North Pacific Fisheries Commission

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A brief summary of current Sablefish science and management in the eastern North Pacific including the NPFC Convention Area

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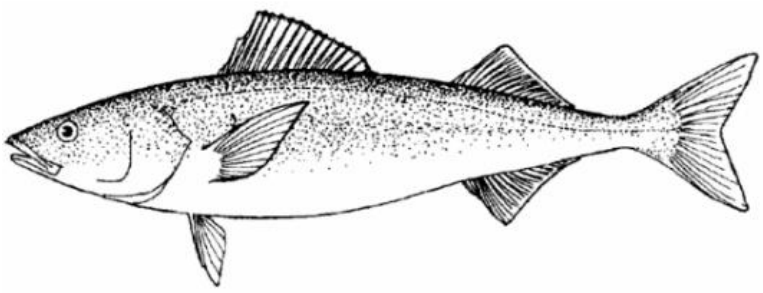

Introduction

Sablefish (*Anoplopoma fimbria*) are a highly valuable commercially harvested groundfish species in the North Pacific Ocean. They are the main target species in the eastern region of the North Pacific Fisheries Commission (NPFC) Convention Area. The goal of this document is to summarize the current data, assessment and management of sablefish populations in Canada, the USA and the NPFC, as well as to document current research activities regarding the species.

Sablefish biology

Sablefish are widely distributed throughout the Pacific Ocean from northern Mexico to the Gulf of Alaska, westward to the Aleutian, and northward into the Bering Sea (Figure 1; Wolotira et al. 1993). They are also found along the western margin of the Pacific Ocean from southern Japan through the Kamchatka Peninsula and northward into the Bering Sea. Adult sablefish occur along the continental slope, shelf gullies, and in deep fjords, generally at depths greater than 200 m. Juvenile sablefish spend their first two to three years on the continental shelf at shallower depths. Spawning is generally in the winter and spring (October-April) and occurs near the shelf break. Spawning timing generally occurs earlier in the south (October-February in California) and later in the north (January – April in Alaska). Eggs are found at depth and larvae are found in surface waters (Figure 2).

Larval sablefish feed on zooplankton prey. Juveniles shift from pelagic to benthic prey including fishes and invertebrates. Adults consume mostly benthic fishes and invertebrates. Sablefish mature at 4 to 5 years. In the eastern Pacific, Sablefish have traditionally been thought to form two populations based on differences in growth rate, size at maturity, and tagging studies. The

northern population inhabits Alaska and northern British Columbia waters and the southern population inhabits southern British Columbia, Washington, Oregon, and California waters, with mixing of the two populations occurring off southwest Vancouver Island and northwest Washington. However, recent genetic work by Jasonowicz et al. (2017) found no population sub-structure throughout their range along the US West Coast to Alaska, and suggested that observed differences in growth and maturation rates may be due to phenotypic plasticity or are environmentally driven. Tagging evidence suggests that the sablefish inhabiting seamounts in the NPFC Convention Area are not distinct from the coast wide sablefish population (Figure 3).

Sablefish fisheries

Canada domestic

Canada has a commercial longline trap fishery inside its EEZ. The fishery is carried out by ~30 longline vessels and occurs throughout the year. Vessels targeting sablefish tend to be small (< 20 m in length). A small amount of sablefish is also captured by the bottom trawl sector as bycatch. Historically, sablefish fisheries on the coast of Canada have been conducted by Canadian and foreign vessels (including USA, Japanese, Russian and Korean vessels) from 1961-1981. The earliest Canadian recorded landings were in 1913. Annual catches have averaged ~4000 mt since 1980 (Figure 4).

USA domestic

The Alaska sablefish fishery has been prosecuted since about 1920. The initial stages of fishery development were by US and Canadian fishers (as in other areas of the coast of North America), with other foreign vessels (primarily Japan, Korea and Russia) fishing along the coast from ~1960-1980 prior to the expansion of EEZ's. Since ~1988 all sablefish landings in Alaska have been in the domestic fishery. Landings have fluctuated between 10,000 and 20,000 mt since 1995 (Figure 3). In Alaska, the sablefish fishery has traditionally utilized longline hook gear. However, since the legalization of pot gear in the Gulf of Alaska in 2017, fishers have moved to alternative gears such as hard and, more recently, collapsible "slinky" pots, which help eliminate whale depredation on catches. Sablefish are also incidentally captured in various bottom trawl fisheries in Alaska. The vessels fishing sablefish in Alaska are mostly small in size (< 20 m length), but there are a handful (< 10) of larger (~40-50 m) longline catcher-processor vessels that also fish for sablefish in Alaska.

On the US West Coast sablefish have been commercially captured since ~1890, with appreciable landings beginning in 1916-1919. In the 1960's and 70's foreign vessels (primarily Japan, Korea and Russia) and an increasing domestic fleet were responsible for increasing harvests. Since ~2000 annual landings have been about 10,000 mt (Figure 3). Sablefish landings have traditionally been harvested by hook and line or pot gear. However, there is also targeted catch from bottom trawl gear. Small vessels (< 20 m length) participate in the US West Coast domestic sablefish fishery.

NPFC CA

In the NPFC Convention Area, sablefish are targeted only by Canadian fishers. The fishery uses longline trap gear at 1-4 seamounts in the Convention Area (CA). Since 2014, a maximum of 3 vessels per year have been allowed to fish in the CA and these have been chosen by lottery. Historically, there were significant and mostly unknown catches of sablefish and other groundfish landed in the NPFC CA by trawl and longline fishers from Canada, Japan, Korea, Russia and the USA. Since 1996 landings of sablefish in the NPFC CA have been around 10-20 mt, with some years (1996, 1998, 2017 and 2018 in particular) having larger catches (Figure 4).

Sablefish data

Fisheries Independent Surveys

Canada domestic

Canada has conducted two longline trap surveys in British Columbia waters. From 1990-2009 a standardized trap survey was conducted at set stations annually. From 2003 to the present DFO conducts a stratified random trap survey along the outer shelf and slope of the BC coast. Both of these surveys generated a fishery independent CPUE as well as biological data that is used in the assessment. The time series of sablefish CPUE in the surveys is shown in Figure 5.

USA domestic

In Alaska, three survey indices are available for use in assessing the status of the sablefish population (Figure 5). There is a longline survey conducted at standard survey stations that provides a relative index of abundance. It has been conducted at depths from 200-1000 m annually since 1978 (cooperatively with Japan from 1978-1994). Bottom trawl surveys are conducted annually or biennially in the three main ecosystems in Alaska since 1982. These are either systematic surveys (eastern Bering Sea) or random-stratified surveys (Gulf of Alaska and Aleutian Islands). Because of limitations associated with catching sablefish with trawl gear and short survey time series in some regions (e.g., Bering Sea), only data from the Gulf of Alaska portion of the trawl survey is utilized for the Alaska stock assessment. Data from the International Pacific Halibut Commission standardized longline survey is also available, although this survey is conducted at the shallowest portion of the sablefish distribution (depths to 500 m) and is not incorporated into the assessment. There is an additional longline survey conducted in inside waters of Southeast Alaska by Alaska Department of Fish and Game, however this data is not used in the assessment of the status of the stock, because the state of Alaska assesses and manages sablefish in state waters independently from federal management.

The U.S. West Coast primarily uses fishery independent survey data from the west coast groundfish bottom trawl survey conducted from 2003-2018 over depths of 55 to ~1300 m as an index of sablefish abundance (Figure 5). The bottom trawl survey follows a random-stratified survey design with four vessels (in most years) conducting the survey annually. The trawl survey data is analyzed with the VAST model (Thorson 2019) to produce the index of abundance for

sablefish. Historically there have been a number of other bottom trawl surveys conducted on the US West Coast with variable survey designs. These surveys are also included in the assessment and modeled using VAST methods to produce abundance indices due to the non-continuous (and thus non-standard) methodology used to generate the data. A longline pot survey has also been conducted in the past, but is considered only as auxiliary information and not modeled explicitly in the current assessment due to its limited spatial scope.

NPFC CA

There is currently no survey conducted in the eastern NPFC Convention Area that captures or monitors sablefish populations.

Catch and effort data

Canada domestic

Historically, the catch and effort of Canadian sablefish fisheries has been generated through an observer program, vessel logbooks and dockside monitoring. In general, the data on catch and effort has improved through the history of the fishery so that early catches are less well known (e.g. derived from only dockside sampling in the early years of the fishery), while more recent data (> 1996) is more reliable (e.g. logbook data verified by fisheries observers).

Since 2006 Canada has 100% at-sea and dockside monitoring for groundfish fisheries. At-sea monitoring for the longline pot fisheries is conducted through a combination of electronic monitoring and catch logbooks. Electronic monitoring on sablefish vessels is contracted through a third party (Archipelago Research). Fishers are responsible for purchasing both the electronic monitoring equipment (~$10K CDN per sablefish vessel) and partially supporting the data processing (on subscription of). The system collects various data streams from the vessel and monitors the status of various systems on the vessel. The sensors trigger multiple cameras that record catches from a variety of angles and locations on the vessel. For example, sensors monitor the hydraulic motor on the vessel and when the hydraulics are started this would trigger multiple cameras to begin recording image. These images would then be linked to GPS and other data streams on the vessel. Upon the vessels return to port, the data and images are downloaded. DFO currently utilizes an audited logbook system. This means that 10% of the catch from each trip is audited by processing the electronic images and data streams. This is compared to the logbook entries from the vessel and data collected on the catch from dockside monitoring. If there are inconsistencies in the data sources, further auditing of the electronic data is undertaken until issues are resolved.

The trawl fishery had 100% at-sea monitoring between 2006 and 2020. During this time, data on catch and effort were provided by observers who monitored and sampled catch by species and also recorded effort. Due to COVID19 considerations, electronic monitoring for the trawl fleet was implemented starting in 2020. Logbooks and dockside sampling are also used to monitor sablefish catches in the trawl fishery.

USA domestic

In Alaska, observers are deployed on bottom trawl, hook and line and pot vessels, although the level of coverage depends on vessel size and target species. Observers are deployed at random according to a published stratified sampling design that targets observer coverage across a variety of sectors and target species. In general about 20-25% of the landings are observed by onboard observers. An electronic monitoring program has also been put in place (similar to the program described above) that covers smaller fixed gear vessels fishing for halibut and sablefish. The electronic monitoring is also deployed at random (similar to the onboard observer program).

The trawl fishery and the sablefish fixed gear fishery are both sampled at-sea by the West Coast Groundfish Observer Program. All trawl vessels are required to carry an observer (or two dependent on the size of the vessel). A combination of electronic monitoring and onboard observers are deployed on the sablefish hook and line fleet. Over the last 20 years about 20% of the landings for the fixed gear fleet have been observed by onboard observers.

NPFC CA

Fishing for sablefish in the NPFC CA conducted by sablefish fishers follows the guidelines of Canada described above. 100% electronic monitoring, vessel logbook auditing and dockside sampling are all required for sablefish vessels operating in the NPFC CA.

Biological data

Canada domestic

In Canada, biological data including length, weight and sex are collected from the scientific survey and by observers and dockside samplers from the commercial fisheries. These are used to generate growth curves for the MSE process. Otoliths for estimating fish ages are also collected from both the surveys and the fisheries.

USA domestic

In Alaska biological data including length, weight and sex are collected from all scientific surveys listed above, as well as by at-sea observers and dockside samplers. Otoliths for age estimation are also collected on scientific surveys and from the commercial catch. These data are used to generate growth curves for use in the stock assessment model (Figure 6). Maturity data previously used in the stock assessment in Alaska were collected in the 1980's by Japanese scientists (Sasaki, 1985). However special histological collections during winter spawning in 2011 and 2015, which included the first estimates of skipped spawning rates for sablefish, have allowed model based estimates of maturity to be generated and incorporated into the assessment.

On the US West Coast biological data including length, weight and sex are collected from the bottom trawl survey, as well as from the fishery by at-sea observers and dockside samplers. Otoliths for age estimation are also collected on the scientific survey and from the commercial catch. These data are used to generate growth curves for use in the stock assessment model (Figure 6). Maturity data currently used in the stock assessment on the US West Coast were collected from

2014-2018 and in general the length at 50% maturity has been found to decrease from north to south and with deeper depths.

NPFC CA

Under the seamount fishing protocol, 5 randomly selected fish per trip are saved by the vessel for sampling when it returns to port. These sablefish are sampled for length, weight and sex. Otoliths are collected for age estimation.

Sablefish stock assessment

Canada domestic

Canada uses a management strategy evaluation (MSE) process to generate recommended harvest. Underlying the MSE is a statistical catch-at-age structured operating model (stock assessment model) that gets updated on a 3 – 5 year cycle. Details of the operating model can be found in DFO 2016 and DFO 2020. The current management procedure, which gets applied annually to estimate harvest advice, has been simulation tested using the operating model. Under the current management procedure, a Schaefer surplus production model fit to updated data is used as input to a harvest control rule. The current surplus production model fit to data is shown in Figure 6.

USA domestic

The USA conducts two stock assessments (one for Alaska and one for the US West Coast). The results of these assessments can be seen in Figure 6. Both are conducted using age-structured models. The current Alaska assessment (Goethel et al. 2020) and most recent USA West Coast assessments are a 2019 benchmark (Haltuch et al. 2019) and 2021 update assessment (Kapur et al. 2021) are available online (https://www.pcouncil.org/stock-assessments-star-reports-stat-reports-rebuilding-analyses-terms-of-reference/groundfish-stock-assessment-documents/).

NPFC CA

No stock assessment is conducted for the portion of the sablefish population found in the NPFC Convention area.

Sablefish management

Canada domestic

In Canada, management of the sablefish fisheries are outlined by the Management Procedure set out in the MSE process. Each year the surplus production model is updated with any newly available data and the prescribed harvest rate is used to calculate a total allowable catch (TAC). The fishery itself is managed on an individual transferable quota system with the bulk of the allowable catch divided among license holders and a small portion (~8%) allocated to bottom trawl groundfish bycatch and a smaller portion allocated to scientific research surveys. The Minister of Fisheries officially adopts the allowable catch after consultation with stakeholders, First Nations, DFO Science and DFO Fisheries Management.

USA domestic

In the United States, fisheries management is governed by the Magnuson-Stevens Reauthorization Act. In Alaska, the sablefish fishery is managed under an individual fishing quota (IFQ) system, where license holders are provided individual allocations of the overall sablefish acceptable biological catch (ABC). A proportion of the acceptable biological catch (20% in the western and central GOA, 5% in the eastern GOA, 50% in the Bering Sea, and 25% Aleutian Islands) is allocated to the trawl fleet as bycatch. The stock is assessed annually to determine the status (overfished, approaching overfished or healthy). The underlying ecosystem conditions are also assessed to determine if there is cause for concern with regards to the stock. Finally, an acceptable biological catch is projected based on a harvest control rule (HCR) that aims to maintain the spawning stock biomass at 40% of the biomass in the absence of fishing ($B_{40\%}$). Projections are based on the fishing mortality ($F_{40\%}$) that achieves $B_{40\%}$ with built in limit reference points and rebuilding requirements when the stock is overfished or overfishing is occurring. Additionally, a risk table approach is utilized to identify externalities to the assessment that may warrant more precautionary management, which can be used to recommend catches below the maximum permissible, in certain instances.. A management body, the North Pacific Fisheries Management Council, officially adopts an acceptable biological catch after review and recommendation of assessment and catch advice by the associated Science and Statistical Committee (SSC) and public comment.

Similar to Alaska, the U.S. West Coast manages the sablefish fishery under an individual fishing quota system for the trawl fishery, although IFQs are not used for the fixed gear fishery, where license holders are provided individual allocations of the overall sablefish acceptable biological catch. A proportion of the acceptable biological catch is allocated to the trawl fleet. The stock is assessed every 4-5 years to determine the status (overfished, approaching overfished or healthy). The underlying ecosystem conditions are also assessed to determine if there is cause for concern with regards to the stock. Stock projections are made over a 12 year medium time scale and a fishing mortality rate is set that meets the 40-10 harvest control rule. This rule sets a mortality rate that projects the spawning stock biomass will remain above a target stock size of 40% of unfished biomass during the projection period (often 10 years). From this rate an annual catch limit and acceptable biological catch is calculated. A management body, the Pacific Fisheries Management Council, officially adopts an acceptable biological catch after review and public comment.

NPFC CA

The sablefish fishery in the NPFC area is managed under a Conservation and Management Measure agreed to by NPFC Members (currently CMM 2019-10 and CMM 2019-06) and the rules regulating the fishery are implemented through the conditions of licensing by DFO Fisheries Management. The allowable catch of sablefish in the eastern portion of the Convention Area is based on a long-term mean of historical catches from seamounts by Canada and assumed to be

sustainable at that level (given the connection and sustainability of the coast wide population). It allows for 34 mt to be landed each month for the 6 months of the fishing season. The fishery is also managed through input controls by only allowing a single vessel to fish in each month. The 1-3 Canadian vessels licensed to fish in the NPFC Convention Area are submitted to the NPFC Secretariat annually.

Ecosystem Indicators and Impacts

Canada domestic

Canada does not currently include ecosystem impacts or environmental conditions directly in the management of sablefish. Research has been conducted on domestic seamounts and is currently underway for the continental slope that attempts to resolve and quantify the potential impacts of sablefish pot fishing on vulnerable marine ecosystems (VME; Doherty et al. 2020). New policies from the 2019 Fisheries Act include accounting for the environment and biology of assessed fishes, so it is anticipated that there will be more research and inclusion of these factors in the future.

USA domestic

Alaska currently incorporates potential environmental effects on sablefish stocks explicitly through a risk table that includes potential challenges to stock health from the environment (Goethel et al. 2020). Much of this information is based on the Ecosystem Status Report (Zador et al. 2019) and the Economic Status Reports (Fissel et al. 2019) of the Stock Assessment and Fishery Evaluation document, which are summarized in the Ecosystem and Socioeconomic Profile therein (Shotwell et al., 2020). These reports are produced annually and compile a large number of ecological and economic indicators for Alaska. These variables are integrated into a set of indicators that are appropriate for sablefish (given their biology and economics) and then presented as an Ecosystem and Socioeconomic Profile (ESP) for the sablefish stock (Shotwell et al., 2020). Similar, information is also included in the US West Coast stock assessment that addresses the Social-Ecological System (SES). In particular for the US West Coast stock, environmental drivers of recruitment and distributional patterns are examined (Figure 7; Haltuch et al. 2019).

Impacts of the US West Coast and Alaska sablefish fisheries on VME are addressed through Essential Fish Habitat regulations. For each species of fish, its habitat must be described and any impacts of its fishery and other fisheries assessed. For example, in Alaska species distribution models are used to describe sablefish habitat in each ecosystem (e.g. Rooney et al. 2017). A fishing effects model is then overlaid on the fish habitat to determine the potential intersections between gear and habitat and the proportion of a species habitat impacted by fishing is estimated. This information is then used to guide decision making. A similar process is used on the U.S. West Coast. Since sablefish have not been found to have strong associations with VME indicator species in Alaska or the U.S. West Coast, the estimated overlap between fishing gear and its essential fish habitat (and other species habitat) has been found to not be a concern. However, longline pot and

hook and line gear is known to have an impact on VME indicator species and because of the nature of the gear, it can be used in areas that are rough and rocky and often support populations of deep sea coral and sponge. Therefore, the gear impacts are of some concern and continuing research is attempting to quantify the types of habitats and extent of habitats that are impacted (Hoff et al. 2021).

NPFC CA

In the eastern NPFC CA, the seamount ecosystems are not currently monitored. There is research underway to assess the potential impacts of sablefish longline pot fishing on VME in the Convention Area (see working papers submitted by Canada – Curtis et al.)

Ongoing sablefish research projects

Canada domestic

- Sablefish under climate change – A series of projects that attempt to predict the impacts of predicted climate change on sablefish distribution on the continental shelf
- Sablefish VME overlap – A project that maps the distribution of VME in Canada and examines the intersections with trawl and longline pot gear on the continental shelf
- Sablefish biology – Projects that address issues in aging sablefish, determining morphometric characteristics that can be used as proxies for fish size and a number of other projects that support stock assessment.
- Sablefish tagging studies – Release and recapture of tagged sablefish throughout their range

USA domestic

- Sablefish recruitment dynamics – Studies in Alaska and the U.S. West Coast to determine the factors affecting recruitment and survival for sablefish in the Gulf of Alaska and California Current.
- VME impacts – Two studies, the first attaching cameras and other sensors to longline gear to determine the area impacted by the gear and a study examining previously fished and closed areas in the Aleutian Islands
    - The 5-year review of essential fish habitat in Alaska occurred in 2021 and will be reviewed and published in early 2022
    - Development of a spatially explicit simulation-assessment model for sablefish in Alaska to determine the feasibility of modeling spatial dynamics using a management strategy evaluation framework

- Development of a management strategy evaluation tool to test the robustness and efficacy of the B40% harvest control rule to spasmodic recruitment events in sablefish
- Understanding sablefish movement ecology through analysis of electronic tagging data
- Ongoing genetic studies for sablefish are being carried out by the AFSC including plans to sequence the sablefish genome

Pacific Transboundary Sablefish Assessment Team

- Joint development of a coast wide (i.e., including the West Coast, Canada, and Alaska stocks) operating model for sablefish, while will be used to explore common dynamics and the impacts of regional management through management strategy evaluation
- Analyses of historical and current tagging data for the entire coast wide stock to estimate connectivity among and within each regional stock unit. NE Pacific wide re-analyses of sablefish data including maturity, growth, aging error, and survey indices.
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Figures

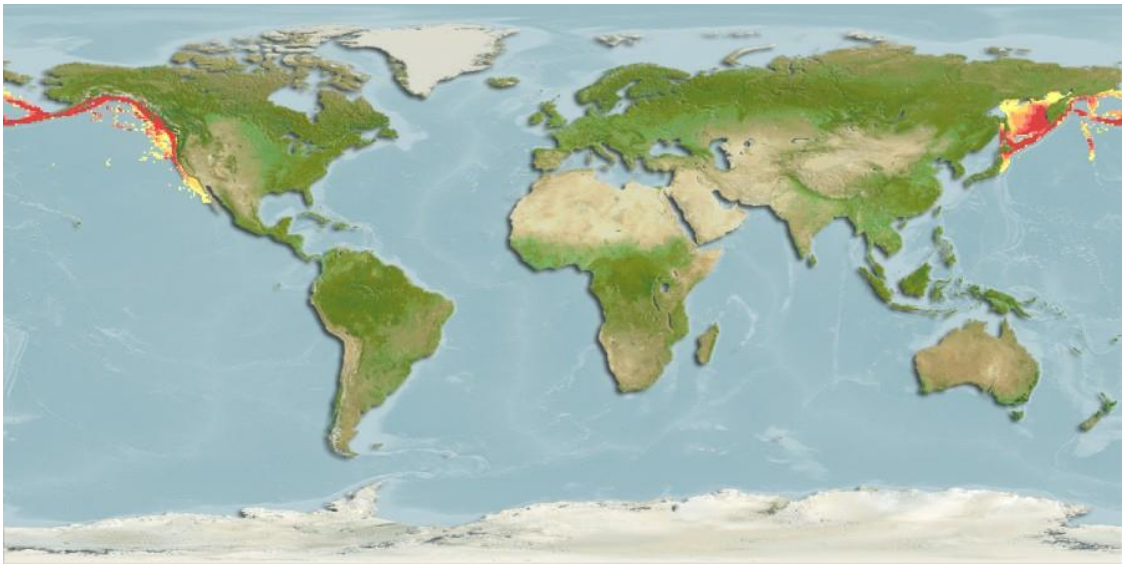

Figure 1. Worldwide distribution of sablefish (*Anaplopoma fimbria*). Reprinted from Aquamaps.

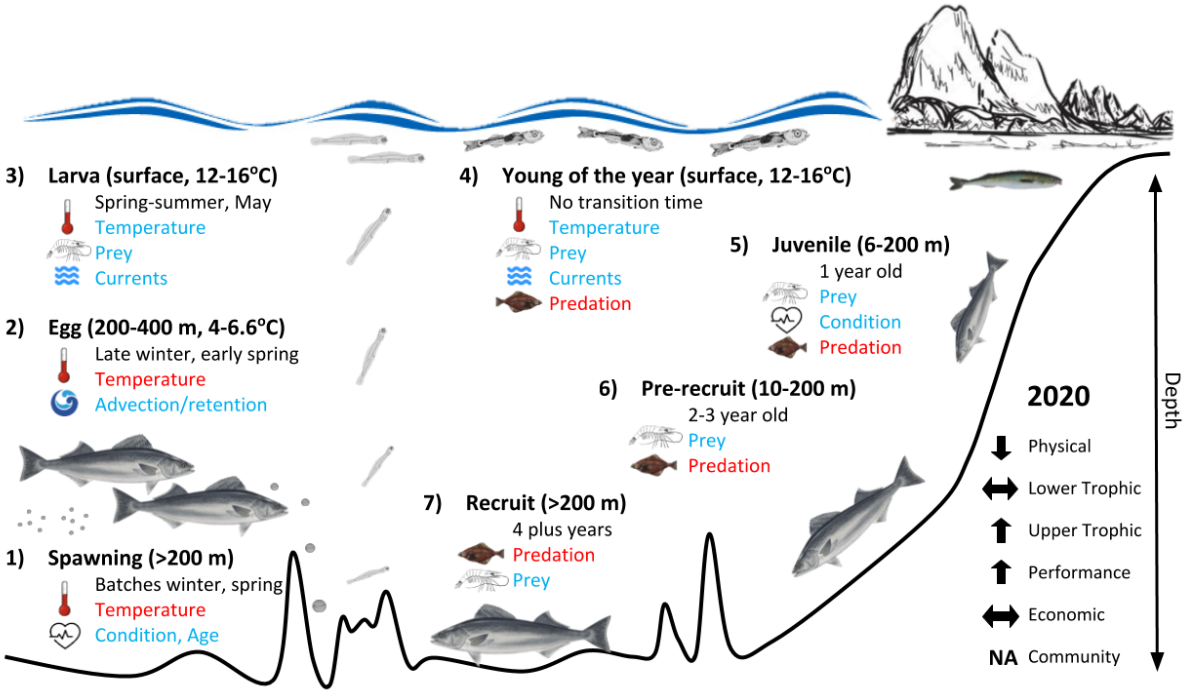

Figure 2. Life history conceptual model for sablefish summarizing ecological information and key ecosystem processes affecting survival by life history stage (reproduced from Shotwell et al. 2020).

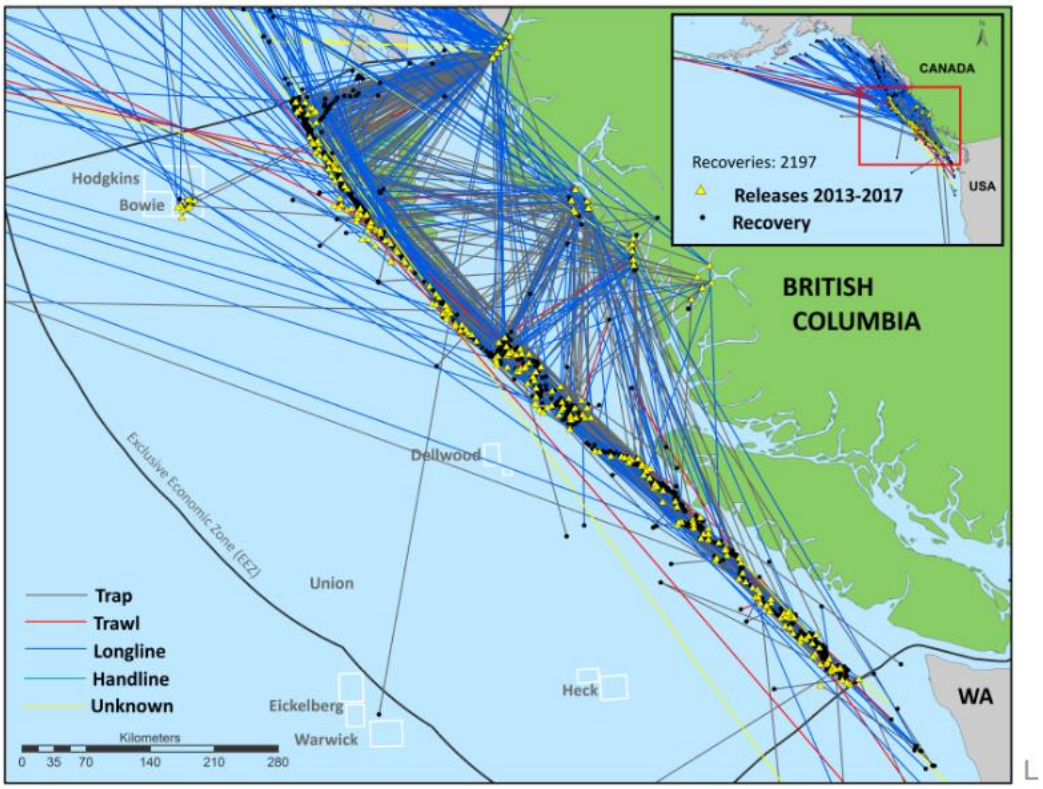

Figure 3. Tag release and recovery locations for sablefish released in British Columbia between 2013-2017. Coloured lines show the distance travelled by individuals between release and

recovery, with specific colours used to indicate the gear type a recovery was made by. White boxes show locations of Seamounts.

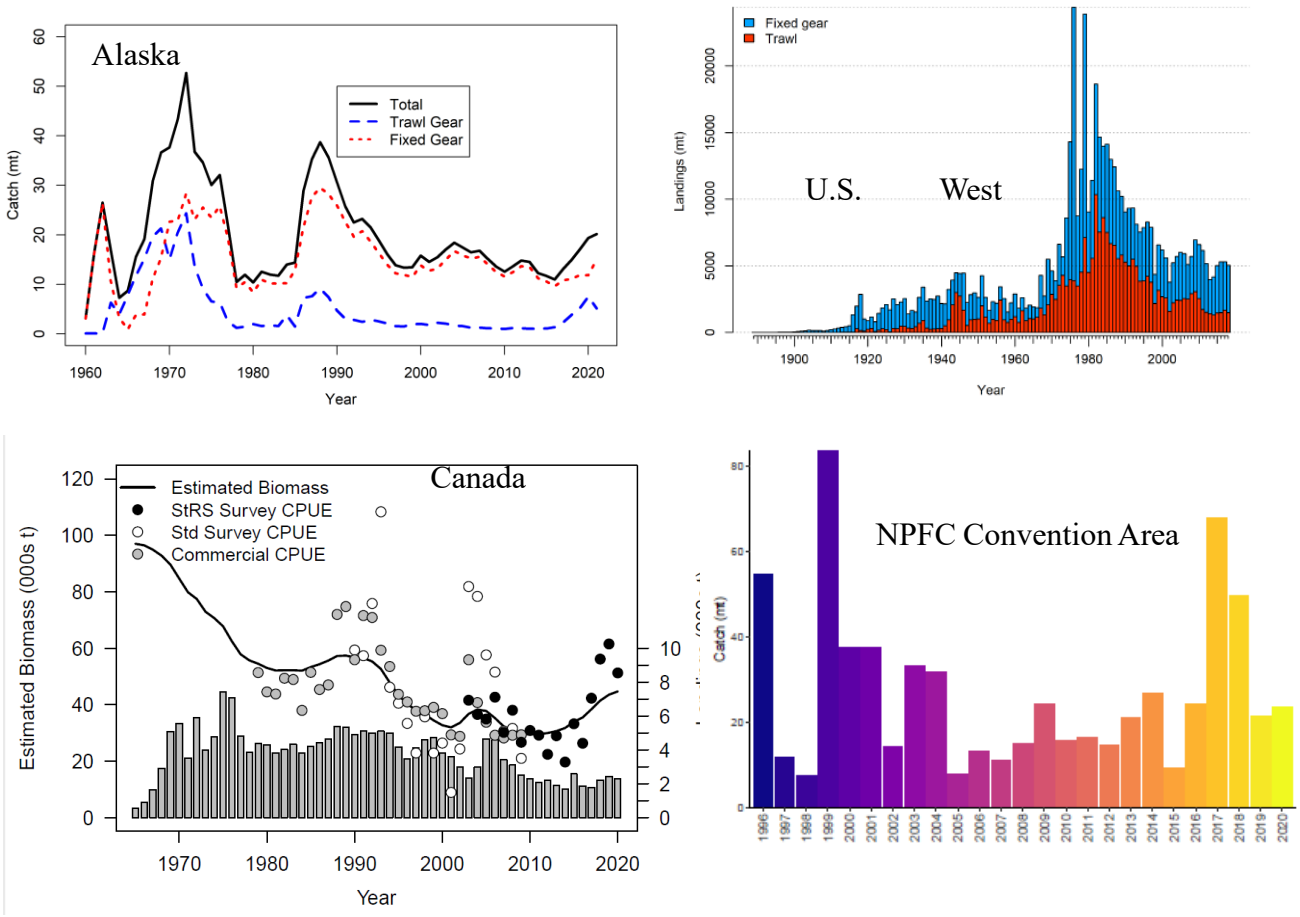

Figure 4. Landings of sablefish on the West Coast of North America.

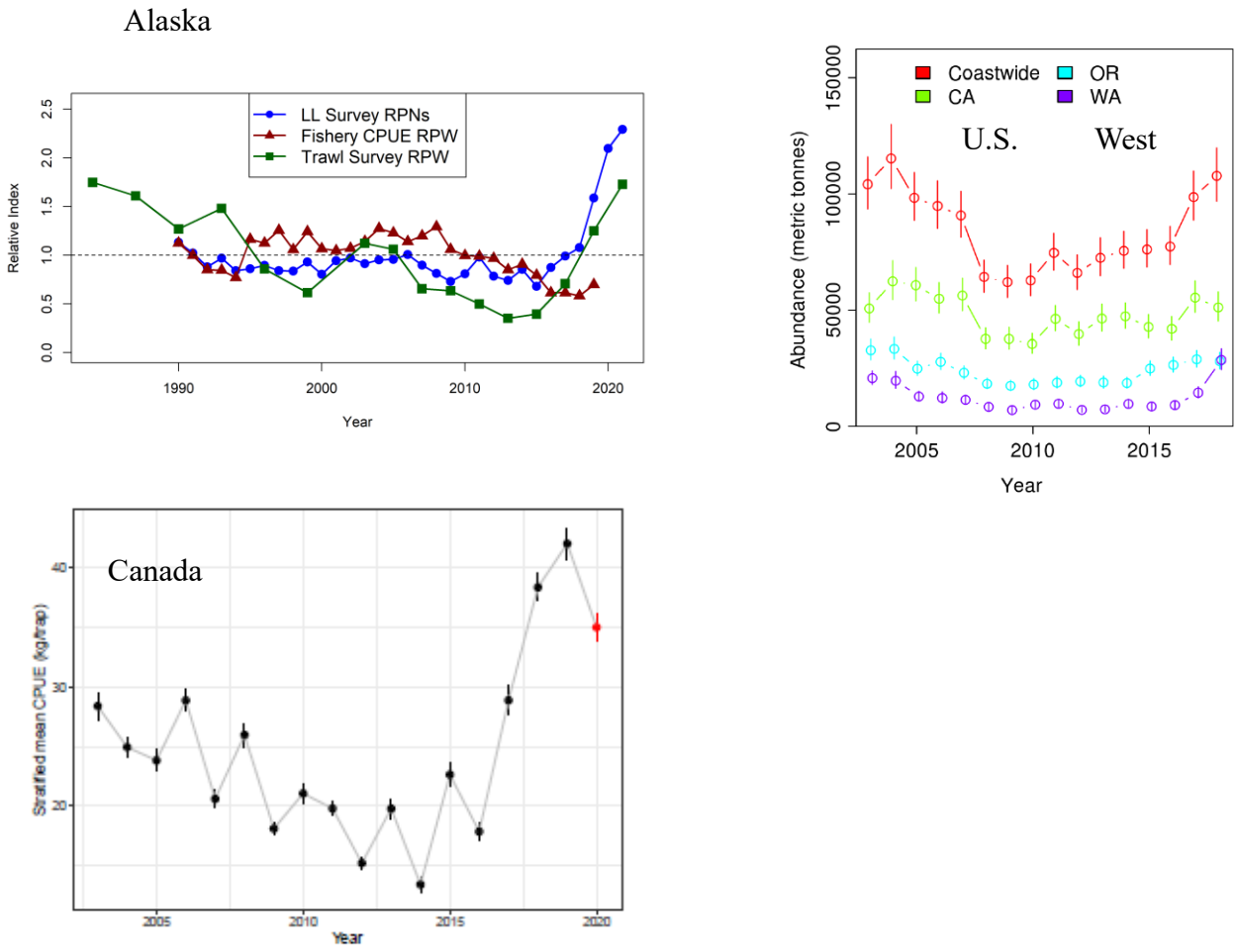

Figure 5. Survey indices of sablefish on the West Coast of North America.

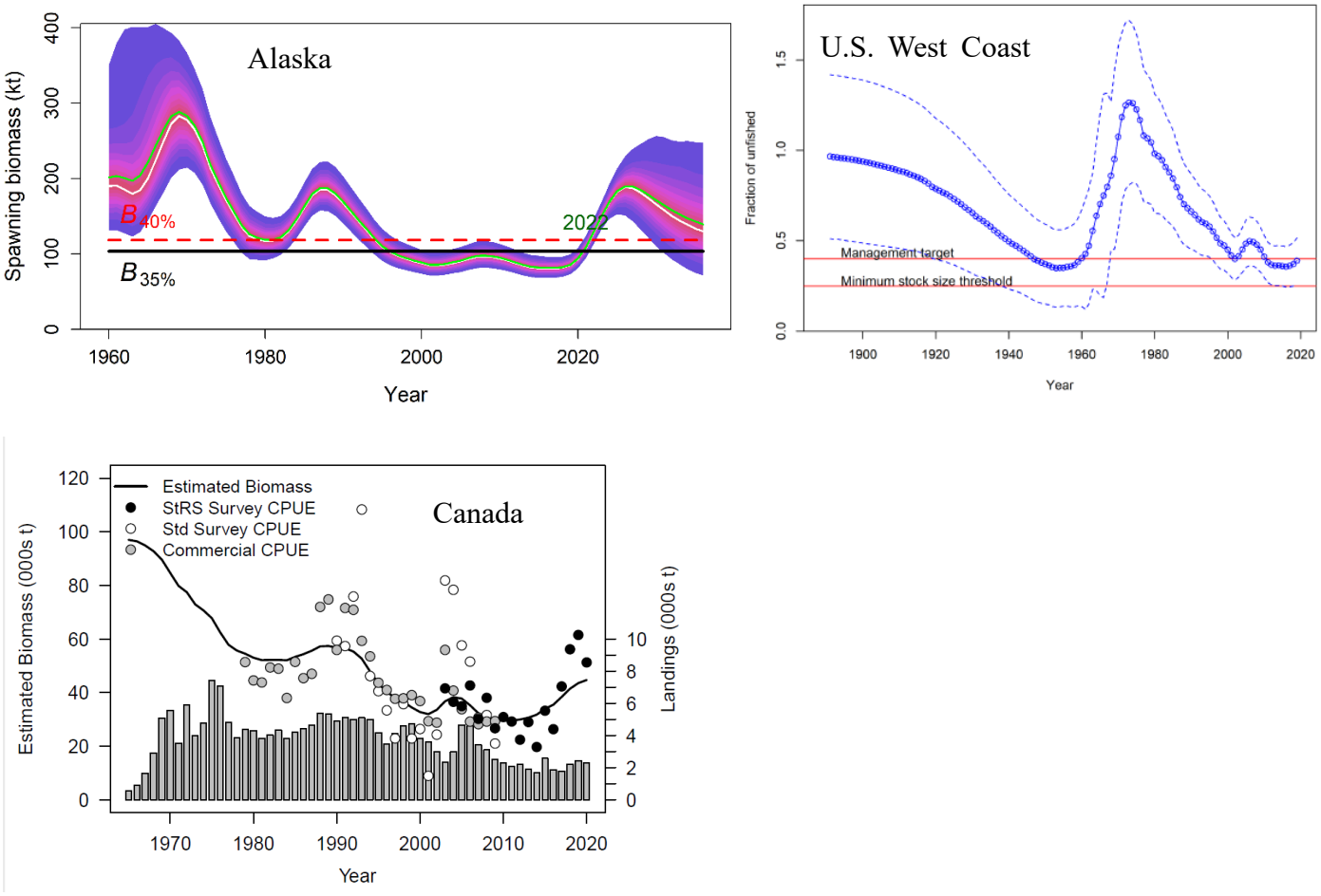

Figure 6. Time series of spawning stock biomass for Alaska, Canada and U.S. West Coast sablefish.

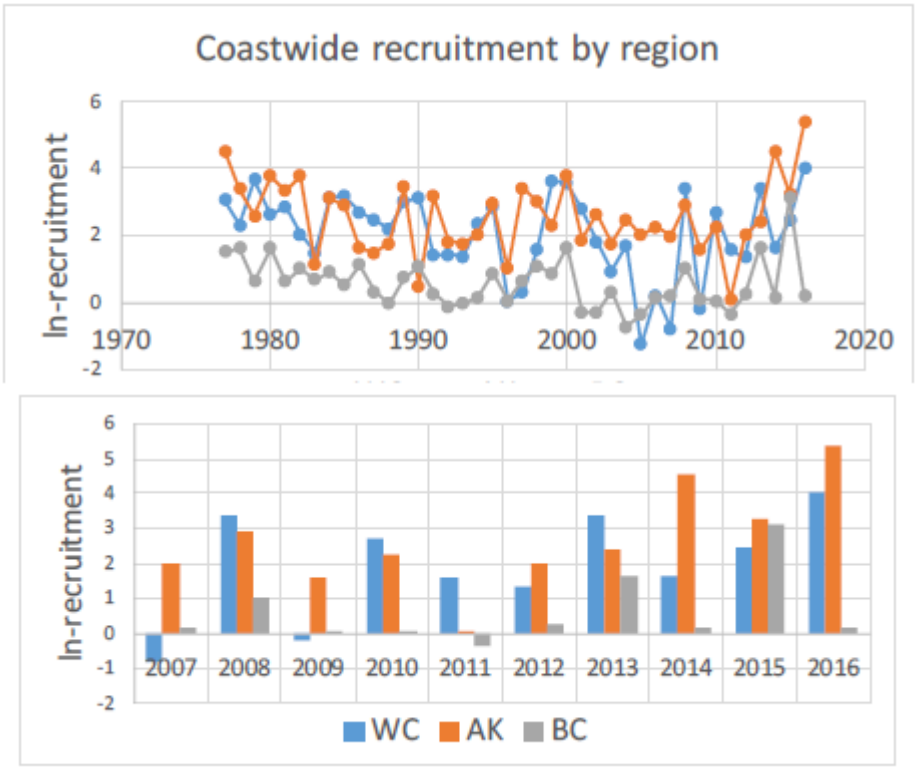

Figure 7. Coastwide patterns of sablefish recruitment for the West Coast of North America (as estimated in 2017).

References

DFO. 2016. A revised operating model for Sablefish (*Anoplopoma fimbria*) in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/015.

DFO. 2020. Evaluating the robustness of candidate management procedures in the BC Sablefish (Anoplopoma fimbria) fpshery for 2019-2020. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/025.

Doherty B, Cox SP, Rooper CN, Johnson SDN, Kronlund AR. 2021. Species distribution models for deep-water gorgonian (Alcyonacea) coral habitats that account for spatial uncertainty in trap-camera fishery data. Mar. Ecol. Prog. Ser. 660:69-93.

Fissel, B., M. Dalton, R. Felthoven, B. Garber-Yonts, A. Haynie, S. Kasperski, J. Lee, D. Lew, A. Santos, C. Seung, and K. Sparks. 2019. Economic status of the groundfish fisheries off Alaska, 2018. In Stock assessment and fishery evaluation report for the groundfish resources of the GOA and BS/AI. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Goethel, D.R., Hanselman, D.H., Rodgveller, C.J., Fenske, K.H., Shotwell, S.K., Echave, K.B., Malecha, P.W., Siwicke, K.A., and Lunsford, C.R. 2020. Assessment of the sablefish stock in Alaska. *In* "Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the GOA and BS/AI." Anchorage, AK: North Pacific Fishery Management

Council.

Haltuch, M.A., Johnson, K.F., Tolimieri, N., Kapur, M.S., and Castillo-Jordán, C.A. 2019. Status of the sablefish stock in U.S. waters in 2019. Pacific Fisheries Management Council, 7700 Ambassador Place NE, Suite 200, Portland, OR. 398 p.

Hoff GR, Malecha PW, Rooper CN, Olson JV, Costa BM, Adams CM, Netburn A, Le JT, Ladd C, Wilborn RE, Goddard P, Coleman HM, Hourigan TF. 2021. Science Plan for the Alaska Deep-Sea Coral and Sponge Initiative (AKCSI) 2020-2023. AFSC Processed Report 2021-01, 45 p. Alaska Fisheries Science Center, NOAA, Natl. Mar. Fish. Ser., 7600 Sand Point Way NE, Seattle WA 98115.

Jasonowicz, A. J., F. W. Goetz, G. W. Goetz, and K. M. Nichols. 2017. Love the one you're with: genomic evidence of panmixia in the sablefish (Anoplopoma fimbria). Can. J. Fish. Aquat. Sci. 74:377-387.

Kapur, M.S., Lee, Q., Correa, G.M., Haltuch,M., Gertseva, V. and Hamel, O.S. 2021. DRAFT Status of sablefish (Anaplopoma fimbria) along the US West Coast in 2021. Pacific Fisheries Management Council, Portland, Oregon, 196 p.

Rooney, S., Laman, E.A., Rooper, C.N., Turner, K., Cooper, D.W., and Zimmermann, M. 2018. Model-based essential fish habitat definitions for Gulf of Alaska groundfish species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-373, 370 p.

Sasaki, T. 1985. Studies on the sablefish resources in the North Pacific Ocean. Bulletin 22, (1-108), Far Seas Fishery Laboratory. Shimizu, 424, Japan.

Shotwell, K., Goethel, D.R., Deary, A., Echave, K., Fenske, K., Fissel, B., Hanselman, D., Lunsford, C., Siwicke, K., and Sullivan, J. 2020. Ecosystem and socioeconomic profile of the sablefish stock in Alaska. *In* "Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the GOA and BS/AI." Anchorage, AK: North Pacific Fishery Management Council.

Thorson, J. 2019. Guidance for decisions using the Vector Autoregressive Spatio-Temporal (VAST) package in stock, ecosystem, habitat and climate assessments. Fisheries Research 210: 143–161. doi:10.1016/j.fishres.2018.10.013.

Wolotira, R. J. J., T. M. Sample, S. F. Noel, and C. R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. NOAA Tech. Memo. NMFS-AFSC-6. 184 pp.

Zador, S., E., Yasumiishi,and G.A. Whitehouse. 2019. Ecosystem Status Report: Gulf of Alaska. In Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99501. 215 p.