined the geographic extent of genetic diversity and concluded that, generally, green turtle nesting sites greater than 500 km apart are genetically distinct enough to form separate MUs (Dethmers et al. 2006). In the absence of genetic data for most documented nesting sites throughout the region, approximately 171 green turtle nesting sites identified in Oceania have been grouped into Nesting Aggregations (NAs) based on this 500 km geographic parameter. Nesting sites that are less than 500 km apart are considered to be part of a single NA.

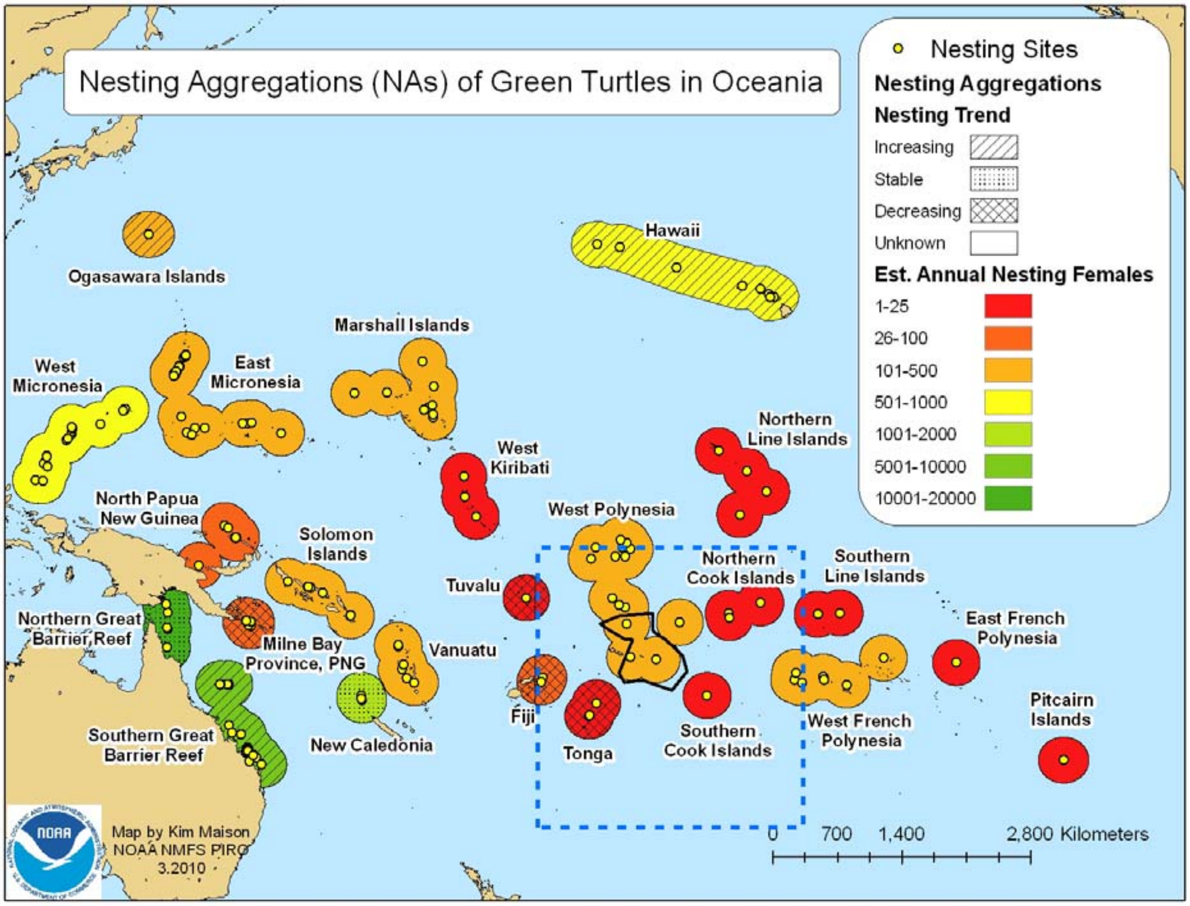

Figure 3. Nesting Aggregations (NAs) of green turtles in Oceania. The action area (dashed blue line) and American Samoa EEZ (black line) are also shown.

Some NAs consist of a single isolated nesting site (e.g., Ogasawara Islands), while others form complexes of nesting sites less than 500 km apart (e.g., West Polynesia; Figure 3). The status and trends of these NAs are described below based on the best currently available information, and summarized in Table 2 below. Since the type of information available for nesting green turtle abundance and trends in each NA varied significantly, estimates of annual nesting females were binned into the following categories: 1-25, 26-100, 101-500, 501-1,000, 1,001-2,000, 2,001-5,000, 5,001-10,000, and 10,001-20,000. In cases where virtually no information was available beyond the presence of some green turtle nesting activity, a conservative approach was taken and it was assumed that 1-25 females nest annually in those NAs.

Sea turtle nesting assemblages exhibit natural annual fluctuations in abundance. As such, a conservative approach was taken by using a minimum estimated range of annual nesting females for each NA, unless otherwise noted. Where information was presented in numbers of nests, an estimate of 4.5 nests per individual was applied to determine the number of nesting females likely represented. While this life history trait has not been studied for most of the rookeries in Oceania, our estimate is based on Van Buskirk and Crowder's (1994) reported average for the Heron Island, Australia rookery and an updated estimate for the nesting assemblage at French Frigate Shoals, Hawaii (S. Hargrove, pers. comm.). The NAs established in this document are based on nesting locations; migrations and feeding grounds have not been considered, therefore NAs presented are not meant to depict the entire range of any group of green turtles, but rather to display geographic groupings of nesting beach origins of individuals that may range much more widely throughout the region during different life stages. These NAs do not represent recovery units or DPSs recognized or recommended under the ESA, but were delineated by resource managers using the best available information to allow for an organized and manageable synthesis of existing data on green turtle nesting locations, abundance, and trends in the region.

Hawaii NA. The Hawaii NA consists of green turtles nesting in the Main Hawaiian Islands (MHI) and Northwestern Hawaiian Islands (NWHI) (Figure 3). Although some nesting sites in the MHI and NWHI are more than 500 km apart, Hawaii is considered a single NA because green turtles nesting and foraging within the Hawaiian Archipelago have been heavily sampled for genetic analysis and are likely comprised of one genetic stock, distinct from other Pacific stocks (Dutton et al. 2008). The primary nesting location for green turtles in this NA is French Frigate Shoals (FFS) in the NWHI which supports over 90% of documented green turtle nesting in Hawaii (Balazs 1976). Minor nesting also occurs at Laysan, Lisianski, Pearl and Hermes, and Midway in the NWHI and on Oahu, Lanai, Maui, Molokai, and Kauai within the MHI. At FFS, over 50% of all nesting occurs on East Island (Balazs 1976; Niethammer *et al*. 1997), where nesting surveys have been conducted annually since 1973. There is high annual variability in nesting female abundance in this NA which has exhibited a consistent upward trend over the past thirty years with an estimated annual growth rate of 5.4% (Chaloupka and Balazs 2007). While nesting female abundance at East Island is estimated at 400-500, this likely represents only half of the nesting population throughout all of French Frigate shoals (REFS). Therefore, based on the available information, it is assumed that 501-1000 green turtles nest in this NA annually (Table 2).

Ogasawara Islands NA. The Ogasawara Islands NA consists of green turtles that nest in the Ogasawara Islands (AKA Bonin Islands) of Japan, a group of over 30 tropical and subtropical islands (only two of which are inhabited) located approximately 1000 km south of Tokyo (Figure 3) . In this NA, green turtles nest mainly at Chichi-jima with a mean annual total of approximately 500 nesting females in recent years, exhibiting an increasing nesting trend and estimated annual growth rate of 6.8% per year (Chaloupka *et al*. 2007). Based on the available information, it is assumed that 101-500 green turtles nest in this NA annually (Table 2).

East Micronesia NA. The East Micronesia NA consists of green turtles that nest in the Marianas archipelago including Guam and CNMI, Elato Atoll, Olimarao Atoll, West Fayu, Gaferut, Pig Island, Pikelot, and Lamotrek in Yap State, Federated States of Micronesia (FSM), Fanang Island, East Fayu Island, and Murilo Atoll in Chuuk State, FSM, and at Oroluk Atoll in Pohnpei State, FSM (Figure 3).

There is regular, low density green turtle nesting on Guam (Pritchard 1995b; NMFS and USFWS 1998). Nesting beaches include: Ritidian National Wildlife Refuge, Haputo, Urunao, Tumon Bay, Cabras Island, the waterfront annex of Naval Base Guam, Spanish Steps, Cocos Island, Acho Bay, Nomña Bay, Jinapsan, and Tarague Beach (Grimm and Farley 2008). From October 1, 2006 through July 31, 2008, 55 green turtle nests were counted at various beaches during opportunistic (not regularly scheduled) surveys throughout Guam (GDAWR 2009) which possibly represents a minimum of ten nesting females per year during that 22 month period. Sufficient information is not available to describe the abundance or trend of nesting green turtles on Guam.

In the CNMI, it is estimated that possibly fewer than 10 individual turtles nest annually on the islands of Saipan, Tinian and Rota (NMFS and USFWS 1998). Marine turtle resources are more abundant in nearshore foraging habitats with an estimated 1,000 to 2,000 turtles inhabiting reef areas in the southern CNMI (Rota, Tinian, Aguiguan, Saipan, and Farallon de Mendillia) (Kolinski *et al*. 2004). With the exception of Anatahan, nesting surveys have not been conducted in the northern islands. There are no reports of turtles nesting at northern island locations, including no recorded observations during the Anatahan survey. Nesting likely occurs on all or most of the accessible beaches on Tinian (Pultz *et al*. 1999). Eleven beaches on Rota are known to support nesting: Songton, Teteto, Mochong, Kokomo, Coral Garden, Okgok, Apanon, and Gaonan (the Cave Beaches), Uyulan, Tatgua, and Latte Stone (Lalayak or I Batko) (Ilo *et al*. 2005). The CNMI Division of Fish and Wildlife (DFW) has monitored nesting activity on Saipan since 1999 and has documented four to 18 nests laid per year (DFW unpublished annual reports). At least five beaches on Saipan have been monitored somewhat consistently over the past five years: Bird Island, Wing, Tank, Lao Lao Bay, and Obyan beaches (Ilo *et al*. 2005; Kolinski *et al*. 2001; DFW 2009). More intensive monitoring occurred on Saipan at seven beaches from March 4 to August 31, 2009 that resulted in documentation of 16 green turtle nests (DFW 2009) possibly representing approximately five females. Of major concern, however, is that three of the potentially five nesting turtles and three nests were harvested (DFW 2009), which suggests that poaching remains a significant threat to turtles on Saipan. Rapid assessments at Rota beaches, Okgok and Tatgua, on July 12, 2009, yielded 13 nests (possibly representing ~ 4 females), and on Tinian from July 22-31, 2009 documented 35 nests (possibly representing ~ 11 females) at 5 beaches with evidence of one nesting female having been poached (DFW 2009). Sufficient information on nesting trend is not available for the CNMI although anecdotal information from residents suggests that nesting activity has decreased over time, likely as a result of direct harvest. Additional nesting assessments at Tinian and Rota are needed as these islands may provide additional nesting habitat.

In Yap State, FSM, during a four and a half month field season on Olimarao Atoll in 1990, 27 adult females were tagged (Smith et al. 1991). A field season on Elato Atoll in 1992 yielded 36 tagged adult females (Kolinski 1993). A total of 70 nesting green turtles were tagged in Ngulu Atoll on the islands of Lathow and Meseran from May through July in 1992 and another 75 nesting green turtles were tagged the following year from April through July of 1993 (Kolinski 1993). In addition, two tagging efforts were carried out at Elato Atoll where 36 nesting green turtles were observed from July through September of 1992 and 41 nesters from May through August of 1993 (Kolinski 1993).

In Chuuk State, FSM, nesting sites include Fanang Island, East Fayu Island, and Murilo Atoll. According to a report from 1993, six to seven green turtles nest each night from February-June on East Fayu (Pritchard 1995b). One to three turtles per night are also reported to nest on Fanang Island as well as a few per night at Murilo Atoll (Pritchard 1995b). Without being able to identify which of these turtles are repeat nesters within a season, it is difficult to determine actual nesting female abundance from this information.

In Pohnpei State, FSM, green turtle nesting has been recorded at Oroluk Island, Oroluk Atoll. Oroluk is an atoll west of Pohnpei Island and has over 30 sandy islets and sandbanks. Only Oroluk Island is inhabited with fewer than 20 residents. Pritchard (1977) noted that Oroluk Atoll was apparently the only nesting ground of importance for the green turtle in Ponape District (Pohnpei State) and he estimated 9-15 nests per night at Oroluk with up to 20 nests on a good night. Pritchard also reported a nesting pattern with two peaks, December to January and June to July. At least some nesting is reported by inhabitants all year round (Edson and Curren 1987). Surveys in June – July of 1985 resulted in an average of 2.3 nests per month and May – August of 1986 averaged 3.4 nests per month, significantly lower abundance than the 9-15 nests per night reported by Pritchard in the 70s (Edson and Curren 1987). During a one day survey in November, 1990, no evidence of nesting was seen on Oroluk; however, Typhoon Owen had passed just north of the island eight days earlier and caused considerable damage to the island and reefs (Naughton, 2001). During Naughton's 1990 expedition, an individual on the island stated that between five and eight turtles nest or attempt to nest on Oroluk Island every month, except June and July when they are "too numerous to count." He reported that island residents take every turtle they encounter. In the 1990s, nesting activity still occurred on Oroluk, although at a reduced level from that reported in the 1970s. According to Naughton (2001), there is little question that Oroluk Atoll is critically important to green turtles in the Caroline Islands, and is probably the most important site for the species in the Eastern Carolines.

Regarding other sites in Pohnpei, 74% of people surveyed by Buden and Edward (2001) on Pohnpei Island indicated they had no knowledge of nesting activities of turtles on Pohnpei and its lagoon islands. Four people contributed unsolicited comments on nesting on Ant Atoll, and three described incidents of nesting on three different lagoon islands in Kitti (Budden *et al* 2001), indicating the possibility of very low-level nesting at a few sites in addition to Oroluk Atoll.

Based on the available information, it is assumed that 101-500 green turtles nest in this NA annually (Table 2). Estimates for this NA are based on available data from the few nesting sites that are monitored and sampled whereas green turtles may nest at many more sites throughout East Micronesia undocumented. As such, it is likely that we have significantly underestimated the nesting activity in this under-sampled NA.

<u>West Micronesia NA</u>. The West Micronesia NA consists of green turtles nesting at Ngulu Atoll, and the islets of Loosiep, Bulbul, Yeew, Gielop and Iar at Ulithi Atoll in Yap State, FSM, and at Helen Reef and Merir Island with additional low level nesting in Ngarchelong, Kayangel, and Melekeok States in Palau (Figure 3).

Ulithi atoll in Yap State, FSM is home to several "Turtle Islands" which are identified as significant green turtle nesting sites by local people including the trio of Loosiep, Bulbul and Yeew and duo of Gielop and Iar (Cruce-Johnson 2006). These islands may be among the largest green turtle rookeries in Micronesia (Kolinski 1992). Turtles nesting on or mating near these islands have traditionally been hunted for their meat and eggs (Lessa 1983). In 1991, 417 nesting green turtles were tagged on Gielop during a three month field season (Kolinski 1992). This study site was revisited subsequently when a turtle tagging project was carried out on the islands of Gielop and Iar from June 9, 2005 through August 24, 2005. Nesting beaches were monitored a total of 59 nights on Gielop and 25 nights on Iar. A total of 310 adult nesting green turtles (186 from Gielop and 124 from Iar) and one nesting hawksbill turtle (on Iar) were tagged (Cruce-Johnson 2006). In 2006, Gielop Island was monitored a total of 59 nights between June 2 and August 20 and 328 nesting green turtles were tagged (Cruce-Johnson 2007). During 84 nights between April 13 and August 2, 2009, a total of 553 nesting green turtles, two non-nesting female green turtles, and one male turtle (total 556) were tagged and assessed on Gielop Island (Cruce 2009). Based on these four field seasons, approximately five nesting females were tagged each night during the nesting season at Gielop.

Of seven post-nesting green turtles satellite tracked from Gielop during 2005-2006, five migrated to the Philippines and one to Malaysia while another turtle's transmitter ceased sending signals while still in the FSM EEZ (Kolinski *et al.* Draft manuscript 2007). An additional seven post-nesting greens were tracked from Gielop in 2007; four turtles migrated to the Ryukyu Islands, Japan and three to the Philippines (PIRO and PIFSC unpublished data).

In 2008, a research ban was instituted by local chiefs of Gielop and therefore monitoring efforts switched to the nearby island, Loosiep, where 66 nesting green turtles were tagged between April 22 and July 18 (Cruce 2008). Research continued during the 2009 nesting season and a total of 109 nesting green turtles, eight non-nesting female green turtles, and one male turtle were tagged and assessed between April 13 and August 2. Many nests are depredated by exotic varanids and pigs on Loosiep; 17 of 20 staked study nests were depredated in 2009 (Cruce 2009).

Palau is an island nation made up of four populated islands and several hundred smaller islands and atolls organized into 16 states. Summaries for each state are as follows.

Hatohobei State: During a study at Helen Reef from April 19 through December 8, 2005, 301 green turtle nests were counted while 47 individual nesting turtles were flipper tagged. Nesting turtles emerged almost every night between April and August 2005 (Barr 2006). On April 22, 2008 a female green originally tagged on Helen Island, Hatohobei State, on September 5, 2006 was speared with a traditional harpoon near Goulburn Island, Northern Territory, Australia (Palau BMR 2008).

Sonsorol State: From November 2004 through September 2005, 331 green turtle nests were documented during daily surveys and 36 individual turtles were tagged during night surveys at Merir Island (Palau BMR 2005). Five green turtle nests were documented during surveys conducted on April 17 and 25, 2005 at Pulo Ana Island (Palau BMR 2005). During daily monitoring from November 2007 to August 2008, 739 green turtle nests (possibly representing ~246 females) and 382 non-nesting emergences were documented with peak nesting observed in May (Palau BMR 2008). A green turtle tagged on June 7, 2007 by conservation officers on Merir Island, Sonsorol State was recaptured in a set net near the village of Yomitami, Okinawa, Japan on October 15, 2007. The turtle was retagged and released (Palau BMR 2008).

Ngarchelong State: Between March and August of 2008, four surveys found eleven green turtle nests along 2.4 km of the island of Ngerechur, nine of which had been destroyed by wild pigs (Palau BMR 2005). On July 22 and 23, 2008 turtle nesting surveys were conducted along a 1.5

km beach on Ngerechur Island, just off of Ngarchelong state where 1 green turtle nest was documented (Palau BMR 2008).

Kayangel (Ngcheangel) State: Kayangel is an atoll with four islets on its east side. Kayangel Island with a land area of 1.12 km^2 and a perimeter of 6 km, is the largest island in the atoll. Ngeriungs is just south of Kayangel and is the second largest island of the atoll with a land area of .32 km and a perimeter of 3 km. Between April 28 and October 10, 2005, two green turtle nests were documented during occasional nesting beach surveys on Kayangel Atoll (1 on Kayangel and 1 on Ngeriungs) (Palau BMR 2005). Green turtle nesting also occurs at Ngeruangel Islet, Ngeruangel Atoll, 10 km northwest of Kayangel. Between June 22, 2005 and October 10, 2005, five green turtle nests were documented as a result of three surveys (Palau BMR 2005).

Melekeok State: Melekeok is a town on the east coast of Babeldaob Island with a beach area of 4.43 km^2. On, November 11, 2005, five sites along the beach were surveyed with no turtle nests documented. Interviews with several residents resulted in mention of turtle nesting in the area with a maximum of five green turtle nests in a year (Palau BMR 2005).

While the bulk of nesting in Palau occurs at Helen Reef and Merir Island, it is likely that only a few individuals nest annually at sites in Ngarchelong, Kayangel, and Melekeok States. Based on the available information, it is assumed that 501-1,000 green turtles nest in the NA annually (Table 2).

Northern Papua New Guinea NA. The Northern Papua New Guinea (PNG) NA consists of green turtles that nest in the New Ireland Province and on Long Island, Papua New Guinea (Figure 3). Offshore islands in the New Ireland Province include New Hanover, the Tigak Islands, Djaul (including Mait Island), the St. Mathias Group (Tench, Emirau and Mussau), Tabar, Lihir, Tanga and Anir islands. Very little information is available on the abundance and trends of nesting green turtles in this NA. According to a PNG National Fisheries Authority (NFA) report, nests are raided for eggs at Nago, Atmago, and Ral islands indicating nesting activity at these locations (NFA 2007). Villagers around Kavieng indicated a peak nesting season for greens of August through October. Around Kavieng, green turtles nest at Nago Island, Atmago, Nusalaman, Usen and Lemus. In the past, green turtles used beaches on Limanak, Limalam and Nusailas Islands to nest although they are no longer in use which may be attributed to the increase in human population on these islands which led to increased harvest pressure (NFA 2007). A comprehensive survey of PNG for green turtle nesting abundance is not available nor is current trend information, but previous studies completed in the 1980s indicated that numbers of green, hawksbill and leatherback turtles were decreasing throughout PNG (Pritchard 1982; Spring 1982; Bedding and Lockhart 1989). It is likely that this declining trend has continued over time, with the exception of green turtles nesting in areas of Seventh Day Adventists (this religion prohibits eating meat, including turtles), such as Mussau and Emirau Islands in the St. Mathias Group (NFA 2007). In these areas, Pritchard (1995) reports a “noticeable increase in the turtle populations over a 30-50 year period,” although NFA (2007) reports that people from Kavieng and Manus visit the islands to harvest turtles.

Long Island is a volcanic island located north of the island of New Guinea in PNG. There is limited information on green turtle nesting at this location although this rookery has been sampled for genetic analysis (Moritz 2002). According to local inhabitants, greens are the most common nesters and nest all year long but with a pronounced peak nesting season from May through October (Pritchard 1979). Nesting density was reported as variable with anywhere from two or three nests between the villages of Malala and Point Kiau up to six or seven on a given night, according to local inhabitants. In September, 1978, Pritchard (1979) walked the seven mile stretch of beach between the villages of Malala and Point Kiau on Long Island and observed twelve nesters and tracks of at least seven others in one night. He estimated a total of 35 for the night with more likely beyond the scope of the survey (Pritchard 1979). Informants revealed that 20-30 nesting turtles per month were eaten by island residents and also that, at the time, turtles were considered "as plentiful as they ever have been." Much of this information is inconsistent making it difficult to estimate an abundance of annual nesting females at this site. Considering the harvest pressure that was apparent in 1978 that has likely continued, a more recent survey of turtle nesting activity on Long Island is needed for a reliable estimate.

Based on the limited available information, it is assumed that 26-100 green turtles nest in this NA annually (Table 2).

Milne Bay PNG NA. The Milne Bay PNG NA consists of green turtles that nest in the Milne Bay Province of Papua New Guinea (Figure 1). In January 2003, the first assessment of turtle stocks in the Milne Bay Province commenced at Panayayapona Island of the Brooker Islands (Kinch 2003a). Sixteen green turtle nests were documented from January 21-27, 2003 with a total of 71 tracks recorded on arrival. For comparison, during a reconnaissance survey on Nov 28, 1998 a total of 177 tracks (not discerned by species) were recorded on arrival at Panayayapona. The previous year 126 tracks were counted (not discerned by species), in mid-December 1997 an average of 30 to 40 turtles arrived each night to nest, and on one night in mid-January 2002, 72 tracks (not discerned by species) were counted (Kinch 2003b). More intensive surveying December 1-21, 2004 at the Jomard Islands (Panadaludalu and Panayayapona), Siva of the Bramble Haven group, and Irai, Pananiu, and Tobiki islands of the Conflicts group resulted in 115 green turtle nests recorded (Wangunu *et al*. 2004). A comprehensive survey of PNG for green turtle nesting abundance is not available nor is current trend information, but previous (dated) studies indicated that numbers of green, hawksbill and leatherback turtles were decreasing throughout PNG (Pritchard 1982; Spring 1982; Bedding and Lockhart 1989). It is likely that this declining trend has continued over time. Based on the available information, it is estimated that 26-100 green turtles nest in this NA annually (Table 2).

Solomon Islands NA. The Solomon Islands NA consists of green turtles that nest in the Solomon Islands (Figure 3). Limited information is available regarding current overall nesting information for green turtles in the Solomons. McKeown (1977) estimated that 45 green turtle nests were laid in the Arnavons. Vaughan (1981) estimated that the number of breeding individuals of all sea turtle species combined in the Solomons was about 1,500 females, and that 42% of hawksbill and green turtles present in the Solomon Islands nested in Isabel Province. This survey recorded 53 green turtles nesting on Kerehikapa, Arnavon Island, during the months of September to March, with Hakelake Island also supporting 15-20 nests per year. Ramohia and Pita (1996) identified only five green turtles nesting in the Arnavon Islands during the summer of 1995.

Vaughan (1981) also documented green turtle nesting activity within the provinces of Choiseul, Shortlands and Makira primarily on the islands of Wagina, Ausilala, Maifu, Balaka, and Three Sisters (Malaulaul and Malaupaina), with approximately 50-100 green turtle nests laid per year at each island. While Vaughan's 1980 survey noted anecdotal reports of a reduction in abundance, Leary and Laumani (1989) estimated a modest increase of nesting activity in Isabel province of 259-438 nests (possibly representing ~86 – 146 females), compared to 211-341 nests (possibly representing ~ 70 – 114 females) in 1980 (not including the Arnavon Islands). This discrepancy is likely a result of normal fluctuations in turtle nesting activity and not necessarily indicative of a measurable trend in this nesting assemblage. Sufficient data on abundance and trend for Solomon Islands green turtles are not available. Based on the available information, it is assumed that 101-500 green turtles nest in this NA annually (Table 2).

Northern Great Barrier Reef NA. The Northern Great Barrier Reef (NGBR) NA consists of green turtles that nest in the NGBR area of Australia (Figure 3). This NA includes the largest nesting concentration of green turtles in the world (Chaloupka *et al*. 2007), with 90% of nesting activity in the NA occurring on Raine Island, Moulter Cay, and No. 7 and No. 8 Sandbanks (Limpus 2009). Minor breeding aggregations also occur on the Murray Islands, Bramble Cay, and other outer barrier islands of the NGBR, most inner shelf cays and mainland beaches north of Cape Grenville and along the Torres Strait (Limpus 2009). Raine Island is the primary index beach for the NGBR stock, but a total tagging census has not been attempted and there has been limited annual monitoring of the nesting aggregation at NGBR and Torres Strait rookeries due to size of the nesting assemblage and site remoteness (Limpus 2009). This region experiences significant inter-annual fluctuations, ranging, at certain sites, from a few dozen to over 10,000 annual nesting females, driven primarily by the El Niño Southern Oscillation (Limpus *et al*. 2003; Chaloupka *et al*. 2007; Limpus 2009). Moulter Cay has nightly nesting activity and average density that is strongly correlated with the activity and density at Raine Island. An estimated 41,000 females nest in the NGBR during a typical high-density nesting season (Limpus 2009). Additionally, it is expected that in a high density season, several thousand additional females nest at No. 7 and No. 8 Sandbanks, the Murray Islands, Bramble Cay and other smaller nesting sites in the NGBR and Torres Strait (Limpus 2009).

Chaloupka *et al*. (2007) identified a nonlinear nesting trend, increasing from the mid-1970s and leveling off by the mid-1990s. Lack of continued increasing trend at Raine Island may be due to a number of factors including: increasing sea surface temperature (Chaloupka and Limpus 2001; Limpus *et al*. 2003); decreasing reproductive output as the stock approaches carrying capacity (Troëng & Chaloupka 2007); over-harvest in northern Australian and New Guinean waters (Limpus *et al*. 2003; Limpus 2009); and hydrology or rising groundwater that floods egg chambers (Limpus *et al*. 2003). Therefore there is concern regarding long-term stability of the NGBR nesting assemblage given a significant decline in breeding success (low hatchling production and recruitment) over the last three decades at Raine Island (Limpus *et al*. 2003; Limpus 2009). Additionally, there has been a significant downward trend in mean curved carapace length (CCL) of nesting females at Raine and Moulter Cay over 26 breeding seasons, 1976-2001 (Limpus *et al*. 2003). This decrease in carapace size has occurred in conjunction with a progressive increase in remigration interval (Limpus 2009), and while long-term monitoring for abundance of annual nesters has not provided a clear indication of the stability of this stock, changes in CCL and remigration interval are consistent with a group that could be in early stages of decline as a result of excessive loss of adult females (Limpus *et al*. 2003; Limpus 2009). Based on the available information, a reasonable conservative estimate of the annual mean number of nesting females in this NA is 10,001-20,000 (Table 2).

<u>Southern Great Barrier Reef NA</u>. The Southern Great Barrier Reef (SGBR) NA consists of green turtles that nest in the SGBR area and in the Coral Sea Cays, or the Coringa-Herald National Nature Reserve (CHNNR), in Australia (Figure 3).

In the SGBR, major green turtle breeding areas include the islands of the Capricorn Bunker Group: Northwest, Wreck, Hoskyn, Tryon, Heron, Lady Musgrave, Masthead, Erskine, Fairfax, North Reef, and Wilson Islands. Minor breeding aggregations occur at Bushy Island, the Percy Islands, Bell Cay, Lady Elliot Island, mainland beaches from Bustard Head to Bundaberg, and the northern part of Fraser Island. Greater than 90 percent of all SGBR nesting occurs within protected habitats of National Parks and Conservation Parks (Limpus 2009). Size of the annual breeding assemblage has been monitored at several rookeries for varying periods since 1964 and there exists a wealth of information for this stock (summarized in Limpus 2009). Heron Island is the SGBR index nesting beach that has exhibited a stable fluctuation (i.e., no significant upward or downward trend) in annual nesting activity for almost four decades, 1967-2004 (Limpus 2009). However, there has been significant long-term reduction in mean size of breeding females within this stock over 26 breeding seasons that may be indicative of over-harvest of adult females (Limpus 2009). Based on mid-season nightly track counts, the SGBR is estimated to support 5,000-10,000 nesting green turtles per season (Limpus *et al*. 1984 and Limpus 1985, in Limpus 2009).

The CHNNR is afforded some protection by virtue of its remoteness and lack of introduced predators (Harvey *et al*. 2005). The reserve is located 440 km east of Queensland, Australia and is comprised of three pairs of islets: Herald Cays (NE & SW), Coringa Islet (SW & Chilcott), and Magdelaine Cays (NW & SE). Nesting takes place at NE Herald Cay, SW Herald Cay, Chilcott Islet and SW Coringa Islet. Nesting season at CHNNR extends from late October until approximately mid April, peak nesting occurring from late November through February. With the exception of the 1992/93 nesting season, NE Herald Cay was monitored for 13 years from 1991/92 through 2003/04 with surveys that ranged from four to 33 nights per season. Additionally, SW Herald Cay, Chilcott Islet and SW Coringa Islet were monitored sporadically during this 13 year timeframe. A total of 6,193 female turtles were recorded nesting at all four islets, 4,924 of which nested at NE Herald Cay. Yearly nesting abundance ranged from 12 females (2000/01 season) to 1,445 females (1999/00 season) (Harvey *et al*. 2005). During the 13 year monitoring period 3,141 turtles were tagged, 2,267 of which were tagged at NE Herald Cay (Harvey *et al*. 2005). Moritz *et al*. (2002) report 1,095 green turtles tagged during the 1999/00 season in the CHNNR. In the same season, Harvey *et al*. (2005) recorded 1,715 total nesting turtles during 33 survey nights of which 922 individual turtles were tagged at three islets: NE & SW Herald Cays and SW Coringa Islet. Insufficient data are available to discern an overall nesting trend; however curved carapace length of nesting females has declined significantly over time which may be the result of harvest pressure or other sources of adult mortality, potentially from the Torres Strait/Papua New Guinea region (Harvey *et al*. 2005).

Based on the available information, it is assumed that 5,001- 10,000 green turtles nest in this NA annually (Table 2).

New Caledonia NA. The New Caledonia NA consists of green turtles that nest in New Caledonia which consists of one large main island (Grand Terre), the Loyalty Islands group, and additional small islands and islets (Figure 3). The biggest known nesting area is 160 miles north of Grand Terre in a region known as d'Entrecasteaux Reef, comprised of Surprise, LeLeixour, Fabre, and Huon Islands. This site hosts an estimated peak of 80 nesting females per night on the island of Huon (Anon. 2004). In December 1979 there was evidence of 'major nesting', similar to that described 125 years previously by American explorer William Billings (Pritchard 1994). Pritchard (1994) described turtles to be "abundant on the southern island of Surprise, and saturation level on the additional three (LeLeixour, Fabre, and Huon Islands)… with numerous tracks seen on Beautemps-Beaupre, but not in the same category as the d'Entrecasteaux reef islands." Based on this survey, Pritchard (1995) estimated that 50 nesting emergences occurred per night at Huon (or approximately 2,800 nests, possibly representing ~933 females). In a 1991 survey, 310 tracks were counted on Surprise island with 14 turtles tagged; Huon island resulted in 1,800 tracks counted with 149 turtles tagged, including one turtle that had been tagged on Wistari reef, Queensland in 1985; and on Fabre island, 572 tracks were counted, with 54 turtles tagged in one night on both Fabre and Leleixior islands. Additionally, a total of 280 tracks and 80 nests were found on small unnamed sandy islets (Pritchard 1994). More recently, a country-wide survey of over 6,000 km of nesting habitat in December 2006 and January 2007 identified 22 green turtle nesting locations hosting an estimated 1,000 – 2,000 nesting females annually (Limpus *et al*. 2009). Based on the available information, it is assumed that 1,001 – 2,000 green turtles nest in this NA annually (Table 2). While trend information is not available, this recent information compared to historic accounts (Pritchard 1994 & 1995) suggests there has not been a significant decline in abundance of turtles nesting in New Caledonia.

Vanuatu NA. The Vanuatu NA consists of green turtles that nest in Vanuatu, an independent nation consisting of approximately 82 islands, 65 of which are inhabited (Figure 3). Turtles in Vanuatu are described as "plentiful" with Malekula island identified in 1979 as an important nesting area with 40 to 120 turtles nesting annually (although species was not specified, this likely refers to a combination of greens and hawksbills) (Pritchard 1982 in Pritchard 1995). Currently, the only published information on sea turtle nesting activity is summarized in Petro (2007) based on interviews of knowledgeable turtle monitors and limited surveys that occurred from November to December 2002 and January to February 2003 and was focused primarily on leatherback turtles. During this survey at Votlo, Southern Epi island, two green turtles were tagged and 10 false crawls and 15 nests were identified. Current information collected at Wan Smolbag workshops in 2007 and 2008 by monitors of the Vanua-Tai network identified over 189 nesting sites on 33 islands of Vanuatu, with approximately 200 turtles (both green and hawksbill) nesting at Malekula island per year (Fletcher and Petro, unpublished 2009). Additionally, Santo Island and its offshore neighboring island of Thion support 50 or more nesting turtles per year, and approximately 30 turtles nest annually at Tegua and Hiu islands. Coverage of Vanuatu's beaches is not yet comprehensive so total nesting activity may be underestimated. A number of sites have emerged over the past few years as index sites, in particular the Bamboo Bay area on the island of Malekula for greens. Based on the available information, it is assumed that 101-500 green turtles nest annually in this NA (Table 2). Current trend information is not available for this NA. Green turtles and their eggs are commonly harvested in Vanuatu, and there is a current movement to revive traditional management systems to regulate (or sustainably manage) community-based harvest of turtles (Hickey 2007). Other primary threats to green turtles identified in Vanuatu include nest predation by dogs and wave inundation (erosion).

<u>Marshall Islands NA</u>. The Marshall Islands NA consists of green turtles that nest in the Republic of the Marshall Islands (RMI), made up of 29 atolls and 5 islands with a total land area of approximately 70 square miles, and a total lagoon area of about 4,500 square miles (Figure 3). Atolls and low coral islands are aligned in two roughly parallel northwest-southeast chains: the northeastern Ratak Chain and the southwestern Ralik Chain. Green turtles are most common in the RMI with hawksbill turtles considered rare or scarce (NMFS 1998). Atolls most recognized as significant green turtle nesting areas include: Bikar, Erikub and the island of Jemo. Additional minor nesting sites include the atolls of Bokak, Ailinginae, Rongerik, Bikini, Wotje, and Taka (McCoy 2004). First described by Tobin (1952 in McCoy 2004), northern RMI atolls are well known traditionally as "game reserves" due to the presence of nesting turtles and seabirds (this refers to Bikar, Bokak, and Taka atolls, the island of Jemo, and certain islands in Erikub atoll). Nesting occurs from May through November, peaking mid-June to mid-September. Lagoons throughout Marshall Islands atolls provide significant areas of potential shallow water foraging habitat for sea turtles (Eckert 1993), but in general, sea turtle nesting and foraging activity are more common in inverse proportion to the closeness or density of human habitations and activities in the RMI (McCoy 2004).

Bikar Atoll likely supports the largest green turtle nesting assemblage in the RMI. Based on Hendrickson's observations in 1972 (cited in McCoy 2004), approximately 950 nests were laid, or 237 females may have nested annually at Bikar. At the time, Hendrickson concluded that Bikar represented one of the major breeding groups of sea turtles in the then-Trust Territory of the Marshall Islands (McCoy 2004). NMFS (1998) estimated a mean annual total of approximately 100-500 nesting females at Bikar Atoll based on an 11 night survey where 48 turtles were tagged in 1992. During the same expedition, 8 turtles were tagged in one night on Jemo and a one-time survey of Erikub Islet at Erikub Atoll revealed "…many nesting excavations, some well within the interior of the islet. So numerous were these excavations that no attempts were made to count them" (Puleloa and Kilma 1992). Also at Erikub, two pits were observed on Aradojairek Islet and 48 pits on Aradojairen Islet, although it was apparent that some of these were from previous seasons. Based on the available information, it is assumed that 101-500 green turtles nest in this NA annually (Table 2). Turtles in the RMI have long been known as a food source and have played an important cultural role in the lives of inhabitants. There has not, however, been a concerted research or management effort to conserve this cultural resource in the RMI. The level of exploitation of turtles is unknown, and there are no reports available on status of turtle stocks in the RMI (McCoy 2004). While there does not appear to be enough data to conclude if trends are increasing or decreasing, anecdotal information from local people suggests that number of nesters has decreased over time, possibly by as much as 50 percent in the last 10 years (McCoy 2004).

<u>West Kiribati NA</u>. The West Kiribati NA consists of green turtles that nest in the westernmost island group of Kiribati (formerly known as the Gilbert or Tungaru Islands) (Figure 3). The westernmost islands in Kiribati consist of a chain of 16 atolls and coral islands including Tawara,

the capital of Kiribati. In this NA, green turtles have been documented nesting at Tawara Atoll, Katangateman Sandbank northeast of Makin, and another sandbank by Nonouti Island (although anecdotally, turtles have historically nested at all 16 atolls and islands except Banaba [SPC 1979a]) with a minimum total of approximately 20 nests (possibly representing ~ 6 females) at Tarawa in 2007-2008 (Bell, Ruata, and Bebe 2009). No information is available regarding nest numbers at other sites or trend for this NA. Based on the limited available information, it is assumed that 1-25 green turtles nest annually in this NA (Table 2). In this NA, it is likely that we do not have accurate information about the abundance of nesting females because surveys of many potential nesting sites have not been conducted. Tawara Atoll, the most populated of Kiribati's islands and atolls, supports almost half of the human population. Green turtles may nest at many uninhabited or less populated islands and atolls for the most part undetected.

Tuvalu NA. The Tuvalu NA consists of green turtles that nest in Tuvalu, an independent nation made up of nine coral islands and atolls (Figure 3). In this NA, green turtles nest in the capital of Funafuti as well as on several outer islands (Pita 1979). The only available information on nesting turtles in Tuvalu is from a 10 day survey of nesting sites on Funafuti conducted in December 2006 where a total of 9 nest sites were identified (likely representing fewer than five females) (Alefaio *et al*. 2006). In 1979, turtle meat was rarely consumed in the capital of Funafuti but turtles were still taken from the water and nesting beaches for consumption in the outer islands where there was no refrigeration (Pita 1979). According to interviews with local fishermen in 2006, the number of turtles sighted and harvested has declined rapidly (Alefaio *et al*. 2006). Based on the limited available information, it is assumed that 1-25 females nest annually in this NA (Table 2).

Fiji NA. The Fiji NA consists of green turtles that nest in Fiji (Figure 3). In this NA, the last remaining nesting sites for green turtles are small, isolated islands and sand isles north of Taveuni including Nanuku Levu and Nukumbalati Islands within the Hemskercq and Ringgold reef systems. In 1970, eight nests were observed and in January 1980, 16 nests were observed at Nanuku Levu and Nukumbalati (Guinea 1993). As of 1996, the Fisheries Division estimated 30-40 nesting green turtles in Fiji (Weaver 1996) with a more recent estimate of 50-75 (Batibasaga *et al*. 2006). Based on the limited available information, it is assumed that 26 – 100 green turtles nest annually in this NA (Table 2). A commercial ban on sea turtle harvest was instituted in 1997 (Batibasaga 2002). However, green turtles in Fiji are regularly harvested for consumption and harvest continues to play a significant role in the subsistence economy of many Fijian communities despite harvest moratoriums [May 1997 to December 2000, and February 2004 to December 2008, recently extended through 2018] (Guinea 1993; Laveti and MacKay 2009). There are no long term studies in Fiji to provide information on sea turtle nesting trends but evidence suggests a decline in nesting green turtles due mainly to overharvest (Batibasaga *et al*. 2006).

Tonga NA. The Tonga NA consists of green turtles that nest in Tonga (Figure 3). The Kingdom of Tonga is composed of at least 170 islands, 36 of which are inhabited. Islands are grouped into three main regions: the Ha`apai Group, Vava`u Group, and Tongatapu Group. In this NA, green turtles nest in low levels on several islands in the Ha`apai Group as well as islands in the Vava`u Group, with an estimated 10-20 green turtle nests annually based on anecdotal information from turtle hunters (Havea and MacKay 2009). Sporadic nesting surveys were carried out in the

Ha`apai Group in December 1971, December 1973, and December 2007-January 2008 (Bell, Matoto, and Fa`anunu 2009) although most did not distinguish between hawksbill and green nests and effort was not consistent among surveys. Based on the limited available information, it is assumed that 1-25 females nest annually in this NA (Table 2). Havea and MacKay (2009) surveyed fishermen for their perceptions of sea turtle abundance trends in this island group. In spite of previous reports and an apparent decline in nesting turtles, <50 percent of fishermen reported that turtle stocks are declining and almost 40 percent indicated stocks were increasing. However, the survey did not distinguish between greens and hawksbills. Directed take of green turtles for consumption and sale still occurs in Tonga and protective laws and size limits are generally not adhered to or enforced (Havea and MacKay 2009). Limited available data on nesting in addition to these survey results suggest there may be a decline in green turtle nesting in Fiji (Havea and MacKay 2009).

West Polynesia NA. The West Polynesia NA consists of green turtles that nest in American Samoa, Tokelau, Pukapuka Atoll in the northern Cook Islands, and the Phoenix Islands in central Kiribati (Figure 3). In this NA, green turtles nest at Swains Island, Rose Atoll and Tutuila in American Samoa, all eight Phoenix Islands in Kiribati, all three atolls in Tokelau, and Pukapuka Atoll in the northern Cook Islands.

In American Samoa, sub-adult and adult green turtles occur in low abundance in nearshore waters around Tutuila, Ofu, Olosega, Ta’u and Swains Islands. Up to several dozen green turtles nest on Rose Atoll annually (review provided by Balazs 2009). No nesting trend data are available, but anecdotal information suggests major declines in the last 50 years (Tuato’o-Bartley *et al* 1993, Utzurrum 2002). Since 1971, 42 individual nesting green turtles have been flipper tagged on Rose Atoll (Grant *et al.* 1997) during various trips. Of seven post-nesting green turtles satellite-tagged at Rose Atoll in 1993-95, six migrated nearly directly to Fiji, possibly to feed on Fiji’s extensive seagrass beds (Craig *et al.* 2004). Several studies cited in a summary of nesting observations at Rose Atoll 1839-1993 (Balazs 2009) mention pits on Sand and Rose Islands (up to 301 in one survey), however it is unclear how that relates to numbers of individuals because some pits may have been from prior nesting seasons. To date, four genetic samples from stranded or foraging turtles around Tutuila have been analyzed. Two samples from stranded green turtles in Pago Pago harbor had a haplotype known from nesting green turtles in American Samoa, Yap, and the Marshall Islands. However, since many green turtle nesting aggregations in the Pacific still have not been sampled, it is possible that this haplotype occurs at more than these three sites. In addition, two samples have been analyzed from foraging green turtles at Fagaalu, but the haplotype is of unknown nesting origin (Peter Dutton, pers. comm.).

No green turtle nesting occurs in Independent Samoa, though 36 adult females and 14 adult males were opportunistically examined during a hawksbill research program conducted by the Western Samoa Fisheries Division during October 1970 to May 1973 (Witzell 1982). While adult greens were observed near reefs year-round, during December-February, they were observed gathering near reef passages connecting large lagoonal foraging areas near Upolu Island. Witzell (1982) surmised that these adults may be part of the group that nests on Rose Atoll during August-September.

The Phoenix Islands are under jurisdiction of Kiribati and consist of eight low coral islands and atolls. Green turtle nesting has been observed at all eight locations including Canton, Nikumaroro, Enderbury (aka Rawaki), Phoenix, Birnie, Hull (aka Orona), Sydney (aka Manra), and McKean Islands. Canton and Enderbury Islands reportedly host the largest numbers of nesting green turtles of these eight sites. Observations in the early 1970s suggested several hundred nesting females occurred on Canton Island (Balazs 1975) and a survey done in the summer of 2002 recorded at least 160 old nests on Enderbury Island (Obura and Stone 2002). A combined total of 60-80 nests were recorded annually (possibly representing ~ 20-30 females) at the other six islands in the Phoenix group during surveys in the summers of 2000 (Stone *et al*. 2001) and 2002 although this is likely an underestimate of nesting activity because the peak nesting season regionally is October – November (Balazs 1995). Combining available information, it is estimated that 100-300 green turtles may nest in the Phoenix group annually. Little to no information on trend is available for the Phoenix group.

Tokelau consists of three coral atolls, Atafu, Nukunonu, and Fakaofu, all of which are known to have green turtle nesting. Balazs (1983) estimated 120 total nesting females annually in Tokelau. Sea turtle capture rates declined from the early 1900s to the 1980s despite more sophisticated hunting methods, indicating a likely decline resident or nesting turtles (Balazs 1983). Updated information regarding abundance and trends of nesting green turtles in Tokelau was not available to the authors at the time of writing.

Pukapuka is a coral atoll in the northern Cook Islands. Green turtles nest on one of the uninhabited islets and there is some directed harvest of turtles and eggs (Balazs 1995). No further information on abundance or trends of nesting green turtles at this site was available to the authors at the time of writing.

Based on the available information, it is assumed that a mean annual total of approximately 101-500 females nest in this NA (Table 2). There is little to no information on the trend of nesting green turtles in this NA, although the available information suggests there may be a decline in recent times.

<u>Northern Cook Islands NA</u>. The Northern Cook Islands NA consists of green turtles that nest in the northern Cook Islands, except for Pukapuka Atoll, which is included as part of the West Polynesia NA (Figure 3). The Cook Islands consist of 15 volcanic islands and atolls. In this NA, green turtles nest at Penrhyn, Rakahanga and Manihiki Atolls. Reports from the 1960s and 1970s indicate the presence of green turtle nesting activity at these locations but no further details on nesting female abundance or trends are available (Balazs 1995). Woodrom-Rudrud (2010) additionally lists green turtle nesting activity at Suwarrow atoll and Nassau island, although information regarding number of nesting females is not included for these sites. Based on limited available information, it is assumed that 1-25 green turtles nest annually in this NA (Table 2).

<u>Southern Cook Islands NA</u>. The Southern Cook Islands NA consists of green turtles that nest in the southern Cook Islands (Figure 3). In this NA, green turtles nest primarily at Palmerston Island, which hosts the majority of green turtle nesting within the Cook Islands. According to a review provided by Balazs (1995), reports from the 1960s and 1970s refer to Palmerston as an

important nesting location for green turtles in the Pacific, although no indications of numbers of nesting females were provided. From 1972 to 1977 a decline in the number of nesting turtles was observed by inhabitants (Balazs 1995). Annual nesting numbers declined from 30-40 to <10 in under ten years (Helfrich 1974). Additional sites in the southern Cook Islands identified by Woodrum-Rudrud (2010) include Mangaia, Atiu, Mauke, and Roratonga islands, although no further information on nesting abundance is available. Based on the limited available information, it is assumed that 1-25 green turtles nest annually in this NA (Table 2).

Northern Line Islands NA. The Northern Line Island NA consists of green turtles that nest in the northern Line Islands. The Line Islands consist of eleven atolls and coral islands in the central Pacific south of Hawaii, eight of which belong to Kiribati and three of which are the U.S. possessions of Palmyra Atoll, Kingman Reef, and Jarvis Island (Figure 3). In this NA, green turtles have been documented nesting at Palmyra Atoll, Jarvis Island, and Christmas and Fanning Islands in Kiribati. Information on abundance of nesting females in recent years is not available for this NA as no surveys have been conducted. Low-level nesting at Palmyra was observed in 1987 and along the west coast of Jarvis Island in the 1930s (NMFS & FWS 1998) but more recent information is not available. Turtles appear to have declined considerably at both Fanning and Christmas Islands between the early 1800s when human habitation began and the 1990s (Balazs 1995). Based on the limited available information, it is assumed that 1-25 green turtles nest annually in this NA (Table 2).

Southern Line Islands NA. The Southern Line Islands NA consists of green turtles that nest in the southern Line Islands of Kiribati (Figure 3). In this NA, green turtles have been reported nesting at Vostok and Caroline Islands although details regarding numbers of nesting females were not provided (Balazs 1995). Further information is not available for green turtle nesting abundance or trends in this NA. Based on the limited available information, it is assumed that 1-25 green turtles nest annually in this NA (Table 2).

West French Polynesia NA. The West French Polynesia NA consists of green turtles that nest in western and central French Polynesia (Figure 3). French Polynesia consists of 130 islands and atolls spread over a large geographic area in the central south Pacific. In this NA, green turtles have historically been observed nesting at Tupai, Bellinghausen, Mopelia, Manihi Atoll, Tetiaroa Atoll, and Scilly Atoll. Based on the available information, approximately 101-500 green turtles nest annually in this NA (Table 2). Nesting is concentrated at Scilly Atoll (AKA Manuae) in the Leeward Islands, and observations in the late 1970s, early 1980s, and early 1990s suggested 300-400 nesting females occurred there annually (Lebeau 1985; Balazs *et al.* 1995). These observations in conjunction with information from local residents indicate a decline in nesting numbers between the 1950s and early 1970s, although numbers may have stabilized between 1972 and 1991 (SPC 1979b; Balazs *et al.* 1995; Pritchard 1995). Nesting females and adult males tagged at Scilly Atoll have been recovered in Tonga, New Caledonia, Vanuatu, the Cook Islands, and Fiji; this tag return information reveals some of the longest range migrations recorded for green turtles (SPC 1979b).

Nesting occurred on Manihi Atoll in 1971 (Hirth 1971, cited in Pritchard 1995) but no more recent information is available. Sporadic nesting surveys at Tetiaroa Atoll have been conducted since 2004 (Te Mana o te Moana 2008) although 2008-2009 was the first nesting season with an organized, sustained survey effort which revealed 81 crawls and 33 nests (Te Mana O Te Moana 2009). Low level nesting has also been observed at Tikehau Atoll (Te Honu Tea 2008).

East French Polynesia NA. The East French Polynesia NA consists of green turtles that nest in eastern French Polynesia (Figure 3). In this NA, green turtles have been documented historically nesting at Pukapuka Island (a different island from Pukapuka coral atoll in the northern Cook Islands). The most recent information is from 1938 and does not provide an estimate of annual nesting females, although it is noted that turtles and eggs were regularly taken for consumption and residents were already beginning to observe turtles "dying out" (Beaglehole and Beaglehole 1938, cited in Pritchard 1995). Based on the limited available information, it is assumed that 1-25 green turtles nest annually in this NA (Table 2).

Pitcairn Islands NA. The Pitcairn Islands NA consists of green turtles that nest in the Pitcairn Islands, a British overseas territory consisting of four volcanic islands (Figure 3). In this NA, green turtles nest at Henderson Island with an estimated total of 10 females annually (Brooke 1995). No nesting was recorded at Pitcairn, Ducie, or Oeno Islands during the 1991-1992 nesting season. Pitcairn and Ducie were deemed to have unsuitable substrate for nesting while Oeno had suitable substrate but no activity was observed (Brooke 1995). This small nesting assemblage does not appear to be threatened by direct harvest or other major anthropogenic sources of impact. Based on the limited available information, 1-25 green turtles nest annually in this NA (Table 2).

Summary for Green Turtles in Oceania. According to the information above, the total number of green turtles nesting annually in Oceania is 17,399-37,525 females (Table 2). The region is divided into 24 NAs, but the Australian NAs (Northern GBR, Southern GBR) make up approximately 90 percent of the total (Table 2). Over half of all nesting in Oceania occurs at a single island in the Northern GBR NA, Raine Island. Trend data are not available for all of the 24 NAs. However, trend data are available for certain nesting sites within the Ogasawara Island, Northern GBR, Southern GBR, and Hawaii NAs where long term monitoring projects have been collecting data for long enough to determine a significant trend. Trend information provided for other NAs is based on strong documented anecdotal evidence from local residents, not long term nesting beach monitoring datasets. Nesting trends appear stable at Raine Island in the Northern GBR NA as well as at Heron Island in the Southern GBR NA, and increasing at Chichi-jima in the Ogasawara Island NA (Chaloupka *et al*. 2007, Dobbs 2002).

However, stable and increasing nesting trends at these sites do not necessarily correlate with a stable or increasing trend overall for Oceania because of low nesting success, hatchling production, and recruitment at Raine Island, where the majority of nesting for the entire region occurs (Limpus *et al*. 2003, Hamann *et al*. 2009). In addition, NAs with small numbers of nesting females may be of greater importance than their proportional numbers indicate (Bjorndal and Bolten 2008). Loss of individuals from smaller, more vulnerable Pacific island rookeries is likely to have a greater impact on that particular nesting assemblage than removal of individuals from a large rookery. Over half of the 24 NAs in Oceania have 100 or fewer documented nesting females annually. Many of these NAs are geographically isolated and likely harbor unique genetic diversity. Small nesting assemblages of green turtles are unlikely to re-colonize historic nesting areas after they have been extirpated (Avise and Bowen 1994).

Table 2. Summary of best currently available nesting information for green turtles in Oceania.

Nesting Aggregation	Annual nesting females	
	Number	Trend
Hawaii	501-1,000	Increasing
Ogasawara Islands	101-500	Increasing
East Micronesia	101-500	Unknown
West Micronesia	501-1,000	Unknown
Northern Papua New Guinea	26-100	Unknown
Milne Bay, Papua New Guinea	26-100	Decreasing*
Solomon Islands	101-500	Unknown
Northern Great Barrier Reef	10,001-20,000	Stable
Southern Great Barrier Reef	5,001-10,000	Stable
New Caledonia	1,001-2,000	Stable*
Vanuatu	101-500	Unknown
Marshall Islands	101-500	Decreasing*
West Kiribati	1-25	Unknown
Tuvalu	1-25	Decreasing*
Fiji	26-100	Decreasing*
Tonga	1-25	Decreasing*
West Polynesia	101-500	Unknown
Northern Cook Islands	1-25	Unknown
Southern Cook Islands	1-25	Unknown
Northern Line Islands	1-25	Unknown
Southern Line Islands	1-25	Unknown
West French Polynesia	101-500	Unknown
East French Polynesia	1-25	Unknown
Pitcairn Islands	1-25	Unknown
Total	17,399-37,525	Unknown

* = Trend information is based on strong documented anecdotal evidence from local residents, not on long term nesting beach monitoring data sets.

5.1.2 Life History Characteristics Affecting Vulnerability to Proposed Action

Green turtle life history is characterized by early development in the oceanic (pelagic) zone followed by later development in coastal areas. Average size at recruitment to neritic habitats for Pacific green turtles ranges from 35-50cm CCL (Balazs 1980; Limpus *et al*. 2003). Eleven of the thirteen green turtles observed caught by the American Samoa longline fishery in April 2006-August 2010 were within this range (see Section 7.2 below for more information about the 13 observed turtles). Adults forage in shallow coastal areas, primarily on algae and seagrass. Unlike some other sea turtle species, upon maturation green turtle adults do not typically undertake trans-oceanic migrations to breeding sites. However, long migrations may still occur between foraging and nesting areas, such as those undertaken by Hawaiian green turtles between the main Hawaiian Islands and French Frigate Shoals (NMFS & USFWS 2007a). All observed interactions of green turtles in the American Samoa longline fishery have been juveniles 24-50 cm SCL that had not yet recruited to nearshore habitat. Hence, the main aspect of green turtle life history affecting their vulnerability to longline fishing appears to be utilization of pelagic habitats, especially during the juvenile life history stage.

During their post-hatchling/juvenile life history stage, green turtles in the southwestern Pacific inhabit the pelagic zone, and at an average of 44 cm SCL they recruit to inshore foraging habitats where they become primarily herbivorous on algae and seagrass (Arthur *et al*. 2008). In the southwest Pacific Ocean, juvenile green turtles have a pelagic phase of approximately five to ten years. Little is known of the migration and ecology of juvenile green turtles during their pelagic phase (the "lost years"). It is generally accepted that after the initial 'swim frenzy' period to reach offshore habitats, post-hatchlings are dispersed by the prevailing surface ocean currents for a period of time before beginning active swimming as pelagic juveniles to eventually recruit to neritic foraging grounds (Carr 1987; Collard and Ogren 1990; Luschi *et al*. 2003). A study of post-hatchling green turtles from the Great Barrier Reef (GBR) found that juveniles from the northern GBR are most likely associated with offshore warm water gyres in the Coral and Tasman Seas, whereas juveniles from the southern GBR are most likely associated with the offshore warm water gyres that are formed by the Eastern Australian Current off the eastern Australian shelf (Boyle 2006).

Because of the large number of post-hatchlings produced from the tens of thousands of annual nesting females in the GBR area, and the long duration of the juvenile pelagic phase (5 – 10 years), some juvenile green turtles from the GBR area may eventually enter the action area at some point. For example, of the nine sampled juvenile turtles from the American Samoa longline fishery, two had haplotypes known from nesting females in the GBR, Coral Sea, and New Caledonia (see Section 7.1 for more details). In addition, a juvenile green turtle caught just north of the action area by a purse seine fishery had a haplotype known from nesting females in the GBR, and also from nesting females in the Marshall Islands, Timor Sea, and Indian Ocean, but not yet identified in nesting females in or near the action area (Peter Dutton, pers. comm.).

During their pelagic phase, juvenile green turtles feed omnivorously on a range of planktonic material including crustaceans, jellyfish and ctenophores. Green turtles take tuna hooks baited with squid or fish, as demonstrated by bycatch of green turtles in several tuna longline fisheries in the Pacific (Beverly and Chapman, 2007). For example, both juvenile and adult green turtles are caught in the Hawaii deep-set longline fishery, although at a much lower rate than previous years (NMFS 2005). Very little is known of juvenile or adult green turtle pelagic foraging behavior, such as foraging depth. The deepest dives recorded for green turtles are from adults migrating from the main Hawaiian Islands to the Northwestern Hawaiian Islands. Several turtles dived to >100 m depth in pelagic areas, where they may have been exploiting a planktonic food source, resting, or avoiding predators (Rice and Balazs 2008).

Green turtles nest on Rose Atoll in American Samoa (Balazs 2009). From 1971-1996, 46 adult female green turtles were flipper tagged at Rose Atoll after they nested, but only three were recaptured; two in Fiji and one in Vanuatu, all dead (Balazs *et al*. 1994). Migrations of seven post-nesting green turtles at Rose Atoll were tracked by satellite transmitters in 1993–1995. Most turtles migrated 1,600 km to foraging areas in Fiji, whereas one turtle migrated to Raiatea in French Polynesia (Craig *et al*. 2004). In addition to the above 53 green turtles tagged at Rose Atoll, 513 were tagged at Scilly Atoll in French Polynesia between 1972 and 1991. Of these, a total of 14 were recovered in Fiji (6 turtles), Vanuatu (3), New Caledonia (2) Wallis Island (1), Tonga (1) and Cook Islands (1). Thus, of the 17 recovered turtles that were flipper-tagged in American Samoa or French Polynesia, 8 were recovered in Fiji. Of the seven turtles that were satellite tagged in American Samoa, 6 went to Fiji. Green turtles in American Samoa and French Polynesia are thought to migrate to Fiji after nesting to forage in Fiji's abundant, shallow seagrass and algae habitats (Craig *et al*. 2004). In so doing, these migrating adult green turtles pass through the action area where they may be vulnerable to the American Samoa longline fishery.

While all green turtles observed caught so far in the American Samoa longline fishery have been juveniles, the Hawaii deep-set longline fishery interacts with both juvenile and adult green turtles. As described above, adult green turtles may undertake migrations between nesting and foraging habitat, during which time they may cross large expanses of pelagic habitat where these fisheries operate. Therefore, although no adult green turtles have been observed captured in the American Samoa longline fishery thus far, it is likely that adults occur in the action area.

5.1.3 Threats to the Species

Global threats to green turtles are listed and discussed in the 5-year review (NMFS & USFWS 2007a). Major threats according to this document are alteration of nesting and foraging habitat, fishing bycatch, and direct harvest, which are briefly described below. Impacts that may occur as a result of climate change also appear to be having an effect on this species, and are also addressed below.

Destruction and alteration of green turtle nesting and foraging habitats are occurring throughout the species' global range, especially coastal development, beach armoring, beachfront lighting, and vehicular/ pedestrian traffic. While under natural conditions beaches can move landward or seaward with fluctuations in sea level, extensive shoreline hardening (e.g., seawalls) inhibits this natural process. Beach armoring is typically done to protect coastal development from erosion during storms, but armoring blocks turtle nesting and often leads to beach loss. Coastal development also increases artificial lighting, which may disorient emerging hatchlings, causing them to crawl inland towards lights instead of seaward. Coastal development also improves beach access for humans, resulting in more vehicular and foot traffic on beaches, causing compaction of nests and thereby reducing emergence success. Adult green turtles are primarily herbivores that forage on seagrass and algae in shallow areas. Contamination from runoff degrades seagrass beds, and introduced algae species may reduce native algae species preferred by green turtles (NMFS & USFWS 2007a).

Although fisheries bycatch of loggerheads and leatherbacks has received most of the attention relative to sea turtle bycatch (e.g., Lewison *et al*. 2004), green turtles are also susceptible, particularly in the nearshore environment, to artisanal fisheries gear. These fisheries use a vast diversity of gears, including drift gillnets, long-lining, set-nets, pound-nets, trawls, and others, and are typically the least regulated of all fisheries while operating in the areas with greatest density of adult green turtles (NMFS & USFWS 2007a). Industrial fisheries also interact with green turtles, especially juveniles, like in the Hawaii-based deep-set and American Samoa longline fisheries.

Harvest of green turtles for their meat, shells, and eggs has been a major factor in the past declines of green turtles, and continues to be a major factor in some areas. For example, a legal fishery operates in Madagascar that harvested about 10,000 green turtles annually in the mid-1990s. On the Pacific coast of Mexico in the mid-1970s, more than 70,000 green turtle eggs were harvested every night. Globally, harvest of adults and eggs is reduced from previous levels, but still exists in some parts of the species' range. In Mexico, extensive illegal adult harvest still takes place. Many nations that host nesting or foraging green turtle aggregations in Oceania still allow harvest or have poorly enforced restrictions. Fiji in particular has extensive seagrass beds that serve as a regionally significant mixed foraging ground for green turtles from a variety of nesting aggregations (Craig *et al*. 2004; Limpus 2004); however these turtles are subject to unsustainable direct harvest pressure (Laveti and MacKay 2009). Unregulated harvest continues throughout other central and south Pacific Island areas as well (SPREP 2007). The curio trade in Southeast Asia also harvests a large but unknown number of green turtles annually (NMFS & USFWS 2007a). Although it is unclear exactly which stocks are impacted by commercial poaching activities, it is believed that impacts are greatest to turtles originating from the western range of the Western/South Pacific region (Limpus and Miller 2008).

Although green turtles are probably already beginning to be affected by impacts associated with anthropogenic climate change in several ways (described in more detail in the Environmental Baseline section below), no significant climate change-related impacts to green turtle populations have been observed to date. However, impacts from climate change are likely to influence biological trajectories in the future over the long-term, on a century scale (Paremsan and Yohe 2003). For example, increasing temperatures at nesting beaches may impact sex ratios of hatchlings (many rookeries already exhibit strong female bias [Binckley et al. 1998; Chan and Liew 1995; Godfrey et al. 1996; Godfrey et al. 1999; Godley et al. 2001; Kaska et al. 2006; Marcovaldi et al. 1997; Oz et al. 2004]) and/or increase embryonic mortality (Matsuzawa et al. 2002). Increased nest mortality has also been linked to erosion due to increased typhoon frequency (VanHoutan and Bass 2007) and intensity, a predicted consequence of climate change (Webster et al. 2005). Seagrasses are a major food source for green turtles worldwide. Seagrass habitats may suffer from decreased productivity and/or increased stress due to sea level rise and salinity and temperature changes (Short and Neckles 1999; Duarte 2002). Climate change induced shifts in ocean productivity linked to temperature changes (Harwood 2001; Edwards & Richardson 2004; Hays et al. 2005) may affect foraging strategies and therefore reproductive capacity for green turtles (Solow et al. 2002), similar to what has been observed during El Nino events in the western Pacific (Limpus and Nicholls 1994; Chaloupka 2001). While there is some available data on past trends, this data is limited, and current scientific methods are not able to reliably predict the future magnitude of climate change and associated impacts or the adaptive capacity of this species. Due to a lack of scientific data, specific effects climate change will have on this species in the future are not predictable or quantifiable to any degree such as would allow for more detailed analysis in this consultation (Hawkes et al. 2009). Based on the available information, climate change-related impacts are not considered significant within the context of the temporal scale of this action, as discussed further in the Environmental Baseline and Cumulative Effects sections below.

5.1.4 Conservation of the Species

Green turtles nesting in the U.S. have benefited from both State and Federal laws passed in the early 1970s banning the harvest of turtles and their eggs. Protection and management activities since 1974 throughout the Hawaiian Archipelago and habitat protection at the French Frigate Shoals nesting area since the 1950's have resulted in increased trends of both nesting and foraging turtles in Hawaii (Balazs and Chaloupka 2004). Elsewhere, the protection of nesting beaches from large-scale egg harvest appears to have reversed downward nesting trends in some cases. For example, nesting beach protection began at Colola, Mexico in 1979, and the number of nesting green turtles began to increase 17 years later in 1996 after reaching a low point in the late 1980s through mid-1990s. Using long-term data sets, encouraging trends in green turtle nester or nest abundance over the past 25 years have become apparent in at least six locations including Hawaii, Australia, Japan, Costa Rica and Florida (Chaloupka *et al*. 2007). Efforts to reduce fisheries bycatch of loggerheads, leatherbacks, and olive ridleys also benefit green turtles, such as the improvements made in the Hawaii-based longline fishery since the 1990s (NMFS & USFWS 2007a).

Between 2004 and 2007, the Inter American Tropical Tuna Commission (IATTC) coordinated and implemented a circle hook exchange program to experimentally test and introduce circle hooks and safe handling measures to reduce sea turtle bycatch in mahi-mahi and tuna/billfish artisanal longline fisheries in Ecuador, Peru, Panama, Costa Rica, Guatemala and El Salvador. Almost all (99 percent) of fishery/turtle interactions identified by this program were with green and olive ridley sea turtles. By the end of 2006, over 1.5 million J hooks had been exchanged for turtle-friendly circle hooks (approximately 100 boats). Overall, circle hooks have reduced interaction rates by 40 to 80 percent in most artisanal fisheries that switched gear types, with deep hookings reduced by 20 to 50 percent. Experiments to reduce longline gear entanglements have also been successful. Importantly, the project has demonstrated that turtle interaction rates in artisanal mahi-mahi and tuna/billfish fisheries can be studied and reduced (Largacha *et al*. 2005; Hall *et al*. 2006).

The conservation and recovery of green turtles is facilitated by a number of regulatory mechanisms at international, regional, national and local levels, such as the FAO Technical Consultation on Sea Turtle-Fishery Interactions, the Inter-American Convention for the Protection and Conservation of Sea Turtles, CITES, IOSEA, and others. As a result of these designations and agreements, many of the intentional impacts on sea turtles have been reduced: harvest of eggs and adults have been slowed at several nesting areas through nesting beach conservation efforts and an increasing number of community-based initiatives are in place to slow the take of turtles in foraging areas (Gilman *et al*. 2007b; NMFS & USFWS 2007a). It is worth noting, however, that in many of the countries that host nesting aggregations of green turtles that may contribute juveniles to the action area, direct harvest of green turtles is still legal and, in some cases, unregulated.

5.2 Hawksbill Turtles

Information in this section is summarized primarily from the most recent hawksbill turtle 5-year status review (NMFS & USFWS 2007b), Volume III of the State of the World's Sea Turtles Report (SWOT 2007-2008), and other sources cited below.

5.2.1 Distribution and Abundance

Hawksbills occur in at least the Insular and Western Caribbean, Southwestern and Eastern Atlantic, the Southwestern, Northwestern, and Central/ Eastern Indian Ocean, and the Western, Central, and Eastern Pacific. As described in the recent 5-year review (NMFS & USFWS 2007b), available trend data for the past 20 years suggest that, while some Caribbean/Atlantic sub-populations may be increasing, nearly all Indian and Pacific sub-populations are decreasing. The American Samoa longline fishery is not known to have interacted with any hawksbills, but observer coverage has been <10 percent, and there is one unconfirmed report of a hawksbill interaction in this fishery. Hawksbill interactions occasionally occur in other longline fisheries in the Atlantic (Yeung 1999) and Pacific (Robins *et al*. 2002), and hawksbills are the most common sea turtle species in nearshore American Samoa waters and on nesting beaches, thus the American Samoa longline fishery may interact with adult hawksbills migrating to or from their nesting beach or resident foraging hawksbills while vessels are transiting through nearshore waters.

As with green turtles, hawksbill turtles nest broadly in Oceania, with by far the largest nesting concentration occurring on remote islands in the Great Barrier Reef (GBR) area. But unlike green turtles, hawksbills are solitary nesters, hampering data collection on nesting female numbers, thus all nesting numbers cited below are rough estimates. Hawksbill nesting information is available for eight locations within Oceania: GBR, PNG, Solomon Islands, Vanuatu, Fiji, Micronesia (Federated States of Micronesia and Palau), the Samoan Islands (Western Samoa and American Samoa), and the Mariana Islands (Guam and CNMI). Hawksbill nesting may occur elsewhere within this region, but any such nesting is thought to be in very low numbers. Thus, the total number of annual nesting females in Oceania is estimated based on information from the eight locations mentioned above at 5,400 – 6,140 females annually for the last few years, with an overall downward trend (NMFS & USFWS 2007b). Nesting information from each of the eight locations is described in more detail below.

Great Barrier Reef (GBR). Approximately 4,000 female hawksbills may nest annually on offshore islands in the northern GBR area. The Milman Island index population in this area, surveyed since 1990, is declining at a rate of 3 percent annually (NMFS & USFWS 2007b). Limpus and Miller (2008) estimate that large numbers of hawksbills sourced from Australian rookeries are being harvested in neighboring countries including Indonesia, PNG, Solomon Islands and Fiji to supply meat and/or tortoiseshell for use locally or for export.

Papua New Guinea (PNG). Approximately 500-1,000 female hawksbills may nest in PNG annually (NMFS & USFWS 2007b), and previous anecdotal assessments indicated decreasing trends (Pritchard 1979; Spring 1982). PNG continues to be a trade hub for hawksbill turtles. Based on a survey of eight provinces, Kinch (2007) estimates that approximately 250 hawksbill turtles are sold annually in Port Moresby; however, this take may represent only a small fraction of the overall subsistence and semi-commercial take of hawksbills in PNG.

Solomon Islands. Approximately 200-300 hawksbills may nest annually in the Solomon Islands, including 100-200 in the Arnavon Islands (NMFS & USFWS 2007b). Approximately 400 nesting hawksbill turtles were tagged in the Anarvon Islands from when monitoring first began in the 1970's through 1998 (Broderick unpublished, 1998). Broderick then estimated that approximately 1000 hawksbill turtles may nest within the Anarvons; however continued exploitation at an unsustainable level has reduced the number of nesting turtles. Meylan and Donnelly (1999) estimated at least a 50 percent decline since 1980, due largely to local consumption and the tortoiseshell trade and the decline is thought to be ongoing (NMFS & USFWS 2007b).

Vanuatu. Approximately 300 hawksbills may nest annually in Vanuatu. Nesting occurs at several locations throughout the country, some of which experience heavy hawksbill harvest. However, other nesting areas have little or declining harvest, because of successful public awareness programs. While hawksbill nesting trends are declining nearly everywhere in the Pacific, in Vanuatu they may be stable or even increasing, but adequate information is not available to determine the actual trend (NMFS & USFWS 2007b).

Fiji. Approximately 100-200 hawksbills may nest annually in Fiji. Little data exist for the major nesting areas, with the exception of Namena Lai Lai, where a 50 percent decline in nesting over 20 years was reported in 2007. Commercial harvest of hawksbill turtles in Fiji resulted in over 30,000 shells exported during the 1980s (Rupeni *et al*. 2002). It is likely that overall numbers of nesting female hawksbills in Fiji are declining (NMFS & USFWS 2007b).

Tonga. In the 1970s, surveys revealed that hawksbills nested on over thirty islands throughout the Vava`u and Ha`apai Island groups in Tonga, although this aggregation was perceived as declining precipitously (Wilkinson 1979). Another limited survey in December 2007-January 2008 only recorded nesting activity on two islands but suggests nesting levels may be similar to those in the 1970s (Havea and MacKay 2009). Abundance of annual nesting females is unknown for Tonga but the aggregation is likely small, possibly fewer than 50 individuals per year.

Micronesia (FSM & Palau). The Federated States of Micronesia (FSM) and Republic of Palau likely support approximately 300 nesting hawksbills annually. Palau appears to have the largest remaining nesting area (20-50 females annually) at Helen Reef, Hatohobei State. In FSM, hawksbills are heavily exploited, thus the overall trend for Micronesia is thought to be declining (NMFS & USFWS 2007b).

Samoan (Samoa and American Samoa) and Mariana (Guam and CNMI) Islands. In the Samoan Islands, fewer than 30 hawksbills are estimated to nest annually. However, there is some uncertainty regarding the number of hawksbill turtles nesting in American Samoa as a result of new information from the Manu’a Islands (Ofu, Olosega, and Ta’u islands). Nesting activity in Manu’a has been inferred from occasional tracks found on beaches, but has only recently been confirmed via a beach monitoring project. In January 2008, nine sets of hawksbill turtle tracks were recorded on two beaches of Ofu Island and one beach on Olosega Island. Approximately 30 pits were documented at the airport beach area of Ofu Island (DMWR/Wildlife Division, unpublished data). A project implemented in 2010 will monitor and quantify this nesting activity. The Aleipata islands of Nu’utele and Nu’ulua are the most important hawkbill nesting sites in Western Samoa (Bell and Mulipola 1995). Nesting beach monitoring at the Aleipata islands has been relatively inconsistent, although available information suggests that nesting activity has declined since the first monitoring activities in 1971 (Ward and Asotai 2008). In the Mariana

Islands, fewer than 10 hawksbills are estimated to nest annually. In both archipelagos, hawksbill nesting trends are declining (NMFS & USFWS 2007b).

Summary: Based on the above information, the total number of nesting female hawksbills in Oceania is estimated at 5,400-6,140 females annually for the last few years, with an overall downward trend likely, in part, due to continued exploitation (NMFS & USFWS 2007b). This status and trend information is summarized below in Table 3.

Table 3. Summary of best currently available nesting information for hawksbills in Oceania.

Location	Annual nesting females	
	Range	Trend
Great Barrier Reef	4,000	Decreasing
Papua New Guinea	500-1,000	Decreasing*
Solomon Islands	200-300	Decreasing*
Vanuatu	300	Unknown
Fiji	100-200	Decreasing*
Tonga	1-50	Decreasing*
Micronesia	300	Decreasing*
Samoan Islands	1-30	Decreasing*
Mariana Islands	1-10	Decreasing*
Total	5,402-6,140	Decreasing

* = Trend information is based on strong documented anecdotal evidence from local residents, not on long term nesting beach monitoring data sets.

5.2.2 Life History Characteristics Affecting Vulnerability to Proposed Action

As with green turtles, hawksbill life history is characterized by early development in the pelagic zone followed by later development in nearshore habitats. Adults forage on coral reefs, primarily on sponges. Upon maturation adults do not typically undertake trans-oceanic migrations to breeding sites, but hawksbills are known to undertake long migrations in the Caribbean between foraging and nesting areas (NMFS & USFWS 2007b). In the Western/South Pacific Region, more than a decade of tag recovery data indicate regular hawksbill migration between nesting and foraging sites in Queensland and the Solomon Islands (Limpus 2009). One hawksbill satellite tagged in 2006 migrated through seven exclusive economic zones in the central South Pacific (NMFS 2006, unpublished satellite telemetry data).

The main aspect of hawksbill life history affecting their vulnerability to the American Samoa longline fishing appears to be juvenile pelagic foraging, but almost nothing is known of this life history stage of hawksbill turtles. There is no bycatch in Pacific U.S. longline fisheries to provide information on the relative vulnerability of juvenile hawksbill turtles to the various types of longline fishing. Because juvenile hawksbills recruit to coastal habitat at <40 cm carapace length, perhaps they are too small to ingest bait and hooks used in the American Samoa longline fishery during their pelagic phase (NMFS & USFWS 2007b).

As with green turtles, while adult hawksbill habitat is primarily nearshore areas far within the longline exclusion areas of the action area, post-nesting adults are known to migrate great distances that take them into pelagic habitat where the American Samoa longline fishery operates. Some hawksbill nesting occurs in American Samoa, especially on Tutuila Island. Of two post-nesting hawksbills fitted with satellite tags on Tutuila, one migrated several hundred km to Samoa, and one migrated > 1,000 km to the Cook Islands (Tagarino *et al*. 2008). In addition, post-nesting hawksbills on the GBR migrated >2,000 km (Miller *et al*. 1998). This contrasts with post-nesting hawksbills in the Hawaiian Archipelago, which migrated < 100 km (Parker *et al*. 2009), perhaps because Hawaii is more isolated than archipelagos in the western and south Pacific where there are multiple atolls and islands within a few hundred km of each other.

5.2.3 Threats to the Species

Global threats to hawksbill turtles are spelled out in the 5-year review (NMFS & USFWS 2007b). The major threats to the species, according to this document, are alteration of nesting and foraging habitat, and direct harvest, which are briefly described below. While hawksbill interactions occur in fisheries, their bycatch rates are much lower than for the other sea turtle species, especially in industrial fisheries. The impacts associated with climate change also appear to be having an effect on this species, as it is for green turtles.

Destruction and alteration of hawksbill nesting and foraging habitats are occurring throughout the species' global range, especially coastal development, beach armoring, beachfront lighting, and vehicular/ pedestrian traffic. While under natural conditions beaches can move landward or seaward with fluctuations in sea level, extensive shoreline hardening (e.g., seawalls) inhibits this natural process. Beach armoring is typically done to protect the coastal development from erosion during storms, but armoring blocks turtle nesting and often leads to beach loss. Coastal development also increases artificial lighting, which may disorient emerging hatchlings, causing them to crawl inland towards the lights instead of seaward. Coastal development also improves beach access for humans, resulting in more vehicular and foot traffic on beaches, causing compaction of nests and thereby reducing emergence success. Adult hawksbills are primarily spongivores that forage on coral reefs, hence human impacts on their foraging habitat can be devastating. Contamination from runoff degrades coral reefs, and introduced algae species may outcompete and overgrow coral reefs, eventually killing them and the sponges they harbor. In addition, increasing boat traffic increases the likelihood of boat strikes (NMFS & USFWS 2007b).

Hawksbills are harvested for their shells ('tortoiseshell') and eggs. Because of the beauty of their shells, hawksbill adults have been harvested more heavily than other sea turtle species. The largest source of mortality identified for south Pacific hawksbills is continued harvest for food and tortoiseshell in the broader Coral Sea region (Limpus and Miller 2008). Between 1950 and 1992, approximately 1.3 million hawksbill shells were collected to supply tortoiseshell to the Japanese market, the world's largest. Japan stopped importing tortoiseshell in 1993 in order to comply with CITES. However, tortoiseshell trade continues in the Americas and Southeast Asia for both tortoiseshell and the curio trade. As with other sea turtle species, egg harvest has occurred on a large scale in the past, but is somewhat reduced globally. However, egg harvest continues unabated in Asia, especially in Sri Lanka, Thailand, Malaysia and Indonesia. In addition, adults are also still heavily harvested on their nesting beaches and in foraging areas, especially in Southeast Asia, Melanesia, and Polynesia (NMFS & USFWS 2007b).

Although hawksbill turtles are probably already beginning to be affected by impacts associated with anthropogenic climate change in several ways (described in more detail in the Environmental Baseline section below), no significant climate change-related impacts to hawksbill turtle populations have been observed to date. However, over the long-term, climate change-related impacts will likely influence biological trajectories in the future on a century scale (Paremsan and Yohe 2003). In the future, climate change-related increasing temperatures, sea level rise, changes in ocean productivity, and increased frequency of storms events as a result of climate change are all potential threats to hawksbills for the same reasons described above for green turtles. Additionally, because hawksbills typically inhabit coral reef communities, they are vulnerable to changes that affect these communities including bleaching events, increased occurrence of disease, and weakening of coral skeletons as a result of global climate change (McWilliams et al. 2005; Langdon et al. 2000; Ohde and Hossain 2004). As with green turtles, only limited data are available on past trends, and current scientific methods are not able to reliably predict the future magnitude of climate change and associated impacts or the adaptive capacity of this species. Due to a lack of scientific data, the specific effects climate change will have on this species are not predictable or quantifiable to any degree that would allow for more detailed analysis in this consultation (Hawkes et al. 2009). Given the available data, climate change-related impacts are not considered significant within the context of the temporal scale of this action, as discussed further in the Environmental Baseline and Cumulative Effects sections below.

5.2.4 Conservation of the Species

Numerous conservation programs are being implemented around the world to protect nesting habitat and reduce harvesting and fisheries bycatch of all sea turtle species, and numerous regulatory mechanisms are in place at international, regional, national and local levels to protect sea turtles (Section 5.1.4 above). Many of these programs undoubtedly help hawksbills, but the species continues to rapidly decline in the Pacific and Indian Ocean areas due, in part, to unsustainable harvest for food and tortoiseshell (Limpus and Miller 2008; Kinch 2007; Pita and Broderick 2005). Some sub-populations in the Insular Caribbean appear to be increasing (NMFS & USFWS 2007b).

5.3 Leatherback Turtles

Information in this section is summarized primarily from the 2008 shallow-set BiOp (NMFS 2008A), Volume II of the State of the World's Sea Turtles Report (SWOT 2006-2007), the most recent leatherback 5-year status review (NMFS & USFWS 2007c), and other sources cited below.

5.3.1 Distribution and Abundance

Leatherbacks have the widest distribution of any sea turtle and can be found from the equator to subpolar regions in both hemispheres. In the Pacific, tagging studies have shown that leatherbacks can traverse entire ocean basins when foraging. Nesting occurs on tropical coastlines and insular beaches. Leatherback nesting tends to be less broadly distributed across many sites and more concentrated at a few sites than green and hawksbill nesting. Leatherbacks occur in at least the Western Pacific, the Eastern Pacific, the Indian Ocean, Florida, the Caribbean, Africa, and Brazil, with further population structure at smaller spatial scales in some areas (e.g., the Caribbean), as described in the recent 5-year review (NMFS & USFWS 2007c) and the Turtle Expert Working Group's report on Atlantic leatherbacks (TEWG 2007).

The 18 leatherbacks sampled from bycatch in the Hawaii shallow-set longline fishery through 2008 were from nesting beaches in the Western Pacific, based on genetic analyses. However, of the 12 leatherbacks sampled through 2008 from bycatch in the Hawaii deep-set longline fishery, one individual was determined to be from nesting beaches in the Eastern Pacific (NMFS 2008A). This interaction occurred between Hawaii and American Samoa. Recent tagging studies have shown that Eastern Pacific females migrate southward to the South Pacific after nesting in Costa Rica (Shillinger *et al*. 2008), whereas Western Pacific females migrate northward to the North Pacific after nesting in Papua (Benson *et al*. 2007a, b). While the study of 46 tagged leatherbacks tracked over 12,095 cumulative tracking days demonstrated that Eastern Pacific leatherbacks migrate towards the action area after nesting, they remained east of 130° W longitude (Shillinger *et al*. 2008), whereas the action area is west of 155° W longitude. Thus, Eastern Pacific leatherbacks are not likely to be affected by the proposed action.

Western Pacific leatherbacks nest primarily in Papua Indonesia (formerly Irian Jaya, hereafter referred to as Papua), Papua New Guinea (PNG), and the Solomon Islands. Minor nesting occurs on Vanuatu and possibly elsewhere in the region. The total number of nests per year in the Western Pacific was estimated at 5,067 – 9,176 for the period 1999-2006 (Dutton *et al*. 2007). Based on 5,067 – 9,176 Western Pacific nests, estimates of nesting females (844 – 3294) and breeding females (2,110 – 5,735) in this aggregation were derived, but the authors recommended using nest numbers instead of estimated female numbers because of uncertainty in the assumptions (Dutton *et al*. 2007). Estimates derived from Dutton *et al*. (2007) suggest that during 1999-2006, two-thirds of the nesting occurred in Papua, most of the remainder occurred in PNG and the Solomon Islands, and a small fraction (about 1 percent) occurred in Vanuatu. Of the 28 nesting sites identified by Dutton *et al*. (2007) in these four countries, nesting data for more than 5 years are only available for the Jamursba-Medi site.

The largest nesting site for leatherbacks in the Western Pacific is at Jamursba-Medi, with an estimated mean of 2,733 nests annually in 1999-2006, making up approximately 38 percent of the total estimated nesting for the Western Pacific aggregation during this time period (Dutton *et al*. 2007). Nest data were not collected consistently or reliably until the early 1990s, hence most reports of Jamursba-Medi nesting trends start at that time. However, anecdotal reports from the early 1980s suggest that nesting at Jamursba-Medi declined during the decade preceding initiation of nest counts in 1993 (Dutton *et al*., Hitipeuw *et al*. 2007). Leatherback nesting at Jamursba-Medi occurs primarily between April and October. Nest data from Jamursba-Medi are highly variable from year to year, and no data are available from 1998. Nesting data suggest a decline from the 1993-1997 period to the 1999-2007 period, although the higher nesting level during 1993-1997 is due primarily to the high data point for 1996. Nesting during the 1999-2007 period has fluctuated annually, with the overall trend stable or slightly declining.

Besides Jamursba-Medi, Dutton *et al*. (2007) reported leatherback nesting at 27 other sites in the Western Pacific region (6 in Papua, 10 in PNG, 8 in the Solomon Islands, and 3 in Vanuatu).

Approximately 62 percent of the leatherback nesting in 1999-2006 occurred at these 27 sites, while the remaining 38 percent occurred at Jamursba-Medi, the largest nesting site. The largest of the non-Jamursba-Medi sites is Wermon, 30 km east of Jamursba-Medi. Wermon produced approximately 30 percent of all Western Pacific nests in 1999-2006 (Dutton *et al*. 2007). Leatherback nesting at Wermon occurs primarily between November and March, the opposite of Jamursba-Medi (Wurlianty & Hitipeuw 2007). Nest counts have been carried out at Wermon since 2002, thus data are available for the 5 year period from 2002–03 (Nov-Oct) to 2007-08 (Nov-Oct): 2002-03 = ,2054 nests, 2003-04 = 2,973 nests, 2004-05 = 2103 nests, 2005-06 = 1,170 nests, 2006-07 = 1,378 nests, and 2007-08 = 1,388 nests. Since the first complete survey in 2002-03, nesting levels at Wermon have been variable, with fewer nests during the last 3 years (2005-06, 2006-07, 2007-08) than in previous years.

The Huon Coast of PNG hosts an estimated 50 percent of leatherback nesting in that country. Anecdotal information in Quinn *et al*. (1983), Quinn and Kojis (1985), and Bedding and Lockhart (1989) suggest that 200 to 300 females nested annually between Labu Tali and Busama on the Huon Coast in the late 1980s (summarized in Hirth *et al*. 1993). Between 2003 and 2006 the Huon Coast project expanded to incorporate more nesting habitat at Kamiali and seven communities. As a result, nesting trends are somewhat deceptive and reflective of increased monitoring effort. The most reliable trend information is from the 2006-07 nesting season forward which appear to indicate a stable or slightly increasing trend although three seasons is not enough data to determine a reliable trend estimate. Additionally, total nest counts for these years reflect a decline of approximately 93% in nesting activity since 1980 estimates (Pilcher 2009). While hatchling production has increased over time and nest predation and harvest of eggs has been reduced in associated communities since implementation of the project (Pilcher 2009), current information indicates continuing impacts to leatherbacks from egg harvesting, beach erosion and wave inundation, and domestic dog predation.

The Solomon Islands support leatherback nesting (Steering Committee Bellagio II 2008) that 30 years ago was widely distributed across at least 61 beaches (Vaughan 1981). Dutton *et al*. (2007) estimated that approximately 640 – 700 nests were laid annually in the Solomon Islands between 1999 and 2006. No information exists regarding trends over time, but it is believed that local consumption of turtles and eggs has reduced nesting aggregations over the last few decades (Steering Committee Bellagio II 2008).

Leatherback turtles have only recently been reported nesting in Vanuatu. Petro *et al* (2007) reviewed archival data and unpublished reports, and interviewed residents of coastal communities, all of which suggested that leatherback nesting has declined in recent years. There appears to be low levels of scattered nesting on at least 4 or 5 beaches with a total of approximately 50 nests laid per year (Dutton *et al*. 2007). Adult leatherbacks are opportunistically hunted for meat in some areas. In addition, leatherback eggs are occasionally collected from these beaches (Steering Committee Bellagio II, 2008).

Abundance estimates for sea turtles are problematic due to lack of demographic information. Few estimates are available, especially for Pacific populations. The total number of Pacific leatherbacks susceptible to longline fishing was estimated at 32,000 individuals in 2000 (Lewison *et al*. 2004). The total number of adult females in the Jamursba-Medi component of the

Western Pacific nesting aggregation was estimated at 1,515 for the period 2005-07 by Snover (2008), which is estimated to make up 38 percent of the aggregation (Dutton *et al*. 2007), giving a total number of adult females in the Western Pacific of 1,515/0.38 = 3,987. This estimate lies within the range of 2,110 – 5,735 breeding females estimated for this aggregation by Dutton *et al*. (2007).

5.3.2 Life History Characteristics Affecting Vulnerability to Proposed Action

Leatherback life history is characterized by juvenile and adult life history stages occurring primarily in the pelagic zone. Adult leatherbacks range more widely across pelagic habitat than any other reptile, including into subpolar waters (NMFS 2008A, NMFS & USFWS 2007c). Recent tagging studies have shown that adults originating from the Western Pacific sometimes migrate to highly productive upwelling areas near continental shelves, such as off Oregon and Washington (Benson *et al*. 2007a). On January 5, 2010, NMFS issued a proposed rule revising current critical habitat for leatherbacks and designating an additional 70,600 square miles of marine habitat within the Pacific Ocean U.S. EEZ (75 FR 319; Jan 5, 2010). Specific areas proposed for designation include the California coast from Point Arena to Point Vincente, and Cape Flattery, Washington to the Umpqua River (Winchester Bay), Oregon, and east of a line approximating the 2,000 meter depth contour. Given that the action area is pelagic, the main aspects of Western Pacific leatherback life history affecting their vulnerability to American Samoa longline fishing are migration and foraging behavior, as discussed below.

In recent years, nesting females from beaches in the Western and Eastern Pacific have been satellite tagged, allowing tracking of their post-nesting migration routes. Western Pacific leatherbacks nesting during the northern summer (Jun-Aug) in Papua go northeast, passing north of the action area on their way to productive temperate waters off of the west coast of the U.S (Benson *et al*. 2007a). In contrast, leatherbacks nesting during the northern winter (Nov-Mar) in Papua migrate southeast after nesting, towards Australian and New Zealand waters and the action area (Benson *et al*. 2007a). Additionally, leatherbacks nesting in PNG have also been documented to migrate southeast after nesting (Benson *et al*. 2007b). Eastern Pacific leatherbacks are not known to migrate through the action area after nesting – rather, they migrate south to foraging areas off of South America east of the action area (Shillinger *et al*. 2008). Post-nesting migration routes of tagged females can be viewed on the Tagging of Pacific Predators (TOPP) website. Migratory routes of non-breeding adult females, and of adult males, are unknown for Western and Eastern Pacific leatherbacks.

Adult leatherbacks typically feed on pelagic soft-bodied animals, especially jellyfish, siphonophores, and tunicates. Despite the low nutritive value of their prey, leatherbacks grow rapidly and attain large sizes, hence they must consume enormous quantities of prey. Most water content of the prey is expelled before swallowing to maximize nutritive value per unit volume. Leatherbacks feed from near the surface to depths exceeding 1,000 m, including nocturnal feeding on tunicate colonies within the deep scattering layer. Although the deepest recorded dive for a leatherback was recently reported as 1280 m by Doyle *et al*. (2008), extremely deep dives are relatively rare and, in general, leatherback dives are shallower than 250 m (Hays *et al*., 2004). Approximately 69 percent of the observed leatherback interactions in the Hawaii longline fishery (shallow-set and deep-set fisheries combined) from 1994 to early 2008 were in the shallow-set (swordfish-targeting) fishery (PIRO Observer Program), which sets gear at <100 m depth. Migrating leatherbacks spend a majority of their time submerged and display a pattern of continual diving. Further, they appear to spend almost the entire portion of each dive traveling to and from maximum depth, suggesting continual foraging along the entire depth profile (NMFS 2008A).

5.3.3 Threats to the Species

Global threats to leatherback turtles are spelled out in the recent 5-year review (NMFS & USFWS 2007c), and threats to Western Pacific leatherbacks are described in more detail in the proceedings of a 2004 leatherback workshop (WPFMC 2005), and the proceedings of the Bellagio II meeting (Steering Committee Bellagio II, 2008). The major threats to the species, according to these documents, are fishing bycatch, alteration of nesting habitat, and direct harvest and predation, which are briefly described below. In addition, climate change appears to be having a growing impact on this species, and is also discussed below.

A major threat to leatherback turtles is believed to be bycatch in fisheries, including longline, drift gillnet, set gillnet, bottom trawling, dredge, and trap net fisheries that are operated on the High Seas or in coastal areas throughout the species' range. In the Atlantic, where leatherbacks are more numerous than in the Pacific, fisheries bycatch results in the mortality of thousands of turtles annually. In the eastern Pacific, significant bycatch has been reported in longline and gillnet fisheries, especially those operating off the west coast of South America. Fisheries operating out of Australia and New Zealand are thought to result in high bycatch and high mortality rates of Western Pacific leatherbacks that migrate there after nesting. In the north Pacific, the Hawaii shallow-set longline fishery was estimated to kill many leatherbacks annually before the fishery was closed in 2001, then modified and reopened with measures to minimize bycatch and post-hooking mortality in 2004 which have been effective (Gilman *et al*. 2007a, NMFS 2008a). The Hawaii deep-set longline fishery was also modified at this time to reduce impacts to sea turtles, also resulting in substantial turtle bycatch reduction (NMFS 2005). However, longline fisheries operating out of other countries are likely killing at least hundreds of leatherbacks annually in the Pacific, as described below in the environmental baseline section. In addition, coastal fisheries using gillnetting or trap nets are also resulting in high leatherback mortality (NMFS & USFWS 2007c).

Destruction and alteration of leatherback nesting habitats are occurring throughout the species' global range, especially coastal development, beach armoring, beachfront lighting, and vehicular/ pedestrian traffic. Coastal development includes roads, buildings, seawalls, etc., all of which reduces suitability of nesting beaches for nesting by reducing beach size. Beach armoring is typically done to protect the coastal development from erosion during storms, but armoring blocks turtle nesting and often leads to beach loss. Coastal development also increases artificial lighting, which may disorient emerging hatchlings, causing them to crawl inland towards the lights instead of seaward. Coastal development also improves beach access for humans, resulting in more vehicular and foot traffic on beaches, causing compaction of nests and thereby reducing emergence success. Fortunately, some of the major nesting beaches for leatherback turtles, including those in the Western Pacific, occur in remote areas where the development described above is less prevalent (NMFS & USFWS 2007c).

Harvest of leatherbacks for their meat and eggs has resulted in the extirpation of major nesting aggregations, such as occurred in the 1980s and 90s in Malaysia and Mexico due to egg collection (potentially exacerbated by simultaneous mortality of adults due to fisheries bycatch). Globally, harvest is reduced from previous levels, but in the Western Pacific egg harvest continues throughout the species' range, including hunting of adults near the primary nesting beaches. Predation of eggs is a major problem for Western and Eastern Pacific leatherbacks, for example by feral pigs in Papua and feral dogs in PNG (NMFS & USFWS 2007c).

Although leatherbacks are probably already beginning to be affected by impacts associated with anthropogenic climate change in several ways (described in more detail in the Environmental Baseline section below), no significant climate change-related impacts to leatherback turtle populations have been observed to date. However, over the long-term, climate change-related impacts will likely influence biological trajectories in the future on a century scale (Paremsan and Yohe 2003). In the future, climate change-related increasing temperatures, sea level rise, changes in ocean productivity, and increased frequency of storm events as a result of climate change are all potential sources of impact to leatherbacks for the same reasons described above for green and hawksbill turtles. Additional potential effects of climate change on leatherbacks include range expansion and changes in migration routes as increasing ocean temperatures shift range-limiting isotherms north (Robinson et al. 2008). Additionally, increases in their primary prey source, jellyfish due to ocean warming and other factors (Brodeur et al. 1999; Attrill et al. 2007; Richardson et al. 2009) may occur which may or may not impact leatherbacks as there is no evidence that any leatherback populations are currently food-limited. As with greens and hawksbills, only limited data are available on past trends, and current scientific methods are not able to reliably predict the future magnitude of climate change and associated impacts or the adaptive capacity of this species. Due to a lack of scientific data, the specific effects climate change will have on this species are not predictable or quantifiable to any degree that would allow for more detailed analysis in this consultation (Hawkes et al. 2009). Based on the available data, climate change-related impacts are not considered significant within the context of the temporal scale of this action, as discussed further in the Environmental Baseline and Cumulative Effects sections below.

5.3.4 Conservation of the Species

Considerable effort has been made since the 1980s to document and address leatherback bycatch in fisheries around the world. In the U.S., observer programs have been implemented in most federally-managed fisheries to collect bycatch data, and several strategies have been pursued to reduce both bycatch rates and post-hooking mortality. These include developing gear solutions to prevent or reduce capture (e.g., circle hooks) or to allow turtles to escape without harm (e.g., turtle exclusion devices, but may be too small for adult leatherbacks), implementing seasonal time-area closures to prevent fishing when turtles are congregated, and modifying existing gear (e.g., reducing mesh size of gillnets; NMFS & USFWS 2007c). For example, switching to large circle hooks and mackerel bait in 2004 resulted in approximately 85 percent fewer leatherback interactions in the Hawaii shallow-set longline fishery (Gilman *et al*. 2007a, WPFMC 2008).

Since 2003, WPFMC has been supporting projects to reduce leatherback hunting and egg collection in Papua and PNG. At Wermon and Jamursba-Medi in Papua, village rangers were hired to collect demographic data (tag turtles and record nesting activity), and through their presence on the beach have been able to guard leatherback nests from predation by feral pigs and egg collectors, resulting in protection of approximately 4,400 nests and 143,000 hatchlings at Wermon alone through 2006. From 2003 to 2007, WPFMC worked with local villagers to understand the level of traditional harvest of leatherbacks in coastal foraging habitats of Kei Kecil Islands of Papua Indonesia. This project resulted in identification of a new harvest baseline from a previously estimated harvest level of 100 individuals per year (Suarez and Starbird 1996) to 50 individuals (sub-adults and adults) per year. Since 2003, WPFMC has worked with local villagers in the Huon area of PNG to reduce harvest of adults and eggs, and to protect nesting beaches and nests (Steering Committee Bellagio II 2008, WPFMC 2005, 2008).

The conservation and recovery of leatherback turtles is facilitated by a number of regulatory mechanisms at international, regional, national and local levels, such as the FAO Technical Consultation on Sea Turtle-Fishery Interactions, the Inter-American Convention for the Protection and Conservation of Sea Turtles, CITES, and others. As a result of these designations and agreements, many of the intentional impacts on sea turtles have been reduced: harvest of eggs and adults have been slowed at several nesting areas through nesting beach conservation efforts and an increasing number of community-based initiatives are in place to slow the take of turtles in foraging areas (Gilman *et al*. 2007b; NMFS & USFWS 2007b).

5.4 Olive Ridley Turtles

Information in this section is summarized primarily from the 2008 BiOp (NMFS 2008A), the most recent olive ridley 5-year status review (NMFS & USFWS 2007d), the draft EA for the proposed action (WPFMC 2010), and other sources cited below.

5.4.1 Distribution and Abundance

Olive ridleys are the most abundant sea turtle species and are known for major nesting aggregations called *arribadas* with tens of thousands to over a million nests annually, the largest of which occur on the west coasts of Mexico and Costa Rica, and on the east coast of India. Minor *arribadas* and solitary nesters are found throughout the remaining tropical and warm temperate areas of the world, except in Oceania and the eastern Indian Ocean where the species is uncommon. Population structure and genetics are poorly understood for this species, but olive ridleys occur in at least the Eastern Pacific, Western Pacific, Eastern Indian, Central Indian, Western Indian, West Africa, and Western Atlantic areas (NMFS & USFWS 2007d). The Eastern Pacific includes nesting aggregations on the west coast of Mexico, which are listed under the ESA as endangered. All other olive ridleys are listed as threatened (Table 1).

The Eastern Pacific aggregation is thought to be increasing, while there is inadequate information to suggest trends for the other aggregations. The global status of olive ridleys is described in the most recent 5-year status review (NMFS & USFWS 2007d). While olive ridleys are the most common turtle species that interact with the Hawaii deep-set longline fishery (NMFS 2005), no olive ridley interactions have been reported in the American Samoa longline fishery.

Eastern Pacific olive ridleys nest primarily in the world's largest *arribadas* on the west coasts of Mexico and Costa Rica. Since reduction or cessation of egg and turtle harvest in both countries in the early 1990s, annual nest totals have increased substantially. On the Mexican coast alone, in

2004-2006, the annual total was estimated at 1,021,500 – 1,206,000 nests annually (NMFS & USFWS 2007d). Eguchi *et al*. (2007) counted olive ridleys at sea, leading to an estimate of 1,150,000 – 1,620,000 turtles in the eastern tropical Pacific in 1998-2006 (Eguchi *et al*. 2007). In contrast, there are no known *arribadas* of any size in the Western Pacific, and apparently only a few hundred nests scattered across Indonesia, Thailand and Australia. Data are not available to analyze trends. That is, the Western Pacific aggregation appears to be very small, and the trend is unknown (NMFS 2005, NMFS & USFWS 2007d).

5.4.2 Life History Characteristics Affecting Vulnerability to Proposed Action

Life history of Eastern Pacific olive ridleys is characterized by juvenile and adult life history stages occurring in the pelagic zone. Along with leatherbacks, olive ridleys are the most pelagic of all sea turtle species. Similar to leatherbacks, olive ridleys prey primarily on soft-bodied animals that migrate with the deep scattering layer. Olive ridleys are the most commonly-caught sea turtle species in the Hawaii deep-set longline fishery. However, although olive ridleys frequently dive deeper than 100 m, tagging studies have shown that they spend much more time < 100 m than > 100 m of depth during their foraging dives (NMFS 2005; NMFS & USFWS 2007d; Polovina *et al*. 2003).

5.4.3 Threats to the Species

Global threats to olive ridley turtles are spelled out in the recent 5-year status review (NMFS & USFWS 2007d). Major threats to the species, according to this document, are direct harvest and fishing bycatch, which are briefly described below. Climate change also appears to be having a growing impact on species, as it is for greens, hawksbills, and leatherbacks (see Sections 5.1.3, 5.2.3, and 5.3.3 above).

The largest harvest of sea turtles in human history most likely occurred on the west coasts of Central and South America in the 1950s through the 1970s, when millions of adult olive ridleys were harvested at sea for meat and leather, simultaneously with the collection of many millions of eggs from nesting beaches in Mexico, Costa Rica and elsewhere. The unsustainable harvest led to the extirpation of major *arribadas*, such as at Mismaloya and Chacahua in Mexico by the 1970s, prompting the listing of these nesting aggregations as endangered under the ESA. Globally, the legal harvest of olive ridley adults and eggs was reduced in the late 1980s and early 1990s, but legal harvest of eggs continues in some parts of the species' range, such as in Costa Rica. Illegal harvest of eggs is common in much of the species' range, such as throughout Central America and in India (NMFS & USFWS 2007d).

A major threat to olive ridleys turtles is believed to be bycatch in fisheries, including longline, drift gillnet, set gillnet, bottom trawling, dredge, and trap net fisheries that are operated either on the High Seas or in coastal areas throughout the species' range. Fisheries operating near *arribadas* can take tens of thousands of adults as they congregate. For example, trawl and gillnet fisheries off the east coast of India drown so many olive ridleys that tens of thousands of dead adults wash up on the coast annually (NMFS & USFWS 2007d). In the eastern Pacific, fishery interactions are a major threat to the species, primarily because of development of the shrimp trawl fishery along the Pacific coasts of Central American starting in the 1950s, which is thought to kill tens of thousands of olive ridleys annually. In addition, growth in the longline fisheries of this region in recent years represents a growing bycatch threat to the species, with potential to interact with hundreds of thousands of turtles annually (Frazier *et al*. 2007).

As with the other species discussed above, no significant climate change-related impacts to olive ridley turtle populations have been observed to date. However, over the long-term, climate change-related impacts will likely influence biological trajectories in the future on a century scale (Paremsan and Yohe 2003). Only limited data are available on past trends and current scientific methods are not able to reliably predict the future magnitude of climate change and associated impacts or the adaptive capacity of this species. Due to a lack of scientific data, the specific effects climate change will have on this species are not predictable or quantifiable to any degree that would allow for more detailed analysis in this consultation (Hawkes et al. 2009). Based on the available information, climate change-related impacts are not considered significant within the context of the temporal scale of this action, as discussed further in the Environmental Baseline and Cumulative Effects sections below.

5.4.4 Conservation of the Species

Since large-scale direct harvest of adult olive ridleys became illegal, conservation efforts have focused on reducing bycatch of olive ridleys in fisheries, especially those operating near *arribadas* such as the Pacific coast of Mexico/Central America and the east coast of India. Some areas offshore of Central American *arribadas* are closed to fishing in order to reduce turtle bycatch (Frazier *et al*. 2007). Likewise, no mechanized fishing is allowed within 20 km of the *arribada* in India, and turtle excluder devices are mandatory on trawlers operating out of Orissa state (Shankar *et al*. 2004). Enforcement is reported to be lacking in both areas (Frazier *et al*. 2007, Shankar *et al*. 2004).

Between 2004 and 2007, the Inter American Tropical Tuna Commission (IATTC) coordinated and implemented a circle hook exchange program to experimentally test and introduce circle hooks and safe handling measures to reduce sea turtle bycatch in mahi-mahi and tuna/billfish artisanal longline fisheries in Ecuador, Peru, Panama, Costa Rica, Guatemala and El Salvador. Almost all (99 percent) fishery/turtle interactions identified by this program were with green and olive ridley sea turtles. By the end of 2006, over 1.5 million J hooks had been exchanged for turtle-friendly circle hooks (approximately 100 boats). Overall, circle hooks have reduced interaction rates by 40 to 80 percent in most artisanal fisheries that switched gear types, with deep hookings reduced by 20 to 50 percent. Experiments to reduce longline gear entanglements have also been successful. Importantly, the project has demonstrated that turtle interaction rates in artisanal mahi-mahi and tuna/billfish fisheries can be studied and reduced (Largachia *et al*. 2005; Hall *et al*. 2006).

The conservation and recovery of olive ridleys is facilitated by a number of regulatory mechanisms at international, regional, national and local levels, such as the Indian Ocean Southeast Asian Marine Turtle Memorandum of Understanding, the Inter-American Convention for the Protection and Conservation of Sea Turtles, CITES, and others. As a result of these designations and agreements, many intentional impacts on sea turtles have been reduced: harvest of eggs and adults has been slowed at several nesting areas through nesting beach conservation efforts and an increasing number of community-based initiatives are in place to slow the take of turtles in foraging areas (Gilman *et al*. 2007b; NMFS & USFWS 2007d).

6 Environmental Baseline

The environmental baseline for a biological opinion includes the past and present impacts of all State, Federal or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). The Consultation Handbook further clarifies that the environmental baseline is "an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area." (USFWS & NMFS 1998). The purpose of describing the environmental baseline in this manner in a biological opinion is to provide the context for the effects of the proposed action on the listed species.

The past and present impacts of human and natural factors leading to the status of the four sea turtle species addressed by this opinion within the action area include fishing interactions (hooking and/or entanglement in gear), vessel strikes, climate change, pollution, and ingestion of or entanglement in marine debris. The environmental baselines for the green, hawksbill, leatherback, olive ridley sea turtles within the action area are described below.

6.1 Green Turtles

Green turtles are affected by longline fishing, nearshore fishing, and other human activities within the action area. The American Samoa longline fishery occurs partially on the High Seas, and longline fishing by other countries also occurs in these High Seas areas. Thus, longline fishing by all countries combined within the action area is part of the environmental baseline. Longline fishing is the greatest impact on green turtles on the High Seas within the action area. Much less attention has been paid to effects of longline fishing on green turtles than on loggerheads (e.g., Lewison *et al*. 2004) and leatherbacks (e.g., Kaplan 2005), thus no estimates are available for green turtle mortality due to longline fishing in the Pacific. However, Molony (2005) estimated 500 – 3,000 sea turtle mortalities annually in a period ending in 2004 for all species combined in the Western and Central Pacific Ocean. Lewison *et al*. (2004) used a different methodology than Molony (2005), resulting in loggerhead and leatherback mortality estimates from longlining that were 5-fold greater than Molony (2005), or 2,500 – 15,000 sea turtle mortalities annually from longline for all species combined during a similar period.

In the Hawaii deep-set longline fishery between 1994 and 2008, 154 sea turtles were observed bycaught, 17 of which were green turtles, or 11 percent (PIRO Observer Program). Based on the above estimation methods (Lewison *et al*. 2004, Molony 2005), and assuming the action area makes up approximately 5 – 10 percent of the area fished and longlining effort in the Pacific, and that 11 percent of turtle bycatch is green turtles, longlining by all countries combined is estimated to kill a minimum of 3 – 6 green turtles annually within the action area (500 x 0.05 x 0.11 = 2.8, and 500 x 0.10 x 0.11 = 5.5), and a maximum of 83 – 165 (15,000 x 0.05 x 0.11 = 83, to 15,000 x 0.10 x 0.11 = 165). The American Samoa longline fishery alone is estimated to have interacted with an average of 33 green turtles (30 estimated mortalities) annually within the action area between 2006 and 2010, with an estimated range of 4 to 112 green turtles annually (see Section 7.1 Effects of the Action, Green Turtles). The American Samoa longline fishery has been operating at its current level exhibiting relatively stable fishing effort and landings since

2002; however the data used by Lewison et al. (2004) were collected in 2000 and this fishery is not represented in the data used by Molony (2005). Thus mortality caused by the American Samoa longline fishery is in addition to the above estimates of 3 – 6 to 83 – 165 green turtles killed annually by longline fishing within the action area.

As explained further in Section 7.1.2, under the current regulatory regime in the American Samoa longline fishery (not incorporating the anticipated impacts of the proposed action) and after the data used by Lewison *et al*. (2004) and Molony (2005) were collected, the American Samoa longline fishery was estimated to hook or entangle 4 to 112 green turtles annually, with 92 percent mortality. Thus the environmental baseline for the total number of green turtles killed annually by all longlining in the action area can be estimated by adding the American Samoa longline fishery estimates (4 – 103 mortalities) to the green turtle estimates made by Lewison *et al*. (2004) and Molony (2005), giving a minimum of (3 – 6) + 4 = 7 – 10 and a maximum of (83 – 165) + 103 = 186 – 268. Therefore, the environmental baseline for green turtle mortality due to all longlining combined within the action area is estimated at 7 – 268 green turtles annually.

The Secretariat of the Pacific Community observer database also has records of five green turtles incidentally caught in purse seine fisheries within the central region of Western and Central Pacific Fisheries Commission (WCPFC) area from 1990 – 2004 (Molony 2005), although these data are not reliable in a quantitative sense because of low and variable observer coverage and inconsistent logsheet recording. The US purse seine fishery, which has an overlapping action area with that of the American Samoa longline fishery, is authorized to interact with 14 green turtles annually with no mortalities (NMFS 2006).

Some juvenile green turtles in the action area may recruit to nearshore areas throughout the American Samoa archipelago, as suggested by the genetics results from one of the bycaught green turtles from the American Samoa longline fishery that have been sampled so far (see introduction to Section 5 for more information). That is, juvenile green turtles in the action area likely originate from many of the NAs within Oceania, including the American Samoa component of the Western Polynesia NA. Thus, the impacts of nearshore fishing and other human activities in American Samoa on green turtles are included in the environmental baseline.

Nearshore fisheries in American Samoa consist primarily of subsistence fishing, using hook-and-line (handlines or rod-and-reel), free diving, gillnetting, gleaning, and throw netting (Craig *et al*. 1993). Nearshore fisheries may sometimes result in entanglement and drowning of green turtles. Gillnets are the most problematic for turtles, because they are left untended, and entangled animals usually drown. Hook-and-line fishing from shore or boats also hooks or entangles green turtles, although the chance of survival is higher than if caught in a gillnet. In a study of stranded green turtles in Hawaii (stranded turtles are injured, sick, or dead turtles found on shore), the most common known cause of stranding was the tumor-forming disease, fibropapillomatosis (28%) followed by hook-and-line fishing gear-induced trauma (7%) and gillnet fishing gear-induced trauma (5%) (Chaloupka *et al*. 2008b). However, most turtles drowned in fishing gear probably sink rather than stranding, making it very difficult to estimate the total number of green turtles killed annually by nearshore fishing interactions, even in Hawaii where the sea turtle stranding and salvage network is extensive and green turtles are much better monitored and studied than in American Samoa (NMFS 2008b).

In American Samoa, sea turtles are killed by collisions, both with boats when turtles surface, and with cars when adult females are searching for nesting sites. In Hawaii, the total number of green turtles killed annually during the period 1998-2007 by boat collisions was estimated at 25 – 50 turtles, based on stranding data (NMFS 2008b). Boats and green turtles are both less dense in American Samoa nearshore waters than in Hawaiian nearshore waters, thus the number of green turtles killed annually by boat collisions is likely fewer than 25 turtles. Because roads in American Samoa typically run adjacent to beaches, adult females searching for nesting sites sometimes crawl onto the roadway where they may be run over, such as a large hawksbill female that was killed by a vehicle in late 2008 (Mata`afa 2008). However, most green turtle nesting in American Samoa is on the uninhabited Rose Atoll and sparsely inhabited (<6 people) Swains Island, thus vehicle collision is not a major source of mortality for green turtles in American Samoa. Pig predation on turtle eggs has been documented at Swains Island, but the level and intensity has yet to be quantified.

Other impacts contributing to the green turtle environmental baseline within the action area include climate change (see Section 6.5), marine debris, harvest, and contaminants. Marine debris may cause entanglement and possibly drowning, whereas ingested trash may cause intestinal blockage and death. The streams and coastlines of Tutuila are among the most littered within the U.S. Direct harvest of green turtles is likely still occurring in American Samoa (NMFS & USFWS 2007a). Pago Pago Harbor is heavily contaminated because of industrial and sewage effluents, which may be impacting green turtles.

Green turtles are not known to nest in Western Samoa, although they do occur in the near shore reef habitats. Witzell (1982) surmised that green turtles found in waters of Upolu Island may be part of the group that nests on Rose Atoll during the summer. The harvest of turtles is both traditional and legal in Samoa with a minimum size restriction of 27 inches for both green and hawksbill turtles. Green and hawksbill turtle shells are sold in the Apia fish market. A 2006 survey in Samoa documented that turtles are often caught in 33 fishing villages of Upolu, and in 30 villages of Savaii (Momoemausu *et al*. 2006).

During the four year period from October 2004 to September 2008, the American Samoa Department of Marine and Wildlife Resources (DMWR) recorded 15 green turtles stranded on Tutuila measuring 46-85 cm CCL, six of which were dead. Of the four green turtles that were necropsied, two had plastic and aluminum in their guts (Tagarino *et al*. 2008). As a result of the September 29, 2009 tsunami, 51 turtles stranded. Of these, 41 were reportedly returned to sea by communities, several were dead, seven green turtles were released by DEC/SPREP, and one hawksbill turtle was likely consumed (Bell, Ward, and Ifopo 2009). Because DMWR's new turtle stranding program still has little data, and many turtles within the action area that are dead or dying from the above human impacts do not strand in American Samoa, it is not possible to estimate the number of green turtle mortalities resulting from climate change (see Section 6.5), marine debris, harvest, and contaminants in the past few years in the action area.

6.2 Hawksbill Turtles

Like green turtles, juvenile hawksbill turtles recruit to nearshore areas, and are thus impacted by a host of human activities occurring in nearshore waters and on land. Hawksbill turtles within the action area are impacted by at least nearshore fishing, boat and car collisions, climate change, marine debris, harvest, and contaminants. Unlike green, leatherback, and olive ridley turtles, hawksbills are not commonly caught in longline fisheries, but there is evidence that longline fishing is having some impacts. Much less attention has been paid to effects of longline fishing on hawksbills than on loggerheads and leatherbacks, thus no estimates are available for hawksbill mortality due to longline fishing in the Pacific.

No hawksbill bycatch has been recorded in the Hawaii deep-set, Hawaii shallow-set, or American Samoa longline fisheries. A decomposed hawksbill that was entangled in derelict fishing gear was retrieved by longline gear in Hawaii (i.e., the hawksbill was killed by the derelict gear, not the longline gear). However, because: 1) general turtle bycatch rates in foreign longline fisheries are higher than in the Hawaii or American Samoa longline fisheries (NMFS 2008a); 2) foreign longline fisheries constitute more fishing effort than the American Samoa longline fishery; and 3) hawksbill interactions occur in other longline fisheries both in the Atlantic (Yeung 1999) and Pacific (Robins *et al*. 2002), some hawksbill bycatch is likely to be occurring in the foreign longline fisheries. The Secretariat of the Pacific Community observer database has records of 12 hawksbills incidentally caught in longline fisheries within the central region of Western and Central Pacific Fisheries Commission (WCPFC) area from 1990 – 2004 (Molony 2005), although these data are not reliable in a quantitative sense because of low and variable observer coverage and inconsistent logsheet recording. Therefore it is likely that within the action area, juvenile hawksbills from the western and central Pacific are killed annually by longlining, but there are no data upon which to base an estimate of the number killed.

The Secretariat of the Pacific Community observer database also has records of eight hawksbills incidentally caught in purse seine fisheries within the central region of Western and Central Pacific Fisheries Commission (WCPFC) area from 1990 – 2004 (Molony 2005), although, as mentioned previously, these data are not reliable in a quantitative sense because of low and variable observer coverage and inconsistent logsheet recording. The US purse seine fishery, which has an overlapping action area with that of the American Samoa longline fishery, is authorized to interact with 14 hawksbills annually with no mortalities (NMFS 2006).

As with green turtles, nearshore fisheries in American Samoa may sometimes result in entanglement and drowning of hawksbills. Of nine dead stranded hawksbills that were necropsied in 2007-08, four appear to have been killed by entanglement and/or hooking by fishing gear (Tagarino *et al*. 2008). Because hawksbills forage in shallow areas, often remain just below the surface, and surface often to breathe, they are vulnerable to being struck by vessels. In addition, because roads in American Samoa typically run adjacent to beaches, and hawksbills nest on the heavily-populated Tutuila Island, adult females searching for nesting sites sometimes crawl onto the roadway where they may be run over, such as a large hawksbill female that was killed by a vehicle in late 2008 (Mata`afa 2008).

Other impacts contributing to the hawksbill turtle environmental baseline within the action area include climate change, marine debris, harvest, and contaminants. Impacts associated with climate change may be affecting pelagic hawksbill turtle habitat within the action area, as described in Sections 5.2 and 6.5. Marine debris may cause entanglement and possibly drowning, such as four of the nine dead stranded hawksbills that appeared to have died due to fishing gear entanglement (Tagarino *et al*. 2008). Ingested trash may cause intestinal blockage and death. The streams and coastlines of Tutuila are among the most littered within U.S. jurisdiction. Direct harvest of hawksbill turtles is likely still occurring in American Samoa (NMFS & USFWS 2007b). The harvest of turtles is both traditional and legal in Independent Samoa with minimum size restriction of 27 inches for both green and hawksbill turtles. Green and hawksbill turtle shells are known to be sold in the Apia fish market. Results from a 2006 survey in Samoa, indicate that turtles are often caught in 33 fishing villages on Upolu, and 30 villages on Savaii (Momoemausu *et al*. 2006). Pago Pago Harbor is heavily contaminated because of industrial and sewage effluents, which may be impacting hawksbill turtles.

During the four year period from October 2004 to September 2008, the American Samoa Department of Marine and Wildlife Resources (DMWR) recorded 29 hawksbill turtles stranded on Tutuila measuring 33-66 cm CCL, 19 of which were dead. As a result of the September 29, 2009 tsunami, 51 turtles stranded. Of these, 41 were reportedly returned to sea by communities, several were dead, seven green turtles were released by DEC/SPREP, and one hawksbill turtle was likely consumed (Bell, Ward, and Ifopo 2009). Because DMWR's new turtle stranding program still has little data, and many turtles within the action area that are dead or dying from the above human impacts do not strand in American Samoa, it is not possible to estimate the number of hawksbill turtle mortalities resulting from climate change (see Section 6.5), marine debris, harvest, and contaminants in the past few years in the action area.

6.3 Leatherback Turtles

Unlike green and hawksbill turtles, leatherback turtles do not occur in the nearshore waters of the action area. Leatherbacks are affected by longline fishing, climate change, and marine debris. No leatherback bycatch has been recorded in the American Samoa longline fishery. However, in 1993, an American Samoa government vessel engaged in experimental longline fishing caught a small leatherback turtle six km south of Swains Island (Grant 1994; WPFMC 2010). Because the action area includes High Seas, and other nations longline within these High Seas area, the impact of all longlining combined within the action area is part of the environmental baseline.

Estimating the total number of leatherback turtle interactions by all nations combined in the Pacific, or within any part thereof, is difficult because of low observer coverage and inconsistent reporting. However, Lewison *et al*. (2004) collected fish catch data from 40 nations and turtle bycatch data from 13 international observer programs to estimate global longline bycatch of loggerhead and leatherback turtles in 2000. In the Pacific, they estimated that 1,000 – 3,200 leatherbacks were killed by pelagic longlining in 2000 (Lewison *et al*. 2004). An estimate of 626 adult female mortalities from pelagic longlining in 1998 was made by Kaplan (2005), or roughly 2,500 juveniles and adults. However, using effort data from Lewison *et al*. (2004) and bycatch data from Molony (2005), Beverly and Chapman (2007) estimated loggerhead and leatherback longline bycatch to be approximately 20 percent of that estimated by Lewison *et al*. (2004), or 200 – 640 juvenile and adult leatherbacks annually.

As for the number of leatherbacks killed by longlining in the action area, at least two other factors should be considered: (1) the action area represents 5 – 10 percent of the area fished via longlining effort in the Pacific; and (2) leatherbacks appear to be less dense within the action area than elsewhere in the Pacific, as suggested by the lower leatherback bycatch-per-unit-effort in the American Samoa longline fishery than in the Hawaii longline fisheries (NMFS 2008a), and post-nesting migration patterns from leatherback nesting sites (Benson *et al*. 2007a, b; Shillinger *et al*. 2008). For purposes of providing the environmental baseline for leatherbacks in this opinion, NMFS estimates that longlining since 2000 in the action area has killed, and continues to kill, 2 – 5 percent of the Pacific totals estimated by Beverly and Chapman (2007), Kaplan (2005), and Lewison *et al*. (2004): 4 – 16 turtles (2 percent of Beverly and Chapman's 2007 estimate) to 50 – 160 turtles (5 percent of Lewison *et al*.'s 2004 estimate), or 4 – 160 Western Pacific leatherback juveniles and adults annually (2 – 5 percent of Kaplan's 2005 estimate = 13 – 31 turtles).

The Secretariat of the Pacific Community observer database also has records of one leatherback incidentally caught in purse seine fisheries within the central region of Western and Central Pacific Fisheries Commission (WCPFC) area from 1990 – 2004 (Molony 2005) although, as mentioned previously, these data are not reliable in a quantitative sense because of low and variable observer coverage and inconsistent logsheet recording. The US purse seine fishery, which has an overlapping action area with that of the American Samoa longline fishery, is authorized to interact with 11 leatherbacks annually with no mortalities (NMFS 2006).

Other impacts contributing to the leatherback turtle environmental baseline within the action area include climate change and marine debris. Impacts from climate change may be affecting leatherback habitat within the action area, as described in Sections 5.3 and 6.5. Leatherbacks may be particularly susceptible to ingesting of marine debris because plastic bags resemble jellyfish, their primary prey. Derelict fishing gear may cause entanglement and possibly drowning. None of the 45 stranded turtles reported from Tutuila during the four year period from October 2004 to September 2008 were leatherbacks (29 hawksbills, 15 greens, 2 olive ridleys; Tagarino *et al*. 2008). Data are not available to estimate the number of leatherback mortalities resulting from climate change (see Section 6.5) and marine debris in the past few years in the action area.

6.4 Olive Ridley Turtles

Like leatherbacks, olive ridleys do not typically occur in the nearshore waters of American Samoa. However, two stranded olive ridleys were reported from Tutuila during the four year period from October 2004 to September 2008 (described in more detail below; Tagarino *et al*. 2008). Within the action area, olive ridleys are affected by longline fishing, climate change, and marine debris. No olive ridley bycatch has been recorded in the American Samoa longline fishery.

Like the other sea turtle species addressed by this opinion, past and present fisheries interactions have been, and continue to be, the greatest human impact on olive ridley turtles within the action area. Longline fishing is likely the most important past and present impact on olive ridleys. The Secretariat of the Pacific Community observer database has records of 104 olive ridleys incidentally caught in longline fisheries within the central region of Western and Central Pacific Fisheries Commission (WCPFC) area from 1990 – 2004 (Molony 2005), although these data are not reliable in a quantitative sense because of low and variable observer coverage and inconsistent logsheet recording. Olive ridleys and leatherbacks are both susceptible to deep-set longlining because of their deep foraging (NMFS 2005). However, a tagging study of two foraging olive ridleys in the north Pacific suggests that even though the species commonly forages at depths greater than 100 m, most foraging is done at less than 100 m in depth (Polovina *et al*. 2003).

In the Hawaii deep-set longline fishery, bycatch rate of olive ridleys is about 10 times that of leatherbacks. In addition, mortality of bycaught olive ridleys is higher than other sea turtle species (Beverly & Chapman 2007), most likely because they are hooked when in such deep water that they rarely have a chance to get to the surface before drowning. Bycatch rates in foreign deep-set fisheries (for tuna) are more than 10 times higher than in the Hawaii deep-set fishery, and constitute much more fishing effort than the Hawaii fishery. Thus it is likely that tens of thousands of olive ridleys are killed annually in the Pacific by non-domestic longlining (NMFS 2008a).

The northern High Seas portions of the action area are in tropical waters (Figure 2 in Section 4) where olive ridleys are more likely to be found (NMFS & USFWS 2007d). While Eastern Pacific olive ridleys are abundant in the action area of the Hawaii deep-set fishery (NMFS 2005), the abundance of this aggregation in the action area of the American Samoa longline fishery is unknown. As described above in Section 5.4, Western Pacific olive ridleys are much smaller than those from the Eastern Pacific. Due to lack of information about olive ridley abundance in the action area, absence of observed olive ridley bycatch in the American Samoa longline fishery, low observer coverage in this fishery, and absence of turtle bycatch data from the longline fisheries of other nations operating in the action area, it is not possible to estimate the number of olive ridleys being killed by all longlining combined within the action area.

The Secretariat of the Pacific Community observer database also has records of 10 olive ridleys incidentally caught in purse seine fisheries within the central region of Western and Central Pacific Fisheries Commission (WCPFC) area from 1990 – 2004 (Molony 2005) although, as mentioned previously, these data are not reliable in a quantitative sense because of low and variable observer coverage and inconsistent logsheet recording. The US purse seine fishery, which has an overlapping action area with that of the American Samoa longline fishery, is authorized to interact with 11 olive ridleys annually with no mortalities (NMFS 2006).

Other impacts contributing to the olive ridley turtle environmental baseline within the action area include climate change and marine debris. Impacts resulting from climate change may be affecting olive ridley habitat within the action area, as described in Sections 5.4 and 6.5. Derelict fishing gear may cause entanglement and possibly drowning, and ingestion of plastic debris is likely to be causing some mortality. Of the 45 stranded turtles reported from Tutuila during the four year period from October 2004 to September 2008, two were olive ridleys, both dead. Necropsy results from one olive ridley turtle that stranded in Pago Pago harbor suggests that drowning was the possible cause of death. Data are not available to estimate the number of olive ridley mortalities resulting from climate change (see Section 6.5) and marine debris in the past few years in the action area.

6.5 All species: impacts associated with climate change

The four species addressed by this biological opinion are already likely beginning to be affected by global climate change. The global mean temperature has risen 0.76°C over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (Trenberth et al. 2007). Climate change is a global phenomenon so resultant impacts have likely been occurring in the action area, although scientific data describing any impacts that have occurred from climate change in the action area are lacking. As discussed in the Threats Section, climate change impacts are likely beginning to affect sea turtles found in the action area. Such impacts include rising sand temperatures, rising sea level, increased typhoon frequency, and changes in ocean temperature and chemistry.

While sex ratios vary naturally within and among seasons and nesting locations, several species already exhibit female bias throughout their major rookeries worldwide, in many cases producing anywhere from 60 – 99% females (Chan and Liew 1995; Godfrey et al. 1996; Marcovaldi et al. 1997; Binckley et al. 1998; Godfrey et al. 1999; Godley et al. 2001; Oz et al. 2004; Kaska et al. 2006). Monitoring data over a long enough timescale to discern climate change related trends in sex ratio have not been collected in the action area. Sea level rose approximately 17 cm during the 20th century (Bindoff et al. 2007) and further increases are expected. There are several predictions for potential future sea turtle nesting habitat loss due to sea level rise (Fish et al. 2005; Baker et al. 2006; Fuentes et al. 2009); however available data are insufficient to determine an existing correlation between past sea level rise and sea turtle population dynamics (VanHoutan 2010).

Global climate change-induced elevated temperatures, altered oceanic chemistry, and rising sea level may be contributing to changes to coral reef and seagrass ecosystems (as described above in Status of the Species) which provide resting and foraging habitat for green and hawksbill sea turtles, although it is difficult to distinguish impacts of climate-related stresses from other stresses that produce more prominent short term effects (Rosenzweig et al. 2007). Climate change-induced shifts in ocean productivity linked to temperature changes (Harwood 2001; Edwards & Richardson 2004; Hays et al. 2005) may affect foraging strategies and therefore reproductive capacity for sea turtles (Solow et al. 2002; Chaloupka et al. 2008a), similar to what has been observed during El Niño events in the Pacific (Limpus and Nicholls 1994; Chaloupka 2001; Saba et al. 2007; Reina et al. 2008). These shifts in abundance of foraging resources are also directly linked to observed modifications in phenology for sea turtles such as longer re-migration intervals and temporal shifts in nesting activity (Weishampel et al. 2004; Hawkes et al. 2007). However, at this time it is only possible to speculate as to the implications of such impacts, as findings raise numerous follow up questions (listed by Weishampel et al. 2004), including whether earlier nesting will affect overall fecundity, clutch size, incubation length, hatch success, hatchling survivorship, food availability for hatchlings, mating synchrony, and sex ratio. Changes in reproductive capacity and temporal shifts of nesting activity associated with changing environmental conditions have not been studied specifically in the action area.

Additional potential effects of climate change on sea turtles include range expansion and changes in migration routes (Robinson et al. 2008). Leatherbacks have extended their range in the Atlantic north by 330km in the last 17 years as warming has caused the northerly migration of the 15°C SST isotherm, the lower limit of thermal tolerance for leatherbacks (McMahon and Hays 2006). Scientific data on changes in migration routes of the four species that may be adversely affected in the action area are limited, and a similar study has not been done for these species in the action area. Therefore, it is not possible to say with any degree of certainty whether and how their migration routes and ranges have been or are currently affected.

Attempting to determine whether recent biological trends are causally related to climate change is complicated because non-climatic influences dominate local, short-term biological changes. However, the meta-analyses of 334 species and the global analyses of 1,570 species show highly significant, nonrandom patterns of change (in geographic range, phenology, and other biological factors) in accord with observed climate warming in the twentieth century. In other words, it appears that these trends are being influenced by climate change-related phenomena, rather than being explained by natural variability or other factors (Parmesan & Yohe 2003). The details discussed previously in this section support the probability that recently observed changes in sea turtle phenology, sex ratio, and foraging characteristics in studied populations may be influenced by climate change-related phenomena. However, the implications of these changes are not clear in terms of population level impacts, and data specific to the action area are lacking. Therefore, as stated earlier, any recent impacts from climate change in the action area are not quantifiable or describable to a degree that could be meaningfully analyzed in this consultation, but are believed to be insignificant at this time.

7 Effects of the Action

In this section of a biological opinion, NMFS assesses the probable effects of the proposed action on threatened and endangered species. 'Effects of the Action' refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action that will be added to the environmental baseline. 'Indirect effects' are those that are likely to occur later in time (50 CFR 402.02). The Effects of the Action are considered within the context of the Status of Listed Species and Environmental Baseline sections of this Opinion to determine if the proposed action can be expected to have direct or indirect effects on threatened and endangered species that appreciably reduce their likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (50 CFR 402.02), otherwise known as the jeopardy determination.

Approach. NMFS determines the effects of the action using a sequence of steps. The first step identifies potential stressors associated with the proposed action with regard to listed species. NMFS may determine that some potential stressors result in insignificant, discountable, or beneficial effects to listed species, in which case these potential stressors are considered not likely to adversely affect listed species, and subsequently are considered no further in the opinion. Those stressors that are expected to result in significant negative (i.e., adverse) effects to listed species are analyzed via the second, third, and fourth steps described below.

The second step identifies the magnitude of the stressors (e.g., how many individuals of a listed species will be exposed to the stressors; *exposure analysis*). In this step of our analysis, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to a proposed action's effects, and the populations or subpopulations those individuals represent.

The third step describes how the exposed individuals are likely to respond to the stressors (*response analysis*). In this step, NMFS determines if the stressors are likely to result in any of the components of take as defined under the ESA (e.g., harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct).

The final step in determining the effects of the action is establishing the risks those responses pose to listed resources (*risk analysis*). The risk analysis is different for listed species and designated critical habitat. However, the action area does not include proposed or designated critical habitat, thus it is not considered in this opinion. Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (probability of extinction or probability of persistence) of listed species depends on the viability of their populations. Thus, because green and hawksbill turtles are globally listed, and these species consist of nesting aggregations, this final step first determines the risk posed by the proposed action to affected nesting aggregations, then relates that risk to the listed species.

Potential Stressors. The potential stressors associated with the proposed action for the four listed species addressed by this opinion are fishing gear interactions (defined in footnote 1 in Section 1) and fishing vessel collisions. The proposed action is implementation of the management changes proposed in the amenedment to the Pelagics FEP modifying the continued operation of the American Samoa longline fishery (WPFMC 2010). The greatest stressor associated with this action on the four listed species considered in this opinion is interactions with fishing gear. Another potential stressor associated with the proposed action is collisions with fishing vessels. Vessels may travel through areas where green and hawksbill turtles occur, such as when vessels travel to and from port, passing through nearshore waters. The likelihood of vessel collision with sea turtles out at sea is considered very low because of the low density of these species in the action area and is considered discountable and therefore will not be discussed further in this opinion. While additional effects may occur due to the proposed action (e.g., exposure to waste from fishing vessels), they are not considered likely to adversely affect individuals of listed species, and thus are not considered stressors. The potential direct stressors of interactions and collisions are described in detail below in the species sections, because they vary considerably between species.

7.1 Green Turtles

The stressors, exposure, response and risk steps of the effects analysis for green turtles with regard to implementation of the proposed action are described below. The following information was used to conduct these analyses of the proposed action on green turtles: the 2005 Hawaii deep-set opinion (NMFS 2005), the 2006 purse seine opinion (NMFS 2006), the 2008 Hawaii shallow-set opinion (NMFS 2008a), the 2008 Hawaii bottomfish opinion, (NMFS 2008b), and other documents cited below.

7.1.1 Stressors

Longline fishing affects green turtles primarily by hooking, but also by entanglement and trailing of gear. Historically in the Hawaii deep-set longline fishery, green turtles have been more likely to be hooked externally or in the mouth (hook not ingested) than entangled or hooked internally (hook ingested). This appears to hold true in the American Samoa fishery also, according to the small number of observed interactions since the fishery started operating with observer coverage (see Disposition column in Table 4 below). Juvenile and adult interactions both occur in the Hawaii deep-set longline fishery, although most are juveniles (NMFS 2005). Turtle bycatch data for the American Samoa longline fishery are scarce, because the fishery is relatively new, and observer coverage has been low. Since April of 2006, 13 juvenile green turtles have been observed caught in this fishery, and all but one were dead (Table 4). The fishery uses mostly 13/0, 14/0, 15/0, and 16/0 circle hooks (most offset and some non-offset), but these hook types are not required. Sardines (pilchards) are used as bait in this fishery. In addition to fishing gear interactions, because green turtles recruit to nearshore habitat in American Samoa, and green turtles occur in shallow American Samoan waters, fishing vessels traveling to and from port may occasionally strike green turtles (NMFS 2008b).

Table 4. Observed green turtle interactions in the American Samoa longline fishery, 4/06 - 8/10.

Date	Disposition	SCL (cm)
15-Jun-06	Dead, entangled	50
20-Jun-06	Dead, hook in flipper	26.5
7-Oct-06	Dead, hook in mouth	43
2-Jul-07	Dead, hook in mouth	47.5
11-May-08	Dead, hook in mouth	42
11-Jun-09	Dead, hook in flipper	46
2-Sep-09	Dead, hook in mouth	45
31-Oct-09	Dead, hook in mouth	45
18-Feb-10	Alive, hooked in flipper	45
2-Apr-10	Dead, hooked in mouth	24.5
20-May-10	Dead, hooked in mouth	36
7-Jul-10	Dead, hooked in mouth	39.5
9-Jul-10	Dead, hooked in flipper	36.5

While the primary direct effect of the proposed action on green turtles will be the stressor of fishing gear interactions, an indirect effect of the proposed action (one that is likely to occur later in time) may result from market transfer effects. That is, an increase or decrease in fishing effort by the American Samoa longline fishery could result in more or less fishing by competing fleets, potentially resulting in effects to other aggregations of green turtles (NMFS 2008a).

7.1.2 Exposure

Determining exposure of green turtles to fishing gear hooking and entanglement for the proposed action is complicated by low observer coverage, and the fact that the proposed action would implement an untested measure to reduce turtle interactions with fishing gear. This section first estimates the number of green turtle interactions in the American Samoa longline fishery during the 5-year period 2006-2010 (i.e., the interaction rate before implementing the proposed action), and then estimates the extent of the reduction in green turtle interactions that is likely to result from implementing the proposed action. Based on extrapolation (i.e., expansion) from the 13 observed green turtle takes from April 2006 through August 2010, and observer coverage, the American Samoa longline fishery hooked or entangled an average of 33 green turtles annually during this period (Table 5). The minimum mean number of green turtles hooked or entangled by the fishery annually is the mean number of observed interactions (17 observed interactions/5 years = 4 interactions annually). The maximum mean number of green turtles hooked or entangled by the fishery annually is estimated by multiplying the annual mean (33) by a factor of 3.4, based on an analysis of the green turtle takes in this fishery in 2006 (see NMFS 2009c for a more detailed explanation): (33)(3.4) = 112 interactions annually. Thus the estimated range of annual green turtle interactions historically in the American Samoa longline fishery (i.e., during the 5-year period 2006-2010 before potential implementation of the proposed action) = 4 – 112 green turtles annually, with a mean of 33 green turtles annually (Table 5). The mortality rate is estimated at 92 percent.

Table 5. Estimate of green turtle interactions in American Samoa longline fishery, Apr-06 to Aug-10 (i.e., before implementation of proposed action). Mortality estimate = 92%.

Year	Observed interactions	Observer coverage	Expansion factor[1]	Estimated interactions[2]
2006	3(4)*	8.1%	12.3	37(49)*
2007	1	7.1%	14.1	14
2008	1	6.4%	15.6	16
2009	3	7.70%	13.0	39
2010	5(8)*	17.50%	5.7	29 (46)*
Total, Apr. 2006 to Aug. 2010	13(17)*	NA	NA	135 (164)*
Annual mean of total green turtle mortalities in fishery (164 interactions/5 yrs)				33
Estimated annual range of green turtle mortalities in fishery (see above)				4 - 112

* numbers in ( ) are extrapolated to estimate a full year of interactions based on observed interactions; 2006: observer coverage from Apr. – Dec.; 2010: observer coverage from Jan. – Aug.

[1] 100 ÷ observer coverage. E.g., for 2007, 100/7.1 = 14.1.

[2] (Observed interactions) x (Expansion factor). E.g., for 2007, 1(14.1) = 14.

The intent of the amendment is to reduce the likelihood of green turtle bycatch in the American Samoa longline fishery by requiring that hooks be set to fish deeper than 100 m (WPFMC 2010). Although it has been suggested that setting hooks deeper than 100 m depth may decrease the likelihood of hooking or entangling sea turtles (Bigelow and Fletcher 2009, WPFMC 2010), there are no published studies on the testing of this hypothesis. Between April 2006 and August 2010, 13 green turtles were documented by the PIRO Observer Program to be hooked or entangled in the American Samoa longline fishery. Because hook number was recorded by the Observer Program, relative depth of the hooked turtle compared to the other hooks is known, as explained below.

Longline gear consists of sections of hooks suspended between floats. Hooks in the middle of the section are presumed to be the deepest, and hooks on the ends of the section are presumed to be the shallowest. Oceanographic and gear characteristics may cause a limited amount of variation during the soak. Hooks are numbered sequentially between floats, resulting in the smallest- and largest-numbered hooks being the shallowest in each section (Figure 4). Hook number data was collected by the PIRO Observer Program for the 13 green turtles bycaught in the American Samoa longline fishery from April 2006 to August 2010 (Table 6).

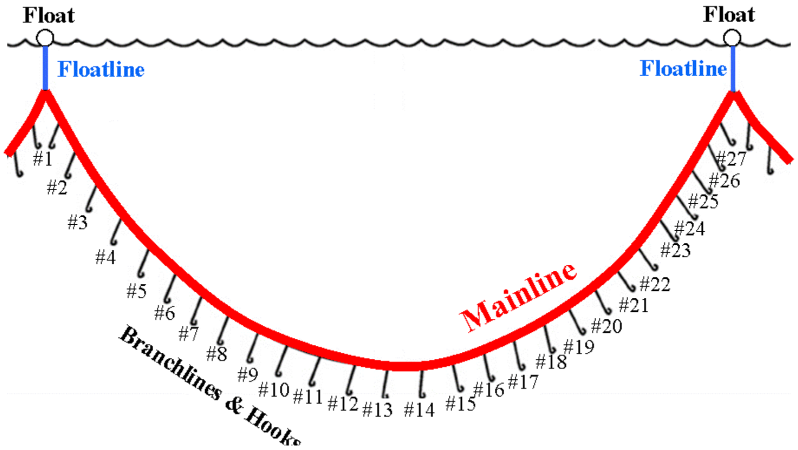

Figure 4. A longline section, showing hook numbers.

Table 6. Hook position of observed bycaught green turtles in the American Samoa longline fishery, April 2006-August 2010.

Date	Hook #	Hooks/Section	Relative Hook Depth
15-Jun-06	#17	27	Shallower than 19%
20-Jun-06	#35	35	Shallower than 94%
7-Oct-06	#1	30	Shallower than 93%
2-Jul-07	#5	32	Shallower than 69%
11-May-08	#2	32	Shallower than 87%
11-Jun-09	#26	26	Shallower than 92%
2-Sep-09	#6	34	Shallower than 65%
31-Oct-09	#21	36	Shallower than 11%
18-Feb-10	#1	34	Shallower than 94%
2-Apr-10	#6	28	Shallower than 57%
20-May-10	#33	35	Shallower than 83%
7-July-10	#6	30	Shallower than 60%
9-July-10	#1	30	Shallower than 93%
Mean Relative Hook Depth = Shallower than 71%			

The number of hooks per section in the 13 interactions varied from 26 to 36 hooks/section. Of the 13 hooked turtles, seven were caught on the shallowest or second-shallowest hooks in the sections. Mean relative hook depth of hooked turtles was shallower than 71 percent of the hooks in the 13 samples from the American Samoa longline fishery (Table 6). These data suggest that green turtles are more likely to be hooked/entangled on the shallower hooks/branchlines than on the deeper hooks/branchlines, supporting the concept that deeper setting may be an effective measure for reducing green turtle bycatch (WPFMC 2010). However, some turtles are still likely to be hooked even when hooks are set deeper than 100 m, as shown by the fact that several turtles were caught on the deeper 50 percent of the hooks (Table 6). Turtles may also be hooked or entangled as the hooks are being set, or when they're being hauled back in (retrieved), at depths between the surface and target fishing depth. According to Bigelow and Fletcher (2009), under the current operating conditions of the fishery, on average, 22.6% of hooks per section are shallower than 100 m. Requiring hooks to be fished below 100 m would essentially remove the shallowest 22.6% of hooks, effectively eliminating turtle hooking or entanglement that might otherwise occur on these hooks. Seven out of the 13 observed interactions, or 54%, occurred within the shallowest 22.6% of hooks in a section. Therefore, based on historical observed bycatch of green turtles (Table 6), NMFS estimates that the proposed action will reduce green turtle bycatch in the American Samoa longline fishery by 54 percent, thus hooking or entangling 15 green turtles annually (46% of the 33 estimated turtle interactions annually in the fishery during the 5-year period 2006-10 – see Table 5).

The proposed action may also affect green turtles due to boat collisions with turtles in the action area. In Hawaii, vessel collisions are thought to be a significant source of green turtle mortality in fisheries with large numbers of vessels that take day trips, resulting in a large number of trips per year through nearshore waters where green turtles are concentrated. For example, the Hawaii bottomfish fishery was estimated in 2008 to take 71,800 trips per year in State and Federal waters, resulting in vessel collisions killing 2 – 5 green turtles per year (NMFS 2008b). The Hawaii longline fishery results in far fewer trips, thus the Hawaii shallow-set fishery was estimated in 2008 to kill essentially zero green turtles due to vessel collisions (NMFS 2008a). In American Samoa, the longline fishery has fewer vessels than in Hawaii, and green turtles are much scarcer than in Hawaii, thus the number of annual green turtle mortalities estimated to result from boat collisions from the proposed action is essentially zero. Therefore, green turtle exposure to the effects of the proposed action is considered to be 15 hookings and/or entanglements by the fishery annually.

The proposed action is not expected to result in significant increases or decreases in fishing effort (WPFMC 2010). Thus, no market transfer effect is expected, therefore indirect effects to other green turtle aggregations are not likely to occur.

7.1.3 Response

Green turtle response to the predicted exposure (15 interactions annually) can be characterized as the annual number of mortalities resulting from this exposure. Twelve of the 13 observed green turtle interactions in April 2006-August 2010 were fatal, thus post-hooking (or entanglement) mortality of green turtles for the proposed action is 92 percent, or 14 mortalities annually. However, the only abundance data available for Oceania green turtles are the estimated number of adult females nesting annually (Table 2). Therefore, in order to assess the risk that the proposed action poses to green turtles in Oceania, it is necessary to determine the number of adult female green turtles (i.e., adult female "equivalents") that are represented by the estimated 15 interactions.

The American Samoa longline fishery interacts with males and females. The 13 observed interactions from April 2006-August 2010 were all juvenile green turtles with SCL 24-50 cm (Table 4). In order to estimate the number of adult female equivalents that would be killed by 15 juvenile interactions resulting in 14 mortalities, it is necessary to calculate: (1) the proportion of adult males and adult females in the aggregation; and (2) the adult equivalent represented by each juvenile interaction. Sex ratio of green turtles in Oceania is unknown, and is thus assumed to be 50 percent. Adult equivalence depends on mean reproductive value, which in turn depends on age to maturity, size at maturity, and survival, none of which are known for this region. In the absence of data, a conservative estimate of 0.50 adult equivalent is assumed for the juvenile green turtles captured in the American Samoa longline fishery.

In order to estimate the response of green turtles to an annual rate of 15 interactions in terms of adult female equivalent mortalities, the estimated 15 interactions were multiplied by the post-hooking mortality rate (0.92), the female sex ratio (0.50), and the adult equivalent rate (0.50), giving an estimate of 3.5 adult female green turtle equivalent mortalities annually from Oceania (Table 5). This number of adult female equivalent mortalities per year is the expected direct Oceania green turtle response to exposure resulting from hooking and entanglement caused by the proposed action. No market transfer effect is expected, thus indirect effects to other green turtle aggregations are not likely to occur.

The genetic results from nine sampled green turtles (all bycaught in the American Samoa longline fishery in 2006-10) indicate six different haplotypes: (1) one individual with a haplotype (CmP80) representing nesting aggregations of the Great Barrier Reef area, the Coral Sea, and New Caledonia; (2) two individuals with a haplotype (CmP22) representing nesting aggregations of the Marshall Islands, Yap and American Samoa; (3) two individuals with a rare haplotype (CmP65) only found so far in the nesting aggregation on the Marshall Islands, (4) two individuals with haplotypes of unknown nesting stock (CmP31 & CmP33) only found so far in foraging green turtles around Fiji , (5) one individual (CmP20) with a haplotype commonly found in nesting aggregations in Guam, Palau, Marshall Islands, Yap, Northern Mariana Islands, Taiwan and Papua New Guinea, and (6) one individual (CmP47) with a haplotype found in nesting aggregations in Yap, northern and southern GBR, New Caledonia, Coral Sea, Timor Sea, and east Indian Ocean (Peter Dutton, NMFS, pers. comm.). That is, seven of the nine sampled turtles with known haplotypes may have originated from small (less than 500 estimated annual nesting females [ANF]) NAs with declining or unknown trends in Oceania, despite the fact that the 21 NAs with fewer than 500 estimated ANF make up only five to ten percent of the regional nesting females, while the four NAs with more than 500 estimated ANF make up 90 - 95 percent.

Based on the genetic results, this opinion assumes that more than half of the 3.5 adult female green turtle equivalent mortalities annually resulting from the proposed action will be from the relatively small (fewer than 500 ANF) NAs, and the remaining adult female green turtle equivalent mortalities annually from the relatively larger (more than 500 ANF) NAs.

7.1.4 Risk

As shown by the nine genetics samples of green turtles from the American Samoa longline fishery (summarized in Section 7.1.3), all green turtles killed by this fishery are thought to be from Oceania. Because the four larger NAs in this region make up 90 - 95 percent of the aggregation, these four NAs together consist of tens of thousands of nesting adult females annually, three out of the four NAs have stable or increasing trends, and a very small number of adult female equivalents are expected to be killed annually, the risk to the four largest green turtle NAs in Oceania (Northern GBR, Southern GBR, New Caledonia, Western Micronesia) from the proposed action is considered negligible.

The 21 smaller NAs only make up five to ten percent of nesting females in Oceania, yet are expected to sustain a larger proportion of the adult female green turtle equivalent mortalities annually resulting from the proposed action. Because the 21 smaller NAs together consist of approximately 1,000 – 2,000 ANF and many of these 21 NAs have decreasing or unknown trends, the risk to the eastern NAs in Oceania from the proposed action is considered substantial.

7.2 Hawksbill Turtles

The stressors, exposure, response and risk steps of the effects analysis for hawksbill turtles with regard to implementation of the proposed action are described below. The following information was used to conduct these analyses of the proposed action on hawksbills: the 2005 Hawaii deep-set opinion (NMFS 2005), the 2006 purse seine opinion (NMFS 2006), the 2008 Hawaii shallow-set opinion (NMFS 2008a), the 2008 Hawaii bottomfish opinion, (NMFS 2008b), and other documents cited below.

7.2.1 Stressors

The 2005 BiOp on the Hawaii-based deep-set longline fishery concluded that the deep-set fishery is not likely to hook, entangle, or otherwise adversely affect hawksbill turtles (NMFS 2005). However, since then, a dead hawksbill that apparently was entangled and drowned in derelict fishing gear (netting) was retrieved by shallow-set gear in Hawaii (NMFS 2008a), and an unconfirmed hawksbill interaction occurred in the American Samoa longline fishery. Longline fishing affects hawksbills primarily by hooking, but also by entanglement and trailing of gear (Robins *et al*. 2002). Because hawksbills, like green turtles, recruit to nearshore habitat in American Samoa, longline vessels traveling to and from port could strike hawksbills (NMFS 2008b). While the primary direct effect of the proposed action on hawksbill turtles will be the stressor of fishing gear interactions, an indirect effect of the proposed action (one that is likely to occur later in time) may result from market transfer effects. That is, an increase or decrease in fishing effort by the American Samoa longline fishery could result in more or less fishing by competing fleets, potentially resulting in effects to other aggregations of hawksbill turtles (NMFS 2008a).

7.2.2 Exposure

Hawksbill interactions are very unlikely in either the Hawaii-based or American Samoa longline fisheries, as shown by zero reported hawksbill interactions in these fisheries since the Observer Program began in 1994 (in Hawaii) and 2006 (in American Samoa). However, satellite telemetry results from SPREP suggest that pelagic juveniles likely sometimes forage in pelagic habitat where these longline fisheries operate. Hawksbill interactions have occurred in longline fisheries in the Atlantic (Yeung 1999) and Pacific (Robins *et al*. 2002).

Like green turtles, hawksbills recruit as adults to nearshore habitat, where they remain except for breeding migrations. However, longline boat collisions with hawksbills are considered discountable because of the small number of vessels in the American Samoa longline fishery, and the small number of hawksbills in the action area. The proposed action is not expected to result in significant increases or decreases in fishing effort (WPFMC 2010). Thus, no market transfer effect is expected, therefore indirect effects to other hawksbill turtle aggregations are not likely to occur.

7.2.3 Response

Due to the rarity of hawksbill bycatch in this fishery, the death of a hawksbill from the proposed action is considered very unlikely. Because the fishery operates far from shore, it is unlikely to affect adult hawksbills. We cannot, however, discount the potential for interaction and thus estimate that one hawksbill will be killed by the proposed action due to hooking or entanglement every three years and conservatively assume that a hawksbill mortality would represent one adult female equivalent.

7.2.4 Risk

Hawksbills within the action area likely originate from Oceania, where an estimated 5,400-6,140 females nest annually (Section 5). The proposed action is expected to result in the mortality of one adult female equivalent hawksbill from this region every three years. Because of the size of the aggregation and the very small number of expected interactions, the risk to Oceania hawksbill turtles from the proposed action is considered negligible.

7.3 Leatherback Turtles

The stressors, exposure, response and risk steps of the effects analysis for leatherback turtles with regard to implementation of the proposed action are described below. The leatherback turtles directly affected by fishing interactions resulting from the proposed action are expected to be entirely from nesting assemblages in the Western Pacific. The following information was used to conduct these analyses of the proposed action on leatherbacks: the 2005 Hawaii deep-set opinion (NMFS 2005), the 2006 purse seine opinion (NMFS 2006), the 2008 Hawaii shallow-set opinion (NMFS 2008a), the 2008 Hawaii bottomfish opinion, (NMFS 2008b), and other documents cited below.

7.3.1 Stressors

Entanglement and foul hooking are the primary effects of longline fishing on leatherbacks, whereas internal hooking is more prevalent in hardshell turtles, especially loggerheads. Leatherbacks seem to be more vulnerable to entanglement and foul hooking, possibly due to their morphology (large size, long pectoral flippers, and lack of a hard shell), their attraction to gelatinous organisms and algae that may collect on buoys and buoy lines at or near the surface, or some combination of these and/or other reasons. Entanglement may result in substantial wounds and reduced mobility, causing impairment of feeding, breeding, or migration of the entangled individual. Besides entanglement and foul hooking, the other two primary effects of longline fishing on leatherbacks are internal hooking and trailing line. Because leatherbacks have more delicate skin and softer tissue and bone structures than hardshell turtles, their risk from longline-related injury is considered to be higher (NMFS 2005, 2008a).

Unlike green and hawksbill turtles, leatherbacks do not recruit to nearshore habitat in American Samoa, thus being struck by longline vessels traveling to and from port is not considered a stressor. While the primary direct effect of the proposed action on leatherbacks will be the stressor of fishing gear interactions, an indirect effect of the proposed action (one that is likely to occur later in time) may result from market transfer effects. That is, an increase or decrease in fishing effort by the American Samoa longline fishery could result in more or less fishing by competing fleets, potentially resulting in effects to other aggregations of leatherback turtles (NMFS 2008a).

7.3.2 Exposure

Leatherback turtles may be exposed to interactions directly caused by the proposed action, due to hooking and entanglement by fishing gear deployed by the American Samoa longline fishery. In 1993, the crew of an American Samoa government vessel engaged in experimental longline fishing, pulled up a small freshly dead leatherback turtle about just south of Swains Island (Grant 1994; WPFMC 2010). This is the only confirmed report of a leatherback being caught by longline gear in American Samoa waters. The proposed action is not expected to result in significant increases or decreases in fishing effort (WPFMC 2010). Thus, no market transfer effect is expected, therefore indirect effects to other leatherback turtle aggregations are not likely to occur.

7.3.3 Response

Due to the rarity of leatherback bycatch in this fishery, the death of a leatherback from the proposed action is considered very unlikely. Because leatherbacks are more likely to be caught on the shallower hooks of a longline (Gilman *et al*. 2006), and the proposed action is to set hooks deeper, the likelihood of leatherback interactions will be further reduced by the proposed action. We cannot, however, discount the potential for interaction and thus estimate that one juvenile or adult leatherback will be killed by the proposed action due to hooking or entanglement every three years. We conservatively assume that a leatherback mortality would represent one adult female equivalent.

7.3.4 Risk

Leatherbacks within the action area are thought to be from the Western Pacific region, estimated to have 3,987 breeding females annually (Section 5). The proposed action is expected to result in the mortality of one adult female equivalent from this population every three years. Because of the size of the population and the very small number of expected interactions, the risk to Western Pacific leatherback turtles from the proposed action is considered negligible.

7.4 Olive Ridley Turtles

The stressors, exposure, response and risk steps of the effects analysis for olive ridley turtles with regard to implementation of the proposed action are described below. The following information was used to conduct these analyses of the proposed action on olive ridleys: the 2005 Hawaii deep-set opinion (NMFS 2005), the 2006 purse seine opinion (NMFS 2006), the 2008

Hawaii shallow-set opinion (NMFS 2008a), the 2008 Hawaii bottomfish opinion, (NMFS 2008b), and other documents cited below.

7.4.1 Stressors

Longline fishing affects olive ridleys primarily by hooking, but also by entanglement and trailing of gear. Olive ridleys are the most commonly-caught sea turtle species in the Hawaii deep-set longline fishery (NMFS 2005), which fishes between 150 and 400 m of depth, and operates mostly between Hawaii and the equator. Unlike green and hawksbill turtles, olive ridleys do not recruit to nearshore habitat in American Samoa, thus being struck by longline vessels traveling to and from port is not considered a stressor. While the primary direct effect of the proposed action on olive ridley turtles will be the stressor of fishing gear interactions, an indirect effect of the proposed action (one that is likely to occur later in time) may result from market transfer effects. That is, an increase or decrease in fishing effort by the American Samoa longline fishery could result in more or less fishing by competing fleets, potentially resulting in effects to other aggregations of olive ridley turtles (NMFS 2008a).

7.4.2 Exposure

No olive ridley interactions have been reported in the American Samoa longline fishery. Olive ridleys are the most commonly-caught sea turtle species in the Hawaii deep-set longline fishery (NMFS 2005) which fishes between 150 and 400 m of depth. Although the proposed action requires deeper fishing, the American Samoa longline fishery action area is much smaller than that of the HI LL fishery and olive ridleys are considered rare in the area. In addition, under current operations American Samoa based longline vessels fish with 77.4% of their hooks below 100m already (Bigelow and Fletcher 2009), yet an olive ridley interaction has not yet been observed or recorded. The proposed action may expose this species to potential hooking and entanglement but for the reasons described, this is considered unlikely. The proposed action is not expected to result in significant increases or decreases in fishing effort (WPFMC 2010). Thus, no market transfer effect is expected, therefore indirect effects to other olive ridley turtle aggregations are not likely to occur.

7.4.3 Response

Due to the rarity of olive ridley bycatch in this fishery, the death of an olive ridley from the proposed action is considered very unlikely. We cannot, however, discount the potential for interaction and thus estimate that one juvenile or adult olive ridley will be killed by the proposed action due to hooking or entanglement every three years. We conservatively assume that an olive ridley mortality would represent one adult female equivalent.

7.4.4 Risk

The proposed action is expected to result in the mortality of one adult female equivalent from the Western Pacific population of olive ridleys every three years. The Hawaii-based deep-set longline fishery was estimated to kill 39 olive ridleys annually, including some individuals from both the Eastern and Western Pacific aggregations. However, the olive ridley population assessment done for the deep-set biological opinion found that this level of mortality would have no effect on either population (NMFS 2005). The Hawaii-based shallow-set longline fishery was estimated to kill one olive ridley annually from the Western Pacific, and concluded that this level of mortality would have negligible impact on the population (NMFS 2008a). Likewise, due to the low level of mortality, the proposed action is expected to pose a negligible risk to Western Pacific olive ridleys.

8 Cumulative Effects

"Cumulative effects", as defined in the ESA implementing regulations, are limited to the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this opinion (50 CFR 402.02). 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. Because the action area is primarily a swath of the South Pacific Ocean (see Figure 2), and cumulative effects, as defined in the ESA, do not include the continuation of actions described under the Environmental Baseline, few actions within the action area are expected to result in cumulative effects.

Cumulative effects on the four species addressed by this opinion may occur as a result of worsening climate change, and any increase in the fishing, ship traffic, and other actions described in the Environmental Baseline section.

Global climate change is expected to continue and to therefore continue to impact sea turtles and their habitat. Rising temperatures at nesting beaches may continue to exacerbate a female bias and could also increase embryonic mortality if beaches are already at the high end of thermal tolerance for sea turtle nests (Matsuzawa *et al.* 2002). Only low-level nesting of greens and hawksbills takes place inside the action area. However, turtles that occur in the action area come from nesting aggregations that may be affected by impacts at their nesting beaches of origin throughout the Pacific. The best available demonstrations of the potential effects of sea level rise indicate that some sea turtle nesting beaches will lose a percentage of their current area by 2100 (Fish et al. 2005; Baker et al. 2006; Fuentes et al. 2009); however these were modeled on static systems and did not account for geomorphological dynamics, such as the natural sinking of islands or the natural growth of coral reefs to keep up with sea level rise. A quantitative analysis of physical changes in 27 atoll islands in the central Pacific over a 19 to 61 year period that corresponds with a rate of sea level rise of 2.0 mm.y^{-1} shows that 86% of islands remained stable (43%) or increased in area (43%) while only 14% of study islands exhibited a net reduction in island area (Webb & Kench 2010), evidence that changes will not be uniform or predictable and sea level rise may or may not result in beach loss.

Alterations to foraging habitats and prey resources, changes in phenology and reproductive capacity that correlate with fluctuations in SST, and potential changes in migratory pathways and range expansion (all discussed previously in Environmental Baseline) are additional ways in which sea turtles may continue to be impacted by climate change. Many marine species, including the pelagic life stages of sea turtle species in the action area, forage in areas of nutrient rich oceanic upwelling, the strength, location, and predictability of which may change with increasing global temperatures (Harwood 2001).

Although there is much speculation on the potential impacts of climate change to species and ecosystems, there are multiple layers of uncertainty associated with these analyses making it impossible to accurately predict the most likely scenario that will result and consequently what impacts species and ecosystems will face, particularly in Pacific Island countries (Barnett 2001). Effects of climate change will not be globally uniform (Walther et al. 2002) and information regarding the magnitude of future climate change is speculative and fraught with uncertainties (Nicholls and Mimura 1988). In particular, there is no comprehensive assessment of the potential impacts of climate change within the action area or specific to sea turtles that may be within the action area.

In addition to the uncertainty of the rate, magnitude, and distribution of future climate change and its associated impacts on temporal and spatial scales, the adaptability of species and ecosystems are also unknown. Impact assessment models that include adaptation often base assumptions on when, how, and to what adaptations occur on theoretical principles, inference from observed observations, and arbitrary selection, speculation, or hypothesis (see review in Smit 2000). Impacts of climate change and hence its ‘seriousness’ can be modified by adaptations of various kinds (Tol et al. 1998). Ecological systems evolve in an ongoing fashion in response to stimuli of all kinds, including climatic stimuli (Smit et al. 2000). Sea turtles may exhibit a variety of adaptations to cope with climate change-related impacts, although it will likely take decades to centuries for both climate-related impacts and associated adaptations to occur (Limpus 2006) making it increasingly difficult to predict future impacts of climate change on sea turtles in the action area. For example, sea turtles are known to be highly mobile and in the past have shown the ability to adapt to changes in their environment and relocate to more suitable foraging and nesting sites over the course of multiple generations. Implications of climate change at the population level are a key area of uncertainty and one of active research (e.g. Jonzén et al. 2007) and cannot currently be reliably quantified in terms of actual mortalities resulting from climate change impacts over any time scale. Nor can they be qualitatively described or predicted in such a way as could be more meaningfully evaluated in the context of this biological opinion. Within the temporal scale of the proposed action, any future synergistic impacts of climate change in the action area that might interact with the effects of the proposed action are not considered significant.

Cumulative effects could also include increases in fishing gear interactions with the four turtle species from non-U.S. Federal fisheries. In addition, any increases in marine debris could also increase entanglements of these species. Although the extent of climate change, increases in fishing, ship traffic, and marine debris are unquantifiable, and the corresponding effects are also unquantifiable, these cumulative effects are likely to pose future challenges to sea turtle species in the action area. Therefore, conservation recommendations are provided at the end of this opinion to further reduce or avoid negative impacts to species resulting from the proposed action, in the context of these continuing cumulative effects.

9 Integration and Synthesis of Effects

The purpose of this Opinion is to determine if the proposed action is likely to jeopardize the continued existence of listed species (50 CFR 402.02). “Jeopardize the continued existence of” means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species. This opinion considers the Effects of the Action within the context of the Status of Listed Species and Environmental Baseline, as described in the Approach section (beginning of Section 7 Effects of the Action).

The jeopardy determination determines if reductions in fitness (in this case mortality) of individuals of listed species resulting from the proposed action are sufficient to reduce the viability of the populations those individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population's extinction risks). In order to make that determination, we use the population's base condition (established in the Status of Listed Species and Environmental Baseline sections of this opinion), considered together with Cumulative Effects, as the context for the overall Effects of the Action on the affected populations. Finally, our opinion determines if changes in population viability are likely to be sufficient to reduce the viability of the species those populations comprise or impair long term recovery of those species, consistent with recovery objectives, as set forth in the species' recovery plan and other sources. The following discussions summarize the probable risks the proposed action poses to the four listed species addressed by this opinion.

Green Turtles. As described in the green turtle section of the Effects of the Action (Section 7.1), the proposed action is likely to result in 15 green turtle interactions annually, 14 resulting in mortality. Thus the proposed action is expected to result in 14 mortalities of green turtles from Oceania, equivalent to 3.5 adult female green turtles annually from this region. Green turtles in Oceania consist of 25 Nesting Aggregations (NAs), four larger NAs estimated to consist of more than 500 ANF each, and 21 smaller NAs estimated to consist of fewer than 500 ANF each. The smaller NAs only make up five to ten percent of the total estimate of nesting females, but more than half of the green turtle mortality from the proposed action will be sustained by these smaller NAs.

As discussed in the green turtle section of the Status of Listed Species (Section 5.1), nesting of green turtles in the 21 smaller NAs within Oceania appears to be declining. As discussed in the green turtle section of the Environmental Baseline (Section 6.1), up to 268 green turtles from Oceania may be killed annually by longlining in the action area alone, which includes the current operations of the American Samoa longline fishery. In addition, green turtles from this region are killed annually by nearshore activities such as direct harvest, fishing, and boat collisions within the action area. Green turtles in the action area may be impacted by worsening climate change, but those impacts are not discernible in the action area and in the context of this analysis and cannot be quantified because of associated uncertainties, as described above in Section 8. The proposed action is likely to reduce the number of green turtles killed by longline fishing as described in the Environmental Baseline section by reducing green turtle mortalities caused by hooking and entanglement in the American Samoa longline fishery by 54%. However, the Effects of the Action will still result in the mortality of 3.5 adult female green turtle equivalents annually. Based on genetic analysis of incidentally caught green turtles in this fishery between 2006 and 2010, the 15 estimated annual interactions (and resultant 3.5 adult female equivalent mortalities) are unlikely to impact only one green turtle NA but rather are likely to be spread among several NAs, diluting the impact of the proposed action on the species as a whole. Viewed within the context of the Status of the Species and the Environmental Baseline, and considered together with the Cumulative Effects, the mortality of 3.5 adult female green turtle equivalents caused by the proposed action (Section 7.1) is insufficient to adversely affect the dynamics of Oceania green turtles. That is, we do not expect the proposed action to appreciably reduce the reproduction, numbers, or distribution of green turtles in this region or the potential for recovery of the species.

While the proposed action is not likely to jeopardize the survival or recovery of green turtles in the wild, it is expected to continue to result in mortalities of green turtles from small nesting aggregations with declining or unknown trends which will have a much greater impact than removing individuals from large increasing or stable aggregations. There is legitimate concern over the loss of small isolated nesting aggregations and the implications for the species as a whole, as well as associated consequences for local ecosystems (McClenachan et al 2006). Female sea turtles tend to exhibit strong natal homing, or returning to the beach from which they hatched to lay their eggs, making particular rookeries effectively autonomous with regard to reproduction over ecological timescales. However, 'mistakes' in natal homing occur with sufficient frequency to facilitate some genetic exchange between conspecific rookeries over short evolutionary timescales (Avise and Bowen 1994). This kind of genetic exchange is only possible within reasonable geographic scales; if the distance of individual migration is much smaller as compared with the entire distribution range of the species, genetic exchange will only occur locally (Kimura and Weiss 1964), although many small nesting aggregations scattered throughout the species range may act as stepping stones between larger rookeries. Removing individuals from small declining nesting assemblages increases the risk of promoting the extirpation of local nesting aggregations, effectively removing stepping stones or connectors within this metapopulation that serve to facilitate genetic exchange. Avise and Bowen (1994) argue that decline or loss of a given rookery is not likely to be compensated for by natural recruitment of females hatched elsewhere (at least over ecological timescales germane to immediate human interests). Many of the small NA's throughout Oceania may serve as stepping stones or connectors between the larger NAs in the Eastern Pacific and Western Pacific. Genetic information from green turtles caught incidentally in the American Samoa longline fishery indicates more are likely killed from small declining nesting aggregations than from large stable ones, therefore, in the absence of conclusive genetics for every sample, to err on the side of caution for the species, it is conservative to assume all turtles caught are from small declining rookeries. As mentioned previously, the estimated mortalities resulting from this fishery are expected to be spread among several such rookeries and the proposed action is not likely to jeopardize the existence of the species or the potential for its recovery. However, removing individuals from small declining rookeries has a larger relative impact than removing individuals from large stable or increasing rookeries so conservation recommendations to benefit this species are included at the end of this opinion.

Hawksbill Turtles. As described in the hawksbill section of the Effects of the Action (Section 7.2), the proposed action is likely to result in one juvenile hawksbill mortality from Oceania due to hooking or entanglement every three years. As discussed in the hawksbill turtle section of the Status of Listed Species (Section 5.2), hawksbill nesting in Oceania has continued to decline in the last decade. As discussed in the hawksbill turtle section of the Environmental Baseline (Section 6.2), hawksbill turtles are likely killed annually by longlining, nearshore fishing, direct harvest, car collisions, and other human activities in the action area. Hawksbill turtles in the action area may be impacted by climate change but those impacts are not discernible in the action area and cannot be quantified because of insufficient data, as described above in Section 8. However, since the proposed action is likely to result in only one hawksbill mortality over a three-year period (Section 7.2), the effects of the proposed action on hawksbills are insufficient to adversely affect the dynamics of Oceania hawksbill turtles. That is, we do not expect the proposed action to appreciably reduce the reproduction, numbers, or distribution of hawksbills in this region or the potential for recovery of the species.

Leatherback Turtles. As described in the leatherback section of the Effects of the Action (Section 7.3), the proposed action is likely to result in one juvenile or adult leatherback mortality from Western Pacific nesting assemblages due to hooking or entanglement every three years. As discussed in the leatherback turtle section of the Status of Listed Species (Section 5.3), nesting in the Western Pacific has continued to decline in the last decade. As discussed in the leatherback turtle section of the Environmental Baseline (Section 6.3), leatherback turtles are likely killed annually by longlining and other human activities in the action area. Leatherback turtles in the action area may be impacted by climate change but those impacts are not discernible in the action area and cannot be quantified because of a lack of information, as described above in Section 8. However, since the proposed action is likely to result in only one leatherback mortality over a three-year period (Section 7.2), the effects of the proposed action on leatherbacks are insufficient to adversely affect the dynamics of Western Pacific leatherback turtles. That is, we do not expect the proposed action to appreciably reduce the reproduction, numbers, or distribution of leatherbacks from this region or the potential for recovery of the species.

Olive Ridley Turtles. As described in the olive ridley section of the Effects of the Action (Section 7.4), the proposed action is likely to result in one juvenile or adult olive ridley mortality from Western Pacific nesting assemblages due to hooking or entanglement every three years. As discussed in the olive ridley turtle section of the Status of Listed Species (Section 5.4), the trend of the Western Pacific aggregation is unknown. As discussed in the olive ridley turtle section of the Environmental Baseline (Section 6.4), olive ridley turtles are likely killed annually by longlining and other human activities in the action area. Olive ridley turtles in the action area may be impacted by climate change but those impacts are not discernible in the action area and cannot be quantified because of a lack of data, as described above in Section 8. However, since the proposed action is likely to result in only one olive ridley mortality over a three-year period (Section 7.4), the effects of the proposed action on olive ridleys are insufficient to adversely affect the dynamics of Western Pacific olive ridley turtles. That is, we do not expect the proposed action to appreciably reduce the reproduction, numbers, or distribution of olive ridleys in this region or the potential for recovery of the species.

All Species: Climate Change. Parmesan and Yohe (2003) consider climate change a driver of small-magnitude but consistent impact that is important in that it systematically affects century-scale biological trajectories and ultimately the persistence of species. Based on this consideration and the available data in predicting future impacts described earlier, the significance of climate change in the context of this analysis is low considering the limited temporal and spatial scale over which the action is likely to occur. There is currently no demonstrated link between climate change-induced environmental impacts such as sea level rise and marine turtle population indices in the modern record. This may be because most sea turtle data sets only overlap with the most recent 20-50 years of climate data, a period which is not long enough to discern changes in climate directly linked to anthropogenic causes. As indicated *supra*, the action which potentially affects ESA-listed species under NMFS jurisdiction consists of fishing operations conducted by the American Samoa longline fishery within the action area which is described in Section 4. While there is not a pre-determined length of operation for this fishery, re-consultation is required as stated in Section 12, (e.g. if ITS is exceeded, new information becomes available, the proposed action is modified, or a new species or critical habitat is designated in the action area) and will require analyses using new and updated information, including with respect to climate change impacts. Re-consultation and the resulting updated analysis of climate change-related impacts to sea turtles is likely to occur well before impacts associated with climate change and resulting adaptations are expected to be evident at a population level for listed sea turtle species. We anticipate that over the expected timeframe of the action and within the action area, recent and future mortalities that can be linked directly to climate change impacts will not be discernible because non-climate related causes dominate local, short-term biological changes. Also, it is difficult to predict how the uncertain effects of climate change will impact sea turtles when combined with other threats. Although it is likely that some sea turtle nesting sites will lose a percentage of their area to rising sea levels and typhoon activity, the synergistic impacts of these threats in the action area, and the sea turtles' ability to adapt, remain uncertain. In summary, as discussed previously in the Status of the Species, Environmental Baseline, and Cumulative Effects sections, very little scientific data have been collected regarding the current or future impacts of anthropogenic climate change on sea turtles, either globally or in the action area. Therefore, we cannot predict with precision how climate change will continue to impact sea turtle populations or how they will adapt to environmental changes in various habitats. Based on the best available data, we conclude that climate change-related impacts to sea turtles and sea turtle adaptations to climate change are both long-term processes that will manifest over a timescale that exceeds the term of this biological opinion. Both processes are also subject to many uncertainties and are not yet well enough understood to permit more meaningful quantitative or qualitative analysis. As such, climate change-related impacts do not appear to have had a measurable impact on these species or to be likely to reduce the potential for recovery of these species in the context of the proposed action.

10 Conclusion

This Conclusion presents NMFS' opinion regarding whether the aggregate effects of the factors analyzed under the Environmental Baseline (Section 6), the Effects of the Action (Section 7), and the Cumulative Effects (Section 8) in the action area, when viewed against the Status of Listed Species (Section 5), are likely to jeopardize the continued existence of the listed species or their recovery (i.e., jeopardy determination). The proposed Federal action addressed by this biological opinion is implementation of the Fishery Ecosystem Plan for Pelagic Fisheries of the Western Pacific Region (Pelagics FEP) as amended by the proposed amendment which includes a modification of the management program for the American Samoa longline fishery. Specifically, the proposed modification is to implement a 100 m minimum hook depth requirement which would be accomplished by requiring a minimum float line length of 30 m, together with a minimum of 70 m of blank mainline (no hooks) between each float line and the first branchline in either direction along the mainline. Additional proposed regulations include requirement of a minimum 15 hooks per float and maximum of 10 swordfish retained on each trip. These proposed regulations are intended to reduce interactions between this fishery and sea turtles and NMFS agrees these regulations should be implemented in an effort to accomplish this reduction. After reviewing the current status of ESA-listed green sea turtles, hawksbill sea turtles, leatherback sea turtles, and olive ridley sea turtles, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence or recovery of these four species. Critical habitat has not been designated in the action area, so no critical habitat would be affected by the proposed action.

While the proposed action is not likely to jeopardize green sea turtles, it is likely to result in the continued removal of individuals from small, declining NAs in Oceania. While these NAs make up a small proportion of the overall Oceania green turtle nesting assemblage, they may possess unique adaptations and ecological significance to their particular environments, and may facilitate some genetic exchange between larger nesting aggregations that are far apart. It is therefore important that NMFS implement conservation recommendations provided at the end of this opinion to further reduce the likelihood of impacting these aggregations.

11 Incidental Take Statement

Section 9 of the ESA and protective regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct. "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 section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the reasonable and prudent measures and terms and conditions of the Incidental Take Statement (ITS).

The measures described below are nondiscretionary, and must be undertaken by NMFS for the exemption in section 7(o)(2) to apply. NMFS has a continuing duty to regulate the activity covered by this ITS. If NMFS fails to assume and implement the terms and conditions, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, NMFS must monitor the progress of the action and its impact on the species as specified in the ITS (50 CFR §402.14(I)(3)).

11.1 Amount or Extent of Take

The annual numbers of interactions and mortalities expected to result from implementation of the proposed action are shown for a 3-year period in Table 7 below (i.e., a 3-year ITS). The incidental take of up to 45 green sea turtles over three years (average of 15 interactions per year) is expected to occur as a result of the proposed action, due to hooking and entanglement with longline fishing gear. The occasional hooking and entanglement (no more than 1 every 3 years per species) of hawksbill, leatherback, and olive ridley turtles is also expected. The ITS is established for a 3-year period (i.e., years 1 – 3) after implementation of the proposed action. If the total number of authorized sea turtle interactions during any consecutive 3-year period is exceeded, reinitiation of consultation will be required (50 CFR 402.16). After implementation of the proposed action and the period of years 1 through 3 has ended, a new 3-year ITS period will begin with years 2 through 4, and so on. The Reasonable and Prudent Measures below and their implementing Terms and Conditions are designed to ensure that the proposed action reduces green turtle interactions to anticipated annual levels and minimizes those impacts.

Table 7. The number of turtle interactions expected in the American Samoa longline fishery as a result of the proposed action.

Species	Interactions	Mortalities	Adult female equivalents
Green turtles	45 every 3 years	41 every 3 years	10 every 3 years
Hawksbill turtles	1 every 3 years	1 every 3 years	1 every 3 years
Leatherback turtles	1 every 3 years	1 every 3 years	1 every 3 years
Olive ridley turtles	1 every 3 years	1 every 3 years	1 every 3 years

11.2 Impact of the Take

In the accompanying biological opinion, NMFS determined that the level of incidental take anticipated from the proposed action is not likely to jeopardize the green turtle, hawksbill turtle, leatherback turtle, or olive ridley turtle.

11.3 Reasonable and Prudent Measures

Section 7(b)(4) of the ESA requires that when an agency is found to comply with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of listed species, NMFS will issue a statement specifying the impact of any incidental taking. It also states that reasonable and prudent measures necessary to minimize impacts, and terms and conditions to implement those measures be provided and must be followed to minimize those impacts. Only incidental taking by the Federal agency or applicant that complies with the specified terms and conditions is authorized.

The incidental take expected to result from the proposed action is shown in Table 7 above for each sea turtle species. NMFS has determined that the following reasonable and prudent measures, as implemented by the terms and conditions (identified in Section 13.4), are necessary and appropriate to minimize the impacts of the American Samoa longline fishery, as described in the proposed action, on sea turtles, and to monitor the level and nature of any incidental takes. These measures are non-discretionary--they must be undertaken by NMFS for the exemption in ESA section 7(o)(2) to apply.

1. NMFS shall implement measures and activities in addition to those included in the proposed action intended to ensure that hooks fish deeper than 100 m from the surface.

2. NMFS shall investigate and promote activities, in addition to setting hooks to fish deeper than 100 m from the surface, to reduce the likelihood of sea turtle interactions.

3. NMFS shall collect data on the capture, injury, and mortality of sea turtles caused by the American Samoa longline fishery, and shall also collect basic life-history information, as available.

4. NMFS shall require that sea turtles captured alive be released from fishing gear in a manner that minimizes injury and the likelihood of further gear entanglement or hooking, as practicable, and in consideration of best practices for safe vessel and fishing operations.

5. NMFS shall require that comatose or lethargic sea turtles be retained on board, handled, resuscitated, and released according to the established procedures, as practicable and in consideration of best practices for safe vessel and fishing operations.

6. NMFS shall require the carcasses of sea turtles that are dead or that appear dead and cannot be resuscitated when brought on board a vessel be discarded and only retained for sea turtle research if requested by NMFS, as practicable and in consideration of best practices for safe vessel and fishing operations.

11.4 Terms and Conditions

NMFS shall undertake and comply with the following terms and conditions to implement the reasonable and prudent measures identified in Section 13.3 above.

1. The following terms and conditions implement Reasonable and Prudent Measure No. 1:

   1A. NMFS shall require that each branch line (gangion) be at least 10 meters long.

   1B. NMFS shall conduct research on the gear configuration specified in the proposed action and 1A above to determine effectiveness in setting hooks to fish deeper than 100m.

   1C. NMFS shall educate and work collaboratively with fishermen to effectively deploy their fishing gear to set hooks to fish deeper than 100 m.

2. The following terms and conditions implement Reasonable and Prudent Measure No. 2:

   2A. NMFS shall conduct research on other potential gear modifications to reduce the number and/or severity of interactions with protected species in the American Samoa longline fishery.

3. The following terms and conditions implement Reasonable and Prudent Measure No. 3:

   3A. As practicable and in consideration of best practices for safe vessel and fishing operations, observers shall collect standardized information regarding the incidental capture, injury, and mortality of sea turtles for each interactions by species, gear, and set information, as well as the presence or absence of tags on the turtles. Observers shall also collect life-history information on sea turtles captured by the American Samoa longline fishery, including measurements (including direct measure or visual estimates of tail length), condition, skin biopsy samples, and estimated length of gear left on the turtle upon release. To the extent practicable, these data are intended to allow NMFS to assign these interactions into the categories developed through NMFS' most current post-hooking mortality guidelines.

3B. NMFS shall disseminate quarterly summaries of the data collected by observers to the NMFS PIRO Assistant Regional Administrators of Protected Resources and Sustainable Fisheries in PIR, as well as the NMFS Sea Turtle Coordinators in the Pacific Islands Region, Southwest Region, and Headquarters.

4. The following terms and conditions implement Reasonable and Prudent Measure No. 4:

4A. NMFS shall continue to require and conduct protected species workshops for all owners and operators of vessels registered for use with American Samoa longline limited access permits, to educate vessel owners and operators in handling and resuscitation techniques to minimize injury and promote survival of hooked or entangled sea turtles. The workshops shall include information on sea turtle biology and ways to avoid and minimize sea turtle impacts to promote sea turtle protection and conservation.

4B. NMFS shall translate sea turtle identification, handling, and release guide placards into Samoan (and possibly other applicable languages) and provide to all longline vessel operators.

4C. NMFS shall continue to train observers about sea turtle biology and techniques for proper handling and resuscitation.

4D. NMFS shall require that American Samoa longline fishermen remove hooks from live turtles as quickly and carefully as possible to avoid further injury to the turtle, as practicable and in consideration of best practices for safe vessel and fishing operations. NMFS shall require that each American Samoa longline vessel carry a line clipper to cut the line as close to the hook as practicable and remove as much line as possible prior to releasing the turtle in the event a hook cannot be removed (e.g., the hook is ingested or the animal is too large to bring aboard).

4E. NMFS shall require that each American Samoa longline vessel with freeboard more than 3 ft carry and use a dip net to lift a sea turtle onto the deck to facilitate gear removal. If the vessel has a freeboard less than 3 ft, sea turtles must be eased onto the deck by grasping its carapace or flippers, to facilitate the removal of fishing gear. Any sea turtle brought on board must not be dropped on to the deck. All requirements should consider practicality and best practices for safe vessel and fishing operations.

4F. NMFS shall require each American Samoa longline vessel to carry and use, as appropriate, a wire or bolt cutter that is capable of cutting through any hook used by the vessel that may be imbedded externally, including the head/beak area of a turtle.

5. The following terms and conditions implement Reasonable and Prudent Measure No. 5:

5A. NMFS shall require that American Samoa longline vessel operators bring comatose sea turtles aboard and perform resuscitation techniques according to the procedures described at 50 CFR 665 as practicable and in consideration of best practices for safe vessel and fishing operations, except that observers shall perform resuscitation techniques on comatose sea turtles if observers are available on board.

6. The following terms and conditions implement Reasonable and Prudent Measure No. 6:

   6A. NMFS shall require that dead sea turtles may not be consumed, sold, landed, offloaded, transshipped, or kept below deck. Fishermen must return turtles to the ocean after identification, unless NMFS, including observers, requests the turtle be kept and returned to port for further study.

12 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to reduce or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or develop information.

The following conservation recommendations are provided pursuant to section 7(a)(1) of the ESA for developing management policies and regulations, and to encourage multilateral research and conservation efforts which would help in reducing adverse impacts to listed species in the Pacific Ocean, specifically those occurring in Oceania.

1. NMFS should maintain observer coverage in the American Samoa longline fishery at greater than or equal to 40 percent of vessel departures for at least two calendar years starting as soon as possible and greater than or equal to 20 percent thereafter to obtain data necessary to provide a statistically robust estimate of sea turtle bycatch in this fishery.

2. NMFS should continue to promote reduction of turtle bycatch in Pacific fisheries by supporting:
   a. The Inter-American Convention for the Protection and Conservation of Sea Turtles;
   b. A binding Western and Central Pacific Fisheries Commission (WCPFC) sea turtle conservation and management measure for commercial longline fisheries operating in the western Pacific;
   c. Implementation of NMFS Sea Turtle Handling Guidelines that increase post-hooking turtle survivorship;
   d. Technical assistance workshops to assist with observer training and transfer of bycatch mitigation technology in other nations with longline fisheries;
   e. Observer programs on commercial vessels operating in the western Pacific region and expansion of existing programs, and;
   f. The continuation of ecological, habitat use, and genetics studies for stock structure analysis of green, hawksbill, leatherback, and olive ridley turtles occurring in Oceania.

3. NMFS should continue to encourage, support and work with regional partners to better understand and quantify threats from human actions (e.g., fishery, pollution, habitat degradation, and harvest-related impacts, etc.), and implement long-term sea turtle monitoring, conservation, and recovery programs at critical nesting and foraging habitats and investigate migratory pathways to address anthropogenic impacts with a focus on the green turtle nesting aggregations in eastern Oceania.

4. NMFS should investigate the possibility of cooperative research with American Samoa longline fishermen to obtain biopsies and other data from sea turtles incidentally captured in the fishery to further our knowledge of stock structure and genetic connectivity for Pacific green turtles.

5. NMFS should conduct research on alternative fishing methods and/or gear configurations to reduce the number and/or severity of sea turtle interactions in the American Samoa longline fishery.

6. NMFS should evaluate and consider for implementation contingent measures to reduce the number and/or severity of sea turtle interactions if the Regional Administrator determines that the Incidental Take Statement above is likely to be exceeded in the American Samoa longline fishery. Such measures could include:
   A. Requiring circle hooks size 13/0 or larger with an offset not to exceed 10° for all longline gear, and/or

   B. Requiring float lines be a minimum of 70 m in length, a minimum of 15 hooks be attached between floats, branch lines be at least 10 m long, and no more than 10 swordfish be retained on any one fishing trip.

13 Reinitiation Notice

This concludes formal consultation on management modifications for the American Samoa longline fishery, as described in the proposed amendment (WPFMC 2010). 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 the incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. If the amount or extent of incidental take identified in the incidental take statement that is enclosed in this biological opinion is exceeded, NMFS SFD should immediately request initiation of formal consultation.

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