Fisheries and Oceans Canada | Pêches et Océans Canada
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Pacific Region
Canadian Science Advisory Secretariat
Science Advisory Report 2013/038

PACIFIC OCEAN PERCH (*SEBASTES ALUTUS*) STOCK ASSESSMENTS FOR THE WEST COAST OF VANCOUVER ISLAND AND THE NORTH AND WEST COASTS OF HAIDA GWAII, BRITISH COLUMBIA

Figure 1. Pacific Ocean Perch (Sebastes alutus). Credit: Schon Acheson, Fisheries and Oceans Canada (DFO).

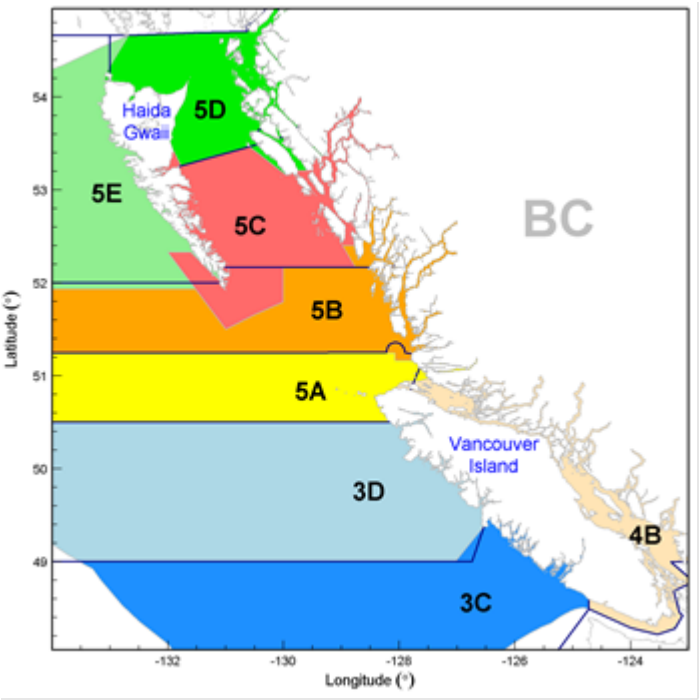

Figure 2. Pacific Marine Fisheries Commission major areas (outlined by blue lines). The assessment for the west coast of Vancouver Island covers areas 3C and 3D (herein 3CD), while the assessment for the north and west coasts of Haida Gwaii covers areas 5D and 5E (5DE). An assessment for area 5ABC was published in 2012. Groundfish Management Unit areas for Pacific Ocean Perch are shaded in seven colours and differ slightly from the Pacific Marine Fisheries Commission areas.

Context

Of the current annual Total Allowable Catch of rockfish on the west coast of Canada, Pacific Ocean Perch is the species that has the largest single-species quota. It accounts for 25% of the total weight of rockfish landed by bottom trawl gear. Key results from the first stock assessments for areas 3CD and 5DE are reported here. Harvest advice was required to determine if current harvest levels are sustainable and compliant with Fisheries and Oceans Canada Fishery Decision-making Framework Incorporating the Precautionary Approach.

This Science Advisory Report is from the Regional Peer Review meeting on the Stock Assessments for Pacific Ocean Perch in Areas 3CD and 5DE (British Columbia), held on November 6-7, 2012. The full stock assessments (Research Documents) and Proceedings from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- Pacific Ocean Perch is a commercially important species of rockfish that has supported a domestic trawl fishery for decades, and was heavily fished by foreign fleets from the mid-1960s to the mid-1970s.

- The stocks in areas 3CD and 5DE are assessed as two independent stocks using an annual two-sex catch-at-age model, implemented in a Bayesian framework to quantify uncertainty of estimated quantities.

- This is the first time that a population dynamics model has been used to assess either stock.

- For area 3CD, the spawning biomass (mature females only) at the beginning of 2013 (B_{2013}) is estimated to be 0.41 (0.19-0.68) of unfished spawning biomass (B_0); numbers denote median (and 5-95 percentiles) of the Bayesian results. Also, B_{2013} is estimated to be 1.53 (0.55-3.32) of the equilibrium biomass at maximum sustainable yield, B_{MSY}.

- For area 5DE, B_{2013} is estimated to be 0.37 (0.16-0.67) of $B_{0,}$ and 1.61 (0.57-3.57) of B_{MSY}.

- An exceptionally strong recruitment of age-1 fish in 1977 was estimated for the stock in area 5DE, though not for area 3CD.

- Decision tables are presented using the provisional reference points from the Fisheries and Oceans Canada *Sustainable Fisheries Framework* Precautionary Approach, namely a limit reference point of $0.4B_{MSY}$ and upper reference point of $0.8B_{MSY}$. For area 3CD, B_{2013} is estimated to have a 0.99 probability of being $>0.4B_{MSY}$, and a 0.87 probability of being $>0.8B_{MSY}$ (i.e. of being in the healthy zone). The probability that the exploitation rate in 2012 was below that associated with MSY is 0.89.

- For area 5DE, B_{2013} is estimated to have a 0.98 probability of being $>0.4B_{MSY}$, and a 0.88 probability of being $>0.8B_{MSY}$. The probability that the exploitation rate in 2012 was below that associated with MSY is 0.84.

- Advice to management is presented in the form of decision tables using ten-year projections for a range of constant catches. For both stocks, catches at levels slightly above recent mean catches indicate essentially no change in the aforementioned probabilities of the spawning biomass being above the reference points.

INTRODUCTION

Pacific Ocean Perch (*Sebastes alutus*, POP) is a long-lived, commercially important species of rockfish found along the rim of the North Pacific Ocean. It supports the largest rockfish fishery in British Columbia with an annual coastwide total allowable catch (TAC) of 5,448 t (metric tonnes) in 2010, which is being progressively reduced to 5,189 t over three years (based on an earlier assessment for Queen Charlotte Sound; DFO, 2011). The mean annual coastwide catch was about 5,000 t from 2006-2010 and the mean coastwide landed value of the POP catch for 2007-2010 was $4.4 million. The trawl fishery is allocated 99.98% of the coastwide POP TAC, with the remainder allocated to the hook and line fishery.

The Pacific Marine Fisheries Commission (PMFC) major areas used in the stock assessments are similar to the groundfish management areas (GMAs) used by the Fisheries and Oceans Canada (DFO) Groundfish Management Unit to set TACs (Figure 2). The GMAs were not used in the assessments because reporting from them has only been available since 1996 and there is no available procedure to alter historical landings to conform to current boundaries. Areas refer to PMFC areas unless otherwise specified.

The TAC for GMA area 3CD has been 530 t since 1998. The mean catch from 2007-2011 in PMFC area 3CD was 547 t. The TAC for GMA 5CD in 2012 was 1,856 t, and the TAC for GMA 5E has been 730 t since 1998. The mean catch from 2007-2011 in PMFC area 5DE was 937 t.

For area 3CD, 98% of the commercial captures of POP lie in the depth range 128-581 m; for area 5DE the equivalent range is 104-530 m.

ASSESSMENT

This report summarises the key results from the first quantitative stock assessments for the stocks of POP in areas 3CD and 5DE. An annual two-sex, catch-at-age model was applied independently to each stock and tuned to fishery-independent trawl survey data, annual estimates of commercial catch since 1940, and age composition data from the commercial fishery and from survey series.

The model estimates stock-recruitment parameters, natural mortality (independently for females and males), catchability coefficients for the survey series, and selectivity parameters for the commercial fishery and those survey series for which age data are available.

The model is used to estimate the past and present vulnerable biomass (the biomass that is vulnerable to capture by the fishery), spawning stock biomass (mature females only) and population age structure. Estimated parameters are then used to calculate maximum sustainable yield (MSY) and reference points. Ten-year projections are performed for a fixed range of constant catches to estimate probabilities of the spawning biomass being greater than the reference points. All calculations are made using the Bayesian Markov Chain Monte Carlo (MCMC) method to quantify the uncertainty associated with parameter estimation. This yields 1,000 MCMC samples from posterior distributions. Estimates of various quantities are calculated from these samples, and are presented as the median (with 5-95% percentiles). Calculated probabilities are also based on the MCMC samples. Uncertainty associated with some data sets is explored through sensitivity runs.

Advice to managers is presented as a set of decision tables that provide probabilities of exceeding reference points for 2013 through 2023 for a range of constant catch levels.

Figure 3 shows the MCMC results for the estimated vulnerable biomass, together with the reconstructed historical catches. Figure 4 shows the estimated medians of vulnerable and spawning (mature females only) biomasses relative to their unfished values. For area 3CD, the results demonstrate a slight decline in biomass from 1940 to 1960 with the onset of fishing, followed by a very sharp decline in the 1960s due to heavy fishing that was primarily by foreign fleets. After the cessation of foreign fishing, the biomass increased through the remainder of the 1970s. The biomass then declined through the 1980s until the mid-1990s, and has since increased, with median values of relative biomass now above the 1980 values (Figure 4).

For area 5DE, Figures 3 and 4 show an increasing trend in the estimated spawning and vulnerable biomasses from about 1948 to 1965; the median of B_t/B_0 (spawning biomass at the

start of year *t*, B_t, relative to the unfished equilibrium spawning biomass, B_0) peaks at 1.25 in 1965. This increase in biomass is the result of above average recruitment in the early 1950s.

Estimates of various quantities of interest are given in Table 1. In particular, the estimate for B_{2013}/B_0, the ratio of current spawning biomass (B_{2013}) to B_0, is 0.41 (0.19-0.68) for area 3CD and 0.37 (0.16-0.67) for area 5DE.

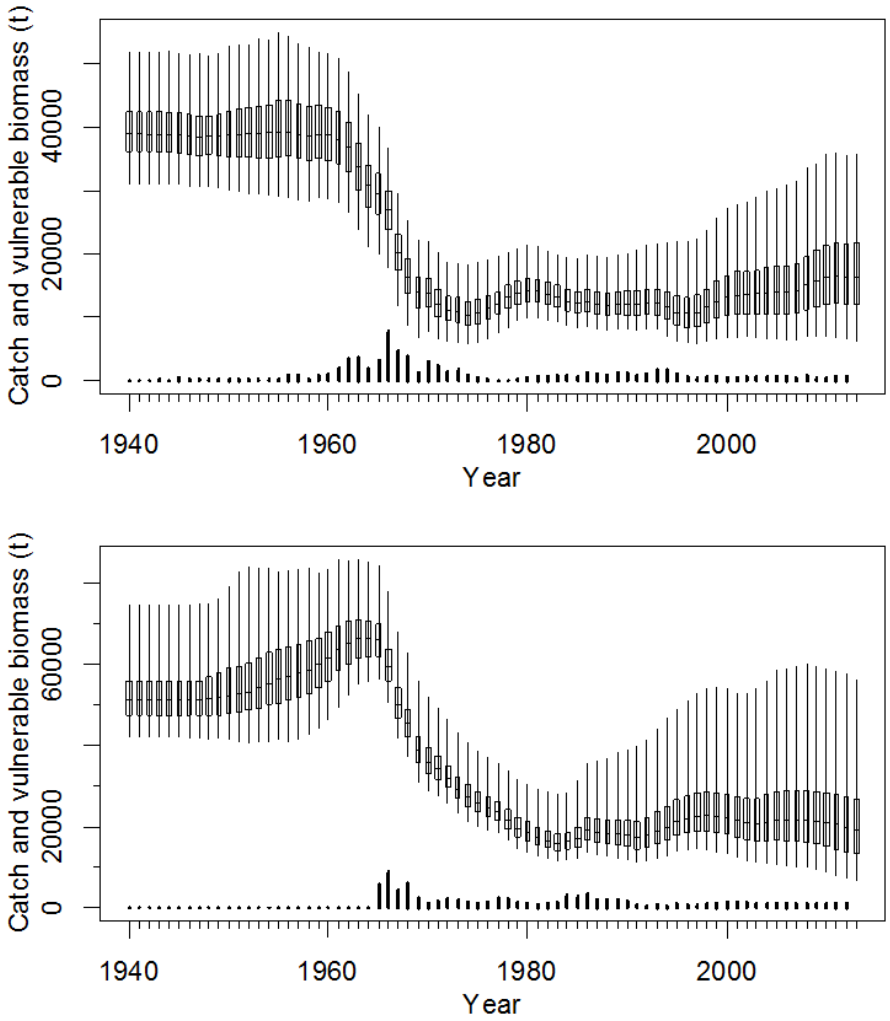

Figure 3. Annual commercial catch (vertical bars) and vulnerable biomass (boxplots showing 2.5, 25, 50, 75 and 97.5 percentiles of the MCMC results for area 3CD (top) and area 5DE (bottom).

For area 3CD, there are a number of year classes with approximately double the long-term average recruitment. However, for area 5DE there was exceptional recruitment of age-1 fish in 1977, with a median value more than five times larger than the long-term mean. This shows up as an increase in estimated vulnerable biomass from around 1988 (Figures 3 and 4) when these fish became old enough for capture by the fishery. A similar exceptional 1977 recruitment event was estimated for the QCS area 5ABC stock (Edwards et al., 2012), whereas for area 3CD the recruitment in 1977 was high, but by no means as exceptional.

For area 3CD, the estimated annual exploitation rate (ratio of total catch to the vulnerable biomass in the middle of the year) peaked in the mid-1960s due to the large foreign catches, and then peaked again in the early 1990s due to increased domestic exploitation. Exploitation

rates have remained low since the mid-1990s, with the exploitation rate for 2012, u_{2012}, estimated to be 0.035 (0.018-0.077).

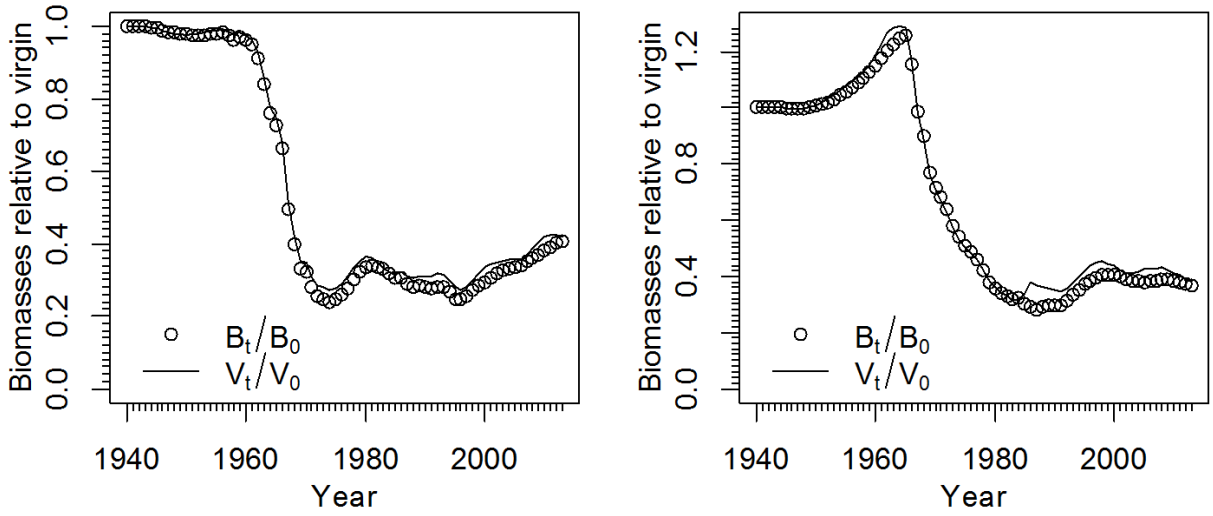

Figure 4. Trajectories of spawning and vulnerable biomass relative to unfished equilibrium levels, B_t / B_0 and V_t / V_0 respectively, shown as MCMC medians for area 3CD (left) and area 5DE (right).

Table 1. The 5th, 50th and 95th percentiles of the MCMC results for areas 3CD and 5DE. Definitions are: B_0 – unfished equilibrium spawning biomass (mature females), V_0 – unfished equilibrium vulnerable biomass (males and females), B_{2013} – spawning female biomass at the start of 2013, V_{2013} – vulnerable biomass in the middle of 2013, u_{2012} – exploitation rate (ratio of total catch to vulnerable biomass) in the middle of 2012, u_{max} – maximum exploitation rate from 1940-2012, B_{MSY} – equilibrium spawning biomass at MSY (maximum sustainable yield), u_{MSY} – equilibrium exploitation rate at MSY, V_{MSY} – equilibrium vulnerable biomass at MSY. All biomass values (and MSY) are in tonnes. For reference, the average catch over the last five years (2007-2011) for area 3CD is 547 t and for area 5DE is 937 t.

p	Area 3CD			Area 5DE		
Quantity▼	5%	50%	95%	5%	50%	95%
B_0	17,562	21,442	27,877	26,148	31,242	40,568
V_0	32,687	38,855	49,469	43,100	51,073	66,999
B_{2013}	3,888	8,745	17,269	4,703	11,286	25,672
V_{2013}	7,360	16,427	32,072	8,140	19,334	43,835
B_{2013}/B_0	0.189	0.406	0.684	0.162	0.366	0.666
V_{2013}/V_0	0.199	0.420	0.708	0.175	0.382	0.675
u_{2012}	0.018	0.035	0.077	0.023	0.053	0.119
u_{max}	0.221	0.288	0.418	0.127	0.192	0.254
$0.4B_{MSY}$	1,433	2,324	3,592	1,832	2,921	4,520
$0.8B_{MSY}$	2,866	4,647	7,183	3,664	5,843	9,041
B_{MSY}	3,583	5,809	8,979	4,580	7,304	11,301
B_{MSY}/B_0	0.178	0.272	0.357	0.150	0.231	0.325
B_{2013}/B_{MSY}	0.552	1.526	3.323	0.574	1.607	3.572
MSY	700	1,048	1,509	998	1,488	2,258
u_{MSY}	0.045	0.091	0.174	0.053	0.109	0.194
u_{2012}/u_{MSY}	0.134	0.384	1.434	0.168	0.482	1.697
V_{MSY}	7,586	11,729	17,112	9,496	14,056	20,861
V_{MSY}/V_0	0.213	0.301	0.379	0.192	0.272	0.359

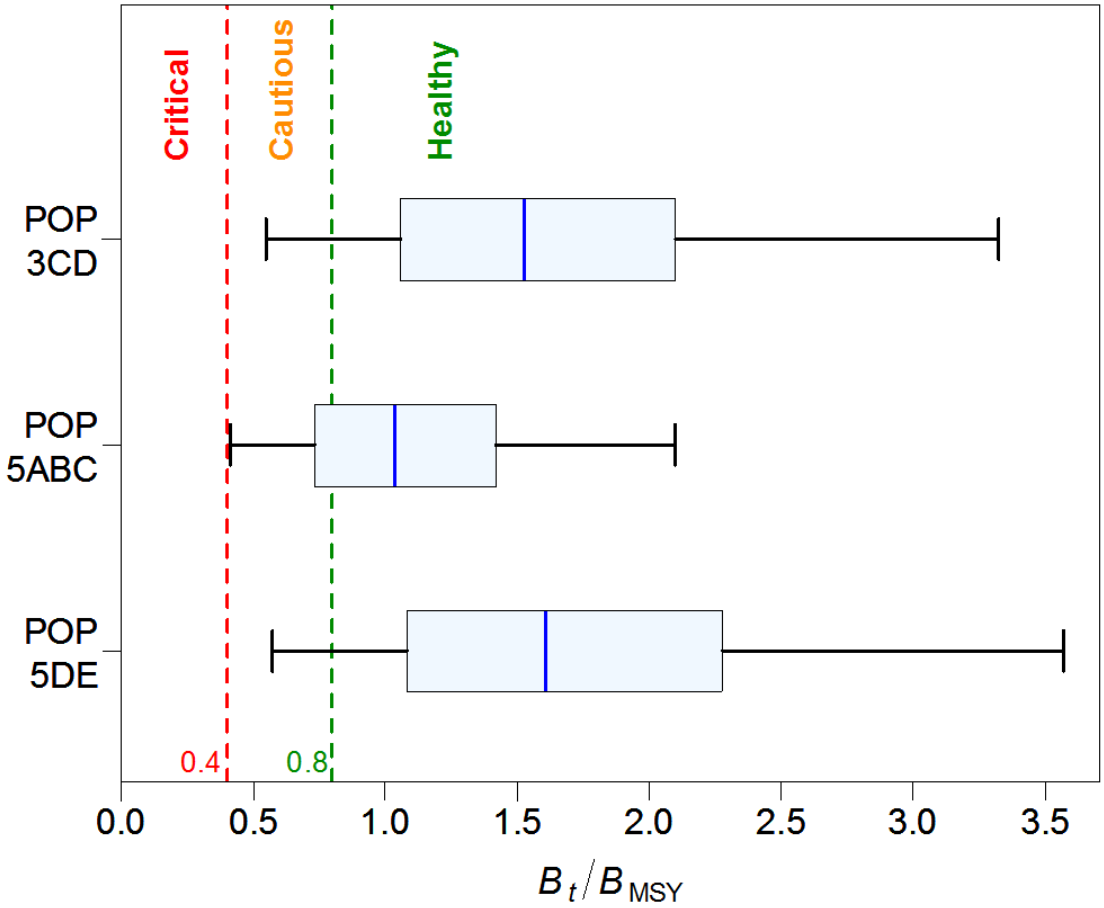

Figure 5. Current status of the three Canadian POP stocks relative to the DFO Precautionary Approach provisional reference points of $0.4B_{MSY}$ and $0.8B_{MSY}$. The value of B_t/B_{MSY} uses t=2013 for 3CD and 5DE, and t=2011 for area 5ABC (run 'Estimate M&h' from Edwards et al., 2011). Boxplots show the 5, 25, 50, 75 and 95 percentiles from the MCMC results.

For area 5DE, estimated exploitation rates reached a median near 0.15 in 1966, associated with high catches by the foreign fleets. The exploitation rate peaked in the mid-1980s (maximum median of 0.19 reached in 1984), caused by the high catches associated with the experimental Langara Spit fishery (which is described by Leaman and Stanley, 1993). These catches were not as large as the foreign fleet catches observed in the 1960s, but were extracted from a smaller biomass. Exploitation rates declined from the early 1990s with the end of the Langara Spit fishery and the introduction of TAC-controlled fishing in 1996. Median exploitation rates rose to near 0.05 in 2000, and then decreased and increased, with u_{2012} estimated to be 0.053 (0.023-0.119).

For area 3CD, the estimated median MSY is 1,048 t (700-1,509 t), compared to the average catch over the last five years (2007-2011) of 547 t. For area 5DE, the estimated median MSY is 1,488 t (998-2,258 t), compared to the average catch over the last five years of 937 t.

Estimates of MSY-based quantities are given in Table 1. In particular, the estimated values of B_{2013}/B_{MSY}, where B_{MSY} is the equilibrium spawning biomass that would support the MSY, are 1.53 (0.55-3.32) for area 3CD and 1.61 (0.57-3.57) for area 5DE.

Reference Points

Figure 5 shows the stock status relative to the provisional DFO (2009) limit and upper stock reference points of $0.4B_{MSY}$ and $0.8B_{MSY}$; the reference points demarcate the critical, cautious and healthy zones. Figure 5 also includes the status in 2011 of the POP stock in area 5ABC (Edwards et al., 2012). For area 3CD, the stock at the beginning of 2013 is estimated to be above the limit reference point with probability $P(B_{2013} > 0.4B_{MSY}) = 0.99$, and above the upper stock reference point with probability $P(B_{2013} > 0.8B_{MSY}) = 0.87$. For area 5DE, the probabilities are $P(B_{2013} > 0.4B_{MSY}) = 0.98$ and $P(B_{2013} > 0.8B_{MSY}) = 0.88$.

A second component of the provisional harvest rule of DFO (2009) concerns the relationship of the exploitation rate relative to that associated with MSY under equilibrium conditions (u_{MSY}). The rule specifies that the exploitation rate should not exceed u_{MSY} when the stock is in the healthy zone. Catches should be reduced when in the cautious zone, and be kept to the lowest level possible when in the critical zone. For area 3CD the estimated ratio of u_{2012}/u_{MSY}, which the harvest rule specifies should be ≤1, is 0.38 (0.13-1.43). The probability that the current exploitation rate is below that associated with MSY is $P(u_{2012} < u_{MSY}) = 0.89$. For area 5DE, the estimated ratio of u_{2012}/u_{MSY} is 0.48 (0.17-1.70), and $P(u_{2012} < u_{MSY}) = 0.84$.

The stock in area 3CD is estimated to have been in the healthy zone since the start of fishing in 1940 (based on median values). The median exploitation rate has been $>u_{MSY}$ for a total of 18 years, and has been $<u_{MSY}$ since 1996. The stock in area 5DE is also estimated to have been in the healthy zone since the start of fishing, with the spawning biomass having always been $>B_{MSY}$ (based on median values). The median exploitation rate has been $>u_{MSY}$ for a total of seven years since 1940, and has been $<u_{MSY}$ since 1990.

Projection Results and Decision Tables

Projections starting with the biomass at the beginning of 2013 were made over a range of constant catch levels (0-2,000 t in 200 t increments for area 3CD, and in 250 t increments for area 5DE). Projections were made for 10 years, a time frame considered adequate for long-term advice, but short enough for the projected recruitments to be mainly based on individuals spawned before 2013 (and therefore explicitly estimated by the model).

Decision tables (Table 2) give the probabilities of the spawning biomass exceeding the reference points in each projected year for each catch level. Note that catches are held constant, so there is no consequent reduction of the exploitation rate in the projections if a stock reaches the cautious or critical zones.

As an example of how to read the tables, the estimated probability that the 3CD stock is in the provisional healthy zone in 2017 under a constant catch strategy of 1,000 t is $P(B_{2017} > 0.8B_{MSY})=0.82$ (corresponding ‘1000’ row and ‘2017' column of Table 2).

For area 3CD with a constant catch of 600 t, which is above the average recent catch of 547 t, the probabilities of the stock remaining above the critical zone, $P(B_t > 0.4B_{MSY})$, or in the healthy zone, $P(B_t > 0.8B_{MSY})$, essentially remain constant over the ten-year projections (‘600' rows for area 3CD in Table 2).

Similarly, for area 5DE with a constant catch of 1,000 t, which is above the average recent catch of 937 t, the probabilities of the stock remaining above the critical zone, $P(B_t > 0.4B_{MSY})$, or in the healthy zone, $P(B_t > 0.8B_{MSY})$, essentially remain constant over the ten-year projections (‘1000' rows for area 5DE in Table 2).

Table 2. Decision tables concerning the reference points $0.4B_{MSY}$ and $0.8B_{MSY}$ for 1-10 year projections for a range of constant annual catch strategies (in tonnes), for area 3CD and area 5DE. Values are the probabilities of the spawning biomass (mature females) at the start of projection year t being greater than the reference point for the given annual catch strategy. The probabilities are the proportion of the MCMC samples for which B_t is greater than the respective reference point. For reference, the average catch over the last five years (2007-2011) is 547 t for area 3CD, and 937 t for area 5DE.

Annual catch strategy	Projection Year										
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Area 3CD											
$P(B_t > 0.4B_{MSY})$											
0	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.00
200	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
400	0.99	0.99	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99
600	0.99	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.97	0.97	0.97
800	0.99	0.98	0.98	0.97	0.97	0.96	0.96	0.96	0.95	0.95	0.95
1000	0.99	0.98	0.97	0.96	0.95	0.95	0.94	0.94	0.93	0.93	0.92
1200	0.99	0.98	0.97	0.95	0.94	0.93	0.92	0.92	0.90	0.90	0.89
1400	0.99	0.98	0.95	0.94	0.92	0.92	0.90	0.88	0.87	0.84	0.83
1600	0.99	0.97	0.95	0.93	0.91	0.89	0.86	0.83	0.81	0.79	0.77
1800	0.99	0.97	0.94	0.92	0.89	0.85	0.82	0.79	0.76	0.74	0.72
2000	0.99	0.96	0.94	0.90	0.86	0.81	0.78	0.75	0.72	0.69	0.65
$P(B_t > 0.8B_{MSY})$											
0	0.87	0.88	0.90	0.92	0.93	0.94	0.94	0.95	0.96	0.96	0.97
200	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.93	0.94	0.95	0.95
400	0.87	0.87	0.88	0.88	0.89	0.90	0.91	0.91	0.92	0.92	0.93
600	0.87	0.86	0.86	0.86	0.87	0.87	0.88	0.88	0.88	0.88	0.89
800	0.87	0.86	0.85	0.84	0.85	0.85	0.85	0.84	0.85	0.85	0.85
1000	0.87	0.85	0.83	0.83	0.82	0.81	0.81	0.81	0.80	0.80	0.79
1200	0.87	0.84	0.82	0.81	0.79	0.78	0.77	0.76	0.75	0.74	0.72
1400	0.87	0.84	0.81	0.79	0.76	0.75	0.73	0.72	0.70	0.69	0.67
1600	0.87	0.83	0.80	0.76	0.74	0.71	0.69	0.67	0.65	0.63	0.61
1800	0.87	0.83	0.78	0.74	0.71	0.68	0.64	0.61	0.59	0.57	0.53
2000	0.87	0.82	0.77	0.72	0.68	0.63	0.60	0.57	0.53	0.49	0.46
Area 5DE											
$P(B_t > 0.4B_{MSY})$											
0	0.98	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	1.00
250	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.00
500	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
750	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
1000	0.98	0.98	0.97	0.97	0.97	0.97	0.97	0.96	0.96	0.96	0.96
1250	0.98	0.98	0.97	0.97	0.96	0.96	0.95	0.95	0.95	0.94	0.94
1500	0.98	0.97	0.96	0.95	0.94	0.94	0.93	0.92	0.92	0.91	0.90
1750	0.98	0.97	0.96	0.94	0.92	0.91	0.90	0.88	0.87	0.86	0.84
2000	0.98	0.97	0.95	0.92	0.91	0.88	0.86	0.85	0.83	0.80	0.78
$P(B_t > 0.8B_{MSY})$											
0	0.88	0.90	0.91	0.92	0.94	0.96	0.96	0.97	0.97	0.97	0.98
250	0.88	0.89	0.90	0.91	0.92	0.94	0.95	0.96	0.96	0.96	0.97
500	0.88	0.88	0.89	0.89	0.90	0.91	0.92	0.93	0.94	0.94	0.95
750	0.88	0.87	0.88	0.88	0.88	0.89	0.90	0.90	0.91	0.91	0.91
1000	0.88	0.86	0.86	0.87	0.86	0.87	0.87	0.87	0.87	0.87	0.87
1250	0.88	0.86	0.85	0.84	0.83	0.83	0.84	0.83	0.83	0.83	0.82
1500	0.88	0.86	0.84	0.82	0.81	0.80	0.79	0.79	0.78	0.77	0.76
1750	0.88	0.85	0.82	0.79	0.77	0.76	0.74	0.72	0.71	0.70	0.69
2000	0.88	0.84	0.80	0.77	0.74	0.71	0.69	0.68	0.66	0.65	0.61

Sources of Uncertainty

Uncertainty in the estimated parameters and quantities is explicitly addressed using a Bayesian approach, but reflects only the specified model and weights assigned to the various data components. Results from sensitivity runs (not shown here) do not differ greatly from the base runs.

Ecosystem Considerations

In 2012, measures were introduced to reduce and manage the bycatch of corals and sponges by the British Columbia groundfish bottom trawl fishery. These measures were developed jointly by industry and environmental non-governmental organisations, and include: limiting the footprint of groundfish bottom trawl activities, establishing a combined bycatch conservation limit for corals and sponges, and establishing an encounter protocol for individual trawl tows when the combined coral and sponge catch exceeds 20 kg. These measures have been incorporated into DFO's Pacific Region Groundfish Integrated Fisheries Management Plan (March 28 2012, version 2.1).

The fishery is also subject to the following management measures: 100% at-sea monitoring, 100% dockside monitoring, individual vessel accountability for all retained and released catch, individual transferable quotas and reallocation of these quotas between vessels and fisheries to cover catch of non-directed species (see aforementioned Management Plan).

CONCLUSIONS AND ADVICE

The assessments depict two slow-growing, low-productivity stocks, that have experienced heavy commercial fishing by foreign and domestic fleets in the past. Exploitation rates have since declined and each stock is estimated to have a high probability of currently being in the provisional healthy zone.

Advice to management is provided in the form of decision tables. The tables assume the model to be valid and also assume no future management intervention if stock status changes.

Catches in the commercial groundfish fisheries are very well recorded by virtue of independent at-sea monitoring of the fishery. Such data, together with ongoing results from surveys, give confidence that future assessments can continue to monitor these stocks and that corrective action can be taken if required.

SOURCES OF INFORMATION

This Science Advisory Report is from the Regional Peer Review meeting on 'Stock Assessments for Pacific Ocean Perch in Areas 3CD and 5DE (British Columbia)', held on November 6-7, 2012. Additional publications from this process (Proceedings and two Research Documents) will be posted the on Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2009. A fishery decision-making framework incorporating the Precautionary Approach, (last reportedly modified 23 May 2009, though figures have since changed).

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.

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Leaman, B.M. and R.D. Stanley. 1993. Experimental management programs for two rockfish stocks off British Columbia, Canada. In S. J. Smith, J. J. Hunt, and D. Rivard, editors, Risk evaluation and biological reference points for fisheries management, pages 403–418. Can. Spec. Pub. Fish. Aquat. Sci. 120.

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ISSN 1919-5087
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Correct Citation for this Publication:

DFO. 2013. Pacific Ocean Perch (*Sebastes alutus*) stock assessments for the west coast of Vancouver Island and the north and west coasts of Haida Gwaii, British Columbia. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/038.

Aussi disponible en français :

MPO. 2013. Évaluations des stocks de sébaste à longue mâchoire (Sebastes alutus) sur la côte ouest de l'île de Vancouver et les côtes nord et ouest de Haida Gwaii, en Colombie-Britannique. Secr. can. de consult. sci. du MPO, Avis sci. 2013/038.