STATUS OF THE BLACK ROCKFISH RESOURCE IN 1999
STAT EXECUTIVE SUMMARY

Farron R. Wallace[2], Annette Hoffmann[1], and
Jack V. Tagart[1]

[1] Washington Department of Fish and Wildlife
600 Capitol Way NE
Olympia, Washington 98501-1091

[2] Washington Department of Fish and Wildlife
48 Devonshire Road
Montesano, Washington 98563

July 25, 1999

BLACK ROCKFISH RESOURCE IN 1999
STAT EXECUTIVE SUMMARY

Introduction

The status of stocks for black rockfish was last determined in 1994 (Wallace and Tagart, 1994). The population was assessed using the age-structured version of the stock synthesis model. The population was regarded as healthy, stock abundance was estimated to be either increasing after passing through a low in the late 1980s or in a gentle decline showing relative stability from 1990 to 1994. The recommended allowable annual yield was 517 mt based on an F45% exploitation strategy. The current analysis reprises estimates based on the 1994 stock synthesis model, introduces a new parameterization of stock synthesis (1998 configuration) and presents a completely new model written in AD Model Builder.

Stock

Tagging data collected by the Washington Department of Fish and Wildlife, suggested that Cape Flattery and Cape Falcon bound a single coastal Washington-northern Oregon black rockfish stock. This hypothesis was corroborated by a recent genetic study that evaluated a set of samples organized into three geographical clusters from California to northern Washington. The northern cluster, encompassing northern Oregon to northern Washington, was found to be significantly different from the southern clusters. We assumed that black rockfish distributed in this area represented a unit stock. All biological parameters, data analysis and yield projections presented in this assessment are intended to describe this portion of black rockfish coast-wide distribution.

Model Inputs:

The stock synthesis model used catch data from 1970 to 1998 for each of three fisheries (trawl, commercial line and sport). The AD model used trawl catch data from 1986 to 1993, line catch data from 1986 to 1995, and sport catch data from 1986 to 1998. The catch data interval corresponds to the period of an active black rockfish fishery for each gear. In addition, AD model also used gear specific estimates of catch variance. For the commercial gears (trawl and line), catch variance was available for each year of catch data. Catch variance for the sport fishery was available for 1990 to 1998.

Age specific inputs included catch-at-age (by numbers or weight), proportion-at-age (by numbers), and proportion-at-age (by weight). The stock synthesis model utilized proportion-at-age in numbers for each fishery weighted by sample size. AD model incorporates proportion-at-age by number for the sport fishery, and proportion-at-age by weight for the trawl and line fishery. Additional AD model inputs were the associated variances for the estimated proportions-at-age.

Revised estimates of weight-at-age and maturity-at-age were generated for the current analysis. We determined that a single weight-at-age vector effectively represented the line and sport fishery, and a separate vector was estimated for the trawl fishery. Inspection of the 1994 stock assessment report revealed that we had inadvertently used the raw proportion mature-at-age data rather than the estimated proportion-at-age from the regression fit to the logistic. Predicted values from the regression were used in this analysis.

Auxiliary data

From 1988 to 1990 and beginning anew in 1998, black rockfish from known areas of high densities were tagged such that the tags were distributed in proportion to perceived relative abundance. Tag release data from 1988 to 1990 and in 1998 and recovery information collected between 1988 and 1994 and in 1998 where used as auxiliary data.

For the "1994" stock synthesis model configuration, two auxiliary data sets were used as black rockfish abundance indicators: tagging CPUE and recreational bottomfish effort (Wallace and Tagart, 1994). Estimates of fishing mortality derived from tag data were used as an effort index to tune the "1998" stock syntheses model configuration. Fishing mortality rates were estimated from the ratio of tags recovered to tags released and adjusted for the fraction of catch that occurred before the tagging study.

In the AD model configuration, tag recovery was modeled explicitly. Auxiliary data inputs were the annual number of tags released, the number of tags recovered stratified by year of release, instantaneous tag loss rate, and tag reporting/recovery rates. Tag reporting rates for the 1988-94 recoveries were unknown. Analyses were conducted to evaluate the sensitivity of estimated abundance to those reporting rates.

Model Description

We used the AD model to assess current black rockfish abundance because the model explicitly included data uncertainty and provided the most statistically rigorous model with the fewest set of assumptions. The two stock synthesis model configurations were provided as a basis for comparison; one as a comparison to the previous assessment ("1994" configuration) and one as a "parallel" to the AD model ("1998" configuration). Neither stock synthesis configuration is presented in detail here.

The two key features of the AD model were (1) the parameterization of the expected catches at age and (2) the definitions of the sampling unit for the different types of data input. The parameterization chosen mostly affected parameter bias whereas the sampling unit designation mostly affected estimator variance. Both bias and variance were components of overall parameter uncertainty. The parameterization and the sampling unit definitions were both designed to conform to the actual sampling protocol used, thereby propagating sampling uncertainty through to the final biomass estimates.

The first key feature, parameterization, was designed to minimize assumptions on the population dynamics. A fully parameterized model included (a) yearly fishing mortalities, (b) initial numbers at sex/age, (c) selectivity by fishery/sex/age and (d) natural mortality by sex/age. In a fully parameterized model the fishing mortalities, initial numbers and selectivities were not constrained. Natural mortality was constrained to fit a four-parameter logistic function where two of the parameters were estimated. Simulation studies conducted on fully parameterized models provided empirical evidence that the estimators and estimator variances were approximately unbiased. Additionally, they showed the estimators were approximately normally distributed.

The model for the black rockfish data included constraints on selectivity and natural mortality. When the black rockfish data were introduced into a fully parameterized model, the estimated selectivity parameters showed no discernible patterns by sex or age. Since there was not enough information in these data to estimate selectivity well, we assumed a selectivity pattern and fixed selectivity parameters at a fully selected rate for all but the youngest ages. Based on the assumptions made for the 1994 assessment (Wallace and Tagart, 1994), a constant rate of natural mortality was assumed for males and age specific rate for females. However those rates were estimated internally in the model. The remaining population's dynamics parameters were freely estimated.

The second key feature, sampling unit definition, affected both catch age data as well as tagging data. For the catch age data, the sampling unit was defined as the "basket" or boat rather than the individual fish to mimic the port sampling procedure. The collection of "baskets" yielded empirical estimates of variance among the proportion at age vectors. Those variances were explicitly fixed into the likelihood functions describing catch at age.

For the tagging data, the sampling unit was the individual tag. This designation yielded a multinomial likelihood function where the tag recovery probabilities were calculated from the catch at age population dynamics parameters and an independently estimated tag loss rate. The recovery probabilities were also a function of a tag-reporting rate. However, the reporting rate was unknown in 1988-1994. Because of changes to the tag sampling protocol, the reporting rate in 1998 was equal to the proportion of the catch that was sampled and thus was treated as known.

Testing demonstrated that the final model converged reliably to the same solution. Initial parameter seeds were forced away from the maximum likelihood estimates by randomly generated deviations up to 10% of the original estimate. With this level of perturbation, virtually 100% of runs converged at the original maximum likelihood estimates. With a 50% perturbation approximately two-thirds of the runs converged to the original maximum likelihood estimates.

Results

We conducted a test to evaluate tag-reporting rate in 1988, 1989 and 1990. Port samplers interviewed charter skippers, deckhands and fishers and recorded observed tags at the dock. Approximately 95% of the tags observed dockside were subsequently redeemed for reward. Personal information indicated that some portion of the charter and private fleet regarded the tag study as an avenue to further restrict the fishery and did not provide accurate information nor return tags. We consider the tag-reporting rate as an unknown parameter that cannot be estimated, but believe that reporting rates may range from a highly optimistic level of 95% to a pessimistic 25%. We use these values to bracket our projections of the stock abundance and use the 50% tag reporting rate model to illustrate outcomes.

The main sources of uncertainty in the final model were sampling uncertainty and the 1988-1994 tag-reporting rate. The sampling uncertainty is represented by 95% confidence bounds on the final biomass estimates. The uncertainty due to the unknown tag-reporting rate is shown by the differences in biomass estimates at different levels of reporting rate. The results showed that initial biomass was far more sensitive to the choice of reporting rate than the final biomass. Estimates of initial biomass increased with increasing reporting rate whereas estimates of final biomass remained largely unchanged. The estimated ratio of final to initial biomass varied from 0.24 for a reporting rate of 75% to 0.82 for a reporting rate of 25%. With a reporting rate set at 50%, the biomass was assessed to be at 0.37 of the initial level.

All projections indicate that the current black rockfish stock is healthy and above target biomass levels (Table 1). Trend in biomass was similar for all tag reporting rates. Projections indicate decreasing biomass over the next 4 years (Figure 1). Table 2 provides a decision table illustrating alternative outcomes. Current catch biomass (300 mt) falls within the range of estimated equilibrium catch.

Table 1. AD model biomass projections based on a range of tag-reporting rates and +/- 2CV's.

		Tag Reporting Rate			
Model	**Quantity**	**95%**	**75%**	**50%**	**25%**
+ 2CV	**Total Biomass 1998**	10,424	10,136	9,747	9,511
	Spawning Biomass 1998	1,684	1,615	1,522	1,463
	SPB(1998)/SPB(EQ)	199%	201%	199%	178%
	Total Biomass 2001	9,681	8,857	7,886	7,543
	Spawning Biomass 2001	1,034	1,040	1,097	1,435
	Mean Catch (1999-2001)	1,604	1,459	1,274	1,118
	SPB(2001)/SPB(EQ)	122%	129%	143%	175%
	EQ Recruitment	4,165,718	3,508,523	2,608,723	1,510,771
	EQ Spawning Biomass	845	804	765	822
	EQ Fishing Mortality	0.252	0.237	0.211	0.166
	EQ Catch	1,435	1,239	980	699
Mean	**Sport Catch Biomass 1998**	254			
	Total Biomass 1998	6,195	6,004	5,741	5,575
	Spawning Biomass 1998	1,001	957	897	858
	SPB(1998)/SPB(EQ)	199%	201%	199%	178%
	Total Biomass 2001	5,753	5,246	4,645	4,421
	Spawning Biomass 2001	615	616	646	841
	Mean Catch (1999-2001)	953	864	750	655
	SPB(2001)/SPB(EQ)	122%	129%	143%	175%
	EQ Recruitment	2,475,616	2,078,174	1,536,473	885,582
	EQ Spawning Biomass	502	476	451	482
	EQ Fishing Mortality	0.252	0.237	0.211	0.166
	EQ Catch	853	734	577	410
- 2CV	**Total Biomass 1998**	1,966	1,871	1,735	1,639
	Spawning Biomass 1998	317	298	271	252
	SPB(1998)/SPB(EQ)	199%	201%	199%	178%
	Total Biomass 2001	1,826	1,635	1,403	1,300
	Spawning Biomass 2001	195	192	195	247
	Mean Catch (1999-2001)	302	269	227	193
	SPB(2001)/SPB(EQ)	122%	129%	143%	175%
	EQ Recruitment	785,515	647,824	464,223	260,392
	EQ Spawning Biomass	159	148	136	142
	EQ Fishing Mortality	0.252	0.237	0.211	0.166
	EQ Catch	271	229	174	121

Table 2. Biomass trend based on a range of tag-reporting rates and +/- 2CV's.

1999 Black Rockfish Decision Table

YEAR	+ 2CV Total Biomass	+ 2CV Spawning Biomass	+ 2CV Catch Biomass	Mean Total Biomass	Mean Spawning Biomass	Mean Catch Biomass	- 2CV Total Biomass	- 2CV Spawning Biomass	- 2CV Catch Biomass
	95% Tag Reporting Rate								
1999	10,928	1,542	1,757	6,495	916	1,044	2,061	291	331
2000	10,087	1,237	1,565	5,995	735	930	1,902	233	295
2001	9,681	1,034	1,488	5,753	615	884	1,826	195	281
2002	9,494	919	1,454	5,642	546	864	1,790	173	274
2003	9,418	865	1,441	5,597	514	856	1,776	163	272
	75% Tag Reporting Rate								
1999	10,354	1,513	1,622	6,133	896	961	1,912	279	300
2000	9,384	1,239	1,426	5,559	734	844	1,733	229	263
2001	8,857	1,040	1,328	5,246	616	787	1,635	192	245
2002	8,588	914	1,279	5,087	542	758	1,586	169	236
2003	8,457	847	1,257	5,009	501	744	1,562	156	232
	50% Tag Reporting Rate								
1999	9,675	1,494	1,439	5,698	880	848	1,722	266	256
2000	8,581	1,283	1,252	5,054	755	737	1,527	228	223
2001	7,886	1,097	1,131	4,645	646	666	1,403	195	201
2002	7,479	959	1,062	4,405	565	625	1,331	171	189
2003	7,245	866	1,023	4,267	510	602	1,289	154	182
	25% Tag Reporting Rate								
1999	9,441	1,604	1,248	5,534	940	732	1,627	277	215
2000	8,402	1,548	1,118	4,925	907	655	1,448	267	193
2001	7,543	1,435	988	4,421	841	579	1,300	247	170
2002	6,915	1,301	894	4,053	763	524	1,192	224	154
2003	6,445	1,161	825	3,778	681	484	1,111	200	142

Figure 1. Biomass trend based on a 50% tag-reporting rate.

AD Model Results (50% Tag Reporting Rate)