STOCK ASSESSMENT FOR THE INSIDE POPULATION OF YELLOWEYE ROCKFISH (*SEBASTES RUBERRIMUS*) IN BRITISH COLUMBIA, CANADA FOR 2010

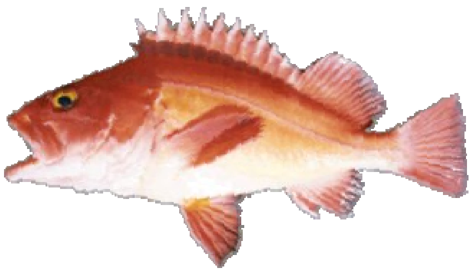

*Figure 1. Yelloweye Rockfish (*Sebastes ruberrimus*) Photo credit: K. Lynne Yamanaka*

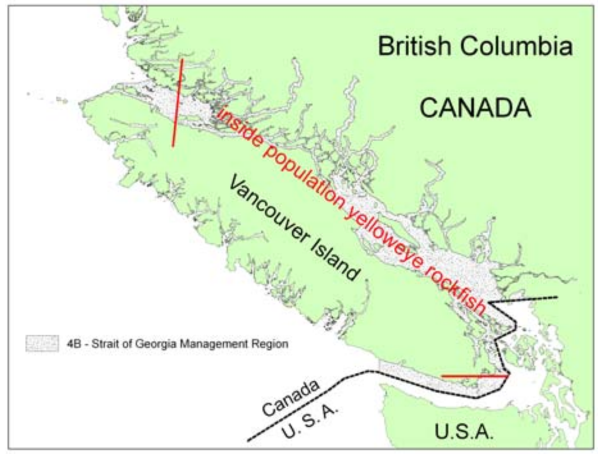

Figure 2: Limits of Inside Population of Yelloweye Rockfish in British Columbia, Canada

Context :

Yelloweye Rockfish are distributed in the northeast Pacific from Alaska to Baja California and have been observed in British Columbia at depths from 20 to 250 metres. Yelloweye Rockfish exhibit a demersal existence over hard, complex substrates such as rock reefs and boulder fields.

Yelloweye Rockfish are caught by all fishing gear types (jig, troll, set-line, and trawl) in Aboriginal, commercial and recreational fisheries. Since the inception of the ZN licensed directed hook and line rockfish fishery in 1986, fishery management has been applied over two management units: inside and outside.

Yelloweye Rockfish have been assessed together with other inshore rockfish species since 1986. In 2006, a stock status report was prepared for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). COSEWIC recognized two designatable units (DUs), or populations, of Yelloweye Rockfish in British Columbia; inside and outside. In 2008, COSEWIC designated both populations as special concern.

This Science Advisory Report has resulted from Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Pacific Regional Advisory Process meetings held on September 22, 2010 and April 8, 2011, on the Stock Assessment for the inside population of Yelloweye Rockfish (Sebastes ruberrimus) in British Columbia, Canada for 2010. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

SUMMARY

- In 2008, COSEWIC recognized two designatable units (DUs), or populations, of Yelloweye Rockfish in British Columbia (B.C.); inside and outside and both these DUs were designated as special concern.
- This document provides a summary of the stock status and projections for the inside population of Yelloweye Rockfish in B.C. Stock status and projections are presented relative to reference points consistent with DFO's decision making framework policy which incorporates the Precautionary Approach.
- Yelloweye Rockfish range throughout B.C. and are observed at depths from 20 to 250 metres. They are demersal and exist over hard, complex substrates such as rock reefs and boulder fields.
- In 2009, an estimated 15.2 t of Yelloweye Rockfish were caught in fisheries throughout the inside management unit; 2.8 t from Aboriginal fisheries, 8.1 t from commercial groundfish fisheries and 4.3 t from recreational fisheries.
- A Bayesian surplus production (BSP) model is used to assess the inside population of Yelloweye Rockfish in B.C. This model employs catch data derived from historic catch records reconstructed back to 1918, life history data to estimate the intrinsic rate of increase (r), and abundance trends from commercial hook and line catch records and two longline research surveys.
- The BSP model provides a fairly good fit to the stock trend data and shows a stock decline in the 1980s and 1990s during high fishery catches. The BSP model accounts for the continued decline in abundance since the 1990s, during a time of lowered catches, by updating the prior for r, to give a posterior mean for r considerably less than the prior mean.
- Sensitivity analyses were conducted to evaluate the sensitivity of model results to a wide variety of alternative input and model settings.
- Stock status for the inside population of Yelloweye Rockfish is evaluated using a reference case BSP model run. This model run estimates that the stock biomass in 2009 is at 780 tonnes (coefficient of variation [CV] 0.46), which is 12% (CV 0.43) of the initial biomass of 6466 t (CV 0.40) in 1918.
- There is a 5% probability that the inside Yelloweye Rockfish population in 2009 is greater than the fisheries Limit Reference Point (LRP), consistent with Fisheries and Oceans Canada's (DFO's) fishery decision-making framework incorporating the Precautionary Approach. The population is likely within the Critical Zone.
- Replacement yield in 2009 ($RepY_{2009}$) is estimated at 19 t (CV 0.49) with catches of 15 t in 2009 estimated at 78% (CV 0.66) of replacement yield. Fishing mortality in 2009 (F_{2009}) is estimated to be 1.38 (CV 0.70) that of the fishing mortality at MSY (F_{MSY}).
- Stock projections show that the stock will increase over time. The probability that the current biomass in 2009 (B_{2009}) >0.4 B_{MSY} at the end of a 5 year horizon is low (< 14%) for all harvest policies. Given a fixed catch (total fishing mortality) harvest policy of 15 t, this probability increases to about 44% at the end of a 40 year time horizon and 56% at the end of an 80 year time horizon.
- An exploratory methodological analysis that extends the BSP model to incorporate pinniped predation on a fish stock is presented for illustrative purposes only.

INTRODUCTION

Yelloweye Rockfish are distributed in the northeast Pacific from South of Umnak Island in the Aleutian Islands (Mecklenburg et al. 2002) to Ensenada, northern Baja California (Phillips 1957) (Figure 1). In B.C., they are commonly observed in depths between 20 and 250 metres and exhibit a demersal existence over hard, complex substrates such as rock reefs and boulder fields (Yamanaka et al. 2006).

Yelloweye Rockfish are targeted or incidentally caught by all gear types (jig, troll, set-line, and trawl) in the Aboriginal, commercial and recreational fisheries for groundfish and salmon. Since the inception of the ZN licensed hook and line rockfish fishery, in 1986, fishery management has been applied over two management units: inside and outside. The inside fishery management area aligns with the Pacific States Marine Fisheries Commission Major Area 4B and wholly encompasses the inside Yelloweye Rockfish population and includes, at both extremes a small portion of the outside population (Figure 2).

Since 1986, Yelloweye Rockfish have been assessed together with other inshore rockfish species (*Sebastes spp.*). In the last assessment, harvest advice to managers was to consider an optimal harvest rate (F), less than or equal to half of the natural mortality rate (M) (Yamanaka and Lacko 2001). At that time, F was determined to be in excess of M, based on estimates of total mortality (Z) from catch curve analyses using ages from research surveys in 1997/98 and 2001 along the B.C. coast. In late 2001, a Rockfish Conservation Strategy was initiated, and worked towards accounting for all rockfish catch, reducing fishing mortality, closing areas to fishing and improving stock monitoring and assessment. (Koolman et al. 2007, Yamanaka and Logan 2010). Managers adopted a harvest rate of less than 2% (F < M) in conjunction with spatial management whereby areas were closed to all harvest.

In 2006, a stock status report was requested and prepared for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Yamanaka et al. 2006). COSEWIC recognized two designatable units (DUs) of Yelloweye Rockfish in B.C.; inside and outside (COSEWIC 2008), and designated both DUs as special concern. A request for science information and advice was received from Fisheries and Aquaculture Management of DFO to determine the current status of the inside Yelloweye Rockfish stock relative to DFO’s Precautionary Approach harvest default reference points and to provide decision tables forecasting the impacts of varying harvest levels. This stock assessment is solely concerned with the inside DU or population of Yelloweye Rockfish (Figure 2). This document aims to provide updated assessment advice required for the development of a management plan.

ASSESSMENT

Methodology

A Bayesian state space surplus production (BSP) model, similar to the one applied in the 2008 stock assessment of B.C. Bocaccio (*Sebastes paucispinis*), is applied for the inside population of Yelloweye Rockfish (Prager 1994; McAllister et al. 2001; Stanley et al. 2009). The BSP model presumes that the main source of interannual variation in mortality has been from fisheries and changes in fishing effort and that the non-fishery mortality rate is constant over time. This is a non-equilibrium state-space surplus production model with a Bayesian statistical methodology for parameter estimation. The model requires a time series of historical annual catch biomass from all fisheries and is fitted to stock trend data derived from hook and line commercial catch records and longline research surveys. The model projects from initial conditions in 1918, the first year of the commercial catch reconstruction, to 2009 accounting for annual catch removals and surplus production.

Priors are specified for the maximum intrinsic rate of increase (r), the ratio of initial stock size in 1918 (B_{1918}) to the equilibrium unfished stock size or carrying capacity (K), or B_{1918}/K, the constants of proportionality for the abundance indices (q), and the catchability coefficient for the recreational fishery that is used to impute recreational fishing mortality up to 1981 (g). Commercial and Aboriginal fisheries catches are treated as fixed and known and the model solves for fishing mortality rates that are consistent with the inputted total fixed annual catch (Prager 1994).

The BSP software that is developed for this stock assessment applies the sampling importance resampling (SIR) algorithm to integrate the joint posterior probability density function of model parameters and to sample from the posterior for stock projections (Rubin 1987; McAllister et al. 1994; McAllister and Ianelli 1997).

Marginal posterior distributions were computed for all model parameters and management quantities of interest including K, r, q, g, B_{1918}/K, the maximum sustainable yield (MSY), biomass at MSY (B_{MSY}), biomass by year (B_y), the most recent biomass (B_{2009}), the ratio of B_{2009}/B_{MSY}, fishing mortality rate at MSY (F_{MSY}), the replacement yield, the ratio of the most recent fishing mortality rate to that at MSY (F_{2009}/F_{MSY}) and the ratio of the most recent catch to replacement yield ($C_{2009}/RepY_{2009}$).

A reference case BSP model is constructed with the “most plausible” data inputs, and sensitivity tests are conducted to determine the influence of varying each of these data inputs on the model outcomes. Management advice is based on this “reference case” model run.

Fisheries reference points consistent with DFO’s fishery decision-making framework incorporating the Precautionary Approach are presented in this assessment (DFO 2009). For surplus production models, B_{MSY} is commonly defined at 0.5 B_0, or half of the unfished biomass. In the BSP assessment model, B_0 is defined as the carrying capacity parameter, K. Hence, for the reference case BSP model:

Limit Reference Point (LRP) = 0.4 B_{MSY} = 0.2 B_0,
Upper Stock Reference (USR) = 0.8 B_{MSY} = 0.4 B_0, and
Target Reference Point (TRP) = B_{MSY} = 0.5 B_0.

Sources of Data

Historic Catch

Reconstructions of commercial landings and discards, recreational retained and released catch, and Aboriginal catch biomass were conducted for a fishery catch time series that spans from 1918 to 2009.

Commercial landings for Yelloweye Rockfish are estimated from aggregated species landing statistics from a variety of sources over time. Data were transcribed from Dominion of Canada Bureau of Statistics volumes from 1918 to 1951, and from B.C. sale slip records between 1952 and 1981. This sale slip system moved to an electronic format in 1982 and continued until 1994. In 1995, groundfish fisheries reported landings by species through dockside monitoring programs and logbooks. In 2006, a Fisheries Operating System (FOS) began to report species catches (landed and discarded) from all groundfish fisheries, with the exception of trawl, through the integration of at-sea observers and electronic video monitoring, dockside monitoring, and logbook reporting. The trawl fishery began reporting through FOS in 2007.

Commercial discards are estimated from At-sea Observer data collected between 2000 and 2004 onboard hook and line vessels and applied to landings in the hook and line rockfish (ZN licensed) and Spiny Dogfish (*Squalus acanthias*) and Lingcod (*Ophiodon elongatus*) (Schedule II, C licensed) fisheries from 1986 to 2005, and the Pacific Halibut (*Hippoglossus stenolepis*) (L licensed) fishery from 1979 to 2005. The discards are considered negligible up until the institution of species specific licensing regimes. After license Integration in 2006 the total landed and discarded catch is accounted for. Shack bait is included in this estimate of discards. Shack baiting practices occur in this and other fisheries and peaked in the mid-1980's (1985-1986).

Unreported catches since the initiation of the ZN licensed fishery (1986) up until the implementation of the 100% monitoring program in 2006 are estimated, by industry, to be equivalent to the commercial catch estimate. For this reason the reference case model is based on double the commercial catch reported between 1986 and 2005.

Recreational fishery retained and released catch is derived from The Strait of Georgia Sport Fishery Creel Survey from 1982 to 2008 (Hardie et al. 2001). Recreational catches prior to the creel survey were reconstructed using a time series of recreational fishing effort prior to the creel survey, based on anecdotal information from local experts and the average Creel catch per unit effort.

Consumption of Yelloweye Rockfish by Aboriginal populations is estimated by applying a consumption rate of Yelloweye Rockfish per person per year to population estimates obtained through the Canada Census and Indian and Northern Affairs Canada for Aboriginal people who reside near, and have access to, the inside Yelloweye Rockfish population.

Life History Parameters

Samples obtained from the inside Yelloweye Rockfish stock area during the inshore rockfish longline surveys were used to estimate life history parameters. A Bayesian estimation model was developed and applied that computes the posterior mean and covariance of the von Bertalanffy growth parameters, fork length to wet weight conversion parameters, and parameters for a function of fraction mature at age for females.

Estimates for Z are based on two applications of Ricker catch curves using inside population of Yelloweye rockfish age data. Estimates of M are derived using Hoenig's equation and a maximum age of 110 years, observed for the inside population. A recent hierarchical meta-analysis of rockfish stock recruit data by Forrest et al. (2010) is used as a source for the input distribution for the steepness parameter (h). We presume a Ricker function for the reference case prior and then apply a Beverton - Holt function in a sensitivity analysis. The methodology developed in the 2008 B.C. Bocaccio stock assessment (Stanley et al. 2009) to compute a prior density function for the maximum intrinsic rate of increase (*r)* is extended to include uncertainty in all of the input parameters for this Monte Carlo algorithm.

Stock Trends

Stock trend data were derived from the Yelloweye Rockfish catch and effort data from the inside directed commercial hook and line fishery from 1986 to 2009 and from two longline research surveys conducted in the inside waters: the Spiny Dogfish survey in the Strait of Georgia in 1986, 1989, 2004, 2005 and 2008 and the inshore rockfish longline survey throughout inside waters in 2003 to 2005, and 2007 to 2009.

The catch per unit of effort (CPUE) time series are standardized using generalized linear models (GLM) where the year effects are assumed to closely follow the abundance trends.

Following the methods of Babcock and McAllister (2002) a Bayesian delta lognormal model is employed with the explanatory variables (factors) year, area, and gear type.

New abundance indices for the Spiny Dogfish and rockfish research longline survey data, based on the instantaneous catch rates, are derived to take into account the competition for baited hooks but also to account for the return of unbaited, empty hooks (Etienne per. Comm.).

Results

Reference Case BSP

The reference case BSP model provided fairly good fits to the three sets of abundance indices. The model shows two periods of relative steep decline in line with the two periods in which the fishery catches were largest, i.e., during the war years and during the mid 1980s to mid 1990s. The estimated population abundance shows relatively little change since the mid-1990s when catches were very substantially reduced. The modeled median inside Yelloweye Rockfish stock biomass is shown below in Figure 3.

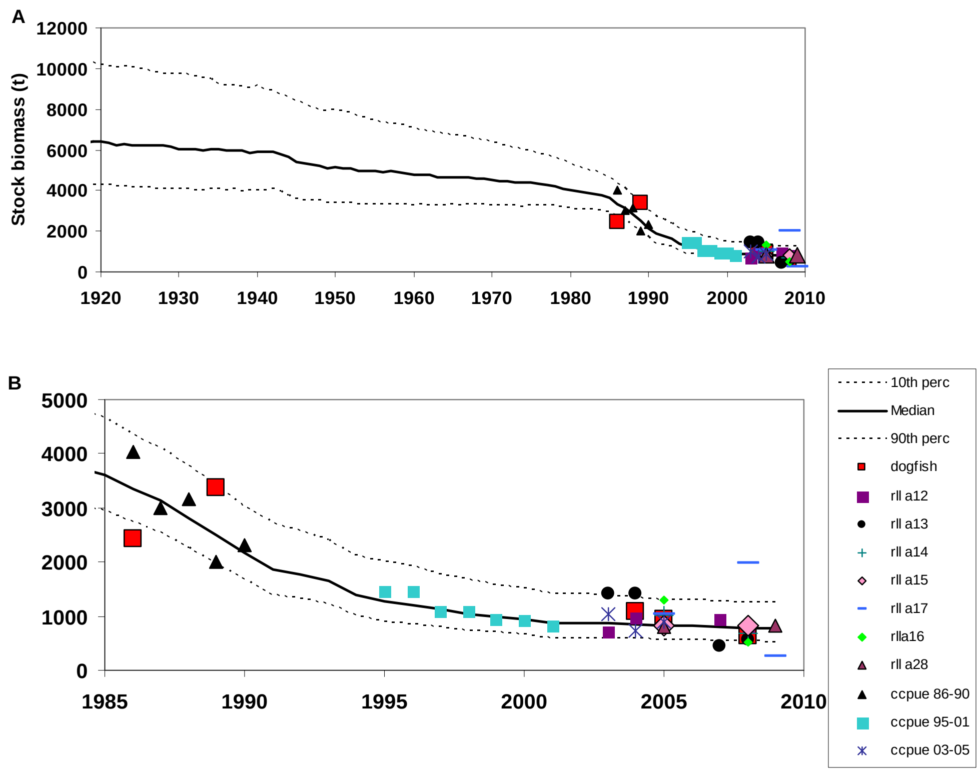

Figure 3. Plots of the posterior median inside Yelloweye Rockfish stock biomass and 90% probability intervals obtained after fitting the BSP model to the inside Yelloweye abundance indices obtained from the Strait of Georgia dogfish research longline survey (dogfish), the inside rockfish longline (rll) survey and GLM standardized inside commercial catch per unit effort data (ccpue). The inside rockfish longline survey dataset is aggregated by Pacific Fishery Management Area from 12 to 17 and 28 (rll a12 to rll a17 and rll a28). The commercial catch per unit effort data is parsed into three stanzas for the years 1986 to 1990 (ccpue 86-90), 1995 to 2001 (ccpue 95-01), and 2003 to 2005 (ccpue 03-05). A. Years 1920-2009. B. Years 1985-2009.

For the reference case BSP model run, median initial stock biomass in 1918 (B_{1918}) is estimated at 6466 tonnes (CV 0.40). Estimate of stock biomass in 2009 is at 780 tonnes which is 12% (CV 0.43) of the initial biomass. Replacement yield in 2009 is estimated at 19 t (CV 0.49) with catches of 15 t in 2009 estimated at 78% of replacement yield. Fishing mortality in 2009 is estimated to be 1.38 (CV 0.70) that of the fishing mortality at MSY.

Priors for some parameters are markedly updated by the data. These include the unfished stock size (K), the constants of proportionality for the stock trend indices (q), and catchability for the recreational fishery (g), all of which had non-informative priors with very large CVs (>3) and posterior CVs all of <0.4. Initial stock size relative to K is only updated slightly. The prior mean *r* predicted population recovery with the marked reduction in catch. The lack of recovery in the indices updated the prior mean so that the posterior mean was considerably lower.

Evaluation of Stock Status

For the reference case BSP model run, median B_{2009}/B_{MSY} is 0.215 (CV 0.4), with a probability that $B_{2009} > 0.4B_{MSY}$ of 4.8% and a probability that $B_{2009} > 0.8\ B_{MSY}$ of 0.1% as illustrated in Figure 4 below. The inside population of Yelloweye Rockfish is likely (90% probability) in the Critical Zone.

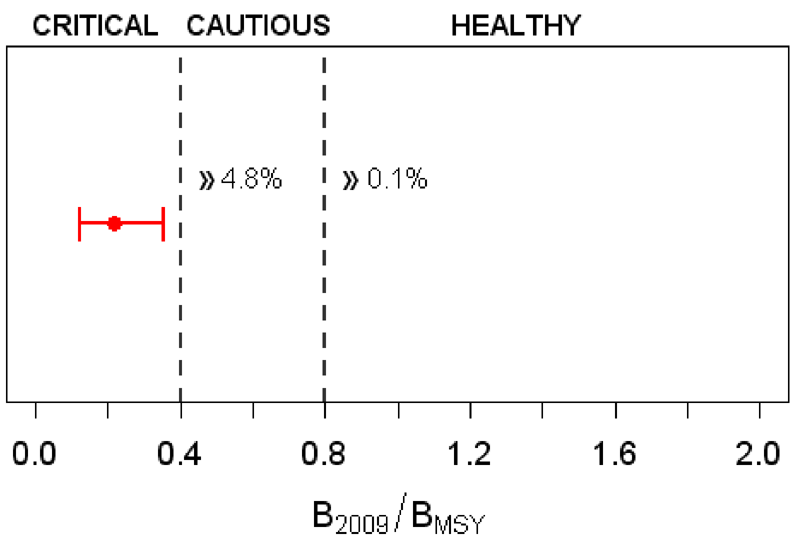

Figure 4. For the reference case Bayesian surplus production model (BSP) run, median (point) and 90% confidence intervals for the ratio of B_{2009} relative to B_{MSY}. Vertical dashed lines indicate the limit reference point (0.4 B_{MSY}) and upper stock reference point (0.8 B_{MSY}). The three stock status zones delineated by these reference points (Healthy, Cautious, and Critical) are indicated at the top of the figure. The arrows and associated probability statements show the probabilities that stock status is within the Cautious Zone and the Healthy Zone.

Sensitivity Tests

The sensitivity of the stock assessment and projection results to a variety of model settings is evaluated (Table 1). High r and lower initial stock size (B_{1918}/K=0.7) assumptions result in higher estimates of stock status (B_{2009}/B_{1918}), as expected. Stock biomass (in 1918 and 2009) but not the stock status estimates are sensitive to the alternative settings for historic catches. Results are insensitive to leaving out the commercial catch and rockfish survey indices but show higher stock status when leaving out the spiny dogfish survey index, because of the relatively steeper decline in this index. With low and high prior means, the priors are updated and the posterior SDs are considerably lower. In all instances, the probabilities of the data are not sufficiently different such that any one model is strongly down-weighted.

Table 1. Stock assessment results for alternative settings to the Bayesian surplus production (BSP) stock assessment model (Run). In the rows, the Reference run is in bold (Ref), followed by the sensitivity tests on the alternative priors for r (low r and high r), initial stock size (B_{1918}/K=0.7 and 1.2), historic catches (50% or 150%) and the effect of excluding different data sets (commercial catch CPUE [CCPUE], the dogfish survey index [dogfish] and the rockfish survey index [rockfish]). In the columns, r refers to the maximum intrinsic rate of increase, B_{1918} and B_{2009} refer to the stock size in 1918 and 2009, B_{2009} /B_{1918} refers to the ratio of biomass in 2009 relative to the biomass in 1918. All biomass values are in tonnes. The posterior median, standard deviation (SD) and coefficient of variation (CV) are shown for each estimated quantity.

	r			B_{1918}			B_{2009}			B_{2009}/B_{1918}		
Run	Median	SD	CV	Median	SD	CV	Median	SD	CV	Median	SD	CV
Reference run												
Ref	**0.027**	**0.014**	**0.48**	**6466**	**2787**	**0.40**	**780**	**391**	**0.46**	**0.123**	**0.057**	**0.43**
r prior												
low r	0.022	0.012	0.50	7066	2783	0.37	828	340	0.38	0.118	0.054	0.42
high r	0.034	0.014	0.38	5889	2006	0.32	765	296	0.36	0.131	0.056	0.40
Initial stock size assumptions												
B_{init}/K = 0.7	0.026	0.015	0.50	5665	2529	0.41	804	328	0.38	0.143	0.066	0.43
B_{init}/K = 1.2	0.028	0.014	0.46	7825	2847	0.34	787	389	0.45	0.103	0.046	0.41
Uncertainty over historic catches												
50% catch	0.027	0.014	0.47	3227	1370	0.39	377	236	0.55	0.123	0.056	0.42
150% catch	0.027	0.014	0.48	9699	4114	0.39	1183	537	0.42	0.123	0.057	0.42
Effect of excluding different data sets												
CCPUE	0.028	0.015	0.49	6567	2564	0.37	925	486	0.47	0.143	0.068	0.44
dogfish	0.037	0.017	0.41	6788	6707	0.78	1687	7112	1.93	0.191	0.319	1.12
rockfish	0.031	0.016	0.46	6261	2630	0.39	884	379	0.4	0.142	0.064	0.41

Projections Considered

Projections are done from 2010 to 2090 (approximately two generations) to evaluate the potential future stock trends resulting from various fixed total allowable catch (TAC) policies (Table 2). For all alternative policies projected in the BSP model, the population shows varying amounts of expected increase. Probability of stock recovery above the Critical Zone over a 5 year horizon is low (<14%) for all harvest policies. Given a fixed catch (total fishing mortality) policy (TAC) of 15 t the probability increases to about 44% over a 40 year horizon and 56% over an 80 year horizon.

Table 2. Projection results for the reference case BSP model at 5, 20, 40 (one-generation) and 80 (two-generation) year horizons. Horizon refers to the time period over which the projections were developed. Policy refers to the various harvest strategies. TAC refers to fixed catch policies that are harvested annually over the time horizon. F refers to constant fishing effort policies that are set at TAC levels in 2010. Median(B_{fin}/B_{MSY}) refers to the posterior median for the ratio of the stock biomass at the end of the horizon to that at B_{MSY}. P(B>0.4 B_{MSY} in Hz) is the probability that stock biomass in any year in the horizon exceeds 40% of stock biomass at B_{MSY}. P(B>0.8 B_{MSY} in Hz) is the probability that stock biomass in any year in the horizon exceeds 80% of stock biomass at B_{MSY}. P(B_{fin}>B_{2009}) refers to the probability that stock biomass at the end of the horizon exceeds stock biomass in 2009.

Horizon	Policy	Median (B_{fin}/B_{MSY})	P(B>0.4 B_{MSY} in Horizon)	P(B>0.8 B_{MSY} in Horizon)	P(B_{fin}>B_{2009})
5 -year	TAC= 0	0.232	0.137	0.008	0.658
	TAC= 5 t	0.228	0.134	0.008	0.617
	TAC= 10 t	0.221	0.129	0.008	0.542
	TAC= 15 t	0.215	0.125	0.008	0.468
	F=F(5 t TAC(2010))	0.228	0.134	0.008	0.616
	F=F(10 t TAC(2010))	0.221	0.129	0.008	0.543
	F=F(15 t TAC(2010))	0.215	0.123	0.008	0.469
20 -year	TAC= 0	0.336	0.421	0.069	0.847
	TAC= 5 t	0.305	0.373	0.058	0.772
	TAC= 10 t	0.271	0.320	0.047	0.674
	TAC= 15 t	0.237	0.278	0.039	0.563
	F=F(5 t TAC(2010))	0.299	0.359	0.055	0.774
	F=F(10 t TAC(2010))	0.265	0.304	0.043	0.676
	F=F(15 t TAC(2010))	0.234	0.260	0.028	0.564
40 -year	TAC= 0	0.519	0.699	0.289	0.885
	TAC= 5 t	0.446	0.619	0.232	0.824
	TAC= 10 t	0.358	0.527	0.182	0.734
	TAC= 15 t	0.275	0.435	0.137	0.577
	F=F(5 t TAC(2010))	0.414	0.595	0.206	0.822
	F=F(10 t TAC(2010))	0.328	0.488	0.135	0.733
	F=F(15 t TAC(2010))	0.260	0.391	0.087	0.595
80 -year	TAC= 0	1.008	0.848	0.658	0.942
	TAC= 5	0.816	0.782	0.566	0.862
	TAC= 10	0.605	0.685	0.474	0.757
	TAC= 15	0.383	0.557	0.377	0.597
	F=F(TAC(icur+1)) 5	0.673	0.766	0.507	0.869
	F=F(TAC(icur+1)) 10	0.456	0.634	0.371	0.763
	F=F(TAC(icur+1)) 15	0.304	0.517	0.251	0.622

Sources of Uncertainty

Continued decline of abundance indices in spite of decreased fishery harvests since the early 1990s is troubling. The BSP model is unable to account for these population declines with fishing effort. Possible explanations for this continued population decline could be a longer lag in population response to the reduction in fishing effort and/or recruitment declines or failure for the inside population. Another possible source of mortality could be attributed to the consumption of Yelloweye Rockfish by local pinniped populations; Harbour Seals (*Phoca vitulina*), Steller (*Eumetopias jubatus*) and California Sea Lions (*Zalophus californianus*).

As part of this stock assessment process, a new methodology explored an extension of the BSP model that explicitly accounts for recent trends in predation rates by pinnipeds. Pinniped consumption based on their abundance, bioenergetic requirements, diet composition, and a Type 1 functional response were included in the BSP model and fitted the stock trend data quite well. It accounted for the continuing decrease in abundance following the very large decrease in catches since the 1990s. Management advice is not based on this pinniped model and the outputs from the model are only used to illustrate possible stock outcomes that are independent from the fisheries. More data on pinniped consumption rates, diet composition, abundance of sea lions, consumption per animal, and the size and age composition of Yelloweye Rockfish consumed is required to utilize this new methodology.

CONCLUSION

The inside population of Yelloweye Rockfish in B.C. is characterized as long-lived and slow-growing with low productivity. Fishery removals from the inside population peaked in the mid to late 1980's and has declined since. Given the reference case model run, the population in 2009 is estimated at 12% of the stock in 1918 (Figure 3). Harvest advice is given in a decision table which projects the stock 5, 20, 40 and 80 years into the future given various harvest policies and presents the probability of reaching various reference points (Table 2). Harvest decisions depend upon the choice of time horizon, harvest policy, and reference point.

OTHER CONSIDERATIONS

U.S. Yelloweye Rockfish Stocks

In the SEO region of Alaska, adjacent to northern B.C. the Yelloweye Rockfish assessment for 2009 indicates a 2010 exploitable biomass of 14,321 t (Brylinsky et al. 2009). In Washington State, to the south of B.C., a ban on the retention of yelloweye rockfish has been in place since 2003. The most recent stock assessment, in 2009, indicated that in California, Oregon, and Washington, the Yelloweye Rockfish relative spawning output is estimated at 16.4%, 22.5%, and 27.3% of unexploited conditions, respectively. Yelloweye Rockfish in Puget Sound/Georgia Basin were proposed by NOAA to be listed as threatened under the U.S. Endangered Species Act in April 2009 (NMFS 2009). Rockfish, in general, in Puget Sound have declined by 70% in abundance over the last 40 years with Yelloweye Rockfish showing greater declines (Williams et al. 2010).

SOURCES OF INFORMATION

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, regional advisory meeting of April 7-8, 2011 on the Stock assessment and harvest advice for Pacific Lingcod in outside waters and for Strait of Georgia Yelloweye Rockfish. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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