Pelagic FMP Amendment 18
Final SEIS

Appendix II

Assessment of the population-level impacts of potential increases in marine turtle interactions resulting from a Hawaii Longline Association proposal to expand the Hawaii-based shallow-set fishery

Melissa L. Snover

May 2008

This page left blank intentionally.

Assessment of the population-level impacts of potential increases in marine turtle interactions resulting from a Hawaii Longline Association proposal to expand the Hawaii-based shallow-set fishery[1]

Melissa L. Snover

Marine Turtle Assessment Program
NOAA/NMFS/Pacific Islands Fisheries Science Center
2570 Dole Street
Honolulu, HI 96822

melissa.snover@noaa.gov

May 2008

[1] PIFSC Internal Report IR-08-010
Issued 3 June 2008

Abstract

The Hawaii Longline Association is proposing to expand the Hawaii-based shallow-set longline fishery, which will likely increase the level of sea turtle interactions. Leatherbacks and loggerheads are the most common turtle species interacting with this fishery and the majority of interacting turtles are released alive (100% since 2004) with varying degrees of injury. The post-interaction mortality rates are estimated at 0.205 for loggerheads and 0.229 for leatherbacks. In this study I estimate the increase in quasi-extinction risk to turtle populations from mortalities associated with this fishery. I use diffusion approximation methods to estimate the mean quasi-extinction risk using a quasi-extinction threshold of 50% of current population size and a time threshold of 63 yr for leatherbacks and 100 yr for loggerheads. As the diffusion approximation uses nest census data, only units of adult females are considered and the turtles interacting with the fishery are converted to adult female 'equivalents' by assuming a 65% female sex ratio and mean reproductive values of 0.41 for loggerheads and 0.85 for leatherbacks. Nesting data from Japan (loggerheads), Jamursba-Medi, Papua, Indonesia (leatherbacks) and Costa Rica (leatherbacks) were used. Results of this study indicated that to minimize increased risks of quasi-extinction, mortalities of adult female (or 'equivalent) Japanese loggerheads should be less than 4, from Jamursba-Medi leatherbacks. the mortalities should be less than 3 adult females, and for the Costa Rica leatherback population, no adult females should be killed. The proposed interaction levels of the expanded fishery are 46 loggerheads and 19 leatherbacks. These levels are estimated to result in 2.51 adult female mortalities for loggerheads in Japan, 1.56 adult female mortalities for leatherbacks from Jamursba-Medi, and 0.12 adult female leatherbacks from Costa Rica.

Introduction

Predicting absolute extinction in populations is complicated by the unpredictable behaviors of small populations and it is a common practice in conservation biology to use quasi-extinction thresholds in population viability assessments (Morris and Doak 2002). Snover and Heppell (in review) present a quasi-extinction risk index called susceptibility to quasi-extinction (SQE) that can be used to classify populations based on relative risks. Using population simulations, they show that the method is robust in assessing actual risk (in terms of a binary assessment of at risk or not at risk), assuming that current conditions remain the same over the time period of the projection. As they use long time frames of 3 generations (following IUCN criteria) they clarify that SQE values are primarily useful as an index for comparing populations and assessing the impacts of increased mortalities by comparing SQE values between perturbed and non-perturbed populations. Here I apply this technique to nest census data for Pacific loggerheads and leatherbacks to assess the impacts of increased mortality expected to result from a proposed expansion of the Hawaii-based shallow-set longline fishery. The analyses presented here are designed to be a tool for managers to assess how different levels of fishery interactions may affect the extinction risk of marine turtle populations.

Data and populations considered

Leatherbacks

Leatherback nesting data for Jamursba-Medi, Papua, Indonesia are reported in Hitipeuw et al. (2007) for 1981, 1984-1985, 1993-1997, and 1999-2004. Nesting occurs year-round for leatherbacks in this region, with peaks from April to October. As not all months were surveyed in all years, Hitipeuw et al. (2007) used information on the proportion of annual nesting that occurs in each month from year-round surveys to estimate the number of nests between April – October for all years. Data for all of 2005 and 2006 through August are in a Report to the Western Pacific Fishery Management Council (WPFMC).[2] I used the same method as Hitipeuw et al. (2007) to estimate nesting in September and October 2006 resulting in a nesting dataset for the time period of 1993-2006 for this region. The data point for 1998 was estimated as the mean of 1997 and 1999 (Fig. 1; Dennis et al. 1991). I used the value of 5.5 nests per female (Martínez et al. 2007) to estimate the number of nesting females.

For the eastern Pacific, nesting leatherback data for Parque Nacional Las Baulas, Playa Grande, Costa Rica are reported in Tomillo et al. (2007) for the 1988/1989 to 2003/2004 nesting seasons (Fig. 1). As there is a saturation tagging program at this beach, all females are identified and the census data are numbers of females nesting per year.

Loggerheads

Loggerheads found in the North Pacific are predominately from nesting beaches in Japan. Genetic analyses of loggerheads taken in the Hawaii-based longline fisheries indicate that 100% of these turtles are from the Japanese nesting populations (P. Dutton, personal communication). Nesting data for Japanese loggerheads are from the Sea Turtle Association of Japan (STAJ; unpublished data provided to the WPFMC) and Kamezaki and Matsuzawa (2002). The STAJ data are from 1998 to 2007 and these were estimated back to 1990 using data from Kamezaki and Matsuzawa (2002). Thirty-three Japanese nesting beaches have been monitored annually for nest counts since 1990 (Kamazaki and

---

[2] Leatherback conservation at Warmon Beach, Papua-Indonesia, Final report for the period of November 2005 – October 2006 (Ref No.: 04-WPC-034)

Matsuzawa 2002)[3]. The 1998 to 2007 STAJ data represent all Japanese nesting data. For 1998 and 1999, the 33 beaches in Kamazaki and Matsuzawa (2002) represented 51.7 and 52.6% of the total nesting reported by the STAJ. I assumed that the 33 beaches with nesting data reported from 1990 to 1998 (Kamazaki and Matsuzawa 2002) represented 52.1% of total nesting in Japan and used this ratio to extend the STAJ time series back an additional 8 years (Fig. 2).

Post-interaction mortality rates

Since the reopening of the Hawaii-based shallow-set fishery in 2004, all of the loggerhead and leatherback turtles taken have been released alive. NMFS convened a workshop to elicit expert opinion on post-interaction mortality rates based on the severity of the injury to the turtle (Table 1; Ryder et al. 2006). Using the observer data from the shallow-set fishery since 2004, each turtle taken in the fishery was assigned a post-interaction mortality rate to assess a mean post-interaction mortality rate for each species (Memorandum to W.L. Robinson 1 Feb. 2008[4]). The overall mean post-interaction mortality rate for the Hawaii-based shallow set fishery from 2004 to 2007 is 20.5% (95% C.I. 14.7 – 26.2%) for loggerhead turtles and 22.9% [5] (95% C.I. 12.6 – 33.1%) for leatherback turtles. Many of the injury categories in Table 1 were not found in the loggerhead and leatherback takes in the shallow-set fishery since 2004. Between 2004 and 2007 16 leatherbacks and 45 loggerheads interacted with the fishery and as those numbers grow it is possible that we will see more turtles in different injury

[3] Previous to 1990, less than 20 beaches were monitored regularly for nesting. Between 1989 and 1990 the number of beaches monitored nearly doubled, therefore data were estimated back to 1990.
[4] Memorandum from Chris Yates to William Robinson dated 1 February 2008; subject: Observed captures and estimated mortality of sea turtles in the Hawaii shallow-set longline fishery, 2004-2007.
[5] This number is slightly different from that presented in the memorandum as a rounding error was found. The number reported in the memo is 22.3% but the correct number, for interactions between 2004 and 2007 is 22.9%.

categories. With these small numbers, even a single event of a serious injury with high a post-interaction mortality rate would alter the mean post-interaction mortality rates reported here, hence these numbers should be monitored as the fishery progresses to ensure they do not change substantially. Large increases in mean post-interaction mortality rates will alter the results presented here.

Nearly half of the leatherbacks were externally hooked and released with the hook and substantial line still attached. The remaining leatherbacks were primarily externally hooked and released with the hook and little line or with no gear. Of the 16 leatherbacks interacting with the shallow-set fishery between 2004 and 2007, only one was mouth-hooked. For loggerheads, the highest interaction category was category III (hooked in soft tissues of the mouth or esophagus above the level of the heart) and most of these were released with all gear removed. The next highest category was externally hooked and again most of these were released with no gear attached.

Population-specific interactions with the fishery

For loggerheads, the current interaction limit for the Hawaii-based longline fishery is 17 and in the proposed expansion of the fishery it is estimated that as many as 46 would interact with the fishery.   For leatherbacks, the current interaction limit is 16 and the expected increase of interactions is 19. The break-down of these numbers in terms of expected interactions associated with each of the nesting populations is considered here.

For loggerheads this is trivial as we know from genetics that 100% of these turtles interacting with the shallow-set fishery are from Japan.

For leatherbacks, Table 1 in Dutton et al. (2007) shows the approximate annual number of nests per beach for the Western Pacific metapopulation. From this table, the Jamursba-Medi nesting assemblage represents ~38% of the nesting in this region. Genetics data for leatherback turtles taken in the Hawaii-based longline fisheries suggest that 6% of takes are from the East Pacific and 94% of takes are from the West Pacific (P. Dutton, personal communication). If all West Pacific leatherbacks are equally likely to migrate to the North Pacific, then 35.7% (0.38*0.94) of leatherbacks interacting with the Hawaii-based shallow-set longline fishery are likely to be from Jamursba-Medi. However, based on satellite telemetry studies, it appears that the direction of post-nesting migration is related to the season of the nesting, with winter nesters heading southeast to the high latitudes of the South Pacific Ocean (Benson et al. 2007a). Summer nesters head either northeast towards the eastern North Pacific Ocean or west to the South China Sea (Benson et al. 2007b). Again from Table 1 in Dutton et al. (2007) the vast majority of summer nesting in this region occurs at Jamursba-Medi with very low levels of summer nesting elsewhere. Hence, because of the nesting seasonality, it is possible that the adult female leatherbacks that interact with the Hawaii-based longline fisheries are predominantly from Jamursba-Medi. The satellite telemetry studies are only of adult females and the migration patterns of juveniles and adult males are unknown. To account for the possibility that the Jamursba-Medi nesting assemblage is disproportionately represented in the shallow-set interactions, I consider the midpoint of the range 38-100% = 69% as the proportion of the West Pacific leatherbacks interacting with the Hawaii-based shallow-set fishery sourcing from the Jamursba-Medi nesting assemblage. This results in 65% (0.69*0.94) of the total leatherbacks interacting with the fishery being attributable to Jamursba-Medi.

For the East Pacific, Martinez et al. (2007) found a total of 346 leatherbacks nesting in Mexico during the 2003-2004 nesting season and Tomillo et al. (2007) found a total of 188 females nesting in Costa Rica. Assuming 5 nests per female and a mean remigration interval of 2.5 yr (Spotila et al. 1996), I estimate 1335 adult female leatherbacks for the Eastern Pacific, with 14% from Costa Rica. Hence, 0.8% (0.14*0.06) of leatherbacks interacting with the Hawaii-based shallow-set longline fishery are likely to be from the Costa Rica population.

Analytical approach

Diffusion Approximation

I used the diffusion approximation approach discussed in Snover and Heppell (in review) to assess the status of the nesting populations considered here. The methods used to estimate parameters for diffusion approximation are reported in Dennis et al. (1991) and Morris and Doak (2002). These methods are based on a model for exponential population growth in a randomly varying environment (Morris and Doak 2002)

(1) $$N_{t+1} = N_t \lambda_t$$

where N is the population size, t is time and λ_t is the population growth rate in year t. Two key parameters estimated by this method are $\hat{\mu}$, the arithmetic mean of the log population growth rate, and $\hat{\sigma}^2$, the variance of the log population growth rate which accounts for sources of variability, including environmental and demographic stochasticity and observation error (Dennis et al. 1991, Morris and Doak 2002). These parameters are used to make inferences regarding total population growth rates and quasi-extinction risks.

Selection of quasi-extinction threshold

Merrick and Haas (2008) applied a diffusion approximation analysis to loggerhead turtle bycatch from the Atlantic Sea Scallop Fishery and they used a quasi-extinction threshold (QET) of 250 adult females for a population with a current estimate of 34,881 adult females (~0.7% of current population size). Looking at time thresholds of 25, 50, 75 and 100 yr, a population of that size would have to decline at rates of 20, 10, 7, and 5 % per year respectively to reach the quasi-extinction threshold. Not surprisingly, they found essentially zero risks of reaching the quasi-extinction threshold, and when they considered the impact of removing the mortality of 75 adult females that the fishery is estimated to kill each year, obviously it could not lower the quasi-extinction risk (there cannot be a risk of < 0). Hence, to achieve the resolution necessary to detect changes in risk of quasi-extinction, it is essential to select a reasonable level of QET for which non-zero values are obtained. A QET of 50% is consistent with the IUCN listing criteria, that a species is considered vulnerable if it is likely to decline by 50% of its current size over 3 generations[6], and it is the value I use in this analysis.

Selection of the time threshold

Similarly, I again follow the IUCN listing criteria which suggests time thresholds of 3 generations or 100 yr, whichever value is smaller[6]. To estimate generation time for leatherbacks, I used the mean value of age to sexual maturity of 14 yr (Zug and Parham

[6] 2001 IUCN Red List Categories and Criteria version 3.1, http://www.iucn.org/themes/ssc/redlists/RLcats2001booklet.html

1996) and an adult survival rate of 0.90 to estimate a generation time of 21 yr. or a 3 generation time period equal to 63 yr (Snover and Heppell in review). Age to maturity for the Japanese loggerhead population is not understood. This parameter is estimated at >30 yr for Atlantic loggerheads (Snover 2002), however Japanese loggerheads nest at a smaller size (Hatase et al. 2004) and potentially at a younger age. If age to maturity is assumed to be 27 and adult survival rate is 0.90, 3 generations is ~101 yr, hence I used the time period of 100 yr as suggested by the IUCN when 3 generations is >100yr.

Susceptibility to quasi-extinction

Following Snover and Heppell (in review), I used the parametric bootstrap estimation procedure from Morris and Doak (2002) to compute quasi-extinction risks to quasi-extinction thresholds (QET) of 50% of current population size based on the 95% CI of $\hat{\mu}$ and $\hat{\sigma}^2$ for a time horizon of T = 3 generations or 100 yr, whichever value is smaller. Snover and Heppell (in review) define susceptibility to quasi-extinction (SQE) as the proportion of the parametric bootstrap replicates that indicate a >90% chance of dropping below a pre-defined quasi-extinction threshold (QET). Using population simulations, Snover and Heppell (in review) demonstrated that SQE values greater than 0.4 indicate that a population is at risk of being reduced to the quasi-extinction threshold (QET) level used. At this critical value (0.40) ‘Type I’ errors (considering a population to not be at risk when it is) occur at a rate of about 10% and reducing the critical value to 0.3 lessens this rate at the expense of increased ‘Type II’ errors (considering a population to be at risk when it is not). The choice of only using replicates that indicate a >90% chance of dropping below the QET was somewhat arbitrary and values other than 90%

could be used, however, new critical values would need to be established for different values.

I have found that this concept of SQE as defined above is not transparent in practical management applications. Hence, I am using the mean value of the parametric bootstrap instead. This has the advantage of being easily interpreted as the mean risk of reaching the quasi-extinction threshold in the specified timeframe. I used the same population simulations as in Snover and Heppell (in review) to determine that the range of critical values for this metric is 0.65-0.75. In other words, populations with a mean risk of quasi-extinction > 0.75 are at risk, populations with a mean risk < 0.65 are not at risk and populations with means between 0.65 and 0.75 are potentially at risk. This definition of SQE classifies populations the same as that of Snover and Heppell (in review) while providing an index for quasi-extinction risk that is more tractable to managers.

Once a baseline SQE was established for each nesting population, I used this mean risk of quasi-extinction in conjunction with an approach similar to Kaplan (2005). Kaplan (2005) estimated that 181 eastern Pacific leatherbacks were killed by the international longline fleet in 1998. Spotilla et al. (2000) estimated a population size of about 1690 adult females in the eastern Pacific. Hence, assuming all mortalities were adults and a 50% sex ratio, Kaplan (2005) calculated that of the total adult female mortality rate, 0.054 per year arises from the international longline fleet. He added this mortality to his estimate of population growth rate, r, to indicate what the population growth rate would be if all mortality from longline interactions were removed. With assumptions regarding age-class and sex ratios of turtles in the bycatch, a similar method can be applied here. Assuming a constant $\hat{\sigma}^2$, new values of $\hat{\mu}$ can be used in the diffusion approximation to establish a new SQE value to determine if mortalities from fisheries bycatch are likely to affect the persistence of the population.

I considered the SQE values estimated for the datasets at QET=50% of the current population size (reduction of 50 % from current population size) as baseline values, resulting in estimates of $\hat{\mu}_b$, $\hat{\sigma}^2{}_b$ and population growth rate r_b, where the subscript *b* denotes baseline. Following recommendations in Snover and Heppell (in review), I used a running-sum of 3 yr and current population size, n_0, was estimated as the sum of the last 3 yr of data. I considered the effect of m_i = 1, 2, 3 …10 additional annual adult female mortalities on SQE values. The intrinsic rate of population increase (*r*) is calculated as

(6) $$r = \mu + \frac{\sigma^2}{2}$$ (Dennis et al. 1991),

hence for each value of m_i, a new value of $\hat{\mu}_i$ was estimated as

(7) $$\hat{\mu}_i = \left[r_b - (\frac{m_i}{n_o}) \right] - \frac{\sigma_b{}^2}{2}.$$

New confidence intervals around $\hat{\mu}_i$ were constructed using the standard error of $\hat{\mu}_b$ and new susceptibility to extinction values were estimated for each m_i using the Dennis et al. (1991) method. The bootstrap results were smoothed by fitting a logistic curve to the results

(8) $$SQE_{new} = \left[1 + (\frac{1}{SQE_0} - 1)\exp(-bA) \right]^{-1}$$

where SQE_0 is the base value of SQE, SQE_{new} is the new value of SQE, A is the number of additional adult female mortalities and b is a fitted parameter that describes the rate of increase of the curve.

Reproductive Values

Sizes of loggerhead turtles interacting with the shallow-set fishery range from 40 to >95 cm carapace length, with an approximate mean of 64 cm carapace length. Therefore, most of the loggerhead turtles interacting with this fishery are juveniles. As the above analysis only deals with adult females (because these are the only portion of the population being censused) we need to equate these juveniles to adult females using reproductive values. To truly assess an individual's reproductive value, precise information on survival rates, fecundity rates, age and individual growth rates are needed. As we don't have this information for Japanese loggerheads, I created a range of population models assuming different ages to maturity, size at maturity and survival rates (Table 2). I used age-based Leslie matrix models where the dominant left eigenvector contains the reproductive value for each age class. Each turtle interacting with the shallow-set fishery from 2004-2007 for which size was recorded was assigned an age, based on the growth curve used in each model, and the corresponding reproductive value; a mean of these reproductive values was calculated. For the models analyzed, mean reproductive values ranged from 0.22 to 0.41. In a letter to the Council, the Pacific Islands Regional Office (PIRO) indicated that they would use the value 0.41 in their jeopardy assessment[7] and so I use that value in this assessment.

[7] Letter from Lance Smith of PIRO to Eric Kingma of WPRFMC dated 24 April 2008, 'Variables for Estimates of Annual Adult Female Mortalities in Shallow-set Fishery'.

For leatherbacks, the estimated lengths range from 100 to 192 cm carapace length with 11 turtles represented (measurements are not available for all leatherbacks interacting with the fishery). Western Pacific leatherbacks reach maturity as small as 126 cm carapace length (Zug and Parham 1996), hence ~82% of the leatherbacks interacting with the fishery are potentially mature. Given the high proportion of adults represented in the bycatch and the uncertainties associated with estimates of growth, survival rates and fecundity parameters, the PIRO[7] recommends using a mean reproductive value of 0.85 to account for the fact that most but not all of the leatherbacks interacting with this fishery are likely to be adults.

Sex Ratios

In addition to reproductive values, a sex ratio of the turtles interacting with the fishery needs to be assumed to estimate the proportion of females in the bycatch. There are no of sex ratio studies for Japanese loggerheads or West Pacific leatherbacks, however studies of other populations typically find a female bias in sex ratios. Table 3 summarizes sex ratio studies for other loggerhead and leatherback populations. Based on this information, PIRO has decided that it will use 0.65 female as the sex ratio for both loggerheads and leatherbacks.[7]

Potential applications of approach to management decisions

As annual takes of adult females are increased, SQE values increase accordingly. The rate of increase in SQE values is closely linked with current population size, small populations will be more impacted by additional takes than large ones. There are numerous ways to consider the point where the increase in SQE, and the corresponding interaction level, becomes unacceptable. In considering which method to use, transparency and ease of application are important for management decisions. I will suggest and implement a method here with the understanding that other approaches can be considered.

As a goal in determining take levels for endangered species is to not appreciably reduce their likelihood of their survival and recovery, I argue that we want to use take levels consistent with very small changes in SQE. Consider the value 1-SQE. A cutoff percentage of this value, for example 1 - 10%, can be used whereby fatal takes of adult females that increase SQE by > 0.01(1-SQE) to 0.1(1-SQE) is considered an unacceptably large increase. 1% of 1-SQE is likely a very conservative value while 10% of 1-SQE is likely liberal and the exact value (whether in this range or outside its bounds) that results in jeopardy is a management decision that must be made with consideration of other threats to the populations (e.g. threats that may not be apparent from the nesting beach trends). The use of 1-SQE has the advantage of being conservative for populations with high SQE and less so for low SQE values. For example, for 0.05(1-SQE), if SQE = 0.99, SQE cannot increase by more than 0.0005, whereas if SQE=0.01, this value can increase by up to 0.0495. To apply this method, I used the parametric bootstrap procedure described above with 10000 repetitions to determine new SQE values for 1 to 10 additional adult female mortalities (Fig. 3). These values were fitted with logistic curves (Eq. 8) and the resulting values of *b* were 0.027 for Jamursba-Medi, 0.174 for Costa Rica, and 0.017 for Japan.

Results and Discussion

All three of the Pacific populations considered here appear to be declining with μ values < 0 (Table 4) and the SQE values were all above the critical range of 0.65-0.75 for

QET = 50% (Table 5). For the Costa Rica population, an annual loss of >1 adult female beyond the current level resulted in excessive (as defined in this paper) increases in SQE (Table 5). The results for the larger Jamursba-Medi nesting population indicated that adult female mortalities of less than 4 (and ideally less than 2 to stay under the 0.05(1-SQE) range) would have a minimal impact on SQE. Of the three populations, the Japanese loggerhead population was the largest and the results for this population indicated that adult female mortalities less than 7 (or 3 for the 0.05(1-SQE) range) would have a minimal impact on the populations risk of extinction.

These numbers are small and may seem to suggest that this method is overly conservative, however these populations are all small and declining and the allowable fatal interactions from them should reflect their status. The values above are in terms of adult females, and once these numbers are placed into a context of total interactions, accounting for sex ratio (0.65 female for both species), reproductive value (0.41 for loggerheads and 0.85 for leatherbacks), and the fact that most turtles interacting with this fishery will survive (mean post-interaction mortality rates of 0.205 and 0.229 for loggerheads and leatherbacks respectively), the total interactions that equate to the numbers of adult female interactions (Table 5) fall within the ranges proposed for expansion of the fishery (Table 6). For example, an interaction level of 46 loggerheads results in ~3 adult female mortalities (Table 6) and the range proposed by the methods presented here is ~1 to ~7 adult females (Table 5).

Conclusions

The SQE values calculated for a nesting beach are strongly and negatively correlated with current population size and population trend (in terms of abundances on nesting beaches; Snover and Heppell, in review) and these parameters obviously change over time. If the populations assessed here continue to decline, detectable changes in SQE may be found with fewer adult female losses, and the reverse of this is true as well. Hence it is advisable to periodically assess the status of the populations interacting with the longline fisheries.

The population growth rates and SQE values considered here apply only to the nesting female segment of the population. For most populations, this is the only portion censused for trends and we cannot assume that what is happening on the nesting beach parallels the rest of the population is not appropriate and caution needs to be applied in interpreting these results. For example, the Japanese loggerhead trends have historically been cyclic with periods of increases alternating with declines. The nesting abundances have been increasing since 1997, but the two most recent years of data for this population are suggestive of a substantial decline in numbers. No real inferences can be made on only two years of data, however the mortalities of juveniles off the Baja peninsula of Mexico are well documented (Peckham et al. 2007) and these mortality levels are relatively recent (increasing to current levels over the last 15-20 years or so; H. Peckham pers comm.). The current declining numbers in the Japanese loggerhead trends may simply be the start of another cycle, however it may also be that the reduction of the juveniles in Baja is just now being manifested in the nesting beach data and the population could be declining at a much more rapid rate than the analyses here represent. Considerations of extenuating circumstances such as these should be accounted for when determining acceptable interaction levels.

Literature Cited

Benson, S.R., P.H. Dutton, C. Hitipeuw, B. Samber, J. Bakarbessy, and D. Parker. 2007b. Post-nesting migrations of leatherback turtles (*Dermochelys coriacea*) from Jamursba-Medi, Bird's Head Peninsula, Indonesia. Chelonian Conservation and Biology 6:150-154.

Benson, S.R., K.M. Kisokau, L. Ambio, V. Rei, P.H. Dutton and D. Parker. 2007a. Beach use, internesting movement, and migration of leatherback turtles, *Dermochelys coriacea*, nesting on the North Coast of Papua New Guinea. Chelonian Conservation and Biology 6:7-14.

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: 291-3.

Casale, P., B. Lazar, S. Pont, J. Tomás, N. Zizzo, F. Alegre, J. Badillo, A. Di Summa, D. Freggi, G. Lacković, J.A. Raga, L. Rositani, and N. Tvrtković. 2006. Sex ratios of juvenile loggerhead sea turtles *Caretta caretta* in the Mediterranean Sea. Marine Ecology Progress Series 324:281-285.

Dennis, B., P.L. Munholland and J.M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecological Monographs 61:115-143.

Dutton, P.H., C. Hitipeuw, M. Zein, S.R. Benson, G. Petro, J. Pita, V. Rei, L. Ambio, J. Bakarbessy. 2007. Status and genetic structure of nesting populations of leatherback turtles (*Dermochelys coriacea*) in the Western Pacific. Chelonian Conservation and Biology 6:47-53.

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

Godley, B.J., A.C. Broderick, J.R. Downie, F. Glen, J.D. Houghton, I. Kirkwood, S. Reece and G.C. Hays. 2001a. Thermal conditions in nests of loggerhead turtles: further evidence suggesting female skewed sex ratios of hatchling production in the Mediterranean. Journal of Experimental Marine Biology and Ecology 263:45-63.

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

Hatase, H., Y. Matsuzawa, K. Sato, T. Bando and K. Goto. 2004. Remigration and growth of loggerhead turtles (*Caretta caretta*) nesting on Senri Beach in Minabe, Japan: life-history polymorphism in a sea turtle population. Marine Biology 144:807-811.

Hitipeuw, C. P.H. Dutton, S.Benson, J. Thebu, and J. Bakarbessy. 2007. Population status and internesting movement of leatherback turtles, *Dermochelys coriacea*, nesting on the northwest coast of Papua, Indonesia. Chelonian Conservation Biology 6: 28-36.

Kamezaki, N., Y. Toji and Y. Matsuzawa. 2002. Current status of Japanese loggerhead turtle nesting and beach environment. Sea turtle Association of Japan, Osaka, 157pp.

Kaplan, I.C. 2005. A risk assessment for Pacific leatherback turtles (*Dermochelys coriacea*). Canadian Journal of Fisheries and Aquatic Sciences **62**:1710-1719.

Kaska, Y. C. 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. 93:338-343.

Morris, W.F. and D.F. Doak. 2002. Quantitative conservation biology: theory and practice of population viability analysis. Sinauer Associates, Inc. Sunderland MA.

Martínez, L.S., A.R. Barragín, D.G. Muñoz, N. García, P. Huerta, and F. Vargas. 2007. Conservation and biology of the leatherback turtles in the Mexican Pacific. Chelonian Conservation and Biology 6:70-78.

National Marine Fisheries Service. 2001. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the Western North Atlantic. U.S. Department of Commerce NOAA Technical Memorandum NMFS-SEFSC-455, 343 pp.

Öz, M. A. Erdoğan, Y. Kaska, S. Düşen, A. Aslan, H. Sert, M. Yavuz, and M.R. Tunç. 2004. Nest temperatures and sex-ratio estimates of loggerhead turtles at Patara beach on the southwestern coast of Turkey. Canadian Journal of Zoology 82:94-101.

Peckham SH, Maldonado D, Walli A, Ruiz G, Nichols WJ, Crowder L (2007) Small-scale fisheries bycatch jeopardizes endangered Pacific loggerhead turtles. PLoS One 2:doi:10.1371/journal.pone.0001041.

Ryder, C.E., T.A. Conant and B. Schroeder. 2006. Report of the Workshop on Marine Turtle Longline Post-Interaction Mortality. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-F/OPR-29, 36 p.

Snover, M.L. 2002. Growth and ontogeny of sea turtles using skeletochronology: methods, validation and application to conservation. Ph.D. dissertation, Duke University, Durham, NC.

Snover, M.L. and S.S. Heppell. In Review. Application of diffusion approximation for risk assessment of sea turtle populations. Submitted to Ecological Applications 7-5-2007.

Spotila, J.R., A.E. Dunham, A.J. Leslie, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino. 1996. Worldwide population decline of Dermochelys coriacea: are leatherback turtles going extinct? Chelonian Conservation and Biology 2: 209-222.

Spotila, J.R., R.D. Reina, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino. 2000. Pacific leatherback turtles face extinction. Nature 405:529-530.

Tomillo, P.S., E. Vélez, R.D. Reina, R. Peidra, F.V. Paladino, and J.R. Spotila. 2007. Reassessment of the leatherback turtle (*Dermochelys coriacea*) nesting population at Parque Nacional Marine Las Baulas, Costa Rica: effects of conservation efforts. Chelonian Conservation and Biology 6:54-62.

Turtle Expert Working Group. 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-555, 116 p.

Zug, G.R. and J.F. Parham. 1996. Age and growth in leatherback turtles, *Dermochelys coriacea* (Testudines: Dermochelyidae): a skeletochronological analysis. Chelonian Conservation and Biology 2:244-249.

Table 1. Post-interaction mortality rates for hardshell and leatherback turtles caught in longline fisheries. Numbers are the percent of hardshell (leatherback) turtles expected to die as a result of the corresponding injury and release condition (as per Ryder et al. 2006).

Nature of Interaction	Released with hook and with line greater than or equal to half the length of the carapace	Released with hook and with line less half the length of the carapace	Released with hook and entangled (line is not trailing, turtle is entangled)	Released with all gear removed
Category	Hardshell (Leatherback)	Hardshell (Leatherback)	Hardshell (Leatherback)	Hardshell (Leatherback)
I Hooked externally with or without entanglement	20 (30)	10 (15)	55 (65)	5 (10)
II Hooked in upper or lower jaw with or without entanglement. Includes ramphotheca, but not any other jaw/mouth tissue parts (see Category III)	30 (40)	20 (30)	65 (75)	10 (15)
III Hooked in cervical esophagus, glottis, jaw joint, soft palate, tongue, and/or other jaw/mouth tissue parts not categorized elsewhere, with or without entanglement. Includes all events where the insertion point of the hook is visible when viewed through the mouth	45 (55)	35 (45)	75 (85)	25 (35)
IV Hooked in esophagus at or below level of the heart (includes all hooks where the insertion point of the hook is not visible when viewed through the mouth) with or without entanglement	60 (70)	50 (60)	85 (95)	N/A
V Entangled only	50 (60)			1 (2)
I Comatose/resuscitated	N/A	70 (80)	N/A	60 (70)

Table 2. Parameters used in the Leslie matrix models to estimate the reproductive values of juvenile loggerheads interacting with the Hawaii-based shallow-set fishery in relation to adults. Size at maturity is based on lengths of nesting females reported in Hatase et al. 2004b.

Parameter	Values
First year survival rate	0.38
Juvenile survival rate	0.74-0.86
Adult survival rate	0.84-0.95
Remigration interval	2.7 yr
Eggs per nest	112
Nests per year	4
Hatch success rate	0.7
Sex ratio	0.65
Size at maturity	74 – 84 cm SCL
Age to maturity	24 – 29 yr

Table 3. Summary of literature on sex ratios in loggerhead and leatherback populations

Loggerheads	
Source	**Results**
Godley et al. 2001a	Found high nest incubation temperatures (above 29° C) suggestive of an 'extremely high proportion of females' in Cyprus.
Godley et al. 2001b	Estimated 89-99% females for Cyprus.
NMFS 2001	Juvenile strandings that were necropsied for sex determination between 1995 and 1999 from Texas to Virginia (N=758) were found to be 67.5% female.
Öz et al. 2004	Estimated 67% and 74% of hatchlings were female in Turkey.
Casale et al. 2006	Necropsy results for 310 loggerheads within the Mediterranean Sea showed 54.2% were female.
Kaska et al. 2006	Estimated 60-65% of hatchlings were female in Turkey
Leatherbacks	
Source	**Results**
Godfrey et al. 1996	Estimated nest sex ratios at 69.4% female in Suriname
Binckley et al. 1996	Estimated nest sex ratios of 74.3 – 100% female in Costa Rica (Pacific coast)
TEWG 2007	Necropsied strandings along the southeast Atlantic coast range from 57-87% female

Table 4. Parameters used in the calculation of the susceptibility to quasi-extinction (SQE) index for each population considered. $\hat{\mu}$ is the arithmetic mean of the log population growth rate and $\hat{\sigma}^2$ is the variance of the log population growth rate. . Calculations were made using a 3-yr running sum and current population size (N) was estimated as the sum of the last three years of data (approximating the total number of adult females). QET is quasi-extinction threshold and T is the time horizon for the quasi-extinction risk (the lesser value of 3 generations or 100 yr).

Population	$\hat{\mu}$	S.E. of $\hat{\mu}$	$\hat{\sigma}^2$	N	QET=50%	T
Leatherbacks, Playa Grande, Costa Rica	-0.185	0.080	0.055	335	168	63
Leatherbacks, Jamursba-Medi, Papua	-0.037	0.052	0.019	1515	758	63
Loggerheads, Japan	-0.032	0.045	0.020	2915	1548	100

Table 5. Susceptibility to quasi-extinction (SQE) values for the three populations considered here and the number of adult female mortalities that will result in an increase of SQE equivalent to 1, 5, and 10% of (1-SQE). For example, for loggerheads, SQE = 0.8311, 10% of (1-SQE) is 0.0169, resulting in a 'new' SQE of 0.8480 which would be achieved by an increase of 7.48 adult females per year (Fig. 3; Eq. 8 with b = 0.017).

	Leatherbacks Costa Rica	Leatherbacks Jamursba-Medi	Loggerheads Japan
SQE	0.9985	0.8001	0.8311
% Increase in SQE	Equivalent adult female mortalities		
0.01(1-SQE)	0.06	0.47	0.72
0.05(1-SQE)	0.30	2.38	3.66
0.10(1-SQE)	0.61	4.85	7.48

Table 6. Expected adult female mortalities and increases in the susceptibility to quasi-extinction (SQE) index based on different interaction levels for the Hawaii-based shallow-set longline fishery. Mean adult female mortalities were estimated using a 65% female sex ratio, 0.205 and 0.229 post-interaction mortality rates for loggerheads and leatherbacks, and 0.41 and 0.85 mean reproductive values for loggerheads and leatherbacks. Increases in SQE are based on the fitted logistic curves in Fig. 3. Numbers in brackets use the 95% CI on the post-interaction mortality rates to estimate adult female mortalities and the percent increase in 1-SQE.

	Proposed Interactions	Expected adult female mortalities			Increase in SQE: **X**(1-SQE)	
Loggerheads						
Current	17	0.93			0.013	
		[0.67, 1.19]			[0.001, 0.016]	
Proposed	46	2.51			0.035	
		[1.81, 3.21]			[0.025, 0.044]	
Leatherbacks		Total	Jamursba-Medi	Costa Rica	Jamursba-Medi	Costa Rica
Current	16	2.02	1.31	0.12	0.027	0.022
		[1.11, 2.93]	[0.34, 1.90]	[0.03, 0.18]	[0.007, 0.040]	[0.006, 0.031]
Proposed	19	2.40	1.56	0.14	0.033	0.043
		[1.32, 3.48]	[0.42, 2.26]	[0.04, 0.21]	[0.009, 0.048]	[0.011, 0.062]

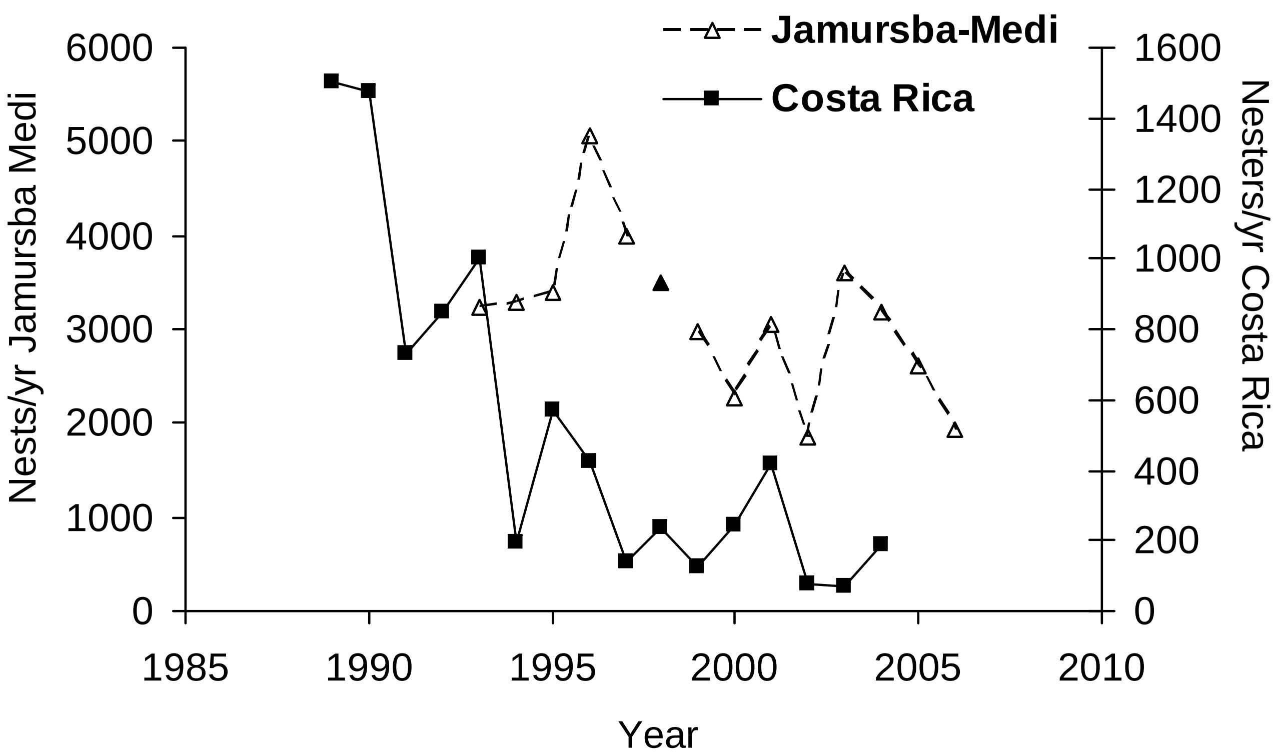


Figure 1. Nest or nester abundance trends for Jamursba-Medi, Papua, Indonesia (Hitipeuw et al. 2007) and for Parque Nacional Las Baulas, Playa Grande, Costa Rica (Tomillo et al. 2007). The 1998 datapoint for Jamursba Medi is missing and it was estimated as the mean of the nest numbers for 1997 and 1999 (filled triangle).

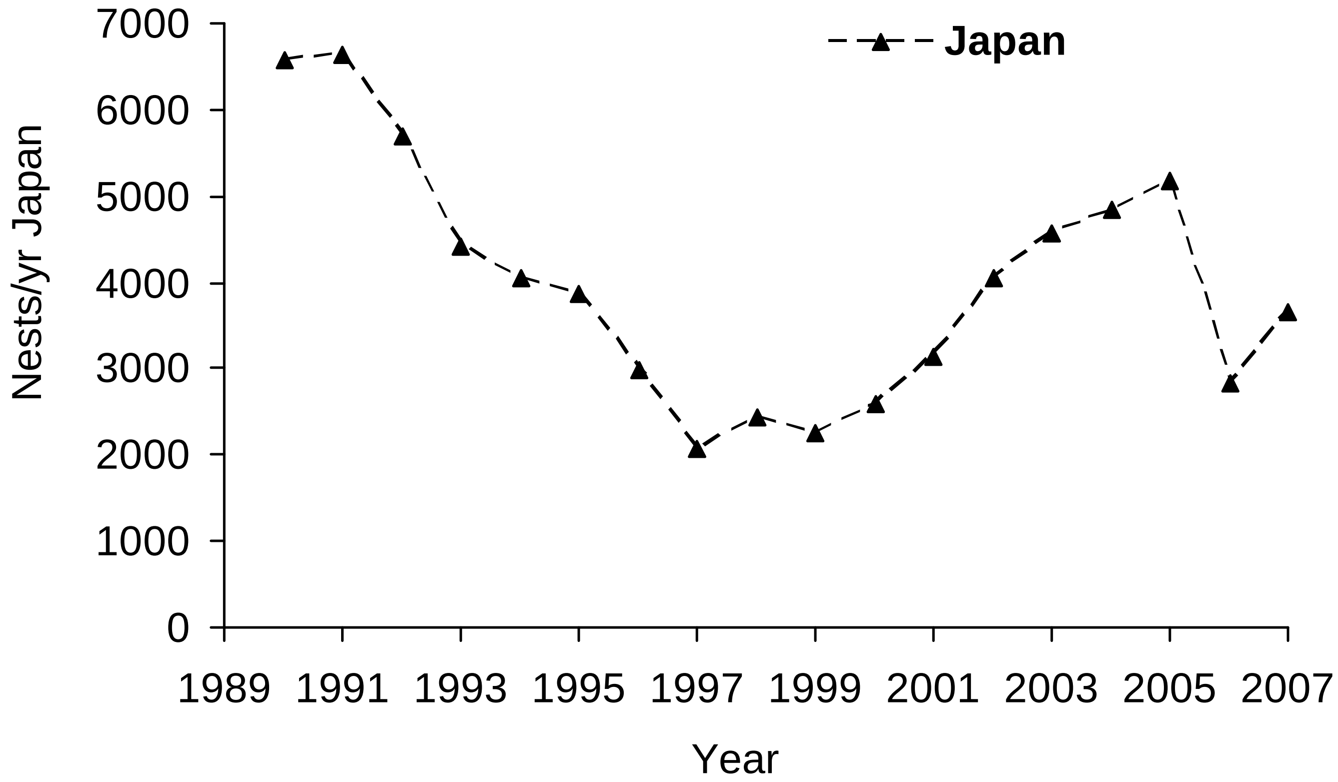


Figure 2. Nest abundance trends for loggerheads in Japan (Sea Turtle Association of Japan, unpublished data and Kamezaki and Matsuzawa 2002).

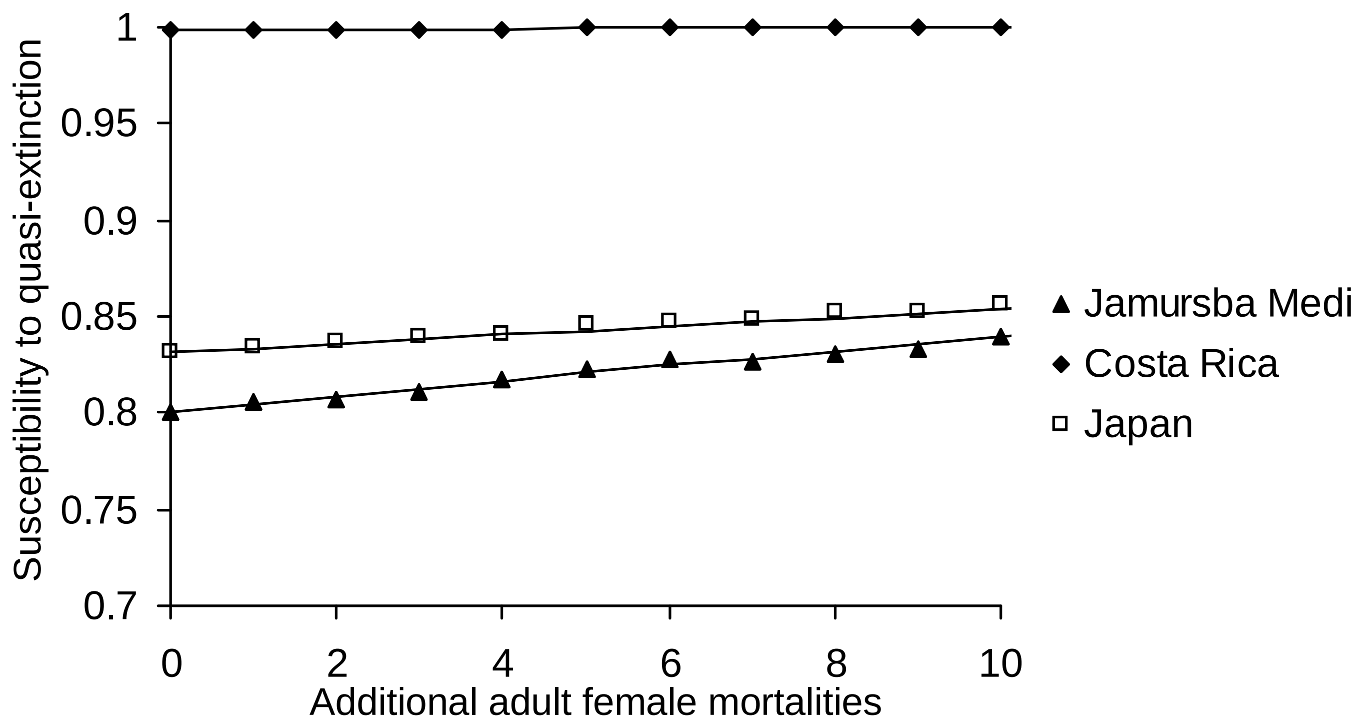


Figure 3. Changes in the susceptibility to quasi-extinction index as mortalities of adult females increases.

Appendix III

Observed Captures and Estimated Mortality of Sea Turtles in the Hawaii Shallow-set Longline Fishery, 2004-2007

This page left blank intentionally.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Pacific Islands Regional Office
1601 Kapiolani Blvd., Suite 1110
Honolulu, Hawaii 96814-4733
(808) 944-2200 • Fax: (808) 973-2941

FEB 1 - 2008

MEMORANDUM FOR: William L. Robinson
Regional Administrator

FROM: Chris Yates
Assistant Regional Administrator

Alvin Katekaru for
Assistant Regional Administrator

SUBJECT: Observed captures and estimated mortality of sea turtles in the Hawaii shallow-set longline fishery, 2004-2007

The February 23, 2004, biological opinion on 'Proposed Regulatory Amendments to the Fisheries Management Plan for the Pelagic Fisheries of the Western Pacific Region' (Pelagics FMP BiOp) analyzed effects of the Hawaii shallow-set longline fishery on ESA-listed sea turtles. The BiOp's incidental take statement (ITS) estimated the annual number of turtles expected to be captured or killed in this fishery ('ITS Limits' columns in Table 1 below). The ITS estimate of number killed was intended to include turtles that died after being hooked or entangled but before being brought on board, as well as projected post-hooking mortality of turtles that were captured alive and released. This memo summarizes the actual number of sea turtles that were captured in this fishery from when the fishery resumed in late 2004 to the end of 2007 ('Actual # captured' columns in Table 1), and provides an estimate of mortality resulting from these interactions ('Estimated # killed' columns in Table 1).

Table 1. Sea turtle interaction limits (**ITS Limit** columns) and total number of interactions by year for the Hawaii shallow-set fishery (individual interactions shown in Tables 2 – 5 below).

	Captured (# turtles)						Killed (# turtles)					
	ITS	Actual # captured					**ITS**	Estimated # killed				
Species	**Limit**	2004	2005	2006	2007	Total	**Limit**	2004	2005	2006	2007	Total
Loggerheads	**17**	1	12	17	15	45	**3**	0.25	2.70	3.61	2.65	9.21
Leatherbacks	**16**	1	8	2	5	16	**2**	0.15	1.26	0.60	1.55	3.56
Olive Ridleys	**5**	0	0	0	1	1	**1**	0	0	0	0.01	0.01
Greens	**1**	0	0	0	0	0	**1**	0	0	0	0	0
Hawksbills	**0**	0	0	0	0	0	**0**	0	0	0	0	0
Total		2	20	19	21	62		0.40	3.96	4.21	4.21	12.78

Although not specifically defined as such, interactions between the Hawaii shallow-set longline fishery and sea turtles are effectively limited to hooking, entanglement, or a combination of hooking and entanglement in the fishing gear. As used in Table 1, the word 'captured' refers to those interactions that result in a turtle being restrained by the fishing gear until it is observed by the crew or the observer. 'Killed' is a subset of that group, consisting of turtles that were either observed or estimated to have suffered mortality as a result of the interaction.

The actual number of sea turtles captured in the fishery was determined with 100 percent observer coverage in 2004 - 2007, and each individual interaction is shown in Tables 2 – 5 below. All turtles captured in the fishery during this period were released (or escaped) alive. The likelihood of a captured turtle dying after being released (post-hooking mortality) was estimated based on the species, the type of injury, and the release condition of each turtle, as summarized in the footnotes for Table 2. These post-hooking mortality criteria were developed at the 2004 'Workshop on Marine Turtle Longline Post-Interaction Mortality' by a panel of experts, including representatives from the NMFS Office of Protected Resources and the Pacific Islands Fishery Science Center[1].

There are two discrepancies between this memo and the annual Observer Program reports for sea turtle interactions in the shallow-set fishery:

1. In 2005 and 2006, the final tallies for total sea turtle interactions in this fishery (all sea turtle species combined) were given as 18 and 21, respectively, in the final Observer Program reports[2]. However, as shown above in Table 1, the actual tallies for 2005 and 2006 were 20 and 19 sea turtles captured, respectively. The discrepancy is due to the fact that observer reporting is based on arrival dates, and the final two loggerheads captured in 2005 were captured in December 2005, but did not arrive in port until January 2006.

2. The 2006 Observer Program annual report notes that two 'unidentified hardshells' were captured in the fishery. However, based on the observers' narratives on the data sheets, both were considered to be loggerheads and thus added to the final loggerhead tally for 2006.

The mortality estimates are not rounded to give whole numbers. This is because the total mortalities (and limits on them) are very low, often < 5 individuals, resulting in the difference in two whole numbers being a large percentage of the total. Thus, rounding may substantially understate or overstate mortality. For example, rounding down the 1.26 leatherbacks in 2005 would result in a mortality estimate of 1 turtle, an approximately 20 percent underestimate for a species that is critically endangered. Likewise, rounding up the 0.01 olive ridleys in 2007 would result in a mortality estimate of 1 turtle, a vast overestimate that also happens to be the annual limit.

During 2004 – 2007, the fishery captured a total of 45 loggerheads, 16 leatherbacks, 1 olive ridley, and no greens or hawksbills (Table 1). All turtles were released (or escaped) alive with various injuries and release conditions (Tables 2 – 5), resulting in total estimated mortality of

---

[1] See Table 1 in Ryder et al. 2006 (Report of the Workshop on Marine Turtle Longline Post-Interaction Mortality, NOAA Technical Memorandum NMFS-OPR-29).

[2] Pacific Islands Regional Observer Program Shallow Set Annual Status Reports for 2005 and 2006. Pacific Islands Regional Office. National Marine Fisheries Service. http://www.fpir.noaa.gov/OBS/obs_hi_ll_ss_rprts.html

9.21 loggerheads (20.5% estimated mortality rate of captured loggerheads), 3.56 leatherbacks (22.3% estimated mortality rate of captured leatherbacks), and 0.01 olive ridleys (estimated mortality rate not calculated due to one sample).

These estimates do not reflect the reproductive cost of the mortalities to the species as a whole or to individual sub-populations. For example, they do not take into account the sex, size, or age class of the turtles. The reproductive value of the turtles and the impact of their loss will be analyzed in subsequent NEPA and ESA analyses of the fishery.

Tables 2 – 5: Individual sea turtle interactions by year and species for Hawaii shallow-set longline fishery, 2004 – 2007.

Table 2. 2004	Date of Interaction	Type of Interaction	Injury Category[3]	Release Condition[4]	Mortality Coefficient[5]
Loggerheads	11/30/2004	Hooked	III	D	0.25
2004 Total Estimated Loggerhead Mortality:					**0.25**
Leatherbacks	11/30/2004	Hooked	I	B	0.15
2004 Total Estimated Leatherback Mortality:					**0.15**

[3] Injury Categories from Table 1 of Ryder et al. 2006 (Report of the Workshop on Marine Turtle Longline Post-Interaction Mortality, NOAA Technical Memorandum NMFS-OPR-29):

I. Hooked externally with or without entanglement.
II. Hooked inside beak (ramphotheca).
III. Hooked inside soft tissue of mouth where hook insertion point is visible.
IV. Hooked in esophagus (or deeper) such that insertion point is not visible.
V. Entangled only, no hook involved.
VI. Comatose/resuscitated.

In some cases, injury category was ambiguous because turtle could not be examined, in which case a range of categories was assigned, and the mean mortality coefficient calculated.

[4] Release Condition from Table 1 of Ryder et al. 2006 (citation given in Footnote 1):

A. Released with hook and trailing line ≥ ½ carapace length.
B. Released with hook and trailing line < ½ carapace length.
C. Released with hook and entangled (line not trailing).
D. Released with all gear removed.

[5] From Table 1 of Ryder et al. 2006 (citation given in Footnote 1): Mortality coefficient is a function of Injury Category and Release Condition, and varies between hardshell species and leatherbacks.

Table 3. 2005	Date of Interaction	Type of Interaction	Injury Category	Release Condition	Mortality Coefficient
Loggerheads	1/27/2005	Hooked	III	D	0.25
	2/17/2005	Hooked	I	D	0.05
	2/18/2005	Entangled	V	D	0.01
	2/20/2005	Hooked	III	D	0.25
	2/21/2005	Entangled	V	D	0.01
	2/23/2005	Hooked	I	D	0.05
	2/24/2005	Hooked	II-III	D	0.175
	2/25/2005	Hooked	III	D	0.25
	3/20/2005	Hooked	I	D	0.05
	11/15/2005	Hooked	III	D	0.25
	12/10/2005	Hooked and Entangled	IV	C	0.85
	12/17/2005	Hooked	IV	B	0.50
2005 Total Estimated Loggerhead Mortality:					**2.70**
Leatherbacks	1/1/2005	Hooked and Entangled	I	D	0.10
	1/6/2005	Hooked	I	D	0.10
	4/23/2005	Hooked	I	B	0.15
	4/23/2005	Entangled	V	D	0.01
	5/4/2005	Hooked	I	A	0.30
	5/11/2005	Hooked	I	A	0.30
	6/30/2005	Hooked	I	D	0.10
	11/16/2005	Hooked	I	A	0.30
2005 Total Estimated Leatherback Mortality:					**1.26**

Table 4. 2006	Date of Interaction	Type of Interaction	Injury Category	Release Condition	Mortality Coefficient
Loggerheads	1/7/2006	Hooked	I	D	0.05
	1/10/2006	Hooked	III	D	0.25
	1/19/2006	Hooked	I	D	0.05
	1/20/2006	Hooked	I	D	0.05
	1/25/2006	Hooked	I-II	D	0.075
	1/28/2006	Hooked	IV	B	0.50
	1/31/2006	Hooked and Entangled	I-II	D	0.075
	2/2/2006	Hooked	III	D	0.25
	2/2/2006	Entangled	V	D	0.01
	2/7/2006	Hooked	IV	B	0.50
	3/3/2006	Hooked	I	D	0.05
	3/5/2006	Hooked	IV	B	0.50
	3/7/2006	Hooked	III	D	0.25
	3/8/2006	Hooked	III	D	0.25
	3/10/2006	Hooked	I	D	0.05
	3/14/2006	Hooked	I	D	0.05
	3/16/2006	Hooked and Entangled	III-IV	A-C	0.65
2006 Total Estimated Loggerhead Mortality:					**3.61**
Leatherbacks	3/3/2006	Hooked	1	A	0.30
	3/17/2006	Hooked	1	A	0.30
2006 Total Estimated Leatherback Mortality:					**0.60**

Table 5. 2007	Date of Interaction	Type of Interaction	Injury Category	Release Condition	Mortality Coefficient
Loggerheads	2/2/2007	Hooked	I	D	0.25
	2/12/2007	Hooked	I	D	0.05
	2/19/2007	Hooked	III	D	0.25
	3/2/2007	Hooked	III	D	0.25
	2/17/2007	Hooked	I	D	0.05
	2/10/2007	Hooked	I	D	0.05
	3/3/2007	Hooked	III	D	0.25
	3/11/2007	Hooked	II-III	D	0.175
	3/26/2007	Hooked	I	D	0.05
	3/21/2007	Hooked	I	D	0.05
	3/31/2007	Hooked and Entangled	I	D	0.05
	3/30/2007	Hooked	III	D	0.25
	4/3/2007	Hooked	II-III	D	0.175
	5/2/2007	Hooked and Entangled	III	D	0.25
	8/8/2007	Hooked	IV	B	0.50
2007 Total Estimated Loggerhead Mortality:					**2.65**
Leatherbacks	1/5/2007	Hooked	I	A	0.30
	2/1/2007	Hooked	I	D	0.10
	4/4/2007	Hooked	I	B	0.15
	4/29/2007	Hooked	I	B	0.15
	4/29/2007	Hooked	III	C	0.85
2007 Total Estimated Leatherback Mortality:					**1.55**
Olive Ridleys	4/5/2007	Entangled	V	D	0.01
2007 Total Estimated Olive Ridley Mortality:					**0.01**

RECOMMENDATION

Recommend that you concur with the final NMFS estimation of post-hooking mortality in the shallow set fishery 2004-2007.

1. I concur. William L Robinson 2/1/2008
(Date)

2. Let's discuss. ____________________
(Date)

This page left blank.

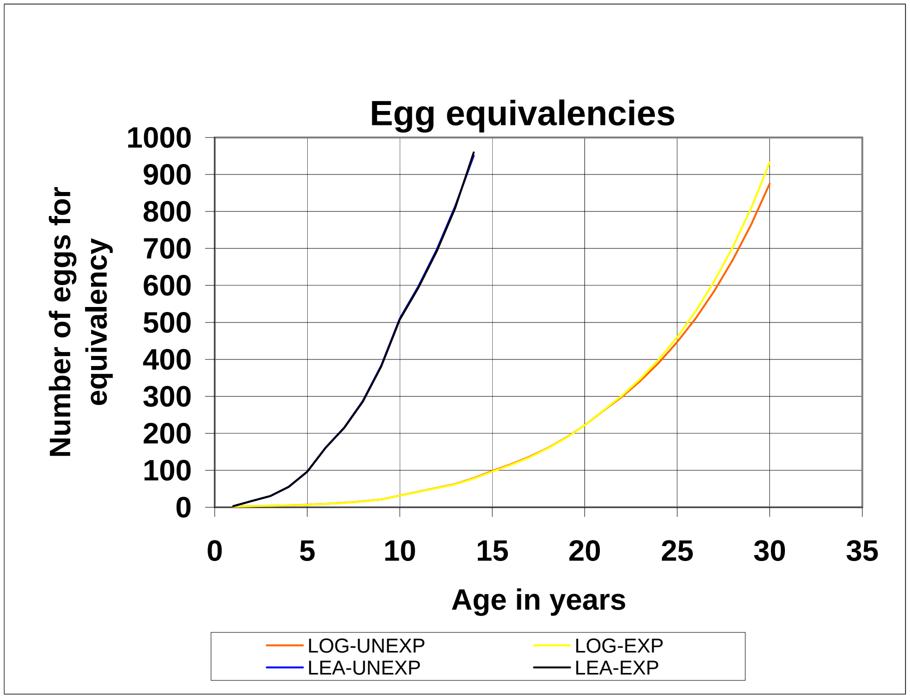
Appendix IV

Leatherback and loggerhead sea turtle egg equivalencies using Chaloupka models

Equivalencies.xls -- July 3, 2003.
Egg equivalencies using Chaloupka models. Values estimated using equilibrium population snapshot ratios.
500 population trajectories averaged, exploited configuration was a long term "coastal fishery" hazard.

Leatherback

Age	Unexploited	Exploited	
1	3.18	3.16	
2	16.74	16.67	
3	30.45	30.31	
4	55.34	55.10	<=Begin exposure to pelagic fisheries
5	96.60	96.18	
6	161.59	160.86	
7	215.47	214.45	
8	287.20	285.75	
9	382.88	380.83	
10	510.33	507.44	<=Begin exposure to coastal fisheries
11	596.29	592.77	
12	696.72	692.44	
13	814.09	809.33	
14	951.23	959.71	<=Maturity



Loggerhead

Age	Unexploited	Exploited	
1	2.38	2.37	
2	2.85	2.83	<=Begin exposure to pelagic fisheries ages 2-12
3	3.79	3.77	
4	5.06	5.03	
5	6.74	6.69	
6	8.99	8.91	
7	11.98	11.86	
8	15.97	15.78	
9	21.30	21.01	*ages 10-12 not shown because data not in model output
13	62.95	61.84	<=Begin exposure to coastal fisheries ages 10-onward
14	78.70	77.33	
15	98.37	96.67	
16	115.76	114.16	
17	136.19	134.76	
18	160.22	159.09	
19	188.48	187.79	
20	221.72	221.66	
21	260.82	261.63	
22	298.42	301.40	
23	341.38	347.14	
24	390.57	399.84	
25	446.80	460.49	
26	511.16	530.36	
27	584.78	610.79	
28	669.01	703.42	
29	765.36	810.07	
30	875.59	932.88	<=Maturity

Appendix V

Initial Regulatory Flexibility Act Analysis and Regulatory Impact Review for Amendment 18 to the Fishery Management Plan for

Pelagic Fisheries of the Western Pacific Region

This page left blank intentionally.

Appendix V

Initial Regulatory Flexibility Act Analysis and Regulatory Impact Review for Amendment 18 to the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region

I. Introduction

To meet the requirements of Executive Order (EO) 12866, "Regulatory Planning and Review," the National Marine Fisheries Service (NMFS) requires that a Regulatory Impact Review (RIR) be prepared for all regulatory actions that are of public interest. The review provides an overview of the problem, policy objectives, and anticipated impacts of the action, and ensures that management alternatives are systematically and comprehensively evaluated so that the public welfare can be enhanced in the most efficient and cost-effective way. In addition, the Regulatory Flexibility Act, 5 U.S.C. 601 et seq. requires government agencies to assess the impact of their regulatory actions on small businesses and other small organizations via the preparation of Regulatory Flexibility Analyses.

This document examines the costs and benefits of regulatory actions proposed for the Hawaii-based shallow-set longline fishery under the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region. It also contains an analysis of the economic impacts of this action on affected small businesses and other small organizations.

In accordance with EO 12866, the following is set forth: (1) this rule is not likely to have an annual effect on the economy of more $100 million or to adversely affect in a material way the economy, a sector of the economy, productivity, jobs, the environment, public health or safety, or state, local, or tribal governments or communities; (2) this rule is not likely to create any serious inconsistencies or otherwise interfere with any action taken or planned by another agency; (3) this rule is not likely to materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights or obligations of recipients thereof; and (4) this rule is not likely to raise novel or policy issues arising out of legal mandates, or the principles set forth in the Executive Order.

II. Objective and Need for Action

The Hawaii-based shallow-set longline fishery currently operates on a limited basis under a suite of regulations (adopted in 2004) designed to test the use of gear and bait technologies proven successful in the Atlantic at reducing sea turtle interaction rates and the severity of remaining interactions in experiments. Based on the successful results demonstrated between 2004-present, the purpose of this action is to provide increased opportunities for the Hawaii-based shallow-set longline fishery to sustainably harvest swordfish and other fish species, while continuing to avoid jeopardizing the continued existence of threatened and endangered sea turtles as well as other protected species. The proposed modifications to the shallow-set fishery management are intended to further the purposes of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) by encouraging optimum yield from the shallow-set longline fishery, while minimizing bycatch and bycatch mortality to the extent practicable.

III. Description of the Alternatives Considered

A wide range of management alternatives was identified during the development and scoping process for this action. Under all alternatives, current regulations requiring circle hooks and mackerel bait, 100 percent observer coverage, and the use of annual loggerhead and leatherback sea turtle interaction hard caps, in addition to other measures, would remain in place. Due to the complexity of issues considered, they were divided into three topic areas, each with its own range of alternatives.

Topic 1: Shallow-set Longline Fishing Effort Limits

The fishery is currently limited to a maximum of 2,120 shallow-sets per year which is half the fishery's average annual fishing effort during 1994-1999. The existing annual sea turtle interaction hard caps of 17 loggerhead turtles and 16 leatherback turtles were determined based on experimental (Atlantic Ocean) interaction rates multiplied by the 2,120 set limit. Under Alternatives 1A-1E below the annual sea turtle interaction hard caps for the fishery were similarly predicted using observed Pacific Ocean sea turtle interaction rates multiplied by each alternative's effort limit. In the case of Alternative 1F (Remove Effort Limit), the sea turtle interaction hard caps were recommended by the Council taking into account the potential for reasonable increases in fishing effort as well as a range of interaction hard caps and their likely impacts on sea turtle populations.

Alternative 1A: No Action: Continue Current Annual Set Limit
Under this alternative, the maximum annual limit on the number of shallow-sets would remain at 2,120.

Alternative 1B: Allow up to 3,000 Sets per Year
Under this alternative, the maximum annual limit on the number of shallow-sets would be 3,000. This effort limit was chosen as a middle-ground effort alternative between the current set limit and the average annual effort between 1994 and 1999 (approximately 4,240 sets).

Alternative 1C: Allow up to 4,240 Sets per Year
Under this alternative, the maximum annual limit on the number of shallow-sets would be 4,240, which represents the average number of annual sets between 1994 and 1999 or double the current set limit of 2,120 (see Figure 26).

Alternative 1D: Allow up to 5,500 Sets per Year
Under this alternative, the maximum annual limit on the number of shallow-sets would be 5,500 which is nearly the maximum annual number sets for any one year between 1994-1999.

Alternative 1E: Set effort level commensurate with current condition of North Pacific Swordfish Stock (~9,925 sets per year)
Under this alternative, the effort level for swordfish would be established based on the condition of the swordfish stock in the North Pacific and the Maximum Sustainable Yield (MSY) for this stock. Establishment of this effort limit would take into account catches by other longline fleets and the portion of the total swordfish catch already made by the Hawaii fleet. Current (domestic and foreign) swordfish landings in the North Pacific amount to about 14,500 mt, which, according to a recent stock assessment, amounts to about 60% of an estimated MSY of 22,284 mt (Kleiber and Yokowa 2004, Bigelow, PIFSC, pers. comm. January 2008)1. Given an MSY of about 22,284 mt for North Pacific swordfish, and a current swordfish catch by the Hawaii-based fishery of between 850-1,637 mt, (1,861,391-3,602,339 lbs) the amount of effort to catch the remaining available 7,784 mt of additional swordfish would be about 9,925 sets per year. Based on the best available information regarding the status of the North Pacific swordfish stock, the effort limit under this alternative would be adjusted over time as appropriate.

Alternative 1F: Remove Effort Limit (Preferred)
Under this alternative, the annual shallow-set effort limit would be removed and the fishery would not be managed using annual set limits. Instead, fishing effort would be indirectly restricted by modifying the annual sea turtle interaction hard caps to 46 interactions with loggerhead sea turtles and 19 interactions with leatherback sea turtles. This would allow direct control of sea turtle interactions.

Topic 2: Fishery Participation

The annual effort limit is currently allocated among interested Hawaii-based longline fishery permittees and tracked using a set certificate program, i.e. participants must acquire and attach a set certificate to each daily fishing log. The set certificate program is administered by NMFS which in November of each year, provides notices to Hawaii longline fishery permit holders that set certificates are available. Set certificates may be sold, traded or otherwise exchanged with other permit holders in the Hawaii-based longline fleet.

Alternative 2A: No Action: Continue Set Certificate Program
Under this alternative, shallow-set certificates would continue to be made available and issued to all interested Hawaii longline permit holders. For each shallow-set made north of the equator, vessel operators would continue to be required to possess and submit one valid shallow-set certificate for each shallow-set made.

Alternative 2B: Discontinue Set Certificate Program (Preferred)
Under this alternative, shallow-set certificates would no longer be issued or required and the annual set-certificate solicitation of interested parties would end. Under alternatives which include effort limits, sets would be cumulatively accounted for on a fleetwide basis and the fishery would close for the remainder of the year if and when the annual set limit was reached.

---

1 The Klieber and Yokawa (2004) assessment contains caveats dealing with a truncated data set (historical catches from Hawaii and Japanese longline fisheries) and model results indicating relative high levels of natural mortality.

Fishery participants would continue to be required to notify NMFS at least 72 hrs before making a shallow-set trip.

<u>Topic 3: Time-Area Closures</u>

Time-area closures are being considered as a way to increase annual fishery profits through potential reductions in the number of sea turtle interactions that may occur in the first quarter of each year. Interaction rates for loggerhead turtles highest during the first quarter of the year, and it has been hypothesized that reducing fishing effort in areas where swordfish and loggerhead turtle habitats may overlap could increase fishery profits by reducing the risk of exceeding a turtle hard cap very early in the year when there are still many more shallow-sets allowed to be made.

Alternative 3A: No Action: Do Not Implement Time-Area Closures (Preferred)
Under this alternative, the fishery would continue to operate without time-area closures.

Alternative 3B: Implement January Time-Area Closure
Under Alternative 3B, an area closure would be implemented during January of each calendar year. The area closure would be located between 175° W and 145° W longitude and encompass the sea surface temperature band of 17.5°-18.5° C. The latitudinal location of this temperature band varies inter-and intra-annually; however, in January it is generally located near 31°-32° N latitude. Research has suggested that the area between sea surface temperatures of 17.5-18.5 C may be a loggerhead sea turtle "hotspot" based on historical and contemporary distribution and foraging studies as well as location data for observed loggerhead sea turtle interactions with the fishery (Howell, PIFSC, pers. comm., December 2008). The month of January was selected because it may be that the number of loggerhead interactions during January is pivotal to whether or not the fishery will reach its annual sea turtle interaction hard cap before all allowable sets are used. For example, in 2006, the fishery interacted with eight loggerheads in January and the fishery reached the cap of 17 on March 17, 2006. In 2007, the fishery did not interact with any loggerheads during January, but ended the first quarter with 15 loggerhead interactions and did not reach the sea turtle cap.

Alternative 3C: Implement In-season Time-area Closure
Under Alternative 3C, the sea surface temperature-based area closure described for Alternative 3B would be implemented in those years for which 75 percent of the annual loggerhead turtle cap was reached and the closure would remain in effect for the remainder of the first quarter. As with Alternative 3B, this alternative is being considered as a way to increase annual fishery profits through reductions in the number of turtle interactions that occur in the first quarter of each year. This alternative differs from 3B in that its implementation is contingent on high numbers of interactions during the first quarter.

IV. Environmental and Economic Background

U.S. swordfish landings
North Pacific swordfish are targeted by U.S. vessels based out of California and Hawaii. Provisional 2006 data for all U.S. longline fisheries operating in the Western and Central Pacific

Ocean (WCPO) out of both Hawaii and California show the bulk of the swordfish were harvested from north Pacific waters and a small amount from south Pacific waters (Table 1). Other U.S. fisheries such as the drift gillnet fishery operating in the Eastern Pacific Ocean (EPO) also harvest North Pacific swordfish.

Table 1: **U.S. landings of Pacific swordfish, 2003 - 2006**

Year	North Pacific (mt)	South Pacific (mt)	Total (mt)
2003	1,957	7	1,964
2004	1,072	4	1,076
2005	1,451	3	1,454
2006	1,131	30	1,161

Source: NMFS 2007 unpublished data

The spatial distribution of the swordfish catch in the WCPO by the U.S. longline fleet is centered around 160° W and 30-35° N. Most of the fishing effort and swordfish harvest is from Hawaii permitted longline vessels, however other domestic fisheries do catch small amounts as described below. None of the alternatives considered here are expected to increase Hawaii-based swordfish catches to the point of affecting the harvests or profits of other domestic fisheries.

Hawaii-based swordfish fisheries

In the Hawaii-based pelagic fisheries, swordfish landings peaked in 1993 and subsequently decreased (Table 2). The trend in swordfish landings reflected both an increase in the number of vessels in the longline fishery and widespread targeting of swordfish by the fishery. Landings remained relatively steady up to 2000 but dropped dramatically with the prohibition on targeting swordfish by the longline fishery. Although the longline fishery for swordfish was reopened under a new set of regulations in April 2004, landings have remained substantially lower than historical levels. Swordfish landings are primarily from the longline fishery with some small amounts by the main Hawaiian Islands (MHI) commercial troll and handline fisheries (Table 2). Provisional data indicate that approximately 3.7 million pounds (16,444 mt) of swordfish was caught by the Hawaii shallow-set fishery in 2007 (WPRFMC 2008; Table 3).

Table 2: Swordfish Landings from the Hawaii-based Pelagic Fisheries 1987 - 2007

	Swordfish Landings (1000 Pounds)			
Year	**Longline**	**MHI Troll**	**MHI Handline**	**All Gear**
1988	52	2	11	65
1989	619	2	14	635
1990	5,372	1	10	5,383
1991	9,939	1	13	9,953
1992	12,566	0	3	12,569
1993	13,027	0	9	13,036
1994	7,002	1	7	7,010
1995	5,981	1	12	5,994
1996	5,517	1	11	5,529
1997	6,352	1	15	6,368
1998	7,193	1	14	7,208
1999	6,835	1	19	6,855
2000	6,205	5	193	6,404
2001	519	4	39	562
2002	681	3	19	703
2003	300	2	19	324
2004	549	0	16	598
2005	3,527	1	11	3,539
2006	2,573	1	9	2,583
2007	3,781	2	12	3,796
Average	**4,930**	**1**	**23**	**4,956**
Std. Dev.	**3,851**	**1**	**40**	**3,848**

Source: 2007 WPRFMC Pelagics Annual Report

Hawaii charter fisheries are considered commercial fisheries by the State of Hawaii and are included in the table above with the MHI Troll category. There are anecdotal reports of charter swordfish fishing off Kona, HI; however, the amount of catch is likely small and encapsulated in the MHI Troll statistics listed above. Hawaii pelagic handline fisheries primarily target bigeye and yellowfin tuna as well as monchong, and commercial landings of swordfish from MHI handline fisheries have been relatively stable over time; however, in 2000, 193,000 lbs of swordfish was reported to be landed from the handline fishery. Although information in lacking on recreational swordfish fisheries in Hawaii, landings are likely very small and likely below the statistics associated with MHI troll fisheries (see Section 3.2.12 for more information Hawaii recreational pelagic fisheries). Approximately 90 percent of catches by Hawaii's shallow-setting longline vessels is swordfish however other species are caught and retained for sale (Table 3),

Table 3: 2007 catches of major species by the Hawaii shallow-set longline fishery

Number of sets made:1,497			
Species	**Number caught**	**Number kept**	**Pounds kept**
Swordfish	20,843	18,769	3,115,654
Bigeye Tuna	1,350	1,167	101,529
Albacore	1,391	853	43,503
Oilfishes	2,392	1,890	32,130
Mahimahi	1,916	1,727	24,178
Striped Marlin	318	279	18,972
Mako Shark	832	104	18,408
Blue Marlin	51	48	7,824
Yellowfin Tuna	129	118	7,552
Moonfish	54	40	3,320
Wahoo	87	81	2,430
Shortbill Spearfish	71	61	1,891
Thresher Sharks	52	7	1,386
Pomfret	141	114	1,482
Blue Shark	15,475	9	900
Skipjack Tuna	35	27	432

Source: PIFSC 2008; NMFS PIFSC 4th Quarter Longline Report

U.S. West coast commercial and recreational swordfish fisheries
The following information was taken from the *Status of the U.S. West Coast Fisheries for Highly Migratory Species through 2005* (PFMC 2006).

Commercial harpoon fishery
California's harpoon fishery for swordfish developed in the early 1990s. Prior to 1980, harpoon and hook-and-line gears were the only methods of take authorized to commercially harvest swordfish. At that time, harpoon gear accounted for the majority of swordfish landings in California ports. In the early 1980s, a limited entry drift gill net fishery was authorized by the State Legislature and soon afterward drift gillnets replaced harpoons as the primary method for catching swordfish, and the number of harpoon permits decreased from a high of 1,223 in 1979 to a low of 23 in 2001. Fishing effort typically occurs in the Southern California Bight (SCB) from May to December, peaking in August, depending on weather conditions and the availability of fish in coastal waters. Some vessel operators work in conjunction with a spotter airplane to increase the search area and to locate swordfish difficult to see from the vessel. This practice tends to increase the catch-per-unit-effort compared to vessels that do not use a spotter plan. To participate in the harpoon fishery a permit and logbook are required in addition to a general resident or non-resident commercial fishing license and a current California Department of Fish and Game vessel registration. Additionally, the HMS FMP requires a federal permit with a harpoon gear endorsement for all U.S. vessels that fish for HMS within the West Coast EEZ and to U.S. vessels that pursue HMS on the high seas (seaward of the EEZ) and land their catch in California, Oregon, and Washington. In 2004, the annual harpoon swordfish catch was 69 mt from 28 vessels, and in 2005 it was 74 mt from 24 vessels participating in the fishery. Fishing

effort was concentrated in coastal waters off San Diego and Orange Counties in the SCB and landings occurred May through December, peaking in August.

The ex-vessel revenue for 2005 was $782,920 compared to $669,955 in 2004. Because harpoon vessels spend less time on the water and are a low-volume fishery, their catch is often fresher than drift-gillnet-caught fish, so markets tend to pay more for harpooned fish. The average ex-vessel price-per-pound for harpooned fish was $7.84 compared to $3.41 for drift gillnet caught fish in 2005.

Commercial drift gillnet

California's swordfish fishery transformed from primarily a harpoon fishery to a drift gillnet fishery in the early 1980's and landings soared to a historical high of 2,371 mt by 1985. The drift gillnet fishery is a limited entry program, managed with gear, seasons, and area closures. The limited entry program was established in 1980 and about 150 permits were initially issued. The permit is transferable under very limited conditions and it is linked to an individual fisherman, not a vessel; thus the value of the vessel does not become artificially inflated, allowing permittees to buy new vessels as needed. Since 1984, the number of permits has declined from a high of 251 in 1986 to a low of 90 in 2005; however, only 38 vessels participated in the swordfish fishery in 2005. Annual fishing effort has also decreased from a high of 11,243 sets in the 1986 fishing season to 1,043 sets in 2005. Industry representatives attribute the decline in vessel participation and annual effort to regulations implemented to protect threatened and endangered marine mammals, sea turtles, and sea birds. To keep a permit active, current permittees are required to purchase a permit from one consecutive year to the next; however, they are not required to make landings using drift gillnet gear. In addition, a general resident or non-resident commercial fishing license and a current vessel registration are required to catch and land fish caught in drift gillnet gear. A logbook is also required. The HMS FMP requires a federal permit with a drift gillnet gear endorsement for all U.S. vessels that fish for HMS within the West Coast EEZ and to U.S. vessels that pursue HMS on the high seas (seaward of the EEZ) and land their catch in California, Oregon, and Washington. Historically, the California drift gillnet fleet has operated within EEZ waters adjacent to the state and as far north as the Columbia River, Oregon, during El Niño years. Fishing activity is highly dependent on seasonal oceanographic conditions that create temperature fronts that concentrate feed for swordfish. Because of the seasonal migratory pattern of swordfish and seasonal fishing restrictions, over 90 percent of the fishing effort occurs August 15 through January 31.

In 2001, NMFS implemented two Pacific sea turtle conservation areas on the West Coast with seasonal drift gillnet restrictions to protect endangered leatherback and loggerhead turtles. The larger of the two closures spans the EPO north of Point Conception, California (34°27' N. latitude) to mid-Oregon (45° N. latitude) and west to 129° W. longitude. Drift gillnet fishing is prohibited annually within this conservation area from August 15 to November 15 to protect leatherback sea turtles. A smaller closure was implemented to protect Pacific loggerhead turtles from drift gillnet gear during a forecasted or occurring El Niño event, and is located south of Point Conception, California and west of 120° W. longitude from January 1 through January 31, and from August 15 to August 31. Since 2000, the number of vessels participating in the swordfish fishery has decreased from 69 in 2001 to 38 in 2005. In 2005, 38 drift gillnet vessels landed 220 mt of swordfish compared to 35 vessels that landed 182 mt in 2004. Landings occurred at ports from San Diego to Monterey and the majority occurred from October to

December. Over 85 percent of the reported effort occurred in the SCB. The ex-vessel revenue was $1.2 million in 2005 compared to $1.0 million in 2004. Most of the swordfish landed in California supports domestic seafood restaurant businesses.

High seas longline fishery

California prohibits pelagic longline fishing within the EEZ and the retention of striped marlin. Under regulations for the Pacific Highly Migratory Species FMP, West Coast based longline vessels are prohibited from making shallow sets to fish for swordfish in the EEZ as well as on the high seas. Vessels operating outside of the EEZ can land fish in California ports if the operator has a general resident or nonresident commercial fishing license and a current CDFG vessel registration. The operator must comply with the High Seas Fishing Compliance Act, which requires U.S. vessel operators to maintain logbooks if they fish beyond the EEZ. Additionally, the HMS FMP requires a federal permit with a pelagic longline gear endorsement for all U.S. vessels that pursue HMS on the high seas (seaward of the EEZ) and land their catch in California, Oregon, and Washington. In recent years, federal regulations promulgated to protect endangered sea turtles east and west of 150° W longitude and north of the equator have impacted the number of landings of swordfish in California ports. In 2005, two longline vessels operating with Hawaii permits made swordfish landings compared to 20 vessels that landed 898 mt in 2004.

Recreational fishery

The following on West Coast recreational swordfish catches has been freely adapted from the Billfish Newsletter (1996) Recreational anglers consider swordfish one of the finest of all trophy game fishes because of their size and strength. However, swordfish are rarely tempted to strike baits or lures. Swordfish typically feed at night in the surface waters on small pelagic fishes, hake and squid. They are also known to feed at depths of at least 300 meters. Most angling is done during the daytime from private boats targeting striped marlin. Drifting at night with chemical light-sticks and squid bait has been conducted more recently but has been more popular on the East Coast. The California recreational fishery for swordfish and striped marlin developed about the turn of the century. Recreational catch records of swordfish are kept by the various sport-fishing clubs in California. The Balboa Angling Club, San Diego Marlin Club and the Tuna Club (Avalon) are three of the major clubs where anglers have their swordfish catches recorded and weighed. The number of swordfish weighed in at these clubs averaged 3 to 4 fish per year. During the period between 1969 and 1980, an average of 30.5 fish per year were caught, with a peak in 1978 of 127 swordfish reported (Figure 7). The increased catches during that period correspond to a similar increase in commercial landings. A generally higher abundance of their prey was also reported during the same period. There is some evidence that swordfish abundance may increase in the years following EI Nino events.

More recently (Billfish Newsletter 2006) recreational landings of swordfish recorded at southern Californian swordfish clubs amounted to about six swordfish taken per year. The Commercial Passenger Fishing Vessel fleet submits logbooks on all fish caught. Reported catch is shown in the Pacific Council's HMS SAFE document (PFMC 2007) indicate that 3 swordfish were caught by the fleet in 2006) recreational catches. A query of the Pacific States Marine Fisheries Commission recreational database (RecFIN) found that since 1980, only one swordfish has been counted and that was caught in Oregon (Suzanne Kohin, NMFS SWFSC pers. comm. May 2008).

Non-U.S. swordfish catches in the North Pacific

In the North Pacific, there are directed swordfish fisheries that operate out of Japan and Taiwan. However, it is likely that most of the swordfish catch in the North Pacific is caught incidentally in tuna longline fisheries (*e.g.* bigeye, albacore) by countries such as Japan, Korea, China, and Taiwan. In recent years, Spanish longline vessels have caught swordfish in the North Pacific.

Hawaii's Regional Economy

Hawaii's economy is dominated by tourism and defense, with tourism by far the leading industry in terms of employment and expenditures. The two represent approximately one quarter of Gross State Product without consideration of ancillary services and also comprise the largest shares of "export" earnings (Tables 4 and 5).

Table 4: Hawaii's gross state product

Year	Gross State Product (billion $)	Per Capita State Product ($)	Resident Population
2004	50.7	40,325	1,259,299
2005	53.7	42,119	1,275,194
2006	58.3	38,083	1,285,498
2007	n/a	n/a	1,283,388

Source: DBEDT 2007
http://hawaii.gov/dbedt/info/economic/library/facts/state

Table 5: Hawaii's "export" industries

Year	Sugar (million $)	Pineapple (million $)	U.S. Military (million $)	Tourism (million $)
2004	94.1	123.2	4,772.	10,862
2005	92.4	113.4	n/a	11,904
2006	n/a	n/a	n/a	12,381

Source: DBEDT 2007

Natural resource production remains important in Hawaii, although nothing compared to the period of the sugar and pineapple plantations from throughout the first 60 or 70 years of the 20th century. Crop and livestock sales were $574.4 million in 2005, with the primary diversified agriculture crops being flower and nursery products, $100.6 million; pineapples, $79.2 million; seed crops, $70.4 million, vegetables and melons, $67.7 million; sugar, $58.8.million; macadamia nuts, $44.4 million; coffee, $37.3 million; cattle, $22.7 million; milk, $18.3 million (DBEDT 2007). Aquaculture production was $28.4 million in 2005 (DBEDT 2006), although much of aquaculture's value to Hawaii comes from development of technology.

Hawaii's commercial economy was particularly vibrant between 2000 and 2005, with a 7.5% growth in Gross State Product in 2005 and an average of 5.8% annual growth rate since 2000. Figure 1 indicates the long-term trend in Gross State Product (1970-2005), with the inflation-adjusted figures clearly showing the downturns in the early 1980s and the mid-1990s, followed by sustained growth recently.

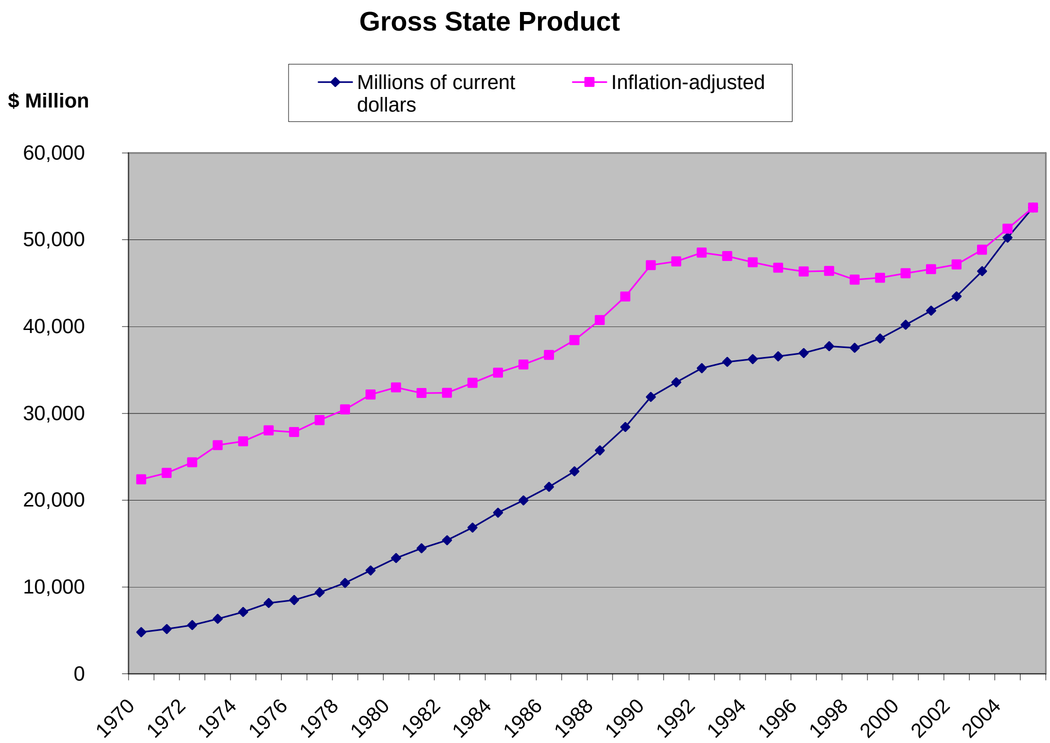


Figure 1: Gross State Product, 1970-2005
Source: DBEDT 2006

The 2006 unemployment rate (see Table 6) of 2.6% (DBEDT 2007) was the lowest in the United States by far, and close to half the U.S. average rate. This marks a major turn-around from the 1990s when Asian economies declined, the U.S. military down-sized due to the end of the Cold War, and Hawaii plantation agriculture was battered by the cost effects of global trade. Construction, manufacturing and agriculture account for only 9% of wage and salary jobs. About 30% of civilian workers are professional or managerial. Federal, state and local government accounts for 20% of wage and salary jobs (DBEDT 2007).

Table 6: Hawaii employment statistics

	2006
Civilian labor force	651,850
Employed	635,100
Unemployment rate	2.6%
Payroll jobs	624,650
Real personal income ($ million)	46,766

Source: DBEDT 2007

Tourism arrivals increased almost monotonically from 1970-1990, but growth was slower in the 1990s until the past three years. There were 7.56 million tourists in Hawaii in 2006. This represents a daily rate of 185,445 tourists, 13% of the “de facto” population (resident, tourist, and military combined), indicating the weight of tourism in many sectors of Hawaii’s economy and society (DBEDT 2007). Tourism arrivals have become more evenly distributed across source locations, with the continental U.S. and Japan being the mainstays, but with arrivals increasing from Europe and China. Nonetheless, Hawaii's tourism economy remains subject to national and international economic factors such as the recent spikes in oil prices which are believed to be hurting tourism markets such as Hawaii.

Total federal expenditures were $12.2 billion in 2004, with 85,900 military personnel and dependents and 31,300 federal civilian workers (not all of whom work on military bases, DBEDT 2007). Research and development spending by the federal government (2003) was $349.6 million representing the importance of the University of Hawaii and a number of other public and private research entities in particular.

Despite these successes, at some individual and community levels Hawaii's commercial economy has been less successful. For example, per capita disposable income in Hawaii ($29,174) has fallen to below the national average due to a cost of living that nearly doubles the national average (Table 7).

Table 7: Hawaii cost of living comparison

Cost of Living Analysis: Ratio of Honolulu living costs compared to U.S. Average at four income levels				
	Income level 1	Income level 2	Income level 3	Income level 4
Honolulu cost of living indexed to U.S. average	192.9	171.6	161.9	155.1
Rent, utilities	241.4	235.4	230.3	229.0

Source: DBEDT 2007

Hawaii per capita income has fallen from 122.5% of the U.S. average in 1970 to 99% in 2005 (Figure 2). Much of this is attributable to housing costs, with the average single family house selling for $744,174 in 2005, with the median being $590,000, the latter discrepancy also indicating the uneven nature of the housing industry in Hawaii over the past several years.

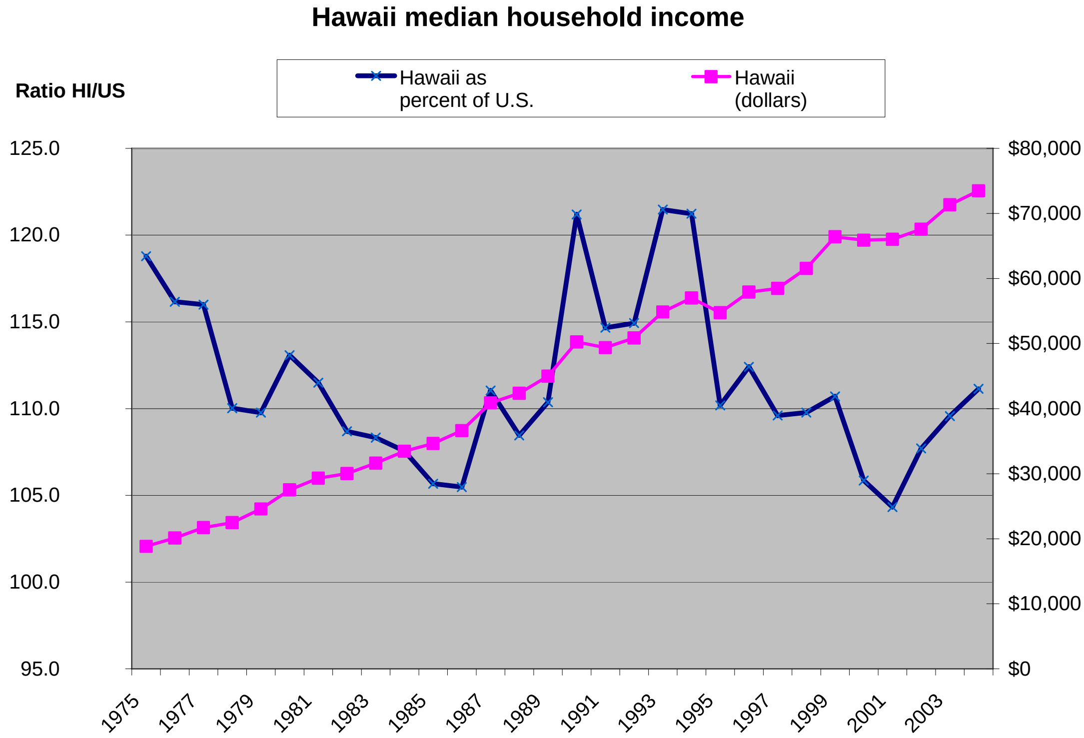


Figure 2: Hawaii median household income, 1975-2005
Source: DBEDT 2006

Tourism is a service industry, and as such, tends to have lower wage levels than manufacturing, for example. So the dominance of tourism means that many workers in Hawaii hold more than one job, with 8 percent of the workforce working more than one job (DBEDT 2007). Similarly, the benefits of the commercial economy are not spread evenly across either islands or ethnic groups in Hawaii. In 2006, 8.6% of Hawaii's population was below the poverty line (DBEDT 2007). The effect of these conditions is that the value of common use resources, such as shorelines, forests, and the ocean, is important for both subsistence and recreational reasons.

The State of Hawaii has been attempting to diversify its economy for many years. Industries encouraged are science and technology, film and television production, sports, ocean research and development, health and education tourism, diversified agriculture and floral and specialty food products. (DBEDT 2007) However, these remain a small percentage of the Hawaii commercial economy.

The most recent estimate of the ex-vessel value of fish sold by the Hawaii-based longline fishery amounts to a small percentage of Gross State Product, in fact, less than 1%. On the other hand, the seafood industry is an important component of local and tourist consumption, and recreational and subsistence fishing represent a substantial proportion of the local population (estimated at 109,000 participants, 8.6% of Hawaii's population).[2] An additional 41,000 tourists are also reported to go fishing while in Hawaii, and total fishing expenditures (resident and

2 DBEDT 2005.

tourist combined) were estimated at $125 million.

The most recent estimate of the total economic contribution of Hawaii's demersal and pelagic commercial, charter, and recreational fishing sectors to the state economy indicated that in 1992, these sectors contributed $118.79 million of output (production) and $34.29 million of household income, employing 1,469 people (Sharma et al. 1999.) These contributions accounted for 0.25 percent of total state output ($47.4 billion), 0.17 percent of household income ($20.2 billion), and 0.19 percent of employment (757,132 jobs). Recreational, subsistence and sport (*e.g.* charter) fisheries provide additional but unquantified economic benefits in terms of angler satisfaction, protein sources, and tourism revenues.

Hawaii's pelagic fisheries are responsible for the largest share of annual commercial landings and ex-vessel revenue, with 28.3 million pounds of pelagic fish landed in 2005 at an ex-vessel value of $ 70.6 million. The domestic longline fishery for tuna, swordfish, and other pelagic species is the largest component of the fishery, landing 23 million pounds in 2005 with an ex-vessel value of $58 million. Among the demersal fisheries, commercial harvests of coral reef species dominate, with MHI and NWHI bottomfish relatively close behind (Table 8). The remainder of Hawaii's commercial fisheries are relatively small, with annual fishery ex-vessel revenues of less than $150,000.

Table 8: Ex-vessel revenues from Hawaii's fisheries

	Pounds Sold	**Ex-vessel Revenue**
Pelagics (2005)	28,384,000	$70,637,000
Coral reef species (2005)	701,624	$1,796,764
MHI bottomfish (2003)	272,569	$1,460,000
NWHI bottomfish (2003)	222,000	$851,219
MHI crustaceans (2005)	10,091	$110,927
Precious corals (1997)	415	$10,394
Total	29,590,699	$74,866,304

Source: State of Hawaii fisheries statistics, unpublished data

V. Description of Small Entities to Which the Rule Would Apply

The preferred alternative would apply to all vessels registered to Hawaii longline permits that use shallow-set longline gear to target swordfish and other pelagic species.

Hawaii's longline fishery began around 1917 and was based on fishing techniques brought to Hawaii by Japanese immigrants. The early Hawaiian sampan-style flagline boats targeted large yellowfin and bigeye tuna using traditional basket gear with tarred rope mainline. This early phase of Hawaii longline fishing declined steadily into the 1970s due to low profitability and lack of investment in an ageing fleet (Boggs and Ito 1993). During the 1980s, tuna longline effort began to expand as there was increasing demand from developing domestic and export markets for high quality fresh and sashimi grade tuna. In the late 1980s and early 1990s, the nature of the fishery changed completely with the arrival of swordfish- and tuna-targeting fishermen from longline fisheries of the Atlantic and Gulf States. The influx of large, modern longline vessels promoted a revitalization of the fishery, and the fleet quickly adopted new technology to better target bigeye tuna at depth. The near-full usage of monofilament mainline longline reels further modernized the fleet and improved profitability. Longline effort increased rapidly from 37 vessels in 1987 to 138 vessels in 1990 (Ito and Machado 2001). An emergency moratorium was placed on the rapidly expanding fishery in 1991.

Longline fishing employs a mainline that is deployed as the fishing vessel moves across the water. The mainline is suspended horizontally below the surface by evenly spaced float lines that are clipped along the mainline's length. Branch lines that terminate with baited fishhooks are clipped to and suspended below the mainline. Longline deployment is typically referred to as "setting", and the gear, once it is deployed, is typically referred to as a "set". Longline sets are normally left to drift for several hours before they are hauled back aboard along with any catch. Mainlines typically consist of a single strand of monofilament line with a test strength of 450 to 680 kg (1000 to 1500 lb). Mainlines are stored on large horizontal reels, and may exceed 74 km (40 nm) in length. Float lines most frequently consist of braided, multi-stand lines with a quick release clip on one end and a large float on the other. Float lines are typically 10 to 30 meters (m) long. Branch lines typically consist of 20 to 30 m of 227 kg (500 lb) test monofilament line with a quick release clip on one end and a fishhook on the other. Depending on the fishery, branch lines may, or may not, have some form of weight attached above the hook.

The longline fleet is composed mostly of steel-hulled vessels and a few wood and fiberglass vessels. The longline fleet has historically operated in two distinct modes based on gear deployment: deep-set longline to target primarily tuna and shallow-set longline used to target swordfish or mixed species including bigeye, albacore and yellowfin tuna. Presently, Hawaii-based longline fishermen must declare themselves as shallow- or deep-set trips 72 hours in advance of their planned departure. Mixed trips are prohibited. Shallow-set fishermen must use of float lines 20 m or less, 10 to 20 m float lines are standard. A typical shallow-set branch line is 15 to 20 m long, with a 45 to 85 gram lead weight in middle, and an 18/0 offset circle hook at end. About 840 hooks are deployed per shallow-set, with 4 to 5 hooks set between each float. Since swordfish are targeted at night, lightsticks are typically attached to every other branch line. Lightsticks are prohibited onboard vessels on deep-set declared trips. Since swordfish are targeted at night, lightsticks attached to the longline gear are used to attract swordfish. Tuna sets use a different type of float placed much further apart, have more hooks per foot between the floats and the hooks are set much deeper in the water column.

To further manage the rapidly expanding fishery, longline fishing was also prohibited within 50 nm of the main Hawaiian Islands to reduce gear conflicts between small troll and handline boats and longline vessels. Another area closure was established prohibiting longline fishing within a 50 nm radius of the Northwestern Hawaiian Islands to prevent interactions with endangered Hawaiian monk seals. A limited access program was established in 1994 allowing for a maximum of 164 transferable longline permits for vessels ≤101 feet in overall length that is administered by NMFS. During the same year, the Hawaii Longline Observer Program was initiated, primarily to monitor interactions with protected species.

In 1985, the longline fishery surpassed landings of the skipjack pole-and-line fleet and has remained the largest Hawaii-based fishery to date. Swordfish landings rose rapidly from 600,000 lbs in 1989 to 13.1 million pounds in 1993 (WPRFMC 2003). The Hawaii-based limited access longline fishery is the largest of all the pelagics fisheries under Council jurisdiction. This fishery accounted for the majority of Hawaii's commercial pelagic landings with an average of 9,672 t or 19.3 million lb for the years 2000 – 2005. The relative importance of swordfish to the fishery declined during the mid 1990s following a 47 percent decrease in landings in 1994. The latter part of 1994 saw a stabilization of swordfish landings at close to 6.5 million pounds/year, a significant increase in shark take, primarily blue shark fins, and a gradual increase in tuna fishing effort and landings. Effort continued to shift away from swordfish and back to tuna targeted trips throughout the latter 1990s (WPRFMC 2004).

During the mid to late 1990's, the fishery was often described as consisting of three components; a core tuna group, a swordfish targeting sector and vessels that were classified as "mixed"; switching between swordfish and tuna throughout the year or even within a single trip. Generally speaking, tuna vessels set deep gear with more than 15 hooks between floats in the morning, began hauling gear in the late afternoon or dusk, usually used a line shooter to deepen the set, preferred saury or sardine bait and made relatively short trips within 500 miles of home port. Swordfish boats were generally larger than tuna boats, set shallow gear at dusk with an average of 4 hooks between floats, used chemical light sticks, hauled gear at dawn, never used a line shooter, preferred large squid bait and made much longer trips beyond 700 miles from port. The swordfish grounds are generally north of Hawaii, between 145° and 175° W and 20° and 40° N, centered around the sub-tropical convergence zone. In the late 1990s, the fishery supplied 37 to 47 percent of the total U.S. domestic swordfish consumption.

Regulations imposed from 2001-2004 prohibited swordfish targeted longline fishing for Hawaii-based vessels due to concerns about interactions with protected sea turtles. As a result of restrictions on swordfish-targeted longline fishing by Hawaii-based boats, a number of vessels temporarily left Hawaii to exploit the same swordfish stocks from bases in California. Other swordfish boats converted gear to remain in Hawaii and target bigeye tuna.

Regulatory Amendment 3, effective April 2, 2004, re-opened the Hawaii-based shallow-set swordfish fishery by allowing 2,120 shallow-sets to be made annually (69 FR 17329, April 2, 2004). In order to reduce[3] and mitigate interactions with sea turtles, use of 18/0 (or larger) circle hooks with 10˚ maximum offset and blue-dyed mackerel-type bait instead of squid were required, along with other mitigation measures and a maximum annual limit on the number of interactions with sea turtles is set at 16 leatherbacks and 17 loggerheads. Integral to this program has been the requirement for 100 percent observer coverage. Most of the swordfish boats that had moved to California have now returned to Hawaii; however, tuna directed effort remains higher than for swordfish.

Presently, Hawaii-based longline fishermen must declare themselves as shallow- or deep-set trips 72 hours in advance of their planned departure. Mixed trips are prohibited. Shallow-set fishermen must use of float lines 20 m or less, 10 to 20 m float lines are standard. A typical shallow-set branch line is 15 to 20 m long, with a 45 to 85 gram lead weight in middle, and an

3 In experiments conducted by NMFS with longline vessels in the Atlantic, the use of circle hooks and mackerel-type bait significantly reduced sea turtle interaction rates. The mean reduction rate for loggerhead turtles was 92%, with a 67% reduction in leatherback interactions.

18/0 offset circle hook at end. About 840 hooks are deployed per shallow-set, with 4 to 5 hooks set between each float. Since swordfish are targeted at night, lightsticks are typically attached to every other branch line. Lightsticks are prohibited onboard vessels on deep-set declared trips

Regulatory Amendment 4, effective December 15, 2005 further reduced and mitigated interactions between turtles and longline gear by requiring that: (1) owners and operators of vessels registered for use under longline general permits attend protected species workshops annually, (2) owners and operators of vessels registered for use under longline general permits carry and use dip nets, line clippers, and bolt cutters, and follow handling, resuscitation, and release requirements for incidentally hooked or entangled sea turtles, and (3) operators of non-longline vessels using hooks to target pelagic management unit species follow sea turtle handling, resuscitation, and release requirements, as well as remove the maximum amount of gear possible from incidentally hooked or entangled sea turtles (70 FR 69282). In addition this rule extended the requirement to use circle hooks, mackerel-type bait and dehookers when shallow-setting north of the equator to include all longline vessels managed under the Pelagics FMP.

All longline vessels carry mandatory VMS monitored by the NMFS and must submit mandatory logsheet data at the completion of every trip. VMS are satellite-based vessel monitoring systems whereby each unit transmits a signal identifying the exact latitude and longitude of a vessel.

The limited access program allows for 164 vessels in the longline fisheries, but active vessel participation has been closer to 120 during the past decade. About 30 vessels have participated in the shallow-set fishery annually since its reopening; 33 in 2005, 37 in 2006, and 29 in 2007. Vessel sizes range up to nearly the maximum 101 foot limit, but the average size is closer to 65 – 70 ft. Most of the vessels are of steel construction and use flake ice to hold catch in fresh/chilled condition. A few older wooden boats persist in the fishery. Some of the boats have mechanical refrigeration that is used to conserve ice, but catch is not frozen in this fishery. Almost all of the Hawaii-based longline catch is sold at the United Fishing Agency auction in Honolulu. It is believed that very little of the longline catch is directly marketed to retailers or exported by the fishermen. For detailed information and annual landings data see the Council’s Annual Reports. Table 9 illustrates that Hawaii’s longline fleet is by far the largest commercial pelagic producer in Hawaii. Figures 3-6 provide data and trends for the Hawaii-based longline fleet and shallow-set fishery.

Table 9: Hawaii commercial pelagic landings, revenue, and average price by fishery

	2005			2006		
Fishery	**Pounds Landed (1000 lbs)**	**Ex-vessel Revenue ($1000)**	**Average Price ($/lb)**	**Pounds Landed (1000 lbs)**	**Ex-vessel Revenue ($1000)**	**Average Price ($/lb)**
Longline	23,275	$61,379	$2.76	21,478	$49,207	$2.66
MHI trolling	2,517	$5,323	$2.40	2,363	$4,713	$2.44
MHI Handline	1,193	$2,138	$1.89	645	$1,187	$2.11
Offshore Handline	313	$410	$2.05	390	$458	$2.11
Aku boat	931	$1,137	$1.23	632	$812	$1.41
Other Gear	155	$250	$2.15	286	$432	$2.41
Total	**28,384**	**$70,637**	**$2.64**	**25,794**	**$56,809**	**$2.59**

Source: 2006 WPRFMC Annual Report.

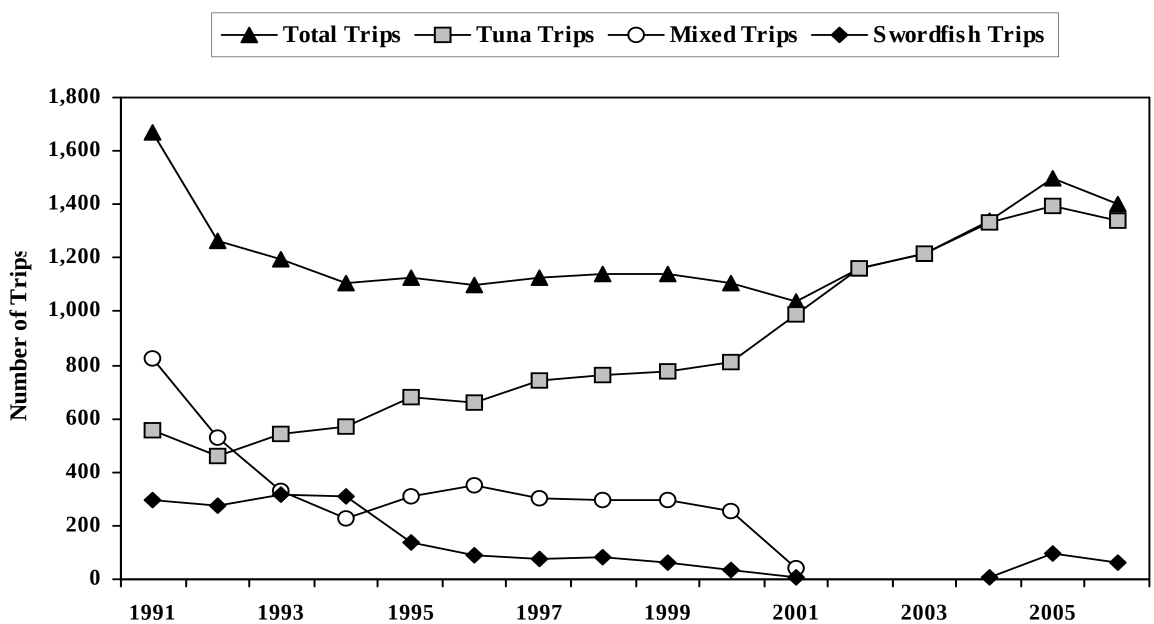


Figure 3: Annual Hawaii-based longline trips, 1991-2006
Source: 2006 WPRFMC Annual Report

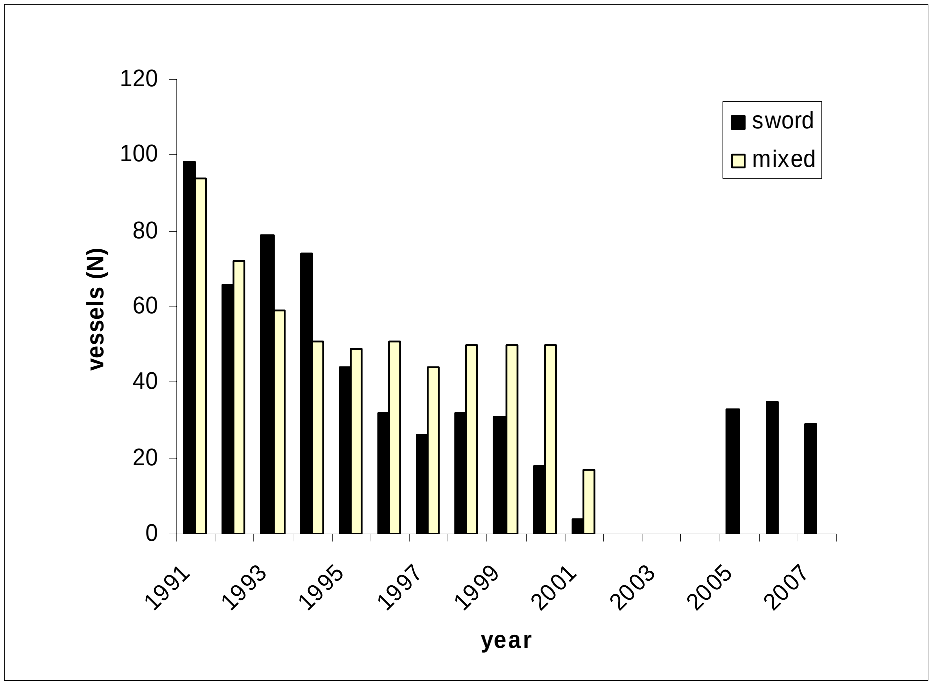


Figure 4: Number of Hawaii longline vessels targeting swordfish, 1991-2007
Source: WPRFMC Pelagics Annual Report 2006

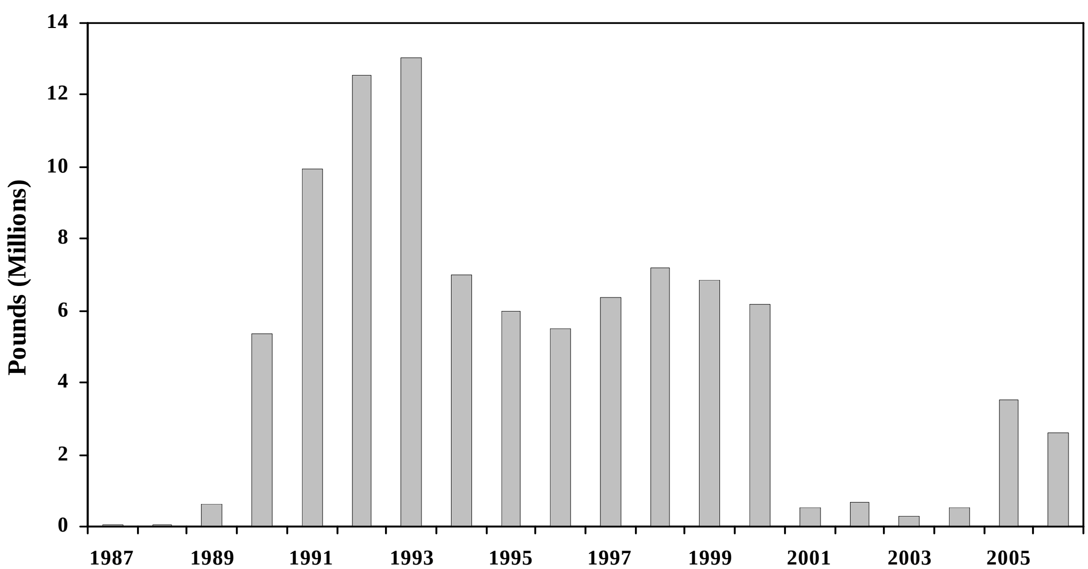


Figure 5: Hawaii Swordfish Landings, 1987-2006
Source: 2006 WPRFMC Annual Report

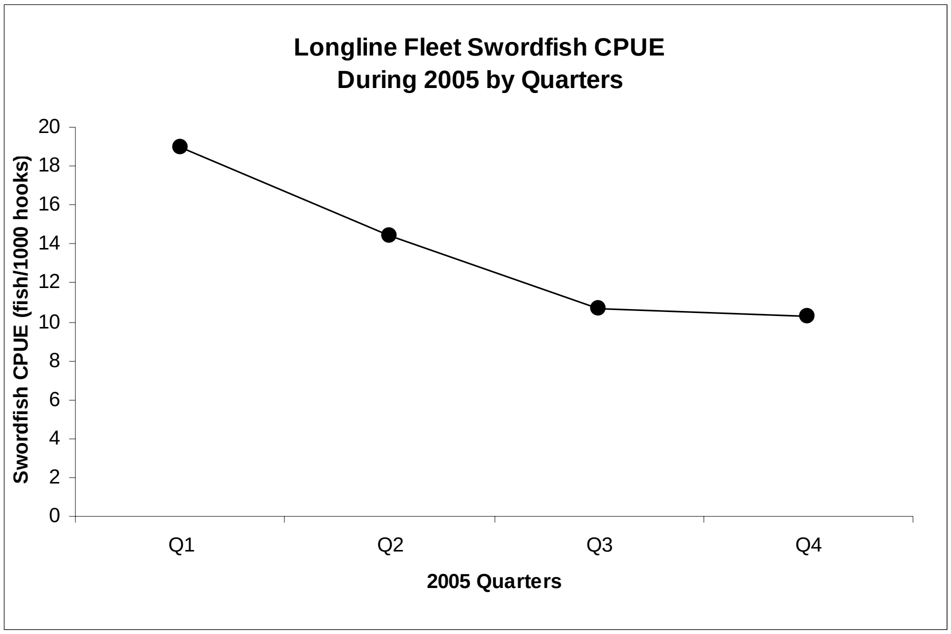


Figure 6: 2005 Hawaii longline swordfish quarterly catch rates
Source: 2006 WPRFMC Annual Report
As seen Figure 6, swordfish catch per unit effort (catch per set or CPUE) is highest in the first quarter of the year with the second quarter also yielding high CPUE levels. Since the reopening of the shallow-set fishery in 2004, effort in the fishery has been highest in the first quarter. However, prior to 2004, effort in the fishery was highest in the second quarter. A plausible explanation for higher first quarter effort since 2004 is linked to possibility that the annual sea turtle hard caps are driving effort in the first quarter, *i.e.* a race to the fish before a potential fishery closure due to reaching the turtle cap.

According to unpublished information from NMFS, about 30 vessels have participated in the shallow-set fishery annually since its reopening; 33 in 2005, 37 in 2006, and 29 in 2007.

Assuming that 100 percent of the swordfish caught by Hawaii permitted longline vessels is caught on shallow-set longline gear and that these vessels only 2005-2007 harvest swordfish, annual participation, trips, and using then 2004-2007 average annual swordfish price of $2.32 per pound, harvests and ex-vessel [gross] revenues are as shown in Table 10. The assumptions regarding catches and prices are necessary as currently available fishery reports do not provide gear specific (i.e. shallow-set vs. deep-set) historical catch or revenue information. The assumption that 100 percent of the longline fishery's swordfish catch can be attributed to shallow-set fishing is likely an overstatement, but only a small one, as deep-setting vessels are prohibited from retaining or landing more than 10 swordfish per trip. On the other hand, the assumption that swordfish is the only species caught by shallow-set gear is an understatement as swordfish has been shown to comprise between 90 and 91 percent of catches by this gear. However given that the primary purpose of Table 10 is to demonstrate that these operations are believed to have annual gross revenues of less than $4.5 million, these shortcomings do not appear unreasonable.

Table 10: Summary of operating information for Hawaii-based longline vessels

Year	Number of active vessels	Number of trips	Pounds of swordfish landed	Total shallow-set fishery ex-vessel revenue	Average shallow-set ex-vessel revenue per vessel
2005	33	99	3,257,000	$7,556,240	$228,978
2006	37	60	2,573,000	$5,969,360	$161,334
2007	29	82	3,781,000	$8,771,920	$302,480
Average	33	80	3,204	$7,432,507	$225,227

Source: 2006 and 2007 WPRFMC Annual Reports

Given an annual average of 33 active shallow-setting vessels between 2005-2007 with an annual average fleet-wide adjusted revenue of $7,432,507 (Table 10), it is estimated that each vessel realized an average of $225,227 in annual ex-vessel revenues from shallow-set longline fishing operations. In addition it is believed that the vast majority of participants are also active in the deep-set longline fishery during the course of a year, thus their shallow-set revenues represent one portion of their total revenue. In 2007 the overall average (combined deep-set and shallow-set longline fisheries) ex-vessel revenue was $62,699,000 realized by a total of 129 active vessels (2007 WPRFMC Annual Report). On a per vessel basis, this yields an average ex-vessel revenue of $486,039 per vessel, still far below the $4.5 million threshold. Although single permit holders may own more than one vessel, none are believed to own more than five active shallow-setting vessels and none are believed to be dominant in their field – making them small businesses under the Regulatory Flexibility Act. Impacts to shoreside businesses would likely be neutral to positive under all alternatives as none would reduce fishing effort and most would increase it, along with associated purchases of fishing gear and supplies and associated sales of swordfish.

VI. Economic Impacts of the Alternatives on Small Businesses

Table 11: Summary of alternatives considered

Topic	Alternative	Description
1. Effort Limit	1A	No action (allow 2,120 shallow-sets per year)
	1B	Allow 3,000 shallow-sets per year
	1C	Allow 4,240 shallow-sets per year
	1D	Allow 5,000 shallow-sets per year
	1E	Allow effort appropriate to swordfish stock status (~9,925 shallow-sets per year)
	1F Preferred	Remove effort limit (rely on turtle hard caps)
2. Fishery Participation	2A	No action
	2B Preferred	Discontinue set certificate program
3. Time Area Closures	3A Preferred	No action
	3B	Implement January time-area closure
	3C	Implement in-season time-area closure

Analytical Methodology
Data used in this analysis were provided by NMFS. Quarter 1 (Q1) comprises January – March of each year, Quarter 2 is April-June, Quarter 3 is July-September, and Quarter 4 is October-December.

Predicted fish catch rates (number of fish caught per set) are based on quarterly logbook data provided by NMFS (PIFSC 2008) for Hawaii-based longline swordfish trips since the 2004 implementation of regulatory requirements to use circle hooks and mackerel-type bait, which may have affected catch rates for swordfish and other species. These 2004-2007 average quarterly rates (Table 12) were applied to the respective quarterly swordfish effort levels (number of sets) anticipated under each alternative to yield fish catches for each alternative.

Table 12: 2004-2007 Hawaii longline average catches (number of fish) per set by quarter

Species	**Q1**	**Q2**	**Q3**	**Q4**
Swordfish	15.15	12.22	8.89	9.78
Striped marlin	0.11	1.24	0.63	0.11
Blue marlin	0.01	0.34	0.19	0.01
Bigeye tuna	1.51	0.58	1.01	0.49
Albacore tuna	1.04	0.03	0.01	2.14
Yellowfin tuna	0.11	0.13	0.06	0.01
Blue shark	12.41	5.04	8.09	10.04
Mahimahi	0.55	5.08	5.74	0.27
Opah	0.05	0.01	0.02	0.22
Ono	0.02	0.14	0.06	0.00
Pomfret	0.14	0.05	0.02	0.14
Mako shark	0.70	0.40	0.33	1.21
Oceanic whitetip shark	0.00	0.24	0.19	0.00
Oilfishes	0.73	2.29	3.01	0.56
Other pelagics	0.04	0.17	0.02	1.09
Other sharks	0.03	0.06	0.01	0.07
Other tuna	0.01	0.00	0.29	0.18
Shortbilled spearfish	0.03	0.18	0.04	0.01
Skipjack tuna	0.04	0.03	0.01	0.01
Thresher sharks	0.02	0.05	0.10	0.02

Source: PIFSC 2008

These catches were converted from numbers of fish to pounds using 2005-2006 average weight recorded per fish for each species (WPRFMC 2006, Table 13). In some cases average weights are not available. This is either because virtually all catches of certain species are discarded (*e.g.* oceanic whitetip sharks) or because related species caught in small numbers have been aggregated into groups (*e.g.* other pelagics, sharks, and tunas).

Table 10: 2005-2006 average weight per fish

Species	2005-2006 average weight per fish (lbs)
Albacore Tuna	51
Bigeye Tuna	87
Blue Marlin	163
Blue Shark	100
Mahimahi	14
Mako Shark	177
Oceanic Whitetip Shark	n/a
Oilfishes	17
Ono	30
Opah	83
Other Pelagics	n/a
Other Sharks	n/a
Other Tunas	n/a
Pomfret	13
Shortbilled Spearfish	31
Skipjack Tuna	16
Striped Marlin	68
Swordfish	166
Thresher Sharks	198
Yellowfin Tuna	64

Source: WPRFMC 2006
n/a = not available

The catch data presented for each alternative begins with the pounds of fish predicted to be caught ("pounds caught") then reduces this number by the discard rates recorded by federal observers for that species to arrive at "pounds kept". The next column indicates the pounds of fish discarded dead (again from NMFS observer data). Total species impacts ("total mortality) can be regarded as the sum of the pounds kept plus the pounds, plus some portion of those discarded alive that subsequently perish due to their experience.

Average annual ex-vessel species specific prices received by Hawaii-based swordfish longline vessels between 2004-2007 (PIFSC 2008) were applied to "pounds kept" to calculate predicted ex-vessel revenues. The one exception to this is swordfish which is the fishery's target species and accounts for approximately 90 percent of its revenue. Because swordfish prices are known to vary within years, swordfish ex-vessel revenues are based on recent quarterly average prices (2004-2007, PIFSC 2008) rather than a single annual average price (Table 14). This provides explicit consideration of temporal swordfish price effects under each alternative.

Table 14: 2004-2007 Hawaii longline average swordfish ex-vessel prices

	Q1	**Q2**	**Q3**	**Q4**
Price per pound	$2.38	$2.11	$2.59	$2.21

Source: PIFSC 2008

Predicted quarterly effort levels for each alternative utilize three temporal effort distributions. The first is that observed in the current “tightly constrained” regulatory environment which restricts annual effort to 2,120 sets (approximately 50 percent of the 1994-1999 average). Swordfish effort data from NMFS (PIFSC 2008) for 2004-2007 revealed that Hawaii-based vessels made the majority of their annual sets in the first quarter, with another third made in the second quarter and smaller amounts in the last two quarters (Table 15). At the other extreme the fishery can be considered to be “unconstrained “prior to 2001 when there was no limitation on the number of annual sets allowed or sea turtle hard caps. In the prior regulatory environment (before 2001), Hawaii-based swordfish vessels made the majority of their sets in the second quarter. By comparison, the current regulatory environment (“tightly constrained”) exhibits signs of a “race to the fish” as participants likely seek to complete trips before either the effort limit or turtle cap is reached. Because the effort limit of 2,120 sets has not been reached in any calendar year since 2004, it appears the sea turtle hard caps of 17 loggerheads and 16 leatherbacks are driving the observed increase in percentage of first quarter effort relative to the historical fishery prior to 2001.

Quarterly shallow-set effort data from 2005-2007 were used to estimate quarterly effort distributions under differing regulatory regimes. In calculating effort distributions in response to varying regulatory restrictions under the alternatives for Topic 1, first quarter 2006 effort data was used while recognizing that the second, third, and fourth quarters of 2006 did not experience effort because the fishery was closed from reaching loggerhead turtle cap. By entering first quarter 2006 effort data as 100 % annual effort for that year skews the predicted effort distributions towards the first quarter for Alternatives 1A, 1B, and 1C. This allows the analysis to present “worst-case” scenarios in terms of sea turtle impacts as interactions are highest in the first quarter of the year. As first quarter catch rates for swordfish are also highest in the first quarter, predicted catches of swordfish similarly presented as well as predicted economic impacts. A strictly objective statistical approach was not possible because data only exists for two full years of fishing effort at the time of conducting this analysis.

Table 11: Hawaii shallow-set fishery quarterly effort (sets) distribution, 2004-2008

Year	Q1	Q2	Q3	Q4	Annual Total
2004	0	5	3	127	135
2005	539	871	54	181	1,645
2006	850	0	0	0	850
2007	948	465	83	27	1,497

Source: NMFS 2008

Due to their relatively restrictive natures, Alternatives 1A and 1B (allow 2,120 and 3,000 sets respectively) are analyzed under the “tightly constrained” temporal effort distribution (Table 16). Alternative 3 (allow 4,240 sets) is analyzed under a “moderately constrained” distribution which lies halfway between the two extremes described above (Table 16). Under this scenario vessels again make the majority of their sets in the first quarter; however, it is a smaller majority than that shown in the “tightly constrained” scenario. Alternatives 1D and 1E (allow 5,500 and 9,925 sets respectively) would allow swordfish fishing levels around the fishery’s historical maximum and are therefore analyzed under the “unconstrained” distribution shown below in Table 16.

Table 12: Swordfish effort distributions for each effort limit alternative

Alternative: scenario	Percent of annual swordfish effort per quarter			
	Q1	Q2	Q3	Q4
Alternatives 1A and 1B: tightly constrained	57%	32%	3%	7%
Alternative 1C: moderately constrained	43%	34%	11%	12%
Alternatives 1D, 1E: unconstrained	29%	36%	19%	17%

Note: Alternative 1F is predicted to lie between 1C and 1D in terms of regulatory constraints.

As the number of allowable sets increase under the alternatives, the predicted protected species interactions must be increasingly regarded as "worst case" scenarios as the Hawaii-based longline fleet has not made 8,500 sets in any one year since 1991 and in fact the average between 1991 and 2000 was 5,600 annual swordfish sets. More recently, since the 2004 implementation of the set certificate program and 2,120 set limit, the fleet has averaged less than 1,400 sets per year (in 2006 the fishery closed in March after 850 sets due to the turtle cap being reached). Anecdotal information indicates that the necessity of buying set certificates under the existing program has acted as a deterrent and limited total effort as well as high demand and established market channels for bigeye tuna. The true reactions of fishery participants and their resultant effort distributions under the alternatives considered here remain uncertain and will likely include considerations of prevailing weather, oceanographic, economic and market conditions. However, resultant effort is not expected to yield higher numbers of protected species interactions than the worst case scenarios presented here which assume that all available sets are used under each alternative. For further information on the calculation of estimated catches and interactions with protected species under each alternative please see Chapter 4 of the main document. Please also see Chapter 4 or information on the expected impacts of the alternatives on other aspects of the physical environment. The following analysis focuses on the expected economic impacts of each alternative to affected fishery participants, and the regional economy of Hawaii.

Topic 1: Shallow-set Longline Fishing Effort Limits

Impacts of Alternative 1A (No action)

Under Alternative 1A, the shallow-set swordfish segment of the Hawaii longline fishery would continue to operate with a maximum effort limit of 2,120 sets and existing hard caps on sea turtle interactions (17 loggerheads or 16 leatherbacks). Based on the 2004 - 2007 fishing seasons, it is unlikely that all this effort will be expended in every year and swordfish landings (retained catches) would then be likely to remain between the 226,000 and 3.1 million pounds retained in 2004 and 2005 respectively. If the fishery was to utilize all 2,120 sets the total retained swordfish catch would be anticipated to be 4.3 million pounds, with another 349,000 pounds discarded dead for a total annual fishing mortality of 4.6 million pounds which is approximately 9.4 percent of MSY. Other (non-swordfish) species would continue to comprise a small fraction of the catch with bigeye tuna accounting for approximately four percent of total fishing mortality and striped marlin and mahimahi each comprising another one percent of fishing mortality within the shallow-set fishery. Other commercial species such as albacore, blue marlin, yellowfin tuna would contribute smaller amounts to the remainder of the retained catch. Catches of these non-swordfish target species under this and all the remaining alternatives are a negligible fraction of total Pacific-wide catches and known MSY values of these species. For example, 194,911 pounds of bigeye is estimated to be 0.00096-0.0013 percent of the WCPO bigeye MSY. Because Alternative 1A is not expected to significantly alter fishing operations, catch and discard rates of non-target species would be anticipated to remain as observed between 2004 and 2007 and these species would be expected to form between six and seven percent of the fishery's total annual catch, with the specific volume proportional to the number of sets actually made. Relative discard conditions would also be expected to remain as observed. Resultant fishing mortality to non-target species would be expected to be a very minor fraction of Pacific-wide catches, and well below known MSY levels.

Using the methodology described above and assuming that all 2,120 sets were utilized, the fleet would be anticipated to retain and sell 4.3 million pounds of swordfish for $9.7 million in ex-vessel revenues. Sales of 424,000 pounds of other species would yield an additional $1.1 million in ex-vessel revenues (Table 17). Currently, there are approximately 30 vessels participating in the fishery and under this alternative, that number is not expected to increase.

Table 13: Predicted annual ex-vessel revenues under Alternative 1A (2,120 sets made)

Species	Annual pounds kept	Annual ex-vessel revenue	Percent of annual revenue
Swordfish	4,263,648	$ 9,781,758	90.22%
Bigeye Tuna	188,900	$ 622,742	5.74%
Mahimahi	53,431	$ 119,507	1.10%
Striped Marlin	60,267	$ 98,838	0.91%
Albacore Tuna	51,531	$ 97,738	0.90%
Blue Marlin	36,501	$ 45,215	0.42%
Yellowfin Tuna	13,594	$ 36,891	0.34%
Oilfishes	4,903	$ 9,904	0.09%
Opah	5,105	$ 9,902	0.09%
Ono	3,432	$ 9,173	0.08%
Pomfret	2,249	$ 5,366	0.05%
Shortbilled Spearfish	3,211	$ 3,629	0.03%
Skipjack Tuna	990	$ 877	0.01%
All Other Pelagics*			
Annual Total	4,687,763	$ 10,841,538	100.00%
* All other pelagics account for less than two percent of total annual fish kept, detailed weight and price, information not available for all species.			

Utilizing the methodology and model presented by Leung and Pooley (2002) for the Hawaii longline fishery, the anticipated ex-vessel revenues under Alternative 1A ($10.8 million, Table 17) would generate $26.3 million in direct and indirect business sales, $11.7 million in personal and corporate income, 362 jobs, and $2 million in state and local taxes (Table 18).

Table 18: Predicted regional impacts under Alternative 1A (2,120 sets made)

Variable	Impact
Predicted Ex-vessel Revenue ($ million)	10.84
Direct Effects	
Business Sales ($ million)	10.84
Income ($ million)	5.25
Employment (jobs)	151.36
State & Local Taxes ($ million)	0.88
Indirect and Induced Effect From Local Purchases of Goods & Services	
Business Sales ($ million)	7.69
Income ($ million)	3.05
Employment (jobs)	95.56
State & Local Taxes ($ million)	0.51
Indirect and Induced Effect From Direct Income of Longline Fishing	
Business Sales ($ million)	7.75
Income ($ million)	3.38
Employment (jobs)	115.57
State & Local Taxes ($ million)	0.56
Total Effect	
Business Sales ($ million)	26.28
Income ($ million)	11.68
Employment (jobs)	362.48
State & Local Taxes ($ million)	1.95

Source: Based on Leung and Pooley (2002)

Impacts of Alternative 1B (Allow 3,000 shallow-sets per year)

Under Alternative 1B and assuming that all 3,000 allowable sets were made, the Hawaii-based swordfish fishery would be expected to retain and sell 6 million pounds of swordfish for $13.8 million in ex-vessel revenues (Table 19). Sales of 600,016 pounds of other species would yield an additional $1.5 million in ex-vessel revenues. As compared to anticipated catches and revenues if all 2,120 sets were made under Alternative 1A, this represents a 41.5 percent increase in retained catch with a directly associated 41.5 percent increase in ex-vessel revenues, for individual and aggregate species. Currently, there are approximately 30 vessels participating in the fishery, and under this alternative, that number would be expected to increase by approximately 5-10 vessels.

Table 19: Predicted annual ex-vessel revenues under Alternative 1B (3,000 sets made)

Species	Annual pounds kept	Annual ex-vessel revenue	Percent of annual revenue
Swordfish	6,033,465	$ 13,842,110	90.22%
Bigeye Tuna	267,312	$ 881,239	5.74%

Species	Annual pounds kept	Annual ex-vessel revenue	Percent of annual revenue
Mahimahi	75,610	$ 169,113	1.10%
Striped Marlin	85,283	$ 139,865	0.91%
Albacore Tuna	72,922	$ 138,309	0.90%
Blue Marlin	51,652	$ 63,984	0.42%
Yellowfin Tuna	19,237	$ 52,204	0.34%
Oilfishes	6,938	$ 14,015	0.09%
Opah	7,224	$ 14,012	0.09%
Ono	4,856	$ 12,980	0.08%
Pomfret	3,183	$ 7,594	0.05%
Shortbilled Spearfish	4,544	$ 5,135	0.03%
Skipjack Tuna	1,401	$ 1,241	0.01%
All Other Pelagics*			
Annual Total	6,633,627	$ 15,341,799	100.00%
* All other pelagics account for less than two percent of total annual fish kept, detailed weight and price information not available for all species			

Utilizing the methodology and model presented by Leung and Pooley (2002) the anticipated ex-vessel revenues under Alternative 1B ($15.3 million, Table 19) would be predicted to have impacts to the regional economy as depicted in Table 20. In sum it is estimated that under Alternative 1B the Hawaii longline swordfish fishery would generate $37.2 million in direct and indirect business sales, $16.5 million in personal and corporate income, 513 jobs, and $2.8 million in state and local taxes.

Table 20: Predicted regional impacts under Alternative 1B (3,000 sets made)

Variable	Impact
Predicted Ex-vessel Revenue ($ million)	15.34
Direct Effects	
Business Sales ($ million)	15.34
Income ($ million)	7.43
Employment (jobs)	214.18
State & Local Taxes ($ million)	1.24
Indirect and Induced Effect From Local Purchases of Goods & Services	
Business Sales ($ million)	10.88
Income ($ million)	4.32
Employment (jobs)	135.23
State & Local Taxes ($ million)	0.72
Indirect and Induced Effect From Direct Income of Longline Fishing	
Business Sales ($ million)	10.97
Income ($ million)	4.78
Employment (jobs)	163.54

State & Local Taxes ($ million) 0.80

Total Effect

Business Sales ($ million)	37.19
Income ($ million)	16.52
Employment (jobs)	512.95
State & Local Taxes ($ million)	2.76

Source: Based on Leung and Pooley 2002

Impacts of Alternative 1C (Allow 4,240 shallow-sets per year)

Under Alternative 1C and assuming that all 4,240 allowable sets were made, the Hawaii-based swordfish fishery would be expected to retain and sell 8 million pounds of swordfish for $18.4 million in ex-vessel revenues (Table 21). Sales of 856,000 pounds of other pelagics would yield an additional $2.1 million in ex-vessel revenues. As compared to anticipated catches and revenues if all 2,120 sets were made under Alternative 1A, this represents an 88 percent increase in swordfish pounds kept and a 90 percent increase in total retained catch as well as total ex-vessel revenues. Currently, there are approximately 30 vessels participating in the fishery, and under this alternative, that number would be expected to increase by approximately 20-30 vessels. This increase in vessels, however, is dependent on several factors such as swordfish and bigeye markets, fuel costs, and other operational costs.

Table 21: Predicted annual ex-vessel revenues under Alternative 1C (4,240 sets made)

Species	Annual pounds kept	Annual ex-vessel revenue	Percent of annual revenue
Swordfish	8,038,241	$ 18,408,854	89.84%
Bigeye Tuna	343,045	$ 1,130,906	5.52%
Mahimahi	129,370	$ 289,357	1.41%
Striped Marlin	134,921	$ 221,270	1.08%
Albacore Tuna	97,107	$ 184,180	0.90%
Blue Marlin	84,115	$ 104,197	0.51%
Yellowfin Tuna	25,031	$ 67,929	0.33%
Oilfishes	11,263	$ 22,751	0.11%
Opah	11,449	$ 22,207	0.11%
Ono	7,418	$ 19,829	0.10%
Pomfret	4,050	$ 9,662	0.05%
Shortbilled Spearfish	6,636	$ 7,498	0.04%
Skipjack Tuna	1,757	$ 1,556	0.01%
All Other Pelagics*			
Annual Total	8,894,403	$ 20,490,196	100.00%

* All other pelagics account for less than three percent of total annual fish kept, detailed weight and price information not available for all species.

Utilizing the methodology and model presented by Leung and Pooley (2002) the anticipated ex-vessel revenues under Alternative 1C ($20.53 million, Table 21) would be predicted to have the following impacts to the regional economy (Table 22). In sum it is estimated that under

Alternative 1C the Hawaii longline swordfish fishery would generate $49.7 million in direct and indirect business sales, $22.1 million in personal and corporate income, 685 jobs, and $3.7 million in state and local taxes.

Table 22: Predicted regional impacts under Alternative 1C (4,240 sets made)

Variable	**Impact**
Predicted Ex-vessel Revenue ($ million)	20.49
Direct Effects	
Business Sales ($ million)	20.49
Income ($ million)	9.92
Employment (jobs)	286.07
State & Local Taxes ($ million)	1.66
Indirect and Induced Effect From Local Purchases of Goods & Services	
Business Sales ($ million)	14.53
Income ($ million)	5.77
Employment (jobs)	180.61
State & Local Taxes ($ million)	0.96
Indirect and Induced Effect From Direct Income of Longline Fishing	
Business Sales ($ million)	14.66
Income ($ million)	6.38
Employment (jobs)	218.42
State & Local Taxes ($ million)	1.07
Total Effect	
Business Sales ($ million)	49.67
Income ($ million)	22.07
Employment (jobs)	685.11
State & Local Taxes ($ million)	3.69

Source: Based on Leung and Pooley (2002)

Impacts of Alternative 1D (Allow 5,000 shallow-sets per year)

Under Alternative 1D and assuming that all 5,500 allowable sets were made, the Hawaii-based swordfish fishery would be expected to retain and sell 9.8 million pounds of swordfish for $22.4 million in ex-vessel revenues (Table 23). Sales of1.1 million pounds of other pelagics would yield an additional $2.7 million in ex-vessel revenues. As compared to anticipated catches and revenues if all 2,120 sets were made under Alternative 1A, this represents a 130 percent increase in swordfish pounds kept and a 130 percent increase in total retained catch as well as total ex-vessel revenues. Currently, there are approximately 30 vessels participating in the fishery, and under this alternative, that number would be expected to increase by approximately 30-40 vessels. This increase in vessels, however, is dependent on several factors such as swordfish and bigeye markets, fuel costs, and other operational costs.

Table23: Predicted annual ex-vessel revenues under Alternative 1D (5,500 sets made)

Species	Annual pounds kept	Annual ex-vessel revenue	Percent of annual revenue
Swordfish	9,792,574	$ 22,381,618	89.41%
Bigeye Tuna	399,904	$ 1,318,349	5.27%
Mahimahi	197,012	$ 440,650	1.76%
Striped Marlin	193,677	$ 317,631	1.27%
Albacore Tuna	118,239	$ 224,261	0.90%
Blue Marlin	123,528	$ 153,020	0.61%
Yellowfin Tuna	29,672	$ 80,523	0.32%
Oilfishes	16,500	$ 33,329	0.13%
Opah	16,459	$ 31,923	0.13%
Ono	10,343	$ 27,645	0.11%
Pomfret	4,671	$ 11,145	0.04%
Shortbilled Spearfish	8,884	$ 10,039	0.04%
Skipjack Tuna	1,989	$ 1,762	0.01%
All Other Pelagics*			
Annual Total	10,913,452	$ 25,031,895	100.00%

* All other pelagics account for less than three percent of total annual fish kept, detailed weight and price information not available for all species.

Utilizing the methodology and model presented by Leung and Pooley (2002) the anticipated ex-vessel revenues under Alternative 1D ($25 million, Table 23) would be predicted to have the following impacts to the regional economy (Table 24). In sum it is estimated that under Alternative 1D the Hawaii longline swordfish fishery would generate $60.7 million in direct and indirect business sales, $27 million in personal and corporate income, 837 jobs, and $4.5 million in state and local taxes.

Table 24: Predicted regional impacts under Alternative 1D (5,500 sets made)

Variable	Impact
Predicted Ex-vessel Revenue ($ million)	25.03
Direct Effects	
Business Sales ($ million)	25.03
Income ($ million)	12.12
Employment (jobs)	349.48
State & Local Taxes ($ million)	2.02
Indirect and Induced Effect From Local Purchases of Goods & Services	
Business Sales ($ million)	17.75
Income ($ million)	7.05
Employment (jobs)	220.65
State & Local Taxes ($ million)	1.18
Indirect and Induced Effect From Direct Income of Longline Fishing	
Business Sales ($ million)	17.90

Income ($ million)	7.79
Employment (jobs)	266.84
State & Local Taxes ($ million)	1.30
Total Effect	
Business Sales ($ million)	60.69
Income ($ million)	26.96
Employment (jobs)	836.98
State & Local Taxes ($ million)	4.50

Source: Based on Leung and Pooley (2002)

Impacts of Alternative 1E (Set effort level commensurate with the current condition of the North Pacific swordfish stock)

Under Alternative 1E, the allowable effort level for swordfish (number of shallow sets allowed) would be established based on the condition of the swordfish stock in the North Pacific and the MSY for this stock. Establishment of this effort limit takes into account catches by other longline fleets and the fraction of the total swordfish catch realized by the Hawaii fleet.

Current swordfish landings in the North Pacific amount to about 14,500 metric tons (31.9 million pounds), which, according to a recent stock assessment, is about 65 percent of an estimated MSY of 22,284 metric tons (49 million pounds; K. Bigelow, PIFSC pers. comm.. based on Kleiber and Yokowa 2004). Thus there are an additional 17.1 million pounds available for harvest before MSY levels are reached. Hawaii's fleet has recently landed an annual average of two million pounds of swordfish with the remaining 29.9 million pounds harvested by foreign fisheries. Assuming that foreign harvest levels remain stable, the Hawaii fleet could harvest up to 19.1 million pounds of swordfish before MSY levels are reached (the two million pounds currently harvested plus the 17.1 million additional available pounds).

Based on the 2004 - 2007 fishing seasons it would take just over 9,925 sets for the Hawaii longline swordfish fishery to catch the available 8,682 metric tons (19.1 million pounds) of swordfish before total North Pacific swordfish catches reach MSY. Therefore under Alternative E, 9,925 Hawaii longline shallow sets would be allowed each year.

Past Hawaii longline shallow set effort peaked in 1991 when 8,355 sets were made. It is not known whether the shallow set fishery would rebound to these levels but the capacity to do so is well within the bounds of current fishery capacity given that there are still 162 longline permits issued (although not all are actively fished every year).

Under Alternative 1E and assuming that all 9,925 allowable sets were made, the Hawaii-based swordfish fishery would be expected to retain and sell 17.7 million pounds of swordfish for $40.4 million in ex-vessel revenues (Table 25). Sales of 2 million pounds of other pelagics would yield an additional $4.8 million in ex-vessel revenues. As compared to anticipated catches and revenues if all 2,120 sets were made under Alternative 1A, this represents a 315 percent increase in swordfish pounds kept, a 320 percent increase in total retained catch and a 317 percent increase in total ex-vessel revenues. Currently, there are approximately 30 vessels participating in the fishery, and under this alternative, that number would be expected to increase by approximately 50-60 vessels. This increase in vessels, however, is dependent on several factors such as swordfish and bigeye markets, fuel costs, and other operational costs.

Table 14: Predicted ex-vessel revenues under Alternative 1E (9,925 sets made)

Species	Annual pounds kept	Annual ex-vessel revenue	Percent of annual revenue
Swordfish	17,671,145	$ 40,388,647	89.41%
Bigeye Tuna	721,644	$ 2,379,021	5.27%
Mahimahi	355,517	$ 795,173	1.76%
Striped Marlin	349,499	$ 573,179	1.27%
Albacore Tuna	213,368	$ 404,688	0.90%
Blue Marlin	222,911	$ 276,132	0.61%
Yellowfin Tuna	53,545	$ 145,307	0.32%
Oilfishes	29,774	$ 60,144	0.13%
Opah	29,701	$ 57,607	0.13%
Ono	18,664	$ 49,886	0.11%
Pomfret	8,430	$ 20,112	0.04%
Shortbilled Spearfish	16,032	$ 18,116	0.04%
Skipjack Tuna	3,590	$ 3,179	0.01%
All Other Pelagics*			
Annual Total	19,693,820	$45,171,191	100.00%
* All other pelagics account for less than three percent of total annual fish kept, detailed weight and price information not available for all species.			

Utilizing the methodology and model presented by Leung and Pooley (2002) the anticipated ex-vessel revenues under Alternative 1E ($45.2 million, Table 25) would be predicted to have the following impacts to the regional economy (Table 26). In sum it is estimated that under Alternative 1E the Hawaii longline swordfish fishery would generate $109.5 million in direct and indirect business sales, $48.7 million in personal and corporate income, 1,510 jobs, and $8.1 million in state and local taxes.

Table 26: Predicted regional impacts under Alternative 1E (9,925 sets made)

Variable	Impact
Predicted Ex-vessel Revenue ($ million)	45.17
Direct Effects	
Business Sales ($ million)	45.17
Income ($ million)	21.87
Employment (jobs)	630.64
State & Local Taxes ($ million)	3.65
Indirect and Induced Effect From Local Purchases of Goods & Services	
Business Sales ($ million)	32.03
Income ($ million)	12.71
Employment (jobs)	398.16
State & Local Taxes ($ million)	2.12

Indirect and Induced Effect From Direct Income of Longline Fishing	
Business Sales ($ million)	32.31
Income ($ million)	14.06
Employment (jobs)	481.51
State & Local Taxes ($ million)	2.35
Total Effect	
Business Sales ($ million)	109.51
Income ($ million)	48.65
Employment (jobs)	1510.32
State & Local Taxes ($ million)	8.12

Impacts of Alternative 1E (Remove effort limit - Preferred)
Under this alternative, the annual effort limit would be removed and fishery would not be managed under an annual set limit cap. Anticipated fishing effort is expected to gradually increase to historic levels between 4,000 and 5,000 sets per year (3.4 - 4.2 million hooks/yr). If anticipated fishing effort incrementally increases under Alternative 1F, impacts to target stocks would be similar in range to those described for Alternatives 1A through 1D and would likely vary by year. For example, in the first 1-3 years after implementation of this alternative, the fishery is expected to expand, and it is annual production of swordfish is predicted to be between 4.6 and 6.5 million lbs (2,085-2,950 mt). Depending on various factors including fuel prices and market demands, swordfish harvests in the near term could further increase to historical levels between 8.6 and 10.6 million pounds (3900-4809 mt) under this alternative. Non-swordfish catches of target species by the shallow-set fishery for species such as bigeye would be expected to also increase as effort increases, with anticipated harvests similar those described under Alternatives 1A through 1D. Because the Hawaii longline fishery (shallow-set and deep-set) in regulated under a limited entry program (maximum 164 permits), any increased effort in the shallow-set fishery would be from vessels that also primarily target bigeye tuna in the deep-set fishery. It is expected that such a shift would reduce bigeye catches by the Hawaii deep-set fishery and thus relieve some pressure (albeit insignificant in terms of overall WCPO bigeye catch and stock status) on bigeye stocks.

Under this alternative, impacts to fishery participants and regional economy depend on the amount fishing of effort expended and the revenues generated. Impacts would be similar to those described for Alternatives 1A-1D. Currently, there are approximately 30 vessels participating in the fishery, and under this alternative, that number would be expected to incrementally increase by approximately 10-30 vessels. This increase in vessels, however, is dependent on several factors such as swordfish and bigeye markets, fuel costs, and other operational costs.

Topic 2: Fishery Participation

Impacts of Alternative 2A (No action)
Maintaining the set certificate requirement under Alternative 2A allows potential participants the opportunity to obtain set certificates for that year from which they could either fish their certificates themselves, trade, sell, or give them to other Hawaii longline limited access permit holders for use during that year.

Financial impacts could be imposed on potential participants that do not apply and obtain set certificates from NMFS and are forced to buy certificates from other participants. On the other hand, financial gains may be obtained by those participants willing to sell their certificates to other participants.

Impacts of Alternative 2B (Discontinue set certificate program - Preferred)
Under this alternative, shallow-set certificates would no longer be issued or required and the annual set-certificate solicitation would be ended. Under alternatives which include effort limits, sets would be cumulatively accounted for on a fleetwide basis and the fishery would close for the remainder of the year when and if the annual set limit was reached.

Eliminating the requirement for certificates in the shallow-set fishery would benefit current shallow-set participants by eliminating the burden to provide written notice by November 1 of each year to obtain certificates. Potential revenue from selling set certificates to other participants would be eliminated and vice versa, potential costs of buying certificates from other participants would also be eliminated. Fishery participants would likely expend effort on a “first come, first served” basis and therefore there may be increased competition for swordfish during the beginning of the year, which is also the time of typically greatest CPUE values, thus leading to higher supply and decreasing ex-vessel revenue.

With international longline quotas already in place for bigeye catches in both the EPO and the WCPO, there is expected to be interest from some Hawaii based tuna-directed fishing vessels to shift their effort into the swordfish-directed fishery. This may also increase competition among participants which could have some market effects. This anticipated effort shift would be facilitated by removing the set certificate requirement through implementation of alternative 2B because deep-set vessels could switch to shallow-setting without the need to possess certificates.

<u>Topic 3 Time-Area Closures</u>

Impacts of Alternative 3A (No action - Do not implement time-area closures - preferred)
Under Alternative 3A the fishery would continue to operate as it has been since re-opening in 2004, with no time-area closures. This is not expected to result in any new impacts to participants or communities. If a turtle hard cap was reached the fishery would be closed for the remainder of the year which may result in some negative impacts to participants through being unable to derive any further income from swordfish harvest; having to switch gear configuration to continue longline fishing by shifting to deep-setting; potential market flooding as occurred in 2006 when the fishery closed which can result in lower prices, time waiting to offload and a reduction in quality of fish onboard; and potentially having to cut a trip short if the closure occurs while at sea. An early closure causing shallow-set vessels to switch to targeting tuna could impact the ability of those currently targeting tuna by increasing competition for a fishery which is now regulated by quotas on bigeye tuna. This would potentially impact all longline fishery participants.

Impacts of Alternative 3B (Implement January time-area closure)

Under Alternative 3B, an area closure would be implemented during January of each calendar year. The area closure would be located between 175° W and 145° W longitude and encompass the sea surface temperature band of 17.5°-18.5° C. The latitudinal location of this temperature band varies inter-and intra-annually; however, in January it is generally located near 31°-32° N latitude. Research has suggested that the area between sea surface temperatures of 17.5-18.5 C may be a loggerhead sea turtle "hotspot" based on historical and contemporary distribution and foraging studies as well as location data for observed loggerhead sea turtle interactions with the fishery (Howell, PIFSC, pers. comm., December 2008). The month of January was selected because it may be that the number of loggerhead interactions during January is pivotal to whether or not the fishery will reach its annual sea turtle interaction hard cap before all allowable sets are used. For example, in 2006, the fishery interacted with eight loggerheads in January and the fishery reached the cap of 17 on March.17, 2006. In 2007, the fishery did not interact with any loggerheads during January, but ended the first quarter with only15 loggerhead interactions and did not reach the sea turtle cap.

A range of time-area and seasonal fishery closures have been examined to date. NMFS scientists at PIFSC examined the use of seasonal closures, a time-area closure combined with a fixed seasonal closure and multiple area and seasonal closures to examine their combined biological and economic impacts. Although this work is ongoing, a preliminary draft appears to indicate that none of the scenarios examined would decrease sea turtle interactions without simultaneously decreasing fishery revenues and presumably profits in the months when the time-area closure is imposed, as fishing effort would be pushed into less productive or less profitable times and areas. However, a large time-area closure may reduce the risk of exceeding a turtle hard cap very early when there are still many more shallow-sets allowed to be made, as occurred in 2006 so that swordfish fishing may continue later in the year (S. Li, PIFSC, pers. comm. Jan. 2008). Fishery participants have indicated that missing the high swordfish catch rates and prices in the first quarter cannot be compensated for by a longer fishing season with more fishing trips. Furthermore, fishery participants would likely find it difficult to respond to changes of closed areas based on sea surface temperatures which can vary in location on a daily basis.

Impacts of Alternative 3C (In-season time-area closure)

Under Alternative 3C, the sea surface temperature-based (17.5° – 18.5° C) area closure described for Alternative 3B would be implemented in those years for which 75 percent of the annual loggerhead turtle cap was reached and the closure would remain in effect for the remainder of the first quarter. This alternative differs from 3B in that it is contingent on high numbers of interactions during the first quarter.

A range of time-area and seasonal fishery closures have been examined to date. NMFS scientists at PIFSC examined the use of seasonal closures, a time-area closure combined with a fixed seasonal closure and multiple area and seasonal closures to examine their combined biological and economic impacts. Although this work is ongoing, a preliminary draft appears to indicate that none of the scenarios examined would decrease sea turtle interactions without simultaneously decreasing fishery revenues and presumably profits in the months when the time-area closure is imposed, as fishing effort would be pushed into less productive or less profitable times and areas. However, a large time-area closure may reduce the risk of exceeding a turtle hard cap very early when there are still many more shallow-sets allowed to be made, as occurred in 2006 so that swordfish fishing may continue later in the year (S. Li, PIFSC, pers. comm. Jan. 2008). Fishery participants have indicated that missing the high swordfish catch rates and prices in the first quarter cannot be compensated for by a longer fishing season with more fishing trips. Furthermore, fishery participants would likely find it difficult to respond to changes of closed areas based on sea surface temperatures which can vary in location on a daily basis.

Skills Necessary to Meet Compliance Requirements

Alternatives that would allow increased fishing effort would potentially allow more vessels to fish in distant waters. Many active vessels have already been observed fishing safely in these offshore areas, therefore it is expected that fishery participants are familiar with the at-sea conditions and are able to operate safely in them. Preferred Alternative 2B would discontinue the set certificate program which means that permit holders would no longer need to apply for these certificates or attach them to each shallow set logbook report. No special skills beyond the ability to read and write in English would be required to continue to fill out the necessary permit applications and logbooks which are already required.

VII. Impacts of the Preferred Alternatives on Net National Benefits

Due to limited data availability, as well our limited understanding of the biological, economic, and social linkages of Hawaii's shallow-set longline fishery and associated economic sectors, it is difficult to predict how fishery participants and other stakeholders would respond to the preferred alternatives and how production operations and markets would be affected. It is thus difficult to predict how the total future stream of national benefits and costs (to both producers and consumers) would be affected. However overall this action is anticipated to have positive net national benefits as it is designed to optimize domestic harvests of Pacific swordfish by Hawaii-based longline vessels without jeopardizing the existence of any protected species or their habitats.

This page left blank.

Appendix VI

2008 NMFS Biological Opinion

on

Proposed Amendment 18 to the Fishery Management Plan for Pelagic Fisheries of the Western Pacific

This page left blank intentionally.

Endangered Species Act – Section 7 Consultation

Biological Opinion

Action Agency: National Marine Fisheries Service, Pacific Islands Region, Sustainable Fisheries Division

Activity: 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.

Consulting Agency: National Marine Fisheries Service, Pacific Islands Region, Protected Resources Division

Approved By: William L. Robinson

William L. Robinson
Regional Administrator, Pacific Islands Region

Date Issued: October 15, 2008

Table of Contents

Figures and Tables

Acronyms

AFM	Adult female mortalities
BA	Biological Assessment
CFR	Code of Federal Regulations
CITES	Convention on International Trade in Endangered Species
DPS	Distinct population segment
DSEIS	Draft Supplement Environmental Impact Statement
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
FAO	Food and Agriculture Organization of the United Nations
FEIS	Final Environmental Impact Statement
FMP	Fishery Management Plan
FR	Federal Register
HLA	Hawaii Longline Association
IAC	Inter-American Convention for the Protection and Conservation of Sea Turtles
ITS	Incidental Take Statement
MHI	Main Hawaiian Islands
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service (also NOAA Fisheries)
NOAA	National Oceanic and Atmospheric Administration
PIFSC	Pacific Islands Fisheries Science Center
PIR	Pacific Islands Region
PIRO	Pacific Islands Regional Office
PMUS	Pelagic Management Unit Species
PNG	Papua New Guinea
PRD	Protected Species Division, NMFS Pacific Islands Regional Office
PSW	Protected Species Workshop
QET	Quasi-extinction threshold
SCL	Standard carapace length
SFD	Sustainable Fisheries Division, NMFS Pacific Islands Regional Office
SQE	Susceptibility to Quasi-Extinction
SSC	Scientific and Statistical Committee of the WPFMC
SSLL	Shallow-set longline
STAJ	Sea Turtle Association of Japan
TEWG	Turtle Expert Working Group
USFWS	U.S. Fish and Wildlife Service
WCP	Western Central Pacific
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. 1539(a)(2)) requires each federal agency to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" an ESA-listed species, that agency is required to consult formally with the National Marine Fisheries Service (for marine species or their designated critical habitat) or the U.S. Fish and Wildlife Service (for terrestrial and freshwater species or their designated critical habitat). Federal agencies are exempt from this formal consultation requirement if they have concluded that an action "may affect, but is not likely to adversely affect" ESA-listed species or their designated critical habitat, and the National Marine Fisheries Service (NMFS, or NOAA Fisheries) or the U.S. Fish and Wildlife Service (USFWS) concur with that conclusion (see ESA Section 7 Implementing Regulations; 50 CFR 402).

The proposed federal action addressed by this biological opinion is modification of the management program for the Hawaii-based shallow-set longline fishery, as recommended in Amendment 18 to the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region (Pelagics FMP). Amendment 18 was developed by the Western Pacific Fishery Management Council (Council or WPFMC), and is described in the Amendment 18, including a Draft Supplemental Environmental Impact Statement (WPFMC 2008). NMFS has responsibility under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) for approving FMPs and their amendments, and NMFS also has responsibility under the ESA for conducting Section 7 consultations on federal actions affecting ESA-listed marine species. Therefore, this biological opinion is an intra-service Section 7 consultation, as described in the Endangered Species Consultation Handbook (USFWS & NMFS 1998).

The Hawaii-based shallow-set longline fishery is one component of the Hawaii-based longline fishery, which also includes a deep-set component. The two components were not managed separately until 2000. Thus, an overview of the Hawaii-based longline fishery is given below to provide context for the shallow-set component.

1.1 The Hawaii-based Longline Fishery

Longline fishing utilizes a type of fishing gear consisting of a mainline that exceeds 1 nautical mile (6,076 ft) in length that is suspended horizontally in the water column, from which branchlines with hooks are attached (NMFS 2008a). The term "Hawaii-based" is used to specify those longline vessels operating out of Hawaii, in order to distinguish them from other longline vessels operating in the same waters, but based in other states or nations. The Hawaii-based longline fleet grew to 141 vessels in 1991 when the Council established a limited entry program to control the fishery's growth. The limited entry program allows a ceiling of 164 vessels, and vessel size is limited to a maximum of 101 feet in length (NMFS 2001, WPFMC 2006a, WPFMC 2008). Some 120-125 vessels typically are active during any given year.

The Hawaii-based longline fishery consists of 2 separately managed components: the deep-set gear configuration fishery (targeting tuna), and the shallow-set gear configuration fishery (targeting swordfish). No regulatory distinction was made between these 2 components of the

Hawaii-based longline fishery until 2000, when the Court ordered the closure of the swordfishing area north of Hawaii due to the bycatch of sea turtles by shallow-set fishing in this area. The Court order led to a complete closure of the swordfish fishery in 2001, while the deep-set fishery was allowed to continue operation, but with seasonal restrictions (NMFS 2001).

After the implementation of numerous measures to reduce turtle bycatch, the shallow-set fishery was reopened in 2004, but it was restricted to considerably less fishing effort than pre-2001 effort levels (NMFS 2004b). The deep-set component became an increasingly larger proportion of the total Hawaii-based longline fishery until there was only deep-setting during the shallow-set closure in 2001-2004. Since 2004, the shallow-set component has made up a small proportion of the total fishery (see figure on PIFSC website http://www.pifsc.noaa.gov/fmsd/reports.php). The regulatory history of Hawaii-based longline fishery is described in the 2001 Pelagics FEIS (NMFS 2001), the 2004 BiOp (NMFS 2004a), and the 2004 Pelagics FSEIS (NMFS 2004b).

Longline fishing allows a vessel to distribute effort over a large area to harvest fish that are not concentrated in great numbers. Overall catch rates in relation to the number of hooks are generally low, especially for tuna. Longline fishing involves setting a mainline horizontally at a preferred depth in the water column using floats spaced at regular intervals. Three to 5 radio buoys are usually attached at fairly regular intervals along the mainline so that the line may be easily located both for initial retrieval and in case the mainline parts during fishing operations. Branchlines are clipped to the mainline at regular intervals, and each branchline has a single baited hook. Mainlines are typically 30 to 100 km (18 to 60 nm) long, and after the mainline is completely deployed, the gear is allowed to “soak” for several hours before being retrieved (“hauled”). In longlining, a “set” is a discrete unbroken section of line floats and branchlines. Usually, only 1 set is fished per day. Fishing trips are typically 2 to 3 weeks long (NMFS 2001, NMFS 2005, WPFMC 2006a, Beverly & Chapman 2007, WPFMC 2008).

Longline fishing for swordfish is known as shallow-set longline fishing because the bait is set at depths of 30 – 90 m. The portion of the mainline with branchlines attached is suspended between floats at about 20 – 75 m of depth, and the branchlines hang off the mainline another 10 – 15 m. Only 4 – 6 branchlines are clipped to the mainline between floats, and a typical set for swordfish uses about 700 – 1,000 hooks. Shallow-set longline gear is set at night, with luminescent light sticks attached to the branchlines. Formerly, J-hooks and squid bait were used, but since 2004, circle hooks and mackerel-type bait have been required. These gear restrictions were implemented to reduce turtle bycatch. The most productive swordfishing areas for Hawaii-based longliners are north of Hawaii outside the U.S. Exclusive Economic Zone (EEZ) on the high seas.

Tunas, primarily bigeye and yellowfin, are targeted in the deep-set fishery, which sets bait at 150 – 400 m depth (depending on the target species). A line shooter is used on deep sets to deploy the mainline faster than the speed of the vessel, so that loops are formed which sink to the desired depth. Deep-set longline gear is typically set in the morning and hauled in the afternoon. In contrast to shallow-set longline fishing, a minimum of 15, but typically 20 to 30, branchlines are clipped to the mainline at regular intervals between the floats. A typical deep-set consists of 1,200 to 1,900 hooks. Lightsticks are not attached to the branchlines, as they are prohibited onboard Hawaii-based deep-set longline fishing vessels. The most productive tuna fishing areas are south of the swordfish areas. A comparison of shallow-set and deep-set longline fishing methods is provided in Bartram and Kaneko (2004).

The Hawaii-based longline fishery is managed by Federal regulations pertaining to the Pelagics FMP, as well as other Federal fisheries regulations that apply to the western Pacific. For the complete set of these Federal regulations, see 50 CFR Part 665, and for a summary see Summary of Hawaii Longline Fishing Regulations (NMFS 2008a).

1.2 The Shallow-set Component of the Hawaii Longline Fishery

The Hawaii-based shallow-set longline fishery began operations in late 2004 to test the effectiveness in the Pacific of a hook-and-bait combination that was found to dramatically reduce interactions[1] with sea turtles when tested on Atlantic pelagic longline vessels. A final rule that implemented Regulatory Amendment 3 (WPFMC 2004) was published and effective on April 2, 2004 (69 FR 17329), established a limited "model" Hawaii-based shallow-set swordfish fishery using circle hooks with mackerel-type bait. This combination had been found to reduce interactions with leatherback and loggerhead turtles by 65 and 90 percent, respectively, in the U.S. Atlantic longline fishery (Watson et al. 2005). In order to test and model the use of this gear in the Hawaii-based shallow-set longline fishery, fishing effort in the model fishery was limited to 50 percent of the 1994-99 annual average number of sets, or 2,120 sets. Those sets were distributed equally among those permit holders who applied each year to participate in the fishery. As an additional safeguard, a limit was implemented for the number of turtle interactions that could occur in the swordfish fishery, and the fishery would be closed for the remainder of the calendar year, if and when either limit was reached. That regulatory amendment also included proposals for a range of conservation measures to protect sea turtles in their nesting and coastal habitats, although these were not regulatory measures for the fishery.

Under the requirements implemented by the April 2, 2004 (69 FR 17329) final rule, vessel operators in the Hawaii-based shallow-set fishery must now use large (18/0) circle hooks with a 10 degree offset and mackerel-type bait, comply with a set certificate program to ensure that the fleet as a whole does not make more than a total of 2,120 shallow-sets per year, and the fleet as whole may not interact with (hook or entangle) more than a total of 17 loggerhead sea turtles or 16 leatherback sea turtles each year. In addition to those requirements, all vessels must carry an observer when shallow-setting (100 percent observer coverage). The sea turtle interaction limits were not intended to represent the upper limit of interactions that would avoid jeopardizing the continued existence of sea turtles, but instead are the annual number of sea turtle interactions anticipated to occur in this fishery, as calculated by multiplying expected fishing effort by interaction rates derived from studies using circle hooks and mackerel bait in U.S. longline fisheries in the Atlantic. The use of circle hooks and mackerel-type bait in Hawaii's shallow-set longline fishery has reduced sea turtle interaction rates by approximately 90 percent for loggerheads and 83 percent for leatherbacks compared to the previous period 1994-2002 when the fishery was operating without these requirements (Gilman et al. 2007a).

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

2 Consultation History

The proposed federal action addressed by this biological opinion is modification of the management program for the Hawaii-based shallow-set longline fishery, as recommended in Amendment 18 to the Pelagics FMP. On August 12, 2008, a public review Draft Supplemental Environmental Impact Statement (DSEIS) was completed for the proposed action, and adopted by NMFS' Pacific Islands Regional Office – Sustainable Fisheries Division (PIRO/SFD) as the Biological Assessment (BA) for this ESA consultation. The notice of availability of the DSEIS was published in the *Federal Register* on August 22, 2008 (73 FR 49667). On August 15, 2008, PIRO/SFD sent a memorandum to PIRO's Protected Resources Division (PIRO/PRD) requesting reinitiation of formal consultation on effects of Amendment 18 on ESA-listed marine species, using the DSEIS (2008) as the BA for the consultation. PRD participated in the development of the DSEIS for use as the BA in this consultation, and PRD agreed that the DSEIS was adequate for ESA consultation. Thus, formal consultation was reinitiated on August 15, 2008.

The August 15, 2008, consultation request constitutes a reinitiation of formal consultation: NMFS previously issued a biological opinion on proposed regulatory amendments to the Pelagics FMP on February 23rd, 2004 (2004 BiOp) (NMFS 2004a), which included the Hawaii-based shallow-set longline, the Hawaii-based deep-set longline, the American Samoa longline, and the regional non-longline pelagic fisheries. Reinitiation of consultation is required if "the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion" (50 CFR 402.16(c)). Amendment 18 proposes to remove the effort limits from the fishery, hence requiring reinitiation. This reinitiation of formal consultation and resulting biological opinion only covers the shallow-set component of the Pelagics FMP and supersedes the shallow-set longline component of the 2004 BiOp.

The 2004 BiOp (NMFS 2004a) included an Incidental Take Statement (ITS) specifying take limits for 3 fishery components of the pelagic longline fishery: (1) Hawaii shallow-set longline; (2) Hawaii deep-set longline; and (3) American Samoa longline and regional non-longline pelagic fisheries combined, such that exceedance of take in 1 component would not require reinitiation of formal consultation in the other 2 components of the fishery in which take levels were not exceeded. In 2004, the Hawaii deep-set longline component of the pelagic longline fishery was estimated to have exceeded the take of olive ridley turtles authorized in the 2004 ITS. Thus, formal consultation was reinitiated on the deep-set component, resulting in a biological opinion on October 4, 2005 (NMFS 2005). In 2006 and 2007, the American Samoa longline component of the pelagic longline fishery exceeded the take of green turtles authorized in the 2004 ITS. Reinitiation of consultation was requested on July 31, 2008, on the American Samoa longline fishery, as well as the regional non-longline pelagic fisheries. Therefore, since the 2004 BiOp was issued, consultation has either been reinitiated (Hawaii-based shallow-set longline, American Samoa longline, non-longline pelagics) or completed (Hawaii-based deep-set longline) on all of the fisheries covered by the 2004 BiOp (NMFS 2004a).

PIRO/PRD provided a draft biological opinion to PIRO/SFD and PIFSC, with a request for comments, on August 22, 2008. On August 27, 2008, PIRO/PRD responded to PIRO/SFD's August 15, 2008 consultation request memo by concurring that the Hawaiian monk seal and blue, fin, sei, sperm, and North Pacific right whales are not likely to be adversely affected by the proposed action. Comments were received from PIFSC on September 3, 2008, and from

PIRO/SFD on September 8, 2008. On September 19, 2008, the draft biological opinion was provided to the Applicant for the proposed action, the Hawaii Longline Association (HLA). A conference call was conducted with HLA on September 23, 2008. Comments were received from HLA on September 26, 2008.

3 Description of the Action

The proposed action addressed by this biological opinion is the continued operation of the Hawaii-based shallow-set longline fishery for swordfish under the Pelagics FMP, with incorporation of the management changes proposed in Amendment 18. The purpose of Amendment 18 is "to provide increased opportunities for the shallow-set fishery to sustainably harvest swordfish and other fish species while continuing to avoid jeopardizing the continued existence and recovery of threatened and endangered sea turtles as well as other protected species" (WPFMC 2008). To achieve this objective, the Council has recommended that NMFS remove the annual limit on fishing effort, specifically the number of fishing gear deployments (sets). Currently, that limit is 2,120 sets per year. Associated with this action, the Council has also recommended that the set certificate program, which is used to monitor and control the number of sets, also be removed because it would be unnecessary in the absence of an effort limit. Amendment 18 and Draft Supplemental Environmental Impact Statement (DSEIS) estimates that the removal of the effort limit could result in 2,120 to 5,550 sets annually (WPFMC 2008). With the effort limitation program removed as recommended, Amendment 18 also recommends a related increase in the loggerhead and leatherback interaction limits (i.e., maximum number of annual allowable interactions). The revised interaction limits correspond to the numbers of interactions expected to result as the fishery expands as a result of removing the effort limit. All other measures currently applicable to the fishery would remain unchanged.

Under ESA section 7(a)(2), NMFS is mandated to ensure that removal of the effort (set) limit for this fishery, and any resulting increase in fishing effort, 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. This opinion defines the proposed action as the continued operation of the Hawaii-based shallow-set longline fishery at an effort level of 5,550 sets annually. The proposed action for this consultation is consistent with the purpose of Amendment 18 and the Council's intent to eliminate the set certificates and to establish new sea turtle interaction caps that would continue to avoid jeopardizing the existence of threatened and endangered sea turtles or their habitat.

A synopsis of the current shallow-set regulations is provided below. Those regulations that would be affected by the changes proposed in Amendment 18, and which are being considered in this opinion, **are noted in bold**. These proposed changes are described in more detail in Section 3.3. The regulations governing the Hawaii-based shallow-set longline fishery are grouped into the following categories, and each category is summarized below:

- Fishing Permits and Certificates:
  - Hawaii Longline Limited Entry Permit.
  - Marine Mammal Authorization Program Certificate.
  - High Seas Fishing Compliance Act Permit, for vessel fishing on the high seas.

- **A Shallow-set Certificate for every shallow-set made north of the Equator (the proposed action would remove this requirement).**
- Protected Species Workshop Certificate.
- Western Pacific Receiving Vessel Permit, if applicable.
- State of Hawaii Commercial Marine License.

❖ Reporting, Monitoring, and Gear Identification:
- Logbook for recording catch, effort and other data.
- Transshipping Logbook, if applicable.
- Marine Mammal Authorization Program (MMAP) Mortality/Injury Reporting Form.
- Vessel Monitoring System (VMS).
- Vessel Identification.
- Gear Identification.

❖ Notification Requirement and Observer Placement:
- Notify the PIRO Observer Program contractor at least 72 hours before departure on a fishing trip to declare the trip type (shallow-set or deep-set).
- All longline fishing trips are required to have a fisheries observer on board if requested by the Regional Administrator; NMFS policy is to place observers on board every shallow-set longline trip.
- Fisheries observer guidelines must be followed.

❖ Prohibited Areas in Hawaii:
- Northwestern Hawaiian Islands Longline Protected Species Zone.
- Main Hawaiian Islands winter and summer Longline Fishing Prohibited Areas.

❖ **Shallow-set Certificate Program and Turtle Interaction limits (the proposed action would remove the certificate requirement and revise the turtle interaction limits):**
- **A maximum of 2,120 shallow-set certificates are available annually.**
- **Interested Hawaii longline limited entry permit holders must submit a written request for certificates at the beginning of the fishing year.**
- **Each Hawaii longline limited entry permit holder receive equal proportions of available certificates.**
- **Certificates can be transferred only among Hawaii longline limited entry permit holders.**
- **Maximum annual limits are established on the numbers of physical interactions that occur each calendar year between leatherback and loggerhead sea turtles and vessels registered for use under Hawaii longline limited access permits while shallow-setting: 16 for leatherbacks and 17 for loggerheads.**
- **If either turtle interaction limit is reached, the shallow-set fishery is closed for the remainder of the calendar year.**

❖ Protected Species Workshop:
- Each year, longline vessel owners and operators must attend a Protected Species Workshop, and receive a Protected Species Workshop (PSW) certificate.
- A valid PSW certificate is required to renew a Hawaii longline limited entry permit.

- The operator of a longline vessel must have a valid PSW certificate on board the vessel while fishing.

- Sea Turtle and Seabird Handling and Mitigation Measures:
  - Longline vessel owners/operators are required to adhere to the regulations for the safe handling and release of sea turtles and seabirds presented in the PSWs.
  - Longline vessel owners/operators must have on board the vessel all required turtle handling/dehooking gear specified in the regulations.
  - Longline vessel owners/operators can choose between side-setting or stern-setting to reduce seabird interactions:
    - Side-setting requirements:
      - Mainline deployed as far forward as possible.
      - If line shooter is used, mount as far forward as possible, and at least 1 m forward of the stern.
      - Branchlines must have 45 g weight within 1 m of hook.
      - When seabirds are present, deploy gear so hooks remain submerged.
      - Deploy a bird curtain.
    - Stern-setting requirements:
      - When seabirds are present, discharge offal while setting or hauling on opposite side of the vessel.
      - Retain sufficient offal between sets.
      - Remove all hooks from offal before discharge.
      - Use swordfish liver and head for offal. The swordfish bill must be removed, and the head split in half vertically.
  - When using basket-style gear, ensure mainline is set slack (seabird measure).
  - Use completely thawed bait, and dye all bait to match NOAA Fisheries-issued color control card (seabird measure).
  - Maintain at least 2 cans of blue dye on board (seabird measure).
  - Deploy set ≥1 hour after sunset, complete deployment before sunrise (seabird measure).
  - When shallow-set longline fishing north of the Equator:
    - Use 18/0 or larger circle hooks with 10° offset.
    - Use mackerel-type bait.
    - **Must have 1 valid shallow-set certificate per set (the proposed action would remove this requirement).**

- Marine Mammal Handling and Release:
  - Longline vessel owners/operators must follow the marine mammal handling guidelines provided at the PSW.
  - Submit the MMPA Mortality/Injury Reporting Form to NOAA Fisheries to report injuries or mortalities of marine mammals.

- Shark Finning and Landings
  - Shark fins, including the tail, cannot be removed from sharks and the carcass disposed at sea.

- Shark fins can be removed if the corresponding carcass is kept. Shark fins can only be sold if the fins and corresponding carcass are weighted at the same time after returning to port.
- Shark fins received from another vessel must be accompanied by the corresponding carcass.
- The total weight of shark fins landed may not exceed 5 percent of the total dressed weight of shark carcasses on board or landed from the vessel.
- NOAA Fisheries must be granted access to shark fin records.

The above regulations can be found at 50 CFR Part 665. A summary of the regulations for the Hawaii-based longline fishery (shallow-set and deep-set components combined) is provided by the Summary of Hawaii Longline Fishing Regulations (NMFS 2008a).

4 Action Area

The action area for this proposed action includes all areas where vessels permitted by the Hawaii-based shallow-set longline fishery operate shallow-set gear, and areas that such vessels travel through on shallow-set fishing trips. Hawaii-based shallow-set longline fishing in 2005-07 all occurred between 180° - 140° W longitude and 20° N - 40° N latitude, hence this rectangle is the action area (Figure 1). The action area includes part of the U.S. Exclusive Economic Zone (EEZ) around the Hawaiian Islands, but as described and shown in the Summary of Hawaii Longline Fishing Regulations (NMFS 2008a), portions of this EEZ are closed to longline fishing. However, these closed areas are included in the action area where longline vessels travel through them on shallow-set fishing trips.

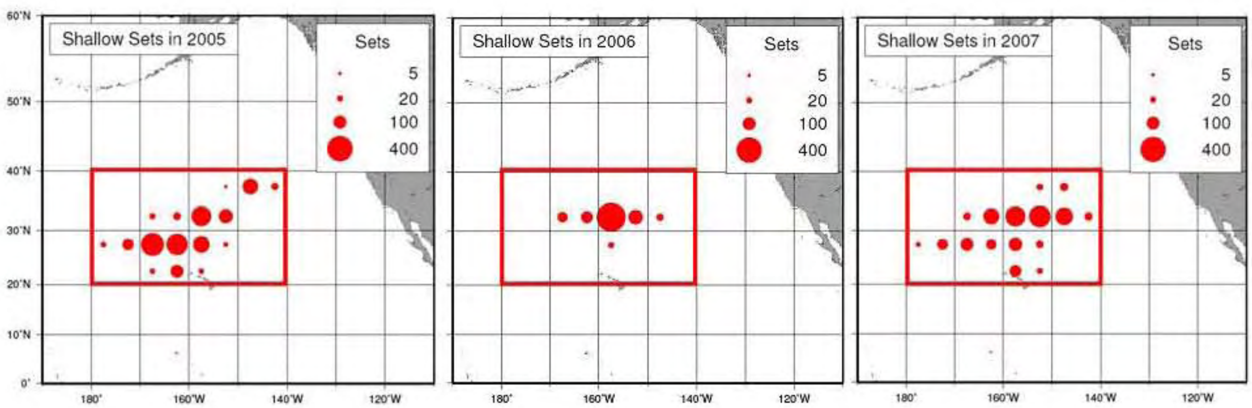


Figure 1. Locations of shallow-sets made in 2005-2007. Action area is shown by the red square (maps provided by Karen Sender, Pacific Islands Fisheries Science Center, 7/24/08).

There is spatial overlap between the shallow-set and deep-set components of the Hawaii-based longline fishery. The proposed action addressed by this biological opinion is management modifications to the shallow-set component only. The shallow-set component of the Hawaii-based longline fishery operates almost entirely north of Hawaii. In some years, depending on the seawater temperature, this component of the longline fishery may operate mostly north of 30° N, such as in 2007 (Figure 1). The deep-set component of the fishery operates primarily to the south of Hawaii between the Equator and 20° N. In some years there may be considerable fishing north of Hawaii also. Thus, the 2 components overlap spatially near Hawaii between 20° N and 30° N (Figure 2).

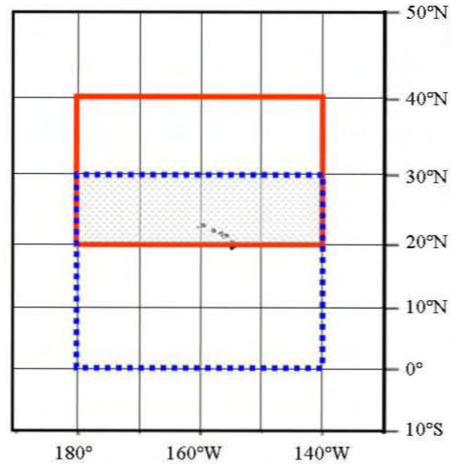


Figure 2: Shallow-set (solid red line) vs. deep-set (dashed blue line) areas of the HI-based longline fishery, with overlap in stippling.

5 Status of Listed Species

The memo of August 15, 2008, from SFD to PRD requesting consultation on the shallow-set longline fishery under Amendment 18 determined that the proposed action may affect the 12 ESA-listed marine species shown in Table 1. The memo further determined that the 6 species shown in Table 1a below are not likely to be adversely affected by the proposed action, and requested concurrence on this determination from PRD. On August 27, 2008, PRD responded with a letter concurring with these determinations, hence these 6 species (Hawaiian monk seal and the 5 whale species except humpbacks) are not addressed further in this biological opinion. The August 15, 2008, consultation request also determined that the 6 species shown in Table 1b below are likely to be adversely affected by the proposed action, and requested formal consultation on these species. The remainder of this biological opinion deals exclusively with these 6 species (humpback whale and 5 sea turtle species).

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

Species	Scientific Name	ESA Status	Listing Date	Federal Register Reference
Table 1a. Species not likely to be adversely affected by the proposed action.				
Hawaiian Monk Seal	*Monachus schauinslandi*	Endangered	11/23/1976	41 FR 51612
Blue Whale	*Balaenoptera musculus*	Endangered	12/02/1970	35 FR 18319
Fin Whale	*B. physalus*	Endangered	12/02/1970	35 FR 18319
Sei Whale	*B. borealis*	Endangered	12/02/1970	35 FR 18319
Sperm Whale	*Physeter macrocephalus*	Endangered	12/02/1970	35 FR 18319
N. Pacific Right Whale	*Eubalaena japonica*	Endangered	12/27/2006	71 FR 77694
Table 1b. Species likely to be adversely affected by the proposed action.				
Humpback Whale	*Megaptera novaeangliae*	Endangered	12/02/1970	35 FR 18319
Loggerhead Sea Turtle	*Caretta caretta*	Threatened	7/28/1978	43 FR 32800
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered	06/02/1970	35 FR 8491
Olive Ridley Sea Turtle	*Lepidochelys olivacea*			
Nesting aggregations on west coast of Mexico		Endangered	7/28/1978	43 FR 32800
All other Olive Ridley turtles		Threatened	7/28/1978	43 FR 32800
Green Sea Turtle	*Chelonia mydas*		7/28/1978	43 FR 32800
Nesting aggregations, west coast Mexico, Florida		Endangered	7/28/1978	43 FR 32800
All other Green turtles		Threatened	7/28/1978	43 FR 32800
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered	7/28/1978	43 FR 32800

This section presents the biological or ecological information relevant to formulating the biological 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 (USFWS & 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 6 species addressed by this biological opinion (humpback whale and the 5 sea turtle species). No critical habitat has been designated for any of these listed species in the Pacific Ocean.

The 6 species addressed by this biological opinion have global distributions, and are listed globally at the species level (Table 1). Under the ESA, a sub-species or a "distinct population segment" (DPS) can also be listed (see ESA Section 7 Implementing Regulations; 50 CFR 402), but none are for these 6 species[2]. However, as shown above in Figure 1, the action area is relatively small compared to the distributions of the 6 species. Since the proposed action can only affect the populations of these species that occur within the action area, this opinion will focus on the affected populations, then relate the effects on the affected populations to the listed species in the Conclusion. In the absence of DPSs or other formally-recognized populations for these species, affected populations must first be identified. For the purposes of this opinion, the 6 species addressed by this biological opinion (humpback whale and the 5 sea turtle species) occur in the Pacific Ocean as the following Pacific populations:

1. Humpback whales: North Pacific and South Pacific populations. NMFS has identified 3 'stocks' in the North Pacific that overlap (see humpback whale Stock Assessment Reports), and likely function as a single population (SPLASH report; Calambokidis et al. 2008). The humpback whale recovery plan (NMFS 1991) states that the Central South Pacific and Eastern South Pacific stocks are 'population sub-units' in the South Pacific.
2. Loggerhead turtles: North Pacific and South Pacific populations. The most recent loggerhead 5-year status review (NMFS & USFWS 2007a) describes the status of loggerhead populations in geographic areas, including the North Pacific and South Pacific areas within the Pacific Ocean.
3. Leatherback turtles: Eastern Pacific and Western Pacific populations. The most recent leatherback 5-year status review (NMFS & USFWS 2007b) describes the status of leatherback populations in geographic areas, including the Eastern Pacific and Western Pacific areas within the Pacific Ocean.
4. Olive Ridley turtles: Eastern Pacific and Western Pacific populations. The most recent olive ridley 5-year status review (NMFS & USFWS 2007c) describes the status of olive ridley populations in geographic areas, including the Eastern Pacific and Western Pacific areas within the Pacific Ocean.
5. Green turtles: Western Pacific, Central Pacific, and Eastern Pacific populations. The most recent green turtle 5-year status review (NMFS & USFWS 2007d) describes the status of green turtle populations in geographic areas, including the Western Pacific, Central Pacific, and Eastern Pacific areas within the Pacific Ocean.
6. Hawksbill turtles: Western Pacific, Central Pacific, and Eastern Pacific populations. The most recent hawksbill turtle 5-year status review (NMFS & USFWS 2007e) describes the

[2] Certain nesting aggregations of olive ridley and green turtles are listed as 'endangered' while each species as a whole is listed as 'threatened' (Table 1). These nesting aggregations are treated as DPSs by NMFS and the USFWS. Also, on July 16, 2007, a petition to designate the North Pacific population of loggerheads as a DPS was received by NMFS. On November 16, 2007, NMFS published a 90-day finding that the petition may be warranted, thereby initiating a status review that is ongoing (72 FR 64585).

status of hawksbill turtle populations in geographically, including the Western Pacific, Central Pacific, and Eastern Pacific areas in the Pacific Ocean.

Not all of the Pacific populations identified above occur within the action area (Figure 1). All humpbacks in the action area are thought to be from the North Pacific population (NMFS 1991, Calambokidis et al. 2008), although these conclusions are not yet based on genetic evidence. For turtles, genetic work has been done to determine the source populations of individuals that interacted with the Hawaii-based longline fishery (shallow-set and deep-set components; Table 2). Over 100 loggerhead samples have been analyzed so far from the shallow-set fishery, and all were from the North Pacific population. The few loggerhead samples from the deep-set component were also from the North Pacific population. The 18 leatherbacks sampled from the shallow-set component were all from the Western Pacific population. However, 1 of the 12 leatherback samples from the deep-set component was from the Eastern Pacific population, but this interaction occurred approximately 6° of latitude south of the shallow-set action area. Olive ridley and green turtles interactions are very rare in the shallow-set component. However, olive ridleys are the most common turtle species in the deep-set component, and about two-thirds are from the Eastern Pacific population. Green turtle bycatch in the deep-set fishery is about evenly split between the Central and Eastern Pacific populations (Table 2).

Table 2. Genetics results from incidentally-caught turtles in HI-based shallow-set longline fishery, 1995-2007 (P. Dutton, personal communication, 7-08).

Species	Shallow-set		Deep-set	
	Samples	Source Pop^{n} (%)	Samples	Source Pop^{n} (%)
Loggerhead	125	125 N. Pacific (100%)	8	8 N. Pacific (100%)
Leatherback	18	18 W. Pacific (100%)	12	11 W. Pacific (92%) 1 E. Pacific (8%)
Olive ridley	3	1 W. Pacific (33%) 2 E. Pacific (67%)	75	23 W. Pacific (31%) 52 E. Pacific (69%)
Green	2	1 E. Pacific (50%) 1 C Pacific (50%)	15	8 E. Pacific (53%) 7 C. Pacific (47%)
Hawksbill	1*	C. Pacific (100%)	0	-

* Turtle was not caught alive in longline gear (rather, it drowned in a derelict net that was then inadvertently snagged by longline gear).

Table 3 below shows sea turtle interactions since the Hawaii-based shallow-set longline fishery re-opened in late 2004 (samples for which genetics results are available were taken from turtles caught between October 2004 and March 2008). During this 3 and a half year period, 45 loggerhead, 17 leatherback, 2 olive ridley, and 1 green turtle interactions occurred in the shallow-set fishery. The number of genetics samples taken and analyzed, and their results, are shown in Table 3 below.

Table 3. Species composition and source populations of incidentally-caught turtles in HI-based shallow-set longline fishery, 10/04-3/08 (P. Dutton, personal communication, 7-08).				
Species	Total Caught	Genetics Samples Taken	Genetics Samples Analyzed	Source Pop^n (%)
Loggerhead	45	41	30	30 N. Pacific (100%)
Leatherback	17	9	6	6 W. Pacific (100%)
Olive ridley	2	2	0	N/A
Green	1	1	0	N/A
Hawksbill	0	0	0	N/A

Based on the genetics results shown in Table 2 above (i.e., all samples available from the shallow-set fishery since 1995), for the purposes of this opinion, the affected populations of the 6 species addressed by this biological opinion (humpback whale and the 5 sea turtle species) are defined as follows:

1. Humpback whales: North Pacific population.
2. Loggerhead turtles: North Pacific population.
3. Leatherback turtles: Western Pacific population.
4. Olive Ridley turtles: Eastern Pacific and Western Pacific populations.
5. Green turtles: Central Pacific and Eastern Pacific populations.
6. Hawksbill turtles: Central Pacific population.

"Affected populations" of sea turtle species are defined by direct interactions with the Hawaii-based shallow-set fishery, as determined by the genetics results summarized in Table 2 above. The focus of this opinion is on these directly affected populations. However, other populations may be indirectly affected because of the market transfer effect (see Section 7, Effects of the Action).

5.1 Humpback Whales

Information in this section is summarized from the humpback whale recovery plan (NMFS 1991), the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the November 1st, 2006 biological opinion on effects of purse seining on sea turtles (2006 BiOp, NMFS 2006a), the biological opinion on the effects of the activities associated with the Navy's Hawaii Range Complex (NMFS 2008b), the humpback whale Stock Assessment Reports (e.g., Angliss & Outlaw 2007), the SPLASH report (Calambokidis et al. 2008), and other sources cited below.

5.1.1. Population Characteristics

Humpback whales are distributed worldwide in all ocean basins, from subtropical to subpolar waters. They carry out seasonal migrations between warmer temperate and subtropical waters in winter for reproduction, and cooler temperate and subpolar waters of high prey productivity in summer for feeding. At least 13 'stocks' have been recognized based on geography of migratory behavior (NMFS 1991), 3 of which occur within the EEZs of the U.S. (Angliss & Outlaw 2007), although genetic evidence may eventually show that some stocks are part of the same population due to extensive gene flow. For example, an individual humpback whale migrated from the

Indian Ocean to the South Atlantic Ocean, demonstrating that individual whales may migrate from 1 ocean basin to another (NMFS 2008b).

Within the North Pacific Ocean, 3 stocks make up the North Pacific population:: 1) the Eastern North Pacific stock that migrates between coastal areas of Mexico/Central America and the west coast of the U.S./southern British Columbia; 2) the Central North Pacific stock that migrates between the Hawaiian Islands and northern British Columbia/Southeast Alaska; and 3) the Western North Pacific stock that migrates between Japan and the Kodiak Archipelago/ Aleutian Islands (Angliss & Outlaw 2007). Based on whaling statistics, North Pacific population of before 1905 was estimated to be 15,000, but this population was reduced by whaling to approximately 1,000 before it was placed under international protection in 1965 (NMFS 1991). Protection from whaling was effective, resulting in the North Pacific population rebounding to approximately 18,000 individuals by 2008. About half of the population winters in Hawaii (the Central North Pacific stock of the population). Annual growth rate for the North Pacific population over the last several decades is estimated at 4.9 to 6.8 percent, depending on which area and time frame are considered (Calambokidis et al. 2008).

5.1.2 Life History Characteristics Affecting Vulnerability to Proposed Action

Depth preference, migration routes, and diving behavior may affect vulnerability of humpback whales to Hawaii-based shallow-set longline fishing. In Hawaii, humpback whales have been sighted as early in the season as October and as late as June, with most mating and calving occurring from December to April. They are generally found in water <600 ft (182 m) deep, and cow and calf pairs appear to prefer even shallower water. However, after arriving in Hawaiian wintering habitat, most humpback whales are unlikely to interact with the Hawaii-based shallow-set longline fishery because of the MHI Longline Fishing Prohibited Area, which varies from 50 to 75 nm from shore, depending on the location and season, as described above in the Action Area section. But while migrating between feeding grounds and Hawaii, humpback whales pass through the action area where they may be exposed to shallow-set longline gear. In addition, humpbacks are shallow divers, with most dives < 60 m. Since shallow-set longline gear is typically set so hooks are < 100 m deep, humpback dives largely overlap with this gear.

5.1.3. Threats to the Species

Whaling was formerly by far the most serious threat to the species, as described in the humpback whale recovery plan (NMFS 1991), the Stock Assessment Reports (e.g., Angliss & Outlaw 2007), and the SPLASH report (Calambokidis et al. 2008): From 1900 - 1965, nearly 30,000 whales were taken in modern whaling operations of the Pacific Ocean. There has been a prohibition on hunting humpback whales since 1966. Current threats include hookings and entanglement in fishing gear, ship strikes, tourism, noise, and possibly the effects of climate change.

Humpback whales are likely hooked or entangled by fishing gear throughout their global range, but data are scarce outside the U.S., especially in the Pacific. Reports of entangled humpback whales found swimming, floating, or stranded with fishing gear attached have increased in recent years in both Alaskan and Hawaiian waters. For example, there was a total of 23 entanglement reports from Hawaii from 2001 through 2006, but 16 of those were from 2005 and 2006. Many of the whales reported entangled in Hawaiian waters most likely brought the gear with them from higher latitude feeding grounds. While the whales are not typically at risk from drowning or immediate death, they are at increased risk of starvation, infection, physical trauma from the gear, and ship strikes as a result of the entanglement.

Many humpback whales are killed by ship strikes throughout the world, including along both coasts of the U.S. On the Pacific coast, a humpback whale is killed about every other year by ship strikes. Worldwide records of vessel collisions and stranding information indicate that humpback whales are one of the more common species to have ship strikes documented (Jensen and Silber 2003, Laist et al. 2001). Humpback whales, especially calves and juveniles, are highly vulnerable to ship strikes and other interactions with non-fishing vessels. Younger whales spend more time at the surface, are less visible and closer to shore, thereby making them more susceptible to collisions. Humpback whale distribution overlaps significantly with the transit routes of large commercial vessels that ply the waters off Alaska. Records of vessel collisions with large whales in Alaska indicate that strikes have involved cruise ships, recreational cruisers, whale watching catamarans, fishing vessels, and skiffs. Vessel lengths associated with these records ranged from approximately 20 feet to over 250 feet, indicating that all types and sizes of watercraft pose a threat of collision for whales. Between 2001 and 2005, reports of vessel collisions with humpback whales indicate an average of 5 whales struck per year in Alaska, whereas in Hawaii 3-4 vessel collisions with humpback whales were reported per year in 2001-2006. During the 2008 humpback whale season in Hawaii, there were 12 humpbacks reported with ship-strikes: 9 reported as hit by vessels, and 3 observed with wounds indicating a recent ship strike (D. Schofield, NMFS PIRO, pers. comm.).

Several other threats affect humpback whales throughout their range. For example, the Central North Pacific stock is the focus of a large whale watching industry in both Hawaii and Alaska. The growth of the whale watching industry is a concern for humpback whales since harassment may occur, preferred habitats may be abandoned, and fitness or survivability may be compromised if disturbance levels are too high. Also humpback whales seem to respond to moving sound sources, such as whale-watching vessels, fishing vessels, recreational vessels, and low-flying aircraft. Their responses to noise are variable and have been correlated with the size and behavior of the whales when the noises occurred. Noise from the U.S. Navy's Low Frequency Active (LFA) sonar program, and other anthropogenic sources (e.g., hydrographic research and shipping noise) throughout the North Pacific may be of concern for this population (NMFS 2006a, NMFS 2008b)

Central North Pacific humpback whales travel to the Hawaiian Islands in the winter/spring to mate and give birth to their young, and then migrate to northern British Columbia and Southeast Alaska to forage on krill and zooplankton during the summer months (NMFS 1991). Global warming resulting from climate change may require humpbacks to extend their foraging range farther north, and also to increase the duration of their foraging periods (Moore and Huntington 2008). Climate change may also affect the wintering areas and ranges of humpback whales because seawater temperature appears to influence the selection of wintering areas. For example, surveys off of Central America (Rasmussen et al, 2007) and in the Northwestern Hawaiian Islands (Johnston et al, 2007) found that wintering areas all had seawater temperatures >21 ^{o}C.

5.1.4. Conservation of the Species

To minimize the possibility of collision and the potential for harassment in Hawaii and Alaska, NMFS implemented regulations that prohibits approach to humpback whales within 100 yards (90 m) when on the water or to operate an aircraft within 1,000 feet (300 m) (50 CFR 224.103). The regulations also make it unlawful to disrupt the normal behavior or prior activity of the whales, which may be manifested in several, specific ways that include but are not limited to interruptions to breeding, nursing or resting activities.

The Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) also protects the winter breeding, calving and nursing range of the largest Pacific population of the endangered humpback whale. The U.S. Congress designated the HIHWNMS on November 4, 1992, and the Hawaiian Islands National Marine Sanctuary Act designated the Sanctuary for the primary purpose of protecting humpback whales and their habitat within the Hawaiian Islands marine environment. It is the only National Marine Sanctuary dedicated to a species of whales and their habitat. The Sanctuary works collaboratively to conserve, enhance and protect humpback whales and their habitat by promoting and coordinating research, enhance public awareness, and fostering traditional uses by Native Hawaiians. The sanctuary is jointly managed by the sanctuary manager, the state of Hawaii co-manager, and other field staff via a cooperative Federal-state partnership. The Sanctuary is a series of 5 noncontiguous marine protected areas distributed across the main Hawaiian Islands (MHI). The total area of the Sanctuary is 1,370 square miles. Encompassing about half of the total Sanctuary area, the largest contiguous portion of the Sanctuary is delineated around Maui, Lanai, and Molokai. The 4 smaller portions are located off the north shore of Kauai, off Hawaii's Kona coast, and off the north and southeast coasts of Oahu (www.hawaiihumpbackwhale.noaa.gov).

The Hawaiian Islands Disentanglement Network is a community based network that was formed in 2002 in an attempt to free endangered humpback whales and other marine animals from life threatening entanglements and at the same time gather valuable information that will help mitigate the issue of marine debris and future entanglements (www.hawaiihumpbackwhale.noaa.gov). Between 2002 and 2007, the network received over 146 reports of animals in distress, 79 of those reports represented entangled animals, including humpback whales. The network has mounted 43 (on-the-water or in-the-air) responses to these reports. To date, 6 humpbacks reported entangled in Hawaii have been confirmed to have gear from Alaska. Five of these represent commercial pot gear. The mean distance traveled with this gear is at least 1200 nm. The greatest known straight line distance a whale may have carried gear is 2350 nm (between the Pribilof Islands in the Bering Sea and the island of Maui where the whale was first reported).

5.2 Loggerhead Turtles

Information in this section is summarized primarily from the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 BiOp (NMFS 2006a), the proceedings of a 2005 loggerhead workshop (WPFMC 2006b), Volume II of the State of the World's Sea Turtles Report (SWOT 2006-2007), the most recent loggerhead 5-year status review (NMFS & USFWS 2007a), the DSEIS for the proposed action (WPFMC 2008), and other sources cited below.

Although this species is listed globally (Table 1), it is difficult to characterize the global status and trend of the loggerhead turtle as a whole because the species consists of many populations (see Section 5.2.1 below) that may increase or decrease independently of one another. The most recent loggerhead 5-year status review (NMFS & USFWS 2007a) does not make a determination regarding global status and trends, but rather limits its conclusions to the status and trends of populations for which information is available. Some populations are increasing, but most populations for which information is available are decreasing, while there is not sufficient information to determine status and trends of many populations (NMFS & USFWS 2007a). The available information is not sufficient to determine the status and trend of the species as a whole.

5.2.1 Population Characteristics

Loggerheads 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 loggerheads to nesting beaches maintains regional population structure, and loggerhead populations occur in at least the North Pacific, South Pacific, the Western North Atlantic, the Western South Atlantic, the East Atlantic, the Mediterranean, and the Indian Ocean. Populations in the Atlantic and Indian Oceans are much larger than in the Pacific, as described in the recent 5-year review (NMFS & USFWS 2007a). Of the 125 loggerheads sampled so far in bycatch of the Hawaii-based shallow-set longline fishery, all have been determined to be from the North Pacific population, based on genetic analyses (Table 2).

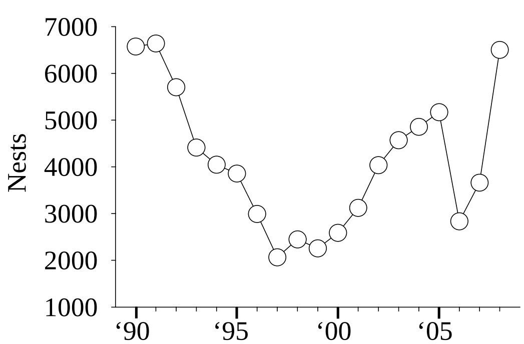


Figure 3. Loggerhead nests, Japan, 1990 – 2008 (data thru 2007 from Sea Turtle Association of Japan, as cited in Snover 2008; 2008 data estimated from Matsuzawa 2008, as explained in text).

North Pacific loggerheads nest exclusively in Japan, where monitoring of loggerheads nesting began in the 1950s on some beaches, and grew to encompass all known nesting beaches starting in 1990 (Kamezaki et al. 2003, Kamezaki et al., in press). The annual total number of nests for all nesting beaches combined are shown in Figure 3 for 1990-2008. Data for 1990 to 2007 were provided by the Sea Turtle Association of Japan, and used in Snover (2008). The majority of nesting is typically completed by the end of July, and the 2008 data point is an estimate based on a total of 3,927 nests through the end of July 2008 on Yakushima provided by the Sea Turtle Association of Japan (STAJ) on August 15, 2008 (Matsuzawa 2008). In recent years, approximately 60 percent of the total nests in Japan have been laid on Yakushima (Sea Turtle Association of Japan unpublished data; Kamezaki et al., In press). Hence, the total for 2008 is estimated in this opinion at 6,500 nests based on the best available data from STAJ at the time this opinion was completed (Matsuzawa 2008). However, the actual total for 2008 may exceed 10,000 nests, after the STAJ data are tallied and verified. Various conservation measures are funded by WPFMC and implemented by STAJ to protect nests and nesting habitat, as described in Section 5.2.4.

For the 19-year period 1990-2008, the total number of nests per year for the North Pacific population ranged between 2,064 – 6,638 nests (using 6,500 as the 2008 total, not 10,000).

Assuming a clutch frequency of 3.49 per female per year (NMFS 2005), the number of nesting females per year during 1990-2008 was 591 – 1,902. The total number of adult females in the population was estimated at 2,915 for the period 2005-07 by Snover (2008).

For the reasons discussed in Section 5.1, population estimates for sea turtles are problematic due to lack of demographic information. Few population estimates are available, especially for Pacific populations. However, in order to estimate loggerhead and leatherback bycatch in Pacific longline fisheries, Lewison et al. (2004) made several assumptions regarding numbers of nesting females, remigration interval, the proportion of nesting-age females to the total population, and sex ratio, leading to a total population estimate across all life stages in 2000 for Pacific loggerheads (North Pacific and South Pacific populations combined) of 335,000 individuals (all ages, both sexes). In addition, they estimated that approximately 20 percent of the population (67,000) was in size classes susceptible to longline fishing (Lewison et al. 2004). Due to the uncertainty of the assumptions used to derive sea turtle population estimates, in this opinion NMFS uses nesting or nesting female data as population indices.

Nesting data from the 2 nesting beaches that have been monitored since the 1950s suggest that the North Pacific loggerhead population declined by 50-90% in the latter half of the 20th century (Kamezaki et al. 2003). However, from 1999 to 2005, annual nests more than doubled (Kamezaki et al., In press), before declining in 2006 and 2007 (Figure 3). Preliminary data for 2008 indicate at least a similar number of nests as the early 1990s (Figure 3, Matsuzawa 2008).

5.2.2 Life History Characteristics Affecting Vulnerability to Proposed Action

Loggerhead 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 where maturation is reached. Adults forage primarily in neritic zones rather than oceanic zones, but adult migrations across oceanic zones may be undertaken for reproduction (NMFS 2004a, 2005, 2006a; NMFS & USFWS 2007a). Given that the action area is oceanic, the main aspects of North Pacific loggerhead life history affecting their vulnerability to Hawaii-based shallow-set longline fishing are juvenile foraging behavior in the oceanic zone, and migration across the oceanic zone, as discussed below.

The Hawaii-based shallow-set fishery interacts mostly with juvenile loggerhead turtles, typically 50 – 80 cm carapace length. In the oceanic zone of the central north Pacific Ocean, foraging juvenile loggerheads 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. This boundary area is referred to as the Transition Zone Chlorophyll Front, and is favored foraging habitat for both juvenile loggerhead turtles (Polovina et al. 2006, Kobayashi et al. 2008) and swordfish, hence bringing the loggerheads into contact with the shallow-set fishery. Data collected from stomach samples of juvenile loggerheads indicate a diverse diet of pelagic food items (NMFS 2006a, Parker et al. 2005).

In addition to the geographic overlap of juvenile loggerheads with the shallow-set fishery, tagging studies indicate that juvenile loggerheads are shallow divers that forage frequently at depths fished by shallow-set gear (<100 m; Polovina et al. 2003, 2004). Because juvenile loggerheads forage within the action area, and they often forage at depths fished by the shallow-set fishery, this species is the most susceptible of the Pacific sea turtle species to interactions with shallow-set gear: About 75 percent of the bycaught turtles observed in the shallow-set fishery from 1994 to early 2008 were loggerheads, whereas only 10 percent of the deep-set observed bycatch was loggerheads during this period. Because deep-set gear is typically set >100 m depth, loggerheads rarely encounter it. The opposite occurs with olive ridleys, which have little bycatch in the shallow-set fishery but make up the majority of the turtle bycatch in the deep-set fishery (PIRO Observer Program).

Loggerheads are a slow-growing species that reach sexual maturity at 25 to 37 years of age, depending on the subpopulation (NMFS & USFWS 2007a). Generation time for the North Pacific population is estimated at 33 years (Snover 2008). North Pacific loggerhead range spans the entire north Pacific Ocean, hence migration of juveniles and adults between terrestrial (nesting), near-shore and pelagic habitats may result in criss-crossing of the action area during all life stages, thereby exposing an individual loggerhead to shallow-set longlining for many years or even decades. Juveniles are likely more abundant than adults in the action area, as most loggerhead bycatch is from this life history stage in the Hawaii-based shallow-set longline fishery. However, adult loggerhead interactions occasionally occur in the fishery (NMFS 2004a, 2005, 2006a).

5.2.3 Threats to the Species

Global threats to loggerhead turtles are spelled out in the recent 5-year review (NMFS & USFWS 2007a), and threats to the North Pacific loggerhead population are described in more detail in the proceedings of the 2005 workshop (WPFMC 2005). A Council workshop was held on December 19-20, 2007 to bring together loggerhead experts in order to provide NMFS with the best available data on loggerhead issues for use in this opinion. Proceedings were not available at the time this opinion was signed, but some presentations were used (e.g., Ishihara 2007). The major threats to the species, according to these sources, are fishing bycatch, alteration of nesting habitat, and direct harvest and predation, which are briefly described below. In addition, climate change appears to be a growing threat to this species, and is also mentioned below.

The most serious threat to loggerhead turtles is believed to be incidental capture (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. In the Atlantic, where the loggerhead population is much larger than in the Pacific, fisheries kill tens of thousands of turtles annually (NMFS & USFWS 2007a). Bycatch and fisheries-related strandings numbering in the thousands annually have been reported from gillnet and longline fisheries operating in loggerhead 'hotspots' off of Baja Mexico (Peckham et al. 2007, 2008). Peckham et al. (2007) was funded by the Council, and this paper provides the first estimates of these major artisanal fishing impacts on North Pacific loggerheads in their major foraging ground.

Bottom trawl fisheries operating out of Australia and New Zealand are thought to result in high bycatch and high mortality rates. In the north Pacific, longline fisheries operating out of Hawaii were estimated to kill hundreds of loggerheads a year before the fishery was closed in 2001, and then modified and reopened with measures to minimize byactch and post-hooking mortality in 2004. However, longline fisheries operating out of other countries are still using traditional methods (J style hooks with squid bait), and are likely injuring and killing at least many hundreds of turtles annually in the North Pacific (NMFS & USFWS 2007a). In addition, coastal fisheries using more traditional methods, like trap nets or pound nets in Japan, are also resulting in high mortality (Ishihara 2007). Pound net and gillnet fisheries are reported to have declined or disappeared around the primary North Pacific loggerhead nesting beaches at Yakushima Island, Japan (Ohmuta 2006), however, further investigation of potential nearshore fishery threats is needed.

Destruction and alteration of loggerhead nesting habitats are occurring throughout the species' global range, especially coastal development, beach armoring, beachfront lighting, and vehicular/ pedestrian traffic. Coastal development includes roads, buildings, seawalls, etc., all of which 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 the coastal development from erosion during storms, but armoring blocks turtle nesting and often leads to beach loss (NMFS & USFWS 2007a). In Japan, where the entire North Pacific loggerhead population nests, many nesting beaches are lined with concrete armoring, thereby causing turtles to nest below the high tide line where most eggs are washed away unless the eggs are 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 also improves beach access for humans, resulting in more vehicle and foot traffic on beaches, which may result in compaction of nests and reduction of emergence success (NMFS & USFWS 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).

Deliberate hunting of loggerheads for their meat, shells, and eggs is reduced from previous levels, but still exists in some parts of the species' range. The South Pacific loggerhead population nests in Australia and New Caledonia. Laws prohibit harvest of turtles or eggs in Australia, but harvest of nesting females may be common in New Caledonia (Limpus et al. 2006). The North Pacific loggerhead population nests exclusively in Japan, especially on Yakushima Island. In 1973, a law was enacted on Yakushima Island prohibiting harvest of sea turtle eggs. A similar law was enacted in 1988 encompassing most of the other loggerhead 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 2005, given that loggerheads mature in about 29 years (Ohmuta 2006). Predation of eggs is a common problem throughout the species' range, for example by raccoons and feral pigs in the southeast U.S., by feral foxes in Australia, and by feral dogs in New Caledonia (NMFS & USFWS 2007a).

Loggerhead turtles are probably already being affected by anthropogenic climate change. The global mean temperature has risen 0.76°C over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (NMFS & USFWS 2007a). Warmer temperatures within the nest chamber produce females while cooler ones produce males. Loggerheads nesting in the US are already skewed towards females (Hansen et al. 1998). As global temperatures increase, so will sand temperatures, which in turn will alter the thermal regime of incubating nests and alter natural sex ratios within hatchling cohorts, likely toward a larger proportion of females. Sea level rose approximately 15 cm during the 20th century (Baker et al. 2006) and further increases are expected, resulting in inundation of nesting beaches. While under natural conditions beaches can move landward or seaward with fluctuations in sea level, extensive shoreline hardening (e.g., seawalls) inhibits this natural process. Erosion due to increased typhoon frequency and extreme temperatures are documented and known to cause high nest mortality (Matsuzawa, 2006). Lower breeding capacity of North Pacific loggerheads in years following higher sea surface temperatures may reflect reduced ocean productivity during warmer years, an indirect effect of climate change on this species (Chaloupka et al. 2008a).

5.2.4 Conservation of the Species

Considerable effort has been made since the 1980s to document and reduce loggerhead bycatch in fisheries around the world, as this is the highest conservation priority for the species. In the U.S., observer programs have been implemented in most federally-managed fisheries to collect bycatch data, and several strategies have been pursued to reduce both bycatch rates and post-hooking mortality. These include developing gear solutions to prevent or reduce capture (e.g., circle hooks) or to allow the turtle to escape without harm (e.g., turtle exclusion devices), implementing seasonal time-area closures to prevent fishing when turtles are congregated, and modifying existing gear (e.g., reducing mesh size of gillnets; NMFS & USFWS 2007a). For example, switching to large circle hooks and mackerel bait in 2004 resulted in approximately 90 percent fewer loggerhead interactions in the Hawaii shallow-set longline fishery (Gilman et al. 2007a, WPFMC 2008). Since 2004, WPFMC has been supporting projects to reduce loggerhead bycatch and mortality in gillnet and longline fisheries that operate in a loggerhead foraging hotspot off Baja California, Mexico. Mortality reduction workshops with fishermen have been conducted, observers have been placed on local boats to quantify interaction rates and ensure that any live loggerheads bycaught in halibut gillnets are returned to the ocean, and agreements have been reached to retire gear (Peckham et al. 2007, WPFMC 2008).

Conservation efforts have also focused on protecting nesting beaches, nests, and hatchlings. For example, WPFMC has been working with Sea Turtle Association of Japan (STAJ) since 2004 to protect loggerhead nests and hatchlings at several nesting beaches in southern Japan, including on Yakushima Island where more than 50 percent of North Pacific loggerhead nesting occurs (Kamezaki et al., In press). Beach management activities include conducting nightly patrols during the summer nesting season to relocate nests from erosion prone areas, protect nests from predators and people with mesh and fences, and cool nests with water 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). Nest relocation in 2004-07 resulted in an estimated 100,000 hatchlings being released that otherwise may have been lost (WPFMC 2008).

The conservation and recovery of loggerhead turtles is facilitated by a number of regulatory mechanisms at international, regional, national and local levels, such as the Food and Agriculture Organization’s (FAO) Technical Consultation on Sea Turtle-Fishery Interactions, the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), the Convention on International Trade in Endangered Species (CITES), and others. As a result of these designations and agreements, many of the intentional impacts on sea turtles have been reduced: harvest of eggs and adults have been slowed at several nesting areas through nesting beach conservation efforts and an increasing number of community-based initiatives are in place to slow the take of turtles in foraging areas. Moreover, as shown by the above examples from Hawaii 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 & USFWS 2007a).

5.3 Leatherback Turtles

Information in this section is summarized primarily from the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 BiOp (NMFS 2006a), the proceedings of a 2004 leatherback workshop (WPFMC 2005), Volume II of the State of the World's Sea Turtles Report (SWOT 2006-2007), the most recent leatherback 5-year status review (NMFS & USFWS 2007b), the May 2007 Leatherback focus issue of the journal Chelonian Conservation and Biology, the Turtle Expert Working Group's report on Atlantic leatherback (TEWG 2007), the DSEIS for the proposed action (WPFMC 2008), and other sources cited below.

Although this species is listed globally (Table 1), it is difficult to characterize the global status and trend of the leatherback turtle as a whole because the species consists of many discrete populations (see Section 5.3.1 below) that may increase or decrease independently of one another. The most recent leatherback 5-year status review (NMFS & USFWS 2007b) does not make a determination regarding global status and trends, but rather limits its conclusions to the status and trends of populations for which information is available. Some populations are stable or increasing, but other populations for which information is available are either decreasing or have collapsed, while there is not sufficient information to determine status and trends of many populations (NMFS & USFWS 2007a, TEWG 2007). The recent discovery of the world's fourth-largest leatherback nesting area on the Atlantic coast of Panama and Columbia (Patino-Martinez et al. 2008) supports the Turtle Experts Working Group's (TEWG) conclusion that leatherback nesting is increasing in parts of the Atlantic and Caribbean (TEWG 2007). However, as with loggerheads, the available information is not sufficient to determine the status and trend of the species as a whole.

5.3.1 Population Characteristics

Leatherbacks have the widest distribution of any sea turtle and can be found from the equator to subpolar regions in both hemispheres. In the Pacific, tagging studies have shown that leatherbacks can traverse entire ocean basins when foraging. Nesting occurs on tropical coastlines and insular beaches. However, the global leatherback population is not homogeneous because natal homing of female leatherbacks to nesting beaches maintains regional population structure. Leatherback populations occur in at least the Western Pacific, the Eastern Pacific, the Indian Ocean, Florida, the Caribbean, Africa, and Brazil, with further population structure at smaller spatial scales in some areas (e.g., the Caribbean), as described in the recent 5-year review (NMFS & USFWS 2007b) and the Turtle Expert Working Group's report on Atlantic leatherback (TEWG 2007).

All 18 leatherbacks sampled so far in bycatch of the Hawaii-based shallow-set longline fishery are from the Western Pacific population, based on genetic analyses. However, of the 12 leatherbacks sampled so far in bycatch of the deep-set component of the Hawaii-based longline fishery, 1 individual was determined to be from the Eastern Pacific population (Table 2). This interaction occurred 6° of latitude south of the shallow-set action area. Recent tagging studies have shown that Eastern Pacific females migrate southward to the South Pacific after nesting in Costa Rica (Shillinger et al. 2008), whereas Western Pacific females migrate northward to the North Pacific after nesting in Papua (Benson et al. 2007a, b). Individual Eastern Pacific leatherbacks are not considered likely to interact with the Hawaii-based shallow-set longline fishery, as modified by the proposed action, because: (1) 100 percent of the sampled leatherbacks from the shallow-set fishery (18/18) were of Western Pacific origin (Table 2); (2) the 1 Eastern Pacific interaction in the deep-set fishery was 6° of latitude south of the shallow-set action area; and (3) a recent study of 46 tagged leatherbacks tracked over 12,095 cumulative tracking days demonstrated that Eastern Pacific leatherbacks migrate south of the action area after nesting (Shillinger et al. 2008). However, Eastern Pacific leatherbacks may benefit from the "market transfer effect" associated with the proposed action (see Section 7 below).

Western Pacific leatherbacks nest primarily in Papua Indonesia (formerly Irian Jaya, hereafter referred to as Papua), Papua New Guinea (PNG), and the Solomon Islands. Minor nesting occurs on Vanuatu and possibly elsewhere in the region. The total number of nests per year in the Western Pacific population was estimated at 5,067 – 9,176 for the period 1999-2006 (Dutton et al. 2007). Based on 5,067 – 9,176 Western Pacific nests, estimates of nesting females (844 – 3294) and breeding females (2,110 – 5,735) in this population were derived, but the authors recommended using nest numbers instead of estimated female numbers because of uncertainty in the assumptions (Dutton et al. 2007). Estimates derived from Dutton et al. (2007) suggest that during 1999-2006, two-thirds of the nesting occurred in Papua, most of the remainder occurred in PNG and the Solomon Islands, and a small fraction (about 1 percent) occurred in Vanuatu. Of the 28 nesting sites identified by Dutton et al. (2007) in these 4 countries, nesting data for more than 5 years are only available for the Jamursba-Medi site (hereafter referred to as the 'Jamursba-Medi component' of the Western Pacific population). The status and trends at Jamursba-Medi are described below, followed by a description based on the little information that is available for the other sites (hereafter collectively referred to as the 'non-Jamursba-Medi component' of the Western Pacific population).

5.3.1.1 Jamursba-Medi Component of the Western Pacific Population

The largest nesting site for the Western Pacific population is at Jamursba-Medi, with an estimated mean of 2,733 nests annually in 1999-2006, making up approximately 38 percent of the total estimated nesting for the Western Pacific population during this time period (Dutton et al. 2007). Nest data were not collected consistently or reliably until the early 1990s, hence most reports of Jamursba-Medi nesting trends start at that time. However, anecdotal reports from the early 1980s suggest that nesting at Jamursba-Medi declined during the decade preceding initiation of nest counts in 1993 (Dutton et al., Hitipeuw et al. 2007).

Leatherback nesting at Jamursba-Medi occurs primarily between April and October. Nest data from Jamursba-Medi are highly variable from year to year, and no data are available from 1998. Nesting data suggest a decline from the 1993-1997 period to the 1999-2007 period, although the higher nesting level during 1993-1997 is due primarily to the high data point for 1996 (Figure 4; annual data points based on totals for Apr-Oct from Hitipeuw et al. 2007, Wurlianty & Hitipeuw

2007). Nesting during the 1999-2007 period has fluctuated annually, with the overall trend stable or slightly declining. These nesting data may be over-estimates: Nesting data collected from the same beaches during the same seasons and years by Japanese turtle researcher Hiroyuki Suganuma (Suganuma 2005, Minami 2008) were 31 – 38 percent lower for 2003 - 2007 than the data points shown in Figure 4, which are from Hitipeuw et al. (2007).

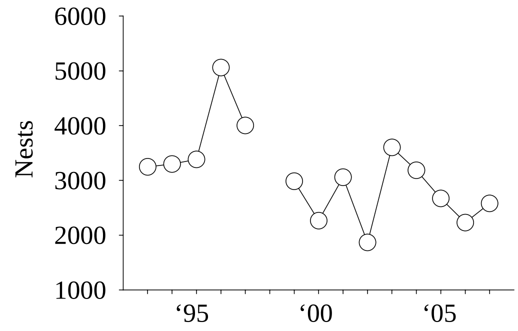


Figure 4. Leatherback nests, Jamursba-Medi, 1993 – 2007 (no data for1998; Hitipeuw et al. 2007; Wurlianty & Hitipeuw 2007).

5.3.1.2 Non-Jamursba-Medi Component of the Western Pacific Population

Besides Jamursba-Medi, Dutton et al. (2007) reported leatherback nesting at 27 other sites in the Western Pacific region (6 in Papua, 10 in PNG, 8 in the Solomon Islands, and 3 in Vanuatu). Approximately 62 percent of the leatherback nesting in 1999-2006 occurred at these 27 sites, while the remaining 38 percent occurred at Jamursba-Medi, the largest nesting site. The largest of the non-Jamursba-Medi sites is Wermon, 30 km east of Jamursba-Medi. Wermon produced approximately 30 percent of all Western Pacific nests in 1999-2006 (Dutton et al. 2007). Leatherback nesting at Wermon occurs primarily between November and March, the opposite of Jamursba-Medi (Wurlianty & Hitipeuw 2007).

Nest counts have been carried out at Wermon since 2002, thus data are available for the 5 year period from 2002–03 (Nov-Oct) to 2006-07 (Nov-Oct): 2002-03 = 1,788 nests, 2003-04 = 2,881 nests, 2004-05 = 2,080 nests, 2005-06 = 1,345 nests, and 2006-07 = 1,319 nests. Since the first complete survey in 2002-03, nesting levels at Wermon have been variable, with fewer nests during the last 2 years (2005-06, 2006-07) than in previous years (NMFS 2008h).

The Huon Coast of PNG hosts an estimated 50 percent of leatherback nesting in that country (NMFS 2008h). Anecdotal information in Quinn et al. (1983), Quinn and Kojis (1985), and Bedding and Lockhart (1989) suggest that 200 to 300 females nested annually between Labu Tali and Busama on the Huon Coast in the late 1980s (summarized in Hirth et al. 1993), but less than 50 females nested annually in 2005-06 and 2006-07 at this location (Pilcher 2006, 2007). Further south along the Huon Coast, an estimated 260 females nested at Kamiali during the 2001-02 nesting season, but only 30 were counted during the 2006-07 nesting season on the same section of beach (WPFMC 2008, Figure 15). Current monitoring data indicate continuing impacts to leatherbacks from egg harvesting, beach erosion and wave inundation, and domestic dog predation (NMFS 2008h).

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

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

5.3.1.3 Conclusion for Western Pacific Population

Population estimates for sea turtles are problematic due to lack of demographic information. Few population estimates are available, especially for Pacific populations. The total number of Pacific leatherbacks susceptible to longline fishing was estimated at 32,000 individuals in 2000 (Lewison et al. 2004). The total number of adult females in the Jamursba-Medi component of the Western Pacific population was estimated at 1,515 for the period 2005-07 by Snover (2008), which is estimated to make up 38 percent of the population (Dutton et al. 2007), giving a total number of adult females in the Western Pacific population of 1,515/0.38 = 3,987. This estimate lies within the range of 2,110 – 5,735 breeding females estimated for this population by Dutton et al. (2007). However, due to the uncertainty of the assumptions used to derive sea turtle population estimates, in this opinion NMFS uses nesting or nesting female data as population indices, as recommended by Dutton et al. (2007).

5.3.2 Life History Characteristics Affecting Vulnerability to Proposed Action

Leatherback life history is characterized by juvenile and adult life history stages occurring primarily in the oceanic zone. Adult leatherbacks range more widely across oceanic habitat than any other reptile, including into subpolar waters (NMFS 2004a, 2005, 2006a; NMFS & USFWS 2007b). Recent tagging studies have shown that adults sometimes migrate to highly productive upwelling areas near continental shelves, such as off Oregon and Washington (Benson et al. 2007a). Given that the action area is oceanic, the main aspects of Western Pacific loggerhead life history affecting their vulnerability to Hawaii-based shallow-set longline fishing are migration and foraging behavior, as discussed below.

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

Adult leatherbacks typically feed on pelagic soft-bodied animals, especially jellyfish, siphonophores, and tunicates. Despite the low nutritive value of their prey, leatherbacks grow rapidly and attain large sizes, hence they must consume enormous quantities of prey. Most water content of the prey is expelled before swallowing to maximize nutritive value per unit volume. Leatherbacks feed from near the surface to depths exceeding 1,000 m, including nocturnal feeding on tunicate colonies within the deep scattering layer (Spotila 2004). Although leatherbacks can dive deeper than any other reptile, most dives are < 80 m, thus primary foraging depth overlaps with fishing depth of the Hawaii-based shallow-set fishery. Approximately 69 percent of the observed leatherback interactions in the Hawaii-based longline fishery (shallow-set and deep-set component combined) from 1994 to early 2008 were in the shallow-set component (PIRO Observer Program). Migrating leatherbacks spend a majority of their time submerged and display a pattern of continual diving. Further, they appear to spend almost the entire portion of each dive traveling to and from maximum depth, suggesting continual foraging along the entire depth profile (NMFS 2006a).

5.3.3 Threats to the Species

Global threats to leatherback turtles are spelled out in the recent 5-year review (NMFS & USFWS 2007b), and threats to the Western Pacific leatherback population are described in more detail in the proceedings of a 2004 leatherback workshop (WPFMC 2005). The major threats to the species, according to these 2 documents, are fishing bycatch, alteration of nesting habitat, and direct harvest and predation, which are briefly described below. In addition, climate change appears to be a growing threat to this species, and is also mentioned below.

A major threat to leatherback turtles is believed to be bycatch in fisheries, including longline, drift gillnet, set gillnet, bottom trawling, dredge, and trap net fisheries that are operated on the high seas or in coastal areas throughout the species' range. In the Atlantic, where the leatherback population is much larger than in the Pacific, fisheries bycatch results in the mortality of thousands of turtles annually. In the eastern Pacific, significant bycatch has been reported in longline and gillnet fisheries, especially those operating off the west coast of South America. Fisheries operating out of Australia and New Zealand are thought to result in high bycatch and high mortality rates of Western Pacific leatherbacks that migrate there after nesting. In the north Pacific, the Hawaii-based shallow-set longline fishery was estimated to kill many leatherbacks annually before the fishery was closed in 2001, then modified and reopened with measures to minimize bycatch and post-hooking mortality in 2004. However, other longline fisheries operating out of other countries are still using traditional methods (J style hooks with squid bait), and are likely killing at least hundreds of leatherbacks annually in the Pacific. In addition, coastal fisheries using gillnetting or trap nets are also resulting in high mortality (NMFS & USFWS 2007b).

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

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

Leatherback turtles have most likely already been affected by anthropogenic climate change. The global mean temperature has risen 0.76°C over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (NMFS & USFWS 2007b). As global temperatures continue to increase, so will sand temperatures, which in turn will alter the thermal regime of incubating nests and alter natural sex ratios within hatchling cohorts, presumably toward a heavier female bias. Sea level rose approximately 15cm during the 20th century (Baker et al. 2006) and further increases are expected, resulting in inundation of nesting beaches. While under natural conditions beaches can move landward or seaward with fluctuations in sea level, extensive shoreline hardening (e.g., seawalls) inhibits this natural process. This may be more of a problem for Eastern Pacific leatherbacks that nest in Costa Rica where development is occurring rapidly near nesting beaches, then for Western Pacific leatherbacks that nest mostly or entirely on undeveloped beaches. Leatherbacks range more widely than any other reptile species, and feed primarily on jellyfish which may become more common with global warming, so effects of climate change on leatherback foraging are difficult to predict (NMFS & USFWS 2007b).

5.3.4 Conservation of the Species

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

Since 2003, WPFMC has been supporting projects to reduce leatherback hunting and egg collection in Papua and PNG. At Wermon and Jamursba-Medi[3] in Papua, village rangers were

[3] Wermon project supported by the Council and the Jamursba-Medi supported by NMFS SWFSC and WWF-Indonesia.

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

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

5.4 Olive Ridley Turtles

Information in this section is summarized primarily from the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 BiOp (NMFS 2006a), the most recent olive ridley 5-year status review (NMFS & USFWS 2007c), the DSEIS for the proposed action (WPFMC 2008), and other sources cited below.

5.4.1 Population Characteristics

Olive ridleys are the most abundant sea turtle species and are known for major nesting aggregations called *arribadas* with tens of thousands to over a million nests annually, the largest of which occur on the west coasts of Mexico and Costa Rica, and on the east coast of India. Minor *arribadas* and solitary nesters are found throughout the remaining tropical and warm temperate areas of the world, except in the western Pacific and eastern Indian Oceans where the species is uncommon. Population structure and genetics are poorly understood for this species, but populations occur in at least the Eastern Pacific, Western Pacific, Eastern Indian, Central Indian, Western Indian, West Africa, and Western Atlantic areas (Spotila 2004, NMFS & USFWS 2007c). The Eastern Pacific population includes nesting aggregations on the west coast of Mexico, which are listed under the ESA as endangered. All other olive ridleys are listed as threatened (Table 1).

The Eastern Pacific population is thought to be increasing, while there is inadequate information to suggest trends for the other populations. The global status of olive ridleys is described in the most recent 5-year status review (NMFS & USFWS 2007c). While olive ridleys are the most common turtle species that interact with the Hawaii-based deep-set longline fishery, they are very uncommon in the shallow-set fishery. Only 3 genetics samples have been collected from the shallow-set fishery and analyzed since 1995; 2 were from the Eastern Pacific population and 1 was from the Western Pacific population (Table 2).

Eastern Pacific olive ridleys nest primarily in the world's largest *arribadas* on the west coasts of Mexico and Costa Rica. Since reduction or cessation of egg and turtle harvest in both countries in the early 1990s, annual nest totals have increased substantially. On the Mexican coast alone, in 2004-2006, the annual total was estimated at 1,021,500 – 1,206,000 nests annually (NMFS & USFWS 2007c). Eguchi et al. (2007) counted olive ridleys at sea, leading to an estimate of 1,150,000 – 1,620,000 turtles in the eastern tropical Pacific in 1998-2006 (Eguchi et al. 2007). In contrast, there are no known *arribadas* of any size in the Western Pacific, and apparently only a few hundred nests scattered across Indonesia, Thailand and Australia. Data are not available to analyze trends (NMFS 2005, NMFS & USFWS 2007c).

5.4.2 Life History Characteristics Affecting Vulnerability to Proposed Action

Life history of the Eastern Pacific population of olive ridleys is characterized by juvenile and adult life history stages occurring in the oceanic zone. Along with leatherbacks, olive ridleys are the most pelagic of all sea turtle species (NMFS 2004a, 2005, 2006a; NMFS & USFWS 2007c). Given that the action area is oceanic, the Hawaii-based shallow-set longline fishery might be expected to frequently encounter olive ridleys. However, the diving behavior and distribution of the species reduces the likelihood of olive ridleys interacting with this fishery, as discussed below.

Similar to leatherbacks, olive ridleys prey primarily on soft-bodied animals that migrate with the deep scattering layer. As a result, olive ridleys typically forage in deep water, often diving deeper than shallow-set gear is fished. In addition, the distribution of this species in the north Pacific tends to be south of the action area for the Hawaii-based shallow-set longline fishery (Polovina et al. 2003, 2004a, NMFS 2006a). Therefore, in contrast to loggerheads, foraging in deep water and distribution generally to the south of the action area provides some spatial separation of olive ridleys from the Hawaii-based shallow-set fishery, resulting in very low olive ridley bycatch rates in this fishery. The opposite situation occurs in the Hawaii-based deep-set longline fishery, which fishes >100 m deep and primarily to the south of the Hawaiian Islands, resulting in olive ridleys being by far the most common turtle species that interacts with that fishery.

5.4.3 Threats to the Species

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

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

Rica. Illegal harvest of eggs is common in much of the species' range, such as throughout Central America and in India (NMFS & USFWS 2007c).

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

5.4.4 Conservation of the Species

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

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

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

5.5 Green Turtles

Information in this section is summarized primarily from the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 BiOp (NMFS 2006a), the most recent green turtle 5-year status review (NMFS & USFWS 2007d), the PIFSC draft green and hawksbill turtle research plan (Snover et al. 2007), and the DSEIS for the proposed action (WPFMC 2008).

5.5.1 Population Characteristics

Green turtle populations occur in at least the Western, Central, and Eastern Atlantic, the Mediterranean, the Western, Northern, and Eastern Indian Ocean, Southeast Asia, and the Western, Central, and Eastern Pacific, according to the recent 5-year review (NMFS & USFWS 2007d). In the 5-year review, the only archipelago included in the Central Pacific was Hawaii, where green turtles have increased since 1975 (NMFS & USFWS 2007d). However, the Central Pacific population also includes green turtles nesting in other archipelagos, such as Federated States of Micronesia and the Marshall Islands, and at least some of these sub-populations appear to be declining (Snover et al. 2007). The Eastern Pacific population includes turtles that nest on the west coast of Mexico, which are listed under the ESA as endangered. The Western Atlantic population includes turtles that nest in Florida, which are listed under the ESA as endangered. All other green turtles (including those in the Eastern Pacific population that nest outside of Mexico, and those in the Western Atlantic population that nest outside of Florida) are listed as threatened (see Table 1 above).

The Hawaii-based shallow-set longline fishery rarely interacts with green turtles, so only 2 turtles have been sampled so far in bycatch of this fishery, and 1 was from the Hawaii component of the Central Pacific population, while the other was from the Eastern Pacific population, based on genetic analyses (Table 2). The Hawaii-based deep-set longline fishery interacts with some green turtles, and of the 15 turtles that have been sampled from this fishery, 7 were from the Central Pacific population and 8 were from the Eastern Pacific population (Table 2). Although the 2 fisheries do not generally fish in the same areas (deep-set fishery is to the south of shallow-set fishery), no other information is available on the source populations of green turtles that interact with the shallow-set fishery. Thus, this opinion assumes that green turtle bycatch from the shallow-set fishery is equally distributed between the Central and Eastern Pacific green turtle populations.

Information is only available for the Hawaii component of the Central Pacific population. The Hawaii component nests exclusively in the Hawaiian Archipelago, with over 90 percent of the nesting at French Frigate Shoals in the Northwestern Hawaiian Islands. Since the initial nesting surveys at French Frigate Shoals (FFS) in 1973, there has been a marked increase in annual green turtle nesting. The increase over the last 30+ years corresponds to an underlying near-linear increase of about 5.7 percent per year. Information on in-water abundance is consistent with the increase in nesting. For example, a significant increase in catch per unit effort of green sea turtles was seen from 1989-1999 during bull-pen fishing for in-water research studies on Molokai. The number of juveniles residing in foraging areas of the MHI has increased. In addition, there has been a dramatic increase in the number of basking turtles in the MHI and throughout the Northwestern Hawaiian Islands. Long-term monitoring of the population indicates a strong degree of island fidelity 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 et al. 1976; Balazs 1980, 1983). This linkage has been firmly established through genetics, satellite telemetry, flipper tagging and direct observation (Balazs 1983, 1994; Leroux et al. 2003). More information is available on green turtle population and trends in the 5-year review (NMFS & USFWS 2007d) and in the PIFSC draft green and hawksbill turtle research plan (Snover et al. 2007).

Eastern Pacific green turtles nest on at least the west coasts of Mexico and elsewhere in Central America, as well as in the Revillagigados Islands (Mexico) and Galapagos Islands (Ecuador). An estimated 3,319 – 3,479 Eastern Pacific females nested annually in the past few years. Nesting has been steadily increasing at the primary nesting sites in Michoacan, Mexico, and in the Galapagos Islands since the 1970s. Both sites are reported in the 5-year status review to host between 1,000 and 2,000 nesting females annually (NMFS & USFWS 2007d), but in recent years nesting females have increased to over 2,000 annually at Michoacan. In addition, previously unknown nesting areas have recently come to the attention of scientists, such as in El Salvador (J. Seminoff, pers. comm.), further boosting estimates of the Eastern Pacific population.

5.5.2 Life History Characteristics Affecting Vulnerability to Proposed Action

Green turtle life history is characterized by early development in the oceanic (pelagic) zone followed by later development in the coastal areas. Recruitment to the coastal areas occurs when carapace length is < 40 cm (smaller than for loggerheads, which spend more years in the pelagic zone, and recruit to coastal areas at a larger size). Adults forage in shallow coastal areas, primarily on algae and seagrass. Unlike loggerheads, upon maturation adults do not typically undertake trans-oceanic migrations to breeding sites, but long migrations may still occur between foraging and nesting areas, such as those undertaken by Hawaiian green turtles between the MHI and FFS (Spotila 2004, NMFS 2004a, 2005, 2006a; NMFS & USFWS 2007d). However, as described above in Section 4 (Description of Action Area), the proposed action does not include fishing within 50 miles of the Hawaiian Islands, and adults migrate directly between the MHI and FFS (Balasz 1994), hence the proposed action is unlikely to encounter migrating adult green turtles from the Hawaii component of the Central Pacific population. Migrating adults are unlikely to be found as far northwest as the action area. Hence, the main aspect of green turtle life history affecting their vulnerability to Hawaii-based shallow-set longline fishing appears to be juveniles utilizing oceanic habitats. Bycatch patterns in Pacific longline fisheries provide limited information on the vulnerability of juvenile green turtles to the various types of longline fishing.

Although foraging juvenile green turtles are more likely to interact with the Hawaii-based shallow-set fishery than adults, even juvenile interactions are very rare in this fishery: Since the fishery re-opened in 2004, 1 green turtle interaction has occurred (in 2008), and green turtle bycatch has been very rare historically in the Hawaii-based shallow-set fishery. Far more juvenile green turtle interactions occur in the Hawaii-based deep-set fishery and the American Samoa longline fishery (albacore fishery operating at 100-200 m depth) than the shallow-set fishery. Because very little is known of juvenile green turtle pelagic habitat use or foraging behavior, the reasons for the much smaller green turtle bycatch in the shallow-set fishery than the other 2 fisheries is not known. Juvenile green turtles would be expected to occur in the action area, and bycatch in the American Samoa longline fisheries demonstrates that juvenile green turtles are susceptible to interacting with longline gear fished at the approximate depth of the shallow-set fishery. Because of the lack of information, it is unknown if juvenile green turtles are less vulnerable than juvenile loggerheads to shallow-set gear (e.g., because of the smaller size of juvenile greens), or if juvenile green turtles are simply scarce in the action area, or if some unknown aspect of juvenile green turtle life history reduces their vulnerability to shallow-set longline fishing.

5.5.3 Threats to the Species

Global threats to green turtles are spelled out in the 5-year review (NMFS & USFWS 2007d). The major threats to the species, according to this document, are alteration of nesting and foraging habitat, fishing bycatch, and direct harvest, which are briefly described below. Climate change also appears to be a growing threat to this species, as it is for loggerheads and leatherbacks (see Sections 5.3.3 and 5.4.3 above).

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

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

Harvest of green turtles for their meat, shells, and eggs has been a major factor in the past declines of green turtles, and continues to be a major factor in some areas. For example, a legal fishery operates in Madagascar that harvested about 10,000 green turtles annually in the mid-1990s. On the Pacific coast of Mexico in the mid-1970s, >70,000 green turtle eggs were harvested every night. Globally, harvest of adults and eggs is reduced from previous levels, but still exists in some parts of the species' range. In Mexico, extensive illegal adult harvest still takes place. The curio trade in Southeast Asia also harvests a large but unknown number of green turtles annually (NMFS & USFWS 2007d).

5.5.4 Conservation of the Species

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

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

5.6 Hawksbill Turtles

Information in this section is summarized primarily from the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 BiOp (NMFS 2006a), the most recent hawksbill turtle 5-year status review (NMFS & USFWS 2007e), Volume III of the State of the World's Sea Turtles Report (SWOT 2007-2008), the DSEIS for the proposed action (WPFMC 2008), and other sources cited below.

5.6.1 Population Characteristics

Hawksbill populations occur in at least the Insular and Western Caribbean, Southwestern and Eastern Atlantic, the Southwestern, Northwestern, and Central/ Eastern Indian Ocean, and the Western, Central, and Eastern Pacific. As described in the recent 5-year review (NMFS & USFWS 2007e), available trend data for the past 20 years suggest that while some Caribbean/Atlantic sub-populations may be increasing, nearly all Indian and Pacific sub-populations are decreasing. Neither the shallow-set nor deep-set components of the Hawaii-based longline fishery are known to have interacted with a live hawksbill. However, hawksbill interactions occasionally occur in other longline fisheries in the Atlantic (Yeung 1998) and Pacific (Robins et al. 2002). In the shallow-set Hawaii-based fishery in 2007, a derelict net with a decomposed hawksbill was hooked and retrieved (the turtle had clearly been killed by the derelict net, not the longline gear). Also, a hawksbill was found entangled in derelict fishing gear on Pearl and Hermes Reef in the Northwestern Hawaiian Islands in 2003, but was released apparently unharmed (Donahue 2003). Hawksbill juveniles from the Central Pacific population are thought to inhabit the action area (NMFS & USFWS 2007e), thus an expanded Hawaii-based shallow-set longline fishery could interact with hawksbills from this population.

Central Pacific hawksbills nest in small numbers in several archipelagos, including Samoa, Fiji, the Marianas, Hawaii, Micronesia, Palau, the Solomons, and Vanuatu. All are declining, except possibly at the small Hawaii rookery (NMFS & USFWS 2007e), where an estimated 10-15 females have nested annually since the early 1990s (Seitz & Kagimoto 2008). The largest Central Pacific hawksbill rookeries are in Fiji and the Solomon Islands, where harvest of adults and eggs still appears to be occurring at unsustainable levels. Total number of nesting females for the Central Pacific hawksbill population was estimated at 940 – 1,200 females annually for the last few years, with an overall downward trend (NMFS & USFWS 2007e).

5.6.2 Life History Characteristics Affecting Vulnerability to Proposed Action

Hawksbill life history is characterized by early development in the pelagic zone followed by later development in nearshore habitats. As with green turtles, hawksbill recruitment to the neritic zone appears to occur at a younger age and smaller size than for loggerheads. Adults forage on coral reefs, primarily on sponges. Unlike loggerheads, upon maturation adults do not typically undertake trans-oceanic migrations to breeding sites, but hawksbills are known to undertake long migrations in the Caribbean between foraging and nesting areas (Spotila 2004; NMFS & USFWS 2007e). In Hawaii, tracking of adult hawksbills suggest that primary adult foraging and nesting areas are around the Big Island (Parker et al., in review), hence migrating adults may not often enter the action area (>50 miles from MHI – see Description of Action Area above in Section 4).

As with green turtles, the main aspect of hawksbill life history affecting their vulnerability to Hawaii-based shallow-set longline fishing appears to be oceanic juvenile foraging or pelagic habitat, but almost nothing is known of this life history stage of hawksbill turtles. Unlike with green turtles, there is no bycatch in Pacific U.S. longline fisheries to provide information on the relative vulnerability of juvenile hawksbill turtles to the various types of longline fishing. In the entire North Pacific, only a few dozen females are thought to nest annually, thus perhaps there is low abundance with very few pelagic juveniles foraging in the action area. Also, because juvenile hawksbills recruit to coastal habitat at < 40 cm carapace length, perhaps they are too small to ingest bait and hooks used in the shallow-set fishery during their pelagic phase (Spotila 2004, NMFS & USFWS 2007e).

5.6.3 Threats to the Species

Global threats to hawksbill turtles are spelled out in the 5-year review (NMFS & USFWS 2007e). The major threats to the species, according to this document, are alteration of nesting and foraging habitat, and direct harvest, which are briefly described below. While hawksbill interactions occur in fisheries, their bycatch rates are much lower than for the other sea turtle species, especially in industrial fisheries. Climate change also appears to be a growing threat to this species, as it is for loggerheads and leatherbacks (see Sections 5.2.3 and 5.3.3 above).

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

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

5.6.4 Conservation of the Species

Numerous conservation programs are being implemented around the world to protect nesting habitat and reduce harvesting and fisheries bycatch of all sea turtle species, and numerous regulatory mechanisms are in place at international, regional, national and local levels to protect sea turtles (see Sections 5.3.4, 5.4.4, 5.5.4, and 5.6.4 above). Many of these programs undoubtedly help hawksbills, but the species continues to rapidly decline in the Pacific and Indian Ocean areas. Some sub-populations in the Insular Caribbean appear to be increasing (NMFS & USFWS 2007e).

6 Environmental Baseline

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

The past and present impacts of human and natural factors leading to the status of the 6 species addressed by this opinion within the action area include fishing interactions, vessel strikes, climate change, pollution, marine debris, and entanglement. The environmental baselines for the 6 ESA-listed marine species addressed by this opinion (humpback whale and the 5 sea turtles) are first briefly summarized below, then followed by more detailed descriptions.

6.1 Humpback Whales

Information in this section is summarized from the humpback whale Stock Assessment Reports (e.g., Angliss & Outlaw 2007), the humpback whale recovery plan (NMFS 1991), the SPLASH report (Calambokidis et al. 2008), and other sources cited below. The primary past and present impacts of human activities within the action area on the North Pacific humpback population are fishery interactions and ship strikes. The estimated annual mortality rates of fishery interactions and ship strikes on this stock is 3.2 and 1.8 whales per year, respectively, for a total 5.0 whales per year. Of the 3.2 killed by fishing interactions, 0.2 are estimated to be caused by U.S. commercial fisheries (Angliss & Outlaw 2007).

Because the North Pacific population inhabits an area much larger than the action area, and fishing interactions with whales occur at a much lower rate in Hawaiian waters than in Alaskan waters (Angliss & Outlaw 2007), the combined impact of past and present fishing interactions and ship strikes within the action area is likely to be less than 1 whale per year. In addition, impacts from sonar within the action area are possible. Floating marine debris in the action area may present an entanglement hazard for humpbacks, but is not likely to result in mortality. Whale-watching may affect humpbacks by vessel strikes and behavior disruption. The historic impact of whaling on this species is at most a minor part of the current environmental baseline, because; (1) the population has recovered from whaling, in terms of the numbers of individuals, and (2) whaling was around the northern Pacific Rim, thus little if any whaling occurred within the action area (NMFS 1991, Gilman et al. 2006, Calambokidis et al. 2008).

6.2 Loggerhead Turtles

Information in this section is summarized from the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 pelagics report (WPFMC 2006a), the DSEIS for the proposed action (WPFMC 2008), and the other sources cited below. Past and present fisheries interactions have been, and continue to be, the greatest human impact on loggerhead turtles within the action area. Currently, the major type of fishing activity in the action area is longline fishing, except for nearshore fisheries that operate within the 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, hence instituting a global prohibition in 1992. Other types of fishing may occur in the action area outside of the longline prohibited areas (e.g., purse seining), but on such a small scale and with such low mortality rates as to be insignificant with regard to the loggerhead environmental baseline. Within the longline prohibited areas around the Hawaiian Islands, numerous fisheries operate, but these do not affect loggerheads. Therefore, the impact on loggerheads in the action area is longline fishing, the past and present impacts of which are described below.

6.2.1 Longline Fishing

The action area lies entirely within the Western Central Pacific (WCP) region. Longline fishing is done by many countries in this region, and there are 2 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 less than 1 month (like the Hawaii longline fleet). The total number of longline vessels in the WCP region was roughly 5,000 vessels in 2004, including 100-125 vessels in the Hawaii longline fishery (a minority of which are involved in the shallow-set fishery). The 4 main target species are yellowfin, bigeye, and albacore tuna, and swordfish. The distribution of total reported longline catch of these 4 species in 2004 is shown in Figure 5 below (WPFMC 2006). The action area is shown by the red rectangle, and consists mostly of international waters. The 2 main target species in the action area are albacore and swordfish, but yellowfin and bigeye tuna are caught too (Figure 5).

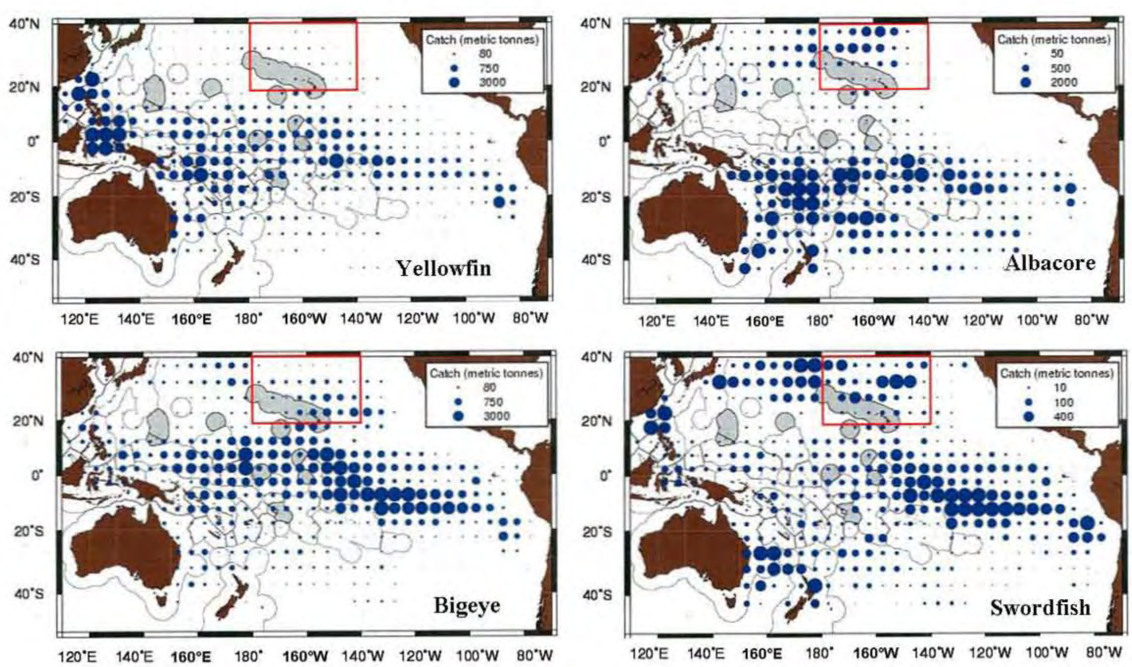


Figure 5. Distribution of Pacific longline catches (all countries) in 2004 for the 4 primary target fish species (WPRFMC 2006a). Action area for this consultation is indicated by the red rectangle.

Estimating the total number of sea turtle interactions in the total longline fishery is difficult because of low observer coverage and inconsistent reporting. However, Lewison et al. (2004) collected fish catch data from 40 nations and turtle bycatch data from 13 international observer programs to estimate global longline bycatch of loggerhead and leatherback turtles in 2000. In the Pacific, they estimated that 2,600 – 6,000 loggerhead juveniles and adults were killed by 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 and leatherback longline bycatch to be approximately 20 percent of that estimated by Lewison et al. (2004), or 520 – 1,200 juvenile and adult loggerheads annually.

As for the number of loggerheads killed by longlining in the action area, at least 3 other factors should be considered: (1) the action area represents less than 10 percent of the area fished and longlining effort in the Pacific, (2) loggerheads may be denser in the action area than elsewhere in the Pacific, and (3) longline fishing effort has increased since 2000. For purposes of providing the environmental baseline for loggerheads in this opinion, NMFS estimates that longlining since 2000 in the action area has killed, and continues to kill, 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.'s 2004 estimate), or 50 - 600 North Pacific juvenile and adult loggerheads annually.

The shallow-set component of the fishery traditionally interacted with far more turtles than the deep-set component, although mortality of turtles in shallow-set gear is lower than in deep-set gear. Loggerheads are particularly susceptible to shallow-set gear, and in the 1990s the Hawaii-

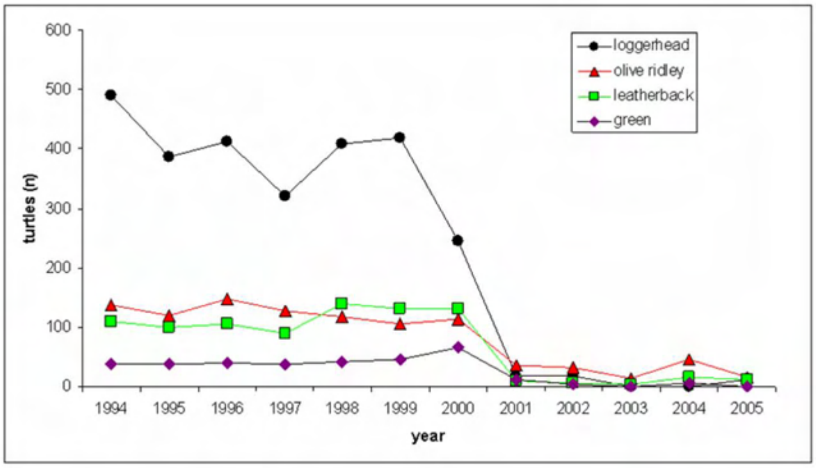


Figure 6. Estimated annual turtle interactions in the Hawaii-based longline fishery (deep-set and shallow-set combined), 1994-2005 (WPRFMC 2008)

based shallow-set fishery interacted with several hundred loggerheads annually in the action area. However, the shallow-set fishery was closed in 2001, and only re-opened in 2004 after instituting many measures for reducing turtle interactions. This reformation of the Hawaii-based shallow-set fishery has resulted in an approximately 90 percent reduction in loggerhead bycatch in this fishery since the 1990s (Figure 6).

Bycatch rates in the Hawaii-based shallow-set fishery (swordfish) are lower than other swordfish or tuna longline fisheries, except for the Hawaii-based deep-set longline fishery for tuna. 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-based shallow-set fishery (Figure 7, modified from Kaneko & Bartram 2008). In 2005-07, turtle bycatch in the Hawaii longline fishery

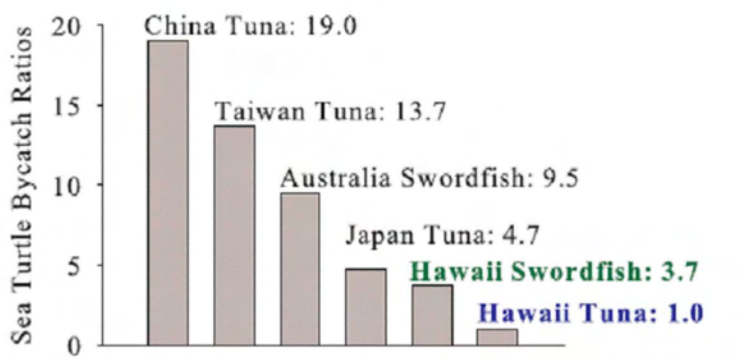


Figure 7. Sea Turtle Bycatch to Catch Ratios (per 190,000 kg of fish) of the Hawaii longline fisheries for **swordfish** and **tuna** compared with other longline fisheries operating in the central and western Pacific (Kaneko & Bartram 2008). All operate in the action area but Australia Swordfish.

(shallow-set and deep-set components combined) within the action area is estimated to have resulted in mean annual mortality of 3 to 4 loggerheads per year (NMFS 2008c,d).

6.2.2 Other Impacts

As mentioned in Section 5.2.3, climate change may be affecting pelagic loggerhead habitat within the action area. Lower breeding capacity of North Pacific loggerheads in years following higher sea surface temperatures may reflect reduced ocean productivity during warmer years within the action area, an indirect effect of climate change on this species (Chaloupka et al. 2008a). In addition, marine debris may 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 mortalities resulting from climate change and marine debris in the past few years in the action area.

6.3 Leatherback Turtles

Information in this section is summarized from the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 pelagics report (WPFMC 2006a), DSEIS for the proposed action (WPFMC 2008), and other sources cited below. Like the other sea turtle species addressed by this opinion, past and present fisheries interactions have been, and continue to be, the greatest human impact on leatherback turtles within the action area. The major type of fishing activity in the action area is longline fishing, which is the most important past and present impact on leatherbacks.

6.3.1 Longline Fishing

Longline fishing within the action area is described in Section 6.3.1 and represented in Figure 5 above. Estimating the total number of sea turtle interactions in the total longline fishery is difficult because of low observer coverage and inconsistent reporting. However, Lewison et al. (2004) collected fish catch data from 40 nations and turtle bycatch data from 13 international observer programs to estimate global longline bycatch of loggerhead and leatherback turtles in 2000. In the Pacific, they estimated that 1,000 – 3,200 leatherbacks were killed by pelagic longlining in 2000 (Lewison et al. 2004). An estimate of 626 adult female mortalities from pelagic longlining in 1998 was made by Kaplan (2005), or roughly 2,500 juveniles and adults. However, using effort data from Lewison et al. (2004) and bycatch data from Molony (2005), Beverly and Chapman (2007) estimated loggerhead and leatherback longline bycatch to be approximately 20 percent of that estimated by Lewison et al. (2004), or 200 – 640 juvenile and adult leatherbacks annually.

As for the number of leatherbacks killed by longlining in the action area, at least 3 other factors should be considered: (1) the action area represents slightly less than 10 percent of the area fished and longlining effort in the Pacific; (2) leatherbacks may be denser in the action area than elsewhere in the action area ; and (3) longline fishing effort has increased since 1998-2000. For purposes of providing the environmental baseline for leatherbacks in this opinion, NMFS estimates that longlining since 2000 in the action area has killed, and continues to kill, 10 percent of the Pacific totals estimated by Beverly and Chapman (2007), Kaplan (2005), and Lewison et al. (2004): 20 – 64 (10 percent of Beverly and Chapman's 2007 estimate) to 100 – 320 (10 percent of Lewison et al.'s 2004 estimate), or 20 - 320 Western Pacific leatherback juveniles and adults annually (10 percent of Kaplan's 2005 estimate = 63).

The shallow-set component of the fishery traditionally interacted with far more turtles than the deep-set component, although mortality of turtles in shallow-set gear is lower than in deep-set gear. Leatherbacks are not as susceptible to shallow-set gear as loggerheads, but nevertheless in the 1990s the Hawaii-based shallow-set fishery was estimated to have interacted with about a hundred leatherbacks annually in the action area (Figure 6). However, the shallow-set fishery was closed in 2001, and only re-opened in 2004 after instituting many measures for reducing turtle interactions. This reformation of the Hawaii-based shallow-set fishery has resulted in an approximately 90 percent reduction in leatherback bycatch in this fishery since the 1990s (Figure 6). Bycatch rates in the Hawaii-based shallow-set fishery (swordfish) are lower than other swordfish or tuna longline fisheries, except for the Hawaii-based deep-set longline fishery for tuna. Other longline fisheries operating in the action area, such as the Taiwan and China tuna fisheries, are thought to have bycatch rates several times higher than the Hawaii-based shallow-set fishery (Figure 7). In 2005-07, turtle bycatch in the Hawaii longline fishery (shallow-set and deep-set components combined) within the action area is estimated to have resulted in mean annual mortality of 1 to 2 leatherbacks per year (NMFS 2008c,d).

6.3.2 Other Impacts

As mentioned in Section 5.3.3, climate change may be affecting pelagic leatherback habitat within the action area. Leatherbacks may be particularly susceptible to ingesting of marine debris because plastic bags resemble jellyfish, their primary prey. Derelict fishing gear may cause entanglement and possibly drowning. Data are not available to estimate the number of leatherback mortalities resulting from climate change and marine debris in the past few years in the action area.

6.4 Olive Ridley Turtles

Information in this section is summarized from the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 BiOp (NMFS 2006a), the most recent olive ridley 5-year status review (NMFS & USFWS 2007c), the DSEIS for the proposed action (WPFMC 2008), and other sources cited below. Like the other sea turtle species addressed by this opinion, past and present fisheries interactions have been, and continue to be, the greatest human impact on olive ridley turtles within the action area. The longline fishing described above is the most important past and present impact on olive ridleys. Much less attention has been paid to effects of longline fishing on this species than on loggerheads and leatherbacks, hence no estimates are available for olive ridley mortality from longline fishing in the Pacific. Olive ridleys and leatherbacks are both susceptible to deep-set longlining because of their deep foraging (loggerhead interactions are rare in deep-set fishing because of shallow foraging). In the Hawaii-based deep-set longline fishery, bycatch rate of olive ridleys is about ten times that of leatherbacks. In addition, mortality of bycaught olive ridleys is higher than the other sea turtle species (Beverly & Chapman 2007), most likely because they are hooked when in such deep water that they rarely have a chance to get to the surface before drowning. Bycatch rates in foreign deep-set fisheries (for tuna) are >10 times higher than in the Hawaii-based deep-set fishery (Figure 7), and constitute much more fishing effort than the Hawaii-based fishery. Thus it is likely that tens of thousands of olive ridleys are killed annually in the Pacific by longlining.

However, the action area for the proposed action is 20° - 40° north (see Figure 1 in Section 4), and olive ridleys are primarily limited to tropical waters (NMFS & USFWS 2007c). While a substantial amount of longlining occurs in the action area (Figure 5), the bycatch rate of olive ridleys is much lower than in tropical waters. Nevertheless, because of the abundance of this species, and amount of longlining occurring within the action area by all fleets combined, at least several hundred olive ridleys have probably been killed, and continue to be killed, annually by longlining (most from the Eastern Pacific population, but some from the Western Pacific population).

The vast majority of olive ridley bycatch in the Hawaii-based longline fishery occurs in the deep-set component of the fishery, which operates primarily to the south of the action area (Figure 2). In 2005-07, turtle bycatch in the Hawaii longline fishery (shallow-set and deep-set components combined) within the action area is estimated to have resulted in mean annual mortality of 8 to 9 olive ridleys per year (NMFS 2008c,d).

As mentioned in Section 5.4.3, climate change may be affecting pelagic olive ridley 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.

6.5 Green Turtles

Information in this section is summarized from the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 BiOp (NMFS 2006a), the most recent green turtle 5-year status review (NMFS & USFWS 2007d), the DSEIS for the proposed action (WPFMC 2008), and the other sources cited below. Like the other sea turtle species addressed by this opinion, past and present fisheries interactions have been, and continue to be, the greatest human impact on green turtles within the action area. However, unlike loggerheads, leatherbacks, olive ridleys, green turtles are affected by both longline fishing and nearshore fishing within the action area. As explained in Section 5.5.2, this is because juvenile green turtles in the Hawaiian population recruit to nearshore areas throughout the Hawaiian Archipelago, hence juveniles are affected by longline fishing while utilizing pelagic habitats, and by nearshore fishing during the adult nearshore life history stage.

Much less attention has been paid to effects of longline fishing on green turtles than on loggerheads and leatherbacks, thus no estimates are available for green turtle mortality due to longline fishing in the Pacific. Approximately 10 times more green turtle interactions occur in the deep-set component than the shallow-set component of the Hawaii-based longline fishery (almost all juveniles). Turtle interactions in deep-set gear have a high mortality rate because they frequently drown. While few green turtle interactions occur in the Hawaii-based deep-set fishery, general turtle bycatch rates in foreign deep-set fisheries (for tuna) are >10 times higher than in the Hawaii-based deep-set fishery (Figure 7), and constitute much more fishing effort than the Hawaii-based fishery. Therefore it is likely that within the action area, up to several hundred juvenile green turtles are killed annually by longlining (about equally split between the Hawaiian and Eastern Pacific populations).

The majority of green turtle bycatch occurs in the deep-set component of the fishery, which operates primarily to the south of the action area. In 2005-07, turtle bycatch in the Hawaii longline fishery (shallow-set and deep-set components combined) within the action area is estimated to have resulted in mean annual mortality of 0 to 1 green turtles per year (NMFS 2008c,d).

Extensive nearshore fisheries in the MHI (e.g. lay gillnets, hook-and-line, etc.) sometimes result in entanglement and drowning of green turtles. Of the many kinds of nets used in Hawaii, gillnets are the most problematic for turtles, because they are left untended, and entangled animals usually drown. Revised State of Hawaii regulation governing lay gillnets began in March 2007, but they can still be legally left untended, hence the likelihood of turtle entanglement and drowning is still considerable. Hook-and-line fishing from shore or boats also hooks or entangles green turtles, although the chance of survival is higher than if caught in a gillnet. 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 turtles killed annually by fishing interactions (NMFS 2008e). The most common known cause of green turtle strandings is the tumor-forming disease, fibropapillomatosis (28%) followed by hook-and-line fishing gear-induced trauma (7%) and gillnet fishing gear-induced trauma (5%) (Chaloupka et al. 2008b).

The total number of green sea turtles killed each year in recent years (1998-2007) in the MHI by boat collisions was estimated by NMFS (2008e) based on the numbers of stranded turtles determined to have been killed by boat collisions (Chaloupka et al. 2008b, Hawaii Sea Turtle Stranding Database 2007). NMFS (2008e) estimated that 10 stranded turtles per year in the MHI are killed by boat collisions (see Figure 3, p. 25, NMFS 2008e), and that these 10 turtles represent 20 – 40% of all green sea turtles killed in the MHI annually by boat collisions, giving a range for of 25 – 50 turtles killed per year. Thus the average number of green turtles killed per year by boat collisions was estimated at 37.5 (NMFS 2008e).

As mentioned in Section 5.5.3, climate change may be affecting pelagic green 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 green turtle mortalities resulting from climate change and marine debris in the past few years in the action area.

6.6 Hawksbill Turtles

Information in this section is summarized from the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 BiOp (NMFS 2006a), the most recent hawksbill turtle 5-year status review (NMFS & USFWS 2007e), the DSEIS for the proposed action (WPFMC 2008), and other sources cited below. Like the other sea turtle species addressed by this opinion, past and present fisheries interactions have been, and continue to be, the greatest human impact on hawksbills within the action area. Like green turtles, hawksbills are affected by both longline fishing and nearshore fishing within the action area. As explained in Section 5.6.2, this is because juvenile hawksbills turtles in the Central Pacific population recruit to nearshore areas, including in the Hawaiian Islands, hence they are affected by longline fishing while utilizing pelagic habitats, and by nearshore fishing during the adult nearshore life history stage.

Much less attention has been paid to effects of longline fishing on hawksbills than on loggerheads and leatherbacks, thus no estimates are available for hawksbill mortality due to longline fishing in the Pacific. No hawksbill bycatch has ever been recorded in the Hawaii-based longline fishery. A decomposed hawksbill that was entangled in derelict fishing gear that was retrieved by longline gear (i.e., the hawksbill was killed by the derelict gear, not the longline gear). However, because: 1) general turtle bycatch rates in foreign longline fisheries are higher than in the Hawaii-based longline fishery (Figure 7); 2) foreign longline fisheries constitute more fishing effort than the Hawaii-based fishery; and 3) hawksbill interactions occur in other longline fisheries both in the Atlantic (Yeung 1999) and Pacific (Robins et al. 2002), some hawksbill bycatch is likely to be occurring in the foreign longline fisheries. Therefore it is likely that within the action area, up to 1 or 2 dozen juvenile hawksbills from the Central Pacific population are killed annually by longlining.

As with green turtles, extensive nearshore fisheries in the MHI may sometimes result in entanglement and drowning of hawksbills. Likewise, because hawksbills forage in shallow areas, often remain just below the surface, and often surface to breathe, they are vulnerable to being struck by vessels. However, because hawksbills are much rarer than green turtles, and forage primarily along remote coastlines, hawksbill mortality from nearshore fishing and vessel strikes in the MHI is probably a rare event.

As mentioned in Section 5.6.3, climate change may be affecting pelagic hawksbill habitat within the action area. Marine debris may cause entanglement and possibly drowning. In addition, derelict fishing gear may cause entanglement, especially monofilament line. For example, a hawksbill was found entangled in derelict fishing gear on Pearl and Hermes Island in the Northwestern Hawaiian Islands in 2003, but was released apparently unharmed (Donahue 2003). Data are not available to estimate the number of hawksbill mortalities resulting from climate change and marine debris in the past few years in the action area.

7 Effects of the Action

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

Approach. NMFS determines the effects of the action using a sequence of steps. The first step identifies 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. However, the action area does not include proposed or designated critical habitat, thus it is not considered in this opinion. Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (probability of extinction or probability of persistence) of listed species depends on the viability of their populations. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the 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. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's 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' and 'Environmental Baseline' sections of this opinion) 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.

Potential Stressors. The potential stressors associated with the proposed action are listed here, then described in more detail for each species in the following sections. The proposed action is the continued operation of the Hawaii-based shallow-set longline fishery at an effort level of 5,550 sets annually. The greatest stressor associated with this action on the 6 listed species considered in this opinion is interactions (defined in footnote 1 in Section 1) with fishing gear. The fishery re-opened in late 2004, and thus has been operating for approximately 4 years. The number of interactions of the fishery with these 6 species during that 4-year period is shown in Table 4 below.

Table 4. Fishing effort (sets), interactions, and interaction rates in the Hawaii-based shallow-set longline fishery for the 6 species considered in this opinion over a 4-year period (4th quarter 2004 – 3rd quarter 2008).

Year	Sets	Interactions					
		Humpbacks	Loggerheads	Leatherbacks	OliveRidleys	Greens	Hawksbills
2004	135[a]	0	1	1	0	0	0
2005	1,645[a]	0	12	8	0	0	0
2006	850[a]	1	17	2	0	0	0
2007	1,570[b]	0	15	5	1	0	0
2008	1,225[c]	1	0	2	2	1	0
Total	5,425	2	45	18	3	1	0
Interaction Rate[d]		0.00037	0.00829	0.00332	0.00055	0.00018	0
Estimated Annual Interactions from Proposed Action[e]		3 (2.1)[e]	46 (46.0)[e]	19 (18.4)[e]	4 (3.1)[e]	1 (1.0)[e]	0

[a] DSEIS, p.44-45.
[b] PIFSC 2008. Hawaii Longline Fishery Logbook Statistics—Summary Tables: 2007 annual tables, p. 6.
[c] Sum of the following 3 sources: For 1st and 2nd Quarters 2008, the PIFSC Hawaii Longline Fishery Logbook Statistics webpage had posted, as of October 6, 2008, a 1st Quarter 2008 Report, p. 7 (744 sets) and a "Quarterly Table of Nominal Effort" for 2nd Quarter 2008 (381 sets). For the 3rd Quarter 2008, on October 6, 2008, the PIRO Observer Program estimated that approximately 100 sets were made, giving the total of 1,225 sets for the first 3 quarters of 2008.
[d] Interaction rates are calculated by dividing total interactions by total sets. The interaction rates then provide the basis for estimating the annual interactions from the proposed action in the final row.
[e] Interactions rounded up from one significant digit (e.g., 1.1 to 1.9 round to 2, but 1.01 to 1.04 round to 1): For humpbacks, 0.00037 x 5,550 = 2.1, round to 3. For loggerheads, 0.00829 x 5,550 = 46.01, round to 46. For leatherbacks, 0.00332 x 5,550 = 18.4, round to 19. For olive ridleys, 0.00055 x 5,550 = 3.1, round to 4. For greens, 0.00018 x 5,550 = 0.999, round to 1.

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 with green turtles. While additional effects may occur due to the proposed action (e.g., exposure to waste from fishing vessels), they are not considered likely to adversely affect individuals of listed species, and thus are not considered stressors. The potential direct stressors of interactions and collisions are described in detail below in the species sections, because they vary considerably between species.

Potential Beneficial "Market Transfer Effect". The proposed action has the potential to result in a beneficial market transfer effect for sea turtles. When multiple fleets compete for the same fishery resource, regulation of one country's fleet may lead to increased or decreased fishing by the other fleets, which may in turn affect the overall impact of fishing on the resource. This phenomenon is known as the "market transfer effect", because it is driven by supply and demand for the resource. The swordfish market and the distribution of most sea turtle species are both global. Hence, regulation of a swordfish fleet in one part of the world may affect swordfish fishing and sea turtle impacts in another part of the world, resulting in a net change in mortalities of the affected sea turtle species. Such a market transfer effect appears to have occurred as a result of the closure of the Hawaii-based shallow-set longline fishery in 2001-2004 (Sarmiento 2006, WPFMC 2008, Rausser et al. 2008), as predicted in 2001 (NMFS 2001, Chapter 4).

Sarmiento (2006) and Rausser et al. (2008) studied the effects of the 2001-2004 closure, and both studies concluded that a market transfer effect had occurred: Swordfish from the Hawaii-based fishery were replaced in the U.S. market by swordfish caught by longline fleets based in Central and South American countries. Since the Hawaii-based swordfish fishery had/has stronger, non-discretionary turtle conservation measures, the shift in swordfish production for the U.S. market from the Hawaii-based fleet to Central and South America-based fleets resulted in an estimated increase of 2,882 sea turtle interactions over the 3-year closure (Rausser et al. 2008). Sarmiento (2006) did not quantify the transfer effect in terms of increased sea turtle interactions. Both authors concluded that the 2001-2004 closure of the Hawaii-based shallow-set swordfish fishery was detrimental for sea turtles because the market transfer effect resulted in more fishing for the U.S. swordfish market by less turtle-friendly longline fleets (Sarmiento 2006, Rausser et al. 2008).

The proposed action may result in a market transfer effect, because the Hawaii-based shallow-set longline fishery has stronger turtle conservation measures than rival fleets competing for U.S. swordfish market share. That is, the expansion of the Hawaii-based fishery may cause a reduction in effort in less turtle-friendly swordfish fisheries, thereby decreasing the overall sea turtle bycatch. In contrast to the market transfer effect in response to the 2001-2004 closure, which was detrimental to sea turtles by increasing overall interactions (Sarmiento 2006, Rausser et al. 2008), the proposed action may result in a market transfer effect that is beneficial to sea turtles by decreasing overall interactions (NMFS 2001). The potential beneficial market transfer effect on each affected sea turtle species is discussed in the species sections below.

7.1 Humpback Whales

The stressors, exposure, response and risk steps of the effects analysis for humpback whales with regard to implementation of the proposed action are described below. The following information was used to conduct these analyses of the proposed action on humpback whales: the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the humpback whale Stock Assessment Reports (e.g., Angliss & Outlaw 2007), the humpback whale recovery plan (NMFS 1991), the SPLASH report (Calambokidis et al. 2008), and other sources cited below.

7.1.1 Stressors.

The primary stressor of the Hawaii-based shallow-set longline fishery on humpback whales is entanglement with fishing gear. Humpbacks are present in the action area as they migrate to and from waters surrounding the Hawaiian Islands during the winter months. However, the longline fishery generally occurs at locations where humpbacks are uncommon. Thus, interactions between the Hawaii-based longline fishery and humpback whales are rare and unpredictable events. Since 2001, there have been 5 observed interactions between humpbacks and the entire Hawaii-based longline fleet, 2 of which were with the shallow-set component (Table 4).

According to descriptions of these interactions by NOAA Fishery observers, the whales were entangled in the mainline. In each instance, efforts were taken to disentangle the whale, and all whales were either released or able to break free from the gear without noticeable impairment of the animal's ability to swim or feed. However, if entanglement results in the gear wrapping around the animal and breaking off, the animal may trail the gear for a long period of time. The effects of trailing longline fishing gear on large whale species are largely unknown. Available evidence from entangled north Atlantic right whales indicates that while it is not possible to predict whether an animal will free itself of gear, a large proportion are believed to extricate themselves based on scarring observed among apparently healthy animals (NMFS 2004a, 2005).

The potentially beneficial market transfer effect described above is likely not relevant to humpback whales. Humpback interactions with the Hawaii-based shallow-set longline fishery are typically with the mainline, and the configuration of the mainlines are similar in the Hawaii-based fishery and competing longline fleets. Thus, there are not likely to be major differences in humpback interaction rates between the Hawaii-based and competing longline fleets, hence a decrease or increase in the Hawaii-based shallow-set longline fishery would not be expected to affect the number of global humpback interactions in all swordfish longline fisheries combined.

7.1.2 Exposure.

Since the shallow-set fishery re-opened in 2004, there have been 2 interactions with humpback whales in 5,425 sets, giving an interaction rate of 0.00037 humpbacks per set (Table 4). The proposed action is defined as up to 5,550 sets annually, thus the number of humpback whales that are likely to be entangled as a result of interactions with longline gear associated with the proposed action is 3 annually (Table 4).

7.1.3 Response.

NMFS rates the severity of marine mammal interactions with fishing gear using serious injury guidelines developed for the MMPA. Interactions involving entanglement or hooking of the head are considered 'serious'. Interactions involving entanglement or hooking of a part of the body other than the head, that result in the animal being released or escaping with no or minimal gear attached, and that are not expected to impede mobility or result in mortality, are considered 'not serious' (Angliss and Demaster 1998). Of the 5 interactions of humpbacks with the Hawaii-based longline fishery since 2001 (3 in deep-set, 2 in shallow-set), 3 were 'not serious', 1 was 'serious', and 1 has yet to be determined (M. Yuen, NMFS PIRO, pers. comm.).

The effects of fishing gear interactions on adult humpback whales are not likely to be different between deep-set and shallow-set gear, because the animals are large enough to pull the deep-set gear to the surface. In contrast, mortality of turtles interacting with deep-set gear is much higher than for shallow-set gear because the turtles usually cannot pull the gear to the surface, and drown (NMFS 2005). Because the effects of deep-set vs. shallow-set gear on humpbacks are likely indistinguishable, the 3 humpback interactions with deep-set gear are considered applicable to this response analysis, along with the 1 shallow-set interaction with known injury. The fact that all 3 deep-set interactions resulted in 'not serious' injuries, and 1 (or possibly both) of the shallow-set interactions resulted in 'serious' injuries, is considered a coincidence, rather than evidence that shallow-set gear is likely to cause more serious injuries.

In the exposure analysis above, humpback exposure to the proposed action is estimated to result in 3 entanglements annually. Of the 4 interactions with known injuries that have occurred since 2001 in the Hawaii-based longline fishery, 1 resulted in serious injury. Thus, if 25 percent of the 3 entanglements result in serious injury, 1 humpback may be seriously injured by the proposed action every 1 – 2 years. The most conservative possible interpretation is that 100 percent of serious injuries result in mortality. Therefore, the proposed action is expected to kill up to 1 humpback whale every 1 – 2 years.

7.1.4 Risk.

As described in Section 5.2, the North Pacific humpback population was recently estimated to number approximately 18,000 individuals, about half of which winter in Hawaii. Annual growth rate for the North Pacific population was estimated at 4.9 to 6.8 percent, depending on which area and time frame are considered (Calambokidis et al. 2008). Based on these growth rates, the population is currently growing at several hundred individuals annually. Thus, the mortality of up to 1 individual humpback whale every 1 – 2 years is not expected to increase the risk of the population to extinction. That is, NMFS does not expect the proposed action to result in a reduction in the numbers, distribution, or reproduction of the North Pacific population of humpback whales.

7.2 Loggerhead Turtles

The stressors, exposure, response and risk steps of the effects analysis for loggerhead turtles with regard to implementation of the proposed action are described below. The loggerhead turtles directly affected by interactions resulting from the proposed action are expected to be from the North Pacific population. The direct and indirect effects of the action on this population, and any indirect effects on other populations, are related to the species as a whole in the Integration and Synthesis of Effects (Section 9). The following information was used to conduct these analyses of the proposed action on loggerheads: the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 BiOp (NMFS 2006a), the DSEIS for the proposed action (WPFMC 2008), the population assessment conducted by PIFSC for the proposed action (Snover 2008), and other documents cited below.

7.2.1 Stressors

Longline fishing affects loggerhead turtles primarily by hooking, but also by entanglement and trailing of gear. Shallow-set longlining is done at night with light-sticks. Since loggerheads feed at about the same depth as the shallow-set gear is fished, and they feed on bioluminescent organisms such as pelagic tunicates, they are highly susceptible to hooking by shallow-set gear. Hooking may be external, generally in the flippers, head, beak, or 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 the organs from their connective tissue. Once the hook is set and pierces an organ, infection may ensue, which may result in the 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, 2005).

Loggerheads are entangled less frequently than leatherbacks. 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 captured and released, particularly line trailing from an ingested hook. Turtles may swallow line trailing from an ingested hook, which may block the gastrointestinal tract. Trailing line can also become snagged on a floating or fixed object, further entangling the turtle, or the drag from the float can cause the line to constrict around a turtle's appendages until the line cuts through it (NMFS 2004a, 2005).

While the primary direct effect of the proposed action on loggerhead turtles will be the stressor of fishing gear interactions, an indirect effect of the proposed action (one that is likely to occur later in time) may be a beneficial market transfer effect. A description of the "market transfer effect" is provided in the introduction to the effects section above. Since the Hawaii-based swordfish fishery had/has stronger, non-discretionary turtle conservation measures, the shift in swordfish production for the U.S. market from the Hawaii-based fleet to Central and South America-based fleets resulted in an estimated increase of 2,882 sea turtle interactions (all species combined) over the 3-year closure (Rausser et al. 2008). An estimate of the number of additional loggerhead mortalities represented by these interactions was made in a pre-publication version of the Rausser et al. (2008) paper (Rausser et al. undated). The species-specific estimates were removed from the published version. NMFS does not believe that adequate data are available to quantify loggerhead mortalities with any precision that may have resulted from the market transfer effect due to the 2001-2004 closure.

The proposed action would considerably expand the Hawaii-based shallow-set swordfish fishery, i.e., the opposite action of the 2001-2004 closure. Therefore, the proposed action would likely result in a decrease in swordfish imports to the U.S., and a reduction in swordfishing effort by less turtle-friendly competing fleets (NMFS 2001). Such a market transfer effect would be the opposite of that which occurred due to the 2001-2004 closure, and would likely result in a reduction in global loggerhead interactions in all swordfish longline fisheries combined. The reduction in loggerhead interactions may affect the North Pacific loggerhead population, and possibly other loggerhead populations.

7.2.2 Exposure

Loggerhead 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-based shallow-set longline fishery. This exposure can be quantified as the expected annual number of interactions. The proposed action would result in up to 5,550 sets annually. Based on the number of sets made, and the number of loggerhead interactions, during the 4-year period (100 percent observer coverage) since the re-opening of the shallow-set fishery (10/04 – 9/08), 5,550 sets would result in 46 loggerhead interactions (Table 4). Therefore, loggerhead exposure to the effects of the proposed action is considered to be 46 loggerhead interactions annually.

A global decrease in loggerhead exposure to interactions with shallow-set gear deployed by other swordfishing fleets is expected to be indirectly caused by the proposed action, due to a market transfer effect. However, information is not available to quantify the reduction in exposure with any precision. Although Rausser et al. (2008) quantified the increased interactions resulting from the 2001-2004 closure (an additional 2,882 sea turtle interactions, all species combined over the 3-year period), uncertainty resulted in a very large 95 percent confidence interval (-59 to 30,680 additional sea turtle interactions). Thus, NMFS cannot quantify the market transfer effect likely to result from the proposed action with any precision for loggerheads. The North Pacific loggerhead population may be affected, and possibly other loggerhead populations.

7.2.3 Response

Loggerhead response to the predicted exposure (46 interactions annually) can be characterized as the annual number of mortalities resulting from this exposure. For the 45 loggerhead interactions observed in the shallow-set fishery from when it re-opened in late 2004 until the end of 2007, based on NMFS' post-hooking mortality criteria (NMFS 2006b), post-hooking mortality of loggerheads in this fishery was 20.5 percent (NMFS 2008c). Using this post-hooking mortality rate, 46 interactions annually would lead to 10 (46 x 0.205 = 9.4, round to 10) loggerhead mortalities (either sex, all ages). However, in order to estimate the risk that the proposed action poses to the North Pacific loggerhead population, a population assessment was done by PIFSC (Snover 2008), which is based on the number of adult females removed from the population. Adult females are the only component of the population for which data are available, from counts of adult females on nesting beaches. The response of loggerheads to 46 interactions must be quantified in terms of adult females in order to interpret the population assessment.

The shallow-set fishery interacts with males and females, and most of these loggerheads are juveniles. In order to estimate the number of adult females that would be killed by 46 interactions, 2 corrections 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. Sex ratio of the North Pacific loggerhead population is unknown, but studies of Atlantic and Caribbean loggerhead populations suggest that sex ratio is not 50:50. Rather, these studies indicate there are more females than males in many sub-populations, hence NMFS estimates the sex ratio in the North Pacific population to be 65 percent female (NMFS 2008f).

Most loggerheads interacting with the shallow-set fishery are juveniles. The smallest of 443 nesting North Pacific loggerheads in Japan was 74 cm standard carapace length (SCL; Hatase et al. 2004). Of the 41 measured loggerheads interacting with the shallow-set fishery from late 2004 through 2007, 30 were <74 cm SCL (NMFS 2008f), hence at least 73 percent (30/41) of these turtles were juveniles. In order to estimate the fraction of 1 adult equivalent represented by each captured juvenile, a reproductive value model was developed by PIFSC for application to the juveniles captured by the shallow-set fishery. The model was run with different assumptions regarding age to maturity, size at maturity, and survival. The mean reproductive values of the loggerheads interacting with the shallow-set fishery ranged from 0.22 to 0.41, depending on age to maturity, size at maturity, and survival (NMFS 2008f). The highest value (0.41) was selected because it is the most conservative.

In order to estimate the response of loggerheads to an annual rate of 46 interactions in terms of annual adult female mortalities, the interactions were multiplied by the post-hooking mortality rate (0.205), the female sex ratio (0.65), and the adult equivalent (0.41), giving an estimate of 2.51 adult female mortalities annually (Table 5)[4]. This number of adult female mortalities per year is the expected loggerhead response to exposure to hooking and entanglement caused by the proposed action. The impact of this level of mortality on the North Pacific loggerhead population was assessed by Snover (2008), and is summarized below in the Risk Analysis, the final step in the analysis of effects of the proposed action.

Table 5. Annual adult female loggerhead mortality from the proposed action.

Variable	Estimate
Maximum annual interactions	46 interactions
Post-hooking mortality	0.205 mortalities/capture
Sex ratio	65:35 (♀:♂) = 0.65 females
Adult equivalents	0.41 adult equivalent
Annual adult female mortalities	2.51 adult females*

*(46 captures)(0.205 mortalities/capture)(0.65 females)(0.41 adult equivalent) = 2.51 adult females

All variables used for the estimate of annual adult female mortalities were selected conservatively in an attempt to estimate the maximum possible number of adult females that could be killed by the proposed action: We used the maximum possible number of interactions per year (46) rather than the more likely scenario of less than 46 interactions per year. For example, while the maximum number of loggerhead interactions in the shallow-set fishery has been 17 per year since 2004, the mean annual number of actual interactions for the 3-year period 2005-07 was 14.7 (NMFS 2008c). The post-hooking mortality rate of 20.5 percent is based on application of the current NMFS criteria (NMFS 2006b) to the 45 observed interactions in the fishery from late 2004 to the end of 2007. However, a more recent study suggests a considerably lower post-hooking mortality rate of 9.5 percent for loggerheads (Swimmer et al. In Press). Likewise, rather than using a 50:50 sex ratio based on absence of information for this population, a female ratio of 0.65 was used based on information from the Atlantic. Finally, the reproductive value model indicated adult equivalents of 0.22 to 0.41 were appropriate, based on the available data, and the highest value was chosen (NMFS 2008f) and applied in the population assessment (Snover 2008). A recently published study using a large sample size from the Hawaii-based longline fishery (n = 44) indicates that the lower end of the 0.22 to 0.41 range is more appropriate (Wallace et al. 2008, Figure 2d). Thus, the estimate of 3 (rounded from 2.51)[4] adult females killed annually is considered to be the maximum number that would be killed by interactions associated with the proposed action, rather than a mean number.

As described in the exposure section above, a market transfer effect resulting from the proposed action is expected to reduce global loggerhead interactions. However, since the decrease in

[4] Snover (2008) used fractions for model inputs rather than rounded numbers. E.g., the effect of 2.51 adult female mortalities annually was tested in the model, rather than 3 adult female mortalities. Hence, fractions are used in this opinion when referring to inputs to the model. Otherwise, adult female mortalities are given in whole numbers, rounded up from one significant digit (e.g., 1.1 to 1.9 round to 2, but 1.01 to 1.04 round to 1).

interactions (exposure) cannot be quantified, the resulting decrease in loggerhead mortalities (response) cannot be quantified. Thus, NMFS cannot quantify with any precision the market transfer effect likely to result from the proposed action in terms of decreased loggerhead mortalities. The North Pacific loggerhead population may be affected by the market transfer effect, and possibly other loggerhead populations.

7.2.4 Risk

The response of loggerheads to interactions with gear deployed by the Hawaii-based shallow-set fishery is considered to be the mortality of 2.51 adult females annually (Tables 5 and 6; not rounded because this number is an input into the population model – see footnote 4 above). The risk posed by this level of mortality to the North Pacific loggerhead population was assessed by Snover (2008) for application to this opinion. Snover (2008) analyzed the proposed action using a risk index called Susceptibility to Quasi-Extinction (SQE), which is designed to assess how different levels of mortality affect a population's risk of extinction (Snover & Heppell, In Press). A Quasi-Extinction Threshold (QET), consisting of a minimum population size reached over a certain amount of time, must first be chosen in order to calculate the effects of different levels of mortality on the population's likelihood of reaching QET. If a low threshold is chosen (e.g., a population decline to 1% of current population in 1 generation), then the method will not be sensitive to minor population declines because the population would have to be nearly wiped out (99 percent decline in 1 generation) to reach QET. Thus, in order to enable the assessment to detect the effects of a small number of annual mortalities, a QET of 50 percent current population over 3 generations (100 years for loggerheads) was chosen for application of SQE to the North Pacific loggerhead assessment (Snover 2008). Such a sensitive, conservative QET is appropriate for assessing effects of actions on ESA-listed species, because the purpose of the ESA is to minimize impacts of human activities and foster recovery of listed species.

After setting QET, the risk assessment calculates a baseline SQE based on available data regarding the status, trends and size of the population. As mentioned above in Sections 5.2.1 and 7.2.3, the only population data available for North Pacific loggerheads are the annual numbers of nests, from which nesting females can be estimated. The approach developed by Snover & Heppell (In Press) is designed specifically for sea turtles to account for environmental and demographic sources of variability in the annual numbers of nesting females, which are used to estimate the baseline SQE. The value of SQE can range from 0.0 (no risk) to 1.0 (certainty of quasi-extinction), with SQE of >0.75 indicating that the population is at risk. Based on the 18 years of nesting data from Japan (1990-2007), the North Pacific loggerhead population is at risk of reaching QET, even in the absence of any Hawaii-based shallow-set fishery, because baseline SQE = 0.8311 (Snover 2008)[5]. Baseline SQE is shown by the flat, dotted line marked as '**E**' in Figure 8 below, which is SQE in the absence of any Hawaii-based shallow-set fishery.

The effect of the proposed action (2.51 adult female mortalities annually) on SQE is quantified in Table 6 and shown in Figure 8 below. Adding 2.51 adult female mortalities annually causes the population's SQE to increase by 0.71 percent (**H** in Figure 8). Another way of interpreting the data is to examine the effect of the additional adult female mortality on "what's left" between baseline SQE (0.8311) and extinction (1.00), or 1-SQE, which in this case is 0.1689 (1.00 – 0.8311). The proposed action would reduce 1-SQE of the North Pacific loggerhead population by 3.49 percent (also represented by **H** in Figure 8). Neither the 0.71 percent increase in SQE, nor the 3.49 percent reduction in 1-SQE, are statistically distinguishable from zero. That is, the effects of direct interactions resulting from the action on SQE and 1-SQE cannot be statistically distinguished from the effect of natural mortality on SQE and 1-SQE.

In order to minimize the risk of a population to quasi-extinction, 1-SQE should not be reduced by more than 5 percent (Snover 2008). The threshold of 5 percent lies between 3 and 4 adult female mortalities annually (i.e., 3 mortalities reduce 1-SQE by <5%, but 4 mortalities reduce 1-SQE by >5%), suggesting that less than 4 mortalities annually minimizes risk. The proposed action is estimated to result in a maximum of 3 adult female mortalities annually due to direct interactions (rounding up from 2.51, Table 6)[5].

Table 6. Risk assessment for effects of proposed action on N. Pacific loggerhead population (Snover 2008).

Adult Female Mortalities (AFM)	
A. AFM w/ proposed action[1]	2.51
B. AFM w/ old interaction limit[2]	0.93
C. Increase in AFM from A to B	1.58
D. Effect of proposed action on AFM	+2.51
Susceptibility to Quasi-Extinction (SQE)	
E. Baseline SQE	0.8311
Baseline 1-SQE	0.1689
F. SQE w/ proposed action[1]	0.8370
1 - SQE w/ proposed action	0.1630
G. SQE w/ old interaction limit[2]	0.8333
1 - SQE w/ old interaction limit	0.1667
H. Increase in SQE from proposed action	0.0059
% increase in SQE (0.0059/0.8311)	0.71%
Decrease in 1 – SQE from proposed action	0.0059
% decrease in 1 – SQE (0.0059/0.1689)	3.49%

[1] Proposed action = 46 loggerhead interactions/yr.
[2] Old interaction limit = 17 loggerhead interactions/yr.

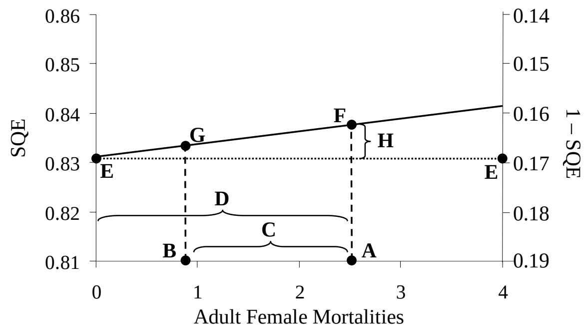


Figure 8. Effect of annual adult female mortalities (**D**) from proposed action on SQE and 1 – SQE (**H**), from data in Table 6 (modified from Snover 2008).

A beneficial market transfer effect from the proposed action may indirectly reduce North Pacific loggerhead mortality, but as described above, the reduction is not quantifiable with any precision. NMFS expects that direct interactions resulting from the proposed action are likely to kill the equivalent of up to 3 adult female North Pacific loggerheads annually. Thus, the overall effect of the action on this population may be the mortality of less than 3 adult females annually. However, since the market transfer effect is less certain and less quantifiable than the effects of direct interactions, it is not prudent to reduce our estimate of overall mortality from the proposed action to less than 3 North Pacific adult females annually. The results of the population assessment suggest that less than 4 adult female mortalities annually would minimize the risk of the proposed action to the North Pacific loggerhead population (Snover 2008)[5].

[5] The risk assessment (Snover 2008) was completed before the 2008 North Pacific loggerhead nesting season in Japan, which occurs primarily between May and August each year. On August 15, 2008, STAJ provided PIRO the nesting total from Yakushima through the end of July (3,927 nests; Matsuzawa 2008). From 2003 to 2006, Yakushima made up approximately 60 percent of the nesting total in Japan (unpublished data from STAJ, Kamezaki et al., In press). Thus, the preliminary estimate for the 2008 nesting total is 6,500 nests, as shown in Figure 3. However, as noted in Section 5.2, the actual number of 2008 nests may be closer to 10,000. If the population assessment (Snover 2008) had been able to include the 2008 data, then baseline SQE, as well as the effects of the proposed action on SQE and 1-SQE, would likely have been less than shown above in Table 6 and Figure 8.

7.3 Leatherback Turtles

The stressors, exposure, response and risk steps of the effects analysis for leatherback turtles with regard to implementation of the proposed action are described below. The leatherback turtles directly affected by fishing interactions resulting from the proposed action are expected to be entirely from the Western Pacific population. The direct and indirect effects of the action on this population, and any indirect effects on other populations, are related to the species as a whole in the Integration and Synthesis of Effects (Section 9). The following information was used to conduct these analyses of the proposed action on leatherbacks: the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 BiOp (NMFS 2006a), the DSEIS for the proposed action (WPFMC 2008), the population assessment conducted by PIFSC for the proposed action (Snover 2008), and other documents cited below.

7.3.1 Stressors

Due to morphological and behavioural differences between loggerhead and leatherback turtles, effects of longline fishing on leatherbacks are somewhat different than those on loggerheads. Entanglement and foul hooking are the primary effects of longline fishing on leatherbacks, whereas internal hooking is more prevalent in hardshell turtles, especially loggerheads. Leatherbacks seem to be more vulnerable to entanglement and foul hooking, possibly due to their morphology (large size, long pectoral flippers, and lack of a hard shell), their attraction to gelatinous organisms and algae that collect on buoys and buoy lines at or near the surface, or some combination of these and/or other reasons. The effects of entanglement on leatherbacks are similar to those described above for loggerheads: substantial wounds and reduced mobility, causing impairment of feeding, breeding, or migration of the entangled individual. Besides entanglement and foul hooking, the other 2 primary effects of longline fishing on leatherbacks are internal hooking and trailing line, the effects of which are similar to those described above for loggerheads in Section 7.2.1. Because leatherbacks have more delicate skin and softer tissue and bone structures than hardshell turtles, their risk from longline-related injury is considered to be higher (NMFS 2004a, 2005, 2006a).

While the primary direct effect of the proposed action on leatherback turtles will be the stressor of fishing gear interactions, an indirect effect of the proposed action (one that is likely to occur later in time) may be a beneficial market transfer effect. A description of the "market transfer effect" is provided in the introduction to the effects section above. Since the Hawaii-based swordfish fishery had/has stronger, non-discretionary turtle conservation measures, the shift in swordfish production for the U.S. market from the Hawaii-based fleet to Central and South America-based fleets resulted in an estimated increase of 2,882 sea turtle interactions (all species combined) over the 3-year closure (Rausser et al. 2008). An estimate of the number of additional leatherback mortalities represented by these interactions was made in a pre-publication version of the Rausser et al. (2008) paper (Rausser et al. undated). The species-specific estimates were removed from the published version. NMFS does not believe that adequate data are available to quantify leatherback mortalities with any precision that may have resulted from the market transfer effect due to the 2001-2004 closure.

The proposed action would considerably expand the Hawaii-based shallow-set swordfish fishery, i.e., the opposite action of the 2001-2004 closure. Therefore, the proposed action would likely result in a decrease in swordfish imports to the U.S., and a reduction in swordfishing effort by less turtle-friendly competing fleets (NMFS 2001). Such a market transfer effect would be the opposite of that which occurred due to the 2001-2004 closure, and would likely result in a reduction in global leatherback interactions in all swordfish longline fisheries combined. The reduction in leatherback interactions may affect the Western Pacific leatherback population, and possibly other leatherback populations.

7.3.2 Exposure

Leatherback 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-based shallow-set longline fishery. This exposure can be quantified as the expected annual number of interactions. The proposed action would result in up to 5,550 sets annually. Based on the number of sets made, and the number of leatherback interactions, during the 4-year period (100 percent observer coverage) since the re-opening of the shallow-set fishery (10/04 – 9/08), 5,550 sets would result in 19 leatherback interactions (Table 4). Therefore, leatherback exposure to the effects of the proposed action is considered to be 19 leatherback interactions annually.

A decrease in global leatherback exposure to interactions with shallow-set gear deployed by other swordfishing fleets is expected to be indirectly caused by the proposed action, due to a market transfer effect. However, information is not available to quantify the reduction in exposure with any precision. Although Rausser et al. (2008) quantified the increased interactions resulting from the 2001-2004 closure (an additional 2,882 sea turtle interactions, all species combined over the 3 year period), uncertainty resulted in a very large 95 percent confidence interval (-59 to 30,680 additional sea turtle interactions). Thus, NMFS cannot quantify the market transfer effect that may result from the proposed action with any precision for leatherbacks. The Western Pacific leatherback population may be affected by the market transfer effect, as well as other leatherback populations.

7.3.3 Response

Leatherback response to the predicted exposure (19 interactions annually) can be characterized as the annual number of mortalities resulting from this exposure. For the 16 leatherback interactions observed in the shallow-set fishery from when it re-opened in late 2004 until the end of 2007, based on NMFS' post-hooking mortality criteria (NMFS 2006b), post-hooking mortality of leatherbacks in this fishery was 22.9 percent (NMFS 2008c, Snover 2008). Using this post-hooking mortality rate, 19 interactions annually would lead to 5 (rounded from 4.35) leatherback mortalities (either sex, all ages). However, in order to estimate the risk that the proposed action poses to the Western Pacific leatherback population, a population assessment was done by PIFSC (Snover 2008), based on the number of adult females removed from the population. Adult females are the only component of the population for which data are available, from counts of adult females on nesting beaches. Thus, the response of leatherback to 19 interactions must be quantified in terms of adult females in order to interpret the population assessment.

The shallow-set fishery interacts with male and female leatherbacks, some of which are juveniles. In order to estimate the number of adult females that would be killed by 19 interactions, 2 corrections 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. Sex ratio of the Western Pacific leatherback population is unknown, but studies of other leatherback populations suggest that sex ratio is not 50:50. Rather, these studies indicate more females than males in many sub-populations, hence NMFS estimates the sex ratio in the Western Pacific population to be 65 percent female (NMFS 2008g). Some leatherbacks interacting with the shallow-set fishery are juveniles. The mean size of nesting Western Pacific leatherback females at onset of maturity is estimated at 163 cm SCL. Mean SCL of the 12 measured leatherbacks interacting with the shallow-set fishery from late 2004 through 2007 was 139 cm SCL, thus each captured leatherback in this fishery is estimated to represent 0.85 of an adult equivalent (139/163; NMFS 2008g).

In order to estimate the response of leatherbacks to an annual rate of 19 interactions in terms of annual adult female mortalities, the interactions were multiplied by the post-hooking mortality rate (0.229), the female sex ratio (0.65), and the adult equivalent (0.85), giving an estimate of 2.40 adult female mortalities annually for the Western Pacific population. Unlike for North Pacific loggerheads, comprehensive nesting data are not available for Western Pacific leatherbacks. However, nesting data are available since 1993 for the Jamursba-Medi component, estimated to represent 38 percent of the Western Pacific population. Because of migration patterns, approximately 69 percent of leatherbacks interacting with the Hawaii-based shallow-set fishery are likely to be from the Jamursba-Medi component. The number of adult female mortalities from the Jamursba-Medi component was estimated using the formula shown in Table 7.

Table 7. Annual adult female leatherback mortality from the proposed action.

Variable	Estimate
Maximum annual interactions	19 interactions
Post-hooking mortality	0.229 mortalities/capture
Sex ratio	65:35 (♀:♂) = 0.65 females
Adult equivalents	0.85 adult equivalent
Annual adult female mortalities from Western Pacific population	2.40 adult females*
Annual adult female mortalities from Jamursba-Medi component	1.66 adult females**

*(19 captures)(0.229 mortalities/capture)(0.65 females)(0.85 adult equivalent) = 2.40 adult females, from the Jamursba-Medi + the non-Jamursba-Medi components of the Western Pacific population.
**Based on assumption that all captured leatherbacks are from the Western Pacific population, including 69% from the Jamursba-Medi component, and 31% from the non-Jamursba-Medi component (none from Eastern Pacific population).

As shown in Table 7, 1.66 adult female mortalities per year is the expected response of the Jamursba-Medi component to entanglement and hooking caused by the proposed action (not rounded because this number is an input into the population model – see footnote 4 above). The impact of this level of mortality on the Jamursba-Medi component of the Western Pacific population was assessed by Snover (2008). The Risk Analysis below includes a summary of Snover (2008) for the Jamursba-Medi component, as well as an analysis of the non-Jamursba-Medi component based on the best available information.

All variables used for the estimate of annual adult female mortalities were selected conservatively in an attempt to estimate the maximum possible number of adult females that could be killed by the proposed action: We used the maximum possible number of interactions per year (19) rather than the more likely scenario of less than 19 interactions per year. For example, while the maximum number of leatherback interactions in the shallow-set fishery has been 16 per year since 2004, the mean annual number of actual interactions for the 3-year period

2005-07 was 5.0 (NMFS 2008c). The post-hooking mortality rate of 22.9 percent is based on application of the current NMFS criteria (NMFS 2006b) to the 16 observed interactions in the fishery from late 2004 to the end of 2007. However, 1 of the 16 leatherbacks was deeply-hooked and entangled, a highly unusual occurrence for leatherbacks in this fishery (Gilman et al. 2007a). The mean estimated post-hooking mortality for the other 15 leatherbacks was 19.0 percent. Likewise, rather than using a 50:50 sex ratio based on absence of information for this population, a female ratio of 0.65 was used based on information from other leatherback populations. Finally, the adult equivalent estimate of 0.85 is based on a simple proportion of mean length of captured leatherbacks (139 cm SCL) to the estimated length at maturity for this population (163 cm SCL; NMFS 2008g). However, this calculation assumes 100 percent survival of the captured juveniles, so a more realistic adult equivalent estimate would be <0.85. Thus, the estimate of 3 (rounded from 2.40, see footnote 4 above regarding rounding) adult females killed annually from the Western Pacific leatherback population is considered to be the maximum number that would be killed by interactions associated with the proposed action, rather than a mean number.

As described in the exposure section above, a market transfer effect resulting from the proposed action is expected to reduce global leatherback interactions. However, since the decrease in interactions (exposure) cannot be quantified, the resulting decrease in leatherback mortalities (response) cannot be quantified. Thus, NMFS cannot quantify with any precision the market transfer effect that may result from the proposed action in terms of decreased leatherback mortalities. The Western Pacific leatherback population may be affected by the market transfer effect, and possibly other leatherback populations.

7.3.4 Risk

The risk assessment for Western Pacific leatherbacks is more complex than for loggerheads because the population assessment done for this proposed action (Snover 2008) only considered the Jamursba-Medi component of the population, due to data limitations[6]. However, this opinion must determine the risk posed by the proposed action to the Western Pacific population, because the fishery interacts with leatherbacks from the Jamursba-Medi and the non-Jamursba-Medi components of the population.

7.3.4.1 Jamursba-Medi Component of the Western Pacific Population

The Jamursba-Medi component of the Western Pacific leatherback population makes up 38 percent of the population (Dutton et al. 2007), but 69 percent of the leatherbacks interacting with the Hawaii-based shallow-set fishery are likely from this component due to migration patterns (Snover 2008). The description in Section 7.2.4 above of Snover's methodology applies here, except that the QET of 50 percent current population over 3 generations is for 63 years rather than 100 years, because leatherbacks mature at an earlier age than loggerheads.

The effect of the proposed action on SQE of the Jamursba-Medi component of the Western Pacific population is quantified in Table 8 and shown in Figure 9 below. The estimated 1.66 annual adult female mortalities (see footnote 4 above regarding rounding) causes the SQE of the

[6] Dutton et al. (2007) derived a total estimate for Western Pacific leatherback nesting for the period 1999-2006, but this was based in part on anecdotal information. The only nesting data of adequate quality and duration for a population assessment is from Jamursba-Medi (Snover 2008).

Jamursba-Medi component to increase by 0.87 percent (**H** in Figure 9). Another way of interpreting the data is to examine the effect of the additional adult female mortality on "what's left" between baseline SQE (0.8001) and extinction (1.00), or 1-SQE, which in this case is 0.1999 (1.00 – 0.8001). The proposed action would reduce 1-SQE of the Jamursba-Medi component by 3.50 percent (also represented by **H** in Figure 9). Neither the 0.87 percent increase in SQE, nor the 3.50 percent reduction in 1-SQE, are statistically distinguishable from zero. That is, the effects of direct interactions resulting from the action on SQE and 1-SQE cannot be statistically distinguished from the effect of natural mortality on SQE and 1-SQE.

In order to minimize the risk of a population to quasi-extinction, 1-SQE should not be reduced by more than 5 percent. The threshold of 5 percent lies between 2 and 3 adult female mortalities annually for the Jamursba-Medi component (i.e., 2 mortalities reduce 1-SQE by <5%, but 3 mortalities reduce 1-SQE by >5%), suggesting that less than 3 mortalities annually minimizes risk (Snover 2008). The proposed action is expected to result in 2 mortalities (1.66) annually from the Jamursba-Medi component (see Table 8), and a total of 3 mortalities (2.40) annually from the Western Pacific population, due to direct interactions.

Table 8. Risk assessment for effects of proposed action on the Jamursba-Medi component of the Western Pacific leatherback population (Snover 2008)[1].

Adult Female Mortalities (AFM)	
A. AFM w/ proposed action[2]	1.66[3]
B. AFM w/ old interaction limit[4]	1.39
C. Increase in AFM between A and B	0.27
D. Increase in AFM from proposed action	+1.66
Susceptibility to Quasi-Extinction (SQE)	
E. Baseline SQE	0.8001
Baseline 1-SQE	0.1999
F. SQE w/ proposed action[2]	0.8071
1 - SQE w/ proposed action	0.1929
G. SQE w/ old interaction limit[4]	0.8057
1 - SQE w/old interaction limit	0.1943
H. Increase in SQE from proposed action	0.0070
% increase in SQE (0.0070/0.8001)	0.87%
Decrease in 1 – SQE from proposed action	0.0070
% decrease in 1 – SQE (0.0070/0.1999)	3.50%

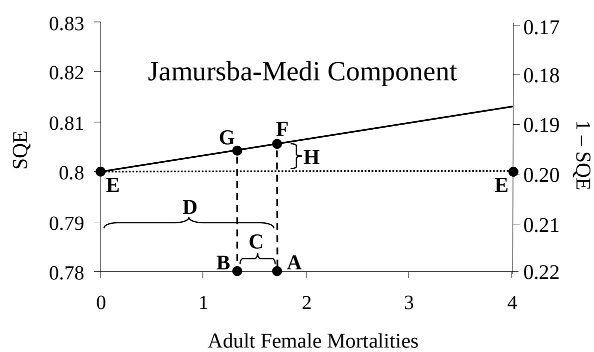


Figure 9. Effect of annual adult female mortalities (**D**) from proposed action on SQE and 1 – SQE (**H**) of the Jamursba-Medi component of the Western Pacific leatherback population, from data in Table 8 (modified from Snover 2008).

[1] Snover (2008) assumed that 6% of leatherbacks captured by the proposed action would be from Eastern Pacific population. However, as described in Section 5.4.1 above, all leatherbacks are expected to be from the Western Pacific population. Hence, Snover's (2008) leatherback proportions of 65% Jamursba-Medi, 29% non-Jamursba-Medi, and 6% Eastern Pacific, were changed to 69% Jamursba-Medi and 31% non-Jamursba-Medi. Therefore, Snover's estimate of 1.56 adult females killed from the Jamursba-Medi component was adjusted to 1.66, as described in footnote #3 below.
[2] Proposed action = 19 leatherback interactions/yr.
[3] Since 69% of leatherbacks caught by the fishery are from the Jamursba-Medi component (Snover 2008), new hard cap will kill (0.69)(2.40) = 1.66 AFM.
[4] Old interaction limit = 16 leatherback interactions/yr.

7.3.4.2 Non-Jamursba-Medi Component of the Western Pacific Population

A risk assessment could not be done for the Western Pacific leatherback population as a whole because of data limitations for the non-Jamursba-Medi component of the population, which refers to all nesting sites except for Jamursba-Medi. The non-Jamursba-Medi component makes up approximately 62 percent of the Western Pacific leatherback population (Dutton et al. 2007), consisting of 27 nesting sites in Papua, PNG, the Solomon Islands, and Vanuatu, as described in Section 5.4.1. Since 31 percent of the leatherbacks interacting with the Hawaii-based shallow-set fishery are expected to originate from the non-Jamursba-Medi component (Table 7), this opinion must determine the effect of the proposed action on the Western Pacific population as a whole. Is the risk assessment for the Jamursba-Medi component (Snover 2008) representative of the non-Jamursba-Medi component? The limited nesting information from the non-Jamursba-Medi sites is summarized below.

As described in Section 5.3.1, annual nest counts at Wermon in Papua have declined from an annual mean of 2,335 nests in 2002-03 and 2003-04, to an annual mean of 1,332 in 2005-06 and 2006-07 (NMFS 2008h). Leatherbacks nesting at sites in the Huon area of PNG appear to have declined by approximately 90 percent within the last 20 years (Hirth et al. 1993, Pilcher 2006, 2007; NMFS 2008h; WPFMC 2008). No information exists regarding populations trends in the Solomon Islands over time, but it is believed that local consumption of turtles and eggs has reduced nesting populations over the last few decades (Steering Committee Bellagio II 2008, NMFS 2008h). Furthermore, conservation activities at these sites are inconsistent and monitoring programs are still in development, hampered by local capacity and funding limitations.

The limited nesting data and other information for the non-Jamursba-Medi component of the Western Pacific leatherback population suggest a more rapid decline than for the Jamursba-Medi component (NFMS 2008h). Jamursba-Medi nesting declined from the 1993-1997 period to the 1999-2007 period, but the nesting trend throughout the 1999-2007 was generally stable (Figure 4). Since the non-Jamursba-Medi component of the Western Pacific population is almost twice as large as Jamursba-Medi component (Dutton et al. 2007), and the non-Jamursba-Medi component may be declining more rapidly than the Jamursba-Medi component (i.e., between the 1993-1997 and 1999-2007 periods), then the Western Pacific population as a whole may be declining more rapidly than Jamursba-Medi alone. Hence, it is reasonable to conclude that the recent Jamursba-Medi nesting trend (Figure 4) and assessment (Snover 2008) are not representative of the Western Pacific population, but rather that the Western Pacific population is declining at a greater rate than the Jamursba-Medi component alone. Therefore, the proposed action could potentially have a more adverse effect on the Western Pacific population than on the Jamursba-Medi component alone.

7.3.4.3 Conclusion for Western Pacific Leatherback Risk Assessment

In conclusion, the proposed action is expected to result in 0.87 and 3.50 percent changes in SQE and 1-SQE, respectively, of the Jamursba-Medi component (Table 8, Figure 9). Available information suggests that the non-Jamursba-Medi component and the Western Pacific population as a whole may be declining more rapidly

Table 9. Conclusion for Western Pacific leatherback risk assessment.

	Jamursba-Medi component	Non-Jamursaba-Medi component	Western Pacific population
Nesting	38% of total	62% of total	100%
Captured by fishery	69% of total	31% of total	100%
Increase in SQE	0.87%	>0.87%	>0.87%
Decrease in 1 - SQE	3.50%	>3.50%	>3.50%

than the Jamursba-Medi component. It follows that direct interactions from the proposed action would therefore result in greater changes in the SQE and 1 – SQE of the Western Pacific population as a whole than the Jamursba-Medi component (Table 9).

A beneficial market transfer effect from the proposed action may indirectly reduce Western Pacific leatherback mortality, but as described above, the reduction is not quantifiable with any precision. NMFS expects that direct interactions resulting from the proposed action are likely to kill the equivalent of up to 3 adult female Western Pacific leatherbacks annually. Thus, the overall effect of the action on this population may be the mortality of less than 3 adult females annually. However, since the market transfer effect is less certain and less quantifiable than the effects of direct interactions, it is not prudent to reduce our estimate of overall mortality from the proposed action to less than 3 Western Pacific adult females annually, 2 of which would be from the Jamursba-Medi component of the population. The results of the population assessment suggest that less than 3 adult female mortalities annually from the Jamursba-Medi component of the Western Pacific leatherback population would minimize the risk of the proposed action to this population (Snover 2008).

7.4 Olive Ridley Turtles

The stressors, exposure, response and risk steps of the effects analysis for olive ridley turtles with regard to implementation of the proposed action are described below. The following information was used to conduct these analyses of the proposed action on olive ridleys: the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2006 BiOp (NMFS 2006a), and other documents cited below.

7.4.1 Stressors

Longline fishing affects olive ridleys primarily by hooking, but also by entanglement and trailing of gear. However, in contrast to loggerheads, olive ridleys only rarely interact with shallow-set gear, most likely because of a combination of deep-foraging and low density in temperate swordfish waters. Olive ridleys are the most commonly-caught sea turtle species in the deep-set component of the Hawaii-based longline fishery (NMFS 2005), which fishes between 150 and 400 m of depth, and operates mostly to the south of Hawaii (Figure 2).

While the primary direct effect of the proposed action on olive ridley turtles will be the stressor of fishing gear interactions, an indirect effect of the proposed action (one that is likely to occur later in time) may be a beneficial market transfer effect. A description of the “market transfer effect” is provided in the introduction to the effects section above. Since the Hawaii-based swordfish fishery had/has stronger, non-discretionary turtle conservation measures, the shift in swordfish production for the U.S. market from the Hawaii-based fleet to Central and South America-based fleets resulted in an estimated increase of 2,882 sea turtle interactions (all species combined) over the 3-year closure (Rausser et al. 2008). An estimate of the number of additional olive ridley mortalities represented by these interactions was made in a pre-publication version of the Rausser et al. (2008) paper (Rausser et al. undated). The species-specific estimates were removed from the published version. NMFS does not believe that adequate data are available to quantify olive ridley mortalities with any precision that may have resulted from the market transfer effect due to the 2001-2004 closure.

The proposed action would considerably expand the Hawaii-based shallow-set swordfish fishery, i.e., the opposite action of the 2001-2004 closure. Therefore, the proposed action may result in a decrease in swordfish imports to the U.S., and a reduction in swordfishing effort by less turtle-friendly competing fleets (NMFS 2001). Such a market transfer effect would be the opposite of that which occurred due to the 2001-2004 closure, and is likely to result in a reduction in global olive ridley interactions in all swordfish longline fisheries combined. The reduction in olive ridley interactions may affect the Eastern Pacific olive ridley population, and possibly other olive ridley populations as well.

7.4.2 Exposure

Olive ridley interactions in the shallow-set fishery are rare, unpredictable events; for example, only 1 olive ridley interacted with the shallow-set fishery in over 3 years between re-opening of the fishery in 2004 and the end of 2007 (NMFS 2008c), but then 2 interacted with the fishery in less than 3 months in early 2008. Based on the number of sets made since the fishery re-opened in 2004, the 3 olive ridley interactions resulting from these sets, and a proposed action of 5,550 sets, NMFS estimates that the proposed action could interact with up to 4 olive ridleys annually (Table 4).

A decrease in global olive ridley exposure to interactions with shallow-set gear deployed by other swordfishing fleets may be indirectly caused by the proposed action, due to a market transfer effect. However, information is not available to quantify the reduction in exposure with any precision. Although Rausser et al. (2008) quantified the increased interactions resulting from the 2001-2004 closure (an additional 2,882 sea turtle interactions, all species combined over the 3 year period), uncertainty resulted in a very large 95 percent confidence interval (-59 to 30,680 additional sea turtle interactions). Thus, NMFS cannot quantify the market transfer effect that may result from the proposed action with any precision for olive ridleys.

7.4.3 Response

Because of the rarity of olive ridley interactions in the shallow-set fishery, data is lacking on post-hooking mortality. Data from post-hooking mortality of this species in the deep-set fishery cannot be used because mortality is much higher (near 100%) in the deep-set than the shallow-set fishery (NMFS 2005). Hence we estimate a post-hooking mortality rate of 0.20 for this species, based on post-hooking mortality rates of the more commonly-caught loggerhead and leatherback turtles in the shallow-set fishery (NMFS 2008c). The population assessment done for this proposed action only included loggerheads and leatherbacks (Snover 2008), thus it is not necessary to estimate the number of adult female olive ridleys killed by the proposed action. Rather, we estimate that 1 olive ridley juvenile or adult (male or female) will be killed by the proposed action annually (4 interactions/yr x 0.20 post-hooking mortality = 0.8 mortality/yr, round to 1).

As described in the exposure section above, a market transfer effect resulting from the proposed action may reduce global olive ridley interactions. However, since the decrease in interactions (exposure) cannot be quantified, the resulting decrease in olive ridley mortalities (response) cannot be quantified. Thus, NMFS cannot quantify the market transfer effect that may result from the proposed action with any precision for olive ridleys. The Eastern Pacific olive ridley population may be affected by the market transfer effect, and possibly other olive ridley populations as well.

7.4.4 Risk

As shown by the few genetics samples of olive ridleys from the shallow-set (Table 2, Section 5), individuals may come from either the Eastern or Western Pacific populations, although most probably come from the Eastern Pacific population. Since we estimate a total of 1 individual will be killed annually by the proposed action, and 2 of the 3 genetic samples analyzed so far were from the Eastern Pacific population, we expect 2 turtles from the Eastern Pacific population to be killed every 3 years, and 1 turtle from the Western Pacific population to be killed every 3 years. In contrast, the Hawaii-based deep-set longline fishery was estimated to kill 39 olive ridleys annually, with about the same proportion of individuals from the Eastern and Western Pacific as in this proposed action. However, the olive ridley population assessment done for the deep-set biological opinion found that this level of mortality would have no effect on either population (NMFS 2005). Thus, even though the Western Pacific population is a small fraction of the size of the Eastern Pacific population, neither population is expected to be affected by 1 annual mortality from the proposed action, therefore the risk to both populations from the proposed action is considered negligible. In addition, a beneficial market transfer effect from the proposed action may indirectly reduce overall olive ridley mortality.

7.5 Green Turtles

The stressors, exposure, response and risk steps of the effects analysis for green turtles with regard to implementation of the proposed action are described below. The following information was used to conduct these analyses of the proposed action on olive ridleys: the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2008 Hawaii bottomfish opinion, (NMFS 2008e), and other documents cited below.

7.5.1 Stressors

Longline fishing affects green turtles primarily by hooking, but also by entanglement and trailing of gear. Historically, the longline fishery has been more likely to hook green turtles externally than to entangle them or hook them internally. Juvenile and adult interactions both occur (NMFS 2005). In addition, because green turtles recruit to nearshore habitat in the MHI, and green turtles are now common in shallow MHI waters, fishing vessels traveling to and from port may occasionally strike green turtles (NMFS 2008e).

While the primary direct effect of the proposed action on loggerhead turtles will be the stressor of fishing gear interactions, an indirect effect of the proposed action (one that is likely to occur later in time) may be a beneficial market transfer effect. A description of the "market transfer effect" is provided in the introduction to the effects section above. Since the Hawaii-based swordfish fishery had/has stronger, non-discretionary turtle conservation measures, the shift in swordfish production for the U.S. market from the Hawaii-based fleet to Central and South America-based fleets resulted in an estimated increase of 2,882 sea turtle interactions (all species combined) over the 3-year closure (Rausser et al. 2008). An estimate of the number of additional green turtle mortalities represented by these interactions was made in a pre-publication version of the Rausser et al. (2008) paper (Rausser et al. undated). The species-specific estimates were removed from the published version. NMFS does not believe that adequate data are available to quantify green turtle mortalities with any precision that may have resulted from the market transfer effect due to the 2001-2004 closure.

The proposed action would considerably expand the Hawaii-based shallow-set swordfish fishery, i.e., the opposite action of the 2001-2004 closure. Therefore, the proposed action would likely result in a decrease in swordfish imports to the U.S., and a reduction in swordfishing effort by less turtle-friendly competing fleets (NMFS 2001). Such a market transfer effect would be the opposite of that which occurred due to the 2001-2004 closure, and would likely result in a reduction in global green turtle interactions in all swordfish longline fisheries combined. The reduction in green turtle interactions may affect the Eastern Pacific green turtle population, and possibly other green turtle populations.

7.5.2 Exposure

As with olive ridleys, green turtle interactions in the shallow-set fishery are rare, unpredictable events; for example, after re-opening in late 2004, the Hawaii-based shallow-set fishery operated for over 3 years without interacting with any green turtles (NMFS 2008c). Based on the number of sets made since the fishery re-opened in 2004, the 1 green turtle interaction resulting from these sets (in 2008), and a proposed action of 5,550 sets, NMFS estimates that the proposed action could interact with up to 1 green turtle annually (Table 4).

The proposed action may also affect green turtles due to boat collisions with turtles in nearshore waters around the MHI. The entire Hawaii-based longline fishery (deep-set and shallow-set components combined) took approximately 1,500 trips annually in 2005-07 (Figure 1), with only a small fraction shallow-set trips (≈100 trips/yr). The proposed action is expected to result in an approximate 4-fold increase in fishing effort (Table 4), hence number of trips resulting from the proposed action is estimated at 400 per year for the proposed action. The number of green turtles likely to be killed due to boat collisions from the Hawaii bottomfish fishery was estimated in a March 18th, 2008, biological opinion (NMFS 2008e). Using the 6-step methodology in the HI bottomfish opinion (Figure 3, p.25), and substituting 400 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 shallow-set longline boats is essentially zero (0.02).

A decrease in global green turtle exposure to interactions with shallow-set gear deployed by other swordfishing fleets may be indirectly caused by the proposed action, due to a market transfer effect. However, information is not available to quantify the reduction in exposure with any precision. Although Rausser et al. (2008) quantified the increased interactions resulting from the 2001-2004 closure (an additional 2,882 sea turtle interactions, all species combined over the 3 year period), uncertainty resulted in a very large 95 percent confidence interval (-59 to 30,680 additional sea turtle interactions). Thus, NMFS cannot quantify the market transfer effect that may result from the proposed action with any precision for green turtles. The Eastern Pacific green turtle population would likely be affected by the market transfer effect, and possibly other green turtle populations.

7.5.3 Response

Because of the rarity of green turtle interactions in the shallow-set fishery, data is lacking on post-hooking mortality. Data from post-hooking mortality of this species in the deep-set fishery cannot be used because mortality is much higher (near 100%) in the deep-set than the shallow-set fishery (NMFS 2005). Thus we estimate a post-hooking mortality rate of 0.20 for this species, based on post-hooking mortality rates of the more commonly-caught loggerhead and leatherback turtles in the shallow-set fishery (NMFS 2008c). The population assessment done for this proposed action only included loggerheads and leatherbacks (Snover 2008), hence it is not necessary to estimate the number of adult female green turtles killed by the proposed action. Rather, we estimate that 1 green turtle juvenile or adult (male or female) will be killed by the proposed action annually (1 interaction/yr x 0.20 post-hooking mortality = 0.20 mortality/yr from shallow-set fishing + 0.01 mortality/yr from shallow-set boat collisions, round to 1).

As described in the exposure section above, a market transfer effect resulting from the proposed action may reduce global green turtle interactions. However, since the decrease in interactions (exposure) cannot be quantified, the resulting decrease in green turtle mortalities (response) cannot be quantified. Thus, NMFS cannot quantify the market transfer effect that may result from the proposed action with any precision for green turtles. The Eastern Pacific green turtle population may be affected by the market transfer effect, and possibly other green turtle populations.

7.5.4 Risk

As shown by the few genetics samples of green turtles from the shallow-set (Table 3, Section 5), individuals may come from either the Central or Eastern Pacific populations. Since we estimate a total of 1 individual will be killed annually by the proposed action, 1 turtle from each population is expected to be killed every 2 years. Both populations are increasing (see Section 5.6.1), hence neither population is expected to be affected by such a low level of mortality. Therefore, the risk to both populations from the proposed action is considered negligible. In addition, a beneficial market transfer effect from the proposed action may indirectly reduce overall green turtle mortality from the Eastern Pacific and possibly other populations.

7.6 Hawksbill Turtles

The stressors, exposure, response and risk steps of the effects analysis for hawksbill turtles with regard to implementation of the proposed action are described below. The following information was used to conduct these analyses of the proposed action on hawksbills: the 2004 BiOp (NMFS 2004a), the 2005 BiOp (NMFS 2005), the 2008 Hawaii bottomfish opinion, (NMFS 2008e), and other documents cited below.

7.6.1 Stressors

The 2005 BiOp on the Hawaii-based deep-set longline fishery concluded that the deep-set fishery is not likely to hook, entangle, or otherwise adversely affect hawksbill turtles (NMFS 2005). However, since then, a dead hawksbill that apparently was entangled and drowned in derelict fishing gear was retrieved by shallow-set gear in Hawaii, and an unconfirmed hawksbill interaction occurred in the American Samoa longline fishery, which fishes at intermediate depths for albacore. Longline fishing affects hawksbills primarily by hooking, but also by entanglement and trailing of gear (NMFS 2004a, Robins et al. 2002). Because hawksbills, like green turtles, recruit to nearshore habitat in the MHI, longline vessels traveling to and from port could strike hawksbills (NMFS 2008e).

While the primary direct effect of the proposed action on hawksbills will be the stressors of fishing gear interactions and vessel collisions, an indirect effect of the proposed action (one that is likely to occur later in time) may be a beneficial market transfer effect. The definition of "market transfer effect", and the market transfer effect that appears to have resulted from the 2001-2004 closure of this fishery, are described in the introduction to the effects section above. The 2001-2004 closure is estimated to have resulted in an additional 1 hawksbill mortality from the Western Pacific population, that would not have occurred if the fishery had stayed open, because of transferred swordfishing effort from Hawaii to Vietnam (Rausser et al. undated, Table 16).

The proposed action would considerably expand the Hawaii-based shallow-set swordfish fishery, i.e., the opposite action of the 2001-2004 closure. Therefore, the proposed action would likely result in a decrease in swordfish imports to the U.S., and a reduction in swordfishing effort by less turtle-friendly competing fleets. Such a market transfer effect would be the opposite of that which occurred due to the 2001-2004 closure, and may result in a reduction in interactions with hawksbills from the Central Pacific or other populations.

7.6.2 Exposure

Hawksbills interactions are very unlikely in either the shallow-set or deep-set components of the Hawaii-based longline fishery, as shown by zero reported hawksbill interactions in the fishery since the Observer Program began in 1994. However, the dead hawksbill retrieved by shallow-set gear described above suggests that pelagic juveniles likely sometimes forage in the action area. Hawksbills interactions have occurred in longline fisheries in the Atlantic (Yeung 1999) and Pacific (Robins et al. 2002). The proposed action will substantially increase fishing effort by the shallow-set fishery (WPFMC 2008), increasing the likelihood of hawksbill bycatch.

Like green turtles, hawksbills recruit as juveniles to nearshore habitat, where they remain except for breeding migrations. However, longline boat collisions with hawksbills is considered discountable because: (1) hawksbills are much less common in the MHI than green turtles; (2) within the MHI, hawksbills are most common around the Big Island, but least common around Oahu where most of the longline boat traffic is; and (3) even for green turtles, the proposed action is expected to only kill 1 turtle from boat collisions every few years at the most (see Section 7.6.2 above). Therefore the proposed action is not likely to result in boat collisions with hawksbills, lethal or otherwise.

A decrease in global hawksbill exposure to interactions with shallow-set gear deployed by other swordfishing fleets is expected to be indirectly caused by the proposed action, due to a market transfer effect. However, information is not available to quantify the reduction in exposure with any precision. Although Rausser et al. (2008) quantified the increased interactions resulting from the 2001-2004 closure (an additional 2,882 sea turtle interactions, all species combined over the 3 year period), uncertainty resulted in a very large 95 percent confidence interval (-59 to 30,680 additional sea turtle interactions). Thus, NMFS cannot quantify the market transfer effect that may result from the proposed action with any precision for hawksbills.

7.6.3 Response
Due to the rarity of hawksbill bycatch in this fishery, and the low post-hooking mortality rate (compared to deep-set longlining), the death of a hawksbill from the proposed action is considered very unlikely. We estimate that up to 1 hawksbill juvenile or adult will be injured by the proposed action due to hooking or entanglement every 5 years.

As described in the exposure section above, a market transfer effect resulting from the proposed action may reduce global hawksbill interactions. However, since the decrease in interactions (exposure) cannot be quantified, the resulting decrease in hawksbill mortalities (response) cannot be quantified. Thus, NMFS cannot quantify the market transfer effect that may result from the proposed action with any precision for hawksbills. The Central Pacific hawksbill population would likely be affected by the market transfer effect.

7.6.4 Risk
Hawksbills within the action area are thought to be from the Central Pacific population (Section 5). The proposed action is not expected to result in the mortality of any hawksbills, hence the risk to the Central Pacific population from the proposed action is considered insignificant. In addition, a beneficial market transfer effect from the proposed action may indirectly reduce overall hawksbill turtle mortality from the Central Pacific and possibly other populations.

8 Cumulative Effects
“Cumulative effects”, as defined in the ESA implementing regulations, are limited to the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this opinion (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. Because the action area is primarily a swath of the 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 6 species addressed by this opinion are likely to occur as a result of worsening climate change, and any increase in the fishing, ship traffic, and other actions described in the Environmental Baseline section. Such effects could include worsening of the climate change effects described in Sections 5 and 6, and could result in corresponding increases in fishing gear entanglements and ship strikes of humpback whales, and in fishing gear interactions of the 5 turtle species. In addition, any increases in marine debris could also increase entanglements of all 6 species. However, since the extent of climate change, and the extent of the increases in fishing, ship traffic, and marine debris, are unquantifiable, the corresponding effects are also unquantifiable.

9 Integration and Synthesis of Effects
The purpose of this biological opinion is to determine if the proposed action is likely to have direct or indirect effects on threatened and endangered species that appreciably reduce their likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (50 CFR 402.02), otherwise known as the jeopardy determination. This is done by

considering the effects of the action within the context of the ‘Status of Listed Species’ and ‘Environmental Baseline’, as described in the *Approach* section (beginning of Section 7 Effects of the Action): We determine if mortality of individuals of listed species resulting from the proposed action are sufficient to reduce the viability of the populations those individuals represent (measured using changes in the populations’ abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population’s extinction risks). In order to make that determination, we use the population’s base condition (established in the Status of Listed Species and Environmental Baseline sections of this opinion) as the context for the overall effects of the action on the affected populations. Finally, our opinion determines if changes in population viability are likely to be sufficient to reduce the viability of the species those populations comprise. The following discussions summarize the probable risks the proposed action poses to the 6 listed species addressed by this opinion.

Humpback Whales. As described in the Effects of the Action (Section 7.1), if we assume that the proposed action will result in 5,550 sets annually, then that level of effort will result in 3 humpback interactions annually, which will result in 1 mortality every 1-2 years from the North Pacific population. As discussed in the humpback section of the Status of Listed Species (Section 5.1), there were an estimated 18,000 adults in the North Pacific population in 2007, and the population has grown at approximately 6 percent annually since 1965. As discussed in the humpback section of the Environmental Baseline (Section 6.1), up to 1 mortality annually is occurring within the action area due to fishery interactions. Viewed within the context of the Status of the Species and the Environmental Baseline, the estimated reductions in humpback numbers caused by the proposed action (Section 7.1) are insufficient to adversely affect the population dynamics of North Pacific humpback whales. That is, we do not expect the proposed action to reduce the reproduction, numbers, or distribution of the North Pacific humpback population, or of the humpback species, as listed under the ESA (Table 1).

Loggerhead Turtles. As described in the loggerhead section of the Effects of the Action (Section 7.2), if we assume that the proposed action will result in 5,550 sets annually, then that level of effort will result in 46 loggerhead interactions annually, which will result in a maximum of 10 mostly juvenile mortalities annually (representing 3 adult females) from the North Pacific population. Also assuming an effort level of 5,550 sets annually (i.e., considerable expansion of the fishery), the market transfer effect may result in some reduction of loggerhead mortality from the North Pacific and possibly other loggerhead populations. However, as explained in the Effects section, it is not possible for NMFS to quantify the beneficial market transfer effect with any precision. Thus, the proposed action is likely to result in up to 3 adult female mortalities annually from the North Pacific loggerhead population. Is the loss of up to 3 adult females annually sufficient to reduce the viability of the North Pacific loggerhead population?

As discussed in the loggerhead section of the Status of Listed Species (Section 5.2), nesting of North Pacific loggerheads in Japan steadily increased from 1999 to 2005, before declining in 2006 and 2007 (Figure 3). However, in 2008, the number of nests was the highest since comprehensive counts were started in the 1980s. While nesting trends do not necessarily reflect population trends, the nesting trend data from Japan is currently the best available information on the status of the North Pacific population. The increase from approximately 2,000 nests (representing approximately 500 nesting females) in 1999, to 6,500 – 10,000 nests (representing approximately 2,000 nesting females) in 2008, suggests that efforts to decrease fishing interactions, along with other factors (described in Section 5.2), are having positive effects at the population level.

As discussed in the loggerhead section of the Environmental Baseline (Section 6.2), 50 to 600 juvenile and adult North Pacific loggerhead mortalities may be occurring annually due to longline fishery interactions within the action area alone. Thus, total fishery-related mortality of the North Pacific loggerhead population due to longline fishing, nearshore fishing in Japan, and other fisheries, is likely at least several hundred adults annually. The increase in nesting since 1999 while sustaining such high mortality suggests that the North Pacific loggerhead population consists of many thousands of adults. Viewed within the context of the Status of the Species and the Environmental Baseline, the annual loss of the equivalent of up to 3 adult females due to the proposed action (Section 7.2) is insufficient to adversely affect the population dynamics of North Pacific loggerhead turtles. That is, the mortality associated with the proposed action is so low relative to the total population size that its effects on the population cannot be distinguished from the effects of natural mortality, and hence does not adversely affect the population dynamics of North Pacific loggerheads. Therefore, we do not expect the proposed action to reduce the reproduction, numbers, or distribution of the North Pacific loggerhead population.

To summarize for loggerhead turtles, we do not expect the combined direct (interactions) and indirect (market transfer effect) effects of the proposed action to reduce the reproduction, numbers, or distribution of the North Pacific loggerhead population. The market transfer effect of the proposed action may benefit this and other loggerhead populations. We do not expect the proposed action to reduce the reproduction, numbers, or distribution of the loggerhead sea turtle species, as listed under the ESA (Table 1).

Leatherback Turtles. As described in the leatherback section of the Effects of the Action (Section 7.3), if we assume that the proposed action will result in 5,550 sets annually, then that level of effort will result in 19 leatherback interactions annually, which will result in a maximum of 5 mostly adult mortalities annually (representing 3 adult females) from the Western Pacific population. Also assuming an effort level of 5,550 sets annually (i.e., considerable expansion of the fishery), the market transfer effect may result in some reduction of leatherback mortality from the Western Pacific and possibly other leatherback populations. However, as explained in the Effects section, it is not possible for NMFS to quantify the beneficial market transfer effect with any precision. Thus, the proposed action is likely to result in up to 3 adult female mortalities annually from the Western Pacific leatherback population. Is the loss of up to 3 adult females annually sufficient to reduce the viability of the Western Pacific leatherback population?

As discussed in the leatherback section of the Status of Listed Species (Section 5.3), the total number of nests per year in the Western Pacific population was estimated at 5,067 – 9,176 for the period 1999-2006, leading to an estimate of 2,110 – 5,735 breeding females in the population during this time period (Dutton et al. 2007). As discussed in the leatherback section of the Environmental Baseline (Section 6.3), 20 to 320 juvenile and adult Western Pacific leatherback mortalities may be occurring annually due to longline fishery interactions within the action area alone. Thus, total fishery-related mortality of the Western Pacific leatherback population is likely at least a few hundred adults annually. The somewhat stable trend in nesting of the Jamursba-

Medi component of the population since 1999 (Figure 4) while sustaining such high mortality suggests that the Western Pacific leatherback population consists of many thousands of adults. Viewed within the context of the Status of the Species and the Environmental Baseline, the estimated reductions in leatherback numbers caused by the proposed action (Section 7.3) are insufficient to adversely affect the population dynamics of Western Pacific leatherback turtles. That is, the mortality associated with the proposed action is so low relative to the total population size that its effects on the population cannot be distinguished from the effects of natural mortality, and hence does not adversely affect the population dynamics of Western Pacific leatherbacks. Therefore, we do not expect the proposed action to reduce the reproduction, numbers, or distribution of the Western Pacific leatherback population.

However, while the proposed action is not likely to reduce the reproduction, numbers, or distribution of the Western Pacific leatherback population, it would potentially increase the harm to the Western Pacific leatherback population by increasing the estimated maximum number of annual interactions from the currently-authorized 16 (NMFS 2004a) to 19. Baseline conditions for this population are already poor, and appear to be getting worse, as described above in this opinion, because: (1) While nesting for the Jamursba-Medi component (38 percent of total) of the Western Pacific leatherback appears stable since 1999, nesting levels in 1999-2007 were lower than in 1993-1997 (Figure 4); (2) the Jamursba-Medi nesting data upon which Figure 4 is based may over-state the number of nests (see Section 5.3.1); and (3) The trends of the nesting sites in the non-Jamursba-Medi component (62 percent of the Western Pacific leatherback population) are unknown, but the best available information suggests they may be declining more rapidly than Jamursba-Medi (described in Sections 5.3.1).

To summarize for leatherback turtles, despite the above concerns for the Western Pacific leatherback population, we do not expect that the effects of the proposed action (i.e., the annual mortality of a maximum of 3 adult female equivalents out of a population of many thousands of adults) will adversely affect the population. That is, we do not expect the combined direct (interactions) and indirect (market transfer effect) effects of the proposed action to reduce the reproduction, numbers, or distribution of the Western Pacific leatherback population. The market transfer effect of the proposed action may benefit this and other leatherback populations. We do not expect the proposed action to reduce the reproduction, numbers, or distribution of the leatherback sea turtle species, as listed under the ESA (Table 1).

Olive Ridley Turtles. As described in the olive ridley section of the Effects of the Action (Section 7.4), if we assume that the proposed action will result in 5,550 sets annually, then that level of effort will result in 4 olive ridley interactions annually, which will result in a maximum of 1 juvenile or adult mortality annually, most likely from the Eastern Pacific population, but possibly from the Western Pacific population. Also assuming an effort level of 5,550 sets annually (i.e., considerable expansion of the fishery), the market transfer effect may result in some reduction of olive ridley mortality from the Eastern Pacific and possibly other olive ridley populations.

As discussed in the olive ridley section of the Status of Listed Species (Section 5.4), nesting of Eastern Pacific olive ridleys steadily increased from 1991 to 2006 up to over 1 million nests annually. The Western Pacific olive ridley population is a small, widely-scattered population with less than 1,000 nests annually. As discussed in the olive ridley section of the Environmental

Baseline (Section 6.4), hundreds of juvenile and adult Eastern Pacific olive ridley mortalities may be occurring annually due to longline fishery interactions within the action area alone. Thus, total fishery-related mortality of the Eastern Pacific olive ridley population is likely at least several hundred adults annually. Viewed within the context of the Status of the Species and the Environmental Baseline, the mortality of 1 individual olive ridley caused by the proposed action (Section 7.4) is insufficient to adversely affect the population dynamics of either Eastern Pacific or Western Pacific olive ridley turtles. That is, we do not expect the proposed action to reduce the reproduction, numbers, or distribution of either population.

To summarize for olive ridley turtles, we do not expect the combined direct (interactions) and indirect (market transfer effect) effects of the proposed action to reduce the reproduction, numbers, or distribution of the Eastern Pacific or Western Pacific olive ridley populations. We do not expect the proposed action to reduce the reproduction, numbers, or distribution of the olive ridley sea turtle species, as listed under the ESA (Table 1).

Green Turtles. As described in the green turtle section of the Effects of the Action (Section 7.5), if we assume that the proposed action will result in 5,550 sets annually, then that level of effort will result in 1 green turtle interactions annually, which will result in a maximum of 1 juvenile or adult mortality annually, from either the Eastern Pacific or the Hawaii component of the Central Pacific populations. Also assuming an effort level of 5,550 sets annually (i.e., considerable expansion of the fishery), the market transfer effect may result in some reduction of green turtle mortality, primarily from the Eastern Pacific population.

As discussed in the green turtle section of the Status of Listed Species (Section 5.5), nesting of Eastern Pacific population, and of the Hawaii component of the Central Pacific population, have increased in the last decade. As discussed in the green turtle section of the Environmental Baseline (Section 6.5), several dozen green turtles (approximately evenly-split between the two populations) are killed annually by longlining in the action area alone. Thus, total fishery-related mortality of green turtles from the two populations is likely a few hundred annually. In addition, up to several dozen green turtles from the Hawaii component of the Central Pacific population are killed annually by nearshore activities such as fishing and boat collisions within the action area. Viewed within the context of the Status of the Species and the Environmental Baseline, the mortality of 1 individual green turtle caused by the proposed action (Section 7.5) is insufficient to adversely affect the population dynamics of either the Eastern Pacific or Central Pacific green turtles. That is, we do not expect the proposed action to reduce the reproduction, numbers, or distribution of either population.

To summarize for green turtles, we do not expect the combined direct (interactions and collisions) and indirect (market transfer effect) effects of the proposed action to reduce the reproduction, numbers, or distribution of the Eastern Pacific or Central Pacific green turtle populations. We do not expect the proposed action to reduce the reproduction, numbers, or distribution of the green sea turtle species, as listed under the ESA (Table 1).

Hawksbill Turtles. As described in the hawksbill section of the Effects of the Action (Section 7.6), if we assume that the proposed action will result in 5,550 sets annually, then that level of effort will result in 1 hawksbill turtle interaction every 5 years from the Central Pacific population. Also assuming an effort level of 5,550 sets annually (i.e., considerable expansion of the fishery), the market transfer effect may result in some reduction of hawksbill turtle mortality from the Western Pacific population.

As discussed in the hawksbill turtle section of the Status of Listed Species (Section 5.6), nesting of Central Pacific population has continued to decline in the last decade. As discussed in the hawksbill turtle section of the Environmental Baseline (Section 6.6), up to 1 or 2 dozen hawksbill turtles are likely killed annually by longlining in the action area alone. Thus, total fishery-related mortality of Central Pacific hawksbills is likely at least several dozen annually. In addition, up to several hawksbills from the Hawaii component of the Central Pacific population are killed annually by nearshore activities such as fishing and boat collisions within the action area. However, since the proposed action is not likely to result in even 1 hawksbill mortality over a 5-year period (Section 7.6), the effects of the proposed action on hawksbill are insufficient to adversely affect the population dynamics of Central Pacific hawksbill turtles. That is, we do not expect the proposed action to reduce the reproduction, numbers, or distribution of this population.

To summarize for hawksbill turtles, we do not expect the combined direct (interactions and collisions) and indirect (market transfer effect) effects of the proposed action to reduce the reproduction, numbers, or distribution of the Central Pacific hawksbill turtle population. We do not expect the proposed action to reduce the reproduction, numbers, or distribution of the hawksbill sea turtle species, as listed under the ESA (Table 1).

10 Conclusion

The purpose of this biological opinion is to determine if the proposed action is likely to jeopardize the continued existence of listed species (i.e., jeopardy determination). “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 humpback whales, loggerhead sea turtles, leatherback sea turtles, olive ridley sea turtles, green sea turtles, and hawksbill sea turtles, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS’ biological opinion that the proposed action is not likely to jeopardize the continued existence of these 6 species. Critical habitat has not been designated in the proposed action area, so no critical habitat would be affected by the proposed action.

While the proposed action is not likely to jeopardize leatherback sea turtles, it would potentially increase the harm to the Western Pacific leatherback population by increasing the estimated maximum number of annual interactions from the currently-authorized 16 (NMFS 2004a) to 19. Baseline conditions for this population are already poor, and appear to be getting worse, as described above in this opinion, because: (1) While nesting for the Jamursba-Medi component (38 percent of total) of the Western Pacific leatherback appears somewhat stable since 1999, nesting levels in 1999-2007 were lower than in 1993-1997 (Figure 4); (2) the Jamursba-Medi nesting data upon which Figure 4 is based may over-state the number of nests (see Section 5.3.1); and (3) The trends of the nesting sites in the non-Jamursba-Medi component (62 percent of the Western Pacific leatherback population) are unknown, but the best available information suggests they may be declining more rapidly than Jamursba-Medi (described in Sections 5.3.1).

11 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. HLA should encourage the use of TurtleWatch (Howell et al. 2008), a continuously-updated, on-line map showing the areas of highest potential loggerhead bycatch, in the shallow-set fishery. NMFS should encourage the use of TurtleWatch among other longline fleets that interact with loggerhead turtles in or near the action area.

2. NMFS should continue to research modifications to fishing gear (e.g., hook size, hook shape, hook offset, hook appendage, bait type, line type, depth configuration, float configuration, deterrents, decoys, etc.) and turtle handling methods (dehookers, lifting methods, etc) to reduce turtle bycatch and mortality in commercial longline fisheries.

3. NMFS should continue to promote reduction of turtle bycatch in Pacific fisheries by supporting:
    a. The Inter-American Convention for the Protection and Conservation of Sea Turtles;
    b. A binding Western and Central Pacific Fisheries Commission (WCPFC) sea turtle conservation and management measure for commercial longline fisheries operating in the western Pacific;
    c. Implementation of NMFS Sea Turtle Handling Guidelines that increase post-hooking turtle survivorship;
    d. Technical assistance workshops to assist other longlining nations;
    e. Observer programs on commercial vessels operating in the western Pacific;
    f. Continuation of ecological, habitat use, and genetics studies of loggerhead turtles occurring in nearshore foraging habitats in Central and South America, and gear mitigation studies for fisheries operating in these waters, and;
    g. A trans-Pacific international agreement that would include relevant Pacific Rim nations for the conservation and management of sea turtle populations, specifically a Japan-U.S.A.-Mexico agreement for North Pacific loggerhead turtles.

4. NMFS should continue to encourage, support and work with Regional partners to implement long-term sea turtle conservation and recovery programs at critical nesting, foraging and migratory habitats.

5. If recent post-hooking mortality studies (e.g. for loggerheads, Sasso and Epperly 2007, Swimmer et al. In press) so indicate, NMFS should update its guidelines (NMFS 2006b).

6. NMFS should conduct a study of the market transfer effect on sea turtles of the expansion of the Hawaii-based shallow-set longline fishery resulting from the proposed action.

12 Reinitiation Notice

This concludes formal consultation on management modifications for the Hawaii-based shallow-set longline swordfish fishery, as proposed in Amendment 18 (WPFMC 2008). 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 over a 3-year period, as specified in Table 10 below;
2. New information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion;
3. The agency action is subsequently modified in a manner that may affect listed species or critical habitat to an extent in a way not considered in this opinion (e.g., if >5,550 sets are made during one calendar year); or
4. A new species is listed or critical habitat designated that may be affected by the action.

13 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)).

13.1 MMPA Authorization

A marine mammal species or population stock that is listed as threatened or endangered under the ESA is, by definition, also considered depleted under the MMPA. The ESA allows takings of threatened and endangered marine mammals only if authorized by section 101(a)(5) of the MMPA. The incidental taking of listed marine mammals must be authorized under section 101(a)(5)(E) of the MMPA, before incidental take of listed marine mammals may be exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA. Because MMPA 101(a)(5)(e) authorization has not been completed, incidental take of humpback whales is not authorized for the proposed action at this time.

13.2 Amount or Extent of Take

The annual numbers of interactions and mortalities expected to result from implementation of the proposed action are shown for 1-year and 3-year periods in Table 10 below (i.e., 1-year and 3-year ITSs). However, only the 3-year ITS will be used for purposes of reinitiation of consultation, as explained below. The interactions and mortalities in Table 10 have been calculated based on observed interaction rates since the re-opening of the fishery in 2004 (see Table 4 in Section 7) and estimated post-hooking mortality rates of loggerheads (see Section 7.2.3) and leatherbacks (see Section 7.3.3) in this fishery. Annual equivalent adult female mortalities (AFMs) are also shown for loggerheads and leatherbacks, because they were the basis for the population assessment (Snover 2008). AFMs are rounded from the estimates derived for loggerheads (2.51 AFMs, see Section 7.2.3) and leatherbacks (2.40 AFMs, Section 7.3.3).[7]

As shown in Table 4, the number of expected green and hawksbill turtle interactions annually is only 1 and 0, respectively. If 2 green turtle interactions, or 1 hawksbill interaction, unexpectedly occurred in the fishery during 1 calendar year, reinitiation of consultation would be required based on the 1-year ITS. Additionally, if the fishery is closed due to reaching a turtle interaction limit, as occurred in 2006 when the loggerhead limit was reached, an additional turtle interaction could occur during the fishery closure process. If that happens, reinitiation of consultation would be required because of exceedance of the turtle interaction limit in the 1-year ITS. NMFS does not believe that these instances merit reinitiation of consultation. In order to avoid unnecessary reinitiations of consultation, NMFS has developed a 3-year ITS (Table 10), similar to that developed for the 2005 deep-set biological opinion (NMFS 2005), that will not result in any more harm to the species than a 1-year ITS, as explained below.

Reasonable and Prudent Measure No. 1 below, and its implementing Terms and Conditions, were developed to provide annual loggerhead and leatherback turtle interaction limits to minimize the incidental take of those species associated with the proposed action. In conjunction with the interaction limits, Reasonable and Prudent Measure No. 2 below, and its implementing Terms and Conditions, were developed to restrict the 3-year ITS in a manner that would not affect the turtle populations any differently than limiting incidental take over a 1-year period for 3 consecutive years. The population assessment (Snover 2008) estimated the risk posed by the proposed action, assuming a consistent annual number of adult female mortalities, based on 46 loggerhead and 19 leatherback interactions, over 3 generations (100 years for loggerheads, 63 years for leatherbacks). The Reasonable and Prudent Measures below have been structured to restrict fluctuations in the maximum possible number of annual adult female mortalities, preventing the 3-year ITS from resulting in more harm to the species than a 1-year ITS.

---

[7] Snover (2008) used fractions for model inputs rather than rounded numbers. E.g., the effect of 2.51 adult female mortalities annually was tested in the model, rather than 3 adult female mortalities. Hence, fractions are used in this opinion when referring to inputs to the model. Otherwise, adult female mortalities are given in whole numbers, rounded up from one significant digit (e.g., 1.1 to 1.9 round to 2, but 1.01 to 1.04 round to 1).

Table 10. The number of turtle interactions expected from the proposed action during 1 calendar year, and **3 consecutive calendar years**. Also shown are the total mortalities (males and females, adults and juveniles) expected to result from this number of interactions, and the annual equivalent adult female mortalities (AFMs).

	1-year			**3-year**	
Species	Interactions	Total mortalities	Equivalent AFMs[a]	**Interactions**	**Total mortalities**
Loggerhead turtles	46	10	3	**138**	**29[b]**
Leatherback turtles[c]	19 (16)[c]	5 (4)[d]	3 (2)[e]	**57 (48)[c]**	**14 (11)[d]**
Olive ridley turtles	4	1	N/A	**12**	**3**
Green turtles	1	1	N/A	**3**	**1**
Hawksbill turtles	0	0	N/A	**1**	**0**

[a] Calculated AFMs are 2.51 North Pacific loggerheads and 2.40 Western Pacific leatherbacks for the proposed action, and rounded as described in footnote 7. AFMs were not calculated or used for the 3-year period. See Sections 7.2.3 and 7.3.3 for AFM calculation methodology. AFMs not calculated for olive ridley, green, or hawksbill turtles.
[b] 138 interactions x 0.205 (post-hooking mortality rate for loggerheads, Section 7.2.3) = 28.3, round to 29.
[c] The proposed action is expected to result in up to 19 and 57 leatherback interactions during 1-year and 3-year periods respectively, as proposed. However, Reasonable and Prudent Measure No. 1 below, as implemented by Term and Condition No. 1B, stipulates an annual (1-year) interaction limit of 16 interactions for this species, with a reinitiation trigger of 48 or more interactions during a period of 3 consecutive calendar years. The rationale for the reduced annual interaction limit is provided in Section 13.4 below.
[d] 16 interactions x 0.229 (post-hooking mortality rate for leatherbacks, Section 7.3.3) = 3.7, round to 4. Likewise, 57 interactions x 0.229 = 13.1, round to 14; 48 interactions x 0.220 = 11.0.
[e] With a reduced leatherback annual interaction limit (see footnote c above), AFMs decline to 2 for this species: (16 interactions)(0.229 mortalities/capture)(0.65 females)(0.85 adult equivalent) = 2.02 AFMs, round to 2. as described in Footnote 7.

13.3 Impact of the Take

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

13.4 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 10 above for each sea turtle species. The full amount of incidental take expected from the proposed action is not authorized for leatherback turtles. For many Federal actions, it is not possible to stipulate Reasonable and Prudent Measures that reduce incidental take by a precise number of individuals in a manner that does not alter the basic design, location, scope, duration, and timing of the action. However, because the Hawaii-based shallow-set fishery has 100 percent observer coverage, NMFS is able to monitor the precise number of individual turtles that interact with the fishery. While this biological opinion has determined that incidentally taking 19 leatherback turtles annually will not jeopardize the continued existence of this species, NMFS believes that there are several reasons to be especially concerned about the conservation of Western Pacific leatherbacks, as explained below.

Baseline conditions for this population are already poor, and appear to be getting worse, as described above in this opinion, because: (1) While nesting for the Jamursba-Medi component (38 percent of total) of the Western Pacific leatherback appears somewhat stable since 1999, nesting levels in 1999-2007 were lower than in 1993-1997 (Figure 4); (2) the Jamursba-Medi nesting data upon which Figure 4 is based may over-state the number of nests (see Section 5.3.1); (3) The trends of the nesting sites in the non-Jamursba-Medi component (62 percent of the Western Pacific leatherback population) are unknown, but the best available information suggests they may be declining more rapidly than Jamursba-Medi (described in Sections 5.3.1); and (4) and the information available on the status and trends of the Western Pacific leatherback population is rather incomplete.

Thus, while the proposed action is not expected to jeopardize leatherback turtles, NMFS is concerned about the decline of the Western Pacific leatherback population. The lack of information on this population means that it could be worse off than it appears. For these reasons, NMFS believes that a cautionary approach is warranted, and is therefore setting the annual interaction limit for leatherback turtles at 16 in Reasonable and Prudent Measure No. 1 below, and its implementing Term and Condition No. 1B. An annual interaction limit of 16 reduces the estimated adult female mortalities resulting from the proposed action from 3 (rounded from 2.40) to 2 (rounded from 2.02), as shown in footnote e to Table 10. An annual interaction limit of 16 leatherbacks was set in the 2004 BiOp (NMFS 2004a).

NMFS has determined that the following reasonable and prudent measures, as implemented by the terms and conditions (identified in Section 13.5), are necessary and appropriate to minimize the impacts of the shallow-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 establish appropriate annual interaction limits for loggerhead and leatherback turtles, such that the fishery is closed when either interaction limit is reached.

2. NMFS shall implement the annual interaction limits in conjunction with the 3-year ITS (Table 10), and to prevent excessive incidental take in any given year. The trigger to reinitiate consultation shall be based on the 3-year ITS limits, and not the annual limits.

3. NMFS shall collect data on the capture, injury, and mortality caused by the shallow-set longline fishery, and shall also collect basic life-history information, as available.

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

5. 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.

6. 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.

13.5 Terms and Conditions

NMFS shall undertake and comply with the following terms and conditions to implement the reasonable and prudent measures identified in Section 13.4 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. NMFS shall establish an annual interaction limit for loggerhead turtles of 46 interactions annually, and shall close the fishery if/when the annual interaction limit is reached.

   1B. NMFS shall establish an annual interaction limit for leatherback turtles of 16 interactions annually, and shall close the fishery if/when the annual interaction limit is reached.

   1C. If either of the two sea turtle interaction limits is *reached* during a given calendar year, the Regional Administrator shall file a Federal Register notice that the interaction limit was reached, and that the shallow-set component of the Hawaii-based longline fishery is closed north of the Equator beginning on a specified date until the end of the calendar year.

   1D. Coincidental with the filing of the fishery closure notice, the Regional Administrator will also provide actual notice of the fishery closure to all holders of Hawaii longline limited access permits via the appropriate methods (e.g., telephone, satellite telephone, radio, electronic mail, facsimile transmission, or post).

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

   2A. In the event that either annual interaction limit specified in 1 above is exceeded, NMFS shall lower the following year's interaction limit by the amount it was exceeded, and include in the fishery closure notice the downward-adjusted annual interaction limit for the following calendar year.

   2B. When an annual interaction limit is not reached, NMFS shall <u>not</u> add the difference to the following year's interaction limit.

2C. NMFS shall reinitiate consultation under ESA section 7 if the amount of incidental take (either interactions or mortalities) as specified for 3 years in Table 10 is exceeded for loggerhead, olive ridley, green, or hawksbill turtles. For leatherback turtles, NMFS shall reinitiate consultation under ESA section 7 if the amount of incidental take during 3 consecutive calendar years exceeds 48 interactions or 11 mortalities (48 x 0.229 = 10.99).

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

3A. *Observers*. NMFS shall continue 100 percent observer coverage aboard Hawaii-based shallow-set longline vessels.

3B. *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 also collect life-history information on sea turtles captured by the shallow-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..

3C. *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, SWR and HQ.

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

4A. NMFS shall continue to require and conduct protected species workshops for 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.

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

4C. NMFS shall require that shallow-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-based shallow-set longline vessel carry a line clipper to cut the line as close to the hook as practicable and remove as much line as possible prior to releasing the turtle in the event a hook cannot be removed (e.g., the hook is deeply ingested or the animal is too large to bring aboard).

4D. NMFS shall require that each Hawaii-based shallow-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.

4E. NMFS shall require each shallow-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.

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

NMFS shall require that shallow-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 shall perform resuscitation techniques on comatose sea turtles if the observer is available.

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

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.

14 Literature Cited

Angliss, R.P. and D.P. DeMaster. 1998. Differentiating serious and non-serious injury of marine mammals taken incidental to commercial fishing operations: report to the serious injury workshop, 1- 2 April 1997, Silver Spring, Maryland. U.S. Dept. of Commerce, NOAA-TM-NMFS-OPR-13.

Angliss, R.P. & R.B. Outlaw. 2007. Stock Assessment Report for Humpback Whale (*Megaptera novaeangliae*), Western North Pacific, 11 p. For this and older humpback Stock Assessment Reports, go to http://www.nmfs.noaa.gov/pr/sars/species.htm#largewhales

Baker, J.D., C.L. Littnan, 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. 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. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-7.

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

Balazs, G.H. 1994. Homeward bound: satellite tracking of Hawaiian green turtles from nesting beaches to foraging pastures. P. 205-208 In: Schroeder, B. A. and B. E. Witherington (compilers). Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-341, 281 pp.

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.

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.

Bedding, S. and B. Lockhart, 1989. Sea turtle conservation emerging in Papua New Guinea. Marine Turtle Newsletter. 47: 13.

Benson, S.R., P.H. Dutton, C. Hitipeuw, B. Samber, J. Bakarbessy, and D. Parker. 2007a. Post-nesting migrations of leatherback turtles (*Dermochelys coriacea*) from Jamursba-Medi, Bird's Head Peninsula, Indonesia. Chelonian Conservation and Biology 6:150-154.

Benson, S.R., K. Kisokau, L. Ambio, V. Rei, P. Dutton, and D. Parker. 2007b. Beach use, internesting movement, and migration of leatherback turtles (*Dermochelys coriacea*) nesting on the North Coast of Papua New Guinea. Chelonian Conservation and Biology 6:7-14.

Beverly, S. and L. Chapman. 2007. Interactions between sea turtles and pelagic longline fisheries. WCPFC-SC3-EB SWG/IP-01. Western and Central Pacific Fisheries Commission, 76 p.

Bolten, A.B. 2003. Variation in life history patterns: Neritic vs. oceanic developmental stages. P. 243-257 *in* The Biology of Sea Turtles, Volume II (edited by P.L. Lutz, J. A. Musick, and J. Wyneken), CRC Press.

Calambokidis, J. and 21 others. 2008. SPLASH: Structure of populations, levels of abundance and status of humpback whales in the North Pacific. Final report for contract AB133F-03-RP-00078. Cascadia Research, Olympia, WA http://www.cascadiaresearch.org

Chaloupka, M., Bjorndal, K.A., Balazs, G.H., Bolten, A.B., Ehrhart, L.M., Limpus, C.J., Suganuma, H., Troeng, S. and M. Yamaguchi. 2007. Encouraging outlook for recovery of a once severely exploited marine megaherbivore. Global Ecology and Biogeography: 1-8.

Chaloupka, M., Kamezaki, N. 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.

Donahue, M.J. 2003. Rare sea turtle saved. Makai (Newsletter of the University of Hawaii Sea Grant College Program). 25:2.

Dutton, P.H., C, Hitipeuw, M. Zein, S.R. Benson, G. Petro, J. Pita, V. Rei, L. Ambio, and J. Bakarbessy. 2007. Status and genetic structure of nesting populations of leatherback turtles (*Dermochelys coriacea*) in the western Pacific. Chelonian Conservation and Biology. 6(1):47-53.

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.

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.

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. P. 253-295 *in* Biology and Conservation of Ridley Sea Turtles (Edited by P.T. Plotkin). The Johns Hopkins University Press, Baltimore.

Gilman, E., D., N. Brothers, G. McPherson, and P. Dalzell. 2006. A review of cetacean interactions with longline gear. Journal of Cetacean Research and Management 8:215-223.

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.

Hall, M. A., Vogel, N., and M. Orozco. 2006. Draft Report of Year Two of the Eastern Pacific Regional Sea Turtle Program. Final project report, June 2006, to the Western Pacific Regional Fishery Management Council. 72 pgs.

Hanson, J., T. Wibbels, and R.E. Martin. 1998. Predicted female bias in sex ratios of hatchling loggerhead sea turtles from a Florida nesting beach. Canadian Journal of Zoology 76: 1850-1861.

Hatase, H., Y. Matsuzawa, K. Sato, T. Bando, and K. Goto. 2004. Remigration and growth of loggerhead turtles (*Caretta caretta*) nesting on Senri Beach in Minabe, Japan: life-history polymorphism in a sea turtle population. Marine Biology 144:807-811.

Hawaii Sea Turtle Stranding Database, 2007. Green Turtle Strandings Related to Vessel Strikes in the Main Hawaiian Islands. Pacific Islands Fisheries Science Center, Honolulu, HI (data through September 2007).

Hirth, H.F., J. Kasu, and T. Mala. 1993. Observations on a leatherback turtle *Dermochelys coriacea* nesting population near Piguwa, Papua New Guinea. Biological Conservation 65:77-82.

Hitipeuw, C., P. H. Dutton, S. Benson, J. Thebu, and J. Bakarbessy. 2007. Population status and internesting movement of leatherback turtles, *Dermochelys coriacea*, nesting on the northwest coast of Papua, Indonesia. Chelonian Conservation and Biology 6:28-36.

Howell, E.A., Kobayashi, D.R., Parker, D.M., Balazs, G.H., 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. Published online July 1, 2008 (open access).

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

Jensen, A.S. and G.K. Silber. 2003. Large whale ship strike database. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-OPR-January 2004. 37 pp.

Johnston, D.W., Chapla, M.E., Williams, L.E., and D.K. Mattlia. 2007. Identification of humpback whale *Megaptera novaeangliae* wintering habitat in the Northwestern Hawaiian Islands using spatial habitat modeling. Endangered Species Research. 3: 249-257.

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. Pages 210-217 *in*: A.B. Bolten and B.E. Witherington (eds.), Loggerhead Sea Turtles. Smithsonian Institution, Washington. 319 pp.

Kamezaki, N., M. Chaloupka, Y. Matsuzawa, K. Omuta, H. Takeshita, K. Goto. In press. Long-term temporal and geographic trends in nesting abundance of the endangered loggerhead sea turtle in the Japanese Archipelago. Endangered Species Research.

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.

Kaplan, I. 2005. A risk assessment for Pacific leatherback turtles (*Dermochelys coriacea*). Canadian Journal of Fisheries and Aquatic Sciences 62:1710-1719.

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.

Kudo, H. Murakami, A., Watanabe, S. 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.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S., and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science. 17 (1): 35-75.

Largacha, E., M. Parrales, L. Rendon, V. Velasquez, M. Orozco, and M. Hall. 2005. Working with the Ecuadorian fishing community to reduce the mortality of sea turtles in longline: The first year 2004-2005. Final project report, March 2005, to the Western Pacific Regional Fishery Management Council. 57 pgs.

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: 22nd Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum, 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.

Lewison, R.L. and L.B. Crowder. 2007. Putting longline bycatch of sea turtles into perspective. Conservation Biology 21:79-86.

Limpus, C.J., M. Boyle and T. Sunderland. 2006. New Caledonian loggerhead turtle population assessment: 2005 pilot study. Pages 77-92 *in* Kinan, I. (compiler). Proceedings of the Second Western Pacific Sea Turtle Cooperative Research & Management Workshop. Vol. II: North Pacific Loggerhead Sea Turtles. Western Pacific Regional Fishery Management Council. Honolulu, HI.

Martinez, L.S., a.R. Barragan, D.G. Munoz, N. Garcia, P. Huerta, and F. Vargas. 2007. Conservation and biology of the leatherback turtle in the Mexican Pacific. Chelonian Conservation and Biology 6:70-78.

Matsuzawa, Y. 2006. Nesting beach management of eggs and pre-emergent hatchlings of north Pacific loggerhead turtles in Japan. Pages 13-22 *in* Kinan, I. (compiler). Proceedings of the Second Western Pacific Sea Turtle Cooperative Research & Management Workshop. Vol. II: North Pacific Loggerhead Sea Turtles. Western Pacific Regional Fishery Management Council. Honolulu, HI.

Matsuzawa, Y. 2008. August 15, 2008, email from Yoshimasa Matsuzawa, Sea Turtle Association of Japan, to Irene Kelly, NMFS PIRO Sea Turtle Recovery Coordinator, providing a preliminary nest total from April to July 2008 for Yakushima (Inakahama and Maehama beaches combined) of 3,927 nests.

McKracken, M. 2006. Estimation of incidental interactions with sea turtles, seabirds, and marine mammals in the 2005 Hawaii longline deep-set fishery. Pacific Islands Fishery Science Center Internal Report IR 06-006, Honolulu, HI.

McKracken, M. 2007. Estimation of incidental interactions with sea turtles, seabirds, and marine mammals in the 2006 Hawaii longline deep-set fishery. Pacific Islands Fishery Science Center Internal Report IR 07-006, Honolulu, HI.

McKracken, M. 2008. Estimation of incidental interactions with sea turtles, seabirds, and marine mammals in the 2005 Hawaii longline deep-set fishery. Pacific Islands Fishery Science Center Internal Report IR 08-007, Honolulu, HI.

Minami, H. 2008. September 10, 2008, email from Hiroshi Minami, National Research Institute of Far Seas Fisheries, Fisheries Research Agency, Japan, to Irene Kelly, NMFS PIRO Sea Turtle Recovery Coordinator, providing Suganuma's Jamursba-Medi unpublished data.

Molony, B. 2005. Estimates of the mortality of non-target species with an initial emphasis on seabirds, turtles, and sharks. Oceanic Fisheries Program, Secretariat of the Pacific Community.

Moore, S.E. and H.P. Huntington. 2008. Arctic marine mammals and climate change: impacts and resilience. Ecological Applications. 18 (2) Supplement: S157-S165.

National Marine Fisheries Service. 1991. Final recovery plan for the humpback whale, *Megaptera novaeangliae.* 115 p.

National Marine Fisheries Service (NMFS). 2001. Final Environmental Impact Statement for Fishery Management Plan, Pelagic Fisheries of the Western Pacific Region. March 30, 2001.

National Marine Fisheries Service (NMFS). 2004a. Biological Opinion on Proposed Regulatory Amendments to the Fisheries Management Plan for the Pelagic Fisheries of the Western Pacific Region. Southwest Region, 281 p.

National Marine Fisheries Service (NMFS). 2004b. Management Measures to Implement New Technologies for the Western Pacific Longline Fisheries including a Final Supplemental Environmental Impact Statement. Pacific Islands Regional Office, 310 p.

National Marine Fisheries Service (NMFS). 2004c. An assessment framework for conducting jeopardy analyses under Section 7 of the Endangered Species Act: A background paper. Modified October 6th, 2004.

National Marine Fisheries Service (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.

National Marine Fisheries Service (NMFS). 2006a. 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.

National Marine Fisheries Service (NMFS). 2006b. Report of the Workshop on Marine Turtle Longline Post-Interaction Mortality (By C.E. Ryder, T.A. Conant, and B.A. Schroeder), NOAA Technical Memorandum NMFS-OPR-29. 40 p.

National Marine Fisheries Service. 2008a. Summary of Hawaii Longline Fishing Regulations. April 7, 2008. NMFS Pacific Island Regional Office, 9 p.

National Marine Fisheries Service. 2008b. June 9, 2008, draft biological opinion on the effects of the activities associated with the Navy's Hawaii Range Complex.

National Marine Fisheries Service. 2008c. February 1, 2008, memo from Chris Yates, Pacific Islands Regional Office, re: Observed captures and estimated mortality of sea turtles in the Hawaii shallow-set longline fishery, 2004-2007.

National Marine Fisheries Service. 2008d. July 25, 2008, memo from Lance Smith, Pacific Islands Regional Office, to the files re: Environmental Baseline for shallow-set fishery: HI-based longline mean annual turtle mortalities 2005-07.

National Marine Fisheries Service. 2008e. March 18, 2008, 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 Regional Office, 35 p.

National Marine Fisheries Service. 2008f. July 25, 2008, memo from Lance Smith, Pacific Islands Regional Office, to the files re: Loggerhead information: sex ratios, carapace length, adult equivalents.

National Marine Fisheries Service. 2008g. July 27, 2008, memo from Lance Smith, Pacific Islands Regional Office, to the files re: Leatherback information: sex ratios, carapace length, adult equivalents.

National Marine Fisheries Service. 2008h. August 20, 2008, memo from Lance Smith, Pacific Islands Regional Office, to the files re: Status of non-Jamursba-Medi Western Pacific leatherbacks.

National Marine Fisheries Service and U.S. Fish & Wildlife Service. 2007a. Loggerhead Sea Turtle (*Caretta caretta*). 5-Year Review: Summary and Evaluation. 81 p.

National Marine Fisheries Service and U.S. Fish & Wildlife Service. 2007b. Leatherback Sea Turtle (*Dermochelys coriacea*). 5-Year Review: Summary and Evaluation. 67 p.

National Marine Fisheries Service and U.S. Fish & Wildlife Service. 2007c. Olive Ridley Sea Turtle (*Lepidochelys olivacea*). 5-Year Review: Summary and Evaluation. 67 p.

National Marine Fisheries Service and U.S. Fish & Wildlife Service. 2007d. Green Sea Turtle (*Chelonia mydas*). 5-Year Review: Summary and Evaluation. 105 p.

National Marine Fisheries Service and U.S. Fish & Wildlife Service. 2007e. Hawksbill Sea Turtle (*Eretmochelys imbricata*). 5-Year Review: Summary and Evaluation. 93 p.

Ohmuta, K. 2006. The sea turtle situation of Yakushima Island. Pages 23-26 *in* Kinan, I. (compiler). Proceedings of the Second Western Pacific Sea Turtle Cooperative Research & Management Workshop. Vol. II: North Pacific Loggerhead Sea Turtles. Western Pacific Regional Fishery Management Council. Honolulu, HI.

Pacific Islands Fishery Science Center (PIFSC). 2008. Hawaii Longline Fishery Logbook Statistics—Summary Tables: 2007 annual tables, p. 6.

Parker, D.M., Cooke, W., 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., G.H. Balazs, C. King, L. Katahira, and W. Gilmartin. In review. Short-range movements of post-nesting hawksbill turtles (*Eretmochelys imbricata*) in the Hawaiian Islands. Pacific Science.

Patino-Martinez, J., A. Marco, L. Quinones, and B. Godley. 2008. Globally significant nesting of the leatherback turtle (*Dermochelys coriacea*) on the Caribbean coast of Columbia and Panama. Biological Conservation 141:1982-88.

Peckham S.H., D. Maldonado-Diaz, A.Walli, G. Ruiz, 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, published on-line October 13, 2008 (open access).

Petro, G., F. Hickey and K.T. MacKay. 2007. Leatherback turtles in Vanuatu. Chelonian Conservation and Biology. 6:135-137.

Pilcher, N. 2006. Final Report: The 2005-2006 leatherback nesting season, Huon Coast, Papua New Guinea. Report prepared for the Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, 39 p.

Pilcher, N. 2007. The Huon Coast leatherback conservation project. Report prepared for the Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, 18 p.

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.

Price, E.R., B.P. Wallace, R.D. Reina, J.R. Spotila, F.V. Paladino, R. Piedra, E. Velez. 2006. Size, growth and reproductive output of adult female leatherback turtles. Endangered Species Research 1:41-48.

Quinn, N., B. Anguru, K. Chee, O. Keon, and P. Muller. 1983. Preliminary survey of leatherback rookeries in Morobe Province with notes on their biology. Research Report, The Papua New Guinea University of Technology, Department of Fisheries. Report Series No. 1, March 1983, 20 p.

Quinn, N.J. and B.L. Kojis. 1985. Leatherback turtles under threat in Morobe Province, Papua New Guinea. PLES: An Environmental Education Magazine for the South Pacific Region 1:79-99.

Rasmussen, K., Palacios, D.M., Calambokidis, J., Saborio, M.T., Dalla Rosa, L., Secchi, E.R., Steiger, G.H., Allen, J.M., and G.S. Stone. 2007. Southern Hemisphere humpback whales off Central America: insights from water temperature into the longest mammalian migration. Biology Letters. 3: 302-305.

Rausser, G., M. Kovach, and S. Hamilton. Undated manuscript. Unintended consequences of a Hawaiian longline pelagic fisheries closure: Implications for Pacific sea turtles. 49 p.

Rausser, G., S. Hamilton, M. Kovach, and R. Sifter. 2008. Unintended Consequences: The spillover effects of common property regulations. Marine Policy, doi:10.1016/j.marpol.2008.03.020

Robins, C.M., S.J. Bache, and S.R. Kalish. 2002. Bycatch of sea turtles in longline fisheries – Australia. Bureau of Rural Sciences: Final Report. Canberra, Australia. Fisheries Resources Research Fund. 133 p.

Sarmiento, C. 2006. Transfer function estimation of trade leakages generated by court rulings in the Hawaii longline fishery. Applied Economics 38:183-190.

Sasso, C.R. and S.P. Epperly. 2007. Survival of pelagic juvenile loggerhead turtles in the open ocean. Journal of Wildlife Management 71:1830-1835.

Seitz, W. and K. Kagimoto. 2008. Hawaii Island Hawksbill Turtle Recovery Project: 2007 Annual Report. Hawaii Volcanoes National Park, 11 p.

Shankar, K., B. Pandav, and B.C. Choudhury. 2004. An assessment of the olive ridley turtle (*Lepidochelys olivacea*) nesting population in Orissa, India. Biological Conservation 115:149-160.

Shillinger, G.L., D.M. Palacios, H. Bailey, S.J. Bograd, and A.M. Swithbank. 2008. Persistent leatherback turtle migrations present opportunities for conservation. PLoS Biol 6(7):e171.doi:10.1371/journal.pbio.0060171.

Snover, M., J. Baker, and M. Sullivan. 2007. U.S. Pacific Islands Research Plan for Green (excluding Hawaii) and Hawksbill Turtles. Pacific Islands Fisheries Science Center, February 2007 draft, 47 p.

Snover, M. 2008. Assessment of the population-level impacts of potential increases in marine turtle interactions resulting from a Hawaii Longline Association proposal to expand the Hawaii-based shallow-set fishery. National Marine Fisheries Service, Pacific Islands Fishery Science Center, Honolulu. PIFSC Internal Report IR-08-010, 30 p.

Snover, M.L. and S.S. Heppell. In Press. Application of diffusion approximation for risk assessment of sea turtle populations. Ecological Applications.

Spotila, J.R. 2004. Sea Turtles. The John Hopkins and University Press. Baltimore, Maryland. 227 p.

State of the World's Sea Turtles (SWOT). 2006-2007. SWOT Report, Vol. II. Edited by Mast, R.B., L.M. Bailey, B,J. Hutchinson, A. Hutchinson, K. Koinig, and M.S. Rowe. Arlington, VA 46 p.

State of the World's Sea Turtles (SWOT). 2007-2008. SWOT Report, Vol. III. Edited by Mast, R.B., L.M. Bailey, B,J. Hutchinson, P.E. Villegas, A. Hutchinson, K. Koinig, and M.S. Rowe. Arlington, VA 48 p.

Steering Committee, Bellagio Sea Turtle Conservation Initiative. 2008. Strategic Planning for Long-term Financing of Pacific Leatherback Conservation and Recovery: Proceedings of the Bellagio Sea Turtle Conservation Initiative, Terengganu, Malaysia; July 2007. WorldFish Center Conference Proceedings 1805, The WorldFish Center, Penang, Malaysia. 79 p.

Suárez, A. and C.H. Starbird. 1996. Subsistence hunting of leatherback turtles, *Dermochelys coriacea*, in the Kei Islands, Indonesia. Chelonian Conservation and Biology 2(2): 190-195.

Suganuma, H. 2005. Leatherback turtle management of feral pig predation in Indonesia. In: Proceedings of the Second Western Pacific Sea Turtle Cooperative Research and Management Workshop. Volume I: West Pacific Leatherback and Southwest Pacific Hawksbill Sea Turtles (Edited by I. Kinan). May 17-21, 2004, Western Pacific Regional Fishery Management Council (WPFMC), 2005. Honolulu, HI.

Swimmer, Y., M. Chaloupka, L.M. McNaughton, M. Musyl, and R. Brill. In Press. Bayesian hazard regression modeling of factors affecting post-release mortality of loggerhead sea turtles caught in pelagic longline fisheries. Ecological Applications.

Tomillo, P.S., E. Velez, R.D. Reina, R. Piedra, F.V. Paladino, and J.R. Spotila. 2007. Reassessment of the leatherback turtle (*Dermochelys coriacea*) nesting population at Parque Nacional Marino Las Baulas, Costa Rica: Effects of conservation efforts. Chelonian Conservation and Biology 6:54-62.

Turtle Expert Working Group (TEWG). 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-555. 116 p.

U.S. Fish & Wildlife Service and National Marine Fisheries Service. 1998. Endangered species consultation handbook: procedures for conducting consultation and conference activities under section 7 of the Endangered Species Act.

Vaughn, P.W. 1981. Marine turtles: a review of their status and management in the Solomon Islands. World Wildlife Fund Report No. 1452, 70 pp.

Wallace, B.P., S.S. Heppell, R.L. Lewison, S. Kelez, and L.B. Crowder. 2008. Impacts of fisheries bycatch on loggerhead turtles worldwide inferred from reproductive value analysis. Journal of Applied Ecology 45:1076-1085.

Watson, J.W., S.P. Epperly, A.K. Shah, and D.G. Foster. 2005. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. Canadian Journal of Fisheries and Aquatic Science 62:965-981.

Western Pacific Fishery Management Council (WPFMC), 2004. Management Measures to Implement New Technologies for the Western Pacific Pelagic Longline Fisheries. March 5, 2004, 310 p.

Western Pacific Fishery Management Council (WPFMC), 2005. Proceedings of the Second Western Pacific Sea Turtle Cooperative Research and Management Workshop. Volume I: West Pacific Leatherback and Southwest Pacific Hawksbill Sea Turtles (Edited by I. Kinan). May 17-21, 2004, Honolulu, HI.

Western Pacific Fishery Management Council (WPFMC), 2006a. Pelagic Fisheries of the Western Pacific Region. 2006 Annual Report. 287 p.

Western Pacific Regional Fishery Management Council (WPFMC), 2006b. Proceedings of the Second Western Pacific Sea Turtle Cooperative Research and Management Workshop. Volume II: North Pacific Loggerhead Turtles (Edited by I. Kinan). March 2-3, 2005, Honolulu, HI.

Western Pacific Regional Fishery Management Council (WPFMC), 2008. Management Modifications for the Hawaii-based Shallow-set Longline Swordfish Fishery: Proposal to Remove Effort Limit, Eliminate Set Certificate Program, and Implement New Sea Turtle Interaction Caps. Draft Amendment 18 to the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region Including a Draft Supplemental Environmental Impact Statement. August 12, 2008.

Wurlianty, B. and C. Hitipeuw. 2006. Leatherback Conservation at War-mon Beach, Papua, Indonesia: October 2005 to October 2006. Final Report prepared for the Western Pacific Regional Fishery Management Council, Honolulu, Hawaii.

Wurlianty, B. and C. Hitipeuw. 2007. Leatherback Conservation at Warmon Beach, Papua-Indonesia. Final Report for the period of November 2006-December 2007. (Ref: No. 04-WPC-034). World Wildlife Fund, 8 p.

Yeung, C. 1999. Estimates of marine mammal and marine turtle bycatch by the U.S. Atlantic pelagic longline fleet in 1998. NOAA Technical Memorandum NMFS-SEFSC-430, 29 p.