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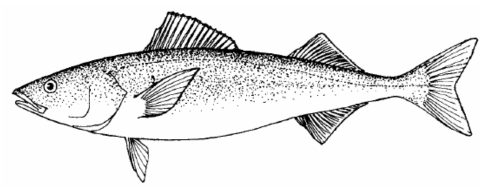
Science Advisory Report 2017/017

EVALUATING THE ROBUSTNESS OF MANAGEMENT PROCEDURES FOR THE SABLEFISH (*ANOPLOPOMA FIMBRIA*) FISHERY IN BRITISH COLUMBIA, CANADA FOR 2017-18



Sablefish (Anoplopoma fimbria), Courtesy DFO

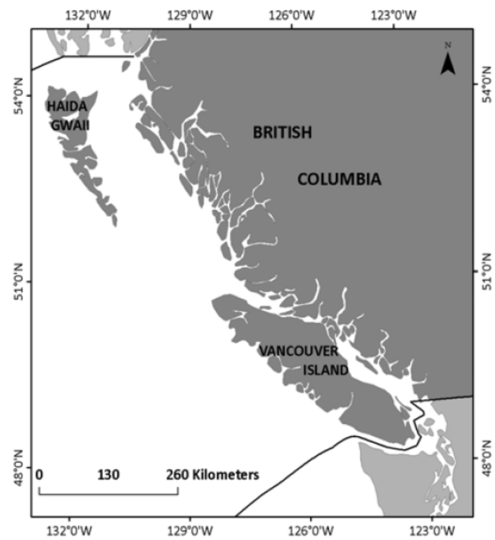


Figure 1. Assessment and management area for sablefish in British Columbia, excluding seamounts.

Context:

Fisheries and Oceans Canada (DFO) and the British Columbia (BC) Sablefish fishing industry collaborate on a management strategy evaluation (MSE) process intended to develop and implement a transparent and sustainable harvest strategy. The sustainability of harvest strategies is determined by simulation testing of alternative management procedures against operating models that represent a range of hypotheses about uncertain Sablefish stock dynamics. Performance of management procedures used in these tests is measured against pre-agreed conservation and catch objectives for the stock and fishery.

Revisions to the Sablefish operating model in 2016 improved model fit to data and resulting estimates of historical recruitment relative to the previous operating model (DFO 2016).These improvements provide a stable platform for simulation testing of the current and alternative management procedures (MPs) for robustness to uncertain stock dynamics.

DFO Fisheries Management has requested advice from DFO Science to inform planning for the 2017-18 fishing year that is compliant with both the "DFO Sustainable Fisheries Framework" (SFF) policy and "A fishery decision-making framework incorporating the Precautionary Approach" (PA) policy.

This Science Advisory Report is from the January 10, 2017 regional peer review of Evaluating the robustness of management procedures for the Sablefish (Anoplopoma fimbria) fishery in British Columbia, Canada, for 2017-18. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule] as they become available.

SUMMARY

- The British Columbia (BC) Sablefish (*Anoplopoma fimbria*) harvest strategy is designed around a management procedure (MP) that is simulation-tested against multiple operating model (OM) scenarios that represent a range of hypotheses about Sablefish stock dynamics and fisheries. The underlying OM used to generate hypotheses about Sablefish stock and fishery dynamics was recently updated to include several structural changes (DFO 2016). A regional peer review meeting was held on January 10, 2017, to evaluate the performance of the current Sablefish MP and alternative MPs using the revised 2016 OM.
- The current MP uses a harvest control rule with a maximum harvest rate set at the estimated harvest rate at maximum sustainable yield (UMSY), as well as a minimum total allowable catch (TAC) floor of 1,992 tonnes (t) and a minimum size limit of 55 cm. Nine alternative MPs that differed in their use of TAC floors (0; 1,800; or 1,992 t), phase-in periods to a new maximum harvest rate (0, 3, 4 or 5 years), and sub-legal release regulations (release Sablefish < 55 cm or full retention with all Sablefish catch counted towards the TAC) were also evaluated. Each of the alternative MPs had a maximum harvest rate of 5.5%.
- The revised Sablefish OM was fitted (or conditioned) to stock monitoring and fishery data collected between 1965 and 2016. Five operating model scenarios were used to capture uncertainty in both stock productivity and female spawning biomass in 2016 (fSSB2016). The base case OM used the mean or expected combination of productivity and fSSB2016, while the other four OM scenarios represented the following combinations:

  1. high productivity, mean fSSB2016 (hiProd/expSSB);
  2. low productivity, mean fSSB2016 (loProd/expSSB);
  3. mean productivity, high fSSB2016 (expProd/hiSSB); and
  4. mean productivity, low fSSB2016 (expProd/loSSB).
- Estimates of female spawning stock biomass in 2017 (fSSB2017) were above the limit reference point (LRP) of 0.4BMSY but below the long-term target of BMSY in four of the five OM scenarios, where BMSY is the female spawning biomass at maximum sustainable yield (MSY). Estimated fSSB2017 in the expProd/loSSB scenario was below the LRP (fSSB2017/BMSY = 0.38). Estimates of fSSB2017/BMSY ranged from 0.42 to 0.46 among the other four OM scenarios.
- Performance of the 10 MPs was measured relative to five objectives for the BC Sablefish fishery (three conservation objectives and two fishery catch objectives) that were developed via consultations between fishery managers, scientists, and industry stakeholders. MP performance was ranked within each of the five operating model scenarios, as well as weighted across scenarios.
- When evaluated against the revised OM (DFO 2016), the current MP was unable to meet the three conservation objectives under any of the five productivity-spawning biomass OM scenarios and was consistently ranked last in conservation performance. It is recommended that consideration be given to alternative MPs for the Sablefish fishery.
- Based on the weighted-average performance across the five OM scenarios, MPs that included TAC floors were not able to achieve conservation objectives while MPs without a TAC floor were able to achieve these objectives. The length of the phase-in period to a lower maximum harvest rate did not have a large effect on MP performance relative to conservation objectives.

- MPs that include the addition of full retention (here meaning all sub-legal (< 55 cm) and legal fish caught are counted against the TAC) resulted in better performance against conservation objectives relative to the identical MPs without full retention.
- Neither the current nor any of the alternative MPs achieved fSSB levels above BMSY, or 0.8 BMSY in 50% of the years measured over two Sablefish generations (the third conservation objective), although some MPs were able to increase spawning biomass to 0.8 BMSY by the end of two Sablefish generations (36 years). It is recommended that the trade-offs between achieving 0.8 BMSY in 50% of the years over two Sablefish generations (the current objective) and achieving 0.8 BMSY in two Sablefish generations be further examined.
- In the absence of full retention of Sablefish, an MP with a phase-in to a new maximum target harvest rate of 5.5% over 5 years was able to achieve two of the conservation objectives while providing 10-year average catch of 1,690 t, which is below the current TAC floor of 1,992 t.
- The revised operating model continues to assume that the BC Sablefish stock is a closed population, despite evidence of movements among Sablefish stocks along the west coast of North America. These movements may have implications for the assumptions made about Sablefish stock dynamics in BC (i.e., recruitment, productivity) that are not currently captured by the revised OM or reflected in MP performance evaluations.
- Inconsistent sampling of age composition data in commercial catches (only Trap fishery age composition data are currently available) has contributed to model issues that have been consistently identified during the BC Sablefish management strategy evaluation (MSE) process (Cox et al. 2011; DFO 2011, 2014). It is recommended that attention be given to designing and implementing a commercial catch sampling program across all fishery sectors.
- MSE is an iterative process of change and improvement. It is recommended that BC Sablefish operating models and MPs be reevaluated for suitability at 3-year intervals.

INTRODUCTION

Fisheries and Oceans Canada (DFO) and the British Columbia (BC) Sablefish (*Anoplopoma fimbria*) fishing industry collaborate on a management strategy evaluation (MSE) process intended to develop and implement a transparent and sustainable harvest strategy for Sablefish in BC. Sustainability of harvest strategies is determined by simulation testing alternative management procedures (MP) against operating models (OM) that represent a range of hypotheses about Sablefish stock and fishery dynamics. The performance of MPs used in these tests is measured against pre-agreed conservation and catch objectives for the stock and fishery (Cox et al. 2011; DFO 2014).

The Sablefish MSE has four components:

1. Operational fishery objectives used to assess the acceptability of alternative MPs;
2. An MP that specifies the data used (total landed catch and three abundance indices), an assessment method (a tuned Schaefer state-space production model) and a precautionary harvest control rule using B_{MSY}, U_{MSY}, and exploitable biomass estimated by the production model;
3. A simulation-based evaluation of the MP against several OMs representing alternative hypotheses about Sablefish stock dynamics; and

4. Application and monitoring of the MP in practice.

Measureable and quantifiable fishery objectives guide the MSE process. Conservation and fishery objectives are developed iteratively via consultations between fishery managers, scientists and industry stakeholders (Cox and Kronlund 2009; Cox et al. 2011; DFO 2014), and are chosen to be consistent with the DFO Fishery Decision-Making Framework Incorporating the Precautionary Approach policy (DFO 2009). The five objectives guiding this fishery are:

1. Maintain female spawning stock biomass (fSSB) above the limit reference point LRP = $0.4B_{\mathrm{MSY}}$, where B_{MSY} is the operating model fSSB at maximum sustainable yield (MSY), in 95% of years measured over two sablefish generations (36 years);
2. When fSSB is between $0.4B_{\mathrm{MSY}}$ and $0.8B_{\mathrm{MSY}}$, limit the probability of decline over the next 10 years from very low (5%) at the LRP to moderate (50%) at B_{MSY}. At intermediate stock status levels, define the tolerance for decline by linearly interpolating between these probabilities;
3. Maintain the fSSB above
   a. B_{MSY}, or
   b. $0.8\ B_{\mathrm{MSY}}$

   when biomass levels are below $0.8B_{\mathrm{MSY}}$, in 50% of the years measured over two sablefish generations;
4. Maximize the probability that annual catch levels remain above 1,992 tonnes (t) measured over two sablefish generations; and
5. Maximize the average annual catch over 10 years subject to Objectives 1-4.

Objectives 1-3 are conservation-related while Objectives 4 and 5 are catch-related. Objective 4 was proposed to reflect the current minimum industry-acceptable catch level of 1,992 t (DFO 2014). The current management procedure for BC Sablefish uses a 1,992 t total allowable catch (TAC) floor to ensure such an objective is met with 100% certainty, essentially acting as an economic safeguard to the fishery.

The Sablefish MSE process has been in place since 2009 (Cox et al. 2009), with updates occurring in 2011 (Cox et al. 2011) and 2014 (DFO 2014). Simulation testing of MPs during the last two updates was based on an OM selected as part of the 2011 process (Cox et al. 2011; DFO 2011). Structural changes to this OM to improve the model fit to key observations were reviewed and implemented in 2016 (DFO 2016). In the present paper, the 2016 revised Sablefish OM is used to evaluate the performance of the current MP and nine alternative MPs against five plausible OM scenarios that represent alternative hypotheses about stock productivity and spawning biomass in 2017.

Sablefish Fishery Management

Sablefish are caught in directed fisheries by longline trap, longline hook, and trawl sectors. Sablefish are also intercepted by non-directed groundfish longline hook fisheries targeting Pacific Halibut (*Hippoglossus stenolepis)*, Rockfishes (*Sebastes* sp.), and Lingcod (*Ophiodon elongatus*). Sablefish fisheries in BC are managed through Individual Transferable Quotas (ITQ) that are allocated annually to 48 Sablefish licence eligibilities (accounting for 91.25% of the TAC), and 139 groundfish trawl license eligibilities (8.75% of TAC). Harvesters in the fisheries targeting Sablefish and the non-directed commercial groundfish fisheries must acquire ITQs to account for landed and discarded Sablefish mortalities (greater than 55 cm fork length). Individual Sablefish smaller than 55 cm fork length (FL) are released by regulation in all fisheries since 1977. The BC Integrated Groundfish Fishery (DFO 2013) operates on a February

21 to February 20 fishing year with allowances for carryover of catches over or under the quota amounts (overage and underage, respectively). The TAC for the 2015/16 fishing year, excluding overages and underages, was set at 1,992 metric tonnes (t), down from 2,129 t in the 2014/15 fishing year.

Sablefish landings have ranged from 1,713 t (2014) to 7,408 t (1975) since 1969 and averaged about 4,741 t annually over the 1969 to 1999 period (Figure 2). Landings have declined from 4,642 t in 2005 to 1,713 t in 2014 in response to TAC reductions over the same period.

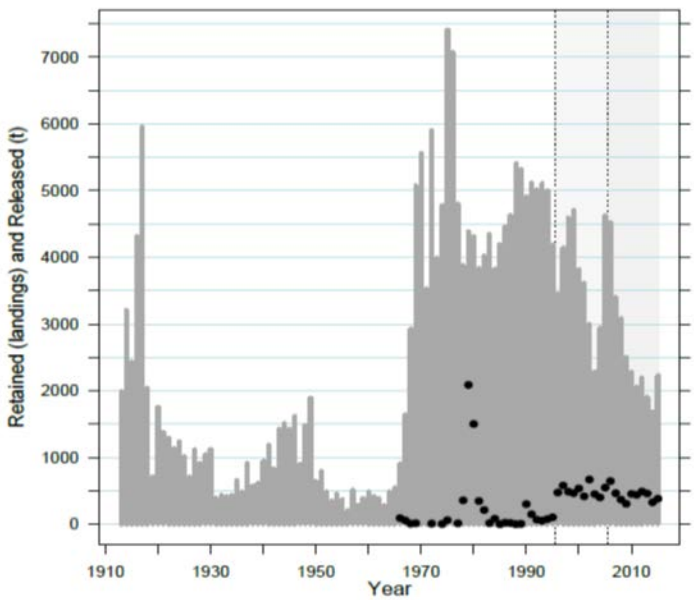


Figure 2. Annual Sablefish retained catch (metric tonnes, t) from 1913 to 2015 from commercial sources (grey bars). Annual released catches are shown as reported (black dots). Vertical dotted lines demarcate the trawl at-sea observer period from 1996 to 2006. Catch data for 2015 are complete to October 31 for both retained catch (grey bar) and released catch (black dots).

Released catch prior to 1996 was voluntarily reported, primarily by the trawl sector, and included reports of very large releases in the few years following the occurrence of the large 1977 year class. Releases of Sablefish reported by the trawl sector increased in 1996, when the at-sea observer program was implemented, and after 2006 when auditing of at-sea electronic monitoring was broadly introduced.

Mortality of fish released at sea (i.e., discard mortality) represents a large uncertainty in fishing mortality estimates (*F*) because they are not measured. Determinants of release mortality for Sablefish are related to gear type, size-specific differences in sensitivity to stress due to interacting environmental factors, and delayed mortality after release due to cumulative stress effects or post-release predation. Deductions are made from quota holdings when legal-sized Sablefish are released using gear-dependent mortality rates, but no quota deductions are applied to releases of sub-legal fish because these fish must be released by regulation (DFO 2014).

Biology

Sablefish are characterized by rapid growth at young ages, followed by extremely slow growth at older ages (Kimura et al. 1993). The species exhibits sexually dimorphic growth, with females attaining larger size-at-age than males after maturing at about ages 5-7 years. Sablefish in BC and Alaska are thought to spawn from January through April (Beamish and McFarlane 1983, Hanselman et al. 2015), with peak spawning occurring in February.

ANALYSIS

Management Procedures

A Sablefish MP consists of monitoring data, a stock assessment method, a harvest control rule (HCR) that provides an annual harvest rate based on estimated stock status, and rules for at-sea release of sub-legal sablefish. All MPs evaluated use the same data and stock assessment method, but differ in harvest control rule options and at-sea release regulations. The current MP uses a HCR with a maximum harvest rate set at the estimated harvest rate at maximum sustainable yield (U_{MSY}), as well as a minimum TAC floor of 1,992 and a minimum size limit of 55 cm (Table 1).

Preliminary simulations showed that the current MP (MP1 in Table 1) may not be robust in the long-term under the revised OM (DFO 2016) since productivity estimates from the revised OM are lower than previously estimated (Cox et al.[1]). As a result, a maximum harvest rate of 5.5%, which was typically less than stock assessment model estimates of U_{MSY} used in the current MP, was tested in the alternative MPs. Improving long-term conservation performance usually involves trade-offs between short-term and long-term yield; however, the current TAC floor limits the scope for adjusting current MP performance in any time period.

Nine alternatives to the current MP (MPs 2-10 in Table 1) were derived based on combinations of TAC floors (0; 1,800; or 1,992 t), phase-in periods over which new, lower maximum harvest rates are introduced (0, 3, 4 or 5 years), and sub-legal release regulations (all Sablefish < 55 cm in length are released or full retention and accounting for all Sablefish caught against ITQs, regardless of size). The nine alternative MPs also include a constraint on upward TAC changes in which TACs remain at a particular level until the recommended TAC increase is at least 200 t. This change was requested by industry to limit unnecessary upward movement in TACs. The nine alternative MPs also differ from the current MP in the level of tuning used to define prior distributions for F_{MSY} and MSY in the simulated stock assessment: they were given tighter and more precise prior distributions for these parameters to reflect the corresponding reductions in these values for the revised OM.

The performance of MPs was evaluated using quantitative performance indicators for each fishery objective (Table 2). Stock status indicators are all measured using the true female spawning stock biomass and catch values from the OM. Two Sablefish generations (36 years) were used as the "reasonable" time frame required by the DFO Precautionary Approach Framework (DFO 2009), and 10 years as the short-term time frame to reflect industry economic interests. Performance indicators and other quantities of interest were calculated over 100 simulation replicates (Table 2).

[1] Cox, S., Holt, K., and Johnson, S. Evaluating the robustness of management procedures for the Sablefish (*Anoplopoma fimbria*) fishery in British Columbia, Canada for 2017-18. CSAP Working Paper 2014GRF08. *In revision*

Table 1. Candidate management procedures evaluated for the BC sablefish fishery. The current management procedure is MP1, MP2-MP10 are alternatives. The Minimum TAC Increase column indicates smallest allowable TAC increase in tonnes (t). The Phase-in period shows the number of years over which the maximum target harvest rate will ramp down from the 2017 value of 0.08 to U_{MAX}. Sub-legal regulations are either the status quo "Release < 55 cm" or "Full Retention" where no size limit is applied to all gears/sectors and all Sablefish caught are accounted for in the ITQ.

Management procedure	Harvest Rate	TAC Floor (t)	Minimum TAC Increase (t)	Phase-in Period (years)	Sub-legal Reg.
MP1: Current	$\hat{U}_{MSY}$	1,992	0	0	Release < 55 cm
MP2	0.055	1,992	200	0	Release < 55 cm
MP3	0.055	1,992	200	0	Full retention
MP4	0.055	1,800	200	0	Release < 55 cm
MP5	0.055	1,800	200	0	Full retention
MP6	0.055	0.000	200	0	Release < 55 cm
MP7	0.055	0.000	200	3	Release < 55 cm
MP8	0.055	0.000	200	4	Release < 55 cm
MP9	0.055	0.000	200	5	Release < 55 cm
MP10	0.055	0.000	200	5	Full retention

Table 2. Performance statistics calculated for each management procedure/OM scenario combination. The interval $t = t_1,\ldots,t_2$ defines the time period over which each statistic is calculated. The probability P(decline) value used for Objective 2 differs among scenarios depending on operating model stock status.

Objective	Description	Performance Indicator
Objective 1	Proportion of projection years where female spawning biomass exceeds $0.4B_{MSY}$. (Period: 2017- 2052)	$P(fSSB > 0.4B_{MSY})$
Objective 2	Proportion of 10-year trends that are declining (Period: 2017 - 2026)	$P(fSS\beta < 0) < P(decline)$
Objective 3a	Proportion of projection years where female spawning biomass exceeds B_{MSY}. (Period: 2017- 2052)	$P(fSSB > B_{MSY})$
Objective 3b	Proportion of projection years where female spawning biomass exceeds $0.8B^{MSY}$. (Period: 2017- 2052)	$P(fSSB > 0.8B_{MSY})$
Objective 4	Proportion of projection years where landed catch is above 1,992 tonnes. (Period: 2017 - 2052)	$P(C \quad > 1{,}992\ t)$
Objective 5	Mean of annual landed catch. (Period: 2017- 2026)	Mean C

Objective	Description	Performance Indicator
Min and Max	Minimum and Maximum landed catch. (Period: 2017- 2026)	Min *C* Max *C*
Industry preference	Average annual absolute change in the landed catch (Period: 2017- 2026)	*AAV*

Operating Model Scenarios and Simulations

The updated Sablefish operating model developed in January 2016 (DFO 2016; Cox et al.[2]) implements a two-sex age-structured model to account for differences in growth, mortality, and maturation of male and female Sablefish. Two additional structural changes that were made include the implementation of an ageing error matrix applied to the model age proportions and a revised multivariate-logistic age composition likelihood that reduces model sensitivity to small age proportions. These changes improved model fit to age composition and at-sea release data compared to the fit of the previous operating model, and reduced the unrealistic recruitment autocorrelation present in the previous model estimates (DFO 2016).

Data scenario D2 from Cox et al.[1] (see DFO 2016 also) was used to condition the OM scenarios for simulation analyses. Each OM scenario was fitted to:

i. time series of retained catch between 1965 and 2016, including three commercial fishery gear-types (trap, longline, and bottom trawl) and two research surveys;

ii. time series of at-sea releases between 1996 and 2016 for trawl and between 2006 and 2016 for trap and longline hook fisheries;

iii. indices of relative abundance from commercial CPUE (1979-2009), standardized trap survey (1991-2009), and stratified random trap survey (2003-2015); and

iv. age composition data from the commercial Sablefish trap fishery, standardized trap survey, and stratified random trap survey.

The data used to condition the operating model were updated from the datasets described by Cox et al.[2] to include an additional year (2016) and a Bayesian estimation approach using Markov Chain Monte Carlo (MCMC) simulation was used to generate posterior parameter estimates for the OM scenarios.

Five OM scenarios were used to capture uncertainty about both productivity (i.e., stock recruitment steepness) and current female spawning biomass ($fSSB_{2016}$). A base case scenario that represented the most plausible hypothesis was based on the expected values for both productivity and $fSSB_{2016}$. The remaining four scenarios were selected by fitting a multivariate normal distribution to the joint MCMC posterior sample distribution for these two variables, and selecting four points on the ellipse capturing the central 80th percentiles in each dimension. The four alternatives to the base case represented the following combinations:

1. high productivity, mean fSSB2016 (hiProd/expSSB);
2. low productivity, mean fSSB2016 (loProd/expSSB);
3. mean productivity, high fSSB2016 (expProd/hiSSB); and

[2] Cox, S.P., Kronlund, A.R., Lacko, L., and Jones, M. A Revised Operating Model for Sablefish in British Columbia, Canada. CSAP Working Paper 2014GRF03. *In revision*.

4. mean productivity, low fSSB2016 (expProd/loSSB).

MP performance relative to the five objectives was ranked within OM scenarios, as well as weighted across OM scenarios. Weights were assigned to scenarios based on normalized probability densities at each associated productivity-$fSSB_{2016}$ point on the joint posterior distribution, which resulted in a 36% probability to the expected base case scenario and probabilities of 16%, 16%, 15%, and 17% to the hiProd/expSSB, loProd/expSSB, expProd/hi SSB, and expProd/loSSB scenarios, respectively.

Results

Simulation results showed that the current MP was unable to meet the three conservation objectives under any of the five OM scenarios considered, and was consistently ranked last in performance for these objectives (Table 3). This finding differs from previous simulation analyses of the current MP that were conducted using the 2011 OM (Cox et al. 2011; DFO 2011), which estimated stock productivity to be higher than the revised 2016 OM used here.

Based on the weighted-average performance across the five OM scenarios, MPs that included TAC floors (MPs 2-5) were unable to achieve any of the conservation objectives, even when sub-legal release regulations required all legal and sub-legal (<55cm) sablefish catch to be counted against the TAC (referred to as full retention in this paper; MPs 3 and 5 in Table 3). MPs that included the addition of full retention (MPs 3, 5 and 10) usually performed better relative to conservation objectives than identical MPs without full retention (MPs 2, 4 and 9, respectively). In the absence of full retention of Sablefish, MP9, which includes a 5-yr phase-in to the lower harvest rate of 5.5%, was able to meet conservation objectives 1 and 2 while providing 10-year average catch of 1,690 t (Table 3), which is below the current TAC floor of 1,992 t. Using similar MPs with shorter phase-in periods (e.g., MPs 6-8) resulted in almost no gains in conservation performance in trade for somewhat reduced catch (Table 3).

None of the MPs evaluated were able to meet conservation objectives 3a and 3b with the required certainty under any of the productivity scenarios (Table 3, Figure 3). Meeting either form of this objective requires spawning biomass to remain above B_{MSY} (Objective 3a), or $0.8B_{MSY}$ (Objective 3b) if the stock is below $0.8B_{MSY}$, in 50% of the years measured over two sablefish generations (36 years). MPs with maximum harvest rates of 5.5% (MPs 6 and 9 in Figure 3) and MPs that required full retention of sub-legal fish (MP10 in Figure 3) were able to promote stock growth towards 0.8 B_{MSY} by the end of the 36 year projection period. However, no MPs were able to increase the stock to this level and remain above it for 18 of the 36 projection years because current stock status is less than $0.5B_{MSY}$ (ranging from $0.38B_{MSY}$ to $0.46B_{MSY}$, depending on OM scenario), and productivity estimates from the revised OM are lower than previously estimated so biomass increases are slower than estimated with the previous OM. Trade-offs between catch, the length of time to achieve these objectives, and acceptable risk for this objective should be further examined. If Objectives 3a and 3b are to be achieved, then alternative MPs will need to be considered that allow for further catch reductions than the ones presented here.

Sources of Uncertainty

The revised operating model continues to assume that the BC Sablefish stock is a closed population, despite evidence of movements among Sablefish stocks in Alaska and US waters south of BC. These movements may have implications for the assumptions made about Sablefish stock dynamics in BC (i.e., recruitment, productivity) that are not currently captured by the revised OM or reflected in MP performance evaluations.

Table 3. Management procedure performance averaged (weighted) over five operating model scenarios with weights equal to 36% for the expected productivity-current female spawning biomass scenario and 16%, 16%, 15% and 17% for the scenarios representing other combinations of productivity and current female spawning biomass. Numerical values under the columns for objectives 1-4 are the estimated probabilities averaged over all operating model scenarios and are shown when an objective is not achieved. A black dot (●) is used to show than a management procedure meets an objective when tested in all five operating model scenarios. The probability P(decline) differs among scenarios depending on operating model stock status. Min C and Max C are minimum and maximum landed catch in the 2017-2026 period in thousands of tonnes (t). AAV is the average annual absolute change in landed catch (2017-2026) in hundreds of t. D2017 and C2017 are stock depletion and estimated landed catch (thousands of t) in 2017.

Management procedure	**Objective**						Min *C*	Max *C*	*AAV*	D_{2017}	C_{2017}
	Obj 1 P(fSSB >$0.4B_{MSY}$)	Obj 2 P(fSSB< 0) < P(decline)	3a P(fSSB >B_{MSY})	3b P(fSSB > $0.8B_{MSY}$)	4 P (C > 1,992t)	5 Mean C (t)					
MP 10	●	●	0.19	0.37	0.54	1.73	1.32	2.16	12.02	0.19	2.00
MP 6	●	●	0.14	0.31	0.43	1.60	1.21	1.87	11.83	0.19	1.38
MP 7	●	●	0.13	0.29	0.43	1.65	1.24	2.11	12.75	0.19	2.00
MP 8	●	●	0.13	0.29	0.43	1.67	1.26	2.13	12.62	0.19	2.00
MP 9	●	●	0.12	0.28	0.44	1.69	1.27	2.15	12.75	0.19	2.00
MP 5	0.91	0.02	0.18	0.35	0.47	1.84	1.79	1.95	2.30	0.19	1.79
MP 3	0.87	0.07	0.16	0.32	0.43	1.99	1.98	2.04	0.59	0.19	1.98
MP 4	0.84	0.10	0.11	0.25	0.36	1.83	1.79	1.92	2.17	0.19	1.79
MP 2	0.77	0.16	0.09	0.21	0.31	1.99	1.98	2.02	0.46	0.19	1.98
MP 1: currMP	0.76	0.18	0.05	0.14	0.48	2.11	1.98	2.26	2.52	0.19	2.02

The 2016 revised OM assumes that that BC sablefish were at unfished equilibrium status in 1965, despite anecdotal evidence to the contrary in the 1960s and 1970s. Future MSE simulations should consider alternative hypotheses for exploitation prior to the 1960s.

CONCLUSIONS AND ADVICE

When evaluated against the revised OM (DFO 2016), the current MP was unable to meet the three conservation objectives under any of the five productivity-spawning biomass OM scenarios and was consistently ranked last in conservation performance. It is recommended that consideration be given to alternative MPs for the Sablefish fishery.

Based on the weighted-average performance across the five productivity-spawning biomass OM scenarios, MPs that included TAC floors were not able to achieve conservation objectives while MPs without a TAC floor were able to achieve these objectives. The length of the phase-in period to a lower maximum harvest rate did not have a large effect on MP performance relative to conservation objectives.

MPs that include the addition of full retention (here meaning all sub-legal (< 55 cm) and legal fish caught are counted against ITQs) resulted in better performance against conservation objectives relative to the identical MPs without full retention.

Neither the current nor any of the alternative MPs achieved fSSB levels above B_{MSY}, or 0.8 B_{MSY} in 50% of the years measured over two sablefish generations (the third conservation objective), although some MPs were able to increase spawning biomass to 0.8 B_{MSY} by the end of the two Sablefish generations (36 years). It is recommended that the trade-offs between achieving 0.8 B_{MSY} in 50% of the years over two Sablefish generations (the current objective) and achieving 0.8 B_{MSY} in two Sablefish generations be further examined. In the absence of full retention of Sablefish, an MP with a phase-in to a new maximum target harvest rate of 5.5% over 5 years was able to achieve two of the conservation objectives while providing 10-year average catch of 1,690 t, which is below the current TAC floor of 1,992 t.

Inconsistent sampling of age composition data in commercial catches (only Trap fishery age composition data are currently available) has contributed to model issues that have been consistently identified during the BC Sablefish MSE process (Cox et al. 2011; DFO 2011, 2014). It is recommended that attention be given to designing and implementing a commercial catch sampling program across all fishery sectors.

MSE is an iterative process of change and improvement. It is recommended that BC Sablefish operating models and MPs be re-evaluated for suitability at 3-year intervals.

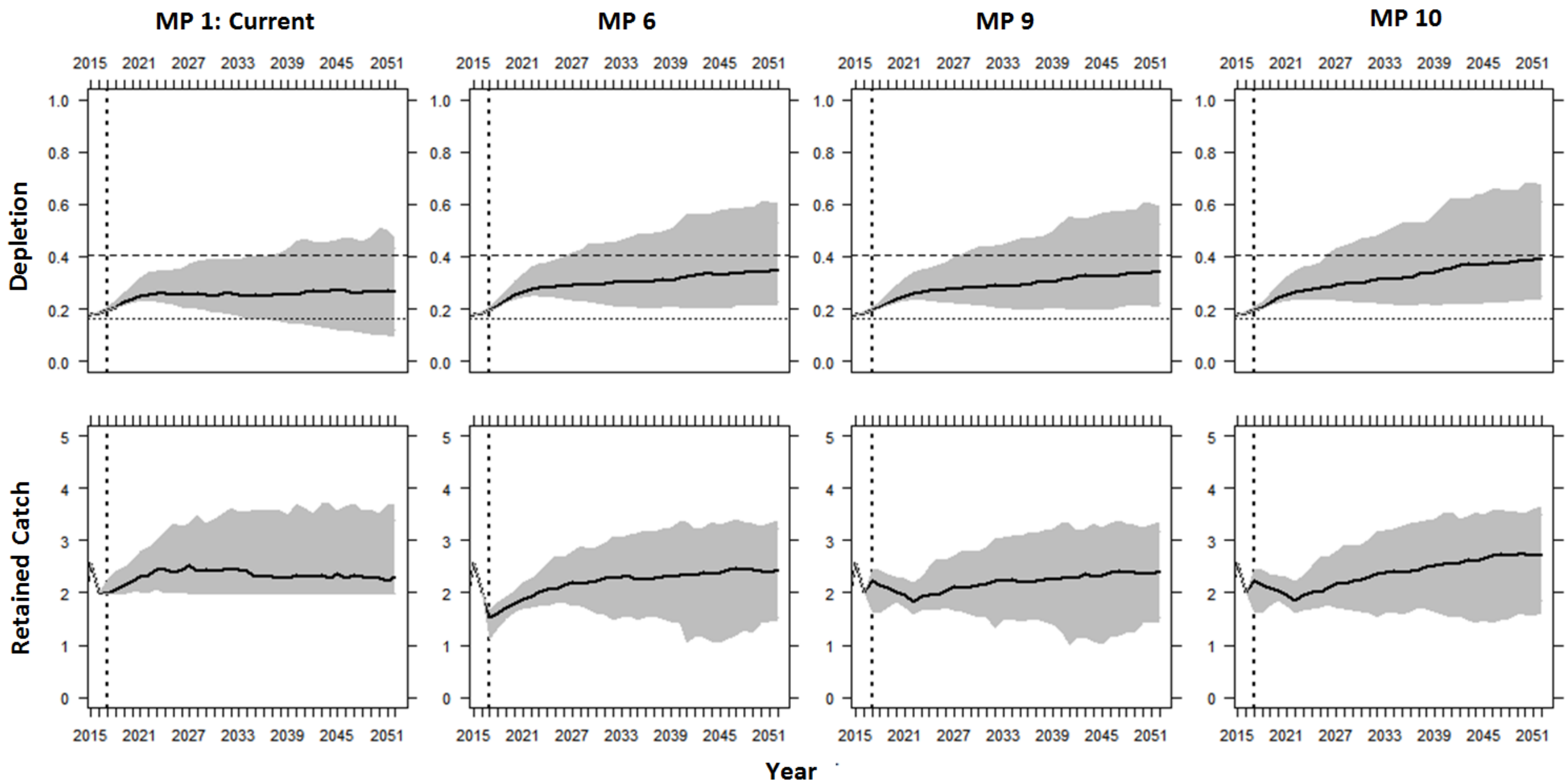


Figure 3. Projection distributions for operating model female spawning biomass depletion (i.e., $fSSB_t/fSSB_0$) (top) and retained catch (bottom) from four simulated management procedures (left to right columns: MP1 (the current MP), MP6, MP9, and MP10) under the base-case scenario (mean productivity/mean $fSSB_{2016}$). Grey shaded distributions represent the central 80% of 100 simulation replicate outcomes, while black solid lines show median values. Horizontal lines in the top panels mark the biomass limit reference point (0.4 B_{MSY}- bottom dotted line) and B_{MSY} (top dashed line).

SOURCES OF INFORMATION

This Science Advisory Report is from the January 10-11, 2017 regional peer review on Evaluating the robustness of management procedures for the Sablefish (*Anoplopoma fimbria*) fishery in British Columbia, Canada, for 2017-18. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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Aussi disponible en français :

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