DRAFT BOOTSTRAPPING A GULFWIDE IMPLEMENTATION OF AN AGE-STRUCTURED-ASSESSMENT-PROCEDURE (ASAP) FOR RED SNAPPER (*LUTJANUS CAMPECHANUS*) FROM 1962 TO 2003

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INTRODUCTION

There was interest at the first red snapper assessment workshop in exploring the sensitivity of the assessment model to changes in natural mortality for young red snapper. The panel recommended that we examine the influence of various levels of natural mortality, varying the natural mortality on age-1 individuals (M_1) from 0.2 to 1. It was further recommended that we simultaneously vary natural mortality on age-0 individuals (M_0), keeping this parameter equal to 5/3 the M_1 value. Finally, it was recommended that we maintain the *status quo* value of 0.1 for natural mortality on fish that were age-2 or older. The age-structured assessment procedure (ASAP) was not designed to allow bootstrapping of parameter values, so we were required to adapt the existing program to do so.

METHODS

A series of executable files, batch files, and data procedures were combined to allow for bootstrapping, or multiple runs varying in parameter values, of the red snapper ASAP model. These steps included an optional preconditioning of the model, designed for when maximum recruitment and steepness of the stock-recruitment relationship were both fixed (not applicable to the 1962-2003 cases). The preconditioning determines an appropriate value for virgin biomass, which varies with natural mortality, by estimating that value in recent years (1984-2003) and then scaling this estimate up by a factor of 8.5. Second, 100 runs were conducted, which varied in their natural mortality values, by randomly drawing from input files, each of which represented a different value. Finally, a combination of an executable and batch file was used to search through the output files for data of particular interest and compile these into a single report file. This report file was imported into Excel to produce tables and charts.

Initial bootstrapping efforts focused on understanding the sensitivity of results to variations in the natural mortality rates on age-0 and -1 fish, but the procedure will need only minor modifications to bootstrap over multiple parameter values (e.g., steepness of the stock-recruitment curve). Natural mortality parameters were varied simultaneously on age-0 and age-1 individuals, with the age-0 natural mortality always set equal to 1-2/3 the value on age-1 fish. Making changes to the natural mortality rates required re-simulating age-composition from sampled size-composition (Turner SEDAR7-AW-###). This was performed prior to the bootstrapping, with the appropriate age-structure entered into forty different input files, each for a different value of M_1, ranging in 0.02 increments between 0.21 and 0.99. During the bootstrapping, these files were selected randomly from a truncated and discretized normal distribution of M_1 values, with mean 0.5886 and standard deviation 0.2357. In all other respects, the models were constructed the same as the base runs (Runs A, B, and C) for the 1962-2003 Gulf-wide ASAP model (Cass-Calay and Sladek Nowlis SEDAR7-AW-###). The difference between these three runs of the bootstrapping was the steepness of the stock-recruitment relationship. A value of 0.81 was used as it represented the median value from a meta-analysis of similar species (SEDAR7-DW report). A value of 0.95 was also tested because it was used in the last assessment due to its better fit to the data, a phenomenon we witnessed again here. Finally, an intermediate value of 0.9 was used.

The base properties of all projection models followed the base model configuration (runs A, B, and C) in Cass-Calay and colleagues (SEDAR7-AW-###). Except where noted, all results are presented as medians and 80% confidence intervals.

RESULTS

The bootstrapping runs showed smooth behavior of the model to variations in natural mortality on age-0 and -1 fish. Changes appeared to be gradual and relatively consistent across a wide range of M_0 and M_1 values at three different steepness levels. These results support the relatively stable behavior of this particular configuration of ASAP (runs A, B, and C in Cass-Calay et al., SEDAR7-AW-###).

Changes in steepness had substantial influence on the model's conclusions. The model fit data best at the highest steepness value examined here (Table 1), while the relative fit to different components stayed remarkably constant across the three values. Fishing mortality rate benchmarks (e.g., $F_{30\%SPR}$, F_{MSY}) dropped with increased steepness while the estimate of current fishing mortality (F(2004)) rose (Table 1). As a result, our impression of the degree of overfishing increased with the steepness value we assumed (Table 1). The dynamics surrounding spawning stock biomass were more complex because both the key benchmark (SS_{MSY}) and current estimate declined with increasing steepness (Table 1). This decline was more pronounced in the current estimate. As a result, our impression of the degree to which the stock was overfished also increases with steepness (Table 1). Yields as a percentage of maximum sustainable yield (MSY) were lower at higher steepness (Table 1).

Generally, the mean fit across the three steepness values and the forty M values was good. Catches were matched overall quite well, with the only problem being matches to bycatch by the shrimp fleet prior to 1973 where all scenarios underestimated (Figs. 2-4). Indices did not fit as well (Figs. 5-7). The biggest problems were seen in the fit to the nominal shrimp CPUE index, which the model assumed was flatter than it was (Figs. 5b-7b), and to the SEAMAP fishery-independent index of 1-year old abundance, where the model underestimated the values in early years, especially at low steepness (Figs. 5d-7d). The only other apparent difference was that the variability across M values was generally more pronounced for the video and larval bongo surveys at higher steepness values (Figs 5e,f-7e,f).

Observed recruitment patterns were quite consistent across steepness values (Fig. 8) with an apparent increase in the late 1980s and early 1990s and a recent dramatic decrease.

Trajectories were also generally similar across steepness values (Figs. 9-11). Some patterns in trajectories have already been discussed in the context of reference points. The other key difference is the magnitude of a rise and then fall of spawning stock biomass during the 1970s (Figs. 9c,d-11c,d). This hump is more pronounced at high steepness. Additionally, the variability with respect to different M values changed with steepness. When steepness was low, the spawning stock biomass estimates were most variable in recent years; when it was high, variability was most pronounced in early years. The projections also indicate a key difference between the runs (Fig. 12). At low steepness, average yield remains very close to 9.12 m pounds, as was directed by the projection scenario, and there is relatively little variability around these estimates across different M values. The variability becomes more pronounced at higher steepness values. This variability was accompanied by a drop in mean values (not shown). This result is due to population collapses, which occurred in the model over a greater range of M values when steepness was high.

Natural mortality also played an important role in our impression of the stock. The best fits occurred at high natural mortality rates (Figs 13a-15a). High M values also corresponded to the most pessimistic fishing mortality ratios (Figs. 13b-15b), and the lowest stock size benchmarks and MSY values (Figs. 13c-15c). At the lower two steepness values, the spawning stock biomass, relative to SS_{MSY}, decreased with increases in M (Figs. 13d-14d). At steepness of 0.95 however, the lowest spawning stock biomass ratios occurred at central M values (Fig. 15d). Projections into the future also varied with M values. The most optimistic projections to 2032 of both fishing rates and spawning stock biomass occurred at low M values (Figs. 13e,f-15e,f). In most cases, projections suggested the stock would rebuild and no longer be experiencing overfishing in 2032. However, there were a number of runs, particularly at high steepness and high natural mortalities, where the stock collapsed in the model.

DISCUSSION

TBD

Table 1. Benchmark Statistics for 1962-2003 Gulf-wide ASAP bootstraps.

Model Description	Run A			Run B			Run C		
Steepness	0.81			0.9			0.95		
Benchmark Statistic	**Median**	**10%**	**90%**	**Median**	**10%**	**90%**	**Median**	**10%**	**90%**
$F_{0.1}$	0.273	0.234	0.357	0.216	0.185	0.292	0.168	0.140	0.213
F_{MAX}	0.351	0.302	0.458	0.279	0.242	0.375	0.221	0.186	0.277
$F_{30\%SPR}$	0.402	0.337	0.533	0.316	0.267	0.432	0.246	0.202	0.315
$F_{40\%SPR}$	0.306	0.256	0.405	0.240	0.202	0.329	0.186	0.152	0.239
F_{MSY}	0.298	0.254	0.391	0.257	0.221	0.346	0.211	0.178	0.266
F_{2004}	0.378	0.355	0.464	0.577	0.550	0.612	0.755	0.728	0.773
MSY	16,104,300	14,644,930	16,502,800	22,015,300	19,102,200	22,456,700	31,101,000	23,832,620	35,241,800
$Yield_{'04}$	9,120,000	9,120,000	9,120,000	9,120,000	9,120,000	9,120,000	9,120,000	9,120,000	9,120,000
SS_{MSY}	91,695,900	53,687,940	143,940,000	66,170,000	38,700,370	103,684,000	50,870,600	29,784,340	81,536,500
SS_{2004}	43,495,600	19,680,630	92,988,300	12,759,800	6,717,197	25,998,600	4,019,080	2,496,838	7,042,150
$tSPR_{2004}$	0.301	0.229	0.383	0.118	0.093	0.159	0.041	0.036	0.050
F_{1962}/F_{MSY}	1.846	1.492	1.932	2.643	2.138	2.791	3.996	3.516	4.218
F_{2004}/F_{MSY}	1.268	0.908	1.823	2.144	1.666	2.766	3.498	2.881	4.329
F_{2032}/F_{MSY}	0.220	0.191	0.321	0.171	0.149	0.466	5.087	0.100	16.872
$Yield_{'62}/MSY$	0.481	0.469	0.529	0.352	0.345	0.405	0.249	0.220	0.325
$Yield_{'04}/MSY$	0.566	0.553	0.623	0.414	0.406	0.477	0.293	0.259	0.383
$Yield_{'32}/MSY$	0.566	0.553	0.623	0.412	0.405	0.472	0.257	0.000	0.282
SS_{1962}/SS_{MSY}	0.043	0.032	0.064	0.038	0.026	0.062	0.037	0.024	0.062
SS_{2004}/SS_{MSY}	0.474	0.367	0.646	0.193	0.173	0.251	0.082	0.079	0.086
SS_{2032}/SS_{MSY}	1.457	1.049	1.666	1.367	0.497	1.578	0.034	0.000	1.533
Objective Fn	13188	12794	13611	12007	11748	12338	11171	11061	11374

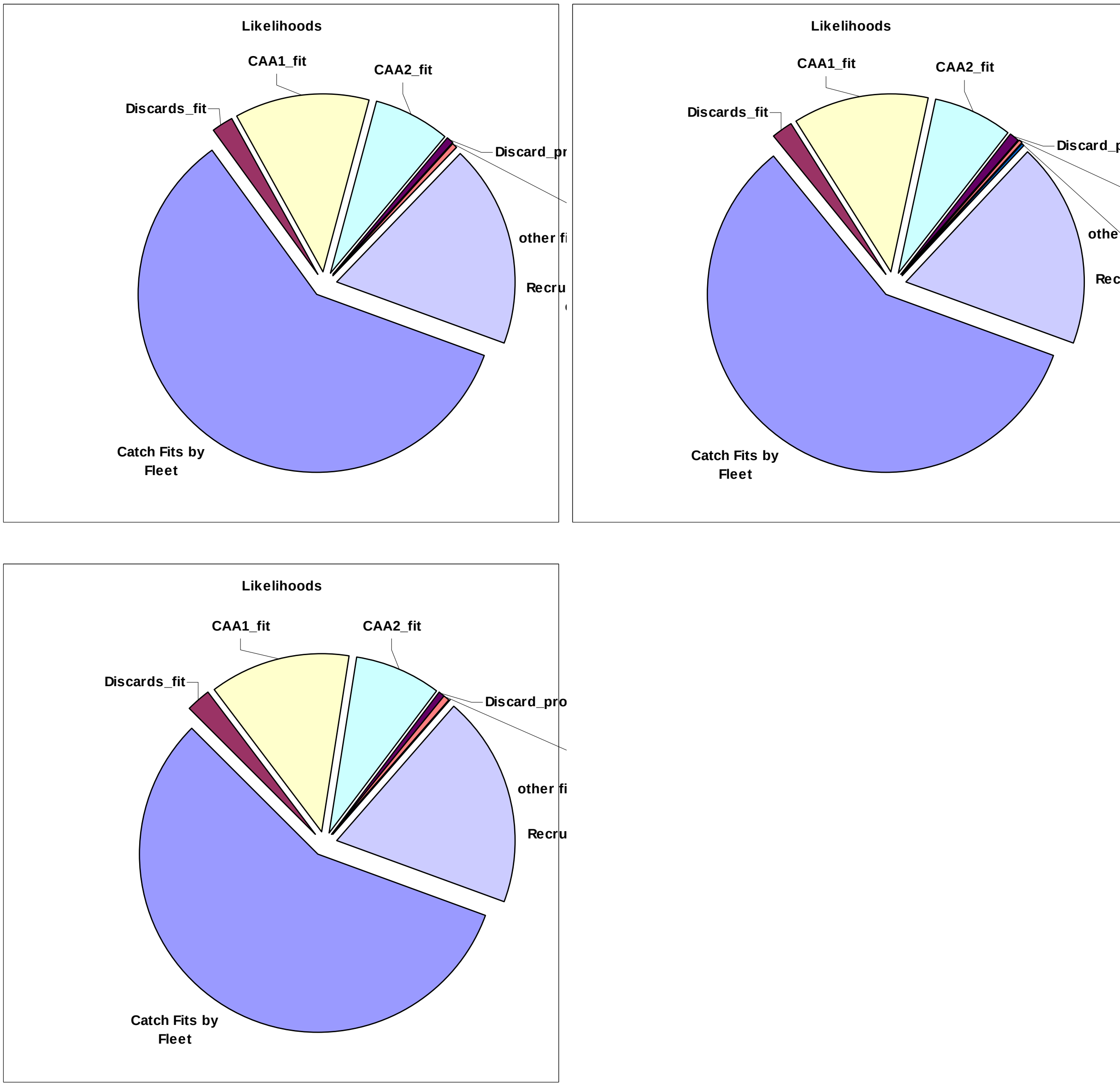

Figure 1. Mean fits to various model components for steepness values of (A) 0.81, (B) 0.9, and (C) 0.95. Overall model fits presented in Table 1.

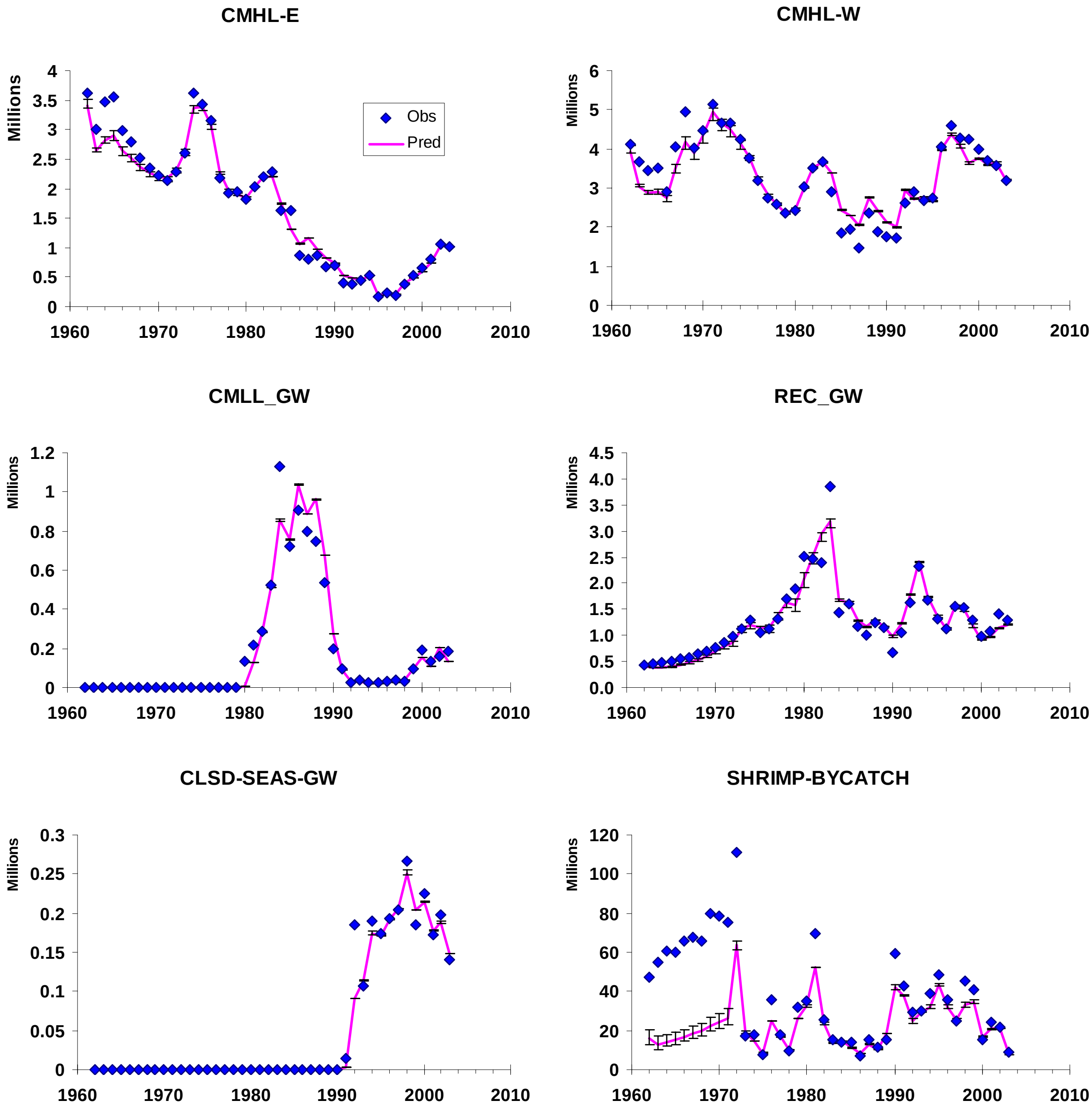

Figure 2. Mean observed and predicted catch values for the model with a steepness of 0.81. (A) Commercial handline E (B) Commercial handline W, (C) Commercial longline Gulf-wide, (D) Recreational handline, (E) Closed season discards, and (F) shrimp fleet bycatch.

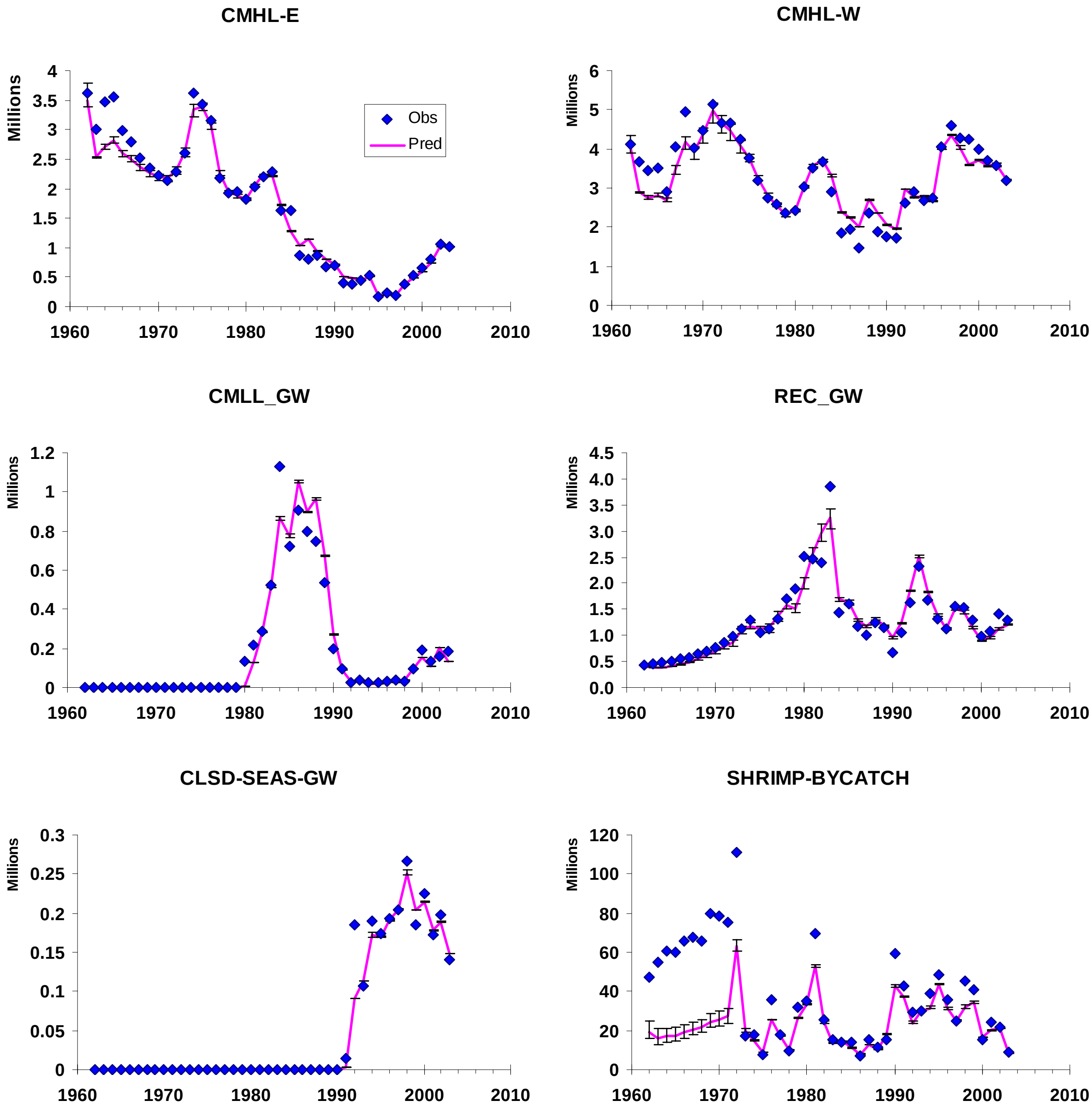

Figure 3. Mean observed and predicted catch values for the model with a steepness of 0.9. (A) Commercial handline E (B) Commercial handline W, (C) Commercial longline Gulf-wide, (D) Recreational handline, (E) Closed season discards, and (F) shrimp fleet bycatch.

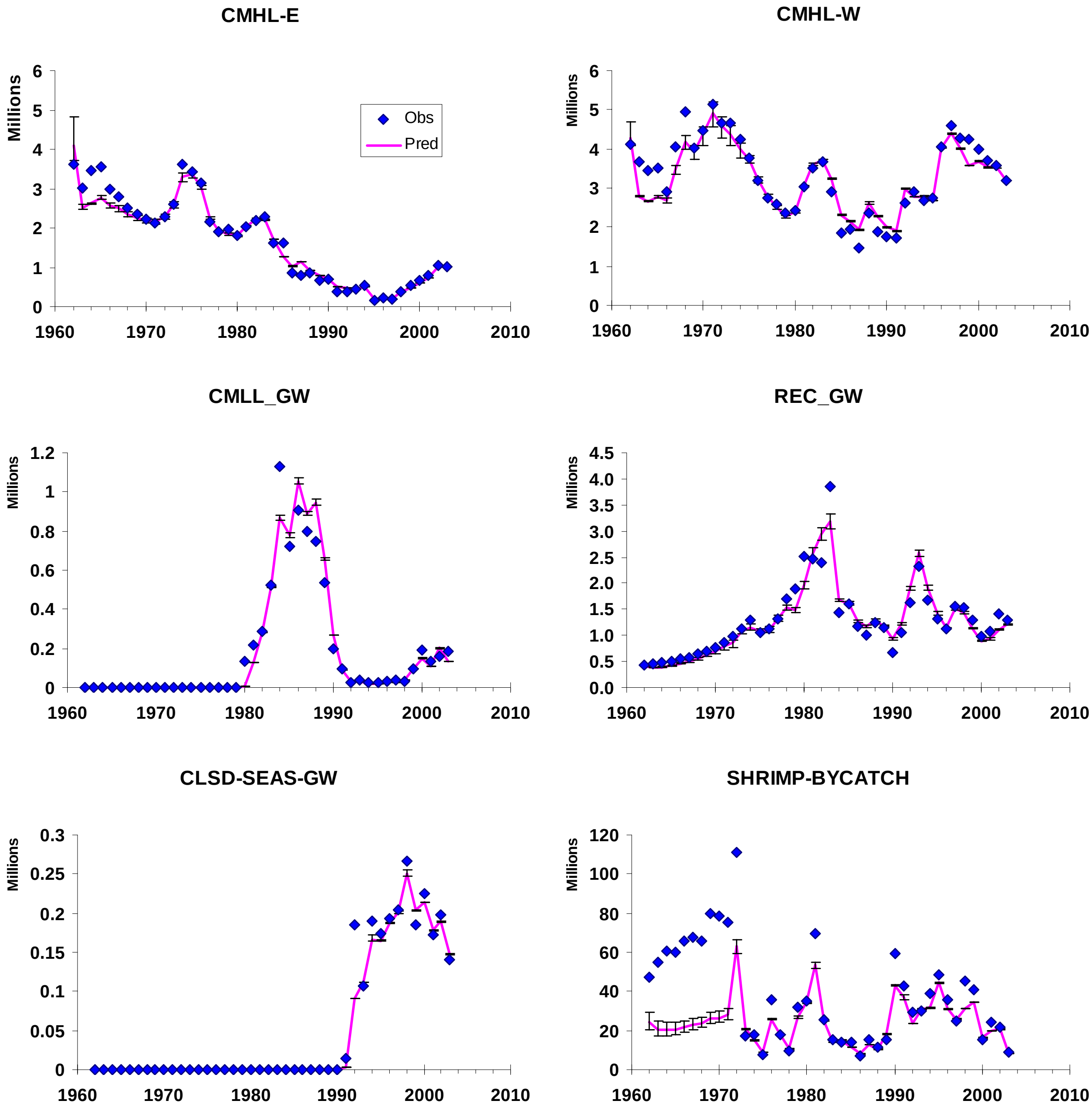

Figure 4. Mean observed and predicted catch values for the model with a steepness of 0.95. (A) Commercial handline E (B) Commercial handline W, (C) Commercial longline Gulf-wide, (D) Recreational handline, (E) Closed season discards, and (F) shrimp fleet bycatch.

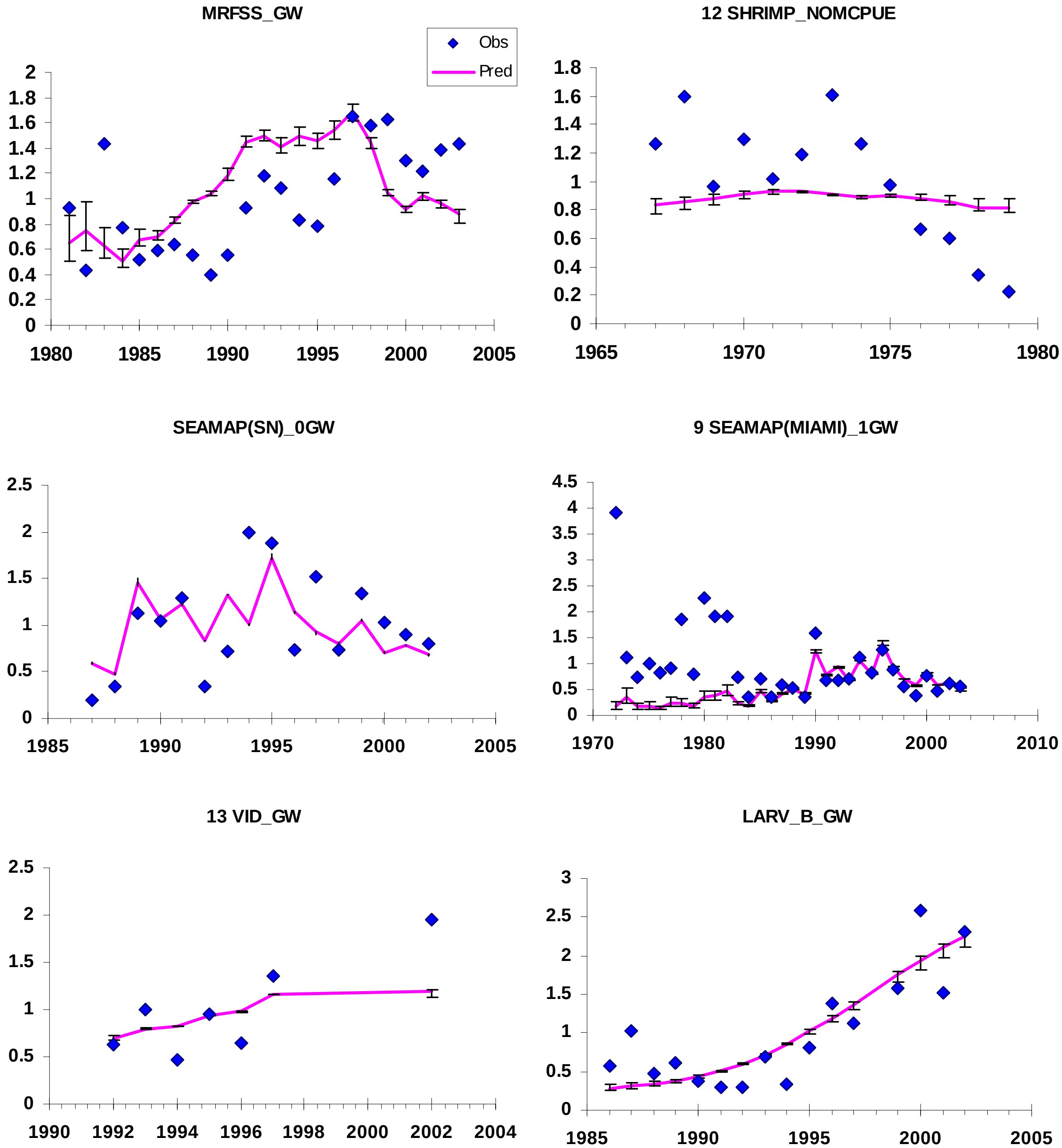

Figure 5. Mean observed and predicted Gulf-wide index values for the model with a steepness of 0.81. (A) Marine Recreational Fishery Statistical Survey,(B) nominal CPUE for adult fish from shrimp vessels, (C) SEAMAP fishery-independent survey 0 year olds compiled by Scott Nichols (REF), (D) SEAMAP 1 year olds compiled by SEFSC Miami, (E) video survey, and (F) larval bongo tow survey.

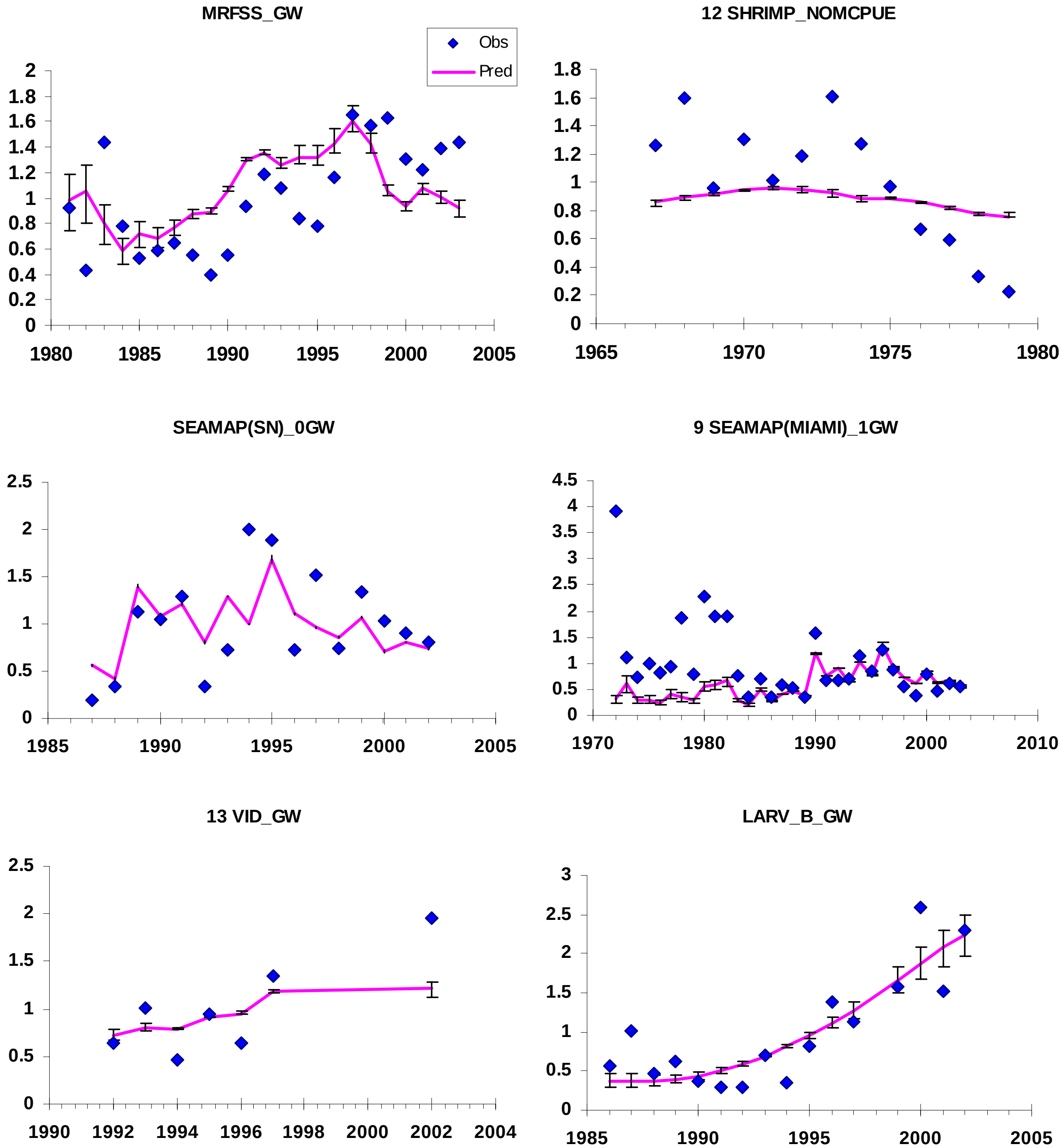

Figure 6. Mean observed and predicted Gulf-wide index values for the model with a steepness of 0.9. (A) Marine Recreational Fishery Statistical Survey,(B) nominal CPUE for adult fish from shrimp vessels, (C) SEAMAP fishery-independent survey 0 year olds compiled by Scott Nichols (REF), (D) SEAMAP 1 year olds compiled by SEFSC Miami, (E) video survey, and (F) larval bongo tow survey.

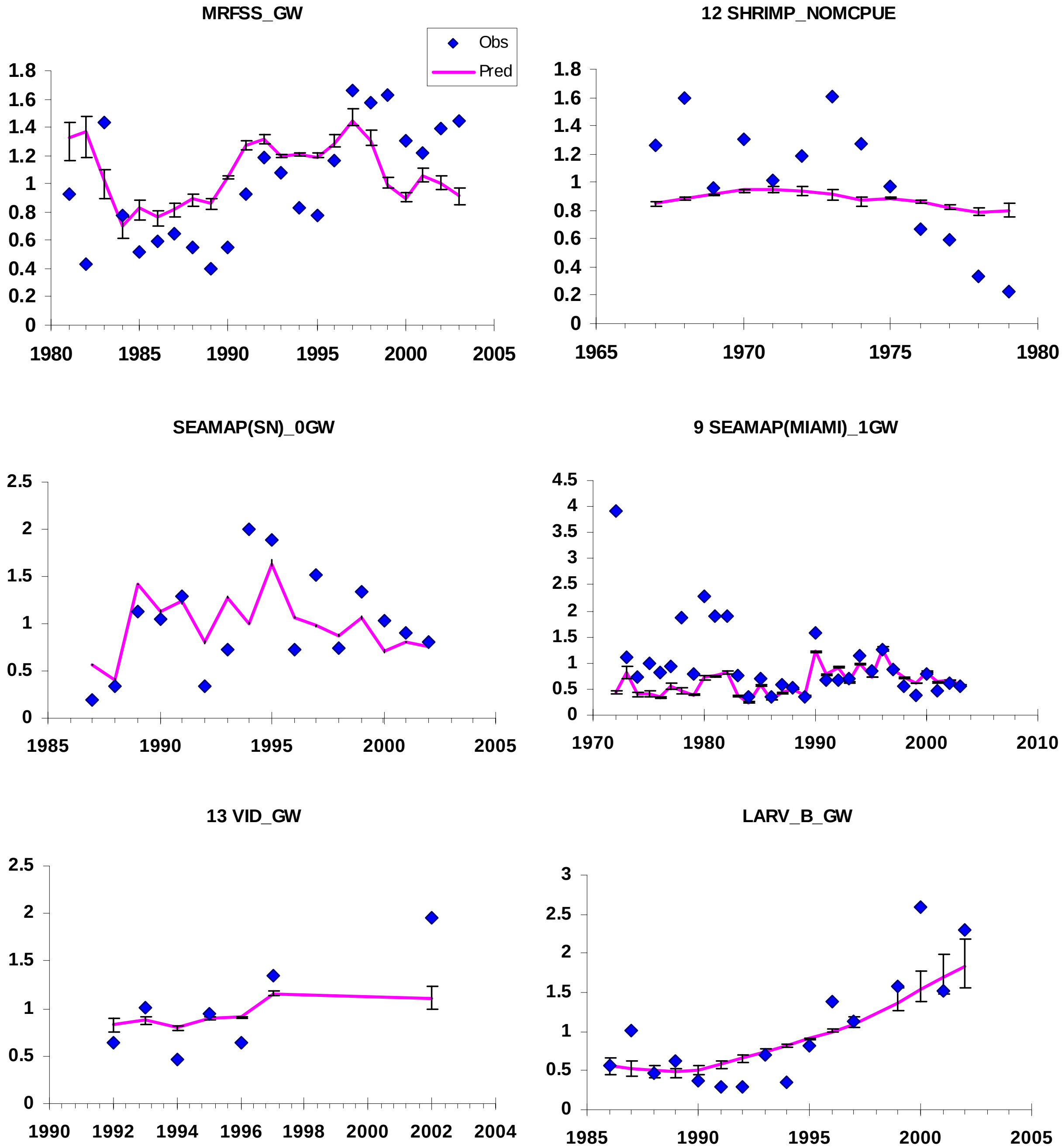

Figure 7. Mean observed and predicted Gulf-wide index values for the model with a steepness of 0.95. (A) Marine Recreational Fishery Statistical Survey,(B) nominal CPUE for adult fish from shrimp vessels, (C) SEAMAP fishery-independent survey 0 year olds compiled by Scott Nichols (REF), (D) SEAMAP 1 year olds compiled by SEFSC Miami, (E) video survey, and (F) larval bongo tow survey.

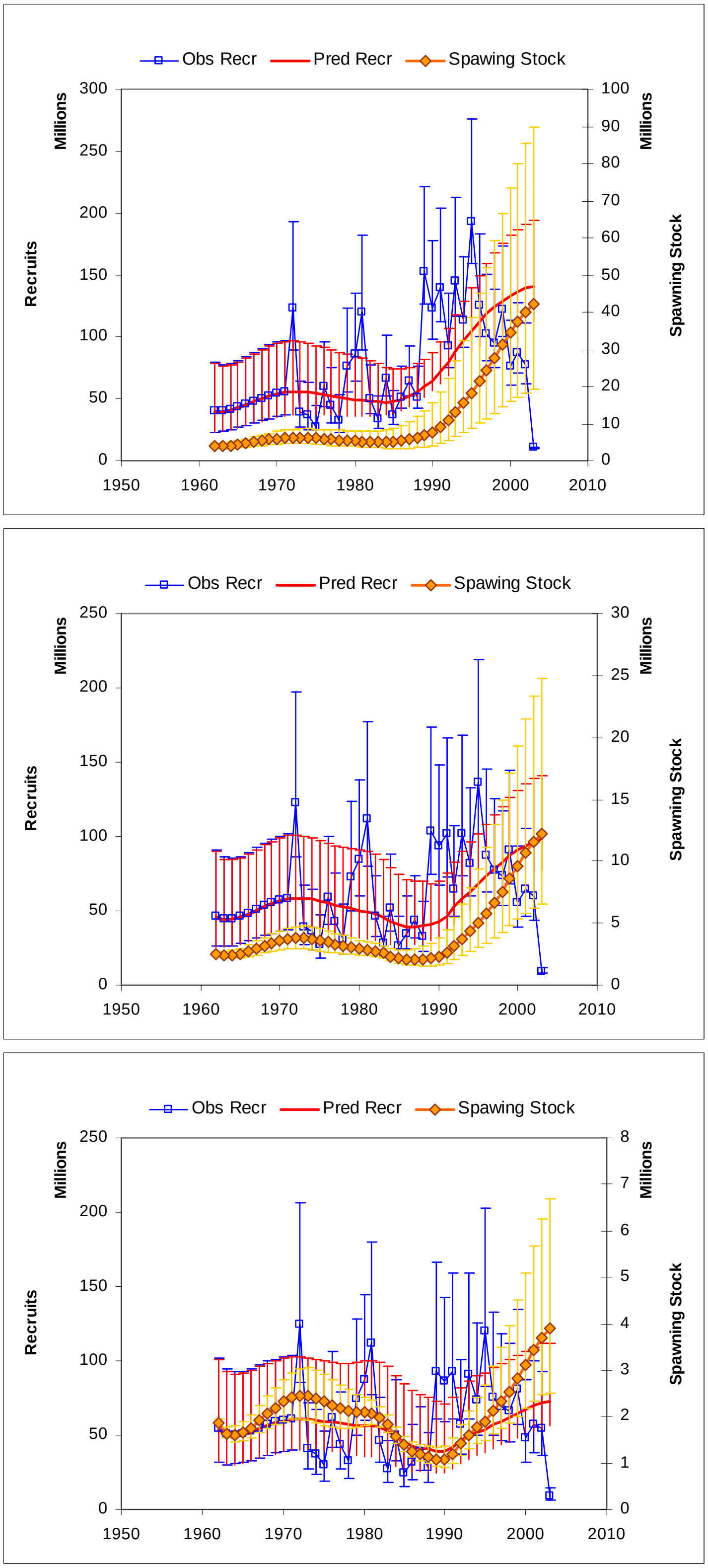

Figure 8. Spawning stock and observed (estimated) and predicted recruitment over time at steepness of (A) 0.81, (B) 0.9, and (C) 0.95.

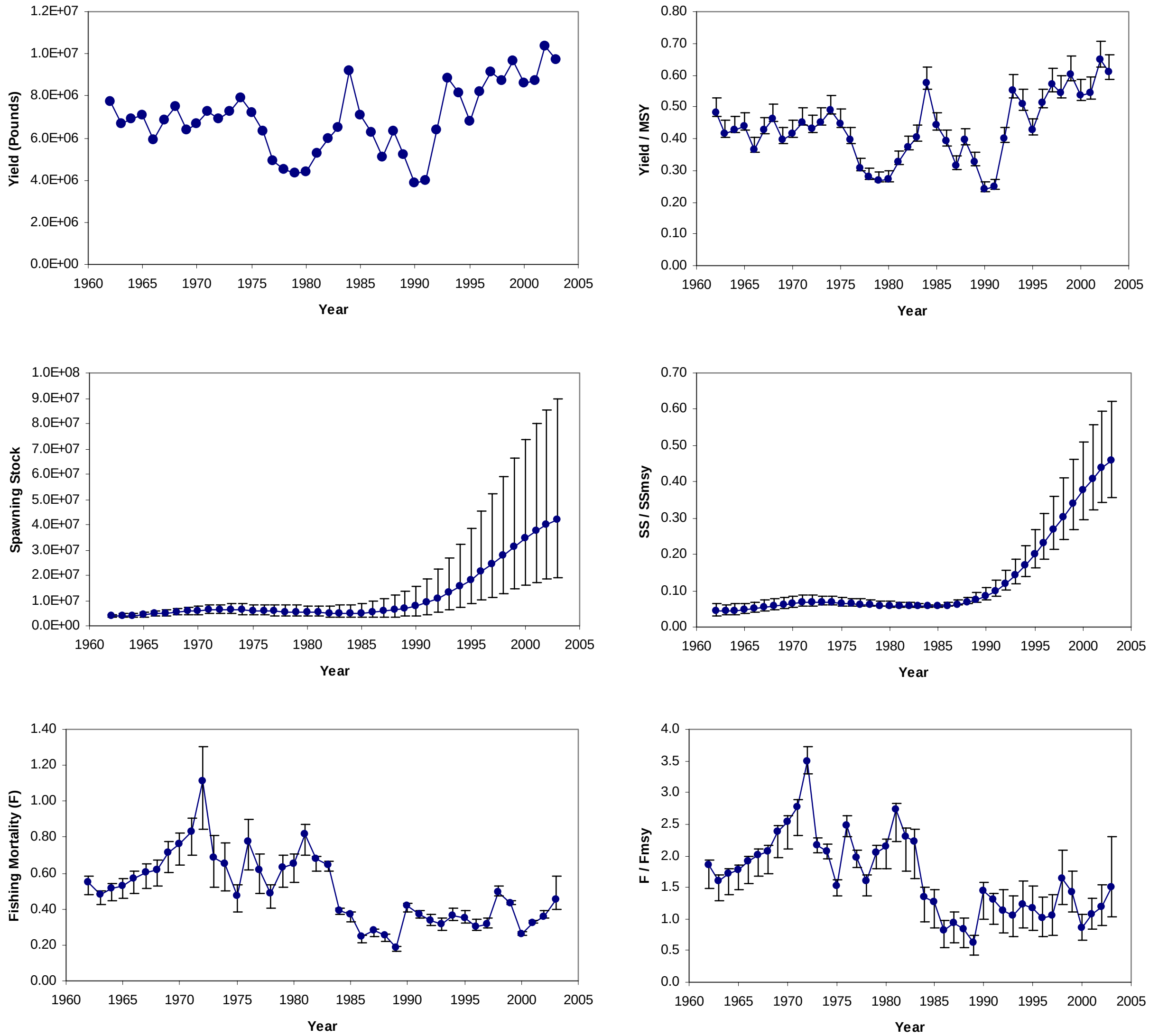

Figure 9. Trajectories for steepness 0.81. (A) yield, (B) ratio of yield to MSY, (C) spawning stock biomass, (D) ratio of SS to SS_{MSY}, (E) fishing mortality, (F) ratio of F to F_{MSY}.

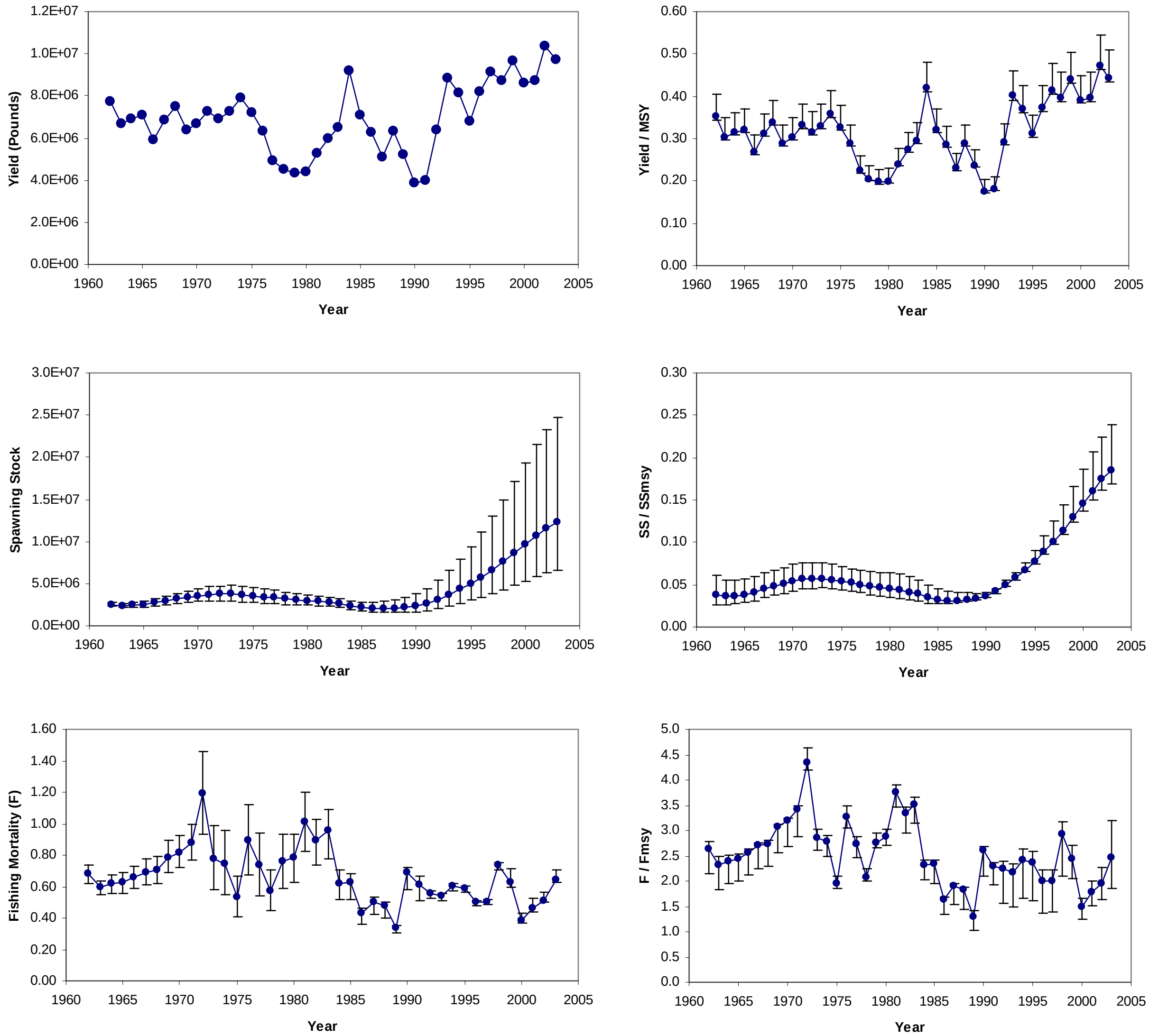

Figure 10. Trajectories for steepness 0.9. (A) yield, (B) ratio of yield to MSY, (C) spawning stock biomass, (D) ratio of SS to SS_{MSY}, (E) fishing mortality, (F) ratio of F to F_{MSY}.

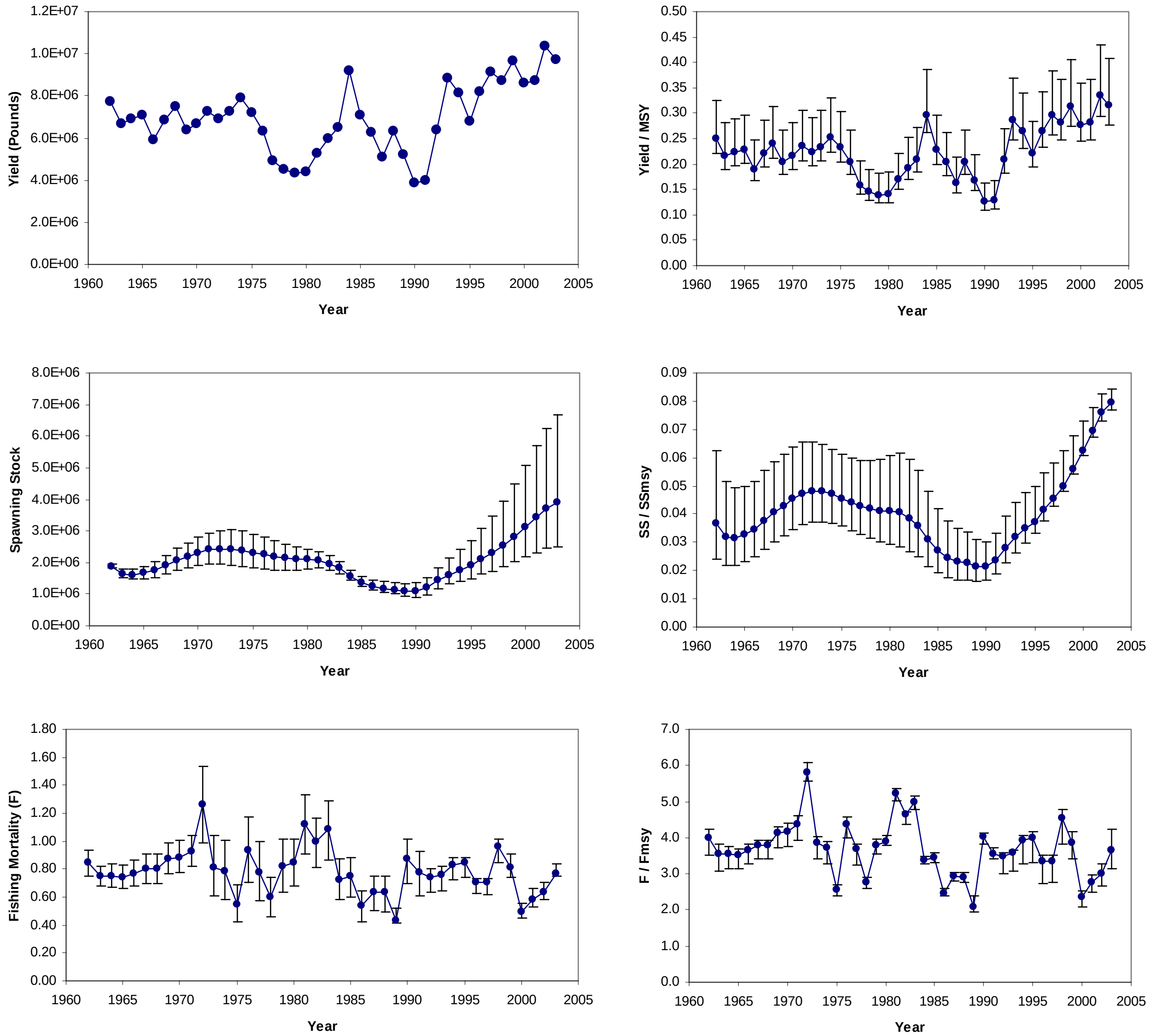

Figure 11. Trajectories for steepness 0.95. (A) yield, (B) ratio of yield to MSY, (C) spawning stock biomass, (D) ratio of SS to SS_{MSY}, (E) fishing mortality, (F) ratio of F to F_{MSY}.

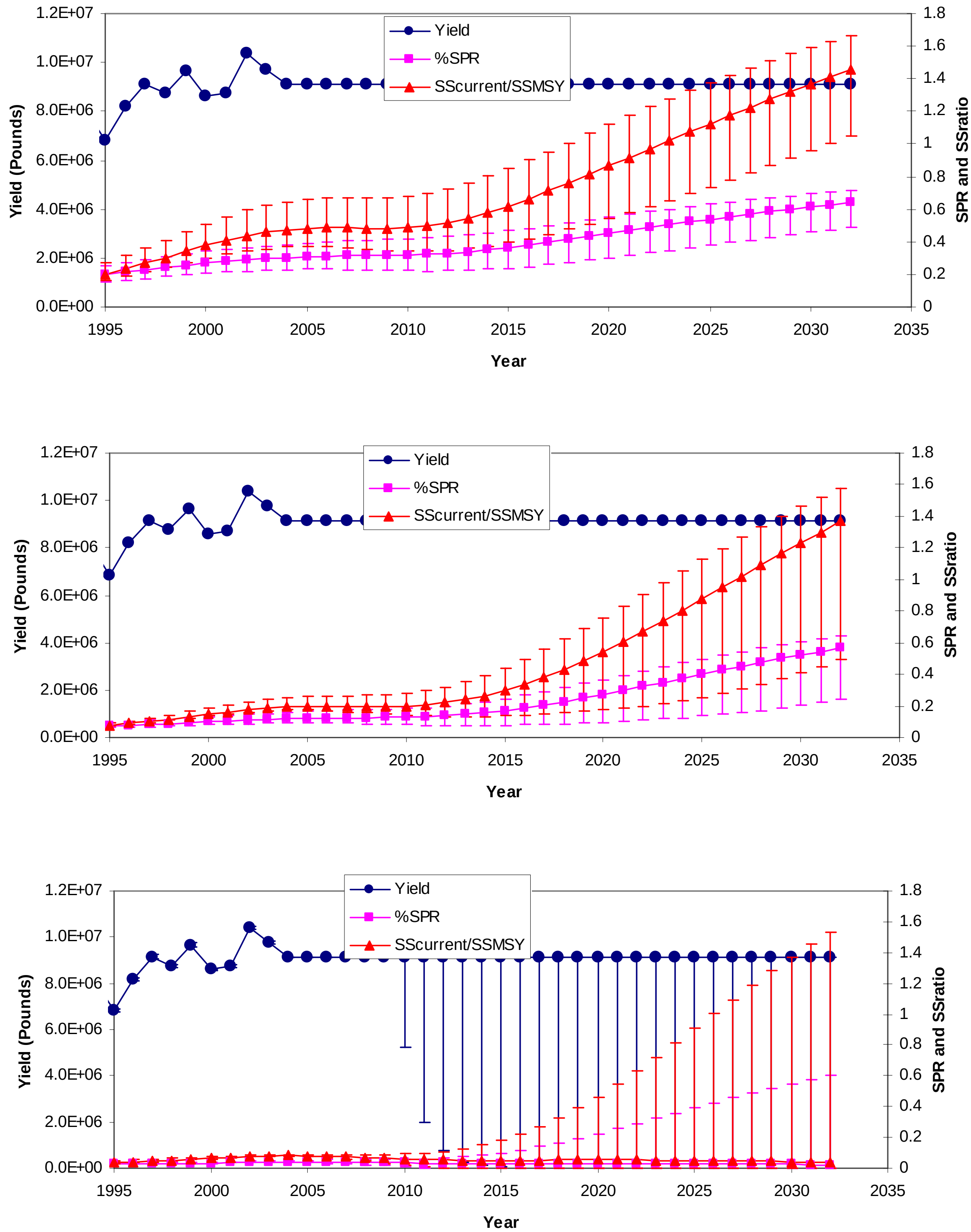

Figure 12. Projection of yield, %SPR, and spawning stock ratio (relative to SS_{MSY}) for steepness (A) 0.81, (B) 0.9, and (C) 0.95.

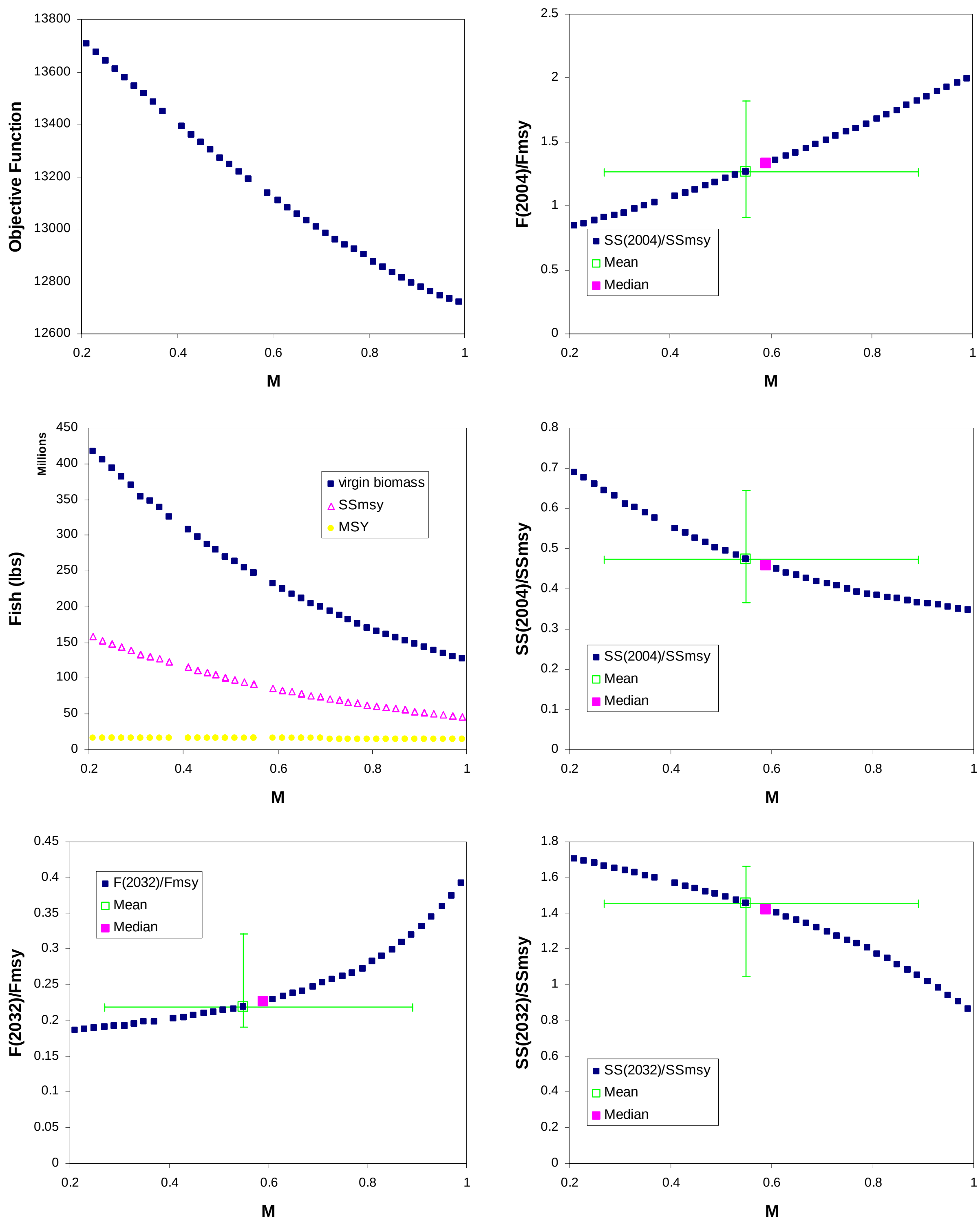

Figure 13. Influence of M_1 (and linked M_0) values, steepness 0.81. (A) spawning stock biomass in 2004 relative to SS_{MSY}, (B) bimass and yield reference points, (C) fishing mortality rate in 2004 relative to F_{MSY}, (D) model fit (lower is better).

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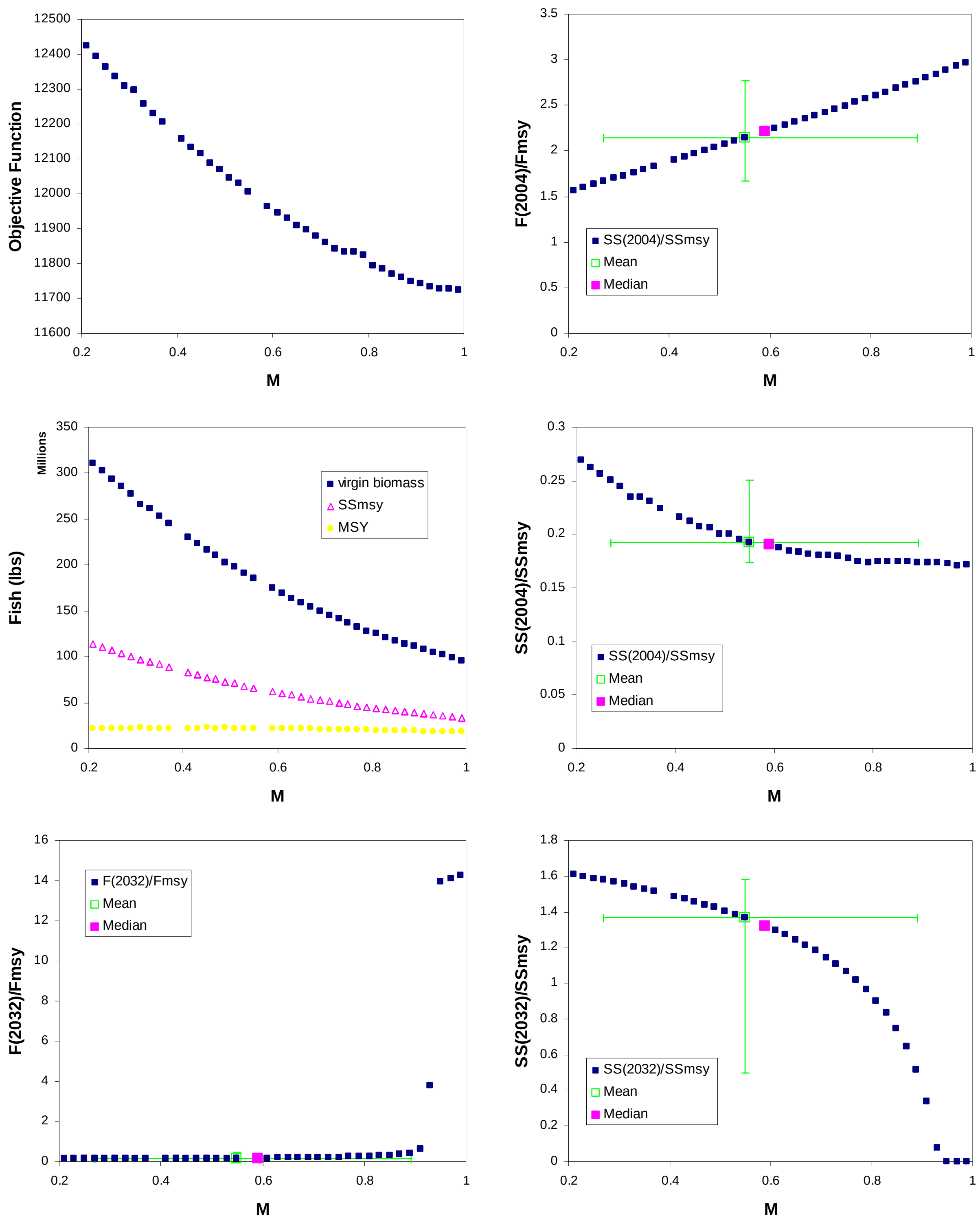

Figure 14. Influence of M_1 (and linked M_0) values, steepness 0.9. (A) spawning stock biomass in 2004 relative to SS_{MSY}, (B) bimass and yield reference points, (C) fishing mortality rate in 2004 relative to F_{MSY}, (D) model fit (lower is better).

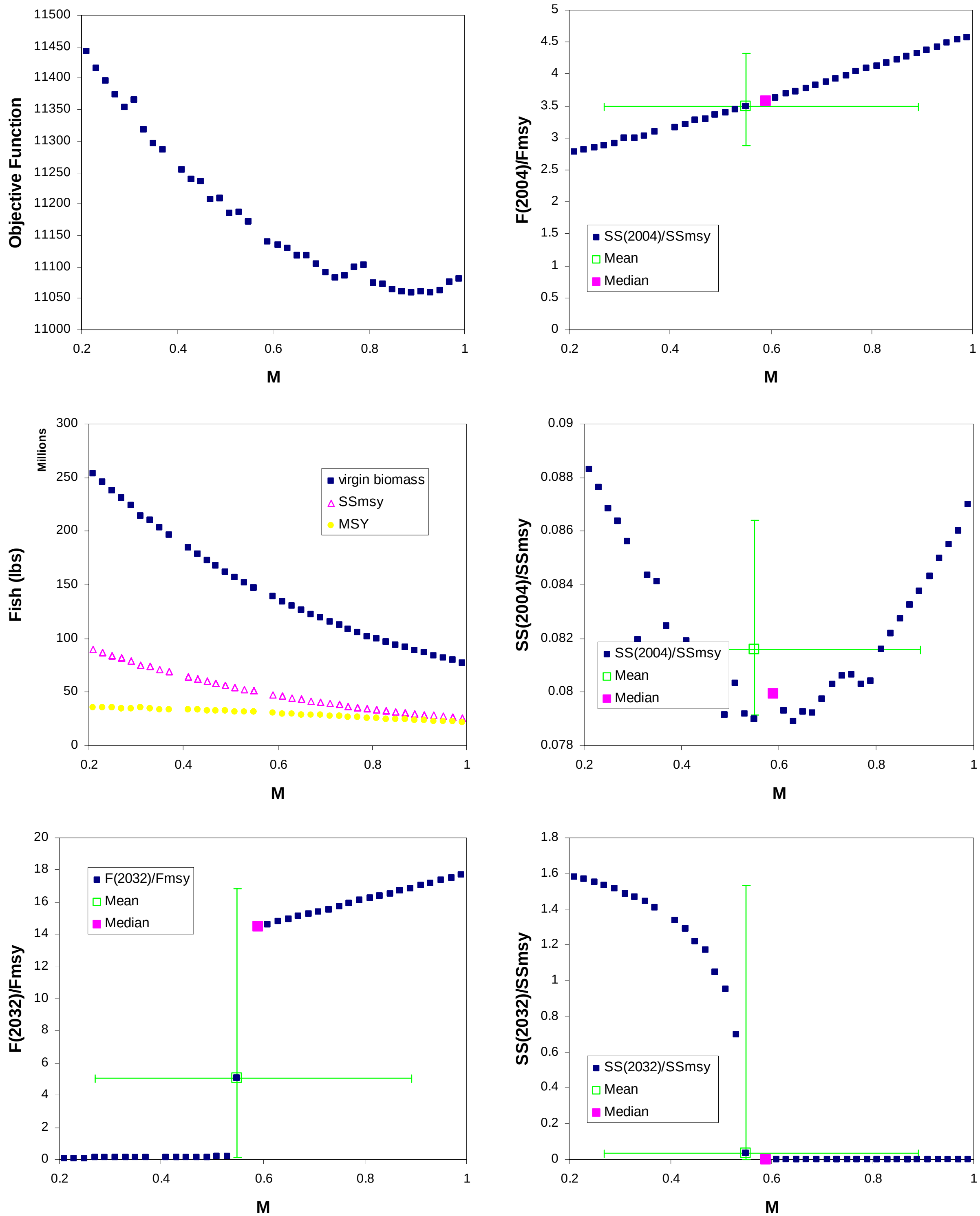

Figure 15. Influence of M_1 (and linked M_0) values, steepness 0.95. (A) spawning stock biomass in 2004 relative to SS_{MSY}, (B) bimass and yield reference points, (C) fishing mortality rate in 2004 relative to F_{MSY}, (D) model fit (lower is better).