Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Pacific Region

Canadian Science Advisory Secretariat
Science Advisory Report 2015/060

# STOCK ASSESSMENT FOR THE OUTSIDE POPULATION OF YELLOWEYE ROCKFISH (*SEBASTES RUBERRIMUS*) FOR BRITISH COLUMBIA, CANADA IN 2014

*Yelloweye Rockfish (Sebastes ruberrimus). Credit: Terri Bonnet (Fisheries and Oceans Canada).*

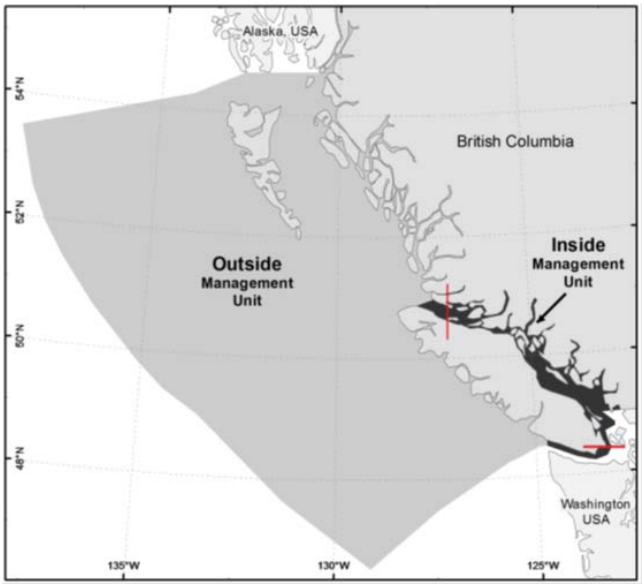


*Figure 1. Map of British Columbia showing the Outside and Inside management regions. Red lines indicate the boundaries of the two genetically distinct Yelloweye Rockfish populations.*

## Context

*Yelloweye Rockfish is one of the longest-living and largest species in the genus Sebastes and occurs in the northeast Pacific from Alaska to Baja California. It is caught by all fishing gear types (jig, troll, longline, 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 regions: Inside and Outside.*

*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, or populations, of Yelloweye Rockfish in British Columbia: Inside and Outside. In 2008, COSEWIC designated both populations as Special Concern and in 2011 both were listed as Special Concern under Schedule 1 of* Species at Risk Act*.*

*This Science Advisory Report is from the September 15, 16, and 24, 2015 Stock Assessment for the Outside population of Yelloweye Rockfish (Sebastes ruberrimus) in British Columbia in 2014. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.*

## SUMMARY


- Yelloweye Rockfish is one of the longest-living and largest species in the genus *Sebastes* and occurs in the northeast Pacific from Alaska to Baja California. The species is caught by all fishing gear types (jig, troll, longline, trap, and trawl) in Aboriginal, commercial and recreational fisheries.
- In 2008, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recognized two designatable units, or populations, of Yelloweye Rockfish in British Columbia (BC); these are referred to as “Inside” and “Outside”. Both populations were designated as Special Concern by COSEWIC and then listed as Special Concern under Schedule 1 of the *Species at Risk Act* in 2011. COSEWIC is scheduled to reassess the status of both populations of Yelloweye Rockfish in 2018.
- A non-equilibrium, age-aggregated Bayesian surplus production (BSP) model was used to assess the Outside population of Yelloweye Rockfish in BC, employing catch data derived from historic commercial, recreational and Aboriginal catch records reconstructed back to 1918, life history data to estimate the intrinsic rate of increase ($r$), and abundance trends derived from research surveys and commercial hook and line catch records.
- Sensitivity analyses considered six different sources of uncertainty: assumptions about the historic catch, priors for the intrinsic rate of increase and carrying capacity, process error standard deviation, various abundance indices, form of the surplus production function, and the form of the stock assessment model.
- The biomass in 2014 ($B_{2014}$) is estimated at 3,821 t (90% credibility interval of 2,428 – 7,138 t), which is 18% (90% credibility interval 10 – 33 %) of the estimated initial biomass ($B_{1918}$) of 21,955 t (90% credibility interval 13,747 – 37,694 t) in 1918.
- Fisheries reference points consistent with DFO’s Precautionary Reference Points are presented for this assessment. There is a 63% probability that stock biomass in 2014 is below the Limit Reference Point (LRP) of $0.4B_{MSY}$ and a 99% probability that it is below the Upper Stock Reference (USR) of $0.8B_{MSY}$.
- Advice to management is presented in the form of decision tables, using 5, 10, and 15 year projections, for constant catch policies between 0 and 300 t/year. Replacement yield or surplus production in 2014 is estimated at 162 t (90% credibility interval 80 – 258 t). The current catch of 287 t in 2014 is estimated at 178% (90% credibility interval 114 – 360%) of replacement yield.
- This assessment suggests that the stock has continued to decline, despite more than a decade of rockfish conservation measures. Increases in Yelloweye Rockfish density have not yet been seen in Rockfish Conservation Areas, but given the low productivity of this species, benefits are not expected to be detected until at least 10 years after their closure.
- With the exception of the commercial groundfish fishery since 2006, the reconstruction of the commercial catch is a source of uncertainty in this assessment. This uncertainty can be attributed to a lack of species identification in landings, and inconsistent regional catch monitoring and catch data reporting. There is uncertainty in the commercial groundfish (pre-2006) and Pacific Salmon troll, recreational, and Aboriginal catches throughout these catch time series. Sensitivity tests to address uncertainties in catch were conducted.
- This assessment considers a single Outside stock based on genetic analyses. Further exploration of more spatially explicit harvest advice is recommended to assist with the management of the fisheries in light of the sedentary habit of Yelloweye Rockfish, current spatial management which includes conservation areas where direct commercial and

recreational fishing is prohibited, and area-based individual transferable quotas in the commercial groundfish fisheries.

# INTRODUCTION

Yelloweye Rockfish is distributed in the northeast Pacific from South of Umnak Island in the Aleutian Islands to the coastal town of Ensenada in northern Baja California, Mexico. In British Columbia (BC), the species is commonly observed at depths between 20 and 250 metres and exhibits a demersal existence over hard, complex substrates such as rock reefs and boulder fields. Yelloweye Rockfish is long-lived with ages recorded to 121 years for females and 115 years for males in BC. Females attain older ages and longer lengths than the males, but males display 23% higher growth rates than females. Age at 50% sexual maturity is 15.2 years for females and 17.5 years for males. Yelloweye Rockfish suffer barotrauma injuries and high rates of mortality when brought up rapidly from depth because they cannot deflate the swim bladder quickly.

Yelloweye Rockfish is targeted or incidentally caught by all gear types (jig, troll, longline, trap, and trawl) in Aboriginal, commercial and recreational fisheries. Since the inception of the ZN licensed hook and line rockfish fishery in 1986, fishery management was applied over two management regions: Inside and Outside. These management units closely align with the two genetically distinct populations of Yelloweye Rockfish that are recognized by COSEWIC in BC. Following the implementation of the Groundfish Integration management regime in 2006, Yelloweye Rockfish management has been applied over five management units. The Outside Yelloweye Rockfish population occurs within Pacific Marine Fisheries Commission (PMFC) major areas 3CD and 5ABCDE. Although the boundaries of the Outside Yelloweye Rockfish Designatable Unit (COSEWIC terminology) are slightly inside the management boundaries of PMFC major area 4B, Area 4B is excluded to be consistent with the management boundaries over the historic catch time series.

Since 1986, Yelloweye Rockfish has been assessed together with other inshore rockfish species (*Sebastes spp.*). In the last assessment (2001), harvest advice to managers was to consider an optimal harvest rate ($F$) less than or equal to half of the natural mortality rate ($M$). 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 BC 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. A target harvest rate of less than 2% ($F < M$) was adopted, in conjunction with spatial management whereby areas were closed to commercial and recreational harvest.

Both Inside and Outside Yelloweye Rockfish populations were designated as Special Concern in November 2008 by COSEWIC and listed as Special Concern under Canada's *Species at Risk* Act in July 2011.

A request for science information and advice was received from DFO Fisheries Management to determine the current status of the Outside Yelloweye Rockfish stock relative to DFO's Precautionary Approach provisional harvest reference points and to provide decision tables forecasting the impacts of varying harvest levels. This stock assessment is solely concerned with the Outside population of Yelloweye Rockfish (Figure 1).

# ASSESSMENT

## Methods

This stock assessment employed a non-equilibrium, age-aggregated Bayesian surplus production (BSP) model. A state-space version of the BSP was applied which incorporates both observation error and stochastic process error in the fish stock dynamics. A Bayesian statistical approach was adopted to fit the model to data which allowed for the use of informed prior probability distributions for model parameters that incorporated information and expert judgment. The fitted model was then used to evaluate stock status relative to reference points (at the beginning of 2014) and the future trends in abundance based on alternative total catch policies. Total catch refers to total combined catch from all modeled fisheries, including commercial (groundfish and Pacific Salmon troll), recreational and Aboriginal catch.

A reference case BSP model run was constructed using the most plausible data inputs and sensitivity tests (alternate model runs) were conducted to determine the influence on the model outcomes from varying the data inputs and model assumptions. These sensitivity tests explored six different sources of uncertainty: various catch scenarios, model priors, process error standard deviation, the influence of different abundance index data sources, the form of the surplus production function, and the form of the stock assessment model (BSP vs. delay-difference).

The catch of Outside Yelloweye Rockfish was reconstructed for commercial groundfish fisheries from 1918 to 2006; commercial groundfish catches from 2007 to 2014 are assumed to be fully reported (Figure 2). The reconstruction of commercial groundfish fishery catch was conducted following established procedures, which were subsequently modified through consultations with industry. The commercial Pacific Salmon troll fishery catch of Yelloweye Rockfish was estimated using post season effort estimates and species specific catches since 2000. Recreational hook and line catch was estimated using DFO creel surveys and lodge/guide logbook programs and were correlated with pilot results from the iRec email survey of recreational license holders coastwide. Food, Social and Ceremonial landings from commercial groundfish dual fishing trips were used as the basis of Aboriginal catch estimates, and were included with commercial catches since 2006.

The reference case BSP model was fit to three sets of abundance indices derived from:

1) three synoptic trawl surveys,
2) three longline hook surveys, and
3) five commercial catch per unit effort series, to reconstruct historical trends in abundance.

The longline hook surveys provide the highest catch rate of Yelloweye Rockfish and new longline survey abundance indices were developed to account for hook saturation, other species caught, and empty hooks. These new methods were applied to data from the International Pacific Halibut Commission (IPHC) standardized stock assessment (SSA) survey and the northern and southern Pacific Halibut Management Association (PHMA) surveys. The trawl surveys provide low but consistent catch rates of Yelloweye Rockfish and data from the Hecate Strait Synoptic Survey, Queen Charlotte Sound Synoptic Survey, West Coast Vancouver Island Synoptic Survey and Queen Charlotte Sound Shrimp Survey were used for abundance indices. The commercial hook and line fishery logbook data provide abundance indices from the rockfish, halibut and lingcod fisheries from 1986 to the present.

## Management Advice Run

The reference case was initially proposed as the model run on which management advice would be formulated. However, after consideration of concerns over the estimated recreational and

Pacific Salmon troll catches in early years and the challenges of using fishery dependent abundance indices, a new model run was proposed by the review committee for use in formulating management advice. For this management advice run the recreational fisheries catch time series was initiated in 1975 (zero catches prior to 1975) and increased exponentially to 2000 at which time species specific data became available; the Pacific Salmon troll fishery catch time series prior to 1950 was set to zero; and, the fishery dependent abundance index derived from logbook data was excluded in the model run over concerns that management influence and spatial considerations were not accounted for in the construction of the abundance index.

While it is acknowledged that historical catch was not zero in the recreational and Pacific Salmon troll fisheries in the early years, data to establish alternate catch estimates were limited.

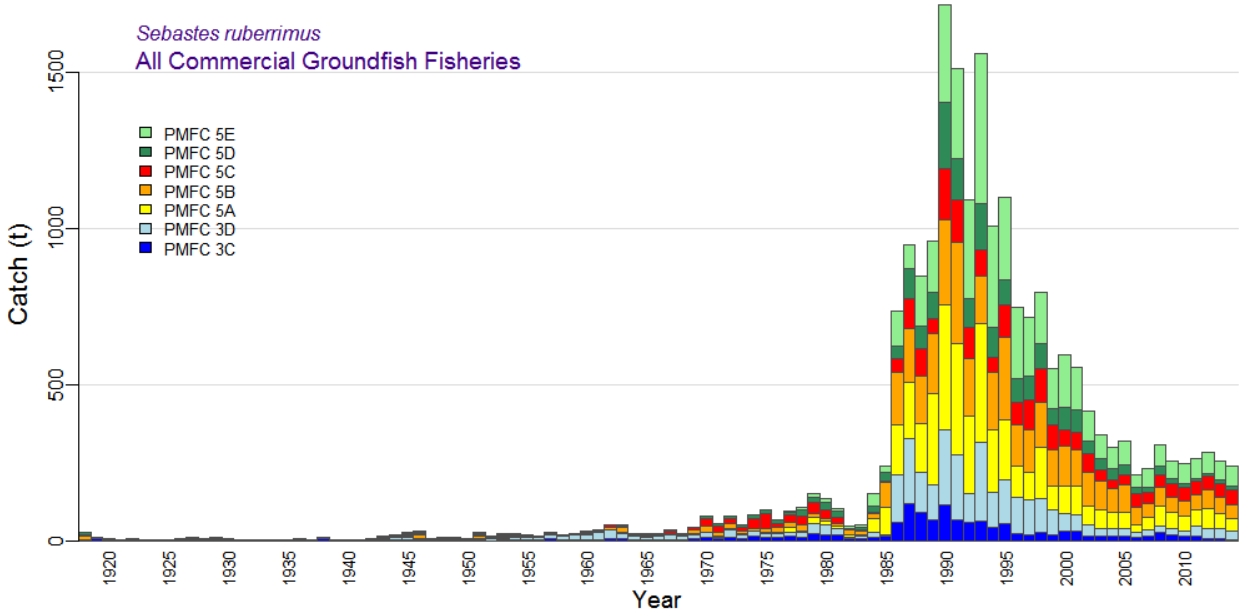


*Figure 2. Outside Yelloweye Rockfish reconstructed groundfish commercial catch from combined groundfish fisheries from 1918 to 2005 and Fishery Operations System catch from 2006 to 2014. Annual catches indicated by coloured stacked bars by Pacific Marine Fisheries Commission (PMFC) management area. Fishery data sources: 1918 – 1950 Canadian Bureau of Statistic, 1951 – 1981 BC Commercial Catch Statistics: Pacific Region, 1982 – 1995 Pacific Region Sales slips, 1996 – 2005 Dockside Monitoring Program, 2006 – 2014 Fisheries Operations System (FOS). Survey catches and dual fishing FSC catches are included in FOS landings.*

# Results

## Reference Case

The BSP model showed good fits to the indices, as the majority of the indices were consistent in their declining trend. Total catches were relatively small up to the mid-1980s and the stock abundance estimates show relatively little decline up until then. The largest catches occurred in the late 1980s and early 1990s from increased effort by the fishing fleets. The IPHC SSA provides the abundance index with the longest time series (1995 to 2014), and initiates after total catches began to decline. This index, together with the other abundance indices, which start after 1995, is consistent with a pronounced decline in the stock from the mid-1980s to about 2005 and a lesser decline since then.

Sensitivity tests showed that model results are sensitive to the various alternative catch histories and relatively insensitive to the various settings for the priors for the maximum intrinsic rate of

increase ($r$) and average unfished stock size or carrying capacity ($K$) and process error standard deviations. The model results were also relatively insensitive to various combinations of abundance indices, largely because these indices all reflect similar declining trends. The results were moderately sensitive to the form of the surplus production function. For example, the posterior medians for $B_{2014}/B_{MSY}$ ranged from 0.45 to 0.25 when model settings for $B_{MSY}/K$ ranged from 0.3 to 0.6 (reference case was set at 0.5). A Delay Difference (DD) model, fitted to the same data as the BSP was used as a sensitivity test for the type of stock assessment employed in the assessment. The DD model results were less optimistic and more precise than the BSP model.

### Management Advice Run

The following results are derived from the review committee proposed management advice run.

The 90% credibility interval for stock biomass supports a very substantial decline since the 1980s (Figure 3), indicating that the catch and stock trend data are informative about the trend in abundance.

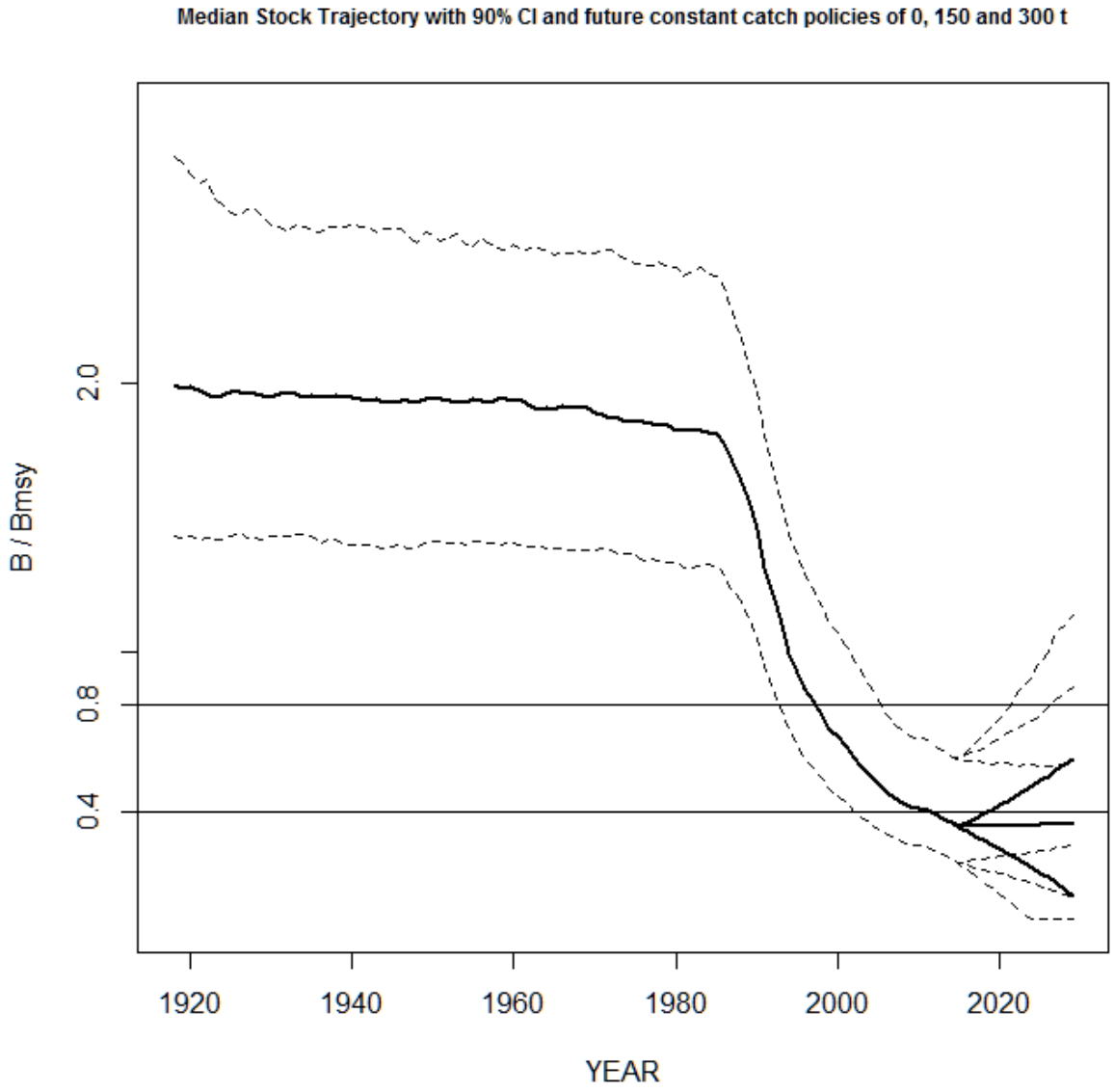


*Figure 3. Outside Yelloweye Rockfish estimated historical median stock biomass and stock trajectory under various total catch scenarios of 0, 150 and 300 tonnes for the management advice run. Solid lines indicate the median and dashed lines show the 90% credibility intervals. Stock projections from 2015 onward show increases given a 0 t catch policy, little change given a 150 t catch policy and further declines given a 300 t catch policy.*

Fisheries reference points consistent with DFO's Precautionary Reference Points (DFO 2009) are presented for this assessment. For the BSP model, $B_{MSY}$ equals 0.5 $B_0$ (half of the unfished biomass for the stock, where $B_0$=$K$). Hence, for the BSP model:

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

*Table 1. The 5th, 50th and 95th percentiles from the posterior distributions of quantities for stock status indicators for BC Outside Yelloweye Rockfish. Variables: r is the maximum intrinsic rate of increase, $B_0$ is the average unfished stock size or carrying capacity, MSY is the maximum sustained yield, $B_{MSY}$ is the biomass at MSY, $B_{1918}$ is the biomass in 1918, the start of the model, $B_{2014}$ is the biomass at the beginning of 2014, F is the fishing mortality rate, $REPY_{2014}$ is the replacement yield at the beginning of 2014, $Catch_{2014}$ is the catch in 2014, P is the probability.*

| | Percentile | | |
|---|---|---|---|
| Variable | 5 | 50 | 95 |
| $r$ | 0.021 | 0.051 | 0.082 |
| $B_0$ | 15833 | 21544 | 33972 |
| MSY | 135 | 276 | 422 |
| $B_{MSY}$ | 7917 | 10772 | 16986 |
| $B_{MSY}/B_0$ | 0.5 | 0.5 | 0.5 |
| $B_{1918}$ | 13747 | 21955 | 37694 |
| $B_{2014}$ | 2428 | 3821 | 7138 |
| $B_{2014}/B_{MSY}$ | 0.227 | 0.360 | 0.604 |
| $B_{2014}/B_{1918}$ | 0.104 | 0.182 | 0.33 |
| $F_{MSY}$ | 0.011 | 0.025 | 0.041 |
| $F_{2014}$ | 0.041 | 0.075 | 0.115 |
| $F_{2014}/F_{MSY}$ | 1.695 | 2.913 | 6.050 |
| $REPY_{2014}$ | 80 | 162 | 258 |
| $Catch_{2014}/REPY_{2014}>0$ | 1.140 | 1.776 | 3.604 |
| $B_{2014}/B_{2002}$ | 0.473 | 0.599 | 0.758 |
| $P(B_{2014}> 0.4B_{MSY})$ | 0.369 | - | - |
| $P(B_{2014}> 0.8B_{MSY})$ | 0.009 | - | - |

The median $B_{2014}/B_{MSY}$ is 0.36 (Table 1) and falls within the Critical zone with the upper bound of the 90% credibility interval spanning into the Cautious zone (Figure 4). There is a 63% probability that stock status is below the LRP and a 1% probability that stock status is above the USR, i.e., a 99% probability that the stock is below the USR.

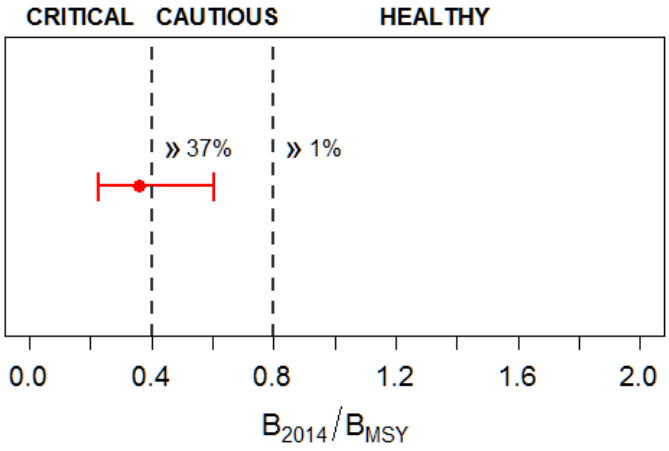


*Figure 4. Stock status for the Outside population of Yelloweye Rockfish from the Bayesian surplus production model run median (point) and 90% credibility interval (horizontal bar) for the ratio of $B_{2014}$ relative to $B_{MSY}$. Vertical dashed lines indicate the limit reference point (0.4 $B_{MSY}$) and upper stock reference point (0.8 $B_{MSY}$). The three stock status zones delineated by these reference points: Critical, Cautious, and Healthy, as indicated at the top of the figure. The arrows show the probabilities that stock status is above the Critical Zone and in the Healthy Zone.*

### Projection Results and Decision Tables

Harvest advice based on the management advice run is presented in a decision table (Table 2) that provides probabilities of the stock being above biomass-based reference points or below exploitation reference points. The projections were made over 5, 10 and 15 year horizons with constant catch policies ranging from 0 to 300 t.

For a catch policy of 0 t, the probability of the biomass exceeding the LRP of 0.4 $B_{MSY}$ any time during a 5 year or 15 year horizon is 55% and 84%, respectively. Similarly for a catch policy of 150 t, the probability of the biomass exceeding the LRP during a 5 year or 15 year horizon is 43% and 54%, respectively. For a catch policy of 300 t, the probability of the stock exceeding the LRP during a 5 year or 15 year horizon is 33% and 35%, respectively.

The probability of the stock exceeding the USR of 0.8 $B_{MSY}$ at a catch policy of 0 t any time during a 5 year or 15 year horizon is 3% and 26%, respectively. Similarly, for a catch policy of 150 t, the probability of the stock exceeding the USR during a 5 year or 15 year horizon is 2% and 8%, respectively. For a catch policy of 300 t, the probability of the stock exceeding the USR during a 5 year or 15 year horizon is 1.5% and 2.4%, respectively.

*Table 2. Stock status indicators for Outside Yelloweye Rockfish after 5, 10 and 15 year time horizons (Hz) under various constant catch policies (total fishing mortality) in tonnes. $B_{fin}$ and $F_{fin}$ are the biomass and fishing mortality, respectively, in the final year of the time horizon, $B_0$ is the average unfished stock size or carrying capacity $B_{2014}$ is the biomass at the beginning of 2014, and $B_{MSY}$ and $F_{MSY}$ are the biomass and fishing mortality, respectively, at maximum sustainable yield. Probabilities are presented for six stock status indicators: $P(B_{fin}>0.4\ B_{MSY})$ is the probability of the biomass in the final year of the time horizon being above the Limit Reference point of 0.4 $B_{MSY}$. $P(B_{fin}>0.8\ B_{MSY})$ is the probability of the biomass in the final year of the time horizon being above the Upper Stock Reference of 0.8 $B_{MSY}$. $P(B>0.4\ B_{MSY}$ in Hz) is the probability of the biomass being above the Limit Reference Point (0.4 $B_{MSY}$) at any time within the given time horizon (Hz), with a similar definition for $P(B>0.8\ B_{MSY}$ in Hz). $P(F_{fin}<F_{MSY})$ is the probability of the fishing mortality in the final year of the Hz ($F_{fin}$) being below the fishing mortality at MSY.*

| Catch Policy | Median($B_{fin}/B_0$) | Median($B_{fin}/B_{MSY}$) | P($B_{fin}$>0.4 $B_{MSY}$) | P($B_{fin}$>0.8 $B_{MSY}$) | P($B_{fin}>B_{2014}$) | P($B$>0.4 $B_{MSY}$ in Hz) | P($B$>0.8 $B_{MSY}$ in Hz) | P($F_{fin}<F_{MSY}$) |
|---|---|---|---|---|---|---|---|---|
| Hz = 5y | | | | | | | | |
| 0 | 0.204 | 0.408 | 0.523 | 0.027 | 0.743 | 0.545 | 0.027 | 1.000 |
| 50 | 0.197 | 0.393 | 0.487 | 0.024 | 0.659 | 0.518 | 0.025 | 0.925 |
| 75 | 0.191 | 0.382 | 0.456 | 0.023 | 0.595 | 0.495 | 0.024 | 0.742 |
| 100 | 0.186 | 0.372 | 0.415 | 0.021 | 0.532 | 0.468 | 0.023 | 0.506 |
| 125 | 0.180 | 0.361 | 0.391 | 0.018 | 0.474 | 0.446 | 0.020 | 0.297 |
| 150 | 0.174 | 0.348 | 0.359 | 0.017 | 0.418 | 0.427 | 0.019 | 0.159 |
| 200 | 0.163 | 0.326 | 0.304 | 0.015 | 0.307 | 0.386 | 0.018 | 0.040 |
| 250 | 0.152 | 0.304 | 0.258 | 0.013 | 0.208 | 0.359 | 0.017 | 0.013 |
| 300 | 0.140 | 0.280 | 0.216 | 0.013 | 0.143 | 0.333 | 0.015 | 0.006 |
| Hz = 10y | | | | | | | | |
| 0 | 0.250 | 0.500 | 0.718 | 0.102 | 0.856 | 0.745 | 0.107 | 1.000 |
| 50 | 0.229 | 0.457 | 0.624 | 0.075 | 0.768 | 0.668 | 0.084 | 0.928 |
| 75 | 0.215 | 0.431 | 0.564 | 0.059 | 0.700 | 0.623 | 0.067 | 0.760 |
| 100 | 0.203 | 0.405 | 0.509 | 0.049 | 0.619 | 0.572 | 0.055 | 0.567 |
| 125 | 0.190 | 0.380 | 0.459 | 0.043 | 0.526 | 0.540 | 0.048 | 0.368 |
| 150 | 0.175 | 0.351 | 0.402 | 0.037 | 0.452 | 0.497 | 0.042 | 0.224 |
| 200 | 0.149 | 0.298 | 0.314 | 0.024 | 0.310 | 0.441 | 0.029 | 0.066 |
| 250 | 0.122 | 0.244 | 0.224 | 0.020 | 0.198 | 0.382 | 0.023 | 0.017 |
| 300 | 0.096 | 0.192 | 0.163 | 0.016 | 0.100 | 0.348 | 0.019 | 0.009 |
| Hz = 15y | | | | | | | | |
| 0 | 0.299 | 0.598 | 0.811 | 0.245 | 0.909 | 0.842 | 0.258 | 1.000 |
| 50 | 0.264 | 0.529 | 0.706 | 0.183 | 0.808 | 0.768 | 0.199 | 0.923 |
| 75 | 0.243 | 0.485 | 0.641 | 0.139 | 0.736 | 0.709 | 0.157 | 0.774 |
| 100 | 0.221 | 0.441 | 0.569 | 0.111 | 0.649 | 0.646 | 0.123 | 0.588 |
| 125 | 0.199 | 0.398 | 0.497 | 0.090 | 0.562 | 0.596 | 0.100 | 0.415 |
| 150 | 0.178 | 0.355 | 0.435 | 0.071 | 0.460 | 0.544 | 0.084 | 0.271 |
| 200 | 0.133 | 0.266 | 0.300 | 0.042 | 0.290 | 0.464 | 0.054 | 0.084 |
| 250 | 0.089 | 0.178 | 0.199 | 0.024 | 0.161 | 0.392 | 0.031 | 0.032 |
| 300 | 0.045 | 0.089 | 0.124 | 0.017 | 0.083 | 0.351 | 0.024 | 0.014 |

## Sources of Uncertainty

The primary sources of uncertainty in this assessment are the catch histories. With the exception of the commercial groundfish fishery since 2006, reconstruction of the commercial, recreational and Aboriginal catch is uncertain. This uncertainty can be attributed to a lack of species identification in landings, and inconsistent regional catch monitoring and catch data reporting. This uncertainty was explored against the initial reference case through multiple sensitivity runs which indicate that the model is sensitive to the catch scenario applied but none of the scenarios considered suggest stock status results dramatically different from the reference case, including the management advice run. The stock has declined with the removal of catches beginning in the mid 1980's and is estimated to be below the LRP.

The fishery independent abundance indices available for use in the assessment are all short time series, with the exception of the International Pacific Halibut Commission Standardized Stock Assessment Survey. All surveys were initiated after the largest fishery removals in the 1980s. All abundance indices show overall declining trends, with the exception of one or two data points. Fishery-dependant abundance indices span the time period of high fishery catches and exist for all years. However, these data were not used to formulate management advice because of the influence that management actions have on the fishery together with the spatial component of fishing, and these influences were not explicitly accounted for in the analysis.

Rockfish Conservation Areas (RCAs), which account for 15% of habitat, were not explicitly considered in this assessment. Research using remotely operated vehicles between 2009 and 2011 has shown that densities of Yelloweye Rockfish in the RCAs are not different from densities in open areas. It is not expected, at this time, that the assessment would be affected by these closed areas. Future Yelloweye Rockfish assessments may need to consider population trends in the RCAs to avoid any potential bias that could be introduced when fish abundance in the RCAs becomes different from those in open areas. Monitoring populations in the RCAs and understanding how to incorporate RCAs into stock assessments may be an important area for future research.

## CONCLUSIONS AND ADVICE

The BC Yelloweye Rockfish is characterized as a long-living and slow growing fish with low productivity. Fishery removals from the Outside population peaked in the mid to late 1980s and have declined since. Model results estimates the stock biomass in 2014 to be 18% of the unfished biomass $B_0$. There is a 63% probability that stock biomass in 2014 is below the LRP of 0.4 $B_{MSY}$ and a 99% probability that stock biomass in 2014 is below the USR of 0.8 $B_{MSY}$.

Harvest advice is presented in the form of decision tables, using 5, 10 and 15 year projections, for constant catches between 0 and 300 t/year. Predicted outcomes of harvest decisions depend upon the choice of time horizon, harvest policy, and reference point. In general, the median $B_{fin}/B_0$ increases with the time horizon and with lower catches. Total catches greater than the replacement yield or surplus production of 162 t (90% credibility interval of 80 – 258 t) in 2014 have a higher probability of resulting in further population declines. Catches in 2015 of 150 t or less show no net population declines over the stock projections to 2029 (Figure 3).

This assessment assumes a single Outside stock. Further analysis to develop more spatially explicit harvest advice is recommended to assist with the management of the fisheries considering various factors:

1) the sedentary characteristics of Yelloweye Rockfish;
2) current spatial management which includes conservation areas where direct commercial and recreational fishing is prohibited; and

3) area-based individual transferable quotas in commercial groundfish hook and line and trap fisheries. Spatially explicit commercial catch and several fishery-independent survey data sets are available and could be used to develop area-based harvest plans.

Monitoring of Rockfish Conservation Areas (RCAs) would need to continue to enable an assessment of whether the population of Yelloweye Rockfish is increasing inside versus outside of the RCAs. While research between 2009 and 2011 has not shown evidence of increases in fish density in the RCAs, the benefits of closed areas are not expected to be detected for at least 10 years after their closure given the low productivity of this species.

Reassessment of Outside Yelloweye Rockfish is recommended in 10 years; however, research into new spatial assessment methods may be conducted within a shorter timeframe. Both the Inside and Outside stocks are scheduled for COSEWIC status reassessment in 2018.

## SOURCES OF INFORMATION

This Science Advisory Report is from the September 15, 16, and 24, 2015 Stock Assessment for the Outside population of Yelloweye Rockfish (*Sebastes ruberrimus*) in British Columbia in 2014. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2009. A fishery decision-making framework incorporating the Precautionary Approach. (Accessed 02 November 2015)

## THIS REPORT IS AVAILABLE FROM THE:

Centre for Science Advice
Pacific Region
Fisheries and Oceans Canada
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

Telephone: (250) 756-7208
E-Mail: csap@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087
© Her Majesty the Queen in Right of Canada, 2015

Correct Citation for this Publication:

DFO. 2015. Stock Assessment for the Outside population of Yelloweye Rockfish (*Sebastes ruberrimus*) for British Columbia, Canada in 2014. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/060.

*Aussi disponible en français :*

*MPO. 2015. Évaluation du stock de sébastes aux yeux jaunes (Sebastes reberrimus) des eaux extérieures de la Colombie-Britannique en 2014. Secr. can. de consult. sci. du MPO, Avis sci. 2015/060.*