HARVEST ADVICE FOR PACIFIC SARDINE (*SARDINOPS SAGAX*) IN BRITISH COLUMBIA WATERS FOR 2017 SEASON

Context

The northern subpopulation of Pacific Sardine (*Sardinops sagax*) in the eastern Pacific Ocean (California Current Ecosystem) has a distribution that can range between Baja California to southeast Alaska. In winter and spring months, most of this stock resides in waters off the California coast in association with spawning. Prior to, and during summer months, large aggregations of Pacific Sardine migrate from spawning habitat to more northern waters mainly to forage. Migratory patterns can be affected by age structure, population size and oceanographic conditions. Typically, most Pacific Sardines that migrate into British Columbia (BC) waters are the larger and older fish in the population. Pacific Sardine has not been fished in BC waters since 2012 due to reduced migration (a general absence of Pacific Sardine in BC waters) and formal fishery closures in 2015 and 2016.

To calculate potential harvest options for the BC sardine fishery, Fisheries and Oceans Canada (DFO) adopted a harvest control rule in 2013 that applies a harvest rate to an estimate of age-1 year and older (age-1+) biomass when it exceeds 150,000 t (DFO 2013). As described in the 2013 Science Advisory Report, a range in harvest rates from 3-5% was selected to calculate potential harvest options. The age-1+ biomass estimate used in the harvest control rule is based on stock assessment efforts conducted by the United States (US) National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA). An updated US stock assessment of the northern subpopulation of Pacific Sardine was conducted and reviewed in February 2017 and adopted for US management in April 2017 (Hill et al. 2017, STAR 2017).

DFO Fisheries Management requested that DFO Science Branch incorporate the updated 2017 US stock assessment results into the 2013 BC fishery harvest control rule and provide harvest advice for Pacific Sardine for the 2017 season. Specifically, this Science Response (SR) provides information on the northern subpopulation of Pacific Sardine (associated with the California Current Ecosystem) to report on its biomass status, exploitation rates, commercial landings, and harvest options for the 2017 BC Pacific Sardine fishing season. Objectives of this report are to:

1. Report the results of applying the harvest control rule for a range of harvest rates from 0.03 to 0.05 in increments of 0.01, if the biomass estimate exceeds the cutoff (escapement buffer) of 150,000 t.
2. Identify uncertainties associated with harvest advice.

A formal Canadian stock assessment will not be undertaken in 2017 and the following advice is based on a multi-year method approved in 2013. As such, for a full understanding of Science recommendations, uncertainties, and future considerations, readers are referred to the 2013 Canadian Science Advisory Secretariat (CSAS) Science Advice Report (DFO 2013).

This Science Response Report results from the Science Response process of May 2017 on Harvest Advice for Pacific Sardine (*Sardinops sagax*) in British Columbia Waters for 2017.

Background

Population assessment

As stated above, the US NMFS assesses the status and population trend of the Pacific Sardine northern subpopulation of the eastern Pacific Ocean (also knowns as the California Current Ecosystem stock) using a Stock Synthesis model (Methot and Wetzel 2013, Hill et al. 2017). Since 2014, the annual Pacific Sardine stock assessment process has been conducted and updated in the spring. The most recent assessment and review of the assessment methodology was conducted in February 2017, which resulted in a recommendation to adopt a modification of the previous Stock Synthesis model for the July 2017-June 2018 fishing periods (Hill et al. 2017, STAR 2017). In order to better align with the first season that data from a fishery independent acoustic-trawl survey was collected to inform the stock assessment model, the model output for the 2017 assessment has a truncated time series that starts in 2005, compared to previous year assessments efforts which had time series starting in 1993. The assessment model is also informed by data from fishery landings and biological samples collected up to December 2016 (Hill et al 2017).

BC Pacific Sardine fishery harvest control rule

In 2013, DFO Fisheries Management adopted a harvest control rule that incorporates a current estimate (forecast) of the population's age-1+ biomass $B_{1+,t}$, an escapement buffer, or cutoff value, of 150,000 tonnes, and a harvest rate, h. The cutoff value of 150,000 tonnes is consistent with the cutoff value used in the US harvest guideline. The harvest rate is applied to the difference between the estimated age-1+ biomass and the cutoff. As described in the 2013 review (DFO 2013), a range in harvest rates (h) from 3-5% was selected in the calculation of potential harvest allowances (in tonnes). When the forecast of age-1+ biomass ($B_{1+,t}$) is less than 150,000 tonnes, the recommendation is that there should be no harvest. The equation for the calculation of a fishing season's potential total allowable (TAC_t) starting in year "t" is:

$TAC_t = h\ (B_{1+,t} - 150{,}000)$

This SR provides the recommended 2017 BC Pacific Sardine fishery harvest options based on the use of that harvest control rule and the 2017 NOAA forecast for the stock's July 2017 age-1+ biomass.

Analysis and Response

Biomass

Recent estimates of the California Current Pacific Sardine age-1+ biomass show a decreasing trend since 2006, reaching historically low levels in recent years (Hill et al. 2017). Declines in recruitment have also occurred since 2005-06, with the exception of a brief period of modest recruitment success from 2009-10 (Hill et al. 2017). In particular, the 2011- 2015 year classes have been among the weakest in recent history. A small increase in recruitment was estimated in 2016, but is based on limited data and is associated with relatively high uncertainty. The age-1+ biomass maximum likelihood estimate for the July 2017 forecast is 86,586 tonnes (with a 90% credible interval of 52,207 to 120,692 tonnes; Hill et al. 2017).

Few or no sardines have been observed in BC waters during the seasons of 2013-2016 from fisheries, surveys or other sources, suggesting curtailed migration and/or stock size. Estimates of mean Pacific Sardine trawl catch densities (a catch per unit effort index) from the west coast of Vancouver Island summer pelagic ecosystem night trawl survey in 2006, and 2008-2014 show a decreasing trend from 2006 with no sardines observed in the last two years of the survey (2013 and 2014). During the summers of 2015 and 2016 sardines were detected off the west coast of Vancouver Island in trawl catches from other multi-species surveys (i.e. led by DFO or NOAA).

BC fishery exploitation

The commercial BC sardine fishery was reinitiated in 2002 following closure since 1947 (Ware 1999, DFO 2012). Most fishing occurred from July to October in association with seasonal migratory behaviour (DFO 2012). From 2002-2012, the annual total allowable catch (TAC), generally increased as a result of management decisions (DFO 2012). Prior to 2008, landings were relatively low (less than 5,000 tonnes), increased considerably from 2007-2012 (up to a maximum of 22,223 tonnes in 2010) but were zero in 2013 through to 2016 due to an apparent absence of Pacific Sardine in BC waters in 2013 and 2014 and fishery closures in 2015 and 2016 (Table 1). Since 2002, total landings of the northern subpopulation (catches from BC, Washington, Oregon, California and Ensenada Mexico combined) were highest in 2007 and lowest in 2016. BC annual fishery exploitation rates were estimated as the annual fishery landings (C_t) divided by the estimated age-1+ biomass in July of year *t*. The exploitation rate on the stock due to fishing in BC waters increased from ≤ 1% prior to 2009 to approximately 5% in 2012 and 0% in 2013-2016 (Table 1).

Table 1: Pacific Sardine fishery BC TAC, landings and total landings for the west coast of North America (BC, Washington, Oregon, California and Ensenada Mexico (northern subpopulation only)). Also shown are Hill et al. (2017) estimates of July age-1+ population biomass, biomass coefficient of variation (CV), and BC exploitation for years 2005-2016. Total landings for 2002-2005 are from Hill et al. (2016) and total landings for 2005-2016 are from Hill et al 2017. TAC, landings, and biomass values are in metric tonnes.

Year	BC TAC	BC Landings (C)	Total Landings	Biomass $B_{1+,\,July}$	CV ($B_{1+,\,July}$)	BC Exploitation ($C/B_{1+,\,July}$)
2002	5,040	822	96,344	--	--	--
2003	9,000	1,006	84,311	--	--	--
2004	15,000	4,259	87,699	--	--	--
2005	15,200	3,266	94,149	1,553,212	10.18%	0.21%
2006	13,500	1,558	92,413	1,798,037	7.57%	0.09%
2007	19,800	1,507	134,365	1,492,373	6.73%	0.10%
2008	12,491	10,435	112,959	1,114,265	6.69%	0.94%
2009	18,196	15,334	100,084	767,891	6.62%	2.00%
2010	23,166	22,223	97,870	607,294	6.80%	3.66%
2011	21,917	20,719	91,890	551,375	7.46%	3.76%
2012	27,279	19,129	121,920	356,650	8.82%	5.36%
2013	25,477	0	73,595	181,928	12.80%	0.00%
2014	17,174	0	23,581	89,264	18.00%	0.00%
2015	0	0	2,994	70,540	21.86%	0.00%
2016	0	0	285	66,983	22.39%	0.00%

Uncertainties

Key uncertainties associated with the 2017 US Pacific Sardine assessment identified in Hill et al. (2017) and STAR (2017) include information related to:

1. acoustic species identification, target strength estimation and spatial boundaries associated with the acoustic-trawl survey. Concern over poor near-shore survey coverage has also been expressed by representatives of the U.S and Canadian sardine fishing industry.
2. empirical weight-at-age data from the fishery and research survey samples and model characterization of population weight-at-age (e.g. time varying versus time-invariant);
3. age-length keys to convert acoustic-trawl survey length compositions to age compositions and selectivity parameterization for the acoustic-trawl survey;
4. lack of empirical justification for increasing natural mortality from 0.4 to 0.6 yr-1; and

Uncertainties and concerns identified in past DFO CSAS reviews related to BC Pacific Sardine fishery harvest advice (e.g. DFO 2013) include:

5. the effect of setting harvest allowances independently of the US and Mexico;
6. unknown effects on stock structure and reproductive capacity from fisheries in different regions targeting different age components of the population;
7. incidental capture of other species in the sardine fishery; and
8. the effects of removing sardine from important forage habitat of sardine predators.

Harvest options

The July 2017 forecasted age-1+ biomass is 86,586 tonnes, which is below the fishery cutoff of 150,000 tonnes. Based on the harvest control rule adopted in 2013, the current recommendation is that there should be no allowable fishery harvest, thus, a TAC of 0 tonnes is recommended for the fishing season starting in 2017.

Conclusions

It is recommended that there should be no allowable targeted harvest of Pacific Sardine in BC waters in 2017.

Contributors

Contributor	Affiliation
Linnea Flostrand	Lead author, DFO Science, Pacific Region
Chris Grandin	Author, DFO Science, Pacific Region
Jennifer Boldt	Author, DFO Science, Pacific Region
Lesley MacDougall	Editor, DFO Science, Pacific Region
Caroline Wells	Reviewer, DFO Fisheries Management, Pacific Region
Corey Jackson	Reviewer, DFO Fisheries Management, Pacific Region
Lorne Clayton	Reviewer, Canadian Pacific Sardine Association
Kevin Hill	Reviewer, NOAA, Southwest Fisheries Science
Barron Carswell	Reviewer, Province of British Columbia

Approved by

Carmel Lowe
Regional Director
Science Branch, Pacific Region
Fisheries and Oceans Canada

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Sources of information

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

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

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