A Preview of Bocaccio Rebuilding

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At the April PFMC meeting it became apparent that a preliminary estimate of harvest constraints for bocaccio rebuilding were needed as soon as possible. This report provides that information, based on simple interpretations of information from the 1996 bocaccio stock assessment (Ralston et al., 1996). A new bocaccio stock assessment is being developed this year, and will almost certainly produce results that are different from the 1996 assessment. It is likely that the rebuilding analysis based on the new assessment will differ from these results, but the amount of difference cannot be determined.

Management Reference Points

Bmsy and rebuilding target: The goal of rebuilding is to increase the abundance to Bmsy, a quantity that must be estimated. An ASPIC production model (Prager 1994) estimates Bmsy at 60,400 mt total biomass, which is 26% higher than the biomass at the beginning of the stock assessment in 1969 (47,930 mt). One possible source of this discrepancy is that by 1969 abundance was already impacted by large undocumented harvests by foreign fleets in the 1960's (David Thomas, CFG, pers. comm.).

An alternative estimate of Bmsy was obtained from analysis of the stock and recruitment history in Ralston et al. (1996); examination of the model documentation indicates that the quantities identified in the assessment as "spawning biomass" are actually measures of egg production. The fitted Beverton&Holt stock-recruitment model (Figure 1) was constrained to a steepness parameter of 0.55, as estimated in Martin Dorn's meta-analysis (manuscript presented at second productivity workshop, Monterey, March 1999). The F=0 replacement line is taken from the length-based stock synthesis model output (2.298 units of egg production per recruit). Bmsy is estimated to be 4349 units of female egg production, which is 46% of the egg production in 1969. A rough conversion based on historical relationships (Ralston et al., Table 7) suggests that this corresponds to about 32,000 mt of total biomass.

The value of Bmsy is poorly determined by the historical data. For the purpose of this preliminary rebuilding analysis, I will assume that "nominal" Bmsy is 50% of the 1969 total biomass, or 23,965 mt. The stock assessment estimated the 1996 total biomass to be 3857 mt, which is 16% of nominal Bmsy. The rebuilding projections in this document ignore more recent information on levels of biomass and recruitment, which would suggest further decline.

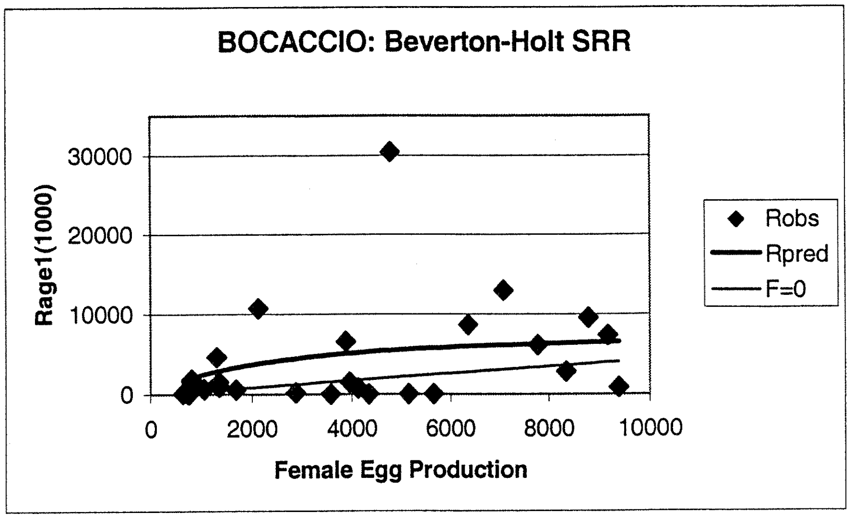

Figure 1. Beverton&Holt stock-recruitment relationship fitted with steepness constrained to a value of 0.55.

Time to rebuild if F=0: The surplus production model (Prager 1994) was used to project population abundance forward in time in the absence of fishing removals. This projection is deterministic, containing no sources of random variability as would be expected to occur in reality. However, it can be considered to be a first approximation to the mean course of rebuilding over many realizations of a stochastic model. Using an initial biomass of 4205 mt in year 1 of the rebuilding plan, and ASPIC estimates of r=0.1269/yr and K=120,800mt, the trajectory of recovery is shown in Figure 2. The projected abundance reaches the rebuilding target of 23,965mt in 15 years (T_{min}).

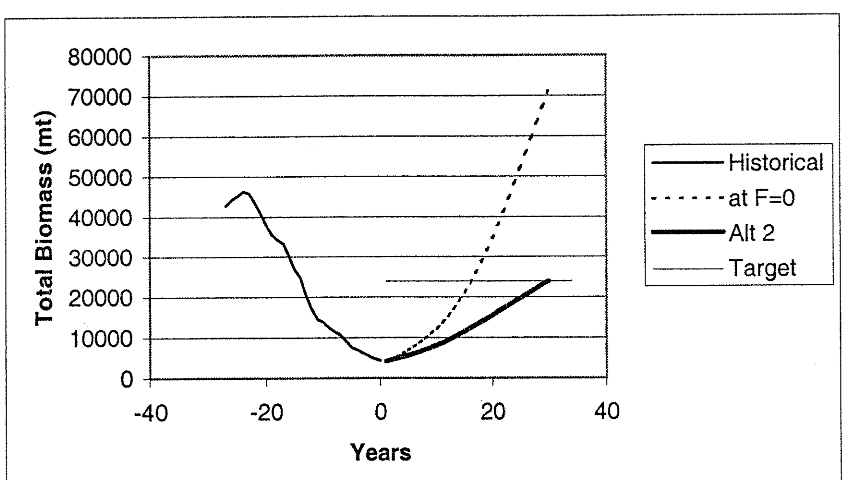

Figure 2. Trajectories of rebuilding if F=0 (T_{min}=15 years) and for an alternative rebuilding option (T_{max}=30 years) based on a constant interim harvest rate.

Mean generation time and maximum time to rebuild: Because the time to rebuild at F=0 exceeds ten years, the maximum allowable time to rebuild (T_{max}) is $T_{F=0}$ plus one generation time. Mean generation time is estimated as the mean age of the net maternity function (abundance multiplied by fecundity at age, see Figure 3), which is 15.4 years, which is rounded to 15 years for this purpose. Thus T_{max} is 15+15= 30 years, or 2026 if rebuilding began in 1997.

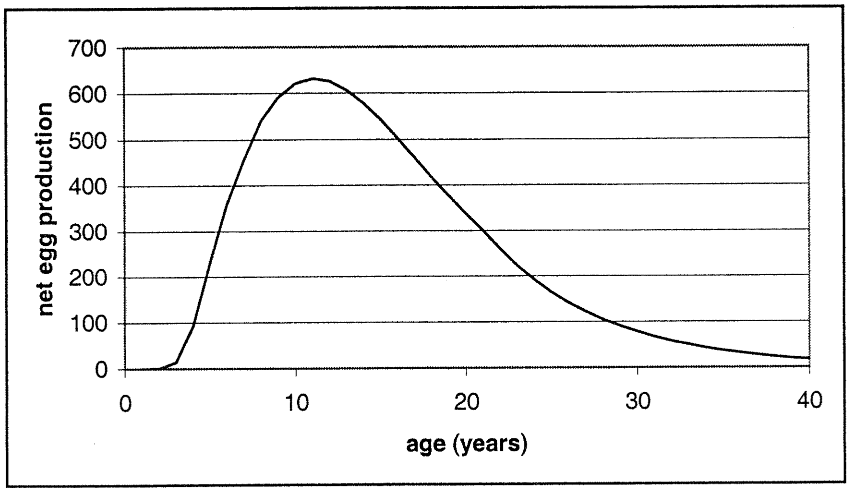

Figure 3. Net maternity function for bocaccio. Mean age of reproduction is 15.4 years.

Maximum F for rebuilding: The projected biomass trajectory achieves the target in 30 years under a constant exploitation rate of 5.4%. This is approximately 85% of F_{msy} as estimated by ASPIC. Applied to the 1997 biomass of 4205 mt, this gives a rebuilding OY of 245 mt. The OY would fluctuate in proportion to future abundances.

Alternative rebuilding policies: Several alternative policies are worth considering. One highly desirable goal would be to return bocaccio management to the standard 40-10 harvest policy at a relatively early date (or biomass) in the 30-year overall time frame. This would result in a natural phasing out of the rebuilding plan. For implementation of the 40-10 policy, I assume that initial biomass is 50,000 mt.(the 1969 biomass, rounded), and F_{msy} corresponds to an exploitation rate of 6.34%. Some possible solutions include:

<u>Constant interim harvest:</u> A constant harvest of 277 mt would be required for 10 years, after which the 40-10 policy would become the rebuilding plan. This is an especially weak scenario, as a constant harvest would perform very poorly in view of fluctuations, and it would become progressively harder to restrict the catches as abundance rebuilds. Also, this rebuilding plan would constitute overfishing (F exceeding Fmsy) for the first few years–it could be very difficult to argue that this is actually a rebuilding plan at all.

Constant interim harvest rate: A constant minimum harvest rate of 4.7% would be required for 14 years, after which the 40-10 policy would become the rebuilding plan. Applied to the 1997 biomass of 4205 mt, this gives an initial rebuilding OY of 200 mt; OY would fluctuate with subsequent biomasses. The minimum harvest rate is 75% of the MSY exploitation rate.

Sensitivity analysis: Although the 1999 stock assessment has not been completed, it is likely that bocaccio abundance has declined from the level given by the 1996 assessment. There has been no sign of recruitment in the intervening three years, and the 1998 triennial survey index is lower than the index three years earlier. Also, addition of three low recruitments to the time series of stock and recruitment estimates will also tend to lower the apparent productivity and hence the estimate of F_{msy}.

Effect of lower initial abundance: If the current biomass is half that assumed above (i.e., 2102.5 mt), the time to reach the target level at F=0 is 22 years. Taking the maximum time to rebuild (37 years) under a constant fishing rate strategy requires an exploitation rate of 4.9% which is 78% of the MSY harvest rate. Because the abundance itself is so much lower, OY at the beginning of rebuilding is only 103 mt, and would not reach 200 mt for ten years.

Effect of lower productivity rate: If the productivity rate is 10% lower than estimated (i.e., r=0.11421/yr), but current biomass remains estimated at 4205 mt, the time to reach the target rebuilding level is 18 years. Again, taking the maximum time to rebuild (33 years) under a constant fishing rate strategy requires an exploitation rate of 4.9%, and OY would begin at 204 mt.

Discussion: Deterministic projections do not provide a reliable sense of the uncertainty in population projections or appropriate management actions. However this limited approach does provide a rough sense of what level of management action is likely to be necessary. Significantly, it does not appear that catches must be restricted to levels far below those being achieved under current management. However, **the recovery model assumes a strong population response, and recent recruitments have not lived up to that assumption**. Rebuilding will be more rapid and more certain if fishery impacts are reduced to the lowest level possible. The sensitivity analysis shows that a lower abundance at the beginning of the rebuilding plan may result in OYs that are extremely difficult to achieve. This underscores the vital importance of keeping bocaccio harvests to a minimum while awaiting development of the rebuilding plan.

References:

Prager, M. 994. A suite of extensions to a nonequilibrium surplus-production model. Fish. Bull. (U.S.) 92:374-389.

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.