Bocaccio Rebuilding Analysis for 2002

Alec D. MacCall and Xi He (June 2002)
NMFS Santa Cruz Laboratory
110 Shaffer Rd.
Santa Cruz, CA 95060
email: Alec.MacCall@noaa.gov, Xi.He@noaa.gov

Introduction

In 1998, the PFMC adopted Amendment 11 of the Groundfish Management Plan, which established a minimum stock size threshold of 25% of unfished biomass. Based on the stock assessment by Ralston et al. (1996), bocaccio was declared formally to be overfished, thereby requiring development of a rebuilding plan for consideration by the Council in the fall of 1999. A new stock assessment (MacCall et al. 1999) found that under continuing recruitment failure, the index of bocaccio spawning output was about half the the estimate made in 1996, but at that time preliminary indications of a strong 1999 year class allowed some optimism.

The most recent stock assessment (MacCall 2002) is based on a wide variety of information from both Central and Southern California. The new estimate of the strength of the 1999 year class is at or below the low end of the range considered in the1999 analyses. The following rebuilding analysis utilizes the SSC Rebuilding Analysis (V1.5) developed by Andre Punt of the PFMC-SSC, and incorporates the information developed in the 2002 bocaccio stock assessment.

Management Reference Points

$B_{unfished}$. Unfished biomass is estimated by multiplying average recruitment by the spawning output per recruit achieved when the fishing mortality rate is zero ($SPR_{F=0}$ = 1.3806, spawning output in billion eggs, recruitment in thousand fish at age 1). The estimated unfished spawning output is 14857 billion eggs, based on the average recruitment between 1953 and 1998. Because recruitment is highly variable, this calculation is imprecise (CV = 31%) as can be seen in Figure 1.

B_{msy}. The rebuilding target is the spawning abundance level that produces MSY. This value cannot be determined directly for bocaccio, so we use the proxy value of 40% of estimated unfished spawning abundance. Estimated B_{msy} is 5943 billion eggs.

Mean generation time. Mean generation time of bocaccio can be estimated from the net maternity function, and is estimated to be 12 years.

Simulation Model

The rebuilding model tracks male and female abundances at age, with an accumulator at age 21+. Values of weights at age, composite selectivity and fecundity are taken from MacCall (2002), and are given in Appendix 1. Population simulations begin with the 2002 age composition. Subsequent recruitments are generated by a random draw of one of the historical values of R/S (from 1953 to 1999), which is multiplied by current spawning output (S) to obtain the following year's recruitment. Resampling R/S is supported by the nearly constant pattern of historical R/S values (Figure 2), whereas the strong historical decline in recruitment strengths argues against resampling recruitments directly (Figure 3). Simulations extend to a maximum of 500 years, and the maximum number of simulations allowed by the program (N=10000) was used to minimize the imprecision in the analysis.

Rebuilding is assumed to have begun in 2000, and three years of rebuilding have elapsed as of the beginning of 2003. The model accounts for further removals that occurred following the beginning of 2002; the catch in 2002 is still unknown but is assumed to be 100MT in the base model. Sensitivity analyses address the consequences of alternative catch scenarios.

The distribution of simulated times (number of years) to reach the rebuilding target at F=0 (T_{min}) is wide, ranging from about 20 years to over 500 years (Figure 4). The mode (most frequent) rebuilding time is about 60 years. The median (50% probability) rebuilding time is 97 yr (SE = 1 yr). The maximum length of time to rebuild is this value plus one generation time (12 yr), less the time already elapsed since the start of rebuilding (3 yr), or 106 years. The maximum allowable fishing mortality rate is that which allows the stock to achieve the target abundance in 106 years (i.e., calendar year 2108), with a probability of 50%. The constant fishing rate that achieves a 50% rebuilding success by year 2108 translates to a catch of 5.8 MT (SE = 0.6MT) in 2003. In most rebuilding plans, options with a higher probability of success (e.g., 60%) are considered. In the case of bocaccio, the maximum probability of rebuilding by year 2108 is 54% under no catch, so options for higher probabilities do not exist at the present time.

Simulated individual rebuilding trajectories are erratic (Figure 5). The time series of percentiles of simulated trajectories (Figure 6) is more informative. A peculiar feature of the boccacio simulations is that the median abundance (dark line in Figure 6) does not reach the target level after 106 years (T_{max}). Although 50% of the simulations achieved the target level <u>at some time</u> on or before 97 years (thus qualifying as having been rebuilt), many of those trajectories subsequently declined so that only about 30% are currently at or above the target after 97 years. This property is consistent with the behavior of individual simulations (Figure 5).

The rebuilding consequences of some of the uncertainties described in the bocaccio stock assessment are examined in Table 1. Most sources of uncertainty have little effect on rebuilding OYs. Note that cases emphasizing Central or Southern California information are for comparison only, and are not properly specified for use as management options.

References

MacCall, A. 2002. Status of bocaccio off California in 2002. Prepared for the PFMC.

MacCall, A., S. Ralston, D. Pearson and E. Williams. 1999. Status of bocaccio off California in 1999, and outlook for the next millennium. Pacific Fishery Management Council.

Ralston,S., J. Ianelli, R. Miller, D. Pearson, D. Thomas, and M. Wilkins. 1996. Status of bocaccio in the Conception/Monterey/Eureka INPFC areas in 1996 and recommendations for management in 1997. Pacific Fishery Management Council.

Table 1. Results of sensitivity analyses.

Model	Tmin	OY	Generation Time
Base Model (100t catch in 2002)	97	5.8	12
M = 0.15	64	9.8	14
M = 0.25	257	1.5	11
Emphasis on Southern California information	47	39.1	12
Emphasis on Central California information	106	2.5	12
Emphasis on abundance data	77	7.9	12
Emphasis on composition data	94	5.2	12
Use unaltered RecFin data	99	6.4	12
Early SoCalif commercial catch at 50%	103	4.9	12
Recent commercial catch at 2x landings	97	5.3	12
Assume 200t catch in 2002	99	5.6	12

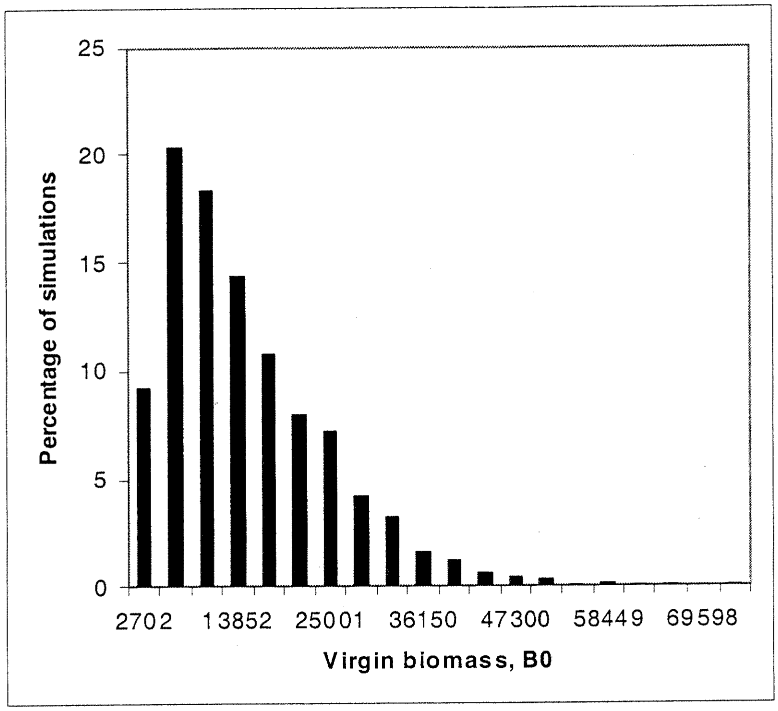

Figure 1. Distribution of simulated unfished abundances (measured as spawning output in billion eggs)

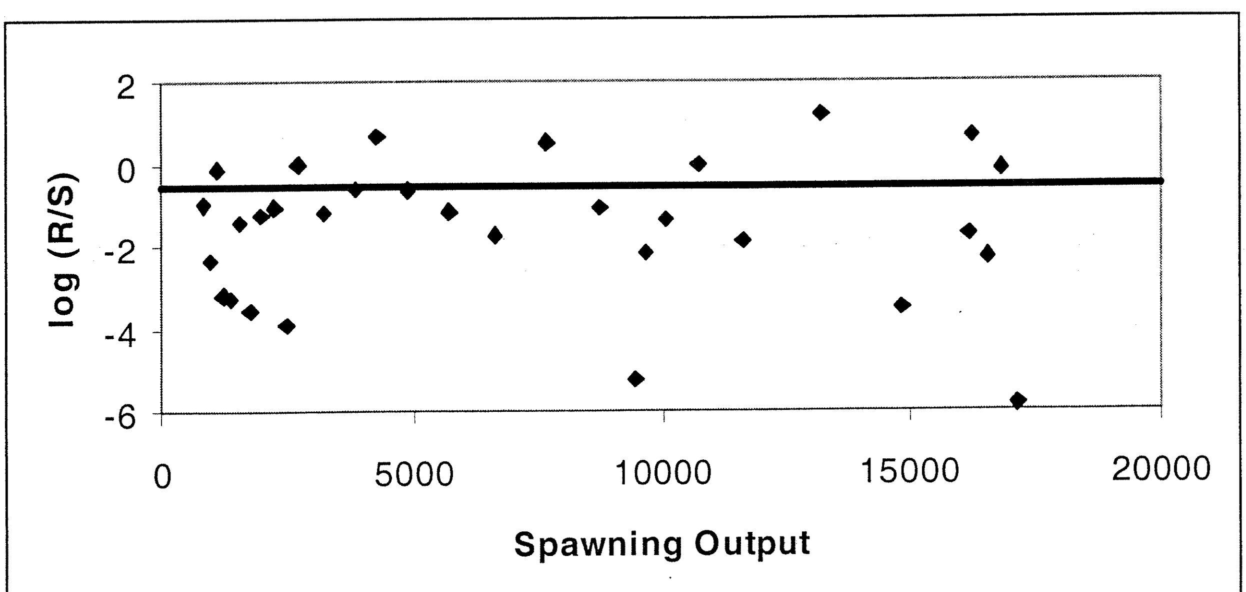

Figure 2. Historical bocaccio reproductive success related to parental abundance. Horizontal line is replacement level in the absence of fishing.

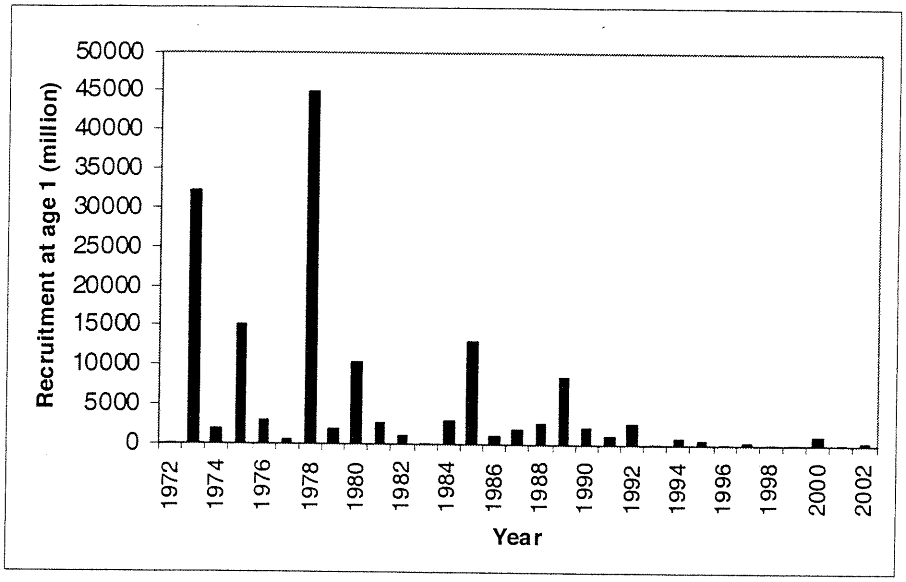

Figure 3. Historical series of bocaccio recruitments.

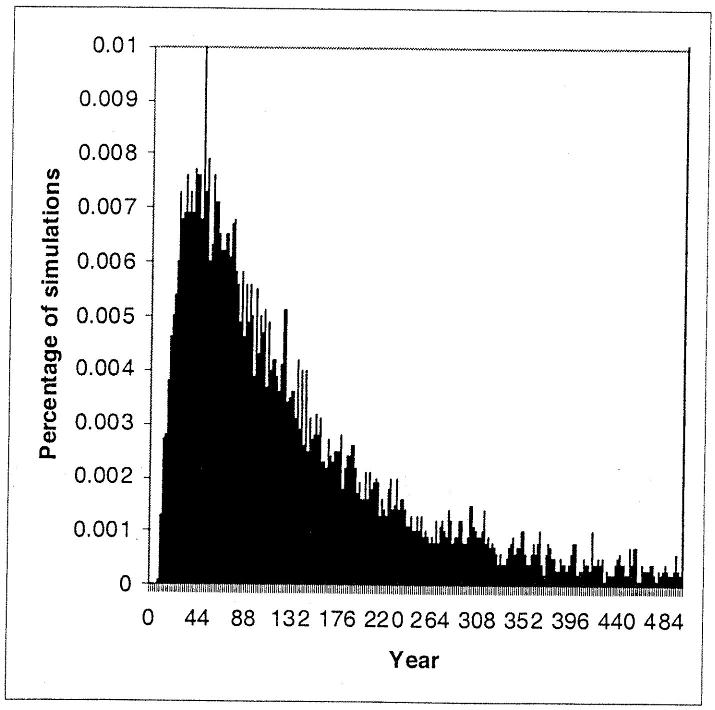

Figure 4. Distribution of simulated bocaccio rebuilding times in the absence of fishing.

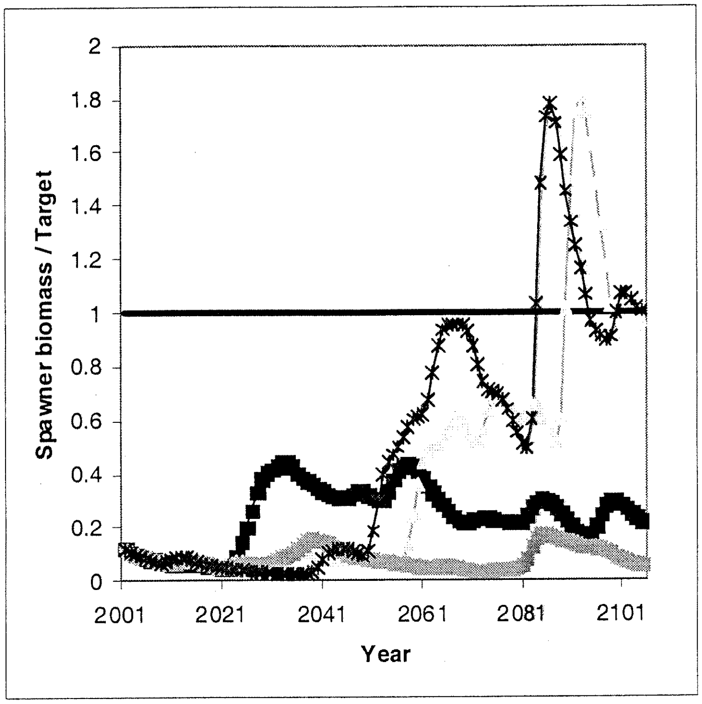

Figure 5. Simulated bocaccio rebuilding trajectories.

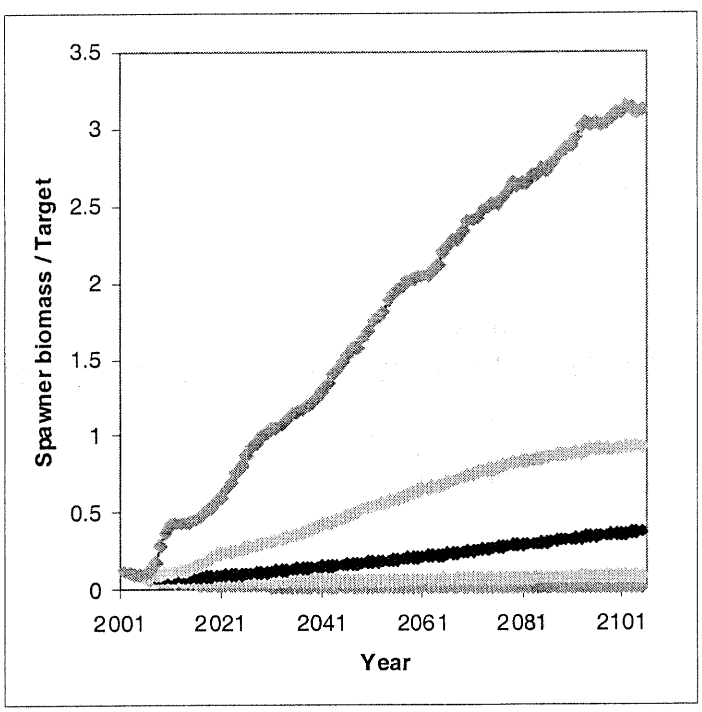

Figure 6. Time series of relative abundance expressed as percentiles (5, 25, 50, 75 and 95) of simulations.