SEBASTES COMPLEX
ASSESSMENT METHODOLOGY

by

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August 1995

INTRODUCTION

Management of rockfish (Sebastes spp.) occurring off the West Coast is complicated due to the number of different species present, many of which are caught together in the commercial and recreational fisheries. There are 68 species of rockfish between the Gulf of California and the Aleutian Islands (Eschmeyer et al. 1983), occupying a wide variety of habitats. Rogers and Pikitch (1992) determined that trawl fishermen caught two basic assemblages of rockfish off the coasts of Oregon and Washington, based on the depth fished: a slope group and a shelf group. They determined that fishermen could often successfully target the separate assemblages, but generally could not selectively catch individual species within the assemblages (Rogers 1994a). To further complicate management, the species composition of rockfish present off the West Coast changes with latitude, so the defined assemblages likely do not apply to catches off the coast of California.

Management to date has been based on separate stock assessments and quantitatively derived allowable biological catches (ABC's) for only a few of the most commercially important species; the remaining species have not been quantitatively assessed. Since 1983, combined ABC's for the remaining rockfish have been estimated for each INPFC area along the coast, based primarily on landings information. The remaining rockfish in the northern areas (US Columbia and Vancouver INPFCs) has included all rockfish species except widow, yellowtail, canary, Pacific ocean perch, and shortbelly rockfishes. In the southern areas (Conception, Monterey, and Eureka INPFC), bocaccio and chilipepper are removed from the complex. Yellowtail and canary rockfishes are added to it in the Conception and Monterey areas. After 1991, thornyheads were managed separately for the Monterey, Eureka, and Columbia areas. ABC's and Harvest Guidelines for the complex have been based primarily on catches. The ABC for the southern areas was set at 1.2 times the 1977 catch of 7914 mt, evidently to allow the fishery to expand. Actual estimated catches, however, have never reached even the 1977 catch (PFMC 1994), so in 1994 the ABC was reduced to 7000 mt to bring it more in line with actual catches. In the northern area, the ABC has gone from 4,500 mt in 1983 (including Canadian Vancouver) to 4,200 mt in 1984 (without Canadian landings), and then to 4,500 mt in 1985-1994.

There has been recent concern that the remaining rockfish may be overfished. Fishermen have expressed concern that the species are becoming harder to find and the size of the fish in the catch is smaller than in the past. The life history of rockfish, which are generally long-lived, may make them especially vulnerable to fishing pressure (Clark 1991). The species which are managed separately, however, have varied assessments of the status of their stocks. Pacific ocean perch and canary in the northern area, along with bocaccio in the southern area, may be overfished ($F > F20\%$). The chilipepper and yellowtail rockfish stocks in the northern area are apparently healthy. Three of the deepwater species have had preliminary assessments, but catches at F35% (the target rate) were not determined and ABC's were not set. The darkblotched rockfish investigation indicated that if the estimated reduction in size in the trawl catches in California was due to fishing, then the species may be overfished (Lenarz 1993). The splitnose rockfish assessment determined that results were inconsistent in indicating any cause for concern (Rogers 1994b). The bank rockfish assessment noted a reduction in size over time and estimated a value for F35%, but was limited by the lack of survey data to estimate changes in biomass over time (Pearson 1994).

In this paper we present the methods we intend to use to provide information to derive ABC (allowable biological catch) estimates for the remaining rockfish in 1996. Any results presented this year should be considered preliminary. In 1996, we will include information from the 1995 triennial survey. An effort will be made during that survey to collect lengths, ages, and maturity data for the remaining rockfish species. The 1996 assessment will also include final estimates of commercial and recreational landings from California. At this time only preliminary estimates of California landings are available.

The general objectives of the assessment will be to provide estimates of possible ABC's for the remaining rockfish, and to determine the potential effects of deriving separate ABC estimates for the slope versus the shelf species. Separating the sebastes complex into shelf versus slope species may be advantageous in that the fewer the species in a complex the easier it is to control and a less conservative approach is possible (Francis, 1986). We will also try to use information on the previously assessed species to gain information on the remaining species. Each of the assemblages defined by Rogers and Pikitch (1992) has a species which has been quantitatively assessed.

The specific objectives of the assessment will be :

1). Estimate F20%, F35%, F45%, and F=M for individual species which predominate the landings or are commercial targets, with the other remaining rockfish as a group, using information from Pacific ocean perch, canary, and yellowtail assessments when possible.

2). Determine the catch in 1995 for the previously unassessed species in the slope assemblage, the shelf assemblage, and combined,
if F was set at F20% for the most vulnerable species and
if F was set at F45% for the least vulnerable species.

3). Determine the catch in 1995 (slope versus shelf and combined) if F is set equal to M for the most and least vulnerable species, using average available biomass as estimated by the shelf surveys, considering possible catchability coefficients for the survey.

METHODS

DATA

Life History Parameters

Life history information was complied for the species which have had prior assessments, as well as the selected remaining individual species. We collected data on natural mortality, maximum age, L_∞ and k from the Von Bertanlaffy growth equation, and age and size at 50% maturity. We looked for distinctions between the slope and shelf species, or between the species which are managed separately versus those less commercially important. Clark (1991) determined that the target fishing intensity (F35%) is relatively greater with increased estimates of natural mortality (M), rapid growth a high k, a low L_∞, recruitment to the fishery lagging maturity, and few age classes vulnerable to the fishery. Adams (1979) also determined that fish are able to withstand greater fishing pressure with high k and low L_∞ values in the V-B age-length equation, with low maximum age and age at first maturity, and high M. We also examined estimated relative year class strengths for the rockfish species which have been quantitatively assessed, and compared shelf versus slope species. It would appear to be easier to manage species as an assemblage if they have similar life history characteristics and strong year classes in the synchrony. As a supplement to the life history information, we summarized information from the available assessments to see if the relative values for F35% corresponded to the expected parameters as listed above.

Landings

A primary problem in attempting to make a quantitative assessment of the remaining rockfish is the lack of accurate data on those species. The commercial landings are usually recorded in market categories containing several species, and those market categories are often sparsely sampled. The three West Coast states vary in the resolution of the Sebastes landings reported to Pacfin. Oregon reports individual landings for the major commercial species, with the rest of the rockfish landings placed in either other rockfish (all species not individually specified) or unspecified (landings for which there was no appropriate sample). Washington Pacfin-reported landings have even fewer individual species landings, but data on additional species are available from Jack Tagart, WDFW, Olympia, WA. California reports many of the species, but still has had substantial landings recorded as other or unspecified. We reduced the resolution of the landings to the major species for which information was available from all three states. Landings in the unspecified rockfish category will be allocated to the known categories.

An additional source of error in the commercial landings estimates is that they may not reflect the actual catches due to discarding at sea. With declining stocks for some of the most preferred species, markets may have developed for some discarded species, and smaller sizes may be accepted at processing plants, so discarding patterns could have changed over time. Estimates of discard are generally available only for the Oregon and Washington trawl fishery, based on data collected by observers in 1985-1987.

Estimated length frequencies for the commercial landings are derived only in California, and although otoliths have sometimes been collected, they have not been aged. A few lengths for Oregon and Washington trawl catches were taken by the observers in 1985-1987. Those lengths were recorded for both the kept and discarded fish.

For the recreational data landings, we used MRFSS data when available. Recreational data for black rockfish was taken from the available assessements.

Surveys

Fishery independent data were available from three surveys. The shelf surveys have been conducted every three years since 1977. In 1977, the depth range was deeper than in later years and the southern extent of the survey has varied from year to year (Rogers 1994b). There is also information available from a slope survey conducted in different areas in different years. The only repeated area was in the central Columbia INPFC in 1988, 1989, and 1993 (Rogers 1994b). A directed POP survey was made in 1979 and 1985 in the northern area. These surveys provide information on trends, but the spotty nature of rockfish tends to produce estimates with either large abundances and large CV's from a few large tows, or small abundances and small CV's when a large tow did not happen to be encountered. This may be further complicated because sampling intensity in different areas changed from year to year in the triennial surveys, so the probability of encountering a huge tow may not be equivalent over time.

Available assessments using the stock synthesis model indicate the catchability (Q) of the shelf survey for rockfish may be between 0.2 and 0.9 This means that the biomass estimates generated by the surveys are less than the estimated biomass which was available to the gear. The estimate of Q for POP was 0.5, for canary 0.41-0.822, for yellowtail 0.23-0.89 (with the best values 0.2-0.4), and for chilipepper 0.5. The estimates for POP and chilipepper would be expected to be less than for the other species because POP is a slope species and the survey did not extend over the range of the area covered by the chilipepper assessment.

Lengths and ages from the survey catches are available for some of the remaining rockfish species. As stated, an effort will be made in 1995 to collect substantially more information for the remaining species.

Effort indices

We will utilize the available estimates of F for rockfish species to derive effort indices for the remaining rockfish species. We will follow the lead of Laurec et. al (1991) in assuming constant multispecies fishing patterns within the slope and within the shelf strategies. In other words, he assumed that the effort exerted on each species caught by a strategy was equal, but the species had different vulnerabilities (catchabilities) to the strategy. We recognize that there may be some noise included in doing this, but the lack of data available for the remaining species would likely otherwise preclude any conclusive results. Estimates of F over time from the quantitative assessments are available for Pacific Ocean perch, a slope species, and canary and yellowtail rockfishes, which were determined to be part of the shelf assemblage. Comparisons of the F's over time were difficult because the assessments covered different areas and fisheries, and different assumptions were made regarding the shape of the selectivity curves (Table 1). Never-the-less, the F values for the shelf species did appear to track, especially in the southern areas (Figure 1). We chose the values of F for canary rockfish as an effort index for the other shelf species. Canary has been less regulated than yellowtail, so the relative catchabilities would be expected to be more stable (fishermen weren't trying alternately catch/avoid them). Pop, the slope species, did not follow the same patterns of F as the shelf species (Figure 1).

Using this assumption:

$C = FB_{ave}$ (Baranov's catch equation as cited in Ricker 1975)

$F = Q*E$ and $B_{ave} = C/(Q*E)$

where F= fishing mortality rate at full selectivity
Q= catchabilitity coefficient
C= catch biomass
E= fishing effort
B_{ave} = average available biomass

Using the assumption of equal effort, we will use estimates of F from the fully assessed species within each complex to help assess the species on which we have limited information. By assuming that the relative catchabilities of the species in the assemblage are stable over time, the F values of the assessed species would be an index of effort for the bycatch species. An index of relative available biomass for the bycatch species would be :

$$\text{Index}_{B1} = C1/F2$$

where 1 = bycatch species and 2=assessed species.

We will also take an independent look at the relative catchabilities of the species within the assemblages, using information from 1986, where we had both observer and research cruise data. Assuming that the species had equal catchabilities in the triennial research cruises (no targeting), the relative commercial catchability for a species was estimated as :

Q1/Q2 = (CO1/[BR1]) / (CO2/[BR2])

where CO = 1986 observed catches in the strategy (1=bycatch, 2=assessed), EO = 1986 effort (hours) observed in strategy, and BR=average available biomass estimates from 1986 triennial cruise.

The relative catchabilities will be used to derive partial fishing mortality rate values for 1986 for the by-catch species based on the fishing mortality rate of the assessed species.

Model Structure

For our initial examination, we will follow the methodology used to derive ABC estimates for many rockfish species in the Gulf of Alaska. We will treat the northern and southern management groups of remaining rockfish as separate stocks. This will be done for simplicity because the two groups include different species, and the proportions of the selected species are likely different for in two areas. We will use the triennial shelf surveys to estimate the biomass available to the fishermen over the range of Q's derived for the previously assessed rockfish species. We will examine the biomass estimates for a trend over time. If no trend is apparent, we will average the biomass estimates and use Baranov's catch equation expressed earlier to determine the catch at F= M. Setting F=M may approximate F42% if the size at 50% maturity = the size at 50% selectivity (Clark 1993). If the size at 50% maturity is greater than the size at 50% selectivity, this policy may not adequately protect the fish, likewise, it may be too conservative if the reverse is true. We will calculate the catch for each of the individual species at their estimated values for M, and the rest of the species at a range of M values. We will then add the catch together to estimate the catch for the group. As an alternative method, we will use the range of M values from the individual species and applied it to the joint biomass average estimate.

This method requires several assumptions which should be acknowledged if the catches are used to determine the ABC's for the group. The most evident are listed below:

1) The biomass available to the trawl survey, given the estimated catchability coefficient, is equal to the biomass available to the commercial trawl fishery.
note: the trawl survey uses smaller mesh than the commercial fishery.

2) Differences in maturity versus selectivity to the gear would not substantially affect the catch which can be taken.

3) If individual species catches are added together -
the separate F values are jointly possible (if effort is considered equal on each species in an assemblage, the relative catchabilities must equal the relative F values).

4) If F values are applied to the combined catch -
if effort on the species is equal, the catches are proportional to the available biomass (catchabilities are equal).

For the more complete analyses, we will utilize the stock synthesis model to incorporate all the information available, as listed under the data section. We plan to complete separate assessments for each of the selected species. We will treat the rest of the species as one species, a suggestion of Laurec et al. (1991) for species with common characteristics. They suggested the use of surplus production models on the aggregate data. We will utilize the synthesis model using only catches and biomass estimates from the surveys. For this group we will try three life histories: the average of the parameters for the remaining species on which we have information, parameters which suggest vulnerability to fishing (see above) and parameters which suggest the species can withstand substantial fishing pressure. We will use selectivities estimated for the other species to fix selectivities to the surveys and fisheries.

PRELIMINARY RESULTS

There was no noticeable distinction between the slope and shelf species, or between the species which are managed separately versus those in the complex in terms of life history parameters (Table 2). There was also no obvious relationship between the estimated values for F35% in the full and partial assessments and the expected predictors (Table 1,2). Bank rockfish, for instance, has a relatively high value for F35% (0.19) (Table 1), yet a low value for k, M, a high L_∞, and a recruitment to the fishery four years before the age at 50% maturity (Table 2). Comparisons are difficult, however, when natural mortality was allowed to increase with age and selectivity is allowed to vary from year-to-year and fishery-to-fishery, and may be forced asymptotic or allowed to be dome-shaped. Values for k may not be comparable if based on different ranges of ages.

Year class strength was correlated to an extent for the assessed rockfish species, but was not entirely synchronous. Table 3 indicates 1977, 80, and 85 were good years for many species, while 1983 was an unusually bad year for most species(areas). POP, the only slope species with estimates of year class strength, did not demonstrate any less consistency with the shelf species than they were with each other.

ACKNOWLEDGEMENTS

I am grateful to Jack Tagart and Tom Jageilo of the WDFW for their input and suggestions regarding the use of the Gulf of Alaska assessment methodology. Many people spent time and energy supplying me the substantial amount of data required by this assessment. They include Mark Wilkins, Jack Tagart, Mark Saelens, Don Pearson, Bob Lauth, and Jim Ianelli.

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Table 1. Comparison of available assessments for rockfish.

Species	♀age 50%(100) selectivity	Selectivity	F35% (%E)	yr	F (%E)	biomass	STOCKS	fisheries
Pop*	**4-12 (6-14)#**	**dome**		**91**	**.08-.4 (13%)**	**9383**	**COL - US VAN**	**foreign trawl domestic trawl**
darkblotched*	**6-7 (>13)**	**asymptotic**	**.04-.06**				**CON- US VAN**	**trawl**
splitnose*	**13#**						**CON-US VAN**	**CON-EUR trawl, setnet COL-US VAN domestic trawl**
bank*	**12 (35)**	**asymptotic**	**0.19**				**Caliifornia-OR**	**trawl setnet**
canary*	7-12(10-21)#	dome	.13-.26	93	.36- .82	4408- 31579	COL- US VAN	Oregon all, Washington all
yellowtail	7-12(10-21)#	asymptotic	..25 .21 .22	93	.18 .12 .64-2.1	25471 28491 8147-13410	EUR-SCOL, N. COL, US.VAN	trawl
bocaccio*	3	dome	0.11 trawl	92	.07-.09 trawl	15978-21026	CON-EUR	trawl, hook, set,recreational
chilipepper*	4-5 (8-9)	dome	(12-15%)	92	(4%)	76481+/-	CON-EUR	trawl, hook, set, recreational

Table 2. Comparison of life history and fishing parameters for slope (bold) versus shelf rockfish.

Species	M	max age	L_{∞} (cm) ♂,♀	k ♂,♀	♀age -size 50(100)% mat.
Pop*	**.05**	**70-90**	**39,42**	**.22,.18**	**7 (9)**
darkblotched*	**.025-.05**	**60-105**	**38,42**	**.24,.18**	**8 (15)**
splitnose*	**.05**	**84**	**30,34**	**.10,.16**	**7 (9)**
yellowmouth	**.06-**	**46,47**	**54**	**0.12**	**44 cm**
bank*	**.08**	**53**	**46,90**	**.05,.04**	**16**
yellowtail*	.11-.36@	64	47,54	.18,.16	10-11(18)
bocaccio*	.20	36	64,75	.23,.19	4-5 (14)
chilipepper*	.15	35	39,52	.28,.20	3 (6)
canary*	.06-.16@	69	52,57	.21,.19	9 (30)
yelloweye	.02	118	67,66	.06,.05	17-21
sharpchin	.05(z)	45	33	.10,.13	26 cm
silvergray	.03-.05	75-80	57,61	.09,.07	8-9
redstripe	.09(z)	40	34,41	.18,.15	29 cm

Table 4 Key: *= taken from latest stock assessment
+= taken from Archibald et al. 1981
.=taken from Hart 1973
#=estimated from figures or other information
@= higher estimate is maximum of increasing mortality with age

Table 3. A comparison of estimated year class strenght for species with stock assessment estimates
where 0 = poor recruitment, 1= moderate recruitment, 2= strong recruitment

SPECIES	YEAR															
	75	76	**77**	78	79	**80**	81	82	83	84	**85**	86	87	88	89	90
bocaccio						**2**	1	1	0	2	**2**	1	1	2	2	
chili					1	**0**	0	0	0	2	**0**	0	1	1	0	0
pop	2	0	**0**	0	1	**0**	2	0	0	0	**2**	0	0	0		
canary1		1	**2**	1	0	**0**	0	1	0	0	**1**	0	0	0	2	
canary2		1	**1.5**	1.5	1	**1**	1	1.5	0	1.5	**2**	0	2	1.5	1.5	
widow	1	0	**2**	2	1	**2**	2	1	1	1	**1.5**					
yt-nc	0	1	**1.5**	0	2	**2**	0	0	0							
yt-esc	0	1	**1**	0	1	**2**	0	0	0							
yt-sv	1	1	**2**	1	1	**1**	0	0	2							

Comparison of shelf (solid lines) versus slope (dashed lines)
rates of fishing mortality