An Aggregated Production Model for the Gulf of Mexico Gray Triggerfish (*Balistes capriscus*) Stock

by

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INTRODUCTION

An ASPIC model (NOAA Fisheries Toolbox Version 5.10, 2005, http://nft.nefsc.noaa.gov) was explored using a number of data sets for the Gulf of Mexico gray triggerfish (*Balistes capriscus*) stock.

A Stock Production Model Incorporating Covariates (ASPIC) is a non-equilibrium implementation of the well-known surplus production model of Schaefer (1954, 1957). ASPIC also allows one to run models with other stock-recruitment relationships along the continuum identified by Pella and Tomlinson (1969). More details can be found in Prager (1994). ASPIC models presented here were conditioned on catch, forcing the model to match the catch inputs while estimating the abundance-related parameters (i.e., effort, CPUE).

METHODS

Data Sources

ASPIC relies on catch and abundance estimates to reconstruct a stock's history. Because ASPIC assumes that a unit of biomass is equivalent regardless of the age of the fish in question, life history information does not influence this aggregated production model. Instead, the model is driven entirely by catch and abundance indices.

Catches were converted into weights and aggregated into three fleets: recreational headboat, other recreational, and all commercial. Discards were ignored because of the extraordinarily high discard survival rate of gray triggerfish (SEDAR9-DW-Report). At present, two sources of catch were not included in the model due to data limitations: Texas recreational catches and bycatch of juvenile fish by the shrimp fleet. The models were conditioned on catches, meaning that they were assumed to be correct measures of fishing removals. Values are shown in Table 1 and Fig. 1.

Six indices were used. The three catch fleets were paired with three related indices calculated from the NMFS Southeast zone headboat survey, the marine recreational fisheries statistics survey (MRFSS), and commercial handline logbook entries (see SEDAR9-AW-## for more information). Additionally, three fishery-independent surveys were considered: the Neuston larval survey (using the standardized index with diurnal cycle accounted for), an age-1-based trawl survey index, and a video survey. Values are shown in Table 2 and Figs. 2 and 3.

Model Configuration

An initial model was configured using a logistic stock-recruitment relationship, equal weighting of indices, and starting points for parameter estimation specified as follows: initial biomass ratio (B_0/K) = 0.75, maximum sustainable yield (MSY) = 1.5 m (range 1m to 4, 6, or 12m), and carrying capacity (K) equal to 10 times MSY (implies an intrinsic population growth rate parameter, *r*, value of 0.4). Note that total catches average about 1.5 m pounds over the time period being modeled. The consequences of varying the maximum possible MSY values were explored.

Next, a similar model was constructed except that the Neuston larval and trawl survey indices were down weighted to 1% of the influence of other indices, effectively turning them off. The base model used a logistic stock-recruitment relationship and starting points for parameter estimation specified as follows: B_0/K = 0.75, MSY = 1.5 m (range 1m to 6m), and K = 10xMSY. Consequences of varying the starting point for the estimation procedure were explored. In a well-conditioned model, the final estimation result should be insensitive to the starting point of its estimation. A finding of sensitivity would raise concern about the ability to make robust conclusions from the model results.

Parameters Estimated

ASPIC estimates surplus production parameters (carrying capacity, intrinsic population growth rate) and biomass trajectories over the course of the time period modeled. These parameters are then combined to determine other useful benchmarks, such as MSY-related biomass and fishing mortality rates, and fishing mortality rate trajectories.

Uncertainty and Measures of Precision

Uncertainties in the ASPIC models were explored in two main steps. First, we checked for sensitivities to the starting point of the fitting procedure by varying the initial estimates. Had that exercise indicated a well-conditioned model, then we would have examined sensitivity to one or more key parameters.

RESULTS

The first problem encountered with the gray triggerfish aggregated production model was conflicting trends among indices. The Neuston larval and trawl survey indices were negatively correlated with several others. Nonetheless, the models did converge and allowed comparisons across different formulations.

When all indices were weighted equally, results were highly dependent on the value set for the maximum boundary for the estimation of MSY. When varied from 4 to 12m, the current status of fishing on the population changed by nearly a factor of two (Fig. 4). Oddly, the best fit, in terms of sum of square errors, was the estimate produced with the smallest range (4m → SSE = 36.8, 6m → SSE = 46.4, 12m → SSE = 68.4). Due to this problem and the negative correlation among the larval, trawl, and other indices, further runs were conducted with the larval and trawl indices substantially down weighted (1% of others).

Runs with these new weightings indicated a generally good fit of the model to the data (Fig. 5). Additionally, population trajectories were consistent with the general findings of indices and conceptually plausible (Fig. 6). Even with the larval and trawl indices down weighted, the model showed sensitivities to the starting points for the estimation procedure. Starting biomass values varied by more than a factor of four, although the lowest estimate was for a solution that fit poorly (Table 3). Final biomass and fishing mortality ratios also varied over a fairly broad range (Table 3, Fig. 7). And, with the exception of the run with initial estimation point for carrying capacity (K) set lower relative to MSY, all runs produced generally good fits to the data (Table 3).

CONCLUSIONS

Due to the sensitivity of the model to the starting point for the estimation procedure, we have concerns about our ability to make robust conclusions from the model results. Clearly, the data are not adequate to resolve the status of the Gulf of Mexico gray triggerfish stock with any precision using an aggregated production model.

However, one finding did stand out as potentially robust. Nearly every run we conducted, from those presented here to numerous runs with draft data, indicated that the Gulf of Mexico gray triggerfish stock was overfished and experiencing overfishing. However, large differences among runs make it difficult to ascertain the magnitude of the problem.

We recommend exploring this model further. The sensitivities identified here are not unique to this stock (e.g., see Caribbean yellowtail snapper, SEDAR8-AW-Report). Phenomena such as the apparent observation of poor status for the Gulf of Mexico gray triggerfish stock could possibly be resolved by investigating a surface of goodness-of-fit values across a broad range of parameter values. Results here and from previous experience would suggest that there is often a ridge of relatively good fit, with many small local peaks. If this is indeed the case, one might be able to draw conclusions about the status of the stock based on where the ridge lies, and might even be able to explore probabilistic projections by bootstrapping across this ridge.

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TABLE 1—Catches by Fleet (in lbs)

Year	Headboat	Other recreational	Commercial	Total
1986	93772	864229	95629	1053630
1987	76584	1115841	123603	1316027
1988	134501	1592524	195062	1922088
1989	162639	1672689	317632	2152960
1990	263606	2184440	459038	2907083
1991	187270	1758437	444530	2390237
1992	222532	1497032	450195	2169759
1993	215132	1268698	558728	2042558
1994	222428	1077372	404720	1704519
1995	200838	1125930	337877	1664645
1996	156388	673879	267516	1097783
1997	129477	605403	184689	919569
1998	107159	517647	176723	801530
1999	82666	388552	219020	690238
2000	67913	341086	158137	567136
2001	82164	531165	176182	789511
2002	110960	670356	235563	1016879
2003	128529	775486	251810	1155825
2004	115965	889761	218533	1224258

TABLE 2—Index Values (CPUE)

Year	Headboat	MRFSS	Commercial Handline	Larval	Trawl	Video
1986	0.8094	1.7697		0.8122		
1987	0.6924	0.8929		0.5985	0.8678	
1988	0.9383	2.5591		0.4037	0.4113	
1989	1.3966	3.0805		0.2314	0.3900	
1990	2.1313	5.5935		0.3990	1.1514	
1991	1.9838	3.0457		0.8050	1.3974	
1992	2.0453	3.1726		2.6547	0.8699	1.8348
1993	1.7649	1.3323	1.5312	0.9001	0.3532	1.0011
1994	1.4882	1.2347	1.4616	1.0343	1.0221	0.9002
1995	1.2666	2.6720	1.4322	1.0305	1.3458	0.8517
1996	1.0442	1.1268	0.8714	0.6992	0.5557	0.7936
1997	1.0093	0.7435	0.8598	0.7347	0.7730	1.6737
1998	0.9698	0.5663	0.8463		0.2781	
1999	0.7009	0.6776	0.7264	0.2326	0.7434	
2000	0.5770	0.5961	0.6296	2.4034	0.3067	
2001	0.6140	0.6567	0.6727	0.3967	1.5582	0.1430
2002	0.8430	0.8021	0.9638	0.5497	1.5220	0.8019
2003	0.8353	0.7308	1.0854		0.2740	
2004	0.8867	0.8609	0.9196		0.5518	

TABLE 3—Sensitivities to Starting Points of the Estimation Procedure

Results from models where larval and trawl survey indices were down weighted. The base model used a logistic stock-recruitment relationship and starting points for parameter estimation specified as follows: $B_0/K = 0.75$, MSY = 1.5 m (range 1m to 6m), and K = 10xMSY.

Model	Bratio	Fratio	Bo ratio	Bo (m)	SSE
Base	0.2828	1.94	0.6661	3.41	31.498
max MSY 4m	0.2128	3.107	0.9872	8.46	52.799
Bo ratio 0.25	0.3003	1.901	0.7408	3.76	25.26
MSY 2.1m	0.2047	3.509	1.137	9.97	38.58
K 5xMSY	0.2336	2.146	0.7069	2.3	1348

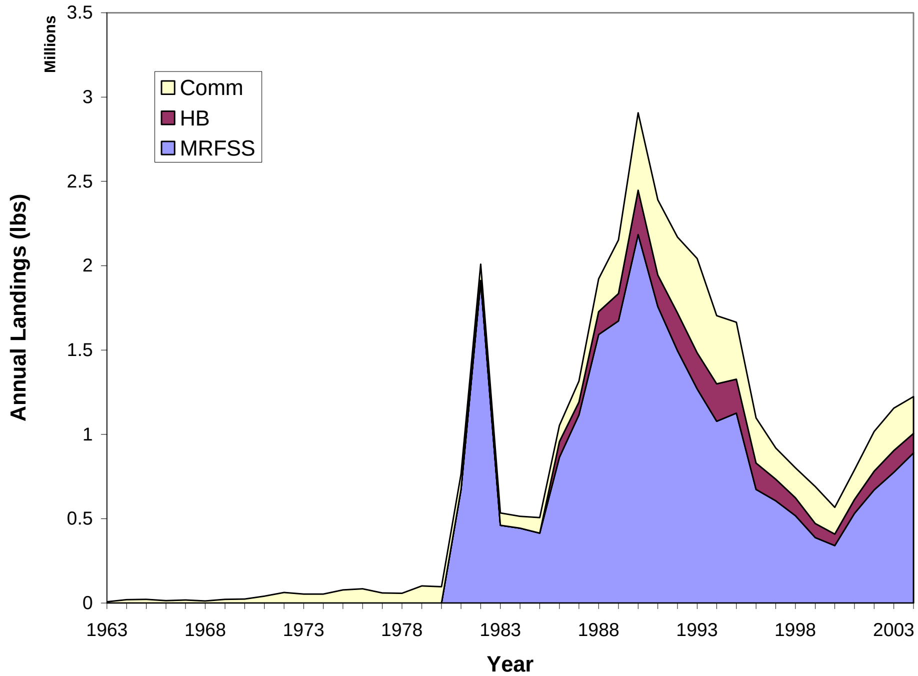

FIG. 1—Catches by Fleet

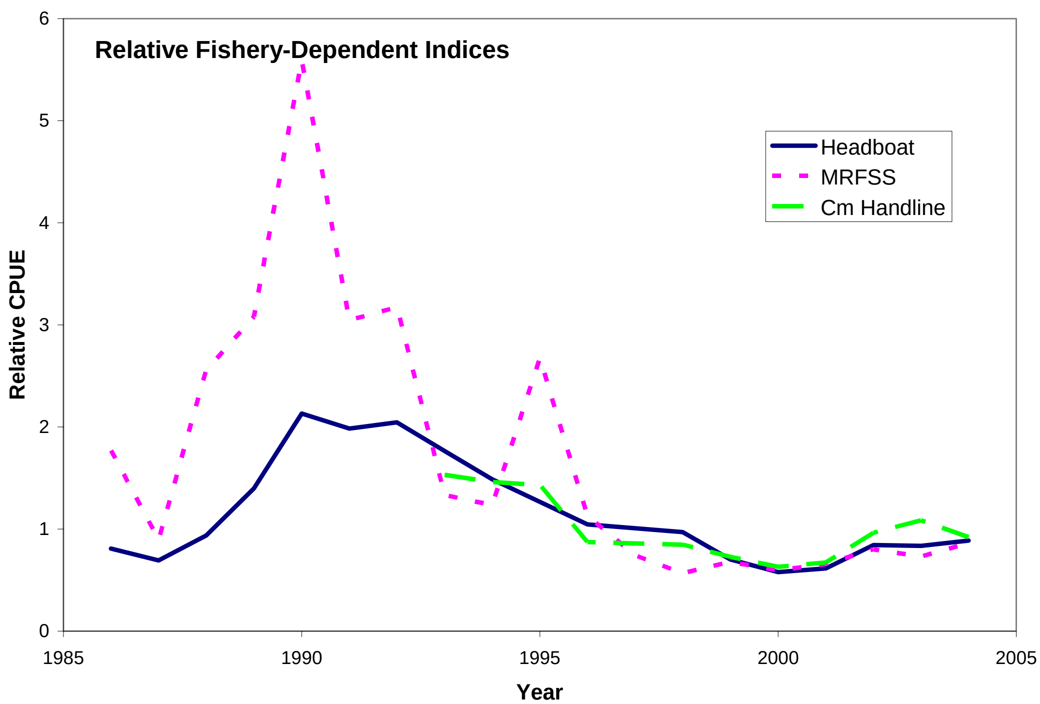

FIG. 2—Relative Standardized Fishery-Dependent Indices
Normalized across the years where all indices were calculated (1993-2004)

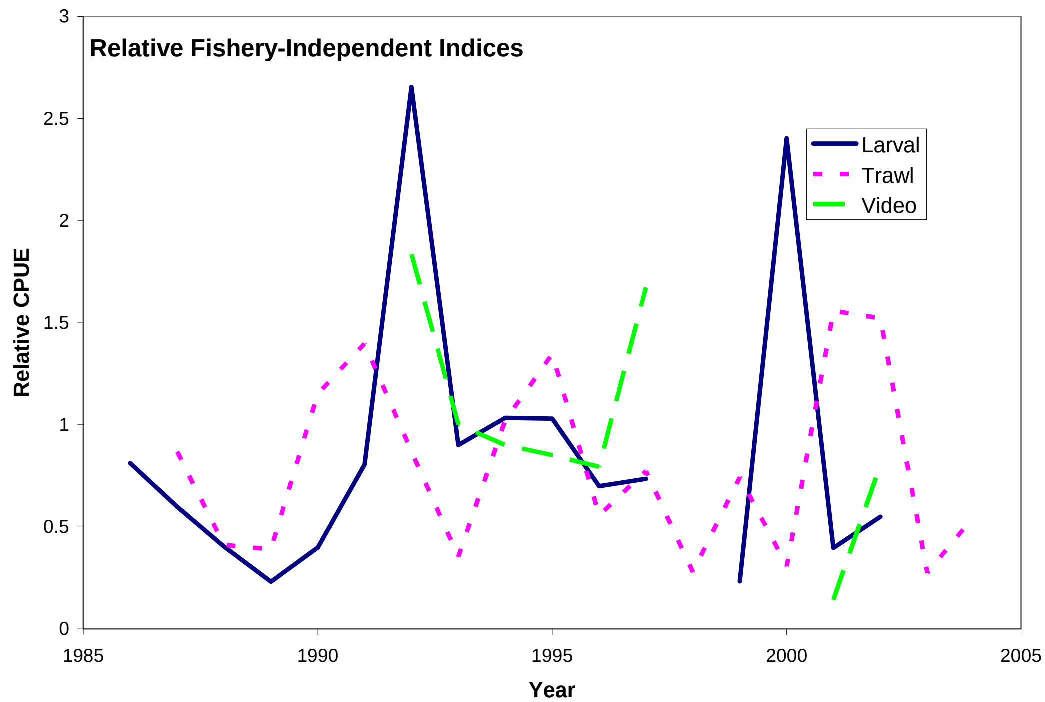

FIG. 3—Relative Standardized Fishery-Independent Indices
Normalized across the years where all indices were calculated (1992-97, 2001-02)

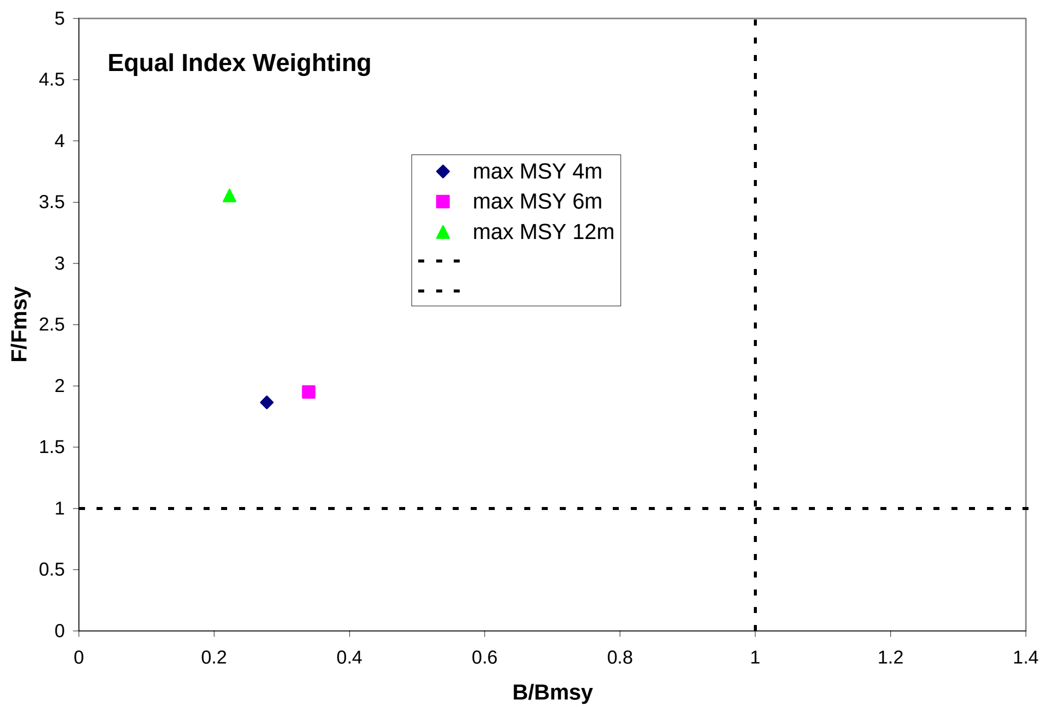

FIG. 4—Status Across Different Initial Estimation Points with Equal Index Weightings

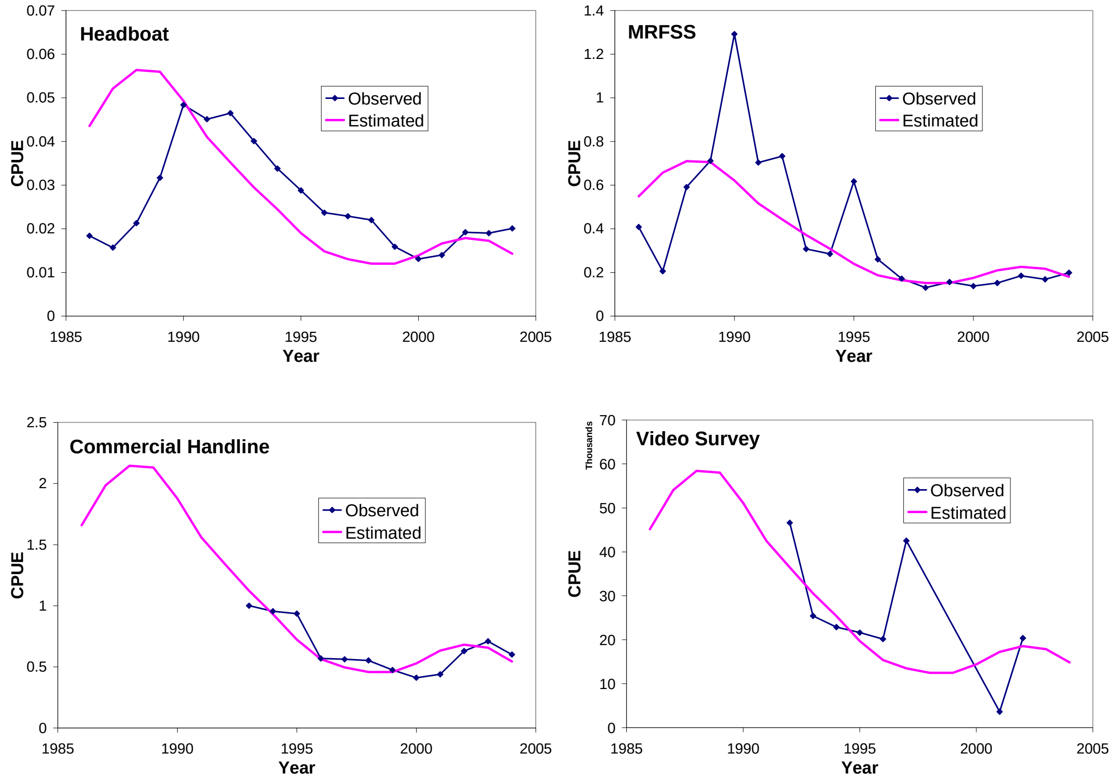

FIG. 5—Base Model Fit to Indices
(A) Headboat, (B) MRFSS, (C) Commercial Handline, (D) SEAMAP Video Survey.

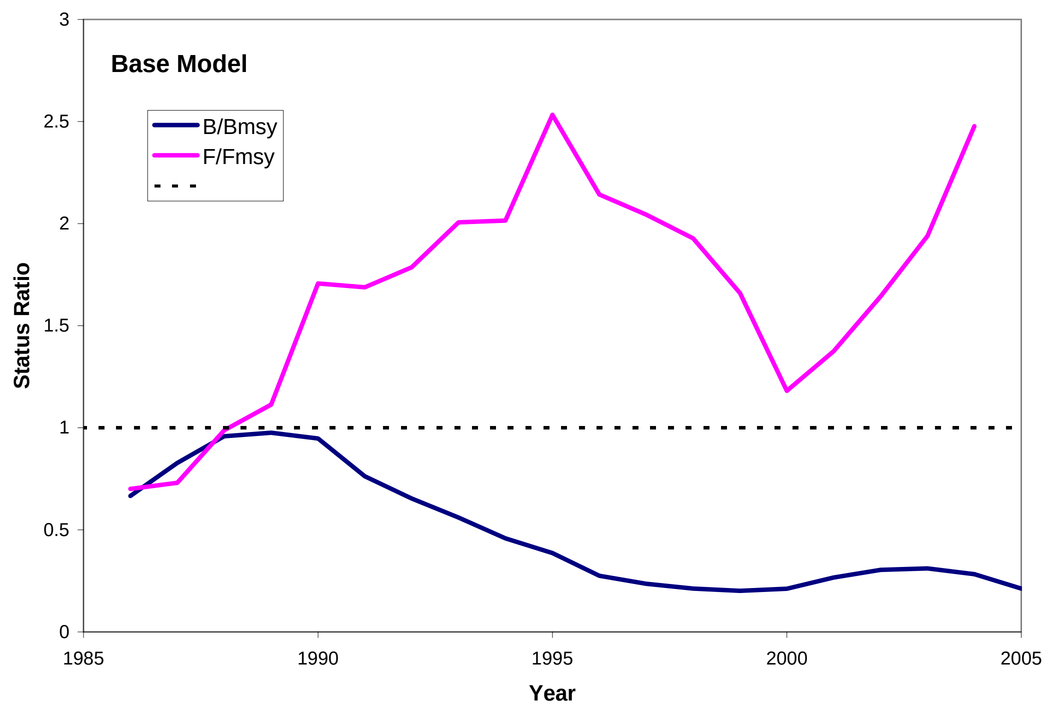

FIG. 6—Status Trajectories of Base Model

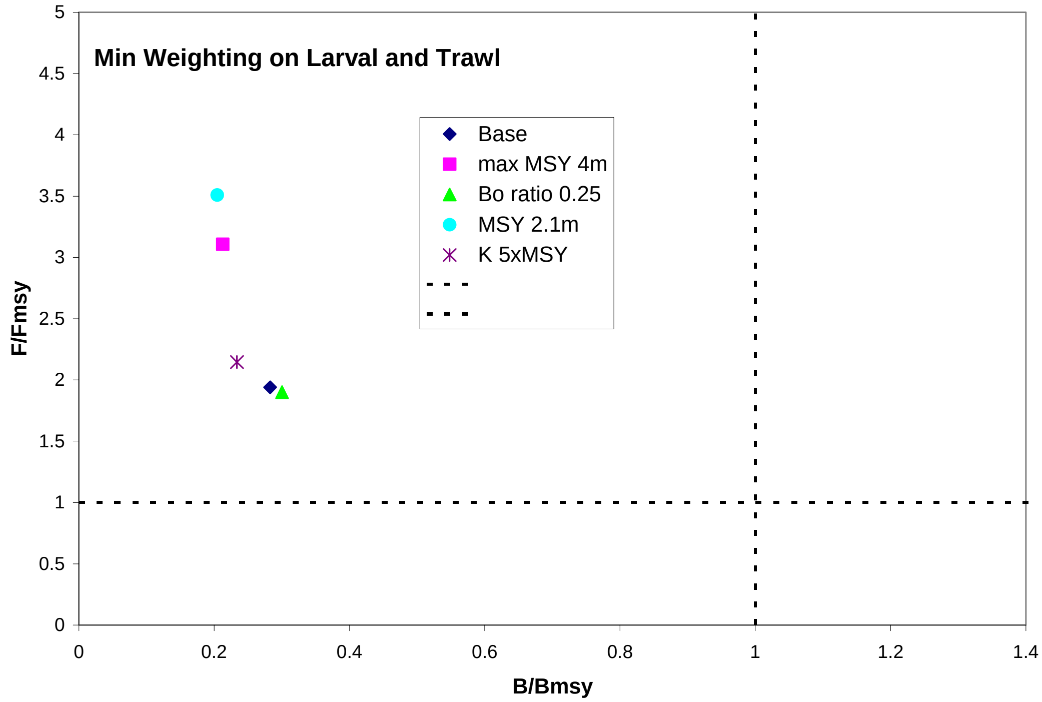

FIG. 7—Status Across Different Initial Estimation Points with Minimal Weightings on Larval and Trawl Indices