Estimates of Historical Red Snapper Recreational Catch Levels Using US Census Data and Recreational Survey Information

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INTRODUCTION

Extending the time-series of catch information available for Gulf red snapper may provide an improved basis for assessing stock status and productivity potentials. Catch information from the commercial fishing sector harvesting this species ranges back to the late 1800's (Schirripa and Legault 1999). Survey-based information about removals by the recreational fishing sector typically ranges back into the early 1980's. However, it is well known that the recreational fishing sector had been active in the region for decades before more formalized statistical sampling surveys of this fishing effort were implemented. In this paper, the trend in growth of the US Gulf of Mexico coastal human population is examined for correlation with estimated recreational fishing effort from a statistical survey and subsequently used to provide a time-series of potential catch level for the period before survey-based estimates are generally available for use in stock status evaluations.

DATA, METHODS, & RESULTS

Human population levels by state and county were obtained from two US Census Bureau websites. For the Census Bureau population estimates from 1900-1990, the website http://www.census.gov/population/www/censusdata/cencounts.html   was accessed, while the 2000 census data were accessed at http://factfinder.census.gov/servlet/DTSubjectShowTablesServlet?_ts=109065982546. Table 1 provides the State-wide and Gulf of Mexico coastal county population estimates for 1900-2000. The patterns in population growth are shown in Figure 1. For modeling purposes, annual human population levels were interpolated based on the decadal census results.

Estimates of fishing effort by mode of fishing in the Gulf of Mexico are available from the MRFSS website http://www.st.nmfs.gov/st1/recreational/queries/effort/effort_time_series.html . Table 2 presents the information extracted for the Gulf of Mexico region. Figure 2 provides a view of the trend in human coastal population and estimates of fishing effort by anglers using private and charter vessels. Note that a change in MRFSS survey method for the charterboat sector was implemented in 2000 and as such, only estimates of charter angling effort from 1986 (the first year for which estimates of charter effort alone are available) through 1999 are shown in this figure to avoid confounding due to change in survey method. These patterns indicate a general correlation between these fishing effort measures and coastal human population level, although there appear differences in the rates of increasing fishing effort in the private and charter angling sectors likely due to different socio-economic features acting on these sectors. Given these general patterns, I proceeded to model estimated red snapper catch as a function of coastal human population as a proxy for fishing effort.

Estimates of red snapper catches (including discarded catch) were available based on the proscriptions made by the SEDAR Red Snapper Data Workshop (April, 2004, New Orleans). Including discarded catch in the analysis provided a basis for accounting for minimum size effects, since the landings have been a diminishing fraction of total catch (see SEDAR7 Data Workshop Report and Figure 3). These estimates are described in the SEDAR7 Data Workshop report and in subsequent documents prepared for the SEDAR7 Assessment Workshop. For the purposes of this analysis, total estimated catch (estimated landings and discards) by year, state and type of fishing (charter and headboat combined plus private and shore (a minor component of catch) combined) was used. Estimated red snapper catches from MRFSS, Texas Parks & Wildlife, and the Beaufort Headboat surveys were used.

Information about red snapper year class strength from the SEAMAP surveys (SEDAR7-DW1, SEDAR7-DW2) was also used in modeling catch, although for the period prior to 1972, relative abundance information was not available. In this case, a 3-year running average of the averaged summer and fall survey indices was used. For years preceding the years of SEAMAP data, the value used for 1972 was carried backward.

Generalized Linear Models (GLM) of (log-transformed) catch as a function of population abundance (log-transformed), state of fishing, type of fishing, and information about year class strengths (log-transformed) were fit to the observed catch data. The resulting model parameters were then used to predict catch prior to 1981.

Main effects and interaction terms were admitted to the model based on Type III F-statistics. Models which included year-class strength information provided a somewhat better fit to the observed data (see Table 3, Figure 4) but also resulted in somewhat higher predictions of historic catch levels (Figure 5, Table 4), largely because the historic (pre-1972)red .

The average size of landed red snapper from recreational fisheries has also changed over time (Figure 6). For estimates of historical recreational removals in weight, I applied the mean size (1.8 pounds whole) from recreational fishing size samples (3090 lengths converted to whole weights) obtained in the pre-1985 to generate plausible time-series of biomass removed pre-1981. These values are also shown in Table 4.

REFERENCE

Schirripa, M.J. and C.M. Legault. 1999. Status of the red snapper in U.S. waters of the Gulf of Mexico: updated through 1998. Sustainable Fisheries Division Contribution SFD-99/00-75

Table 1a. US Census Bureau population estimates for the strata indicated.						
Sum of Gulf Coastal County Population	State					
Decade	Alabama	Florida	Lousiana	Mississippi	Texas	Grand Total
1900	75934	153331	174554	49401	121470	574690
1910	99032	234177	198787	61316	182420	775732
1920	120847	311255	182086	62443	265368	941999
1930	146652	457668	215714	71531	439624	1331189
1940	174298	564072	258114	82728	534256	1613468
1950	272102	821721	333816	127365	780544	2335548
1960	363389	1483616	525906	189050	1004700	3566661
1970	376690	2014693	728382	239944	1077319	4437028
1980	443536	2978700	907413	300217	1307368	5937234
1990	476923	3988084	909052	312368	1413956	7100383
2000	540258	4089783	934493	363988	1633554	7562076

Table 1b. US Census Bureau population estimates for the strata indicated.						
Sum of Total Population	State					
Decade	Alabama	Florida	Lousiana	Mississippi	Texas	Grand Total
1900	1828697	528542	1381625	1551270	3048710	8338844
1910	2138093	752619	1656388	1797114	3896542	10240756
1920	2348174	968470	1798509	1790618	4663228	11568999
1930	2646248	1468211	2101593	2009821	5824715	14050588
1940	2832961	1897414	2363880	2183796	6414824	15692875
1950	3061743	2771305	2683516	2178914	7711194	18406672
1960	3266740	4951560	3257022	2178141	9579677	23233140
1970	3444165	6789443	3641306	2216912	11196730	27288556
1980	3893888	9746324	4205900	2520638	14229191	34595941
1990	4040587	12937926	4219973	2573216	16986510	40758212
2000	4447100	15982378	4468976	2844658	20851820	48594932

Table 2. Effort estimates for Gulf of Mexico coastal states from MRFSS. Charterboat effort estimation methods changed in 2000 and as such, only estimates using the 'old' charterboat method are shown here.

Private/Rental angler trips						
Year	ALABAMA	LOUISIANA	MISSISSIPPI	TEXAS	WEST FLORIDA	Grand Total
1981	292271	933118	268230	962551	5308285	7764455
1982	596248	1472372	311939		3058407	5438966
1983	428853	1674790	435015	233611	4069372	6841641
1984	269899	1228868	353857		5654172	7506796
1985	244458	1217120	329830	1387325	5136155	8314888
1986	410028	1911101	520981		5294131	8136241
1987	269780	1798018	461970		5988021	8517789
1988	448812	2172913	467221		7609586	10698532
1989	360901	1661235	403200		6286971	8712307
1990	381739	1323317	320375		5191075	7216506
1991	304608	1685626	453137		6643368	9086739
1992	390164	1927495	430078		6625517	9373254
1993	463546	2038772	452141		6086848	9041307
1994	440556	1835069	540847		6568329	9384801
1995	524890	2268181	551630		6226194	9570895
1996	457184	2118544	465524		6309765	9351017
1997	551014	2220555	584777		6838737	10195083
1998	508707	1862129	472334		6095735	8938905
1999	612719	1979222	426957		6078906	9097804
2000	545243	2722392	568180		7892650	11728465

Charterboat angler trips					
Year	ALABAMA	LOUISIANA	MISSISSIPPI	WEST FLORIDA	Grand Total
1986	26956	49541	30090	391154	497741
1987	15224	47111	18988	566948	648271
1988	34419	56601	19110	410282	520412
1989	49863	39868	16454	384351	490536
1990	44151	39823	11604	291363	386941
1991	38346	41681	5283	359299	444609
1992	31189	30069	4188	375048	440494
1993	57384	48419	26244	615205	747252
1994	54139	56205	37594	677694	825632
1995	61815	77825	49239	705088	893967
1996	60755	80716	49241	690537	881249
1997	82900	75607	64518	751954	974979
1998	70528	64987	34519	733137	903171
1999	80074	63548	39544	693876	877042

Table 3. ANOVA results for the predicted catch models using (Model A) and not using (Model B) relative abundance information.

Model A Dependent Variable: ln(catch)

Source	DF	Sum of Squares	Mean Square	F Value	Pr>F
Model A	13	290.00	22.31	21.32	<.0001
Error	193	201.92	1.05		
Corrected Total	206	491.92			

R-Square
0.59

Source	DF	Type III SS	Mean Square	F	P>F
ln(people)	1	143.43	143.43	137.10	<.0001
ln(abundance)	1	17.73	17.73	16.95	<.0001
sstate	3	16.30	5.43	5.19	0.0018
Year*sstate	4	17.55	4.39	4.19	0.0028
sstate*Type	4	33.52	8.38	8.01	<.0001

Parameter		Estimate	Standard Error	t-Value	P>|t|
Intercept		-31.165	52.356	-0.60	0.5524
ln(people)		6.471	0.553	11.71	<.0001
ln(abundance)		0.677	0.164	4.12	<.0001
sstate	FL	-108.227	73.437	-1.47	0.1422
sstate	LA	70.139	74.245	0.94	0.3460
sstate	MS/AL	-163.340	64.404	-2.54	0.0120
sstate	TX	0.000	.	.	.
Year*sstate	FL	0.027	0.027	0.99	0.3233
Year*sstate	LA	-0.058	0.026	-2.22	0.0275
Year*sstate	MS/AL	0.062	0.020	3.10	0.0022
Year*sstate	TX	-0.025	0.027	-0.91	0.3621
sstate*Type	FL CB_HB	0.769	0.316	2.44	0.0157
sstate*Type	FL private	0.000	.	.	.
sstate*Type	LA CB_HB	0.058	0.316	0.18	0.8542
sstate*Type	LA private	0.000	.	.	.
sstate*Type	MS/AL CB_HB	-0.616	0.228	-2.70	0.0075
sstate*Type	MS/AL private	0.000	.	.	.
sstate*Type	TX CB_HB	1.367	0.316	4.33	<.0001
sstate*Type	TX private	0.000	.	.	.

Model B Dependent Variable: ln(catch)

Source	DF	Sum of Squares	Mean Square	F	P>F
Model B	12	272.27	22.69	20.04	<.0001
Error	194	219.65	1.13		
Corrected Total	206	491.92			

R-Square
0.55

Source	DF	Type III SS	Mean Square	F	P>F
ln(people)	1	144.05	144.05	127.23	<.0001
sstate	3	16.56	5.52	4.88	0.0027
Year*sstate	4	17.19	4.30	3.79	0.0054
sstate*Type	4	33.72	8.43	7.45	<.0001

Parameter		Estimate	Standard Error	t-Value	P>|t|
Intercept		-14.705	54.306	-0.27	0.7869
ln(people)		6.485	0.575	11.28	<.0001
sstate	FL	-108.256	76.395	-1.42	0.1581
sstate	LA	69.867	77.236	0.90	0.3668
sstate	MS/AL	-165.457	66.996	-2.47	0.0144
sstate	TX	0.000	.	.	.
Year*sstate	FL	0.018	0.028	0.65	0.5134
Year*sstate	LA	-0.066	0.027	-2.45	0.0154
Year*sstate	MS/AL	0.054	0.021	2.64	0.0090
Year*sstate	TX	-0.033	0.028	-1.18	0.2394
sstate*Type	FL CB_HB	0.769	0.328	2.34	0.0202
sstate*Type	FL private	0.000	.	.	.
sstate*Type	LA CB_HB	0.058	0.328	0.18	0.8597
sstate*Type	LA private	0.000	.	.	.
sstate*Type	MS/AL CB_HB	-0.624	0.237	-2.63	0.0092
sstate*Type	MS/AL private	0.000	.	.	.
sstate*Type	TX CB_HB	1.367	0.328	4.16	<.0001
sstate*Type	TX private	0.000	.	.	.

Table 5. Model predicted catch with and without relative abundance signal

No Abundance	Abundance	Year	Pounds, No Abundance	Pounds, Abundance
3187	4637	1900	5777	8406
3261	4784	1901	5912	8672
3334	4930	1902	6043	8936
3404	5074	1903	6170	9198
3471	5217	1904	6293	9456
3537	5357	1905	6411	9711
3599	5497	1906	6524	9964
3659	5633	1907	6633	10212
3716	5768	1908	6736	10455
3771	5899	1909	6835	10694
3823	6029	1910	6929	10929
3391	5393	1911	6147	9776
3008	4825	1912	5453	8746
2670	4317	1913	4839	7826
2370	3865	1914	4296	7006
2106	3462	1915	3817	6276
1873	3105	1916	3395	5629
1668	2790	1917	3024	5057
1490	2511	1918	2700	4552
1334	2268	1919	2419	4111
1200	2056	1920	2174	3727
1300	2245	1921	2356	4069
1415	2462	1922	2564	4462
1547	2713	1923	2805	4918
1702	3007	1924	3085	5451
1883	3352	1925	3413	6076
2095	3758	1926	3798	6811
2345	4236	1927	4250	7678
2637	4799	1928	4780	8700
2979	5463	1929	5400	9902
3380	6242	1930	6126	11315
3670	6833	1931	6653	12386
3978	7464	1932	7210	13529
4302	8136	1933	7798	14748
4643	8853	1934	8417	16047
5003	9614	1935	9068	17427
5381	10423	1936	9753	18893
5777	11280	1937	10472	20447
6192	12188	1938	11225	22093
6627	13148	1939	12013	23832
7081	14162	1940	12836	25672
8712	17554	1941	15792	31820
10659	21640	1942	19322	39227
12969	26531	1943	23509	48092
15695	32356	1944	28451	58651
18893	39248	1945	34248	71144
22626	47367	1946	41013	85862

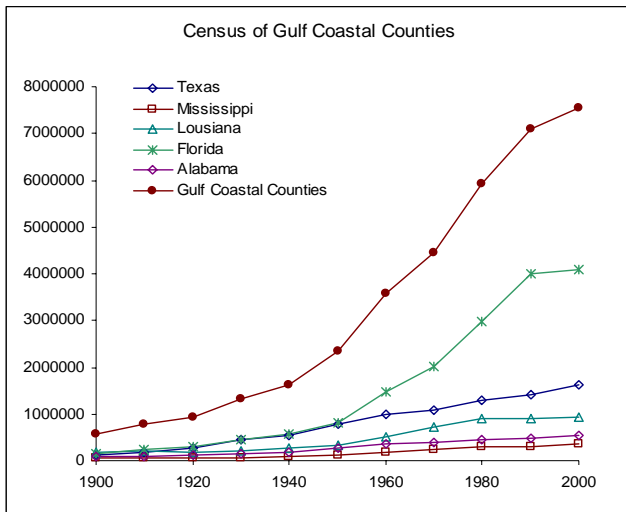|				
26958	56879	1947	48866	103104
31963	67969	1948	57940	123207
37721	80846	1949	68377	146549
44316	95731	1950	80331	173530
53111	115676	1951	96274	209685
63357	139124	1952	114846	252189
75227	166548	1953	136364	301900
88912	198471	1954	161170	359766
104605	235413	1955	189617	426730
122510	277953	1956	222072	503843
142839	326744	1957	258923	592285
165826	382403	1958	300592	693179
191699	445701	1959	347491	807917
220702	517298	1960	400065	937702
238613	563939	1961	432532	1022247
258564	616133	1962	468697	1116857
280691	674373	1963	508807	1222429
305120	739033	1964	553088	1339637
331962	810528	1965	601744	1469236
361280	889348	1966	654889	1612113
393249	975834	1967	712838	1768885
427892	1070348	1968	775636	1940209
465297	1173295	1969	843438	2126821
505560	1285020	1970	916423	2329343
559850	1434439	1971	1014835	2600192
618325	1597026	1972	1120831	2894912
681345	1774009	1973	1235067	3215728
749192	1966330	1974	1358052	3564346
822266	1353959	1975	1490514	2454308
900930	1389704	1976	1633107	2519103
985754	1604536	1977	1786866	2908526
1077217	2125161	1978	1952660	3852258
1176036	2323082	1979	2131788	4211027
1282929	3169113	1980	2325552	5744620

Figure 1. Pattern in Gulf of Mexico coastal county population growth over the period 1900-2000.
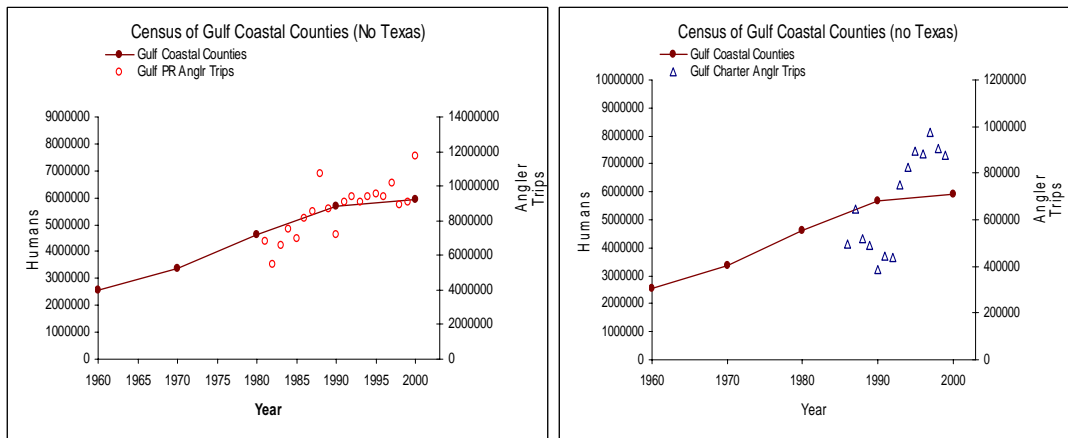

Figure 2. Patterns in growth of human population within Gulf of Mexico coastal counties compared with MRFSS estimates of angling effort by fishing mode. Here, no Texas population information is included since the effort estimates from MRFSS generally exclude Texas anglers.
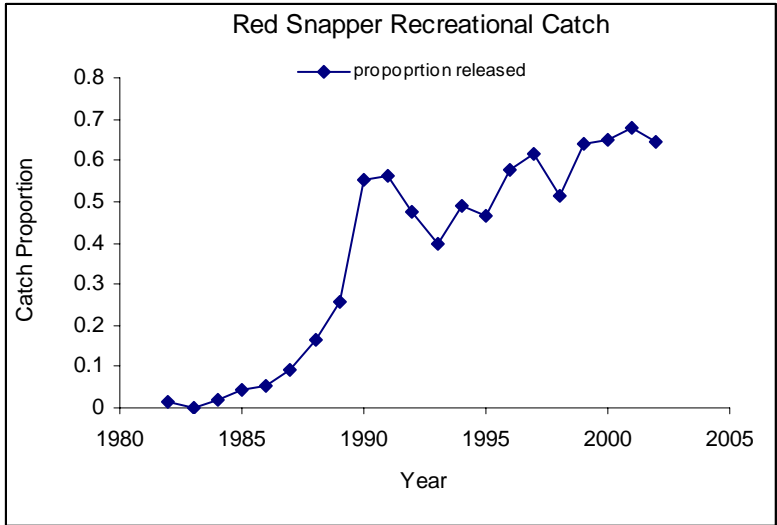
Figure 3. Trend in estimated proportion of total catch released over time based on MRFSS estimates. Very low proportions of the total catch were estimated to have been released in the early 1980's.

Figure 4. Fitted GLM models (lines) to observed catches. Model A (solid line) uses red snapper relative abundance information and the fit is marginally improved compared to Model B (dashed line) which does not use red snapper relative abundance information.
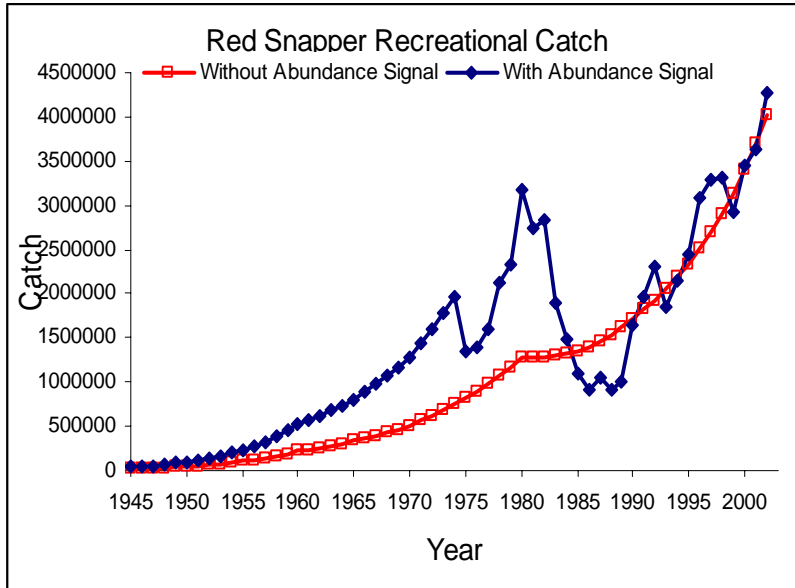
Figure 5. GLM predicted catch of red snapper using Model A (closed diamonds) and Model B (open squares) from the end of WWII to current.
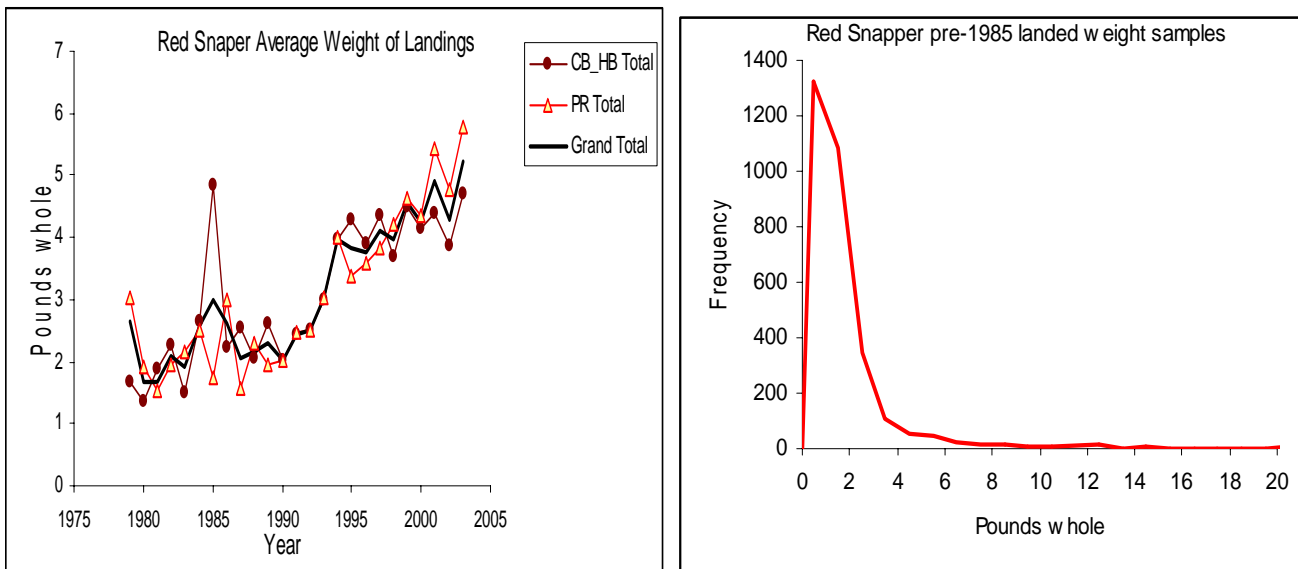

Figure 6. Average weight of landed red snapper by year (left) and the distribution of weights across samples taken pre-1985 (right)