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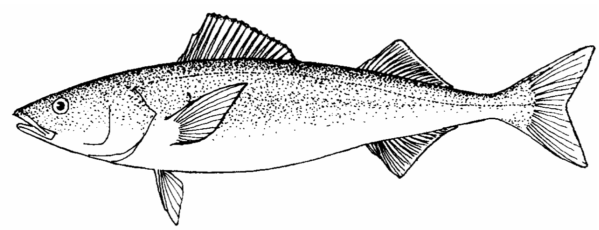
EVALUATION OF INTERIM HARVEST STRATEGIES FOR SABLEFISH (ANOPLOPOMA FIMBRIA) IN BRITISH COLUMBIA, CANADA FOR 2008/09



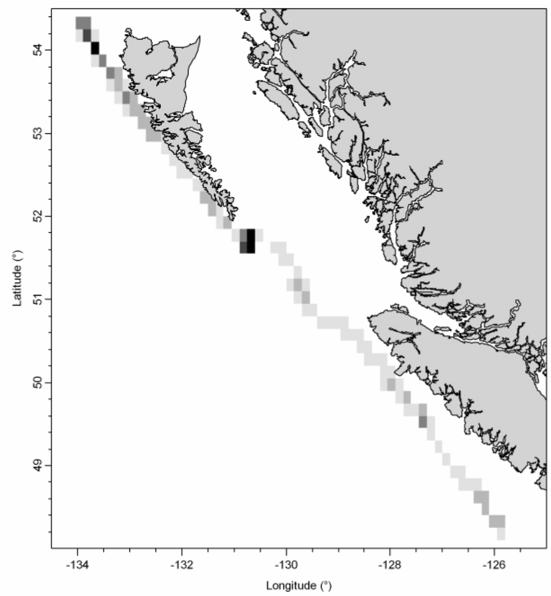


Figure 1: Distribution of sablefish trap gear catch in 2007. Catch is proportional to shading density.

Context:

Sablefish (Anoplopoma fimbria), also referred to as Blackcod, inhabit shelf and slope waters to depths greater than 1500 m, from central Baja California to the Bering Sea and Japan. Spawning is observed from January to March along the continental shelf at depths greater than 300 m. Larval sablefish are found in surface waters over the shelf and slope in April and May. Juveniles migrate inshore over the following six months and rear in near shore and shelf habitats until ages 2 to 5 when they migrate offshore and recruit to deeper waters. Fish become vulnerable to the trawl, longline trap and hook fisheries at this time. Sablefish can be highly migratory, with tagged fish traveling from the waters of Hecate Strait and mainland inlets as far north as the Aleutians. Growth is rapid, with mature females reaching an average length of 55 cm, and a maximum of 80 cm, in 3 to 5 years. The oldest fish recovered from British Columbia was aged at 87 years. Age, growth and maturity parameters vary among areas and depths. Recruitment rates also vary, with infrequent occurrences of very large year classes interspersed with moderate to low year classes.

The directed sablefish fishery is operated under a transferable quota system limited to 48 license holders. The directed catch is taken primarily by longline trap gear with about 20 percent of this catch harvested by longline hook gear. The multi-species trawl sector is allocated 8.75 percent of the total allowable catch. Assessments have been conducted since the late 1980s. Patterns in sablefish recruitment, growth and the movement of tagged fish suggest the presence of northern and southern *stocks in B.C. waters that mix off north western Vancouver Island. Large-scale movement occurs with fish tagged in coastal B.C. being recovered from Oregon to the Aleutian Islands. Fishery management is conducted on stocks in the Gulf of Alaska, British Columbia, and the west coast of the continental United States. Research, assessment, management, and enforcement activities are augmented by a collaborative agreement between Fisheries and Oceans Canada and an industry stakeholder association that represents directed fishery license holders. This report summarizes advice from closed-loop feedback simulations conducted to evaluate management strategies for sablefish.*

SUMMARY

- A closed-loop feedback simulation approach was used to identify interim management procedures to guide the choice of the total allowable catch (TAC) in 2008/2009 and subsequent fishing years;
- A catch-at-age operating model was used to define four stock scenarios that represented states of low/high productivity and low/moderate stock depletion levels;
- The performance of data-based and model-based management procedures was evaluated;
- Each management procedure included a harvest control rule compliant with the DFO (2006) harvest strategy policy;
- Management procedures that met objectives showed the capability to improve stock status within 3-7 years with 90% certainty even under the most pessimistic scenario for stock productivity and current status;
- TAC levels for 2008 under the admissible management procedures ranged from 1,500 to 2,700 tonnes; however, most will decrease TACs by up to 50% between 2009 and 2014 if the current stock decline continues.

INTRODUCTION

A closed-loop feedback simulation approach was applied to identify an *interim* management procedure for setting sablefish (*Anoplopoma fimbria*) total allowable catches in 2008/2009 and beyond. Simulations were used to evaluate the expected performance of data-based and model-based management procedures under four scenarios for sablefish stock and fishery dynamics. At the time sablefish was last assessed in 2004 (Haist et al. 2005), stock abundance indices had increased relative to historically low levels observed in 2000 and 2001. Since 2003, declines in these indices suggest that the stock may again be approaching conditions experienced in 2001/2002 when a total allowable catch (TAC) reduction from 4,000 t to 2,450 t was implemented (Fisheries and Oceans Canada 2002). Subsequent to the 2002 reduction, the TAC was increased to 3,000 t for the 2003/2004 sablefish fishing year (Aug 1-Jul 31) and reached 4,600 t for the 2005/2006 fishing year as increased trap fishery and survey catch rates were observed. As a result of pre-season consultation with the industry-based Sablefish Advisory Committee, the TAC was reduced to 3,900 t for the 2006/2007 fishing year and reduced further to 3,300 t for the 2007/08 fishing year, primarily in response to decreased trap fishing success and continued decline in observed survey indices of abundance. Since 2006, a joint DFO-industry committee has been developing a management strategy evaluation (MSE) approach aimed at identifying a consistent procedure for setting sablefish TACs based on the results of a long-term survey time-series. The results of the analysis in support of 2008/09 advice are based on a detailed assessment by Cox and Kronlund (2009) reviewed by the Pacific Scientific Advice Review Committee (PSARC) in June 2008. The MSE framework by Cox et al. (2009) was reviewed by PSARC in May 2008.

ANALYSIS

Simulation analyses were performed to evaluate management procedure performance against the following operational objectives:

1. Rebuild B.C. spawning stock biomass to at least 20% of unfished within 1.5 generations (22.5 years assuming *M* = 0.08 and 50% maturity at age-5) with a minimum of 90% certainty;
2. Rebuild B.C. spawning stock biomass above the 2007 level within 10 years or less with a minimum of 90% certainty;
3. Maintain less than 20 % interannual variation in catch;
4. Maximize the median average annual catch over 1-10 years subject to the constraints imposed by Objectives 1-3.

Candidate management procedures for sablefish were tested against four scenarios of the age-structured population dynamics operating model specified by Cox et al. (2009). The scenarios were parameterized by fitting the operating model to landings, survey catch rates, and ageing data from both survey and trap fishery sources to 2007. Scenarios were defined by combinations of stock productivity and spawning stock depletion as of 2007, namely: S1 - low productivity/low depletion; S2 – low productivity/moderate depletion; S3 – high productivity/moderate depletion; and S4 - high productivity/optimal depletion. Two general types of management procedures were examined that incorporated variable harvest rate control rules as required by the DFO harvest strategy policy (2006). The types are defined as (*i*) data-based (DB) procedures that set annual TACs by averaging the preceding year's total catch with a multiple of the three-year running average of fishery-independent survey catch rates, and (*ii*) model-based procedures that set annual catch limits using constant exploitation rate policies and estimates of stock biomass from catch-age (CA) models. The relative performance of the various procedures under simulation scenarios was compared by statistics that summarized outcomes in terms of conservation status (e.g., stock depletion), catch, catch volatility and the time required to achieve Objectives 1-2 above.

Data-based procedures were evaluated that compute a catch limit based on survey catch rates according to a 3-year moving average. A smoothing constant was applied that specified the proportion of next year's catch limit that derives from the current catch limit. The data-based procedure was modified to accommodate the variable harvest rate strategy outlined by DFO (2006) by specifying standardized survey catch rates $\left\{I_{low}, I_{high}\right\}$ that define the limit reference and upper stock reference points. Candidate management procedures were distinguished by various choices of the smoothing constant and reference points, and selected values of a survey multiplier parameter that specified the effective harvest rate.

Model-based procedures were evaluated that coupled a multi-gear catch-age model to a variable harvest control rule compliant with DFO (2006). The catch-age model does not estimate unfished biomass. Instead, this stock assessment approach estimates biomass beginning in 1992, which is the start of reliable age composition sampling for the survey. The harvest control rule was rendered compliant with DFO (2006) by specifying reference points $\left\{D_{low}, D_{high}\right\}$ which correspond to depletion levels relative to 1992, i.e., a depletion level of 1.0 means that the spawning stock biomass is at the 1992 level. Candidate management procedures for model-based procedures were distinguished by various choices of the reference points and the harvest rate, U^{ref} .

ADDITIONAL STAKEHOLDER PERSPECTIVES

Two specific modifications to procedures were suggested through consultations with industry and managers. These modifications were evaluated in addition to a subset of procedures examined by Cox et al. (2009). For the first modification, new procedures were introduced that set the 2008 TAC to either 1,500, 1,900, 2,300 or 2,700 tonnes, and then applied a particular data-based or catch-age model-based procedure thereafter. The second modification eliminated the necessity to constrain TAC changes between years to 15% or less during the first five years of management procedure implementation as evaluated by Cox et al. (2009).

CONCLUSIONS AND ADVICE

A hierarchical strategy for choosing among candidate management procedures was applied that orders fishery management objectives linearly according to their level of priority where conservation objectives predominate over volatility and yield considerations. Conservation, catch variability, and catch performance were compared to management objectives 1-4 developed through consultations with industry stakeholders and managers. Simulations indicated that 70-80% of the management procedures examined would likely fail to meet specified conservation objectives under some scenarios for sablefish population dynamics. These failures occurred despite the fact that most procedures rebuild the sablefish stock over 40 years. The remaining "admissible" management procedures show the capability to improve stock status within 3-7 years with 90% certainty even under the most pessimistic scenario for stock productivity and current status. TAC levels for 2008 under these admissible procedures range from 1,500 to 2,700 tonnes; however, most will decrease TACs by up to 50% between 2009 and 2014 if the current stock decline continues. The estimated time required to maintain the spawning stock above 2007 levels with 90% certainty ranged from 4 to 7 years when the 2008 TACs were combined with the highest performing data-based management procedure.

The analysis demonstrated that embedding different 2008 quota choices into several candidate management procedures mainly affected short-term performance relative to conservation objectives. Although the full range of 2008 TAC options (1,500 - 2,700 t) was included in the admissible management procedures, it is expected that quotas in the range 2,000-2,400 t will achieve conservation objectives more rapidly and with greater certainty, while potentially buffering against known uncertainties such as discarding. Importantly, similar average annual catch is expected over 10-years for all quota levels considered.

OTHER CONSIDERATIONS

Scenarios focused on B.C. sablefish stock productivity and the present level of spawning biomass depletion. Although these two uncertainties are amongst the most critical to evaluate in management strategy simulations, these scenarios do not capture the broader range of uncertainties associated with the B.C. sablefish stock and fishery. Advice is subject to several limitations based on current representation of sablefish population dynamics in the operating model scenarios. Potential impacts of high discard rates in all fisheries are of concern because (*i*) the operating model estimates of stock status would be optimistic and (*ii*) failing to account for discard mortality in future projections means that actual recovery rates will be slower.

SOURCES OF INFORMATION

Beamish, R.J. and G.A. McFarlane. 1988. Resident and dispersal behavior of adult sablefish (*Anoplopoma fimbria*) in the slope waters off Canada's west coast. Can. J. Fish. Aquat. Sci. 45: 152-164.

Cox, S.P., Kronlund, A.R., and M.R. Wyeth. 2009. Development of precautionary management strategies for the British Columbia sablefish (*Anoplopoma fimbria*) fishery. DFO. Can. Sci. Advis. Sec. Res. Doc. 2009/043. 161 p.

Cox, S.P. and A.R. Kronlund. 2009. Evaluation of interim harvest strategies for sablefish (*Anoplopoma fimbria*) in British Columbia, Canada for 2008/09. DFO. Can. Sci. Advis. Sec. Res. Doc. 2009/042. 87 p.

DFO. 2006. A harvest strategy compliant with the precautionary approach. DFO. Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/023.

Fisheries and Oceans Canada. 2002. Integrated fishery management plan: sablefish, August 1, 2002 to July 31, 2003. Fisheries and Oceans Canada. 50 p.

Haist, V., Kronlund, A.R., and Wyeth, M.R. 2005. Sablefish (*Anoplopoma fimbria*) in British Columbia, Canada: stock assessment for 2004 and advice to managers for 2005. DFO. Can. Sci. Advis. Sec. Res. Doc. 2005/031. 182p.

Wilkens, M.E. and M.W. Saunders (eds.). 1997. Biology and management of sablefish *Anoplopoma fimbria*. NOAA Tech. Report NMFS 130: 275p.

Wyeth, M.R., Kronlund, A.R, and Elfert, M. 2007. Summary of the 2005 British Columbia sablefish (*Anoplopoma fimbria*) research and assessment survey. Can. Tech. Rep. Fish. Aquat. Sci. 2694. 105p.

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