Combined effects of U.S. Pacific Islands longline fisheries on endangered leatherback (western Pacific) and loggerhead (North Pacific) turtle populations

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This analysis examines the combined effects of three U.S. fisheries on two populations of endangered turtles. The fisheries include the Hawaii-based shallow-set longline (SSLL) fishery which targets swordfish, the Hawaii-based deep-set longline (DSLL) fishery which targets tuna, and the American Samoa-based longline (ASLL) fishery (deep-set) which also targets tuna. The turtle populations include the western Pacific (WP) leatherback population and the North Pacific (NP) loggerhead Distinct Population Segment (DPS). All three fisheries interact with the WP leatherback population, but only the SSLL and DSLL fisheries interact with the NP loggerhead DPS (i.e., the ASLL fishery has no observed or estimated impact on the NP loggerhead DPS). For full details please see NOAA NMFS PIFSC technical memoranda TM-PIFSC-95 and TM-PIFSC-101 (Martin et al. 2020a; 2020b).

The modeling process involves:

1. Fitting an exponential growth model to nesting beach population trends, to estimate a distribution of population growth rates.
2. Calculating mortality rates of intercepted turtles based on a bivariate distribution of mortality and size.
3. Converting turtles intercepted in the longline fisheries to adult nester equivalents (ANEs) given the historical observed size and estimated mortality in each fishery.
4. Adding the estimated ANEs (i.e., from the fisheries combined estimated take) into the historical nesting data set in the appropriate years and removing the projected ANEs from the adult nesting forecasts.

Results from the combined effects take model are summarized in Figures 1 and 2 and Tables 1 through 4, following the format provided in Martin et al. (2020a) and Martin et al. (2020b). When the combined effect of the fisheries is considered, the expected fishery effects are the equivalent of ~1.6 annual nesters at year 10 for the WP leatherback population (Figure 1). Irrespective of take, this population is anticipated to fall below threshold population levels after 100 years with 100% certainty (Table 1). Fishery take has little impact on the timing of reaching these threshold levels for WP leatherbacks (Table 2). The SSLL and DSLL fisheries are estimated to reduce the NP loggerhead DPS ~0.15 annual nesters by year 10. Fishery take is not estimated to have an impact on the time to reach threshold levels for NP loggerheads (Tables 3 and 4).

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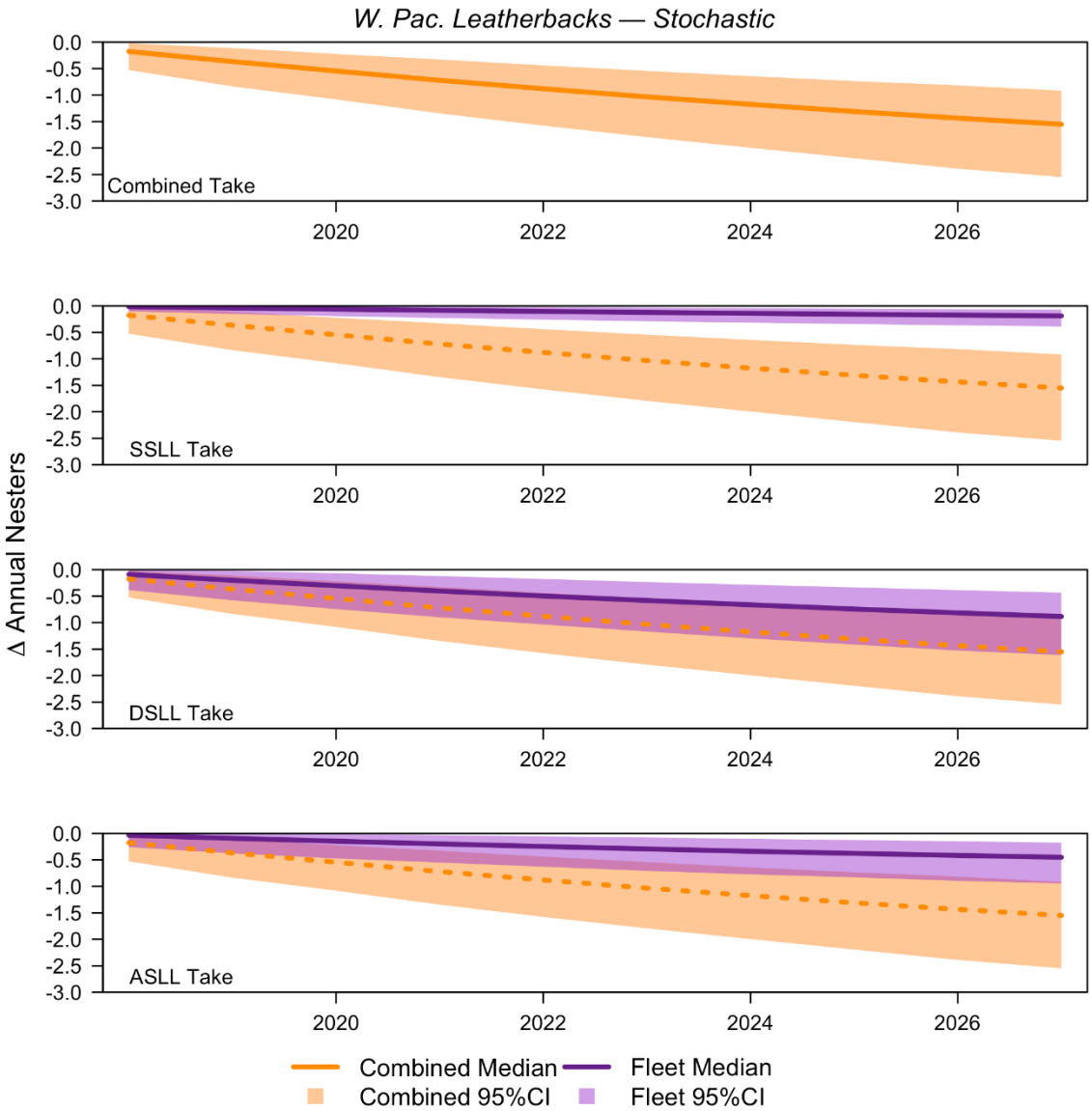

Figure 1. For the western Pacific leatherback population, differences in 10-year annual nester abundance projections under different take scenarios. Top panel is the difference between the unaltered population projections (i.e., no future take by the U.S. Pacific Islands longline fisheries) and projections that incorporate future take from the SSLL, DSLL, and ASLL fisheries combined (median line with 95% credible interval [CI] shaded). At the 10-year point, the median combined effect of the three fisheries is a loss of approximately 1.6 annual nesters. The subsequent panels show the effect of take from the individual fisheries on the population projection. At the 10-year point, the median effects are approximately 0.2 annual nester for the SSLL fishery, 0.9 annual nester for the DSLL fishery, and 0.5 annual nester for the ASLL fishery. Results come from the stochastic take model and incorporate historical ANEs added back into the population. Results are also based on median monthly leatherback nest counts estimated by the imputation model in Martin et al. (2020a) and Martin et al. (2020b).

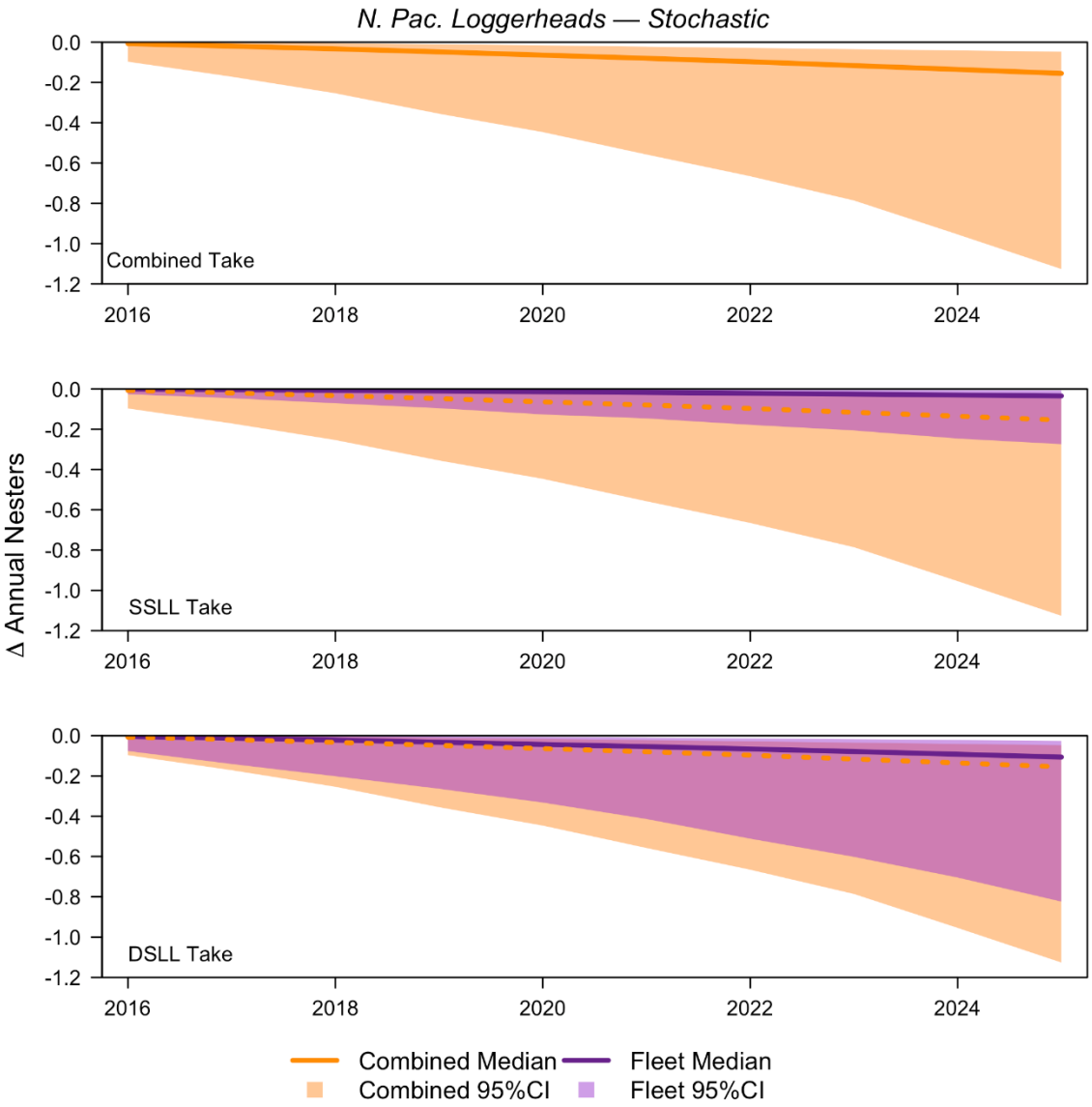

Figure 2. For the North Pacific loggerhead population, differences in 10-year annual nester abundance projections under different take scenarios. The top panel is the difference between the unaltered population projections (i.e., no future take by the U.S. Pacific Islands longline fisheries) and projections that incorporate future take from the SSLL and DSLL fisheries combined (median line with 95% credible interval [CI] shaded). At the 10-year point, the median combined effect of the two fisheries is a difference of approximately 0.15 annual nester. The subsequent panels show the effect of take from the individual fisheries on the population projection. At the 10-year point, the median effects are approximately 0.04 annual nester for the SSLL fishery and 0.11 annual nester for the DSLL fishery. Results come from the stochastic take model and incorporate historical ANEs added back into the population. Results are also based on median monthly leatherback nest counts estimated by the imputation model in Martin et al. (2020a) and Martin et al. (2020b).

Table 1. Time to reach abundance thresholds for the western Pacific leatherback population, including the combined effects of the DSLL, SSLL, and ASLL fisheries take on the population projections. The probability of the population being above or below ($p > \theta$ or $p < \theta$, respectively) abundance thresholds (θ = 50%, 25%, 12.5% of current Annual Nesters) within the 100-year simulation time frame, and the number of years (mean, median, & 95% credible interval [CI]) to reach each threshold for all runs that fall below them. Results are from the stochastic take model, both with and without take, and with historical ANEs added back into the population. Δ(NT – T) shows the difference between the take and no-take projection scenarios.

Threshold	Scenario	$p > \theta$	$p < \theta$	Mean yr	Median yr	L95% yr	U95% yr
50%	No Take	0	1	12.9	12	6	26
	Take	0	1	12.7	12	6	25
	Δ(NT – T)	0	0	0.2	0	0	1
25%	No Take	0	1	24.7	24	14	41
	Take	0	1	24.1	23	13	40
	Δ(NT – T)	0	0	0.6	1	1	1
12.50%	No Take	0	1	36.5	36	22	56
	Take	0	1	35.2	34	21	54
	Δ(NT – T)	0	0	1.3	2	1	2

Table 2. For western Pacific leatherbacks, the probability of reaching abundance thresholds at specified future times, with the combined effects of the DSLL, SSLL, and ASLL longline fisheries take on the probabilities. The probability (median with 95% credible intervals [CI]) of the population reaching abundance thresholds at 5, 10, 25, 50, and 100 years from final data year (2015). Results from the stochastic version of the take model accounted for historical takes by adding the ANEs back into the population. Scenarios with and without take are provided, with Δ(NT – T) showing the difference between the two scenarios.

Threshold	Scenario	5 yr	10 yr	25 yr	50 yr	100 yr
50%	No Take	0.02	0.37	0.97	1	1
	Take	0.02	0.38	0.98	1	1
	Δ(NT – T)	0	−0.01	−0.01	0	0
50%-L95	No Take	0.02	0.37	0.97	1	1
	Take	0.02	0.38	0.98	1	1
	Δ(NT – T)	0	−0.01	−0.01	0	0
50%-U95	No Take	0.02	0.38	0.98	1	1
	Take	0.02	0.39	0.98	1	1
	Δ(NT – T)	0	−0.01	0	0	0
25%	No Take	0	0	0.60	1	1
	Take	0	0	0.62	1	1
	Δ(NT – T)	0	0	−0.02	0	0
25%-L95	No Take	0	0	0.59	1	1
	Take	0	0	0.61	1	1
	Δ(NT – T)	0	0	−0.02	0	0
25%-U95	No Take	0	0	0.60	1	1
	Take	0	0	0.62	1	1
	Δ(NT – T)	0	0	−0.02	0	0
12.5%	No Take	0	0	0.08	0.93	1
	Take	0	0	0.10	0.95	1
	Δ(NT – T)	0	0	−0.02	−0.02	0
12.5%-L95	No Take	0	0	0.08	0.93	1
	Take	0	0	0.10	0.94	1
	Δ(NT – T)	0	0	−0.02	−0.01	0
12.5%-U95	No Take	0	0	0.09	0.93	1
	Take	0	0	0.10	0.95	1
	Δ(NT – T)	0	0	−0.01	−0.02	0

Table 3. Time to reach abundance thresholds for the North Pacific loggerhead population, including the combined effects of the DSLL and SSLL fisheries take on the population projections. The probability of the population being above or below ($p > \theta$ or $p < \theta$, respectively) abundance thresholds (θ = 50%, 25%, 12.5% of current Annual Nesters) within the 100-year simulation time frame, and the number of years (mean, median, & 95% credible interval [CI]) to reach each threshold for all runs that fall below them. Results are from the stochastic take model, both with and without take, and with historical ANEs added back into the population. Δ(NT – T) shows the difference between the take and no-take projection scenarios.

Threshold	Scenario	$p > \theta$	$p < \theta$	Mean yr	Median yr	L95% yr	U95% yr
50%	No Take	0.68	0.32	24.4	17	5	82.7
	Take	0.68	0.32	24.4	17	5	82.5
	Δ(NT – T)	0	0	0	0	0	0.2
25%	No Take	0.72	0.28	36.7	30	10	91
	Take	0.72	0.28	36.7	30	10	91
	Δ(NT – T)	0	0	0	0	0	0
12.50%	No Take	0.75	0.25	45.2	40	14	95
	Take	0.75	0.25	45.2	40	14	96
	Δ(NT – T)	0	0	0	0	0	1

Table 4. For North Pacific loggerheads, the probability of reaching abundance thresholds at specified future times, with the combined effects of the DSLL and SSLL longline fisheries take on the probabilities. The probability (median with 95% credible intervals [CI]) of the population reaching abundance thresholds at 5, 10, 25, 50, and 100 years from final data year (2015). Results come from the stochastic version of the take model with historical takes accounted for by adding the ANEs back into the population. Scenarios with and without take are provided, with Δ(NT – T) showing the difference between the two scenarios.

Threshold	Scenario	5 yr	10 yr	25 yr	50 yr	100 yr
50%	No Take	0.01	0.09	0.21	0.28	0.32
	Take	0.01	0.09	0.21	0.28	0.32
	Δ(NT – T)	0	0	0	0	0
50%-L95	No Take	0.01	0.08	0.21	0.28	0.32
	Take	0.01	0.08	0.21	0.28	0.32
	Δ(NT – T)	0	0	0	0	0
50%-U95	No Take	0.01	0.09	0.22	0.29	0.32
	Take	0.01	0.09	0.22	0.29	0.32
	Δ(NT – T)	0	0	0	0	0
25%	No Take	0	0.01	0.12	0.21	0.28
	Take	0	0.01	0.12	0.21	0.28
	Δ(NT – T)	0	0	0	0	0
25%-L95	No Take	0	0.01	0.11	0.21	0.28
	Take	0	0.01	0.11	0.21	0.28
	Δ(NT – T)	0	0	0	0	0
25%-U95	No Take	0	0.01	0.12	0.22	0.29
	Take	0	0.01	0.12	0.22	0.29
	Δ(NT – T)	0	0	0	0	0
12.5%	No Take	0	0	0.06	0.16	0.25
	Take	0	0	0.06	0.16	0.25
	Δ(NT – T)	0	0	0	0	0
12.5%-L95	No Take	0	0	0.06	0.16	0.24
	Take	0	0	0.06	0.16	0.25
	Δ(NT – T)	0	0	0	0	−0.01
12.5%-U95	No Take	0	0	0.06	0.16	0.25
	Take	0	0	0.06	0.16	0.25
	Δ(NT – T)	0	0	0	0	0

References

Martin SL, Siders Z, Eguchi T, Langseth BJ, Yau A, Baker JD, Ahrens R, Jones TT. 2020a. Assessing the population level impacts of North Pacific loggerhead and western Pacific leatherback interactions in the Hawaii-based shallow set longline fishery. NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-95. 60 p. doi:10.25923/ydp1-f891.

Martin SL, Siders Z, Eguchi T, Langseth BJ, Yau A, Baker JD, Ahrens R, Jones TT. 2020b. Update to assessing the population-level impacts of North Pacific loggerhead and western Pacific leatherback interactions: Inclusion of Hawaii-based deep-set and American Samoa-based longline fisheries. NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-101. 62 p. doi:10.25923/pnf2-2q77.