SEDAR 10 Review Workshop

Assessment Advisory Report
Gulf of Mexico Gag Grouper

July 27, 2006
revised: September 20, 2006

Stock distribution and identification

- The management unit for Gulf of Mexico gag grouper extends from the United States – Mexico border in the west through northern Gulf of Mexico waters and west of the Dry Tortugas and the Florida Keys (waters within the Gulf of Mexico Fishery Management Council Boundaries).
- The SEDAR 10 Review Workshop (RW), using several sources of information, examined and accepted the current stock definitions for the South Atlantic and Gulf of Mexico gag grouper.

Assessment methods

- Gulf of Mexico gag grouper were primarily assessed with a statistical forward projection catch-at-age model (CASAL). Additionally, the assessment model used in the 2001 assessment (VPA, virtual population analysis), was run to show the effects of updated data and the effects of adding indices of abundance not available in 2001. With the statistical catch-at-age model, various configurations and sensitivity runs were explored. Details of all models are available in the Stock Assessment Report.
- The Assessment Workshop (AW) developed two base runs: one assuming constant catchability for the fishery- dependent indices and the other assuming a time-varying catchability. Each base run of the catch-at-age model was the basis for estimation of benchmarks and stock status.
- The SEDAR 10 Review Workshop recommended the run with constant catchability as the preferred 'base run'.
- The RW carefully reviewed the stock recruitment relationships developed from 1983-2004, considering the Beverton- Holt, Ricker and "hockey stick" (Barrowman and Meyers, 2000) models. Although the AW preferred the Beverton-Holt relationship over the Ricker, the RW concluded that both might overestimate virgin recruitment and, thus, MSY and SSB_{MSY}.

Assessment data

- Data sources include abundance indices, recorded landings and catch estimates, and calculated total annual size and age composition from the fisheries.

- Both fishery-dependent and fishery-independent indices of abundance were included in the assessment. Fishery-dependent abundance indices were available from the commercial handline fishery, the commercial longline fishery, the recreational headboat fishery and a combined index from the recreational charter and private boat fisheries (MRFSS) as presented by the SEDAR-10 data workshop. The two fishery-independent abundance indices were developed from the SEAMAP reef fish video survey.
- Catch information (including both landings and dead discards) was available for all recreational and commercial fisheries. This benchmark assessment included data through 2004.
- Complete details are available in the SEDAR 10 Data and Assessment Workshop Reports, and the SEDAR 10 workshop working papers. Additional information and discussion can be found in the companion SEDAR 10 Review Workshop Consensus Summary Report for Gulf of Mexico Gag Grouper.

Catch trends

- Estimated catches (landings and dead discards) in the last 7 years (1998-2004) have exceeded all previous levels and show an increasing trend since 2000. The 2004 estimated catches were about 85% higher than the highest estimated catches before 1998 and about 75% above the latest estimated catches (1999) used in the last assessment. Commercial landings since the late 1990's have increased about 60% compared to the 1980's (Figure 1). Estimated recreational landings have almost doubled since the 1980's while the estimated recreational dead discards have roughly tripled (Figure 2).

Fishing mortality trends

- Estimated annual fishing mortality[1] rates have generally increased over the period of the assessment, ranging from about 0.2 to about 0.5 (Figure 3). In the last four years the annual fishing mortality rate has increased every year and is currently estimated to be 0.49.

Stock abundance and biomass trends

- During the 1980's recruitment was estimated to average about 1.4 million fish (age 1). Since 1990 recruitment has averaged about 3 million fish (Figure 4). The model estimated that there were four strong year classes from 1990 to 2000 which averaged about 4.8 million fish. After 2000, estimated recruitment declined each year and was estimated to be 2.3 million fish in 2004.

- Estimated spawning stock biomass declined during the late 1960's and the 1970's, remained at about 20 million pounds during the 1980's and early 1990's and then increased from 1997 to 2001, perhaps as a result of the higher recruitment. Since 2002 spawning stock biomass has remained at about 41 million pounds (Figure 4). Estimated

[1] Assessment runs with CASAL software output "fishing pressure" rates estimated from a Pope's approximation to fit catches within a specific time and area partition of the model. For comparison fishing pressure values were converted to the equivalent annual fishing mortality rates (F), the common reference benchmark in fisheries.

total biomass followed a similar pattern with lower levels in the 1980's and an increase in the 1990's. Estimated total biomass peaked at about 56 million pounds in 2002 and then declined to an estimated 51 million pounds in 2004.

Status determination criteria

- The SFA and management criteria recommendations and values are estimated from the preferred base model by the RW as follows.

Stock Status	Current Definition	Value from Previous Assessment	Value from Current Assessment
MSST	$SPR_{20\%}$ (pre-SFA)	NA	NA
MFMT	$F_{30\%SPR}$ (F_{MSY} Proxy)	0.45	0.25
MSY	Yield at $F_{30\%SPR}$ (F_{MSY} proxy)	5.5 mp	4.3 mp
OY	Yield at $SPR_{20\%}$	NA	NA
F_{OY}	undefined	NA	NA

Proposed Status Criteria	Constant Catchability	
	Definition	Value
MSST	(1-M)SSB_{MSY} (see Special Comments)	NA
MFMT	F_{MSY}	NA
MSY	Yield at F_{MSY}	NA
OY	Yield at $F_{40\%SPR}$	NA
F_{OY}	$F_{40\%SPR}$	NA
M (Age-varying)	Constant Equivalent	0.14

Constant Catchability, Geometric Mean Recruitment 1984-2004			
Additional Benchmarks	Exploitation Rate	SSB[1]	Yield[1,2]
F_{MAX}	0.23	37.6 mp	8.66 mp
$F_{20\%SPR}$	0.37	23.1 mp	8.24 mp
$F_{30\%SPR}$	0.25	34.6 mp	8.64 mp
$F_{0.1}$	0.13	55.9 mp	8.53 mp

1. Assuming future recruitment is equal to geometric mean recruitment from 1984-2004
2. Yield values reflect both landings and dead discards.

Stock Status

- Estimated recruitment has ranged from 1 to 6 million fish over a moderate range of spawning stock sizes, resulting in a high degree of uncertainty about the stock recruitment relationship and estimates of biomass benchmarks (MSY, SSB_{MSY} and MSST). Because of the uncertainty in the biomass benchmarks, current stock status (SSB_{2004} / SSB_{MSY}) is not reported.
- Because of this, the MSY-based benchmarks in this assessment were not deemed useful for management.
- The current (2004) annual fishing mortality rate on this stock is estimated as 0.49. Relative to the current proxy for F_{MSY} ($F_{SPR30\%}$), estimated as 0.25, overfishing of the Gulf of Mexico gag grouper is occurring.
- For the Gulf of Mexico, a MFMT of 0.25 (current value of $F_{30\%SPR}$) is not consistent with the recent dynamics of gag grouper: fishing mortality has been fluctuating around F = 0.36 for more than twenty years (1985-2004) and the stock biomass is near its historical maximum. The Review Panel could not provide advice on target F and biomass reference points, but noted that the stock has apparently increased as a result of good recruitment under estimated fishing mortality rates that have fluctuated around an average value of F = 0.36 since the early 1980s. The Review Panel advised that it would be prudent to reduce fishing mortality below F = 0.36.
- There is currently not a SFA-compliant definition of stock status relative to abundance. Apparently the Gulf of Mexico Fishery Management Council uses (1-M)*SSB_{MSY} as a working definition. Since the value of that reference point cannot be determined, the status of the stock with respect to biomass is unknown
- The Review Panel notes that available stock recruitment information suggests that recruitment may be impaired below 20 million pounds. Given that the model estimates of the spawning stock biomass benchmarks are uncertain, the Panel recommends that the Council consider 20 million pounds as a temporary operational definition of the lower bound for spawning stock size (i.e. MSST). Relative to the Review Panel's suggestion of an operational MSST of 20 million pounds, the stock is not overfished and is not approaching an overfished state.

Projections

- Projections assumed a constant stock recruitment relationship equal to geometric mean recruitment (1984-2004; 2,124,871 fish). Projections were generated for true yield (landings only) and total removals (landings plus dead discards) assuming 2005 total removals of 12.38 million pounds (5.81 mp landed and 6.57 mp dead discards). Stock projections were done for scenarios of constant catch (fixed quotas) and constant fishing mortality rate (F) but only those assuming constant F are shown here.

- Projections for spawning stock biomass (mature females in mp), annual fishing mortality and total removals and yield at various levels of constant fishing mortality rates starting in 2006 are shown in Table 3 and Figure 8.

Special Comments

- *Constant and time-varying catchability alternative.* The Review Panel discussed the relationship of technology to catchability and the effects of catchability changes on fishery-dependent abundance indices. The Panel recognized that technology improvements over time, particularly better electronics, have likely made fishermen more effective and efficient at catching fish. The Panel, however, did not support an assessment that assumed a simple linear (2% annually) increase. Nevertheless, this is an important issue and the Review Panel recommends further investigations of time-varying catchability.

- *Stock-recruitment relationship.* In both stock areas, the stock and recruitment scatter plot does not suggest that recruitment is strongly linked with SSB. In the South Atlantic, the Beverton-Holt stock-recruitment relationship indicates little change in recruitment for a wide range of SSB's and that B_{MSY} falls in the range of SSB's observed in the past. On the other hand, the Ricker stock-recruitment relationship indicates that maximum recruitment occurs at SSBs lower than those observed over the period of the assessment, which implies that B_{MSY} would also be lower than those observed in the period of the assessment. In the Gulf of Mexico, both the Beverton-Holt and Ricker relationships suggest that considerably higher recruitment would result from larger SSBs and SSB_{MSY} is estimated to be higher than SSB's observed in the past. The Review Panel considers that the stock recruitment relationships in the two stock areas are equally uncertain. The derived benchmarks are considered useful for management in the South Atlantic, because they are within the range of past observed values. In the Gulf of Mexico, more stock and recruitment observations are necessary to confirm that the benchmarks estimated in the current assessment are indeed attainable.

- *Discussion of RW recommended MSST.* MSST, defined as $(1\text{-}M)*SSB_{MSY}$, is very close to SSB_{MSY} because $M = 0.14$ is used. Given the uncertainties in the assessment, the biomass would be expected to be estimated to fall below MSST with a relatively high frequency even if true biomass were close to B_{MSY}. In the Gulf of Mexico, there are indications that recruitment could become impaired below a SSB of 20 million lbs and the Review Workshop suggested that MSST could be set at this level as a temporary operational definition, to be re-examined at the next assessment.

- *Document Revisions.* This document was revised in September 2006 to clarify language regarding the level of fishing. References to 'exploitation rate' and 'fishing pressure' were removed and replaced with 'fishing mortality'. Table and text values reflecting either exploitation rates or fishing pressure were replaced with *F* values (instantaneous fishing mortality rate) where appropriate.

Table 1. Landings and discards for commercial longline fisheries; longline, handline and others, and for recreational fisheries; private/charter (MRFSS) and headboat in columns 1 to 7. Columns 8 to 11 shows the partition of landed and discards by sector, 1963-2004. All values are in gutted weight pounds.

							Landings		Dead discards		
Year	Headboat	MRFSS	Longline	Handline	Others	Total	Commercial	Recreational	Commercial	Recreational	Total
1963	-	443,710	-	1,288,786	1,445	1,733,941	1,290,231	443,710	-	-	1,733,941
1964	-	479,243	-	1,632,460	9,088	2,120,792	1,641,549	479,243	-	-	2,120,793
1965	-	517,622	-	1,815,588	573	2,333,783	1,816,162	514,193	-	3,429	2,333,784
1966	-	559,075	-	1,456,566	1,227	2,016,868	1,457,793	546,372	-	12,703	2,016,868
1967	-	603,848	-	1,155,546	9,839	1,769,233	1,165,387	580,407	-	23,441	1,769,234
1968	-	652,205	-	1,192,284	4,414	1,848,904	1,196,699	616,389	-	35,816	1,848,905
1969	-	704,436	-	1,376,520	3,205	2,084,161	1,379,725	654,412	-	50,024	2,084,161
1970	-	760,849	-	1,283,654	2,502	2,047,005	1,286,158	694,572	-	66,277	2,047,007
1971	-	869,493	-	1,376,502	2,782	2,248,777	1,379,285	779,756	-	89,737	2,248,778
1972	-	993,651	-	1,460,381	3,980	2,458,012	1,464,362	875,105	-	118,546	2,458,013
1973	-	1,135,538	-	1,081,222	4,899	2,221,659	1,086,122	981,786	-	153,752	2,221,660
1974	-	1,297,685	-	1,184,110	1,355	2,483,150	1,185,465	1,101,090	-	196,595	2,483,150
1975	-	1,482,652	-	1,446,621	4,465	2,933,737	1,451,086	1,234,168	-	248,483	2,933,738
1976	-	1,697,042	-	1,198,438	9,115	2,904,595	1,207,552	1,385,311	-	311,731	2,904,594
1977	-	1,942,432	-	977,267	7,513	2,927,212	984,780	1,554,358	-	388,074	2,927,212
1978	-	2,225,942	-	875,262	10,952	3,112,156	886,213	1,745,396	-	480,546	3,112,155
1979	-	2,551,406	1,383	1,342,247	9,685	3,904,721	1,353,314	1,959,527	-	591,879	3,904,720
1980	-	2,908,996	89,304	1,317,859	11,866	4,328,024	1,419,030	2,187,337	-	721,659	4,328,026
1981	-	2,458,563	467,068	1,498,744	15,608	4,439,984	1,981,421	1,829,502	-	629,061	4,439,984
1982	-	3,508,922	1,009,998	1,334,617	14,163	5,867,699	2,358,780	3,216,983	-	291,939	5,867,702
1983	-	7,459,833	681,064	1,039,425	17,652	9,197,974	1,738,139	6,379,368	-	1,080,465	9,197,972
1984	-	2,134,042	433,159	1,098,289	18,407	3,683,897	1,549,855	1,950,479	-	183,563	3,683,898
1985	-	6,967,353	380,850	1,398,341	27,879	8,774,423	1,807,070	6,570,911	-	396,442	8,774,423
1986	308,430	4,263,230	517,405	1,155,013	29,022	6,273,100	1,701,441	3,597,491	-	974,168	6,273,101
1987	230,540	2,827,000	656,042	852,579	29,544	4,595,705	1,538,166	2,447,832	-	609,708	4,595,706
1988	164,606	4,223,613	402,244	791,073	23,178	5,604,715	1,216,494	3,747,483	-	640,736	5,604,713
1989	337,797	3,264,214	426,018	1,235,438	31,374	5,294,841	1,692,830	2,314,324	-	1,287,686	5,294,840
1990	307,722	1,990,704	624,659	1,129,877	40,817	4,093,779	1,793,090	1,259,887	2,261	1,038,538	4,093,777
1991	111,374	4,842,904	509,707	992,667	63,090	6,519,743	1,565,320	2,748,231	145	2,206,048	6,519,744
1992	156,438	3,950,703	592,824	1,002,725	68,548	5,771,238	1,663,880	2,245,860	217	1,861,282	5,771,239
1993	211,126	5,874,147	482,328	1,280,529	105,760	7,953,890	1,865,116	2,787,852	3,502	3,297,421	7,953,892
1994	316,998	6,457,563	351,815	1,148,121	119,046	8,393,543	1,618,740	1,999,707	243	4,774,854	8,393,544
1995	195,110	7,250,518	393,648	1,157,606	104,670	9,101,551	1,651,664	2,700,221	4,260	4,745,406	9,101,551
1996	176,888	5,310,846	397,024	1,106,573	67,504	7,058,835	1,566,658	2,353,437	4,444	3,134,296	7,058,834
1997	167,797	6,793,551	419,837	1,101,101	82,634	8,564,921	1,597,645	2,573,108	5,928	4,388,240	8,564,922
1998	427,681	8,597,631	608,998	1,848,718	81,579	11,564,607	2,530,686	3,519,315	8,610	5,505,998	11,564,609
1999	315,278	7,251,549	549,813	1,481,357	68,278	9,666,274	2,097,739	3,721,784	1,709	3,845,042	9,666,274
2000	270,612	8,375,360	636,817	1,605,425	81,260	10,969,475	2,283,311	4,972,529	40,192	3,673,445	10,969,477
2001	166,914	8,766,604	1,052,744	2,088,284	100,916	12,175,463	3,128,510	4,031,469	113,436	4,902,049	12,175,463
2002	145,311	10,640,507	1,059,401	1,933,577	61,659	13,840,455	2,983,506	4,435,518	71,132	6,350,300	13,840,455
2003	240,352	12,219,344	1,189,696	1,476,593	67,095	15,193,079	2,626,122	3,773,139	107,262	8,686,558	15,193,081
2004	327,271	13,718,083	1,190,773	1,756,584	72,808	17,065,519	2,901,692	4,913,422	118,472	9,131,932	17,065,519

Table 2. Estimated annual fishing mortality rate (F), spawning stock size (millions of pounds of mature females) and recruitment (number age 1) for Gulf of Mexico gag.

Year	F	SSB Female	Recruits
1963	0.030	49.109	214586
1964	0.037	47.911	214574
1965	0.042	46.334	213181
1966	0.040	43.826	211267
1967	0.040	40.962	208019
1968	0.046	37.971	203970
1969	0.056	34.813	199294
1970	0.063	31.532	193783
1971	0.079	28.430	187283
1972	0.098	25.451	180294
1973	0.111	22.661	172637
1974	0.140	20.337	1393800
1975	0.183	17.988	202205
1976	0.202	15.959	721440
1977	0.215	15.804	1267200
1978	0.235	15.164	1216470
1979	0.280	14.805	1541900
1980	0.300	15.072	1712720
1981	0.279	15.696	2094330
1982	0.352	17.165	1972460
1983	0.559	18.335	1364890
1984	0.216	17.021	1358380
1985	0.485	20.498	1252910
1986	0.365	18.521	1476470
1987	0.262	17.885	1192730
1988	0.321	18.595	1086810
1989	0.305	18.550	793166
1990	0.233	18.350	3761120
1991	0.383	18.842	1602020
1992	0.315	17.584	1916250
1993	0.406	20.902	2119320
1994	0.422	21.509	4814020
1995	0.458	20.972	2712410
1996	0.310	20.987	2033390
1997	0.315	26.900	5741390
1998	0.399	30.734	3062170
1999	0.297	30.963	1833230
2000	0.309	37.195	5007130
2001	0.330	40.578	3467710
2002	0.364	40.494	2789170
2003	0.399	41.768	2452980
2004	0.492	40.951	2344190

Table 3. Projection trends for Gulf of Mexico gag grouper assuming constant recruitment and various constant fishing mortality rates. "All Removals" includes landings and dead discards and "Landed Yield" landings only. SPR% refers to fishing rates that will achieve the indicated percent SPR under equilibrium conditions.

ALL REMOVALS

SSB mature female wgt million pounds

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	20.48	20.48	20.48	20.48	20.48	20.48	20.48
1996	20.61	20.61	20.61	20.61	20.61	20.61	20.61
1997	26.81	26.81	26.81	26.81	26.81	26.81	26.81
1998	30.73	30.73	30.73	30.73	30.73	30.73	30.73
1999	31.06	31.06	31.06	31.06	31.06	31.06	31.06
2000	37.67	37.67	37.67	37.67	37.67	37.67	37.67
2001	40.64	40.64	40.64	40.64	40.64	40.64	40.64
2002	40.46	40.46	40.46	40.46	40.46	40.46	40.46
2003	41.78	41.78	41.78	41.78	41.78	41.78	41.78
2004	40.55	40.55	40.55	40.55	40.55	40.55	40.55
2005	33.28	33.28	33.28	33.28	33.28	33.28	33.28
2006	29.16	29.16	29.16	29.16	29.16	29.16	29.16
2007	27.20	30.00	31.81	32.97	30.55	30.55	26.85
2008	25.26	30.26	33.79	36.15	31.32	31.32	24.65
2009	24.49	31.30	36.39	39.93	32.78	32.78	23.72
2010	24.19	32.38	38.90	43.61	34.27	34.27	23.28

F annual mortality rate

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	0.458	0.458	0.458	0.458	0.458	0.458	0.458
1996	0.310	0.310	0.310	0.310	0.310	0.310	0.310
1997	0.315	0.315	0.315	0.315	0.315	0.315	0.315
1998	0.399	0.399	0.399	0.399	0.399	0.399	0.399
1999	0.297	0.297	0.297	0.297	0.297	0.297	0.297
2000	0.309	0.309	0.309	0.309	0.309	0.309	0.309
2001	0.330	0.330	0.330	0.330	0.330	0.330	0.330
2002	0.364	0.364	0.364	0.364	0.364	0.364	0.364
2003	0.400	0.400	0.400	0.400	0.400	0.400	0.400
2004	0.493	0.493	0.493	0.493	0.493	0.493	0.493
2005	0.422	0.422	0.422	0.422	0.422	0.422	0.422
2006	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2007	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2008	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2009	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2010	0.375	0.251	0.177	0.132	0.228	0.228	0.392

Total removals (landed + dead discards)

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	9.11	9.11	9.11	9.11	9.11	9.11	9.11
1996	7.06	7.06	7.06	7.06	7.06	7.06	7.06
1997	8.55	8.55	8.55	8.55	8.55	8.55	8.55
1998	11.55	11.55	11.55	11.55	11.55	11.55	11.55
1999	9.64	9.64	9.64	9.64	9.64	9.64	9.64
2000	10.93	10.93	10.93	10.93	10.93	10.93	10.93
2001	12.13	12.13	12.13	12.13	12.13	12.13	12.13
2002	13.80	13.80	13.80	13.80	13.80	13.80	13.80
2003	15.15	15.15	15.15	15.15	15.15	15.15	15.15
2004	17.03	17.03	17.03	17.03	17.03	17.03	17.03
2005	12.38	12.38	12.38	12.38	12.38	12.38	12.38
2006	9.99	7.00	5.08	3.86	6.42	6.42	10.37
2007	9.39	7.18	5.49	4.31	6.69	6.69	9.64
2008	8.99	7.39	5.91	4.76	6.97	6.97	9.15
2009	8.79	7.62	6.31	5.21	7.27	7.27	8.87
2010	8.66	7.82	6.67	5.61	7.53	7.53	8.70

LANDED YIELD

SSB mature female wgt million pounds

SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
20.48	20.48	20.48	20.48	20.48	20.48	20.48
20.61	20.61	20.61	20.61	20.61	20.61	20.61
26.81	26.81	26.81	26.81	26.81	26.81	26.81
30.73	30.73	30.73	30.73	30.73	30.73	30.73
31.06	31.06	31.06	31.06	31.06	31.06	31.06
37.67	37.67	37.67	37.67	37.67	37.67	37.67
40.64	40.64	40.64	40.64	40.64	40.64	40.64
40.46	40.46	40.46	40.46	40.46	40.46	40.46
41.78	41.78	41.78	41.78	41.78	41.78	41.78
40.55	40.55	40.55	40.55	40.55	40.55	40.55
33.28	33.28	33.28	33.28	33.28	33.28	33.28
30.20	30.20	30.20	30.20	30.20	30.20	30.20
28.06	30.95	32.82	33.57	31.04	31.04	27.69
25.88	31.06	34.67	36.15	31.19	31.19	25.24
24.96	31.92	37.14	39.36	32.11	32.11	24.12
24.49	32.89	39.52	42.44	33.13	33.13	23.55

F annual mortality rate

SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
0.46	0.46	0.46	0.46	0.46	0.46	0.46
0.31	0.31	0.31	0.31	0.31	0.31	0.31
0.32	0.32	0.32	0.32	0.32	0.32	0.32
0.40	0.40	0.40	0.40	0.40	0.40	0.40
0.30	0.30	0.30	0.30	0.30	0.30	0.30
0.31	0.31	0.31	0.31	0.31	0.31	0.31
0.33	0.33	0.33	0.33	0.33	0.33	0.33
0.36	0.36	0.36	0.36	0.36	0.36	0.36
0.40	0.40	0.40	0.40	0.40	0.40	0.40
0.49	0.49	0.49	0.49	0.49	0.49	0.49
0.38	0.38	0.38	0.38	0.38	0.38	0.38
0.37	0.25	0.18	0.15	0.25	0.25	0.39
0.37	0.25	0.18	0.15	0.25	0.25	0.39
0.37	0.25	0.18	0.15	0.25	0.25	0.39
0.37	0.25	0.18	0.15	0.25	0.25	0.39

Total landed yield million pounds

SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
4.45	4.45	4.45	4.45	4.45	4.45	4.45
3.89	3.89	3.89	3.89	3.89	3.89	3.89
4.53	4.53	4.53	4.53	4.53	4.53	4.53
6.61	6.61	6.61	6.61	6.61	6.61	6.61
5.91	5.91	5.91	5.91	5.91	5.91	5.91
7.96	7.96	7.96	7.96	7.96	7.96	7.96
6.98	6.98	6.98	6.98	6.98	6.98	6.98
8.01	8.01	8.01	8.01	8.01	8.01	8.01
7.21	7.21	7.21	7.21	7.21	7.21	7.21
7.63	7.63	7.63	7.63	7.63	7.63	7.63
5.81	5.81	5.81	5.81	5.81	5.81	5.81
5.24	3.68	2.67	2.27	3.64	3.64	5.44
4.79	3.69	2.83	2.46	3.66	3.66	4.91
4.53	3.77	3.04	2.69	3.75	3.75	4.60
4.41	3.90	3.26	2.93	3.88	3.88	4.44
4.32	3.98	3.43	3.12	3.96	3.96	4.33

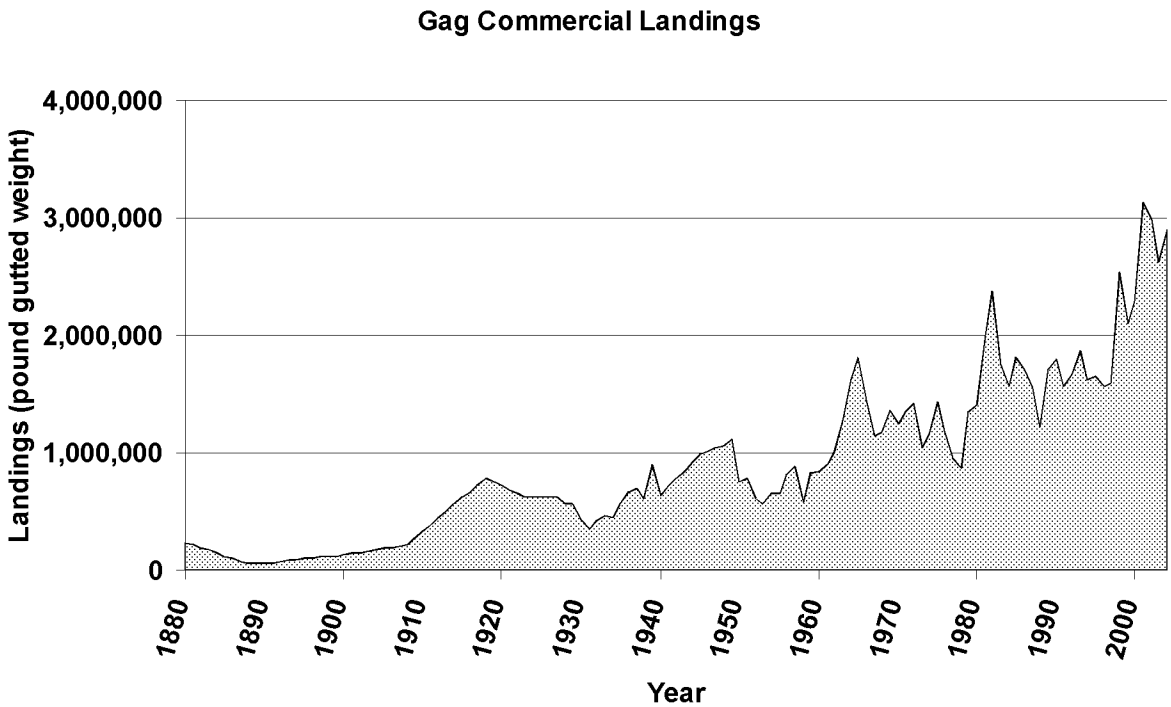

Figure 1. Estimated historical commercial landings of gag from U.S. Gulf of Mexico waters from 1880 to 2004 in pounds gutted weight.

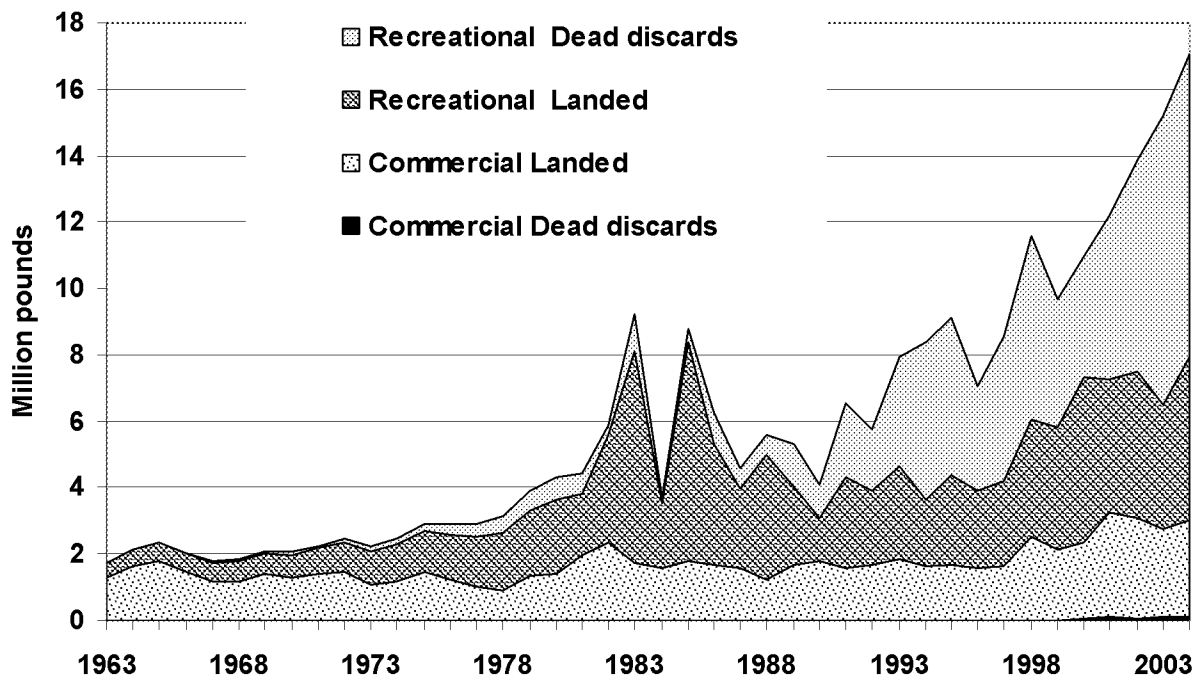

Figure 2. Gulf of Mexico gag landings and dead discards by the commercial and recreational fisheries in pounds gutted weight.

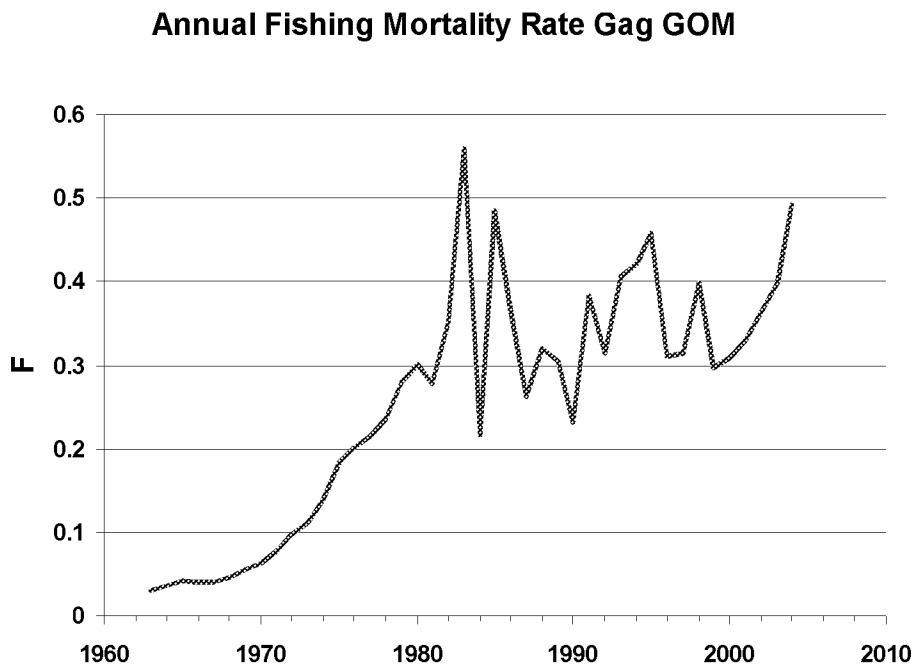

Figure 3. Estimated annual fishing mortality rate on Gulf of Mexico gag.

Figure 4. Estimated recruitment of Gulf of Mexico gag. Early recruitment estimates are considered unreliable and are thought to be due in large part to the absence of age composition and indices of abundance before 1981.

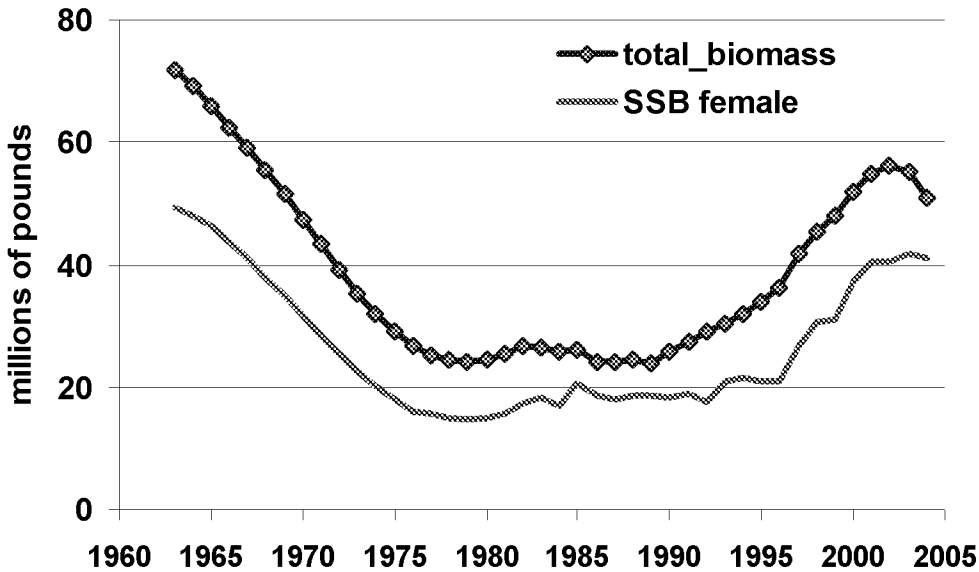

Figure 5. Estimated biomass of Gulf of Mexico showing spawning stock biomass (SSB, mature female) and total biomass in gutted weight.

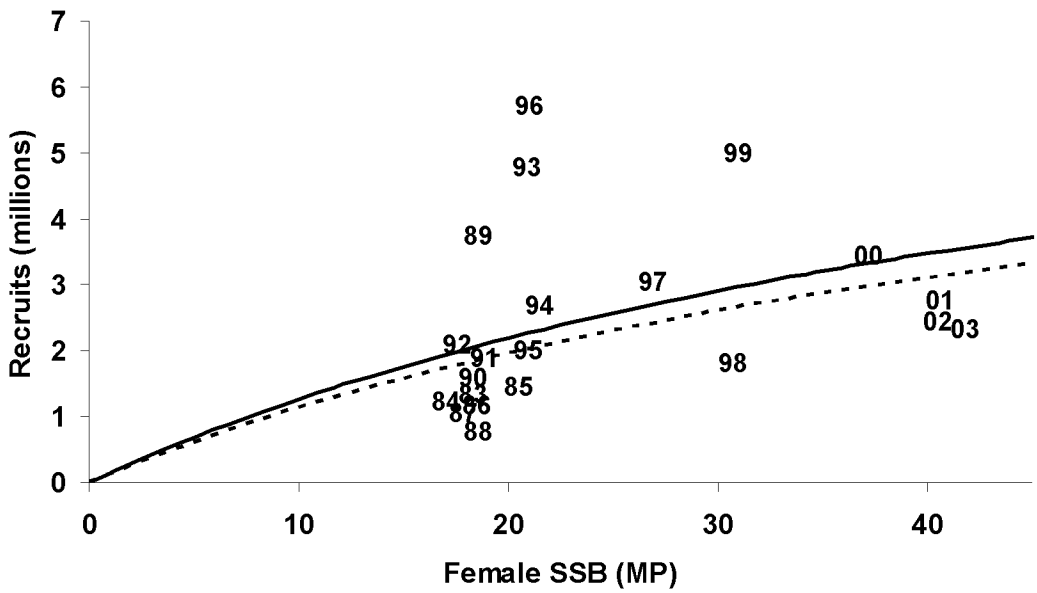

Figure 6. Estimated Beverton-Holt stock-recruitment relationship for Gulf of Mexico gag. Two digit year labels represent estimated recruitment for the 1983-2003 year classes and the associated female spawning stock biomass. The dashed curve is the estimated relationship, and the solid curve is the estimated relationship with lognormal bias correction.

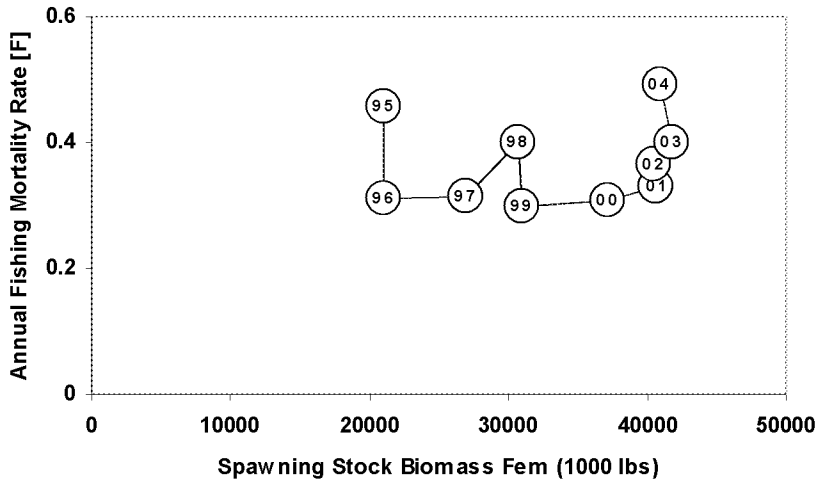

Figure 7. Phase plot of recent estimates of female spawning biomass (thousand pounds, gutted weight) and annual fishing mortality rate for gag GOM stock.

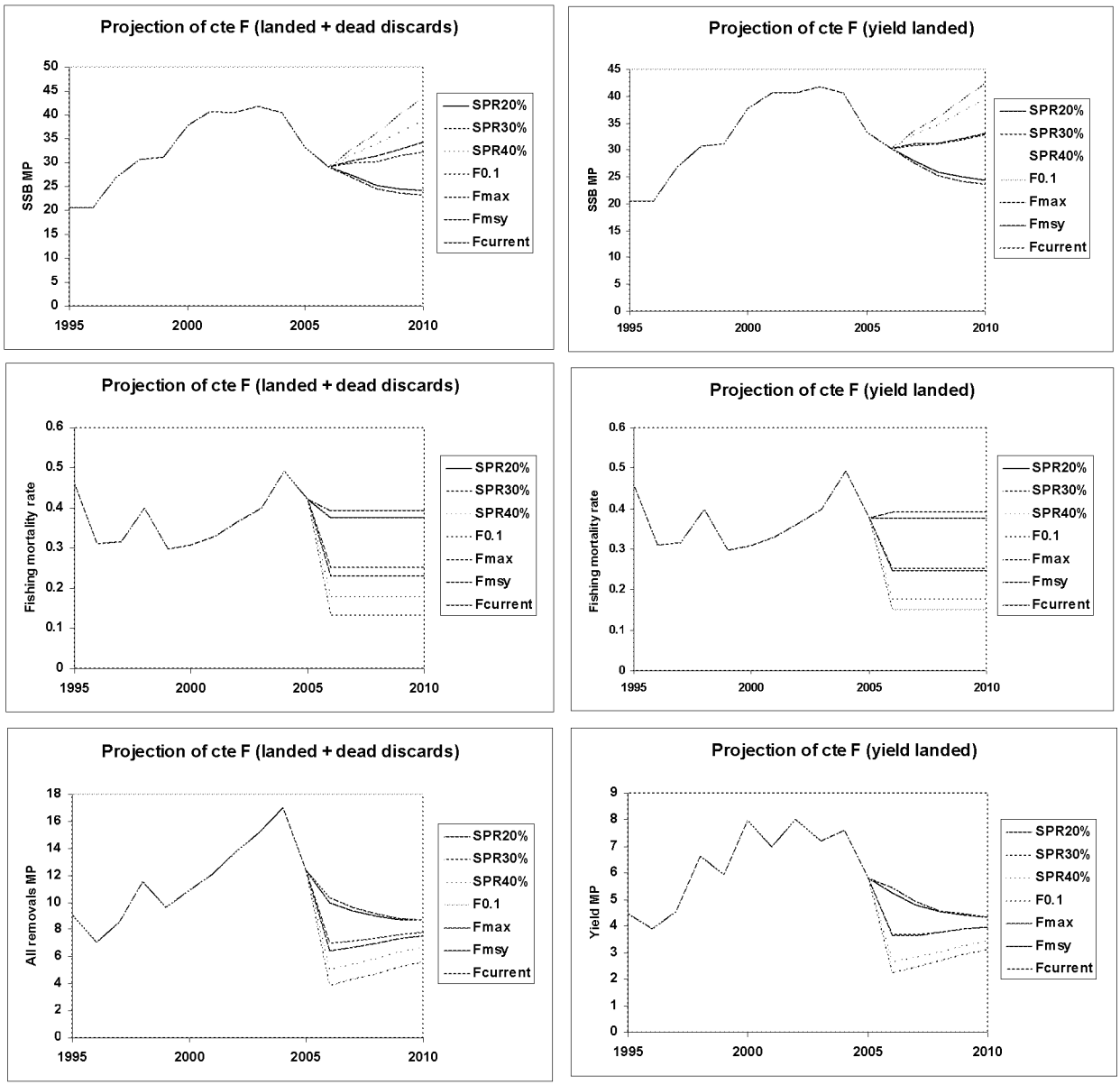

Figure 8. Projection trends from base model run assuming constant future recruitment. Projections of constant F mortality rate scenarios, projections on the left include total removals (landings & dead discards), those shown on the right are landed yield only