APPENDIX I

Donald Kobayashi, *Predicting Sea Turtle Take, Mortality, and Pelagic Fish Catch Under the Five WPRFMC Management Scenarios for the Hawaii-based Longline Fishery*

Predicting Sea Turtle Take, Mortality, and Pelagic Fish Catch Under the Five WPRFMC Management Scenarios for the Hawaii-based Longline Fishery

Donald R. Kobayashi
PIFSC/NMFS/NOAA
December 9, 2003

Purpose

This analysis evaluates the 5 management scenarios suggested by the WPRFMC in the "Draft Action Memorandum -- Sea Turtle Conservation Special Advisory Committee 1st Meeting, October 27-28, 2003" with regard to sea turtle take, mortality, pelagic fish catch, and associated uncertainty. To simplify, scenario 1 allows 75% of historic shallow set effort (approximately 3179 sets) and no southern closure for deep set effort (eliminates the fishing ban south of 15N April-May). Scenario 2 allows 50% of historic shallow set effort (approximately 2120 sets) and allows the Palmyra EEZ to be fished during the southern closure months of April-May. Scenario 3 allows 25% of historic shallow set effort (approximately 1060 sets) and no southern closure for deep set effort. Scenario 4 allows 1560 shallow sets (approximately 36.8% of historic shallow set effort) and no southern closure for deep set effort. Scenario 5 allows 50% of historic shallow set effort (approximately 2120 sets) and no southern closure for deep set effort. Additionally, all scenarios require shallow set longline gear compliance with the Atlantic measures shown by Watson et al. (2003) to reduce the incidence of sea turtle take. These are the extent of scenarios as understood as of 11/14/2003 3PM HST.

Methods

Longline logbook (1994 - 1999 for historical pre-litigation baseline) and observer data (trips #1 - #1068 spanning March 1994 - August 2003) were used in a stratification / expansion approach to predict likely sea turtle takes. This approach splits the two datasets into common strata, and expands the observed sea turtle take into the entire logbook dataset using fishing effort (individual set of longline fishing gear) as the common denominator. Pertinent strata include type of longline gear set (deep vs. shallow), month of the fishing activity, and spatial strata relevant to existing or proposed management (e.g. north or south of 15N, or within Palmyra EEZ). Total fishing effort was conserved by reallocation. Fishing effort reallocation involving changes in gear type transferred fishing effort to other gear type within the same monthly and spatial strata. If reallocation could not be accomplished due to a time/area closure then the fishing effort was transferred to the adjacent spatial strata where fishing was allowed. Predicted sea turtle takes on shallow set gear were further modified using the results of the Watson et al. (2003) report documenting effective sea turtle mitigation techniques in the Atlantic (92% reduction in hardshell sea turtle take, 67% reduction in leatherback sea turtle take). To examine variability, several different approaches amenable to each of the data sources were used. For sea turtle take uncertainty, the longline observer database was bootstrapped 100 times, and a stratification / expansion exercise was accomplished for each bootstrapped data set. For uncertainty in the Atlantic measures, the region bounded by the 95% confidence intervals from the Watson et al. (2003) report was uniformly sampled for hardshell sea turtles (73%-97% reduction) and leatherback sea turtles (38%-82% reduction). This approach of sampling from a uniform distribution is considered precautionary or conservative since less emphasis is placed on a mean or any region of increased probability, and is consistent with Bayesian approaches to handling uncertainty. For each of the bootstrapped sea turtle take estimates, a corresponding randomly drawn reduction value was sampled from the Atlantic measures 95% confidence region and applied. The resultant sea turtle take distributions were sorted and sampled using the percentile method, extracting values at 2.5% and 97.5% for the 95% confidence intervals. Sea turtle mortality was estimated by multiplying the take estimates by mortality rates (Boggs, 2003 pers. comm., see Table 1) recalculated from 1994-1999 observer data, using the Hogarth Memo guidelines. For fish catch uncertainty, the longline logbook data was subset into 6 annual groupings of data. The proposed management measures were evaluated for each annual grouping for each species of interest, and the parametric 95% confidence intervals were estimated. The approach differs from that of sea turtle take estimation since fish catch is well represented in the logbook data which covers the entire fleet, whereas the relatively rare events of sea turtle takes are estimated from a small subset of fishing effort under observer coverage. Since the primary focus of this analysis is sea turtle take, the Atlantic measures were not used to modify predicted fish catch. While these measures appear to significantly increase swordfish catch and decrease bigeye tuna catch in the Atlantic, there are no data available for other species of economic value in Hawaii, and utilizing the changes for just 2 species could be misleading.

Results

Table 1 shows the predicted sea turtle takes and mortalities for each of the scenarios. Predictions are presented both in terms of absolute number of sea turtles in a year as well as the corresponding percent change from the baseline (1994-1999 average) value. The baseline values are also presented for reference. The mortality rates provided by Boggs (2003 pers. comm.) are also shown in Table 1. Table 2 shows the predicted fish catch for each of the scenarios. Predictions are presented both in terms of absolute number of fish caught in a year as well as the corresponding percent change from the baseline (1994-1999 average) value. The baseline values are also presented for reference. It should be noted that the price data used for the revenue calculation are based on a 1998 dataset of dealer prices stratified into cells of species, month, and trip type combinations. While prices have undoubtedly changed since 1998, the use of more recent data would not provide prices for all species, month, and trip type cell combinations due to management measures such as the elimination of shallow set fishing gear in March 2001. Hence the revenue estimate should be treated with some caution, since it is based on 1998 data but cannot be easily updated to reflect current price structure or supply / demand dynamics.

Literature cited

Watson, J. W., D. G. Foster, S. Epperly, and A. Shah. Experiments in the Western Atlantic Northeast distant waters to evaluate sea turtle mitigation measures in the pelagic longline fishery – Report on experiments conducted in 2001 and 2002. http://148.114.89.175/mslabs/docs/watson2.pdf

Table 1. Sea turtle take and mortality predictions, percent changes from baseline values, and baseline values for each of the 5 WPRFMC scenarios differentiated by gear type (S = shallow set, D = deep set, T = total). LOG = loggerhead sea turtle, LEA = leatherback sea turtle, RID = olive ridley sea turtle, and GRE = green sea turtle. The notations 1,2,3,4, and 5 appended to the species code signify the WPRFMC scenario #, as numbered in the original action memo. The mortality rates are also presented.

	Total annual number of takes			Total annual number of mortalities			Percent change from baseline		
	Mean	95%CI Lo	95%CI Hi	Mean	95%CI Lo	95%CI Hi	Mean	95%CI Lo	95%CI Hi
LOG1-S	24.85	11.17	82.35	8.87	3.99	29.40	*-94.04%*	*-97.32%*	*-80.24%*
LEA1-S	23.74	13.63	45.08	6.48	3.72	12.31	*-76.56%*	*-86.54%*	*-55.49%*
RID1-S	7.16	2.99	24.10	2.79	1.17	9.40	*-94.27%*	*-97.61%*	*-80.72%*
GRE1-S	2.16	0.89	7.20	0.62	0.26	2.08	*-94.16%*	*-97.60%*	*-80.57%*
LOG1-D	3.67	0.78	7.75	2.52	0.54	5.32	*387.85%*	*4.25%*	*931.20%*
LEA1-D	17.33	8.46	29.12	8.89	4.34	14.94	*59.17%*	*-22.28%*	*167.49%*
RID1-D	32.13	18.25	52.46	28.21	16.03	46.06	*50.55%*	*-14.48%*	*145.77%*
GRE1-D	4.76	1.35	10.69	3.03	0.86	6.79	*60.85%*	*-54.45%*	*260.80%*
LOG1-T	28.52	11.95	90.10	11.39	4.53	34.72	*-93.17%*	*-97.14%*	*-78.42%*
LEA1-T	41.07	22.09	74.20	15.37	8.06	27.25	*-63.39%*	*-80.31%*	*-33.85%*
RID1-T	39.29	21.25	76.56	31.01	17.19	55.46	*-73.15%*	*-85.48%*	*-47.68%*
GRE1-T	6.93	2.24	17.88	3.65	1.11	8.86	*-82.69%*	*-94.40%*	*-55.30%*
LOG2-S	16.57	7.45	54.90	5.92	2.66	19.60	*-96.02%*	*-98.21%*	*-86.83%*
LEA2-S	15.82	9.09	30.05	4.32	2.48	8.20	*-84.38%*	*-91.03%*	*-70.33%*
RID2-S	4.77	2.00	16.07	1.86	0.78	6.27	*-96.18%*	*-98.40%*	*-87.15%*
GRE2-S	1.44	0.59	4.80	0.42	0.17	1.39	*-96.11%*	*-98.40%*	*-87.05%*
LOG2-D	4.07	0.84	8.76	2.80	0.57	6.02	*442.17%*	*11.37%*	*1065.96%*
LEA2-D	9.85	4.48	18.51	5.05	2.30	9.49	*-9.54%*	*-58.86%*	*69.98%*
RID2-D	38.66	22.19	61.77	33.94	19.49	54.24	*81.10%*	*3.98%*	*189.41%*
GRE2-D	6.10	1.83	14.07	3.87	1.16	8.93	*105.91%*	*-38.33%*	*374.95%*
LOG2-T	20.64	8.28	63.66	8.71	3.23	25.62	*-95.06%*	*-98.02%*	*-84.75%*
LEA2-T	25.67	13.56	48.56	9.37	4.78	17.70	*-77.11%*	*-87.91%*	*-56.71%*
RID2-T	43.43	24.19	77.84	35.80	20.26	60.50	*-70.32%*	*-83.47%*	*-46.81%*
GRE2-T	7.54	2.42	18.86	4.29	1.33	10.32	*-81.15%*	*-93.95%*	*-52.84%*

LOG3-S	8.28	3.72	27.45	2.96	1.33	9.80	*-98.01%*	*-99.11%*	*-93.41%*
LEA3-S	7.91	4.54	15.03	2.16	1.24	4.10	*-92.19%*	*-95.51%*	*-85.16%*
RID3-S	2.39	1.00	8.03	0.93	0.39	3.13	*-98.09%*	*-99.20%*	*-93.57%*
GRE3-S	0.72	0.30	2.40	0.21	0.09	0.69	*-98.05%*	*-99.20%*	*-93.52%*
LOG3-D	4.48	0.89	9.74	3.08	0.61	6.69	*496.49%*	*18.50%*	*1196.58%*
LEA3-D	19.46	10.04	31.72	9.98	5.15	16.27	*78.74%*	*-7.81%*	*191.36%*
RID3-D	42.32	24.01	67.85	37.15	21.08	59.57	*98.24%*	*12.47%*	*217.88%*
GRE3-D	6.35	1.85	14.38	4.04	1.18	9.13	*114.56%*	*-37.38%*	*385.58%*
LOG3-T	12.77	4.61	37.19	6.04	1.94	16.49	*-96.94%*	*-98.89%*	*-91.09%*
LEA3-T	27.37	14.58	46.75	12.14	6.39	20.38	*-75.60%*	*-87.00%*	*-58.32%*
RID3-T	44.70	25.00	75.89	38.08	21.47	62.71	*-69.45%*	*-82.91%*	*-48.14%*
GRE3-T	7.08	2.15	16.78	4.24	1.26	9.83	*-82.31%*	*-94.62%*	*-58.05%*
LOG4-S	12.20	5.48	40.41	4.35	1.96	14.43	*-97.07%*	*-98.68%*	*-90.30%*
LEA4-S	11.65	6.69	22.12	3.18	1.83	6.04	*-88.50%*	*-93.40%*	*-78.16%*
RID4-S	3.51	1.47	11.83	1.37	0.57	4.61	*-97.19%*	*-98.83%*	*-90.54%*
GRE4-S	1.06	0.44	3.53	0.31	0.13	1.02	*-97.14%*	*-98.82%*	*-90.47%*
LOG4-D	4.29	0.87	9.28	2.95	0.59	6.38	*470.85%*	*15.14%*	*1135.03%*
LEA4-D	18.96	9.67	31.04	9.73	4.96	15.93	*74.12%*	*-11.22%*	*185.10%*
RID4-D	39.91	22.61	64.13	35.04	19.85	56.30	*86.99%*	*5.93%*	*200.43%*
GRE4-D	5.98	1.74	13.51	3.80	1.10	8.58	*101.89%*	*-41.41%*	*356.13%*
LOG4-T	16.48	6.35	49.69	7.30	2.55	20.80	*-96.05%*	*-98.48%*	*-88.10%*
LEA4-T	30.61	16.35	53.16	12.91	6.78	21.96	*-72.71%*	*-85.42%*	*-52.60%*
RID4-T	43.42	24.08	75.95	36.41	20.43	60.92	*-70.32%*	*-83.54%*	*-48.10%*
GRE4-T	7.04	2.17	17.04	4.10	1.23	9.60	*-82.40%*	*-94.57%*	*-57.40%*
LOG5-S	16.57	7.45	54.90	5.92	2.66	19.60	*-96.02%*	*-98.21%*	*-86.83%*
LEA5-S	15.82	9.09	30.05	4.32	2.48	8.20	*-84.38%*	*-91.03%*	*-70.33%*
RID5-S	4.77	2.00	16.07	1.86	0.78	6.27	*-96.18%*	*-98.40%*	*-87.15%*
GRE5-S	1.44	0.59	4.80	0.42	0.17	1.39	*-96.11%*	*-98.40%*	*-87.05%*
LOG5-D	4.07	0.84	8.76	2.80	0.57	6.02	*442.17%*	*11.37%*	*1065.96%*
LEA5-D	18.40	9.25	30.37	9.44	4.75	15.58	*68.95%*	*-15.05%*	*178.93%*
RID5-D	37.22	21.05	59.96	32.68	18.48	52.65	*74.39%*	*-1.39%*	*180.92%*

GRE5-D	5.56	1.60	12.53	3.53	1.02	7.96	*87.71%*	*-45.92%*	*323.15%*
LOG5-T	20.64	8.28	63.66	8.71	3.23	25.62	*-95.06%*	*-98.02%*	*-84.75%*
LEA5-T	34.22	18.34	60.42	13.76	7.23	23.78	*-69.49%*	*-83.65%*	*-46.13%*
RID5-T	42.00	23.04	76.03	34.54	19.26	58.91	*-71.30%*	*-84.25%*	*-48.04%*
GRE5-T	7.00	2.19	17.33	3.95	1.19	9.34	*-82.50%*	*-94.51%*	*-56.68%*

Baseline 1994-1999 mean annual takes

LOG-S	416.75
LEA-S	101.28
RID-S	124.99
GRE-S	37.04
LOG-D	0.75
LEA-D	10.89
RID-D	21.35
GRE-D	2.96
LOG-T	417.50
LEA-T	112.17
RID-T	146.33
GRE-T	40.00

Mortality Rate (Boggs 2003 v.4)

LOG-S	0.3570
LEA-S	0.2730
RID-S	0.3900
GRE-S	0.2890
LOG-D	0.6870
LEA-D	0.5130
RID-D	0.8780
GRE-D	0.6350

Table 2. Fish catch predictions, percent changes from baseline values, and baseline values for each of the 5 WPRFMC scenarios for the longline fleet (all gear types combined). SWO = swordfish, BIG = bigeye tuna, ALB = albacore tuna, YEL = yellowfin tuna, REV = total fish catch revenue, BSH = blue shark, MAK = mako shark, THR = thresher shark, BMA = blue marlin, and SMA = striped marlin. The notations 1,2,3,4, and 5 appended to the species code signify the WPRFMC scenario #.

	Total annual number of fish			Percent change from baseline	
	Mean	95%CI Lo	95%CI Hi	Mean	95%CI Lo
SWO1	29602	29458	29746	-22.40%	-22.78%
BIG1	74440	72482	76399	6.40%	3.61%
ALB1	52423	49557	55289	9.28%	3.30%
YEL1	21084	20367	21801	6.06%	2.45%
REV1	39804417	39272775	40336060	-2.20%	-3.50%
BSH1	43868	43268	44468	-19.79%	-20.88%
MAK1	976	921	1031	-0.48%	-6.06%
THR1	1950	1841	2058	9.65%	3.53%
BMA1	6635	6490	6781	2.99%	0.73%
SMA1	16253	15526	16980	7.14%	2.35%
SWO2	21180	20791	21569	-44.48%	-45.50%
BIG2	77848	73337	82360	11.28%	4.83%
ALB2	58371	51854	64888	21.68%	8.09%
YEL2	22624	20886	24362	13.80%	5.06%
REV2	38910996	37828711	39993282	-4.39%	-7.05%
BSH2	33057	31885	34229	-39.55%	-41.70%
MAK2	990	871	1110	1.02%	-11.14%
THR2	1851	1517	2186	4.12%	-14.71%
BMA2	6830	6547	7112	6.01%	1.62%
SMA2	17546	16119	18973	15.66%	6.26%
SWO3	12511	12080	12943	-67.20%	-68.33%
BIG3	83401	77526	89276	19.21%	10.82%
ALB3	61323	52725	69920	27.83%	9.90%
YEL3	23492	21341	25644	18.17%	7.35%
REV3	38017546	36422618	39612475	-6.59%	-10.50%
BSH3	22227	20426	24028	-59.36%	-62.65%
MAK3	966	802	1131	-1.44%	-18.19%
THR3	2293	1967	2619	28.95%	10.60%
BMA3	7021	6584	7457	8.97%	2.20%
SMA3	18420	16240	20600	21.43%	7.05%
SWO4	16545	16181	16908	-56.63%	-57.58%
BIG4	81287	76336	86237	16.19%	9.11%
ALB4	59222	51977	66467	23.45%	8.35%
YEL4	22924	21111	24737	15.31%	6.19%
REV4	38439248	37095255	39783241	-5.55%	-8.85%
BSH4	27334	25817	28852	-50.02%	-52.79%
MAK4	969	830	1107	-1.21%	-15.33%

THR4	2212	1937	2487	24.39%	8.93%
BMA4	6930	6562	7297	7.56%	1.86%
SMA4	17909	16071	19746	18.05%	5.94%
SWO5	21057	20769	21344	-44.80%	-45.56%
BIG5	78921	75004	82838	12.81%	7.21%
ALB5	56873	51141	62605	18.55%	6.60%
YEL5	22288	20854	23723	12.11%	4.90%
REV5	38910982	37847696	39974267	-4.39%	-7.00%
BSH5	33047	31847	34248	-39.57%	-41.77%
MAK5	971	862	1081	-0.96%	-12.13%
THR5	2121	1904	2339	19.30%	7.07%
BMA5	6828	6537	7119	5.98%	1.47%
SMA5	17337	15883	18790	14.28%	4.70%

	Baseline 1994-1999 mean
SWO	38148
BIG	69960
ALB	47973
YEL	19880
REV	40697853
BSH	54688
MAK	981
THR	1778
BMA	6442
SMA	15170