Endangered Species Act – Section 7 Consultation

Supplement to the 2014 Biological Opinion

Action Agency:	National Marine Fisheries Service, Pacific Islands Region, Sustainable Fisheries Division
Activity:	Continued operation of the Hawaii deep-set pelagic longline fishery.
Consulting Agency:	National Marine Fisheries Service, Pacific Islands Region, Protected Resources Division
NMFS File No. (PCTS): PIRO Reference No.:	PIR-2016-9869 I-PI-16-1421-AG
Approved By:	[signature]
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Acronyms

ANE	Adult nester equivalent
CFR	Code of Federal Regulations
CNMI	Commonwealth of the Northern Mariana Islands
DPS	Distinct population segment
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
FFS	French Frigate Shoals
FR	Federal Register
FSM	Federated States of Micronesia
FWS	Fish and Wildlife Service
ITS	Incidental Take Statement
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWHI	Northwestern Hawaiian Islands
PDO	Pacific Decadal Oscillation
PIFSC	Pacific Islands Fisheries Science Center
PIRO	Pacific Islands Regional Office
SCL	Straight carapace length
SFD	Sustainable Fisheries Division, NMFS Pacific Islands Regional Office
STAJ	Sea Turtle Association of Japan
TED	Turtle excluder device
WCPFC	Western and Central Pacific Fisheries Commission
WPFMC	Western Pacific Fishery Management Council

1 Introduction

Section 7(a) (2) of the Endangered Species Act (ESA) of 1973, as amended (ESA; 16 U.S.C. 1536(a) (2)) requires each federal agency to ensure that any action it authorizes, funds, or carries 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 (NMFS; for marine species or their designated critical habitat) or the U.S. Fish and Wildlife Service (FWS; 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 NMFS or the FWS concur with that conclusion (50 CFR 402.14 (b)).

If an action is likely to adversely affect a listed species, the appropriate agency (either NMFS or FWS) must provide a Biological Opinion (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.

After the deep-set fishery exceeded its incidental take statement for certain sea turtle species, including olive ridley, green, and the North Pacific loggerhead DPS, NMFS Pacific Islands Regional Office (PIRO) Sustainable Fisheries Division (SFD) re-initiated formal consultation with the Protected Resources Division on April 13, 2016 on their continued operation of the Hawaii deep-set pelagic longline fishery (deep-set fishery) as currently managed under the existing regulatory framework and described in the 2014 Opinion (NMFS 2014a, NMFS 2016) . For purposes of this Supplement, NMFS expects the deep-set fishery to continue to operate largely unchanged in terms of fishing location, the number of vessels, catch rates of target, non-target, and bycatch species, depth of hooks, or deployment techniques in setting longline gear. From 2004-2008 the number of hooks gradually increased from just over 30 million hooks to over 40 million hooks set.

Based on an analysis of fishery effort trends, NMFS continues to estimate that 128 vessels will make approximately 1,305 trips, 18,592 sets, and deploy 46,117,532 hooks annually (NMFS 2014a). In 2015, 142 vessels made approximately 1,448 trips, with 18,469 sets, and 47,489,544 hooks. This represents a slight increase in some measures of effort over anticipated levels (i.e. active vessels, trips, and hooks). However, NMFS has no information to believe that this slight increase in some effort measures in 2015 (e.g., less than a 3 percent increase in hooks set) will result in a material change in the future conduct of the fishery that will introduce effects to listed species in a manner or to an extent not considered in the 2014 Opinion. We incorporated NMFS revised climate guidance (NMFS 2016f) into the analytical approach for this supplement. Further the analytical approach used in the 2014 Opinion was consistent with this guidance specifically with respect to the use of best available climate information and climate uncertainty. Accordingly, this supplement to the 2014 Opinion only addresses the effects of the continued operation of the Hawaii Deep-set longline fishery on sea turtle species for which reiniation has been triggered, under the existing regulatory framework, and their designated critical habitat. All other determinations in the 2014 Opinion remain valid and unaffected by this Supplement. This Supplement and new Incidental Take Statement supersede the 2014 BiOp for these sea turtle species. All other information and determinations in the 2014 BiOp remain valid and unaffected by this Supplement.

2 Consultation History

The Consultation history of the Hawaii deep-set longline fishery is described in detail in the 2014 Opinion and is incorporated herein by reference. On September 19, 2014, NMFS issued that Opinion for the deep-set longline fishery which authorized incidental take of green sea turtles, leatherback sea turtles, loggerhead sea turtles, olive ridley sea turtles, humpback whales, sperm whales, and main Hawaiian islands insular false killer whales (NMFS 2014a). NMFS anticipated and authorized a three-year incidental take statement (ITS) of nine green sea turtles, nine loggerhead sea turtles, and 99 olive ridley sea turtles in the fishery. The ITS was effective on September 19, 2014. The Opinion required NMFS to re-initiate consultation under ESA Section 7 if (1) the amount or extent of the incidental take authorized in the Opinion 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 the 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 the Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

On December 8, 2014, and November 7, 2015, NMFS observers on deep-set longline vessels documented two fishery interactions with green sea turtles, both of which resulted in mortalities. Observer coverage in the fourth quarter of 2014 was 19.8 percent, resulting in an expansion factor of approximately five green sea turtle (100/19.8 = 5.05) (NMFS 2016d). Observer coverage in the fourth quarter of 2015 was 19 percent, resulting in an expansion factor of 5.26 (100/19 = 5.26) (NMFS 2016d). These two estimates resulted in an expanded fleet-wide total of 11 interactions with this species since July 2014. This number of interactions exceeds the three-year ITS of nine interactions with green sea turtles exempted by the Opinion.

On February 18, 2015, October 12, 2015, January 31, 2016, and February 1, 2016, NMFS observers on deep-set longline vessels documented four fishery interactions with loggerhead sea turtle sea turtles, three of which resulted in mortalities, the fourth turtle was released injured. Observer coverage in the first quarter of 2015 was 19.8 percent, resulting in an expansion factor of approximately five loggerhead sea turtles (100/19.8 = 5.05) (NMFS 2016d). Observer coverage in the fourth quarter of 2015 was 19 percent, resulting in an expansion factor of 5.26 (100/19 = 5.26) (NMFS 2016d). An estimate of 20 percent observer coverage in the first quarter of 2016 results in an expansion factor of five. These four interactions result in an expanded fleet-wide total of approximately 21 interactions with this species since July 2014. This number of interactions exceeds the three-year ITS of nine interactions with loggerhead sea turtles exempted by the Opinion.

Since July 2014, NMFS observers on deep-set vessels documented 23 interactions with olive ridley sea turtles, most of which resulted in mortalities (NMFS 2016d). These 23 interactions result in an expanded fleet-wide total of approximately 116 interactions since July 2014. This number of interactions exceeds the three-year ITS of 99 interactions authorized under the Opinion.

On April 6, 2016, NMFS and FWS issued a final rule to list 11 distinct population segments (DPSs) of green sea turtles under the ESA (81 CFR 20058). This final rule removed the previous range-wide listing and, in its place, listed eight DPSs as threatened and three as endangered. Green sea turtles most likely to occur in the range of the deep-set longline fishery are the East Pacific DPS, the Central North Pacific DPS, the East Indian-West Pacific DPS, the Southwest Pacific DPS, the Central West Pacific DPS, or the Central South Pacific DPS.

On August 21, 2015, NMFS published a final rule designating critical habitat for the Hawaiian monk seal in the MHI and expanding critical habitat in the NWHI (80 FR 50926). On September 16, 2016, NMFS concurred with SFD's determination that Hawaii longline fisheries, inclusive of both the deep-set and shallow-set fisheries, may affect, but are not likely to adversely affect fin whales, or adversely modify monk seal critical habitat.

Other than the September 16, 2015, memorandum of concurrence, the interactions with green, North Pacific loggerhead, and olive ridley sea turtles described above, and the final rule listing DPSs for green sea turtles, there is no new information indicating that the fishery may affect listed species or their habitat in a manner, or to an extent, not previously considered in the 2014 Opinion for the fishery. There has been no other change to the action as described in the 2014 Opinion that has introduced impacts to protected species not previously analyzed in the 2014 Opinion. Therefore, the 2014 Opinion and determinations remain valid for all other species. As such, this Supplement incorporates the environmental baseline, effects analyses, and conclusions of the Opinion for all other species by reference and do not discuss them further.

PIRO/Protected Resources Division provided a draft Supplement to PIRO/SFD, with a request for comments, on December 15, 2016. We received comments from PIRO/SFD on January 3, 2017. On February 10, 2017, we provided the draft Supplement to the Applicant, the Hawaii Longline Association, for the proposed action.

3 Description of the Action

The proposed action is the continued operation of the deep-set fishery, as currently managed under the Pelagics Fishery Ecosystem Plan, and the existing regulatory regime as described in the 2014 Opinion. NMFS expects 128 vessels to make approximately 1,305 trips, with 18,592 sets, and 46,117,532 hooks annually. NMFS anticipates the deep-set fishery will continue to operate throughout the year, fish sustainably, and utilize proven bycatch mitigation measures to manage impacts to ESA-listed marine mammals and sea turtles as required under regulations in 50 CFR parts 229 and 665.

4 Action Area

The action area is where the Hawaii deep-set fishing vessels operate, including transiting and fishing. This generally includes the exclusive economic zone (EEZ) around Hawaii and the

Pacific Remote Island Areas (Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Palmyra Atoll, and Wake Island) and the adjacent high seas areas (NMFS 2014a). Regulations prohibit the fishery from operating in specific areas as specified in the 2014 Opinion[1]. Fishing locations may vary seasonally based on oceanographic conditions, catch rates of target species, and management measures, among others. The deep-set fishery operates around the main Hawaiian islands mostly within 300-400 nm (556-741 km). In general, deep-set longline vessels operate out of Hawaii ports, with the vast majority based in Honolulu and a few in Hilo. Some deep-set trips originate from other ports such as Long Beach or San Francisco, California, or Pago Pago, American Samoa. Fishermen departing from California begin fishing on the high seas, outside of the U.S. EEZ. Fishermen departing from American Samoa usually begin fishing near the equator or farther north in the North Pacific where they expect higher catch rates of bigeye tuna. Regardless of the port where a deep-set longline trip begins or ends, all vessels with a Hawaii longline permit must report their catch and fishing effort information to PIRO within 72 hours of landing.

5 Analytical Approach

The jeopardy analysis relies upon the regulatory definition of “to jeopardize the continued existence of a listed species,” which is “to engage in an action that 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” (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

The adverse modification analysis considers the impacts of the Federal action on the conservation value of designated critical habitat. This Supplement uses the regulatory definition of "destruction or adverse modification" of critical habitat as defined at 81 FR 7214, February 11, 2016.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the range wide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an “exposure-response-risk” approach.

[1] On March 25, 2015, NMFS established requirements for fishing in the Pacific Remote Islands Marine National Monument Expansion (PRIMNM) in order to implement required provisions of Presidential Proclamation 9173 (80 FR 15693). The Proclamation expanded the PRIMNM to incorporate waters and submerged lands at Jarvis Island, Wake Island, and Johnston Atoll to the seaward limit of the U.S. Exclusive Economic Zone and called for the prohibition of commercial fishing in the Monument Expansion. As this Monument expansion has just recently occurred, there is no useful information about the conservation benefits they may afford to listed species in the action area. On August 26, 2016, President Barack Obama issued Presidential Proclamation 9478 (August 26, 2016, 81 FR 60225), expanding the Papahanaumokuakea Marine National Monument (PMNM) to the full extent of the U.S. Exclusive Economic Zone around the Northwestern Hawaiian Islands west of 163°W. The Proclamation establishes the PMNM Expansion for the protection of the objects within its boundaries and directs the Secretaries to prohibit commercial fishing while allowing for sustainable non-commercial fishing within the expanded PMNM. The Western Pacific Fisheries Management Council is currently evaluating options for developing regulations to implement the commercial and non-commercial fishing provisions of the Proclamation.

In this section of an 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 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. “Direct effects” are those affects that are caused directly by the action. “Indirect effects” are those that are reasonably certain to occur later in time (50 CFR 402.02).

Approach. NMFS determines expected effects of the action using a sequence of steps. The first step identifies stressors (or benefits) associated with the proposed action with regard to listed species. The second step identifies the magnitude of 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 these stressors (e.g., the mortality rate of exposed individuals; *response analysis*).

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. 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 populations that comprise them, viability (probability of extinction or probability of persistence) of listed species depends on viability of their populations. Similarly, the continued existence of populations are determined by the fate of individuals that comprise them; populations grow or decline as individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations. We begin by identifying the probable risks the action poses to listed individuals that are likely to be exposed to an action’s direct and indirect effects. Our analyses then integrate those individuals risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individual’s “fitness,” which are changes in an individual’s growth, survival, annual reproductive success, or lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual’s probable responses to an action’s effects on the environment (which we identify during our response analyses) are likely to have consequences for the individual’s fitness.

When individual listed plants or animals are expected to experience reductions in fitness, we would expect those reductions to also reduce the abundance, reproduction rates, or growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

Reductions in one or more of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species' viability. On the other hand, when listed plants or animals exposed to an action's effects are *not* expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise. If we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

If, however, we conclude that listed plants or animals are likely to experience reductions in their fitness, our assessment tries to determine if those fitness reductions are likely to be 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 this step of our analyses, we use the population's base condition (established in the 'Status of Listed Species', 'Environmental Baseline', and 'Cumulative Effects' sections of this Supplement) as our point of reference. Finally, our assessment tries to determine if changes in population viability are likely to be sufficient to reduce the viability of the species those populations comprise.

This introduction summarizes stressors and interactions resulting from the proposed action. It is included here to set the stage for following sections.

<u>*Potential Stressors*</u>. Potential stressors associated with the proposed action are listed here, and then described in more detail for each species in chapter eight. The proposed action is the continued operation of the Hawaii deep-set longline fishery. The greatest stressor associated with this action on the nine listed sea turtle species considered in this Supplement is interactions with fishing gear. Another potential stressor associated with the proposed action is collisions with fishing vessels. Vessels travel through areas with dense concentrations of some listed species, such as when vessels travel to and from port, passing through nearshore waters where green sea turtles occur. 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, are not considered stressors. Collisions are a potential direct stressors and described in detail below in the species sections, because they vary considerably between species.

<u>*Exposure*</u>

In this section we determine how many species were exposed to the hooking/entanglement stressor using the data collected by observers from 2004-2016 (Table 5). We use the observed interactions to calculate the total number of turtle interactions for the entire fleet and then use this to anticipate the future level of exposure for the action described in detail for each species in section eight. We then determine what the response is to the hooking/entanglement. We use Ryder at al. (2006) to assess the potential for mortality and applies a mortality rate to determine the future response.

After we determine the level of exposure and response due to the action we describe the cumulative effects in the action area and then we integrate and synthesize all of these factors to assess the risk that the proposed action poses to species and critical habitat and reach our jeopardy and adverse modification conclusions.

5.1 Evidence Available for the Consultation

To conduct our analyses, we considered lines of evidence available through published and unpublished sources that represent evidence of adverse impacts or the absence of such consequences. In particular, we considered information contained in NMFS's Opinions on the Hawaii and American Samoa Longline fisheries (NMFS 2004, 2005, 2006, 2008a, 2012, 2014a), status reviews (NMFS and FWS 2014, Conant et al., 2009, Seminoff et al., 2015), and recovery plans (NMFS and FWS 1998a, NMFS and FWS 1998b, NMFS and FWS 1998c, NMFS and FWS 1998d).

We supplemented this information by conducting electronic searches of literature published in English or with English abstracts using research platforms in the *Science Direct,Lexis-Nexis, and Google Scholar*. These platforms allowed us to cross search multiple databases for journals, open access resources, books, proceedings, web sites, for literature on the biological, ecological, and fisheries sciences. In addition to all of these searches we monitor listserves for new studies on sea turtles, bycatch, and climate change to keep abreast of new information on a regular basis.

For our literature searches, we used paired combinations of the keywords sea turtles, fisheries, bycatch, climate change, and many others to search these electronic databases. Electronic searches have important limitations, however. First, often they only contain articles from a limited time span. Second, electronic databases commonly do not include articles published in small or obscure journals or magazines. Third, electronic databases do not include unpublished reports from government agencies, consulting firms, and non-governmental organizations. To overcome these limitations, we identified additional papers that had not been captured in our electronic searches and searched their literature cited sections and bibliographies. We acquired references that, based on a reading of their titles and abstracts, appeared to comply with our keywords. If a references' title did not allow us to eliminate it as irrelevant to this inquiry, we acquired the reference.

6 Status of Listed Species

The Sustainable Fisheries Division's April 13, 2016 Biological Evaluation determined that the proposed action may adversely affect the nine ESA-listed marine turtles shown in Table 1.

Table 1. ESA-listed marine species considered in this consultation.

Species	Scientific Name	ESA Status	Listing Date	Federal Register Reference
Loggerhead sea turtle North Pacific DPS	*Caretta caretta*	Endangered	9/22/2011	76 FR 58868
Olive Ridley Sea Turtle	*Lepidochelys olivacea*			
Nesting aggregations Pacific coast of Mexico		Endangered	7/28/1978	43 FR 32800
All other Olive Ridley turtles		Threatened	7/28/1978	43 FR 32800
Green Sea Turtle DPSs	*Chelonia mydas*			
Central West Pacific		Endangered	4/06/2016	81 FR 20057
East Indian-West Pacific		Threatened	4/06/2016	81 FR 20057
Southwest Pacific		Threatened	4/06/2016	81 FR 20057
Central South Pacific		Endangered	4/06/2016	81 FR 20057
Central North Pacific		Threatened	4/06/2016	81 FR 20057
East Pacific		Threatened	4/06/2016	81 FR 20057

This section presents the biological and ecological information relevant to formulating the agency's Opinion, including population characteristics (population structure, size, trends) for the populations affected by the proposed action, life history characteristics (especially those affecting vulnerability to the proposed action), threats to the species, major conservation efforts, and other relevant information (FWS and NMFS 1998). Factors affecting the species within the action area are described in more detail in the Environmental Baseline section. The status of the species is first summarized below, followed by more detailed descriptions for each of the nine species addressed by this Supplement.

We have determined the source populations of individual of sea turtles caught in the Hawaii longline fisheries by comparing genetic samples collected from those individuals to the genetics information of known nesting populations. Over 200 loggerhead sea turtle samples were analyzed from the shallow-set fishery, and all were from the North Pacific DPS. The thirteen loggerhead sea turtle samples from the deep-set fishery were also from the North Pacific DPS. Olive ridley sea turtles are the most common turtle species hooked or entangled in the deep-set fishery, and about three-fourths are from the eastern Pacifc and the remaining are from the western Pacific (NMFS 2014a). The olive ridley sea turtles from the eastern Pacific are either from the Endangered Mexico population or from the threatened Central American populations. It is not possible to distinguish Eastern Pacific subpopulations based on genetics at this time. The western Pacifc olive ridley sea turtles are from the threatened population in the western Pacific and Indian oceans.

There have been a total of 14 samples that produced genetic results from the deep-set fishery for green sea turtles and a total of seven different haplotypes have been identified which are from four different DPSs (Dutton, pers comm, August 31, 2016). Ten of the 14 are from the East Pacific DPS, two from the Central North Pacific DPS, and one each from the East Indian-West

Pacific and Central South Pacific DPS (Dutton, pers comm, August 31, 2016). Due to the very limited number of samples, area of operation of the fishery, and the proximity of the DPSs we expect that the Central West Pacific DPS and Central South Pacific DPS are also likely to be affected by the action at low levels.

6.1 North Pacific Loggerhead Sea Turtle DPS

The Services (NMFS and FWS) determined that the loggerhead sea turtle (*Caretta caretta*) is composed of nine distinct population segments (DPSs) that constitute ''species'' that may be listed as threatened or endangered under the ESA. These loggerhead sea turtle DPSs are the North Pacific Ocean, South Pacific Ocean, North Indian Ocean, Southeast Indo-Pacific Ocean, Southwest Indian Ocean, Northwest Atlantic Ocean, Northeast Atlantic Ocean, South Atlantic Ocean, and Mediterranean Sea. Two loggerhead sea turtle DPSs, North Pacific and South Pacific are listed in the Pacific (76 FR 58868; September 22, 2011). The deep-set fishery only effects the North Pacific Ocean DPS of the loggerhead sea turtle.

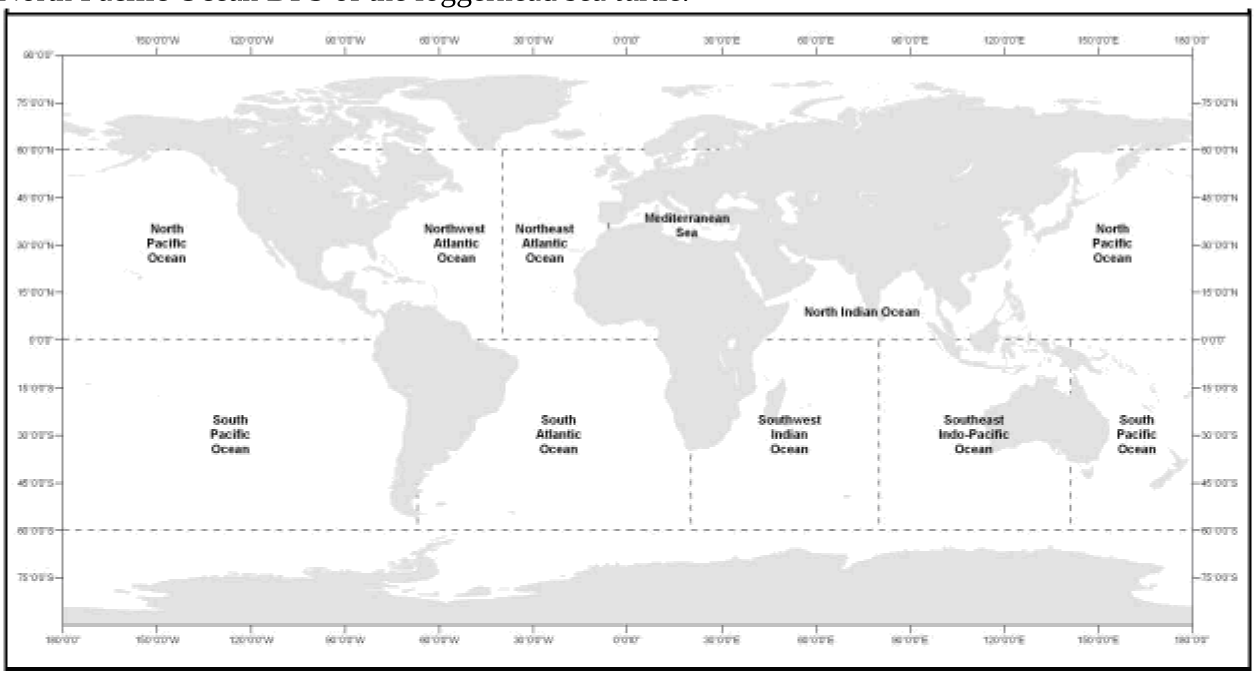

Figure 1. Map of Loggerhead sea turtle DPS boundaries (76 FR 58868; September 22, 2011).

Population Characteristics

Loggerhead sea turtles are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics. Natal homing of female loggerhead sea turtles to nesting beaches maintains regional population structure. The North Pacific loggerhead sea turtle DPS nests primarily in Japan (Kamezaki et al., 2003), although low level nesting may occur outside of Japan in areas surrounding the South China Sea (Chan et al., 2007, Conant et al., 2009).

Nesting beach monitoring in Japan began in the 1950s on some beaches, and grew to encompass all known nesting beaches starting in 1990 (Kamezaki et al., 2003). Along the Japanese coast, nine major nesting beaches (greater than 100 nests per season) and six "submajor" beaches (10–100 nests per season) exist, including Yakushima Island where 40 percent of nesting occurs (Kamezaki et al., 2003). Census data from 12 of these 15 beaches provide composite information on longer-term trends in the Japanese nesting assemblage. As a result, Kamezaki et al., (2003) concluded a substantial decline (50–90 percent) in the size of the annual loggerhead sea turtle nesting population in Japan since the 1950s. As discussed in the 2011 final ESA listing determination, current nesting in Japan represents a fraction of historical nesting levels (Conant et al., 2009; 76 FR 58868, September 22, 2011). Nesting declined steeply from an initial peak of approximately 6,638 nests in 1990–1991, to a low of 2,064 nests in 1997. During the past decade, nesting has been variable, increasing and decreasing over time as is typical of sea turtle nesting trends. Nesting increased gradually to 5,167 nests in 2005 (Conant et al., 2009), peaked to 11,082 nests in 2008, declined and then has risen steadily to a record high of 15,396 nests in 2013 (Sea Turtle Association of Japan (STAJ) 2008, 2009, 2010, 2012; Y.Matsuzawa, pers.comm 2014). Nesting activity, declined in 2014 to less than 10,000 nests, and again in 2015 with less than 5,000 nests laid (Irene Kelly pers comm.).

For the 23-year period 1990-2013, the total number of nests per year for the North Pacific DPS ranged between 2,064 – 15,396 nests. The 2015 International Union for Conservation of Nature Redlist Assessment estimated the total number of nests in the subpopulation, including beaches with less than 10 years of monitoring (62 nesting beaches in total), between years 2009-2013 was about 9,050 nests yr-1 (Limpus and Casale 2015). Assuming a clutch frequency of four per female per year (Van Houtan 2011), the number of nesting females per year between 1990 and 2013 ranged between 516 – 3849. There are 6,673 adult females in the population (Van Houtan 2013).

Given that population estimates for sea turtles are problematic due to lack of demographic information of all life stages (NRC 2010), NMFS will use nesting or nesting female data as population indices in this Supplement. A recent study determined that the current mean annual abundance of loggerhead sea turtles in the North Pacific is 43,226 (Seminoff et al., 2014). In 2011 we conducted a classical and a climate-based population viability assessment using nesting data (Van Houtan 2011, NMFS 2012). The classical population viability assessment calculated population growth and its variability from time series of nest counts, and this model resulted in a population increase over the next 100 years.

The second approach was the climate-based population viability assessment that considers bottom-up climate forcing at two life stages, neonates and breeding females. The climate-based population viability assessment forecasted a population decline below a 50 percent quasi-extinction threshold-level set by Van Houtan (2011) within one generation (25 years). Although the model is considered accurate based on its ability to account for historical population changes, because of the difficulty predicting the Pacific Decadal Oscillation (PDO), the model cannot forecast population trends beyond 25 years. While both the classical and climate-based approaches have limitations, NMFS expects that the climate-based model is more rigorous in applying actual data, and therefore generally more useful for assessing population trends. Both the classical and climate forcing model indicated that there is little to no difference in the extinction risk with the annual removal of one adult female loggerhead, which is greater than the level of of annual adult female mortality when considering both the deep-set and shallow-set fishery together.

Life History Characteristics Affecting Vulnerability to Proposed Action

Loggerhead sea turtle life history is characterized by early development in the oceanic (pelagic) zone followed by later development in the neritic zone over continental shelves. The oceanic developmental period may last for over a decade, followed by recruitment to the neritic zone of older age classes where maturation is likely reached. Satellite tracking of juvenile loggerhead sea turtles indicates the Kuroshio Extension Bifurcation Region to be an important pelagic foraging area for juvenile loggerhead sea turtles (Polovina et al., 2006, Kobayashi et al., 2008, and Howell et al., 2008). Baja California Sur, Mexico is an important foraging area for juvenile turtle loggerhead sea turtles (Peckham and Nichols 2006, Peckham et al., 2007, Conant et al., 2009, Wingfield et al., 2011). After spending years foraging, potentially two decades (Tomaszewicz et al., 2014), in the central and eastern Pacific, loggerhead sea turtles return to their natal beaches for reproduction (Resendiz et al., 1998, Nichols et al., 2000) and remain in the western Pacific for the remainder of their life cycle (Iwamoto et al., 1985, Kamezaki et al., 1997, Conant et al., 2009, Hatase et al., 2002, Ishihara et al., 2011). The East China Sea is a major habitat for post-nesting adult females based on tag-recapture studies (Iwamoto et al., 1985; Kamezaki et al., 1997, 2003; Kobayashi et al., 2008, 2011).

Given that the action area is oceanic, the main aspects of North Pacific loggerhead sea turtle life history affecting their vulnerability to Hawaii deep-set longline fishing are juveniles foraging and migrating across the oceanic zone, as discussed below. The Hawaii deep-set fishery primarily interacts with juvenile loggerhead sea turtles (Van Houtan 2013). In the central North Pacific Ocean, foraging juvenile loggerhead sea turtles congregate in the boundary between the warm, vertically-stratified, low chlorophyll water of the subtropical gyre and the vertically-mixed, cool, high chlorophyll transition zone water. The Transition Zone Chlorophyll Front is a favored foraging and developmental habitat for juvenile loggerhead sea turtles (Polovina et al., 2001). Satellite telemetry of loggerhead sea turtles also identified the Kuroshio Extension Current, specifically the Kuroshio Extension Bifurcation Region, as a forage hotspot (Polovina et al., 2006, Kobayashi et al., 2008). The Kuroshio Extension Bifurcation Region is an area of high primary productivity that concentrates zooplankton and other organisms that in turn attract higher trophic level predators, including sea turtles (Polovina et al., 2004). Loggerhead sea turtle habitat in the North Pacific occurs between 28° N. and 40° N. lat. (Polovina et al., 2004) and sea surface temperatures (SST) of 14.45° C to 19.95° C (Kobayashi et al., 2008), but is highly correlated at the 17/18°C isotherm (Howell et al., 2008). Data collected from stomach samples of juvenile loggerhead sea turtles indicate a diverse diet of pelagic food items (NMFS 2006, Parker et al., 2005). The Pacific Coast of the Baja California Peninsula, Mexico is a foraging hotspot for loggerhead sea turtles that originate from nesting beaches in Japan (Wingfield et al., 2011). Abundance estimates by Seminoff et al., (2014) indicated that upwards of 43,000 loggerhead sea turtles may occur in the Gulf of Ulloa, which likely represents a significant portion of the entire North Pacific loggerhead sea turtle DPS. Turner-Tomaszewicz et al., (2015) estimated loggerhead sea turtles in the Gulf of Ulloa range from three to 24 years of age based on skeletochronological analysis, suggesting that individuals moving into the eastern Pacific during their early development may spend 20 plus years in this region before reaching maturity and returning to the western Pacific for their adult life phase.

Loggerhead sea turtles are a slow-growing species that reach sexual maturity at 25 to 37 years of age depending on the DPS (NMFS and FWS 2007a). Conant et al., (2009) estimate age to maturity of the North Pacific DPS to be 30 years +/- 5 yrs. Van Houtan and Hailey (2011) estimated age at first reproduction to be 25 years. Given the maximum age estimated for loggerhead sea turtles in the Gulf of Ulloa and a one-year migration to western Pacific nesting beaches, Turner-Tomaszewicz et al., (2015) calculated that loggerhead sea turtles from the Gulf of Ulloa reach sexual maturity at approximately 25 years old, which is consistent with estimates by Van Houtan and Halley (2011). The North Pacific loggerhead sea turtle DPS range spans the entire North Pacific Ocean, hence migration of juveniles and adults between terrestrial (nesting), near-shore and pelagic habitats may result in crisscrossing of the action area during life stages. However, tagging studies indicate that juvenile loggerhead sea turtles are shallow divers, less than 100 m, that do not forage frequently at depths fished by deep-set gear (Polovina et al., 2003, 2004), spending 40–80 percent of time at surface and 90 percent of time at depths less than 15 m (Howell el al., 2010). Although juvenile loggerhead sea turtles may forage within the action area, they do not typically forage at depths fished by the deep-set fishery; hence they are not as susceptible to interactions with deep-set gear as they are too shallow-set gear.

Threats to the Species
Global threats to loggerhead sea turtles are spelled out in the 5-year review (NMFS and FWS 2007a), and threats to the North Pacific loggerhead sea turtle DPS are described in more detail in Conant et al., 2009, and Van Houtan 2010. Fisheries bycatch, alteration of nesting habitat, direct harvest, and predation, are major threats to the species. Anthropogenic climate change and marine debris are a growing threat to this species.

Sources of mortality for North Pacific loggerhead sea turtles include: human encroachment and egg harvest/predation on nesting beaches, nesting beach alteration (armoring and habitat degradation), incidental capture in coastal and pelagic fisheries (including longline, drift gillnet, set-net, bottom trawling, dredge, and trap net) throughout the species' range (Conant et al., 2009; Dutton and Squires 2008; Peckham et al., 2007, 2008; Kudo et al., 2003; Ishihara 2009, Ishihara et al., 2011; Koch et al., 2006; Van Houtan and Halley 2011). Interactions and mortality with coastal and artisanal fisheries in Mexico and the Asian region likely represent the most serious threats to North Pacific loggerhead sea turtle DPS (Peckham et al., 2007, 2008; Ishihara 2009; Conant et al., 2009).

Bycatch and fisheries-related standings' numbering in the thousands annually have been reported from gillnet and longline fisheries operating in loggerhead sea turtle 'hotspots' off of Baja Mexico, where intense coastal fishing pressure overlaps with high densities of loggerhead sea turtles foraging in nearshore habitats, producing among the highest bycatch rates reported worldwide (Peckham et al., 2007, 2008; Conant et al., 2009; Wingfield et al., 2011). Results of a recent study suggest that up to 11 percent of the region's loggerhead sea turtle population may perish each year (Seminoff et al., 2014). Between 2003 and 2010, annual stranding surveys to assess mortality have documented 3,096 dead loggerhead sea turtles (with a mean of 420 ± 274/year) along 45 km stretch of beach of Playa San Lazaro in Baja California SUR, Mexico (Peckham 2010). For comparison purposes, along this same beach during same time period, 144 olive ridley and 279 green turtles were documented (Peckham et al., 2007, 2008). Recent efforts to estimate at-sea mortality of sea turtles in Baja using drifter experiments concluded that stranding probability estimates may vary between 5-20 percent, and it is likely that 150 loggerhead sea turtles may have died during a 15 day period in 2010 (Koch et al., 2013). In July 2012, a record 483 dead loggerhead sea turtles stranded along 43 kilometers of the shoreline of Playa San Lazaro, Baja California Sur. This was a 600 percent increase over the annual average of 78 loggerhead sea turtles in July since 2003. This prompted the U.S. to identify Mexico under the Magnuson Stevens Reauthorization Act for fishing interactions involving the bycatch of loggerhead sea turtles (Benaka et al., 2012, NMFS 2013b). Mexico was given two years (by January 2015) to demonstrate that they have a comparable regulatory program to the U.S. to reduce sea turtle bycatch or they would be negatively certified under the Magnuson Stevens Reauthorization Act. A negative certification could result in prohibitions on the importation of certain fishery products into the United States or the denial of port privileges for vessels of that nation. In August 2015, Mexico received a negative certification from NMFS and were advised to revise and resubmit their proposed regulations. In September 2016, NMFS issued a positive determination based on changes Mexico made to their regulatory program and additional commitments regarding the duration of their regulations and co-operative research with the U.S. (NMFS 2016e).

Preliminary research of coastal pound net fisheries in Japan also suggests high mortality to loggerhead sea turtles and that these fisheries may pose a major threat to mature stage classes due to their proximity of nesting beaches and coastal foraging areas (Ishihara 2007, 2009). Pound nets in Japan operate nearshore in depths up to 100 m and range in size measuring up to 10,000m^3. Nets consist of a leader set perpendicular to the coast that directs fish into standing nets that entrain fish into an enclosed trap mounted either at the surface or midwater. Turtles are removed from surface traps daily when the fish are retrieved. However, pound nets with midwater traps prevent sea turtles from reaching the surface to breathe and thus can result in high mortality rates. Therefore coastal pound net fisheries off Japan may pose a significant threat to the North Pacific DPS (76 FR 58868; September 22, 2011).

In addition to interactions in Hawaii longline fisheries which resulted in approximately 31 loggerhead sea turtle mortalities since 2005(NMFS 2016 a,b), longline fisheries operating out of other countries which have fewer regulations than the U.S. are likely injuring and killing at least hundreds of turtles annually in the North Pacific (NMFS and FWS 2007a).

The Hawaii longline fisheries interacted with an average of 417 loggerhead sea turtles a year before 2001 in the North Pacific (McCracken 2000). If we apply the old mortality rate of 40 percent (Gilman et al., 2007a), this would give us an estimated mortality of 167 (417*40 percent= 166.8) annually before the shallow-set portion of the fishery was closed in 2001. The Hawaii shallow-set longline fishery reopened in 2004 and was subject to a number of management measures to minimize bycatch and post-hooking mortality. The 2004 management measures have proven to be effective by reducing loggerhead sea turtle interaction rates by 90 percent (Gilman et al., 2007a, WPFMC 2009b). Other U.S. fisheries that operate in the Pacific and interact with loggerhead sea turtles are the California/Oregon drift gillnet fishery that targets swordfish and thresher shark off the west coast and the California longline experimental fishery. This fishery has been observed by the NMFS Southwest Region since 1990, with roughly 20 percent observer coverage. From 1990 to 2015, the California/Oregon drift gillnet fishery was observed to incidentally capture 19 loggerhead sea turtles (14 released alive, 1 injured, and 4 mortalities). Since 2000, restrictions have been in place to close areas to drift gillnet fishing off Southern California when loggerhead sea turtles are expected to be in the area (i.e., closed during June, July and/or August during forecasted or occurring El Niño events). The Pacific Loggerhead Sea Turtle Conservation Area was closed due to El Nino conditions in 2014, 2015, and 2016 (79 FR 43268; 80 FR 31486; 81 FR 35653). The California Oregon drift gillnet fishery has an incidental take statement for up to seven anticipated loggerhead sea turtle interactions and four anticipated mortalities during a 5-year period (NMFS 2013a). The loggerhead sea turtle regulations were modified in 2004 (69 FR 1844, April 7, 2004) and 2007 (72 FR 31756, June 8, 2007). Only two loggerhead sea turtles have been observed taken incidentally in the California drift gillnet fishery since 2001, one in 2001 and one in 2006 (NMFS 2013a). The Eastern Tropical purse seine fishery caught five loggerhead sea turtles in 2000 but because the location of capture is unknown we cannot determine if these were from the North or South Pacific DPS (NMFS 2005).

Destruction and alteration of loggerhead sea turtle nesting habitats are occurring throughout the species' range, especially coastal development, beach armoring, beachfront lighting, and vehicular/ pedestrian traffic. Coastal development includes roads, buildings, seawalls, etc., all of which reduce suitability of nesting beaches for nesting by reducing beach size and restricting beach migration in response to environmental variability. Beach armoring is typically done to protect coastal development from erosion during storms, but armoring can block turtles from accessing nesting areas and can often lead to beach loss (NMFS and FWS 2007a). In Japan, where the North Pacific loggerhead sea turtle DPS nests, many nesting beaches are lined with concrete armoring, causing turtles to nest below the high tide line where most eggs are washed away unless they are manually moved to higher ground (Matsuzawa 2006). Coastal development also increases artificial lighting, which may disorient emerging hatchlings, causing them to crawl inland towards the lights instead of seaward. Coastal development, while improving beach access for humans, can result in more vehicle and foot traffic on beaches, which may result in compaction of nests and reduction of emergence success (NMFS and FWS 2007a). In Japan, threats to nesting and nest success include light pollution, poorly managed ecotourism operations, and trampling due to the thriving tourist economy on Yakushima Island, and increasing numbers of beachfront hotels and roadways (Kudo et al., 2003). Overall, the Services have concluded that coastal development and coastal armoring on nesting beaches in Japan are significant threats to the persistence of this DPS (76 FR 58868; September 22, 2011). On July 10, 2014, NMFS issued a final rule to designate critical habitat for the Northwest Atlantic Ocean loggerhead sea turtle DPS within the Atlantic Ocean and the Gulf of Mexico (79 FR 39856). Specific areas for designation include 38 occupied marine areas within the range of the Northwest Atlantic Ocean DPS. There is no critical habitat designated for the North Pacific DPS (NMFS 2014b).

Deliberate hunting of loggerhead sea turtles for their meat, shells, and eggs is reduced from previous levels, but still occurs. The North Pacific loggerhead sea turtle DPS nests almost exclusively in Japan, especially on Yakushima Island. Japan enacted a law in 1973 on Yakushima Island to prohibit the harvest of sea turtle eggs. A similar law was enacted in 1988 encompassing most of the other loggerhead sea turtle nesting beaches in Japan, resulting in great reductions in egg harvest. The 1973 law may in part explain the increasing number of nesting turtles from 2001 to 2011, given that loggerhead sea turtles mature in about 25 years (Ohmuta

2006). Predation of eggs also occurs, for example by raccoons and feral animals in Japan (NMFS and FWS 2007a, STAJ 2010). While sea turtles have been protected in Mexico since 1990 (Conant et al., 2009), studies have shown that loggerhead sea turtles continue to be caught, both indirectly in fisheries and by a directed harvest of juvenile turtles (Gardner and Nichols 2001; Koch et al., 2006; Peckham et al., 2007; Mancini et al., 2011).

Marine debris is also a source of mortality to all species of sea turtles because small debris can be ingested and larger debris can entangle animals leading to death. Marine debris is any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment. Manmade materials like plastics, micro plastics, and derelict fishing gear (e.g., ghost nets) that may impact turtles via ingestion or entanglement can reduce food intake and digestive capacity, cause distress and/or drowning, expose turtles to contaminants, and in some cases cause direct mortality (Arthur et al., 2009, Balazs 1985, Bjorndal et al., 1994, Bugoni et al., 2001, Doyle et al., 2011, Keller et al., 2004, Parker et al., 2011, Wabnitz and Nichols 2010). All marine turtles have pelagic stages; including when they leave the nesting habitat as hatchlings and enter a period known as the "lost years" that can last for years or decades (Lutz and Musick 1997, Zug et al., 2002). While the impact of marine debris to Pacific turtles during pelagic life stages is currently unquantified, it is quite likely that impacts may be severe given the increase of plastics and other debris and pollution entering the marine environment over the past 20-30 years (Arthur et al., 2009, Doyle et al., 2011, Stewart et al., 2011, NMFS and FWS 2007a, Hutchinson and Simmonds 1992, Law et al., 2010, Mrosovsky et al., 2009, Wabnitz and Nichols 2010). The addition of debris from the earthquake and tsunami that hit Japan in March 2011 increases concern due to the large amount of debris that entered the water in a short time. The Japanese government estimated that 25 million tons of debris was generated but there is no confirmed estimate of how much entered the water, and little information as to the type of debris that entered the water. It is highly unlikely that the debris is radioactive for several reasons; the vast majority of the debris was many miles away from the reactor that leaked, the leak of contaminated water from the reactor into the sea started days to weeks after the debris was washed out to sea, and vessels coming into the U.S. from Japan were monitored for radiation, and readings were below the level of concern. The large debris field that was initially generated has broken up so it is no longer visible by satellite, which means that it can no longer be monitored so the location of the debris is unknown and projections of when it will reach shore can only be predicted using models that take into account oceanic and wind conditions (NOAA Marine Debris Program). For loggerhead sea turtles the greatest risk is in the pelagic environment but there is no information to quantify what the impact will be.

As highly migratory, wide-ranging organisms that are biologically tied to temperature regimes, sea turtles are vulnerable to effects of climate change in aspects of their physiology and behavior (Van Houtan 2011). Climate refers to average weather conditions, as well as associated variability. The term climate change refers to any distinct change in measures of climate lasting a long period of time, which means major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer. Climate change may result from: natural factors, such as changes in the Sun's energy or slow changes in the Earth's orbit around the Sun; natural processes within the climate system (e.g., changes in ocean circulation); and human activities that change the atmosphere's makeup (e.g., burning fossil fuels) and the land surface (e.g., cutting down forests, planting trees, building developments in cities and suburbs, etc.), also known as anthropogenic climate change (U.S. Environmental Protection Agency). Impacts to marine turtle populations resulting from climate change may occur at different rates or at different levels between marine turtle species based on a number of factors.

Increasing temperatures at nesting beaches may impact sex ratios of hatchlings and/or increase embryonic mortality (Matsuzawa et al., 2002). The North Pacific DPS is estimated to have a 1:1 male to female ratio (NMFS and FWS 2007a), and while nest temperatures in Japan may be within survival thresholds, high beach incubation temperatures have also occurred resulting in mortality of pre-emergent hatchlings in Japan (Matsuzawa 2006). This population may be less vulnerable to increases in sand temperature than those already highly skewed toward female or at the high end of thermal tolerance, but 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. In the future, increasing temperatures, sea level rise, changes in ocean productivity, and increased frequency of storm events are expected as a result of climate change and are all potential threats for loggerhead sea turtles.

A final factor when considering the effects of future anthropogenic climate change is the role the PDO plays in influencing turtle populations. A recent study mentioned above combined two factors of climate variability, changes in ocean circulation and SST on two different life stages of loggerhead sea turtle sea turtles, (neonates[2] and adult females) to see how they influence population trends (Van Houtan and Halley 2011). This study found that changes in loggerhead sea turtle nesting over at least the last several decades are strongly correlated with ocean oscillations due to environmental influences on juvenile recruitment (Van Houtan and Halley 2011, Van Houtan 2011). In the next 20 years, loggerhead sea turtles are projected to decrease due to unfavorable conditions in the PDO in recent years. Beyond this time we do not have information to predict what the population will do (NMFS 2012, Van Houtan 2011). Arendt et al., (2013) found that historical climate forcing on the oceanic habitat of neonate sea turtles in the Atlantic explained only two-thirds of interannual variability and concluded that annual nest count trends are more influenced by remigrants than neophytes; however the same analysis has not been done for loggerhead sea turtles in the Pacific. Juvenile recruitment appears to be strongly correlated with the PDO in the Kuroshio Bifurcation Extension Region where juveniles congregate (Polovina et al., 2006) as they are most susceptible to oceanographic variability given their limited ability to exploit their environment for food (Van Houtan and Halley 2011). SST in the months preceding nesting has been demonstrated to influence whether females nest due to the need for sufficient nutrients for yolk production (Van Houtan and Halley 2011). Additional studies that simulated changes in physical ocean properties in northern hemisphere westerly's in response to various future CO^2 emission scenarios predict that the area and primary production of the temperate oceanic biome in the North Pacific is anticipated to decrease by 34 percent over the next century (Polovina et al., 2011). The extent of the impact on species in the region, such as loggerhead sea turtles, is unknown because we do not know how species may or may not adapt to changes over the long-term (Chaloupka et al., 2009).

[2] Neonates are defined as hatchlings up to six months of age for the purpose of this study (Van Houtan, pers. Comm.).

Conservation of the Species
Considerable effort has been made since the 1980s to document and reduce loggerhead sea turtle bycatch in Pacific Ocean fisheries, as this is the highest conservation priority for the species. NMFS has formalized conservation actions to protect foraging loggerhead sea turtles in the North Pacific Ocean which were implemented to reduce loggerhead sea turtle bycatch in U.S. fisheries. Observer programs have been implemented in federally-managed fisheries to collect bycatch data, and several strategies have been pursued to reduce both bycatch rates and post-hooking mortality. In Pacific Ocean fisheries, these include developing gear solutions to prevent or reduce capture (e.g., circle hooks), implementing seasonal time-area closures to prevent fishing when turtles are congregated, modifying existing gear, and developing and promoting Sea Turtle Handling Guidelines (NMFS and FWS 2007a). For example, switching to large circle hooks and mackerel bait in 2004 reduced the interaction rate by approximately 90 percent in the Hawaii shallow-set longline fishery (Gilman et al., 2007a, WPFMC 2009b). In 2003, NMFS implemented a time/area closure in southern California during forecasted or existing El Niño-like conditions to reduce the take of loggerhead sea turtles in the California/Oregon drift gillnet fishery (68 FR 69962; December 16, 2003). On July 25, 2014, El Niño conditions off the coast of California were determined to have been met for the first time which closed the Pacific Loggerhead sea turtle Conservation Area through August 31, 2014 to swordfish drift gillnet fishing (79 FR 43268; July 25, 2014). Efforts to elevate the awareness level of fishermen regarding protected species interactions and the potential impacts to their fisheries (i.e., closures if allowable take levels are exceeded in the shallow-set component of the fishery), and efforts to educate boat owners and operators via annual (and mandatory) protected species workshops cannot be discounted. NMFS has also developed a mapping product known as TurtleWatch that provides a near real time product that recommends areas where the deployment of pelagic longline shallow-sets should be avoided to help reduce interactions between Hawaii pelagic longline fishing vessels and loggerhead sea turtles (Howell et al., 2008).

Since loggerhead sea turtle interactions and mortalities with coastal fisheries in Mexico and Japan are of concern and are considered a major threat to North Pacific loggerhead sea turtle recovery, NMFS and U.S. non-governmental organizations have worked with international entities to: (1) assess bycatch mortality through systematic stranding surveys in Baja California Sur, Mexico; (2) reduce interactions and mortalities in bottom-set gillnet fisheries in Mexico; (3) conduct gear mitigation trials to reduce bycatch in Japanese pound nets; and (4) convey information to fishers and other stakeholders through participatory activities, events and outreach. In 2003, Grupo Tortuguero's ProCaguama (Operation Loggerhead) was initiated to partner directly with fishermen to assess and mitigate their bycatch while maintaining fisheries sustainability in Baja California, Mexico. ProCaguama's fisher-scientist team discovered the highest turtle bycatch rates documented worldwide and has made considerable progress in mitigating anthropogenic mortality in Mexican waters (Peckham et al., 2007, 2008). As a result of the 2006 and 2007 tri-national fishermen's exchanges run by ProCaguama, STAJ, and the Western Pacific Fisheries Management Council, a prominent Baja California Sur fleet retired its bottom-set longlines in 2007 (Peckham et al., 2008, Peckham and Maldonado-Diaz, 2012). Prior to this closure, the longline fleet interacted with an estimated 1,160-2,174 loggerhead sea turtles annually, with nearly all (89 percent) of the takes resulting in mortalities (Peckham et. al. 2008). Because this fleet no longer interacts with loggerhead sea turtles, conservation efforts have resulted in the continued protection of approximately 1,160-2,174 juvenile loggerhead sea turtles annually (76 FR 58868; September 22, 2011). Additionally, stranding data collected since 2003 at Playa San Lazaro indicates a 60 percent reduction in standings' during 2010 compared to previous 2003-2009 averages (Peckham 2010).

Led by the Mexican Wildlife Service, a federal loggerhead sea turtle bycatch reduction task force, comprised of federal and state agencies and non-governmental organizations, was organized in 2008 to ensure loggerhead sea turtles receive the protection they are afforded by Mexican law. In 2009, while testing a variety of potential solutions, ProCaguama's fisher-scientist team demonstrated the commercial viability of substituting bycatch-free hook fishing for gillnet fishing. ProCaguama, in coordination with the task force, is working to develop a market-based bycatch solution consisting of hook substitution, training to augment ex-vessel fish value, development of fisheries infrastructure, linkage of local fleets with regional markets, and concurrent strengthening of local fisheries management (Conant et al., 2009). As of 2012, a number of members of the gillnet fleet had retired their gear (a total of 140 gillnets), 18 crews have converted to hook and line fishing (a more sustainable practice in the 'hotspot' area that results in zero bycatch), and local NGO efforts were underway to implement the market-based solutions mentioned above to encourage consumption of sustainably caught sea food (Peckham 2014, Conant et al., 2009). Market-based efforts are underway to promote and support sustainable fisheries that use fishing gear, such as hand line, which have low (or no) sea turtle bycatch in Baja (Peckham 2014).

In Japan, due to concerns of high sub-adult and adult loggerhead sea turtle mortality in mid-water pound nets, researchers with the STAJ, ProCaguama, local fisherman, and NMFS are working together to investigate and test pound net mitigation options to reduce the impact and mortality of sea turtle bycatch. This effort has included public education and outreach activities with media events to raise public awareness of the bycatch problems. The first phase of the project was completed in February 2012, and three promising gear mitigation options for pound net fisheries were discovered (Matsuzawa et al., 2012). Continued collaborative efforts continue to progress development of mitigation measures that include refinement of solutions and testing in an operating net to assess target and non-target catch rates to secure industry uptake and buy-in (Ishihara et al., 2012).

Conservation efforts have also focused on protecting nesting beaches, nests, and hatchlings. Much of Japan's coastline is "armored" using concrete structures to prevent and minimize impacts to coastal communities from natural disasters. These structures have resulted in a number of nesting beaches losing sand suitable for sea turtle nesting, and nests often need relocating to protect them from erosion and inundation. In recent years, a portion of the concrete structures at a beach in Toyohashi City, Aichi Prefecture, was experimentally removed to create better nesting habitat (76 FR 58868; September 22, 2011). The STAJ along with various other organizations in Japan, are carrying out discussions with local and Federal Government agencies to develop further solutions to the beach erosion issue and to maintain viable nesting sites. The Ministry of Environment has supported the local NGO conducting turtle surveys and conservation on Yakushima in establishing guidelines for tourism to minimize impacts by humans on nesting beaches (Conant et al., 2009). Yet, beach erosion and armament still remain one of the most significant threats to nesting beaches in Japan (Conant et al., 2009).

Since 2003, WPFMC has contracted with STAJ to protect loggerhead sea turtle nests and increase hatchling survivorship at several nesting beaches in southern Japan, including at the two primary beaches on Yakushima Island. Beach management activities include conducting nightly patrols during the summer nesting season to relocate nests from erosion prone areas, protecting nests from predators and people with mesh and fences, and cooling nests with water and shading to prevent overheating during incubation. STAJ has developed techniques for nest relocation that now result in an average of 60 percent hatchling success rates (compared to nearly zero survival of the same nests laid in erosion prone areas). Conservation efforts funded by the WPFMC continued through 2012, with approximately 270,000 hatchlings conserved from relocated nests over the nine-year project period that otherwise may have been lost (Ishizaki 2015).

The conservation and recovery of loggerhead sea turtles is facilitated by a number of regulatory mechanisms at international, regional, national, and local levels, such as the Food and Agriculture Organization's Technical Consultation on Sea Turtle-Fishery Interactions, the Inter-American Convention for the Protection and Conservation of Sea Turtles, the Convention on International Trade in Endangered Species, and others. In 2008 the Western and Central Pacific Fisheries Commission (WCPFC) adopted a Conservation and Management Measure (Conservation and Management Measure 2008-03) to mitigate the impacts on turtles from longline swordfish fisheries in the western central Pacific Ocean. The measure includes the adoption of Food and Agriculture Organization of the United Nations guidelines to reduce sea turtle mortality through safe handling practices and to reduce bycatch by implementing one of three methods by January 2010. The three methods to choose from are: 1) use only large circle hooks, or 2) use whole finfish bait, or 3) use any other mitigation plan or activity that has been approved by the Commission. 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. Moreover, as shown by the above examples from Hawaii, Japan, and Baja Mexico, international efforts are growing to reduce sea turtle interactions and mortality in artisanal and industrial fishing practices (Gilman et al., 2007b, Peckham et al., 2007, NMFS and FWS 2007a, Ishihara et al., 2012).

6.2 **Olive Ridley Sea Turtles**

Population Characteristics

Olive ridley sea turtles 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 occur throughout the remaining tropical and warm temperate areas of the world, including the western Pacific. Population structure and genetics are poorly understood for this species, but populations occur in at least the eastern Pacific, western Pacific, eastern Indian Ocean, central Indian Ocean, western Indian Ocean, West Africa, and the western Atlantic (NMFS and FWS 2014). The eastern Pacific population includes nesting aggregations on the coast of Mexico, which are listed under the ESA as endangered. All other olive ridley populations are listed as threatened (Table 1). The deep-set fishery effects both endangered and threatened olive ridley sea turtles.

In 2014, the NMFS and FWS completed a status review of the olive ridley sea turtle. Based on the best available information, the Services concluded the olive ridley sea turtle breeding colony populations on the Pacific coast of Mexico may warrant reclassification (NMFS and FWS 2014). No change to the threatened populations is recommended. However, for the current population listings for the olive ridley (both endangered and threatened), information indicates an analysis and review of the species should be conducted in the future to determine the application of the DPS policy.

Olive ridley sea turtles are the most common turtle species that interacts with the Hawaii deep-set longline fishery. In the deep-set fishery, 106 observed interactions have occurred between 1995 and 2014, of which 82 were from the eastern Pacific (endangered and threatened populations) (77 percent) and 24 were from the western Pacific (23 percent) (NMFS 2014a), which is comprised of turtles that are genetically similar to turtles with haplotypes identified in Sri Lanka, Malaysia and India (Dutton pers. comm.). In the shallow-set fishery, fourteen genetic samples have been collected and analyzed since 1995; eight were from the eastern Pacific populations and six were from the western Pacific population (NMFS 2014a).

Endangered Pacific Coast of Mexico population

The endangered poplation of the eastern Pacific is thought to be increasing in many areas, while there is inadequate information to suggest trends for other populations. The endangered olive ridley sea turtles nest primarily in large *arribadas* on the west coasts of Mexico with some solitary nesting throughout the region. Since reduction or cessation of egg and turtle harvest in Mexico in the early 1990s, annual nest totals have increased substantially, but have not returned to their pre-1960s abundance estimates. On the Mexican coast, three populations appear stable, two are increasing (Ixtapilla and La Excobilla), and one decreasing, with over one million nests laid annually (NMFS and FWS 2014).

Table 2. Endangered populations of olive ridley arribada and solitary nesting beaches in Mexico, and estimates of annual abundance at each site and current trends. Table has been adapted from table in NMFS and FWS 2014.

Location	Annual Number	Trend
ARRIBADA		
La Escobilla	1,013,034 females	increasing
Mismaloya	2,328 nests	stable
Ixtapilla	2,900 – 10,000 nests	increasing
Moro Ayuta	10,000 – 100,000 nests	stable
Tlacoyunque	608 nests	stable
Chacahua	2,042 nests	decreasing
SOLITARY		
El Verde	1,160 nests	stable
Platanitos	1,301 nests	increasing
Cuyutlán	1,257 nests	increasing
Maruata-Colola	4,198 nests	stable
Puerto Arista	707 nests	stable
Moro Ayuta	no estimate available	stable
Nuevo Vallarta	4,900 nests	unknown
San Cristobal	89 nests	unknown
El Suspiro	220 nests	unknown

Threatened Eastern Pacific population

In Costa Rica, the Ostional nesting assemblage is one of the largest in the world, second only to La Escobilla, Mexico (Valverde et al., 2012). As with other arribadas, a large variability in the magnitude of mass nesting events in Costa Rica can occur, with arribadas at Ostional ranging between 3,564 and 476,550 egg-laying females during the period 2006–2010 (Table 3) (Valverde et al., 2012). Valverde et al., (2012) estimated the nesting population size by dividing the estimated arribada abundance totals by estimated olive ridley nesting frequency of 2.21 (Van Buskirk and Crowder 1994 in Valverde et al., 2012). The NMFS and FWS (2014) estimate that females may lay two clutches on average per arribada nesting season, with approximately 100-110 eggs laid per clutch. However, Ballestero et al., (2000) utilized a fixed quadrant method (vs. line transects) to estimate that the nesting population was approximately 588,500 fluctuating between 232,318 and 1,147,969 turtles per arribada between 1988 and 1997. If these estimates are correct, then Valverde et al., (2012) concludes that the Ostional assemblage has decreased in abundance over the past two decades likely as a result of low hatching rates. In contrast to solitary nesting beaches, survivorship is low on high density arribada nesting beaches because of density-dependent mortality (NMFS and FWS 2014). This density-dependent effect negatively impacts nesting populations because in addition to nest disturbance and egg mortality, high nesting density alters the nutrient composition of sand, gas exchange, and ammonica concentration in the sand which results in high concentrations of fungal and bacterial pathogens resulting in lower hatch success thus affecting population growth (NMFS and FWS 2014).

Table 3. Threatened olive ridley arribada and solitary nesting beaches in the Eastern Pacific and estimates of abundance expressed as arribada size, nests, or females at each site and trends. Table has been adapted from table in NMFS and FWS 2014.

Location	Annual Number	Trend
ARRIBADA		
Nancite, Costa Rica	256- 41,149 females	decreasing
Ostional, Costa Rica	3,564 to 476,550 females	increasing but declining recently
Nancite, Costa Rica	256-41,149 turtles per arribada	decreasing
Chacocente, Nicaragua	27,947 females	unknown
La Flor, Nicaragua	521,440 females	stable
Isla Canas, Panama	8,768 females	decreasing
SOLITARY		
Hawaii Beach, Guatemala	1,004 females	decreasing

Threatened western Pacific population

In the western Pacific, olive ridley sea turtles are solitary nesters and typically occur in tropical and warm temperate waters from Australia through southeast Asia (NMFS and FWS 2014). In the Indian Ocean, arribadas occur in northeastern India in the Indian State of Odisha (formerly known as Orissa), at Gahirmatha and Ryshikulya, have estimates exceeding 700,000 turtles nesting per arribada (Table 4) (NMFS and FWS 2014). A number of other locations in western and eastern India are also described as sites of potential solitary nesting activity, but nesting activity is unquantified at these locations (NMFS and FWS 2014). Survey effort on India beaches has fluctuated over the years and methods used to census nesting populations have also changed. As a result, reported trends and abundance numbers may be somewhat speculative and potentially unreliable. The most reliable abundance estimate for Gahirmatha during the 1999 arribada was approximately 180,000 nesting females, with long-term data indicating the population may be in decline (NMFS and FWS 2014). During the 2012 nesting season, an estimated 100,000 olive ridley sea turtles laid eggs in Orissa compared to 250,000 in 2011 (IOSEA, 2013). Lower numbers of eggs are often laid following a good year of nesting. Yet this arribada (that often occurs in February) was delayed about a month, raising concerns about the influence of climate change, storms (such as the effects of Cyclone Thane that struck the Bay of Bengal December 30, 2011), fishing activity, or coastal erosion (IOSEA, 2013). 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 (Limpus 2009a). Data are not available to analyze trends (NMFS 2005, NMFS and FWS 2014).

Table 4. Threatened olive ridley arribada and solitary nesting beaches in the Western Pacific and estimates of abundance expressed as arribada size, nests, or females at each site and trends. Table has been adapted from table in NMFS and FWS 2014.

Location	Annual Number	Trend
ARRIBADA		
Gahirmatha, India	150 - 250,000 females	stable
SOLITARY		
Australia	3000 females	unknown
Alas Purwo, Indonesia	250 females	increasing
Terengganu, Malaysia	10 nest	decreasing

In Indonesia, olive ridley sea turtles nest on beaches in the West Papua Province, in the Manokwari region the number of nests recorded from 2008 through 2011 ranged from 53 to 236, however survey effort was limited and likely not consistent across years (Suganuma et al., 2012). On Jamursba-Medi beach, 77 olive ridley nests were documented from May to October 1999, on Hamadi beach, Jayapura Bay in June 1999, an estimated several hundred ridleys were observed nesting (NMFS and FWS 2014). Extensive hunting and egg collection, in addition to rapid rural and urban development, have reduced nesting activities in Indonesia. In eastern Java, olive ridley nesting was documented from 1992-1996 that ranged from 101 to 169 nests. In Malaysia, olive ridley sea turtles nest on the eastern and western coasts; however, nesting has declined rapidly in the past decade. The highest density of nesting was once reported in Terrenganu, Malaysia, which once yielded 2,400 nests, but the populations were virtually extirpated by 1999 due to long-term over-harvest of eggs (NMFS and FWS 2014). In Australia, olive ridley nesting is scattered throughout northern Australia, with a few thousand females nesting annually (Limpus 2009a). The breeding population in northern Australia may be the largest population remaining in the western Pacific region, although a full evaluation of their distribution and abundance is needed (Limpus 2009a, NMFS and FWS 2014). There is no evidence to suggest that the current nesting numbers in Australia are the remnant of a population that has declined substantially within historical times (Limpus 2009a).

The once large nesting populations of olive ridley sea turtles that occurred in peninsular Malaysia and Thailand have been decimated through long term over-harvest of eggs (Limpus 2009a). The species nests in low numbers at many sites in Indonesia and is only rarely encountered nesting in the Republic of the Philippines or Papua New Guinea (Limpus 2009a).

Life History Characteristics Affecting Vulnerability to Proposed Action from all populations

Life history of Pacific olive ridley sea turtles is characterized by juvenile and adult stages occurring in the oceanic zone. Along with leatherbacks, olive ridley sea turtles are the most pelagic of all sea turtle species (NMFS 2004, 2005a, 2006a, 2008a; NMFS and FWS 2014). Olive ridley sea turtles appear to have the shortest age to maturity at approximately 13 years of age (Zug et al., 2006). The Hawaii deep-set longline fishery encounters olive ridley sea turtles at rates greater than any other sea turtle due to the area of operation of the fishery and the diving behavior and distribution of the species as discussed below.

Olive ridley sea turtles occupy marine ecosystems that occur over vast areas and are considered nomadic in the eastern Pacific (Plotkin 2010). They often associate with the highly productive area called the Costa Rica Dome located between 8 to 10°N and 88 to 90°W, which is characterized by a shallow (within 10 m of the surface) thermocline and areas of upwelled waters rich in prey items (Swimmer et al., 2009). Olive ridley sea turtles appear to forage throughout the eastern tropical Pacific Ocean, often in large groups, or flotillas, and are occasionally associated with floating debris (Arenas and Hall 1992 in NMFS and FWS 2014). The direct impact of El Niños on olive ridley sea turtles is unknown, but olive ridley sea turtles appear to change migration pathways in response to shifts in food availability during El Niño (Plotkin 2010).

Polovina et al., (2003, 2004) tracked 10 olive ridley sea turtles caught in the Hawaii pelagic longline fishery. The olive ridley sea turtles identified as originating from the eastern Pacific populations stayed south of major currents in the central North Pacific-southern edge of the Kuroshio Extension Current, North Equatorial Current, and Equatorial Counter Current; whereas, olive ridley sea turtles identified from the western Pacific associated with these major currents, suggesting that olive ridley sea turtles from different populations may occupy different oceanic habitats (Polovina et al., 2003, 2004). Long-term satellite tracking data of 30 eastern Pacific post-nesting olive ridley sea turtles revealed that they were widely distributed in the pelagic zone from Mexico to Peru and lacked migratory corridors (Plotkin 2010). These turtles migrated long distances, swam continuously, displayed no fidelity to specific feeding habitats, and were nomadic. Eguchi et al., (2007) estimated the density and abundance of the olive ridley sea turtle from shipboard line-transects which resulted in an estimate of 1,150,000 – 1,620,000 turtles in the eastern tropical Pacific in 1998-2006. During 2010, vessel surveys from the coast to 185 km offshore of the Mexican Central Pacific (Jalisco, Colima, and Michoacan waters) covered 3,506 km and recorded 749 sightings (Martín del Campo et al., 2014). The weighted average of the three periods (winter, spring, and autumn 2010) of olive ridley sea turtles was 177,617 (CI: 150,762-204,471, CV: 17.2 percent, 95 percent), with the highest abundance recorded in winter in the oceanic region of Jalisco (N: 181,150, CI: 117,150-280,110, CV:21.4 percent). Martín del Campo et al., (2014) conclude that olive ridley sea turtles are abundant in coastal and oceanic waters of the Mexican Central Pacific and their numbers are probably still increasing as a result of the protection programs that began in the 1990s.

Olive ridley sea turtles forage on a variety of marine organisms, including tunicates, gastropods, crustaceans, and fishes that tend to migrate with the deep scattering layer. As a result, olive ridley sea turtles typically forage in deep water, often diving within the range that deep-set gear occurs. In addition, the distribution of this species in the North Pacific tends to be within the action area for the Hawaii deep-set longline fishery (Polovina et al., 2003, 2004; NMFS 2006).

Threats

Major threats to the species are impacts to nesting beaches resulting from development, direct harvest, and fishing bycatch, which are briefly described below. Climate change and marine debris may also be a growing threat to this species, as it is for other sea turtle species and is discussed below.

Impacts to nesting habitat and habitat loss resulting from development, construction, beach armoring, sea level rise, human encroachment, lighting pollution, etc. on the breeding populations in Mexico are lacking, although human-induced habitat impacts are expected to increase as Mexico's population expands and tourism increases (NMFS and FWS 2014). 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 ridley sea turtles 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. Unsustainable harvest led to extirpation of major *arribadas*, such as at Mismaloya and Chacahua in Mexico by the 1970s, prompting listing of these nesting aggregations as endangered under the ESA and their protection in Mexico since 1990. Globally, legal harvest of olive ridley adults and eggs was reduced in the late 1980s and early 1990s, but legal harvest of eggs continues in Ostional, Costa Rica. Illegal harvest of eggs is common throughout Central America, Western Pacific, and India (NMFS and FWS 2014).

Ostional beach in northwest Costa Rica is an arribada rookery that supports a large mass-nesting assemblage along with a legal community-based egg-harvest program (Campbell 1998, Campbell et al., 2007). The rationale that supports the Ostional egg harvest is based on data that showed a significant number of clutches are destroyed during arribadas by nesting turtles, that the hatching rate at this beach is very low, and that legalizing the harvest may help to limit the previously uncontrolled illegal take of eggs (Alvarado-Ulloa 1990 and Cornelius et al., 1991 in Valverde et al., 2012). The egg harvest functions much as it was suggested by the scientific community: the associates are allowed to harvest eggs for the first 2.5 days of each arribada (the first 2 days for commercialization and the last half a day for local consumption), while keeping the beach clean and reducing the impact of feral predators (Ordonez et al., 1994 in Valverde et al., 2012). Between 2006 and 2010, Valverde et al., (2012) estimated the mean egg harvest was 4,746 eggs, ranging between 1,527 to 8,138 total clutches. The estimated mean of clutches harvested was 21.2 percent (Valverde et al., 2012). It is not clear whether the Ostional arribadas underwent a significant change in abundance during the study period, and the number of years covered is too short to establish a long-term trend, however the population appears to have declined when compared with historical data given that the population appears to be suffering from low hatch success (18 percent), high clutch destruction rates, and low recruitment (Valverde et al., 2012).

A major threat to olive ridley sea turtles is 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 ridley sea turtles that tens of thousands of dead adults wash up on the coast annually (NMFS and FWS 2014).

In the eastern Pacific, fishery interactions are a major threat to the species, primarily because of development of a shrimp trawl fishery along the Pacific coasts of Central America starting in the 1950s, which is thought to kill tens of thousands of olive ridley sea turtles annually (NMFS and FWS 2014). Trawlers in Costa Rica are reported to catch over 15,000 sea turtles annually, and 90 percent of those are olive ridley sea turtles (Arauz et al., 1998). As a result of litigation brought about by six environmental NGOs, trawl fishing was banned in Costa Rica in September 2013 (Arias 2013). In addition, the growth in longline fisheries in the region over recent years represents a growing bycatch threat to the species, with the potential to interact with hundreds of thousands of turtles annually (Frazier et al., 2007, Dapp et al., 2013). From 1999 to 2010, an observer program collected data to assess the impact of the Costa Rican longline fishery and documented an estimated 699,600 olive ridley sea turtles caught, including 92,300 adult females and an additional 23,000 green turtles (Dapp et al., 2013). Artisanal gillnet and longline fisheries of Peru and Chile are known to interact with olive ridley sea turtles (Alfaro-Shigueto et al., 2011, Donoso and Dutton, 2010). Small scale fisheries operating in Peru using bottom set nets, driftnets, and longline fisheries were observed between 2000 and 2007. Approximately 6,000 sea turtles were captured annually; 240 were olive ridley sea turtles (Alfaro-Shigueto et al., 2011). Threats to olive ridley sea turtles in Australia include high bycatch in gillnet and trawl fisheries, ghost net entanglement, egg loss due to pig and dog predation, and significant egg harvest as a result of Indigenous practices (Limpus 2009a).

The Hawaii-deep set fishery interacts with olive ridley sea turtles and had an incidental take statement for up to 121 olive ridley interactions and 117 mortalities over a three year period (NMFS 2005); these were not divided among the threatened and endangered populations. The interactions that have occurred in the fishery since then were slightly lower than anticipated. Between 2005 and 2014 there were 277 olive ridley interactions in the deep-set fishery and from this the estimated mortality is 264 (McCracken 2006, 2007, 2008, 2009a, 2009b, 2010, 2011, 2012, 2013, 2014a; NMFS 2014a). Based on the genetic samples, 75 percent are from either the endangered Mexico population or threatened population in the Eastern Pacific, and 25 percent are from the threatened western Pacific population of olive ridley sea turtles. The Hawaii shallow-set fishery rarely interacts with olive ridley sea turtles and since 2004, only four have been incidentally caught. All four were released alive. The California Oregon drift gillnet fishery has an incidental take statement for up to 2 anticipated olive ridley interactions and 1 anticipated estimated mortality every five years (NMFS 2013a). Since 2001 no olive ridley sea turtles have been captured in the California Oregon drift gillnet fishery and only one has been observed since 1990 (NMFS 2013a).

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. However, olive ridley sea turtles in the east Pacific Ocean are highly migratory, and seemingly adaptable to fluctuating environmental conditions. They possess the ability to shift from an unproductive habitat to one where the waters are biologically productive, which may minimize the impacts of climate change (Plotkin 2010 in NMFS and FWS 2014). As with leatherback turtles nesting in the eastern Pacific, olive ridley’s may also be affected by the occurrence of El Nino events. It is possible that the variation in numbers of turtles in the Ostional arribadas are also affected by changes in productivity in their foraging areas, because olive ridley females also need time to amass sufficient nutrients to support their metabolic, migratory, and reproductive activities (Valverde et al., 2012).

Marine debris is also a source of concern for olive ridley sea turtles due to the same reasons described for loggerhead sea turtles. Olive ridley sea turtles can ingest small debris and larger debris can entangle animals leading to death. For olive ridley sea turtles the greatest risk is when they are in the pelagic environment but there is no data to quantify what the impacts are.

Conservation

Since large-scale direct harvest of adult olive ridley sea turtles became illegal, conservation efforts have focused on reducing bycatch 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), and trawl fishing which was estimated to catch over 15,000 turtles per year (90 percent of which were olive ridley sea turtles), was banned in Costa Rica in September 2013 (Arias 2013). 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 (Shanker et al., 2003). However, enforcement is lacking in both areas (Frazier et al., 2007; Shanker et al., 2003).

In India, the Odisha Government has enacted a seven-month ban (November 1 to May 31) restricting fishing near the Gahirmatha marine sanctuary in Kendrapara district along the 20 km stretch of the Dhamra-Rushikulya river mouth to protect nesting olive ridley sea turtles. An estimated 26,000 traditional marine fishermen in coastal Kendrapara and Jagatsinghpur districts are affected by the measure. Trawl operators are prohibited in the protected zone, and orders are being enforced with nearly 100; trawls and vessels were seized and their crew arrested during the ban in 2011 (The Hindu Business Line News 2011).

Between 2004 and 2007, the Inter-American Tropical Tuna Commission 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 reduced interaction rates by 40 to 80 percent in artisanal fisheries that switched gear types, with deep hookings reduced by 20 to 50 percent. Experiments to reduce longline gear entanglements were also successful. This project ended in 2007 and no follow up study has been initiated to assess continued use of circle hooks or dehooking and safe handling methods in fisheries where these measures were introduced.

The conservation and recovery of olive ridley sea turtles 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, the Convention on International Trade in Endangered Species, and others. Within the WCPFC, NMFS has worked to modify and improve international bycatch mitigation requirements and aided in establishing a binding Sea Turtle Conservation Measure implementing the Food and Agriculture Organization of the United Nations Guidelines (e.g., circle hooks and safe handling measures) which has likely helped reduce interactions and improve survivorship in international longline fisheries. As a result of these designations and agreements, many of the intentional impacts on olive ridley sea turtles have been reduced: harvest of eggs and adults have been reduced at several nesting areas through nesting beach conservation efforts and an increasing number of community-based initiatives are in place to reduce the take of turtles in foraging areas (Gilman et al., 2007b, NMFS and FWS 2014).

6.3 Green Sea Turtles

The green sea turtle was listed as threatened on July 28, 1978 (43 FR 32800), except for breeding populations that occur in Florida and the Pacific coast of Mexico, which were listed as endangered. On April 6, 2016, NMFS and the FWS published a final rule finding that the green sea turtle is composed of 11 Distinct Population Segments (DPSs) (Figure 2) that qualify as a "species" for listing. The Services removed the current range-wide listing and, in its place, listed eight DPSs as threatened and three as endangered. The Green sea turtles most likely to occur in the range of the Hawaii deep-set longline fishery are those DPSs that occur in the Pacific Ocean. PIRO's observer program collected 14 samples from green sea turtles and the NMFS Southwest Fisheries Science Center conducted genetic analysis. They used two different approaches: a mixed stock analysis (MSA) of pooled data, and a direct count of individual assignments based on haplotype that incorporated photo identification (Dutton pers comm, August 31, 2016).

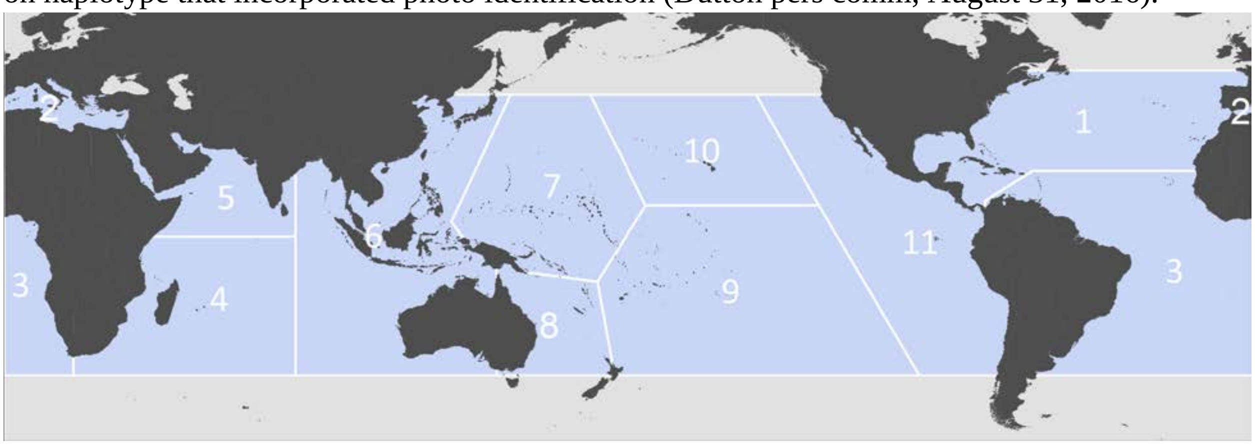

Figure 2. Green sea turtle DPSs. 1) North Atlantic; 2) Mediterranean; 3) South Atlantic; 4) Southwest Indian; 5) North Indian; 6) East Indian-West Pacific; 7) Central West Pacific; 8) Southwest Pacific; 9) Central South Pacific; 10) Central North Pacific; 11) East Pacific.

Table 5. Genetic composition of green turtles sampled from the fishery (Dutton pers comm, August 31, 2016). The number of genetic samples column is from the direct approach and the MSA percent is the mixed stock analysis with the 95 percent confidence interval.

DPS	Number of genetic samples	MSA percent	95 percent CI
East Pacific (11)	10	70	44-92
Central North Pacific (10)	2	12	0-34
East Indian-West Pacific (6)	1	8	0-26
Southwest Pacific (8)	1	7	0-25
Central West Pacific (7)	0	1	0-7
Central South Pacific (9)	0	1	0-7

While there have not been any green sea turtles identified from either the central west pacific DPS or the central south pacific DPS thus far, we are including them in the analysis as likely to be adversely affected for several reasons. There have been very few samples over the years, the action area overlaps with these two DPSs, and turtles from DPSs further away have been taken by the fishery. In addition, turtles from these two DPSs have been taken by the American Samoa longline fishery in an area where the deep-set fishery may operate.

Life History Characteristics of Pacific DPSs Affecting Vulnerability to Proposed Action

Green sea turtle life history is characterized by early development in the oceanic (pelagic) zone followed by later development in the coastal areas. After hatching, juveniles spend at least several years in pelagic areas where they feed primarily on small invertebrates. Between six to 10 years of age, at approximately 40 cm curved carapace length, most green turtles recruit to coastal habitats. Average size at recruitment to these neritic habitats for Pacific green sea turtles ranges from 35-50 cm CCL (Balazs 1980; Limpus et al., 2003). However, one recent study has shown that some green sea turtles don't recruit to nearshore areas until they are around 70 cm; curved carapace length, moving between open ocean areas and nearshore regions. This appears to be most prevalent with the East Pacific DPS (Parker et al., 2011).

During their pelagic phase, juvenile green sea turtles feed omnivorously on a range of planktonic material including crustaceans, jellyfish and ctenophores. Green sea turtles take tuna hooks baited with squid or fish, as demonstrated by bycatch of green sea turtles in several tuna longline fisheries in the Pacific (Beverly and Chapman, 2007). Very little is known of juvenile or adult green turtle pelagic foraging behavior, such as foraging depth. The deepest dives recorded for green sea turtles are from adults migrating from the main Hawaiian islands to the NWHI. Several turtles dove to greater than 100 m depth in pelagic areas, where they may have been feeding on plankton, resting, or avoiding predators (Rice and Balazs 2008). As described above, adult green sea turtles may undertake migrations between nesting and foraging habitat, during which time they may cross large expanses of pelagic habitat where longline fisheries operate; therefore, adults may be vulnerable to the proposed action.

Neritic green sea turtles typically forage in shallow coastal areas, primarily on algae and seagrass. Unlike other sea turtle species, upon maturation adults do not typically undertake transoceanic migrations to breeding sites, but long migrations may still occur between foraging and nesting areas, such as those undertaken by the Central North Pacific green sea turtle DPS between the main Hawaiian islands and French Frigate Shoals (FFS) (NMFS 2004, 2005a, 2006a; NMFS and FWS 2007b). Galapagos nesters from the East Pacific DPS showed multiple behavior patterns, including migration to Central American foraging areas, resident foraging areas within the Galapagos, and open ocean foraging areas where they foraged on soft-bodied invertebrates and surface dwelling prey that aggregate in frontal zones (Seminoff et al., 2008). Green sea turtles are strongly tied to coastal areas with abundant seagrass. However, results of satellite telemetry work (Seminoff et al., 2008) with at-sea observations (IATTC 2012) indicate that many East Pacific green sea turtles live their lives in the high-seas of the eastern Pacific likely because food is abundant in surface waters where currents converge and frontal zones exist.

While the proposed action includes waters of the Hawaiian Islands, longline fishing does not occur within 75 nm from the main Hawaiian islands. Adults migrate directly between the main Hawaiian islands and FFS (Balazs 1994), but the proposed action is unlikely to encounter many migrating adult green turtles from the Central North Pacific DPS. Green sea turtles from this region reach maturity at approximately 80 cm straight carapace length (SCL) (Zug et al., 2002). Since 1998, 15 green sea turtles have been observed incidentally caught in the deep-set fishery and all were less than 75 cm SCL (PIRO Observer program, unpublished data) (Table 6). Therefore we expect that the main aspect of green turtle life history affecting their vulnerability to Hawaii deep-set longline fishing are juveniles and sub-adults utilizing oceanic habitats.

Table 6. Green sea turtle interactions in the deep-set fishery showing size (straight carapace length) and the assigned DPS based on haplotype and photos (Dutton pers comm, August 31, 2016).

Date of interaction	Size SCL (cm)	DPS
2/11/1998	66	East Pacific
4/27/1999	54	East Pacific
5/27/2000	67	East Pacific
11/20/2000	40	East Pacific
5/13/2004	39	East Pacific
4/22/2006	73	East Pacific
8/20/2006	50.5	East Pacific
4/12/2010	38	Southwest Pacific
3/17/2011	39.5	East Indian West Pacific
11/1/2013	35	Central North Pacific
12/28/2013	40	Central North Pacific
5/23/2014	44.5	East Pacific
12/8/2014	51	East Pacific
11/17/2015	46.5	no results
4/20/2016	62	East Pacific

6.3.1 East Pacific Green Sea Turtle DPS

Distribution and Abundance

The range of the East Pacific green sea turtle DPS extends from the California/Oregon border southward along the Pacific Coast of the Americas to central Chile. This DPS encompasses the Revillagigedos Archipelago, Mexico and the Galapagos Archipelago, Ecuador. An estimated

3,319–3,479 eastern Pacific females nested annually (NMFS and FWS 2007b), and nesting has been steadily increasing at the primary nesting sites in Michoacan, Mexico, and in the Galapagos Islands since the 1990s (Delgado and Nichols 2005; Senko et al., 2011). Nesting trends at Colola have continued to increase since 2000 with the overall eastern Pacific green turtle population also increasing at other nesting beaches in the Galapagos and Costa Rica (Wallace et al., 2010, NMFS and FWS 2007b). Based on nesting beach data, the current adult female nester population for Colola, Michocan is 11,588 females, which makes this the largest nesting aggregation in the East Pacific DPS, comprising nearly 58 percent of the total adult female population. The total for the entire Eastern Pacific DPS is estimated at 20,112 nesting females (Seminoff et al., 2015).

Threats

The largest threat on nesting beaches to the East Pacific green sea turtle DPS is reduced availability of habitat due to heavy armament and subsequent erosion. In addition, while nesting beaches in Costa Rica, Revillagigedos Islands, and the Galapagos Islands are less affected by coastal development than green sea turtle nesting beaches in other regions around the Pacific. Several of the secondary green sea turtle nesting beaches in Mexico suffer from coastal development. For example, effects of coastal development are especially acute at Maruata, a site with heavy tourist activity and foot traffic during the nesting season (Seminoff 1994). Nest destruction due to human presence is also a threat to nesting beaches in the Galapagos Islands (Za´rate et al., 2006). However, such threats vary by site.

Incidental capture in artisanal and commercial fisheries is a significant threat to the survival of green sea turtles throughout the Eastern Pacific Ocean. The primary gear types involved in these interactions include longlines, drift nets, set nets, and trawl fisheries. These are employed by both artisanal and industrial fleets, and target a wide variety of species including tunas, sharks, sardines, swordfish, and mahi mahi. In the Eastern Pacific Ocean, particularly areas in the southern portion of the range of this DPS, significant bycatch has been reported in artisanal gill net and longline shark and mahi mahi fisheries operating out of Peru (Kelez et al., 2003; Alfaro-Shigueto et al., 2006) and, to a lesser extent, Chile (Donoso and Dutton 2010).

The fishing industry in Peru is the second largest economic activity in the country and, over the past few years, the longline fishery has rapidly increased. During an observer program in 2003/2004, 588 sets were observed during 60 trips, and 154 sea turtles were taken as bycatch. Green sea turtles were the second most common sea turtle species in these interactions. In many cases, green sea turtles are kept on board for human consumption; therefore, the mortality rate in this artisanal longline fishery is likely high because sea turtles are retained for future consumption or sale. Koch et al., (2006) reported green sea turtle bycatch-related dead strandings numbering in the hundreds in Bahia Magdalena.

In Baja California Sur, Mexico, from 2006–2009 small-scale gill-net fisheries caused massive green sea turtle mortality at Laguna San Ignacio, where Mancini et al., (2012) estimated that over 1,000 turtles were killed each year in nets set for guitarfish. Bycatch in coastal areas occurs principally in shrimp trawlers, gill nets and bottom longlines (Orrego and Arauz 2004). However, since 1996, all countries from Mexico to Ecuador declared the use of turtle excluder devices (TEDs) as mandatory for all industrial fleets to meet the requirements to export shrimp to the United States under the U.S. Magnuson- Stevens Fishery Conservation and Management

Act (Helvey and Fahy 2012). Since then, bycatch has not been thoroughly evaluated but it is widely expected that most fishers either improperly implement TEDs or remove them entirely from their trawls.

The American Samoa longline fishery is estimated to have interacted with an average of 24 green sea turtles (22 estimated mortalities) annually between 2006 and June 30, 2015 (NMFS 2015). Based on genetic samples NMFS estimates that 12 percent of the turtles caught in the American Samoa longline fishery are from the East Pacific DPS (Dutton pers. Comm.).

In some countries and localities within the range of the East Pacific DPS, harvest of green sea turtle eggs is legal, while in others it is illegal but persistent due to lack of enforcement. The impact of egg harvest is exacerbated by the high monetary value of eggs, consistent market demand, and severe poverty in many of the countries in the Eastern Pacific Region. Egg harvest is a major conservation challenge at several sites in Costa Rica, including Nombre de Jesus and Zapotillal Beaches, where 90 percent of the eggs were taken by egg collectors during one particular study (Blanco 2010). Egg harvest is also expected to occur at unprotected nesting sites in Mexico, Guatemala, El Salvador, and Nicaragua (NMFS and FWS 2007b). Mancini and Koch (2009) describe a black market that killed tens of thousands of green sea turtles each year in the Eastern Pacific Region. Sea turtles were, and continue to be, harvested primarily for their meat, although other products have served important non-food uses. Sea turtle oil was for used as a cold remedy and the meat, eggs and other products have been highly-valued for their aphrodisiacal qualities.

Effects of climate change include, among other things, sea surface temperature increases, the alteration of thermal sand characteristics of beaches (from warming temperatures), which could result in the reduction or cessation of male hatchling production (Hawkes et al., 2009; Poloczanska et al., 2009), and a significant rise in sea level, which could significantly restrict green sea turtle nesting habitat. While sea turtles have survived past eras that have included significant temperature fluctuations, future climate change is expected to happen at unprecedented rates, and if sea turtles cannot adapt quickly they may face local to widespread extirpations (Hawkes et al., 2009). Impacts from global climate change induced by human activities are likely to become more apparent in future years (IPCC, 2007). However, at the primary nesting beach in Michoacan, Mexico (Colola), the beach slope aspect is extremely steep and the dune surface at which the vast majority of nests are laid is well-elevated. This site is likely buffered against short-term sea level rise as a result of climate change. In addition, many nesting sites are along protected beach faces, out of tidal surge pathways. For example, multiple nesting sites in Costa Rica and in the Galapagos Islands are on beaches that are protected from major swells.

Conservation

Protection of green sea turtles is provided by local marine reserves throughout the region. In addition, sea turtles may benefit from the following broader regional efforts: (1) The Eastern Tropical Pacific Marine Corridor Initiative supported by the governments of Costa Rica, Panama, Colombia, and Ecuador, which is a voluntary agreement to work towards sustainable use and conservation of marine resources in these countries' waters; (2) the Eastern Tropical

Pacific Seascape Program managed by Conservation International that supports cooperative marine management in the Eastern Tropical Pacific, including implementation of the Marine Corridor Initiative; (3) the Inter-American Tropical Tuna Commission and its bycatch reduction efforts that are among the world's finest for regional fisheries management organizations; (4) the Inter-American Convention for the Protection and Conservation of Sea Turtles, which is designed to lessen impacts on sea turtles from fisheries and other human impacts; and (5) the Permanent Commission of the South Pacific (Lima convention), which has developed an Action Plan for Sea Turtles in the Southeast Pacific. There are indications that wildlife enforcement branches of local and national governments are stepping up their efforts to enforce existing laws, although successes in stemming sea turtle exploitation through legal channels are few and far between.

The following countries have laws to protect green turtles: Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru, and the United States. In addition, at least 10 international treaties and/or regulatory mechanisms apply to the conservation of green sea turtles in the East Pacific DPS.

Since 1996, all countries from Mexico to Ecuador declared the use of TEDs as mandatory for all industrial fleets to meet the requirements to export shrimp to the United States under the U.S. Magnuson- Stevens Fishery Conservation and Management Act (Helvey and Fahy 2012).

In 2008, the Western and Central Pacific Fisheries Commission issued a Conservation and Management Measure (2008–03; https://www.wcpfc.int/doc/cmm-2008- 03/conservation-and-management-sea- turtles) to reduce sea turtle mortality during fishing operations, collect and report information on fisheries interactions with turtles, and encourage safe handling and resuscitation of turtles. This measure requires purse seine vessels to avoid encircling turtles and to release entangled turtles. It also requires longline vessels to use line cutters and dehookers to release turtles.

6.3.2 Central North Pacific DPS green sea turtle DPS

Distribution and Abundance

The Central North Pacific green sea turtle DPS covers the Hawaiian Archipelago and Johnston Atoll. The Hawaiian Archipelago is the most geographically isolated island group on the planet and, therefore, it is perhaps unsurprising that green sea turtles in this DPS are geographically discrete in their range and movements, as evidenced by mark-recapture studies using flipper tags, PIT tags, satellite-linked transmitter tracking, and genetic analyses (Seminoff et al., 2015). Green sea turtle nesting in the Central North Pacific DPS is remarkably concentrated geographically. More than 96 percent of the females in this DPS nest at FFS in the Northwestern Hawaiian Islands (NWHI), with approximately 50 percent of those nesting on East Island, FFS. Each of the remaining 12 nesting sites in this DPS has fewer than 40 females in their nesting population. However, nesting was historically abundant at various sites across the archipelago as recently as 1920 (Kittinger et al., 2013). In sum, the DPS has a total of 3,846 breeding females (Seminoff et al., 2015).

Since initial nesting surveys at the FFS index beach in 1973, there has been a marked increase in annual green turtle nesting (Balazs and Chaloupka 2004). This increase over the last 40 years corresponds to an annual increase of 4.8 percent (Seminoff et al., 2015). Between 1973 and

2015, nesting activity has been variable, as is typical of green turtle nesting dynamics, ranging between a low of 67 in 1973 and an all-time high of 808 nesting females observed during the 2011 six week sampling period at East Island, FFS (with a total estimate of 843 nesters for the season) (NMFS-PIFSC unpublished). Surveys in 2013 were not be possible due to a December 2012 storm that destroyed the FFS field station making residence for biologists unsafe. Monitoring resumed in 2014. In-water abundance of green turtles is consistent with the increase in nesting trends (Balazs 1996; Balazs and Chaloupka 2004; Chaloupka et al., 2007). In addition, there has been a dramatic increase in the number of basking turtles in the main Hawaiian Islands and throughout the NWHI (Balazs 1996, Balazs and Whittow 1982, Parker and Balazs 2010). Long-term monitoring of the population indicates a strong degree of island fidelity exists within the rookery, and tagging studies have shown that turtles nesting at FFS come from numerous foraging areas where they reside throughout the Hawaiian Archipelago (Balazs 1976; Balazs 1980, 1983; Dutton et al., 2008). This linkage has been firmly established through genetics, satellite telemetry, flipper tagging and direct observation (Balazs 1983, 1994; Leroux et al., 2003; Dutton et al., 2008). The increase of the long-term nester trend can be attributed to increased survivorship (since harvesting of turtles in foraging grounds was prohibited in the mid-1970s) and cessation of habitat damage at the FFS rookery since the early 1950s (Balazs and Chaloupka 2004).

Green turtles in the Central North Pacific DPS have been studied extensively for decades and as a result there is a multitude of information on this population. Flipper tag returns and satellite tracking studies demonstrate that post-nesting females in the NWHI return to their foraging grounds in the main Hawaiian islands, and that foraging remains exclusively within geographic boundaries of this DPS. Genetic sampling in the Central North Pacific green sea turtle DPS has been extensive and representative given that there are few nesting populations in this region. Results of mtDNA analysis indicate a low level of spatial structure with regard to minor nesting around the main Hawaiian islands and the NWHI although the same haplotypes occur throughout the DPS. Information from tagging at FFS, other areas in the NWHI, areas in the main Hawaiian islands, and Johnston Atoll show that the vast majority of reproductive females and males periodically migrate to FFS for seasonal breeding from these distant locations. At the end of the season, they return to their respective foraging areas. Conventional tagging using PIT and metal flipper tags have documented 164 turtles making reproductive movements from or to FFS and foraging pastures in the main Hawaiian islands, and 58 turtles from or to FFS and the foraging pastures in the NWHI.

Threats

While the nesting population trajectory is positive and encouraging, more than 96 percent of nesting occurs at one site in the NWHI and it is highly vulnerable to threats. Results of mtDNA analysis indicate a low level of spatial structure and low genetic diversity within the DPS. Survival of this DPS is currently highly dependent on successful nesting at FFS (Niethammer et al., 1997). There has been a significant constriction in the spatial distribution of important reproduction sites, presenting a challenge to the population’s future and making this DPS highly vulnerable. As much as 80 percent of historically major nesting populations could be extirpated or have heavily reduced nesting abundances, and what was once geographically distributed nesting is now concentrated at a single site (Kittinger et al., 2013). The one nesting site, FFS, is a low-lying coral atoll that is susceptible to erosion, geomorphological changes and sea level rise, and has already lost significant nesting area (Baker et al., 2006).

Coastal development and construction, vehicular and pedestrian traffic, beach pollution, tourism, and other human related activities is an increasing threat to the basking and nesting population in the main Hawaiian islands (currently very limited) and may negatively affect hatchling and nesting turtles on these beaches. Climatic changes in the NWHI pose threats through reduction in area of nesting beaches critical to this DPS (Baker et al., 2006). The primary nesting area for the Central North Pacific DPS is threatened by sea level rise. For example, Whale-Skate Island at FFS was formerly a primary green turtle nesting site for this DPS but the island has subsided and is no longer available for nesting (Kittinger et al., 2013).

Threats to green sea turtle habitat in neritic and/or oceanic zones of the Central North Pacific DPS include contamination and degradation of foraging areas due to nearshore development, land based sources of marine pollution and increased human activity, contamination due to past military practices, vessel groundings, and fishing practices. Impacts to the quality of coastal habitats in the main Hawaiian islands are a threat to this DPS and are expected to continue and possibly increase with an increasing human population and annual influx of millions of tourists. Loss of foraging habitat or reduction in habitat quality in the main Hawaiian islands due to nearshore development is a threat to this DPS. Marina construction, beach development, siltation of forage areas, contamination of forage areas from anthropogenic activities, resort development or activities, increased vessel traffic, and other activities are all considered threats to this DPS and its habitat (Seminoff et al., 2015). In general, main Hawaiian islands coral reefs have suffered from land-based sources of pollution, overfishing, recreational overuse, invasive species, and are threatened by climate change and increased temperatures resulting in coral bleaching events, coral disease, coastal development and runoff, and waste water (point and non-point source pollution) (Friedlander et al., 2008). Climate change influences on water temperatures, ocean acidification, sea level and related changes in coral reef habitat, wave climate and coastal shorelines are expected to continue.

Incidental bycatch in fishing gear, marine pollution, interactions with recreational and commercial vessels, beach driving, and major storm events all negatively affect green turtles in the Central North Pacific DPS. Three of the most common reasons for sea turtle strandings in Hawaii are entanglement in fishing gear, interactions with fishing hooks, and interaction with marine debris (usually entanglement in nets). Human disturbance (e.g., by tourism) of foraging and basking sea turtles can occur in Hawaii, however it is unclear what level of threat this disturbance presents. Interactions between Central North Pacific green sea turtles and nearshore fisheries in the main Hawaiian islands can result in entanglement, injury, and mortality. Each year green sea turtles are incidentally entangled in gear, or hooked by nearshore fisheries, some of which result in mortality (e.g., Francke, 2013). The number of reported strandings are expected to be a smaller subset of the actual level of interaction with this gear. Nearshore fishery interactions have increased over time. NMFS and its partners are attempting to reduce the impact on green turtles from hook-and-line fishing.

The fibropapillomas disease affects green sea turtles that occur in the Central North Pacific Ocean (Francke et al., 2013). This disease results in internal and/or external tumors that may grow large enough to hamper swimming, vision, feeding, and potential escape from predators. Due to limitations of stranding data, the exact numbers are unknown as reported strandings are an unknown fraction of all green turtle mortalities. Fibropapillomas appears to have peaked in some areas of Hawaii, remained the same in some regions, and increased in others (Van Houtan et al., 2010). Environmental factors may be significant in promoting fibropapillomas, and eutrophication (increase in nutrients) of coastal marine ecosystems may promote this disease (Van Houtan et al., 2010). Fibropapillomas remains an important concern due to increasing human impacts in coastal areas.

In summary, the concentrated nature and relatively small size of the DPS make it vulnerable to random variation and stochasticities in the biological and physical environment, including natural catastrophes, as well as changes in climate and resulting effects such as sea level rise. This increases its risk of extinction, even though it may have positive population growth (Seminoff et al., 2015). Both non-stochastic as well as stochastic events are significant current and future threats to this small, isolated, concentrated population.

Conservation

There are many ongoing conservation efforts for green sea turtles in the Central North Pacific DPS by numerous Federal and State agencies and other non-governmental organizations. Green sea turtles in this DPS are protected by the ESA and in Hawaii, they are also protected by the Hawaii Revised Statutes, Chapter 195D (Hawaii State Legislature, accessed 9/10/2010) and Hawaii Administrative Rules, 13-124 (Hawaii Administrative Rules, accessed 9/10/2010), which adopt the same definitions, status designations, and prohibitions as the ESA and carry additional penalties for violations at the State government level. These two statutes have been, and currently are, key tools in efforts to recover and protect this DPS, and both have been effective in improving the status of sea turtles in Hawaii. Non-governmental organizations assist in the conservation of Hawaii's green sea turtles by conducting public outreach programs, protecting basking green sea turtles, conducting beach monitoring of turtles, and conducting in-water surveys. Intensive monitoring and protective efforts are ongoing in the NWHI, in the main Hawaiian islands, and in nearshore waters. Debris "clean up" efforts are also conducted in Hawaii by the NOAA Marine Debris Program and non-government organizations (Friedlander et al., 2008).

The State of Hawaii's Department of Land and Natural Resources efforts to conserve green turtles include wildlife regulations, coordination of stranding response and specimen storage on some islands; issuance and management of special activity permits; statewide outreach and education activities; and nest monitoring on Maui (Department of Land and Natural Resources, 2013). The Department of Land and Natural Resources Division of Conservation and Resources Enforcement investigates reports of illegal poaching, provides support and security at some nest sites and strandings, and addresses complaints from the public regarding turtle disturbances. Through ESA Section 6 (Species Recovery Grant) funding, the Department of Land and Natural Resources is working cooperatively with NMFS to minimize threats to green sea turtles in the main Hawaiian islands.

To raise awareness among fishers to reduce impacts to sea turtles around the Main Hawaiian

Islands, NMFS has developed a "Fishing Around Sea Turtles" program. The program was developed in 2010 (and refined 2012) through a multiagency partnership that includes NMFS, the State of Hawaii, the Western Pacific Fisheries Management Council, local experts, and fishers. This program is designed to promote "Turtle Friendly" fishing gear, such as barbless circle hooks, and provide best-practice guidelines for fisherman. It includes practical fishing tips suggested by fishermen that may reduce the potential for interactions, and encourages reporting injured or dead turtles to NMFS' sea turtle stranding program.

The Papahānaumokuākea Marine National Monument in the NWHI is a conservation area that encompasses coral reefs, islands, and shallow water environments that are important habitats for green sea turtles. The Monument is working to reduce threats through an ecosystem approach to management. This includes the development of an effective regulatory framework and permitting process, education and outreach, preventative measures to minimize risk, response, and restoration to damaged or degraded natural resources. The Pacific Remote Islands Marine National Monument was established in January 2009. The areas extend 50 nautical miles from the mean low water lines and include green sea turtle habitat. The protected area provides some protection to sea turtles and their habitat (through permitted access) and its remoteness. On August 26, 2016, President Obama issued Proclamation 9478 establishing the Papahanaumokuakea Marine National Monument Expansion (81 FR 60227). The Expansion area includes waters and submerged lands in the U.S. EEZ west of 163 West Longitude adjacent to the PMNM. The Monument Expansion consists of approximately 442,781 square miles. The Proclamation directs the Secretarties of Commerce and Interior to prohibit various activities, including commercial fishing, while allowing for sustainable non-commercial fishing and Native Hawaiian practices. The Western Pacific Fisheries Management Council is currently evaluating options for developing regulations to implement the commercial and non-commercial fishing provisions of the Proclamation.

At least 16 international treaties and/or regulatory mechanisms that apply to green sea turtles regionally or globally apply to green sea turtles within the Central North Pacific DPS. This includes: Convention on Biological Diversity, Convention on International Trade in Endangered Species, Indian Ocean-South-East Asian Marine Turtle Memorandum of Understanding, Inter-American Convention for the Protection and Conservation of Sea Turtles, and Secretariat of the Pacific Regional Environment Programme. Regulatory mechanisms in U.S. jurisdiction are in place through the ESA, Magnusen Stevens Act, and the State of Hawaii that currently address direct and incidental take of Central North Pacific green sea turtles, and these regulatory mechanisms have been an important factor in the increasing trend in this DPS.

In 2008, the Western and Central Pacific Fisheries Commission issued a Conservation and Management Measure (2008–03; https://www.wcpfc.int/doc/cmm-2008- 03/conservation-and-management-sea- turtles) to reduce sea turtle mortality during fishing operations, collect and report information on fisheries interactions with turtles, and encourage safe handling and resuscitation of turtles. This measure requires purse seine vessels to avoid encircling turtles and to release entangled turtles. It also requires longline vessels to use line cutters and dehookers to release turtles.

6.3.3 East Indian-West Pacific green sea turtle DPS

Distribution and Abundance

Green sea turtle nesting is widely dispersed throughout the East Indian-West Pacific DPS, with important nesting sites occurring in Northern Australia, Indonesia, Malaysia (Sabah and Sarawak Turtle Islands), Peninsular Malaysia, and the Philippine Turtle Islands. The largest nesting site lies within Northern Australia, which supports approximately 25,000 nesting females (Limpus 2009b). Currently, the East Indian-West Pacific DPS hosts 58 reported nesting sites; in some cases nesting sites are made up of multiple beaches with six of these sites supporting more than 5,000 nesting females each (including the 25,000 nesters in Northern Australia). Green sea turtles within this DPS have experienced increases at some nesting sites and decreases at others. Nonetheless, populations are substantially depleted from historical levels.

The in-water range of the East Indian-West Pacific DPS is similarly widespread with shared foraging sites throughout the range. Tagged green sea turtles that nest in Western Australia have been resighted in Arnhem Land and as far north as the Java Sea near Indonesia (Baldwin et al., 2003; Limpus et al., 2007). The extensive coastline and islands of Indonesia support a large range of nesting and foraging habitat for green sea turtles (Halim and Dermawan 1999). Waayers and Fitzpatrick (2013) found that in the Kimberly region of Australia, the green sea turtle appears to have a broad migration distribution and numerous potential foraging areas. A satellite-tagged female green sea turtle at Redang, Malaysia, travelled near Koh Samui, Thailand (Liew 2002). Green sea turtle foraging grounds occur around the Andaman and Nicobar Islands (Andrews et al., 2006). The estimated total nester abundance for this DPS is approximately 77,009 (Seminoff et al., 2015).

Threats

In the East Indian-West Pacific DPS, the majority of green sea turtle nesting beaches are extensively eroded. Nesting habitat is degraded due to a variety of human activities largely related to tourism. Coastal development and associated artificial lighting, sand mining, and marine debris affect the amount and quality of habitat that is available to nesting green sea turtles. Most of the beaches in Vietnam have a large amount of marine debris, which includes glass, plastics, polystyrenes, floats, nets, and light bulbs. This debris can entrap turtles and impede nesting activity and hatchling transit to the sea. In Australia, the majority of green sea turtle nesting along the beaches of the Gulf of Carpentaria occurs outside of the protection of the National Park. Other minor nesting sites lie within the protected lands of the Indigenous Protected Areas (Limpus 2009b). In Western Australia, the impacts to nesting and hatchling green sea turtles by independent turtle watchers as well as off-road vehicles has increased in the Ningaloo region as the number of visitors has increased over the years (Waayers 2010). Nesting turtles and hatchlings are routinely disturbed by people with their cars and flashlights (Kelliher et al., 2011). Burn-off flares associated with oil and gas production on the Northwest shelf of Australia are in sufficiently close proximity to the green sea turtle nesting beaches and possibly cause hatchling disorientation (Pendoley 2000).

Green sea turtles forage in the seagrass beds around the Andaman and Nicobar Islands in India. Some of these seagrass beds in the South Andaman group are no longer viable foraging habitat because of siltation and degradation due to waste disposal, a byproduct of the rapid increase in tourism (Andrews 2000). Green sea turtles that forage off the waters of the Bay of Bengal in south Bangladesh also face depleted foraging habitat from divers collecting seagrass for commercial purposes and by anchoring of commercial ships, ferries, and boats in this habitat (Sarkar 2001). In the nearshore waters of Thailand, seagrass beds are partially protected since fishing gear such as trawls are prohibited (Charuchinda et al., 2002). In the waters surrounding the islands of Togean and Banggai in Indonesia, the use of dynamite and potassium cyanide are common, and this type of fishing method destroys green sea turtle foraging habitat (Surjadi and Anwar 2001).

Incidental capture in artisanal and commercial fisheries is a significant threat to the survival of green sea turtles in the East Indian-West Pacific DPS. Green sea turtles may be caught in drift and set gill nets, bottom and mid-water trawling, fishing dredges, pound nets and weirs, and haul and purse seines. Bycatch in fisheries using gears such as trawlers, drift nets, and purse seines is thought to be one of the main causes of decline in the green sea turtle population in Thailand and Malaysia. The rapid expansion of fishing operations is largely responsible for the increase in adult turtle mortality due to bycatch (Settle 1995). The most used fishing gears in the waters of Thailand are trawling and drift gill nets. Heavy fishing is the main threat to foraging sea turtles (Chan et al., 1988; Chantrapornsyl 1993; Liew 2002). Gill nets and set bag nets are the two major fishing gears used in the Bay of Bengal, and green sea turtles are likely captured during these fishing operations (Hussain and Hoq 2010). Along the coast of Andaman and Nicobar Islands, the main type of fishery is gill nets and purse seines with thousands of turtles killed annually by fisheries operations including the shark fishery (Chandi et al., 2012; Shanker and Pilcher 2003). In 1994, Bhaskar estimated at least 600 green sea turtles were killed as a result of the shark fishery in this area. Over the last decade, there has been an increase in the large predator fishing industry. Green sea turtle mortality can be expected to be much higher than that estimated in the 1990s as a result of these current operations (Namboothri et al., 2012). Trawl fishing is also common in Bangladesh. No green sea turtle stranding information is available to determine the fishery threat level to the green sea turtle population; however, it is expected to be high as TEDs are not used and the population has declined (Ahmed et al., 2006).

On the Turtle Islands in the Philippines, there have been an increased number of dead turtles as a result of fishing activities, such as shrimp trawlers and demersal nets (Cruz 2002). One of the main threats to green sea turtles in Vietnam and Indonesia is the incidental capture from gill and trawl nets and the opportunistic capture by fishers. Hundreds of green sea turtles are captured by fisheries per year in Vietnam (Ministry of Fisheries 2003; Hamann et al., 2006; Dethmers 2010). In Indonesia, green sea turtles were recorded as one of the main species caught in the longline fisheries. Trawl gear is still allowed in the Arafura Sea, posing a major threat to green sea turtles (Dethmers 2010). Shrimp trawl captures in Indonesia are high because of the limited use of TEDs (Zainudin et al., 2008). The American Samoa longline fishery is estimated to have interacted with an average of 24 green sea turtles (22 estimated mortalities) annually between 2006 and June 30, 2015 (NMFS 2015). Based on genetic samples NMFS estimates that two percent of the turtles caught in the American Samoa longline fishery are from the East Indian-West Pacific DPS (Dutton pers. comm.).

Current legal and illegal collection of eggs and turtles occur throughout the East Indian-West Pacific DPS and persists as a significant threat. The harvest of nesting females continues to threaten the stability of green sea turtle populations in many areas by reducing adult abundance and reducing egg production. Local islanders in Indonesia have traditionally considered turtles, especially green sea turtles, as part of their diet (Hitipeuw and Pet-Soede, 2004). Illegal egg harvesting continues, but there is an increased effort to fully protect green sea turtles from harvest on the islands of Bilang-Bilangan and Mataha in Indonesia (Reischig et al., 2012). In Australia, green sea turtles are harvested by Aboriginal and Torres Strait Islanders for subsistence purposes. There is a widespread use of motorized aluminum boats in contrast to the traditional dugout canoes powered by paddles or sail. The total harvest of green sea turtles by indigenous people across northern and Western Australia is probably several thousand annually (Kowarsky 1982; Henry and Lyle 2003).

Pollution from oil spills, as well as from agricultural and organic chemicals, is a major threat to the waters used by green sea turtles in the Bay of Bengal (Sarkar 2001). The result of human population growth in China has been an increased amount of pollutants in the coastal system. Discharges from untreated sewage have occurred in Xisha Archipelago (Li et al., 2004). Concentrations of nine heavy metals (iron, manganese, zinc, copper, lead, nickel, cadmium, cobalt, and mercury) and other trace elements occur in the liver, kidney, and muscle tissues of green sea turtles collected from Yaeyama Islands, Okinawa, Japan (Anan et al., 2001). The accumulation of cadmium found in the green sea turtles is likely due to accumulations of this heavy metal in the plant materials on which they forage (Sakai et al., 2000). In the Gulf of Carpentaria, Australia, discarded fishing nets have caused a high number of turtle deaths with the majority being green turtles (Chatto et al., 1995).

In addition to the effects from climate change described above, natural environmental events, such as cyclones and hurricanes, may affect green sea turtles in the East Indian-West Pacific DPS. Typhoons have caused severe beach erosion and negatively affect hatching success at green sea turtle nesting beaches in Japan, especially in areas already prone to erosion.

Conservation

There are numerous ongoing conservation efforts in this region. Hatcheries have been set up throughout the region to protect a portion of the eggs laid and prevent complete egg harvesting. In addition, bycatch reduction efforts have been made in some areas, protected areas are established throughout the region, and monitoring, outreach and enforcement efforts have made progress in sea turtle conservation. In India, since 1978, the Centre for Herpetology/Madras Crocodile Bank Trust has conducted sea turtle surveys and studies in the islands. In a bilateral agreement, the Governments of the Philippines and Malaysia established The Turtle Island Heritage Protected Area, made up of nine islands (six in the Philippines and three in Malaysia). This area is one of the world's major nesting grounds for green sea turtles and management of the area is shared by both countries. One of the nesting beaches for this DPS, Australia's Dirk Hartog Island, is part of the Shark Bay World Heritage Area and recently became part of Australia's National Park System. This designation may facilitate monitoring of nesting beaches and enforcement of prohibitions on direct take of green sea turtles and their eggs. Conservation efforts on nesting beaches have included invasive predator control.

In order to reduce the threat of illegal trade, the Vietnamese Government, with assistance from the International Union for Conservation of Nature, World Wildlife Fund, TRAFFIC the wildlife trade monitoring network, and the Danish Government, formulated a Marine Turtle Conservation

Action Plan in 2010 to expand awareness to fishers and enforcement officers, and to confiscate sea turtle products (Stiles 2009).

The South East Asian Fisheries Development Center encourages the use of TEDs in Thailand, Malaysia, the Philippines, Indonesia and Brunei but widespread implementation and use is unknown (Food and Agriculture Organization of the United Nations, 2004). In 2000, the use of TEDs in the Northern Australian Prawn Fishery was made mandatory. Prior to the use of TEDs, this fishery took between 5,000 and 6,000 sea turtles as bycatch annually, with a mortality rate estimated to be 40 percent (Poiner and Harris, 1996). Since the mandatory use of TEDs has been in effect, the annual bycatch of sea turtles in the Northern Australian Prawn Fishery has dropped to fewer than 200 sea turtles per year, with a mortality rate of approximately 22 percent (based on recent years).

In 2008, the Western and Central Pacific Fisheries Commission issued a Conservation and Management Measure (2008–03; https://www.wcpfc.int/doc/cmm-2008- 03/conservation-and-management-sea- turtles) to reduce sea turtle mortality during fishing operations, collect and report information on fisheries interactions with turtles, and encourage safe handling and resuscitation of turtles. This measure requires purse seine vessels to avoid encircling turtles and to release entangled turtles. It also requires longline vessels to use line cutters and dehookers to release turtles.

6.3.4 Southwest Pacific Green Sea Turtle DPS

Distribution and Abundance

The range of the Southwest Pacific DPS extends from the western boundary of Torres Strait, to the eastern tip of Papua New Guinea and out to the offshore coordinate of 13° S., 171° E.; the eastern boundary runs from this point southeast to 40° S., 176° E.; the southern boundary runs along 40° S. from 142° E. to 176° E.; and the western boundary runs from 40° S., 142° E north to Australian coast then follows the coast northward to Torres Strait. There are approximately 12 total nesting sites, which occurs at moderate to high levels throughout the DPS. The abundance estimate for this DPS is 83,058 (Seminoff et al., 2015). The bulk of this DPS nests within Australia's Great Barrier Reef World Heritage Area and eastern Torres Strait. The northern Great Barrier Reef and Torres Strait support some of the world's highest concentrations of nesting (Chaloupka et al., 2008c). Nesting sites also occur on the Coral Sea Islands, New Caledonia, and Vanuatu. The largest known nesting area for green sea turtles in New Caledonia is the d'Entrecasteaux atolls, which are located 258 km north of Grande Terre and include Surprise, LeLeixour, Fabre, and Huon Islands (Maison et al., 2010). Vanuatu hosts over 189 nesting sites on 33 islands (Maison et al., 2010).

Roughly 90 percent of the nesting activity occurs at Raine Island and Moulter Cay, with appreciable nesting also occurring at Number Seven and Number Eight Sandbanks and Bramble Cay (Limpus 2009b). Estimates of annual nesters at Raine Island vary from 4,000 – 89,000 (Seminoff et al., 2004; NMFS and FWS 2007b; Chaloupka et al., 2008c; Limpus 2009b). Female nesting abundance in the northern Great Barrier Reef is not directly counted throughout the nesting season. This is largely because of the remoteness of the site and the sheer numbers of turtles that may nest on any given night, which makes accurate counting very difficult. A mark-recapture approach (Limpus et al., 2003) is used at Raine Island to estimate the number of adult female green sea turtles in the waters surrounding Raine Island during the sampling period. Females are painted during nightly tally counts, and then marked and unmarked adult female turtles are counted in the surrounding internesting habitats the following day using a structured survey protocol.

The number of turtles nesting in the Great Barrier Reef area of Australia differs widely from year to year and is well correlated with an index of the Southern Oscillation (Limpus and Nicholls, 2000). For example, the estimate of annual nesters at Raine Island during a medium density nesting season is about 25,000 (Limpus 2009b), while in a high density season (1999–2000) the estimate of nesters at Raine Island increases to 78,672 ± 10,586. Heron Island is the index nesting beach for the southern Great Barrier Reef, and nearly every nesting female on Heron Island has been tagged since 1974 (Limpus and Nicholls 2000). The mean annual nester abundance varied between 26 and 1,801 during 1999–2004 (Limpus 2009b).

Threats

Destruction and modification of green sea turtle nesting habitat in the Southwest Pacific DPS result from beach erosion, beach pollution, removal of native vegetation, and planting of non-native vegetation, as well as natural environmental change (Limpus, 2009). Coastal development and construction, placement of erosion control structures and other barriers to nesting, and vehicular traffic minimally impact green sea turtles in this DPS (Limpus, 2009). Artificial light levels have increased significantly for green sea turtles in minor nesting sites of the northern Great Barrier Reef and remained relatively constant for the mainland of Australia (part of southern Great Barrier Reef) south of Gladstone (Kamrowski et al., 2014). Most of the nests at the documented nesting sites within this DPS occur within the protected habitat, but there is still concern about the viability of nesting habitat (Limpus 2009b).

Southwest Pacific DPS green sea turtles are vulnerable to harvest throughout Australia and neighboring countries such as New Caledonia, Fiji, Vanuatu, Papua New Guinea, and Indonesia (Limpus 2009b). Cumulative annual harvest of green sea turtles that nest in Australia may be in the tens of thousands, and it appears likely that historical native harvest may have been in the same order of magnitude (Limpus 2009b). The Australian Native Title Act (1993) gives Aboriginal and Torres Strait Islanders a legal right to hunt sea turtles in Australia for traditional, communal, non-commercial purposes (Limpus 2009b). Although indigenous groups, governments, wildlife managers and scientists work together with the aim of sustainably managing turtle resources (Maison et al., 2010), traditional harvest remains a threat to green sea turtle populations. However, quantitative data are not sufficient to assess the degree of impact of harvest on this DPS.

Incidental capture in artisanal and commercial fisheries is a threat to the survival of green sea turtles in the Southwest Pacific DPS. The primary gear types involved in these interactions include trawl fisheries, longlines, drift nets, and set nets. These are employed by both artisanal and industrial fleets, and target a wide variety of species including prawns, crabs, sardines, and large pelagic fish. Nesting turtles of the Southwest Pacific DPS are vulnerable to the Queensland East Coast Trawl Fisheries and the Torres Strait Prawn Fishery, and to the extent other turtles forage west of Torres Strait, they are also vulnerable (Limpus 2009b). In 2000, the use of TEDs in the Northern Australian Prawn Fishery became mandatory, due in part to several factors: (1)

Objectives of the Australian Recovery Plan for Marine Turtles, (2) requirements of the Australian Environment Protection and Biodiversity Conservation Act for Commonwealth fisheries to become ecologically sustainable, and (3) the 1996 U.S. import embargo on wild caught prawns taken in a fishery without adequate turtle bycatch management practices (Robins et al., 2002). Australian and international longline fisheries capture green sea turtles. Precise estimates of international capture of Southwest Pacific Ocean DPS green turtles by the international longline fleet are not available, but they are thought to be larger than the Australian component (DEWHA 2010). In addition to threats from prawn trawls, green sea turtles may face threats from other fishing gear (summarized from Limpus, 2009). Take of green sea turtles in gill nets (targeting barramundi, salmon, mackerel, and shark) in Queensland and the Northern Territory has been observed but not quantified. Untended ‘‘ghost’’ fishing gear that has been intentionally discarded or lost due to weather conditions may entangle and kill many hundreds of green sea turtles annually. The American Samoa longline fishery is estimated to have interacted with an average of 24 green sea turtles (22 estimated mortalities) annually between 2006 and June 30, 2015 (NMFS 2015). Based on genetic samples NMFS estimates that 33 percent of the turtles caught in the American Samoa longline fishery are from the Southwest Pacific DPS (Dutton pers. Comm.).

Green sea turtles are captured in shark control programs, but protocols are in place to reduce the impact. The Queensland Shark Control Program is managed by the Queensland Department of Primary Industries and Fisheries (Limpus 2009b) and has been operating since 1962 (Gribble et al., 1998). In 1992, their operations began to be modified to reduce mortality of nontarget species (Gribble et al., 1998). Observed green sea turtle annual mortality during 1998–2003 was 2.7 per year (Limpus 2009b). Green sea turtles have been captured in the New South Wales shark-meshing program since 1937, but total capture for all turtle species from 1950 through 1993 is roughly five or fewer turtles per year (Krogh and Reid 1996). Post-release survival does not appear to have been monitored.

The magnitude of mortality from boat strikes may be in the high tens to low hundreds per year in Queensland (Limpus 2009b). This threat affects juvenile and adult turtles and may increase with increasing high-speed boat traffic in coastal waters. The magnitude of mortality from port dredging in Queensland may be in the order of tens of turtles or less per year (Limpus 2009b).

Toxic compounds and bio-accumulative chemicals threaten green sea turtles in the Southwest Pacific DPS. Poor health conditions (debilitation and death) have been reported in the southern Gulf of Carpentaria for green sea turtles, many of which had unusual black fat (Kwan and Bell 2003; Limpus 2009b). Heavy metal concentrations have also been reported in Australia (Gladstone and Dight 1994; Reiner 1994; Gordon et al., 1998; Limpus 2009b), but the health impact has not been quantified. The magnitude of mortality from ingestion of synthetic material in Queensland is expected to be at least tens of turtles annually (Limpus 2009b).

Green sea turtle could be affected by the effects of climate change on nesting grounds (Fuentes et al., 2011) as well as in marine habitats (Hamann et al., 2007; Hawkes et al., 2009). Potential effects of climate change include changes in nest site selection, range shifts, diet shifts, and loss of nesting habitat due to sea level rise (Hawkes et al., 2009; Poloczanska et al., 2009). Climate change will likely also cause higher sand temperatures leading to increased feminization of surviving hatchlings (i.e., changes in sex ratio), and some beaches will likely experience lethal incubation temperatures that will result in losses of complete hatchling cohorts (Glen and Mrosovsky 2004; Fuentes et al., 2010; Fuentes et al., 2011). While sea turtles have survived past eras that have included significant temperature fluctuations, future climate change is expected to happen at unprecedented rates, and if turtles cannot adapt quickly they may face local to widespread extirpations (Hawkes et al., 2009). Impacts from global climate change induced by human activities are likely to become more apparent in future years (IPCC, 2007). In a study of the northern Great Barrier Reef nesting assemblages, Bramble Cay and Milman Islet were vulnerable to sea-level rise, and almost all sites in the study were expected to be vulnerable to increased temperatures by 2070 (Fuentes et al., 2011). Similar data are not available for other nesting sites. The Southwest Pacific DPS contains some atolls, as well as coral reef areas that share some ecological characteristics with atolls. Barnett and Adger (2003) state that coral reefs, which are essential to the formation and maintenance of the islets located around the rim of an atoll, are highly sensitive to sudden changes in sea-surface temperature. Thus, climate change impacts could have long-term impacts on green sea turtle ecology in the Southwest Pacific DPS, but it is not possible to project the impacts at this point in time.

Conservation

Regulatory mechanisms are in place throughout the range of the DPS that address the direct capture of green sea turtles within this DPS. There are regulations that specially address the harvest of green sea turtles. Australia, New Caledonia, and Vanuatu are the only countries with nesting that have laws to protect green sea turtles. National protective legislation generally regulates intentional killing, possession, and trade (Limpus 2009b; Maison et al., 2010). In addition, at least 17 international treaties and/or regulatory mechanisms apply to the conservation of green sea turtles in the Southwest Pacific DPS. The majority of nesting beaches (and often the associated internesting habitat) are protected in Australia, which is the country with the vast majority of the known nesting. In Australia, the conservation of green sea turtles is governed by a variety of national and territorial legislation. Conservation began with 1932 harvest restrictions on turtles and eggs in Queensland in October and November, south of 17° S., and by 1968 the restriction extended all year long for all of Queensland (Limpus 2009b). Other conservation efforts include sweeping take prohibitions, implementation of bycatch reduction devices, improvement of shark control devices, safer dredging practices, and the development of community based management plans with Indigenous groups. Australia has undertaken extensive marine spatial planning to protect nesting turtles and internesting habitat surrounding important nesting sites. The Great Barrier Reef's listing on the United Nations Educational, Scientific and Cultural Organization's World Heritage List in 1981 has increased the protection of habitats within the World Heritage Area (Dryden et al., 2008).

In New Caledonia, 1985 fishery regulations contained some regional sea turtle conservation measures, and these were expanded in 2008 to include the EEZ, the Main Island, and remote islands (Maison et al., 2010). In Vanuatu, new fisheries regulations in 2009 prohibit the take, harm, capture, disturbance, possession, sale, purchase of or interference, import, or export of green sea turtles (Maison et al., 2010).

In 2008, the Western and Central Pacific Fisheries Commission issued a Conservation and Management Measure (2008–03; https://www.wcpfc.int/doc/cmm-2008- 03/conservation-and-management-sea- turtles) to reduce sea turtle mortality during fishing operations, collect and report information on fisheries interactions with turtles, and encourage safe handling and resuscitation of turtles. This measure requires purse seine vessels to avoid encircling turtles and to release entangled turtles. It also requires longline vessels to use line cutters and dehookers to release turtles.

6.3.5 Central West Pacific green sea turtle DPS

Distribution and Abundance

The range of the Central West Pacific DPS encompasses the Republic of Palau (Palau), Federated States of Micronesia (FSM), New Guinea, Solomon Islands, Marshall Islands, Guam, the Commonwealth of the Northern Mariana Islands (CNMI), and a portion of Japan. Green sea turtle nesting occurs at least at low levels throughout the geographic distribution of the DPS, with isolated locations having high nesting activity. Currently, there are approximately 51 nesting sites and 6,518 nesting females in the Central West Pacific. There are a number of unquantified nesting sites, possibly with small numbers; however, specifics regarding these sites are unknown. The highest numbers of females nesting in this DPS are located in Gielop and Iar Island, Ulithi Atoll, Yap, FSM (1,412); Chichijima (1,301) and Hahajima (394), Ogasawara, Japan; Bikar Atoll, Marshall Islands (300); and Merir Island, Palau (441) (NMFS and FWS 1998d; Bureau of Marine Resources 2005; Barr 2006; Palau Bureau of Marine Resources 2008; Maison et al., 2010; Seminoff et al., 2015).

There are numerous other populations in the FSM, Solomon Islands, and Palau. There are approximately 22 nesting green sea turtles in Guam, and 57 nesting green sea turtles in the CNMI. Historical baseline nesting information in general is not widely available in this region, but exploitation and trade of green sea turtles throughout the region is well-known (Groombridge and Luxmoore 1989).

Green sea turtles departing nesting grounds in this DPS travel throughout the western Pacific Ocean. Results of three post-nesting green sea turtles from Palau in 2006 showed they remained nearby or traveled to the Aru Islands in Indonesia – roughly 1,100 km away (Klain et al.,2007 in NMFS & FWS 2015). Five postnesting green sea turtles leaving Erikub Atoll in the Marshall Islands in 2007 traveled to the Philippines, Kiribati, FSM, or remained in the Marshallese EEZ (Kabua et al., 2012 in NMFS & FWS 2015). Turtles tagged in Yap (FSM) were recaptured in the Philippines, Marshall Islands, Papua New Guinea, Palau, and Yap (Palau BMR 2008; Cruce 2009). A turtle tagged on Gielop Island, Yap in 1991 was recaptured in Muroto Kochi prefecture, Japan in 1999 (Miyawaki et al., 2000). A nesting female tagged on Merir Island, Palau was captured near the village of Yomitan Okinawa, Japan (Palau BMR, 2008). Hundreds of nesting females tagged in Ogasawara Island were recaptured in the main islands of Japan, the Ryukyu Archipelago (Okinawa), Taiwan, China, and Philippines (H. Suganuma, Everlasting Nature of Asia, pers. comm., 2012 in NMFS & FWS 2015; Ogasawara Marine Station, Everlasting Nature of Asia. unpublished data in NMFS & FWS 2015). A turtle tagged in Japan was recorded nesting in Yap, FSM (Cruce 2009 in NMFS & FWS 2015).

In addition to nesting beaches, green sea turtles occupy coastal waters in low to moderate densities at foraging areas throughout the DPS. Aerial sea turtle surveys show that an in-water population exists around Guam (DAWR 2011 in NMFS & FWS 2015). In-water green sea turtle density in the Marianas Archipelago is low and mostly restricted to juveniles (Pultz et al., 1999; Kolinski et al., 2005, 2006; Palacios 2012). In-water information in this DPS overall is particularly limited.

There is insufficient long-term and standardized monitoring information to describe abundance and population trends adequately for many areas of the Central West Pacific DPS. The limited available information suggests a nesting population decrease in some portions of the DPS like the Marshall Islands, or unknown trends in other areas such as Palau, Papua New Guinea, the Marianas, Solomon Islands, or the FSM (Maison et al., 2010).

Threats

In the Central West Pacific DPS, some nesting beaches have become severely degraded from a variety of activities. Destruction and modification of green sea turtle nesting habitat results from coastal development and construction, placement of barriers to nesting, beachfront lighting, vehicular and pedestrian traffic, sand extraction, beach erosion, beach pollution, removal of native vegetation, and presence of non-native vegetation. In the FSM, construction of houses and pig pens on Oroluk beaches in Pohnpei State interferes with turtle nesting by creating barriers to nesting habitat (NMFS and FWS 1998d). Nesting habitat destruction is also a major threat to Guam turtles and has resulted mainly from construction and development due to increased tourism (NMFS and FWS 1998d; Project GloBAL, 2009a). Coastal construction is a moderate problem on Majuro Atoll in the Republic of the Marshall Islands (NMFS and FWS 1998d); however, it is unknown to what extent nesting beaches are being affected. On the outer atolls of the Marshall Islands, beach erosion has been aggravated by airfield and dock development, and by urban development on Majuro and Kwajalein Atolls. In Palau, increasing nesting habitat degradation from tourism and coastal development has been identified as a threat to sea turtles (Eberdong and Klain 2008; Isamu and Guilbeaux 2002), although the extent and significance of the impacts are unknown.

Incidental capture in artisanal and commercial fisheries is a threat to the survival of green turtles in the Central West Pacific DPS. Sea turtles may be caught in longline, pole and line, and purse seine fisheries. Within the Marshall Islands, Palau, the FSM, and the Solomon Islands, a purse-seine fishery for tuna and a significant longline fishery operate, and sea turtles have been captured in both fisheries with green sea turtle mortality occurring (Oceanic Fisheries Programme 2001; McCoy 2003; Hay and Sablan-Zebedy 2005; McCoy 2007a; McCoy 2007b; Western and Central Pacific Fisheries Commission 2008). Numerous subsistence and small-scale commercial fishing operations occur along Saipan's western coast and along both the Rota and Tinian coasts (CNMI Coastal Resources Management Office 2011). Incidental catch of turtles in Guam's coastal waters by commercial fishing vessels likely also occurs (NMFS and FWS, 1998a). In 2007, 222 fishing vessels (200 purse-seiners and 22 longliners) had access to Papua New Guinea waters (Kumoru 2008). Although no official reports have been released on sea turtle bycatch within these fisheries (Project GloBAL 2009b), sea turtle interactions with both fisheries have been commonly observed (Kumoru 2008). However, the level of mortality is unknown. The American Samoa longline fishery is estimated to have interacted with an average of 24 green sea turtles (22 estimated mortalities) annually between 2006 and June 30, 2015 (NMFS 2015). Based on genetic samples NMFS estimates that three percent of the turtles caught in the American Samoa longline fishery are from the Central West Pacific DPS (Dutton pers. Comm.).

Directed take of eggs is an ongoing problem for the Central West Pacific DPS in the CNMI, FSM, Guam, Kiribati (Gilbert Islands chain), Papua, Papua New Guinea, Marshall Islands, and Palau (Eckert 1993; Guilbeaux 2001; Hitipeuw and Maturbongs 2002; Philip 2002). In addition to the collection of eggs from nesting beaches, the killing of nesting females continues to threaten the stability of green turtle populations. Ongoing harvest of nesting adults has been documented in the CNMI (Palacios 2012), FSM (Cruce 2009), Guam (Cummings 2002), Papua (Hitipeuw and Maturbongs, 2002), Papua New Guinea (Maison et al., 2010), and Palau (Guilbeaux 2001). Mortality of turtles in foraging habitats is also problematic for recovery efforts. Ongoing intentional capture of green sea turtles in their marine habitats has been documented in southern and eastern Papua New Guinea (Limpus et al., 2002) and the Solomon Islands (Broderick 1998; Pita and Broderick, 2005). Green sea turtles have long been harvested for their meat in the Ogasawara Islands, and records show a rapid decline in the sea turtle population between 1880 and 1920 (Horikoshi et al., 1994; Ishizaki 2007). Sea turtle harvest has been strictly regulated with a limit of 135 mature turtles per year in recent decades (Ishizaki 2007), and the population is increasing at approximately 6.8% annually (Chaloupka et al., 2008).

The impacts of vessel strikes to the Central West Pacific DPS are unknown, but not thought to be of great consequence, except possibly in Palau where high speed skiffs constantly travel throughout the lagoon south of the main islands (NMFS and FWS 1998d). However, green sea turtles have been documented as occasionally being hit by boats in Guam (Guam Division of Aquatic and Wildlife Resources 2012).

In the FSM, debris is dumped freely and frequently off boats and ships (including government ships). Landfill areas are practically nonexistent in the outer islands and have not been addressed adequately on Yap, Chuuk, and Pohnpei. The volume of imported goods, including plastic and paper packaging appears to be increasing (NMFS and FWS 1998d). In Palau, entanglement in abandoned fishing nets has been identified as a threat to sea turtles (Eberdong and Klain 2008). In the Marshall Islands, debris and garbage disposal in coastal waters is a serious problem on Majuro Atoll and Ebete Island (Kwajalein Atoll), both of which have inadequate space, earth cover, and shore protection for sanitary landfills. This problem also exists to a lesser extent at Daliet Atoll (NMFS and FWS 1998d). A study of the gastrointestinal tracts of 36 dead green turtles in the Ogasawara Islands of Japan in 2001 revealed the presence of marine debris in the majority of the turtles (Sako and Horikoshi 2003).

Over the long term, the Central West Pacific DPS could be affected by the alteration of thermal sand characteristics (from global warming), resulting in the reduction or cessation of male hatchling production (Caminas 2004; Hawkes et al., 2009; Kasparek et al., 2001; Poloczanska et al., 2009). Further, a significant rise in sea level would restrict green sea turtle nesting habitat in the Central West Pacific. Coastal erosion has been identified as a high risk in the CNMI due to the existence of concentrated human population centers near erosion-prone zones, coupled with the potential increasing threat of erosion from sea level rise (CNMI Coastal Resources Management Office 2011). In the FSM, Yap State's low coralline atolls are extremely vulnerable to sea level rise (NMFS and FWS 1998d). These risks are high for all beaches in the Central West Pacific. Barnett and Adger (2003) identified projected increases in sea-surface temperature as the greatest long-term risk of climate change to atoll morphology and thus to atoll countries like those in the Central West Pacific. They state that coral reefs, which are essential to the formation and maintenance of the islets located around the rim of an atoll, are highly sensitive to sudden changes in sea-surface temperature.

Climate change impacts could have profound long-term impacts on green sea turtle nesting in the Central West Pacific, but it is not possible to project the impacts at this point in time. Natural environmental events such as cyclones and hurricanes may affect green sea turtles in the Central West Pacific DPS. These storm events have been shown to cause severe beach erosion with likely negative effects on hatching success at many green turtle nesting beaches, especially in areas already prone to erosion. Shoreline erosion occurs naturally on many islands in the atolls of the Marshall Islands due to storms, sea level rise from the El Nino– Southern Oscillation, and currents (NMFS and FWS 1998d). Some erosion of nesting beaches at Oroluk was reported in 1990 after passage of Typhoon Owen (NMFS and FWS 1998d). However, effects of these natural events may be exacerbated by climate change. While sea turtles have survived past eras that have included significant temperature fluctuations, future climate change is expected to happen at unprecedented rates, and if turtles cannot adapt quickly they may face local to widespread extirpations (Hawkes et al., 2009).

Conservation

Regional and national legislation to conserve green sea turtles exists throughout the range of the DPS. National protective legislation generally prohibits intentional killing, harassment, possession, trade, or attempts at these. The following countries and territories have laws to protect green sea turtles: CNMI, FSM, Guam, Japan (Ogasawara Islands), Kiribati, Marshall Islands, Nauru, Palau, Papua, Papua New Guinea, Solomon Islands, and Wake Island. In addition, at least 17 international treaties and/or regulatory mechanisms apply to the conservation of green sea turtles in the Central West Pacific DPS. These are implemented to various degrees throughout the range of the DPS. There are some national regulations, within this DPS, that prohibit the harvest of green sea turtles while a few regulations are allow for limited harvest of turtles of certain sizes, times of years, or allow for harvest for tradition use.

In 2008, the Western and Central Pacific Fisheries Commission issued a Conservation and Management Measure (2008–03; https://www.wcpfc.int/doc/cmm-2008- 03/conservation-and-management-sea- turtles) to reduce sea turtle mortality during fishing operations, collect and report information on fisheries interactions with turtles, and encourage safe handling and resuscitation of turtles. This measure requires purse seine vessels to avoid encircling turtles and to release entangled turtles. It also requires longline vessels to use line cutters and dehookers to release turtles.

6.3.6 Central South Pacific Green Sea Turtle DPS

Distribution and Abundance

The range of the Central South Pacific DPS extends north and east of New Zealand to include a longitudinal expanse of 7,500 km- from Easter Island, Chile in the east to Fiji in the west, and encompasses American Samoa, French Polynesia, Cook Islands, Fiji, Kiribati, Tokelau, Tonga, and Tuvalu. Central south Pacific Ocean green sea turtles nest sporadically across American Samoa, Cook Islands, Fiji, French Polynesia, Kiribati, Tokelau, Tonga, Tuvalu, and United Kingdom Overseas Territory. Nesting occurs sporadically throughout the geographic distribution of the DPS at low levels. The estimated number of nesting females for this DPS is 2,677 (Seminoff et al., 2015).

Green sea turtle temporal population trends in the Central South Pacific are unavailable because no nesting sites have five contiguous years of standardized monitoring that span entire nesting seasons. Partial and inconsistent monitoring from the largest nesting site in this aggregation, Scilly Atoll, suggests significant nesting declines from persistent and illegal commercial harvesting (Petit 2013). Nesting abundance is stable to increasing at Rose Atoll, Swains Atoll, Tetiaroa, Tikehau, and Maiao. However, these sites are of moderate to low abundance and in sum represent less than 16 percent of the population abundance at Scilly Atoll alone. Nesting abundance is stable to increasing at Tongareva Atoll (White and Galbraith 2013). Community-based monitoring activities at Tongareva Atoll in 2014 and 2015 resulted in 292 and 161 nests, respectively, with peak nesting typically from November to February (White 2015). Although trend data is currently lacking, the Tongareva rookery is successful and likely sustainable, given a lack of land-based predators and high hatch success (97 percent). The uncertainty surrounding trends, and the general dearth of long-term monitoring and data from this nesting aggregation, presents significant challenges to any trend analyses.

Threats

In Samoa, degradation of habitat through coastal development and natural disasters as cited in Secretariat of the Pacific Regional Environment Programme (2012) remains a threat (J. Ward, Ministry of Natural Resources and Environment, Samoa, pers. comm., 2013 as cited in NMFS & FWS 2015). In Kiribati, historical destruction (bulldozing) of the vegetation zone next to the nesting beach on Canton Island in the Phoenix Islands occurred during World War II and may have negatively affected the availability of a portion of nesting beach area (Balazs 1975). The remoteness of these islands and minimal amount of study of sea turtles in this area makes recent information on nesting beach condition and threats difficult to obtain. In the Cook Islands, the major nesting site for green sea turtles, Tongareva Atoll, is uninhabited and there are not likely threats related to development or human disturbance (White 2012b). However, elsewhere in the Cook Islands, sand extraction (for building purposes) and building developments are reported as potential threats to sea turtles; for instance, the best potential site at Tauhunu motu on Manihiki appears to be no longer used for nesting (White 2012a). Weaver (1996) notes that sea turtles are negatively affected in Fiji by modification of nesting beaches. Coastal erosion in Tonga and Tuvalu is reported as a major problem for turtle nesting (Alefaio and Alefaio 2006; Bell et al., 2010).

Destruction and alteration of green sea turtle nesting and foraging habitats are occurring throughout the range of this DPS. NMFS and FWS (1998) noted that degradation of coral reef habitats on the south side of Tutuila Island, American Samoa is occurring due to sedimentation from erosion on agricultural slopes and natural disasters. Ship groundings are also potential threats to habitat in American Samoa. For example, a ship grounded at Rose Atoll in 1993, damaging reef habitat and spilling 100,000 gallons of fuel and other contaminants (FWS 2014). In the nearby neighboring country of Samoa, coastal and marine areas have been negatively impacted by pollution (Government of Samoa, 1998). Sea turtles have been negatively affected by alteration and degradation of foraging habitat and to some extent pollution or degradation of nearshore ecosystems in Fiji (Batibasaga et al., 2006). Jit (2007) also suggests that sea turtles in Fiji are threatened by degradation of reefs and seagrass beds. Given that turtles outside of Fiji appear to use this foraging habitat, negative effects to this foraging area have important implications for the entire DPS. Tourism development on the eastern coast of Viti Levu could negatively impact sea turtle foraging sites (Jit, 2007). In Tonga, marine habitat is being affected by anthropogenic activities. Heavy sedimentation and poor water quality have killed patch reefs; high nutrients and high turbidity are negatively impacting seagrasses; and human activities are negatively impacting mangroves (Prescott et al., 2004).

Incidental capture in artisanal and commercial fisheries is a significant threat to the survival of green sea turtles throughout the Central South Pacific DPS. The primary gear types involved in these interactions include longlines and nets. Incidental capture in line, trap, or net fisheries presents a threat to sea turtles in American Samoa (Tagarino, 2011). Subsistence gill nets have been known to occasionally catch green sea turtles. Industrial fisheries also interact with green sea turtles, especially juveniles, like the American Samoa longline fishery. The American Samoa longline fishery is estimated to have interacted with an average of 24 green sea turtles (22 estimated mortalities) annually between 2006 and June 30, 2015 (NMFS 2015). Based on genetic samples NMFS estimates that 50 percent of the turtles caught in the American Samoa longline fishery are from the Central South Pacific DPS (Dutton pers. Comm.).

In Fiji, green sea turtles are killed in commercial fishing nets; however, the exact extent and intensity of this threat is unknown (Rupeni et al., 2002). Jit (2007) and McCoy (2008) report that green sea turtle bycatch is occurring in longline tuna fisheries in Fiji. The exact level of interaction with green sea turtles is unclear. In the Cook Islands, longline fishery regulations require fishers to adopt the use of circle hooks and to follow ‘‘releasing hooked turtles’’ guidelines (Goodwin, 2008), although it is unclear how effective these regulations are. McCoy (2008) suggests that sea turtle bycatch is occurring in tuna fisheries in the Cook Islands; however, no information is provided on the extent of sea turtles killed or injured in these fisheries or the species that are effected.

Human consumption has had a significant impact on green sea turtles in the Central South Pacific DPS. Hirth and Rohovit (1992) report that exploitation of green sea turtles for eggs, meat, and parts has occurred throughout the South Pacific Region, including American Samoa, Cook Islands, Fiji Islands, French Polynesia, and Kiribati. Allen (2007) notes that in Remote Oceania (which includes this DPS) sea turtles were important in traditional societies but, despite this, have experienced severe declines since human colonization approximately 2,800 years ago. At western contact, some of the islands supported sizable human populations resulting in intense pressures on local coastal fisheries. At Scilly Atoll in French Polynesia local residents (approximately 20 to 40 people) are allowed to take 50 adults per year from a nesting population that could be as low as 300–400 (M. S. Allen 2007; Balazs et al., 1995). Balazs et al., (1995) reported that declines in nesting green sea turtles at the important areas of Scilly, Motu-one, and Mopelia, among the highest density nesting sites in the DPS, have occurred due to commercial exploitation for markets in Tahiti, as well as exploitation due to human habitation. Illegal harvest of sea turtles has been reported for French Polynesia by Te Honu Tea (2008). Brikke (2009) conducted a study on Bora Bora and Maupiti islands and reported that sea turtle meat remains in high demand and that fines are rarely imposed.

Directed take in the marine environment has been a significant source of mortality in American Samoa, and turtle populations have seriously declined (Tuato’o-Bartley et al., 1993; NMFS and

FWS, 1998). Although take of sea turtle eggs or sea turtles is illegal (the ESA applies in this territory), turtles from American Samoa migrate to other countries (e.g., Fiji, Samoa, French Polynesia) where turtle consumption is legal or occurs illegally (Craig, 1993; Tuato'o-Bartley et al., 1993). Turtles have been traditionally harvested for food and shells in the country of Samoa, and over-exploitation of turtles has negatively affected local populations (Government of Samoa, 1998). Unsustainable harvest (direct take for meat) remains a major threat to green sea turtles in Samoa (J. Ward, Government of Samoa, pers. comm. 2013 as cited in NMFS & FWS 2015). In Fiji, Weaver (1996) identified the contemporary harvest and consumption of turtles by humans for eggs, meat, and shells as a significant threat for sea turtles. This includes commercial harvest, as well as subsistence and ceremonial harvest. In Kiribati (e.g., Phoenix Islands), an unknown number of sea turtles are caught as bycatch on longlines and eaten (Obura and Stone 2002). Poaching has been reported for Caroline Atoll, but to what extent it currently occurs is unknown (Teeb'aki, 1992).

In Tonga, Bell et al., (1994) report that collection of eggs for subsistence occurs. Prescott et al., (2004) and Havea and MacKay (2009) also note that it is still a practice on islands where turtles nest. Bell et al., (2009) report that in Tonga sea turtles are harvested and live turtles are often seen transported from outer islands to the main island, Tongatapu. It is unclear if this harvest is sustainable, especially given the increased catch rates in Tungua for the commercial market (Havea and MacKay, 2009). In Tuvalu, harvest of sea turtles for their meat has been cited as a major threat (Alefaio and Alefaio 2006; Ono and Addison 2009). In the Cook Islands, turtles are sometimes killed during nesting at Palmerston and Rakahanga, while nesting and fishing on Nassau, and while nesting at Manihiki, Tongareva, and probably at other atolls (White 2012). In Tokelau, Balazs (1983) reported human take of both sea turtle eggs from nests and adult males and females while copulating, nesting, or swimming (by harpoon).

Green sea turtles forage in shallow areas, surface to breathe, and often occur just below the surface. The majority of turtles in coastal areas spend their time at depths less than five meters below the surface (Schofield et al., 2007, Hazel et al., 2009), and hence are vulnerable to being struck by vessels. A study completed in Australia found the proportion of green sea turtles that fled to avoid an approaching vessel increased significantly as vessel speed decreased (Hazel et al.,2007). Sixty percent of observed turtles encountered during low speed trials (2.2 knots) fled the approaching vessel. Flight response dropped to 22 percent and four percent at moderate (5.9 knots) and fast (10.3 knots) vessel speeds, respectively. Those that fled at higher vessel speeds did so at significantly shorter distances. The results implied that sea turtles cannot be expected to actively avoid a vessel traveling faster than 2.2 knots. The authors suggested that visual rather than auditory cues were more likely to provoke a flight response and that vessels transiting at slower speeds can assure a "turtle-safe" transit so both turtles and vessels have time to evade collisions (Hazel et al., 2007).

Climate change has the potential to greatly affect green sea turtles. Potential impacts of climate change on green turtles include loss of beach habitat from rising sea levels, repeated inundation of nests, skewed hatchling sex ratios from rising incubation temperatures, and abrupt disruption of ocean currents used for natural dispersal (Fish et al., 2005, 2008; Hawkes et al., 2009; Poloczanska et al., 2009). A study of 27 atoll islands in the central Pacific (including Kiribati and Tuvalu), demonstrated that 14 percent of islands decreased in area over a 19–60 year time span (Webb and Kench 2010). That same study also showed that 86 percent of the islands remained stable or increased in area which demonstrates that changes will not be uniform. This occurred in a region considered most vulnerable to sea-level rise (Nicholls and Cazenave 2010) during a period in which sea-levels rose 2 mm per year. Catastrophic natural environmental events, such as cyclones or hurricanes, may affect green turtles in the Central South Pacific Ocean, and may exacerbate issues such as decreased available habitat due to sea level rise. These types of events may disrupt green turtle nesting activity (Van Houtan and Bass 2007), even if just on a temporary scale.

Direct or indirect disposal of anthropogenic waste introduces potentially lethal materials into green turtle foraging habitats. Green sea turtles will ingest plastic, monofilament fishing line, and other marine debris (Bjorndal et al., 1994), and the effects may be lethal or non-lethal, resulting in varying effects that may increase the probability of death (Balazs 1985; Carr 1987; McCauley and Bjorndal 1999). Marine debris presents a threat to green sea turtles in American Samoa (Aeby et al., 2008; FWS 2014; Tagarino et al., 2008). It is potentially hazardous to adults and hatchlings and is present at Rose Atoll (FWS 2014). It is also a threat at nearby inhabited islands. Pago Pago Harbor in American Samoa is seriously polluted, and uncontrolled effluent contaminants have impaired water quality in some coastal waters (Aeby et al., 2008). Effects to coastal habitat (e.g., reefs) from sedimentation related to development and runoff are significant potential threats in American Samoa, and human population pressures place strains on shoreline resources (Aeby et al., 2008). Ship groundings (e.g., at Rose Atoll in 1993) that damage reef habitat and spill fuel and other contaminants, degradation of coastal waters due to silt laden runoff from land and nutrient enrichment from human discharges and wastes, and contamination by heavy metals and other contaminants are threats to green turtles in American Samoa (NMFS and FWS 1998d; FWS 2014). In Fiji, Weaver (1996) identified potential threats to sea turtles from heavy metals and industrial waste, organic loadings in coastal areas, plastic bags, and leachate poisoning of seagrass foraging areas. In the Cook Islands, White (2012) noted possible issues with oil, tar, or toxic chemicals and terrestrial run-off into lagoons at Rarotonga, and Bradshaw and Bradshaw (2012) note pollution (e.g., accumulation of plastics on the beach) on Mauke (M.White, unpubl. data, www.honucookislands.com).

Conservation

Numerous countries have reserves (French Polynesia, Kiribati, Samoa, and the U.S. Pacific Remote Islands and Rose Marine National Monument), national legislation, and/or local regulations protecting turtles. These include the foreign Cook Islands, Fiji, French Polynesia, Kiribati, Pitcairn Islands, Samoa, Tonga, Tuvalu, and the U.S. territories of Wake, Baker, Howland and Jarvis Islands, Kingman Reef and Palmyra Atoll. In some places such as Tokelau and Wallis and Futuna, information on turtle protection was either unclear or could not be found. At least 17 international treaties and/or regulatory mechanisms apply to the conservation of green sea turtles from the Central South Pacific DPS. Green sea turtles in American Samoa are fully protected under the ESA. Green sea turtles are also protected by the Fishing and Hunting Regulations for American Samoa (24.0934), which prohibit the import, export, sale, possession, transport, or trade of sea turtles or their parts and take (as defined by the ESA) and carry additional penalties for violations at the local government level (Maison et al., 2010). Additionally, an American Samoa Executive Order in 2003 established the territorial waters of American Samoa as a sanctuary for sea turtles and marine mammals; American Samoa declared its submerged lands a Whale and Turtle Sanctuary. It is not known how effective implementation of these protections are in American Samoa. The NOAA National Marine Sanctuary of American Samoa is comprised of six protected areas, covering 35,175 km2 of nearshore coral reef and offshore open ocean waters across the Samoan Archipelago. Additionally, Rose Atoll Marine National Monument was established in 2009 and encompasses the Rose Atoll National Wildlife Refuge. These protected areas should provide some level of protection for green turtles and their habitat; however the effectiveness of these monuments for this species is unknown.

In 2008, the Western and Central Pacific Fisheries Commission issued a Conservation and Management Measure (2008–03; https://www.wcpfc.int/doc/cmm-2008- 03/conservation-and-management-sea- turtles) to reduce sea turtle mortality during fishing operations, collect and report information on fisheries interactions with turtles, and encourage safe handling and resuscitation of turtles. This measure requires purse seine vessels to avoid encircling turtles and to release entangled turtles. It also requires longline vessels to use line cutters and dehookers to release turtles.

7 Environmental Baseline

The environmental baseline for an Opinion includes past and present impacts of all state, federal or private actions and other human activities in the action area, 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"(FWS and NMFS 1998). The purpose of describing the environmental baseline in this manner in an Opinion is to provide context for effects of the proposed action on listed species.

The past and present impacts of human and natural factors leading to the status of the nine species addressed by this Supplement within the action area include fishery interactions, vessel strikes, climate change, pollution, marine debris, and entanglement. The environmental baseline for the nine ESA-listed marine species addressed by this Supplement are described below.

Information in this section is summarized from the 2004 Opinion (NMFS 2004), the 2005 Opinion (NMFS 2005), the 2006 Opinion (NMFS 2006), the 2006 pelagics report (WPFMC 2006), the green turtle 5-year status review (NMFS and FWS 2007b), the 2008 Opinion (NMFS 2008a), the 2009 Status Review, the 2011 Loggerhead sea turtle DPS listing, the 2012 Opinion (NMFS 2012), the olive ridley 5-year status review (NMFS and FWS 2014), the 2014 Opinion (NMFS 2014a), and the other sources cited as cited in subsequent subsections.

7.1 Loggerhead Sea Turtle

Past and present fisheries interactions have been, and continue to be, a threat to loggerhead sea turtles within the action area. Currently, primary fishing activity in the action area is longline fishing, except for nearshore fisheries that operate within longline prohibited areas around the Hawaiian Islands. In the past, drift gillnetting also occurred on a large scale within the action area, but because of high bycatch rates of protected species, a United Nations resolution banned this fishing method, instituting a global prohibition in 1992. Other types of fishing may occur in the action area outside of longline prohibited areas (e.g., main Hawaiian islands offshore handline mixed gear), but on such a small scale and with assumed low mortality rates as to be insignificant with regard to the loggerhead sea turtle environmental baseline. Within longline prohibited areas around the Hawaiian Islands, numerous fisheries operate, but these do not affect loggerhead sea turtles. Therefore, fisheries impacts on loggerhead sea turtles in the action area are limited to longline fishing, past and present impacts of which are described below.

Longline Fishing

The action area lies entirely within the central North Pacific. Longline fishing is done by many countries in this region, and there are two types of vessels: (1) large distant-water freezer vessels that undertake long voyages (months) and operate over large areas of the region; and (2) smaller offshore vessels with ice or chill capacity that typically undertake trips of about one month (like the Hawaii longline fleet). The total annual number of longline vessels in the western central Pacific region has fluctuated between 3,000 and 6,000 for the last 30 years, this includes the 100-140 vessels in the Hawaii longline fisheries (the majority of which are involved in the deep-set fishery). The four main target species are yellowfin, bigeye, albacore tuna, and swordfish. The distribution of longline effort from 2000-2014 is shown in Figure 3 below. The action area is shown by the red rectangle, and consists mostly of high seas areas, although some effort continues to occur within the US EEZ.

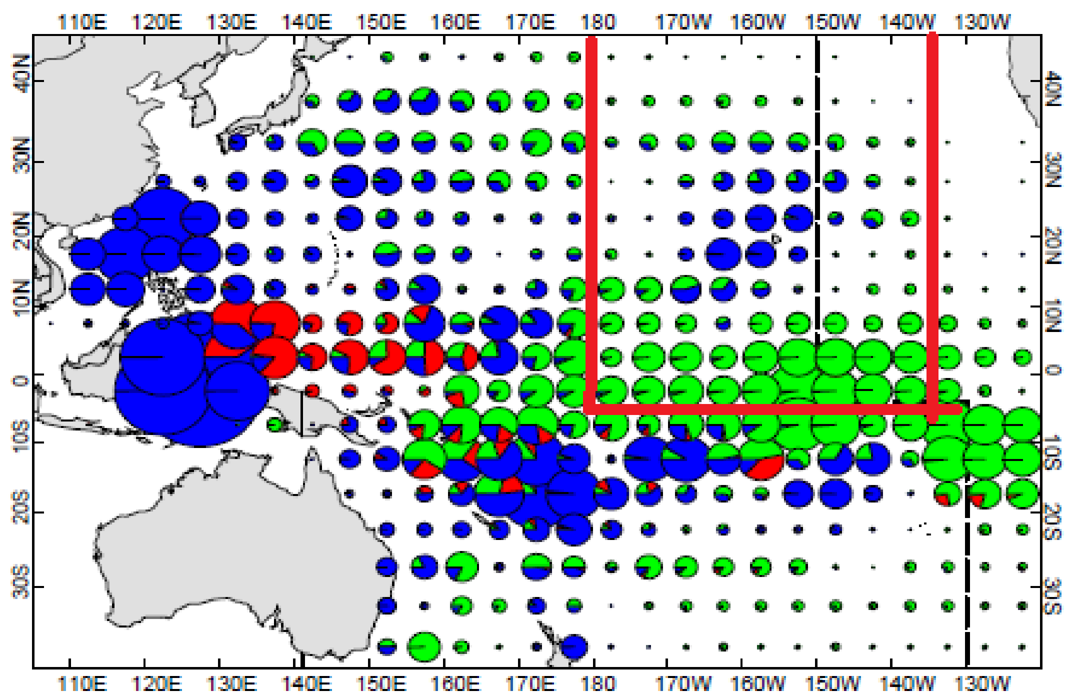

Figure 3. Distribution of longline effort of distant-water fleets (green), foreign-offshore fleets (red) and domestic fleets (blue) for the period 2000-2014 (Williams and Terawasi 2015). Action area for Hawaii Deep-set longline fishery highlighted by red rectangle.

Because of low observer coverage and inconsistent reporting from international fleets, the total number of sea turtle interactions in all Pacific longline fisheries (domestic and international) must be estimated. The deep-set longline fishery rarely catches loggerhead sea turtles. The shallow-set fishery operates further north and catches more loggerhead sea turtles than the deep-set fishery. Other longline fisheries operating in the action area, such as the Taiwan and China tuna fisheries, have bycatch rates several times higher than the Hawaii deep-set fishery (Kaneko and Bartram 2008, Chan and Pan 2012). 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 sea turtle and leatherback turtles in 2000. In the Pacific, they estimated 2,600 – 6,000 loggerhead sea turtle juvenile and adult mortalities from pelagic longlining in 2000 (Lewison et al., 2004). However, using effort data from Lewison et al., (2004) and bycatch data from Molony (2005), Beverly and Chapman (2007) estimated loggerhead sea turtle and leatherback longline bycatch to be approximately 20 percent of that estimated by Lewison et al., (2004), or 520 – 1,200 juvenile and adult loggerhead sea turtles annually. Chan and Pan (2012) estimated that there were approximately 1866 total turtle interactions in 2009 in the central and North Pacific by comparing swordfish production and turtle bycatch rates from fleets fishing in the central and North Pacific area. From this we estimate that approximately 989[3] were loggerhead sea turtle interactions and about 495 occurred in the central and North Pacific in 2009 (NMFS 2012). A similar study has not been done comparing tuna production due to the more complex nature of the international tuna fisheries. We expect that the interactions with loggerhead sea turtles and international fleets in the action area for the deep-set fishery would be lower than the shallow-set fishery because more of the effort occurs in warmer water.

For purposes of providing the environmental baseline for loggerhead sea turtles in this Supplement, NMFS estimates that longlining in the action area has killed 10 percent of the Pacific totals estimated by Beverly and Chapman (2007) and Lewison et al., (2004): 50–120 (10 percent of Beverly and Chapman’s 2007 estimate) to 260–600 (10 percent of Lewison et al., 2004 estimate), or 50-600 North Pacific juvenile and adult loggerhead sea turtles annually.

The deep-set fishery has traditionally interacted with fewer loggerhead sea turtles than the shallow-set-set fishery, although mortality rates of turtles caught by shallow-set gear is lower than in deep-set gear. The reason for the higher mortality rates in the deep-set fishery is due to the gear being at greater depths, which does not allow the turtles to reach the surface to breath. From 2005-2016 there have been six observed Loggerhead sea turtle interactions with an estimate of 43 total (NMFS 2016a). Loggerhead sea turtles are particularly susceptible to shallow-set gear and in the 1990s the Hawaii shallow-set fishery interacted with several hundred loggerhead sea turtles annually in the action area. However, the shallow-set fishery was closed in 2001 and only re-opened in 2004 after instituting measures for reducing turtle interactions. This reformation of the Hawaii shallow-set fishery, including gear modifications and reduced effort, has resulted in an approximately 97 percent reduction in the average number of loggerhead sea turtle interactions in this fishery since the 1990s (McCracken 2000, NMFS 2012). From 2005-

[3] Chan and Pan 2012 calculated that there were 1866 total turtle interactions in the Central and North Pacific in 2009. Approximately 53percent of turtle interactions in the Hawaii shallow-set fishery are with loggerheads; this percent was applied to the total number in order to estimate loggerhead sea turtle interactions (1866 * 53percent=989).

2016, turtle bycatch in Hawaii longline fisheries (shallow-set and deep-set combined[4]) within the action area is estimated to have resulted in mean annual mortality of four loggerhead sea turtles per year (NMFS 2016c).

Other Impacts

As mentioned in Section 5.2.4, and described in further detail below, climate change and marine debris may be affecting pelagic loggerhead sea turtle habitat within the action area. Lower breeding capacity of North Pacific loggerhead sea turtles in years following higher sea surface temperatures may reflect reduced ocean productivity during warmer years within the action area (Chaloupka et al., 2008a). In addition, marine debris may entangle or be ingested by turtles, leading to injury or possibly starvation, and derelict fishing gear may cause entanglement and possibly drowning. Data are not available to estimate the number of loggerhead sea turtle mortalities resulting from climate change and marine debris in the past few years in the action area.

7.2 Olive Ridley Sea Turtles

Past and present fisheries interactions have been, and continue to be, a threat to olive ridley sea turtles within the action area. Longline fishing as described above is the most important past and present impact on olive ridley sea turtles. Olive ridley sea turtles are susceptible to deep-set longlining because of their deep foraging behavior (loggerhead sea turtle interactions are rare in deep-set fishing because of shallow foraging) (Polovina et al., 2003, 2004). In the Hawaii deep-set longline fishery, the bycatch rate of olive ridley sea turtles is higher than other species (McCracken 2006, 2007, 2008, 2009a, 2009b, 2010, 2011, 2012, 2013, 2014a). In addition, mortality of bycaught olive ridley sea turtles is higher than the other sea turtle species, most likely because they are hooked in deep water and unable to reach the surface to breath. Bycatch rates in foreign deep-set fisheries (for tuna) are greater than 10 times higher than in the Hawaii deep-set fishery, and constitute much more fishing effort than the Hawaii fishery (Beverly and Chapman 2007). Thus it is likely that thousands of olive ridley mortalities occur annually in the Pacific via longlining.

Due to the abundance of this species and the amount of longlining occurring within the action area by all fleets combined, at least several hundred olive ridley mortalities are thought to have occurred annually, and are still occurring annually via longlining (most from the eastern Pacific population, but some from the western Pacific population).

From 2005-2016, turtle bycatch in Hawaii longline fisheries (shallow-set and deep-set combined[5]) within the action area is estimated to have resulted in mean annual mortality of 42

[4] The shallow-set fishery does not occur entirely in the action area. For purposes of this Supplement the two fisheries are considered to have an overlap of approximately 25 percent; therefore 25percent of the mortalities from the shallow-set fishery are added to the environmental baseline. The total number of mortalities resulting from the shallow-set fishery are discussed in the status of the species sections for all turtles.

[5] The shallow-set fishery does not occur entirely in the action area. For purposes of this Supplement the two fisheries are considered to have an overlap of approximately 25 percent; therefore 25 percent of the mortalities from the shallow-set fishery are added to the environmental baseline. The total number of mortalities resulting from the shallow-set fishery are discussed in the status of the species sections for all turtles.

olive ridley sea turtles per year (NMFS 2016c), and just about all have been from the deep-set fishery.

As mentioned in Section 6, and described in further detail below, climate change may be affecting pelagic olive ridley sea turtle habitat within the action area. Marine debris and derelict fishing gear may cause entanglement and possibly drowning. Data are not available to estimate the number of olive ridley mortalities resulting from climate change and marine debris in the past few years in the action area.

7.3 Green Sea Turtles

Past and present fisheries interactions have been, and continue to be a threat to green sea turtles within the action area. There are no estimates available for green sea turtle mortality due to longline fishing in the entire Pacific or by DPS. While few green sea turtle interactions occur in Hawaii fisheries, general turtle bycatch rates in foreign deep-set fisheries (for tuna) are 10 times higher than in the Hawaii fisheries (Bartram and Kaneko 2004), and constitute much more fishing effort than the Hawaii fisheries. Therefore it is likely that within the action area, up to several hundred juvenile green turtle mortalities occur annually by longlining. In addition, climate change and marine debris may be affecting this species in the action area.

7.3.1 East Pacific Green Sea Turtle DPS

There are no complete estimates available for the East Pacific green sea turtle DPS mortality due to longline fishing. From 2005- 2016, turtle bycatch in Hawaii longline fisheries (shallow-set and deep-set combined[6]) within the action area is estimated to have resulted in mean annual mortality of four green sea turtles per year (NMFS 2016c). The majority of these greens belong to the Eastern Pacific DPS (approximately 70%, Table 5) and therefore we expect that the non US fleets are also interacting with greens from this DPS in the action area as well with much smaller numbers from the other DPSs.

7.3.2 Central North Pacific Green Sea Turtle DPS

There are no complete estimates available for the Central North Pacific green sea turtle DPS mortality due to longline fishing. From 2005- 2016, turtle bycatch in Hawaii longline fisheries (shallow-set and deep-set combined) within the action area is estimated to have resulted in mean annual mortality of four green sea turtles per year (NMFS 2016c). Approximately 12 percent (Table 5) are from the Central North Pacific DPS. While it is possible that non-US longline fleets interact with this DPS we expect that it occurs at very low levels. Foreign fleets are prohibited from fishing within the US EEZ and due to the migratory patterns of this DPS described above we expect that interactions are less likely than they are with other DPSs of green sea turtles.

Interactions in nearshore fisheries in the main Hawaiian islands (e.g. lay gillnets, hook-and-line, etc.) sometimes result in entanglement and drowning of green sea turtles from the Central North Pacific DPS. Of the many kinds of nets used in Hawaii, gillnets are most problematic for sea

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[6] The shallow-set fishery does not occur entirely in the action area. For purposes of this Supplement the two fisheries are considered to have an overlap of approximately 25 percent; therefore 25 percent of the mortalities from the shallow-set fishery are added to the environmental baseline. The total number of mortalities resulting from the shallow-set fishery are discussed in the status of the species sections for all turtles.

turtles, because they are left untended, and entangled animals usually drown. Revised State of Hawaii regulations governing lay gillnets began in March 2007: they cannot be set after sunset, can be legally left untended in ½ hour increments, must be inspected completely every two hours, and may not be used for more than four hours during any set. However the likelihood of sea turtle entanglement and drowning still persists even if all fishers comply with State regulations. Hook-and-line fishing from shore or boats also hook or entangles green sea turtles, although the chance of survival is higher than if caught in a gillnet (Chaloupka et al., 2008b). Sea turtles drowned in fishing gear do not typically 'strand' (come ashore to die, or wash up on shore dead), so there are no estimates for the total number of green sea turtle mortalities that occur annually from non-longline fishing interactions (NMFS 2008b). Between 1982 and 2013 the most common known cause of green sea turtle standings was the tumor-forming disease, fibropapillomatosis (27 percent) with an 88 percent mortality rate of stranded afflicted turtles, followed by hook-and-line fishing gear-induced trauma (11 percent) and gillnet fishing gear-induced trauma (five percent) (PIFSC Turtle Stranding Database 2014). Since 2002, there has been a steady increase in the rate of hook and line fishing induced standings' from 20 turtles per year to over 40, ranging from 10 percent to 20 percent of reported standings' (PIFSC unpublished quarterly stranding report to PIRO).

Total annual green sea turtle mortalities from 1998-2007 in the main Hawaiian islands by boat collisions was estimated by NMFS (2008e) based on stranded sea turtle mortalities (Sb, PIFSC Turtle Stranding Database 2007). An estimate of 10 stranded sea turtle mortalities from boat collisions in the main Hawaiian Islands (see Figure 3, p. 25, NMFS 2008b) was determined to represent 20-40 percent of all annual green turtle mortalities in the main Hawaiian Islands by boat collisions, resulting in a range of 25-50 turtle mortalities per year. Thus the average number of green sea turtle mortalities per year by boat collisions from the central north Pacific DPS was estimated at 37.5 (NMFS 2008b). Between 1982 and 2013, seventy-three records of sea turtle standings' exist from Ala Moana Regional Park to Kaka'ako Waterfront Park and Kewalo Basin, which is a busy area for boaters, the location where longline boats harbor and transit to and from port, and an area with a high abundance of green sea turtles. Of stranding cases, only two strandings involved a boat collision as the determined cause of stranding (PIFSC Turtle Stranding Database 2014), which may mean that earlier estimates are exaggerated.

7.3.3 East Indian-west Pacific Green Sea Turtle DPS

There are no complete estimates available for the East Indian-west Pacific green sea turtle DPS mortality due to longline fishing. From 2005-2016, turtle bycatch in Hawaii longline fisheries (shallow-set and deep-set combined) within the action area is estimated to have resulted in mean annual mortality of four green sea turtles per year (NMFS 2016c). A small percentage of these greens belong to the East Indian-west Pacific DPS (approximately eight percent, Table 5) and therefore we expect that the non US fleets are also interacting with greens from this DPS in the action area at low numbers.

7.3.4 Southwest Pacific Green Sea Turtle DPS

There are no complete estimates available for the Southwest Pacific green sea turtle DPS mortality due to longline fishing. From 2005-2016, turtle bycatch in Hawaii longline fisheries (shallow-set and deep-set combined) within the action area is estimated to have resulted in mean annual mortality of four green sea turtles per year (NMFS 2016c). A small percentage of these greens belong to the Southwest Pacific DPS (approximately seven percent, Table 5) and therefore we expect that the non US fleets are also interacting with greens from this DPS in the action area at low numbers.

7.3.5 Central West Pacific Green Sea Turtle DPS

There are no complete estimates available for the Central West Pacific green sea turtle DPS mortality due to longline fishing. From 2005-2016, turtle bycatch in Hawaii longline fisheries (shallow-set and deep-set combined) within the action area is estimated to have resulted in mean annual mortality of four green sea turtles per year (NMFS 2016c). A small percentage of these greens belong to the Central West Pacific DPS (approximately one percent, Table 5) and therefore we expect that the non US fleets are also interacting with greens from this DPS in the action area at low numbers.

7.3.6 Central South Pacific Green Sea Turtle DPS

There are no complete estimates available for the Central South Pacific green sea turtle DPS mortality due to longline fishing. From 2005- 2016, turtle bycatch in Hawaii longline fisheries (shallow-set and deep-set combined) within the action area is estimated to have resulted in mean annual mortality of four green sea turtles per year (NMFS 2016c). A small percentage of these greens belong to the Central South Pacific DPS (approximately one percent, Table 5) and therefore we expect that the non US fleets are also interacting with greens from this DPS in the action area at low numbers.

All species: impacts associated with climate change

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 (Solomon 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 is likely beginning to affect sea turtles that occur in the action area through the impacts of rising sand temperatures, rising sea level, increased typhoon frequency, and changes in ocean temperature and chemistry.

While sea turtle hatchling 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 percent 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 sea turtle sex ratio have not been collected in the action area. Sea level rose approximately 17 cm during the 20th century (Solomon 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 (Van Houtan 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 some sea turtles, although it is difficult to distinguish impacts of climate-related stresses from other stresses that produce more prominent short term effects (Parry et al., 2007). Climate change-induced shifts in ocean productivity linked to temperature changes (Edwards and Richardson 2004, Hays et al., 2005) may affect foraging strategies and therefore reproductive capacity for sea turtles (Solow et al., 2002, Chaloupka et al., 2007, Van Houtan and Halley 2011, Van Houtan 2011), similar to what has been observed during El Nino 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, mating synchrony, and sex ratio. Recent studies have demonstrated that climate conditions influence juvenile recruitment and impact population trends in the North Pacific loggerhead sea turtle DPS, Northwest Atlantic loggerhead sea turtle DPS, western pacific leatherbacks, and Gulf of Mexico hawksbills (Van Houtan and Halley 2011, Van Houtan 2011, del Monte-Luna et al., 2012). 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 330 km 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). Similar studies on changes in migration routes for loggerhead sea turtles, leatherbacks, olive ridley sea turtles, and greens have not been done in the Pacific. Therefore, it is not possible to say with any degree of certainty whether or how their migration routes and ranges have been or are currently affected.

Attempting to determine whether recent biological trends are causally related to anthropogenic 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 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 and 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.

In summary, several factors of climate change are impacting turtle populations or may impact populations in the future. Climate variability from year to year influences juvenile recruitment and influences nesting for several populations of turtles; turtles have encountered this type of climate variability throughout their entire existence but changes in climate variability due to anthropogenic climate change is a less understood issue. There are different life stages that will be affected by different aspects of climate change, some may be positive and others negative. Since it is anticipated that changes due to increasing temperatures are expected to occur slowly over the next century, species may adapt as they have done with a variable climate throughout their existence.

8 Effects of the Action

'Effects of the action' refers to the direct and indirect effects of an action on 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 as described in Section 5 above.

The first step identifies stressors (or benefits) associated with the proposed action with regard to listed species. The second step identifies the magnitude of 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 these stressors (e.g., the mortality rate of exposed individuals; *response analysis*).

Potential Stressors. Potential stressors associated with the proposed action are listed here, and then described in more detail for each species in the following sections. The proposed action is the continued operation of the Hawaii deep-set longline fishery. The greatest stressor associated with this action on the nine listed species considered in this Supplement is interactions with fishing gear. Another potential stressor associated with the proposed action is collisions with fishing vessels. Vessels travel through areas with dense concentrations of some listed species, such as when vessels travel to and from port, passing through nearshore waters where green sea turtles occur. 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.

Exposure

In this section we determine how many species were exposed to the hooking/entanglement stressor using the data collected by observers from 2004-2016 (Table 7). We expect that other turtles were exposed to the gear but did not become hooked and/or entangled and therefore we find that to be insignificant and do not address them further. In addition it is possible for a turtle to be hooked/entangled and the observer not see it because it came off the gear before it was hauled out of the water. We expect that this occurs extremely infrequently and not at levels that will change the impacts based on observed incidents. In many instances turtles that are very lightly hooked/entangled make it onto the vessel where the gear is removed easily or falls off on its own which makes it unlikely that turtles would get off the gear on their own before being observed. We use the observed interactions to calculate the total number of turtle interactions for the entire fleet and then use this to anticipate the future level of exposure for the action described in detail for each species below.

Response

The response to stressors that can be quantified in the proposed action is the number of mortalities that can be expected to result from interactions with fishing gear from the Hawaii deep-set fishery. In some cases the turtle comes up dead making it straightforward to determine what the response to the stressor was. In some cases the turtle comes up alive and goes back into the water alive. In cases where the turtle goes back alive we use the NMFS post hooking criteria (Ryder et al., 2006) to determine the probability that the turtle will die due to their injuries. We then calculate a mortality rate to apply to future interactions from the proposed action. If animals are not killed, they may still suffer from unknown residual impacts due to the stress of the encounter that may have physiological or behavioral effects on the animal which could impact growth and reproduction. These sublethal effects are not possible to determine at this time due to the difficulties in detecting effects in the long term after an interaction. In addition many of the turtles that are caught in the longline fishery are juveniles or subadults with high natural mortality rates making it difficult to discern natural mortality from mortality due to the interaction even if the technology was capable of long term monitoring after an interaction. Due to the very limited information we have on sublethal effects, the focus of this Supplement will be on lethal effects to individuals and what that impact will be to the affected populations.

Table 7. Table showing number of observed interactions with loggerhead, olive ridley, and green sea turtles (data not available by DPS or listed population). Total caught estimated by McCracken where available (McCracken 2009a, 2009b, 2011, 2012, 2013, 2014). Expansion factor is used for years when estimates are not yet available by McCracken, which are 2015 and 2016. Observed take by year is based on vessel arrival date, which is consistent with the PIRO Observer Program Annual Status Reports.

Year	**Loggerhead sea turtles**		**Olive ridley sea turtles**		**Greens**		**Unknown Hardshell**
	Obs	Est	Obs	Est	Obs	Est	Obs
2004	0	0	13	45	1	4	0
2005	0	0	4	17	0	0	0
2006	0	0	11	55	2	6	0
2007	1	6	7	26	0	0	0
2008	0	0	3	17	0	0	0
2009	0	0	4	18	0	0	0
2010	1	6	4	10	1	1	0
2011	0	0	7	36	1	5	0
2012	0	0	6	34	0	0	0
2013	2	11	9	44	1	5	0
2014	0	0	8	39	3	15	0
2015	2	10	13	64	1	5	0
2016*	2	9	25	121	1	5	1
Total	**8**	**42**	**114**	**526**	**11**	**46**	**1**

*Interactions are up to June 30, 2016.

In 2016 an observer reported an interaction with an unidentified hardshell turtle. Since the turtle could not be identified we assigned a percentage to each hardshell species based on the proportion of each species that has been sampled in the fishery and applying the Wilson 'score method' to account for error. The Wilson score method uses the following formulae to calculate confidence intervals:

$$\text{Lower CI} = \frac{2np + z^2 - z \cdot \sqrt{(z^2 + (4 \cdot n \cdot p \cdot q)}}{2(n + z^2)} \qquad \text{Upper CI} = \frac{2np + z^2 + z \cdot \sqrt{(z^2 + (4 \cdot n \cdot p \cdot q)}}{2(n + z^2)}$$

Where: n = sample size; p = simple proportion (r/n); z = the standard deviation of a standard normal distribution (that is, the z-score), for the 95 percent confidence interval, z = 1.96; and q = 1 – p. The results of these calculations are presented in Tables 8 & 9. The upper 95 percent confidence interval (Table 9) was the amount added to each species observed in 2016 (see Tables 10-12).

Table 8. Estimated proportions of the different species of turtles captured in the deep-set longline fishery using observer data up through 2016.

Species	Original Data			Proportions		Confidence Interval for Proportions	
	Number of Individuals Assigned to Species	Number of Individuals Not Assigned to Species	Sample Size	p (Species Proportion)	1 – p (not Species)	Wilson LCI (Species)	Wilson UCI (Species)
Olive Ridley	114	19	133	0.86	0.14	0.7876	0.9066
Green	11	122	133	0.08	0.92	0.0468	0.1420
Loggerhead	8	126	133	0.06	0.94	0.0306	0.1142

Table 9. Allocation of one unidentified hardshell turtle based on the mean proportions and lower and upper confidence intervals from Table 8.

Allocation of interaction	1		
Species	Mean Estimate	Lower 95 percent Confidence Interval	Upper 95 percent Confidence Interval
Olive Ridley	0.86	0.79	0.91
Green	0.08	0.05	0.14
Loggerhead	0.06	0.03	0.11

8.1 North Pacific Loggerhead Sea Turtle DPS

Stressors, exposure, response and risk steps of the effects analysis for loggerhead sea turtles with regard to implementation of the proposed action are described below. Loggerhead sea turtles directly affected by interactions resulting from the proposed action are from the North Pacific Ocean DPS. Direct and indirect effects of the action on this DPS are related to the base condition of the DPS in the Integration and Synthesis of Effects (Section 10).

Stressors

Longline fishing affects loggerhead sea turtles primarily by hooking, but also by entanglement and trailing of gear that remains attached to an animal. Deep-set longlining is done during the day and loggerhead sea turtles generally feed at shallower depths than the gear is fished which makes them less susceptible to deep-set gear than shallow-set longline gear. Hooking may be external, generally in the flippers, head, beak, mouth, or internal, when the animal has attempted to forage on the bait, and the hook is ingested. When a hook is ingested, the process of movement, either by the turtle's attempt to get free of the hook or by being hauled in by the vessel, can traumatize the turtle by piercing the esophagus, stomach, or other organs, or by pulling organs from their connective tissue. Once the hook is set and pierces an organ, infection may ensue, which may result in death of the animal. If a hook does not become lodged or pierce an organ, it can pass through to the colon, and be expelled (NMFS 2004a, 2005a, 2008a).

Loggerhead sea turtles also become entangled in fishing gear but not as frequently as becoming hooked (NMFS 2016a, b). Entanglement in monofilament line (mainline or branchline) or polypropylene (float line) can result in substantial wounds, including cuts, constriction, or bleeding on any body part. In addition, entanglement can directly or indirectly interfere with mobility, causing impairment in feeding, breeding, or migration. 'Trailing line' refers to line that is left on a turtle after it has been incidentally caught and released, particularly line trailing from a hook. Turtles may swallow line trailing from a hook, which may block the gastrointestinal tract and cause other serious injuries. Trailing line can also become snagged on a floating or fixed object, entangling or further entangling the turtle, or the drag can cause the line to constrict around a turtle's appendage until the line cuts through it (NMFS 2004, 2005a, 2008a).

Exposure

Loggerhead sea turtles are expected to be exposed to interactions directly caused by the proposed action due to hooking and entanglement by fishing gear deployed by the Hawaii deep-set longline fishery. This exposure can be quantified as the expected annual number of interactions. The proposed action would result in approximately 1,305 trips, and 18,592 sets with 46,117,532 hooks annually. Based on analysis of interactions that occurred between 2008-June 30, 2016, (this time frame was selected because it had the most consistent systematic sampling of observer coverage at 15 percent for each quarter), NMFS expects up to six loggerhead sea turtle interactions annually (Table 10). The level of loggerhead sea turtle exposure to the direct effects of the proposed action is six loggerhead sea turtle interactions annually.

Table 10. Table showing number of observed interactions with loggerhead sea, total caught estimated by McCracken where available (McCracken 2009a, 2009b, 2011, 2012, 2013, 2014), total estimate using expansion factor, and interaction rate. Expansion factor is used for years when estimates are not yet available by McCracken. Observed take by year is based on vessel arrival date, which is consistent with the PIRO Observer Program Annual Status Reports.

Year	Observed	Estimated McCracken	percent Observer Coverage	Expansion Factor[a]	Estimated Interactions[b]	Total Hooks	Interaction Rate (Turtles per 1,000 hooks)
2008	0	0	-	-	NA	40,083,935	0
2009	0	0	-	-	NA	37,770,913	0
2010	1	6	-	-	NA	37,197,582	0.0001613
2011	0	0	-	-	NA	40,719,827	0.0000000
2012	0	0	-	-	NA	43,965,781	0.0000000
2013	2	11	-	-	NA	46,919,110	0.0002344
2014	0	NA	20.80	4.81	0	45,646,747	0.0000000
2015	2	NA	20.60	4.85	10	9,393,234	0.0002129
2016[c]	2.11	NA	21.40	4.67	10	4,968,300	0.0004254
	Sum of the interaction rate per 1000hks / 8.5 = 0.00012						
Future	46,117,532*0.00012/1000= 5.61 annually						

[a] 100/ observer coverage. For example, for 2014, 100/20.80 = 4.81.

[b] (Observed interactions) x (Expansion factor). For example, for 2015, 2(4.85) = 10 (9.7).

[c] For 2016: Used total observed hooks from the Pacific Islands Regional Observer Program deep-set quarterly status report, Q1 and Q2 2016. The two turtles were observed in Quarter 1. The number of observed turtles includes the portion of the unidentified turtle calculated above in Table 9 based on the upper 95 percent CI.

Response

The response to stressors that can be quantified in the proposed action is the number of mortalities that can be expected to result from interactions with fishing gear from the Hawaii deep-set fishery. Loggerhead sea turtle response to the predicted exposure (six interactions annually) from the proposed action can be converted to the annual number of estimated mortalities resulting from this exposure. Since there are so few observed interactions in the deep-set fishery with loggerhead sea turtles and there have been no major gear modifications to the fishery that are known to impact sea turtles, all historic interactions were used to calculate the post-hooking mortality rate. There have been 12 loggerhead sea turtle interactions observed in the deep-set fishery from 1994 through 2016 and based on NMFS’ post-hooking mortality criteria (Ryder et al., 2006), post-hooking mortality of loggerhead sea turtles in this fishery is 73.4 percent (NMFS 2016a). Using this post-hooking mortality rate, six interactions annually would lead to 4.40, (round to five) loggerhead sea turtle mortalities. However, in order to estimate the risk that the proposed action poses to the North Pacific loggerhead sea turtle DPS, an analysis was done by NMFS (Jones and Martin 2016) to determine the number of adult females removed from the DPS. Adult females are the only component of the DPS for which data are available, from counts of adult females on nesting beaches. The response to the population from six interactions must be quantified in terms of adult females in order to interpret the population assessment. As explained below, six loggerhead sea turtle interactions equate to an estimate of 0.31 adult females annually, which equates to one adult female mortality every 3.26 years (Jones and Martin 2016).

The deep-set fishery interacts with male and female loggerhead sea turtles, and most of these are juveniles that already experience reduced survivorship rates to adulthood based on environmental factors unrelated to the proposed action. In order to estimate the number of adult female mortalities that would occur if there were three interactions, two adjustments must be applied to the calculation above: (1) the proportion of females in the adult population; and (2) the adult equivalent represented by each juvenile interaction. These adjustments are described in greater detail below.

The proportion of females in the adult population.
We assume the sex ratio of the North Pacific loggerhead sea turtle population is 50:50 (Conant et al., 2009, Van Houtan 2013, Jones and Martin 2016). Therefore, we estimate that approximately half of animals incidentally caught are females.

The adult equivalent represented by each juvenile interaction.
Vaughan (2009) estimated the relationship between age and size (SCL) for loggerhead sea turtles in the North Atlantic. Assuming similar loggerhead sea turtle growth in the North Pacific, the Hawaii deep-set fishery described under the proposed action would be expected to interact most frequently with juvenile loggerhead sea turtles (Van Houtan 2013). Age at first reproduction (maturity) for this DPS is estimated at 25 years (Van Houtan and Halley 2011, Todd and Martin 2016). NMFS applied a conversion formula to determine the annual effect of the action on adult females. In order to estimate adult equivalents that will be affected by the action, survival rates (Snover 2002) were applied to three distinct life stages that would occur before the age at first reproduction estimate of 25 years. The three survival rates applied to convert juveniles to adults were 0.81, 0.79, and 0.88 (Snover 2002; Van Houtan 2011, 2013, Jones and Martin 2016). Five juvenile mortalities results in the annual removal of the equivalent of 0.31 adult females which is analogous to incurring a single adult female mortality every 3.26 years for loggerhead sea turtles (Jones and Martin 2016).

Risk

The response of loggerhead sea turtles to interactions with gear deployed by the Hawaii deep-set fishery is considered to be the mortality of 0.31 adult females annually or one adult female every 3.26 years. The risk posed by this level of mortality to the North Pacific loggerhead sea turtle population was assessed by Jones and Martin (2016) for application to this Supplement. This represents 0.00345 percent of the nesting population, which is not significant to the population. We considered re-running the PVA models (climate forcing and classical models) that were used in the NMFS 2012 Opinion to assess population level impacts but due to the very small level of take of ANE we determined that it was unnecessary. In that Opinion we analyzed the impact of one adult female mortality annually for the population level impacts from the shallow-set action, which was rounded up from 0.31 adult females. That model, along with the classical model showed that the mortality of one adult female on an annual basis is not a detectable loss to the population, and was not likely to appreciably reduce the likelihood of the species' survival and recovery. By rounding the adult female mortality to one annually the model fully accounted for the additional loss of 0.31 adult females annually from the deep-set fishery. Therefore we determined that running the models again for this action would not provide us any additional information to assess the population level impacts.

8.2 Olive Ridley Sea 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.

Stressors

Longline fishing affects olive ridley sea turtles primarily by hooking, but also by entanglement and trailing of gear. Olive ridley sea turtles are the most commonly-caught sea turtle species in the Hawaii deep-set longline fishery (NMFS 2014a), which fishes between 40 and 350 m of depth, and rarely interact with shallow-set gear, most likely because of a combination of deep-foraging and low density in temperate waters where fishing for swordfish occurs.

Exposure

Olive ridley sea turtles are expected to be exposed to interactions directly caused by the proposed action, due to hooking and entanglement by fishing gear deployed by the Hawaii deep-set longline fishery. This exposure can be quantified as the expected annual number of interactions. The proposed action would result in approximately 1,305 trips, 18,592 sets with 46,117,532 hooks annually. Based on the number of olive ridley sea turtle interactions that occurred between 2008-June 30, 2016 (this time frame was selected because it had the most consistent systematic sampling of observer coverage at 15 percent for each quarter), NMFS expects up to 61 olive ridley interactions annually (Table 11 presents the aggregate estimate for the biological species, i.e., all listed olive ridley populations). Therefore, olive ridley sea turtle exposure to the effects of the proposed action is considered to be 61 interactions annually.

Table 11. Table showing number of observed interactions with olive ridley sea turtles, total caught estimated by McCracken where available (McCracken 2009a, 2009b, 2011, 2012, 2013, 2014), total estimate using expansion factor, and interaction rate. Expansion factor is used for years when estimates are not yet available by McCracken. Observed take by year is based on vessel arrival date, which is consistent with the PIRO Observer Program Annual Status Reports. Observed interactions are aggregated according to the biological species (the combination of all listed olive ridley sea turtles considered in Table 1), and are not proportioned according to the listed species (or population) effected.

Year	Observed	Estimated McCracken	percent Observer Coverage	Expansion Factor[a]	Estimated Interactions[b]	Total Hooks	Interaction Rate (Turtles per 1,000 hooks)
2008	3	18	-	-	NA	40,083,935	0.0004491
2009	4	18	-	-	NA	37,770,913	0.0004766
2010	4	10	-	-	NA	37,197,582	0.0002688
2011	7	36	-	-	NA	40,719,827	0.0008841
2012	6	34	-	-	NA	43,965,781	0.0007733
2013	9	42	-	-	NA	46,919,110	0.0009700
2014	8	NA	20.80	4.81	38	45,646,747	0.0008326
2015	13	NA	20.60	4.85	63	9,393,234	0.0013840
2016[c]	Q1 13.91 Q2 12	NA	21.4 19.77	4.67 5.05	126	4,968,300	0.0052145
	Sum of the interaction rate per 1000hks / 8.5 = 0.0013239						
Future	46,117,532*0.0013239/1000= 61.05						

[a] 100/ observer coverage. For example, for 2014, 100/20.80 = 4.81.

[b] (Observed interactions) x (Expansion factor). For example, for 2015, 13(4.85) = 63 (63.05).

[c]For 2016: Used total observed hooks from the Pacific Islands Regional Observer Program deep-set quarterly status report, Q1 and Q2 2016. The 13 turtles were observed in Quarter 1 and 12 in quarter 2. The number of observed turtles includes the portion of the unidentified turtle in quarter 1, calculated above in Table 9 based on the upper 95 percent CI. Quarters were calculated separately due to the difference in observer coverage between the two quarters and added together to get 126.

The deep-set fishery interacts with male and female olive ridley sea turtles at various life stages. In order to estimate the number of adult female mortalities that would occur if there were 61 interactions, two adjustments must be applied to the calculation above: (1) the proportion of females in the adult population; and (2) the adult equivalent represented by each juvenile interaction. These adjustments are described in greater detail below.

The proportion of females in the adult population.

We assume the sex ratio of the olive ridley populations are 50:50 (Van Houtan 2015, Jones and Martin 2016). Therefore, we estimate that approximately half of animals incidentally caught are females.

The adult equivalent represented by each interaction.

The ANE calculations for both populations incorporated several biological parameter estimates. We used an annual survival rate for juveniles of 0.85 (Van Houtan 2011), a growth rate of two cm per year (derived from Zug et al., 2006), and size at maturity of 63.33 cm and age at maturity of 19.5 years (Jones and Martin 2016).

Response

Olive ridley sea turtle response to predicted exposure (61 interactions annually) can be characterized as the annual number of mortalities estimated to result from this exposure. For the 139 olive ridley sea turtle interactions observed in the deep-set fishery from 1994 through 2016, based on NMFS' post-hooking mortality criteria (Ryder et al., 2006), post-hooking mortality of olive ridley sea turtles in this fishery is 95.0 percent (NMFS 2016a). Using this post-hooking mortality rate, 61 interactions annually would lead to 58 olive ridley sea turtle mortalities (either sex, all ages).

Risk

As shown by genetic samples of olive ridley sea turtles from the deep-set fishery, individuals may come from either the eastern or western Pacific populations (NMFS 2014a). As described previously we cannot determine the number of individuals that come from the endangered Mexico population versus the ones that come from the threatened sub-population in the eastern Pacific. Therefore we applied a precautionary approach and estimated that all of the olive ridley sea turtles could be from either portion and assessed the maximum risk to each. We estimate 77 percent of the take occurs from the eastern Pacific population (both endangered and threatened sub-population) and 23 percent from the Western Pacific (NMFS 2014a). Since we estimate a total of 58 olive ridley sea turtles will be killed annually by the proposed action, and 77 percent will be from the eastern Pacific population, we expect 45 (58*77 percent=44.66) turtles from the eastern Pacific population (endangered or threatened) to be killed every year, and 13(58*23 percent=13.34) olive ridley sea turtles from the western Pacific population to be killed every year.

The response of western pacific olive ridley sea turtles to interactions with gear deployed by the Hawaii deep-set fishery is considered to be the mortality of 3.96 adult females annually. The risk posed by this level of mortality to the western pacific olive ridley sea turtle population was assessed by Jones and Martin (2016) for application to this Supplement. This represents 0.00193 percent of the nesting population, which is not significant to the population (Jones and Martin 2016).

The response of eastern pacific olive ridley sea turtles to interactions with gear deployed by the Hawaii deep-set fishery is considered to be the mortality of 13.27 adult females annually. Since we cannot determine which are from the endangered Mexico population or the threatened central American population we assess the total amount to each population which is 13.27 adult females annually. The risk posed by this level of mortality to the endangered Mexico olive ridley population was assessed by Jones and Martin (2016) for application to this Supplement. This represents 0.00133 percent of the nesting population, which is estimated to have over one million nesters. This is not considered significant to the population (Jones and Martin 2016). The threatened portion of the eastern Pacific sub-population also has over a million nesters, so we used the same numbers that were used for the endangered population by Jones and Martin; 13.27 adult females represents 0.00133 percent of this nesting population, which is not considered significant.

8.3 Green Sea Turtles

The stressors, exposure, response, and risk steps of the effects analysis for green sea turtles with regard to implementation of the proposed action are described below. We calculated the total number of green sea turtles interactions (Table 12) and then determined the proportion of turtles to assign to each DPS (Tables 13 & 14). We adopted this method because of the very small sample size of green sea turtles and the uncertainty surrounding the DPS determinations with genetics.

Stressors

Longline fishing affects green sea turtles primarily by hooking, but also by entanglement and trailing of gear. Historically, the longline fishery has been more likely to hook green sea turtles externally than to entangle them or hook them internally. Juvenile and adult interactions both occur (NMFS 2005). In addition, because green sea turtles from the Central North Pacific DPS recruit to nearshore habitat in the main Hawaiian Islands, and are common in shallow main Hawaiian Islands waters, fishing vessels traveling to and from port may strike a green sea turtle during transit (NMFS 2008b).

Exposure

Green sea turtle interactions in the deep-set fishery are rare, unpredictable events. Since 2004, there have been 11 observed interactions with green sea turtles in the deep-set fishery. Based on the number of observed interactions between 2008 and 2016, NMFS estimates that there could be up to five interactions with green sea turtles annually if the Hawaii deep-set fleet were to make approximately 1,305 trips, with 18,592 sets and 46,117,532 hooks annually (Table 12).

Table 12. Table showing number of observed interactions with green sea turtles, total caught estimated by McCracken where available (McCracken 2009a, 2009b, 2011, 2012, 2013, 2014), total estimate using expansion factor, and interaction rate. Observed take by year is based on vessel arrival date, which is consistent with the PIRO Observer Program Annual Status Reports. Observed interactions are aggregated according to the biological species (the combination of all listed green sea turtles considered in Table 1), and are not proportioned according to the listed species (or DPS) effected.

Year	Observed	Estimated McCracken	percent Observer Coverage	Expansion Factor[a]	Estimated Interactions[b]	Total Hooks	Interaction Rate (Turtles per 1,000 hooks)
2008	0	0	-	-	NA	40,083,935	0
2009	0	0	-	-	NA	37,770,913	0
2010	1	1	-	-	NA	37,197,582	0.0000269
2011	1	5	-	-	NA	40,719,827	0.0001228
2012	0	0	-	-	NA	43,965,781	0
2013	1	5	-	-	NA	46,919,110	0.0001078
2014	3 [c]	NA	20.80	4.81	14	45,646,747	0.0003122
2015	1	NA	20.60	4.85	5	9,393,234	0.0001065
2016[d]	1.14	NA	21.40	4.67	6	4,968,300	0.0002297
	Sum of the interaction rate per 1000hks / 8.5 = 0.0001066						
Future	46,117,532*0.0001066/1000= 4.91						

[a] 100/ observer coverage. For example, for 2014, 100/20.80 = 4.81

[b] (Observed interactions) x (Expansion factor). For example, for 2015, 1(4.85) = 5 (4.85).

[c] A NMFS observer documented an interaction with a green sea turtle on December 28, 2013. This vessel did not return to port until 2014, so this take is counted against the 2014 total and not included in the 2013 McCracken estimate.

[d] For 2016: Used total observed hooks from the Pacific Islands Regional Observer Program deep-set quarterly status report, Q1 and Q2 2016. The number of observed turtles includes the portion of the unidentified turtle calculated above in Table 9 based on the upper 95 percent CI.

Because we cannot determine the DPS a green sea turtle belongs to during the time of an interaction, our analysis provides an estimate of the number of interactions with each DPS. Specifically, we estimate the proportion of all six DPSs of green sea turtles whose pelagic distribution overlaps with the deep-set fishery in the Pacific. Because available data on green sea turtle interactions is limited to 14 samples, which is a very small sample size, we are concerned about the low predictive power of our data. Specifically, the margin of error has an inverse relationship with sample size, and the low statistical power negatively effects the chance of predicting an effect. To overcome this challenge, we estimated confidence intervals to capture the uncertainty associated with proportions based on such a small sample size; and calculated confidence intervals using methods that do not produce zero-width intervals.

Proportions represent the number of desired outcomes (denoted “r”) out of a sample of size “n.” When r = 0.0, the Wald method that is traditionally used to calculate confidence intervals for proportions (Vollset 1993, Newcombe 1998) produces a confidence interval from 0.0 to 0.0 and when r = n, the Wald method produces a confidence interval from 1.0 to 1.0. These are called zero-width intervals and are computational errors: when r = 0.0, the lower confidence interval would be 0.0, but the upper confidence interval should be a non-zero value. When r = n, the upper confidence interval would be 1.0, but the lower confidence interval would be less than 1.0. Several alternatives to the Wald method correct this error (Wilson 1927, Newcombe 1998, Newcombe and Altman 2000). Of these, the Wilson 'score' method (from Wilson 1927) using asymptotic variance [θ(1 - θ)/n] with no continuity correction is easily executed using spreadsheet software available to most biologists and produces results that are comparable to the most robust alternative (Newcombe 1998, Newcombe and Altman 2000).

The Wilson score method uses the following formulae to calculate confidence intervals:

$$\text{Lower CI} = \frac{2np + z^2 - z \cdot \sqrt{(z^2 + (4 \cdot n \cdot p \cdot q)}}{2(n + z^2)} \qquad \text{Upper CI} = \frac{2np + z^2 + z \cdot \sqrt{(z^2 + (4 \cdot n \cdot p \cdot q)}}{2(n + z^2)}$$

Where: n = sample size; p = simple proportion (r/n); z = the standard deviation of a standard normal distribution (that is, the z-score), for the 95 percent confidence interval, z = 1.96; and q = 1 – p.

The results of these calculations are presented in Table 13. The upper and lower confidence intervals associated with the Central West and Central South Pacific green sea turtles reveal the benefits of using this method. Neither of these species were represented in the genetic samples; however, because the number of genetic samples is small (n = 14), there is uncertainty in the proportions estimated from these samples. The 95 percent confidence intervals that capture this uncertainty suggest that if a large number of additional genetic samples were collected, Central South Pacific or Central West Pacific green sea turtles would occur in up to 21.53 percent of those samples. We can also interpret these proportions as probabilities: the probability of interacting with 1.0 green turtle representing the Central South or Central West Pacific green turtle species in the future is as high as 21.53 percent (Tables 13).

Table 13. Estimated proportions of the different DPS of green sea turtles based on genetics data.

Species (= DPS)	Original Data			Proportions		Confidence Interval for Proportions	
	Number of Individuals Assigned to Species	Number of Individuals Not Assigned to Species	Sample Size	p (Species Proportion)	1 – p (not Species)	Wilson LCI (Species)	Wilson UCI (Species)
East Pacific	10	4	14	0.71	0.29	0.4535	0.8828
Central North Pacific	2	12	14	0.14	0.86	0.0401	0.3994
East Indian-West Pacific	1	13	14	0.07	0.93	0.0127	0.3147
Southwest Pacific	1	13	14	0.07	0.93	0.0127	0.3147
Central West Pacific	0	14	14	0.00	1.00	0.0000	0.2153
Central South Pacific	0	14	14	0.00	1.00	0.0000	0.2153

Table 14. Allocation of interactions of five green sea turtles to the different species of green sea turtles DPSs based on the mean proportions and lower and upper confidence intervals from Table 12.

Allocation of interaction	**5**		
Species	**Mean Estimate**	**Lower 95 percent Confidence Interval**	**Upper 95 percent Confidence Interval**
East Pacific	4	2	4
Central North Pacific	1	0	2
East Indian-West Pacific	0	0	2
Southwest Pacific	0	0	2
Central West Pacific	0	0	1
Central South Pacific	0	0	1

After determining the proportions for each DPS in Table 12, we then allocated the anticipated interactions of five green sea turtles annually to each of the six DPS using the 95 percent confidence interval and rounding to the nearest whole number to calculate the anticipated level of take for each green sea turtle DPS (Table 14).

The proposed action may also affect green sea turtles from the Central North Pacific DPS due to collisions with boats in nearshore waters around the main Hawaiian islands. The proposed action is expected to result in approximately 1305 trips per year. The number of green turtles likely to be killed due to boat collisions from the Hawaii bottomfish fishery was estimated in a March 18, 2008, Opinion (NMFS 2008b). Using the 6-step methodology in the HI bottomfish Opinion (Figure 3, p.25), and substituting 1305 trips per year for the 71,800 bottomfishing trips per year, then completing Steps 3 and 4, the number of annual green turtle mortalities estimated to result from boat collisions from deep-set longline boats is effectively zero (0.08).

Response

For seventeen green interactions observed in the deep-set fishery from 1998 through 2016 based on NMFS' post-hooking mortality criteria (Ryder et al., 2006), post-hooking mortality of greens in this fishery was 94.1 percent (NMFS 2016a). We apply this rate to each of the green sea turtle DPSs to determine the response shown in Table 15.

Table 15. Number of interactions, mortalities, and ANE mortalities annually for each green sea turtle DPS.

Green Turtle DPS	Annual Interactions	Mortality rate	Response (#mortalitites annually)	ANE
East Pacific DPS	4	0.941	4 (3.764)	0.054
Central North Pacific DPS	2	0.941	2(1.882+0.08)*	0.027
East Indian-west Pacific DPS	2	0.941	2(1.882)	0.027
Southwest Pacific DPS	2	0.941	2(1.882)	0.027
Central West Pacific DPS	1	0.941	1(0.941)	0.013
Central South Pacific DPS	1	0.941	1(0.941)	0.013

*The number of anticipated vessel collision mortalities from longline vessels was added to the fishing gear mortality to determine total response level.

To determine the population-level (also green sea turtle DPS) effects from the proposed action, we use annual survival rates of various turtle life stages to estimate the number of turtles that are predicted to die from the action that would otherwise be expected to reach breeding age (ANEs). Once we have calculated the ANEs using this discounting method, we compare the number of ANEs to the total number of breeding feamals in each population or DPS. The number of mortalities shown in Table 15 are all ages and either sex.

In order to calculate the impact to each DPS the ANE was calculated for each of the six DPSs. In order to calculate the ANE from the sizes of the sea turtles captured historically in the fishery, Jones and Martin used an annual survival rate for juveniles of 0.812 (Seminoff et al., 2015), age at maturity of 22.5 years (Van Houtan et al., 2014), and growth curve based on parameter estimates from Van Houtan et al., (2014). The proportion of females in the population is 0.514 (Jones and Martin 2016).

Risk

Table 16 contains the the predicted annual mortality, according to annual nester equivalent, for each green sea turtle DPS effected by the Hawaii deep-set fishery. Jones and Martin (2016) compared the ANE to the total nester abundance to determine the risk of the fishery to the DPS. Based on their analysis, Jones and Martin (2016) determined that at the proposed interaction levels it would take at least 18.62 years to kill the equivalent of one adult female in the East Pacific DPS and much longer for the remaining DPSs. The risk to each DPS was low because it affected such a small proportion of the nesting population of each DPS (Table 16) (Jones and Martin 2016).

Table 16. Total estimated annual effect of adult mortalities to each DPS.

Green Turtle DPS	ANE	Nester abundance	Proportion of nesting population	Years to adult female mortality
East Pacific DPS	0.054	20,000	0.0000027	18.62
Central North Pacific DPS	0.027	3,800	0.0000071	37.25
East Indian-west Pacific DPS	0.027	77,000	0.0000003	37.25
Southwest Pacific DPS	0.027	83,000	0.0000003	37.25
Central West Pacific DPS	0.013	6,500	0.0000021	74.49
Central South Pacific DPS	0.013	2,600	0.0000052	74.49

9 Cumulative Effects

The Opinion also considers whether the proposed action, taken together with cumulative effects, is likely to jeopardize the species, or adversely modify or destroy critical habitat. 50 CFR 402.14(g). "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 Supplement (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 North Pacific Ocean (see Figure 1) 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 nine species addressed by this Supplement are likely to occur as a result of climate change, and any increase in fishing from Hawaii state fisheries or international fisheries, ship traffic, and other actions described in the Environmental Baseline section. Such effects could include worsening of the climate change effects and also could result in corresponding increases in fishing gear entanglements and vessel strikes of the nine turtle species. In addition, any increases in marine debris could also increase entanglements or ingestion in all eight species.

Hawaii state and international fisheries that occur in the action area are expected to continue and therefore may impact turtles and their habitat in the future. The future effort level of these fisheries in the action area may vary considerably, although NMFS has no information to suggest that impacts to protected species will materially change from historic levels.

Global anthropogenic climate change is expected to continue and to therefore continue to impact sea turtles and their habitats. Rising temperatures at nesting beaches may continue to exacerbate a female bias in hatchling sex ratio 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, Hays et al., 2003, Pike 2013). In addition the number of severe storms is expected to increase with warming ocean temperatures which is expected to change the shape of nesting beaches and to wipe out nests. This has been documented in the Atlantic; comparisons were made between loggerhead and green sea turtle nesting and cyclone intensity and they found that hatching success declines with increased cyclone intensity (Van Houtan and Bass 2007). 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/year shows that 86 percent of islands remained stable or increased in area while only 14 percent of study islands exhibited a net reduction in island area (Webb and Kench 2010, Van Houtan 2010), evidence that changes will not be uniform or predictable and sea level rise may or may not result in nesting 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).

Recent studies have shown that several sea turtle populations are correlated with climate variability over long periods of time (Van Houtan and Halley 2010, del Monte-Luna et al., 2012). The PDO and the Atlantic Multidecadal Oscillation (AMO) reflect atmospheric circulation patterns that regulate oceanographic processes and ecosystem productivity. The greatest influence appears to occur early on in a hatchling's life, when "climate is the parent," and there is high or low productivity (Van Houtan and Halley 2010). Years of high productivity are correlated later in time (when they reach maturity) with higher levels of nesters appearing at beaches, and low productivity years with the opposite for loggerhead sea turtles in both the Atlantic and the Pacific (Van Houtan and Halley 2010). Another component of this study is the climate influence on nesting females, where SST temperatures have been shown to influence breeding remigration, as mentioned earlier.

Although there is much speculation about 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 1998). 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 observations, and arbitrary selection, speculation, or hypothesis (see review in Smit et al., 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 these species 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 Supplement.

10 Integration and Synthesis of Effects

The purpose of this Supplement is to determine if the proposed action reasonably can be expected, directly or indirectly, to appreciably reduce the likelihood of both survival and recovery of endangered and threatened sea turtles in the wild by reducing their reproduction, numbers, or distribution (50 CFR 402.02), otherwise known as the jeopardy determination. This is done by considering the effects of the action together with the 'Status of Listed Species' together with the 'Environmental Baseline' and the 'Cumulative Effects', as described in the Approach section. We determine if mortality of individuals of listed species resulting from the proposed action is 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 a population's base condition (established in the Status of Listed Species and Environmental Baseline sections of this Supplement) as context for the overall effects of the action on affected populations. Finally, our Opinion determines if changes in population viability, based on the Effects of the Action and the Cumulative Effects, are likely to be sufficient to reduce viability of the species those populations comprise. The following discussions summarize the probable risks the proposed action poses to the nine listed species addressed by this Supplement.

10.1 **North Pacific Loggerhead Sea Turtle DPS**

As discussed in the loggerhead sea turtle section of the Status of Listed Species (Section 6.1), nesting of North Pacific loggerhead sea turtles in Japan has been variable over time, but has steadily increased from 1999-2013 (NMFS 2011, STAJ 2012). In 2013, the number of nests laid was the highest on record, with 15,396 nests laid (excluding Yakushima Island which has typically represented 40 percent of nesting activity) (Y. Matsuzawa pers comm.) since comprehensive counts were started in the 1980s. Nesting activity, declined in 2014 to less than

10,000 nests, and again in 2015 with less than 5,000 nests laid. While nesting trends do not necessarily reflect overall population status (NRC 2010), the nesting trend data from Japan are currently the best available information on the status of the North Pacific DPS. The increase from approximately 2,000 nests (representing approximately 500 nesting females) in 1999, to 6,500 – 14,632 nests (representing approximately 3,600 nesting females) in 2012 demonstrates that the population trend may not directly correlate with fishing mortality rates because large numbers of sea turtles were caught before, during, and after this time period as described in section 6. Surveys in Japan indicated a greater than three-fold (linear scale) increase from 2007–2008. While a purely demographic model could not reproduce this trend, the climate-based model that combines the PDO and winter SST, better captures this dramatic increase emphasizing the potential importance (forcing) of climate on this population (Van Houtan and Halley 2011; Van Houtan 2011). The climate forcing model also predicted a decline which is what has occurred over the last couple of seasons.

As discussed in the loggerhead sea turtle section of the Environmental Baseline (Section 7.1), 50-600 juvenile and adult North Pacific loggerhead sea turtle mortalities may be occurring annually due to longline fishery interactions from all vessels within the action area Thus, total fishery-related mortality of the North Pacific loggerhead sea turtle population due to longline fishing, nearshore fishing in Japan, and other fisheries, is likely over several hundred annually.

As described in the loggerhead sea turtle section of the Effects of the Action (Section 8.1), our analysis assumes that the proposed action will result in up to approximately 1,305 trips, with 18,592 sets and 46,117,532 hooks annually. That level of effort is expected to result in six loggerhead sea turtle interactions annually, and a maximum of five mortalities annually (representing 0.31 adult females) from the North Pacific DPS. This represents one female mortality every 3.26 years or 0.003 percent of breeding females in the North Pacific DPS. NMFS has determined that the loss of one adult female every 3.3 years as a result of the proposed action will have a negligible effect on the North Pacific DPS (Jones and Martin 2016).

As discussed in the Cumulative Effects section (Section 9), effects to this DPS are likely to occur as a result of worsening climate change, and any increase in fishing, marine debris, and other actions described in the Environmental Baseline section. Such effects could include worsening of the climate change effects as well as an increase in effects resulting from fishing gear interactions with this DPS. In addition, any increases in marine debris could also increase entanglements. Global climate change is expected to continue and therefore may impact sea turtles and their habitats in the future. As discussed in this Supplement, rising temperatures at nesting beaches may have negative consequences for incubating nests. While loggerhead sea turtle nesting does not take place inside the action area, 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, although changes will likely not be uniform or predictable. As also discussed in the Cumulative Effects section of this Supplement, climate change may impact aquatic aspects of sea turtle biology and ecology, including foraging habitats and prey resources, phenology, and migration. As discussed earlier in this Supplement, although there is much speculation about potential impacts of anthropogenic induced climate change to species and ecosystems, there are multiple layers of uncertainty associated with these analyses and the effects of climate change will not be globally uniform. In particular, there is no comprehensive assessment of potential impacts of anthropogenic climate change within the action area or specific to sea turtles that may be within the action area. In addition to 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. Implications of climate change at the population level are a key area of uncertainty and one of active research 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 Supplement. 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. Viewed together with the Status of the Species, the Environmental Baseline, and the Cumulative Effects, the annual loss of the equivalent of 0.31 of an adult female, or one adult female every 3.26 years due to the proposed action is not expected to adversely affect population dynamics of the North Pacific loggerhead sea turtle DPS.

We considered to what extent the effects of the action affect survival and recovery of the loggerhead sea turtle. The NMFS and FWS' ESA Section 7 Handbook (FWS and NMFS 1998) provides further definitions for *survival* and *recovery*, as they apply to the ESA's jeopardy standard[7].

> *Survival* means: the species' persistence beyond the conditions leading to its endangerment, with sufficient resilience to allow recovery from endangerment. Said another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficiently large population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter.
>
> *Recovery* means: improvement in the status of a listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a) (1) of the Act. Said another way, recovery is the process by which species' ecosystems are restored and/or threats to the species are removed so self-sustaining and self-regulating populations of listed species can be supported as persistent members of native biotic communities.

The NMFS and FWS (1998b) loggerhead sea turtle recovery plan contains a number of goals and criteria that should be met to achieve recovery. These include reducing, to the extent possible, take in international waters; identifying regional stocks to source beaches; ensuring all females estimated to nest annually at "source beaches" are either stable or increasing for over 25 years; ensuring each "stock" has an average of 5,000 nesting females annually (or a biologically reasonable estimate based on the goal of maintaining a stable population in perpetuity) over six years; ensuring foraging areas are maintained as healthy environments; ensuring foraging

[7] "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" (50 CFR 402.02).

populations are exhibiting statistically significant increases at several key foraging grounds within each stock region; ensuring all priority one tasks have been implemented; ensuring a management plan designed to maintain stable or increasing populations of turtles is in place; ensuring there is a formal cooperative relationship with a regional sea turtle management program; and ensuring international agreements are in place to protect shared stocks (e.g., Mexico and Japan). Priority one tasks include a number of actions, including but not limited to, monitoring of nesting activity, determining population trends, identifying stock boundaries, reducing incidental mortality in commercial fisheries, and ensuring protection of marine habitat.

Adult female nesting population size for the North Pacific DPS has been estimated at approximately 8,897 (Jones and Martin 2016). As discussed above, the anticipated deaths resulting from the continued authorization of the deep-set fishery results in the removal of approximately 0.31 female annually, or 0.003 percent of breeding females in the North Pacific loggerhead sea turtle population (Jones and Martin 2016). Because this contribution to mortality is an insignificant fraction of what total mortality for the species might be, we do not expect that the small effect posed by the lethal takes in this fishery, when considered together with the environmental baseline and the cumulative effects, will be detectable or appreciable.

We conclude that the incidental take and resulting mortality of North Pacific loggerhead sea turtles associated with the direct and indirect effects of the proposed action, when considered together with the environmental baseline and cumulative effects, are not reasonably expected to cause an appreciable reduction in the likelihood of survival or recovery of the DPS. We expect the overall population to remain large enough to maintain genetic heterogeneity, broad demographic representation, and successful reproduction. The proposed action will have a small effect on the overall size of the population, and we do not expect it to affect the loggerhead sea turtles' ability to meet their lifecycle requirements and to retain the potential for recovery.

Moreover, we do not expect that the proposed action will impede progress on carrying out any aspect of the recovery plan or achieving the overall recovery strategy. The majority of the recovery criteria and priority one tasks will not be affected by the proposed action. Those that could potentially be affected and are most relevant to the analysis of the proposed action on recovery are 1) To the best extent possible, reducing take in international waters, 2) Ensuring all females estimated to nest annually at "source beaches" are either stable or increasing for over 25 years; 3) Ensuring each "stock" has an average of 5,000 nesting females annually (or a biologically reasonable estimate based on the goal of maintaining a stable population in perpetuity) over six years"; 4) Ensuring foraging populations are exhibiting statistically significant increases at several key foraging grounds within each stock region; and 5) Reducing incidental mortality in commercial, recreational fisheries.

The ESA allows for incidental take of species resulting from otherwise lawful activities (such as the proposed action), provided that such take does not result in jeopardy, and the impact of such take is minimized to the extent practicable. While the direct effects of the proposed action would result in some incidental take of this DPS by the U.S. fishery, take would be subject to existing mitigation measures as described in the terms and conditions section below, to reduce its impact. We have applied the post-release mortality criteria conservatively to ensure that sea turtles that are likely to be seriously injured by capture in the fisheries are counted as lethal takes. The anticipated non-lethal takes are not expected to impact the reproductive potential, fitness, or growth of any of the incidentally caught sea turtles because they will be released unharmed shortly after capture, or released with only minor injuries from which they are expected to fully recover.

The proposed action will result in the mortality of less than one nesting female annually, as discussed above, this level of mortality would present negligible additional risk to the North Pacific DPS. Since it represents a negligible risk to the DPS, the proposed action would not prohibit the DPS from stabilizing or increasing, nor would it prohibit the DPS from reaching a biologically reasonable number of adult females nesting annually based on the goal of maintaining a stable population in perpetuity. The negligible risk to the DPS nesting population, which is the source of animals found at foraging grounds, means it would not substantially impair or prohibit increases to DPS foraging populations at key foraging grounds. The effects of the action would not prohibit or substantially impair continuing efforts to reduce mortality in commercial fisheries. Additionally, there would be no negative indirect effects to nesting females from the proposed action.

We expect that the incidental lethal and non-lethal takes of loggerhead sea turtles associated with the proposed action would not cause an appreciable reduction in the likelihood of survival of the North Pacific DPS. Although any level of take and mortality can have an adverse effect on the overlying population, we find that the expected level of take from the action, considered together with all impacts described in the Status of the Species, Baseline, and Cumulative Effects sections, including other federally authorized fisheries and foreign fisheries, is not likely to affect the viability of the population those individuals represent, and therefore would not affect the survival or recovery of the species. As stated previously, the proposed action is expected to result in the annual mortality of 0.31 of an adult female equivalent. Moreover, we do not expect that the proposed action is reasonably likely to result in an appreciable reduction in the likelihood of recovery of the North Pacific DPS. The proposed action does not appreciably impede progress on carrying out any aspect of the recovery program or achieving the overall recovery strategy.

To summarize, when considering the effects of the proposed action, together with the status of the listed species, the environmental baseline, and the cumulative effects, we expect that the lethal and non-lethal takes of loggerhead sea turtles associated with the proposed action are not expected to cause an appreciable reduction in the likelihood of both the survival and recovery of the North Pacific loggerhead sea turtle DPS in the wild.

10.2 **Olive Ridley Sea Turtles**

As discussed in the olive ridley sea turtle section of the Status of Listed Species (Section 6.2), nesting of eastern Pacific olive ridley sea turtles steadily increased from 1991 to present up to over one million nests annually. The western Pacific olive ridley population is a smaller, widely-scattered population with the largest nesting occurring in the Indian Ocean; an estimate of 205,000 adult females nest annually (Jones and Martin 2016).

As discussed in the olive ridley sea turtle section of the Environmental Baseline (Section 7.2), hundreds of juvenile and adult olive ridley sea turtle mortalities may be occurring annually due to longline fishery interactions within the action area alone. Thus, total fishery-related mortality of the olive ridley sea turtle populations is likely at least several hundred adults annually via longlining (most from the eastern Pacific population, but some from the western Pacific population).

As described in the olive ridley sea turtle section of the Effects of the Action (Section 8.2), if we assume that the proposed action will result in approximately 1,305 trips, with 18,592 sets and 46,117,532 hooks annually, then that level of effort will result in 61 olive ridley sea turtle interactions annually (Table 11), which will result in approximately 58 juvenile or adult mortalities annually. Fourty-five are expected to be from the larger eastern Pacific population, which is comprised of the endangered Mexico and threatened Central America subpopulations, and 13 from the western Pacific population. The response of eastern pacific olive ridley sea turtles to interactions with gear deployed by the Hawaii deep-set fishery is considered to be the mortality of 13.27 adult females annually from the endangered Mexico population or from the threatened population of the eastern Pacific which is part of the global species. This represents 0.00133 percent of each nesting population which is not significant to either of these populations (Jones and Martin 2016). The response of western Pacific olive ridley sea turtles to interactions with gear deployed by the Hawaii deep-set fishery is considered to be the mortality of 3.96 adult females annually. This represents 0.00193 percent of the nesting population, which is not a significant loss to the population (Jones and Martin 2016).

As also discussed in the Cumulative Effects section of this Supplement, climate change may impact aquatic aspects of sea turtle biology and ecology, including foraging habitats and prey resources, phenology, and migration. As discussed earlier in this Supplement, 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 and the effects of climate change will not be globally uniform. In particular, there is no comprehensive assessment of the potential impacts of climate change within the action area or specific to sea turtles that occur 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. Implications of climate change at the population level are a key area of uncertainty and one of active research 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 Supplement.

We considered to what extent the effects of the action affect survival and recovery of the olive ridley sea turtle. The NMFS and FWS' ESA Section 7 Handbook (FWS and NMFS 1998) provides further definition for *survival* and *recovery*, as they apply to the ESA's jeopardy standard (please refer to the loggerhead sea turtle discussion of this section for definitions).

The NMFS and FWS (1998c) olive ridley sea turtle recovery plan contains a number of goals and criteria that should be met to achieve recovery of both the endangered and threatened populations. These include all regional stocks that use U.S. waters have been identified to source beaches based on reasonable geographic parameters; foraging populations are statistically significantly increasing at several key foraging grounds within each stock region; all females estimated to nest annually at "source beaches" are either stable or increasing for over 10 years; a management plan based on maintaining sustained populations for turtles is in effect; international agreements are in place to protect shared stocks.

As discussed above, the anticipated deaths resulting from the continued authorization of the deep-set fishery results in the removal of approximately 58 turtles (either sex) annually; 45 from the endangered and threatened populations of the Eastern Pacific and 13 from the threatened western Pacific population. Viewed together with the Status of the Species, the Environmental Baseline, the Effects of the Action, and the Cumulative Effects, we expect the annual mortality of 45 olive ridley sea turtles caused by the proposed action will not adversely affect the population dynamics of the endangered Mexico population.

Viewed together with the Status of the Species, the Environmental Baseline, the Effects of the Action, and the Cumulative Effects, we expect the annual mortality of 45 olive ridley sea turtles caused by the proposed action will not adversely affect the population dynamics of the threatened population in the Eastern Pacific. Nor do we expect the annual mortality of 13 olive ridley sea turtles to adversely affect the population dynamics of the threatened population in the western Pacific. Moreover, we do not expect the proposed action to appreciably reduce the reproduction, numbers, or distribution of either population, and thus the species.

We conclude that the incidental take and resulting mortality of olive ridley sea turtles associated with the proposed action are not reasonably expected to cause an appreciable reduction in the likelihood of survival and recovery of the endangered Mexico population or the threatened global species. We expect the overall endangered and threatened populations to remain large enough to maintain genetic heterogeneity, broad demographic representation, and successful reproduction. The proposed action will have a negligible effect on the overall size of the endangered and threatened populations, and we do not expect it to affect the olive ridley sea turtles' ability to meet their lifecycle requirements and to retain the potential for recovery.

Moreover, we do not expect that the proposed action will impede progress on carrying out any aspect of the recovery plan or achieving the overall recovery strategy. The majority of the recovery criteria will not be affected by the proposed action. Those that could potentially be affected and are most relevant to the analysis of the proposed action on recovery are: 1) ensuring foraging populations are statistically significantly increasing at several key foraging grounds within each stock region; and 2) all females estimated to nest annually at "source beaches" are either stable or increasing for over 10 years.

Although the proposed action would result in the mortality of up to 45 olive ridley sea turtles from the endangered Mexico population and 13 from the threatened population annually, as discussed above, this level of mortality would present negligible risk to both listed populations. Since it represents a negligible risk to the populations, the proposed action would not prohibit the populations from stabilizing or increasing, nor would it prohibit them from reaching a biologically reasonable number of females nesting annually based on the goal of maintaining stable populations in perpetuity. The negligible risk to the olive ridley sea turtle nesting populations, which is the source of animals that occur at foraging grounds, means it would not substantially impair or prohibit increases to olive ridley sea turtle foraging populations at key foraging grounds. The effects of the action would not prohibit or substantially impair continuing efforts to reduce mortality in commercial fisheries. Additionally, there would be no negative indirect effects to the endangered and threatened populations from the proposed action.

We expect that the incidental lethal and non-lethal takes of olive ridley sea turtles associated with the proposed action are not reasonably expected to cause an appreciable reduction in the likelihood of survival of the endangered and threatened populations. Although any level of take and mortality can have an adverse effect on the overlying population, we find that the expected level of take from the action, considered together with all impacts described in the Status of the Species, Baseline, and Cumulative Effects sections, including other federally authorized fisheries and foreign fisheries, is not likely to affect the viability of the population those individuals represent, and therefore would not affect the survival or recovery of the species. Notwithstanding the expected annual mortalities resulting from the proposed action, we expect that the populations will remain large enough to retain the potential for recovery. Moreover, we do not expect that the proposed action is reasonably likely to result in an appreciable reduction in the likelihood of recovery of the olive ridley sea turtle. The proposed action does not appreciably impede progress on carrying out any aspect of the recovery program or achieving the overall recovery strategy.

To summarize, when considering the effects of the proposed action, together with the status of the listed species, the environmental baseline, and the cumulative effects, we expect that the lethal and non-lethal takes of olive ridley sea turtles associated with the proposed action are not expected to cause an appreciable reduction in the likelihood of both the survival and recovery of the olive ridley sea turtle, including the endangered eastern and threatened eastern and western populations, in the wild.

10.3 **East Pacific Green Sea Turtle DPS**

As discussed in the Status of the species section (6.3.1), the East Pacific DPS is estimated at 20,112 nesting females (Seminoff et al., 2015). Nesting has been steadily increasing at the primary nesting sites in Michoacan, Mexico, and in the Galapagos Islands since the 1990s (Delgado and Nichols 2005; Senko et al., 2011). Nesting trends at Colola have continued to increase since 2000 with the overall eastern Pacific green turtle population also increasing at other nesting beaches in the Galapagos and Costa Rica (Wallace et al., 2010, NMFS and FWS 2007b).

As discussed in the green sea turtle section (7.3.1) of the Environmental Baseline, up to several hundred juvenile green sea turtle mortalities occur annually by longlining in the action area and based on the results from the genetics from turtles sampled in the US longline fleet, the largest majority are expected to be from the East Pacific DPS.

As described in the green sea turtle section of the Effects of the Action (8.3), our analysis assumes that the proposed action will result in up to approximately 1,305 trips, with 18,592 sets and 46,117,532 hooks annually. That level of effort is expected to result in four East Pacific green sea turtle interactions annually all leading to mortalities (representing 0.054 adult females). This represents one female mortality every 18.62 years or 0.0003 percent of breeding females in the East Pacific DPS. NMFS has determined that the loss of one adult female equivalent every

18.62 years as a result of the proposed action will have a negligible effect on the East Pacific DPS (Jones and Martin 2016). Viewed within the context of the Status of the Species and the Environmental Baseline, and considered together with the Cumulative Effects, the mortality of 0.054 adult female green turtle equivalents caused by the proposed action is insufficient to adversely affect the dynamics of the East Pacific DPS. That is, we do not expect the proposed action to appreciably reduce the reproduction, numbers, or distribution of green sea turtles in this DPS or the potential for recovery.

10.4 **Central North Pacific Green Sea Turtle DPS**

As discussed in the Status of the species section, the Central North Pacific DPS (7.3.2) is estimated at 3,800 nesting females (Seminoff et al.,2015). Nesting has been steadily increasing since the 1990s (Delgado and Nichols 2005; Senko et al., 2011).

As discussed in the green sea turtle section of the Environmental Baseline (Section 7.3.2), several dozen green sea turtles are likely to be killed annually by longlining in the action area alone. Thus, total fishery-related mortality of green sea turtles in the Pacific Ocean is likely a few hundred annually, with the majority belonging to the Eastern Pacific DPS, and a much smaller percentage from the Central North Pacific DPS. In addition, up to several dozen green sea turtles from this DPS are killed annually by nearshore activities such as fishing and boat collisions around the Hawaiian Islands.

As described in the green sea turtle section of the Effects of the Action (Section 8.3), our analysis assumes that the proposed action will result in up to approximately 1,305 trips, with 18,592 sets and 46,117,532 hooks annually. That level of effort is expected to result in two Central North Pacific green sea turtle DPS interactions annually all leading to mortalities (representing 0.027 adult females). This represents one female mortality every 37.25 years or 0.0007 percent of breeding females in the Central North Pacific DPS. NMFS has determined that the loss of one adult female equivalent every 37.25 years as a result of the proposed action will have a negligible effect on the Central North Pacific DPS (Jones and Martin 2016). Viewed within the context of the Status of the Species and the Environmental Baseline, and considered together with the Cumulative Effects, the mortality of 0.027 adult female green turtle equivalents caused by the proposed action is insufficient to adversely affect the dynamics of the proposed Central North Pacific DPS. That is, we do not expect the proposed action to appreciably reduce the reproduction, numbers, or distribution of green sea turtles in this DPS or the potential for recovery.

10.5 **East Indian-West Pacific Green Sea Turtle DPS**

The largest nesting site for the East Indian-West Pacific DPS (Section 6.3.3) lies within Northern Australia, which supports approximately 25,000 nesting females, calculated from the 5,000 nesting female’s order of magnitude (Limpus, 2009). Currently, the East Indian-West Pacific DPS hosts 58 reported nesting sites (in some cases nesting sites are made up of multiple beaches based on nesting survey information) with six of these sites supporting more than 5,000 nesting females each (including the 25,000 nesters in Northern Australia). The total nester abundance for this DPS is estimated to be approximately 77,009 (Seminoff et al., 2015). Green sea turtle populations within this DPS have experienced increases at some nesting sites and decreases at others. Nonetheless, populations are substantially depleted from historical levels.

As discussed in the green turtle section of the Environmental Baseline (Section 7.3.3), several dozen green turtles are likely to be killed annually by longlining in the action area alone. Thus, total fishery-related mortality of green turtles in the Pacific Ocean is likely a few hundred annually, with the majority belonging to the Eastern Pacific DPS, and a much smaller percentage from the East Indian-West Pacific DPS.

As described in the green sea turtle section of the Effects of the Action (Section 8.3), our analysis assumes that the proposed action will result in up to approximately 1,305 trips, with 18,592 sets and 46,117,532 hooks annually. That level of effort is expected to result in two East Indian-west Pacific green sea turtle DPS interactions annually all leading to mortalities (representing 0.027 adult females). This represents one female mortality every 37.25 years or 0.0003 percent of breeding females in the East Indian-west Pacific DPS. NMFS has determined that the loss of one adult female equivalent every 37.25 years as a result of the proposed action will have a negligible effect on the Indian-west Pacific green sea turtle DPS (Jones and Martin 2016). Viewed within the context of the Status of the Species and the Environmental Baseline, and considered together with the Cumulative Effects, the mortality of 0.027 adult female green turtle equivalents caused by the proposed action is insufficient to adversely affect the dynamics of the East Indian-west Pacific DPS. That is, we do not expect the proposed action to appreciably reduce the reproduction, numbers, or distribution of green sea turtles in this DPS or the potential for recovery.

10.6 **Southwest Pacific Green Sea Turtle DPS**

As discussed in the Status of the Species Section (6.3.4) the abundance estimate for the Southwest Pacific DPS is 83,058 (Seminoff et al., 2015). Nesting occurs in many islands throughout the region but there are only two nesting areas (Raine Island and Heron Island) with long-term (>15 years) annual indices of nesting abundance. The Raine Island, Australia index count (1994–2004, intermittent) has high inter-annual variability and a slightly increasing linear trend. Heron Island, Australia, index count (1967–2004, intermittent) also has high interannual variability and a slightly increasing linear trend. Although long robust time series are not available for New Caledonia, recent and historic accounts do not suggest a significant decline in abundance of green sea turtles nesting in New Caledonia (Maison et al., 2010).

As discussed in the green turtle section of the Environmental Baseline (Section 7.3.4), several dozen green turtles are likely to be killed annually by longlining in the action area alone. Thus, total fishery-related mortality of green turtles in the Pacific Ocean is likely a few hundred annually, with the majority belonging to the Eastern Pacific DPS, and a much smaller percentage from the Southwest Pacific DPS.

As described in the green sea turtle section of the Effects of the Action (Section 8.3), our analysis assumes that the proposed action will result in up to approximately 1,305 trips, with 18,592 sets and 46,117,532 hooks annually. That level of effort is expected to result in two

Southwest Pacific green sea turtle DPS interactions annually all leading to mortalities (representing 0.027 adult females). This represents one female mortality every 37.25 years or 0.0003 percent of breeding females in the Southwest Pacific DPS. NMFS has determined that the loss of one adult female equivalent every 37.25 years as a result of the proposed action will have a negligible effect on the Southwest Pacific green sea turtle DPS (Jones and Martin 2016). Viewed within the context of the Status of the Species and the Environmental Baseline, and considered together with the Cumulative Effects, the mortality of 0.027 adult female green sea turtle equivalents caused by the proposed action is insufficient to adversely affect the dynamics of the Southwest Pacific DPS. That is, we do not expect the proposed action to appreciably reduce the reproduction, numbers, or distribution of green sea turtles in this DPS or the potential for recovery.

10.7 Central West Pacific Green Sea Turtle DPS

As discussed in the Status of the Species Section (6.3.5) there are approximately 51 nesting sites and 6,518 nesting females in the Central West Pacific DPS. There is insufficient long-term and standardized monitoring information to adequately describe abundance and population trends for many areas of the Central West Pacific DPS. The limited available information suggests a nesting population decrease in some portions of the DPS like the Marshall Islands, or unknown trends in other areas such as Palau, Papua New Guinea, the Marianas, Solomon Islands, or the FSM (Maison et al., 2010).

As discussed in the green turtle section of the Environmental Baseline (Section 7.3.5), several dozen green turtles are likely to be killed annually by longlining in the action area alone. Thus, total fishery-related mortality of green turtles in the Pacific Ocean is likely a few hundred annually, with the majority belonging to the Eastern Pacific DPS, and a much smaller percentage from the Central West Pacific DPS.

As described in the green sea turtle section of the Effects of the Action (Section 8.3), our analysis assumes that the proposed action will result in up to approximately 1,305 trips, with 18,592 sets and 46,117,532 hooks annually. That level of effort is expected to result in up to one Central West Pacific green sea turtle DPS interactions annually all leading to mortalities (representing 0.013 adult females). This represents one female mortality every 74.49 years or 0.0002 percent of breeding females in the Central West Pacific DPS. NMFS has determined that the loss of one adult female equivalent every 74.49 years as a result of the proposed action will have a negligible effect on the Central West Pacific green sea turtle DPS (Jones and Martin 2016). Viewed within the context of the Status of the Species and the Environmental Baseline, and considered together with the Cumulative Effects, the mortality of 0.013 adult female green turtle equivalents caused by the proposed action is insufficient to adversely affect the dynamics of the Central West Pacific DPS. That is, we do not expect the proposed action to appreciably reduce the reproduction, numbers, or distribution of green sea turtles in this DPS or the potential for recovery.

10.8 Central South Pacific Green Sea Turtle DPS

As discussed in the Status of the Species section (6.3.6) the number of nesting females in the Central South Pacific DPS is 2,677 (Seminoff et al., 2015). Green turtle temporal population trends in the Central South Pacific are poorly understood. Partial and inconsistent monitoring from the largest nesting site in this aggregation, Scilly Atoll, suggests significant nesting declines from persistent and illegal commercial harvesting (Petit). Nesting abundance is reported to be stable to increasing at Rose Atoll, Swains Atoll, Tetiaroa, Tikehau, and Maiao. However, these sites are of moderate to low abundance and in sum represent less than 16 percent of the population abundance at Scilly Atoll alone. Nesting abundance is reported to be stable to increasing at Tongareva Atoll (White and Galbraith 2013).

As discussed in the green turtle section of the Environmental Baseline Section (7.3.6), several dozen green turtles are likely to be killed annually by longlining in the action area alone. Thus, total fishery-related mortality of green turtles in the Pacific Ocean is likely a few hundred annually, with the majority belonging to the Eastern Pacific DPS, and a much smaller percentage from the Central South Pacific DPS.

As described in the of the Effects of the Action (Section 8.3), our analysis assumes that the proposed action will result in up to approximately 1,305 trips, with 18,592 sets and 46,117,532 hooks annually. That level of effort is expected to result in one Central South Pacific green sea turtle DPS interactions annually all leading to mortalities (representing 0.013 adult females). This represents one female mortality every 74.49 years or 0.0005 percent of breeding females in the Central South Pacific DPS. NMFS has determined that the loss of one adult female equivalent every 74.49 years as a result of the proposed action will have a negligible effect on the Central South Pacific DPS (Jones and Martin 2016). Viewed within the context of the Status of the Species and the Environmental Baseline, and considered together with the Cumulative Effects, the mortality of 0.013 adult female green turtle equivalents caused by the proposed action is insufficient to adversely affect the dynamics of the Central South Pacific DPS. That is, we do not expect the proposed action to appreciably reduce the reproduction, numbers, or distribution of green sea turtles in this DPS or the potential for recovery.

Summary for all green sea turtle DPSs

As discussed in the Cumulative Effects (Section 9), effects to these green sea turtle DPSs are likely to occur as a result of worsening climate change, and any increase in fishing, marine debris, and other actions described in the Environmental Baseline section. Such effects could include worsening of the climate change effects, as well as an increase in effects resulting from fishing gear interactions with this species. In addition, any increases in marine debris could also increase entanglements or ingestion impacts. Global climate change is expected to continue and therefore may impact sea turtles and their habitat in the future. As discussed in this Supplement, rising temperatures at nesting beaches may have negative consequences for nesting females and developing embryos. 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, although changes will likely not be uniform or predictable. As also discussed in the Cumulative Effects section of this Supplement, climate change may impact aquatic aspects of sea turtle biology and ecology, including foraging habitats and prey resources, phenology, and migration. Although there is much speculation on the potential impacts of anthropogenic climate change to species and ecosystems, there are multiple layers of uncertainty associated with these analyses and the effects of climate change will not be globally uniform. 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. Implications of climate change at the population level are a key area of uncertainty and one of active research 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.

We considered to what extent the effects of the action affect survival and recovery of the green sea turtle and for each DPS. The NMFS and FWS' ESA Section 7 Handbook (FWS and NMFS 1998) provides further definition for *survival* and *recovery*, as they apply to the ESA's jeopardy standard.

The NMFS and FWS (1998d) Green Turtle and (1998a) East Pacific Green Turtle recovery plans contain a number of goals and criteria that should be met to achieve recovery. There are no recovery plans for the green sea turtle DPSs at this time. These include all regional stocks that use U.S. waters have been identified to source beaches based on reasonable geographic parameters; each stock must average 5,000 (or a biologically reasonable estimate based on the goal of maintaining a stable population in perpetuity) females estimated to nest annually over six years; nesting populations at "source beaches" are either stable or increasing over a 25-year monitoring period; existing foraging areas are maintained as healthy environments; foraging populations are exhibiting statistically significant increases at several key foraging grounds within each stock region; all Priority one tasks have been implemented; a management plan to maintain sustained populations of turtles is in place; and international agreements are in place to protect shared stocks.

As discussed above, the anticipated mortalities resulting from the continued authorization of the Hawaii deep-set fishery results in the removal of four from the East Pacific DPS, two from the Central North Pacific DPS, two from the East Indian-West Pacific DPS, two from the Southwest Pacific DPS, one from the Central West Pacific DPS, and one from the Central South Pacific DPS. Viewed within the context of the Status of the Species, the Environmental Baseline, the Effects of the Action, and the Cumulative Effects, we expect the annual mortality of green sea turtles caused by the proposed action is insufficient to adversely affect the population dynamics of the East Pacific DPS, the Central North Pacific DPS, the East Indian-West Pacific DPS, the Southwest Pacific DPS, the Central West Pacific DPS, or the Central South Pacific DPS. We do not expect the proposed action to reduce the reproduction, numbers, or distribution of these DPSs.

We conclude that the incidental take and resulting mortality of green sea turtles associated with the direct effects of the proposed action are not reasonably expected to cause an appreciable reduction in the likelihood of survival or recovery of the six listed DPSs. We expect the overall populations to remain large enough to maintain genetic heterogeneity, broad demographic representation, and successful reproduction. The direct effect of the proposed action will have a small effect on the overall size of the DPSs, and we do not expect it to affect the green sea turtles' ability to meet their lifecycle requirements and to retain the potential for recovery.

Moreover, we do not expect that the proposed action will impede progress on carrying out any aspect of the recovery plan or achieving the overall recovery strategy. The majority of the recovery criteria and priority one tasks will not be affected by the proposed action. Those that could potentially be affected and are most relevant to the analysis of the proposed action on recovery are: 1) each stock must average 5,000 (or a biologically reasonable estimate based on the goal of maintaining a stable population in perpetuity) females estimated to nest annually over six years; 2) nesting populations at "source beaches" are either stable or increasing over a 25-year monitoring period; 3) foraging populations are exhibiting statistically significant increases at several key foraging grounds within each stock region; and 4) reduce incidental mortality in fisheries.

The ESA allows for incidental take of species resulting from otherwise lawful activities (such as the proposed action), provided that such take does not result in jeopardy, and the impact of such take is minimized to the extent practicable. While the direct effects of the proposed action would result in some incidental take of these DPSs by the U.S. fishery, take would be subject to mitigation measures to reduce its impact. We have applied the post-release mortality criteria conservatively to ensure that sea turtles that are likely to be seriously injured by capture in the fisheries are counted as lethal takes. Anticipated non-lethal takes are not expected to impact the reproductive potential, fitness, or growth of any of the incidentally caught sea turtles because they will be released unharmed shortly after capture, or released with only minor injuries from which they are expected to recover. Individual takes may occur anywhere in the action area and turtles would be released within the general area where they are caught.

Although the proposed action would result in the mortality of juvenile green sea turtles, as discussed above, this level of mortality would present negligible additional risk to each DPS. Since it represents a negligible risk, the proposed action would not prohibit the species from stabilizing or increasing, nor would it prohibit the species from reaching a biologically reasonable number of females to nest annually based on the goal of maintaining a stable population in perpetuity. The negligible potential risk to the green nesting populations, which is the source of animals that occur at foraging grounds, means it would not substantially impair or prohibit increases to green sea turtle foraging populations at key foraging grounds. The effects of the action would not prohibit or substantially impair continuing efforts to reduce mortality in commercial fisheries. Additionally, there would be no negative indirect effects to each of the DPSs from the proposed action.

We expect that the incidental lethal and non-lethal takes of green sea turtles associated with the proposed action are not reasonably expected to cause an appreciable reduction in the likelihood of survival of each of the DPSs. Although any level of take and mortality can have an adverse effect on the overlying population, we find that the expected level of take from the action, considered together with all impacts described in the Status of the Species, Baseline, and Cumulative Effects sections, including other federally authorized fisheries and foreign fisheries, is not likely to affect the viability of the population those individuals represent, and therefore would not affect the survival or recovery of the species. Moreover, we do not expect that the proposed action is reasonably likely to result in an appreciable reduction in the likelihood of recovery of the green sea turtle DPSs. The proposed action does not appreciably impede progress on carrying out any aspect of the recovery program or achieving the overall recovery strategy.

To summarize, when considering the effects of the proposed action, together with the status of the listed species, the environmental baseline, and cumulative effects, we expect that the lethal and non-lethal takes of green sea turtles associated with the proposed action are not expected to cause an appreciable reduction in the likelihood of both the survival and recovery of the East Pacific DPS, the Central North Pacific DPS, the East Indian-West Pacific DPS, the Southwest Pacific DPS, the Central West Pacific DPS, or the Central South Pacific DPS.

11 Conclusion

The purpose of this Supplement is to determine if the proposed action is likely to jeopardize the continued existence of listed species (i.e., jeopardy determination) or result in destruction or adverse modification of designated critical habitat. "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" (50 CFR 402.02). After reviewing the current status of ESA-listed North Pacific loggerhead sea turtle DPS, olive ridley sea turtles (endangered Mexico population and threatened global species), East Pacific green sea turtle DPS, Central North Pacific green sea turtle DPS, East Indian-west Pacific DPS, Southwest Pacific DPS, Central West Pacific DPS, and the Central South Pacific DPS, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' Opinion that the proposed action is not likely to jeopardize the continued existence of these nine species, and since no critical habitat will be adversely affected the action is not likely to destroy or adversely modify designated critical habitat.

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 minimize 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 efforts which would help in reducing adverse impacts to listed species in the Pacific Ocean.

1. NMFS should continue to promote reduction of sea turtle bycatch in Pacific fisheries by supporting:
    a. The Inter-American Convention for the Protection and Conservation of Sea Turtles;
    b. The Western Central Pacific Fisheries Commission and Inter-American Tropical Tuna Commission sea turtle conservation and management measures for commercial longline fisheries operating in the Pacific;
    c. The wide dissemination and implementation of NMFS Sea Turtle Handling Guidelines that increase post-hooking turtle survivorship;

d. Technical assistance workshops to assist other longlining nations to build capacity for observer programs and implement longline gear and handling measures on commercial vessels operating in the western and eastern Pacific;
e. Continuation of ecological, habitat use, and genetics studies of all sea turtles occurring in foraging and migratory habitats in the Pacific, continue monitoring impacts through stranding programs, and promote mitigation studies and handling measures for fisheries operating in these waters, and;
f. Continuation of bycatch reduction efforts in the western and eastern Pacific to reduce commercial and artisanal fishery impacts (e.g., mitigation of Japan poundnets and other fisheries operating in the South China and Sulu Sulawesi Seas, and bycatch reduction in coastal gillnet and trawl fisheries).

2. NMFS should continue to encourage, support and work with Regional partners to implement long-term sea turtle monitoring, conservation, and recovery programs at important nesting habitats.

3. NMFS should continue to investigate long term climate variability and its impacts to turtle populations and distribution.

4. NMFS should continue to promote tools, like Turtle Watch, to help fishermen avoid longline fishery interactions.

5. NMFS should continue to investigate and promote programs to reduce fishery interactions with turtles in the action area.

13 Reinitiation Notice

This concludes formal consultation on the continued operation of the Hawaii deep-set longline tuna fishery. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law, and if:

1. The amount or extent of incidental take for any species 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 Supplement;
3. The agency action is subsequently modified in a manner that may affect listed species or critical habitat to an extent in a way not considered in this Supplement; or
4. A new species is listed or critical habitat designated that may be affected by the action.

14 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)).

14.1 **Anticipated Amount or Extent of Incidental Take**

NMFS anticipates the following incidental takes may occur as a result of the continued operation of the Hawaii deep-set longline fishery with approximately 1,305 trips with 18,592 sets and 46,117,532 hooks annually. 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 15 below (i.e., 3-year ITSs). The interactions are a form of take which can result in mortalities; the interactions and mortalities composes the total amount of take that is anticipated under the proposed action. Annual take estimates can have high variability because of natural variation. It is unlikely that all species evaluated in this Supplement will be consistently impacted year after year by the fishery. The interactions and mortalities in Table 17 have been calculated based on observed interaction rates (see Section 8) and estimated post-hooking mortality rates of sea turtles. Use of a 3-year approach will allow for an accurate assessment of the deep-set fishery's impacts on protected species, while avoiding unnecessary reinitiation in response to short-term variability in interactions.

Table 17.The total number of turtle interactions (i.e. take) expected from the proposed action over a three –year period. Also shown are the total mortalities (i.e. take). Observed takes are extrapolated to total interactions (takes) in order to monitor the ITS by multiplying the number of confirmed observed takes by an expansion factor based on current observer coverage. Example calculation for loggerhead sea turtles at 20 percent coverage: 100 ÷ observer coverage= expansion factor [100/20=5]. Expansion factor * number observed=total takes [5*1=5].

	3-Year	
Species	Interactions	Total mortalities
North Pacific loggerhead sea turtle DPS	18	13
Olive ridley sea turtles (Endangered Mexico and threatened eastern Pacific populations) (77)	141	134
Olive ridley sea turtles (Threatened western pacific population) (23)	42	40
East Pacific green sea turtle DPS (70)	12	12
Central North Pacific DPS (12)	6	6
East Indian-west Pacific DPS (8)	6	6
Southwest Pacific DPS (7)	6	6
Central West Pacific DPS (1)	3	3
Central South Pacific DPS (1)	3	3

Observed interactions are extrapolated to total interactions in order to monitor the ITS by multiplying the number of confirmed observed interactions by an expansion factor based on current observer coverage. We note the estimated proportion of each DPS and population in parentheses, which will be used to prorate green and olive ridley turtle interactions to the applicable DPSs and population. Assignment of green turtle takes to DPSs may be informed by genetic analysis of a particular turtle, where applicable, rather than the mixed stock analysis percentages from Table 5. At this time the endangered Mexico population of olive ridley sea turtles cannot be identified genetically from the threatened population in the eastern Pacific which is part of the globally listed species, therefore when a turtle is identified as being from the eastern Pacific we will count it as being from either the endangered Mexico population or from the threatened eastern Pacific subpopulation.

14.2 **Impact of the Take**

In this Supplement, NMFS determined that the level of incidental take anticipated from the proposed action is not likely to jeopardize the North Pacific loggerhead sea turtle DPS, olive ridley sea turtle (endangered Mexico population and threatened global species), East Pacific green sea turtle DPS, Central North Pacific green sea turtle DPS, East Indian-west Pacific green sea turtle DPS, Southwest Pacific green sea turtle DPS, Central West Pacific green sea turtle DPS, and the Central South Pacific green sea turtle DPS.

14.3 **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 17 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 14.4), are necessary and appropriate to minimize the impacts of the deep-set 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 collect data on interactions with protected species, including the capture, injury, and mortality caused by the deep-set longline fishery, and shall also collect basic life-history information, as available.

2. NMFS shall require that sea turtles incidentally caught alive be released from fishing gear in a manner that minimizes injury and the likelihood of further gear entanglement or entrapment to increase post-release survivorship, as practicable and in consideration of best practices for safe vessel and fishing operations.

3. NMFS shall require that comatose or lethargic sea turtles shall 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.

4. NMFS shall require sea turtles that are dead when brought on board a vessel or that do not resuscitate be disposed of at sea unless NMFS requests retention of the carcass for sea turtle research, as practicable and in consideration of best practices for safe vessel and fishing operations.

14.4 **Terms and Conditions**

NMFS shall undertake and comply with the following terms and conditions to implement the reasonable and prudent measures identified in Section 14.3 above. These terms and conditions are non-discretionary, and if NMFS fails to adhere to these terms and conditions, the protective coverage of section 7(o) (2) may lapse.

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

   1A. *Observers*. NMFS shall maintain observer coverage at rates that have been determined to be statistically reliable for estimating protected species interaction rates onboard Hawaii deep-set longline vessels.

   1B. *Data Collection*. 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 place tags on any untagged turtles that are brought aboard a vessel. Observers shall also collect life-history information on sea turtles incidentally caught by the deep-set 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 at 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.

   1C. *Information Dissemination*. NMFS shall disseminate quarterly, summaries of the data collected by observers to the NMFS Assistant Regional Administrators of Protected Resources and Sustainable Fisheries in PIR, as well as the NMFS Sea Turtle Coordinators in PIR, West Coast Region and Headquarters.

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

   2A. NMFS shall continue to require and conduct protected species workshops for owners and operators of vessels registered for use with Hawaii limited entry longline fishing permits, to educate vessel owners and operators in handling and resuscitation techniques to minimize injury and promote survival of hooked or entangled sea turtles, as specified in 50 CFR 665. 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, including disseminating new scientific information such as TurtleWatch for loggerhead sea turtles.

2B. NMFS shall continue to train observers about sea turtle biology and techniques for proper handling, dehooking, and resuscitation.

2C. NMFS shall require that deep-set longline fishermen remove hooks from turtles as quickly and carefully as possible to avoid injuring or killing the turtle, as practicable and in consideration of best practices for safe vessel and fishing operations. NMFS shall require that each Hawaii deep-set longline vessel carry a line clipper or cutter 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 all of the fishing gear cannot be removed (e.g., the hook is deeply ingested or the animal is too large to bring aboard).

2D. NMFS shall require that each Hawaii deep-set longline vessel carry a dip net to hoist a sea turtle onto the deck to facilitate hook removal. If the vessel is too small to carry a dipnet, sea turtles must be eased onto the deck by grasping its carapace or flippers, to facilitate the removal of the hook. 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.

2E. NMFS shall require each deep-set longline vessel to carry and use, as appropriate, a wire or bolt cutter that is capable of cutting through a hook that may be imbedded externally, including the head/beak area of a turtle.

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

3A. NMFS shall require that deep-set longline vessel operators bring comatose sea turtles aboard and perform resuscitation techniques according to the procedures described at 50 CFR 665 and 50 CFR 223.206, as practicable and in consideration of best practices for safe vessel and fishing operations, except that the observer may perform resuscitation techniques on comatose sea turtles if the observer is available.

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

4A. NMFS shall require that dead sea turtles may not be consumed, sold, landed, offloaded, transshipped, or kept below deck, but must be returned to the ocean after identification, unless NMFS requests the turtle be kept for further study.

15 DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the Opinion addresses these DQA components, documents compliance with the DQA, and certifies that this Supplement has undergone pre-dissemination review.

15.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this Supplement are [*name of Federal action agency(ies)*]. Other interested users could include [*e.g., permit or license applicants, citizens of affected areas, others interested in the conservation of the affected ESUs/DPS*]. Individual copies of this Supplement were provided to the [*name of action agency(ies)*]. This Supplement will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

15.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

15.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this Supplement contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and reviewed in accordance with Pacific Islands Region ESA quality control and assurance processes.

16 Literature Cited

Aeby, G., Aletto, S. C., Anderson, P., Carroll, B., DiDonato, E., DiDonato, G., Vroom, P. S. (2008). The State of Coral Reef Ecosystems of American Samoa. In J. Waddell & A. M. Clarke (Eds.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008 (pp. 307–351). NOAA Technical Memorandum NOS NCCOS 73. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team. Silver Spring, MD.

Ahmed, R., Khan, A., & Nishat, A. (2006). Community-based awareness programme for the conservation of sea turtles in Bangladesh. In N. J. Pilcher (Ed.), Proceedings of the Twenty-Third Annual Symposium on Sea Turtle Biology and Conservation (p. 25). NOAA Technical Memorandum NMFS-SEFSC-536.

Alefaio, S. T., & Alefaio, A. R. (2006). Turtle monitoring on Funafuti, Tuvalu, 4th December-14th December (p. 8). Administered by the Institute of Marine Resources, the Universtiy of the South Pacific, Suva. 8 pages.

Alfaro-Shigueto, J., J.C. Mangel, F. Bernedo, P.H. Dutton, J.A. Seminoff, and B.J. Godley. 2011. Small-scale fisheries of Peru: a major sink for marine turtles in the Pacific. Journal of Applied Ecology. doi: 10.1111/j.1365-2664.2011.02040.x

Allen, M. S. (2007). Three millennia of human and sea turtle interactions in Remote Oceania. Coral Reefs, 26(4), 959–970. doi:10.1007/s00338-007-0234-x

Alvarado-Ulloa, M.A. 1990. The results of more than two years of turtle egg harvests at Ostional, Costa Rica. Pp. 175-178 in: T.H. Richardson, J.I. Richardson, and M. Donnelly (compilers), Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation. U.S. Dept. of Comm., NOAA Tech. Memo. NMFS-SEFC-278. 286 p.

Anan, Y., Kunito, T., Watanabe, I., Sakai, H., & Tanabe, S. (2001). Trace element accumulation in hawksbill turtles (Eretmochelys imbricata) and green turtles (Chelonia mydas) from Yaeyama Islands, Japan. Environmental Toxicology and Chemistry, 20(12), 2802–2814.

Andrews, H. V. (2000). Current marine turtle situation in the Andaman and Nicobar Islands - An urgent need for conservation action. Kachhapa, 3, 21–25.

Andrews, H. V., Krishnan, S., & Biswas, P. (2006). Distribution and status of marine turtles in the Andaman and Nicobar Islands. In K. Shanker & B. C. Choudhury (Eds.), Marine turtles of the Indian subcontinent, Part 2: Marine turtles of the Bay of Bengal (pp. 33–57). Hyderabad, India: Universities Press, Hyderabad.

Arauz, R.M., R. Vargas, L. Naranjo, and C. Gamboa. 1998. Analysis of the incidental capture of sea turtles in the shrimp fleet of Pacific Costa Rica. Pp. 1-5 in: S.P. Epperly and J. Braun (compilers), Proceedings of the 17th Annual Sea Turtle Symposium. U.S. Dept. of Comm., NOAA Tech. Memo. NMFS-SEFSC-415. 342 p.

Arena, P. and M. Hall. 1992. The association of sea turtles and other pelagic fauna with floating objects in the eastern tropical Pacific Ocean. Pp. 7-10 in M. Salmon and J. Wyneken (compilers), Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation. U.S. Dept. of Comm., NOAA Tech. Memo. NMFS-SEFSC-302.

Arendt, M.D., J.A. Schwenter, B.E. Witherington, A.B. Meylan, V.S. Saba. 2013. Historical versus Contemporary Climate Forcing on the Annual Nesting Variability of Loggerhead Sea Turtles in the Northwest Atlantic Ocean. PLoS ONE 8(12): e81097.

Arias, L. 2013. Costa Rice bans shrimp trawling. The Tico Times. August 7, 2013. http://www.ticotimes.net/2013/08/08/costa-rica-bans-shrimp-trawling

Arthur, C., J. Baker, and H. Bamford (eds). 2009. Proceedings of the International Research Workshop on the Occurrence, Effects and Fate of Microplastic Marine Debris. Sept 9-11, 2008. U.S. Dept. of Comm., NOAA Tech. Memo. NOS-OR&R-30. 49 p.

Baker, J.D., C.L. Littnan, and D.W. Johnston. 2006. Potential effects of sea level rise on the terrestrial habitats of endangered and endemic megafauna in the Northwestern Hawaiian Islands. Endangered Species Research 4: 1-10.

Balazs, G.H. 1975. Marine turtles in the Phoenix Islands. Atoll Research Bulletin No. 184.

Balazs, G. H. 1976. Green turtle migrations in the Hawaiian archipelago. Biological Conservation 9: 125-140.

Balazs, G. H. 1980. Synopsis of biological data on the green turtle in the Hawaiian Islands. U.S. Dept. of Comm., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-7. 141 p.

Balazs, G.H. 1983. Recovery records of adult green turtles observed or originally tagged at French Frigate Shoals, Northwestern Hawaiian Islands. U.S. Dept. of Comm., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-36. 42 p.

Balazs, G.H. 1985. Impact of ocean debris on marine turtles: Entanglement and Ingestion. In: R.S. Shomura and H.O. Yoshida (eds.), Proceedings of the Workshop on the Fate and Impact of Marine Debris, 27-29 November 1984. Honolulu Hawaii. U. S. Dept. of Comm., NOAA Tech. Memo. NMFS-SWFC-54, pp. 387-429.

Balazs, G.H. 1994. Homeward bound: satellite tracking of Hawaiian green turtles from nesting beaches to foraging pastures. Pp. 205-208 in: Schroeder, B.A. and B.E. Witherington (compilers), Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation. U. S. Dept. of Comm., NOAA Technical Memorandum NMFS-SEFSC-341.

Balazs, G.H. 1996. Behavioral changes within the recovering Hawaiian green turtle population. In: Proceedings of the 15th Annual Symposium on sea turtle biology and conservation. U. S. Dept. of Comm., NOAA Tech. Memo. NMFS-SEFSC 387, pp.16-20.

Balazs, G.H., P. Siu and J.P. Landret. 1995. Ecological aspects of green turtles nesting at Scilly Atoll in French Polynesia. In: Richardson, J.I. and T.H. Richardson (compilers).

Proceedings of the Twelfth Annual Workshop on Sea Turtle Biology and Conservation, NOAA Technical Memorandum NMFS-SEFSC-361, p.7-10.

Balazs, G.H. and M. Chaloupka. 2004. Thirty-year recovery trend in the once depleted Hawaiian green sea turtle stock. Biological Conservation 117: 491-498.

Balazs, G.H. and G.C. Whittow. 1982. Basking behavior of the Hawaiian green turtle Chelonia mydas. Pacific Science 36(2): 129-139.

Barnett, J. 2001. Adapting to climate change in Pacific Island countries: The problem of uncertainty. World Development 29(6): 977-993.

Barr, J.M. 2006. Community based sea turtle monitoring and management at Helen Reef, Hatohobei State, Republic of Palau. Master’s Thesis, Oregon State University. 216 p.

Bartram, P.K. and J.J. Kaneko. 2004. Catch to bycatch ratios: Comparing Hawaii's longline fishery with others. SOEST Publication 04-05, JIMAR Contribution 04-352. 40 p.

Bell, B.A., J.R. Spotila, F.V. Paladino, and R.D. Reina. 2003. Low reproductive success of leatherback turtles, Dermochelys coriacea, is due to high embryonic mortality. Biological Conservation 115:131-138.

Bell, L., J. Ward, and P. Ifopo. 2009. Marine turtles strand on land after the Samoa Tsunami. SPREP/DEC technical report.

Bell, C. D., Blumenthal, J. M., Broderick, A. C., & Godley, B. J. (2010). Investigating potential for depensation in marine turtles: how low can you go? Conservation Biology, 24(1), 226–235. doi:10.1111/j.1523-1739.2009.01313.x

Benaka, L.R., Cimo, L.F. and L.D. Jenkins. 2012. Bycatch Provisions in the Reauthorized Magnuson-Stevens Act. Marine Fisheries Review 74(2): 1-12.

Beverly, S. and L. Chapman. 2007. Interactions between sea turtles and pelagic longline fisheries. Western and Central Pacific Fisheries Commission, Scientific Committee Third Regular Session, August 13-24 2007, WCPFC-SC3-EB SWG/IP-01. 76.

Binckley, C.A., J.R. Spotila, K.S. Wilson, and F.V. Paladino. 1998. Sex determination and sex ratios of Pacific leatherback turtles, Dermochelys coriacea. Copeia 1998(2): 291-300.

Bjorndal, K.A., A.B. Bloten, and C.J. Lagueux. 1994. Ingestion of marine debris by juvenile sea turtles in coastal Florida habitats. Marine Pollution Bulletin 28(3): 154-158.

Blanco, G. S. (2010). Movements and Behavior of the East Pacific Green Turtle (Chelonia mydas) from Costa Rica. PhD thesis, Drexel University.

Broderick, D. 1998. Subsistence harvesting of marine turtles in the Solomon Islands. Patterns of resource use in Kia, Wagina, and Katupika communities, Isabel and Choiseul Provinces.

Progress Report, Center for Conservation Biology and the Department of Zoology, University of Queensland, Brisbane, Australia. 12pp.

Bugoni, L., L. Krause, and M.V. Petry. 2001. Marine Debris and Human Impacts on Sea Turtles in Southern Brazil. Marine Pollution Bulletin 42(12): 1330-1334.Bush, A. 2003.

Bureau of Marine Resources. (2005). Palau marine turtle conservation and management project, September 2004 to September 2005. Bureau of Marine Resources, Republic of Palau.

Camiñas, J. A. (2004). Sea turtles of the Mediterranean Sea: population dynamics, sources of mortality and relative importance of fisheries impacts. In Papers presented at the Expert Consultation on Interactions between Sea Turtles and Fisheries within an Ecosystem Context (pp. 27–84). Rome, Italy: FAO Fisheries Report. No. 738, Supplement.

Campbell, L.M. 1998. Use them or lose them? Conservation and the consumptive use of marine turtle eggs at Ostional, Costa Rica. Environmental Conservation 25(4): 305-319.

Campbell, L.M., B.J. Haalboom, and J. Trow. 2007. Sustainability of community-based conservation: sea turtle egg harvesting in Ostional (Costa Rica) ten years later. Foundation for Environmental Conservation 34: 1–10.

Carr, A. 1987. New perspectives on the pelagic stage of sea turtle development. Conservation Biology 1(2): 103-121.

Chaloupka, M., 2001. Historical trends, seasonality and spatial synchrony in green turtle egg production. Biological Conservation 101: 263–279.

Chaloupka, M. and C. Limpus. 2001. Trends in the abundance of sea turtles resident in southern Great Barrier Reef waters. Biological Conservation 102: 235-249.

Chaloupka, M., K.A. Bjorndal, G.H. Balazs, A.B. Bolten, L.M. Ehrhart, C.J. Limpus, H. Suganuma, S. Troeng, and M. Yamaguchi. 2007. Encouraging outlook for recovery of a once severely exploited marine megaherbivore. Global Ecology and Biogeography. Published online December 11, 2007. DOI: 10.1111/j.1466-8238.2007.00367.x.

Chaloupka, M., N. Kamezaki, and C. Limpus. 2008a. Is climate change affecting the population dynamics of the endangered Pacific loggerhead sea turtle? Journal of Experimental Marine Biology and Ecology 356: 136-143.

Chaloupka, M., G.H. Balazs, S.K.K. Murakawa, R. Morris, and T.M. Work. 2008b. Cause-specific spatial and temporal trends in green sea turtle strandings in the Hawaiian Archipelago. Marine Biology 154: 887-898.

Chaloupka, M. Y., Bjorndal, K. A., Balazs, G. H., Bolten, A. B., Ehrhart, L. M., Limpus, C. J., Yamaguchi, M. 2008c. Encouraging outlook for recovery of a once severely exploited marine megaherbivore. *Global Ecology and Biogeography*, *17*, 297–304. doi:10.1111/j.1466-8238.2007.00367.x

Chaloupka M, G.H. Balazs, and T.M. Work. 2009. Rise and fall over 26 years of a marine epizootic in Hawaiian green sea turtles. Journal of Wildlife Diseases 45: 1138–1142.

Chan, E.H. and H.C. Liew. 1995. Incubation temperatures and sex ratios in the Malaysian leatherback turtle Dermochelys coriacea. Biological Conservation 74: 169-174.

Chan, E. H., Liew, H. C., & Mazlan, A. G. (1988). The incidental capture of sea turtles in fishing gear in Terengganu, Malaysia. Biological Conservation, 43, 1–7.

Chan, H.L. and M. Pan. 2012. Spillover effects of environmental regulation for sea turtle protection: the case of the Hawaii shallow-set longline fishery. U.S. Dep. Of Comm., NOAA Tech. Memo. NMFS-PIFSC-30. 38 p. + Appendices.

Chan, S.K., I.-J. Cheng, T. Zhou, H.-J. Wang, H.-X. Gu, and X.-J. Song. 2007. A comprehensive overview of the population and conservation status of sea turtles in China. Chelonian Conservation and Biology 6(2): 185-198.

Chandi, M., Deol, R., & Shetty, R. S. (2012). Socioeconomic Monitoring for Coastal Managers of South Asia: Field Trials and Baseline Surveys, Havelock and Neil Islands, Rani Jhansi Marine National Park, Andaman Islands, ANET, India.

Chantrapornsyl, S. (1993). Status of marine turtles in Thailand. In Proceedings of the First ASEAN Symposium-Workshop on Marine Turtle Conservation, Manila, Philippines (pp. 123–128).

Charuchinda, M., Monanunsap, S., & Chantrapornsyl, S. (2002). Status of sea turtle conservation in Thailand. In I. Kinan (Ed.), Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop. February 5–8, 2002 (pp. 179–184). Honolulu, Hawaii, USA: Honolulu, HI: Western Pacific Regional Fishery Management Council.

Chatto, R., Guinea, M. L., & Conway, S. (1995). Sea turtles killed by flotsam in northern Australia. Marine Turtle Newsletter, 69, 17–18.

Conant, T.A., P.H. Dutton, T. Eguchi, S.P. Epperly, C.C. Fahy, M.H. Godfrey, S.L. MacPherson,E.E. Possardt, B.A. Schroeder, J.A. Seminoff, M.L. Snover, C.M. Upite, and B.E. Witherington. 2009. Loggerhead sea turtle (Caretta caretta) 2009 status review under the U.S. Endangered Species Act. Report of the Loggerhead Biological Review Team to the National Marine Fisheries Service, August 2009. 222 pages.

Craig, P., B. Ponwith, F. Aitaoto, and D. Hamm. 1993. The commercial, subsistence, and recreational fisheries of American Samoa. Marine Fisheries Review 55(2):109-116.

Cruce, J. 2009. Monitoring of Nesting Green Turtles (Chelonia mydas) on Gielop Island and Loosiep Island, Ulithi Atoll, Yap, Federated States of Micronesia: 2009 Draft Technical Report Prepared for JIMAR. 23pp.

Cruz, R. D. (2002). Marine Turtle Distribution in the Philippines. In I. Kinan (Ed.), Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop (pp.

57–66). Honolulu, Hawaii, USA: Honolulu, HI: Western Pacific Regional Fishery Management Council.

Cummings, V. (2002). Sea turtle conservation in Guam. In I. Kinan (Ed.), Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop. February 5–8, 2002 (pp. 37–38). Honolulu, Hawaii, USA: Honolulu, HI: Western Pacific Regional Fishery Management Council.

Dapp, D., R. Arauz, J.R. Spotila, and M.P. O'Connor. 2013. Impact of Costa Rican longline fishery on its bycatch of sharks, stingrays, bony fish and olive ridley turtles (Lepidochelys olivacea). Journal of Experimental Marine Biology and Ecology 448: 228–239.

Division of Aquatic and Wildlife Resources. (2011). Final annual progress report, Guam sea turtle recovery (p. 19).

Department of Marine and Wildlife Resources American Samoa (DMWR). 2015. Investigation into the status of Marine turtles of Manu'a Islands, American Samoa: An Intense Monitoring of Hawksbill Nesting Beaches in OFU Island and Nesting Beach Mapping of Ta'u Island FY 14. Investigator: Mark A. MacDonald.

Delgado S.G. and W.J. Nichols. 2005. Saving sea turtles from the ground up: awakening sea turtle conservation in northwestern Mexico. Maritime Studies 4: 89-104.

Del Monte-Luna, P., V. Guzmán-Hernández, E.A. Cuevas, F. Arreguín-Sánchez, and D. Lluch-Belda. 2012. Effect of North Atlantic climate variability on hawksbill turtles in the Southern Gulf of Mexico. Journal of Experimental Marine Biology and Ecology 412: 103-109.

Dethmers, K. E. M., Jensen, M. P., FitzSimmons, N. N., Broderick, D., Limpus, C. J., & Moritz, C. (2010). Migration of green turtles (Chelonia mydas) from Australasian feeding grounds inferred from genetic analyses. Marine and Freshwater Research, 61(12), 1376–1387.

DEWHA. (2010). Australian Tuna and Billfish Longline Fisheries: Bycatch and discarding workplan (p. 19).

Donoso, M. and P.H. Dutton. 2010. Sea turtle bycatch in the Chilean pelagic longline fishery in the southeastern Pacific: Opportunities for conservation. Biological Conservation 143: 2672–2684.

Doyle, M., W. Watson, N. Bowlin, and S. Sheavly. 2011. Plastic particles in coastal pelagic ecosystems of the Northeast Pacific Ocean. Marine Environmental Research. 71(1): 41-52.

Dryden, J., Grech, A., Moloney, J., & Hamann, M. (2008). Rezoning of the Great Barrier Reef World Heritage Area: does it afford greater protection for marine turtles? Wildlife Research, 35(5), 477. doi:10.1071/WR07087

Dutton, P. H. and D. Squires. 2008. Reconciling biodiversity with fishing: a holistic strategy for Pacific sea turtle recovery. Ocean Development and International Law 39: 200–222.

Dutton, P.H., G.H. Balazs, R.A. LeRoux, S.K.K. Murakawa, P. Zarate, and L.S. Martinez. 2008. Composition of Hawaiin green turtle foraging aggregations: mtDNA evidence for a distinct regional population. Endangered Species Research 5: 37-44.

Eberdong, J., & Klain, S. (2008). Palau marine turtle conservation and monitoring program. In A. F. Rees, M. Frick, A. Panagopoulou, & K. Williams (Eds.), Proceedings of the Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation (pp. 230–231). NOAA Technical Memorandum NMFS-SEFSC-569.

Eckert, K.L. 1993. The biology and population status of marine turtles in the North Pacific. NOAA-TM-NMFS-SWFSC-186.

Edwards, M. and A.J. Richardson. 2004. Impact of climate change on marine pelagic phenology and trophic mismatch. Nature 430: 881-884.

Eguchi, T., T. Gerrodette, R.L. Pitman, J.A. Seminoff, and P.H. Dutton. 2007. At-sea density and abundance estimates of the olive ridley turtle Lepidochelys olivacea in the eastern tropical Pacific. Endangered Species Research 3: 191-203.

Fish, M.R., I.M. Cote, J.A. Gill, A.P. Jones, S. Renshoff, and A.R. Watkinson. 2005. Predicting the impact of sea –level rise on Caribbean sea turtle habitat. Conservation biology 19(2): 482-491.

Fish, M. R., Côté, I. M., Horrocks, J. A., Mulligan, B., Watkinson, A. R., & Jones, A. P. (2008). Construction setback regulations and sea-level rise: mitigating sea turtle nesting beach loss. Ocean & Coastal Management, 51(4), 330–341. doi:10.1016/j.ocecoaman.2007.09.002

Food and Agriculture Organization of the United Nations, 2004. Expert consultation on interactions between sea turtles and fisheries within an ecosystem context. FAO Fish. Rep.No. 738.

Francke, D.L., 2013. Marine Turtle Strandings in the Hawaiian Islands January-December 2012. Marine Turtle Research Program, Protected Species Division, NOAA Pacific Islands Fisheries Science Center.

Frazier, J. , R. Arauz, J. Chevalier, A. Formia, J. Fretey, M.H.Godfrey, R. Marquez, B Pandav, and K. Shanker. 2007. Human-turtle interactions at sea. Pp. 253-295 in: P.T. Plotkin (ed.), Biology and Conservation of Ridley Sea Turtles. The Johns Hopkins University Press, Baltimore, Maryland. 356 p.

Friedlander, A.M., Aeby, G., Brainard, R., Brown, E., Chaston, K., Clark, A., Mcgowan, P., Montgomery, T., Walsh, W., Williams, I., Wiltse, W., 2008. The state of coral reef ecosystems of the Main Hawaiian Islands, in: Waddell, J., Clarke, A.M. (Eds.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008. NOAA Technical Memorandum NOS NCCOS 73. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team. Silver Spring, MD, pp. 219–253.

Fuentes, M.M.P.B., C.J. Limpus, M. Hamann, and J. Dawson. 2009. Potential impacts of projected sea level rise on sea turtle rookeries. Aquatic Conservation Marine and Freshwater Ecosystems. DOI: 10.1002/aqc.1088.

Fuentes, M. M. P. B., Hamann, M., & Limpus, C. J. (2010). Potential impacts of projected sea level rise to sea turtle rookeries. Aquatic Conservation : Marine and Freshwater Ecosystems.

Fuentes, M. M. P. B., Limpus, C. J., & Hamann, M. (2011). Vulnerability of sea turtle nesting grounds to climate change. Global Change Biology, 17(1), 140–153. doi:10.1111/j.1365-2486.2010.02192.x

Gardner, S. and W. Nichols. 2001. Assessment of sea turtle mortality rates in the Bahia Magdalena region, Baja California Sur, Mexico. Chelonian Conservation and Biology 4(3): 197–199.

Gilman, E., D. Kobayashi, T. Swenarton, N. Brothers, P. Dalzell, and I. Kinan. 2007a. Reducing sea turtle interactions in the Hawaii-based longline swordfish fishery. Biological Conservation 139: 19-28.

Gilman, E., T. Moth-Poulsen, and G. Bianchi. 2007b. Review of measures taken by intergovernmental organizations to address sea turtle and seabird interactions in marine capture fisheries. FAO Fisheries Circular No. 1025. Food and Agricultural Organization of the United Nations, Rome. 42 p.

Gladstone, W., & Dight, I. J. (1994). Torres Strait baseline study. Marine Pollution Bulletin, 29(1), 121–125.

Godfrey, M.H., R. Barret, and N. Mrosovsky. 1996. Estimating past and present sex ratios of sea turtles in Suriname. Canadian Journal of Zoology 74: 267-277.

Godfrey, M.H., A.F. D'Amato, M.A. Marcovaldi, and N. Mrosovsky. 1999. Pivotal temperature and predicted sex ratios for hatchling hawksbill turtles from Brazil. Canadian Journal of Zoology 77: 1465-1473.

Godley, B.J., A. C. Broderick, and N. Mrosovsky. 2001. Estimating hatchling sex ratios of loggerhead turtles in Cyprus from incubation durations. Marine Ecology Progress Series 210: 195-201.

Goodwin, S. F. (2008). MARINE RESOURCES (LONG LINE FISHERY) REGULATIONS 2008.

Gordon, A., Pople, A., & Ng, J. (1998). Trace metal concentrations in livers and kidneys of sea turtles from south-eastern Queensland, Australia. Marine & Freshwater Research, 49(5), 409–414.

Government of Samoa. (1998). National report to the Convention on Biological Diversity. Division of Environment and Conservation, Department of Lands Survey and Environment, December.

Gribble, N. A., McPherson, G., & Lane, B. (1998). Effect of the Queensland Shark Control Program on non-target species: whale, dugong, turtle and dolphin, a review. Marine & Freshwater Research, 49, 645–651.

Groombridge, B., & Luxmoore, R. (1989). The green turtle and hawksbill (Reptilia: Cheloniidae): world status, exploitation and trade. Flora (p. 601). Lausanne, Switzerland: CITES.

Guam Division of Aquatic and Wildlife Resources. 2012. Guam sea turtle recovery. Final report to NMFS Pacific Islands Regional Office under grant number NA11NMF4540237.

Guilbeaux, M. D. (2001). USE Relating to sea turtles, their management, and policy in the Republic of Palau: an assessment of stakeholder perception. Volumes 1 & 2 (p. 164). Koror, Palau: The Palau Conservation Society. 164 pages.

Halim, M.H., Dermawan, A., 1999. Marine turtle research, management and conservation in Indonesia, in: Report of SEAFDEC-ASEAN Regional Workshop on Sea Turtle Conservation and Management. Kuala Trengganu, Malaysia, p. 328 pp.

Hamann, M., Cuong, C. T., Hong, N. D., Thuoc, P., & Thuhien, B. T. (2006). Distribution and abundance of marine turtles in the Socialist Republic of Viet Nam. Biodiversity and Conservation, 15(11), 3703–3720. doi:10.1007/s10531-005-4880-4

Hamann, M., Limpus, C. J., & Read, M. (2007). Vulnerability of sea turtle nesting grounds to climate change. In Climate Change and the Great Barrier Reef: A Vulnerability Assessment. Part II: Species and Species Group (pp. 466–496).

Hatase, H., M. Kinoshita, T. Bando, N. Kamezaki, K. Sato, Y. Matsuzawa, K. Goto, K. Omita, Y. Nakashima, H. Takeshita, and W. Sakamoto. 2002. Population structure of loggerhead turtles, Caretta caretta, nesting in Japan: bottlenecks on the Pacific population. Marine Biology 141: 299-305.

Havea, S. and K.T. MacKay. 2009. Marine turtle hunting in the Ha`apai Group, Tonga. Marine Turtle Newsletter 123: 15-17.

Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2007. Investigating the potential impacts of climate change on a marine turtle population. Global Change Biology 13: 923-932.

Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2009. Climate change and marine turtles. Endangered Species Research 7: 137-154.

Hay, E., & Sablan-Zebedy, E. (2005). USE Republic of the Marshall Islands: country environmental analysis (p. 157). ADB Technical Assistance Consultant’s Report.

Hays, G.C., A.C. Broderick, F. Glen, and B.J. Godley. 2003. Climate change and sea turtles: a 150-year reconstruction of incubation temperatures at a major marine turtle rookery. Global Change Biology 9(4): 642-646.

Hays, G.C., A.J. Richardson, and C. Robinson. 2005. Climate change and marine plankton. Trends in Ecology and Evolution 20(6): 337-344.

Hazel, J., I.R. Lawler, H. Marsh, and S. Robson. 2007. Vessel speed increases collision risk for the green turtle, Chelonia mydas. Endangered Species Research 3: 105–113.

Hazel, J., I.R. Lawler, and M. Hamann. 2009. Diving at the shallow end: green turtle behavior in near-shore foraging habitat. Journal of Experimental Marine Biology and Ecology 371: 84-92.

Helvey, M., & Fahy, C. C. (2012). Fisheries management off the U.S. West Coast: a progressive model for sea turtle conservation. In J. A. Seminoff & B. P. Wallace (Eds.), Sea Turtles of the Eastern Pacific: Advances in Research and Conservation (pp. 113–135). Tucson, Arizona: University of Arizona Press.

Henry, G. W., & Lyle, J. M. (2003). The National Recreational and Indigenous Fishing Survey.

Hitipeuw, C. and J. Maturbongs. 2002. Marine turtle conservation program Jamurbamedi nesting beach, North Coast of the Birds Head Peninusla, Papua. Pp. 161- 175 in: I. Kinan (ed.), Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop, February 5-8, 2002, Honolulu, Hawaii. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii. 300 p.

Hitipeuw, C., & Pet-Soede, L. (2004). A need to align and integrate incentive strategies. In Expert Consultation on Interactions between Sea Turtles and Fisheries within an Ecosystem Context (p. 238 pp). Rome: FAO Fisheries Report. No. 738, Supplement, FAO.

Horikoshi, K., Suganuma, H., Tachikawa, H., Sato, F., & Yamaguchi, M. (1994). Decline of Ogasawara green turtle population in Japan. In K. A. Bjorndal, A. B. Bolten, D. A. Johnson, & P. J. Eliazar (Eds.), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation (pp. 235–236). Miami, FL: US Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-351.

Hussain, M. G., & Hoq, M. E. (2010). Sustainable management of fisheries resources of the Bay of Bengal-Compilation of national and regional workshop Reports. Support to Sustainable Management of the BOBLME Project, Bangladesh Fisheries Research Institute. SBOBLMEP Pub./Rep.2., 122 p.

Howell, E.A., D.R. Kobayashi, D.M. Parker, G.H. Balazs, and J.J. Polovina. 2008. TurtleWatch: A tool to aid in the bycatch reduction of loggerhead turtles *Caretta caretta* in the Hawaii-based pelagic longline fishery. Endangered Species Research 5: 267-278.

Hutchinson, J. and M.P. Simmonds. 1992. Escalation of threats to marine turtles. Oryx: 26: 95-102.IATTC (Inter-American Convention for the protection and conservation of sea turtles).

2012. Conservation status and Habitat use of sea turtles in the Eastern Pacific Ocean. CIT-CC8-2011-Tec.1. 27 p.

Inter-American Convention for the protection and conservation of sea turtles. 2012. Conservation Status and Habitat use of sea turtles in the Eastern Pacific Ocean. CIT-CC8-2011-Tec.1

IOSEA (Indian Ocean – South-east Asian Marine Turtle Memorandum of Understanding). 2013. 2012 End-of-Year Review and Look Ahead to 2013. IOSEA Feb 2013 electronic newsletter. 27 p.

IPCC (Intergovernmental Panel on Climate Change). 2007. Summary for Policymakers. Pp. 1-18 in: S. Solomon, D. Quin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, and New York, New York, USA.

Isamu, T., & Guilbeaux, M. D. (2002). USE Sea turtle conservation in Palau. In I. Kinan (Ed.), Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop (pp. 195–196). Western Pacific Regional Fishery Management Council, Honolulu, Hawaii.

Ishihara, T. 2007. Coastal bycatch investigations. Presentation at North Pacific Loggerhead Expert Workshop, December 19-20, 2007. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii.

Ishihara, T. 2009. Status of Japanese Coastal Sea Turtle Bycatch. In: E. Gilman (Ed.), Proceedings of the Technical Workshop on Mitigating Sea Turtle Bycatch in Coastal Net Fisheries. 20-22 January 2009, Honolulu, U.S.A. Western Pacific Regional Fishery Management Council, IUCN, Southeast Asian Fisheries Development Center, Indian Ocean – South-East Asian Marine Turtle MoU, U.S. National Marine Fisheries Service, Southeast Fisheries Science Center: Honolulu; Gland, Switzerland; Bangkok; and Pascagoula, USA. 76 p.

Ishihara T., N. Kamezaki, Y. Matsuzawa, F. Iwamoto, T. Oshika, Y. Miyagata, C. Ebisui, and S. Yamashita. 2011. Reentery of juvenile and subadult loggerhead turtles into natal waters of Japan. Current Herpetology 30(1): 63–68.

Ishihara, T., Y. Matsuzawa, J. Wang, and H. Peckman. 2012. Building a Better Pound Net. SWOT Report p.16

Ishizaki, A. (2007). Toward reducing human-caused impacts on green turtle (Chelonia mydas) nesting activity in Ogasawara Islands, Japan. Colorado State University, Fort Collins, Colorado.

Ishizaki, A. 2015. Protected Species Conservation by the Western Pacific Regional Fishery Management Council. Pacific Islands Fishery Monographs, No.4. Western Pacific Regional

Fishery Management Council, Honolulu, HI. http://www.wpcouncil.org/fisheryplans-policies-reports/monographs/

Iwamoto, T., M. Ishii, Y. Nakashima, H. Takeshita, and A. Itoh. 1985. Nesting cycles and migrations of the loggerhead sea turtle in Miyazaki, Japan. Japanese Journal of Ecology 35: 505-511.

Jit, J. N. (2007). Status of sea turtle conservation in Fiji: an assessment of the international, regional and national Focus. School of Marine Studies, University of the South Pacific.

Jones T.T, and S.L. Martin 2016. Population-level impacts of proposed incidental take of olive ridley, loggerhead, and green turtles in the Hawaii deep-set longline fishery. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-17-007. 6p.

Jonzén N, Ergon T, Lindén A, Stenseth NC (2007) Introduction (Bird migration and climate, Spec Issue 17). Climate Research 35:1–3.

Kabua, E., Langidrik, M., Boktok, K., Parker, D.M., Frutchey, K.P., 2012. Marine turtle-fisheries interaction mitigation training, data collection activities and satellite telemetry in the Republic of the Marshall Islands, in: Belskis, L., Frick, M., Panagopoulou, A., Rees, A.F., Williams, K. (Eds.), Proceedings of the Twenty-Ninth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NOAA NMFS-SEFSC-630, Brisbane, Australia, p. 120.

Kamezaki, N., I. Miyakawa, H. Suganuma, K. Omuta, Y. Nakajima, K. Goto, K. Sato, Y. Matsuzawa, M. Samejima, M. Ishii, and T. Iwamoto. 1997. Post-nesting migration of Japanese loggerhead turtle, Caretta caretta. Wildlife Conservation Japan 3: 29-39.

Kamezaki, N., Y. Matsuzawa, O. Abe, H. Asakawa, T. Fujii, K. Goto, S. Hagino, M. Hayami, M. Ishii, T. Iwamoto, T. Kamata, H. Kato, J. Kodama, Y. Kondo, I. Miyawaki, K. Mizobuchi, Y. Nakamura, Y. Nakashima, H. Naruse, K. Omuta, M. Samejima, H. Suganuma, H. Takeshita, T. Tanaka, T. Toji, M. Uematsu, A. Yamamoto, T. Yamato, and I. Wakabayashi. 2003. Loggerhead Turtles Nesting in Japan. Pp. 210-217 in: A.B. Bolten and B.E. Witherington (eds.), Loggerhead Sea Turtles. Smithsonian Institution, Washington. 319 pp.

Kamrowski, R. L., Limpus, C. J., Jones, R., Anderson, S., & Hamann, M. (2014). Temporal changes in artificial light exposure of marine turtle nesting areas. Global Change Biology. doi:10.1111/gcb.12503

Kaneko, J.J. and P.K. Bartram. 2008. What if you don’t speak “CPUE-ese”? Pelagic Fisheries Research Program Newsletter, University of Hawaii, 13(2): 1-3.

Kaska, Y., Ç. Ilgaz, A. Özdemir, E. Başkale, O. Türkozan, İ. Baran and M. Stachowitsch. 2006. Sex ratio estimations of loggerhead sea turtle hatchlings by histological examination and nest temperatures at Fethiye beach, Turkey. Naturwissenschaften 93(7): 338-343.

Kasparek, M., Godley, B. J., & Broderick, A. C. (2001). Nesting of the Green Turtle, Chelonia mydas, in the Mediterranean: a review of status and conservation needs. Zoology in the Middle East, 24, 45–74.

Keller, J.M., J.R. Kucklick, M.A. Stamper, C.A. Harms, and P.D. McClellan-Green. 2004. Associations between organochlorine contaminant concentrations and clinical health parameters in loggerhead sea turtles from North Carolina, U.S.A. Environmental Health Perspectives 112(10): 1074-1079.

Kelliher, S., Lusty, C., & Prophet, M. (2011). Ningaloo turtle program annual report 2010-2011. Ningaloo Turtle Program, Exmouth, Western Australia.

Kittinger, J.N., K.S. Van Houtan, L.E. McClenachan, and A.L. Lawrence. 2013. Using historical data to assess the biogeography of population recovery. Ecography 36(8): 868-872.

Klain, S., Eberdong, J., Kitalong, A., Yalap, Y., Matthews, E., Eledui, A., Morris, M., Andrew, W., Albis, D., Kemesong, P., 2007. Linking Micronesia and Southeast Asia: Palau sea turtle satellite tracking and flipper tag returns. Mar. Turt. Newsl. 118, 9–11.

Kobayashi, D.R., J.J. Polovina, D.M. Parker, N. Kamezaki, I.J. Cheng, I Uchida, P.H. Dutton and G.H. Balazs. 2008. Pelagic habitat utilization of loggerhead sea turtles, Caretta caretta, in the North Pacific Ocean (1997-2006): Insights from satellite tag tracking and remotely sensed data. Journal of Experimental Marine Biology and Ecology 356: 96-114.

Kobayashi, D.R., I-J. Cheng, D.M. Parker, J.J. Polovina, N. Kamezaki, and G.H. Balazs. 2011. Loggerhead turtle (Caretta caretta) movement off the coast of Taiwan: characterization of a hotspot in the East China Sea and investigation of mesoscale eddies. ICES Journal of Marine Science 68(4): 707-718.

Koch, V., W.J. Nichols, H. Peckham, and V. de la Toba. 2006. Estimates of sea turtle mortality from poaching and bycatch in Bahía Magdalena, Baja California Sur, Mexico. Biological Conservation 128: 327-334.

Koch V, H. Peckham, A. Mancini, and T. Eguchi. 2013. Estimating At-Sea Mortality of Marine Turtles from Stranding Frequencies and Drifter Experiments. PLoSONE 8(2): e56776.

Kolinski, S. P., Hoeke, R. K., Holzwarth, S. R., & Vroom, P. S. (2005). Sea Turtle Abundance at Isolated Reefs of the Mariana Archipelago. Micronesica, 37(2), 287–296.

Kolinski, S.P., R.K. Hoeke, S.R. Holzwarth, L.I. Ilo, E.F. Cox, R.C. O'Conner, and P.S. Vroom. 2006. Nearshore distribution and an abundance estimate for green sea turtles, Chelonia mydas, at Rota Island, Commonwealth of the Northern Mariana Islands. Pacific Science 60(4): 509–522.

Kowarsky, J. (1982). Subsistence hunting of sea turtles in Australia. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (pp. 305–313). Washington D.C.: Smithsonian Institution Press.

Krogh, M., & Reid, D. (1996). Bycatch in the protective shark meshing programme off south-eastern New South Wales, Australia. Biological Conservation, 77, 219–226.

Kudo, H., A. Murakami, and S. Watanabe. 2003. Effects of sand hardness and human beach use on emergence success of loggerhead sea turtles on Yakushima island, Japan. Chelonian Conservation and Biology 4(3): 695-696.

Kumoru, L. (2008). Tuna fisheries report – Papua New Guinea.

Kwan, D., & Bell, I. (2003). Response to community concerns about green turtle (Chelonia mydas) and dugong (Dugong dugon) in waters adjacent to the Wellesley Group of islands in the Gulf of Carpentaria. Report to the Mornington Shire Council (unpublished).

Law, K., S. Moret-Ferguson, N. Maximenko, G. Proskurowski, E. Peacock, J. Hafner, and C. Reddy. 2010. Plastic Accumulation in the North Atlantic Subtopical Gyre. Science 329(5996): 1185-1188.

Leroux, R.A., G.H. Balazs, and P.H. Dutton. 2003. Genetic stock composition of foraging green turtles off the southern coast of Moloka'I, Hawai'i. In: J.A. Seminoff (ed.), Proceedings of teh 22nd Annual Symposium on Sea Turtle Biology and Conservation. U.S. Dept. of Comm., NOAA Tech. Memo. NMFS-SEFSC-503.

Lewison, R.L., S.A. Freeman, and L.B. Crowder. 2004. Quantifying the effects of fisheries on threatened species: the impact of pelagic longlines on loggerhead and leatherback sea turtles. Ecology Letters 7: 221-231.

LI, Y. H., HUANG, X. P., & YUE, W. Z. (2004). Environmental quality and management measures in Yongxing Island of Xisha Archipelago, South China Sea. Marine Environmental Science, 23(1), 50–53.

Liew, H.-C., 2002. Status of marine turtle conservation and research in Malaysia, in: Kinan, I. (Ed.), Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop. February 5–8, 2002. Honolulu, HI: Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, USA, pp. 51–56.

Limpus, C.J. 2006. Impacts of climate change on marine turtles: A case study. Pp. 34-39 in: H. Frisch (ed.), Migratory species and climate change: impacts of a changing environment on wild animals. UNEP/CMS Secretariat, Bonn.

Limpus, C.J. 2009a. A biological review of Australian marine turtle species: Chapter 4, Olive Ridley. The State of Queensland, Environmental Protection Agency. Pp. 220-245.

Limpus, C.J. 2009b. A biological review of Australian marine turtle species: Chapter 2, Green Turtle. The State of Queensland, Environmental Protection Agency. Pp. 72-165.

Limpus, C.J. and N. Nicholls, 1994. Progress report on the study of the interaction of the El Niño — Southern Oscillation on annual Chelonia mydas at the southern Great Barrier Reef rookeries. In: R. James, Editor, Proceedings of the Marine Turtle Conservation Workshop, Australian National Parks and Wildlife Service, Canberra (1994), pp. 73–78.

Limpus, C. J., & Nicholls, N. (2000). ENSO regulation of indo-Pacific green turtle populations. In G. L. Hammer, N. Nicholls, & C. Mitchell (Eds.), Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems (Vol. 21, pp. 399–408). Dordrecht, The Netherlands: Kluwer Academic Publications.

Limpus, C.J., J.D. Miller, D.J. Limpus, and M. Hamann. 2002. The Raine Island green turtle rookery: Y2K update. Pages 132-134 in Mosier, A., A. Foley, and B. Brost (editors). Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-477.

Limpus, C. J., J.D. Miller, C.J. Parmenter, and D.J. Limpus. 2003. The green turtle, Chelonia mydas, population of Raine Island and the northern Great Barrier Reef, 1843-2001. Memoirs of the Queensland Museum 49: 349-440.

Limpus, C.J., D.J. Limpus, M. Munchow, and P. Barnes. 2007. Queensland Turtle Conservation Project: Raine Island Turtle Study, 2004-2005, Environmental Protection.

Limpus, C. & Casale, P. 2015. Caretta caretta (South Pacific subpopulation). The IUCN Red List of Threatened Species 2015: e.T84156809A84156890. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T84156809A84156890.en

Lutz, P. and J. Musick. 1997. The Biology of Sea Turtles. CRC Press. 887 p.

MacLeod, C.D. 2009. Global Climate Change, range changes and potential implications for the conservation of marine cetaceans: a review and synthesis. Endangered Species Research7: 125-136.

Maison K.A., I. Kinan Kelly, and K.P. Frutchey. 2010. Green turtle nesting sites and sea turtle legislation throughout Oceania. U.S. Dept. of Comm., NOAA Tech. Memo. NMFS-F/SPO-110. 52 p.

Mancini A, J. Senko, R. Borquez-Reyes, J.G. Po´o, J.A. Seminoff, and V. Koch. 2011. To poach or not to poach an endangered species: Elucidating the economic and social drivers behind illegal sea turtle hunting in Baja California Sur, Mexico. Human Ecology 39: 743–756.

Mancini, A., Koch, V., Seminoff, J. A., & Madon, B. (2012). Small-scale gill-net fisheries cause massive green turtle Chelonia mydas mortality in Baja California Sur, Mexico. Oryx, 46(1), 69–77. doi:10.1017/S0030605310001833

Marcovaldi, M.A., M.H. Godfrey, and N. Mrosovsky. 1997. Estimating sex ratios of loggerhead turtles from pivotal incubation durations. Canadian Journal of Zoology 75(5): 755-770.

Martin del Campo, J.R; C.D. Ortega; M.A. Pardo, and A. Abreu. 2014. Abundance estimation of the olive ridley turtle in the Mexican Central Pacific waters during 2010. 34th Annual

Symposium on Sea Turtle Biology and Conservation, April 10-17, 2014, New Orleans, Louisiana, USA.

Matsuzawa, Y. 2006. Nesting beach management of eggs and pre-emergent hatchlings of north Pacific loggerhead turtles in Japan. Pp. 13-22 in I. Kinan (ed.), Proceedings of the Second Western Pacific Sea Turtle Cooperative Research and Management Workshop, Vol. II: North Pacific Loggerhead Sea Turtles. March 2-3, 2005, Honolulu, Hawaii. Western Pacific Regional Fishery Management Council. Honolulu, Hawaii. 96 p.

Matsuzawa, Y., Ishihara, T., Wang, J., and H. Peckham. 2012. Poundnet escape devices (PEDs) can mitigate loggerhead bycatch in Japanese coastal fisheries. 32nd Annual Symposium on Sea Turtle Biology and Conservation, March 13-16, 2012, Huatulco, Mexico.

McCauley, S. J., & Bjorndal, K. A. (1999). Conservation implications of dietary dilution from debris ingestion: sublethal effects in post-hatchling loggerhead sea turtles. Conservation Biology, 13(4), 925–929.

McCoy, M. A. (2003). Some aspects of sea turtle interaction with tuna longline fleets in The Federated States of Micronesia (p. 19).

McCoy, M.A., 2007a. Marshall Islands sea turtle-fisheries interaction outreach and education, phase 2. Final Report to the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Islands Region, January 2, 2007. 43 pages.

McCoy, M.A., 2007b. Sea turtle bycatch mortality mitigation in the Palau tuna longline fishery. Report to the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Islands Region, Contract AB133F-05-SE-6409, December 31, 2007. 43 pages.

McCoy, M. A. (2008). Sea turtle bycatch mortality mitigation and outreach: Fiji and Cook Islands longline fisheries. Final report. National Oceanic and Atmospheric Administration Contract Number AB133F07SE3919. Gillbert, Preston and Associates Inc.

McCracken, M.L. 2000. Estimation of Sea Turtle Take and Mortality in the Hawaiian Longline Fisheries. National Marine Fisheries Service, Southwest Fisheries Science Center, Administrative Report H-00-06. 29 p.

McCracken, M.L. 2006. Estimation of incidental interactions with sea turtles, seabirds, and marine mammals in the 2005 Hawaii longline deep-set fishery. National Marine Fisheries Service, Pacific Islands Fishery Science Center, PIFSC Internal Report IR 06-006. 3 p.

McCracken, M.L. 2007. Estimation of incidental interactions with sea turtles, seabirds, and marine mammals in the 2006 Hawaii longline deep-set fishery. National Marine Fisheries Service, Pacific Islands Fishery Science Center, PIFSC Internal Report IR 07-006. 4 p.

McCracken, M.L. 2008. Estimation of incidental interactions with sea turtles, seabirds, and marine mammals in the 2007 Hawaii longline deep-set fishery. National Marine Fisheries Service, Pacific Islands Fishery Science Center, PIFSC Internal Report IR 08-007. 3 p.

McCracken, M.L. 2009a. Estimation of incidental interactions with sea turtles and seabirds in the 2008 Hawaii longline deep set fishery. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-09-011. 4 p.

McCracken, M.L. 2009b. Estimation of incidental interactions with sea turtles and seabirds in the 2009 Hawaii longline deep set fishery. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-10-009. 3 p.

McCracken, M.L. 2011. Estimation of incidental interactions with sea turtles and seabirds in the 2010 Hawaii longline deep set fishery. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-11-005. 3 p.

McCracken, M.L. 2012. Estimation of incidental interactions with sea turtles and seabirds in the 2011. Hawaii longline deep set fishery. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-12-012. 3 p.

McCracken, M.L. 2013. Estimation of incidental interactions with sea turtles and seabirds in the 2012. Hawaii longline deep set fishery. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-13-014. 6 p.

McCracken, M.L. 2014. Estimation of incidental interactions with sea turtles and seabirds in the 2013. Hawaii longline deep set fishery. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-14-022. 4 p.

McMahon, C.R. and G.C. Hayes. 2006. Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. Global Change Biology 12: 1330-1338.

Molony, B. 2005. Estimates of the mortality of non-target species with an initial emphasis on seabirds, turtles, and sharks. Working Paper prepared for the 1st Meeting of the Scientific Committee, Western and Central Pacific Fisheries Commission, WCPFC-SC1, EB-WP-1. 84 p.

Ministry of Fisheries. (2003). Conservation Status Report Marine Turtles and Their Habitats in Viet Nam (pp. 1–39). IUCN.

Miyawaki, I., Kamezaki, N.I., Kolinski, S.P., 2000. A migration of a green turtle from Yap Islands to Muroto, Kochi Prefecture, Japan. Umigame Newsl. Japan 45, 13.

Mrosovsky, N., G.D. Ryan, and M.C. James. 2009. Leatherback turtles: The menace of plastic. Marine Pollution Bulletin 58: 287-289.

Namboothri, N., Swaminathan, A., & Shanker, K. (2012). A compilation of data from Satish Bhaskar’s sea turtle surveys of the Andaman and Nicobar Islands. Indian Ocean Turtle Newsletter, 16, 4–13.

Newcombe, R. G. 1998. Two-sided confidence intervals for the single proportion: comparison of seven methods. Statistics in Medicine 17:857–872.

Newcombe, R. G. and D. G. Altman. 2000. Proportions and their differences. Pages 45–57 in D. G. Altman, D. Machin, T. N. Bryant, and M. J. Gardner, editors. Statistics with confidence. Second Edition. British Medical Journal Books, Bristol, United Kingdom.

Nicholls, R. J., & Cazenave, A. (2010). Sea-level rise and its impact on coastal zones. Science, 328, 1517–1520.

Nicholls, R.J. and N. Mimura. 1998. Regional issues raised by sea level rise and their policy implications. Climate Research 11: 5-18.

Nichols, W.J., A. Resendiz, J.A. Seminoff, and B. Resendiz. 2000. Transpacific migration of a loggerhead turtle monitored by satellite telemetry. Bulletin of Marine Science 67(3): 937-947.

Nichols, W. J., Aridjis, H., Hernandez, A., Machovina, B., & Villavicencios, J. (2002). Black market sea turtle trade in the Californias. WiLDCOAST.

Niethammer, K.R., G.H. Balazs, J.S. Hatfield, G.L. Nakai, and J.L. Megyesi. 1997. Reproductive biology of the green turtle (Chelonia mydas) at Tern Island, French Frigate Shoals, Hawaii. Pacific Science 51(1):36-47.

NMFS. 2004. Biological Opinion on Proposed Regulatory Amendments to the Fisheries Management Plan for the Pelagic Fisheries of the Western Pacific Region. Southwest Region. 281 p.

NMFS. 2005. Biological Opinion on Continued authorization of the Hawaii-based Pelagic, Deep-Set, Tuna Longline Fishery based on the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region. Pacific Islands Region. 168 p.

NMFS. 2006. Biological Opinion on the U.S. Western and Central Pacific Purse Seine Fishery as authorized by the South Pacific Tuna Act and the High Seas Fishing Compliance Act. Pacific Islands Region, 185 p.

NMFS. 2008a. Biological Opinion on Proposed Management Modifications for the Hawaii-based Shallow-set Longline Swordfish Fishery-Implementation of Amendment 18 to the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region. Pacific Islands Region. 91p.

NMFS. 2008b. Biological Opinion on effects of Implementation of Bottomfish Fishing Regulations within Federal Waters of the Main Hawaiian Islands on ESA-listed marine species. Pacific Islands Region. 35 p.

NMFS. 2010. Biological opinion on 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 on ESA-listed marine species. Pacific Islands Regional Office. 91 p.

NMFS. 2011. October 14, 2011, memo from Irene Kelly, Pacific Islands Regional Office, to the record re: Nesting trends of the North Pacific loggerhead DPS and Western Pacific leatherback turtle population.

NMFS. 2012. Biological opinion on continued operation of the Hawaii-based Shallow-set Longline Swordfish Fishery – under Amendment 18 to the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region. Pacific Islands Region. 162 p.

NMFS. 2013a. Biological opinion on continued management of the drift gillnet fishery under the Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species 2012/03020:DDL. Southwest Region. 158 p.

NMFS. 2013b. Improving International Fisheries Management Pursuant to Section 403(a) of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006. January 2013 Report to Congress. U.S. Dept. of Comm. 97 p.

NMFS. 2014a. Biological Opinion on the continued operation of the Hawaii-based deep-set pelagic longline fishery, 216 p.

NMFS. 2014b. Critical Habitat for the Northwest Atlantic Ocean Loggerhead Sea Turtle Distinct Population Segment (DPS) and determination regarding critical habitat for the North Pacific Ocean Loggerhead DPS. 79 FR 39855, July 10, 2014.

NMFS 2015. Biological Opinion on the continued operation of the American Samoa longline fishery, 190 p.

NMFS. 2016a. August 18, 2016, memo from Dawn Golden, Pacific Islands Regional Office, to the file re: Observed captures and estimated mortality of sea turtles in the Hawaii Deep-set longline fishery, 2004-2016. 14 p.

NMFS. 2016b. September 30, 2016, memo from Dawn Golden, Pacific Islands Regional Office, to the file re: Observed captures and estimated mortality of sea turtles in the Hawaii Shallow-set longline fishery, 2004-2016. 11 p.

NMFS. 2016c. September 30, 2016, memo from Dawn Golden, Pacific Islands Regional Office, to the file re: Hawaii longline fisheries mean annual turtle mortalities 2005-2016 for Baseline section. 3 p.

NMFS. 2016d. Biological evaluation from the Sustainable Fisheries Division on the potential impacts of the Hawaii Deep-set Pelagic longline fishery on green, North Pacific Distinct Population segment of loggerhead, and olive ridley sea turtles.

NMFS. 2016e. Positive Certification Determination for Mexico's 2013 Identification for Bycatch of North Pacific Loggerhead Sea Turtles.NMFS. 2016f. Guidance for Treatment of Climate Change in NMFS Endangered Species Act Decisions. National Marine Fisheries Service Procedural Instruction 02-110-18. September 27, 2016.

NMFS and FWS. 1998a. Recovery Plan for U.S. Pacific Populations of the East Pacific Green Turtle (*Chelonia mydas*). National Marine Fisheries Service, Silver Spring, MD. 51 p.

NMFS and FWS. 1998b. Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*). National Marine Fisheries Service, Silver Spring, MD. 59 p.

NMFS and FWS. 1998c. Recovery Plan for U.S. Pacific Populations of the Olive Ridley Turtle (Lepidochelys olivacea). National Marine Fisheries Service, Silver Spring, MD. 52 p.

NMFS and FWS. 1998d. Recovery Plan for U.S. Pacific Populations of the Green Turtle (*Chelonia mydas*). National Marine Fisheries Service, Silver Spring, MD. 84 p.

NMFS and FWS. 2007a. Loggerhead Sea Turtle (Caretta caretta) 5-Year Review: Summary and Evaluation. 81 p.

NMFS and FWS. 2007b. Green Sea Turtle (Chelonia mydas). 5-Year Review: Summary and Evaluation. 105 p.

NMFS and FWS. 2007c. Olive Ridley Sea Turtle 5-Year Review: Summary and Evaluation. 64 p.

NMFS and FWS. 2014. Olive Ridley Sea Turtle (Lepidochelys olivacea) 5-Year Review: Summary and Evaluation. 87 p.

NRC (National Research Council). 2010. Assessment of Sea-Turtle Status and Trends: Integrating Demography and Abundance. The National Academies Press, Washington DC. 162 p.

Obura, D., and G.S. Stone (eds.). 2002. Phoenix Islands Summary of Marine and Terrestrial Assessments Conducted in the Republic of Kiribati, June 5 – July 10, 2002. Primal Ocean Project Technical Report: NEAq-03-02. New England Aquarium, Boston, MA, USA.

Oceanic Fisheries Programme. (2001). A review of turtle by-catch in the western and central Pacific Ocean tuna fisheries, 26.

Ohmuta, K. 2006. The sea turtle situation of Yakushima Island. Pp. 23-26 in: I. Kinan (ed.), Proceedings of the Second Western Pacific Sea Turtle Cooperative Research and Management Workshop, Vol. II: North Pacific Loggerhead Sea Turtles. March 2-3, 2005, Honolulu, Hawaii. Western Pacific Regional Fishery Management Council. Honolulu, Hawaii. 96 p.

Ono, R., & Addison, D. J. (2009). Ethnoecology and Tokelauan fishing lore from Atafu Atoll, Tokelau. SPC Traditional Marine Resource Management and Knowledge Information Bulletin #26.

Ordóñez, G., M. Arauz, C.M. Sombarriba, and J.C. Castro. 1994. Ostional: a community which lives together with the olive ridley marine turtle, Lepidochelys olivacea. Pp. 129-131 in: B.A. Schroeder and B.E. Witherington (compilers), Proceedings of the Thirteenth Annual

Symposium on Sea Turtle Biology and Conservation. U.S. Dept. of Comm, NOAA Tech. Memo. NMFS-SEFSC-341. 281 p.

Orrego, C. M., & Arauz, R. (2004). Mortality of sea turtles along the Pacific Coast of Costa Rica. In M. S. Coyne & R. D. Clark (Eds.), Proceedings of the Twenty-First Annual Symposium on Sea Turtle Biology and Conservation (pp. 265–266). NOAA Tech Memo NMFS-SEFSC-528.

Oz, M., A. Erdogan, Y. Kaska, S. Dusen, A. Aslan, H. Sert, M. Yavuz, and M.R. Tunc. 2004. Nest temperatures and sex-ratio estimates of loggerhead turtles at Pantara beach on the southwestern coast of Turkey. Canadian Journal of Zoology 82(1): 94-101.

Palacios, A.I. 2012. CNMI sea turtle program annual report, January 1, 2011 - December 31, 2011. Commonwealth of the Northern Mariana Islands, Department of Lands and Natural Resources, Saipan, CNMI.

Palau Bureau of Marine Resources. 2008. Palau Marine Turtle Conservation & Monitoring Program Final Report. Unpublished grant report. 31 p.

Parker, D. and G. Balazs. 2010 [unpublished]. Draft Map Guide to Marine Turtle Nesting and Basking in the Hawaiian Islands. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, Marine Turtle Research Program.

Parker, D.M., W. Cooke, and G.H. Balazs. 2005. Diet of oceanic loggerhead sea turtles (Caretta caretta) in the central North Pacific. Fishery Bulletin 103: 142-152.

Parker, D.M., P.H. Dutton, G.H. Balazs. 2011. Oceanic Diet and Distribution of Haplotypes for the Green Turtle, Chelonia Mydas, in the Central North Pacific. Pacific Science 65(4): 419-431.

Parmesan, C. and G. Yohe. 2003. A globally coherent fingerprint of climate change impacts across natural systems.Nature 421: 37-42.

Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds). 2007. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press: Cambridge, United Kingdom and New York, NY, USA.

Peckham, H. 2010. Integrated initiative for the conservation of the North Pacific loggerhead sea turtle: threat assessment, threat mitigation, and management. ProCaguama progress report to PIRO, May 1, 2009 to Oct 31, 2010.

Peckham, H. 2014. Market based approaches to augment the sustainability of small-scale fisheries. 34th Annual Symposium on Sea Turtle Biology and Conservation, April 10-17, 2014, New Orleans, Louisiana, USA.

Peckham, S.H. and D. Maldonado-Diaz. 2012. Empowering small scale fishermen to be conservation heroes: a trinational fishermen’s exchange to protect loggerhead turtles. Pp.

279-301 in: J.A. Seminoff and B.P. Wallace (eds.), Sea Turtles of the Eastern Pacific: Advances in Research and Conservation. Arizona-Sonora Desert Museum Studies in Natural History. University of Arizona Press: Tucson, 376 p.

Peckham, H. and W.J. Nichols. 2006. An integrated approach to reducing mortality of north Pacific loggerhead turtles in Baja California, SUR, Mexico. Pp. 49-57 in: I. Kinan (ed.), Proceedings of the Second Western Pacific Sea Turtle Cooperative Research and Management Workshop, Vol. II: North Pacific Loggerhead Sea Turtles. March 2-3, 2005, Honolulu, Hawaii. Western Pacific Regional Fishery Management Council. Honolulu, Hawaii. 96 p.

Peckham S.H., D. Maldonado-Diaz, A.Walli, G. Ruiz, and L.B. Crowder. 2007. Small-Scale Fisheries Bycatch Jeopardizes Endangered Pacific Loggerhead Turtles. PLoS ONE 2(10): e1041

Peckham S.H., D. Maldonado-Diaz, V. Koch, A. Mancini, A. Gaos, M.T. Tiner, and W.J. Nichols. 2008. High mortality of loggerhead turtles due to bycatch, human consumption and strandings at Baja California Sur, Mexico, 2003 to 2007. Endangered Species Research 5: 171-183.

Pendoley, K. (2000). The influence of gas flares on the orientation of green turtle hatchlings at Thevenard, Western Australia. In N. J. Pilcher & G. Ismail (Eds.), Sea Turtles of the Indo-Pacific: Research, Management and Conservation (pp. 130–142). London: ASEAN ACADEMIC Press, Ltd.

Philip, M. (2002). Marine turtle conservation in Papua New Guinea. In I. Kinan (Ed.), Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop (pp. 143–146). Honolulu, Hawaii, USA: Western Pacific Regional Fishery Management Council.

Pike, D.A. 2013. Climate influences the global distribution of sea turtle nesting. Global Ecology and Biogeography 22: 555–566.

Pita, J. and D. Broderick. 2005. Hawksbill turtles in the Solomon Islands. IN: I.Kinan (ed.) Proceedings of the Western Pacific Sea Turtle Cooperative Research & Management Workshop, second edition. WPRFMC. May 17-21, 2004.

Plotkin, T.P. 2010. Nomadic behaviour of the highly migratory olive ridley sea turtle Lepidochelys olivacea in the eastern tropical Pacific Ocean. Endang Species Research 13: 33–40.

Poiner, I.R. and A.N.M. Harris. 1996. Incidental capture, direct mortality and delayed mortality of sea turtles in Australia’s northern prawn fishery. Marine Biology 125: 813-825.

Poloczanska, E. S., Limpus, C. J., & Hays, G. C. (2009). Vulnerability of Marine Turtles to Climate Change. In D. W. Sims (Ed.), Advances in Marine Biology (Vol. Volume 56, pp. 151–211). Burlington, Academic Press.

Polovina, J.J., E.A. Howell, D.R. Kobayashi, and M.P. Seki. 2001. The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. Progress in Oceanography 49: 469-483.

Polovina, J.J., E. Howell, D.M. Parker, G.H. Balazs. 2003. Dive-depth distribution of loggerhead (Caretta caretta) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacific: Might deep longline sets catch fewer turtles? Fishery Bulletin 101(1): 189-193.

Polovina, J.J., G.H. Balazs, E.A. Howell, D.M. Parker, M.P. Seki and P.H. Dutton. 2004. Forage and migration habitat of loggerhead (Caretta caretta) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacific. Fisheries Oceanography. 13(1): 36-51.

Polovina, J.J., I. Uchida, G.H. Balazs, E.A. Howell, D.M. Parker, and P.H. Dutton. 2006. The Kuroshio Extension Bifurcation Region: a pelagic hotspot for juvenile loggerhead sea turtles. Deep-sea Research II 53: 326-339.

Prescott, N., Pole, F., Kami, V., Hoponoa, T., Ngaluafe, P., Palaki, A., Samani, T. (2004). Tonga biodiversity stocktaking. Technical Report No. 1. For The Development Of A National Biodiversity Strategic Action Plan (NGSAP). Department of Environment.

Project GloBAL, 2009a. Country profile: Guam. Project GloBal - Global Bycatch Assessment of Long-Lived Species Report. 19 pages.

Project GloBAL. (2009b). Country profile: Papua New Guinea (p. 23). Project GloBal - Global Bycatch Assessment of Long-Lived Species Report. 23 pages.

Pultz, S., D. O'Daniel, S. Krueger, H. McSharry, and G. Balazs. 1999. Marine turtle survey on Tinian, Mariana Islands. Micronesica 31(2):85-94.

Reina, R.D., J.R. Spotila, F.V. Paladino, and A.E. Dunham. 2008. Changed reproductive schedule of eastern Pacific leatherback turtles (Dermochelys coriacea) following the 1997-98 El Nino to La Nina transition. Endangered Species Research. Published online June 24, 2008: doi: 10.3354/esr00098.

Reiner, A. (1994). Laminar distribution of the cells of origin of ascending and descending tectofugal pathways in turtles: implications for the evolution of tectal lamination. Brain, Behavior and Evolution, 43(4-5), 274–283.

Reischig, T., Basuki, N. R., Moord, V. A., Cordes, H., & Latorra, R. (2012). Green turtles (Chelonia mydas) in the Berau Archipelago, Indonesia: Population assessment, nesting activities, and protection status. In T. T. Jones & B. P. Wallace (Eds.), Proceedings of the 31st Annual Symposium on Sea Turtle Biology and Conservation (p. 243). San Diego, California: NOAA Technical Memorandum NMFS-SEFSC-631.

Resendiz, A., B. Resendiz, W.J. Nichols, J.A. Seminoff, and N. Kamezaki. 1998. First confirmed east-west transpacific movement of a loggerhead sea turtle, Caretta caretta, released in Baja California, Mexico. Pacific Science 52(2): 151-153.

Rice, M.R. and G.H. Balazs. 2008. Diving behavior of the Hawaiian green turtle (Chelonia mydas) during oceanic migrations. Journal of Experimental Marine Biology and Ecology. 356:121-127.

Robins, C. M., Goodspeed, A. M., Poiner, I. R., & Harch, B. D. 2002. Monitoring the Catch of Turtles in the Northern Prawn Fishery. Fisheries Research and Development Corporation Final Report, Canberra.

Robinson, R.A., H.Q.P. Crick, J.A. Learmonth, I.M.D. Maclean, C.D. Thomas, F. Bairlein, M.C. Forchhammer, C.M. Francis, J.A. Gill, B.J. Godley, J. Harwood, G.C. Hays, B. Huntley, A.M. Hutson, G.J. Pierce, M.M. Rehfisch, D.W. Sims, M.B. Santos, T.H. Sparks, D.A. Stroud, and M.E. Visser. 2008. Traveling through a warming world: climate change and migratory species. Endangered Species Research. Published online June 17, 2008. doi: 10.3354/esr0009.

Rupeni, E., Mangubhai, S., Tabunakawai, K., & Blumel, P. (2002). Establishing replicable community-based turtle conservation reserves in Fiji. In I. Kinan (Ed.), Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop, Honolulu, HI, USA (pp. 119–124).

Ryder, C.E., T.A. Conant, and B.A. Schroeder. 2006. Report of the Workshop on Marine Turtle Longline Post-Interaction Mortality. U.S. Dept. of Commer., NOAA Tech. Memo. NMFS-OPR-29. 40 p.

Saba, V.S., P. Santidrian-Tomillo, R.D. Reina, J.R. Spotila, J.A. Musick, D.A. Evans, and F.V. Paladino. 2007. The effect of the El Nino southern oscillation on the reproductive frequency of eastern Pacific leatherback turtles. Journal of Applied Ecology 44: 395-404.

Sakai, H., Saeki, K., Ichihashi, H., Kamezaki, N. I., Tanabe, S., & Tatsukawa, R. (2000). Growth-related changes in heavy metal accumulation in green turtle (Chelonia mydas) from Yaeyama Islands, Okinawa, Japan. Archives of Environmental Contamination and Toxicology, 39(3), 378–385. doi:10.1007/s002440010118

Sako, T., & Horikoshi, K. (2003). Marine debris ingested by green turtles in the Ogasawara Islands, Japan. In J. A. Seminoff (Ed.), Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation (p. 305). NOAA Technical Memorandum NMFS-SEFSC-503.

Sarkar, S. (2001). Threat to survival and conservation efforts in Bangladesh. In M. S. Coyne & R. D. Clark (Eds.), Proceedings of the Twenty-First Annual Symposium on Sea Turtle Biology and Conservation (pp. 307–308). NOAA Technical Memorandum NMFS-SEFSC-528.

Schofield. G., C.M. Bishop, G. MacLean, P. Brown, M. Baker, K.A. Katselidis, P. Dimopoulos, J.D. Pantis, and G.C. Hays. 2007. Novel GPS tracking of sea turtles as a tool for conservation management. Journal of Experimental Marine Biology and Ecology 347: 58-68.

Seminoff, J. A. (1994). Conservation of the marine turtles of Mexico, a survey of nesting beach conservation projects. Masters Thesis. Department of Ecology and Evolutionary Biology, The University of Arizona.

Seminoff, J. A., Jones, T. T., Resendiz, A., Nichols, W. J., & Chaloupka, M. Y. (2003). Monitoring green turtles (Chelonia mydas) at a coastal foraging area in Baja California, Mexico: multiple indices to describe population status. Journal of the Marine Biological Association of the United Kingdom, 83(6), 1355–1362. doi:10.1017/S0025315403008816

Seminoff, J. A., Crouse, D. T., Pilcher, N. J., Eckert, K. L., Marcovaldi, M. Â., Mortimer, J. A., & Nichols, W. J. (2004). 2004 global status assessment - Green turtle (Chelonia mydas). IUCN (p. 71).

Seminoff, J.A., P. Zarate, M.S. Coyne, A. Foley, D.M. Parker, B.N. Lyon, and P.H. Dutton. 2008. Post-nesting migrations of Galápagos green turtles Chelonia mydas in relation to oceanographic conditions: integrating satellite telemetry with remotely sensed ocean data. Endangered Species Research 4: 57-72.

Seminoff , J.A., T. Eguchi, J. Carretta, C.D. Allen, D. Prosperi, R. Rangel, J.W. Gilpatrick Jr., K. Forney, S.H. Peckham. 2014. Loggerhead sea turtle abundance at a foraging hotspot in the eastern Pacific Ocean: implications for at-sea conservation. Endangered Species Research Vol. 24: 207-220, 2014.

Seminoff, J.A., C.D. Allen, G.H. Balazs, P.H. Dutton, T. Eguchi, H.L. Haas, S.A. Hargrove, M.P. Jensen, D.L. Klemm, A.M. Lauritsen, S.L. MacPherson, P. Opay, E.E. Possardt, S.L. Pultz,E.E. Seney, K.S. Van Houtan, R.S. Waples. 2015. Status Review of the Green Turtle (Chelonia mydas) Under the U.S. Endangered Species Act. NOAA Technical Memorandum, NOAANMFS- SWFSC-539. 571pp.

Senko, J, A.J. Schneller, J. Solis, F. Ollervides, W.J. Nichols. 2011. People helping turtles, turtles helping people: Understanding resident attitudes towards sea turtle conservation and opportunities for enhanced community participation in Bahia Magdalena, Mexico. Ocean and Coastal Management 54: 148-157.

Settle, S. (1995). Status of nesting populations of sea turtles in Thailand and their conservation. Marine Turtle Newsletter, 68, 8–13.

Shanker, K., & Pilcher, N. J. (2003). Marine Turtle Conservation in South and Southeast Asia: Hopeless Cause or Cause for Hope? Marine Turtle Newsletter, 100, 43–51.

Shanker, K., B. Pandav, and B.C. Choudhury. 2003. An assessment of the olive ridley turtle (Lepidochelys olivacea) nesting population in Orissa, India. Biological Conservation 115: 149-160.

Simmonds M.P. and W.J. Elliot. 2009. Climate change and cetaceans: concerns and recent developments. Journal of the Marine Biological Association of the United Kingdom 89(1): 203-210.

Smit, B., I. Burton, R.J.T. Klein, and J. Wandel. 2000. An anatomy of adaptation to climate change and variability. Climatic Change 45: 223-251.

Snover, M.L. 2002. Growth and ontogeny of sea turtles using skeletochronology: methods, validation, and application to conservation. Doctoral dissertation, Duke University. 156 p.

Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). 2007. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Solow, A., K. Bjorndal, and A. Bolten. 2002. Annual variation in nesting numbers of marine turtles: the effect of sea surface temperature on remigration intervals. Ecology Letters 5: 742–746.

SPREP. (2012). Pacific Islands regional marine species programme 2012-2017. Apia, Samoa.

STAJ (Sea Turtle Association of Japan). Matsuzawa, Y. 2008. Nesting beach management in Japan to conserve eggs and pre-emergent hatchlings of the north Pacific loggerhead sea turtle. Final Contract Report to the Western Pacific Regional Fishery Management Council.

STAJ. Matsuzawa, Y. 2009. Nesting beach management in Japan to conserve eggs and pre-emergent hatchlings of the north Pacific loggerhead sea turtle. Final Contract Report to the Western Pacific Regional Fishery Management Council.

STAJ. Matsuzawa, Y. 2010. Nesting beach management in Japan to conserve eggs and pre-emergent hatchlings of the north Pacific loggerhead sea turtle. Final Contract Report to the Western Pacific Regional Fishery Management Council.

STAJ. Matsuzawa, Y. 2012. Nesting beach management in Japan to conserve eggs and pre-emergent hatchlings of the north Pacific loggerhead sea turtle. Final Contract Report to the Western Pacific Regional Fishery Management Council.

Stewart, K.R., Keller, J.M. Templeton, R., J.R. Kucklick and C. Johnson. 2011. Monitoring persistent organic pollutants in leatherback turtles (Dermochelys coriacea) confirms maternal transfer. Marine Pollution Bulletin 62(7): 1396-1409.

Stiles, D. (2009). The marine turtle product trade in Viet Nam. Marine Turtle Newsletter, (124), 6–9.

Suganuma, H., S. Tanaka, and E. Inoguchi. 2012. Conservation of sea turtles and management of the monitoring system by local people for leatherback turtle, Dermochelys coriacea, in Manokwari region, West Papua, Indonesia. Everlasting Nature of Asia Final Report to the Western Pacific Regional Fishery Management Council. Contract No. 11-turtle-001. 6 p.

Surjadi, P., & Anwar, K. (2001). Exploitation of marine resources in the Togean and Banggai Islands, Sulawesi, Indonesia. In G. R. Allen & S. A. McKenna (Eds.), A Marine Rapid

Assessment of the Togean and Banggai Islands, Sulawesi, Indonesia (p. 59). Washington D.C.: RAP Bulletin of Biological Assessment 20, Conservation International.

Swimmer, Y., L. McNaughton, D. Foley, L. Moxey, and A. Nielson. 2009. Movements of olive ridley sea turtles Lepidochelys olivacea and associated oceanographic features as determined by improved light-based geolocation. Endangered Species Research 10: 245-254.

Tagarino, A., K.S. Saili, and R. Utzurrum. 2008. Investigations into the Status of Marine Turtles in American Samoa, with Remediation of Identified Threats and Impediments to Conservation and Recovery of Species. NOAA/NMFS Unallied Management Grant: Award No. NA04NMF4540126. FINAL REPORT (01 October 2004 to 30 September 2008), 44 p.

Tagarino, A. (2011). Investigations into the status of marine turtles of Ofu and Olosega, American Samoa: An intensive monitoring of hawksbill nesting beaches FY ‘11-‘13, semi-annual report #2, grant number: NA10NMF4540387. Department of Marine and Wildlife Resources, American Samoa Government, Pago Pago, American Samoa.

Teeb’aki, K. (1992). Republic of Kiribati. Unpublished.

Tol, R.S.J., S. Fankhauser, and J.B. Smith. 1998. The scope for adaptation to climate change: what can we learn from impact literature? Global Environmental Change 8(2): 109-123.

Tomaszewicz, C.T., J. Seminoff, H. Peckman, L. Avens, L.R. Goshe, K. Bickerman, V. de la Toba, J.M. Rodriguez-Baron, and C. Kurle. 2014. Habitat use of North Pacific Loggerhead turtles (Caretta caretta) and duration spent in a high-bycatch area near Baja California Peninsula using skeletochronology and stable isotope analysis. 34th annual Symposium on Sea Turtle Biology and Conservation, April 10-17, 2014. New Orleans, Louisiana.

Tuato’o-Bartley, N., T.E. Morrell, and P. Craig. 1993. Status of Sea Turtles in American Samoa in 1991. Pacific Science 47(3):215-221.

USFWS and NMFS. 1998. Endangered Species Consultation Handbook - Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act. 315 p.

Valverde, R.A., C.M. Orrego, M.T. Tordoir, F. M. Gómez, D.S. Solís, R.A. Hernández, G.B. Gómez, L.S. Brenes, J.P. Baltodano, L.G. Fonseca, and J.R. Spotila. 2012. Olive ridley mass nesting ecology and egg harvest at Ostinal Beach, Costa Rica. Chelonian Conservation and Biology 11(1): 1-11.

Van Buskirk, J. and L.B. Crowder. 1994. Life-history variation in marine turtles. Copeia 1994(1): 66-81.

Van Houtan, K.S. 2010. Future climate impacts to marine turtle populations, with a focus on the North Pacific Ocean. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-10-023. 11 p.

Van Houtan, K.S. 2011 Assessing the impact of fishery actions to marine turtle populations in the North Pacific using classical and climate-based models. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-11-024. 25 p.

Van Houtan K.S. 2013. Assessing the impact of the Hawaii deep-set longline fishery to marine turtle populations in the North Pacific Ocean. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-13-019. 5 p.

Van Houtan K.S. 2015. Impacts of incidental bycatch from the American Samoa-based longline fishery to marine turtle populations. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-15-027. 10p.

Van Houtan, K.S. and O.L. Bass. 2007. Stormy oceans are associated with declines in sea turtle hatching. Current Biology 17(15): R590-591.

Van Houtan, K.S. and J.M. Halley. 2011. Long-Term Climate Forcing in Loggerhead Sea Turtle Nesting. PLoS ONE 6(4): e19043.

Van Houtan K.S, S.K. Hargrove, and G.H. Balazs. 2010. Land Use, Macroalgae, and a Tumor-Forming Disease in Marine Turtles. PLoS ONE 5(9): e12900.

Vollset, S. E. 1993. Confidence intervals for a binomial proportion. Statistics in Medicine, 12, 809—824.

Vaughan, J.R. 2009. Evaluation of Length Distributions and Growth Variance to Improve Assessment of the Loggerhead Sea Turtle *(Caretta caretta)*. Master of Science Thesis, Oregon State University, Corvallis, Oregon. 71 p.

Waayers, D. (2010). A Holistic Approach to Planning for Wildlife Tourism: A Case Study of Marine Turtle Tourism and Conservation in the Ningaloo Region, Western Australia. Murdoch University, Western Australia.

Wabnitz, C. and W.J. Nichols. 2010. Plastic Pollution: An Ocean Emergency. Marine Turtle Newsletter 129: 1-4.

Wallace, B.P., A.D. DiMatteo, B.J. Hurley, E.M. Finkbeiner, A.B. Bolten, M.Y. Chaloupka, B.J. Hutchinson, F.A. Abreu-Grobois, D. Amorocho, K.A. Bjorndal, J. Bourjea, B.W. Bowen, R. Briseño Dueñas, P. Casale, B.C. Choudhury, A. Costa, P.H. Dutton, A.Fallabrino, A. Girard, M. Girondot, M.H. Godfrey, M. Hamann, M. López-Mendilaharsu, M.A. Marcovaldi, J.A. Mortimer, J.A. Musick, R. Nel, N.J. Pilcher, J.A. Seminoff, S.Troëng, B. Witherington, and R.B. Mastl. 2010. Regional Management Units for Marine Turtles: A Novel Framework for Prioritizing Conservation and Research across Multiple Scales. PLoS ONE 5(12): e15465.

Walther, G-R, E. Post, P. Convey, A. Menzel, C. Parmesan, T.J.C. Beebee, J-M Fromentin, O. Hoegh–Guldberg, and F. Bairlein. 2002. Ecological responses to climate change. Nature 416: 389-395.

Webb, A.P. and P.S. Kench. 2010. The dynamic response of reef islands to sea level rise: evidence from multi-decadal analysis of island change in the central pacific. Global and Planetary Change 72(3): 234-246.

Weishampel, J.F., D.A. Bagley, and L.M. Ehrhart. 2004. Earlier nesting by loggerhead sea turtles following sea surface warming. Global Change Biology 10: 1424-1427.

Western and Central Pacific Fisheries Commission (WCPFC). 2008. 2007 national tuna fishery report - Solomon Islands (p. 18).

White, M. 2012a. An assessment of sea turtles at Palmerston Atoll, Southern Cook Islands, 68. Retrieved from http://www.seaturtle.org/PDF/WhiteM_2012_RuffordTrustExpeditiontoPalmerstonA.pdf

White, M. 2012b. Sea Turtles in the Cook Islands. Volume One: 2009-2012 (pp. 2009–2012).

White, M. 2013. The first study of sea turtles at Rarotonga, Southern Cook Islands. Testudo, 7(5), 12–29.

White, M. 2015. In-water assessment and management of sea turtle habitats at Tongareva Atoll, Northern Cook Islands. Final grant report to NOAA PIRO (June 1, 2014 – May 31, 2015): NA14NMF4540140.

White, M. and G. Galbraith. 2013. Rakahanga Atoll: Sea turtles at a remote site in Oceania. Testudo 7(5): 30-48.

Williams, P. and P. Terawasi. 2015. Overview of tuna fisheries in the western and central Pacific Ocean, including economic conditions – 2014. Working Paper prepared for the 11th Regular Session of the Scientific Committee, Western and Central Pacific Fisheries Commission, WCPFC-SC11-2014/GN-WP-1. Issued July 28, 2015. 68 p.

Wilson, E. B. 1927. Probable inference, the law of succession, and statistical inference. Journal of the American Statistical Association 22:209–212.

Wingfield D.K., S.H. Peckham, D.G. Foley, D.M. Palacios, B.E. Lavaniegos, R. Durazo, W.J. Nichols, D.A. Croll, and S.J. Bograd. 2011. The making of a productivity hotspot in the coastal ocean. PLoS ONE 6(11): e27874.

WPFMC. 2006. Pelagic Fisheries of the Western Pacific Region - 2006 Annual Report. 282 p.

WPFMC. 2009a. Fishery Ecosystem Plan for the Pacific Pelagic Fisheries of the Western Pacific Region. 249 p.

WPFMC. 2009b. Management Modifications for the Hawaii-based Shallow-set Longline Swordfish Fishery that Would Remove Effort Limit, Eliminate the Set Certificate Program, and Implement New Sea Turtle Interaction Caps. Amendment 18 to the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region, Including a Final

Supplemental Environmental Impact Statement, Regulatory Impact Review, and Initial Regulatory Flexibility Analysis. 333 p.

Zainudin, I. M., Pet-Doede, L., Hitipeuw, C., & Adnyana, I. B. W. (2008). Interaction of sea turtles with Indonesia fisheries – preliminary findings.

Zárate, P., Cahoon, S. S., Contato, M. C. D., Dutton, P. H., & Seminoff, J. A. (2006). Nesting beach monitoring of green turtles in the Galapagos Islands: a 4-year evaluation. In M. Frick, A. Panagopoulou, A. F. Rees, & K. Williams (Eds.), Book of Abstracts. Twenty Sixth Annual Symposium on Sea Turtle Biology and Conservation (p. 337). Athens, Greece: International Sea Turtle Society.

Zug, G.A., G.H. Balazs, J.A. Wetherall, D.M. Parker, and S.K.K. Murakawa. 2002. Age and Growth of Hawaiian green seaturtles (Chelonia mydas): an analysis based on skeletochronology. Fishery Bulletin 100: 117–127.

Zug, G.R., M. Chaloupka, and G.H. Balazs. 2006. Age and growth in olive ridley sea turtles (Lepidochelys olivacea) from the north-central Pacific: a skeletochronological analysis. Marine Ecology 26: 1-8.