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Shrimp Fishery Bycatch Estimates for Gulf of Mexico Data Limited Species: Wenchman and Lane Snapper, 1972-2014

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Abstract

Shrimp bycatch estimates for Gulf of Mexico data limited species were generated using the approach developed by Nichols and used in SEDAR 7 Gulf of Mexico Red Snapper assessment. Initial evaluation indicated that only two of eight species were represented in the bycatch in sufficient numbers to warrant analysis: a total of 156,357 Wenchman were caught in a total of 6,507 hauls; 45,641 Lane Snapper were caught in a total of 4,239 hauls.

Methods

Shrimp bycatch estimates for Gulf of Mexico data limited species were generated using the same approach developed by Nichols (2004a, 2004b) and used in 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).

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 catch per unit effort (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 model (Nance 2004). Shrimp effort is used as an index of shrimp fishing mortality in the assessment, in addition to its use in the estimation of shrimp bycatch. Shrimp effort estimates by region are presented in Table 2 and Figure 1.

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 2014 (Figure 1, Table 2). Some year, season, area and depth combinations lacked reported effort. Empty cells were restricted to depths greater than 30 fm where shrimp effort tends to be low. As effort estimates were used to specify year, season, area, and depth -specific priors on predicted effort, no cells could remain void. Therefore, empty effort cells were filled using average and standard error calculated from the same year, season, area, and depth combinations in the two years preceding and following the empty cell (i.e., a four year average). Most observer program effort data were expressed net-hours, but shrimp fleet effort data were expressed in vessel-days. Observer effort was converted from net-hours to net-days, then multiplied by the mean number of nets per vessel to convert from net-days to vessel-days. Mean number of nets per vessel was estimated from the Vessel Operating Unit File (VOUF). 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 2014 at approximately three nets per vessel (Table 3).

The following Bayesian model was used to estimate shrimp bycatch (model 02; 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 4. 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 (http://www.mrc-bsu.cam.ac.uk/software/bugs/the-bugs-project-winbugs/). Markov Chain Monte Carlo (MCMC) methods were used to estimate the marginal posterior distributions of key parameters and derived quantities. Two parallel chains of 55,000 iterations each were run. The first 5,000 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 10,000 – iteration chains. 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.

Results and Discussion

Initial evaluation indicated that only two of eight species were represented in the bycatch in sufficient numbers to warrant further analysis (Table 5). A total of 156,357 Wenchman were caught in a total of 6,507 hauls, and 45,641 Lane Snapper were caught in 4,239. Some issues remain. The degree of classification by observers of shrimp bycatch has changed through time. One category, unclassified *Epinephalus* species, contains twelve species. Unclassified *Sceriola* species contains six species. It may be possible to use the proportion of *Sceriola* species in classified catches to portion species in unclassified catches. However, the number of positive observations still remains low for species under consideration in this study. Surprisingly, very few Red Drum were observed. As Juvenile Red Drum are primarily found in bays and estuaries, state-run fishery independent studies were evaluated for the presence of red drum. Although red drum were caught relatively frequently in gill nets, they occurred infrequently in trawl samples suggesting red drum are not particularly vulnerable to that gear.

Median estimated bycatch of Wenchman and Lane Snapper in the shrimp fishery are presented in Tables 6 - 13. Bycatch of Lane Snapper was similar in the eastern and western Gulf of Mexico across years. Bycatch of Wenchman was concentrated in the western Gulf of Mexico and was relatively volatile.

Region-specific median annual bycatch estimates of Wenchman and Lane Snapper in the Gulf of Mexico shrimp fishery from the three-depth-zone model are presented in Figures 2 and 3, and Tables 6 - 13. Bycatch of Lane Snapper was similar in the eastern and western Gulf of Mexico across years. Bycatch of Wenchman was concentrated in the western Gulf of Mexico and was relatively volatile.

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Tables

Table 1.—Summary list of shrimp observer programs in the Gulf of Mexico (1972-2014).

Years	Program Description
1972-1982	Historical studies
	Bycatch studies
	Turtle capture study
	TED evaluations
1992-1997	Regional Research Program
1998	BRD effectiveness evaluations
2001-2014	Modern observer program

Table 2.—Gulf of Mexico shrimp fishery effort (vessel-days).

	East		West		Gulfwide	
Year	Effort	CV	Effort	CV	Effort	CV
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
2012	12,113	110	58,392	99	70,505	141
2013	12,571	112	52,193	92	64,764	128
2014	10,167	93	63,515	99	73,682	141

Table 3.—Average number of nets per vessel in the Gulf of Mexico shrimp fishery calculated from Vessel Operating Units File data.

Year	Nets	Standard 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	2.73	0.406
2012	2.75	0.407
2013	2.80	0.495
2014	2.74	0.725

Table 4.—List of factor levels for the main effects of the Bayesian shrimp bycatch estimation model.

Main Effect	Levels	Description
Year	43	1972-2014
Season	3	Jan-Apr, May-Aug, Sep-Dec
Area	4	Statistical grids 1-9, 10-12, 13-17, 18-21
Depth	3	Inside 10 fm, 10 fm to 30 fm, Outside 30 fm
Data Set	2	Observer program, Research vessel

Table 5.—Total number landed (Catch) and total number of positive tows (Tows) for the eight SEDAR49 data-limited species.

Species	Catch	Tows
Wenchman	156,357	6,507
Lane Snapper	45,641	4,239
Red Drum	401	226
Snowy Grouper	109	57
Lesser Amberjack	69	28
Almaco Jack	56	19
Yellowmouth Grouper	4	2
Speckled hind	4	1

Table 6.—Summary statistics of marginal posterior densities (millions of fish) of annual estimates Lane Snapper as bycatch in the Gulf of Mexico shrimp fishery.

Region	mean	sd	MC error	2.50%	median	97.50%
Total	12.17	3.08	0.07	7.46	11.73	19.45
East	5.58	1.73	0.04	3.06	5.30	9.71
West	4.60	1.19	0.03	2.71	4.45	7.36

Table 7.—Summary statistics of marginal posterior densities of annual estimates Lane Snapper as bycatch (millions of fish) in the Gulf of Mexico shrimp fishery.

Year	Mean	SD	MC error	2.50%	Median	97.50%
1972	54.02	139.9	1.2920	5.051	27.890	256.1
1973	5.28	14.18	0.1131	0.514	2.597	25.4
1974	12.20	35.35	0.2775	1.428	6.218	56.1
1975	19.56	48.23	0.3523	2.596	10.030	91.4
1976	8.38	15.66	0.0991	2.581	5.767	29.0
1977	6.45	10.56	0.0692	1.677	4.489	22.6
1978	6.70	12.38	0.0973	1.898	4.624	23.1
1979	8.05	18.23	0.2447	0.592	3.958	40.3
1980	5.83	5.438	0.0448	2.281	4.566	17.0
1981	21.96	46.05	0.3946	3.729	12.640	94.4
1982	17.44	37.22	0.3206	2.024	9.571	78.9
1983	6.38	13.03	0.1281	0.707	3.530	28.6
1984	8.42	16.86	0.1768	0.917	4.668	38.2
1985	5.99	12.73	0.1158	0.629	3.262	27.4
1986	19.09	41.62	0.3209	1.980	10.600	86.1
1987	28.44	62.35	0.5165	2.902	15.740	127.0
1988	17.50	39.97	0.3217	1.909	9.822	78.5
1989	22.76	43.28	0.3839	2.570	13.030	101.0
1990	25.54	54.77	0.4599	2.791	14.150	113.0
1991	67.65	131.80	1.1660	7.743	38.380	299.3
1992	15.98	25.16	0.1544	6.248	11.440	51.7
1993	11.32	22.63	0.1173	4.389	7.339	43.0
1994	14.04	13.79	0.0866	7.270	11.480	35.7
1995	21.17	16.74	0.1164	10.44	17.990	50.2
1996	23.26	42.03	0.3167	4.233	14.430	94.3
1997	34.85	74.57	0.4918	5.497	19.840	147.9
1998	27.07	59.83	0.4316	2.986	14.310	126.9
1999	115.60	238.8	2.0260	13.370	64.880	516.1
2000	175.40	327.5	3.1880	19.930	99.500	768.1
2001	158.50	299.5	2.8170	16.600	88.900	714.4
2002	113.20	218.5	2.0230	12.470	63.690	508.4
2003	105.80	273.2	2.0280	11.420	58.720	467.7
2004	75.60	172.5	1.4470	7.242	39.590	355.1
2005	88.79	214.8	1.7280	7.554	43.710	433.5
2006	53.64	120.2	0.9298	5.997	30.170	234.9
2007	39.25	68.4	0.6431	4.814	23.380	167.6
2008	21.06	51.45	0.4045	2.423	11.880	92.4
2009	36.91	84..00	0.7050	3.950	19.700	171.2
2010	13.09	26.93	0.2247	1.469	7.448	57.5
2011	21.40	47.74	0.3612	2.086	11.490	98.1
2012	29.22	75.28	0.5665	3.053	15.750	132.5
2013	22.72	49.79	0.4122	2.049	11.930	106.9
2014	46.27	96.16	0.7254	4.761	24.990	210.5

Table 8.—Summary statistics of marginal posterior densities of annual estimates Lane Snapper as bycatch (millions of fish) in the **eastern** Gulf of Mexico shrimp fishery.

Year	Mean	SD	MC error	2.50%	Median	97.50%
1972	32.27	123.8	0.844	1.574	12.51	180.6
1973	4.49	14.0	0.101	0.247	1.84	24.0
1974	9.45	34.7	0.241	0.617	3.77	50.3
1975	15.73	47.1	0.305	1.516	6.70	82.4
1976	6.97	15.6	0.094	1.535	4.35	27.5
1977	5.77	10.4	0.065	1.228	3.83	21.5
1978	4.39	10.7	0.082	1.089	2.75	16.5
1979	4.92	16.0	0.161	0.181	1.75	28.7
1980	3.68	5.3	0.041	0.727	2.36	14.6
1981	12.97	40.9	0.288	0.768	5.14	71.3
1982	11.07	32.8	0.226	0.695	4.61	59.2
1983	4.11	11.8	0.091	0.244	1.74	21.8
1984	5.32	14.9	0.122	0.328	2.28	28.3
1985	3.90	11.4	0.083	0.219	1.60	21.1
1986	10.96	36.9	0.211	0.559	4.44	60.3
1987	15.31	54.6	0.334	0.733	5.95	84.0
1988	9.34	30.1	0.197	0.528	3.90	50.0
1989	12.09	32.3	0.234	0.749	5.26	65.0
1990	13.34	44.6	0.277	0.770	5.55	70.0
1991	31.33	97.1	0.635	1.825	13.06	167.5
1992	6.55	22.8	0.125	0.488	2.46	36.0
1993	7.08	22.6	0.114	0.999	2.97	38.5
1994	5.06	6.0	0.029	2.701	4.20	12.2
1995	9.86	8.7	0.053	4.685	8.24	24.2
1996	5.95	11.7	0.096	0.737	3.26	26.9
1997	22.38	70.2	0.384	1.358	8.90	119.7
1998	20.21	57.4	0.366	1.112	8.42	108.5
1999	68.26	207.1	1.400	3.915	28.18	362.5
2000	89.59	258.3	1.883	5.170	37.30	478.5
2001	83.75	234.9	1.666	4.439	34.80	452.7
2002	67.62	189.4	1.437	3.732	27.96	368.8
2003	62.12	248.6	1.386	3.441	25.88	327.9
2004	50.93	161.1	1.107	2.326	19.49	286.6
2005	65.40	198.0	1.414	2.769	24.42	371.4
2006	30.80	99.3	0.620	1.827	13.12	163.3
2007	19.13	50.0	0.355	1.321	8.65	99.8
2008	12.19	45.3	0.276	0.731	5.05	64.2
2009	23.90	76.9	0.522	1.326	9.43	129.7
2010	7.36	23.5	0.150	0.384	3.01	40.2
2011	14.26	41.8	0.260	0.906	6.33	73.0
2012	20.97	68.5	0.435	1.373	9.36	108.2
2013	15.96	43.1	0.314	0.954	7.00	83.8
2014	28.56	80.1	0.499	2.006	12.99	143.7

Table 9.—Summary statistics of marginal posterior densities of annual estimates Lane Snapper as bycatch (millions of fish) in the **western** Gulf of Mexico shrimp fishery.

Year	Mean	SD	MC error	2.50%	Median	97.50%
1972	21.75	60.00	0.517	1.69	10.28	106.60
1973	0.79	1.38	0.016	0.11	0.48	3.32
1974	2.75	5.61	0.050	0.36	1.56	12.33
1975	3.83	9.05	0.080	0.39	1.90	18.64
1976	1.40	0.94	0.008	0.64	1.21	3.24
1977	0.68	1.24	0.008	0.21	0.48	2.28
1978	2.31	5.89	0.033	0.38	1.34	9.69
1979	3.13	7.42	0.093	0.21	1.50	15.57
1980	2.15	0.99	0.009	1.08	1.94	4.48
1981	8.99	20.07	0.140	1.88	5.44	36.27
1982	6.37	16.63	0.124	0.57	3.19	30.09
1983	2.27	4.95	0.045	0.21	1.17	10.89
1984	3.09	7.11	0.064	0.26	1.55	14.91
1985	2.10	5.13	0.041	0.19	1.09	10.05
1986	8.13	17.50	0.143	0.69	4.20	38.78
1987	13.13	28.03	0.232	1.10	6.75	63.78
1988	8.16	21.86	0.156	0.69	4.17	38.41
1989	10.66	27.22	0.184	0.91	5.44	50.77
1990	12.20	29.87	0.221	1.01	6.10	59.38
1991	36.32	85.16	0.641	3.07	18.23	176.60
1992	9.43	10.40	0.052	4.83	8.01	21.74
1993	4.24	1.44	0.011	2.75	3.99	7.13
1994	8.98	12.33	0.070	3.67	6.77	26.90
1995	11.31	14.08	0.079	3.95	8.82	32.71
1996	17.30	39.96	0.246	2.38	9.34	79.08
1997	12.47	23.17	0.189	2.42	7.88	49.51
1998	6.86	15.36	0.102	0.89	3.57	31.89
1999	47.36	110.00	0.800	4.41	24.90	220.60
2000	85.81	189.40	1.531	7.52	44.14	411.10
2001	74.78	173.90	1.361	6.11	37.75	357.60
2002	45.54	99.80	0.739	4.12	23.77	213.40
2003	43.71	104.30	0.811	3.68	21.91	210.70
2004	24.67	53.70	0.447	2.18	12.97	117.00
2005	23.39	75.39	0.441	2.11	12.16	110.10
2006	22.84	64.50	0.414	2.04	11.70	107.90
2007	20.12	44.09	0.344	1.92	10.77	92.82
2008	8.87	21.88	0.165	0.86	4.77	40.83
2009	13.01	30.87	0.240	1.24	6.75	60.73
2010	5.73	11.94	0.095	0.56	3.12	26.04
2011	7.14	21.48	0.135	0.46	3.13	37.87
2012	8.25	27.53	0.176	0.62	3.88	41.02
2013	6.75	22.79	0.136	0.41	2.92	35.02
2014	17.71	50.28	0.315	0.99	7.24	96.28

Table 10.—Summary statistics of marginal posterior densities of annual estimates Wenchman as bycatch (millions of fish) in the western Gulf of Mexico shrimp fishery.

Region	mean	sd	MC error	2.50%	median	97.50%
Total	5.57	1.66	0.05	3.00	5.34	9.38
East	0.33	0.10	0.00	0.17	0.31	0.56
West	4.87	1.52	0.04	2.55	4.64	8.38

Table 11.—Summary statistics of marginal posterior densities of annual estimates of Wenchman as bycatch (millions of fish) in the Gulf of Mexico shrimp fishery.

Year	Mean	SD	MC error	2.50%	Median	97.50%
1972	15.75	26.84	0.437	1.56	8.85	72.16
1973	1.48	2.98	0.032	0.17	0.83	6.59
1974	19.18	24.33	0.285	5.61	13.96	63.74
1975	8.11	14.82	0.161	1.09	4.72	34.82
1976	18.49	16.02	0.165	8.20	15.36	47.33
1977	3.96	7.61	0.063	0.61	2.36	16.86
1978	7.83	14.77	0.144	1.21	4.61	32.89
1979	9.00	18.64	0.299	0.75	4.77	42.03
1980	1.29	4.40	0.028	0.13	0.63	6.23
1981	7.68	17.86	0.159	0.87	4.21	34.86
1982	9.48	16.58	0.185	1.22	5.67	40.55
1983	5.67	9.43	0.112	0.75	3.45	23.85
1984	21.41	33.05	0.400	2.97	13.28	89.41
1985	20.10	33.57	0.367	2.52	11.94	86.08
1986	19.69	35.84	0.361	2.45	11.75	82.73
1987	21.63	43.79	0.411	2.57	12.44	94.87
1988	13.21	32.00	0.270	1.50	7.62	58.30
1989	15.59	29.44	0.301	1.76	9.00	68.39
1990	20.03	49.88	0.459	1.92	10.20	95.54
1991	7.78	14.44	0.140	0.91	4.52	33.69
1992	11.12	7.61	0.054	5.79	9.86	23.12
1993	10.21	2.20	0.019	7.30	9.88	15.04
1994	13.38	8.14	0.064	6.22	11.79	29.56
1995	0.95	1.55	0.014	0.21	0.61	3.71
1996	2.77	6.69	0.051	0.30	1.43	12.82
1997	1.32	2.06	0.023	0.24	0.87	5.06
1998	2.45	6.63	0.046	0.30	1.40	10.73
1999	17.72	44.14	0.388	2.03	10.01	77.12
2000	14.58	28.10	0.285	1.70	8.42	63.24
2001	14.41	26.60	0.265	1.61	8.52	61.68
2002	18.48	33.87	0.360	2.23	11.01	79.90
2003	21.86	36.94	0.380	2.68	13.36	91.64
2004	19.78	47.71	0.414	1.65	10.00	94.99
2005	31.29	75.42	0.616	2.47	15.70	153.60
2006	6.49	14.65	0.145	0.66	3.56	29.63
2007	9.24	19.59	0.190	0.89	5.06	41.86
2008	4.71	16.67	0.124	0.47	2.52	21.49
2009	5.00	9.71	0.103	0.53	2.81	22.43
2010	10.87	20.76	0.203	1.07	6.02	49.36
2011	6.28	11.69	0.117	0.69	3.59	27.76
2012	5.48	23.13	0.128	0.53	2.89	24.56
2013	14.26	29.50	0.252	1.42	7.83	65.28
2014	5.31	10.61	0.098	0.53	2.95	24.02

Table 12.—Summary statistics of marginal posterior densities (millions of fish) of annual estimates of Wenchman as bycatch in the **eastern** Gulf of Mexico shrimp fishery.

Year	Mean	SD	MC error	2.50%	Median	97.50%
1972	1.19	3.77	0.037	0.09	0.57	5.84
1973	0.10	0.17	0.002	0.01	0.05	0.42
1974	0.81	1.62	0.018	0.08	0.45	3.66
1975	0.57	0.73	0.008	0.15	0.41	1.88
1976	0.55	1.04	0.011	0.06	0.31	2.52
1977	0.30	0.51	0.005	0.04	0.18	1.26
1978	0.48	0.89	0.010	0.06	0.28	2.07
1979	0.60	1.36	0.020	0.04	0.30	2.92
1980	0.06	0.12	0.001	0.01	0.03	0.25
1981	0.34	0.70	0.008	0.03	0.18	1.60
1982	0.69	1.57	0.015	0.07	0.38	3.13
1983	0.38	0.74	0.008	0.04	0.22	1.69
1984	2.18	4.34	0.043	0.21	1.17	10.14
1985	1.16	2.16	0.023	0.12	0.65	5.30
1986	0.97	4.01	0.022	0.09	0.51	4.40
1987	0.93	1.89	0.018	0.09	0.50	4.30
1988	0.70	1.44	0.014	0.07	0.38	3.20
1989	0.79	1.62	0.016	0.07	0.43	3.65
1990	0.99	2.30	0.021	0.10	0.55	4.43
1991	0.42	0.84	0.008	0.04	0.24	1.81
1992	0.31	0.65	0.005	0.04	0.17	1.38
1993	1.00	1.01	0.010	0.34	0.78	2.96
1994	0.74	2.55	0.011	0.29	0.53	2.44
1995	0.11	0.23	0.002	0.01	0.06	0.49
1996	0.21	0.43	0.004	0.03	0.12	0.91
1997	0.28	0.57	0.005	0.03	0.16	1.23
1998	0.30	0.67	0.006	0.03	0.16	1.39
1999	1.08	1.85	0.021	0.11	0.62	4.84
2000	0.94	2.44	0.020	0.10	0.52	4.21
2001	1.20	3.24	0.025	0.11	0.66	5.52
2002	1.05	1.93	0.022	0.11	0.59	4.77
2003	1.10	2.32	0.022	0.10	0.58	5.09
2004	0.55	1.14	0.012	0.05	0.30	2.51
2005	1.21	2.73	0.024	0.09	0.62	5.84
2006	0.53	1.28	0.011	0.04	0.26	2.58
2007	1.11	3.38	0.026	0.07	0.47	5.82
2008	0.24	0.47	0.005	0.02	0.13	1.10
2009	0.40	0.80	0.008	0.04	0.22	1.86
2010	0.34	0.82	0.006	0.03	0.17	1.63
2011	1.30	2.75	0.025	0.10	0.64	6.51
2012	1.36	3.55	0.028	0.08	0.59	7.29
2013	3.03	8.11	0.059	0.18	1.32	15.98
2014	0.89	2.64	0.018	0.06	0.42	4.42

Table 13.—Summary statistics of marginal posterior densities (millions of fish) of annual estimates of Wenchman as bycatch in the **western** Gulf of Mexico shrimp fishery.

Year	Mean	SD	MC error	2.50%	Median	97.50%
1972	14.57	26.22	0.404	1.26	7.83	69.21
1973	1.39	2.97	0.030	0.14	0.74	6.43
1974	18.37	24.17	0.270	5.23	13.20	62.24
1975	7.54	14.75	0.155	0.74	4.15	34.10
1976	17.94	15.92	0.156	7.87	14.83	46.49
1977	3.67	7.57	0.059	0.47	2.07	16.36
1978	7.35	14.69	0.136	1.00	4.14	32.21
1979	8.40	18.39	0.281	0.61	4.25	40.53
1980	1.24	4.39	0.028	0.10	0.57	6.13
1981	7.34	17.81	0.153	0.72	3.87	34.30
1982	8.79	16.41	0.173	0.95	5.00	39.19
1983	5.28	9.34	0.106	0.60	3.09	23.18
1984	19.23	32.43	0.363	2.17	11.25	84.82
1985	18.93	33.31	0.347	2.04	10.82	83.97
1986	18.73	35.43	0.346	2.07	10.86	81.05
1987	20.70	43.56	0.396	2.20	11.53	93.20
1988	12.51	31.87	0.258	1.25	6.94	56.80
1989	14.80	29.22	0.289	1.47	8.24	66.59
1990	19.04	49.68	0.441	1.54	9.25	93.96
1991	7.37	14.35	0.133	0.76	4.12	32.91
1992	10.81	7.56	0.051	5.58	9.56	22.59
1993	9.21	1.93	0.014	6.56	8.93	13.44
1994	12.63	7.68	0.059	5.65	11.08	28.51
1995	0.84	1.52	0.012	0.17	0.51	3.50
1996	2.56	6.66	0.049	0.21	1.23	12.45
1997	1.04	1.95	0.019	0.15	0.62	4.40
1998	2.15	6.57	0.042	0.20	1.11	10.14
1999	16.64	43.95	0.370	1.63	8.97	75.16
2000	13.65	27.83	0.269	1.37	7.54	61.44
2001	13.21	26.19	0.244	1.25	7.41	59.21
2002	17.42	33.62	0.341	1.84	10.01	77.79
2003	20.76	36.69	0.364	2.26	12.31	89.52
2004	19.23	47.61	0.404	1.43	9.46	93.94
2005	30.08	75.16	0.597	2.08	14.57	150.90
2006	5.96	14.50	0.137	0.50	3.08	28.39
2007	8.13	19.10	0.169	0.64	4.13	38.78
2008	4.47	16.63	0.119	0.38	2.30	21.05
2009	4.60	9.62	0.096	0.40	2.43	21.65
2010	10.53	20.68	0.198	0.95	5.70	48.78
2011	4.98	11.12	0.096	0.39	2.51	24.34
2012	4.12	22.76	0.109	0.28	1.86	20.29
2013	11.23	27.92	0.209	0.81	5.43	55.62
2014	4.42	10.15	0.084	0.33	2.20	21.59

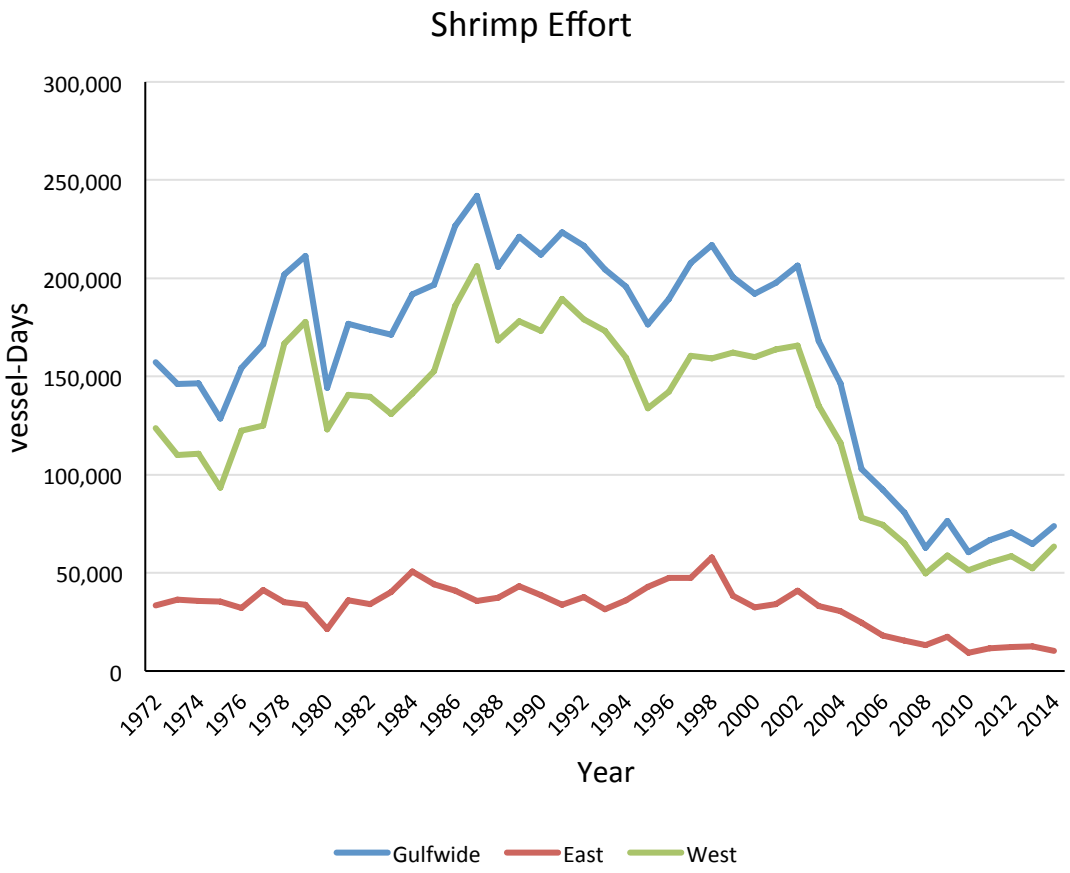

Figure 1.—Gulf of Mexico shrimp fishery effort (thousand vessel-days) provided by the NMFS Galveston Lab. The reported effort does not include the average effort values used to fill empty cells.

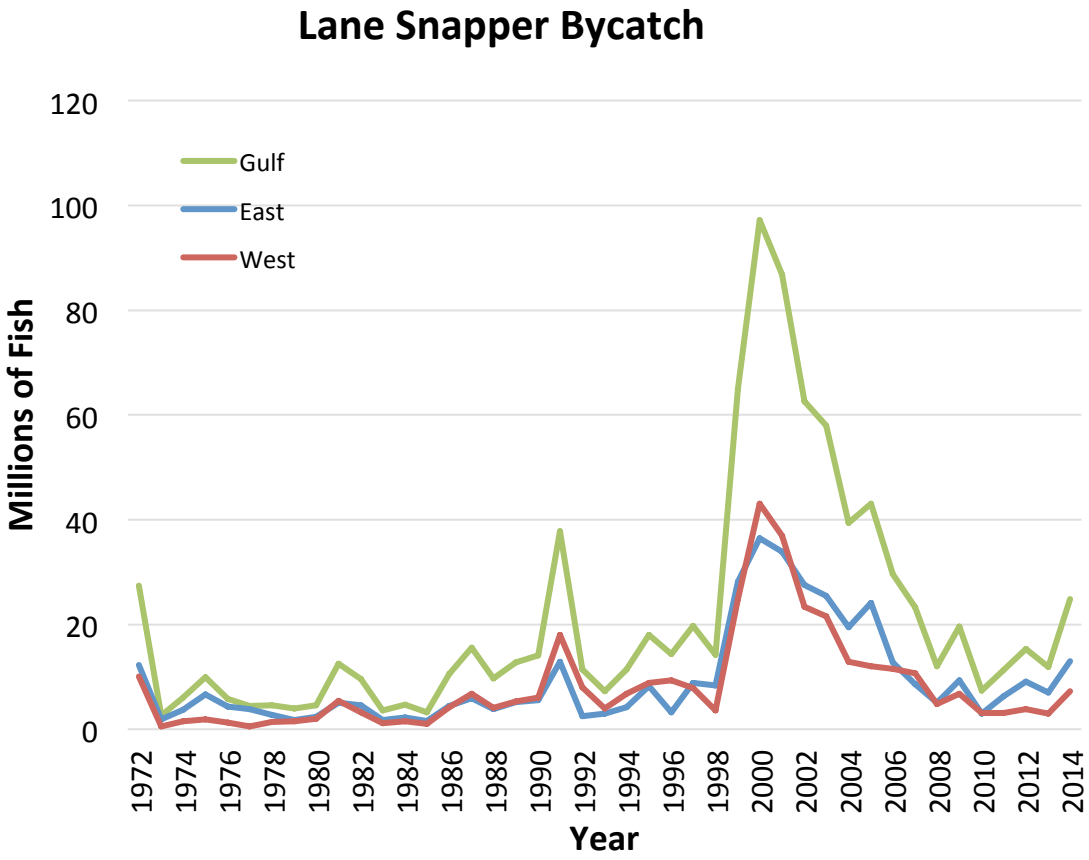

Figure 2.—Median annual bycatch (millions of fish) for Lane Snapper in the Gulf of Mexico shrimp fishery.

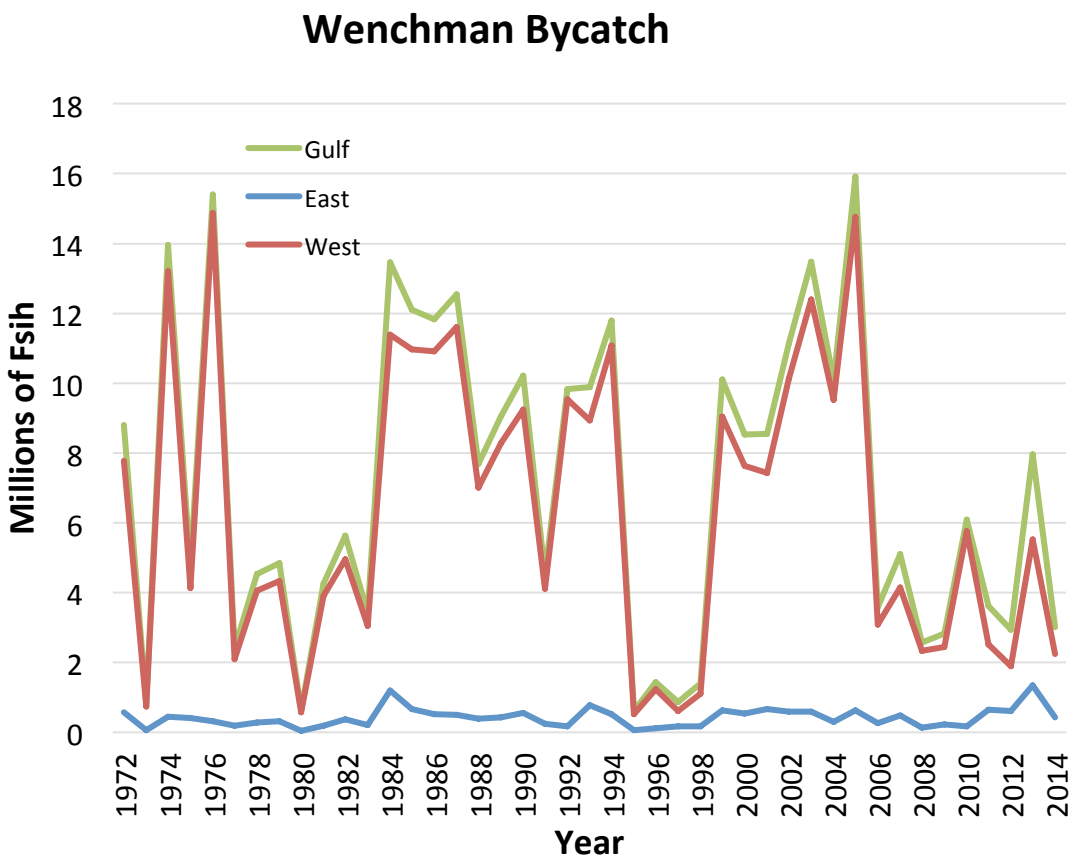

Figure 3.—Median annual bycatch (millions of fish) for Wenchman in the Gulf of Mexico shrimp fishery.