BSAI Halibut Abundance-based Management (ABM) of PSC Limits
Preliminary Review Draft
September 2018[1]

The purpose of this preliminary review draft is to assist the Council in refining alternatives for analysis. Preliminary analysis of these alternatives is therefore focused upon those aspects of the alternatives in need of clarification and revision. No environmental or socio-economic impacts are included at this time but shown in outline form for clarity as to what will be included in the Draft EIS/RIR. Upon further refinement of alternatives, the full initial review draft of the EIS/RIR, including environmental and socio-economic impacts and a social impact analysis, will be brought forth in October 2019.

Included in this Preliminary Review Draft:

1. Review of request to analysts and roadmap of what has been included to address the Council motion from April 2018 [Executive Summary/Summary of Action]
2. Draft Sections of an EIS/RIR specifically:
    a. Chapter 1 Purpose and Need [Chapter 1];
    b. Chapter 2 Description of Alternatives [Chapter 2] which includes
        i. Preliminary historical application of PSC limits by alternative
        ii. Comparison of PSC limits by alternative using historical data and
        iii. Workgroup suggestions for refining the alternative set
    c. Preliminary "Fishery Description" section (to inform the RIR) regarding the commercial groundfish fisheries that are subject to halibut PSC limits. This section develops the real-world context to which the ABM alternatives would be applied. The analysts seek continued feedback on how the document helps the public and the Council understand operational aspects of the groundfish fishery that will determine participants' decision-sets when responding to potential changes in PSC limits. [Section 4.1].
    d. Three appendices describing: 1) the halibut operational model proposed for use in projecting the impacts of the alternatives for the initial review draft; 2) mathematical equations used in calculating PSC limits for the range of alternatives and 3) the Council motion from April 2018

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List of Acronyms and Abbreviations

Acronym or Abbreviation	Meaning
AAC	Alaska Administrative Code
ABC	acceptable biological catch
ABM	Abundance-based management
ADF&G	Alaska Department of Fish and Game
AFA	American Fisheries Act
AFSC	Alaska Fisheries Science Center
AKFIN	Alaska Fisheries Information Network
BSAI	Bering Sea and Aleutian Islands
BTS	Bottom Trawl Survey
CAS	Catch Accounting System
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
COAR	Commercial Operators Annual Report
Council	North Pacific Fishery Management Council
CP	catcher/processor
CV	catcher vessel
DPS	distinct population segment
E.O.	Executive Order
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	essential fish habitat
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESU	endangered species unit
FMA	Fisheries Monitoring and Analysis
FMP	fishery management plan
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FRFA	Final Regulatory Flexibility Analysis
ft	foot or feet
GOA	Gulf of Alaska
IPHC	International Pacific Halibut Commission
IPA	Incentive Plan Agreement
JAM	jeopardy or adverse modification
lb(s)	pound(s)
LEI	long-term effect index
LLP	license limitation program
LOA	length overall
m	meter or meters
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MMPA	Marine Mammal Protection Act
MSST	minimum stock size threshold
t	tonne, or metric ton
NAICS	North American Industry Classification System
NAO	NOAA Administrative Order
NEPA	National Environmental Policy Act
NMFS	National Marine Fishery Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
NPPSD	North Pacific Pelagic Seabird Database
Observer Program	North Pacific Groundfish and Halibut Observer Program
OMB	Office of Management and Budget
O26	Over 26” halibut
PBR	potential biological removal
PSC	prohibited species catch
PPA	Preliminary preferred alternative
PRA	Paperwork Reduction Act
PSEIS	Programmatic Supplemental Environmental Impact Statement
RFA	Regulatory Flexibility Act
RFFA	reasonably foreseeable future action
RIR	Regulatory Impact Review
RPA	reasonable and prudent alternative
SAFE	Stock Assessment and Fishery Evaluation
SAR	stock assessment report
SBA	Small Business Act
Secretary	Secretary of Commerce
SPLASH	Structure of Populations, Levels of Abundance, and Status of Humpbacks
SRKW	Southern Resident killer whales
TAC	total allowable catch
U.S.	United States
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
VMS	vessel monitoring system

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Executive Summary/Summary of Action

In 2015, in conjunction with actions to reduce existing BSAI halibut prohibited species catch (PSC) limits in groundfish fisheries (Amendment 111), the North Pacific Fishery Management Council (Council or NPFMC) requested that Council and International Pacific Halibut Commission (IPHC) staff evaluate approaches to link BSAI halibut PSC limits to data, such as model-based abundance estimates of halibut.

Since December 2015, beginning with a paper authored by IPHC staff, the Council has reviewed several discussion papers with information compiled by analysts from the following organizations: IPHC, NMFS National Marine Fisheries Service (NMFS) Alaska Fishery Science Center (AFSC), NMFS Alaska Regional Office (AKRO) and NPFMC staff. Those papers provided information on appropriate data indices for use in linking halibut abundance to PSC limits in the Bering Sea and highlighting other issues for Council consideration in the development of abundance-based management (ABM) for halibut PSC limits.

After considerable review of a range of data and model-based indices, the Council elected to focus on two indices of halibut abundance for indexing halibut PSC limits in the BSAI. These indices are the annual NMFS Eastern Bering Sea (EBS) Bottom Trawl Survey (BTS) and the IPHC annual fishery-independent setline survey in Areas 4ABCDE. Additional information on both surveys is contained in Section 1.4 of this paper as well as in previous discussion papers with links available in Table 1-1 of this paper.

Purpose and Need

Through iterative discussion papers, the Council has drafted a purpose and need for this action as well as a draft suite of Alternatives for analysis. The Purpose and Need for this action is the following:

> *The current fixed yield-based halibut PSC caps are inconsistent with management of the directed halibut fisheries and Council management of groundfish fisheries, which are managed based on abundance. When halibut abundance declines, PSC becomes a larger proportion of total halibut removals and thereby further reduces the proportion and amount of halibut available for harvest in directed halibut fisheries. Conversely, if halibut abundance increases, halibut PSC limits could be unnecessarily constraining. The Council is considering linking PSC limits to halibut abundance to provide a responsive management approach at varying levels of halibut abundance. The Council is considering abundance-based PSC limits to control total halibut mortality, particularly at low levels of abundance. Abundance-based PSC limits also could provide an opportunity for the directed-halibut fishery and protect the halibut spawning stock biomass. The Council recognizes that abundance-based halibut PSC limits may increase and decrease with changes in halibut abundance.*

The Council derived the following objectives from the purpose and need statement for this action to guide the development of appropriate management measures:

- Halibut PSC limits should be indexed to halibut abundance
- Halibut spawning stock biomass should be protected especially at lower levels of abundance
- There should be flexibility provided to avoid unnecessarily constraining the groundfish fishery particularly when halibut abundance is high
- Provide for directed halibut fishing operations in the Bering Sea.
- Provide for some stability in PSC limits on an inter-annual basis.

As noted in previous discussion papers these objectives have not been prioritized by the Council and may be in opposition to others thus designing a management program which meets all of them equivalently may be challenging. The goal of the analysis of the Council's alternatives, once developed, will be to evaluate how well each alternative meets the purpose and need statement, and these competing objectives.

Where are we in the analytical process?

The Council is still in the process of refining alternatives for analysis in a draft EIS/RIR to come forward in 2019. Figure A1 shows a schematic of actions by the Council to date and proposed timeline to final action. At this meeting the Council will continue the process of refining the alternatives under consideration for the draft EIS/RIR analysis.

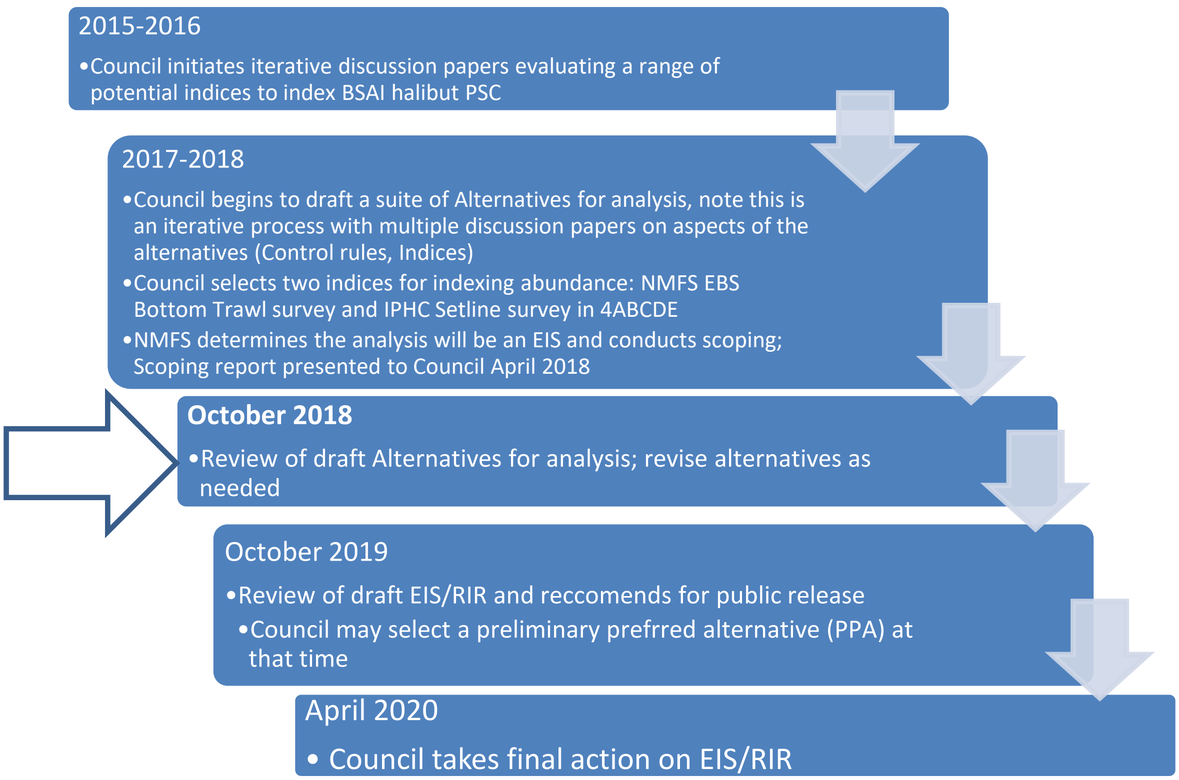

Figure A-1 Actions to date by Council on BSAI Halibut ABM PSC limits and projected future timeline

Alternatives Under Consideration

There are 5 alternatives currently moved forward (April 2018) by the Council. These have been developed through multiple discussion papers and will need further refinement before they can be fully analyzed. One Alternative (Alternative 6) has been included by the Workgroup for Council consideration in this preliminary analytical document. These 6 alternatives range from status quo with fixed halibut PSC limits by sector to a range of gear specific PSC limits indexed to BSAI halibut abundance. Once calculated by gear, PSC limits are then allocated to sectors within each gear type.

A brief description of these alternatives is shown below with additional detail contained in Chapter 2.

Alternative 1: Status Quo. BSAI halibut PSC limits are fixed at 3,515 t total for all sectors. This total is allocated to sectors as indicated below:

	Current PSC limit
Amendment 80 cooperatives	1,745 t
BSAI trawl limited access fisheries	745 t
Longline fisheries	710 t
CDQ fisheries	315 t
TOTAL	3,515 t

Alternative 2: Fixed gear halibut PSC limits are indexed to the abundance estimate derived from the IPHC setline survey in 4ABCDE, while trawl PSC limits are indexed to the abundance of halibut from the NMFS EBS bottom trawl survey.

Alternatives 3, 4, 6: These alternatives are all similar in that they use information from both indices to calculate the PSC limit by gear type. There is a primary index that is similar to the gear type of the gear-specific PSC limit and uses a control rule, as in Alternative 2, to determine the PSC limit for that gear. However, a secondary index, which is the other of the two indices and differs from the gear linked to the PSC, modifies the PSC when above and below a specified threshold. For example, the primary index for fixed gear is the setline survey while the secondary index is the trawl survey. The difference between these three alternatives lies in the degree to which the secondary index modifies the PSC limit when that index is above and below a specified threshold. **Furthermore, Alternatives 3 and 4 are identical under the conditions specified by the Council, thus the analysts recommend removing Alternative 3 from the Alternative set as it is redundant. Further explanation is provided in Chapter 2 and Appendix II.**

Under Alternative 4, the secondary index causes the PSC limit to change abruptly when the abundance reaches a threshold value. Alternative 6 was suggested to accommodate an alternative with a less abrupt change at the same threshold value for the secondary index. **Note that Alternative 6 is not in the Council's April motion and is instead suggested by the Workgroup for inclusion in the suite of alternatives at this time.**

Alternative 5: This alternative is for fixed gear only. The trawl component of the PSC limit would need to be calculated using one of the other alternatives. Here, the PSC limit is indexed to both indices and is presented as a look up table to determine the annual PSC fixed gear limit based upon specified values of each index in relation to a PSC limit. Abrupt changes in the PSC limit would occur at specified values of each index. **The workgroup notes several issues with the alternative as drafted and recommends the Council clarify several aspects at this meeting in order to move forward with this in the suite of alternatives.**

Objectives of Council Review in October

One objective of Council review at this meeting is to revise the alternatives for analysis. As such and per Council request, some preliminary analysis of alternatives has been done. Section 2.6 summarizes a comparison of the alternatives across a subset of Elements and Options. This has been done to demonstrate the behavior of certain elements and options and to indicate where clarification from the Council may be needed with respect to some of the alternatives. **Alternative 3 was eliminated from the preliminary analysis and is recommended for removal from the suite of alternatives as it is redundant with, and its intent already covered by, Alternative 4.**

The preliminary analysis uses a default set of elements and options to compare across four alternatives (Alternative 2,4 and 6 as compared to Alternative 1). For each Alternative (2,4,6) a starting point (Element 1) of 3,515 t (Option 4), maximum amount of the PSC limit allowed (ceiling; Element 3) of 4,426 t (Option 2) and minimum amount t of the PSC limit possible (floor; Element 4) of 2,354 t (Option 2) was used. This is done to show how these alternatives behave differently due to their underlying structure to alert the Council and the public as to the fundamental differences between these alternatives with respect to the relative PSC limits that are calculated based upon similar values of the two indices. They are compared against Alternative 1 (fixed PSC limits) to show the change in alternative historical PSC limits relative to changes in the historical value of the indices.

Elements 5 and 6 are unique to Alternatives 4 and 6. To compare and contrast these, two bookended options were selected under each Element. Under Element 5 which describes the threshold value for the secondary index (exceeding a threshold would result in modifying the PSC limit), a 'high' and a 'low' option were selected to meet the intent of the Element "High and Low values for the Secondary Index". The high option was selected as the 2nd highest value of the time series (1998-2016) while the 'low' option was the 2nd lowest value of the time series (1998-2016). Again, these values form the thresholds at which the secondary index would modify the PSC limit upward or downward from the PSC limit calculated with the primary index.

Comparative results using tables and figures demonstrate the relative percentage change in each index from the previous year and the corresponding percent change in the PSC limits from the previous year under each alternative. The difference in the PSC limit generated under each alternative is illustrated by comparing the percent change in PSC from the previous year for a given percent change in the relevant index or indices. This exercise is played out using historical data from 1998 through 2017 in Tables 2-3 through 2-13. Selection of different Elements and Options beneath each alternative may modify the observed variability between alternatives.

Element 1, which can act to dampen interannual variability in PSC limits, was not used in the calculation. This dampening effect, however, can be applied to any alternative after the PSC limit is calculated to reduce inter-annual variability in PSC limits. The tables and figures enable the reader to see how often changes larger than 5%, 15% and 25% would occur, which would give an indication of how often each alternative would have been altered by Element 1. **The workgroup recommends that Element 1 be moved from within individual alternatives to an option that could be applied to any of the alternatives after the PSC limit is calculated.**

Additional requests in the Council's April 2018 motion

The Council made several additional requests to the Workgroup for the preliminary (and subsequent initial review) analysis. These are listed below with an explanation of how they were addressed and where in the document they can be found (as applicable).

Time series of the indices used. Provide the Council biological considerations for selecting the baseline years for the index, as described by the SSC.

The analysts were unable to describe specific biological considerations that would support the use of less than the entire time frame available for the surveys (1998-present) for use as an appropriate index of abundance upon which to base calculations for thresholds used by the control rules. Using a static reference time frame that is as long as possible captures the most comprehensive picture of the range of previously observed conditions. For purposes of this preliminary analysis, the years 1998-2016 were used, but 2017 could be included as well. The intent would be to maintain a defined reference time series for determining control rule thresholds and where current indices fall with respect to this time series

Index values for high, medium and low. In Alternatives 3 and 4, a secondary index may modify the PSC limit if the secondary index is determined to be at a high or low value. The Council requested a biological basis for determining when an index is high or low, as well as guidance on how to interpret and adjust the response associated with each value.

For this preliminary analysis, the analysts used the Council's Motion for Element 5 and selected Option 1 (High = 2nd highest value of time series, Low = 2nd lowest value of time series) to indicate the response mechanism between alternatives and compared these results to Option 2 (High = 25% above the 1998-2016 average of the time series, Low = 25% below the 1998-2016 average of the time series).

Alternative PSC limits. A small number of fixed PSC values should be included in the analysis to allow investigation of the performance of ABM alternatives relative to differences in the scale of the starting points, as outlined by the SSC.

This will be included in the initial review analysis for October 2019. Here the analysts used the same starting points across the calculated PSC limits. The full analysis will evaluate the performance of ABM alternatives under different starting points and will contrast them against a range of fixed PSC limits.

Evaluate using a 3-5 year rolling average of PSC limits, as described by the SSC.

In conjunction with the Comparison of Alternatives (Section 2.6), a subsection addresses the differences between use of a 3-year moving average of the specific index value to the use of each year's individual index value (Section 2.6.3). As expected, the use of a 3-year moving average for each index results in smaller changes in calculated PSC limits from the previous year.

Consider how to allocate CDQ PSC between fixed gear and trawl gear.

The analysts did not allocate the PSC limits to sectors. For purposes of this preliminary analysis, the CDQ by default was included in the trawl PSC. Additional information on actual use of CDQ halibut PSC is included in Section 2.1. **Analysts note that some guidance is needed on how to allocate the CDQ component to gear type for all the alternatives (except status quo) as they are all now specified by gear type and then allocated to sectors.**

Describe the steps and process that produces the EBS trawl IPHC survey index values.

Section 1.4.1 describes the two abundance indices considered and the overall description of both surveys with specific links to where additional detailed methodology is described.

Description of BSAI Groundfish Fisheries

Section 4.1 provides a narrative description of how the three directly regulated BSAI groundfish sectors approach their fishing year in the context of the various constraints they face, including but not limited to halibut PSC limits. This section provides the reader with the context necessary to understand interactions between fisheries and the factors that drive the decisions made during the year by fleet managers and vessel operators in the Amendment 80 sector, the trawl limited access sector, and the hook-and-line catcher-processor sector. The operational decision-drivers in these dynamic multispecies fisheries define the bounds within which fishery participants can respond to an emergent constraint like a reduced annual PSC limit. Those factors are not always obvious and are not adequately described by the conventional presentation of annual catch and bycatch by species or by target fishery. The description of fisheries presented in this document is a jumping-off point for the social and economic impact analysis to be completed in the RIR chapter of the Draft EIS/RIR. Ultimately, that analysis will convey whether and how a marginal annual change in PSC limits resulting from halibut abundance indices and other selected elements is likely to affect business planning, in-season decisions, and socioeconomic outcomes. Those effects are likely not straight-forward in the sense of a lower halibut PSC limit triggering a fishery closure earlier in the calendar year. Indirectly affected fisheries such as the halibut IFQ fishery are not described in this document but will be considered in the Draft EIS/RIR.

Requests of Council at this meeting

Based on preliminary analysis of the Alternatives from the April 2018 motion, the workgroup has the following suggestions for refining the alternative set for initial review analysis.

Alternative/Element/ Option	**Recommendation**	**Rationale**
Alternative 3	Remove	As discussed in Section 2.3, this is redundant with Alternative 4 and the formulation of Alternative 4 is the recommended approach
Alternative 6 (NEW)	Add	Rationale provided in Section 2.5 and Appendix II. Provides similar framework as Alt 4 but with less abrupt transitions.
Element 1 (Alternatives 2- 6)	Move to an option that applies to all alternatives	This element is not a required element for formulating the control rule and is applied after the PSC limit is calculated. It would be cleaner to have this outside of the specific elements and options for the Alternatives and have it as an option that can be applied to any alternative for inter-annual stability as desired
Alternative 5	Need dimensions of look up table. Need clarification on general intent of alternative	No details were provided on dimensionality of look up table. Consider removing Alternative 5 or clarify details noted in Section 2.4.5.
Alternative 5 Element 1	Clarify overlap with Elements 1 and 4.	Overlapping elements of 1 and 4 would provide for 15 different alternatives just between these two provisions (3 floors and 5 different mechanisms for moving to the floor outside of the actual look up table)
All alternatives/elements/ options	Need guidance of subset for analysis as currently unwieldy number of combinations of options. Workgroup will provide a strawman approach at the October Council meeting	Alternative 1, 2, 4, 5, and 6, along with the elements and options for each, results in a total of 2,881 different combinations. Just for the 4 elements of alternative 2, there are 144 combinations of options.
Alternatives 2,4,5,6	Need direction on relative proportion of trawl and non-trawl CDQ allocation	Previous PSC limits were set to CDQ allocation as a sector and not by gear type. Under all alternatives, except Alternative 1, the PSC limit is calculated by gear type (first) then allocated to sector. Usage by gear could inform this (Section 2.1)
Alternatives 4 and 6	Remove Option 2 Element 5 which modifies PSC limit above and below average value of index	Received criticism from SSC (April 2018) and Council discussions on potential for volatile changes to PSC limits from previous year due to an index always at a high or low value and never at average

1. Introduction

This document analyzes proposed management measures to index Pacific halibut prohibited species catch (PSC) limits in the Bering Sea and Aleutian Islands (BSAI) groundfish fisheries to halibut abundance. PSC limit modifications are considered for various sectors, including the BSAI trawl limited access sector, the Amendment 80 sector, longline catcher vessels, longline catcher processors, and the Community Development Quota (CDQ) sector (i.e., a reduction to the CDQ's allocated prohibited species quota reserve). The objective of modifying PSC limits would be to index PSC limits to halibut abundance which may achieve different goals of providing flexibility to the groundfish fisheries in times of high halibut abundance, protecting spawning biomass of halibut especially at low levels, and stabilizing in inter-annual variability in PSC limits, all of which may provide additional harvest opportunities in the commercial halibut fishery.

This document is an Environmental Impact Statement/Regulatory Impact Review/Initial Regulatory Flexibility Analysis (EIS/RIR). An EIS/RIR provides assessments of the environmental impacts of an action and its reasonable alternatives (the EIS), the economic benefits and costs of the action alternatives, as well as their distribution (the RIR). This EIS/RIR addresses the statutory requirements of the Magnuson Stevens Fishery Conservation and Management Act (MSA), the National Environmental Policy Act, and Presidential Executive Order 12866. An EIS/RIR is a document produced by the Council and the National Marine Fisheries Service (NMFS) Alaska Region to provide the analytical background for decision-making.

Pacific halibut (*Hippoglossus stenolepis*) is utilized in Alaska as a target species in subsistence, personal use, recreational (sport), and commercial halibut fisheries. Halibut has significant social, cultural, and economic importance to fishery participants and fishing communities throughout the geographical range of the resource. Halibut is also incidentally taken as bycatch in groundfish fisheries.

The Council is examining abundance-based approaches to set halibut PSC limits in the BSAI. Currently halibut PSC limits are a fixed amount of halibut mortality in metric tons (t). When halibut abundance declines, halibut PSC becomes a larger proportion of total halibut removals and can result in lower catch limits for directed halibut fisheries. Both the Council and the IPHC have expressed concern about impacts on directed halibut fisheries under the status quo and identified abundance-based halibut PSC limits as a potential management approach to address these concerns.

1.1 Purpose and Need

The Council's purpose and need statement for this action is:

> *The current fixed yield-based halibut PSC caps are inconsistent with management of the directed halibut fisheries and Council management of groundfish fisheries, which are managed based on abundance. When halibut abundance declines, PSC becomes a larger proportion of total halibut removals and thereby further reduces the proportion and amount of halibut available for harvest in directed halibut fisheries. Conversely, if halibut abundance increases, halibut PSC limits could be unnecessarily constraining. The Council is considering linking PSC limits to halibut abundance to provide a responsive management approach at varying levels of halibut abundance. The Council is considering abundance-based PSC limits to control total halibut mortality, particularly at low levels of abundance. Abundance based PSC limits also could provide an opportunity for the directed-halibut fishery and protect the halibut spawning stock biomass. The Council recognizes that abundance-based halibut PSC limits may increase and decrease with changes in halibut abundance.*

The Council derived the following objectives from the purpose and need statement for this action to guide the development of appropriate management measures:

- Halibut PSC limits should be indexed to halibut abundance
- Halibut spawning stock biomass should be protected especially at lower levels of abundance
- There should be flexibility provided to avoid unnecessarily constraining the groundfish fishery particularly when halibut abundance is high
- Provide for directed halibut fishing operations in the Bering Sea.
- Provide for some stability in PSC limits on an inter-annual basis.

As noted in previous discussion papers these objectives have not been prioritized by the Council and may be in opposition to others thus designing a management program which meets all of them equivalently may be challenging. The goal of the analysis of the Council's alternatives, once developed, will be to evaluate how well each alternative meets the purpose and need statement, and these competing objectives.

The International Pacific Halibut Commission (IPHC) and National Marine Fisheries Service (NMFS) manage Pacific halibut fisheries through regulations established under the authority of the Northern Pacific Halibut Act of 1982 (Halibut Act) (16 U.S.C. 773-773k). The IPHC adopts regulations governing the target fishery for Pacific halibut under the Convention between the United States of America and Canada for the Preservation of the Halibut Fishery of the Northern Pacific Ocean and Bering Sea (Convention), signed at Ottawa, Ontario, on March 2, 1953, as amended by a Protocol Amending the Convention (signed at Washington, DC, on March 29, 1979). For the United States, regulations governing the fishery for Pacific halibut developed by the IPHC are subject to acceptance by the Secretary of State with concurrence from the Secretary of Commerce. After acceptance by the Secretary of State and the Secretary of Commerce, NMFS publishes the IPHC regulations in the Federal Register as annual management measures pursuant to 50 CFR 300.62. Section 773c(c) of the Halibut Act also provides the Council with authority to develop regulations that are in addition to, and not in conflict with, approved IPHC regulations. The Council has exercised this authority in the development of Federal regulations for the halibut fishery such as 1) subsistence halibut fishery management measures, codified at § 300.65; 2) the limited access program for charter vessels in the guided sport fishery, codified at § 300.67; and 3) the Individual Fishing Quota (IFQ) Program for the commercial halibut and sablefish fisheries, codified at 50 CFR part 679, under the authority of section 773 of the Halibut Act and section 303(b) of the Magnuson-Stevens Act.

The Magnuson-Stevens Act (MSA) defines bycatch as "fish which are harvested in a fishery, but which are not sold or kept for personal use and includes economic discards and regulatory discards. The term does not include fish released alive under a recreational catch and release fishery management program." 16 U.S.C 1802 3(2).

The Magnuson-Stevens Act authorizes the Council and NMFS to manage groundfish fisheries in the Alaska EEZ that take halibut as bycatch. The groundfish fisheries cannot be prosecuted without some level of halibut bycatch because groundfish and halibut occur in the same areas at the same times and no fishing gear or technique has been developed that can avoid all halibut bycatch. However, the Council and NMFS have taken a number of management actions over the past several decades to minimize halibut bycatch in the BSAI groundfish fisheries. Most importantly, the Council has designated Pacific halibut and several other species (herring, salmon and steelhead, king crab, and Tanner crab) as "prohibited species" (Section 3.6.1 of the FMP). By regulation, the operator of any vessel fishing for groundfish in the BSAI must minimize the catch of prohibited species (§ 679.21(b)(2)(i)).

Although halibut is taken as bycatch by vessels using all types of gear (trawl, hook-and-line, pot, and jig gear), halibut bycatch primarily occurs in the trawl and hook-and-line groundfish fisheries. NMFS manages halibut bycatch in the BSAI by (1) establishing halibut PSC limits for trawl and non-trawl fisheries; (2) apportioning those halibut PSC limits to groundfish sectors, fishery categories, and seasons; and (3) managing groundfish fisheries to prevent PSC from exceeding the established limits. Consistent with National Standard 1 and National Standard 9 of the Magnuson-Stevens Act, the Council and NMFS use halibut PSC limits in the BSAI groundfish fisheries to balance the objectives to minimize bycatch to the extent practicable and achieving, on a continuing basis, optimum yield from the groundfish fisheries. Halibut PSC limits in the groundfish fisheries provide an additional constraint on halibut PSC mortality and promote conservation of the halibut resource. With one limited exception, groundfish fishing is prohibited once a halibut PSC limit has been reached for a particular sector or season. Therefore, halibut PSC limits must be set to balance the needs of fishermen, fishing communities, and U.S. consumers that depend on both halibut and groundfish resources.

IPHC and NMFS regulations authorize the harvest of halibut in commercial, personal use, sport and subsistence fisheries by hook-and-line gear and pot gear. In the BSAI (Area 4), halibut is harvested primarily in commercial fisheries and secondarily in personal use, subsistence, and sport fisheries.

The groundfish fisheries cannot be prosecuted without some level of halibut bycatch. Although fishermen are required by the BSAI FMP to avoid the capture of any prohibited species in groundfish fisheries, the use of halibut PSC limits in the groundfish fisheries provides a constraint on halibut PSC and promotes conservation of the halibut resource. Halibut PSC limits provide a regulated upper limit to mortality resulting from halibut interceptions, as continued groundfish fishing is prohibited once a halibut PSC limit has been reached for a particular sector and/or season. This management tool is intended to balance the optimum benefit to fishermen, communities, and U.S. consumers that depend on both halibut and groundfish resources.

The IPHC accounts for halibut PSC in the groundfish fisheries, recreational and subsistence catches, and other sources of halibut mortality, before setting commercial halibut catch limits each year. Specifically, the IPHC uses the current year's projection of the PSC amount to establish the following year's commercial halibut fishery catch limit. Recently, there have been concerns about the levels of halibut PSC in the commercial groundfish trawl and hook-and-line (longline) sectors. First, the exploitable biomass of Pacific halibut in the 1990s was the highest ever observed in the last one-hundred years, and has since declined to levels that are likely more common. Second, the declining biomass from these unprecedented levels has resulted in decreases in the Pacific halibut catch limits set by the IPHC for the BSAI commercial halibut fisheries (IPHC Area 4), especially in 2013 and 2014, for the commercial halibut fishery in the northern and eastern Bering Sea (Area 4CDE). The Council addressed this concern by reducing halibut PSC limits for the BSAI groundfish fisheries implemented by Amendment 111 to the FMP.

The Council recognizes efforts by the groundfish industry to reduce total halibut PSC in the BSAI but continuing low levels of halibut exploitable biomass have continued to result in reduced directed fishery catch limits in Area 4. Based on the IPHC management objectives as well as estimates of exploitable biomass and PSC, directed fishery stakeholders remain concerned that catch limits will not be sufficient to provide for a directed fishery at the PSC limits implemented by Amendment 111 to the FMP. Therefore, the Council is considering this new approach to link PSC limits to halibut abundance.

The Council does not have authority to set catch limits for the commercial halibut fisheries. The Council does set halibut PSC limits in the groundfish fisheries, and this is one of the factors that affects harvest limits for the commercial halibut fisheries. Halibut PSC in the groundfish fisheries are a significant portion of total mortality in BSAI IPHC areas and have the potential to affect catch limits for the commercial halibut fisheries in IPHC Area 4. While the impact of halibut PSC reductions on catch limits for commercial halibut fisheries is partially dependent on IPHC policy and management decisions, linking current halibut PSC limits in the BSAI to halibut abundance could provide additional harvest opportunities in the BSAI commercial halibut fishery, particularly at low levels of abundance.

Under National Standard 8, the Council must provide for the sustained participation of and minimize adverse economic impacts on fishing communities that depend on both halibut and groundfish resources. BSAI coastal communities are affected by reduced catch limits for the commercial halibut fishery, especially in IPHC Area 4CDE. In considering changes to the management of halibut PSC limits in the BSAI, the Council must balance these communities' involvement in and dependence on halibut with community involvement in and dependence on the groundfish fisheries that rely on halibut PSC in order to operate, and with National Standard 4, which states that management measures shall not discriminate between residents of different states. National Standard 4 also requires allocations of fishing privileges to be fair and equitable to all fishery participants. To be consistent with the requirements of the MSA, a Council action to implement abundance-based halibut PSC limits must minimize halibut PSC in the commercial groundfish fisheries to the extent practicable, while preserving the potential for the optimum harvest of the groundfish total allowable catch (TACs). Abundance-based halibut PSC limits should minimize halibut PSC to the extent practicable in consideration of the regulatory and operational management measures currently available to the groundfish fleet, and the need to ensure that catch in the trawl and non-trawl fisheries contributes to the achievement of optimum yield in the groundfish fisheries. Minimizing halibut PSC to the extent practicable is necessary to maintain a healthy marine ecosystem, ensure long-term conservation and abundance of the halibut stock, provide optimum benefit to fishermen, communities, and U.S. consumers that depend on both halibut and groundfish resources, and comply with the MSA and other applicable Federal law.

Consistent with the Council's purpose and need statement, abundance-based halibut PSC limits may provide harvest opportunities in the Area 4 commercial halibut fishery that meet IPHC and Council management objectives, particularly at low levels of halibut abundance. This would be consistent with the Council's objective to provide for directed halibut fishing operations and IPHC's objective to maintain the Pacific halibut stock at a level that will permit optimum yield from the fishery, and thus preserve the halibut fishery. If halibut PSC is reduced relative to the status quo, benefits to BSAI directed halibut fisheries could result from PSC reductions of halibut that are over 26 inches in length (O26). These O26 halibut could be available to the commercial halibut fishery in the area the PSC reductions occurred, in the year following the PSC reductions, or when the fish reach the legal-size limit for the commercial halibut fishery (greater than or equal to 32 inches in total length). Longer term benefits to the commercial halibut fisheries could accrue throughout the distribution of the halibut stock, from a reduction of halibut PSC from fish that are less than 26 inches (U26). Benefits from reduced mortality of these smaller halibut could occur both in the Bering Sea and elsewhere as these halibut migrate and recruit into the commercial halibut fisheries. At higher levels of halibut abundance, abundance-based halibut PSC limits may provide the groundfish fisheries with higher PSC limits. This would be consistent with the Council's objective to avoid constraining groundfish harvests, particularly at higher levels of abundance.

1.2 History of this Action

In February 2015, in conjunction with initial review of the analysis prepared for Amendment 111 to the BSAI FMP that considered reductions of BSAI Pacific halibut PSC limits, the Council also requested that Council and IPHC staff evaluate possible approaches to link BSAI halibut PSC limits to data or model-based abundance estimates of halibut.

Following the Council's February 2015 request, IPHC staff took the lead on drafting a paper examining several aspects of exploring abundance-based halibut PSC limits in the BSAI, including a review of harvest policies by both Council and IPHC staff, fishery trends, a range of potential candidate abundance indices, a discussion of basing allocation on yield (biomass) versus spawning capital (relative fishing impact), and a review of research recommendations (Martell et al., 2016). This paper was presented to the AP and the Council at the December 2015 Council meeting[2].

The Council then initiated subsequent discussion papers and requested that analysts from within the different agencies (IPHC, NMFS AFSC, NMFS RO and NPFMC staff) collaborate to provide additional information on appropriate indices for use in indexing halibut abundance to PSC in the Bering Sea. In April 2016, the analysts provided a discussion paper which addressed a number of different issues including a range of indices, information on establishing control rules and data on current usage of halibut bycatch by sector and gear type in the groundfish fisheries. Following review, the Council adopted a Purpose and Need Statement and provided additional direction for the analysts in a subsequent discussion paper.

In October 2016, the Council reviewed a discussion paper which addressed characteristics of a range of indices and control rule combinations as well as provided an overview of development of performance metrics that could be used in the subsequent analysis. These control rule combinations and indices were explored further in the April 2017 discussion paper where strawmen alternatives, or draft Abundance Based Management Alternatives (ABMs) were developed. The Council requested further clarification and a broadening of considerations for these ABM combinations in a subsequent paper. Performance metrics for the analysis of alternatives were discussed at a public workshop in February 2017 as well as in the June 2017 discussion paper along with characteristics of indices. A comprehensive review of all of the discussions papers was then provided in October 2017.

The Council has been reviewing all of these iterative discussion papers on establishing BSAI abundance-based management (ABM) prohibited species catch (PSC) limits for halibut since 2015. Table 1-1 provides a brief summary of the papers reviewed by the Council and the focus of these papers. The most recent paper reviewed by the Council was in April 2018 when a comprehensive synthesis of all available information contained in previous papers as well as further development of control rule options was provided. In June 2018 the SSC reviewed a paper on proposed methodology for the impact analysis. This methodology is further developed in this paper for additional background on how the analysis will be developed over the next 12 months. The action by the Council at this time is to review the current suite of alternatives, preliminary analyses of a subset of these as well as the Work Group's recommended modifications to the alternatives and revise these alternatives for analysis.

[2] The paper, Exploring index-based PSC limits for Pacific halibut by S. Martell, I. Stewart and C. Wor can be accessed at: http://goo.gl/hFPRpf

Table 1-1 Information contained in previous materials provided April 2016-June 2018

Information	Date and document available	Link
Data sources from which to derive indices including strengths and weaknesses of each	April 2016 discussion paper	April 2016
Fishery characteristics (halibut PSC by target; observed trawl and longline effort, CPUE, PSC rates)	Supplement to April 2016 discussion paper	Supplement April 2016
Description of potential abundance indices IPHC assessment; EBS trawl survey; combined and applied in a control rule	April 2016 discussion paper and attachment	April 2016
Control rule background	April 2016 discussion paper; October 2016 Discussion paper; April 2017 Discussion paper April 2018 Discussion paper	April 2016 October 2016 April 2017 April 2018
Control rule features	April 2016 discussion paper; October 2016 Discussion paper; April 2017 Discussion paper April 2018 Discussion paper	April 2016 October 2016 April 2017 April 2018
Control rule examples already in use	April 2016 discussion paper; April 2017 Discussion paper	April 2016 April 2017
Performance metrics	February Workshop materials; April 2017 discussion paper	February 2017 April 2017
	June 2017 Discussion paper	June 2017
Incentives	April 2017 Discussion paper	April 2017
Example ABM alternatives	April 2016 discussion paper; October 2016 Discussion paper; April 2017 Discussion paper; Supplement April 2017 Disc paper Strawman ABM examples April 2018	April 2016 October 2016 April 2017 Supplmnt Apr 17 April 2018
Management issues	October 2016 Discussion paper	October 2016
Analytical considerations and example scenarios	April 2016 Discussion paper Supplemental presentation on model October 2016 Discussion paper April 2017 Discussion paper Supplement to April 2017 Discussion paper (example calculations)	April 2016 Supplement ppt October2016 April2017 SupplmntApr17
Methodology for analysis	June 2018 (SSC only)	June 2018(a)
Proposed O26 performance standard	June 2018 [No Action by Council]	June 2018 (b)

1.3 Description of Management Area

The proposed action would be implemented in the BSAI groundfish management areas, which overlap IPHC regulatory areas 4A, 4B, 4C, 4D, and 4E (Figure 1-1).

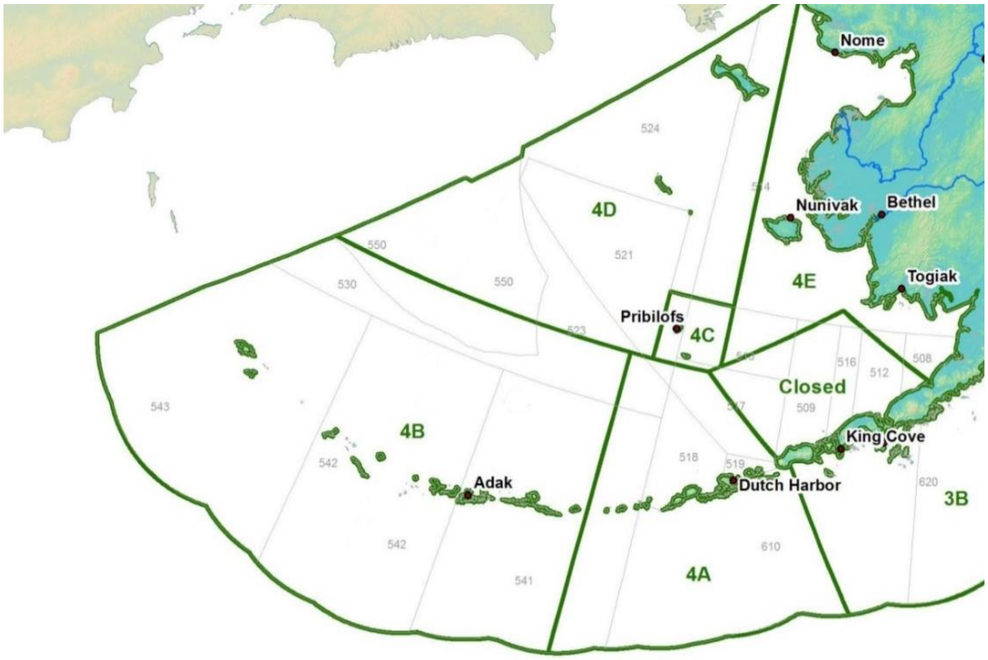

Figure 1-1 Alaska groundfish reporting areas and IPHC regulatory areas for Pacific halibut.

Source: Adapted from NMFS Alaska Region map by Northern Economics Inc.

NMFS management areas do not match exactly to IPHC regulatory areas (Figure 1-1). In IPHC management, and for the purposes of this analysis, the groundfish BSAI reporting areas are equated with IPHC areas as shown in Table 1-2.

Table 1-2 Alaska groundfish reporting areas and IPHC regulatory areas for Pacific halibut. NMFS management area reassignments used to aggregate groundfish and halibut statistics to IPHC regulatory areas

<table>
<tr><th>NMFS Areas</th><th>IPHC Area</th><th>Region</th></tr>
<tr><td>517, 518, 519</td><td>4A</td><td rowspan="4">BSAI</td></tr>
<tr><td>541, 542, 543</td><td>4B</td></tr>
<tr><td>513, 514, 521, 523, 524</td><td rowspan="2">4CDE and Closed area</td></tr>
<tr><td>508, 509, 512, 516</td></tr>
</table>

1.4 Abundance indices

Two abundance indices have been selected to track Pacific halibut abundance and guide setting PSC limits in the BSAI groundfish fisheries. These are from the NMFS AFSC EBS shelf bottom trawl survey and from the IPHC setline survey covering IPHC Areas 4ABCDE. A short description of each index is provided below for context in understanding the alternatives which index halibut PSC to abundance (Alternatives 2-6 in Section 2.2 - 2.5).

1.4.1 AFSC EBS shelf bottom trawl surveys

The NMFS and Alaska Fisheries Science Center (AFSC) has conducted the eastern Bering Sea shelf bottom trawl survey (EBS shelf survey) annually since 1982 (using standardized protocols). The AFSC designed the EBS shelf survey to describe the composition, distribution and abundance of demersal fish, shellfish and principle epibenthic invertebrate resources of the eastern Bering Sea. The continental shelf area of the eastern Bering Sea has proven to be one of the most productive fishing areas in the world in terms of both species abundance and commercial value.

Results of the EBS shelf survey are necessary for up-to-date estimates of biomass, abundance and population structure of groundfish populations in support of stock assessment and ecosystem forecast models that form the basis for groundfish and crab harvest advice. Additional data collected on the survey are used to improve understanding of life history of the fish and invertebrate species and the ecological and physical factors affecting their distribution and abundance. The EBS shelf survey provide fisheries independent population trends that are invaluable for stock assessments and the development of management strategies for commercially exploited fish and invertebrate species in the Bering Sea. The EBS shelf survey is generally described in a NOAA Technical Memo (Stauffer, 2004)

The main objective of AFSC groundfish trawl surveys is to collect fishery-independent data for multiple species which describe the:

- temporal distribution and abundance of the commercially and ecologically important groundfish and crab species,
- changes in the species composition and size and age compositions of species over time and space,
- reproductive biology and food habits of the groundfish community
- the physical environment of the groundfish habitat.

Relative abundance (catch per unit effort) and size and/or age composition data are key results from this survey and covers Pacific halibut in addition to target species such as walleye pollock, Pacific cod, yellowfin sole, northern rock sole, red king crab, and snow and tanner crabs.

The stratified random design of the EBS shelf survey consists of a grid with stations placed at the center of each 20 × 20 nautical square miles (Figure 1-2). Beginning in 1982, the same 356 stations were sampled annually. The AFSC added 20 stations to the northwest sector in 1987, resulting in a total of 376 stations.

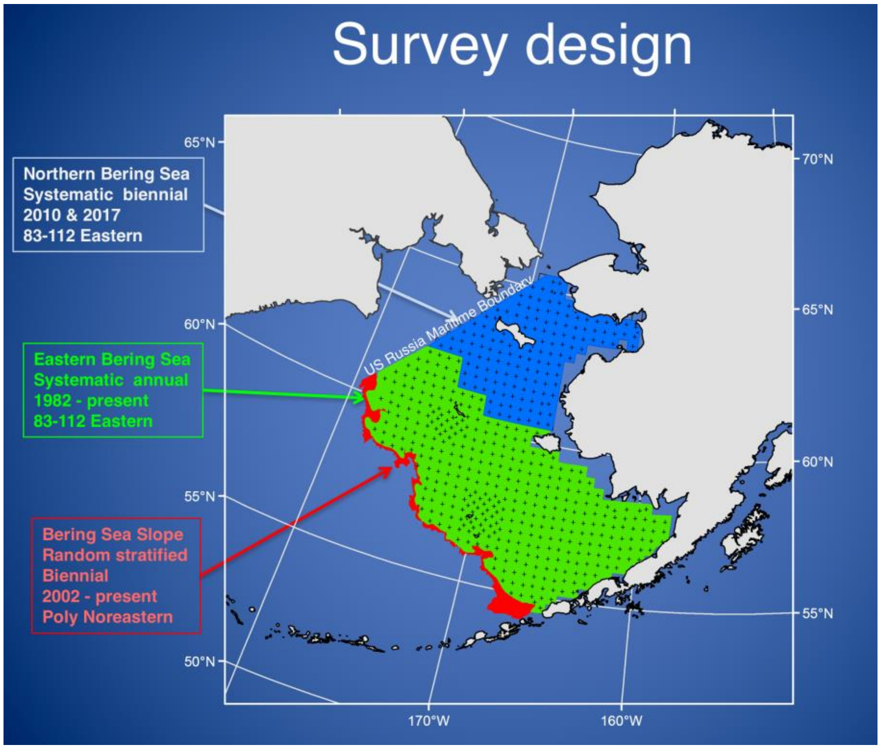

Figure 1-2 Layout of NMFS trawl survey designs (Source: Bob Lauth, AFSC).

The bottom trawl gear and trawling protocols used in AFSC surveys are described in Stauffer (2004). Samples obtained from the survey's standard 30-min tow range in weight from 30 to 17,800 kg (median = 1,167 kg). The time available to process this volume of catch is approximately equal to the time required for the vessel to traverse the 20 nautical miles to the next towing site (approx. 2 hours). Catches weighing 1,200 kg or less by visual estimate are lifted by crane from the trawl deck to a sorting table, where the catch is sorted and enumerated in its entirety. Catches from these tows are processed completely. However, roughly half of all EBS tows exceed the limits of the sorting table and must be subsampled. This is accomplished by lifting the whole catch off the deck, obtaining its weight with a load cell, and emptying it into a large bin containing a brailing net. The catch is subsampled by lifting the contents of the brailing net to a sorting table. The catch from the sorting table is weighed and enumerated by species, and weights and numbers are extrapolated to the total catch based on weight. The remaining catch on deck is sifted or "whole-hauled" for Pacific halibut (*Hippoglossus stenolepis*) and commercial crabs (*Lithodes* spp., *Paralithodes* spp., *Chionoecetes* spp.) and, in more recent years, other large-bodied species including Greenland turbot (*Reinhardtius hippoglossoides*), Pacific cod (*Gadus macrocephalus*), skates (*Raja* spp., *Bathyraja* spp.) and some species of sculpins (*Hemitripterus bolini*, *Hemilepidotus* spp., *Myoxocephalus* spp.).

Catches larger than the lifting capacity of the crane (approx. 5 metric tons) are emptied on deck and measured volumetrically using a density coefficient applied to calculate total catch weight. Once the weight of these very large catches (approx. 1.5% of all catches) is estimated, a sample is brought to the table for sorting and enumeration, and then extrapolated to the total catch. Whole-hauling occurs for the species mentioned above even on these large catches.

The AFSC developed trawl efficiency and enumeration confidence matrices for both fishes and invertebrates collected during the EBS shelf survey from 1982 through 2014. The trawl efficiency index scores, provided for each taxon code appearing in the survey database, are subjective, but were influenced by the results from several catch efficiency field experiments using NMFS trawl gear (e.g., Weinberg and

Munro 1999, Munro and Somerton, 2001, Somerton and Munro, 2001, Weinberg et al. 2002, Kotwicki and Weinberg 2005, Somerton et al. 2007; Weinberg et al. 2016). The efficiency index for Pacific halibut received the highest score, indicating that the AFSC believes the Pacific halibut CPUE calculated from the EBS shelf survey is an accurate and consistent indicator of relative animal density. Pacific halibut also received the highest score for confidence in the enumeration of weight and counts from the EBS shelf survey. A detailed description of the efficiency and enumeration confidence indices is provided in a 2016 NOAA Technical Memo.

The IPHC has deployed a biologist on the EBS shelf survey every year since 1998 to collect halibut samples. The IPHC participates in the EBS shelf survey to gather information collected in its coastwide setline survey. The setline survey is the primary fishery-independent source of data for the halibut stock assessment (Henry et al. 2015). However, Pacific halibut occupy a vast area of the Bering Sea shelf for which the IPHC lacks the financial resources to sample in its entirety. And as described above, the fishing gear used in the coastwide setline survey data generally catches halibut that are over 26 inches in length (O26) and available for harvest in the directed commercial fishery. Therefore, in most years, the EBS shelf survey is the only measure of relative abundance of smaller sizes of halibut (under 26 inches in length or U26) for much of this area. The halibut data collection (including ages) and treatment of information collected by the IPHC during the EBS shelf survey is described and the results are reported in the IPHC Report of Assessment and Research Activities 2016 (IPHC-2016-RARA-26-R).

The EBS shelf survey has different size-selectivity than setline gear, making it necessary to apply a calibration to the EBS shelf survey based on relative selectivity in the two surveys to include these data directly in the IPHC halibut stock assessment. In 2006, the IPHC added shelf stations to its setline survey in the Bering Sea region in order to compare information from setline stations in that area with data collected on the EBS shelf survey. After the study, the IPHC concluded that the EBS shelf survey, along with periodic IPHC survey calibrations, provided an adequate accounting of Pacific halibut biomass on the EBS shelf (Clark and Hare 2007) and is a useful tool for constructing a population-density index for the IPHC stock assessment (Webster 2014). The 2006 study was repeated in 2015 and confirmed the earlier finding (IPHC-2016-RARA-26-R). Based on this information, the EBS shelf survey would be an appropriate index of halibut abundance in the Bering Sea.

1.4.1.1 Halibut Data availability

The EBS shelf survey is conducted annually. The data from the survey is available each year in the fall and is used to prepare groundfish stock assessments. Therefore, the most recent EBS shelf survey data would be available for use as an index for the annual BSAI groundfish harvest specifications process in which the halibut PSC limits are established.

The IPHC estimate of total Pacific halibut abundance in the EBS using the shelf bottom trawl survey catches in 2016 was 66 million halibut, slightly higher than in 2015. As shown in Figure 1-3, estimated abundance declined by 4% to 22% annually beginning in 2006 from a high of 133.4 million halibut. However, since 2013, abundance has been fairly stable. In contrast, biomass estimates were down in 2016 with a total of 338.8 million pounds (153,677 t) compared to 380 million pounds (172,365 t) in 2015.

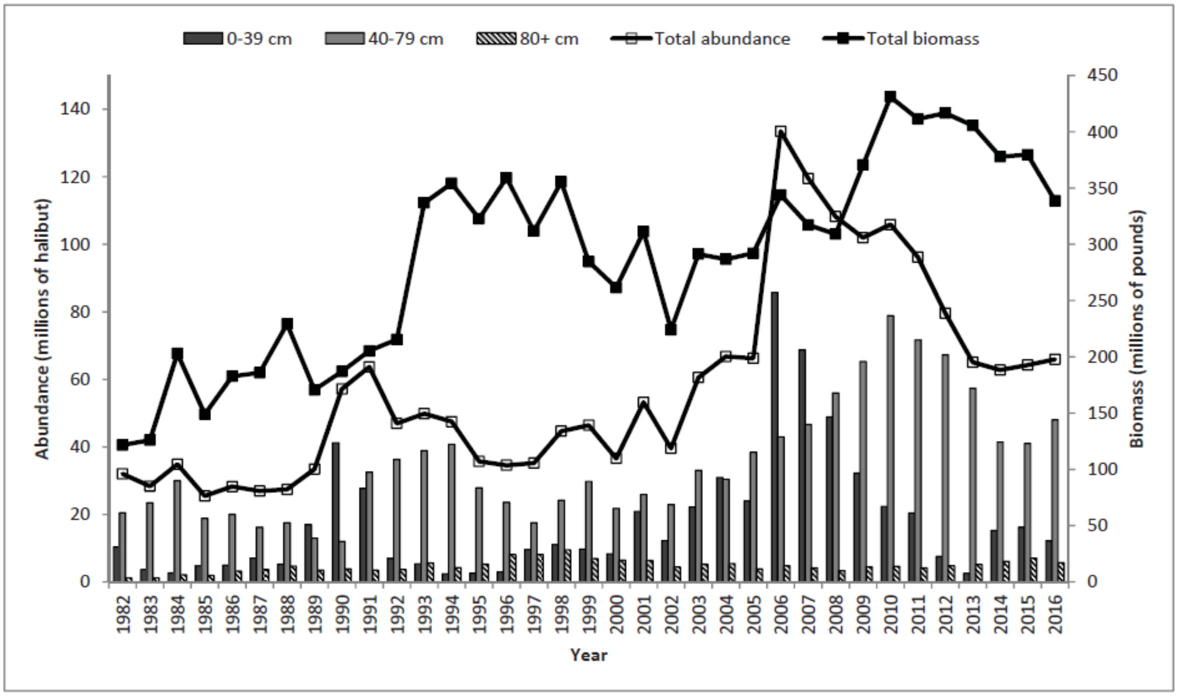

Figure 1-3 Estimated abundance (numbers of Pacific halibut) by length category, total biomass (pounds) as estimated by the NMFS Bering Sea Trawl survey data, 1982-2016. Source: 2016 IPHC RARA.

The trawl survey index was the area-swept biomass (catch-per-unit-effort multiplied by stratum area) estimated for the EBS by the annual NMFS EBS trawl survey during 1998–2017. These include all the standard core area strata (10+20+31+32+41+42+43+50+61+62) (Table 1-3), but not the northwest area strata (82 + 90).

Table 1-3 Estimated trawl survey index for the year 1998–2017.

Year	Trawl Index	Year	Trawl Index
1998	161,256	2008	140,247
1999	129,116	2009	168,102
2000	118,677	2010	195,535
2001	141,219	2011	186,666
2002	101,706	2012	189,000
2003	132,151	2013	183,989
2004	130,075	2014	171,427
2005	132,518	2015	172,237
2006	155,964	2016	153,704
2007	143,903	2017	126,684

1.4.2 IPHC Standardized Coastwide Stock Assessment (SSA) Survey or Setline Survey

The IPHC's annual standardized stock assessment (SSA) survey (referred to as the setline survey in this document) is the most important and comprehensive data input to the annual Pacific halibut stock assessment. The main priority of the setline survey is to measure catch rates and biological information for Pacific halibut, but many other projects are included such as tagging of halibut, collection of environmental data, collecting data from other species, and recording observations of seabirds.

The survey typically charters 12 to 14 fishing vessels during the summer months to survey more than 1300 stations on a 10nm by 10nm grid in nearshore and offshore waters of southern Oregon, Washington, British Columbia, southeast Alaska, the central and western Gulf of Alaska, Aleutian Islands, and northern Bering Sea (Henry et al 2017). Depths surveyed typically range from 20–275 fathoms (37–503 m), but shallower stations from 10–20 fathoms (18–37 meters) and deeper stations up to 400 fathoms (732 m) are often surveyed as part of expansion studies.

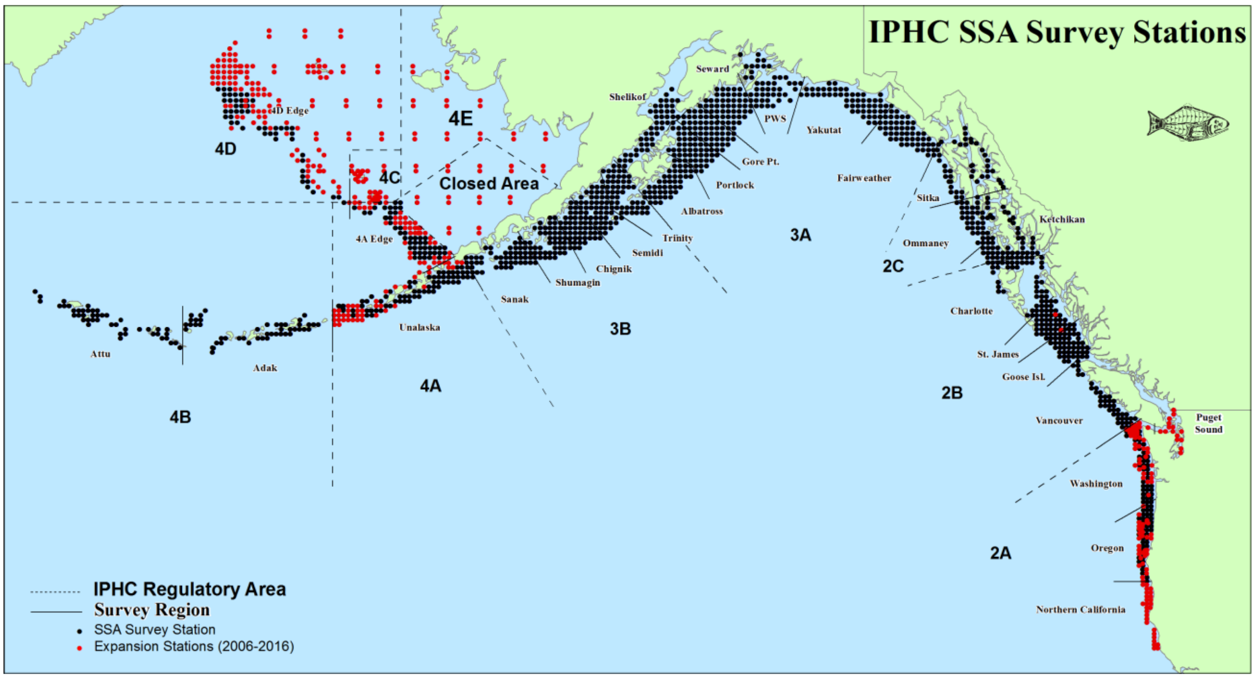

Figure 1-4 Standard stations (black) and expansion stations (red, 2006–2016) for the IPHC setline survey.

The standard grid of survey stations has been in place since 1998, with the addition of stations around the Pribilof and St. Matthew Islands beginning in 2006, and twelve stations in the Washington/Oregon regions beginning in 2011. Prior to 1997, the survey had less coverage, but data are available for many Regulatory Areas (Stewart & Monahan 2016). Certain areas include expansion stations (additional stations to cover additional area) in some years to investigate catch rates outside of the normal survey area and to calibrate with other surveys (e.g., the eastern Bering Sea trawl survey).

The fishing gear used in the setline survey data generally catches halibut that are O26 and available for harvest in the directed commercial fishery. Six skates of baited gear were fished in 2016, but the number of skates may increase or decrease in each year depending on the expected encounter rate with Pacific halibut. The other specifications for gear, setting schedule, and soak time have remained consistent since 1998 (Henry et al 2017). A set is considered ineffective for stock assessment if predetermined limits for lost gear, depredation, or displacement from station coordinates are exceeded.

Pacific halibut observations are recorded by IPHC sea samplers on the vessel. The fork lengths of all Pacific halibut were recorded to the nearest centimeter. Each length was converted to an estimated weight using a standard formula (Clark 1992), and these weights were then used to generate the weight per unit effort (WPUE) data. Average WPUE, expressed as net pounds per skate, was calculated by dividing the estimated catch in pounds (net weight) of Pacific halibut equal to or over 32 inches (81.3 cm; O32 Pacific halibut) in length by the number of skates hauled for each station. The sex, state of maturity, prior hook injuries, and depredation are also recorded. Otoliths are collected from a subsample of O32 and U32 halibut. Finally, the presence and abundance of seabird species within a 50-meter radius of the vessel's stern are recorded (Geernaert 2017).

The setline survey data are analyzed to estimate the coastwide numbers-per-unit-effort (NPUE) and weight-per-unit-effort (WPUE) of halibut over 32 inches (O32) and all halibut caught (Total). In 2016, an improved approach (spatio-temporal modeling) was used to estimating density indices (Webster 2017). This space-time model improves estimation by fitting models to the data that account for spatial and temporal dependence, making use of the degree to which the halibut distribution is patchy (has regions of high and low density), and that those patches tend to persist with time. For example, if WPUE is high at a particular location it is more likely to be high at nearby locations, and at the same location in previous and subsequent years. Therefore, we not only have information about density at a location and time from a direct observation, but from other data recorded nearby in space and time. Similarly, such an approach also allows estimation of a density index at a location with no data (e.g., a location between stations, a station with an ineffective set, or a region not surveyed annually). Additionally, auxiliary information collected on the survey (such as station depth) can provide further improvements.

The IPHC annual setline survey does not include stations on the eastern Bering Sea flats, except for those around St Matthew Island and the Pribilof Islands. Instead, data from annual National Marine Fisheries Service (NMFS) trawl surveys are calibrated to the 2006 and 2015 IPHC setline surveys in the eastern Bering Sea (Webster et al. 2016). The annual NMFS trawl survey is used in conjunction with the NMFS/ADFG surveys of Norton Sound (Soong and Hamazaki 2012) to develop an estimate of the density of Pacific halibut in the Bering Sea (see Webster 2014 for details). Additionally, data from the NMFS sablefish longline survey have been used to index deep water (>275 fathoms, 503 meters) on the IPHC Regulatory Area 4D edge.

The WPUE and NPUE are standardized to account for hook competition (competition for baits among Pacific halibut and other species) and timing of the survey relative to the total harvest of Pacific halibut. The hook competition adjustment will increase the raw WPUE or NPUE at an individual station slightly with more competition (fewer baits returned) and is applied before the space-time model is used to account for variability in the standardization among stations. The standardization to account for the amount of harvest taken before the setline survey uses target harvest rates for each IPHC Regulatory Area and is done for each IPHC Regulatory Area instead of individual stations.

The space-time model provides WPUE and NPUE for each IPHC Regulatory Area, where 4CDE is combined into a single area. The IPHC Regulatory Areas can be summed together after weighting by bottom area of suitable habitat for Pacific halibut. Space-time model results of Total WPUE for IPHC Regulatory Areas 4A, 4B, and 4CDE are shown in Table 1-4 and Figure 1-5 along with an appropriately combined Total WPUE for all three areas (4ABCDE). The correlation between all of these index time-series is high, and we consider 4ABCDE as an index of abundance as a potential ABM index. However, the index for any of the individual areas can easily be substituted.

Table 1-4 IPHC setline survey Total WPUE for the entire coast (coastwide), specific areas in IPHC Regulatory Area 4, and the sum of all areas in IPHC Regulatory Area 4 (4ABCDE). The indices are standardized to their means (1998-2017) for comparison, except for "Index 4ABCDE," which is the calculated weight-per-unit-effort index (WPUE) for all sizes of Pacific halibut.

Year	Coastwide	4A	4B	4CDE	4ABCDE	Index 4ABCDE
1998	1.48	2.09	2.53	0.99	1.75	18,179
1999	1.37	1.82	2.02	0.96	1.52	15,850
2000	1.41	1.83	1.85	1.05	1.53	15,867
2001	1.27	1.53	1.35	1.02	1.29	13,441
2002	1.26	1.37	1.01	0.96	1.14	11,815
2003	1.14	1.18	0.82	0.96	1.02	10,609
2004	1.13	1.06	0.74	0.92	0.94	9,773
2005	1.03	0.97	0.71	0.93	0.90	9,344
2006	0.97	0.83	0.81	1.09	0.93	9,643
2007	0.97	0.79	0.99	1.01	0.92	9,525
2008	0.91	0.91	1.00	1.02	0.97	10,109
2009	0.84	0.89	0.82	1.03	0.93	9,700
2010	0.80	0.76	0.71	1.05	0.87	9,009
2011	0.79	0.68	0.74	1.02	0.82	8,561
2012	0.84	0.67	0.62	1.01	0.79	8,267
2013	0.73	0.53	0.74	1.00	0.76	7,868
2014	0.78	0.55	0.64	1.03	0.76	7,872
2015	0.80	0.56	0.66	1.05	0.77	8,021
2016	0.82	0.49	0.67	1.02	0.74	7,665
2017	0.68	0.50	0.58	0.89	0.67	6,976

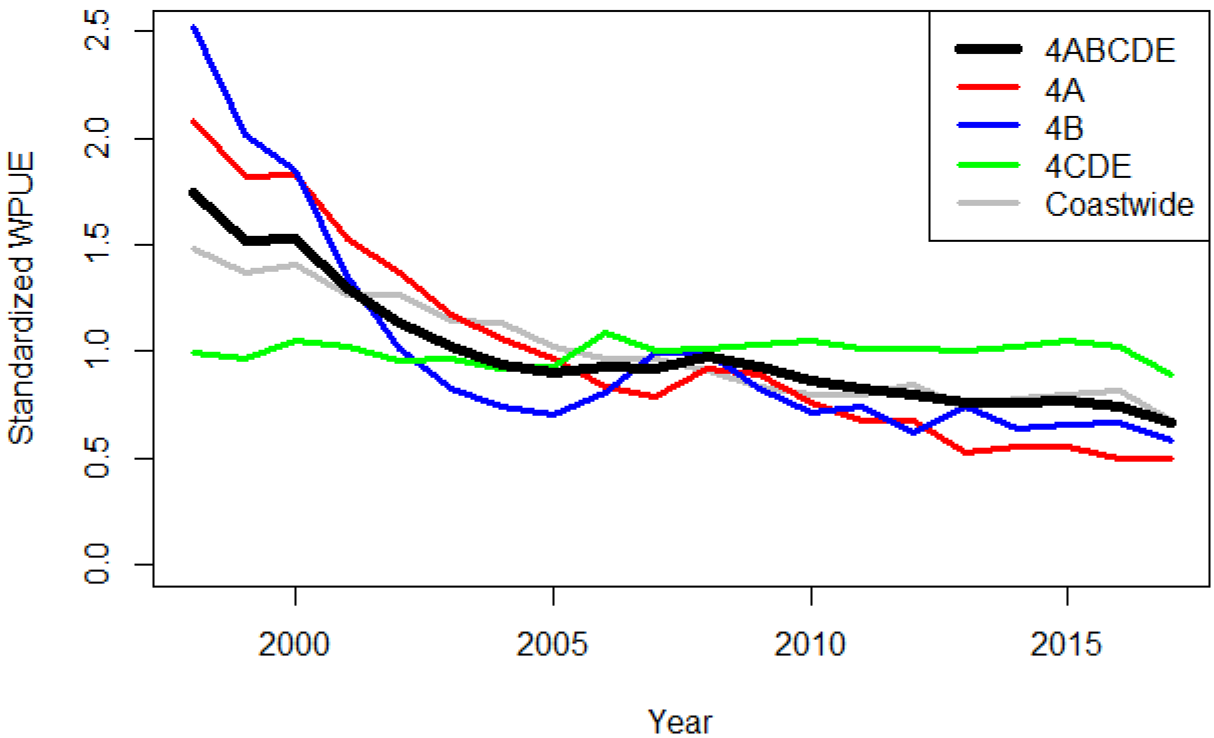

Figure 1-5 WPUE all Pacific halibut (Total) for IPHC Regulatory Areas in Area 4 standardized to the mean of the time series (1998-2017) for each Area. Area 4ABCDE is the sum of Areas 4A, 4B, and 4CDE, and Coastwide is all IPHC Regulatory Areas summed. Summed indices are appropriately weighted by bottom area.

1.4.2.1.1 Halibut Data availability

The space-time model provides WPUE and NPUE for each IPHC Regulatory Area, where 4CDE is combined into a single area. The IPHC Regulatory Areas can be summed together after weighting by bottom area of suitable habitat for Pacific halibut. Space-time model results of Total WPUE for IPHC Regulatory Areas 4A, 4B, and 4CDE are shown in Table 1-4 and Figure 1-5 along with an appropriately combined Total WPUE for all three areas (4ABCDE). The correlation between all of these index time-series is high, and we consider 4ABCDE as an index of abundance as a potential ABM index. However, the index for any of the individual areas can easily be substituted.

Table 1-5 IPHC setline survey Total WPUE for the entire coast (coastwide), specific areas in IPHC Regulatory Area 4, and the sum of all areas in IPHC Regulatory Area 4 (4ABCDE). The indices are standardized to their means (1998-2017) for comparison, except for "Index 4ABCDE," which is the calculated weight-per-unit-effort index (WPUE) for all sizes of Pacific halibut.

Year	Coastwide	4A	4B	4CDE	4ABCDE	Index 4ABCDE
1998	1.48	2.09	2.53	0.99	1.75	18,179
1999	1.37	1.82	2.02	0.96	1.52	15,850
2000	1.41	1.83	1.85	1.05	1.53	15,867
2001	1.27	1.53	1.35	1.02	1.29	13,441
2002	1.26	1.37	1.01	0.96	1.14	11,815
2003	1.14	1.18	0.82	0.96	1.02	10,609
2004	1.13	1.06	0.74	0.92	0.94	9,773
2005	1.03	0.97	0.71	0.93	0.90	9,344
2006	0.97	0.83	0.81	1.09	0.93	9,643
2007	0.97	0.79	0.99	1.01	0.92	9,525
2008	0.91	0.91	1.00	1.02	0.97	10,109
2009	0.84	0.89	0.82	1.03	0.93	9,700
2010	0.80	0.76	0.71	1.05	0.87	9,009
2011	0.79	0.68	0.74	1.02	0.82	8,561
2012	0.84	0.67	0.62	1.01	0.79	8,267
2013	0.73	0.53	0.74	1.00	0.76	7,868
2014	0.78	0.55	0.64	1.03	0.76	7,872
2015	0.80	0.56	0.66	1.05	0.77	8,021
2016	0.82	0.49	0.67	1.02	0.74	7,665
2017	0.68	0.50	0.58	0.89	0.67	6,976

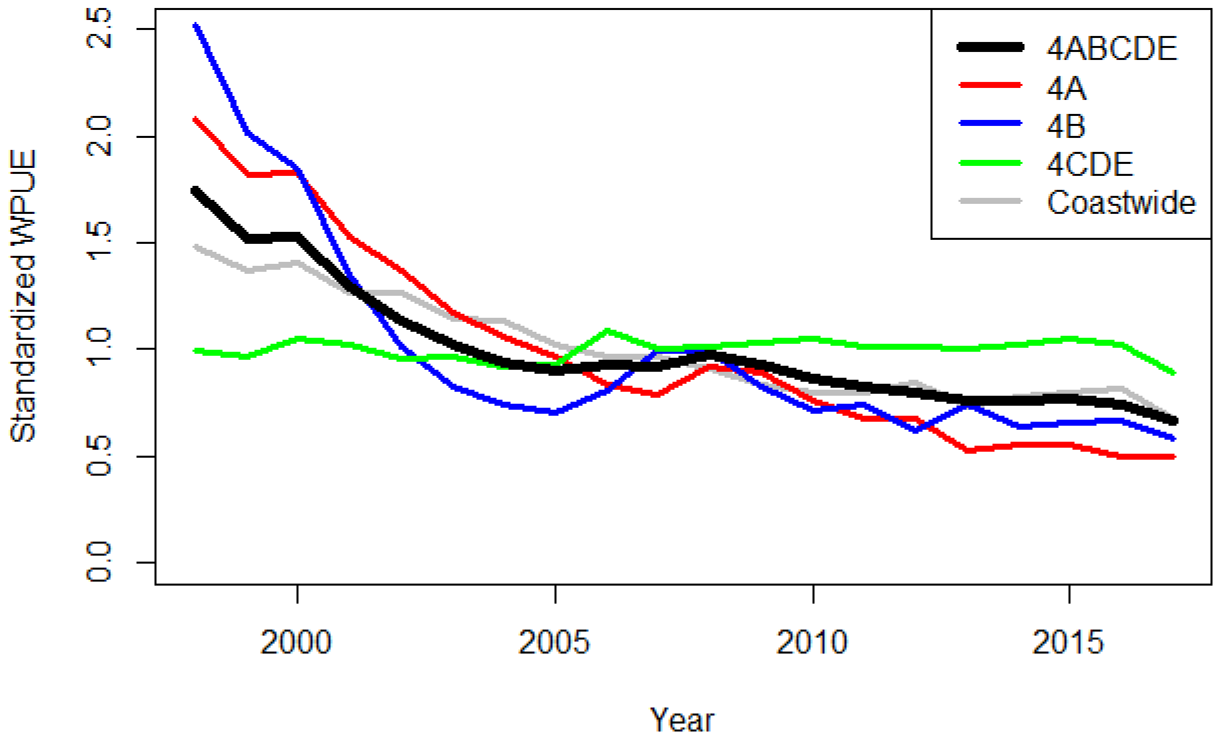

Figure 1-6 WPUE all Pacific halibut (Total) for IPHC Regulatory Areas in Area 4 standardized to the mean of the time series (1998-2017) for each Area. Area 4ABCDE is the sum of Areas 4A, 4B, and 4CDE, and Coastwide is all IPHC Regulatory Areas summed. Summed indices are appropriately weighted by bottom area.

The IPHC setline survey is typically completed in late summer and preliminary results are presented at the IPHC interim meeting in late November. It is possible that some minor changes due to data quality control and data checking may occur before the IPHC Annual Meeting in January, but these are not likely to be substantial. In the past, only WPUE for O32 and NPUE to all fish (Total) has been reported, but since 2017, WPUE will be available for O32 and Total. Therefore, Total WPUE is used throughout this report since it is most congruent with the IPHC's concept of TCEY (O26 halibut).

2. Description of Alternatives

NEPA requires that an EIS analyze a reasonable range of alternatives consistent with the purpose and need for the proposed action. The alternatives in this chapter were designed to accomplish the stated purpose and need for the action. All of the alternatives were designed to index PSC limits to abundance. The halibut PSC limits for the trawl Amendment 80 and BSAI trawl limited access sectors are established in the BSAI FMP, along with the total allocation of halibut PSC limit (from trawl and non-trawl) to the CDQ Program. Changing these PSC limits (under Alternatives 2-6), requires an FMP (and regulatory) amendment. The halibut PSC limit for non-trawl fisheries combined is currently only specified in regulation, and only requires a regulatory amendment to change.

There are 5 Alternatives currently under consideration by the Council. These have been developed through multiple discussion papers and will need further refinement before they can be fully analyzed. One Alternative (Alternative 6) has been included by the Workgroup for Council consideration in this preliminary analytical document. These 6 alternatives range from status quo with fixed halibut PSC limits by sector to a range of gear specific PSC limits indexed to BSAI halibut abundance.

Alternative 1: Status Quo. BSAI halibut PSC limits are fixed at 3,515 t total for all sectors. Alternative 2: Fixed gear halibut PSC limits are indexed to the abundance estimate derived from the IPHC setline survey in 4ABCDE, while trawl PSC limits are indexed to the abundance of halibut from the NMFS EBS bottom trawl survey. Once calculated by gear, PSC limits are then allocated to sectors within each gear type.

Alternatives 3, 4, 6: These alternatives are all similar in that they use information from both indices to calculate the PSC limit by gear type. There is a primary index that is similar to the gear type of the gear-specific PSC limit and uses a control rule, as in Alternative 2, to determine the PSC limit for that gear. However, a secondary index, which is the other of the two indices and differs from the gear linked to the PSC, modifies the PSC when above and below a specified threshold. For example, the primary index for fixed gear is the setline survey while the secondary index is the trawl survey. The difference between these three alternatives lies in the degree to which the secondary index modifies the PSC limit when that index is above and below a specified threshold. The formulation of Alternative 4 as it relates to the secondary index causes the PSC limit to change abruptly when the abundance reaches a threshold value. Alternative 6 was suggested to accommodate an alternative with a less abrupt change at the same threshold value for the secondary index.

Alternative 5: This alternative is for fixed gear only. The trawl component of the PSC limit would need to be calculated using one of the other alternatives. Here, the PSC limit is indexed to both indices and is presented as a look up table to determine the annual PSC fixed gear limit based upon specified values of each index in relation to a PSC limit. Abrupt changes in the PSC limit would occur at specified values of each index.

Under each of the Alternatives 2-6 there are multiple Elements and Options for specifying the maximum PSC limit (Ceiling), Minimum PSC limit (floor), starting point for the PSC limit as well as provisions for responsiveness to changes in index values and percentage change in PSC limits inter-annually.

2.1 Alternative 1, No Action

Under Alternative 1, the No Action or status quo alternative, the BSAI trawl and non-trawl halibut PSC limits are set in regulation as an amount of halibut equivalent to 3,515 mt of halibut mortality for trawl and non-trawl fisheries. A proportion of each of these overall limits is allocated to the CDQ program as a PSQ reserve, which is not apportioned by gear or fishery. A proportion of the trawl PSC limit is specifically allocated to Amendment 80. The remaining trawl and non-trawl PSC limits can then be annually allocated in the harvest specifications process to the fishery categories specified in the regulations, on an annual or seasonal basis. Figure 2-1illustrates how the PSC limits are currently apportioned. When an annual or seasonal PSC limit is reached, all vessels fishing in that fishery category must stop fishing for the remainder of the year or season, except that NMFS does not have authority to close the pollock and Atka mackerel if the PSC limit for that fishery is reached.

	Current PSC limit
Amendment 80 cooperatives	1,745 t
BSAI trawl limited access fisheries	745 t
Longline fisheries	710 t
CDQ fisheries	315 t
TOTAL	3,515 t

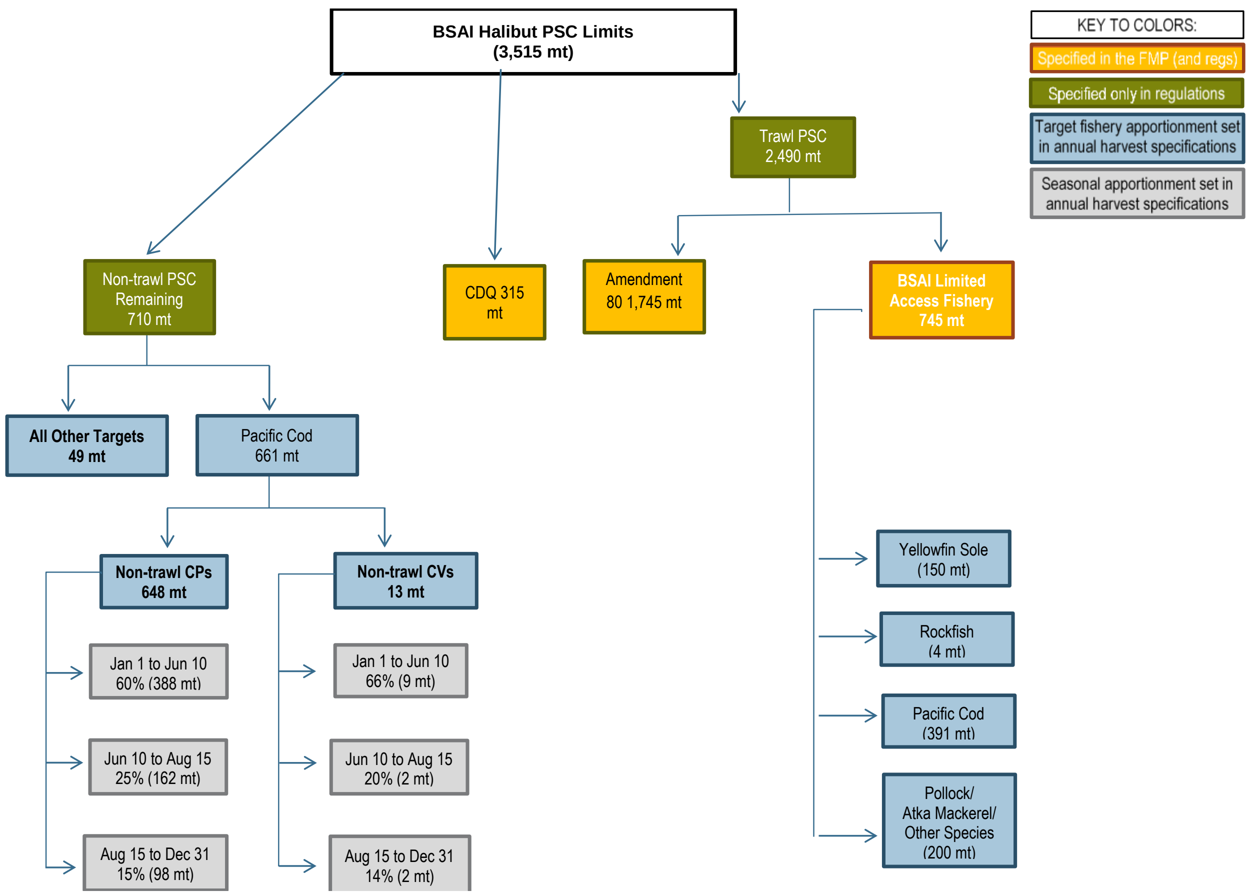

Figure 2-1 Flow Chart of BSAI Halibut PSC Limits for 2017

The regulations establish the current total BSAI non-trawl PSC and authorize NMFS to apportion the remaining non-CDQ halibut PSC to the established fishery categories through the annual harvest specifications process. The regulations do not specify halibut PSC limits for the non-trawl sectors (i.e., hook-and-line Pacific cod CV, hook-and-line Pacific cod CP, and hook-and-line and other target fisheries CV and CP). Establishing the halibut PSC limits for these sectors through the harvest specifications process enables the Council to annually determine the PSC apportionment among these sectors after considering relevant information such as changes in seasonal distribution of halibut or target groundfish species, changes in halibut biomass or groundfish TACs), and variations in fishing effort that could occur during the upcoming year. Under status quo, the BSAI TLA sector's PSC limit is apportioned among target fishery categories during the annual harvest specifications process. Separate halibut PSC limits for the hook-and-line Pacific cod CV, hook-and-line Pacific cod CP, and hook-and-line other target fisheries CV and CP sectors are not be specified in regulations.

For CDQ a single limit is specified which is then apportioned to CDQ entities and is prosecuted by both trawl and non-trawl fishing operations. Table 2-1 shows the proportion of CDQ PSQ usage by gear from 2011-2017. On average, usage over this time is 80% trawl and 20% non-trawl.

Table 2-1 Percentage usage of CDQ PSQ by gear type from 2011-2017.

Year	*Trawl*	*% Total*	*Non-Trawl*	*% Total*	*Total*
2011	173	71%	71	29%	243
2012	215	79%	59	21%	274
2013	207	77%	60	23%	267
2014	206	84%	39	16%	245
2015	108	83%	23	17%	130
2016	149	86%	24	14%	173
2017	135	88%	18	12%	154
Total	*1,192*	*80%*	*294*	*20%*	*1,486*

2.2 Alternative 2: Index trawl PSC limit to EBS trawl survey biomass. Index longline PSC limit to setline survey biomass.

Under Alternative 2 the groundfish fishery PSC limit would be calculated by gear type following abundance of halibut indexed by the same gear type. That is, the trawl fishery PSC limit (in aggregate) would be calculated based upon the selected control rule (from amongst the elements and options below) applied to the estimate of halibut biomass from the EBS trawl survey. The longline fishery PSC limit (in aggregate) would be calculated based upon the selected control rule (from amongst the elements and options below) to the estimated halibut relative biomass from the IPHC setline survey in Area 4ABCDE. Once the aggregate limits by gear type are calculated, sectors within those categories (e.g., Amendment 80, trawl limited access, and CDQ trawl, CDQ longline and non-CDQ longline fisheries) would be allocated PSC limits proportional to their status quo proportions[3].

Elements and options described below relate to the shape of the control rule and the relative responsiveness of the control rule to fluctuations in inter-annual changes in the biomass indices. Of these, selection of an option under Elements 2-6 is required (Element 1 is optional).

[3] Note that staff requires direction from the Council on the relative allocation by gear type for the trawl and non-trawl CDQ components under Alternatives 2-6. The usage table provided in Table 2-1 may help inform the appropriate allocation to gear types for calculation of the abundance-based gear PSC limit. It is assumed that in practical terms the gear-based PSC apportionments to CDQ would be summed to operate as a single CDQ limit as with status quo. This would be consistent with the Council's intent that there would be no change to the status quo process of allocating BSAI halibut PSC limits amongst sectors.

2.2.1 Element 1: PSC limit responsiveness to abundance changes

Three options are considered to modify how responsive the calculated PSC limit is to inter-annual changes. Options 1-3 may be selected if desirable to damp down the variability of the PSC limit. This is imposed after the PSC limit itself is calculated.

Option 1: PSC limit varies no more than 5% per year
Option 2: PSC limit varies no more than 15% per year
Option 3: PSC limit varies no more than 25% per year

2.2.2 Element 2: Starting point for PSC limit

The starting point is the value of the limit prescribed by the control rule when the indices are at their 2016 values. Four options are provided. One option must be selected in formulating the control rule alternative.

Option 1. 10% below 2016 PSC use (2,119 t)
Option 2. 2017 use (1,958 t)
Option 3. Average of 2016 PSC use and limit (2,935 t)
Option 4. 2016 PSC limit (3,515 t)

2.2.3 Element 3: Maximum PSC limit (ceiling)

Element 3 provides the maximum level of the PSC. Under this element the PSC limit would remain static at that level for all values of the index above that which provides for this PSC limit. Three options are provided. One option must be selected in formulating the control rule alternative.

Option 1. 2016 PSC limit (3,515 t)
Option 2. 2015 PSC limit (4,426 t)
Option 3. No ceiling

2.2.4 Element 4: Minimum PSC limit (floor)

Element 4 provides for a minimum level of PSC annually regardless of the control rule prescribing a lower value. Four options are provided under this element. One option must be selected in formulating a control rule alternative.

Option 1. No floor (PSC goes to 0)
Option 2. 2016 use (2,354 t)
Option 3. ½ of 2016 PSC limit (1,758)
Option 4. PSC limit is zero at IPHC 20% Coastwide stock status (or proxy)

2.3 Alternatives 3,4, and 6: Index trawl gear PSC limit and fixed gear PSC limit to both EBS trawl survey (primary index for trawl, secondary index for longline) and setline survey (primary index for longline, secondary index for trawl).

Under Alternatives 3 and 4 (and proposed Alternative 6), the PSC limit is set by gear type and indexed to both EBS trawl survey and setline survey. The primary index is the one which matches the fishery gear type of the PSC limit with the secondary index matching the other gear. Specifically, the trawl fishery PSC limit is indexed to both EBS trawl and setline survey for 4ABCDE, with the trawl survey forming the primary index while information on the setline survey for 4ABCDE will be used as a secondary index as applied to the control rule. The fixed gear (longline fisheries) PSC limit is indexed to both EBS trawl and setline survey for 4ABCDE with the setline survey forming the primary index while information on the trawl survey will be used as a secondary index to influence the final PSC limit after the control rule is applied. The secondary index modifies the final PSC according to values and responsiveness as determined by Elements 5 and 6.

The primary difference between Alternatives 2, and 3, 4, and 6, is that the PSC limit is still directly indexed to the primary biomass index for that gear type, but when the index for the other gear type is above or below a threshold value, that index exerts an additional change in the PSC limit.

The April Council motion (See Appendix III) specified both Alternatives 3 and 4. They were listed as the following:

> *Alternative 3*: Index trawl gear PSC and fixed gear PSC to both EBS trawl survey (primary index for trawl, secondary index for longline) and setline survey (primary index for longline, secondary index for trawl). The secondary index modifies a multiplier on the starting point of the control rule when the secondary index is in a "high state" or a "low state" (e.g., the PSC is multiplied by 1.1 when the secondary index is at a "high" value and by 0.9 when the secondary index is a "low" value).
>
> *Alternative 4*: Index trawl gear PSC and fixed gear PSC to both EBS trawl survey (primary index for trawl, secondary index for longline) and setline survey (primary index for longline, secondary index for trawl). The secondary index modifies the multiplier on the final PSC limit after the primary index is applied when the secondary index is in a "high state" or a "low state" (e.g., the PSC is multiplied by 1.1 when the secondary index is at a "high" value and by 0.9 when the secondary index is at a "low" value).

The primary difference between the two alternatives was the distinction between the multiplier on the starting point (Alternative 3) and the multiplier on the final PSC limit (Alternative 4). The April 2018 Council Motion also specified that proportional or percent change in the index value should lead to the same proportional or percent change in the PSC limit (i.e., the control rule slope should be equal to 1). When the proportional effect is equal to 1 and, in addition, the PSC limit set so that the starting point is attained at the 2016 values of the index (which is a desired property of all of the control rules), Alternatives 3 and 4 are mathematically identical. Both of these conditions are met for all Elements and Options in the April 2018 Motion. **Therefore, Alternatives 3 and 4 can be reduced to one alternative for the purpose of this analysis and we recommend referring to it as Alternative 4**. Additional details on the justification for reducing these to one alternative is contained in Appendix II.

Elements and options described below relate to the shape of the control rule and the relative responsiveness of the control rule to fluctuations in PSC based upon inter-annual changes in biomass. Of these elements, selection of an option under Elements 2-6 is necessary while Element 1 is optional.

2.3.1 Element 1: PSC limit responsiveness to abundance changes

Three options are considered to modify how responsive calculated PSC limit is to inter-annual changes. Options 1-3 may be selected if desirable to damp down the variability of the PSC limit. This is imposed after the PSC limit itself is calculated.

> Option 1: PSC limit varies no more than 5% per year
> Option 2: PSC limit varies no more than 15% per year
> Option 3: PSC limit varies no more than 25% per year

2.3.2 Element 2: Starting point for PSC limit

The starting point is the value of the limit prescribed by the control rule when the indices are at their 2016 values. Four options are provided. One option must be selected in formulating the control rule alternative.

Option 1. 10% below 2016 PSC use (2,119 t)
Option 2. 2017 use (1,958 t)
Option 3. Average of 2016 PSC use and limit (2,935 t)
Option 4. 2016 PSC limit (3,515 t)

2.3.3 Element 3: Maximum PSC limit (ceiling)

Element 3 provides the maximum level of the PSC. Under this element the PSC limit would remain static at that level for all values of the index above that which provides for this PSC limit. Three options are provided. One option must be selected in formulating the control rule alternative.

Option 1. 2016 PSC limit (3,515 t)
Option 2. 2015 PSC limit (4,426 t)
Option 3. No ceiling

2.3.4 Element 4: Minimum PSC limit (floor)

Element 4 provides for a minimum level of PSC annually regardless of the abundance estimate indicating a lower value. Four options are provided under this element. One option must be selected in formulating a control rule alternative.

Option 1. No floor (PSC goes to 0)
Option 2. 2016 use (2,354 t)
Option 3. ½ of 2016 PSC limit (1,758)
Option 4. PSC limit is zero at IPHC 20% Coastwide stock status (or proxy)

2.3.5 Element 5: High and low values for secondary index

Element 5 determines the relative values for high and low of the secondary index which is then related to the relative influence of the secondary index on the resulting PSC limit. Three options are provided for this element. One option must be selected in formulating a control rule alternative.

Option 1. High = 2nd highest value of time series, Low = 2nd lowest value of time series
Option 2. Index is 25% below or above average
Option 3. Index is above or below average

2.3.6 Element 6: Multiplier for secondary index

Element 6 determines the responsiveness of the secondary index in influencing the PSC limit. Higher values would indicate a higher sensitivity of the PSC limit to changes in the abundance of the secondary index. Three options are provided under this element. Each of these options is framed as a range of values therefore both an option and a value must be selected in formulating a control rule alternative.

Option 1. High = range of 1.1 to 1.5
Option 2. Low = range of 0.5 to 0.9
Option 3. Other high, medium and low ranges to be selected between 0.5 and 1.5

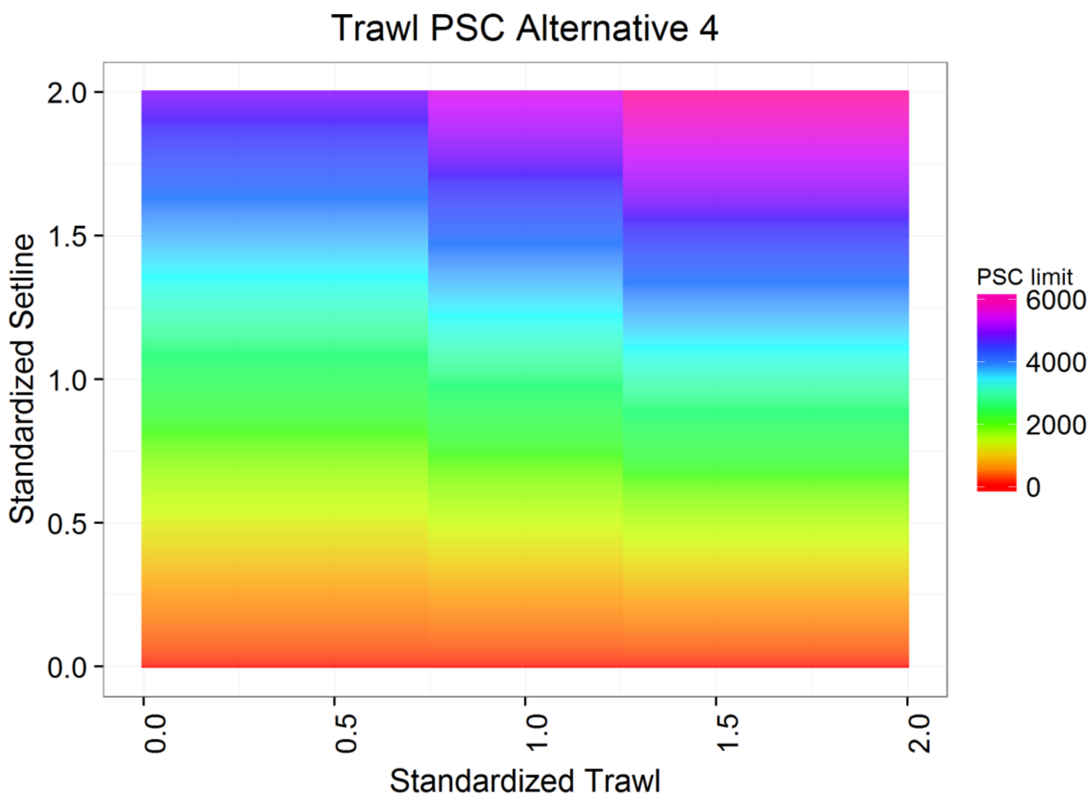

Figure 2-2 Trawl PSC limits for the Alternative 4 multidimensional control rule assuming Option 2 of Element 5 where multipliers are applied when the secondary index is either 25% above average or 25% below average.

Figure 2-2 shows an example of calculated PSC limits under Alternative 4. Here the secondary index influences the PSC limit when it is either 25 percent above its' average value or 25 percent below its average value. The selected options for each element shown are listed in Section 2.6. Figure 2-3 shows a cross-section of the control rule when the trawl survey index is at a value of 1. This demonstrated the influence of the setline survey at thresholds above and below 25 percent of its average value.

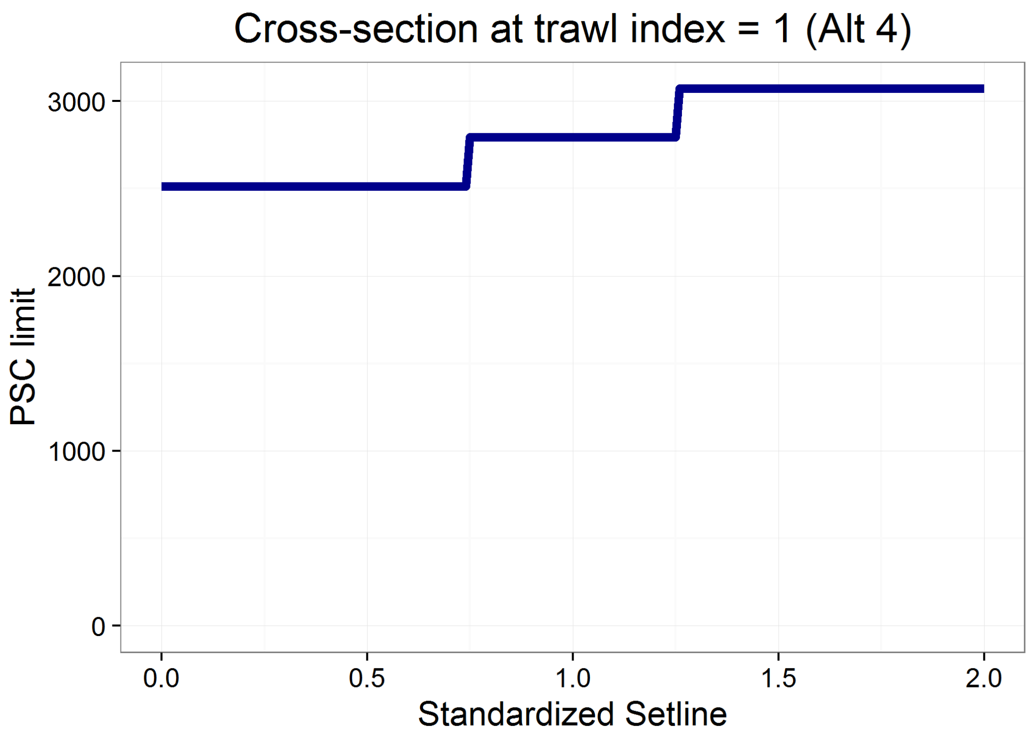

Figure 2-3 Trawl PSC limit when the trawl index is at 1 over the range of the setline index. Example uses the Alternative 4 multidimensional control rule assuming Option 2 of Element 5 where multipliers are applied when the secondary index is either 25% above average or 25% below average.

2.4 Alternative 5 Index fixed gear PSC to combination of IPHC Area 4 all sizes survey and EBS shelf trawl survey.

Alternative 5 uses information from both surveys to set a fixed gear PSC limit. Here, the PSC limit is presented in a look-up table based on halibut abundance from the IPHC Area 4 setline survey and the EBS trawl survey. As noted below **Alternative 5 lacks sufficient detail for preliminary analysis and needs to be clarified before it can be included in the alternative set for analysis.**

Alternative 5 sets a fixed gear PSC limit only. Therefore, in selecting Alternative 5, one of the other Alternatives must be used to establish the trawl gear PSC.

2.4.1 Element 1: PSC limit responsiveness to abundance changes

Element 1 triggers a new PSC limit set at the floor (to be determined under Element 4). The trigger for this is automatic when the Coastwide Stock biomass drops below 20%. When Coastwide biomass is above 20% this new PSC limit set at the floor may be triggered based upon the options 1-4 below.

Option 1: EBS survey decline 25%
Option 2: EBS survey decline 50%
Option 3: IPHC setline survey Area 4ABCDE declines 25%
Option 4: IPHC setline survey Area 4ABCDE declines 50%

2.4.2 Element 2: Starting point for PSC limit

The starting point is the value of the limit prescribed by the control rule when the indices are at their 2016 values. Four options are provided. One option must be selected in formulating the control rule alternative.

Option 1. 2016 limit (710 mt)
Option 2. 10% below 2016 limit (639 mt)
Option 3. 20% below 2016 limit (568 mt)
Option 4: 2016 PSC use (205 mt).

2.4.3 Element 3: Maximum PSC limit (ceiling)

Element 3 provides the maximum level of the PSC. Under this element the PSC limit would remain static at that level for all values of the index above that which provides for this PSC limit. Three options are provided. One option must be selected in formulating the control rule alternative.

Option 1. 2015 PSC limit (833 mt)
Option 2. 2016 PSC limit (710 mt)
Option 3. No ceiling

2.4.4 Element 4: Minimum PSC limit (floor)

Element 4 provides for a minimum level of PSC annually regardless of the abundance estimate indicating a lower value. Four options are provided under this element. One option must be selected in formulating a control rule alternative. Note that option 3 imposes a floor at 0 when the spawning stock biomass is below 20 percent. This is in addition to provisions under Element 1 that the PSC limit drops to the floor at this value. This should be clarified.

Option 1. 2002-2016 avg. PSC use = 462 mt
Option 2. 50% of 2016 PSC limit = 355 mt
Option 3. PSC limit is zero at SB 20% Coastwide stock status (or proxy)

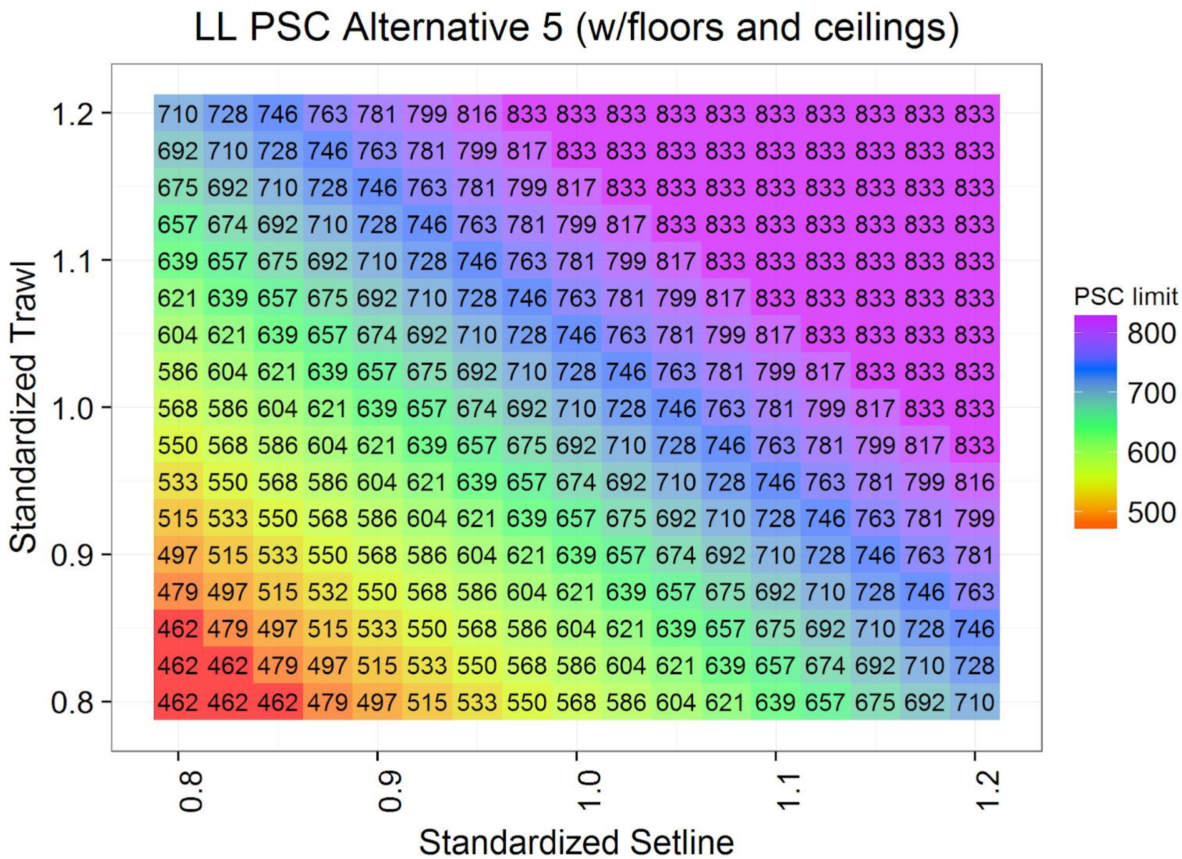

Figure 2-4 Example lookup table for Alternative 5 as described in the April 2018 motion. The alternative was intended to apply only to the longline PSC. In this example, the PSC limits move in proportion to both indices simultaneously with a starting point at the 2016 PSC limit of 710 t (the diagonal of the table).

2.4.5 Issues in need of clarification with Alternative 5

In describing this alternative based upon the Council's motion from April the analysts noted several areas that would benefit from clarification. The alternative specifies a look up table to prescribe the limit based upon the two indices but lacks specificity on the dimensions of the table. An example fine scale look up table for this alternative is provided in Figure 2-4. Here the starting point of 710 t is employed with the PSC limit then in proportion simultaneously to both indices. A ceiling of 833 t is used (Element 3 Option 1) with a floor at 462 (Element 4 Option 1). Here Element 1 options are not shown.

Elements 1 and 4 also require some clarification. Element 1 specifies when the PSC limit should go to the floor regardless of the look up table/control rule specification. A range (25-50%) was provided in the motion for decreases in the individual survey which would cause the PSC limit to drop to the floor. These were used as bookends in the suggested options. However, Element 1 also prescribes that the PSC limit goes to the floor when the coastwide spawning stock biomass is below a threshold. This is also captured in Element 4 which prescribes the floor using 3 different options. Between the two elements which overlap somewhat in their structure and would benefit from clarity, there are 15 different Alternative floors and mechanisms that would be analyzed.

The structure of Alternative 5 that was in the April motion (Appendix III) differed from analysts understanding of the intent of the Alternative as it was being conceived. Conceptually the alternative was set up as an ‘If Then’ system which would cause modification in the PSC limit based upon threshold changes in the relative indices. Table 2-2 show a schematic of an interpretation of an alternative that was discussed prior to the Council’s motion for alternative 5. This would represent a coarse look up table with PSC limits specified based upon the indices being between a range of values. Should the Council intend that Alternative 5 would be functionally similar to Table 2-2, some substantial revisions to the Alternative structure and description would be necessary as well as clarification on the missing aspects to the table (as listed in bold).

Table 2-2 An interpretation of a 3x3 look up table with some provisions related to Alternative 5, based discussions with stakeholders and the working group at the April Council Meeting. This interpretation of the alternative is more closely aligned to the April 2018 AP minutes.

	Standardized EBS Shelf Trawl Survey		
Standardized IPHC All Sizes Setline Survey	**>1.1**	**<1.1 and > = 0.5**	**<0.5**
> 1.1	PSC limit = Ceiling	PSC limit = Ceiling	**Does PSC limit equal the Ceiling or the Floor?**
<1.1 and > = 0.5	PSC limit = Ceiling	PSC limit = Starting Point	PSC limit = Floor
<0.5	**Does PSC limit equal the Ceiling or the Floor?**	PSC limit = Floor	PSC limit = Floor

2.5 Alternative 6 (recommended by Workgroup)

Alternative 6 is recommended for inclusion by the Workgroup to contrast against Alternative 4. Under Alternative 6 (as with Alternative 4), the PSC limit is set by gear type and indexed to both EBS trawl survey and setline survey. The primary index is the one which matches the gear type of the PSC limit. The trawl gear PSC is indexed to both EBS trawl and setline survey for 4ABCDE, with the trawl survey forming the primary index while information on the setline survey for 4ABCDE will be used as a secondary index to influence the final PSC limit after the control rule is applied. In contrast, the fixed gear PSC is indexed to both EBS trawl and setline survey for 4ABCDE with the setline survey forming the primary index while information on the trawl survey will be used as a secondary index to influence the final PSC limit after the control rule is applied. The secondary index modifies the final PSC according to values and responsiveness as determined by Elements 5 and 6.

The primary difference between Alternative 3 and 4 and Alternative 6 is the way that it responds to values of the secondary index that are above or below the threshold. For Alternative 4, when the secondary index is below or above the specified threshold, this results in a discontinuity or an abrupt change in PSC limit, while Alternative 6 uses the same multiplier to change the proportionality constant at the threshold. For example, if the multiplier for Alternative 4 was to decrease the PSC limit by an additional 10% upon breaching that threshold, Alternative 6 could be used to modify the rate of decrease in PSC limit by 10% of the decline of the secondary index from the threshold (or some other specified value). This results in a smooth transition near a threshold, but a PSC limit can become more or less responsive when it has passed the threshold depending on the desired outcome.

Elements and options described below relate to the shape of the control rule and the relative responsiveness of the control rule to fluctuations in PSC based upon inter-annual changes in survey biomass. Of these elements, selection of an option under elements 2-6 is necessary while element 1 is optional.

2.5.1 Element 1: PSC limit responsiveness to abundance changes

Three options are considered to modify how responsive calculated PSC limit is to inter-annual changes. Options 1-3 may be selected if desirable to damp down the variability of the PSC limit. This Element is imposed after the PSC limit itself is calculated.

Option 1: PSC limit varies no more than 5% per year
Option 2: PSC limit varies no more than 15% per year
Option 3: PSC limit varies no more than 25% per year

2.5.2 Element 2: Starting point for PSC limit

The starting point is the value of the limit under the mean value of the index of abundance. Four options are provided. One option must be selected in formulating the control rule alternative.

Option 1. 10% below 2016 PSC use (2,119 t)
Option 2. 2017 use (1,958 t)
Option 3. Average of 2016 PSC use and limit (2,935 t)
Option 4. 2016 PSC limit (3,515 t)

2.5.3 Element 3: Maximum PSC limit (ceiling)

Element 3 provides the maximum level of the PSC. Under this element the PSC limit would remain static at that level for all values of the index above that which provides for this PSC limit. Three options are provided. One option must be selected in formulating the control rule alternative.

Option 1. 2016 PSC limit (3,515 t)
Option 2. 2015 PSC limit (4,426 t)
Option 3. No ceiling

2.5.4 Element 4: Minimum PSC limit (floor)

Element 4 provides for a minimum level of PSC annually regardless of the abundance estimate indicating a lower value. Four options are provided under this element. One option must be selected in formulating a control rule alternative.

Option 1. No floor (PSC goes to 0)
Option 2. 2016 use (2,354 t)
Option 3. ½ of 2016 PSC limit (1,758)
Option 4. PSC limit is zero at IPHC 20% Coastwide stock status (or proxy)

2.5.5 Element 5: High and low values for secondary index

Element 5 determines the relative values for high and low of the secondary index which is then related to the relative influence of the secondary index on the resulting PSC limit. Three options are provided for this element. One option must be selected in formulating a control rule alternative.

Option 1. High = 2nd highest value of time series, Low = 2nd lowest value of time series
Option 2. Index is 25% below or above average
Option 3. Index is above or below average

2.5.6 Element 6: Multiplier for secondary index

Element 6 determines the responsiveness of the secondary index in influencing the PSC limit. Higher values would indicate a higher sensitivity of the PSC limit to changes in the abundance of the secondary index. Three options are provided under this element. Each of these options is framed as a range of values therefore both an option and a value must be selected in formulating a control rule alternative.

Option 1. High = range of 1.1 to 1.5
Option 2. Low = range of 0.5 to 0.9
Option 3. Other high, medium and low ranges to be selected between 0.5 and 1.5

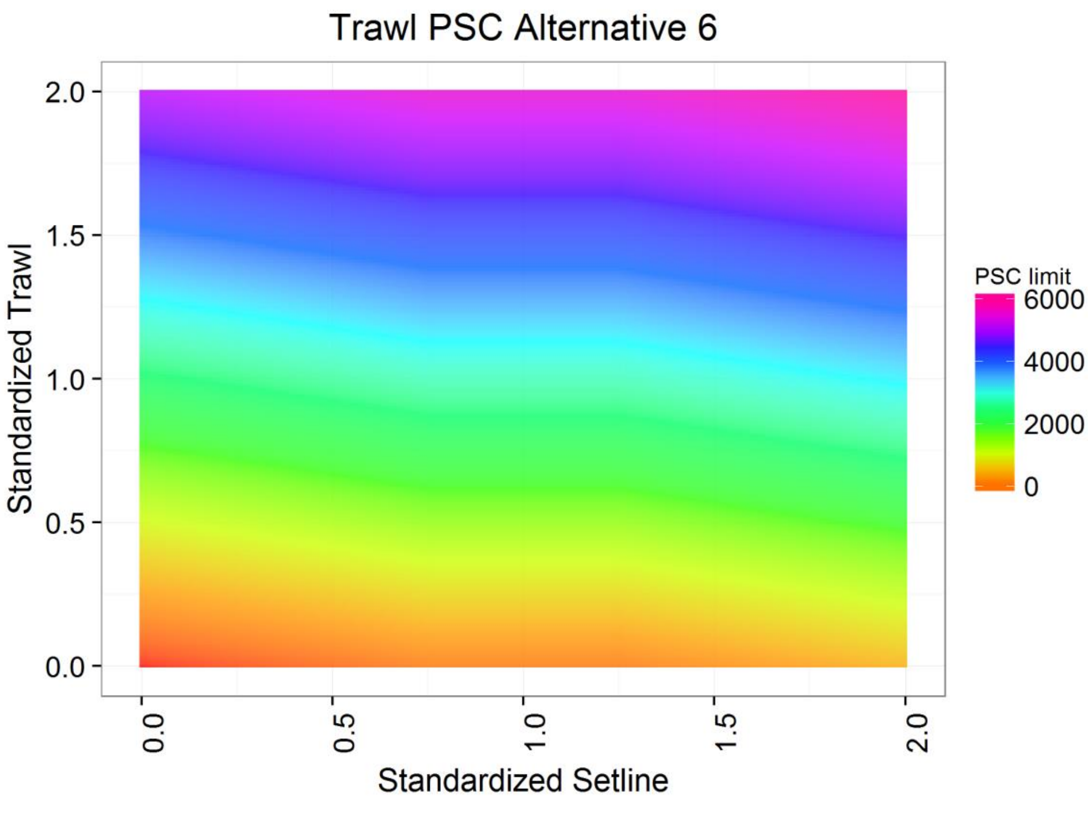

Figure 2-5 Trawl PSC limits for the Alternative 6 multidimensional control rule. In this example, the setline index affects the trawl PSC when the index is 25% higher than average or 25% lower than average.

Figure 2-5 shows an example of calculated PSC limits under Alternative 4. Here the secondary index influences the PSC limit when it is either 25 percent above its' average value or 25 percent below its average value. The selected options for each element shown are listed in Section 2.6. Figure 2-6shows a cross-section of the control rule when the trawl survey index is at a value of 1. This demonstrated the influence of the setline survey at thresholds above and below 25 percent of its average value. Note that this is in contrast to the more abrupt change seen in Alternative 4 at these values (Figure 2-3). Figure 2-7 shows the same Elements and Options for Alternative 6 as in Figure 2-5 but instead of the default slope = 1, this is reduced to 0.5 to demonstrate how Element 1 might behave when the interannual variability is dampened. Note that the scale of this is lower as there is less variability in the PSC limit under this example.

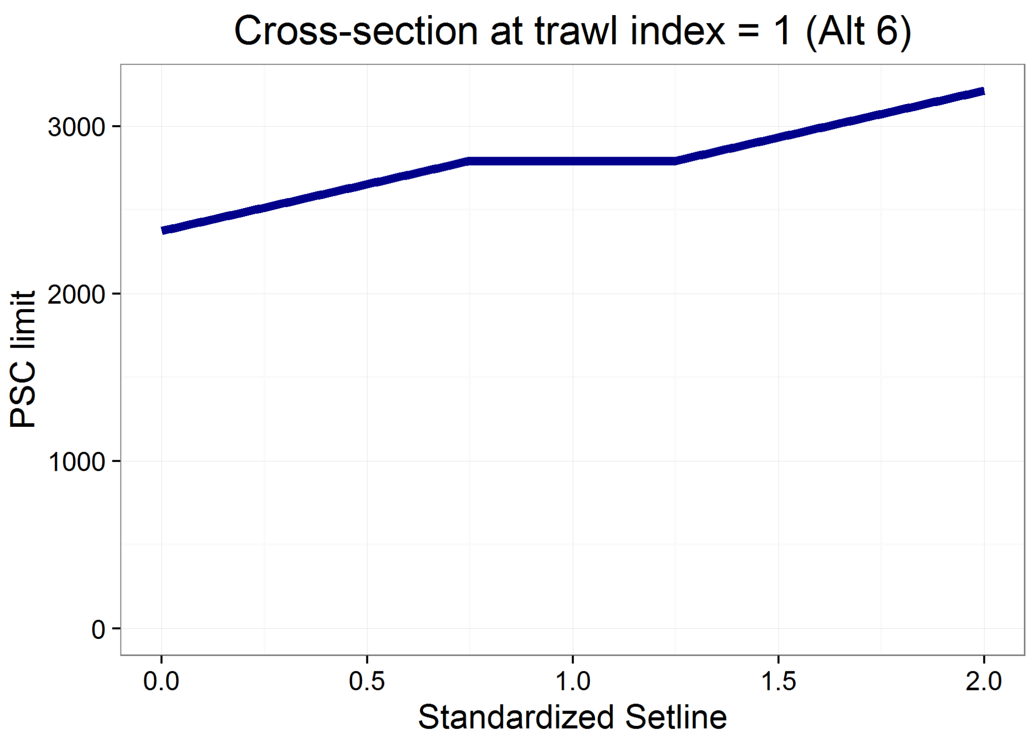

Figure 2-6 Trawl PSC limits for the Alternative 6 multidimensional control rule when the trawl index is set at 1. In this example, the setline index affects the trawl PSC when the index is 25% higher than average or 25% lower than average.

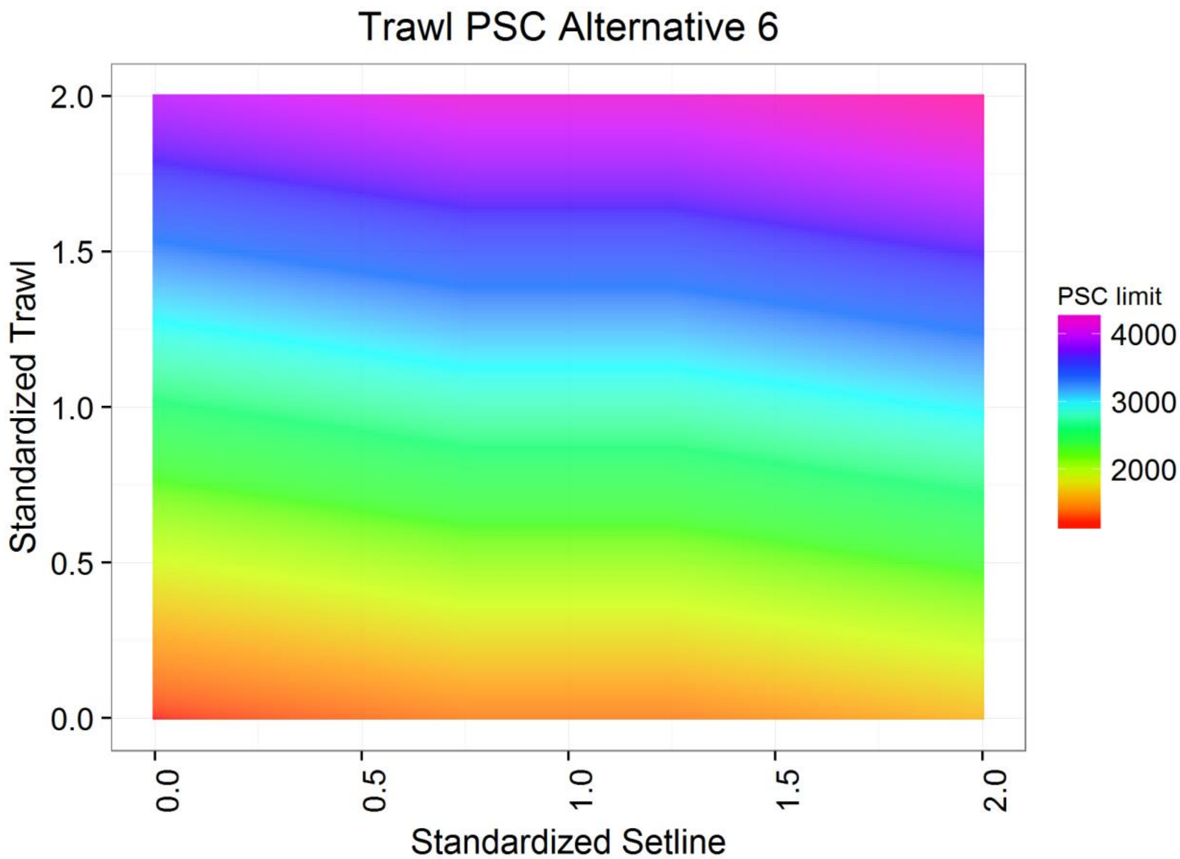

Figure 2-7 Alternative 6 with a proportionality constant (*a*) = 0.5. Note the different scale than Figure 3. This is one way to attempt to address Element 1 and reduce interannual variation and should behave similarly to a moving average.

2.6 Comparison of Alternatives

One objective of Council review at this meeting is to revise the alternatives for analysis. As such and per Council request, some preliminary analysis of alternatives has been done. This has been done to demonstrate the behavior of certain elements and options and to indicate where clarification from the Council may be needed with respect to some of the alternatives. **Alternative 3 was eliminated from the preliminary analysis and is recommended for removal from the suite of alternatives as it is redundant with, and its intent already covered by, Alternative 4.**

In this section, we use the historical values of the EBS trawl index and the all sizes 4ABCDE setline survey index in years 1998-2017 to calculate the Alternative 2, 4, and 6 PSC limits in each of these years. The preliminary analysis uses a default set of elements and options to compare across four alternatives (Alternative 2,4 and 6 as compared to Alternative 1). For each Alternative (2,4,6) a starting point (Element 1) of 3,515 (Option 4), maximum amount of the PSC limit allowed (ceiling; Element 3) of 4,426 t (Option 2) and minimum amount t of the PSC limit possible (floor; Element 4) of 2,354 t (Option 2) was used. This is done to show how these alternatives behave differently due to their underlying structure to alert the Council and the public as to the fundamental differences between these alternatives with respect to the relative PSC limits that are calculated based upon similar values of the two indices. They are compared against Alternative 1 (fixed PSC limits) to show the change in alternative historical PSC limits relative to changes in the historical value of the indices of the range of alternatives.

Results are shown for a default set of Elements and Options first, and then show the effects of alternative Options under Elements 5 and 6. Elements 5 and 6 are unique to Alternatives 4 and 6. To compare and contrast these, two bookended options were selected under each Element. Under Element 5 which describes the threshold value for the secondary index (exceeding a threshold would imply a resulting modification to the PSC limit), a 'high' and a 'low' option were selected to meet the intent of the Element "High and Low values for the Secondary Index". The high option was selected as the 2nd highest value of the time series (1998-2016) while the 'low' option was the 2nd lowest value of the time series (1998-2016). Again, these values form the thresholds at which the secondary index would modify the PSC limit upward or downward from the PSC limit calculated with the primary index.

Comparative results using tables and figures demonstrate the relative percentage change in each index from the previous year and the corresponding percent change in the PSC limits from the previous year under each alternative. The difference in the PSC limit generated under each alternative is illustrated by comparing the percent change in PSC from the previous year for a given percent change in the relevant index or indices. This exercise is played out using historical data from 1998 through 2017 in Tables 2-3 through 2-13. Selection of different Elements and Options beneath each alternative may modify the observed variability between alternatives.

The default set of Options for Elements 2-6 used in this exercise are as follows:

Element	**Option**	**Value**
Element 2 **(Alts 2-6)** Starting Point	Option 4	3,515 t (2016 PSC Limit)
Element 3 **(Alts 2-6)** Maximum PSC Limit (ceiling)	Option 2	4,426 t (2015 PSC Limit)
Element 4 **(Alts 2-6)** Minimum PSC Limit (floor)	Option 2	2,354 t (2016 PSC usage)
Element 5 (Alts 4,6 only) Values for 2nd Index	Option 1	High = 2nd highest value of time series (1998-2016) Low = 2nd lowest value of time series (1998-2016)
Element 6 **(Alts 4,6 only)** Multiplier for 2nd Index	Option 1 Option 2	High = 1.5 Low = 0.5

The meaning of the multiplier values for Alternative 6 are different than for Alternative 4. A standardization was done to translate Alternative 4 multipliers into equivalent or similar multipliers for Alternative 6 and the methods are fully described in Appendix II. The Alternative 6 multiplier values were chosen such that the PSC limits resulting from the two alternatives will be the same when the following three conditions are met: (1) the secondary index is 50% above or below its average value, (2) the low and high breakpoints (Element 5) used are 25% below and above the average value for the secondary index, respectively, and (3) the primary index is equal to 1 (its 2016 value). As these three conditions may never be met all at once in reality or in the exercises presented below, the Alternative 4 and 6 multipliers will never be fully comparable, but using this standardization yields Alternative 4 and 6 scenarios that are within a similar range. Lastly, Alternative 4 and 6 multipliers were chosen such that the proportional effect of a multiplier on the PSC limit is equal for "high" and "low" secondary index values (see Appendix II for more details).

The time series used to calculate the high and low values for the secondary index was limited to 1998-2016. Though some tables and figures show results for 2017, 2017 was not considered to be one of the base years used in the Element 5 calculations.

Element 1, which can act to dampen interannual variability in PSC limits, was omitted from this exercise but could be added to any alternative after its calculation. This dampening effect, however, can be applied to any alternative after the PSC limit is calculated to reduce inter-annual variability in PSC limits. We instead use a set of tables, such as Table 2-3 and Table 2-5 to show the percent change from the previous year in the index values and corresponding PSC limits for each alternative to enable the reader to see how often changes larger than 5%, 15% and 25% would occur, which would give an indication of how often each alternative would have been altered by Element 1. **The workgroup recommends that Element 1 be moved from within individual alternatives to an option that could be applied to any of the alternatives after the PSC limit is calculated.**

Secondary index influences PSC limit when above or below threshold

Primary index matches gear type for PSC limit

Alternative 2 is only influenced by the primary index while Alts 4 and 6 are influenced by both

Year	Primary (trawl) index % change	Secondary (longline) index status	Alternative 2 % change in PSC limit	Alternative 4 % change in PSC limit	Alternative 6 % change in PSC limit	Historical % change in bycatch mortality	Historical % change in PSC limit
1998	NA	high	NA	NA	NA	NA	NA
1999	-20%		-20%	-33%	-33%	3%	0%
2000	-8%		-8%	-8%	-8%	-8%	0%
2001	19%		19%	19%	19%	1%	0%
2002	-28%		-27%	-27%	-27%	6%	0%
2003	30%		28%	28%	28%	4%	0%
2004	-2%		-2%	-2%	-2%	-4%	0%
2005	2%		2%	2%	2%	4%	0%
2006	18%		18%	18%	18%	-3%	0%
2007	-8%		-8%	-8%	-8%	2%	0%
2008	-3%		-3%	-3%	-3%	-19%	0%
2009	20%		20%	20%	20%	1%	-1%
2010	16%		15%	15%	15%	-2%	0%
2011	-5%		-4%	-4%	-4%	-8%	-1%
2012	1%		1%	1%	1%	19%	-1%
2013	-3%		-3%	-3%	-3%	-1%	0%
2014	-7%		-7%	-7%	-7%	-2%	0%
2015	0%		0%	0%	0%	-34%	0%
2016	-11%	low	-11%	-40%	-12%	7%	-22%
2017	-18%	low	-18%	0%	-22%	-38%	0%

Dark gray = hit ceiling therefore cannot go higher

light gray = hit floor therefore cannot go lower

Figure 2-8 How to interpret the following comparison of alternatives tables. Note that each is formulated with similar columns by year. NA is shown when there is no preceding year from which to estimate the percentage change difference.

2.6.1 Trawl Sector PSC Limit Results Using Default Options for each Element

Table 2-3 shows that the secondary index was above the high Element 5 breakpoint value (in a high state) in 1998, which triggered a multiplier that acted to inflate the PSC limit when using Alternatives 4 or 6. In the year 1999, the value of the primary (trawl) index dropped by 20% and again by 8% the following year and the PSC limits for all of the alternatives were calculated to be very low, hitting the trawl-sector floor of 1,879 t. The secondary index was below the low Element 5 breakpoint value (in a low state) in 2016, and 2017. In 2016, the EBS trawl survey index declined by 11% and in addition the setline survey index was in a low state. Alternative 2 is not affected by the value of the setline survey, and the PSC limit dropped by the same proportion as for the EBS trawl survey. The percent change from the previous year in the Alternative 2 PSC limit will always be equal to the percent change from the previous year in the EBS trawl survey as long as the proportionality constant remains equal to 1 (as requested in the April Motion), unless it is calculated to be below a floor or above a ceiling.

In 2016, the Alternative 4 PSC limit dropped by 40% and was equal to the floor (1,879 t). This occurred because a multiplier of 0.5 was applied on the basis that the secondary index was below its lower breakpoint. Here, it is obvious that the multiplier chosen as the default option (0.5 when the secondary index is below its low breakpoint and 1.5 when the secondary index is above its high breakpoint) can lead to large changes in the PSC limit from one year to the next. In 2017, the Alternative 4 PSC limit was still equal to the floor and therefore, even though the primary index dropped by 18% and the secondary index was again in a low state, there was a 0% change in the Alternative 4 PSC limit.

Alternative 6 applies an adjustment to the PSC limit when the secondary index is in a low or a high state, but the impact of the adjustment depends on how low (or high) the secondary index is in comparison to the breakpoint. Therefore, if the secondary index is just under the low breakpoint value, the Alternative 6 PSC limit will be slightly lower than the Alternative 2 PSC limit where no multiplier is applied, but not as low as the Alternative 4 PSC limit. This can be seen in the 2016 PSC limit for the trawl sector where the secondary index (the setline survey index) dropped below the low breakpoint but was only a 4% drop. The EBS shelf survey index dropped by 11%, as did the Alternative 2 PSC limit, and the Alternative 6 PSC limit dropped by 14%, because the secondary index was slightly lower than the breakpoint (Table 2-3), and the Alternative 6 PSC limit remained above the floor. In 2017, when there was another 18% drop in the primary index and the secondary index was again in a low state, the Alternative 6 PSC limit dropped substantially more than the EBS shelf survey index, by 16%, but was still above the floor. These effects are illustrated in Figure 2-9 (upper left plot): when the secondary index is in a "normal" state and the PSC limits are above the floor and below the ceiling, the percent change in the primary index is equal to the percent change in the resulting PSC limit for all alternatives. Otherwise, percent changes can be smaller or larger. This figure simply provides an illustration of the range of percentage changes in PSC limits that occur for each alternative, as compared to Element 1 Options. It may be easier to consult Table 2-3 and Table 2-4 to investigate reasons for the percentage changes in individual years.

Table 2-3 Percent changes from the previous year in the trawl index, the PSC limits for trawl gear corresponding to Alternatives 2, 4, and 6, and in historical trawl bycatch mortality and PSC limits.

Light grey shading denotes an instance where the PSC limit was equal to the floor (1,879 t). Dark grey shading denotes an instance where the PSC limit reached the ceiling (3,532 t). The secondary index status is “high” when the index was above the upper breakpoint and a multiplier was applied to increase the PSC limit for Alternatives 4 and 6. Likewise, the secondary index is “low” when it is below the lower breakpoint such that a multiplier is applied to lower the PSC limit for Alternatives 4 and 6.

Year	Primary (trawl) index % change	Secondary (longline) index status	Alternative 2 % change in PSC limit	Alternative 4 % change in PSC limit	Alternative 6 % change in PSC limit	Historical% change in bycatch mortality	Historical% change in PSC limit
1998	NA	high	NA	NA	NA	NA	NA
1999	-20%		-20%	-33%	-33%	3%	0%
2000	-8%		-8%	-8%	-8%	-8%	0%
2001	19%		19%	19%	19%	1%	0%
2002	-28%		-27%	-27%	-27%	6%	0%
2003	30%		28%	28%	28%	4%	0%
2004	-2%		-2%	-2%	-2%	-4%	0%
2005	2%		2%	2%	2%	4%	0%
2006	18%		18%	18%	18%	-3%	0%
2007	-8%		-8%	-8%	-8%	2%	0%
2008	-3%		-3%	-3%	-3%	-19%	0%
2009	20%		20%	20%	20%	1%	-1%
2010	16%		15%	15%	15%	-2%	0%
2011	-5%		-4%	-4%	-4%	-8%	-1%
2012	1%		1%	1%	1%	19%	-1%
2013	-3%		-3%	-3%	-3%	-1%	0%
2014	-7%		-7%	-7%	-7%	-2%	0%
2015	0%		0%	0%	0%	-34%	0%
2016	-11%	low	-11%	-40%	-14%	7%	-22%
2017	-18%	low	-18%	0%	-30%	-38%	0%

Table 2-4 The trawl index, the PSC limits for trawl gear corresponding to Alternatives 2, 4, and 6, and historical trawl bycatch mortality and PSC limits.

Light grey shading denotes an instance where the PSC limit was equal to the floor (1,879 t). Dark grey shading denotes an instance where the PSC limit reached the ceiling (3,532 t).

Year	Primary (trawl) index	Secondary (longline) index	Alternative 2 PSC limit	Alternative 4 PSC limit	Alternative 6 PSC limit	Historical bycatch mortality	Historical PSC limit
1998	161,256	18,179	2,943	3,532	3,532	3,379	3,734
1999	129,116	15,850	2,356	2,356	2,356	3,481	3,734
2000	118,677	15,867	2,166	2,166	2,166	3,208	3,734
2001	141,219	13,441	2,577	2,577	2,577	3,245	3,734
2002	101,706	11,815	1,879	1,879	1,879	3,423	3,734
2003	132,151	10,609	2,412	2,412	2,412	3,545	3,734
2004	130,075	9,773	2,374	2,374	2,374	3,402	3,734
2005	132,518	9,344	2,418	2,418	2,418	3,552	3,734
2006	155,964	9,643	2,846	2,846	2,846	3,457	3,734
2007	143,903	9,525	2,626	2,626	2,626	3,526	3,734
2008	140,247	10,109	2,559	2,559	2,559	2,843	3,734
2009	168,102	9,700	3,068	3,068	3,068	2,885	3,693
2010	195,535	9,009	3,532	3,532	3,532	2,823	3,684
2011	186,666	8,561	3,407	3,407	3,407	2,611	3,634
2012	189,000	8,267	3,449	3,449	3,449	3,117	3,593
2013	183,989	7,868	3,358	3,358	3,358	3,080	3,593
2014	171,427	7,872	3,128	3,128	3,128	3,029	3,593
2015	172,237	8,021	3,143	3,143	3,143	1,999	3,593
2016	153,704	7,665	2,805	1,879	2,697	2,132	2,805
2017	126,684	6,976	2,312	1,879	1,879	1,324	2,805

2.6.2 Longline Sector PSC Limit Results Using Default Options for each Element

In the initial years of the time series (1998 to 2004), the setline survey index was at particularly high values. As a result, even though it consistently declined over each of those years, the PSC limits for each alternative were equal to the ceiling for the longline sector (894 t; Table 2-5 and Table 2-6), even when the secondary index was in a low state in 2002. There was one exception: The Alternative 4 PSC limit in 2002 was 39% lower than in 2001 and was not equal to the ceiling. In 2002, there was a 10% drop in the setline survey index and the EBS trawl survey (secondary) index was in a low state. The effect of the large multiplier (0.5) applied to Alternative 4 led to a 39% drop in the Alternative 4 PSC limit. In Alternative 6, the effect of the multiplier depends on how far the secondary survey index is below the lower breakpoint. In 2002, even though there was a 28% drop in the EBS trawl survey (secondary) index, it was just below the low breakpoint, and therefore the Alternative 6 PSC limit did not fall below the ceiling. In 2010, the EBS trawl survey (secondary) index was in a high state. Therefore, a multiplier inflated the PSC limit under Alternatives 4 and 6. The PSC limit reached the ceiling under both Alternatives.

Figure 2-10 (top left plot), as for Figure 2-10 (for the trawl sector), is an illustration of the percentage changes from the previous year in the setline survey index value and the resulting PSC limit for each alternative. It shows, generally, how the percent change from the previous year in the PSC limit is the same as the percent change from the previous year in the index value when the secondary index is in a normal state and PSC limits are within floors and ceilings. It also shows the general magnitude of percent changes from the previous year that resulted from applying each alternative to the historical index values under a variety of scenarios and can be used as a tool to think about desired values for percent changes in Element 1. For understanding percent changes in PSC limits in particular years, it may be easier to look at Table 2-6 and Table 2-6.

Table 2-5 Percent changes from the previous year in the longline index, the PSC limits for longline gear corresponding to Alternatives 2, 4, and 6, and in historical longline bycatch mortality and PSC limits.

Light grey shading denotes an instance where the PSC limit was equal to the floor (475 t). Dark grey shading denotes an instance where the PSC limit reached the ceiling (894 t). The secondary index status is "high" when the index was above the upper breakpoint and a multiplier was applied to increase the PSC limit for Alternatives 4 and 6. Likewise, the secondary index is "low" when it is below the lower breakpoint such that a multiplier is applied to lower the PSC limit for Alternatives 4 and 6.

Year	Primary (longline) index % change	Secondary (trawl) index status	Alternative 2 % change in PSC limit	Alternative 4 % change in PSC limit	Alternative 6 % change in PSC limit	Historical% change in bycatch mortality	Historical% change in PSC limit
1998	NA		NA	NA	NA	NA	NA
1999	-13%		0%	0%	0%	-25%	0%
2000	0%		0%	0%	0%	43%	0%
2001	-15%		0%	0%	0%	0%	0%
2002	-12%	low	0%	-39%	0%	-23%	0%
2003	-10%		0%	63%	0%	3%	0%
2004	-8%		0%	0%	0%	-20%	0%
2005	-4%		-3%	-3%	-3%	21%	0%
2006	3%		3%	3%	3%	-24%	0%
2007	-1%		-1%	-1%	-1%	8%	0%
2008	6%		1%	1%	1%	27%	0%
2009	-4%		0%	0%	0%	0%	-1%
2010	-7%	high	-7%	0%	0%	-11%	1%
2011	-5%		-5%	-11%	-11%	-6%	0%
2012	-3%		-3%	-3%	-3%	11%	-1%
2013	-5%		-5%	-5%	-5%	-15%	0%
2014	0%		0%	0%	0%	-16%	0%
2015	2%		2%	2%	2%	-28%	0%
2016	-4%		-4%	-4%	-4%	-30%	-15%
2017	-9%		-9%	-9%	-9%	-37%	0%

Table 2-6 The longline index, the PSC limits for longline gear corresponding to Alternatives 2, 4, and 6, and historical longline bycatch mortality and PSC limits. Light grey shading denotes an instance where the PSC limit was equal to the floor (475 t). Dark grey shading denotes an instance where the PSC limit reached the ceiling (894 t).

Year	Primary (longline) index	Secondary (trawl) index	Alternative 2 PSC limit	Alternative 4 PSC limit	Alternative 6 PSC limit	Historical bycatch mortality	Historical PSC limit
1998	18,179	161,256	894	894	894	777	842
1999	15,850	129,116	894	894	894	582	842
2000	15,867	118,677	894	894	894	834	842
2001	13,441	141,219	894	894	894	834	842
2002	11,815	101,706	894	547	894	640	842
2003	10,609	132,151	894	894	894	657	842
2004	9,773	130,075	894	894	894	524	842
2005	9,344	132,518	866	866	866	635	842
2006	9,643	155,964	893	893	893	484	842
2007	9,525	143,903	882	882	882	525	842
2008	10,109	140,247	894	894	894	668	842
2009	9,700	168,102	894	894	894	667	833
2010	9,009	195,535	835	894	894	595	842
2011	8,561	186,666	793	793	793	561	842
2012	8,267	189,000	766	766	766	623	833
2013	7,868	183,989	729	729	729	527	833
2014	7,872	171,427	729	729	729	442	833
2015	8,021	172,237	743	743	743	318	833
2016	7,665	153,704	710	710	710	222	710
2017	6,976	126,684	646	646	646	140	710

2.6.3 Using a three-year moving average for index values

Table 2-7 through Table 2-10 and Figure 2-9 through Figure 2-10 (bottom left panel) show the results of applying Alternatives 2, 4, and 6 to the historical trawl index for all of the default Options for each Element, but use a three-year moving average (instead of each year's individual index value) when calculating PSC limits. While Figure 2-9, top left panel (showing percent changes from year to year in the index and PSC limits for each alternative without using a moving average of index data for the trawl sector) shows a spread beyond +-25% for multiple years and alternatives without using the three-year moving average, the bottom left panel (showing the moving average approach) shows that for all but two instances of Alternative 4, and one instance of Alternative 6, the year-to-year changes in PSC limits are within +-15%. A similar effect is evident for the longline sector (Figure 2-10), where, without using the moving average, the change in the PSC limit from the previous year under Alternative 4 in 2002 is between -25 and 50%, but using the moving average, the change in the PSC limit in 2002 is approximately 5% or less.

Table 2-7 As for Table 2-3 (Percent changes from the previous year in the trawl index, the PSC limits for trawl gear corresponding to Alternatives 2, 4, and 6, and in historical trawl bycatch mortality and PSC limits), but using a three-year moving average of index values to calculate PSC limits for each alternative.

Year	Primary (trawl) index % change	Secondary (longline) index status	Alternative 2 % change in PSC limit	Alternative 4 % change in PSC limit	Alternative 6 % change in PSC limit	Historical% change in bycatch mortality	Historical% change in PSC limit
1998	NA	high	NA	NA	NA	NA	NA
1999	-20%		NA	NA	NA	3%	0%
2000	-8%		NA	NA	NA	-8%	0%
2001	19%		-5%	-33%	-18%	1%	0%
2002	-28%		-7%	-7%	-7%	6%	0%
2003	30%		4%	4%	4%	4%	0%
2004	-2%		-3%	-3%	-3%	-4%	0%
2005	2%		8%	8%	8%	4%	0%
2006	18%		6%	6%	6%	-3%	0%
2007	-8%		3%	3%	3%	2%	0%
2008	-3%		2%	2%	2%	-19%	0%
2009	20%		3%	3%	3%	1%	-1%
2010	16%		11%	11%	11%	-2%	0%
2011	-5%		9%	9%	9%	-8%	-1%
2012	1%		4%	4%	4%	19%	-1%
2013	-3%		-2%	-2%	-2%	-1%	0%
2014	-7%		-3%	-3%	-3%	-2%	0%
2015	0%		-3%	-3%	-3%	-34%	0%
2016	-11%	low	-6%	-41%	-6%	7%	-22%
2017	-18%	low	-9%	0%	-14%	-38%	0%

Table 2-8 As for Table 2-4 (the trawl index, the PSC limits for trawl gear corresponding to Alternatives 2, 4, and 6, and historical trawl bycatch mortality and PSC limits), but using a three-year moving average of index values to calculate PSC limits for each alternative.

Year	Primary (trawl) index	Secondary (longline) index	Alternative 2 PSC limit	Alternative 4 PSC limit	Alternative 6 PSC limit	Historical bycatch mortality	Historical PSC limit
1998	161,256	18,179	NA	NA	NA	3,379	3,734
1999	129,116	15,850	NA	NA	NA	3,481	3,734
2000	118,677	15,867	2,488	3,532	2,894	3,208	3,734
2001	141,219	13,441	2,366	2,366	2,366	3,245	3,734
2002	101,706	11,815	2,200	2,200	2,200	3,423	3,734
2003	132,151	10,609	2,282	2,282	2,282	3,545	3,734
2004	130,075	9,773	2,214	2,214	2,214	3,402	3,734
2005	132,518	9,344	2,401	2,401	2,401	3,552	3,734
2006	155,964	9,643	2,546	2,546	2,546	3,457	3,734
2007	143,903	9,525	2,630	2,630	2,630	3,526	3,734
2008	140,247	10,109	2,677	2,677	2,677	2,843	3,734
2009	168,102	9,700	2,751	2,751	2,751	2,885	3,693
2010	195,535	9,009	3,065	3,065	3,065	2,823	3,684
2011	186,666	8,561	3,348	3,348	3,348	2,611	3,634
2012	189,000	8,267	3,475	3,475	3,475	3,117	3,593
2013	183,989	7,868	3,404	3,404	3,404	3,080	3,593
2014	171,427	7,872	3,312	3,312	3,312	3,029	3,593
2015	172,237	8,021	3,210	3,210	3,210	1,999	3,593
2016	153,704	7,665	3,026	1,879	3,017	2,132	2,805
2017	126,684	6,976	2,753	1,879	2,587	1,324	2,805

Table 2-9 As for Table 2-5 (percent changes from the previous year in the longline index, the PSC limits for longline gear corresponding to Alternatives 2, 4, and 6, and in historical longline bycatch mortality and PSC limits) but using a three-year moving average of index values to calculate PSC limits for each alternative.

Year	Primary (longline) index % change	Secondary (trawl) index status	Alternative 2 % change in PSC limit	Alternative 4 % change in PSC limit	Alternative 6 % change in PSC limit	Historical% change in bycatch mortality	Historical% change in PSC limit
1998	NA		NA	NA	NA	NA	NA
1999	-13%		NA	NA	NA	-25%	0%
2000	0%		NA	NA	NA	43%	0%
2001	-15%		0%	0%	0%	0%	0%
2002	-12%	low	0%	0%	0%	-23%	0%
2003	-10%		0%	0%	0%	3%	0%
2004	-8%		0%	0%	0%	-20%	0%
2005	-4%		0%	0%	0%	21%	0%
2006	3%		-1%	-1%	-1%	-24%	0%
2007	-1%		-1%	-1%	-1%	8%	0%
2008	6%		2%	2%	2%	27%	0%
2009	-4%		0%	0%	0%	0%	-1%
2010	-7%	high	0%	0%	0%	-11%	1%
2011	-5%		-5%	-5%	-5%	-6%	0%
2012	-3%		-5%	6%	-4%	11%	-1%
2013	-5%		-4%	-15%	-6%	-15%	0%
2014	0%		-3%	-3%	-3%	-16%	0%
2015	2%		-1%	-1%	-1%	-28%	0%
2016	-4%		-1%	-1%	-1%	-30%	-15%
2017	-9%		-4%	-4%	-4%	-37%	0%

Table 2-10 As for Table 2-6 (the longline index, the PSC limits for longline gear corresponding to Alternatives 2, 4, and 6, and historical longline bycatch mortality and PSC limits), but using a three-year moving average of index values to calculate PSC limits for each alternative.

Year	Primary (longline) index	Secondary (trawl) index	Alternative 2 PSC limit	Alternative 4 PSC limit	Alternative 6 PSC limit	Historical bycatch mortality	Historical PSC limit
1998	18,179	161,256	NA	NA	NA	777	842
1999	15,850	129,116	NA	NA	NA	582	842
2000	15,867	118,677	894	894	894	834	842
2001	13,441	141,219	894	894	894	834	842
2002	11,815	101,706	894	894	894	640	842
2003	10,609	132,151	894	894	894	657	842
2004	9,773	130,075	894	894	894	524	842
2005	9,344	132,518	894	894	894	635	842
2006	9,643	155,964	888	888	888	484	842
2007	9,525	143,903	880	880	880	525	842
2008	10,109	140,247	894	894	894	668	842
2009	9,700	168,102	894	894	894	667	833
2010	9,009	195,535	890	890	890	595	842
2011	8,561	186,666	842	842	842	561	842
2012	8,267	189,000	798	894	811	623	833
2013	7,868	183,989	763	763	763	527	833
2014	7,872	171,427	741	741	741	442	833
2015	8,021	172,237	734	734	734	318	833
2016	7,665	153,704	727	727	727	222	710
2017	6,976	126,684	700	700	700	140	710

2.6.1 Comparing Alternative Options for Elements 5 and 6

This section compares results for the default options shown above with alternative options for Elements 5 and 6. We show PSC limits resulting from index values for historical years only for Alternatives 4 and 6 here, as Alternative 2 is not influenced by Elements 5 and 6. The alternative options shown are:

Element 5, low and high breakpoints that are 25% above and below the average value of the secondary index.

Element 6, low multiplier = 0.9 and high multiplier = 1.1 for Alternative 4 (a smaller range than the default options of 0.5, 1.5). Alternative 6 multipliers were calculated based on these Alternative 4 multipliers, as detailed in Appendix II.

Figure 2-9 and Figure 2-10 are a succinct way to illustrate the changes in PSC limits from the previous year across all of the scenarios in this exercise and to compare Alternatives 2, 4, and 6. For the trawl sector (top right panel on both figures), we can see that using 0.9 and 1.1 as multipliers led to little or no difference in PSC limits among the alternatives, while changing the breakpoints defining when the secondary index was in a high or low status (bottom right panel on both figures) led to some large decreases in PSC limits from the previous year for the trawl sector. Figure 2-10 shows that changes from the previous year in longline sector PSC limits were generally limited to a range of -15% to 5%, with the exception of a couple of extreme decreases in PSC limits from the previous year when using Alternative 4 with the default Options for each Element (top left), or with alternative breakpoints defining when the secondary index was in a low or high state were 25% above and below the average value of the secondary index. It is worth noting that changes from the previous year in PSC limits for the longline sector were greatly affected by the number of years in which the PSC limit hit the ceiling, which were the early years of the index. The values observed in these years may or may not be an indication of what will be observed in the future, and larger changes in PSC limits from the previous year (as was seen in the trawl sector results of this exercise) are possible in the future under each of these alternatives.

Table 2-11-Table 2-14 show detailed results in percent changes from the previous year in index values and PSC limits for Alternatives 4 and 6, indicators for whether the secondary index used in the exercise was in a low or high state, and index and PSC values, as for the previous tables, and are useful for understanding what led to the results of these exercises. Below, we describe the results in these tables in detail.

Multipliers 0.9 and 1.1

Multipliers 0.9 and 1.1 changed the PSC limit by only 10% when the secondary index was in a high or low state, while the default multiplier values change the PSC limit by 50% (before accounting for floors and ceilings). This effect can be seen in Table 2-11-Table 2-12, where in 1998 the secondary index was in a high state, but in 1999 was in a normal state. Here, the multiplier of 1.1 increased the PSC limit in 1998, but not enough to hit the ceiling (as happened for the default scenario) for both Alternatives 4 and 6. Similarly, the secondary index was in a low state in 2016-2017 and the results and using a multiplier of 0.9 led to a decrease in the PSC limit PSC limits decrease in these years, but limits remained above the floor, while use of a multiplier of 1.5 led to PSC limits that hit the floor for both Alternatives 4 and 6.

In Table 2-13 and Table 2-14, the longline PSC limit was at the ceiling in 2001, prior to 2002 when the secondary index was in a low state. The less extreme 10% multiplier didn't have an effect on the PSC limit because the 10% change in the PSC limit calculated by the control rules led to a PSC limit that was still above the ceiling. In 2010, the primary index dropped by 7%, which would lead to a 7% drop in PSC limits before accounting for the secondary index. This primary index value led to a PSC limit that was below the ceiling, but in the default case with a 50% multiplier applied, the PSC limit reached the ceiling for another year. Using a multiplier of 1.1, the PSC limit remained a little below the ceiling at 847 t.

Breakpoints 25% above and below average (the 25% scenario)

For the trawl sector results, the scenario in which breakpoints were calculated as 25% above or below the average value for the secondary index (we will call this the 25% scenario for brevity), led to several high state years at the beginning of the time series (1998-2001) and two additional low state years (2013-2014) that were not low state years in the default scenario. These differences led to a greater amount of change in PSC limits from the previous year because a multiplier was being applied more often and intermittently than for the default scenario (Table 2-11 and Table 2-12). In contrast, for the longline sector, the two ways to choose breakpoints led to the same high state and low state years. Therefore, the results for these two scenarios (the default scenario and the 25% scenario) are almost identical. In 2010, the Alternative 6 PSC limit for the 25% scenario was slightly lower than that for the default scenario; this happens because the secondary index value is closer to the 25% scenario breakpoint than it is to the default breakpoint (which is defined as the 2nd highest value of the secondary index). This makes sense when we recall that the effect of a multiplier for Alternative 6 is influenced by the difference between the secondary index value and the breakpoint.

Table 2-11 Percent changes from the previous year in the trawl index, the PSC limits for trawl gear corresponding to Alternatives 4, and 6, comparing PSC limits calculated with (1) the default set of Options for each Element, (2) an alternative Option under Element 5 to use breakpoints that are 25% above and below the average index value, and (3) an alternative Option under Element 6 to apply a low multiplier of 0.9 and a high multiplier of 1.1.

Light grey shading denotes an instance where the PSC limit was equal to the floor (1,879 t). Dark grey shading denotes an instance where the PSC limit reached the ceiling (3,532 t). The secondary index status is "high" when the index was above the upper breakpoint and a multiplier was applied to increase the PSC limit for Alternatives 4 and 6. Likewise, the secondary index is "low" when it is below the lower breakpoint such that a multiplier is applied to lower the PSC limit for Alternatives 4 and 6.

Year	Primary (trawl) Index	Default Secondary (longline) Index	Above or Below 25% of Average Secondary (longline) Index	Default Alternative 4 PSC	Multiplier 0.9 to 1.1 Alternative 4 PSC	Breakpoints 25% above and below average index Alternative 4	Default Alternative 6 PSC	Multiplier 0.9 to 1.1 Alternative 6 PSC	Breakpoints 25% above and below average index Alternative 6
1998	NA	high	high	NA	NA	NA	NA	NA	NA
1999	-20%		high	-33%	-27%	0%	-33%	-26%	0%
2000	-8%		high	-8%	-8%	-8%	-8%	-8%	0%
2001	19%		high	19%	19%	9%	19%	19%	-24%
2002	-28%			-27%	-27%	-47%	-27%	-27%	-30%
2003	30%			28%	28%	28%	28%	28%	28%
2004	-2%			-2%	-2%	-2%	-2%	-2%	-2%
2005	2%			2%	2%	2%	2%	2%	2%
2006	18%			18%	18%	18%	18%	18%	18%
2007	-8%			-8%	-8%	-8%	-8%	-8%	-8%
2008	-3%			-3%	-3%	-3%	-3%	-3%	-3%
2009	20%			20%	20%	20%	20%	20%	20%
2010	16%			15%	15%	15%	15%	15%	15%
2011	-5%			-4%	-4%	-4%	-4%	-4%	-4%
2012	1%			1%	1%	1%	1%	1%	1%
2013	-3%		low	-3%	-3%	-46%	-3%	-3%	-4%
2014	-7%		low	-7%	-7%	0%	-7%	-7%	-7%
2015	0%			0%	0%	67%	0%	0%	2%
2016	-11%	low	low	-40%	-20%	-40%	-14%	-11%	-15%
2017	-18%	low	low	0%	-18%	0%	-30%	-20%	-29%

Table 2-12 The trawl index, the PSC limits for trawl gear corresponding to Alternatives 2, 4, and 6, and PSC limits comparing PSC limits calculated with (1) the default set of Options for each Element, (2) an alternative Option under Element 5 to use breakpoints that are 25% above and below the average index value, and (3) an alternative Option under Element 6 to apply a low multiplier of 0.9 and a high multiplier of 1.1.

Light grey shading denotes an instance where the PSC limit was equal to the floor (1,879 t). Dark grey shading denotes an instance where the PSC limit reached the ceiling (3,532 t).

Year	Primary (trawl) Index	Secondary (longline) Index	Default Alternative 4 PSC	Multiplier 0.9 to 1.1 Alternative 4 PSC	Breakpoints 25% above and below average index Alternative 4	Default Alternative 6 PSC	Multiplier 0.9 to 1.1 Alternative 6 PSC	Breakpoints 25% above and below average index Alternative 6
1998	161,256	18,179	3,532	3,237	3,532	3,532	3,188	3,532
1999	129,116	15,850	2,356	2,356	3,532	2,356	2,356	3,532
2000	118,677	15,867	2,166	2,166	3,249	2,166	2,166	3,532
2001	141,219	13,441	2,577	2,577	3,532	2,577	2,577	2,688
2002	101,706	11,815	1,879	1,879	1,879	1,879	1,879	1,879
2003	132,151	10,609	2,412	2,412	2,412	2,412	2,412	2,412
2004	130,075	9,773	2,374	2,374	2,374	2,374	2,374	2,374
2005	132,518	9,344	2,418	2,418	2,418	2,418	2,418	2,418
2006	155,964	9,643	2,846	2,846	2,846	2,846	2,846	2,846
2007	143,903	9,525	2,626	2,626	2,626	2,626	2,626	2,626
2008	140,247	10,109	2,559	2,559	2,559	2,559	2,559	2,559
2009	168,102	9,700	3,068	3,068	3,068	3,068	3,068	3,068
2010	195,535	9,009	3,532	3,532	3,532	3,532	3,532	3,532
2011	186,666	8,561	3,407	3,407	3,407	3,407	3,407	3,407
2012	189,000	8,267	3,449	3,449	3,449	3,449	3,449	3,449
2013	183,989	7,868	3,358	3,358	1,879	3,358	3,358	3,320
2014	171,427	7,872	3,128	3,128	1,879	3,128	3,128	3,093
2015	172,237	8,021	3,143	3,143	3,143	3,143	3,143	3,143
2016	153,704	7,665	1,879	2,524	1,879	2,697	2,783	2,660
2017	126,684	6,976	1,879	2,081	1,879	1,879	2,217	1,879

Table 2-13 As for Table 2-11, but for the longline sector.

Year	Primary (longline) Index	Secondary (trawl) Index	Above or Below 25% of Average Secondary (trawl) Index	Default Alternative 4 PSC	Multiplier 0.9 to 1.1 Alternative 4 PSC	Breakpoints 25% above and below average index Alternative 4	Default Alternative 6 PSC	Multiplier 0.9 to 1.1 Alternative 6 PSC	Breakpoints 25% above and below average index Alternative 6
1998	NA			NA	NA	NA	NA	NA	NA
1999	-13%			0%	0%	0%	0%	0%	0%
2000	0%			0%	0%	0%	0%	0%	0%
2001	-15%			0%	0%	0%	0%	0%	0%
2002	-12%	low	low	-39%	0%	-39%	0%	0%	0%
2003	-10%			63%	0%	63%	0%	0%	0%
2004	-8%			0%	0%	0%	0%	0%	0%
2005	-4%			-3%	-3%	-3%	-3%	-3%	-3%
2006	3%			3%	3%	3%	3%	3%	3%
2007	-1%			-1%	-1%	-1%	-1%	-1%	-1%
2008	6%			1%	1%	1%	1%	1%	1%
2009	-4%			0%	0%	0%	0%	0%	0%
2010	-7%	high	high	0%	0%	0%	0%	-5%	-2%
2011	-5%			-11%	-11%	-11%	-11%	-6%	-9%
2012	-3%			-3%	-3%	-3%	-3%	-3%	-3%
2013	-5%			-5%	-5%	-5%	-5%	-5%	-5%
2014	0%			0%	0%	0%	0%	0%	0%
2015	2%			2%	2%	2%	2%	2%	2%
2016	-4%			-4%	-4%	-4%	-4%	-4%	-4%
2017	-9%			-9%	-9%	-9%	-9%	-9%	-9%

Table 2-14 As for Table 2-12, but for the longline sector.

Year	Primary (longline) Index	Secondary (trawl) Index	Default Alternative 4 PSC	Multiplier 0.9 to 1.1. Alternative 4 PSC	Breakpoints 25% above and below average index Alternative 4	Default Alternative 6 PSC	Multiplier 0.9 to 1.1. Alternative 6 PSC	Breakpoints 25% above and below average index Alternative 6
1998	18,179	161,256	894	894	894	894	894	894
1999	15,850	129,116	894	894	894	894	894	894
2000	15,867	118,677	894	894	894	894	894	894
2001	13,441	141,219	894	894	894	894	894	894
2002	11,815	101,706	547	894	547	894	894	894
2003	10,609	132,151	894	894	894	894	894	894
2004	9,773	130,075	894	894	894	894	894	894
2005	9,344	132,518	866	866	866	866	866	866
2006	9,643	155,964	893	893	893	893	893	893
2007	9,525	143,903	882	882	882	882	882	882
2008	10,109	140,247	894	894	894	894	894	894
2009	9,700	168,102	894	894	894	894	894	894
2010	9,009	195,535	894	894	894	894	847	874
2011	8,561	186,666	793	793	793	793	793	793
2012	8,267	189,000	766	766	766	766	766	766
2013	7,868	183,989	729	729	729	729	729	729
2014	7,872	171,427	729	729	729	729	729	729
2015	8,021	172,237	743	743	743	743	743	743
2016	7,665	153,704	710	710	710	710	710	710
2017	6,976	126,684	646	646	646	646	646	646

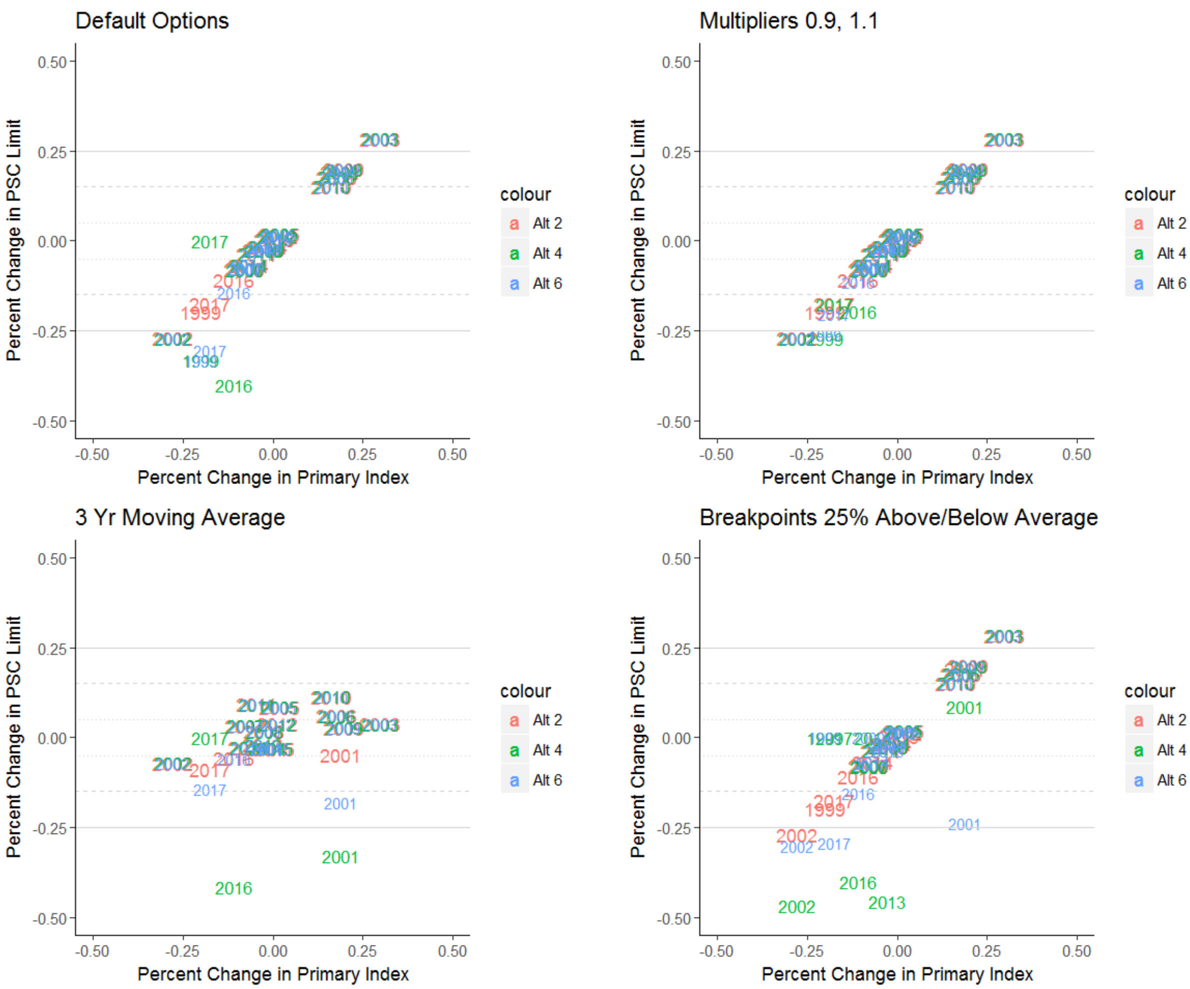

Figure 2-9 Percent change from the previous year in the trawl index and corresponding percent change in the PSC limit for trawl fleets using historical index data, and for four scenarios: the default Options for chosen for each Element, described at the beginning of the “Comparison of Alternatives” section (top left), use of smaller multipliers mL = 0.9 and mH = 1.1 for Alternative 4, and the corresponding smaller multipliers for Alternative 6 (top right), using a three-year moving average of the trawl index value in PSC limit calculations (bottom left), and specifying the Element 5 breakpoint values for the secondary index above and below which a multiplier is applied for Alternatives 4 and 6 to 25% above and below the average (over the period 1998-2016) secondary index value, respectively (bottom right).

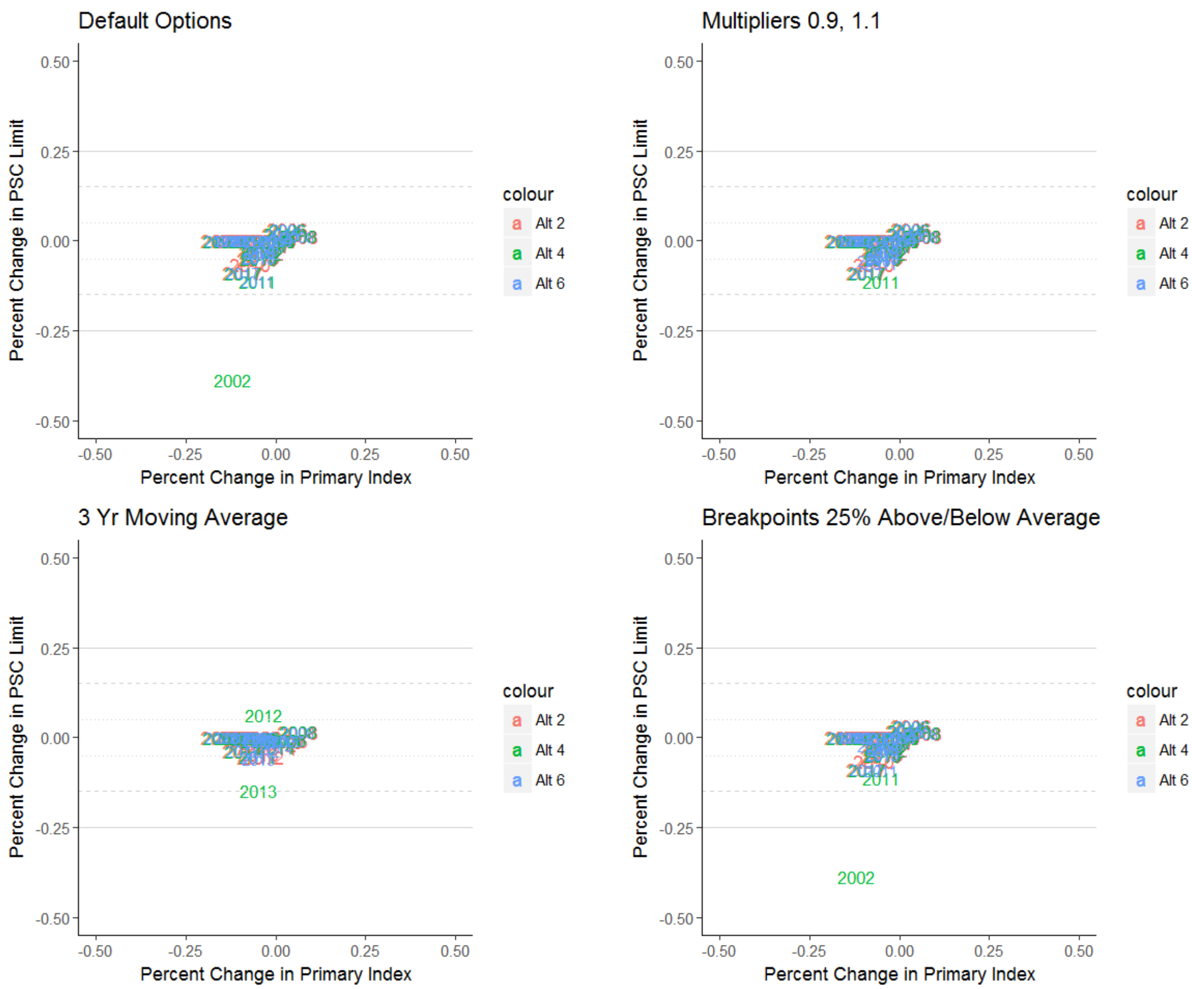

Figure 2-10 As for Figure 2-9, but for the longline sector PSC limit calculations.

2.7 Suggestions for refining Alternatives, Elements and Options

Based on preliminary analysis of the Alternatives from the April 2018 motion, the workgroup has the following suggestions for refining the alternative set for initial review analysis (Table 2-15)

Table 2-15 Workgroup suggestions for refinement to Alternatives and Clarifications requested

Alternative/Element/ Option	**Recommendation**	**Rationale**
Alternative 3	Remove	As discussed in Section 2.3, this is redundant with Alternative 4 and the formulation of Alternative 4 is the recommended approach
Alternative 6 (NEW)	Add	Rationale provided in Section 2.5 and Appendix II. Provides similar framework as Alt 4 but with less abrupt transitions.
Element 1 (Alternatives 2- 6)	Move to an option that applies to all alternatives	This element is not a required element for formulating the control rule and is applied after the PSC limit is calculated. It would be cleaner to have this outside of the specific elements and options for the Alternatives and have it as an option that can be applied to any alternative for inter-annual stability as desired
Alternative 5	Need dimensions of look up table. Need clarification on general intent of alternative	No details were provided on dimensionality of look up table. Consider removing Alternative 5 or clarify details noted in Section 2.4.5.
Alternative 5 Element 1	Clarify overlap with Elements 1 and 4.	Overlapping elements of 1 and 4 would provide for 15 different alternatives just between these two provisions (3 floors and 5 different mechanisms for moving to the floor outside of the actual look up table)
All alternatives/elements/ options	Need guidance of subset for analysis as currently unwieldy number of combinations of options. Workgroup will provide a strawman approach at the October Council meeting	Alternative 1, 2, 4, 5, and 6, along with the elements and options for each, results in a total of 2,881 different combinations. Just for the 4 elements of alternative 2, there are 144 combinations of options.
Alternatives 2,4,5,6	Need direction on relative proportion of trawl and non-trawl CDQ allocation	Previous PSC limits were set to CDQ allocation as a sector and not by gear type. Under all alternatives, except Alternative 1, the PSC limit is calculated by gear type (first) then allocated to sector. Usage by gear could inform this (Section 2.1)
Alternatives 4 and 6	Remove Option 2 Element 5 which modifies PSC limit above and below average value of index	Received criticism from SSC (April 2018) and Council discussions on potential for volatile changes to PSC limits from previous year due to an index always at a high or low value and never at average

3. Environmental Assessment [PLACEHOLDER FOR INITIAL REVIEW DRAFT]

3.1 Methods

3.2 Target species

3.3 Non-target species

3.4 Marine Mammals

3.5 Seabirds

3.6 Habitat

3.7 Ecosystem

3.8 NEPA Summary

4. Regulatory Impact Review: Description of Fisheries section

4.1 Description of Fisheries

The following material will be revised and expanded upon with fishery data to fulfill the NEPA requirement for a description of the directly regulated fisheries in the RIR chapter of the Draft EIS:

The Council has invested considerable time in an iterative process to develop alternatives for ABM indices, control rules, starting points, and other features that would directly affect the amount of halibut PSC available to the Federal BSAI groundfish sectors. To date, ABM discussion documents have not been paired with contextual information about how the fisheries operate, how fishing decisions are made, the steps that groundfish sectors have recently taken to minimize halibut mortality, and how annual or periodic changes in abundance-based PSC limits might interact with other constraints. Fishery stakeholders have commented that the potential impacts of the many embedded decisions (elements) that will define the complete ABM tool – such as starting points, ceilings, or floors – cannot be fully understood without this context. The selected starting points, for example, will be critical in determining the impact of the marginal change in halibut PSC limits that result annually from the combination of the relevant index/indices and the control rule. The Council will likely want to consider starting points (Element 2) in light of how the groundfish sectors operate in the present, how they might operate in the foreseeable future, and the steps they have taken to reduce halibut mortality to date. The most accurate and most relevant picture of how the BSAI groundfish sectors operate is not necessarily captured by looking at a time series of annual harvest and halibut mortality outcomes dating back to the years immediately pre/post implementation of Amendment 80 and the definition of the BSAI trawl limited access sector. When considering ceilings and floors (Elements 3 and 4) and control rule options, the Council will likely want to consider the degree to which halibut PSC is currently – or could become – a sector's decision-driving constraint relative to other factors.

This section provides a first step in connecting the ABM design process to an eventual analysis of potential impacts. The fully developed EIS will characterize the likely range of benefits and costs of ABM for both directly and indirectly affected stakeholders. This section is looking ahead specifically to the benefit-cost analysis of economic and social impacts and is limited to the directly regulated groundfish fisheries. Indirectly affected fisheries such as the halibut IFQ fishery will be considered in the Draft EIS.

This section consists of three "thumbnail" descriptions of key Federal BSAI groundfish sectors that are managed under halibut PSC limits: Amendment 80 non-pollock trawl catcher-processors (A80), the BSAI trawl limited access sector (TLAS), and the longline catcher-processor sector that is managed under the Freezer Longline Coalition (FLC) voluntary cooperative. As described below, these sectors are interlinked in many ways including company affiliation, operational interdependency, shared fishing grounds, and annual harvest limits and inseason rollovers for key groundfish species. This description also considers the American Fisheries Act (AFA) pollock fishery in terms of its relationship with the TLAS fleet (participation) and the A80 sector (availability of inseason reallocations of non-pollock groundfish TAC and halibut PSC). Individually, the operation and management of each of these sectors is vastly complex. Taken together, their interactions account for years of past Council work. As such, this write-up does not attempt to list every piece of relevant regulation or FMP text, *nor is this an impact analysis of the ABM alternatives that are still being developed*. Rather, the purpose of this exercise is to identify key operational decision-drivers – both halibut and non-halibut related – that shape how fleet managers and skippers approach their fishing year and how they are most likely to respond to management change in terms of when and where they will fish. The eventual analysis will illustrate that not all sectors, or even sub-groups within a sector, face the same decision-making environment. A given percent-change in available halibut PSC might cross an inflection point in one sector while the same percent-change might have only a modest marginal effect on another sector.

Fishery context is particularly important for understanding changes to a PSC constraint because halibut is one – but *only* one – factor that determines when, where, and for what a sector/company/vessel fishes. Moreover, halibut PSC is not always the primary constraint; others include groundfish TACs, markets, closed areas, preempted grounds, weather, and access to other fisheries (permits, endorsements, sideboards) to name a few. Nevertheless, PSC availability plays a role in most decisions. One cannot conclude that the operational decisions made within a sector that did not reach its halibut PSC limit were not impacted by halibut. Rather, vessel operators are constantly working to minimize halibut mortality and strategizing to ensure that the minimum amount required to prosecute late-year fisheries is available when needed.

Though not extensively discussed in this document, the full analysis will also incorporate recent or foreseeable macro-level changes in the resource that might impact how sectors operate and interact with one another. Such considerations include biomass trends in Pacific cod (negative), and sablefish and Pacific ocean perch (positive). Pacific cod functions as both a target and a choke-species in the BSAI groundfish fishery; the potential effects of future shifts in abundance or distribution should be considered qualitatively. Sablefish is a high-value secondary species for BSAI groundfish sectors and, as such, opportunities to retain it are likely to shift fleet behavior relative to what is observable in historical time/area catch data. A spike in sablefish effort is also likely to provoke a precautionary management response, so the analysis must consider the extent to which higher abundance does or does not represent a meaningful change in how the groundfish sectors design their annual fishing plans. While AI Pacific ocean perch (POP) is an allocated species for A80, the increasing ABC for the BS area stock affects multiple groundfish sectors as an unallocated species. AFA CPs and CVs are increasingly encountering BS POP as bycatch, though the species is closed to directed fishing. Greater BS POP availability to A80 after the pollock fishery winds down (September/October) could shift incentives to reserve Pacific cod quotas or halibut PSC in order to exploit that opportunity; the amount of BS POP that remains after the AFA fishery depends in part on the size of pollock TACs and the amount of POP bycatch in that fishery. Other macro-level changes that could affect fishery operations stem from environmental factors. For example, recent reports based on survey work have noted a dissipation in the Bering Sea "cold pool," which could allow groundfish stocks to spread farther north. While speculative at this time, spatial changes in target groundfish stocks might reduce catch per unit of effort (CPUE) in areas that are open to groundfish vessels. Reduced CPUE could theoretically increase fishing-time and thus the potential for halibut bycatch incidents. Vessels in the already-congested BSAI trawl Pacific cod fishery might fish even harder for a share of the competitive TAC, pushing halibut avoidance one step lower on the list of operators' decision-driving considerations.

Staff does not presume that the following sector characterizations capture all of the nuance in these fisheries. Because this exercise is a building block for a better decision-making document, staff expects and invites criticism and further insight from those who prosecute the fisheries. Receiving public feedback at this stage will help the analysts identify where and how regulatory impacts would manifest under ABM. Those impacts are likely *not* straight-forward in the sense of a lower PSC limit triggering a fishery closure earlier in the calendar year.

In putting this together the analyst relied partly on interviews with sector participants and NMFS inseason management. The information provided to analysts "on background" is presented here in generalities so as not to be specific to any identifiable operator. At the EIS stage, the analysts will present fishery data that illustrate the patterns of movement, target-switching, and underlying PSC rates that play out over the course of a year. The purpose of these interviews was to ascertain how to ask better questions of the data.

For example, it is helpful to understand how recent vessel acquisitions within the A80 sector might change the focus on flatfish versus roundfish at the sector-level, and thus why fishery data from several years prior might not be a reliable indicator of how the fishery will be prosecuted in 2019 or 2020. Discussions with fishery participants were built around prompts such as: *What does your annual fishing calendar look like under recent normal circumstances, and what options are available to your unique operation when an opportunity is constrained? What business factors limit your choice-set when deciding when/where to fish and what to target?* and most critically, *What do the Council, the public, and the analysts need to know about how you approach your fisheries that is not obvious from simply looking at the timing, area, and amount of fishing that occurred in past years?*

4.1.1 Sector Descriptions

To provide a snapshot of the potentially affected BSAI groundfish sectors, the following bullets describe the groundfish vessels that were active in 2017:

- **30 longline CPs** that primarily target Pacific cod. Most vessels are members of the voluntary FLC cooperative.
- **19 A80 CPs** that target an array of flatfish and roundfish species. A80 cooperatives are allocated yellowfin sole (YFS), rock sole, flathead sole, Atka mackerel, Pacific cod, and AI Pacific ocean perch (POP). A80 vessels also derive revenue from sablefish, Greenland turbot, arrowtooth/Kamchatka flounder, and Alaska plaice. Typically the highest grossing *target* species for the sector are YFS, Atka mackerel, and rock sole (note that target gross includes catch of other saleable species while in that fishery). A80 companies vary in the number of CPs they own, whether or not they own the CVs with which they partner in the TLAS fisheries (vertical integration), and – most importantly – the portfolio of groundfish species and PSC limits available to them each year. The A80 fleet sorts roughly into companies or groups of vessels that focus more on flatfish or roundfish (i.e. Atka mackerel) based on the qualified catch history that they bring to their cooperative. Until 2018 the A80 sector was comprised of two separate cooperatives that received annual allocations from NMFS. Currently the entire sector operates under a single cooperative that manages vessel-level allocations each year.
    - **8 of the A80 CPs acted as motherships** in the TLAS fishery, taking at-sea deliveries from CVs. Note that the CPs taking deliveries as motherships do not necessarily own the CVs.
- **3 AFA CPs participated in the TLAS fisheries**. Within TLAS, AFA CPs primarily target YFS. Their participation in that fishery is not currently sideboarded because the TAC is greater than 125,000 mt (as has been the case dating back to 2008). AFA CPs also participate to a lesser degree in TLAS Pacific cod and Atka mackerel fisheries. One AFA CP that participated in BSAI non-pollock groundfish fisheries acted as a mothership for TLAS CVs.
- **61 CVs participated in the TLAS fisheries**. This fleet is diverse in terms of its trade group affiliations, participation in other allocated fisheries (e.g. AFA and CGOA Rockfish Program), and the processing component to which vessels deliver while operating in the BSAI (inshore/offshore). From 2008 through 2013, roughly 80% of active TLAS CVs were affiliated with an AFA cooperative. A subset of TLAS CVs also participate in groundfish fisheries off the U.S. west coast. While in the BSAI, this set of vessels derives most of its non-pollock revenue from the Pacific cod and YFS fisheries, with the relative share of YFS increasing since the implementation of A80 in 2008 (NPFMC 2016, Section 4.4.3). BSAI FMP Amendment 116, which is currently in the process of implementation, will cap the number of trawl CVs that can deliver YFS to CPs acting as motherships (NPFMC 2018). In 2019 the Council will begin to

review an analysis of alternatives that could affect the relative amounts of TLAS Pacific cod that is delivered shoreside versus to the at-sea (mothership) processing component.

4.1.2 Amendment 80

A qualitative understanding of the A80 fishing year and the diversity of business plans within the sector is especially important because the sector works with the most varied portfolio of allocated target species as well as profitable groundfish species that are not allocated. A simple data report on *annual* harvest volume and gross revenue – either by Catch Accounting System (CAS) "target species" or by individual species – does not reflect how species are physically comingled or, critically, the decisions that vessel operators make to derive value from a trawl tow. For example, CAS might indicate that fishing occurred in the YFS target based on volume, but the fishing was made profitable by the value of other retainable species. Annual data also gloss over calendar-based decision factors like roe content, flesh quality, aggregation (CPUE), fishing conditions (e.g., water temperature or lunar cycles), market demand, and the timing of inseason TAC reallocations from other fisheries.

Skippers make in-season decisions about targeting and location based on expected halibut PSC rates associated with a given target, area, or time of year. By the same token, a vessel operator must manage an annual allocation of important "choke species" such as Pacific cod or risk losing the opportunity to keep the vessel working later into the year or in other profitable targets that have an intrinsic cod encounter rate. Section 3.1.7.2 of the Amendment 80 Program 5-Year Review (NEI 2014) describes how allocation of Pacific cod transitioned the species from a target to an incidental catch species, and how that reality influences vessels' annual fishing plans. After Pacific cod was allocated to A80 cooperatives, fleet managers have had to calculate the amount of cod their vessels will need in fall fisheries and adjust their targeting decisions in the earlier part of the year. The 5-Year Review notes that 55% to 75% of the fishery's Pacific cod was taken in a CAS "target" fishery prior to the program's 2008 implementation, whereas recently cod "targeting" accounts for less than 10% of the sector's cod catch. The Review cites as examples that effort in high cod-rate fisheries like flathead sole and Alaska plaice has declined in favor of arrowtooth and Kamchatka flounder, for which directed fishing is not opened until May 1. Among the key allocated A80 species, YFS has a relatively low cod catch rate, as do roundfish like Atka Mackerel. While cod rates are low in the YFS fishery, managing cod quota is important due to the high YFS TAC. Rock sole, which is a higher-value flatfish species, has among the highest cod rates. *As analysis of this sector moves forward, it is important to acknowledge that cod can drive decision-making as much as halibut, and that each company or vessel enters the fishing year with a different intra-cooperative cod allocation based on qualifying catch history*. Analysis should also consider the extent to which reduced BSAI Pacific cod TACs might impact decision-making: cod could become the preeminent constraint or, if fewer cod are being encountered alongside A80 flatfish targets, it could become less of a consideration in the near- to medium term.

A80 companies and vessel operators work within constraints other than halibut PSC and allocations of "choke species" like Pacific cod. Trawl vessels are excluded from certain areas by regulation – e.g., crab protection zones – and might be excluded de facto if fishing grounds are preempted by fixed-gear vessels in Federal or state-waters fisheries. Vessel operators might not be able to follow a school of "clean" (low-bycatch) A80 species if it moves into a prohibited or preempted area. Other constraints might be temporal. An A80 vessel that is experiencing intolerable Pacific cod bycatch or halibut PSC rates in an early-season flatfish target might wish to switch focus to an unallocated target that is not yet open to directed fishing. Those unallocated species might include arrowtooth/Kamchatka flounder and Greenland turbot, which open on May 1, or BS POP which is only opened to directed fishing as the BS pollock fishery winds down in the fall. "Fall-back" opportunities for A80 vessels when early season fisheries are utilizing too much of a constraining species vary depending an operation's ability to fish in the AI or its endorsement to fish in the GOA (arrowtooth flounder in the spring or the Central GOA Rockfish Program after May 1). Broadly speaking, alternatives to BS flatfish for A80 vessels are not an option to consider until May or June. Non-regulatory constraints that affect how A80 operations might respond to a bycatch or PSC challenge are described in the following sketch of "annual planning."

Finally, the correct baseline for regulatory impact analysis should consider the evolving makeup of the A80 sector in terms of business ownership and the portfolios of species being fished on certain platforms. Fishery data from recent years would not reflect the transfer of some vessels and quotas to companies that might use the assets differently – i.e., increased utilization of flatfish quotas.

4.1.2.1 Annual Planning

The allocation of BSAI non-pollock species to A80 CPs has allowed companies to plan for groundfish fisheries that span most of the calendar year and has insulated companies that want or need to pursue late-year opportunities from the effects of other participants whose incidental catch or PSC might have closed the entire sector. Many vessels strive to stay working from January 20 to November. While staff has no insight into companies' operational costs or their net profitability, participants report that most A80 companies rely on a full and varied season to run their business. When constraints such as high Pacific cod or halibut bycatch rates emerge, vessel operators do not have the option to cease fishing completely because cost accrual on such large platforms would be unsustainable. Participants also noted that a mid-year stand down could result in crew-retention issues. Moreover, it was noted that shutting down and restarting CP factory could actually cause mechanical challenges, spinning off new costs. As a result, A80 operators do not follow a uniform progression from one target to the next over the course of the season. Annual fishing plans are designed with contingency in mind, and when all options are suboptimal the response is often to stay active and look for areas with the right species combinations even if it is in a time/area where history would not have predicted. Participants noted that "looking" for the right fish does not necessarily require a net in the water, and that it is better to continue learning the present situation on the grounds than to leave and reestablish that knowledge later. Short test-tows that might be a viable strategy for a CV are not as common a practice on large CPs because running a factory at low capacity can be a losing proposition. In short, A80 vessels are unlikely to stop fishing under a mid-year constraint.

The annual planning process begins the preceding fall with harvest specifications. The A80 sector has a unique consideration in the harvests specifications flexibility procedure where the cooperative(s) (and CDQ groups) can exchange TAC of YFS, rock sole, or flathead sole for TAC of another from that group, up to the limit of the ABC and the 2 million mt cap. It is possible that flexibility exchanges could be made with expected bycatch rates in mind if the PSC limit became the preeminent decision-driver for the sector.

A80 operators tend to spend the early months of the year in the BS, striking a balance between CPUE, profitability, and market demand while managing Pacific cod and halibut bycatch to preserve opportunities to fish later in the year. Some opportunities are only available early in the year, such as the rock sole roe fishery which is reported to carry a relatively high Pacific cod bycatch rate. The optimal timing of allocated species catch is also driven by market quality. Markets for flatfish and roundfish can differ, meaning that not all companies are facing the same decision-set in regards to targeting at a given time of year.

Operators must also manage their catch of unallocated species that NMFS manages under the "non-specified reserve." Inseason management uses this reserve to account for unallocated species on a BS-wide basis, meaning that bycatch in other fisheries (e.g., AFA pollock) can affect how much of a species like POP is available for a directed fishing allowance by A80 CPs. The availability of turbot as a secondary species, for example, might determine whether arrowtooth flounder is a viable fall-back fishery if other targets are yielding high halibut or cod bycatch. Decisions about the use of the reserve are typically resolved mid-year, during the summer.

May through August is typically when A80 vessels might branch out to the GOA or to the AI depending on their particular endorsements, CGOA Rockfish Program or other GOA rockfish and flatfish participation. Opportunities to diversify in the case of constraining bycatch expand in June as AI fisheries are pursued. Vessels that overuse cod or other allocations early in the year might be forced to trade within the cooperative in order to fish in the fall. Similarly, vessels that accrue halibut in spring or summer fisheries might jeopardize their ability to fish YFS in October and November. Because some fall fisheries for unallocated species such as BS POP are reliant on usage in other fisheries, companies might plan their business strategy and bycatch usage differently from one year to the next. Finally, A80 vessels will also return to allocated species in the fall, with the fleet breaking down across YFS vessels and Atka mackerel vessels depending on the history that they brought to the cooperative.

A80 companies are not uniform in their area endorsements or their cooperative allocations of flatfish and roundfish, and thus might have different levels of exposure to a lower halibut PSC limit. Operators that have greater Atka mackerel and AI POP allocations are more able to move out of the BS if early-year halibut bycatch rates are unusually high. The flatfish-oriented operations might only have the option to remain in the BS or to move into the GOA. The ability to fish in the GOA is limited in regulation by endorsements but can also be limited by halibut PSC limits in that area. GOA CPs and CVs share seasonal halibut PSC apportionments, and GOA deepwater complex flatfish fisheries could be closed if effort and bycatch by GOA CVs targeting arrowtooth flounder are high. Finally, at least one A80 vessel is only endorsed to fish in the BS, meaning its response options are uniquely limited.

4.1.2.2 Halibut Avoidance

Section 1.4.4 of the October 2017 ABM discussion paper summarized the A80 sector's developing tools and approaches to minimizing halibut PSC (NPFMC 2017). The sector developed its own set of rate-based halibut PSC standards for the calendar year and, separately, for the last quarter of the year. The latter measure is meant to prevent overuse of halibut PSC if the annual rate does not appear to be a constraint in that year. Acceptable rates are established on the basis of target species. Intra-cooperative accountability measures for failure to meet the standards include monetary fines, increased monitoring, and possible reduction in vessel-level halibut PSC allocations the following year.

The foundations of halibut avoidance efforts are data sharing and communication on the fishing grounds about bycatch rates, the size of halibut measured onboard, and the effectiveness of halibut excluder devices. Participants noted that the fleet does not presume seasonal halibut movement to be constant from one year to the next, underlining the importance of continuous data collection and real-time communication. An A80 skipper's primary decision drivers are the catch and bycatch rates in the particular area where they are fishing. Participants also noted that actively looking for clean fishing can be more productive and less risky than leaving the grounds and returning to make their next decisions based on older information.

The existing cooperative is also investing in research on how to utilize halibut decksorting to reduce halibut bycatch mortality, and how decksorting as a tool interacts with excluder use. Practitioners within the sector report that decksorting and excluder use do not necessarily provide additive benefits, so communication about which tool to use in a given circumstance is critical. Though it is not yet observable in fishery data, staff understands that recent vessel acquisitions within the sector could result in platforms that were primarily focused on roundfish during recent years returning to flatfish targets. Those vessels will likely be interested in decksorting but are still developing their own unique implementations to do it effectively. The ongoing development of halibut avoidance and minimization tools across a diverse and evolving fleet bears consideration when thinking about the appropriate "status quo" for ABM options as starting points.

4.1.3 Trawl Limited Access Sector

The TLAS fishery is made up of AFA CPs that catch and process limited access groundfish and CVs that deliver to both shoreside and at-sea (mothership) processors. The primary species for this sector (not including BS pollock) are Pacific cod and YFS. Halibut PSC limits are apportioned annually to the TLAS sector with no seasonal limits (except that halibut for TLAS rockfish only becomes available on April 15).[4] Since the sector was established with the creation of A80, the AFA trawl CP/CV Pacific cod and TLAS YFS fisheries have not closed as a result of halibut PSC, though they have come close to the limit. These fisheries are primarily TAC-driven competitive fisheries. As such, the TLAS fishery is somewhat distinct among the three sectors covered here in that the direct effect of a potentially reduced halibut PSC limit could be conceptualized as a shortened fishery. The regulatory impact analysis will be concerned with which fisheries are most likely to be curtailed – relative to No Action – and the specific nature of the stakeholders in the fisheries most at risk.

The non-pollock groundfish caught by AFA CPs accrue to allocations for TLAS while the groundfish caught by A80 CPs accrues to their own sector allocations. TLAS CVs break down generally into AFA and non-AFA subcategories, as defined by whether they are members of cooperatives with secure BS pollock allocations (and halibut PSC management responsibilities within those cooperatives). TLAS CVs also vary in their access to fisheries outside of the BSAI. Some CVs trawl in the GOA, others spend part of the year off the U.S. west coast (i.e. whiting fisheries), and others are dependent on BSAI non-pollock fishing. Those distinctions do not break down strictly on AFA/non-AFA lines. In general, CVs with access to cooperatively managed fisheries such as AFA pollock or the Central GOA Rockfish Program face a different set of decisions about when to fish and how to respond to the current constraint (cod TAC) or theoretical future constraints (a reduced PSC limit). Access to cooperative quota for other fisheries insulates some TLAS CVs from overall business risk if the Pacific cod or YFS fishery were to close prematurely relative to past expectations.

4.1.3.1 Annual Planning

The fishery in which a TLAS CV begins the season depends on whether it is an AFA or non-AFA vessel. Some CVs have contracts with, or are owned by, companies that operate CPs as motherships, opening up opportunities for YFS and AI POP/Atka mackerel that other CVs do not have. When trawl gear opens on January 20, AFA CVs choose between BS pollock or trawl Pacific cod/YFS. Recently these vessels have begun the season in the cod fishery because of its increasingly competitive nature where the TAC may be taken relatively quickly and harvest opportunities are not secured by a catch share program. Roughly 75% of the annual trawl CV Pacific cod TAC is allocated to the A season, January 20 to April 1. In 2018, roughly 10% of the TLAS cod TAC was allocated to the B season (April 1 to June 10), and 15% was allocated to the C season (June 10 to November 1). Catch rates and TAC utilization tend to be greater early in the calendar year, making the A season the focal point of the fishery and demanding competitive participation when it is open. The trawl CV cod fishery is both spatially and temporally confined. Within those confines, the cod fishery is experiencing pressures from participation; for example, AFA vessels without a cod sideboard exemption (lower historical cod dependency) are fishing at increasing levels.

AFA CVs that begin in cod might move into the pollock fishery when roe content is optimal. Non-AFA CVs begin with a choice between trawl CV Pacific cod and YFS; some vessels may fish in the YFS fishery until cod CPUE becomes established. CVs that have GOA trawl endorsements but also fish BS Pacific cod are typically making a choice between BSAI trawl CV cod or A/B season pollock and A season Pacific cod in the GOA. If the BSAI trawl CV Pacific cod season closes on TAC in February or early March, CVs could filter back to the YFS fishery go to the GOA for B season pollock. Some CVs that are not GOA-endorsed go to the AI for Atka mackerel and POP after the cod TAC is taken. For

[4] https://alaskafisheries.noaa.gov/sites/default/files/18_19bsaitable16.pdf

BSAI-focused CVs that are vertically integrated, the decision about where to fish outside of the early Pacific cod season is dictated by where their mothership market is fishing.

CVs that participate in the Pacific whiting fishery will typically be down on the west coast by May 15. Non-whiting CVs that remain in the BS would either return to pollock fishing for the B season on June 10 (AFA) or might get a mothership market for summer cod or YFS, if open. In recent years, the TLAS YFS fishery has dissipated by June or July due to either the TAC being taken, low CPUE in the summer, or low market demand during that time of year. Other opportunities for CVs during the summer months include tender contracts in salmon fisheries and research charters.

AFA CVs tend to wind down their season by finishing their pollock quota in September before Chinook salmon bycatch rates are expected to increase. Opportunities for non-AFA CVs in the late summer and fall are mostly limited to Pacific cod until November 1 and YFS. In recent years the TLAS YFS TAC has not been available that late in the year, having closed in June. Moreover, a pending rule will limit the number of CVs that could deliver YFS offshore (NPFMC 2018). That rule, implementing BSAI Amendment 116 was, in part, motivated by concern that increasing participation in the TLAS YFS fishery could drive up halibut PSC usage, thus closing the fishery and impacting CPs that depended on TLAS harvest and deliveries as a source of non-pollock revenue. Under the rule, CVs that cannot deliver to CPs will still be able to deliver YFS shoreside if the fishery is open and they possess the necessary refrigerated seawater system to make that delivery. Some TLAS CVs participate in the fall Pacific whiting fishery on the west coast. The timing of that fishery may depend on when AFA CPs finish their BS B-season and can move south to make an offshore whiting market.

4.1.3.2 Halibut Avoidance

As noted in the October 2017 discussion paper (NPFMC 2017), the TLAS fishery is distinct in having a mix of participants with and without affiliations to other cooperatives that have formalized halibut avoidance protocols. AFA CV cooperatives apply a “halibut mortality allowance” to their TLAS activity. This allowance is established by cooperatives and is proportional to the cooperative’s non-pollock groundfish sideboard percentage. After adjustments are made to account for sideboard exempt/non-exempt status and a “traditional time and area buffer,” co-op vessels receive a halibut mortality allocation. Cooperatives agree to manage their vessels such that PSC limits are not exceeded, and allow PSC that is not needed to harvest the co-op’s sideboard allocations to be redistributed in a timely manner to other cooperatives at no cost.

AFA CVs have established Better Practices Protocols that vessels must adhere to when fishing with trawl gear for BS Pacific cod. Vessels must tow halibut excluders that meet agreed upon specifications. The protocols allow room to innovate new designs, as smaller or slower vessels might experience different levels of effectiveness using the same design towed by a larger vessel. Vessels are not allowed to fish for cod during night hours, when halibut encounters tend to be greater. The protocols also set a minimum codend mesh size to allow some escapement of undersized fish. In terms of monitoring, AFA CVs fishing in limited access may voluntarily carry 100% observer coverage for the expressed purpose of internally managing the cooperative’s halibut mortality allowances. By virtue of their cooperative affiliations, many TLAS participants also share with each other near real-time catch, bycatch, and location data (including rates) through a third-party. Cooperatives impose internal accountability measures through vessel rankings of PSC rates and through monetary sanctions for vessels that are not complying with Better Practices Protocols. While unaffiliated vessels – mostly non-AFA CVs – are not subject to agreements that carry internal accountability measures, co-op managers communicate with those vessels to share avoidance measures and encourage them to adopt the same.

In recent years, TLAS vessels have been able to coordinate informally on avoidance plans that are responsive to Council objectives, even meeting voluntary mortality reduction targets. That coordination is largely facilitated through existing cooperative programs (i.e., AFA and A80). Entry by newer participants could make coordination more challenging because voluntary cooperatives often parcel out halibut mortality allowances (or the like) based on catch history in the TLAS fishery.

If a collective action problem were to arise it would likely appear in the TLAS Pacific cod fishery. That fishery is more spatially and temporally constrained and has more vessels to organize than the YFS fishery and is thus less well-suited for voluntary cooperation. It might be particularly difficult to engage independent vessels in a voluntary PSC stand down if those vessels are in a rush to complete the trawl CV cod A season before returning to another fishery, such as GOA B season pollock.

4.1.4 Longline CP Sector (FLC)

The BSAI hook-and-line (longline) CP sector is primarily focused on the Pacific cod fishery. The TAC is divided in to two seasons: A season runs from January 1 to June 10; B season runs from June 10 to December 31. The sector's annual cod quota is divided roughly evenly between the two seasons and has been harvested at or near capacity in recent years.[5] The even A/B season Pacific cod TAC split stands out from other gear sectors and underlines that this sector is a year-round operation for some vessels. While FLC operations derive some value from secondary species such as Greenland turbot, IFQ sablefish, and GOA Pacific cod, the fact that the sector is essentially a single-species business limits options in a scenario where halibut PSC poses a constraint.

Large-scale hook-and-line vessels are similar to one another in their mode of operation, which is distinct from that of a trawl vessel. Longline CPs deploy a large amount of baited groundline; fishery participants approximate that an active CP will occupy a 10-mile by 20-mile rectangle on the fishing grounds. Hauling, rebaiting, and moving that gear is more time- and fuel-intensive than a trawl vessel's move. If a longline CP wants to move in search of higher CPUE or lower PSC rates, its options are limited to what grounds are available. In other words, moving away from halibut can be a costly process and choices might still be limited. Longline CP operators also consider seabird bycatch rates when deciding whether to enter or remain in a fishing position. Companies that manage multiple vessels may choose to coordinate fishing in order to hold productive grounds. In addition to preempting one another, longline CPs must also share grounds with the trawl and pot sectors and with longline CVs. In some cases – for example, around the Pribilof Islands – CPs will coordinate to reserve areas for smaller-scale longline vessels that do not have the range to fish safely farther from port.

The degree to which grounds preemption or potential gear conflict affects the longline CP fleet's set of in-season fishing options may change from year to year depending on environmental factors or the ebbs and flows of effort in other fisheries. In some years, sea ice might concentrate the longline CP fleet spatially. From a fishery competition perspective, increased effort in the state-waters pot cod fishery could impact the amount of grounds and TAC available for Federal fixed-gear (and trawl) operators. Year-on-year changes in groundfish TACs (especially Pacific cod), and potentially halibut PSC limits under ABM, could affect the timing and location of trawl effort which in turn affects the extent to which that effort overlaps grounds that are preferred by longliners for their productivity and availability of profitable secondary species.

4.1.4.1 Annual Planning

At the most basic level, longline CP managers design their season around the amount of cod their company/vessel plans to catch, as influenced by TAC levels and operational constraints. The amount of fishing a vessel intends to do affects annual plans for how many crews to rotate through the vessel and when it might build shipyard time into its calendar. Skippers' decisions about where to fish are based around not only CPUE but also predicted or observed product recovery rates. Individual platforms will

[5] https://alaskafisheries.noaa.gov/fisheries-catch-landings

approach product recovery and optimal fishing differently depending on wholesale markets and their vessel's ability to produce ancillary cod products. In contrast to the trawl sectors, longline CP operators must also weigh bait costs as a factor in the quality and profitability of a fishing area. Markets for ancillary products can become saturated, leading to inseason shifts in the profile of a profitable fishing area when considering operational costs.

The January through March period is key for longline CPs. That period typically exhibits higher CPUE, better market demand, good flesh quality (product recovery), and lower halibut bycatch rates. Fishery participants report that halibut bycatch rates are often lower in the northern part of the BS relative to the Pribilof Islands, Bristol Bay, and the slime bank north of Unimak Island. However, the ability to fish in the more northern fishing grounds can be restricted by weather and ice during the early part of the year.

As the remaining Pacific cod TAC is depleted over the course of the season – or if a bycatch constraint such as halibut PSC emerges – a multi-vessel company will rotate its less technically efficient or financially productive platforms out of the fishery. Depending on markets and fish size, these might be the vessels that are less able to generate ancillary products.

As the calendar year progresses, NMFS inseason managers are able to reallocate Pacific cod TAC to other sector allocations including the longline CP fishery from sectors where it would have gone unharvested. For that reason, the cooperative has an incentive to manage constraining bycatch species such as halibut so that emergent opportunities in October, November or December can be exploited.

4.1.4.2 Halibut Avoidance

As described in the October 2017 discussion paper (NPFMC 2017), FLC's efforts to reduce halibut bycatch mortality are centered around avoidance, release viability, and vessel accountability. Avoidance measures are generally framed around near real-time communication on the fishing grounds, facilitated through a third party. FLC members can access third-party catch monitoring with location data, including both target and bycatch as well as observed discard mortality rates (DMR). Members receive weekly accountability reports on fleet-wide PSC totals and rates. Those internal reports are vessel-specific ("clean/dirty list"), triggering social incentives to avoid activity that would result in lost fishing opportunities for the voluntary cooperative as a whole. Inseason reporting on observed DMRs reinforces the need to prioritize careful release practices to increase viability (fish handling) and can also inform choices about where to set gear.

FLC promotes communication and accountability in three ways: an annual symposium for owners, officers, and crew; bycatch status updates for the fleet monthly and at board meetings; and an ad hoc bycatch committee. The annual symposium aims to educate participants – from owners to crew members – on the resource and business imperative to minimize halibut mortality, and how measures like fish handling that can improve outcomes. The event also includes interaction with fishery managers from NMFS and third-party data managers. FLC formed a bycatch committee in 2014 to engage in the process of developing BSAI FMP Am. 111 (reduced halibut PSC limits) and to encourage halibut avoidance efforts. That committee has not met on a regular basis but could be recalled to aid in coordination or reporting.

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Appendix 1. Halibut ABM Single-species Operating Model (OM)

The purpose of this analysis is to evaluate abundance-based PSC management alternatives for Pacific halibut in the Bering Sea. Following advice from NPFMC SSC (June 2018) we have developed a single-species, age and sex structured, simulation model with two spatial regions. The simulation model tracks the population dynamics of Pacific halibut in two areas (1) the Being Sea and Aleutian Islands (4ABCDE) and (2) the remaining distribution of Pacific halibut along the US West Coast. Here we provide a description of the simulation model and several examples of outcome sensitivity to recruitment allocation among model areas and assumed movement rates.

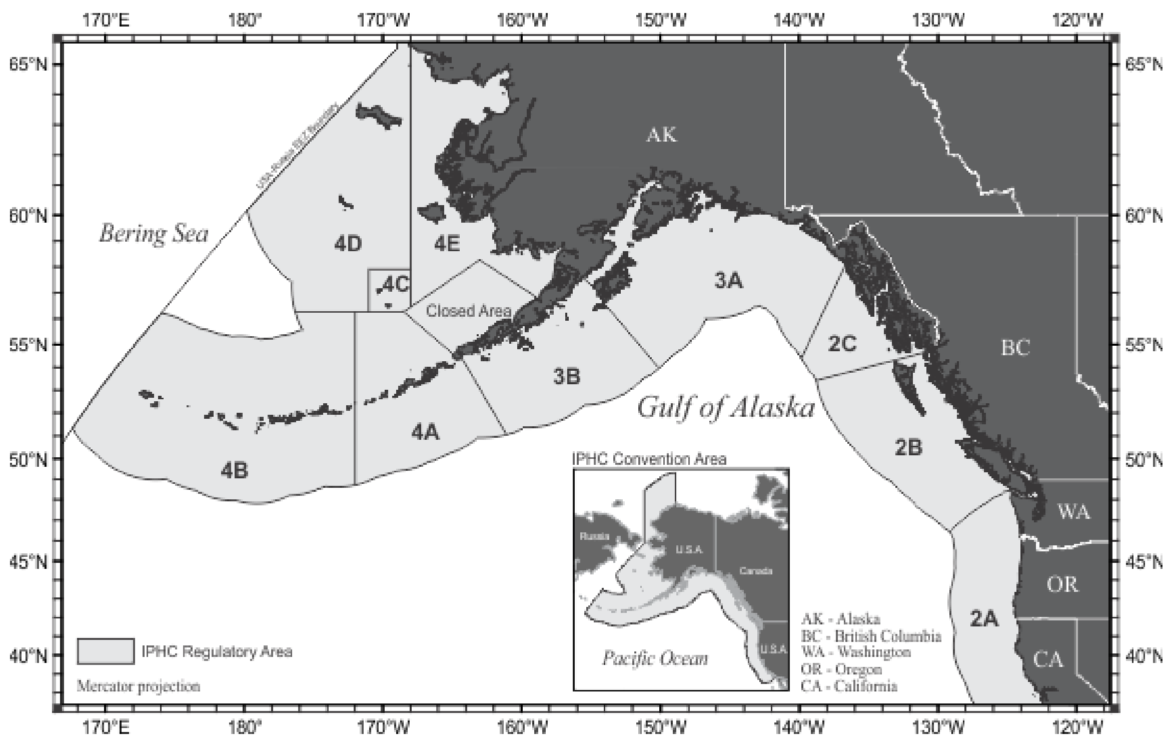

Figure 1. Map of International Pacific Halibut Commission management areas. Figure from www.iphc.int.

Model Structure

Recruitment

Pacific halibut recruitment is represented as a Beverton-Holt stock-recruitment relationship with a steepness of $h = 0.75$ and apportioned among model areas:

(1) $$R_{l,y} = d_l \frac{SSB_y 4hR_0}{SSB_0\left(1 - h\right) + SSB_y\left(5h - 1\right)} e^{e_y - \frac{s_r^2}{2}}$$

where SSB_y is the coast-wide spawning stock biomass in year y and δ_l is the proportion of recruits to each area l.

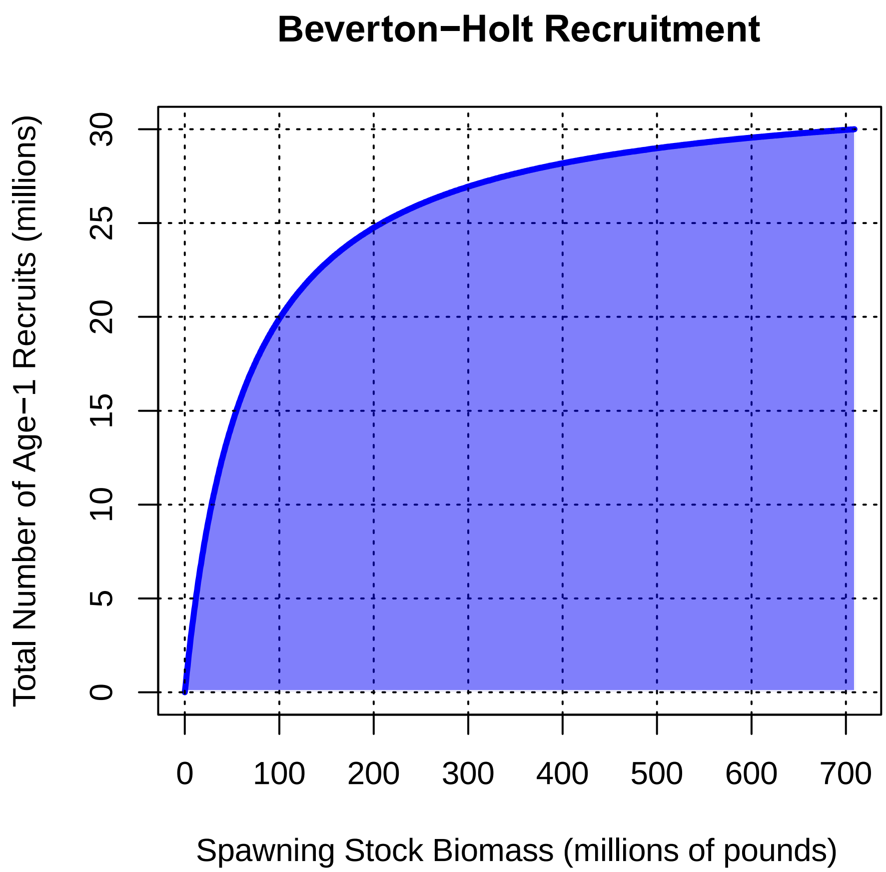

Figure 2. Total Beverton-Holt recruitment across model areas as a function of spawning stock biomass.

Random process variation in recruitment is log-normal with standard deviation of $\sigma_r = 0.6$:

(2) $$\varepsilon_y \sim Normal\left(0, \sigma_r\right)$$

Recruitment parameters were taken from the 2015 International Pacific Halibut Commission (IPHC) Coastwide Long (1888-2015) assessment model (Stewart & Martell 2016), as described in the appendix to the 2015 assessment. Spawning stock biomass is product of female biomass at age and maturity at age, summed across both areas and ages:

(3) $$SSB_y = \sum_l \sum_a N_{l,s,y,a} w_{s,a} m_{s,a} = \sum_l \sum_a B_{l,s,y,a} m_{s,a}$$

where $w_{s,a}$ and $m_{s,a}$ are the weight and maturity for each sex s at each age a, and equivalently $B_{l,s,y,a}$ is biomass at age.

A key uncertainty to be addressed is how to allocate the coast-wide halibut recruitment between the two areas, through specification of δ_l. Sensitivities to δ_l are presented at the bottom of this document.

Survival

Cohorts of halibut are tracked forward in time across ages within areas, subject to both sex-specific natural mortality M_s and annual fishing mortality by area, year, and fishing sector or gear type g. Currently two gear types are specified representing the directed fishery and PSC harvest sectors, although the PSC sector will be split between trawl and longline. Total instantaneous mortality is:

(4) $$Z_{l,s,y,a} = M_s + \sum_g v_{g,s,a} F_{l,g,y}$$

where $v_{g,s,a}$ is the gear, sex, and age-specific selectivity for fishing gear, and $F_{l,g,y}$ is the annual (y) fishing mortality by gear g and area l. Natural mortality rates (M_s) are age-independent and equal to 0.15 for females and 0.13 for males.

Halibut numbers at age are updated based upon annual recruitment and age-specific survival, with numbers at $a = 1$ calculated as:

(5) $$N_{l,s,y,a=1} = 0.5 R_{l,y-1}$$

Numbers at age for all ages $1 < a < A$ are updated by:

(6) $$N_{l,s,y,a} = N_{l,s,y-1,a-1} e^{-Z_{l,s,y-1,a-1}}$$

where A is the plus age group and equal to age 30. The plus age group in year y is equal to the surviving individuals at age A, plus surviving entrants into the plus age group:

(7) $$N_{l,s,y,a=A} = N_{l,s,y-1,a=A} e^{-Z_{l,s,y-1,a=A}} + N_{l,s,y-1,a-1} e^{-Z_{l,s,y-1,a-1}}$$

Harvest

Age-specific total catch in numbers by year is calculated as:

(8) $$C_{l,s,y,a} = \left(\frac{f_{l,s,y,a}}{Z_{l,s,y,a}}\right) N_{l,s,y,a}\left(1 - e^{-Z_{l,s,y,a}}\right)$$

with $f_{l,s,y,a} = \sum_g v_{g,s,a} F_{l,g,y}$ being the sum of fishing mortality across gear types. The gear-specific annual catch is:

(9) $$c_{l,s,y,a,g} = \left(\frac{v_{g,s,a} F_{l,g,y}}{Z_{l,s,y,a}}\right) N_{l,s,y,a}\left(1 - e^{-f_{l,s,y,a}}\right)$$

Harvest in units of biomass by gear type is the product of gear-specific catch and weight at age, summed across sexes and ages:

(10) $$H_{l,y,g} = \sum_s \sum_a c_{l,s,y,a,g} w_{s,a}$$

Movement

Movement of halibut is currently assumed to occur after removals from both natural and fishing mortality. Within the current simulation framework movement rates are implemented as age-specific transition probabilities between areas. In this way a fixed proportion of individuals of each age move from one model area to another in each year. The simulation model currently includes two areas, the Being Sea and Aleutian Islands (4ABCDE) and the remaining west coast range of Pacific halibut. The number of migrants from area i to area j in each year is:

(11) $$\tau_{i,j,s,y,a} = N_{l=i,s,y,a} \pi_{i,j,a}$$

where $\pi_{i,j,a}$ is the transition probability at age. Once the number of annual migrants is calculated, numbers in each area, of each sex and age, is updated to by adding the number of immigrants into an area less emigrants out of an area:

(12) $$N_{l,s,y,a} = N_{l,s,y,a} + \sum_{k \in areas} \tau_{i=k,j=l,s,y,a} - \sum_{k \in areas} \tau_{i=l,j=k,s,y,a}$$

Management Process

The fishing mortality rate for each gear type in each year will be approximated given the established IPHC harvest control rule and established allocation procedure across sectors and areas for the directed fishery and various alternative ABM control rules for each PSC gear type. Currently, spawning stock size is assumed to be known without error, however in future a simple assessment model to be used to add outcome uncertainty to the implementation of the current fishery management structures for both directed and PSC gear types.

Forward Simulation

Population dynamics of Pacific halibut within the two model areas are simulated over time, replicated across simulations with different random recruitment deviations. The simulation model is conditioned with a starting biomass $Bstart$ and initial biomass proportions at age in each area. In each simulation the numbers at age in the first year are calculated as:

(13) $$N_{l,s,y=1,a} = B_{start} p_{l,s,a} / w_{s,a} = B_{l,s,y=1,a} / w_{s,a}$$

During each year of each simulation fishing mortality rates will be calculated based on the management process described above, based on relative stock status for the directed fishery and the values of the simulated indices used in the ABM control rules. As such fishing mortality rates by gear type differ among both years and simulations.

Key Uncertainties

At present several uncertainties remain regarding the value of specific simulation model parameters that will need to be addressed prior to implementation. The first uncertainty is the annual movement rates between the model areas ($\pi_{i,j,a}$) and whether these movement rates change across ages as fish mature and migrate. While IPHC tagging data suggest little to no movement of halibut into the BSAI area, movement rates out of the BSAI area will need to be specified. The second key uncertainty is how total recruitment is allocated between the two model areas (δ_l). Together these two quantities dictate the distribution of halibut biomass and the age structure of individuals across areas. Below we provide a several examples illustrating the sensitivity of outcomes to these two parameters, assuming no directed fishery or PSC mortality.

To explore the interaction between the assumed proportion of annual recruitment allocated among model areas and the annual movement probability out of the BSAI area we simulated hypothetical outcomes over time with random variation in recruitment and at equilibrium. Figure 3 illustrates the predicted female spawning stock biomass at age over a 100-year interval, with the same random recruitment deviations in each scenario and all recruitment allocated to the BSAI area ($\delta_{l=BSAI} = 1$). Left panels describe female spawning stock biomass at age over time with an annual movement rate out of the BSAI area of 0.01 and no movement into the BSAI, while right panels show these same simulations with an annual movement rate out of the BSAI of 0.05. Movement rates were specified as constant across ages and sexes. Simulation results indicate that the distribution of spawning stock biomass among areas is highly sensitive to the assumed movement rate out of the BSAI area.

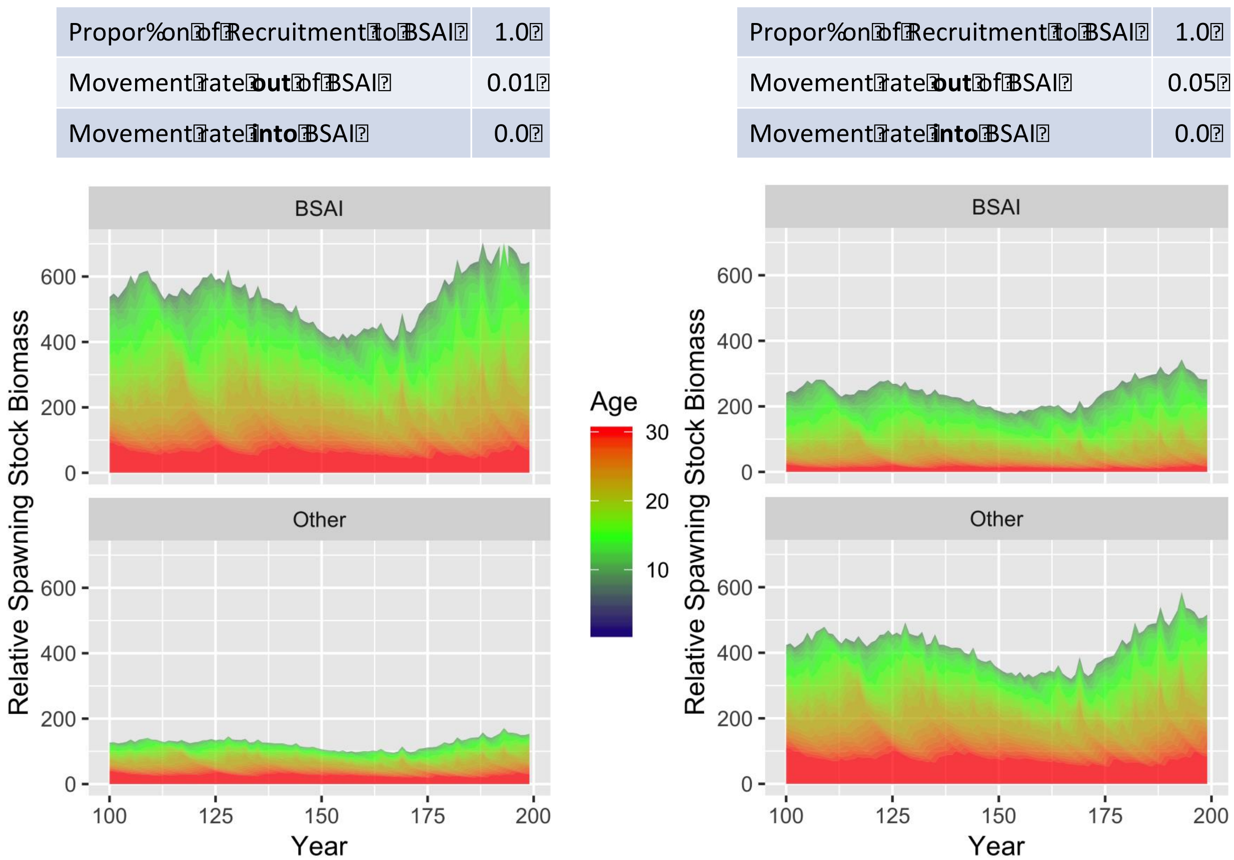

Figure 3. Simulated female spawning stock biomass at age over time under two movement scenarios, with no fishing mortality and all recruitment allocated to the BSAI area. Annual movement rates are constant across ages and sexes.

In order to illustrate the interaction between recruitment allocation and movement rates, equilibrium biomass was simulated assuming the proportion of recruitment allocated to the BSAI area was 1.0, 0.7, and 0.5, and annual movement rates out of the BSAI area of 0, 0.01, and 0.05 for both sexes and all ages (Figure 4). Simulations suggest that the equilibrium distribution of biomass among regions and the age distribution of halibut in the two areas is highly sensitive to both recruitment allocation and movement rates. With all recruitment allocated to the BSAI area and the higher movement rate (0.05 out of BSAI) total biomass is comprised of a higher proportion of younger age classes in the BSAI area compared with the remaining West Coast area.

Together these examples highlight the sensitivity of simulation outcomes to these two input parameters and suggest that the distribution of recruitment across areas and annual movement rates should be clearly defined, or a range of reasonable scenarios identified, before simulating ABM alternatives.

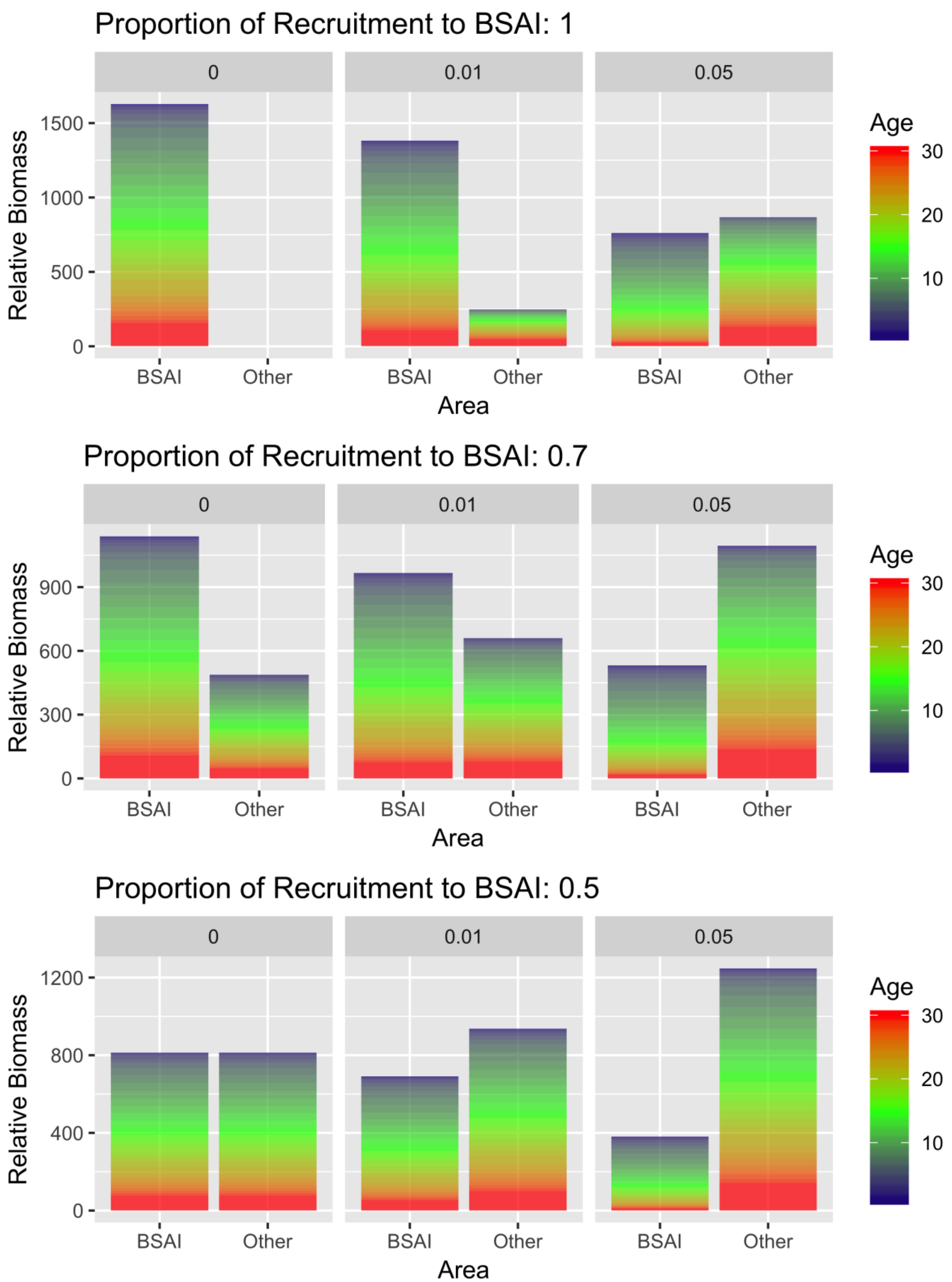

Figure 4. Equilibrium biomass at age in each model area, as a function of the proportion of recruitment allocated to the BSAI area and annual movement rates out of the BSAI. The value heading at the top of each individual panel is the assumed movement rate out of the BSAI.

Model Components

Symbols

Symbol	Description
l	Area or location (Bering Sea and Aleutian Islands and remaining West Coast halibut range)
y	Year
s	Sex
a	Age
g	Gear type or fishing sector
i	Area migrating **from**
j	Area migrating **to**

Derived Parameters

Parameter	Description
$R_{l,y}$	Recruitment
SSB_y	Spawning stock biomass
$N_{l,s,y,a}$	Numbers at age
$B_{l,s,y,a}$	Biomass at age
$Z_{l,s,y,a}$	Total mortality
$F_{l,g,y}$	Fishing mortality rate
$f_{l,s,y,a}$	Age and sex-specific fishing mortality rate
$C_{l,s,y,a}$	Total catch in numbers
$c_{l,s,y,a,g}$	Catch in numbers by gear type
$H_{l,y,g}$	Harvest in biomass by gear type

Input Parameters

Parameter	Description
M_s	Natural mortality by sex
$w_{s,a}$	Weight at age by sex
$m_{s,a}$	Maturity at age (note this is equal to zero for males)
$v_{g,s,a}$	Selectivity
B_{start}	Initial biomass
$p_{l,s,a}$	Initial biomass proportions at age by area

Appendix 2. Background and equations for Alternatives

The Council motion suggested several alternatives for consideration and this appendix describes their differences mathematically and qualitatively.

The abundance-based Alternative 2 control rule is applied as follows:

It is a linear rule that passes through the point ($I_y, \frac{PSC_{y+1}}{X}$) = (1,1), where PSC_{y+1} is the prohibited species catch limit for the next year, X is the "starting point," or the desired PSC limit associated with a particular index value, and I_y is the abundance index value in year y. The y-axis is in the units $\frac{PSC_{y+1}}{X}$. Using the point-slope form for a line this is:

$\frac{PSC_{y+1}}{X} - 1 = a(I_y - 1)$, where a is the slope of the line, which is also the proportional effect of the index on the PSC. Rearranging, PSC in year y+1 is

$$PSC_{y+1} = \left(1 - \left(1 - I_y\right)a\right)X \qquad \text{(Equation 1)}$$

In slope-intercept form this is:

$\frac{PSC_{y+1}}{X} = aI_y + (1 - a)$, where the intercept of the line is $1 - a$. If the proportional effect (or slope) is equal to 1, as requested in the April Motion, then the equation reduces to:

$\frac{PSC_{y+1}}{X} = I_y$, and the intercept is always equal to 0. Therefore, Alternative 3 and Alternative 4 will always be the same when assuming that the control rule passes through the point ($I_y, \frac{PSC_{y+1}}{X}$) = (1,1) and has a proportional effect (or slope) equal to 1. Alternative 3 and Alternative 4 will differ from each other when these two conditions are not met.

If the value desired was to have the PSC limit equal to what it was in a particular historical year, X could be set at the PSC limit in that year divided by the primary index value in that year. For example, if the desired "starting point" was to be equal to the 2016 PSC limit, X would be set at the 2016 PSC limit divided by the primary index value in 2016. An exact alternative to this is to standardize the time series to the 2016 index value and the starting point (X) then becomes the 2016 PSC limit and not the 2016 PSC limit divided by the index value in 2016.

The value of a is simply a proportionality constant and could take on any value depending on whether the induced variability of the abundance index is deemed too high to be practically managed, or too low to reflect real changes in abundance. For example, when a is a value of 1, it has the effect that a 10% increase in the index would lead to a 10% increase in the PSC limit. Values below 1 would reduce variability and values above 1 would increase variability. The April 2018 motion stated that this proportionality constant remain equal to 1 for all alternatives.

If may be desirable to use the status or value of a secondary index (e.g., high, medium, low) to influence the PSC limit. Alternatives 3 and 4 use a direct multiplier at certain threshold values, and when the proportionality constant is fixed at 1 they are the same (as shown above) and can be implemented as follows:

When secondary index is in a "low" state ($S_y < L$):

$$PSC_{y+1} = X\left(1 - a\left(1 - I_y\right)\right) m_L \qquad \text{(Equation 2)}$$

When secondary index is in a "medium" state" ($L < S_y < H$)

$$PSC_{y+1} = X\left(1 - a\left(1 - I_y\right)\right) \qquad \text{(Equation 3)}$$

When secondary index is in a "high" state ($S_y > H$):

$$PSC_{y+1} = X\left(1 - a\left(1 - I_y\right)\right) m_H \qquad \text{(Equation 4)}$$

This can result in a significant discontinuity in the control rule at breakpoints (Figure A2.1, A2.2, and A2.3), such that PSC limits may differ substantially with a small change in the value of the secondary index from the "normal" state to a "high" or "low" state. If it is desired to avoid this discontinuity, Equation 1 can be extended to a "variable slope" control rule with a secondary index as follows:

When secondary index is in a "low" state ($S_y < L$):

$$PSC_{y+1} = X\left(1 - a\left(1 - \left(I_y + m_L(S_y - L)\right)\right)\right) \qquad \text{(Equation 5)}$$

When secondary index is in a "medium" state" ($L < S_y < H$):

$$PSC_{y+1} = X\left(1 - a\left(1 - I_y\right)\right) \qquad \text{(Equation 6)}$$

When secondary index is in a "high" state ($S_y > H$):

$$PSC_{y+1} = X\left(1 - a\left(1 - \left(I_y + m_H(S_y - H)\right)\right)\right) \qquad \text{(Equation 7)}$$

Where $m_L$and m_H are multipliers that determine the rate of change of the PSC in proportion to the primary index when the secondary index is in a "low" or "high" state, respectively. The parameters L and H are the threshold values (breakpoints) determining values above or below which the secondary index (S_y) is considered to be in a high or low state, respectively. For example, if L could be specified as the value of the secondary index when it is is 50% below its average value ($L = 0.5$), such that whenever the secondary index is below L, the multiplier m_L will be applied, which will reduce the PSC limit to a value that is lower than it would be if using Equation 6 (no multiplier is applied). The magnitude of the reduction in PSC that occurs as a result of m_L is determined both by the value of m_L and the difference between the secondary index value and the chosen breakpoint (L). A secondary index value just below the breakpoint will lead to a smaller reduction in PSC than a secondary index value far below the breakpoint. The essence of the rule is that it is adding an additional amount of PSC in the proportion of m_H to the percent the secondary index is above the threshold and subtracting an amount of PSC in proportion of $m_L$to the percent the secondary index is below the lower threshold (L). If it is desired for the PSC to drop dramatically as the secondary index declines below the threshold, a value of m_L greater than 1 could be used. Conversely, if it was desired to only have a subtle effect of the secondary index on the PSC, a value of m_L close to zero could be chosen. For example, it may never be desirable to have the PSC limit increase faster than the primary index, even in a high state, which could be done by setting m_H to zero. Using these equations allows for the use of any default value of a for when the stock is in a "medium" state and a change in status of the secondary index can be used to influence the control rule in a continuous way (Figure A2.4, A2.5). An additional example of using a less responsive proportionality constant (a = 0.5) is shown in Figure A2.6. Except for Figure A2.6, the examples are using the parameters in Table A2.2.

Choosing the multiplier values for Alternative 6

In the section “Comparison of Alternatives,” all examples assume $a = 1$. Values of m_L and m_H were chosen such that a particular percent difference between the secondary index value and its breakpoint (whether above the upper breakpoint H or below the lower breakpoint L) would lead to the same percent difference (positive or negative) in the PSC limit from what it would have been without the application of a multiplier effect applied (i.e. if PSC were calculated from Equation 6). We can describe this desired property in equations to determine the relationship between m_L and m_H that would be needed to achieve it. Simplifying by assuming $a = 1$ and d is the difference between the secondary index and the breakpoint ($d = S_y - H = -(S_y - L)$), we have a system of two equations:

$$(1+p)\left[X\left(1-\left(1-I_y\right)\right)\right] = X\left(1-\left(1-\left(I_y + m_H(d)\right)\right)\right) \qquad \text{(Equation 8)}$$

$$(1-p)\left[X\left(1-(1-I_y)\right)\right] = X\left(1-\left(1-\left(I_y + m_L(-d)\right)\right)\right), \qquad \text{(Equation 9)}$$

where p is the proportion of change in PSC limit that occurs as a result of applying a multiplier in the context of a Equation 5 or 7 (Alternative 6 when the secondary index is in a “high” or “low” state). Solving for m_H leads to the result that m_H=m_L. Therefore, in all of the examples presented in this discussion paper, we choose m_H=m_L.

One difficulty is that the multipliers for Alternative 6 have a different meaning than those used for Alternative 4. The Options for Element 6 refer to Alternative 4 multipliers. Choosing multipliers to compare Alternatives 4 and 6 in the “Comparison of Alternatives” section requires making an arbitrary choice about how Alternative 4 multipliers will relate to Alternative 6 multipliers. Alternative 4 and 6 already lead to the same PSC limits when the secondary index is in a “medium” state. When the secondary index is in a “low” or “high” state, we chose for Alternative 6 PSC limits to equal those for Alternative 4 when: (1) the secondary index was 50% above or below its average value, (2) the low and high breakpoints used are 25% below and above the average value for the secondary index, respectively, and (3) the primary index is equal to 1 (its 2016 value). In all of our examples, we chose Alternative 4 breakpoints that would lead to the same proportional effect *(p)* on the PSC limit when above or below the breakpoint, such that $m_{L(Alt4)} = 1-p$ and $m_{H(Alt4)} = 1+p$. We then find m (where m=m_H=m_L) such that:

$$(1+p)X\left(1-\left(1-I_y\right)\right) = X\left(1-\left(1-\left(I_y + m(1.5\bar{S} - 1.25\bar{S})\right)\right)\right), \qquad \text{(Equation 10)}$$

where $\bar{S}$ is the average value of the secondary index over the years 1998-2016; the secondary index is already standardized to its mean value (as described earlier in Appendix II), and therefore $\bar{S} = 1$. Simplifying, and dropping the starting point from both sides of the equation,

$$(1+p)\left(1-\left(1-I_y\right)\right)=\left(1-\left(1-\left(I_y+0.25m\right)\right)\right), \qquad \text{(Equation 11)}$$

and further simplifying,

$$(1+p)I_y=\left(I_y+0.25m\right), \qquad \text{(Equation 12)}$$
$$I_y+pI_y=I_y+0.25m, \qquad \text{(Equation 13)}$$
$$pI_y=0.25m, \qquad \text{(Equation 14)}$$

which leads to the result that $m=m_L=m_H=pI_y/0.25=p/0.25$ when $I_y=1$. The values for the default and alternative value are shown in Table A2.1 and in Figure A2.1. This exercise shows the difficulty in creating scenarios for Alternatives 4 and 6 that are directly comparable.

Table A2.1. The values used to achieve the same outcomes with Alternative 4 and 6, when the secondary index is at 50% above or below average.

	Option 1 (default)			Option 2		
Multiplier	m_{alt4}	p	m_{alt6}	m_{alt4}	p	m_{alt6}
Lower	0.5	0.5	2.0	0.9	0.1	0.40
Upper	1.5	0.5	2.0	1.1	0.1	0.40

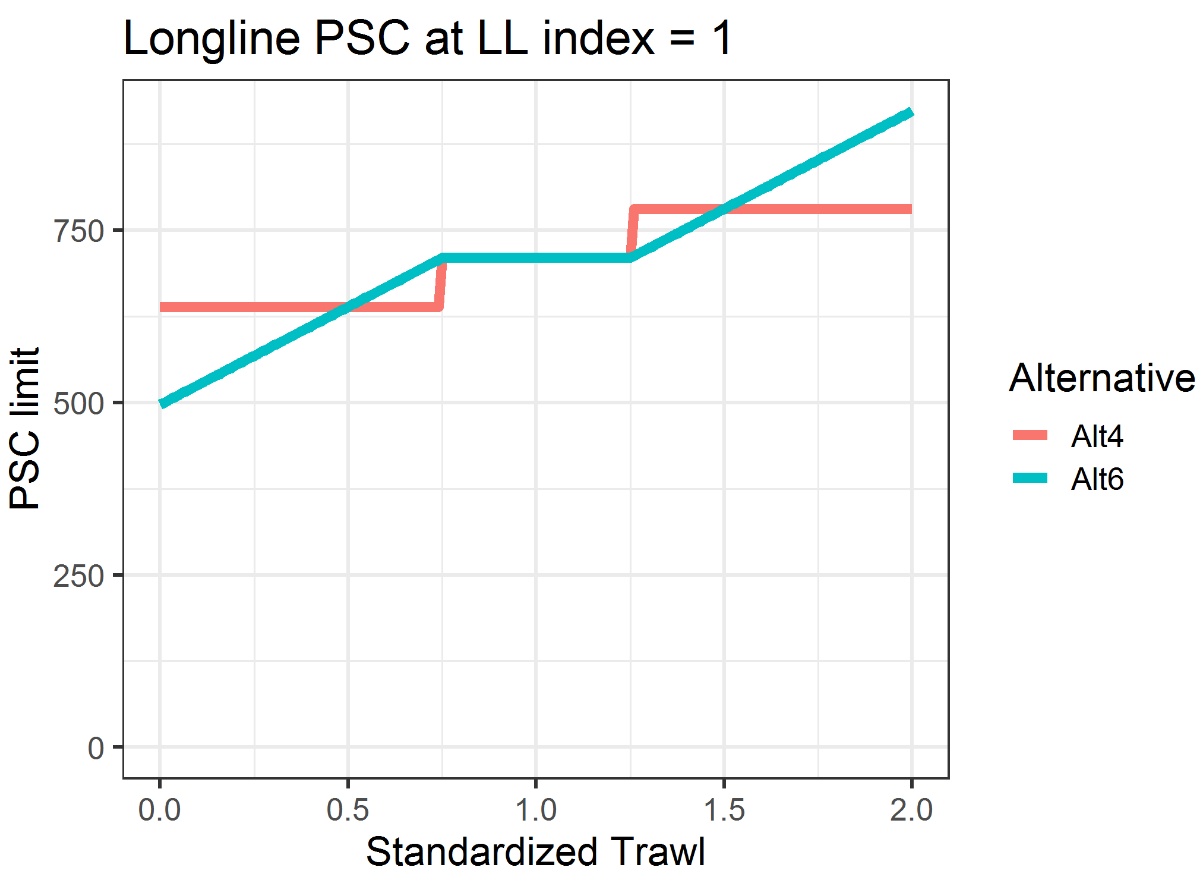

Figure A2.1. Longline PSC limits when multiplier values are used to achieve the same outcomes with Alternative 4 and 6, when the secondary index is at 50% above or below average. In this case the multipliers are 0.9,1.1 for Alternative 4 and 0.4 for Alternative 6.

Examples:

Table A2.2. Parameter values used in figures below.

Parameter	Value	Description
X	2793	starting point (standardized to 2016)
a	1.0	Slope
L	0.75	Secondary index “low” cutoff
H	1.25	Secondary index “high” value
m_L ***(Alt 6)***	0.2	Multiplier when secondary index is below ***L***
m_H ***(Alt 6)***	0.2	Multiplier when secondary index is above ***H***
m_L ***(Alt 4)***	0.9	Multiplier when secondary index is below ***L***
m_H***(Alt 4)***	1.1	Multiplier when secondary index is above ***H***

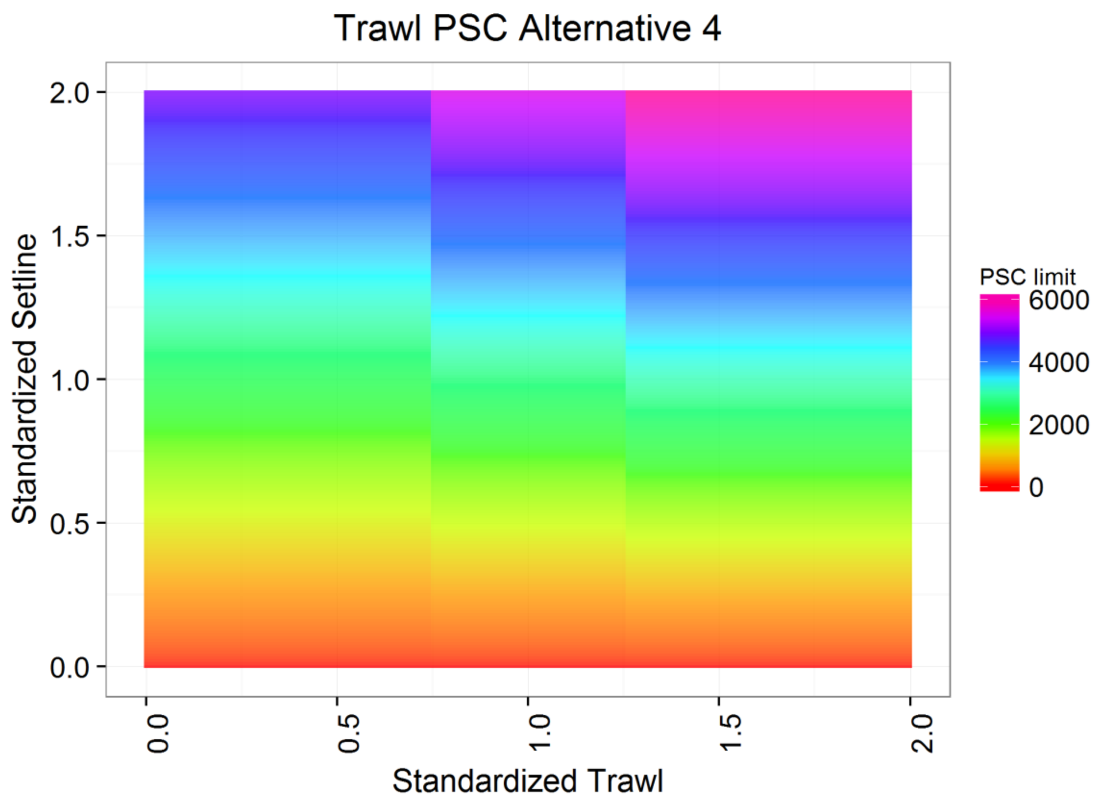

Figure A2.2. Trawl PSC limits for the Alternative 4 multidimensional control rule

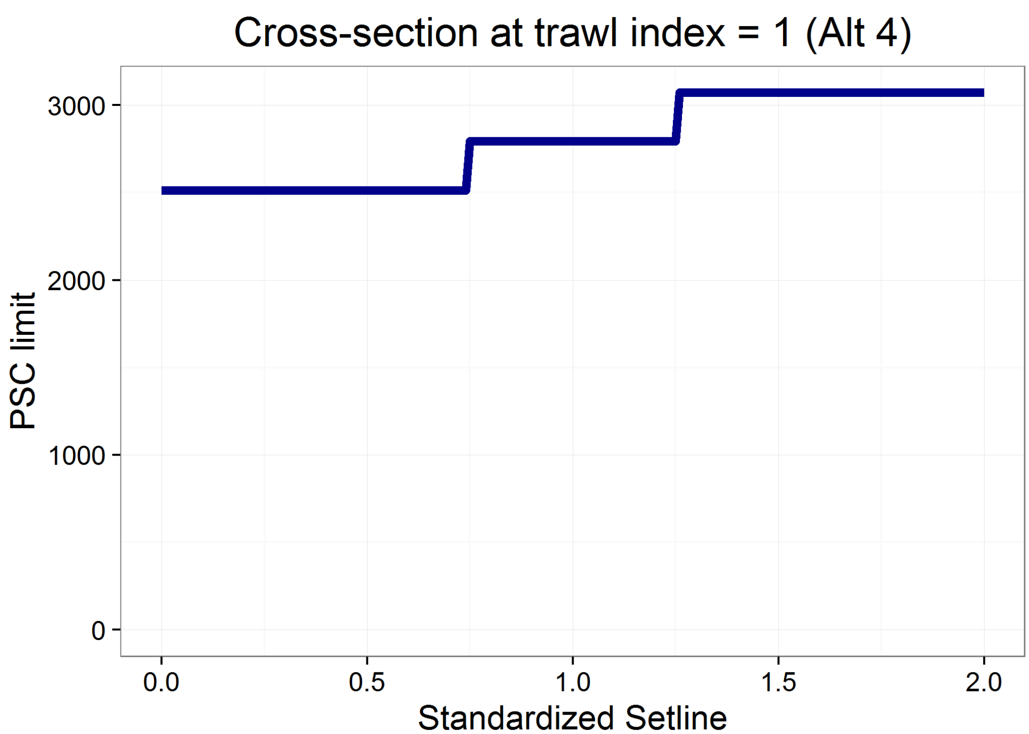

Figure A2.3. Trawl PSC limit when the trawl index is at 1 over the range of the setline index.

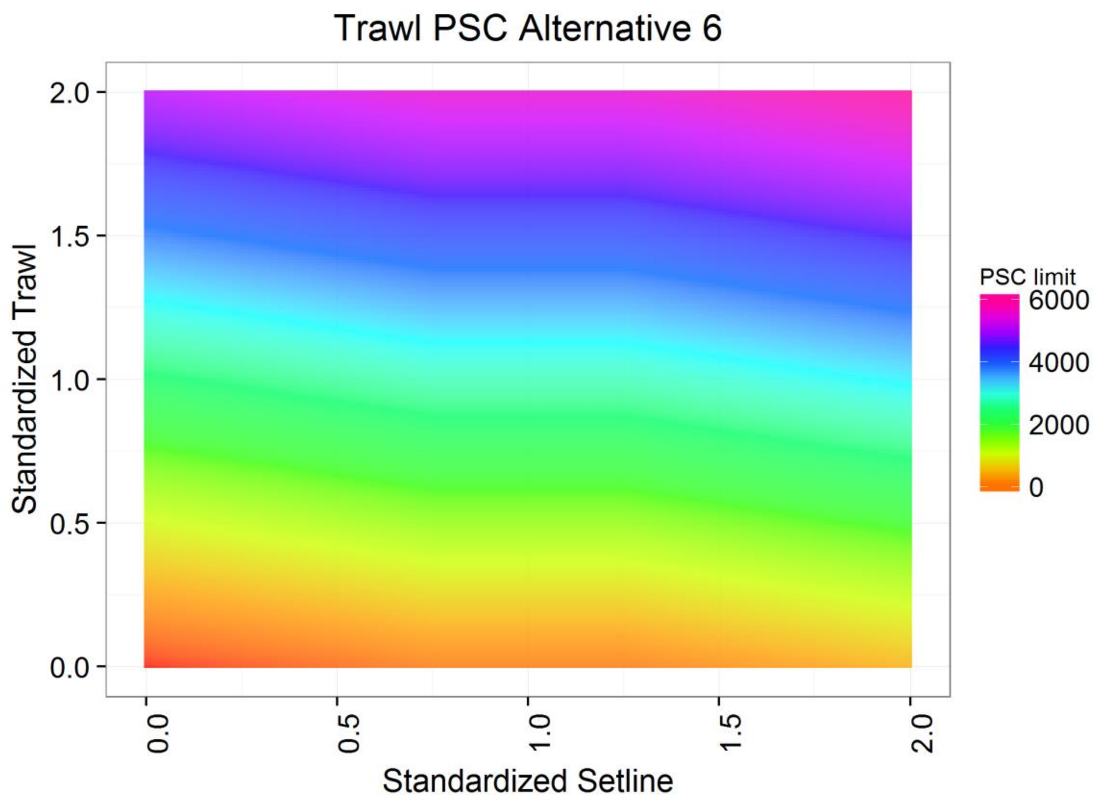

Figure A2.4. Trawl PSC limits for the Alternative 6 multidimensional control rule

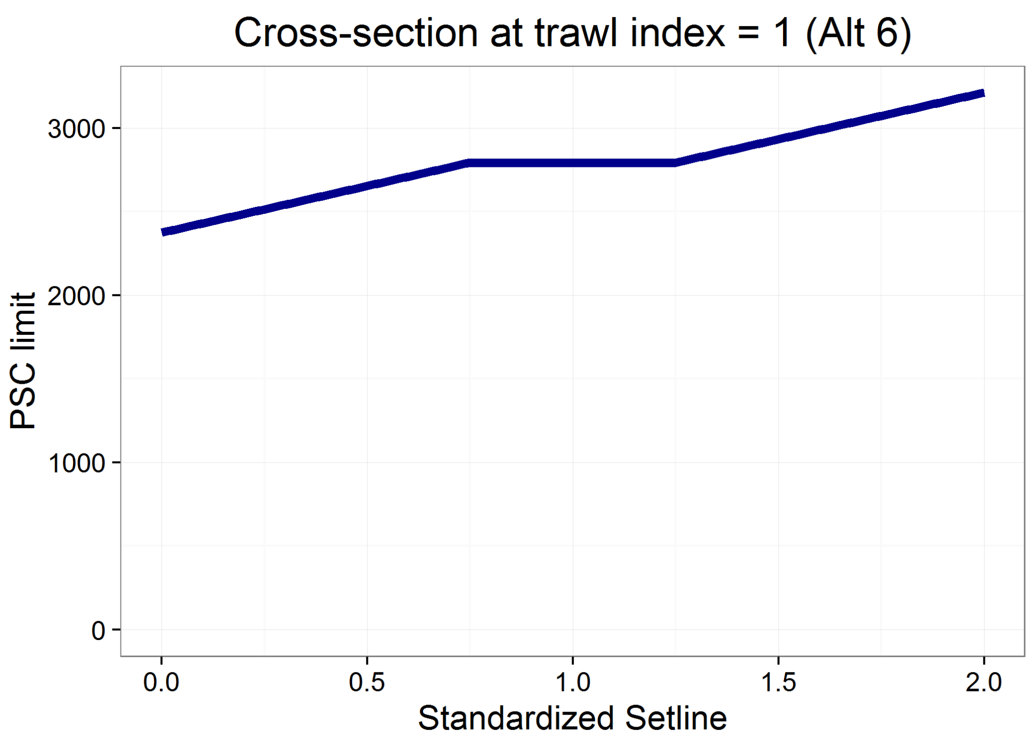

Figure A2.5. Trawl PSC limit from Alternative 6 when the trawl index is at 1 over the range of the setline index.

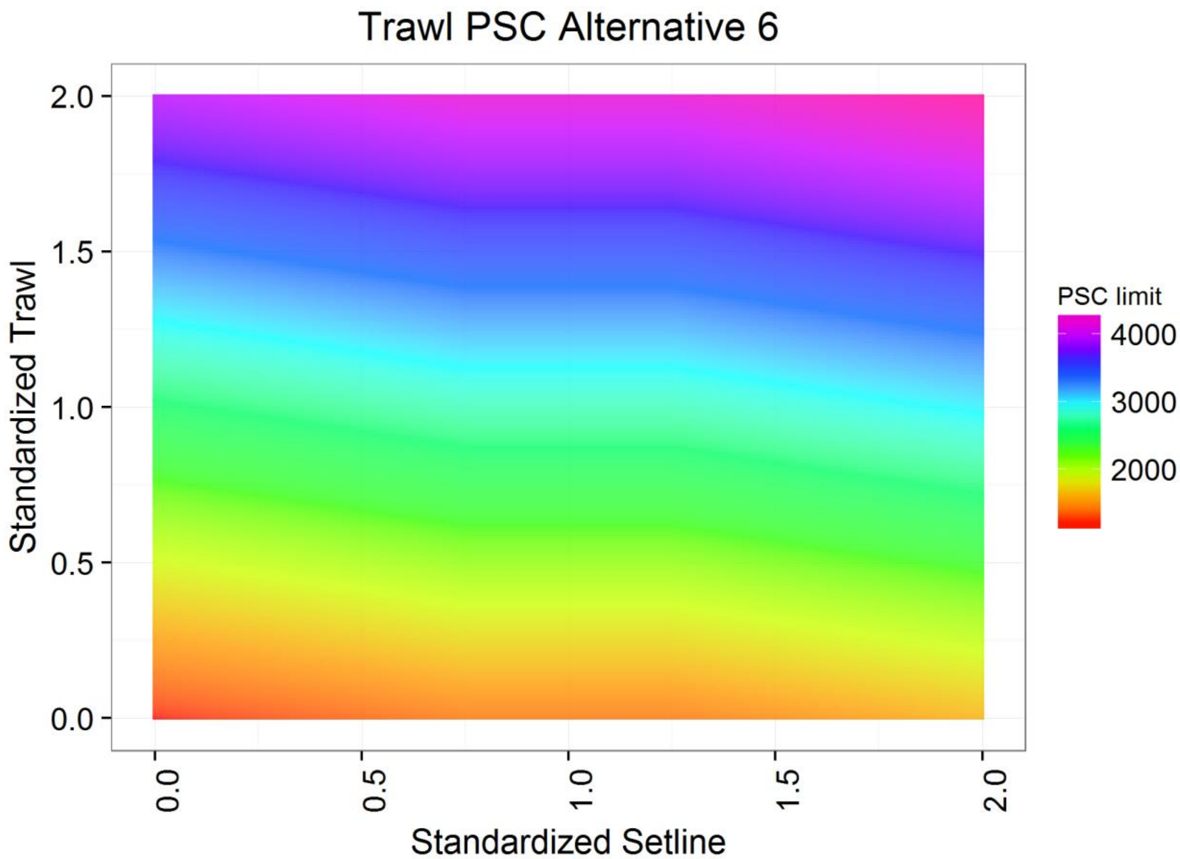

Figure A2.6. Alternative 6 with a proportionality constant (a) = 0.5. Note that the scale is different from that in Figure 3.

Appendix 3. Council motion from April 2018

D1 Halibut Abundance Based Management
Council Motion - April 8, 2018

The Council initiates analysis of the following alternatives (No changes have been made to the purpose and need statement).

Alternative 1: No action

Alternative 2: Index trawl PSC to EBS trawl survey biomass. Index longline PSC to setline survey biomass.

Alternative 3 (former ABM 4): Index trawl gear PSC and fixed gear PSC to both EBS trawl survey (primary index for trawl, secondary index for longline) and setline survey (primary index for longline, secondary index for trawl). The secondary index modifies a multiplier on the starting point of the control rule when the secondary index is in a "high state" or a "low state" (e.g., the PSC is multiplied by 1.1 when the secondary index is at a "high" value and by 0.9 when the secondary index is a "low" value).

Alternative 4 (former ABM 4): Index trawl gear PSC and fixed gear PSC to both EBS trawl survey (primary index for trawl, secondary index for longline) and setline survey (primary index for longline, secondary index for trawl). The secondary index modifies the multiplier on the final PSC limit after the primary index is applied when the secondary index is in a "high state" or a "low state" (e.g., the PSC is multiplied by 1.1 when the secondary index is at a "high" value and by 0.9 when the secondary index is at a "low" value).

For each alternative above the slope of the control rule is fixed at a value of 1.0

The following elements and options are exclusive to Alternatives 2-4

Element 1 – PSC limit responsiveness to abundance changes
Option 1: PSC limit varies no more than 5% per year
Option 2: PSC limit varies no more than 15% per year
Option 3: PSC limit varies no more than 25% per year

Element 2 – Starting point for PSC limit
Option 1. 10% below 2016 PSC use (2,119 t)
Option 2. 2017 use (1,958 t)
Option 3. Average of 2016 PSC use and limit (2,935 t)
Option 4. 2016 PSC limit (3,515 t)

Element – Maximum PSC limit (ceiling)
Option 1. 2016 PSC limit (3,515 t)
Option 2. 2015 PSC limit (4,426 t)
Option 3. No ceiling

Element 4 – Minimum PSC limit (floor)
Option 1. No floor (PSC goes to 0)
Option 2. 2016 use (2,354 t)
Option 3. ½ of 2016 PSC limit (1,758)
Option 4. PSC limit is zero at IPHC 20% Coastwide stock status (or proxy)

Element 5 – High and low values for secondary index (Only applies to Alternatives 3 and 4)
Option 1. High = 2nd highest value of time series, Low = 2nd lowest value of time series
Option 2. Index is 25% below or above average
Option 3. Index is above or below average

Element 6 – Multiplier for secondary index (only applies to Alternative 3 and 4)
Option 1. High = range of 1.1 to 1.5
Option 2. Low = range of 0.5 to 0.9
Option 3. Other high, medium and low ranges to be selected between 0.5 and 1.5

Alternative 5: Index fixed gear PSC to combination of IPHC Area 4 all sizes survey and EBS shelf trawl survey. BSAI fixed gear PSC limit is presented in a look-up table based on halibut abundance from the IPHC Area 4 setline survey and the EBS trawl survey.

The following elements are exclusive to Alternative 5

Element 1 – PSC limit responsiveness to abundance changes
A reduction (options 25-50%) in the EBS halibut index for either survey triggers a reduction from the existing cap to the floor. Also, SB 20 coastwide halibut control rule (or proxy) triggers going to the floor (independent of the two surveys).

Element 2 – Starting Point
Option 1. 2016 limit (710 mt)
Option 2. 10% below 2016 limit (639 mt)
Option 3. 20% below 2016 limit (568 mt)
Option 4: 2016 PSC use (205 mt).

Element 3 – Maximum PSC limit (ceiling)
Option 1. 2015 PSC limit (833 mt)
Option 2. 2016 PSC limit (710 mt)
Option 3. Option 3. No ceiling

Element 4 – Minimum PSC limit (floor)
Option 1. 2002-2016 avg. PSC use = 462 mt
Option 2. 50% of 2016 PSC limit = 355 mt
Option 3. PSC limit is zero at SB 20% Coastwide stock status (or proxy)

In this analysis, the Council also tasks staff to evaluate the following items, and other comments from the SSC as practicable:

- *Time series of the indices used*. Provide the Council biological considerations for selecting the baseline years for the index, as described by the SSC.
- *Index values for high, medium and low*. In Alternatives 3 and 4 a secondary index may modify the PSC limit based on the secondary index being high, medium or low. The Council request a biological basis for determining when an index is high or low, as well as guidance on how to the response associated with each value.
- *Alternative PSC limits*. A small number of fixed PSC values should be included in the analysis to allow investigation of the performance of ABM alternatives relative to differences in the scale of the starting points, as outlined by the SSC.
- Evaluate using a 3-5 year rolling average of PSC limits, as described by the SSC.
- Consider how to allocate CDQ PSC between fixed gear and trawl gear.
- Describe the steps and process that produces the EBS trawl IPHC survey index values.