Shrimp Fishery Bycatch Estimates for Gulf of Mexico Red Snapper, 1972-2011

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SEDAR31-DW30

21 August 2012

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Sustainable Fisheries Division Contribution SFD-2012-017

Abstract

Shrimp bycatch estimates for Gulf of Mexico red snapper were generated using the same approach developed by Scott Nichols in the SEDAR 7 Gulf of Mexico red snapper assessment (Nichols 2004a, 2004b). The Bayesian shrimp bycatch analysis is currently under way. Estimates of shrimp bycatch should be available for the SEDAR 31 Data Workshop.

Methods

Shrimp bycatch estimates for Gulf of Mexico red snapper 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 (VOUF). 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. Mean observed CPUEs of red snapper in the shrimp fishery are presented in Table 2.

Point estimates and associated standard errors of shrimp effort were generated by the NMFS Galveston Lab using their SN-pooled model (Nance 2004). Effort was estimated by year, season, area, and depth zone. Shrimp effort declined sharply from 2002 to 2008, and has remained at relatively low levels from 2008 to 2011 (Table 3, Figure 1). Five out of 1,440 cells did not have estimates of shrimp effort due to a lack of reported effort for those year/season/area/depth combinations. All five empty cells represented depths greater than 30 fm, where shrimp effort tends to be low. Since the Galveston lab effort estimates were used to specify year/season/area/depth-specific priors on the predicted effort in the Bayesian bycatch estimation model, the empty cells needed to be filled to ensure that each cell had a prior. Therefore, the empty cells were filled using the average effort and standard error calculated from the same season/area/depth combinations in the two years preceding and following the empty cell (i.e., a four year average).

Most observer program CPUE data were expressed in fish per net-hour, while the shrimp effort data were expressed in vessel-days. Therefore, data from the VOUF were needed to estimate the average number of nets per vessel for the shrimp fishery. The VOUF data were only available through 2010. Therefore, the 2008-2010 average was used for 2011. The VOUF average nets per vessel were used to specify priors on the predicted nets per vessel in the Bayesian bycatch estimation model. The average number of nets per vessel increased gradually from 1972 to 1996, and remained relatively constant from 1996 to 2011 at approximately three nets per vessel (Table 4).

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 5. 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.

Two model runs were made using different depth zone stratifications:
1.) A three depth zone run (0 fm – 10 fm, 10 fm – 30 fm, 30+ fm), and
2.) A two depth zone run (0 fm – 10 fm, 10+ fm).

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 key parameters and derived quantities. Two parallel chains of 54,000 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 saved) was applied to each chain, to reduce autocorrelation in parameter estimates and derived quantities. The marginal posterior distributions were calculated from the remaining 20,000 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.

Status of Analysis

The Bayesian shrimp bycatch estimation runs described above are currently under way. Estimates of shrimp bycatch should be available for the SEDAR 31 Data Workshop.

References

Brooks, S. P., and Gelman, A. 1998. Alternative methods for monitoring convergence of iterative simulations. Journal of Computational and Graphical Statistics. 7: 434-455.

Nance, J. 2004. Estimation of effort in the offshore shrimp trawl fishery of the Gulf of Mexico. NOAA Southeast Fisheries Science Center, Galveston Laboratory. SEDAR7-DW-24.

Nichols, S. 2004a. Some Bayesian approaches to estimation of shrimp fleet bycatch. NOAA Southeast Fisheries Science Center, Pascagoula Laboratory. SEDAR7-DW-3.

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Tables

Table 1. Summary list of shrimp observer programs in the Gulf of Mexico (1972-2011).

Years	Program Description
1972-1982	Historical studies
	Bycatch studies
	Turtle capture study
	TED evaluations
1992-1997	Regional Research Program
1998	BRD effectiveness evaluations
2001-2011	Modern observer program

Table 2. Mean observed CPUEs (fish/net-hour) of Gulf of Mexico red snapper in the shrimp fishery. CPUEs were calculated from shrimp observer program and SEAMAP groundfish trawl data.

Year	East	West	Gulfwide
1972	45.33	23.16	32.58
1973	11.26	9.18	10.10
1974	7.10	4.20	5.48
1975	7.41	5.84	6.55
1976	11.87	5.97	7.75
1977	10.64	9.16	9.50
1978	3.71	3.27	3.53
1979	5.73	9.51	7.87
1980	13.23	9.86	11.45
1981	18.09	7.65	11.28
1982	22.62	6.81	13.34
1983	5.68	4.92	5.30
1984	4.07	2.30	2.95
1985	1.84	6.39	4.87
1986	1.10	7.08	5.44
1987	2.62	3.71	3.55
1988	0.62	5.13	4.45
1989	2.52	9.41	8.17
1990	13.33	16.47	15.80
1991	8.81	11.72	11.32
1992	2.26	3.68	3.49
1993	3.23	4.93	4.60
1994	0.80	13.99	8.84
1995	0.71	12.75	9.32
1996	2.49	10.41	9.15
1997	4.97	13.92	13.01
1998	0.47	3.76	3.25
1999	9.96	6.92	7.15
2000	3.63	5.67	5.43
2001	1.66	4.84	3.92
2002	0.99	2.69	1.90
2003	1.57	4.95	3.60
2004	1.49	7.76	5.76
2005	1.12	3.44	2.72
2006	3.58	7.70	7.35
2007	1.15	5.94	5.37
2008	1.00	2.18	2.00
2009	0.78	4.68	3.65
2010	0.30	2.56	1.84
2011	0.42	1.44	1.19

Table 3. Gulf of Mexico shrimp fishery effort (vessel-days) provided by the NMFS Galveston Lab. The reported effort does not include the average effort values used to fill empty cells.

	East		West		Gulfwide	
Year	Effort	Std Error	Effort	Std Error	Effort	Std Error
1972	33,449	121	123,746	415	157,194	433
1973	36,229	143	109,861	473	146,089	494
1974	35,714	142	110,701	431	146,415	454
1975	35,308	129	93,212	305	128,520	331
1976	32,221	122	122,254	507	154,475	521
1977	41,287	162	125,020	597	166,307	618
1978	35,168	146	166,834	1,065	202,002	1,075
1979	33,728	121	177,769	1,672	211,497	1,677
1980	21,249	79	123,007	866	144,256	870
1981	36,067	170	140,659	352	176,727	391
1982	34,212	149	139,681	398	173,894	425
1983	40,298	236	131,012	532	171,311	582
1984	50,521	184	141,218	541	191,739	572
1985	44,017	168	152,612	467	196,628	497
1986	40,896	167	185,902	590	226,798	613
1987	35,722	181	206,181	771	241,902	792
1988	37,366	188	168,446	634	205,812	662
1989	43,155	259	178,010	772	221,165	815
1990	38,665	295	173,195	733	211,860	790
1991	33,811	182	189,578	753	223,388	775
1992	37,674	260	178,994	728	216,669	774
1993	31,361	166	173,121	766	204,482	784
1994	36,101	200	159,641	917	195,742	939
1995	42,802	228	133,787	577	176,589	620
1996	47,326	244	142,327	625	189,653	671
1997	47,546	244	160,366	672	207,912	715
1998	57,747	314	159,251	760	216,999	822
1999	38,401	224	162,073	711	200,475	745
2000	32,274	158	159,799	708	192,073	725
2001	33,986	171	163,659	796	197,644	814
2002	40,917	287	165,703	950	206,621	992
2003	33,168	214	134,967	603	168,135	640
2004	30,473	210	116,151	431	146,624	479
2005	24,632	126	78,207	345	102,840	368
2006	18,032	72	74,340	266	92,372	276
2007	15,580	58	65,153	234	80,733	241
2008	13,110	598	49,687	142	62,797	615
2009	17,527	77	58,981	170	76,508	187
2010	9,248	52	51,271	160	60,518	168
2011	11,560	48	55,217	159	66,777	166

Table 4. Average number of nets per vessel in the Gulf of Mexico shrimp fishery calculated from Vessel Operating Units File data.

Year	Avg Nets per Vessel	Std Dev
1972	1.87	0.076
1973	1.88	0.076
1974	1.87	0.081
1975	1.88	0.086
1976	1.95	0.112
1977	2.14	0.130
1978	2.26	0.156
1979	2.37	0.187
1980	2.44	0.213
1981	2.47	0.238
1982	2.49	0.250
1983	2.46	0.247
1984	2.43	0.267
1985	2.42	0.265
1986	2.42	0.263
1987	2.51	0.252
1988	2.52	0.258
1989	2.55	0.231
1990	2.61	0.258
1991	2.77	0.242
1992	2.67	0.218
1993	2.67	0.231
1994	2.67	0.237
1995	2.85	0.236
1996	2.96	0.224
1997	2.95	0.211
1998	2.84	0.122
1999	2.97	0.224
2000	2.99	0.246
2001	2.99	0.221
2002	3.02	0.199
2003	3.03	0.198
2004	2.96	0.076
2005	2.80	0.248
2006	2.96	0.294
2007	2.85	0.323
2008	2.85	0.311
2009	3.17	0.756
2010	2.91	0.403
2011	2.97	0.406

Table 5. List of factor levels for the main effects of the Bayesian shrimp bycatch estimation model.

Main Effect	Levels	Description
Year	40	1972-2011
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
	3	Inside 10 fm, 10 fm to 30 fm, Outside 30 fm
Data Set	2	Observer program, Research vessel

Figures

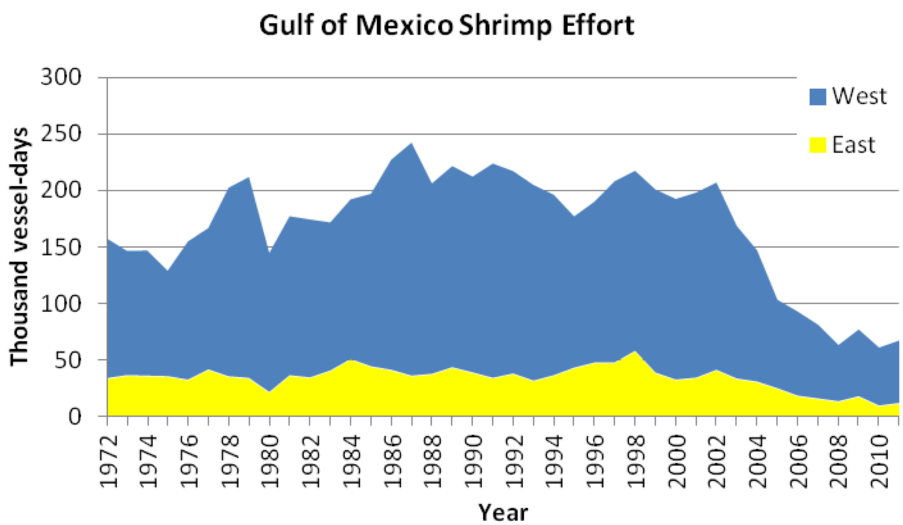

Figure 1. Gulf of Mexico shrimp fishery effort (thousand vessel-days) provided by the NMFS Galveston Lab. The reported effort does not include the average effort values used to fill empty cells.