Draft

June 14, 2000

Cowcod Rebuilding

John Butler and Tom Barnes

Introduction

The west coast cowcod (*Sebastes levis*) resource is currently considered to be one continuous population that extends from Washington south into Mexico. Fishable biomass is similar to spawning biomass because cowcod are recruited to the fishery at the size of first maturity. The INPFC Conception Area portion of the stock was assessed by U. S. scientists in 1999 at which time the spawning biomass was determined to have fallen below 10% of its unfished size (Figure 1). The Pacific Fishery Management Council responded by imposing significant reductions in quotas.

Management Reference Points

B_{msy}: The rebuilding target is the spawning biomass level that produces MSY. Experience from other fisheries has shown the B_{msy} is often near 40% of initial biomass, which is also the biomass target for rebuilding the stock. Butler et al (1999) estimated initial biomass at 3370 mt with 2840 mt and 3990 mt as lower and upper 95% confidence intervals. The rebuilding target for the Conception Area is then 1350 mt biomass with 1140 and 1600 mt as lower and upper 95% confidence intervals respectively.

Mean Generation Time

If the stock cannot be rebuilt within 10 years, then the maximum time allowed for rebuilding is the length of time required to rebuild at F=0 plus one mean generation time. Mean generation time can be estimated from the net maternity function (product of survivorship and fecundity at age (Figure 2). Parameters used to estimate mean generation time are taken from Butler et al. (1999). Because larger and older cowcod females have high reproductive values, mean generation time is sensitive to maximum age. The oldest cowcod in a sample of 264 fish was 55 y (Butler et al. 1999), but it may not represent maximum age of this species. It is likely that older fish could be found if a larger sample size were available, or if samples were available from the un-exploited population. Consequently we used 75 y as the maximum age for cowcod and estimated mean generation time at 37 y. This long generation time is due in part to the fact that cowcod continue to grow after maturity, and thus older and larger female cowcod have very high reproductive value.

Simulation Model

We modeled cowcod rebuilding using a surplus production model because of the density dependent recruitment inherent in the logistic equation (Appendix I). We also tried the delay difference model used in the cowcod stock assessment (Butler et al. 1999), but that model yielded unrealistic rebuilding times. Population simulations began with the 1998 cowcod biomass. Surplus production was modeled using a log-normal distribution fitted to recruitment during 1951-1998 (Butler et al. 1999). Population trajectories with a fixed mean r indicated that minimum time to BMSY with no fishing was 61 y.

The maximum time to rebuild to B_{MSY} allowed by the SSFA is the minimum time (61 y) plus one mean generation time (37 y) or a total of 98 y. Population trajectories with randomly sampled log-normal production were repeated 250 times with different constant values of F to find a fishing rate that provided some catch but assured a 60% probability of achieving B_{MSY} within the maximum allowed time.

Initial Conditions

The cowcod stock assessment (Butler et al. 1999) found uncertainty in the 1998 biomass. Upper and lower 95% confidence intervals indicated that the 1998 cowcod biomass could be at 5-12% (126-451 MT) of unfished stock size. In order to capture the uncertainty in cowcod stock size, population trajectories were initialized at 126, 238 and 451 MT. Mean time to B_{MSY} with no fishing varies, which under different initial conditions, are 42, 62 and 80 y respectively.

Projections

The probability of rebuilding success under alternative fishing rates and three initial conditions are presented in Table 1. If the 1998 population is as low as 5% of the virgin biomass, almost no realistic quota achieves rebuilding. If the 1998 biomass is 7% of virgin biomass, then a quota of 2.4 MT will achieve rebuilding in about 95y. If the 1998 biomass is 12% of the virgin biomass, then a quota of 4.5 MT will achieve rebuilding in 67y.

Discussion

The combination of an unproductive stock and extremely low current biomass level compounds the difficulties to rebuild cowcod. Rebuilding yields are very low compared to the large amount of fishing effort that is present in California waters. This provides the opportunity for target yields to be inadvertently exceeded due to inherent imprecision in catch statistics, and unrecorded fishing mortality from discarded bycatch. Calculations show that the long-term consequence of small over harvest could be significant. Unaccounted removals as small 1-2 tons per year may sufficiently jeopardize the rebuilding plan. Although it will be necessary to closely monitor annual commercial and recreational landings, additional information will be necessary to provide assurance that rebuilding targets are not exceeded. Reliable estimates of discards are one important element to rebuilding efforts. Identification of geographic areas where cowcod density is comparative high may also be of interest to managers seeking ways to assure that cowcod catches do not exceed rebuilding targets.

Future reassessments will demonstrate whether management measures have accomplished intended objectives. However, it is likely that many years will need to pass before it is possible to detect statistically significant change in abundance for an unproductive species such as cowcod.

Rebuilding yields have been calculated for that portion of the stock which is found in the Conception Management Area. The stock ranges much further to the north, and a significant fishery has also occurred in the Monterey Management Area. The Monterey Area was not included in rebuilding calculations because that portion of the stock is data poor, and consequently was outside the area of the stock assessment. However, significant catches have occurred in the Monterey Area over many years, and it is likely that the stock is also overfished in that portion of the range. One possible approach for estimating rebuilding yields for the Monterey Area is to take proportional catch reductions to that which are necessary in the Conception Area.

Literature cited

Butler, J. L., L. D. Jacobson, J. T. Barnes, H. G. Moser, and R. Collins. 1999. Stock assessment of cowcod. In: Pacific Fishery Management Council. 1999. Appendix: Status of the Pacific Coast Groundfish Fishery through 1998 and recommended biological catches for 1999: Stock assessment and fishery evaluation. Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland, Oregon, 97201.

List of Figures

Table 1. Probabilities of cowcod rebuilding under a constant harvest rate, assuming three alternative 1998 biomass levels. **Catch** is the mean annual catch during the first three years of the projection period (1999-2000); **Percent Success** is the percentage of simulations that achieve rebuilding schedule; **Median Time** is median time (y) to reach Bmsy (=0.4*3370 MT).

LOW 1998 BIOMASS (4 % OF VIRGIN BIOMASS)

F	CATCH MT	PERCENT SUCCESS	MEDIAN TIME
0	0	100	81
0.002	0.25	66	86
0.01	1.3	1	121
0.02	2.5	0	277
0.03	3.7	0	>300
0.04	5	0	>300

MEDIUM 1998 BIOMASS (7 % OF VIRGIN BIOMASS)

F	CATCH	PERCENT SUCCESS	MEDIAN TIME
0	0	100	62
0.009	2.1	60	90
0.01	2.4	55	95
0.02	5	0	227
0.03	7	0	>300
0.04	9	0	>300

HIGH 1998 BIOMASS (11 % OF VIRGIN BIOMASS)

F	CATCH	PERCENT SUCCESS	MEDIAN TIME
0	0	100	42
0.01	4.5	99	67
0.014	6.4	60	92
0.02	9	0	186
0.03	13	0	>300
0.04	16	0	>300

Figure 1. Basecase model results for cowcod spawning biomass with 95% confidence interval.

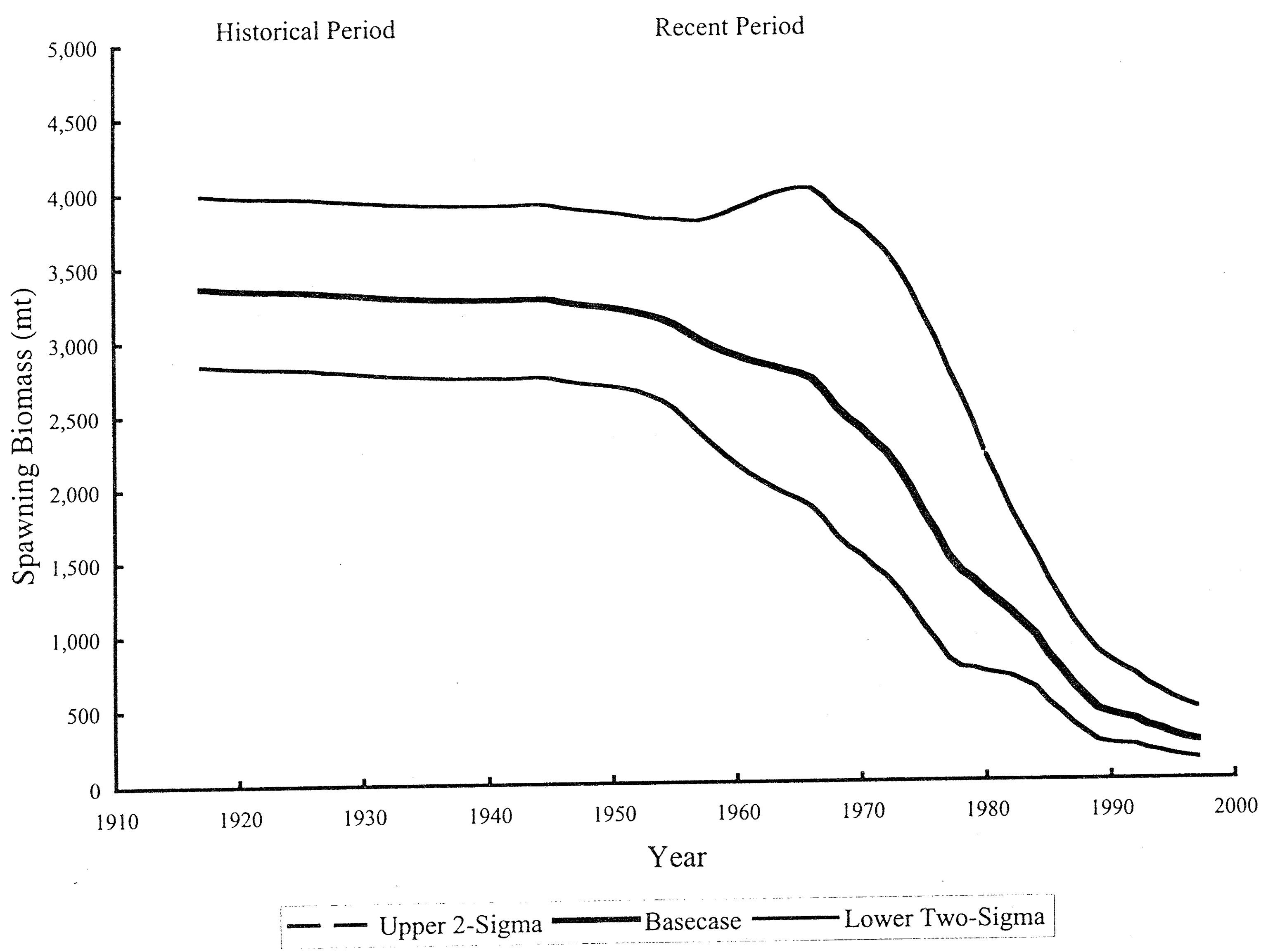
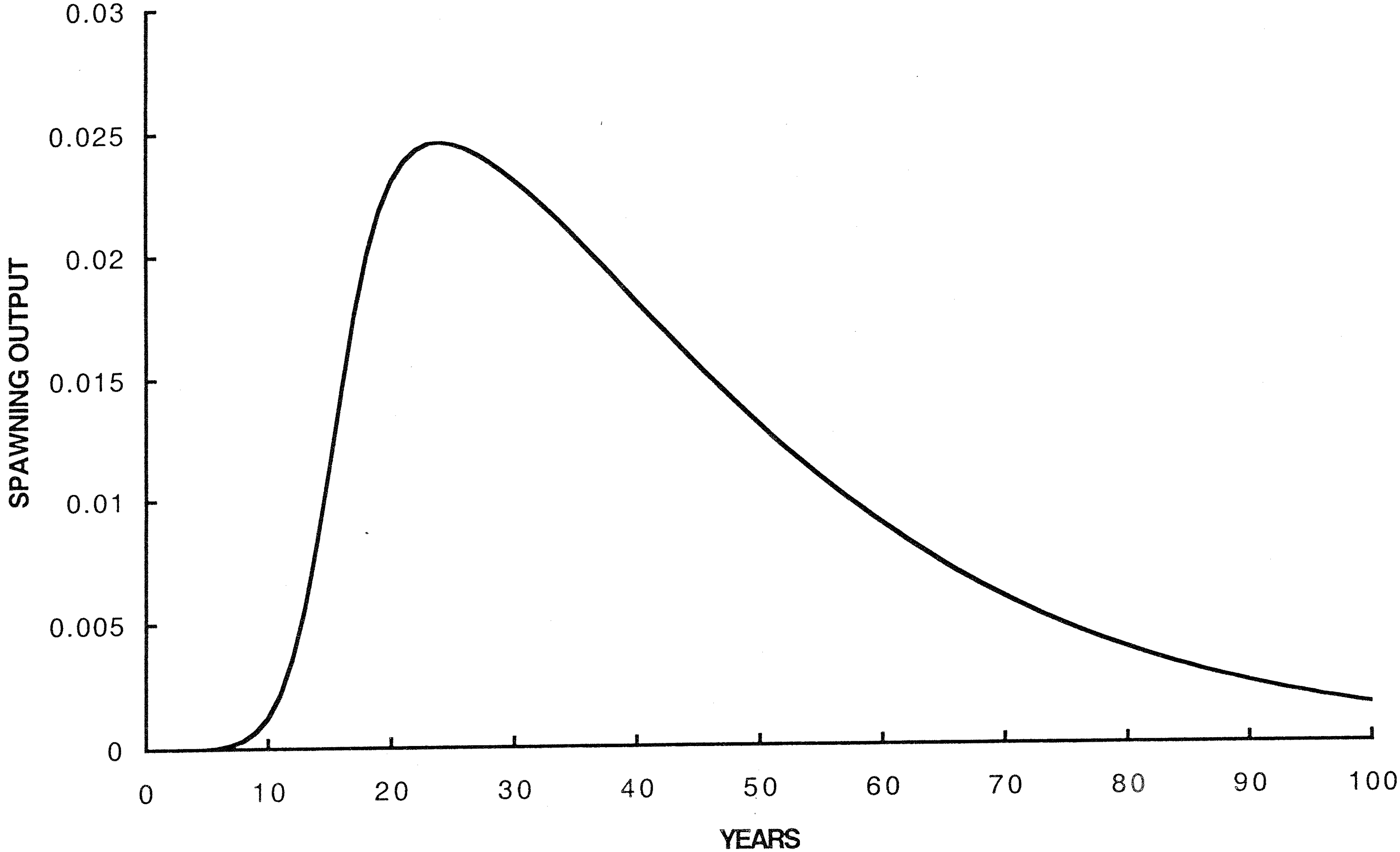


Figure 2. Net maturnity function for female cowcod.



Appendix I

Surplus Production was computed by:

$$P_y = B_{y+1} - B_y + C_y$$

Where B_y was estimated from the delay difference model (Butler et al. 1999) at the beginning of the year y, K is the population carrying capacity or "virgin biomass," C_y was catch data and r is the slope of the production function at the origin. Production was modeled using the logistic model with process errors:

$$P_y = r B_y \left(1 - \frac{B_y}{K}\right)$$

Solving for r_y gives:

$$r_y = \frac{P_y K}{B_y \left(K - B_y\right)}$$

The recruitment parameter r_y was calculated for each year from 1951-1998 and modeled using the lognormal distribution. Then forward projections of biomass were obtained from rearranging Eq (1), giving:

$$B_{y+1} = B_y + P_y - C_y$$

Where P_y was obtained from Eq. (2) using a stochastic lognormal r.