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Proceedings of the Pacific regional peer review on the stock assessment for Pacific Ocean Perch (*Sebastes alutus*) in Queen Charlotte Sound, British Columbia in 2017

June 1 - 2, 2017
Nanaimo, British Columbia

Chairperson: Lesley MacDougall
Editor: Linnea Flostrand

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

These proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting on June 1-2, 2017 at the Pacific Biological Station in Nanaimo, British Columbia (BC). The working paper focusing on Pacific Ocean Perch (*Sebastes alutus*, POP) stock assessment in Queen Charlotte Sound was presented for peer review.

In-person and web-based participation included Fisheries and Oceans Canada Science and Fisheries and Aquatic Management Sectors staff; and external participants from the U.S. National Ocean and Atmospheric Administration (NOAA), the BC commercial fishing sector, Central Coast Indigenous Resource Alliance (CCIRA), Parks Canada, and non-governmental environmental organizations.

The conclusions and advice resulting from this review will be published in a Science Advisory Report (SAR) providing advice to DFO Fisheries and Aquaculture Management to inform fisheries management decisions. The Science Advisory Report and supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat website.

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) meeting was held on June 1-2, 2017 at the Pacific Biological Station in Nanaimo to review the stock assessment of Pacific Ocean Perch in Queen Charlotte Sound, British Columbia (BC), Canada.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from DFO Fisheries and Aquaculture Management. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from DFO Science and Fisheries and Aquatic Management Sectors staff, First Nations, U.S. National Ocean and Atmospheric Administration (NOAA), Alaska Department of Fish and Wildlife, the BC commercial and recreational fishing sector, Central Coast Indigenous Resource Alliance (CCIRA), Parks Canada, and non-governmental environmental organizations.

The following working paper (WP) was prepared and made available to meeting participants prior to the meeting (see WP abstract in Appendix B):

Stock assessment for Pacific Ocean Perch (Sebastes alutus) in Queen Charlotte Sound, British Columbia in 2017. CSAS WP 2014GRF005.

The meeting Chair, Lesley MacDougall, welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chair discussed the role of participants, the purpose of the various RPR publications (Research Document, Science Advisory Report, and Proceedings), and the definition and process around achieving consensus decisions and advice. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the Terms of Reference, working papers, written reviews and agenda.

The Chair reviewed the Agenda (Appendix C) and the Terms of Reference for the meeting, highlighting the objectives and identifying Linnea Flostrand as the Rapporteur for the review. The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. The room was equipped with microphones to allow remote participation by web-based attendees, and in-person attendees were reminded to address comments and questions so they could be heard by those connecting via phone.

Members were reminded that everyone at the meeting had equal standing as participants and that they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. In total, 17 people participated in the RPR (Appendix D).

Participants were informed that Dr. Paul Spencer (NOAA) and Chris Grandin (DFO) had been asked before the meeting to provide detailed written reviews of the working paper to assist everyone attending the peer-review meeting. Participants were provided with copies of the written reviews.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report (SAR) to Fisheries and Aquaculture Management to inform planning of groundfish fisheries. The SAR and supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

REVIEW

Working Paper: Stock assessment for Pacific Ocean Perch (*Sebastes alutus*) in Queen Charlotte Sound, British Columbia in 2017. CSAS WP 2014GRF005.

Rapporteur: Linnea Flostrand

Presenters: Rowan Haigh, Paul Starr, and Andrew M. Edwards

PRESENTATION OF WORKING PAPER

A summary of the methods and findings reported in the WP was presented, which included information on:

- the geographical representation of catches and catch density from commercial trawl fishing and research surveys;
- catch data sets, data weighting procedures and trends from survey time series, with emphasis on new information since 2010 assessment;
- provisional base case assessment model inputs:
  - three sets of trawl survey index values, commercial trawl fishery and research survey age frequency (AF) data, and trawl catch data from 1940 to 2016;
- changes since the 2010 assessment: outlining the main differences adopted in 2017:
  - the inclusion of catches from waters south of 52°20’ in Pacific Marine Fisheries Commission (PMFC) Area 5E (Anthony Island) – these catches were ignored in 2010;
  - the relative abundance index coefficients of variation (CVs) were adjusted for each survey to bring the SDNR (standard deviation of normalized residuals) close to 1.0, the theoretical value it should hold if the distributional assumption is correct. This calculation was done *before* re-weighting the age frequency data and no process error was added afterwards. This procedure was also followed in 2010, but was done in conjunction with reweighting the age composition data;
  - the Francis (2011) procedure to reweight the effective sample size for the age frequency data was applied;
  - uniform priors for the survey selectivity parameters was applied – whereas in 2010 informative normal priors were applied;
- base case MPD (mode of the posterior distribution) results;
- base case Markov Chain Monte Carlo (MCMC) results:
  - estimated parameters (medians and 90% credibility intervals);
  - MCMC diagnostic plots (trace plots, cumulative traces for three consecutive segments, autocorrelation) for the leading parameters;
  - plots comparing the prior and posterior distributions;
  - time series plots showing the trajectories of catch and estimates of: vulnerable (males + females) and spawning (females) biomass, spawning biomass depletion, recruitment, exploitation, and projected biomass under various catch strategies;
  - a phase plot of the medians of u_{t-1}/u_{MSY} vs. B_t/B_{MSY};

- decision tables for 2017-2022 providing projection probabilities of B_t exceeding the interim DFO targets of $0.4B_{MSY}$ (limit reference point, LRP) and $0.8\ B_{MSY}$ (upper stock reference, USR), and of u_t remaining below u_{MSY} (harvest rate at MSY);
- sensitivity analyses and MCMC simulation results representing four model input changes:
  - removal of the Queen Charlotte Sound (QCS) shrimp survey relative abundance index series;
  - halving and doubling the catch during the foreign fleet period (1965-75);
  - using the observed survey CVs instead of reweighting to achieve standard deviation of normalized residuals (SDNR) =1.0;
- MCMC trace plots and summaries of median quantities provided for each sensitivity run;
- stock status box plots relative to $0.4B_{MSY}$ and $0.8B_{MSY}$ showing results from:
  - the 2017 base case and sensitivity runs reported in the working paper;
  - the 2010 stock assessment (Edwards et al. 2012);
  - a bridging analysis using 2010 data with 2017 methods, showing that the main changes are due to updated data;
- environmental/ climatological effects on POP recruitment for assessing potential prediction power, which included:
  - a recruitment estimation method in a Bayesian framework using JAGS (Just Another Gibbs Sampler, Plummer 2003);
  - 10 time series of climate indices (regional and large scale indicators);
  - an indicator of sea level at Prince Rupert linked to mechanics of Haida Gwaii eddies;
  - results that indicated “no discernable effect” because the 90% credible interval of the influence of each covariate (climate index) included 0;
  - a main conclusion that strong climatic or environmental drivers of Pacific Ocean Perch (POP) 5ABC recruitment could not be detected; therefore, ecosystem information could not be incorporated at this time;
  - methods used are applicable to studies on other fish stocks;
- the 5ABC POP stock assessment is already included in a multi-year assessment schedule framework:
  - authors recommended keeping the next scheduled assessment in 2022;
  - additional information will be available from 3 more years of the QCS synoptic trawl survey and 5 more years of fishery data by 2022;
  - decision table projections explicitly provide harvest advice in interim years;
- no potential indicators recommended for interim harvest advice (between 2017 and 2022) because none are believed to be sufficiently informative;
- the removal of the QCS shrimp survey index from the base case stock assessment advice was suggested by authors due to:
  - the survey having poor spatial coverage, both aerial and by depth, in the region (QCS);
  - redundancy with the QCS synoptic trawl survey;

- recommended future work:
    - continue data collection and incorporation of age and length samples from fishery and survey sources;
    - develop an informative selectivity prior for the QC Sound synoptic groundfish survey;
    - further investigate POPs ecological role;
- authors noted they would be presenting additional information (reported below) to address reviewer feedback.

PRESENTATION OF WRITTEN REVIEWS

Paul Spencer (NOAA) and Chris Grandin (DFO) provided written reviews of the WP in advance of the meeting, which reviewed the validity of the approach, including the use of data and the applied methodology. Below is a brief summary of the main points discussed during the reviews.

PAUL SPENCER, NOAA

The authors clarified that the length data were not used in the assessment but were provided in the WP for general information; the authors suggested the removal of the length data from the final research document. They also clarified that the otolith sample collections for ageing are intended to represent random samples. The reviewer suggested that age-length keys could be used in years when there are insufficient ageing data for direct use in the model. The reviewer's suggestion was deemed reasonable and worth considering in future assessments but it was not a priority for the current assessment (5ABC POP) because there is already a considerable amount of age data available.

Information presented on predicted and observed proportions-at-age was reviewed. The reviewer noted that some fits were quite poor (e.g. 2005 trawl fishery) and it was recognized that causes may be related to changes in fishery behaviour (selectivity) over time and sampling issues. The reviewer suggested using the root mean square error (RMSE) could be used as a diagnostic tool of the differences between model and data estimates. This was acknowledged by authors as reasonable and that future work to explore tradeoffs between data components could be done using RMSE or other methods. The reviewer explained that he had been similarly challenged and took the approach of estimating selectivity for different fishing periods which required fewer parameters. The reviewer offered to provide literature examples. The authors commented that estimating changing selectivities over time made strong demands on the available data, with the potential for confounding with abundance trends.

The reviewer suggested using dome-shaped selectivity for the QCS Shrimp survey to see if that may help the fit by accounting for the survey not fishing in deeper waters where older fish are expected to reside (see author response below).

Future work suggested by the reviewer included the use of retrospective analysis to show residual patterns of survey indices and selectivities. The authors agreed that such analyses may prove useful but acknowledged that time and resource constraints had prevented their implementation to date.

Clarification was sought on how density estimates from surveys are expanded across a survey area to account for untrawlable/protected fishing grounds. The response was that as more sites are identified as unfishable, the time series is reanalyzed based on an adjusted and smaller estimate of the survey area. Consequently, unfishable ground is not included in the survey biomass estimates.

Clarity was sought on how exploitation rates were calculated and if variation in the size-at-age composition of catch between years was included in the calculation. Authors explained they calculated exploitation by dividing biomass of reported catch by assessment model estimates of (vulnerable) biomass for a given year, which assumes that size-at-age remains constant. Authors thought that this assumption was reasonable for long-lived species and that there was no strong evidence for variation in growth over time and space.

The reviewer wanted to know why constant catch projections were provided instead of advice related to exploitation rate or fishing mortality. It was explained that DFO Fishery Managers prefer constant catch projections, and that these fisheries were not managed on the basis of exploitation rates because such a management approach requires more frequent stock assessment updates.

CHRIS GRANDIN, DFO

The reviewer acknowledged that the authors had addressed his suggestion to present MCMC diagnostics for the sensitivity cases (which they had provided in their presentation) and applauded their attempt at relating environmental effects with recruitment.

Authors clarified the reviewer's question about MCMC subsampling (6 million iterations sampled every 5000th for 1200 samples with the first 200 discarded as burn-in, not 1000 samples selected every 6000th across 6 million iterations with no burn-in).

Authors agreed to remove sentence referencing Ketchen (1980) who estimated rockfish/POP catch from areas 3CD and 5DE (waters outside 5ABC) as the information was confusing and unnecessary in the current assessment paper.

The authors explained that there are no doorspread data for the QCS shrimp survey because net mensuration gear was not used. The estimate of 29.6 m was provided by a DFO Science staff member not able to participate in the review. It was agreed that since the abundance index is relative, the actual value used for the doorspread is not important. The authors agreed that the assumption of a constant doorspread value is likely an over-simplification.

The reviewer noted possible editorial confusion in the WP related to the plotted maturity ogives and the description in the text. Authors clarified that the fitted relationship was derived using only data from ages 2 to 25 but the predicted ogive from this fit was applied to ages 9 to 60 year olds, with age 15 being the first age to reach 100% maturity and all ages after 15 were fixed to be 100% mature. The authors also noted that the maturity ogive is only used to estimate the size of the female spawning population and does not directly enter into the model reconstruction calculations.

The reviewer corrected his point in the written review that stated there was no evidence to support the need for a two-sex model. He had not noticed that the scales of the plots depicting female and male von Bertalanffy growth curves were different when he wrote the review.

The reviewer suggested additional editorial revisions related to: interpretation of equation C.5 (Hoenig's 1983 equation for total mortality), which assumes continuous, non-varying recruitment (whereas the assessment model does not), and clarifying in Appendix F that the 3 MCMC chains of 220,000 were combined to pool recruitment samples. Authors agreed to the revisions.

The reviewer asked whether shore-side and freezer-trawl POP caught incidentally by the hake trawl fishery were included in the assessment. Authors stated that they believed so, but would check with the colleague who maintains the catch data.

A future work suggestion was made to conduct histological analysis of ovary samples to improve the maturity ogive. There was agreement that the information would be useful but that new resources would be required to undertake histological analyses. The authors noted that if female maturity has been modelled correctly, the assessment should be fine as is. However, if batch- or skip-spawning occurs, it would be important to characterize this behaviour as it would affect the accuracy of the assessment.

The suggestion to incorporate ageing error was made. The authors agreed that including ageing error would be a better representation of the ageing procedure, but noted that model results would likely remain very similar to what was presented because as long as the ageing was unbiased, recruitments would be spread over more age classes but the net amount of recruitment would be similar to what was presented.

ADDITIONAL AUTHORS' RESPONSES

In response to points reported in the written reviews, the authors presented additional slides relating to information summarized below.

Under the Francis (2011) re-weighting procedure, the weighting of survey samples by adding process error and age frequency data by adjusting for mean age will increase the relative weight on the abundance data and decrease the weight for the composition data.

Authors explained why trawl survey catchability (*q*) estimates should be small (because the area surveyed is small compared to the entire assessment area) and it was pointed out that the model fits multiple parameters, in addition to *q*. The authors endorsed future work to investigate QCS synoptic trawl survey catchability, including the development of an informative prior on *q* for this survey.

The authors presented an alternative fit to the maturity data using a logistic model instead of the double normal function to see how each represented maturity-at-age. The authors pointed out that fits of both models were similar but the logit fit tending to over represent maturity at younger ages, and the logistic model appeared to never reach 100% maturity (asymptotic). Previous work with Rick Stanley (retired DFO, pers. comm.) indicated that these analytic models (logistic or double normal) overestimated the proportion of mature females at younger ages. Consequently, the maturity proportions at ages 2-8 were set at the observed values rather than use the inflated model estimates and then were switched to the fitted values from age 9 and up. Maturity at ages greater than 15 were fixed to 1.0 because it was assumed that females could not become "immature" after reaching maturity.

Standardized residuals for the model fits of the age data (by sex) from the trawl surveys and fishery are within the expected tolerances, given the distributional assumptions (< 2 standard deviations). Model fits to the trawl survey age data show greater variability. There are some patterns in the age composition residuals. For instance, the fits to the commercial fishery female age 60+ group are negative while those for the males are positive. Other age groups show patterns in the residual fits where they are not centered near zero. Such patterns are often caused by processes outside the model's domain for which there may not be data to explore.

An additional analysis was prepared and presented to compare empirical maturity ogives estimated within 6-year groupings ordered by time. This comparison showed considerable overlap, suggesting no strong temporal shift in maturation over time. Some participants noted that the maturity estimates for older females were often below 1.0, possibly indicating cyclic or skipped spawning. It was noted that some stock assessments in Alaska no longer use spawner-recruit curves but incorporate skipped spawning in their models. Skipped spawning has also been identified for hake and some rockfish species.

It was noted that age distributions from the 1999 QCS shrimp survey appeared to be consistent with the equivalent age distribution from the 1999 commercial trawl fishery. Consequently, it may be possible to include this age frequency in future 5ABC stock assessments.

Based on Paul Spencer's review, four additional sensitivity runs which included MCMC simulation were presented on the second day of the meeting. Trace plots and cumulative frequency distributions of leading parameters were presented, along with boxplots comparing stock status (B_t/B_{MSY}) and M posterior distributions. Summary points related to the additional sensitivity runs are listed below.

- Revised M prior: μ=0.07; SD= 0.014; CV= 0.2, with QCS shrimp survey data:
  - biomass status slightly greater than the comparable WP model;
  - considerable autocorrelation in M and R_0.
- Same as previous sensitivity case but without QCS shrimp survey data:
  - biomass status and width of credibility interval increased (with omission of QCS shrimp survey data);
  - considerable autocorrelation in M and R_0.
- Model run which included QCS shrimp age data (1999 only), assumed dome-shaped selectivity which was estimated using uniform priors (M prior: μ=0.06 SD= 0.06; CV= 0.1):
  - similar biomass status unchanged relative to comparable WP model;
  - autocorrelation in selectivity parameters.
- Uniform prior on M (no assumed information), without QCS shrimp survey:
  - poor MCMC diagnostics;
  - strong autocorrelation in $\log(R_0)$, M and q.

MCMC diagnostics showed that loosening the restrictions on the informative M prior (by assuming a normal prior distribution with a higher mean and wider SD or using a uniform distribution) led to instabilities in the MCMC diagnostics, with unacceptable autocorrelation, even though the MPD estimates were similar to those using the initial WP base case.

GENERAL DISCUSSION

ACCIDENTAL INCLUSION OF ADDITIONAL SURVEY PROCESS ERROR

At the end of the first day, the authors realized that additional process error (CVpro) had been inadvertently added to the survey CVs. The bug in the code was fixed, and the authors re-ran three representative MCMC runs overnight to compare results using the intended survey weighting with those from the unintended weighting (presented on Day 1). The corrected runs resulted in survey SDNRs which approximately equal 1.0, the expected value given the distributional assumption:

- Run09 – the sensitivity case without the QCS shrimp survey (the putative new base case);
- Run08 – the initially proposed WP base case which included the QCS shrimp survey; and
- Run12 – same as Run08 (include QCS shrimp) but did not add any additional process error to the observed survey CVs.

In general, the revised runs estimated similar values for all parameters, including the derived parameters used to provide management advice, with less uncertainty in the credibility intervals.

ENVIRONMENTAL VARIABILITY ON RECRUITMENT

Meeting participants asked whether previous work (e.g. Hourston and Thompson 2010) on upwelling indices was considered when exploring climatological information. In response, the authors explained that this past work was applied mainly to the west coast of Vancouver Island (out of the scope of this stock assessment) but more recent work associated with particle experiments and regional ocean modeling systems models may be worth considering for future work in the POP 5ABC region.

It was suggested that histograms relating environmental variability with POP recruitment might suggest possible effects. The approach taken, assigning significance based solely on whether an estimated difference lies within a 90% credibility interval, may incorrectly lead to the conclusion that an index has no effect. It treats Bayesian output in a frequentist manner. The Bayesian results might better be used in terms of the probability that an index has on a recruitment event (e.g., the probability that a negative Pacific Decadal Oscillation index has on doubling the average recruitment).

It was pointed out that the time series of recruitment estimates shows little contrast due to the infrequency of very strong year classes, thus providing limited observations for building relationships with environmental indices. There was general agreement that the methods undertaken for the WP were reasonable but might be more appropriate for species with greater and more frequent variability in recruitment (e.g. Rock Sole).

MULTI-YEAR/ INTERIM ADVICE

The meeting participants agreed that the next POP 5ABC stock assessment should occur in 2022. This five year assessment cycle would mean that three new years of synoptic trawl survey indices and five years of commercial fishery data would be available for the next assessment. Intervals of 5-6 years between stock assessments have been the standard since 2000 for many groundfish species, with acceptance that shorter-lived species should be assessed more frequently. There was also agreement that management advice for the interim years should be based on the decision tables, which provide 5-year probability projections of stock status with respect to reference points under various constant-catch scenarios. Uncertainties in the projections were acknowledged, stemming from the inability to detect strong year classes due to time lags until when they have recruited to the fishery (~10 years), interruptions in survey time series, and long breaks in assessment cycles.

Possible interim-year stock status indicators were discussed. It was agreed that CPUE information was expected to be a poor indicator of stock status due to the variability in fishery behaviour. Data from the QCS synoptic trawl survey were considered to be the most likely interim-year stock status indicator, but this is a biannual index and there are no DFO guidelines on how to address uncertainty related to survey catchability. Finally, any update to the stock assessment would require a one-year notice so that age samples can be made available for inclusion in the model. These built-in delays mean that a 5-6 year assessment interval reflects the reality of preparing for this stock assessment.

UNCERTAINTIES

The below sources of uncertainty were identified.

- This species exhibits episodic high-recruitment events with no predictable pattern.

- Unaccounted for skipped spawning and variations in fecundity may occur thus biasing stock assessment outcomes.
- Uncertainty in the stock assessment results associated with multi-year biomass projections increases with length of projection period.
- All observations used to inform the assessment are from bottom trawl fishing and there is uncertainty whether a midwater stock component exists and if so to what extent.

FUTURE WORK

In association with uncertainties and information gaps, the below suggestions for future work were identified.

- The exploration of alternative candidate reference points is warranted because estimates of B_{MSY} and B_0 are sensitive to changes in data and modelling methods. Examples of possible alternative reference points include estimates related to exploitation rates or spawner per recruit.
- The development of informative priors on survey catchability (q).
- The exploration of alternative methods of characterizing natural mortality (M).
- The exploration of autocorrelation in recruitment (lags).
- The exploration of alternative ways to model age or sized based fecundity, which may include the use of weighted maturity curves, gonad histological studies, and developing a statistical technique to represent ageing error.
- The development and incorporation of a length-age key to represent years with missing age data.
- The model assumes that the entire 5ABC POP stock remains in the geographic area represented by 5ABC, but investigating stock movements (migration, dispersion, etc.) could be considered for future research.
- Additional investigation and collection of data to further explore possible temporal shifts in maturity may be warranted as available data to investigate such shifts are sparse.
- The inclusion of retrospective analyses in future stock assessments.

CONCLUSIONS

The Working Paper was accepted. There was consensus among participants that revisions only include assessment runs without the CVpro error and to adopt the stock assessment run which excludes the QCS shrimp trawl survey data as the revised base case for the Science Advisory Report and Research Document. The reasons to exclude the shrimp trawl survey data from the accepted base case include:

- limited depth and areal coverage for POP in 5ABC,
- no improvement provided when fitting the model assuming dome-shaped selectivity, and
- redundancy with the QCS synoptic survey, which does a better job of representing POP habitat and stock dynamics.

Participants contributed to drafting the Science Advisory Report (SAR) by outlining conclusions, recommendations, sources of uncertainty, suggested future work ideas and discussing the figures and tables to include. The time lines and steps for drafting, revising and submitting the SAR, Proceedings, and Research Document were explained.

There was agreement that advice to management be provided in the form of decision tables providing probabilities of exceeding various reference points over 5 years under a set of constant catch policies. The provisional DFO reference points (0.4B_{MSY}, 0.8B_{MSY}, u_{MSY}) were accepted for advice and alternative reference points (B_{MSY}, B_{2017}, 0.2B_0, and 0.4B_0) were provided as standard supplements in POP assessments. There was agreement on the recommendation that the next stock assessment be scheduled in 2022, with the catch projection decision tables providing interim advice. This timeframe allows for the inclusion of three more years of QCS synoptic survey data and five more years of commercial catch and ageing data in the next full stock assessment.

ACKNOWLEDGEMENTS

We appreciate the time contributed to the RPR process by all participants. In particular, we thank the reviewers, Paul Spencer and Chris Grandin for their time and expertise. We also thank Lesley MacDougall as Chair of the meeting and Linnea Flostrand as the Rapporteur.

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APPENDIX A: TERMS OF REFERENCE

STOCK ASSESSMENT FOR PACIFIC OCEAN PERCH (SEBASTES ALUTUS) IN QUEEN CHARLOTTE SOUND, BRITISH COLUMBIA IN 2016

Regional Peer Review Process – Pacific Region

June 1-2, 2017
Nanaimo, British Columbia

Chairperson: Lesley MacDougall

Context

Pacific Ocean Perch (POP, *Sebastes alutus*) is a commercially important species of rockfish that inhabits the marine canyons along the coast of British Columbia. Of the current annual Total Allowable Catch (TAC) of rockfish on the west coast of Canada, POP has the second largest single-species quota after Yellowtail Rockfish (*S. flavidus*). The status of Pacific Ocean Perch in Queen Charlotte Sound (QCS), British Columbia will be assessed under the assumption that it is a single stock harvested in Pacific Marine Fisheries Commission (PMFC) major areas 5A, 5B, 5C, and 5E south of 52º20′, collectively referred to as 5ABC.

The last assessment of this POP stock occurred in 2010, at which time trends in survey abundance indices, plus reports from industry, indicated that the stock was showing signs of decline. The assessment presented various model runs and two were accepted for advice to managers. Both model runs depicted a slow-growing, low productivity stock that was heavily exploited by foreign commercial fleets for a decade starting in the mid-1960s. This early fishery was sustained from a strong recruitment event that occurred in the early 1950s. The depletion of the QCS stock halted briefly after the 1977 introduction of the 200 nautical mile limit, before resuming with the development of a domestic bottom trawl fleet. The domestic fishery was sustained from a few strong year classes starting in the late 1970s and early 1980s. However, spawning (mature female) biomass in 2011 was estimated to be at historic low levels (in the range of 12-43% [median 26%] or 8-24% [median 14%] of the equilibrium unexploited biomass across the two accepted model runs). Exploitation rates were estimated to be approaching historic high levels.

As a result of the 2010 POP assessment (DFO 2011, Edwards et al. 2012), the TAC for QCS was cut by 258 t/y over three years, starting in 2011. Fisheries and Oceans Canada (DFO) Fisheries and Aquaculture Management has requested updated advice from DFO Science on the current biomass and status of POP in QCS relative to reference points consistent with DFO's Fishery Decision-Making Framework Incorporating the Precautionary Approach (the PA framework) (DFO 2009), and implications of varying harvest rates on expected stock status.

The assessment, and advice arising from this Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR), will be used to inform fisheries management decisions.

Objectives

The following working paper will be reviewed and provide the basis for discussion and advice on the specific objectives outlined below.

Haigh, R., Starr, P.J., Edwards, A.M, King, J.R., and Lecomte, J-B. Stock assessment for Pacific Ocean Perch (*Sebastes alutus*) in Queen Charlotte Sound, British Columbia in 2016. CSAP Working Paper 2014GRF005.

Guided by the DFO Sustainable Fisheries Framework, the following objectives for this assessment have been established:

1. Assess the current biomass and status of Pacific Ocean Perch (*Sebastes alutus*) in Queen Charlotte Sound (area 5ABC defined above).
2. Apply the PA-compliant MSY-based reference points defined in the 2010 assessment of 5ABC POP (Limit Reference Point $0.4B_{MSY,}$ Upper Stock Reference Point $0.8B_{MSY,}$ removal rate U_{MSY},).
3. Provide decision tables projecting the predicted status of Pacific Ocean Perch relative to reference points across a range of management actions.
4. If possible, propose an appropriate time interval between assessments and a trigger point that may affect the assessment schedule; or, provide rationale why this is not possible.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Participation

- Fisheries and Oceans Canada (DFO) Pacific Region – Offshore/Inshore Sections of Science, Fisheries and Aquaculture Management
- Industry – Canadian Groundfish Research and Conservation Society (CGRCS), Commercial Industry Caucus (CIC), etc.
- Aboriginal communities/organizations (e.g., Central Coast Indigenous Resource Alliance)
- Non-governmental agencies (e.g., David Suzuki Foundation)
- Peer review experts from government and/or academia.

References

DFO 2009. A Fishery Decision-Making Framework Incorporating the Precautionary Approach.

DFO. 2011. Stock assessment for Pacific ocean perch (*Sebastes alutus*) in Queen Charlotte Sound, British Columbia in 2010. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/017.

Edwards, A.M., Starr, P.J., and Haigh, R. 2012. Stock assessment for Pacific ocean perch (*Sebastes alutus*) in Queen Charlotte Sound, British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/111. viii + 172 p.

APPENDIX B: WORKING PAPER ABSTRACT

Pacific Ocean Perch (*Sebastes alutus*, POP) is a commercially important species of rockfish that inhabits the marine canyons along the coast of British Columbia. The status of POP in Queen Charlotte Sound, British Columbia, is assessed under the assumption that it is a single stock harvested entirely in Pacific Marine Fisheries Commission (PMFC) major areas 5A, 5B, 5C, and in 5E south of 52°20'. This stock has supported a domestic trawl fishery for decades and was heavily fished by foreign fleets from the mid-1960s to mid-1970s.

An annual catch-at-age model was used to assess the stock, based on model runs that were tuned to three fishery-independent trawl survey series, annual estimates of commercial catch since 1940, and age composition data from two of the survey series (11 years of data) and the commercial fishery (34 years of data). The model starts from an assumed equilibrium state in 1940, and the survey data cover the period 1967 to 2016 (although not all years are represented). The two-sex model was implemented in a Bayesian framework (using the Markov Chain Monte Carlo procedure) under a scenario that estimates both natural mortality (M) and steepness of the stock-recruit function (h). Sensitivity analyses were performed to test the effect of data inputs to the model. The base model run suggests that strong recruitment in the early 1950s sustained the foreign fishery, and that a few strong year classes spawned in the late 1970s and 1980s sustained the domestic fishery into the 1990s.

Advice to managers is presented as decision tables that provide probabilities of exceeding limit and upper stock reference points for five-year projections across a range of constant catches. As previously adopted in the last assessment of this stock in 2010, the DFO provisional 'Precautionary Approach compliant' reference points were used which specify a 'limit reference point' of $0.4B_{MSY}$ and an 'upper stock reference point' of $0.8B_{MSY}$.

A Bayesian method to investigate potential ecosystem influences on recruitment was developed and applied to this stock using a suite of climatic and environmental indicators. Results show that none of the investigated indicators were able to reliably predict observed recruitment deviations, leading to the conclusion that environmental information cannot be used as this time to improve model predictions for this stock.

APPENDIX C: AGENDA

Stock assessment for Pacific Ocean Perch (*Sebastes alutus*) in Queen Charlotte Sound, British Columbia in 2017

June 1-2, 2017

Nanaimo, British Columbia

Chair: Lesley MacDougall

DAY 1 – Thursday June 1, 2017

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping CSAS Overview and Procedures	Chair
0915	Review Terms of Reference	Chair
0930	Presentation of Working Paper	Authors
1030	***Break***	
1050	Presentation of Working Paper	Authors
1145	***Lunch Break***	
1300	Written Reviews and Author discussion	Paul Spencer, Chris Grandin, Authors
1345	General Discussion of reviews and response	RPR Participants
1445	***Break***	
1500	Identification of Key Issues for Group Discussion	RPR Participants
1630	Discussion & Resolution of Technical Issues	RPR Participants
1700	Adjourn for the Day	

DAY 2 - Friday, June 2, 2017

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping Review Status of Day 1	Chair
0930	*(As Necessary)* Carry forward outstanding issues from Day 1	RPR Participants
	Develop Consensus on Paper Acceptability & Agreed-upon Revisions	RPR Participants
1030	***Break***	
1045	*Science Advisory Report (SAR)* Develop consensus on the following for inclusion: • Sources of Uncertainty • Results & Conclusions • Additional advice to Management (as warranted)	RPR Participants
1200	***Lunch Break***	
1300	*Science Advisory Report (SAR)* • Continued	RPR Participants
1445	***Break***	
1500	Next Steps – Chair to review • SAR review/approval process and timelines • Research Document & Proceedings timelines • Other follow-up or commitments (*as necessary)*	Chair
1515	Other Business arising from the review	Chair & Participants
1530	***Adjourn meeting***	

APPENDIX D: MEETING PARTICIPANTS

Last Name	First Name	Affiliation
Anderson	Sean	DFO Science
Edwards	Andrew	DFO Science
Flostrand	Linnea	DFO Science
Grandin	Chris	DFO Science
Haigh	Rowan	DFO Science
Holmes	John	DFO Science, Division Manager
Holt	Kendra	DFO Science
King	Jackie	DFO Science
Lee	Lynn	Parks Canada
MacDougall	Lesley	DFO Centre for Science Advice Pacific Coordinator
McGreer	Madeleine	Central Coast Indigenous Resource Alliance
Spencer	Paul	National Ocean and Atmospheric Administration
Starr	Paul	Canadian Groundfish Conservation Society
Tadey	Rob	DFO Fisheries Management
Tonnes	Dan	National Ocean and Atmospheric Administration
Turris	Bruce	BC Groundfish Conservation Society
Wallace	Scott	David Suzuki Foundation