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Preliminary Calculations of Yield Per Recruit and Spawning Biomass Per Recruit Biological Reference Points for Striped Marlin[1]

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Preliminary Calculations of Yield Per Recruit and Spawning Biomass Per Recruit Biological Reference Points for Striped Marlin[1]

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At the March 2007 Intersessional Marlin and Swordfish Working Group Meeting, the Working Group (WG) reviewed some preliminary calculations of biological reference points for striped marlin. The input data for these calculations included the growth curve, maturity at age probabilities, and fishery selectivities (Table 1) from the base case assessment model (Model 1, steepness h=0.7). Yield-per-recruit and spawning-biomass-per-recruit calculations were computed using the NOAA Fisheries Toolbox software YPR version 2.6.2. The reference points were calculated using a quarterly time step for age and a quarterly natural mortality rate of M = 0.075. As a result, the output reference points, $F_{0.1}$, F_{MAX}, and $F_{\%MSP}$, where %MSP refers to specified fraction of maximum spawning potential (unfished spawning output), were quarterly fishing mortality values. The WG noted that the plus-group age was 10 years and that it would be useful to increase the plus-group age to cover fish over 200 cm EFL. The WG concluded that the reference point calculations should be refined to incorporate more age groups and thereby represent the size range of the catch. It was also suggested the fishery selectivity from the environmentally-forced recruitment model (Model 2, steepness h=1) could be used to characterize some of the model-based uncertainty in the biological reference points.

In the work reported here, biological reference points were recalculated to incorporate the WG's comments. In particular, more age groups were included. The number of quarterly age groups was increased to represent ages 1.0 through 19.75 years. In addition, reference points were calculated using the fishery selectivity estimates from Model 1 and Model 2. The results showed that yield-per-recruit and spawning-biomass-per-recruit as functions of fishing mortality were very similar for the two models (Figures 1 and 2). Estimates of spawning potential ratios and associated biological reference points from the two models were also very similar (Table 2, Figure 3).

Although estimates of striped marlin reference points were similar, equilibrium yields were higher under Model 2 than Model 1. This was due to differences in recent recruitment estimates from the two models; both models exhibit a declining trend in recruitment since the 1970s. Equilibrium yields were lower under Model 1, assuming either recent average (1996-2006) or long-term average (1965-2006) recruitment (Figure 4). Catches at the recent average yield (1996-2003) of approximately 6,200 mt would not be sustainable at any fishing mortality rate under Model 1 assuming recent average recruitment. This suggests that fishing hard enough to maintain the recent average yield in future years will cause further declines in striped marlin stock abundance and yield. In contrast, catches at the recent average yield under Model 2 (Figure 5) would be

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marginally sustainable at high quarterly fishing mortality rates of 0.3 or more (over 3-fold larger than the quarterly natural mortality rate) assuming the recent recruitment pattern persists. This suggests that maintaining the recent average yield in future years may be possible, but only if there are no further declines in recruitment.

Table 1. Quarterly data for yield- and spawning-biomass-per-recruit reference point calculations including fishery selectivities for Model 1 and Model 2, natural mortality, mean weight, and fraction mature at age.

Age	Model 1 Fishery Selectivity	Model 2 Fishery Selectivity	Natural Mortality	Mean Weight (kg)	Fraction Mature	Age	Model 1 Fishery Selectivity	Model 2 Fishery Selectivity	Natural Mortality	Mean Weight (kg)	Fraction Mature
1.00	0.00	0.00	0.075	3.725	0	10.50	0.96	0.95	0.075	47.780	1
1.25	0.01	0.02	0.075	5.474	0	10.75	0.96	0.95	0.075	48.216	1
1.50	0.02	0.06	0.075	7.251	0	11.00	0.96	0.95	0.075	48.629	1
1.75	0.07	0.15	0.075	9.042	0	11.25	0.96	0.95	0.075	49.021	1
2.00	0.16	0.24	0.075	10.833	0	11.50	0.96	0.95	0.075	49.392	1
2.25	0.25	0.29	0.075	12.613	0	11.75	0.96	0.95	0.075	49.743	1
2.50	0.25	0.29	0.075	14.374	0	12.00	0.96	0.95	0.075	50.075	1
2.75	0.31	0.33	0.075	16.108	0	12.25	0.96	0.95	0.075	50.390	1
3.00	0.34	0.36	0.075	17.808	0	12.50	0.96	0.95	0.075	50.689	1
3.25	0.38	0.41	0.075	19.470	0	12.75	1.00	1.00	0.075	50.971	1
3.50	0.38	0.41	0.075	21.089	0	13.00	1.00	1.00	0.075	51.238	1
3.75	0.43	0.46	0.075	22.663	0	13.25	1.00	1.00	0.075	51.491	1
4.00	0.48	0.53	0.075	24.188	0	13.50	1.00	1.00	0.075	51.730	1
4.25	0.48	0.53	0.075	25.664	0	13.75	1.00	1.00	0.075	51.956	1
4.50	0.55	0.60	0.075	27.090	0	14.00	1.00	1.00	0.075	52.170	1
4.75	0.55	0.60	0.075	28.464	0	14.25	1.00	1.00	0.075	52.372	1
5.00	0.62	0.66	0.075	29.787	0	14.50	1.00	1.00	0.075	52.564	1
5.25	0.62	0.66	0.075	31.058	0	14.75	1.00	1.00	0.075	52.745	1
5.50	0.70	0.73	0.075	32.278	0	15.00	1.00	1.00	0.075	52.916	1
5.75	0.70	0.73	0.075	33.448	0	15.25	1.00	1.00	0.075	53.078	1
6.00	0.70	0.73	0.075	34.569	1	15.50	1.00	1.00	0.075	53.231	1
6.25	0.76	0.78	0.075	35.641	1	15.75	1.00	1.00	0.075	53.375	1
6.50	0.76	0.78	0.075	36.666	1	16.00	1.00	1.00	0.075	53.512	1
6.75	0.76	0.78	0.075	37.645	1	16.25	1.00	1.00	0.075	53.641	1
7.00	0.82	0.83	0.075	38.579	1	16.50	1.00	1.00	0.075	53.763	1
7.25	0.82	0.83	0.075	39.470	1	16.75	1.00	1.00	0.075	53.878	1
7.50	0.82	0.83	0.075	40.320	1	17.00	1.00	1.00	0.075	53.987	1
7.75	0.87	0.87	0.075	41.129	1	17.25	1.00	1.00	0.075	54.090	1
8.00	0.87	0.87	0.075	41.899	1	17.50	1.00	1.00	0.075	54.188	1
8.25	0.87	0.87	0.075	42.631	1	17.75	1.00	1.00	0.075	54.280	1
8.50	0.87	0.87	0.075	43.328	1	18.00	1.00	1.00	0.075	54.367	1
8.75	0.87	0.87	0.075	43.991	1	18.25	1.00	1.00	0.075	54.449	1
9.00	0.92	0.91	0.075	44.620	1	18.50	1.00	1.00	0.075	54.526	1
9.25	0.92	0.91	0.075	45.218	1	18.75	1.00	1.00	0.075	54.600	1
9.50	0.92	0.91	0.075	45.786	1	19.00	1.00	1.00	0.075	54.669	1
9.75	0.92	0.91	0.075	46.324	1	19.25	1.00	1.00	0.075	54.734	1
10.00	0.92	0.91	0.075	46.836	1	19.50	1.00	1.00	0.075	54.796	1
10.25	0.92	0.91	0.075	47.320	1	19.75	1.00	1.00	0.075	54.854	1

Table 2. Quarterly estimates of fishing mortality reference points to achieve spawning potential ratios of 5% to 50% (in relation to maximum spawning potential) along with estimates of $F_{0.1}$ and F_{MAX} using fishery selectivities from Models 1 and 2.

Biological Reference Point	Fishing Mortality Reference Point using Model 1	Fishing Mortality Reference Point using Model 2
$F_{5\%}$	0.230	0.214
$F_{10\%}$	0.165	0.154
$F_{15\%}$	0.130	0.122
$F_{20\%}$	0.106	0.100
$F_{25\%}$	0.089	0.084
$F_{30\%}$	0.075	0.071
$F_{35\%}$	0.064	0.060
$F_{40\%}$	0.055	0.052
$F_{45\%}$	0.046	0.044
$F_{50\%}$	0.040	0.038
$F_{0.1}$	0.123	0.117
F_{MAX}	0.532	0.428

Figure 1. Striped marlin yield and spawning biomass per recruit using fishery selectivity from Model 1

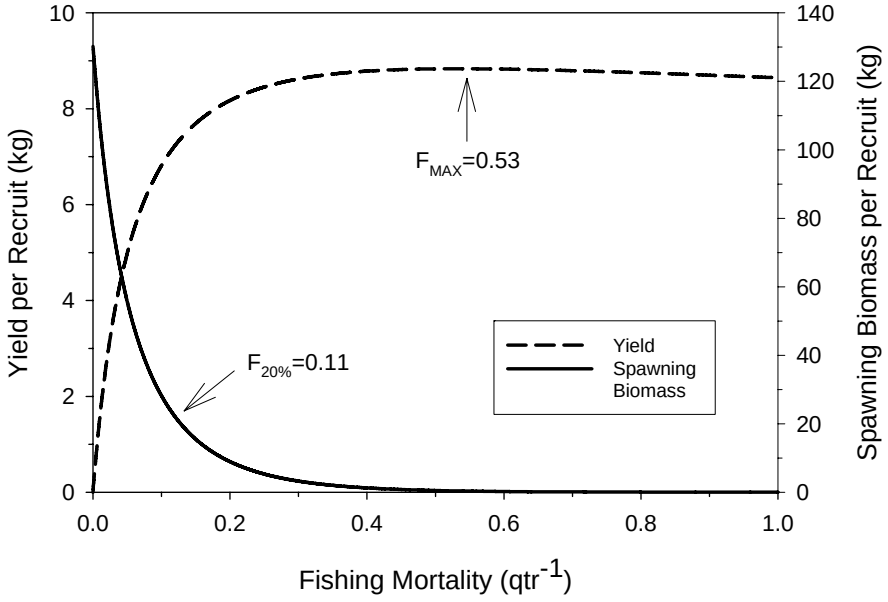

Figure 2. Striped marlin yield and spawning biomass per recruit using fishery selectivity from Model 2

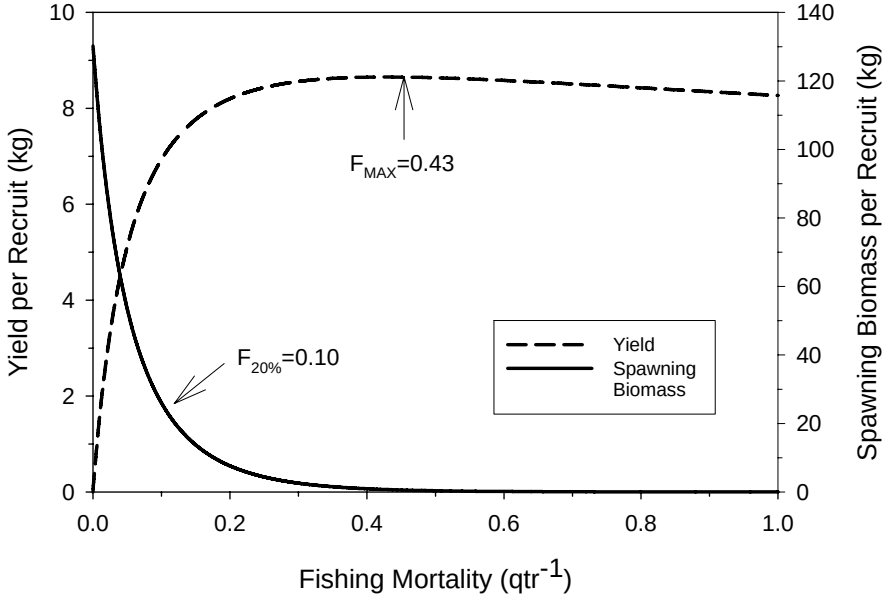

Figure 3. Striped marlin spawning potential ratio using fishery selectivities from Models 1 and 2

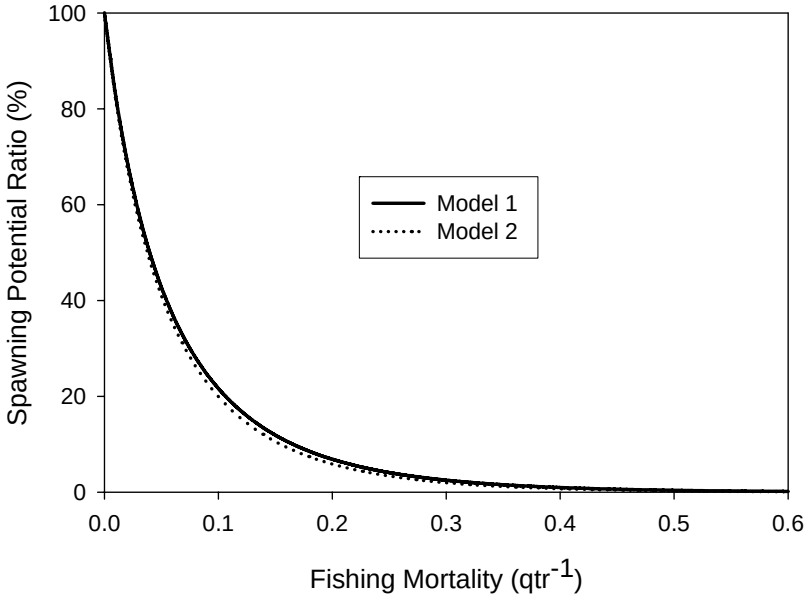

Figure 4. Striped marlin equilibrium yields (mt) using Model 1 assuming recent and long-term average recruitment in comparison to recent average yield

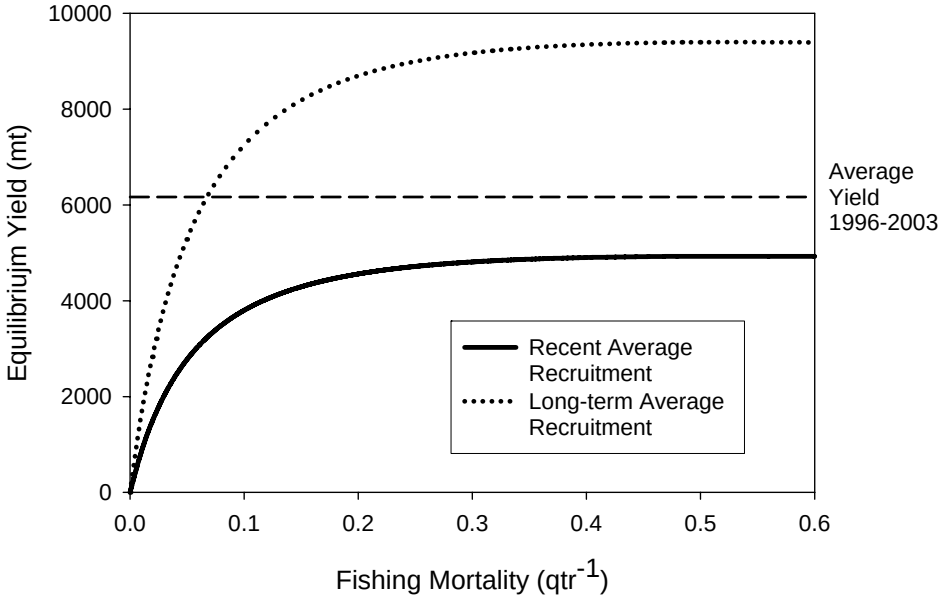

Figure 5. Striped marlin equilibrium yields (mt) using Model 2 assuming recent and long-term average recruitment in comparison to recent average yield