Methods for estimating shrimp bycatch of Gulf of Mexico Spanish mackerel and cobia

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Preliminary results added

Methods for Estimating Shrimp Bycatch of Gulf of Mexico Spanish Mackerel and Cobia: Addendum

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Abstract

Shrimp bycatch estimates for Spanish mackerel and cobia in the Gulf of Mexico were generated using the SEDAR 7 Gulf of Mexico red snapper assessment. The uncertainties associated with annual bycatch estimates for both species were high. In addition, the marginal posterior densities of the annual bycatch estimates demonstrated significant skew for both species.

Methods

Shrimp bycatch estimates for Gulf of Mexico Spanish mackerel and cobia were generated using the same approach developed by Scott Nichols in the SEDAR 7 Gulf of Mexico red snapper assessment. A brief summary of the data sources and model are provided in this report, while a more detailed description can be found in Nichols (2004a, 2004b).

The data used in this analysis came from various shrimp observer programs, the SEAMAP groundfish survey, shrimp effort estimates and the Vessel Operating Units file. The primary data on CPUE in the shrimp fishery came from a series of shrimp observer programs, which began in 1972 and extend to the current shrimp observer program (Table 1). Additional CPUE data were obtained from the SEAMAP groundfish survey. Only data from 40 ft trawls by the Oregon II were used in this analysis, because these trawls were identified as being most similar to trawls conducted by the shrimp fishery. Point estimates and associated standard errors of shrimp effort were generated by the NMFS Galveston Lab using their SN-pooled method of effort estimation (Nance 2004). Most observer program CPUE data were expressed in numbers per net-hour, while the shrimp effort data were expressed in vessel-hours. Therefore, data from the Vessel Operating Units file were needed to estimate the average number of nets per vessel for the shrimp fishery.

The following Bayesian model was used to estimate shrimp bycatch (i.e., model 02 from Nichols 2004a):

$$\ln(CPUE)_{ijklm} = year_i + season_j + area_k + depth_l + data\_set_m + local_{ijklm}.$$

The factor levels for the main effects are presented in Table 2. Catch in numbers for each cell was assumed to follow a negative binomial distribution. The main effects and local term, as expressed above

(i.e, on the log-scale), were assigned normal prior distributions. A lognormal hyperprior was assigned to the precision ($1/\sigma^2$) parameter of the local term. Therefore, the data determined the distribution of the local term in cells with data, while the distribution of the local term defaulted to the prior with fitted precision for cells without data. In effect, the local term became a fixed effect for cells with data and a random effect for cells without data.

The shrimp bycatch estimation model was fit using WinBUGS version 1.4.3. Markov Chain Monte Carlo (MCMC) methods were used to estimate the marginal posterior distributions of the parameters and important derived quantities. Two parallel chains of 29,000 iterations each were run. The first 4,000 iterations of each chain were dropped as a burn-in period, to remove the effects of the initial parameter values. A thinning interval of five iterations (i.e., only every fifth iteration was used) was applied to each chain, to reduce autocorrelation in parameter estimates and derived quantities. The marginal posterior distributions were calculated from the remaining 10,000 iterations. Convergence of the chains was determined by visual inspection of trace plots, marginal posterior density plots, and Gelman-Rubin statistic (Brooks and Gelman 1998) plots.

Preliminary Results

Predicted Gulf of Mexico shrimp effort is reported in Table 3 and Figure 1. There was a slight increase in shrimp effort between 2008 and 2009, but this increase was followed by a sharp decline in effort in 2010.

Observed bycatch of Gulf of Mexico Spanish mackerel and cobia from the observer program and SEAMAP groundfish survey is reported in Table 4 and Figures 2 and 3. Observed cobia bycatch was relatively low, with 724 fish observed between 1972 and 2010. A minimum of zero fish was observed in 1988, and a maximum of 164 fish was observed in 1980. Seventy-seven percent of cobia bycatch was observed between September and December. Sixty-six percent of cobia bycatch was observed in the western Gulf (i.e., stat areas 13-21). Cobia bycatch appears to have been relatively equally distributed across depth zones. Fifty-nine percent of cobia bycatch was observed in the SEAMAP groundfish survey. In contrast, observed Spanish mackerel bycatch was relatively high, with 72,955 fish observed between 1972 and 2010. A minimum of 13 fish was observed in 1985, and a maximum of 17,407 fish was observed in 2004. Sixty-five percent of Spanish mackerel bycatch was observed between May and August. Eighty-six percent of Spanish mackerel bycatch was observed in the western Gulf of Mexico, with 59% of total observed bycatch coming specifically from stat areas 13-17. Seventy-seven percent of Spanish mackerel bycatch was observed in depths less than 10 fm. Ninety-three percent of Spanish mackerel bycatch was observed through the observer program.

Inspection of trace plots, marginal posterior density plots, and Gelman-Rubin statistic plots for model parameters and key derived quantities suggests that both Spanish mackerel and cobia models reached convergence. Thinning of the MCMC chains did reduce the amount of autocorrelation in all parameter estimates and derived quantities, though autocorrelation is still high for some parameters and quantities.

Annual estimates of shrimp bycatch for cobia in the Gulf of Mexico are reported in Table 5 and Figure 4. The CVs associated with the bycatch estimates were relatively high, ranging from 66% to 208%. Only 4 of the 39 years (i.e., 1977, 1980, 1992 and 1993) had CVs below 100%. In addition to the high uncertainty associated with the bycatch estimates, the marginal posterior densities of those estimates showed a high degree of skew in every year. The marginal posterior densities for two arbitrarily selected years (i.e., 1976 and 2006) are presented in Figure 5 to demonstrate the skew.

Annual estimates of shrimp bycatch for Spanish mackerel in the Gulf of Mexico are reported in Table 6 and Figure 6. The CVs associated with the bycatch estimates showed a greater range than the CVs for cobia, ranging from 25% to 911%. In the case of Spanish mackerel, 10 of the 39 years (i.e., 1976, 1977, 1980, 1992, 1993, 2004, 2005, 2007, 2009 and 2010) had CVs below 100%. In addition to the high uncertainty associated with the bycatch estimates, the marginal posterior densities of those estimates showed a high degree of skew in every year, except for 2008 which still showed a moderate degree of skew. The marginal posterior densities for two arbitrarily selected years (i.e., 1976 and 2006) are presented in Figure 7 to demonstrate the skew.

References

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Tables

Table 1. Summary list of shrimp observer programs in the Gulf of Mexico (1972-Present).

Years	Program Description
1972-1982	Historical studies
	Bycatch studies
	Turtle capture study
	TED evaluations
1992-1997	Regional Research Program
1998	BRD effectiveness evaluations
2001-Present	Modern observer program

Table 2. List of factor levels for the main effects of the shrimp bycatch estimation model.

Main Effect	Levels	Description
Year	39	1972-2010
Season	3	Jan-Apr, May-Aug, Sep-Dec
Area	4	Stat grids 1-9, 10-12, 13-17, 18-21
Depth	2	Inside 10 fm, Outside 10 fm
Data Set	2	Observer program, Research vessel

Table 3. Predicted shrimp effort and associated standard errors for the Gulf of Mexico, 1981-2010. Effort is reported in days fished.

Year	Effort	SE
1981	176,727	391
1982	173,894	425
1983	171,311	582
1984	191,739	572
1985	196,628	497
1986	226,798	613
1987	241,902	792
1988	205,812	662
1989	221,165	815
1990	211,860	790
1991	223,388	775
1992	216,669	774
1993	204,482	784
1994	195,742	939
1995	176,589	620
1996	189,653	671
1997	207,912	715
1998	216,999	822
1999	200,475	745
2000	192,073	725
2001	197,644	814
2002	206,621	992
2003	168,135	640
2004	146,624	479
2005	102,840	368
2006	92,372	276
2007	80,733	241
2008	62,797	615
2009	76,508	187
2010	8,359	235

Table 4. Observed shrimp bycatch of Spanish mackerel and cobia in the Gulf of Mexico from the observer program and SEAMAP groundfish survey. Bycatch is reported in numbers of fish.

	Obs Bycatch (numbers of fish)	
Year	Cobia	Spanish Mackerel
1972	8	57
1973	3	111
1974	32	96
1975	34	338
1976	16	739
1977	5	1228
1978	8	526
1979	10	76
1980	164	2048
1981	6	275
1982	13	165
1983	16	41
1984	9	554
1985	5	13
1986	1	69
1987	3	29
1988	0	92
1989	4	129
1990	5	181
1991	6	140
1992	65	1787
1993	39	6164
1994	50	790
1995	10	242
1996	16	115
1997	24	55
1998	9	83
1999	17	79
2000	2	156
2001	18	1243
2002	34	2968
2003	11	2444
2004	17	17407
2005	9	11432
2006	10	64
2007	6	3545
2008	19	7096
2009	7	5027
2010	13	5351

Table 5. Predicted annual shrimp bycatch (millions of fish) of cobia in the Gulf of Mexico.

year	mean	sd	MC error	2.50%	25.00%	median	75.00%	97.50%	start	sample
1972	1.244	1.753	0.05454	0.1671	0.4659	0.8064	1.419	5.08	4001	10000
1973	0.2121	0.258	0.007769	0.03364	0.08707	0.1481	0.2501	0.7686	4001	10000
1974	1.737	1.906	0.06236	0.3185	0.7509	1.224	2.047	6.272	4001	10000
1975	0.506	0.5604	0.01377	0.1117	0.2402	0.3688	0.5898	1.71	4001	10000
1976	0.3027	0.3229	0.008143	0.08088	0.1568	0.2293	0.3528	0.9417	4001	10000
1977	0.1424	0.1349	0.003506	0.03105	0.06922	0.1074	0.17	0.463	4001	10000
1978	0.188	0.1884	0.004405	0.04033	0.09085	0.1411	0.2232	0.5986	4001	10000
1979	2.704	3.312	0.09374	0.3463	0.9971	1.748	3.189	10.5	4001	10000
1980	0.6132	0.4181	0.01206	0.2153	0.3734	0.5108	0.7286	1.582	4001	10000
1981	0.2806	0.3764	0.009106	0.04663	0.1167	0.1902	0.3272	1.049	4001	10000
1982	1.025	1.493	0.04325	0.1777	0.4286	0.7015	1.18	3.745	4001	10000
1983	1.534	1.763	0.0566	0.2654	0.6522	1.063	1.793	5.61	4001	10000
1984	0.9985	1.424	0.03663	0.1608	0.3975	0.6644	1.162	3.783	4001	10000
1985	1.187	1.436	0.03371	0.181	0.4737	0.8142	1.407	4.403	4001	10000
1986	1.271	1.825	0.04377	0.1367	0.428	0.7761	1.482	5.314	4001	10000
1987	1.968	2.471	0.05831	0.2287	0.6957	1.25	2.353	8.177	4001	10000
1988	0.7849	1.016	0.02604	0.07888	0.2659	0.4874	0.9271	3.355	4001	10000
1989	1.797	2.587	0.06434	0.2483	0.6807	1.181	2.092	7.01	4001	10000
1990	1.445	1.723	0.04351	0.205	0.5653	0.9971	1.707	5.42	4001	10000
1991	1.781	2.182	0.05984	0.2459	0.6668	1.159	2.044	7.193	4001	10000
1992	1.053	0.6917	0.01574	0.3664	0.641	0.8837	1.251	2.703	4001	10000
1993	0.751	0.6681	0.01453	0.2103	0.4002	0.5731	0.8687	2.363	4001	10000
1994	1.081	1.081	0.02497	0.2475	0.534	0.8122	1.289	3.539	4001	10000
1995	3.936	4.779	0.1273	0.5401	1.511	2.612	4.6	15.24	4001	10000
1996	4.843	6.439	0.1674	0.6576	1.816	3.114	5.576	19.58	4001	10000
1997	8.827	11.74	0.3109	1.259	3.313	5.77	10.29	34.75	4001	10000
1998	3.502	4.734	0.1125	0.4319	1.269	2.251	4.119	13.99	4001	10000
1999	4.044	4.454	0.1243	0.6899	1.676	2.766	4.791	15.02	4001	10000
2000	1.271	1.813	0.05021	0.1508	0.4327	0.795	1.445	5.339	4001	10000
2001	3.074	4.714	0.1099	0.4582	1.201	2.053	3.566	11.32	4001	10000
2002	0.476	0.5503	0.01354	0.1114	0.226	0.3451	0.5399	1.669	4001	10000
2003	2.712	3.809	0.08589	0.3775	1.044	1.788	3.159	10.26	4001	10000
2004	4.407	6.559	0.1545	0.616	1.645	2.878	5.122	17.25	4001	10000
2005	4.023	8.383	0.1464	0.4599	1.358	2.419	4.502	16.06	4001	10000
2006	2.182	3.282	0.07989	0.2966	0.7888	1.373	2.43	8.716	4001	10000
2007	8.272	10.05	0.264	0.8996	2.9	5.338	9.87	33.55	4001	10000
2008	19.2	21.47	0.5524	2.868	7.902	13.49	23	69.45	4001	10000
2009	0.8531	1.04	0.028	0.1161	0.3287	0.5635	0.9894	3.31	4001	10000
2010	0.05572	0.07236	0.001798	0.00741	0.02039	0.03628	0.06586	0.222	4001	10000

Table 6. Predicted annual shrimp bycatch (millions of fish) of Spanish mackerel in the Gulf of Mexico.

year	mean	sd	MC error	2.50%	25.00%	median	75.00%	97.50%	start	sample
1972	22.05	53.44	0.981	1.194	4.487	9.378	20.59	122.6	4001	10000
1973	2.035	4.095	0.06811	0.2053	0.6094	1.096	2.125	9.168	4001	10000
1974	5.957	23.65	0.3076	0.4607	1.411	2.686	5.483	29.74	4001	10000
1975	5.087	9.934	0.1324	0.9573	2.052	3.216	5.501	19.29	4001	10000
1976	7.031	5.969	0.0854	2.433	4.135	5.682	8.142	19.2	4001	10000
1977	20.24	18.72	0.2544	5.826	10.36	15.02	23.01	67.97	4001	10000
1978	22.96	37.12	0.5091	5.326	10.02	14.85	24.01	86.13	4001	10000
1979	68.18	620.9	7.318	2.5	9.513	20.86	50.7	340.1	4001	10000
1980	17.2	11.11	0.1539	6.621	10.88	14.53	20.31	42.55	4001	10000
1981	9.979	27.39	0.3813	1.346	2.768	4.567	8.762	52.79	4001	10000
1982	15.48	43.81	0.577	0.9467	3.19	6.35	13.92	84.47	4001	10000
1983	13.8	56.97	0.8974	0.8958	2.932	5.925	12.87	73.64	4001	10000
1984	32.54	82.47	1.225	2.278	7.124	14.03	30.82	173.1	4001	10000
1985	7.824	24.26	0.3157	0.4689	1.663	3.354	7.241	39.12	4001	10000
1986	20	56.73	0.6918	1.118	3.989	8.151	18	104.5	4001	10000
1987	17.9	54.35	0.675	0.958	3.627	7.335	16.42	96.49	4001	10000
1988	31	105.2	1.292	1.796	6.149	12.63	27.54	162.4	4001	10000
1989	45.25	211	2.662	2.594	8.899	17.75	38.1	253.6	4001	10000
1990	63.69	340.5	3.603	3.792	12.67	25.75	56.09	335	4001	10000
1991	44.37	124.5	1.61	2.809	9.5	18.97	40.88	240.9	4001	10000
1992	23.91	15.12	0.1936	9.944	15.71	20.53	27.57	58.61	4001	10000
1993	69.27	61.61	0.7912	21.34	36.96	53.08	80.59	214.9	4001	10000
1994	12.89	42.35	0.5414	1.423	3.123	5.479	11.02	66.6	4001	10000
1995	12.8	32.24	0.3707	1.09	3.095	5.826	12.11	65.56	4001	10000
1996	11.69	38.36	0.472	0.7456	2.502	4.969	10.62	61.63	4001	10000
1997	12.84	34.18	0.4091	0.871	2.82	5.561	11.75	67.04	4001	10000
1998	17.97	62.92	0.6922	1.043	3.58	7.443	16.39	96.55	4001	10000
1999	12.81	35.74	0.4432	0.7573	2.738	5.555	12.06	65.19	4001	10000
2000	31.68	140.5	1.66	1.807	6.258	12.94	28.21	161.4	4001	10000
2001	14.4	36.56	0.4504	1.925	4.005	7.007	13.54	70.56	4001	10000
2002	8.296	13.72	0.1602	2.393	3.953	5.718	8.95	28.61	4001	10000
2003	15.9	15.84	0.1806	4.245	7.811	11.49	18.17	54.36	4001	10000
2004	23.01	18.39	0.2313	11.44	15.83	19.32	24.64	56.29	4001	10000
2005	26.84	20.9	0.2839	11.36	17.32	22.66	30.67	64.84	4001	10000
2006	12.21	34.85	0.3982	0.7668	2.592	5.3	11.44	64.48	4001	10000
2007	10.34	6.653	0.1023	4.164	6.683	8.831	12.12	25.27	4001	10000
2008	4.105	4.462	0.05798	2.099	2.7	3.204	4.069	11.8	4001	10000
2009	2.873	0.7141	0.008543	1.77	2.371	2.766	3.268	4.527	4001	10000
2010	2.913	1.05	0.01266	1.762	2.32	2.723	3.244	5.229	4001	10000

Figures

Figure 1. Predicted shrimp effort for the Gulf of Mexico, 1981-2010. Effort reported in thousand days fished.

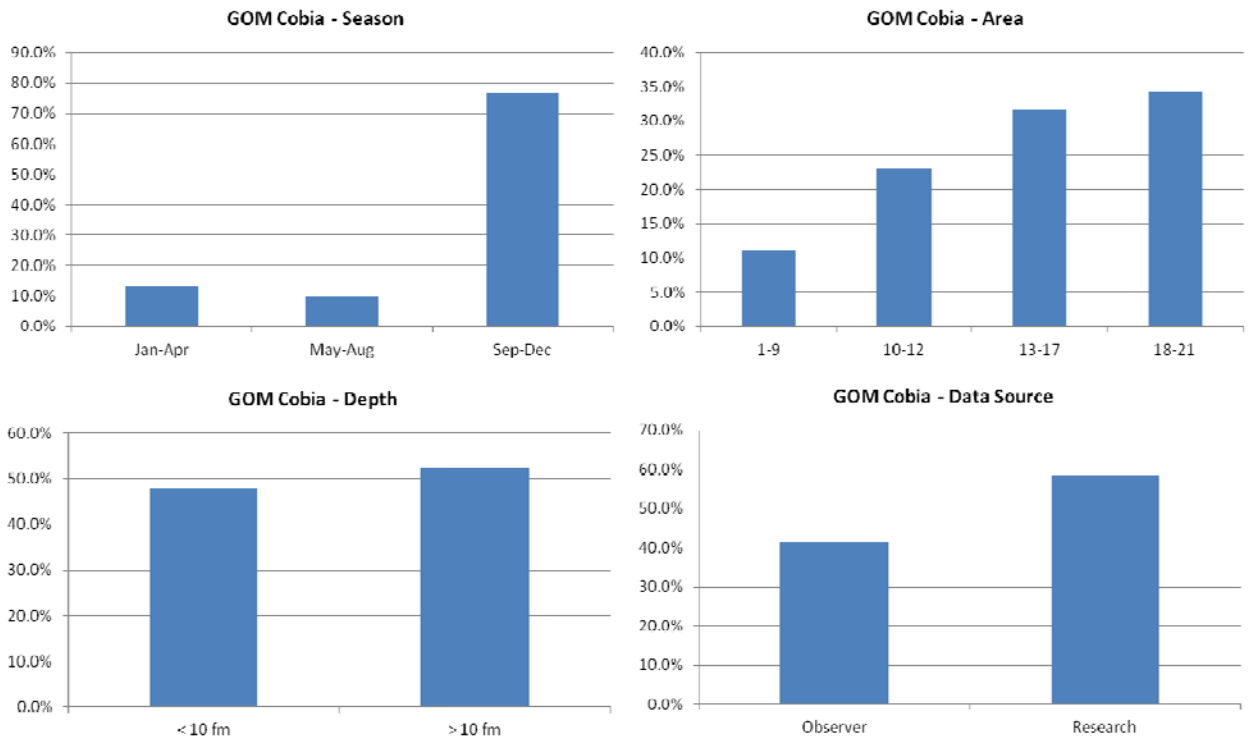

Figure 2. Distribution of observed shrimp bycatch of cobia in the Gulf of Mexico from the observer program and SEAMAP groundfish survey.

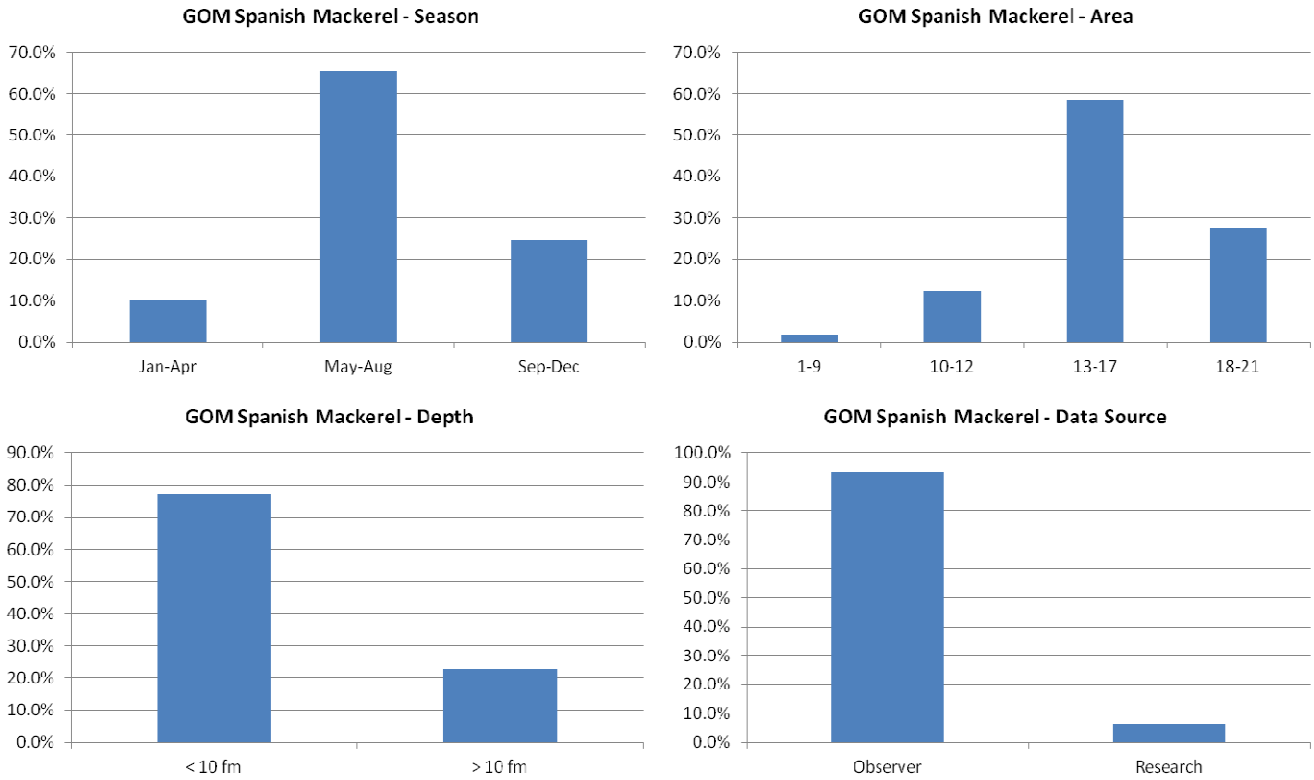

Figure 3. Distribution of observed shrimp bycatch of Spanish mackerel in the Gulf of Mexico from the observer program and SEAMAP groundfish survey.

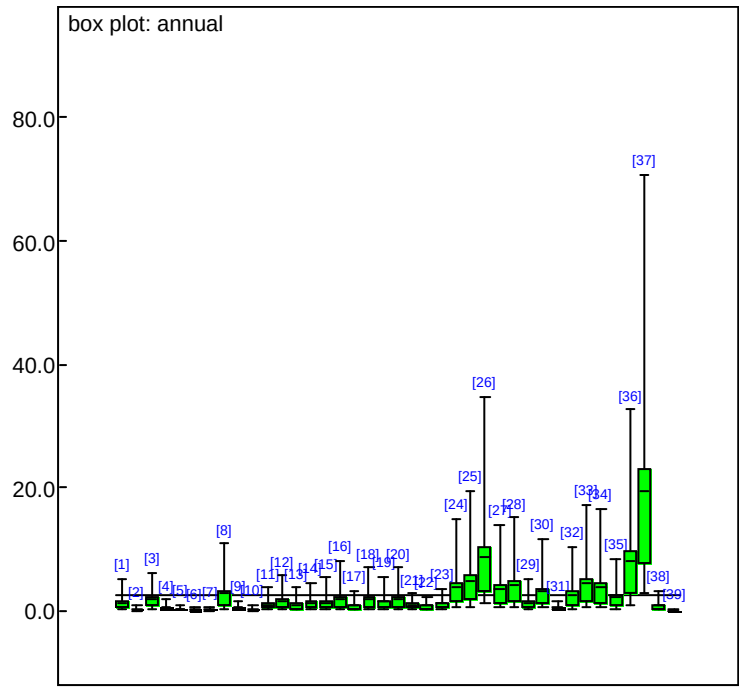

Figure 4. Predicted annual shrimp bycatch (millions of fish) of cobia in the Gulf of Mexico. Year 1 is 1972.

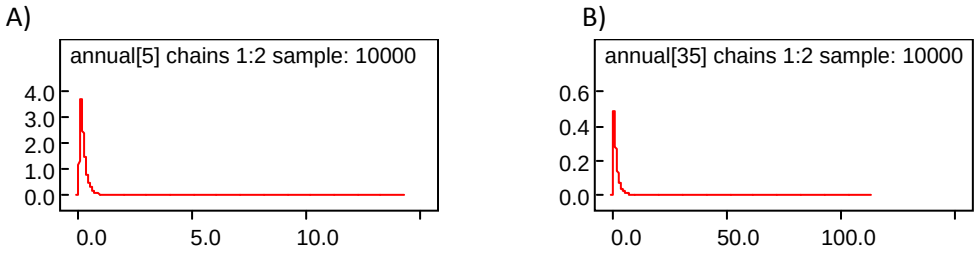

Figure 5. Marginal posterior densities of annual shrimp bycatch of cobia (millions of fish) in the Gulf of Mexico in two arbitrarily selected years: A) 1976 and B) 2006.

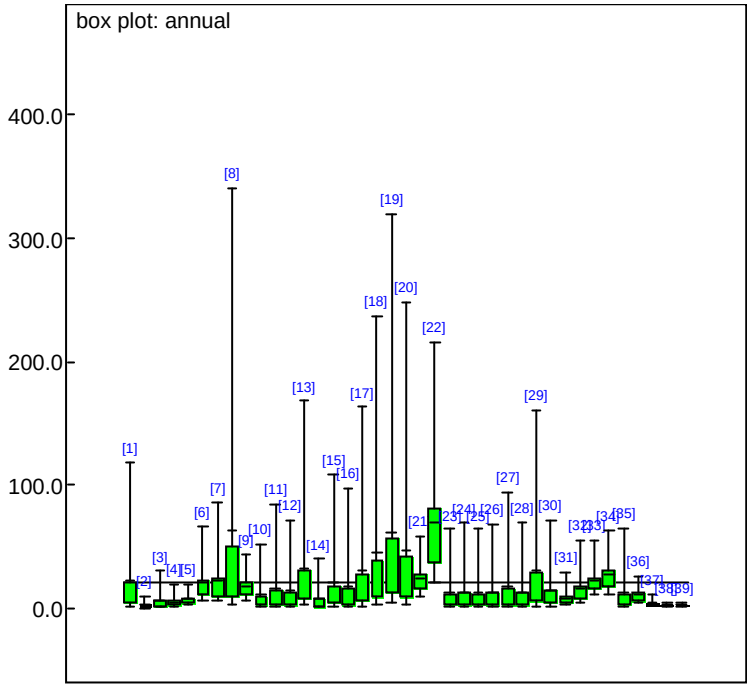

Figure 6. Predicted annual shrimp bycatch (millions of fish) of Spanish mackerel in the Gulf of Mexico. Year 1 is 1972.

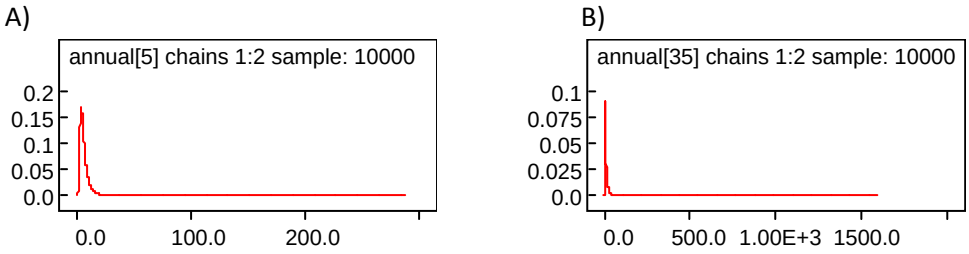

Figure 7. Marginal posterior densities of annual shrimp bycatch of Spanish mackerel (millions of fish) in the Gulf of Mexico in A) 1976 and B) 2006.