Red Porgy Recovery Projections Under Five Potential Management Strategies

Population Dynamics Team
NOAA Center for Coastal Habitat and Fisheries Research
Beaufort, NC 28516

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Introduction

This report describes new recovery projections of the red porgy population off the Southeastern U.S. under five potential management strategies. The computations, benchmarks, initial status of the stock, and operating model (assumed model of the stock and fishery) are based on the SEDAR assessment report of May 6, 2002. The projections are presented to aid the Council in choosing a recovery strategy for this stock.

The report also presents estimates of annual equilibrium yield (landings plus dead discards) and spawning-stock biomass (SSB) at various levels of fishing mortality rate (F) relative to Fmsy, also based on the red porgy SEDAR assessment of May 6, 2002. These estimates are presented to aid the Council in choosing an optimum yield strategy for this stock.

The five management strategies explored in recovery projections are

Strategy 1: Maximum constant annual landings (total removals) that allow the stock to rebuild by December 31, 2017 (the end of the 18-year recovery period).

Strategy 2: Maximum constant fishing mortality (F) that will allow the stock to rebuild by December 31, 2017.

Strategy 3: F = 75% of F_{MSY} in 2005–2010, followed by the F that will allow the stock to rebuild by December 31, 2017.

Strategy 4: F = F_{MSY} in 2005–2010, followed by the F that will allow the stock to rebuild by December 31, 2017.

Strategy 5: F=50% of current F in 2005–2010, followed by the F that will allow the stock to rebuild by December 31, 2017.

Methods

Projections

Each management strategy was projected with two sets of initial conditions. In the first, the F in 2001 from the base model run was used for 2001–2004; this approach corresponds to the base model run, the run that was selected by the SEDAR Review Workshop. It does not account for a likely recent increase in dead discards. In the second set of initial conditions, F for 2001–2004 was higher, and was taken from the assessment report's sensitivity run that included an adjustment for increased recent dead discards. That projection approach was preferred by Assessment Workshop participants (as more realistic) and was taken in the assessment report.

All projections described here are consistent with recent black seabass projections in using deterministic values of F in each projection year. That differs from the stochastic values of F used in the assessment report. However, any differences due to that change are expected to be minor.

Initial status of the stock was taken from the base run in the assessment report, which also provided needed parameter estimates. Stochastic recruitment (number at age 0) was added to the 2001 population size based on the spawning-stock biomass estimated for 2001. Initial F, which was based on the 2001 estimate and applied to years 2001–2004, was estimated in the assessment report as 0.085/yr for projections based on the base run and 0.107/yr for projections based on the discard-sensitivity run. Selectivity at age in all projections was based on the catch-weighted average selectivity from the component fisheries in the corresponding assessment run.

Projections included considerable stochasticity in the stock–recruit relationship. Recruitment was predicted by the fitted Beverton–Holt function, with random deviation added to each year's predicted recruitment. Each deviation was chosen at random from the 1972–2000 residuals estimated by the assessment model.

The rebuilding criterion used was that the spawning stock biomass (SSB) must reach or exceed the SSB at MSY by December 31, 2017 (or equivalently, January 1, 2018). That criterion is based on the time required to rebuild with F=0 (10 years) plus one generation time (8 years), all under the assumption (as used in the assessment) that M=0.25/yr. Thus in the projections, year 1 of the rebuilding period is 2000; year 18 is 2017.

For each combination of management strategy and initial conditions, 1000 replicate projections were computed, based on 1000 different streams of stochastic recruitments. Across bootstrap replicates, the 5^{th}, 50^{th} (median), and 95^{th} percentiles were computed on spawning stock biomass, fishing mortality rate, and landings or total removals. Rebuilding status was based on the median projected SSB.

Equilibrium yield

Estimates of equilibrium yield (defined as all removals; i.e., landings plus dead discards) at various levels of fishing mortality are also based on the base-run model from the red porgy SEDAR assessment report of May 6, 2002. The calculations were made using the selectivity vectors, recruitment model, and growth model from that assessment.

General

This report follows standard fishery-science conventions in labeling years. For a given year, population size and spawning-stock biomass are reported at the start of the year (nominally, January 1). Yield is reported as a total for the year. The fishing mortality rate is the average value during the year.

Results and comments

Projections

Recovery occurs at the end of the 18-year period under all strategies examined (Figures 1–10), while corresponding total removals (yield plus dead discards) vary only slightly among management strategies. Removals are tabulated for 2004, representing the earliest year in which changed management might potentially take place, through 2017, the last year of the rebuilding period. Strategy 2 (the constant-catch policy) results in the highest total removals over the rebuilding period when projections are based on the assessment's base run. Strategy 5 (50% initial cut in F) provides the highest yields when projections are based on the discard-sensitivity run. In both cases, the least variability in removals from year to year is provided by strategy 1, the constant-removals strategy (Tables 1 and 2).

The division of removals in Tables 1 and 2 between landings and dead discards in any year will depend on the management measures in place and the population size structure. Depending on the type of management measures used (e.g., size limits), discarding may increase significantly as the stock rebuilds.

If the proportion of the catch discarded increases over time, as might happen with a recovering stock managed with bag and size limits, the portion of Tables 1 or 2 that represents landings will decrease with time. (That assumes that total removals are kept at the levels listed.) To the degree that management measures can avoid dead discards while still controlling fishing mortality, that issue can be alleviated.

A separate issue concerning discards is modeling the likely recent increase in dead discards due to regulatory changes. The minimum size limit was raised to 14 inches in 1999, and bag and trip limits went into effect in 2000 with Amendment 12. Results in Table 2 and Figures 6–10 represent an attempt to account for those discards. The method used, devised by the SEDAR Assessment Workshop, does not account for size-selective discards, but instead simply raised the estimate of total removals (after accounting for release mortality) in recent years, and estimated recent F under those conditions. That procedure provides only a rough approximation of the effects of discards and is intended to be illustrative, rather than quantitative.

Projections are inherently uncertain. All caveats discussed in the assessment report also apply to these strategies.

Several issues arise in choosing among management strategies. In general, allowing higher fishing mortality rates at first gives higher initial yields, but tends to slow recovery and results in lower yields over the entire recovery period (Figures 1–10). Relatively larger initial reductions in F provide higher yields over the medium to long term (Tables 1, 2).

It is believed that fishing at a lower fishing mortality rate provides more population robustness to environmental perturbations, and thus can be helpful in assuring recovery of a depleted stock and easing restrictions more quickly. If a fishing mortality rate is implemented that is found at the next assessment to have been too low, a dividend should be available in the form of larger allowable catches. If a fishing mortality rate is implemented that is found at the next assessment to have been too high, further reductions in catch will probably be needed at that time.

Equilibrium yield

Estimates of equilibrium yield (landings plus dead discards) and spawning-stock biomass (SSB) at various levels of fishing mortality rate (F) are typical of such analyses (Table 3). The estimated yield decreases relatively slowly as the fishing mortality rate decreases. The corresponding standing spawning-stock size increases at a rate faster than the yield decreases. For example, reducing F from F=Fmsy to F=0.75Fmsy corresponds to a reduction in equilibrium yield from 375 mt/yr (826,700 lb/yr) to 364 mt/yr (802,500 lb/yr), or about a 3% decrease. The corresponding increase in SSB is from 3064 mt (6,755,000 lb) to 3776 mt (8,325,000 lb), or about a 23% increase. As mentioned above in a different context, such an increase could provide a buffer against environmental fluctuations or other causes of future poor year classes.

Table 1. Removals projections (mt, landings plus dead discards), using the base-run assessment model for initialization (no accounting of discards). Results presented are the median of 1000 bootstrap replicates.

Year	Strategy 1	Strategy 2	Strategy 3	Strategy 4	Strategy 5
2004	92	92	92	92	92
2005	180	129	160	208	51
2006	180	137	167	209	57
2007	180	146	175	214	64
2008	180	157	185	221	71
2009	180	167	194	229	78
2010	180	175	203	236	83
2011	180	187	154	111	286
2012	180	190	163	122	268
2013	180	197	171	132	266
2014	180	206	181	142	270
2015	180	217	192	152	279
2016	180	225	200	160	285
2017	180	231	207	168	288
Total	2432	2456	2444	2396	2438

Table 2. Removals projections (mt, landings plus dead discards), using the discard sensitivity assessment model (includes accounting of recent discards). Results presented are the median of 1000 bootstrap replicates.

Year	Strategy 1	Strategy 2	Strategy 3	Strategy 4	Strategy 5
2004	109	109	109	109	109
2005	173	118	151	198	60
2006	173	127	160	201	68
2007	173	137	169	207	76
2008	173	148	179	216	84
2009	173	157	188	223	92
2010	173	166	197	230	98
2011	173	176	142	107	260
2012	173	181	151	118	249
2013	173	187	160	128	248
2014	173	196	169	138	253
2015	173	208	180	148	262
2016	173	216	188	156	269
2017	173	222	195	164	275
Total	2358	2348	2338	2343	2403

Table 3. Estimates of equilibrium yield (landings plus dead discards) and spawning-stock biomass (SSB) at various levels of fishing mortality rate (F) relative to Fmsy. Results are based on the base-run model from the red porgy SEDAR assessment report of May 6, 2002.

Percent of Fmsy	F (/yr)	Yield (mt/yr)	SSB (mt)
100%	0.188	375	3064
95%	0.179	375	3191
90%	0.169	373	3326
85%	0.160	371	3467
80%	0.150	368	3617
75%	0.141	364	3776
70%	0.132	358	3944
65%	0.122	351	4123
60%	0.113	342	4313
55%	0.103	332	4516
50%	0.094	319	4732

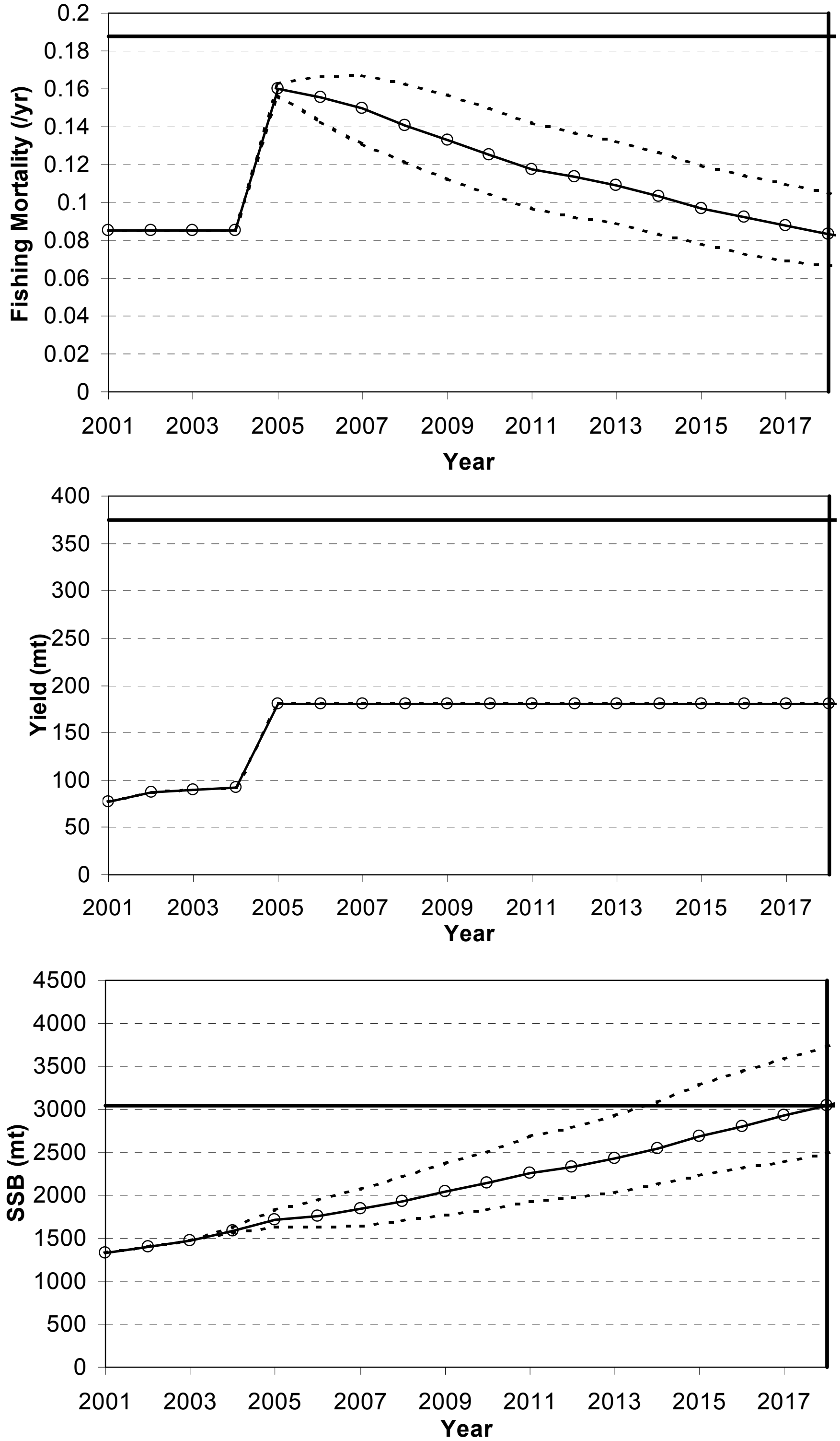

Figure 1. Strategy 1 (base run model) projection results. Results presented for the median (circles), 5th percentile, and 95th percentile (dashed lines) of 1000 bootstrap replicates. The solid horizontal line in the top, bottom, and middle panels corresponds to Fmsy, MSY, and SSBmsy, respectively. Yield includes landings and dead discards.

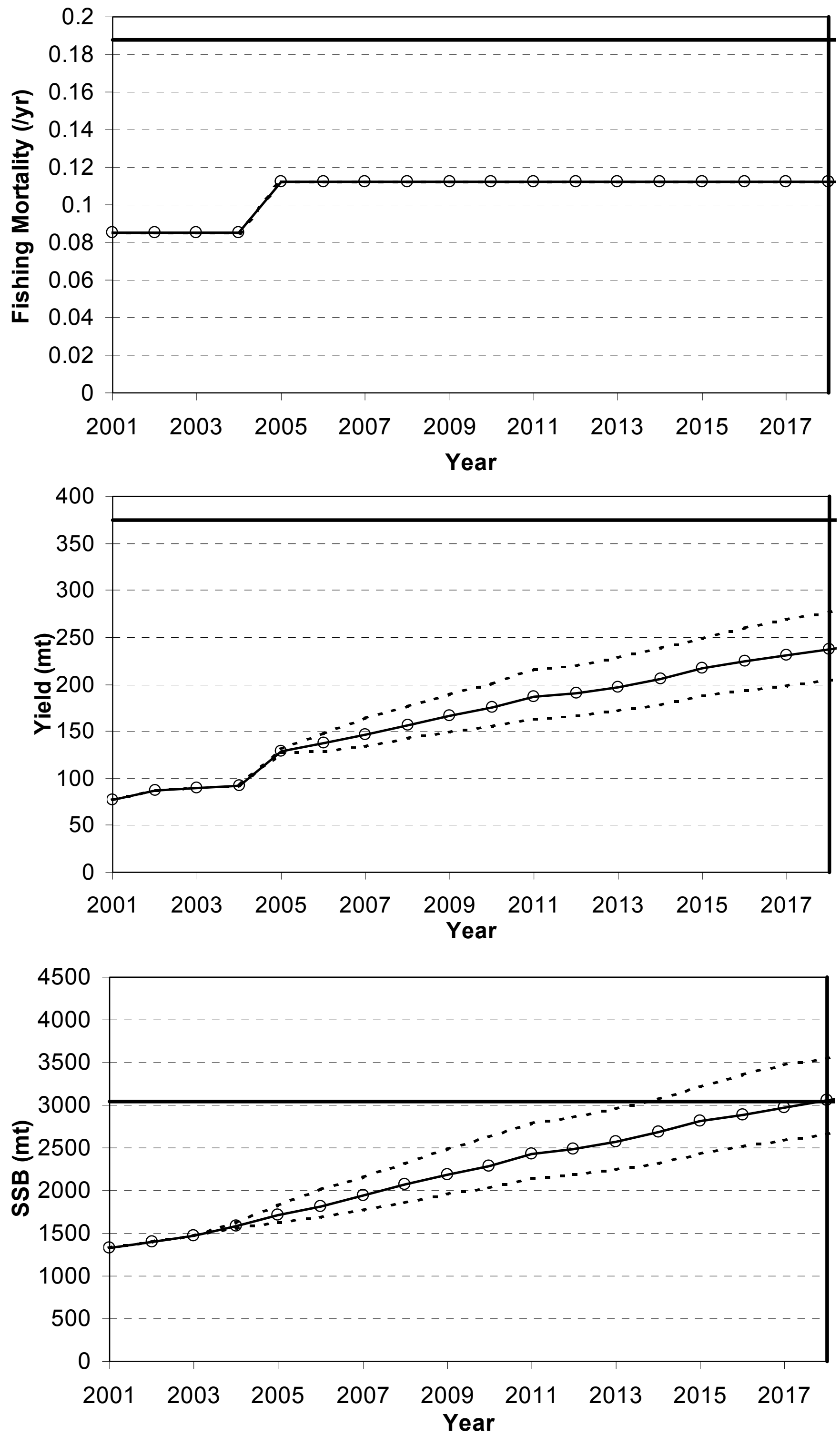

Figure 2. Strategy 2 (base run model) projection results. Results presented for the median (circles), 5^{th} percentile, and 95^{th} percentile (dashed lines) of 1000 bootstrap replicates. The solid horizontal line in the top, bottom, and middle panels corresponds to Fmsy, MSY, and SSBmsy, respectively. Yield includes landings and dead discards.

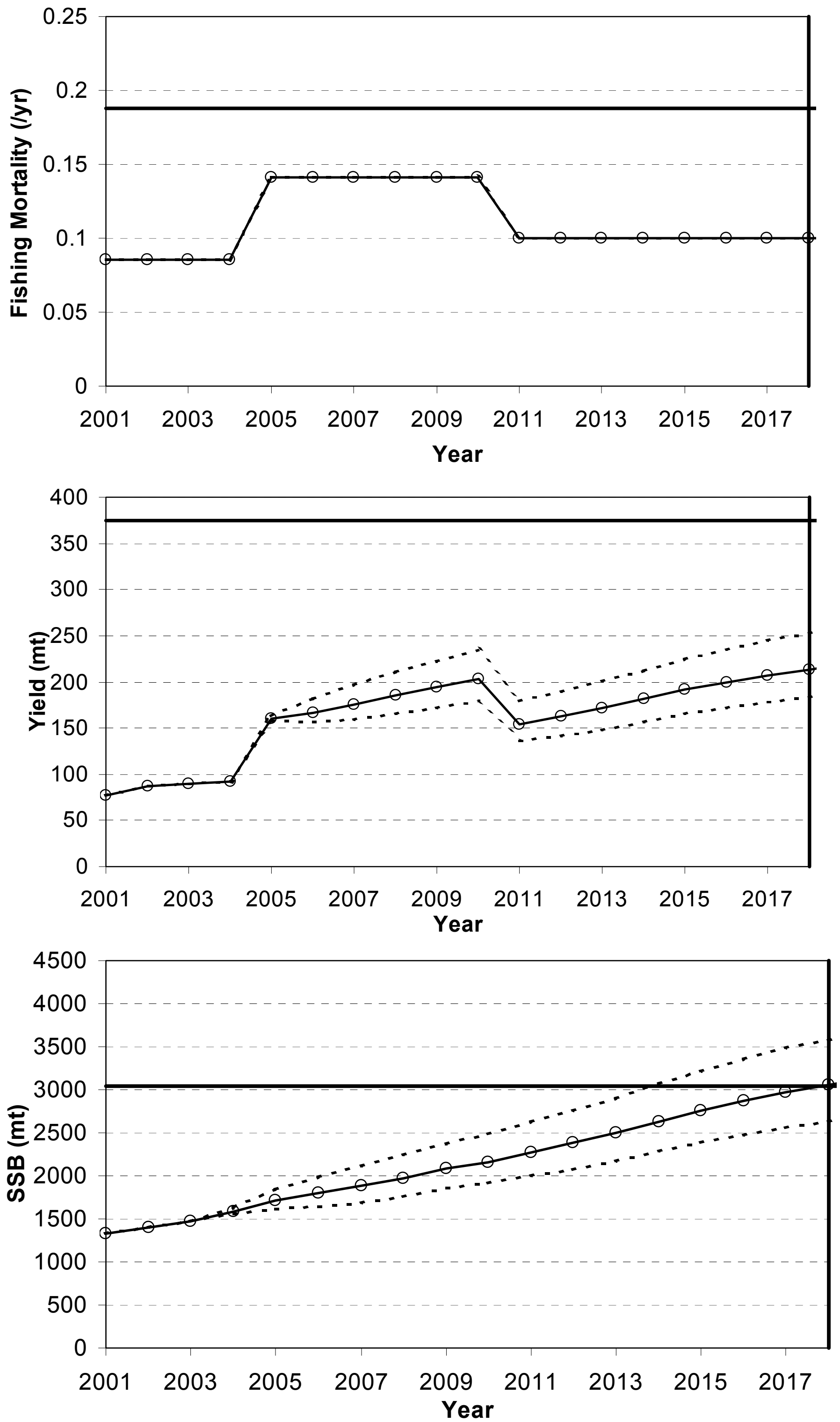

Figure 3. Strategy 3 (base run model) projection results. Results presented for the median (circles), 5th percentile, and 95th percentile (dashed lines) of 1000 bootstrap replicates. The solid horizontal line in the top, bottom, and middle panels corresponds to Fmsy, MSY, and SSBmsy, respectively. Yield includes landings and dead discards.

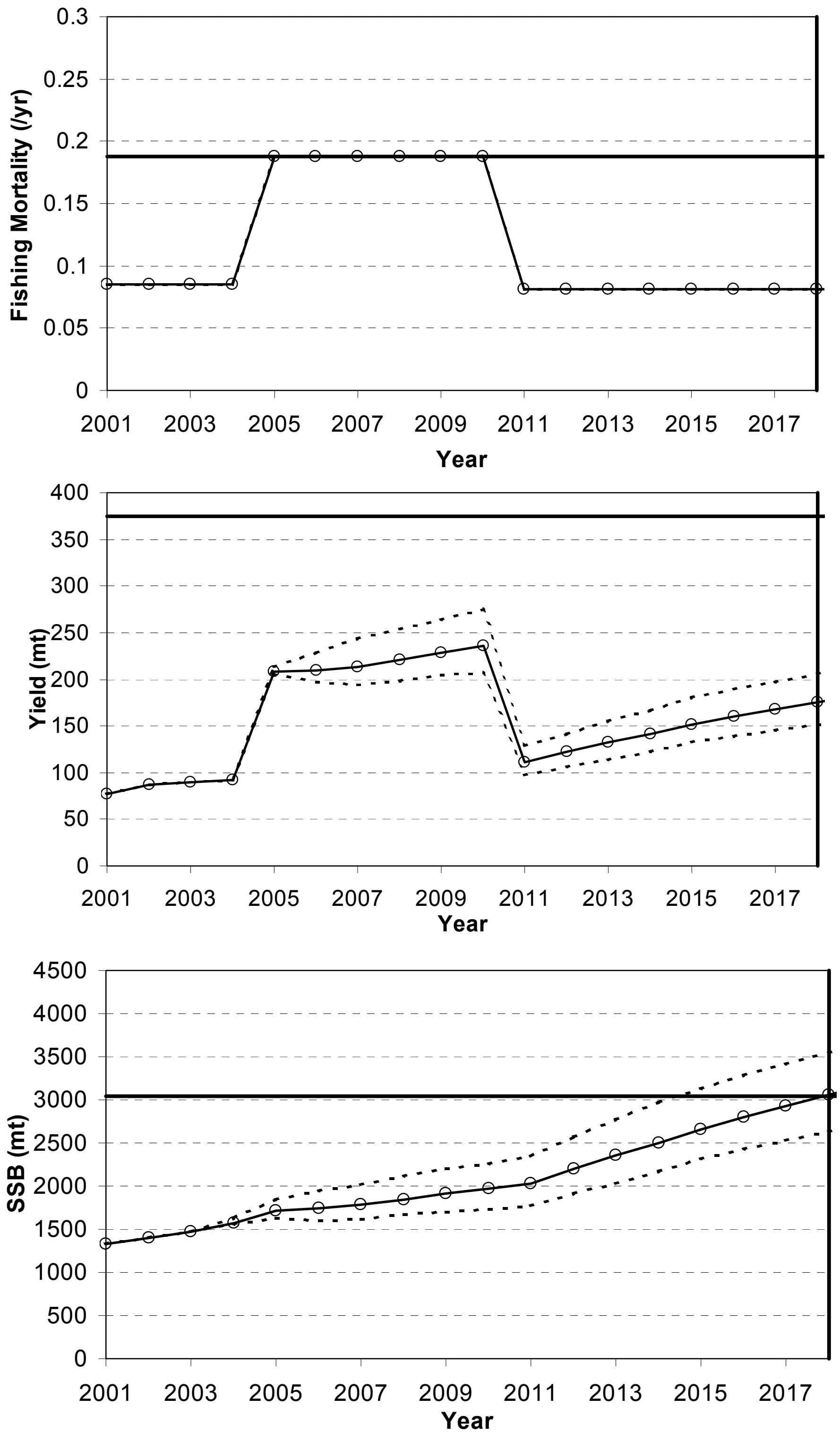

Figure 4. Strategy 4 (base run model) projection results. Results presented for the median (circles), 5th percentile, and 95th percentile (dashed lines) of 1000 bootstrap replicates. The solid horizontal line in the top, bottom, and middle panels corresponds to Fmsy, MSY, and SSBmsy, respectively. Yield includes landings and dead discards.

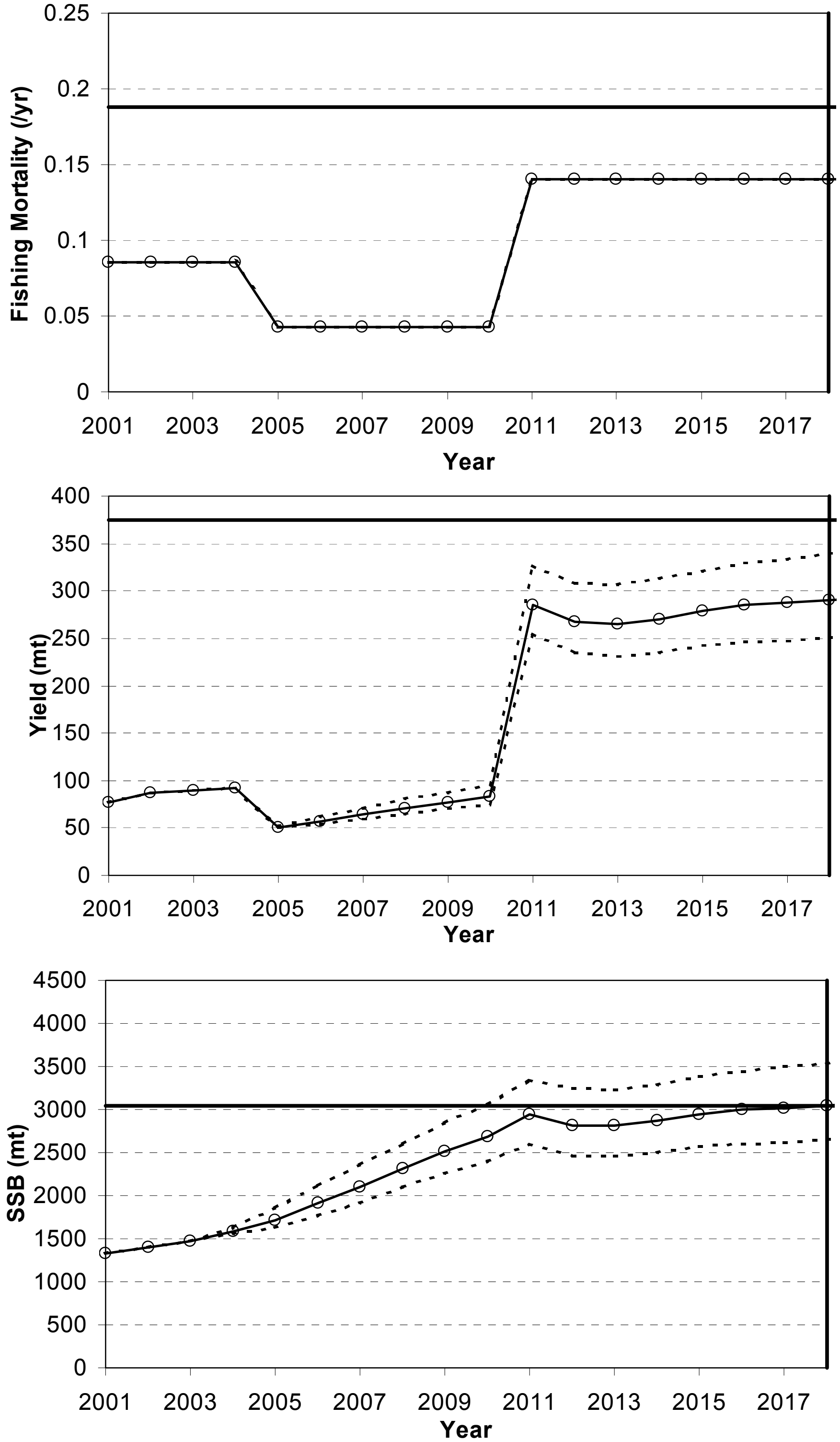

Figure 5. Strategy 5 (base run model) projection results. Results presented for the median (circles), 5th percentile, and 95th percentile (dashed lines) of 1000 bootstrap replicates. The solid horizontal line in the top, bottom, and middle panels corresponds to Fmsy, MSY, and SSBmsy, respectively. Yield includes landings and dead discards.

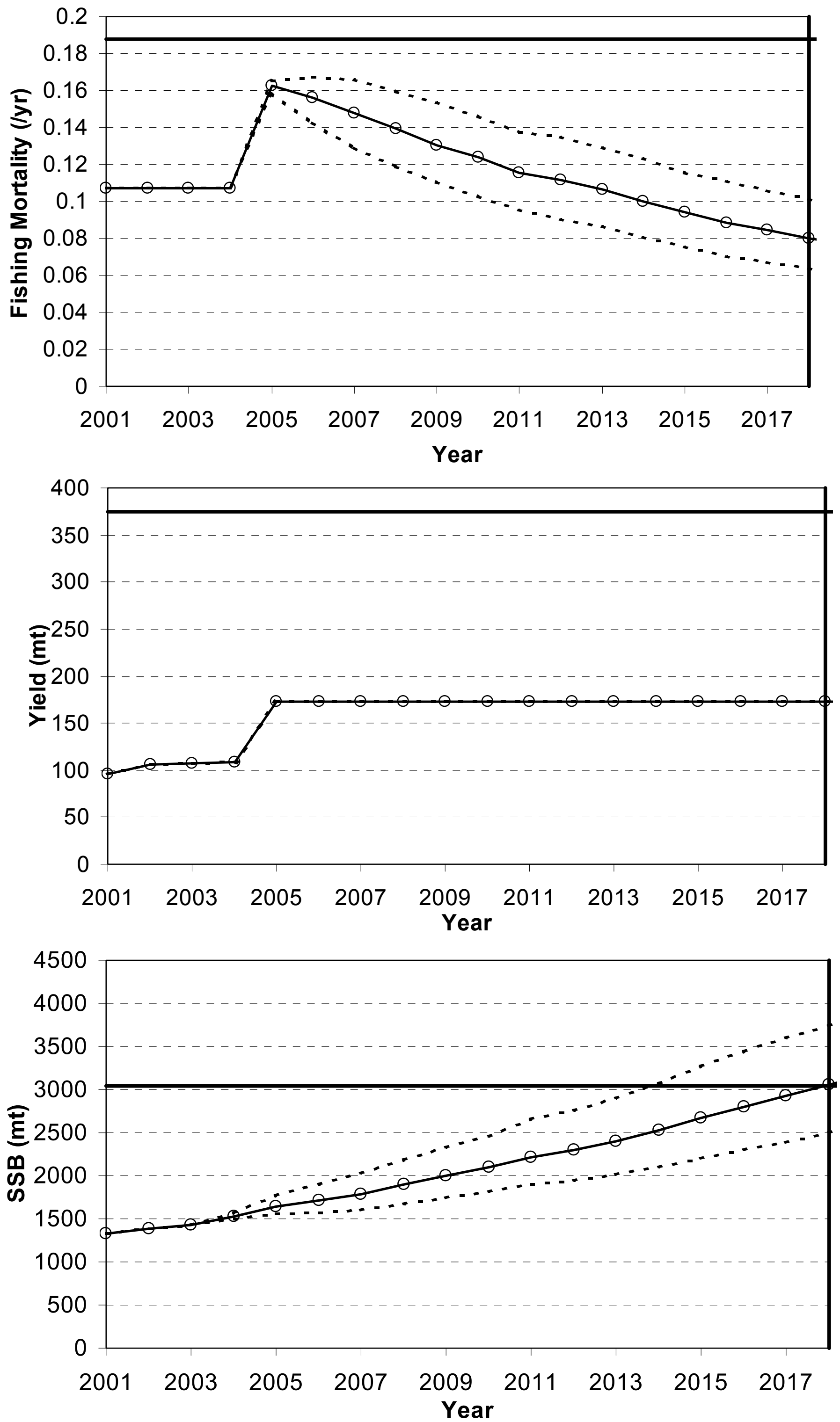

Figure 6. Strategy 1 (discard sensitivity model) projection results. Results presented for the median (circles), 5th percentile, and 95th percentile (dashed lines) of 1000 bootstrap replicates. The solid horizontal line in the top, bottom, and middle panels corresponds to Fmsy, MSY, and SSBmsy, respectively. Yield includes landings and dead discards.

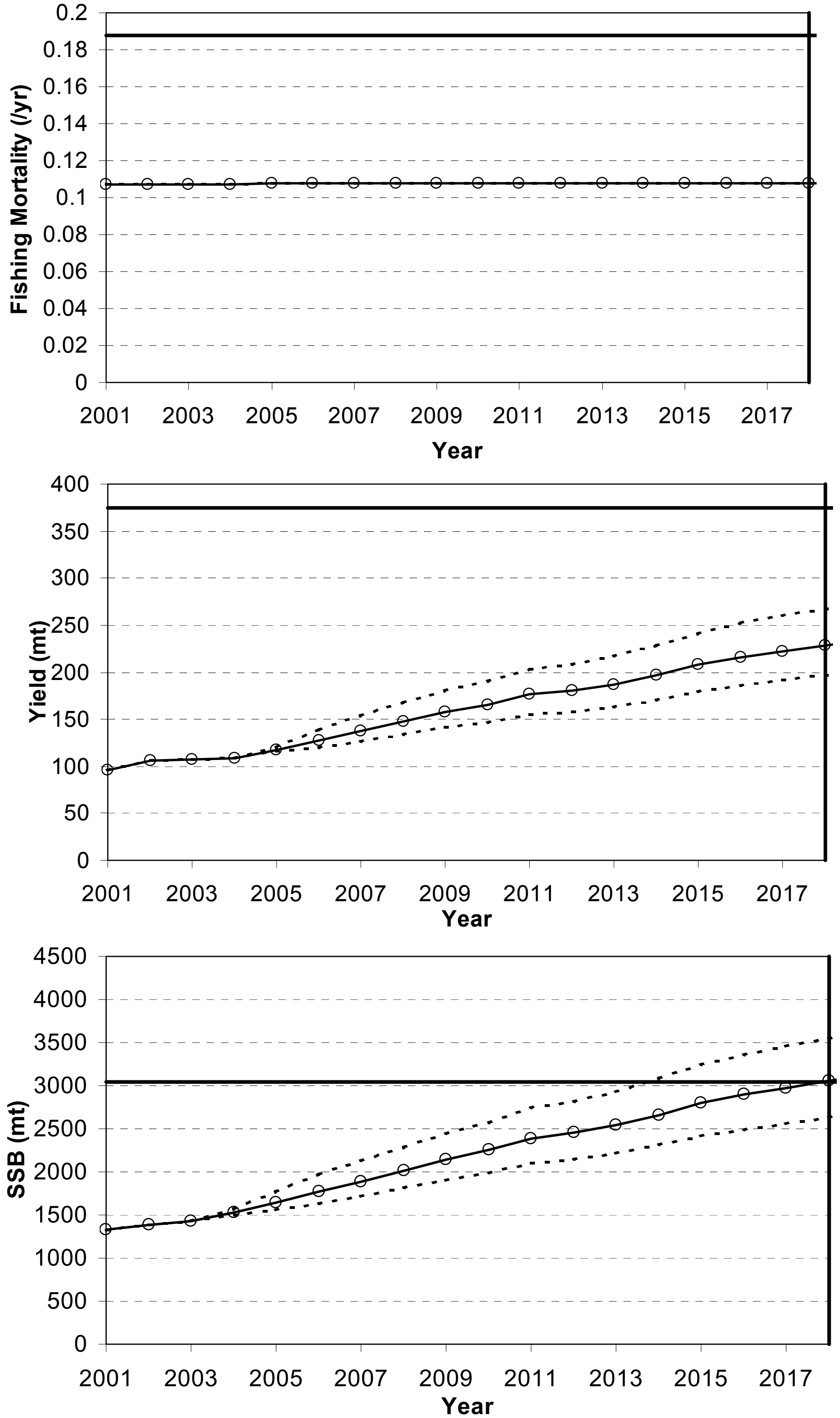

Figure 7. Strategy 2 (discard sensitivity model) projection results. Results presented for the median (circles), 5th percentile, and 95th percentile (dashed lines) of 1000 bootstrap replicates. The solid horizontal line in the top, bottom, and middle panels corresponds to Fmsy, MSY, and SSBmsy, respectively. Yield includes landings and dead discards.

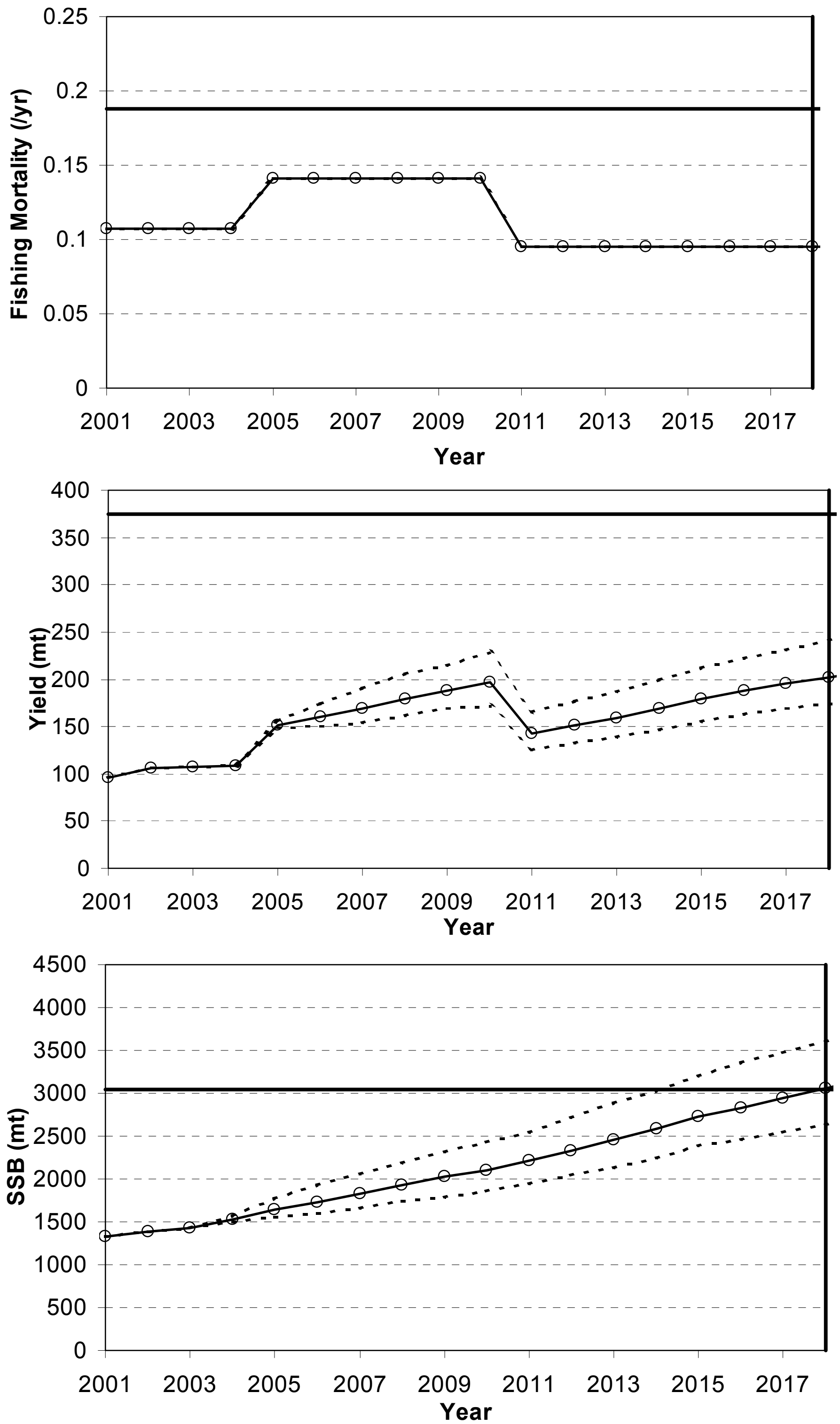

Figure 8. Strategy 3 (discard sensitivity model) projection results. Results presented for the median (circles), 5th percentile, and 95th percentile (dashed lines) of 1000 bootstrap replicates. The solid horizontal line in the top, bottom, and middle panels corresponds to Fmsy, MSY, and SSBmsy, respectively. Yield includes landings and dead discards.

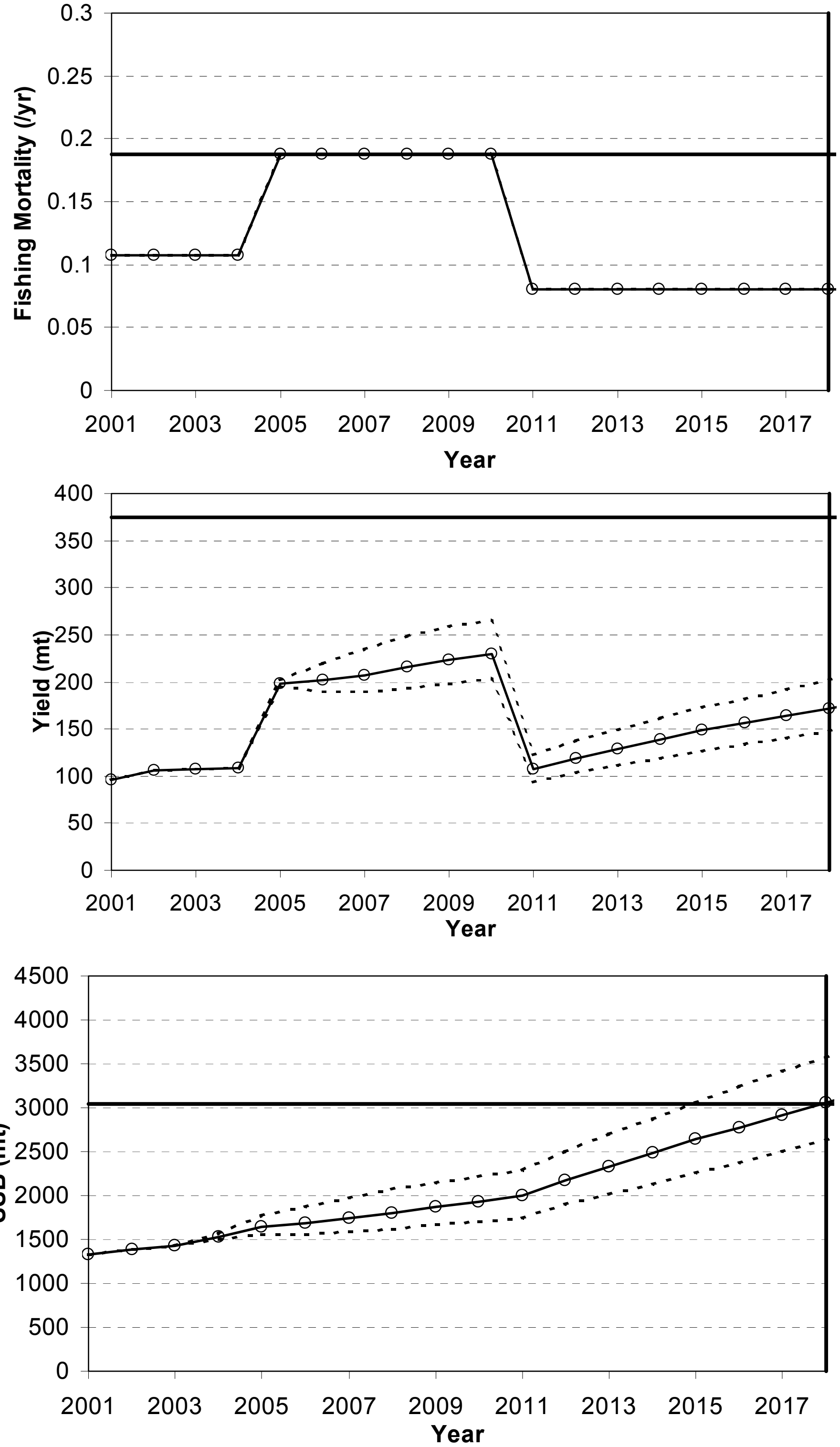

Figure 9. Strategy 4 (discard sensitivity model) projection results. Results presented for the median (circles), 5th percentile, and 95th percentile (dashed lines) of 1000 bootstrap replicates. The solid horizontal line in the top, bottom, and middle panels corresponds to Fmsy, MSY, and SSBmsy, respectively. Yield includes landings and dead discards.

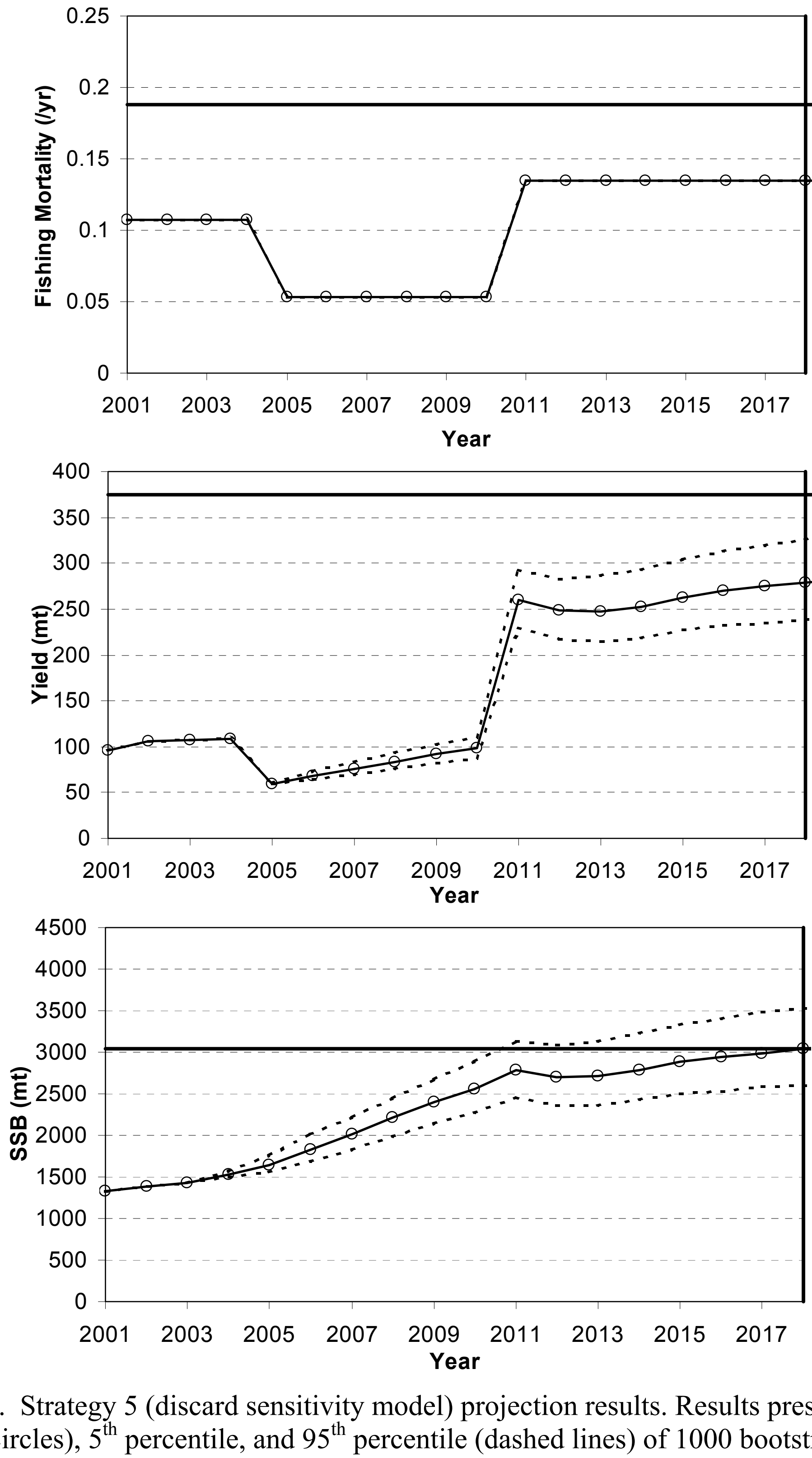

Figure 10. Strategy 5 (discard sensitivity model) projection results. Results presented for the median (circles), 5th percentile, and 95th percentile (dashed lines) of 1000 bootstrap replicates. The solid horizontal line in the top, bottom, and middle panels corresponds to Fmsy, MSY, and SSBmsy, respectively. Yield includes landings and dead discards.