BSAI Halibut Abundance –based PSC discussion paper April 2016

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EXECUTIVE SUMMARY

The Halibut Abundance-Based Prohibited Species Catch (PSC) Workgroup (Workgroup) comprised of Council, NMFS, and IPHC staff met on March 3, 2016 to consider the information and approach needed to establish abundance based halibut PSC limits. Based on Council guidance, the Workgroup focused on the Bering Sea and Aleutian Islands Management Area (BSAI) and reviewed: (1) the current status of Halibut PSC limits and use in the BSAI; (2) indices that may be available to assess the abundance of halibut and the potential strengths and limitations of those indices to setting an abundance based halibut PSC limit; (3) general types, or models, that could be used to set abundance-based halibut PSC limits; (4) different types of control rules that could be used to establish halibut PSC limits (e.g., "stair-step" PSC limits with or without "floors" or "ceilings"); and (5) described the types of policy decisions that the Council would need to consider as this effort progresses. This paper identifies some areas where Council input would be helpful before proceeding, provides a preliminary work schedule, and presents some ideas and data evaluations that were further developed by individual Workgroup members after the Workgroup met.

1 INTRODUCTION

The Council is examining abundance-based approaches because current halibut PSC limits are a fixed amount of halibut mortality in metric tons. 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.

While establishing abundance-based halibut PSC limits is an intuitive approach to managing halibut bycatch, the Council realizes that establishing appropriate limits is challenging because of complex Pacific halibut population and fisheries dynamics and the difficulties and uncertainties involved in assessing the spawning biomass of the coastwide Pacific halibut stock. As such, it is clear that any evaluation of impacts due to bycatch on the status of the halibut stock as a whole will be highly uncertain as will impacts on directed Pacific halibut fisheries.

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 (Amendment 111), the Council also requested that requested that Council and IPHC staff evaluate possible approaches to link BSAI halibut PSC limits to data or model-based abundance estimates of halibut in a discussion paper. The Council recommended that the SSC also review this paper.

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., 2015). This paper was presented to the AP and the Council at the December 2015 Council meeting[1]. The SSC was not able to review the paper at that time. After reviewing this discussion paper in December 2015 the Council made the following motion:

> *"The Council initiates a workgroup with Council, NMFS, and IPHC staff to identify and evaluate alternative methods to index halibut PSC limits based on halibut abundance (yield). The workgroup should describe potential data and management advantages and challenges provided by alternative methods to index halibut PSC limits based on halibut abundance. The workgroup should also evaluate the effects of various assumptions on an abundance based approach, such as those related to natural mortality (by size and age), growth rates, size composition of PSC by sector, and the long-term potential spawning capital of juvenile halibut with the goal of returning abundance-based recommendations back to the Council as soon as possible."*

In making its December 2015 motion, the Council reiterated its intent that this discussion paper be focused on abundance based approaches for halibut PSC in the BSAI. This discussion paper was drafted in response to the Council's request. Members of the Workgroup[2] met by teleconference and in-person to discuss on-going and potential analyses that would inform the Council as to potential abundance indices, to summarize and discuss the items noted in the Council motion and to provide the draft recommendations contained within this paper. To the extent relevant, further discussion items noted by the Council and members of the public in conjunction with the Halibut Management Framework review at the February 2016 Council meeting are also referenced here

1.1 Summary of Workgroup Recommendations

1.1.1 Pacific halibut data and abundance indices

The Workgroup evaluated the pros and cons of the available Pacific halibut data. The indices, described in further detail in Section 2 include: 1) the results from the annual IPHC coastwide stock assessment, 2) the NMFS Eastern Bering Sea bottom trawl survey (shelf and slope), 3) an index combining data from three surveys: the NMFS Eastern Bering Sea bottom trawl survey, the IPHC setline survey, the AFSC Bering Sea longline survey, and 4) an integrated model-based index that utilizes the IPHC stock assessment and incorporates additional empirical information as applicable.

[1] 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

[2] Workgroup members include: AFSC: Jim Ianelli, Carey McGilliard and Dana Hanselman; IPHC: Bruce Leaman; NOAA AKRO: Rachel Baker; NPFMC: Diana Stram. Additional participants in discussions and review include: Chris Oliver, David Witherell, Glenn Merrill, Steve Martell and Kotaro Ono.

1.1.2 Halibut PSC Control Rule and Council decision points

The Workgroup discussed potential options for developing a control rule for BSAI halibut PSC limits (i.e., how the PSC limits would change in response to changes in the adopted halibut abundance index or indices). The Workgroup reviewed the types of PSC control rules established for other fisheries and considered identifying candidate control rules (see Section 3). After further discussion, the Workgroup noted that some of the identified methods could be more or less practicable, depending on the goals of the PSC limit and methods for assessing bycatch. They also noted that developing a control rule will be an iterative process and that specification of performance indicators and objectives would be important prior to evaluating any candidate control rule. **The workgroup recommended that feedback from the SSC and Council on approaches to specifying candidate control rules and performance indicators would be valuable.**

1.1.3 Workplan for Council analysis

The Workgroup discussed the development of the analysis for this action in terms of information that would be needed. Additional information include issues identified in the December 2015 Council motion, SSC recommendations from its June 2015 review of the Amendment 111 EA/RIR/IRFA, evaluation of halibut discard mortality rates (DMRs) in the groundfish fisheries by a staff workgroup, and Management Strategy Evaluations by the IPHC and staff at the Alaska Fisheries Science Center (AFSC). **The Workgroup agreed that a thorough evaluation of the management and fishery impacts is needed so that the Council has the information to determine whether abundance-based Pacific halibut PSC limits would better meet management objectives compared to the status quo approach.**

1.2 Current BSAI Halibut PSC Limits

Amendment 111 to the BSAI FMP applies BSAI halibut PSC limits to four fishery sectors. Amendment 111 was recommended by the Council in June 2015, and was implemented in 2016. The four fishery sectors and halibut PSC limits are described in the following table.

	Current PSC limit	PSC limit reduction	New PSC limit
Amendment 80 cooperatives	2,325 t	-25%	1,745 t
BSAI trawl limited access fisheries	875 t	-15%	745 t
Longline fisheries	833 t	-15%	710 t
CDQ fisheries	393 t	-20%	315 t
TOTAL	4,426 t	-21%	3,515 t

The PSC limits since 2008, and the Pacific halibut mortality estimates (and ratio relative to limits) by sector are shown in Tables 1 and 2, respectively.

Table 1. Evolution of Pacific halibut PSC limits by main sectors in the BSAI region, 2008-2016.

	Am80	BSAI TLA	Longline fisheries	CDQ	Total PSC limit
2008	2,525	875	833	343	4,576
2009	2,475	875	833	343	4,526
2010	2,425	875	833	393	4,526
2011	2,375	875	833	393	4,476
2012	2,325	875	833	393	4,426
2013	2,325	875	833	393	4,426
2014	2,325	875	833	393	4,426
2015	2,325	875	833	393	4,426
2016	2,325	875	833	393	4,426
2016[+]	1,745	745	710	315	3,515

Table 2. Pacific halibut mortality estimates (top rows) and mortality relative to the limits (bottom rows) by sector for 2008-2016.

	Am80	BSAI TLA	Longline fisheries	CDQ	Total PSC mortality
2008	1,869	838	593	215	3,515
2009	1,985	815	597	155	3,552
2010	2,154	584	526	162	3,426
2011	1,722	717	498	243	3,179
2012	1,890	1,012	570	272	3,744
2013	2,089	784	471	266	3,611
2014	2,106	717	408	247	3,478
2015	1,362	527	299	130	2,318
	Am80	**BSAI TLA**	**Longline fisheries**	**CDQ**	**% of Total PSC limit**
2008	74%	96%	71%	63%	77%
2009	80%	93%	72%	45%	78%
2010	89%	67%	63%	41%	76%
2011	72%	82%	60%	62%	71%
2012	81%	116%	68%	69%	85%
2013	90%	90%	57%	68%	82%
2014	91%	82%	49%	63%	79%
2015	59%	60%	36%	33%	52%

2 DATA SOURCES FOR USE IN DERIVING AN ABUNDANCE INDEX

Data on Pacific halibut in the eastern Bering Sea is extensive. Annual bottom trawl surveys are used reasonably successfully to index abundances of 22 groundfish stocks and 6 crab stocks. As such, it should provide reasonable information on some components of Pacific halibut living in the Bering Sea. A list of available data for consideration includes:

- AFSC observer data
- AFSC EBS shelf bottom trawl survey (relative numbers or biomass)
- AFSC EBS slope bottom trawl survey (relative numbers or biomass)
- AFSC longline survey (relative numbers)

- IPHC setline survey (relative numbers)
- IPHC assessment results

The data sources listed here are all active for the period 1997-2015. In odd years, all three AFSC surveys are available while in even years the AFSC longline survey is missing. Size composition data is also available for both the EBS trawl survey as well as the IPHC setline survey.

Empirical observations (set line or trawl) from the current year or years could be used as indices to set PSC limits for the following fishing season. The following sections discuss the available data and indices:

2.1.1 AFSC observer data

The workshop highlighted the need to correct for the Pacific halibut bycatch individual measurements to account for when and where the actual bycatch occurred (the length samples are out of proportion to the gears and locales where bycatch occurs). This is important since comparisons between survey indices and bycatch patterns are required (and to better account for SPR and selectivity factors by gear types).

As such, after the workshop staff explored appropriate strata and settled on 16 partitions: 2 gear types (fixed and trawl), 4 quarters of the year, and 2 areas. Figures 1 and 2 show the distribution of measurements compared to the report Pacific halibut bycatch, respectively. These estimates were then used along with a proxy length-weight for computing the ratio of weight of fish measured within each strata to the proportion of bycatch (in biomass) within the same strata so that the observations on length frequencies can be appropriately summed to account for disproportional sampling. The coefficients for the length-weight relationships for this process was assumed constant over all years and areas. It should be noted that previous analyses (including those conducted by the IPHC) using NMFS observer data on raw length frequencies should be updated with these (or similarly corrected) estimates of bycatch length frequencies (by gear type). Development of a standard protocol to provide overall PSC length frequency estimates would be useful.

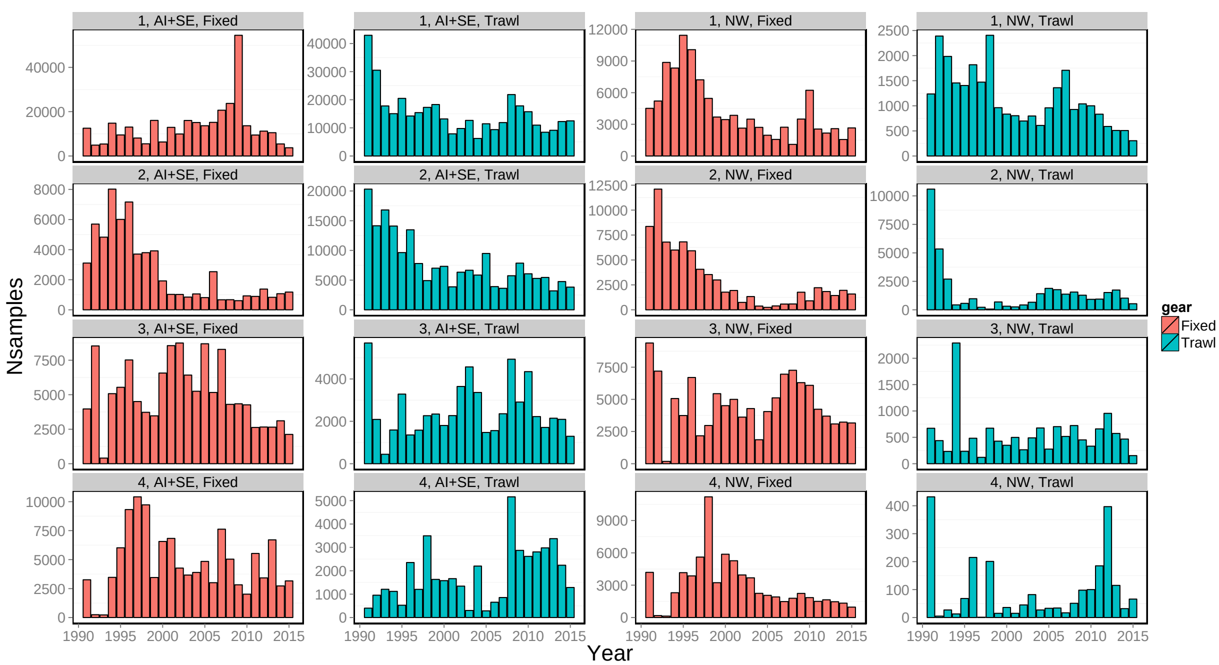


Figure 1. Catch-weighting strata definition evaluation of observer sample sizes by year (number of fish, horizontal axes), quarter (rows), and region + gear combinations (columns). Note that the vertical scale on each plot varies.

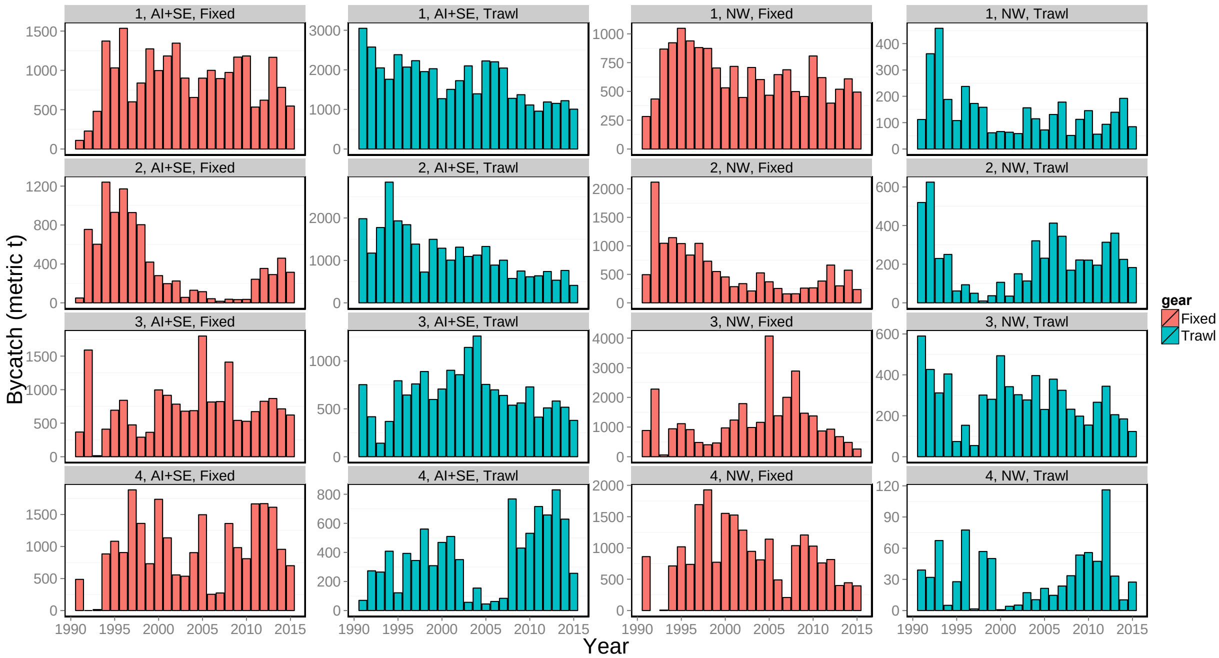


Figure 2. Pacific halibut bycatch by year and strata by quarter (rows) and region + gear combinations (columns). Note that the vertical scale on each plot varies.

2.1.2 AFSC EBS trawl surveys

The National Marine Fisheries Service eastern Bering Sea shelf trawl survey has been conducted annually since 1979. The survey time series is useful for tracking some year classes of Pacific halibut as they move through the population and approach commercial size. However, there is generally a low or negative correlation of abundance in the BTS and either recruitment into the adult stock of halibut or lagged estimated abundance at age 0 (Martell et al. 2015). An IPHC field biologist has been deployed on the survey every year since 1998 to collect halibut samples. The IPHC operates a coastwide setline survey as 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. Therefore, in most years, the NMFS trawl survey is the only measure of relative abundance of smaller sizes of halibut for much of this area. The halibut data collection (including ages) and treatment by IPHC is described in: (http://goo.gl/JT6nVn) and the most recent report is here: http://goo.gl/AnJLem)

The EBS shelf trawl survey has different size-selectivity than setline gear, making it necessary to apply a selectivity curve to include these data directly in the halibut stock assessment generated by the IPHC. Because of both gear differences, and the depth limits of the survey, halibut are vulnerable to the trawl from about 20-85 cm fork length (FL), but a substantial portion of the commercial-sized population (O32 or > 81.3 cm FL) exceeds 85 cm. In 2006 and repeated in 2015, 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 trawl survey. The IPHC staff concluded that the trawl survey provided an adequate index of halibut biomass on the EBS shelf (Clark and Hare 2007, Webster 2015) and is a useful tool for constructing a density index for the IPHC stock assessment (Webster 2014, 2015[3]). In addition to a stock assessment tool, trawl survey information is useful as an indicator of U26 Pacific halibut that are subject to bycatch in the other groundfish fisheries. To a lesser extent, the information on younger Pacific

[3] http://www.iphc.int/publications/rara/2015/RARA2015_31EBScalibration.pdf

halibut in the EBS may have some limited ability (perhaps only for very strong cohorts) to forecast recruitment into the commercial Pacific halibut fishery.

The time series of survey data shows considerable variability in the average weight in the survey which is somewhat consistent with what's been observed in the fisheries (including foreign and joint venture period from 1982 onwards; Fig. 3). The time series of survey data shows a stable and increasing overall biomass whereas the relative abundance (in numbers of fish, scaled to have mean value of 1.0) showed a showed a sharp increase in 2006 followed by a subsequent decline back to the mean value (Fig. 4).

Relative to the NMFS EBS bottom trawl survey, the fishery bycatch (by trawl vessels) catches a similar size range but misses some of the smallest halibut observed in the survey (1991-2015; Fig. 5).

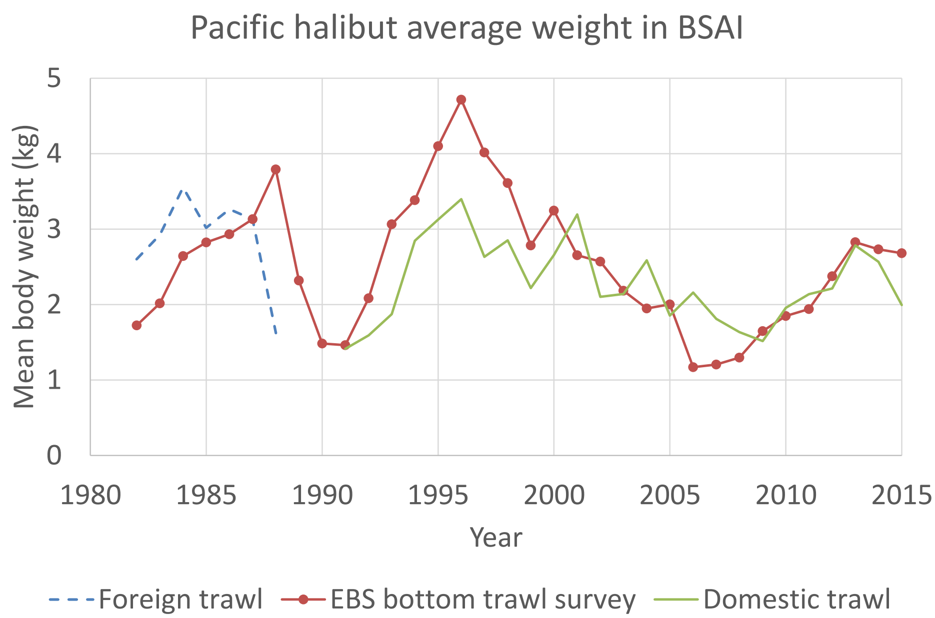


Figure 3. Estimated average weights in the fishery and bottom-trawl survey, 1982-2015. The correlation between the EBS bottom trawl survey and the Pacific halibut bycatch domestic trawl fisheries is 0.78.

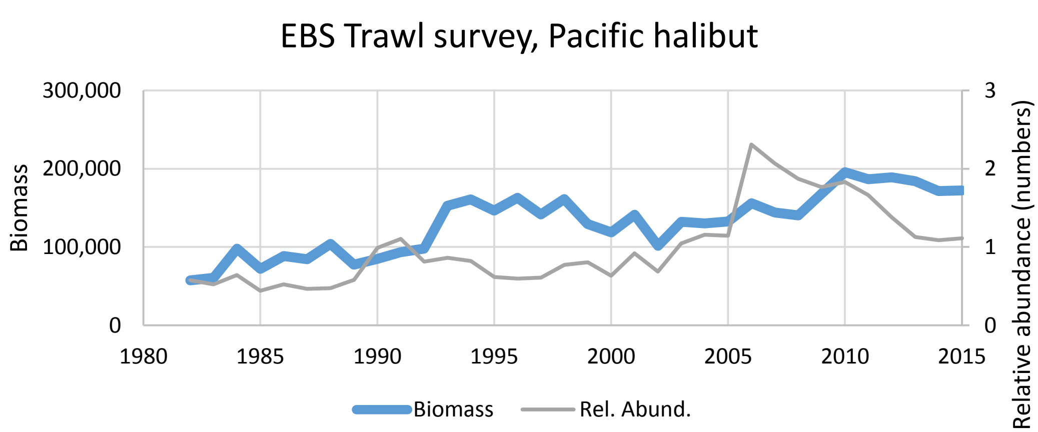


Figure 4. Biomass and relative abundance (in numbers) of Pacific halibut from the EBS bottom trawl survey, 1982-2015.

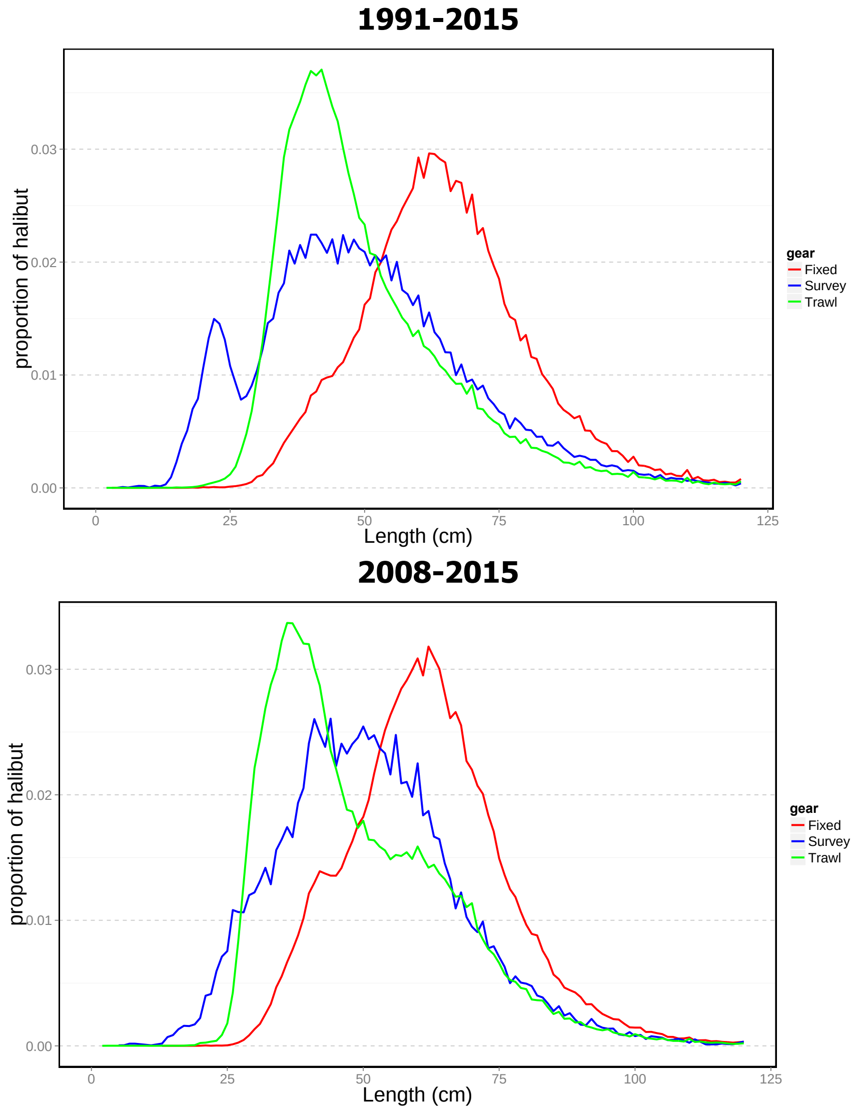


Figure 5. Trawl and longline fishery aggregate length frequencies for BSAI Pacific halibut compared to the bottom trawl survey length frequencies, 1991-2015 (top) and 2008-2015 (bottom).

2.1.3 AFSC EBS slope trawl surveys

This—typically biennial—survey covers the western region of the shelf down to 1,000 meters and may provide an index of Pacific halibut for corroboration with other data. The survey years and index results are shown in Fig. 6 and size compositions in Fig. 7. The average weights in the survey (along with the other estimates are shown in Table 3.

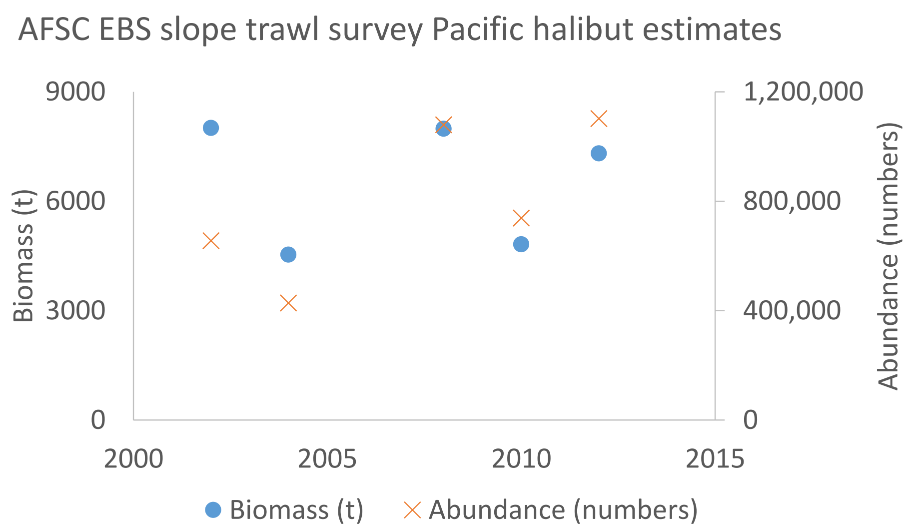


Figure 6. AFSC eastern Bering Sea **slope** bottom trawl survey biomass and abundance estimates, 2002-2012 (the next survey is planned for 2016).

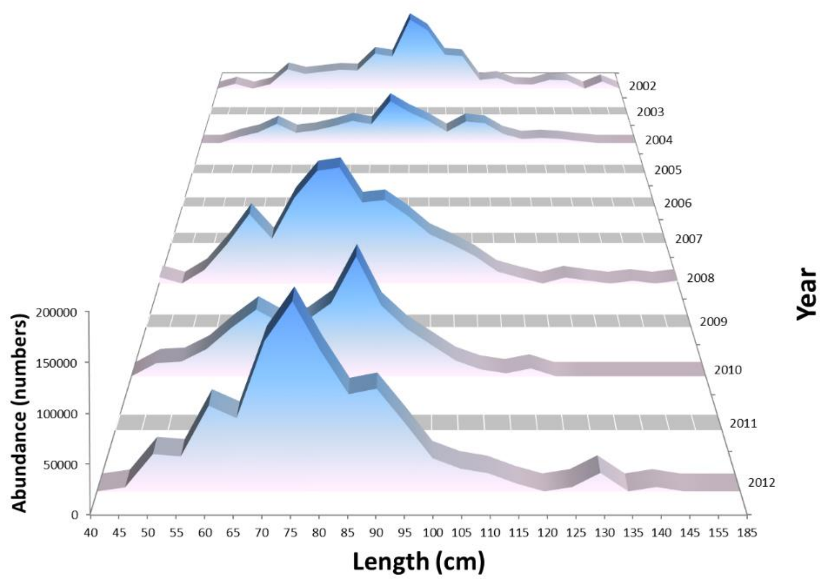


Figure 7. AFSC eastern Bering Sea **slope** bottom trawl survey population-at-length estimates, 2002-2012 (the next survey is planned for 2016).

Table 3. Biomass, abundance, and average weight estimates from the eastern Bering Sea **slope** bottom trawl survey.

	Biomass (t)	Abundance (numbers)	Avg wt (kg)
2002	8,004	655,153	12.22
2004	4,530	427,892	10.59
2008	7,985	1,079,208	7.40
2010	4,819	737,851	6.53
2012	7,308	1,101,379	6.64

2.1.4 AFSC Longline Survey

NMFS sablefish longline survey stations in the BS and AI are sampled every other year in May-June from 1997 – 2015, with the BS sampled in odd years and the AI in even years. Survey stations generally align with commercial longline fishing grounds along the continental slope and are systematically spaced approximately 30 - 50 km apart. In a given year, each station is fished for one day from shallow to deep (depths ranging from roughly 150 - 1000 m) using two sets hauled end to end. In the BS, each set consists of 90 skates (string of 45 hooks), providing a total of 180 skates (8100 hooks) fished per station. In the AI, 160 skates are fished per day. Hooks are spaced two meters apart and baited with squid. At each station, halibut catch and effort were collected. These data are used to derive annual estimates of relative population numbers (RPN, an abundance index). The RPN indices are computed across six depth strata (150-200 m, 200-300 m, 300-400 m, 400-600 m, 600-800 m, and 800-1000 m). Specifically, halibut CPUE data are computed for each station and depth stratum by dividing total catch by the number of effective hooks fished. CPUE data are then averaged across stations, multiplied by strata-specific habitat area sizes, and summed across depth strata.

2.1.5 IPHC Longline survey

The IPHC’s annual setline survey data and data from the directed fisheries are used as one component of the stock assessment. One option is to index halibut abundance to the annual International Pacific Halibut Commission (IPHC) halibut assessment. The IPHC completes the assessment in late November each year to incorporate as much fishery data from the current year as possible. Therefore, the halibut stock assessment would not be available for the BSAI groundfish harvest specifications cycle that begins with Plan Team meetings in September. The objective of the halibut stock assessment is to estimate the biomass of halibut over 26 inches in length (O26) that is available for harvest in the directed fishery. Some portion of halibut that are caught as bycatch in the groundfish fisheries are U26, The IPHC setline survey and directed fishery data provide information mainly on O26 halibut, and the IPHC must incorporate an estimated amount of U26 mortality in the stock assessment based on observed size compositions from their setline survey data.

2.1.6 Fishery data

An exploration of fishery data for halibut bycatch is provided in Appendix 2. The figures in the appendices show the patterns of (observed) effort by season and over time for longline and trawl gears in the BSAI. They also proceed to examine CPUE patterns relative to the number of hooks and duration of tows. Finally, there are a set of figures to examine the relative bycatch rates to target species by gear types and over time.

Understanding the gear types and the amounts of halibut caught as bycatch relative to target species is important background to understanding the impacts of any proposed abundance-based Pacific halibut PSC limits. For trawl gear, tow-by-tow data can be used to evaluate how species co-occur and a series of figures related to trawling and key flatfish species were provided to the Workgoup and is available as supplemental material. To summarize, patterns over time show clear shifts pre- and post-implementation of the Amendment 80 Program in 2008 for trawl gear. The species overlap is highest for yellowfin sole and northern rock sole which was confirmed by examining station-by-station data from the bottom trawl survey. Survey data also indicated a positive correlation between occurrence of yellowfin sole and northern rock sole was the highest (0.53) followed by correlation between arrowtooth flounder and flathead sole (0.39). Pacific halibut correlations with these species for trawl gear (on a summer survey station-by-station basis) were relatively low with the highest at 0.23 with northern rock sole (Fig. 8).

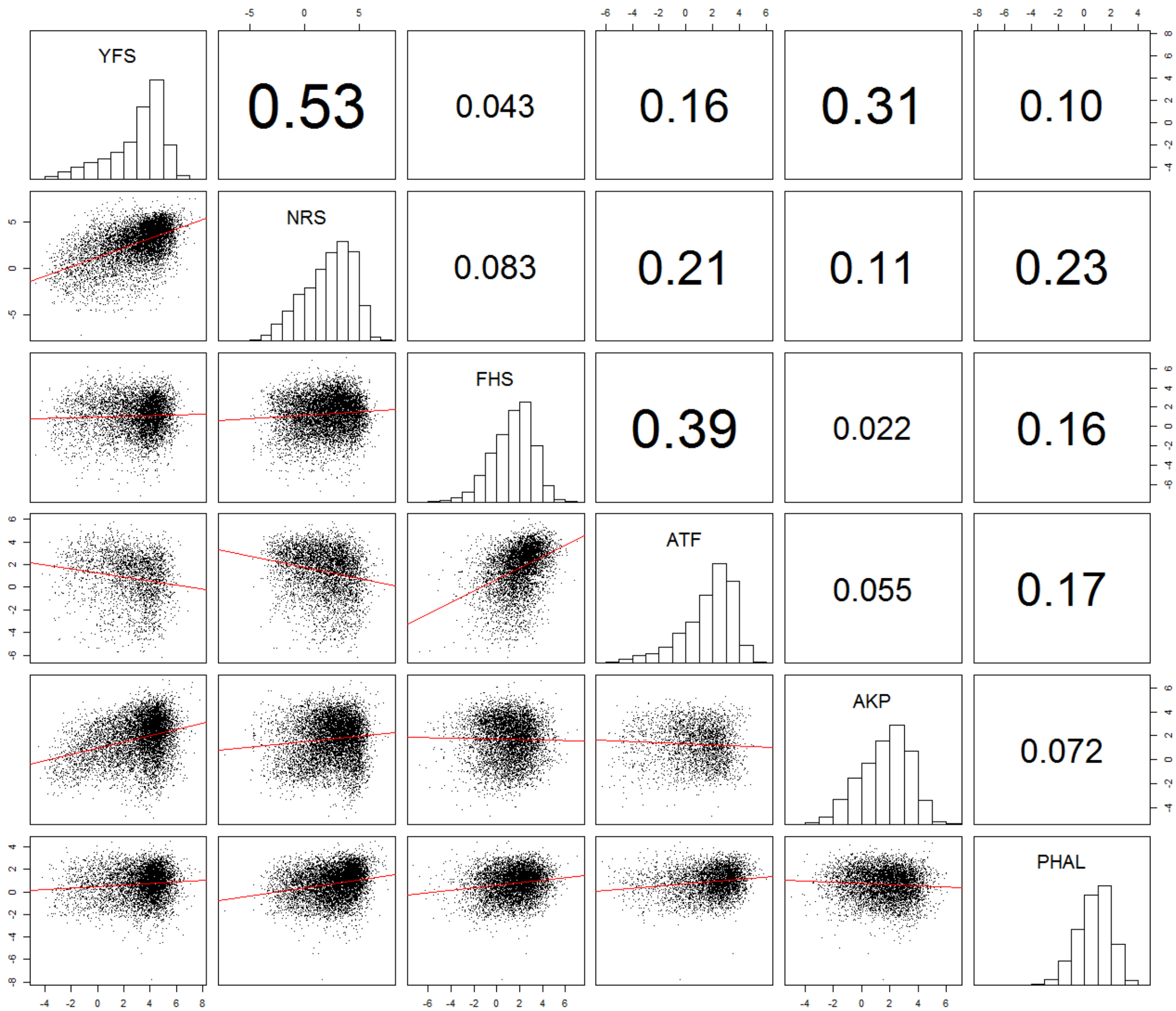


Figure 8. Pairwise plot of all EBS bottom trawl survey station non-zero log-densities for key flatfish species, 1982-2015. Numbers in upper cells represent correlation of the densities between diagonal species. For example, the bottom row vertical scale within each graph is for Pacific halibut whereas the horizontal scales correspond (from left to right most) densities of yellowfin sole, northern rock sole, flathead sole, arrowtooth flounder, and Alaska plaice. The histogram in the diagonal panels represent the distribution of non-zero log densities observed in survey tows.

Table 4 provides a summary of the data sources available for use in compiling and evaluating abundance information on Pacific halibut in the BSAI for use in indexing potential PSC limits, as well as strengths and limitations of these data sources.

Table 4. Summary of strengths and limitations of different data available for evaluating abundance based Pacific halibut PSC limits.

Data sources	Frequency of data collection	Strengths	Weaknesses
AFSC EBS bottom trawl survey (EBS BTS)	• Annual	• Size composition matches observed bycatch	• Mostly smaller Pacific halibut
AFSC EBS slope trawl survey	• Biennial	• May link shelf with older halibut	• Gear differs from EBS BTS •
AI Trawl survey data	• Biennial		• Limited halibut data
IPHC setline	• Annual	• Stations visited each year • Size composition similar to directed fishery • Calibrated w/EBS BTS twice, with same result	• Calibrated with EBS BTS • Limited area on EBS flats • Mostly larger Pacific halibut
BS AFSC longline survey	• Biennial	• Size composition similar to directed fishery	• Indexes larger Pacific halibut • Lengths unavailable
AI AFSC longline survey	• Biennial	• Size composition similar to directed fishery	• Indexes larger Pacific halibut • Lengths unavailable
Observer data	• Annual	• Comprehensive, especially post-2008 • May help form control rule	• Size composition needs to account for sampling versus catch
Commercial groundfish catch	• Annual	• Bycatch rates could inform policy decisions	• Bycatch per unit effort likely a poor measure of abundance (confounded with changes in behavior)

3 POTENTIAL ABUNDANCE INDICES

Given the available data as described, the group discussed the fundamental issues surrounding alternative indices. The local abundance of Pacific halibut that occurs in the eastern Bering Sea bottom trawl survey appears to have variable and weak relationship to the coast-wide Pacific halibut resource. Yet Pacific halibut tagging programs show that some proportion of fish of the sizes seen in the survey move from this region at older ages and thus the bycatch is reasonably considered as in interception fishery to some unknown degree. Therefore, the amount of Pacific halibut taken as BSAI bycatch should consider the “downstream” effects and current status of the (older) fishable (and mature) biomass of the coastwide resource. Local abundance of halibut in the Bering Sea should balance with Pacific halibut management goals. In addition to the available data as noted in the previous section, some alternative analyses and approaches using these data were discussed and presented.

3.1 IPHC ASSESSMENT

Currently the IPHC assessment provides projected biomass estimates from an ensemble of model alternatives that could be used to index PSC limits.

3.2 AFSC BOTTOM TRAWL SURVEY INDICES

Presently designed-based estimates of survey biomass and abundance can fail to account for differences in relative abundance due to spatial correlation and covariates such as bottom temperature and sediment type. Consequently, recent developments of an alternative index using the spatially disaggregated length-specific data was applied and presented to the workgroup. This geostatistical approach examined putative Pacific halibut age categories based on length groups which, when lagged by years showed reasonable consistency (Fig. 9) and lagged correlations (Table 5). This figure suggests in some periods and cohorts an increase length class 1 is followed by increases in length class (classes approximately split by ages 1, 2, 3…). However, beyond that the linkages are weak suggesting that this approach may fail to provide an obvious index for future older-age halibut abundances. A solution might be to fit an age-structured model to ascertain at least the relative selectivity of the mortality of EBS bycatch and survey abundance (for Pacific halibut on the shelf region).

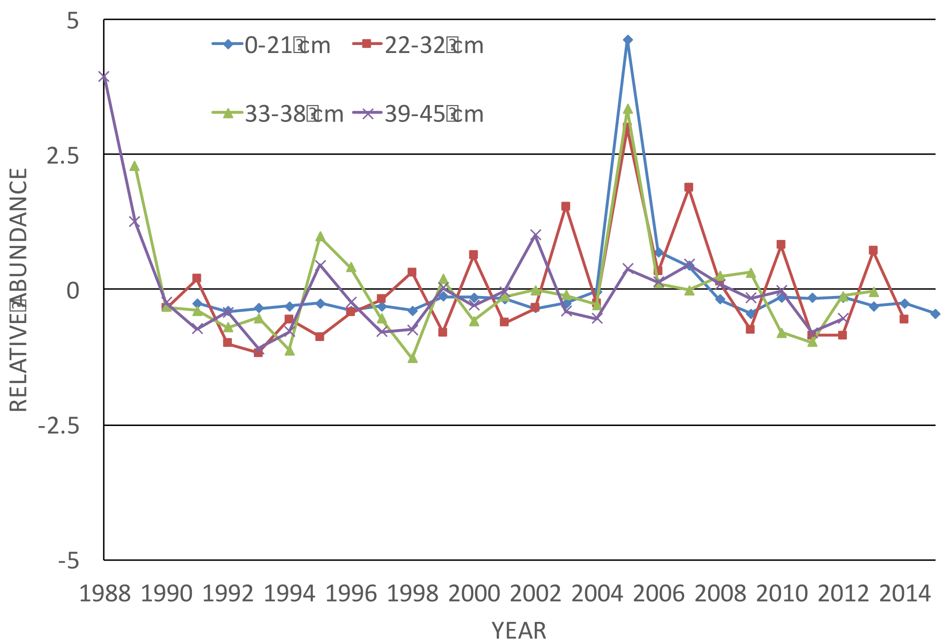


Figure 9. EBS Pacific halibut lagged relative abundance indices arising from the Delta-GLM (Ono et al. 2016) geostatistical model applied to 4 length categories: 0-21 cm, 22-31 cm, 32-38 cm, and 39-45 cm, 1991-2015.

Table 5. Correlation matrix of annually lagged abundance indices by length groups from four (one for each length group) independently run Delta-GLM geostatistical models (Ono et al. 2016).

	0-21 cm	22-31 cm	32-38 cm	39-45 cm
0-21 cm (lag 1)	1.000	0.708	0.816	0.335
22-31 cm (lag 2)	0.708	1.000	0.489	0.345
32-38 cm (lag 3)	0.816	0.489	1.000	0.565
39-45 cm (lag 4)	0.335	0.345	0.565	1.000

The geostatistical approach holds some promise as it seems to link coherent size classes over time which may correspond with halibut ages. These may help with providing insight on halibut abundance prior to entering the groundfish fisheries as bycatch.

3.3 Combined AFSC shelf and slope trawl + ABL LL survey + AI LL and trawl

An evaluation of a number of different surveys and trade-offs using abundance (in numbers of Pacific halibut) was discussed. The EBS bottom trawl survey was considered to be the most useful for the areas of primary bycatch because of its broad annual coverage and similar size composition to the bycatch in the fishery. The IPHC and AFSC longline surveys cover less area. Both surveys use large hooks (16/0 and 13/0, respectively) so are limited in their ability to capture very small halibut (and may differ from Pacific cod directed fishing). The AFSC longline survey is biennial and only covers the older fish in the population because it surveys the deep slope from 150-1000 meters. The IPHC longline survey has limited geographic coverage compared to the bottom trawl survey. The Bering Sea Slope trawl survey was also discussed, but not evaluated in detail (the data were made available after the workgroup meeting).

A preliminary analysis showed a method of linking the three Bering Sea surveys described above and weighting them inversely by their coefficients of variation into an integrated index (Fig. 10). An index like this might then be linked to some minimum amount of PSC bycatch. The method was considered, but generally thought to be heavily linked to the adult population by including the two longline surveys.

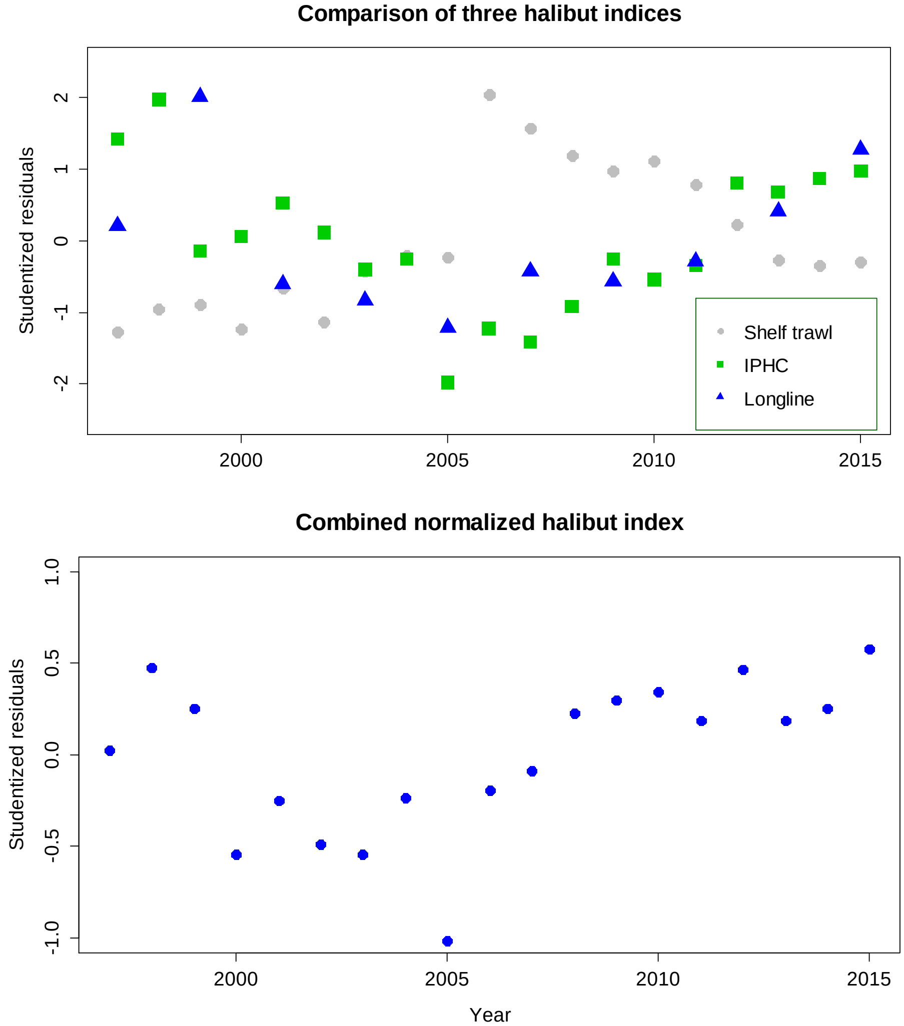


Figure 10. Comparison of some alternative survey trend indices (top) and their normalized combined (inverse-variance) weighted values (bottom); 1997-2015.

3.4 Integrated Model-Based Index

The Workgroup discussed the form of a model based index and noted that a comprehensive approach would include aspects of the IPHC assessment data or model results. After the workshop, a simplified form of an integrated approach which considers an index combined with the IPHC assessment was developed and included in Attachment 1 (but here as a generalized way to treat different existing indices). The Workgroup noted that a more complete development of such a specific model will require additional resources and time.

3.5 Summary

Even for a simple control rule (e.g., applying a rate to an abundance estimate) selecting an index will ultimately depend on objectives and relative performance against these objectives. The AFSC bottom trawl survey data appear to reflect well the conditions facing the groundfish fishery relative to species co-occurrence and relative abundances and bycatch rates. For the larger (older) component of the Pacific halibut resource, integrated survey abundance estimates could be used (e.g., the multiple survey compilation presented during the working group meeting). Alternatively, application of the most recent

CW assessment would be reasonable to include. A summary of the indices considered are provided in Table 6.

As noted in the section on Control Rule considerations below, there are data and synthesized information about the Pacific halibut stock that could be used that track different age groups of the stock. As such, their selection will require evaluating the performance of the index (or indices) within the BCR. The Workgroup noted that the selection of candidate abundance indices is just the first step with respect to evaluating the issues identified by the Council in its December 2015 motion, including natural mortality (by size and age), growth rates, size composition of PSC by sector, and the long-term potential spawning capital of juvenile halibut.

Table 6. Evaluation of strengths and weaknesses of indices to be considered for abundance based PSC limits.

Candidate abundance index	Strengths	Weaknesses
IPHC coastwide stock assessment	Comprehensive, annually available	Appears to be a poor index of (mostly younger) Pacific halibut taken as bycatch in the BSAI region One-year lag in assessment timing
AFSC EBS bottom trawl survey	Good index of (mostly younger) Pacific halibut taken as bycatch in the BSAI region, timely, available. Geostatistical approach accounts for several covariates.	Appears to be an inconsistent index of future Pacific halibut that recruit to the directed fisheries
Combined 3 (or 4) survey index	Uses more information and includes some insight on different stock components	Needs more development, some components unavailable on an annual basis
Integrated model-based index	Current simplified form (BCR1 in attachment 1) available Would allow for evaluation of younger and older halibut	Requires more development if more complex integration is desirable

4 CONTROL RULE CONSIDERATIONS

The Council has employed abundance-based PSC limits in the BSAI groundfish fisheries for Bristol Bay red king crab, EBS Tanner crab, Snow crab and herring. For Bering Sea Chinook salmon PSC in the EBS pollock fishery, PSC limits are not explicitly abundance-based being instead established at levels approximating historical bycatch levels by the fishery. However, BSAI Amendment 110, once implemented, adds an additional lower threshold of PSC limits in times of low western Alaska Chinook salmon abundance.[4]

[4] The proposed rule for Amendment 110 is available at https://alaskafisheries.noaa.gov/sites/default/files/81fr5681.pdf.

4.1 Examples of other PSC species in the BSAI indexed to abundance

The Council has recommended a range of different type of control rules to establish PSC limits for various fishery management objectives. Several key examples include the abundance-based PSC limits established for crab, and herring, fisheries. Current abundance-based PSC limits for crab and herring in the BSAI groundfish fisheries trigger time and area closures, but do not result in the closure of specific groundfish fisheries as is currently the case for halibut PSC limit in the BSAI. Table 7 indicates these limits, fisheries in the BSAI to which they apply, and closures that are triggered when fishery-specific PSC limits are reached. These PSC limits are annually specified by the Council in the BSAI groundfish harvest specifications process.

The original control rules for snow crab PSC limit and Tanner crab PSC limits are shown in Figure 11. The process by which these crab caps were initially established was a combination of proposals for limits put forward by the State of Alaska, recommendations from the Crab Plan Team, and by committee discussions amongst interested stakeholders. For Tanner crab, proposed lower threshold limits were based upon the average observed bycatch for the stock at that level of abundance (NPFMC 1996). The upper range of the limit was based on negotiated amounts when the stock was at a high abundance in 1988 (NPFMC 1996). The middle "step" level was established at an intermediary level between steps 1 and 3.

Amendment 41 to the BSAI FMP established a "stair step" approach to for Tanner crab PSC limits that are determined based on the EBS bottom trawl survey. The specific "floor" "slope" and "ceiling" were established through an iterative process through the Council and based on observed bycatch at the levels of abundance when the measure was considered in 1996.

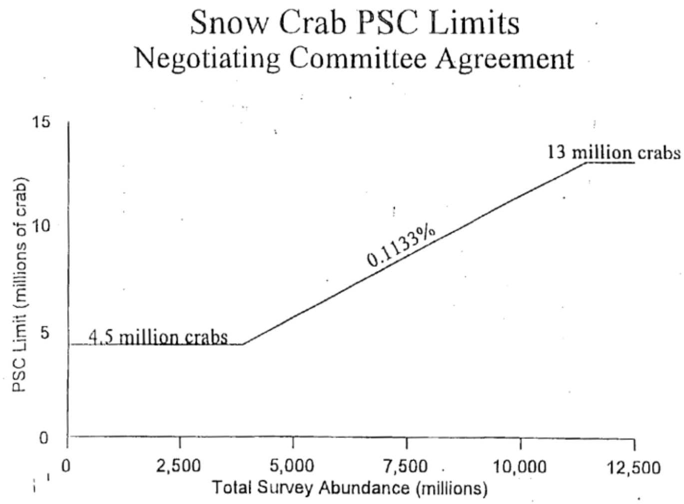
EBS snow crab trawl PSC limits are based on total abundance of snow crab as indicated by the NMFS standard trawl survey. In recent years, the assessment model estimate of trawl survey crab numbers is used to calculate the limit. The cap is set at 0.1133% of snow crab abundance index, with a minimum of 4.5 million snow crabs and a maximum of 13 million snow crabs; the cap is further reduced by 150,000 crabs (Figure 11). Only snow crab taken within the COBLZ accrue toward the PSC limits established for individual trawl fisheries.

Bristol Bay red king crab PSC limits were established in 1996. At that time, the Council recommended adoption of a stair-step limit regime for red king crab in Zone 1 based on abundance rather than a straight rate-based percentage because stair-steps smoothed year-to-year variability while providing for reduced bycatch limits at low stock sizes. The stair-step limits were originally recommended by the Crab Plan Team and based on the number and weight of crab, similar to the State's definition for harvest threshold for Bristol Bay red king crab in the State harvest strategy. The Council's recommended PSC limits are based on thresholds of the estimated number of mature female red king crab.

Amendment 16a to the BSAI groundfish FMP established bycatch management measures for Pacific herring in groundfish trawl fisheries in 1991 (NPFMC 1991). The adopted PSC limits trigger area closures (Herring savings areas) as indicated in Table 7. In the development of alternatives the Council considered a range of percentage rates applied to the overall estimated biomass of herring in the eastern Bering Sea. Prior to the analysis, exploitation rates by groundfish trawl vessels were estimated to have increased from less than 2% in 1983 to between 4%-7% in 1989. At that time herring stocks in nearly all Bering Sea areas were declining prompting the need for some action to further limit the bycatch of herring by trawl gear (NPFMC, 1991). The Council selected 1% as the appropriate rate to apply to the aggregate biomass of herring as a PSC limit. This limit is specified based on updated information on the appropriate biomass estimate for the Bering Sea herring stock by the State of Alaska annually during the specifications process.

Table 7. Current PSC limits associated with abundance of prohibited species in the BSAI groundfish fisheries

BSAI Prohibited species	Limit	Area / action	Limit based on:
Red king crab	Thresholds based on effective spawning biomass (ESB) of BBRKC If ESB < 14.5 million lb PSC limit = 32,000 crab If ESB ≥ 14.5<55.0 mill lb PSC limit = 97,000 crab If ESB > 55.0 million lb PSC limit = 197,000 crab	Zone 1	Thresholds relate to state harvest strategy for BBRKC. Lower limit is based on the level of bycatch observed in the 1995 flatfish fisheries in Zone 1 with the Crab Savings Area closed to trawling Middle limit corresponds to a 50% reduction from the previous PSC limit. Limit is the same percentage as applied by the BOF in 1996
EBS Tanner crab	Zone 1 limits 0-150 million crabs 150-270 million crabs 270-400 million crabs over 400 million crabs Zone 2 limits 0-175 million crabs 175-290 million crabs 290-400 million crabs over 400 million crabs	Zone 1 0.5% of abundance 730,000 830,000 980,000 Zone 2 1.2% of abundance 2,070,000 2,520,000 2,970,000	Lower threshold limits were based upon the average observed bycatch for the stock at that level of abundance. The upper range of the limit was based on negotiated amounts when the stock was at a high abundance in 1988. The middle "step" level was established at an intermediary level between steps 1 and 3
EBS snow crab	Survey abundance of crabs *0.1133 with 4.35 million minimum and 13 million maximum	COBLZ	Council committee charged with negotiating acceptable limits between trawl industry and crab industry
Herring	1% of EBS biomass estimate from State	Herring saving closures	Council considered range of 1-8% based on historical exploitation rates by groundfish fisheries on herring.
EBS Chinook salmon	If 3-river index >250,000 fish then 60,000/47,591 else 45,000/33,318 If lower cap reached >3 times in a rolling 7 year period then lower cap in place permanently (and subject to reduced cap level in years of low abundance)	Seasonal and sector allocated limits. If reached closes directed fishing for pollock for that sector (season or remainder of year). Area is Eastern Bering Sea.	PSC limits considered by Council ranged from 25,000 – 85,000 based on historical bycatch in EBS fishery.



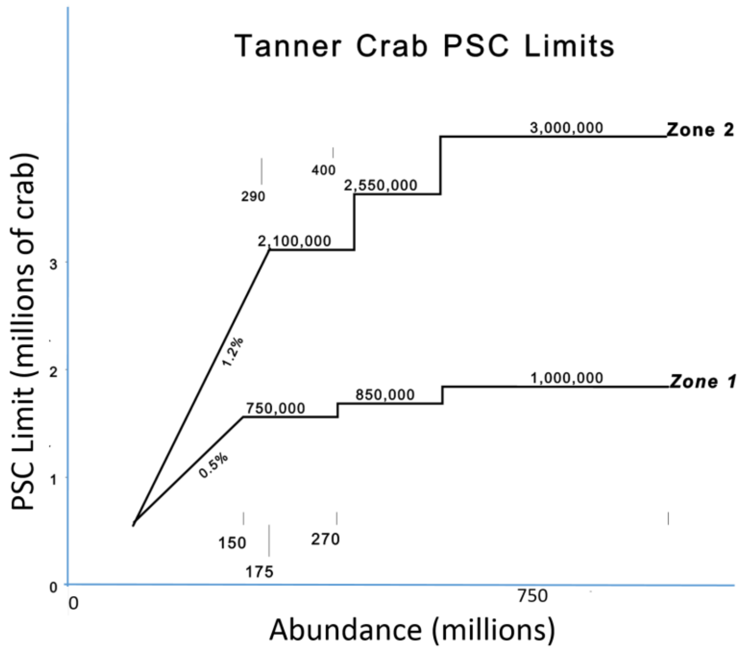


Figure 11. Control rule for snow crab (top) and tanner crab (bottom) PSC limits (from NPFMC 1997).

Although not a PSC limit, the Council has also used a sloped control rule for allocations of halibut between charter and commercial fisheries in the Gulf of Alaska. The Council established the halibut catch sharing plan in Areas 2C and 3A, which allocates the halibut catch limits between the commercial and charter halibut fisheries based on a control rule that varies with halibut abundance. The control rule specifies that each sector will be allocated a specific percentage of the available catch limit at different levels of halibut abundance. At lower levels of abundance, the charter sector is allocated a larger proportion of the catch limit than at higher levels of abundance. The control rule also includes a “stair step” that allocates the charter fishery a fixed amount of the catch limit in pounds at specific abundance levels in order to smooth the transition between allocation percentages as abundance increases.

4.2 Information to consider to inform a Halibut PSC control rule

There are a variety of options to consider for the formulation of a control rule that may be applied to the different abundance indices under consideration. Not all of these options were discussed by the Workgroup during the meeting.

4.2.1 Historical bycatch rates and the effect of discard mortality rates

A summary of halibut catch (kg) per metric ton of groundfish catch, without any discard mortality estimate applied is shown in Table 8 and using halibut “mortality” (the current management metric) is provided in Table 9.

Table 8. Pacific halibut bycatch rate in kg of Pacific halibut ***caught*** per metric t of groundfish.

	Longline	Pot	Trawl	Total
2008	54.876	3.309	3.318	6.755
2009	51.559	1.058	3.822	7.700
2010	57.125	1.984	3.729	7.454
2011	40.496	2.759	2.588	5.255
2012	40.022	2.372	2.903	5.897
2013	38.105	1.325	2.730	5.394
2014	32.200	1.065	2.606	4.856
2015	22.176	1.165	1.708	3.386
Average	40.302	1.804	2.853	5.678

Table 9. Pacific halibut bycatch rate in kg of Pacific halibut ***mortality*** per t of groundfish.

	Longline	Pot	Trawl	Total
2008	6.036	0.232	2.181	2.411
2009	5.672	0.074	2.572	2.795
2010	5.712	0.159	2.493	2.678
2011	4.050	0.221	1.716	1.855
2012	4.002	0.190	2.036	2.164
2013	3.429	0.106	1.936	2.016
2014	2.898	0.085	1.891	1.929
2015	1.996	0.093	1.267	1.304
Average	4.007	0.140	1.969	2.092

As with some of the Crab PSC control rules, average historical bycatch rates can be used to help inform a range of candidate threshold bycatch rates for halibut PSC control rule considerations as opposed to threshold amounts of PSC. For example, using a rate based approach, a period could be selected from which bycatch rates by sector (or overall across all gears and sectors) could be computed. However, bycatch would not necessarily be linked with the status of the local halibut abundance in the BSAI region nor with the Pacific halibut stock as a whole.

Given implementation of Amendment 80 in 2008, the improved flexibility for bycatch avoidance this program has provided to Amendment 80 catcher/processors in the BSAI groundfish fisheries, and the proportion of halibut PSC taken in the BSAI by the Amendment 80 sector, the Workgroup suggested that the Council consider bycatch rates and mortality only from 2008 to present in the formulation of threshold levels or rates. The Council should also consider whether separate control rules by gear type would be warranted given the observed differences in size composition of the catch between hook-and-line gear and trawl gear. The Workgroup proposes PSC limits be considered in both numbers of fish and weight with and without discard mortality applied.

The Workgroup did not try to define which specific approach would be most appropriate, and noted that depending on the goals of the PSC limit and methods for assessing bycatch, some of these methods could be more or less practicable. For example, if information indicated that conserving the numbers of fish was particularly important to the long-term spawning capital of the halibut stock, than that may be a more appropriate metric. The Workgroup also noted that if discard mortality rates were more variable than anticipated (e.g., rates were higher for hook-and-line gear than estimated) then applying a PSC limit based on numbers may ameliorate some of those concerns. The Workgroup did not address how different methods for establishing PSC limits could affect operational choices by harvesters to avoid halibut or reduce mortality of halibut bycatch. This could be a topic for further discussion.

The Workgroup also considered the specific time period that would be most appropriate to consider when looking at historic performance that could guide future PSC limits. All of these approaches would use 2008 as the initial year for examining PSC rates and fishery performance beginning with the implementation of the Amendment 80 Program.

General approaches to inform a control rule were outlined to examine PSC rates by gear type and combined across gear types. These include the following:

- Average overall PSC rate for trawl and hook-and-line gear 2008-2015
- Average PSC rate for hook-and-line gear 2008-2015
- Average PSC rate for trawl gear 2008-2015

4.2.2 Pacific halibut bycatch relative to their apparent abundance

Evaluation of bycatch relative to abundance estimates (in weight or in numbers of halibut) were considered by the Workgroup as a potential starting point for control rule development. Estimates contrasting NMFS EBS bottom-trawl biomass with Pacific halibut bycatch mortality suggests an average ratio of 0.019 (1.9%) for 2008-2015 with 85% of this mortality estimated to be from trawl fisheries (15% to fixed gear). For the period 1994-2015 the average ratio of bycatch mortality to survey biomass is 2.7%. In terms of numbers of individuals, the ratio is 1.8% for 2008-2015. These historical bycatch to survey index ratios could provide insight on forming control rules (Fig. 12). An example (ignoring Pacific halibut population trends elsewhere for this discussion) would be to simply set the PSC limit as a ratio similar or bracketing historical ratios.

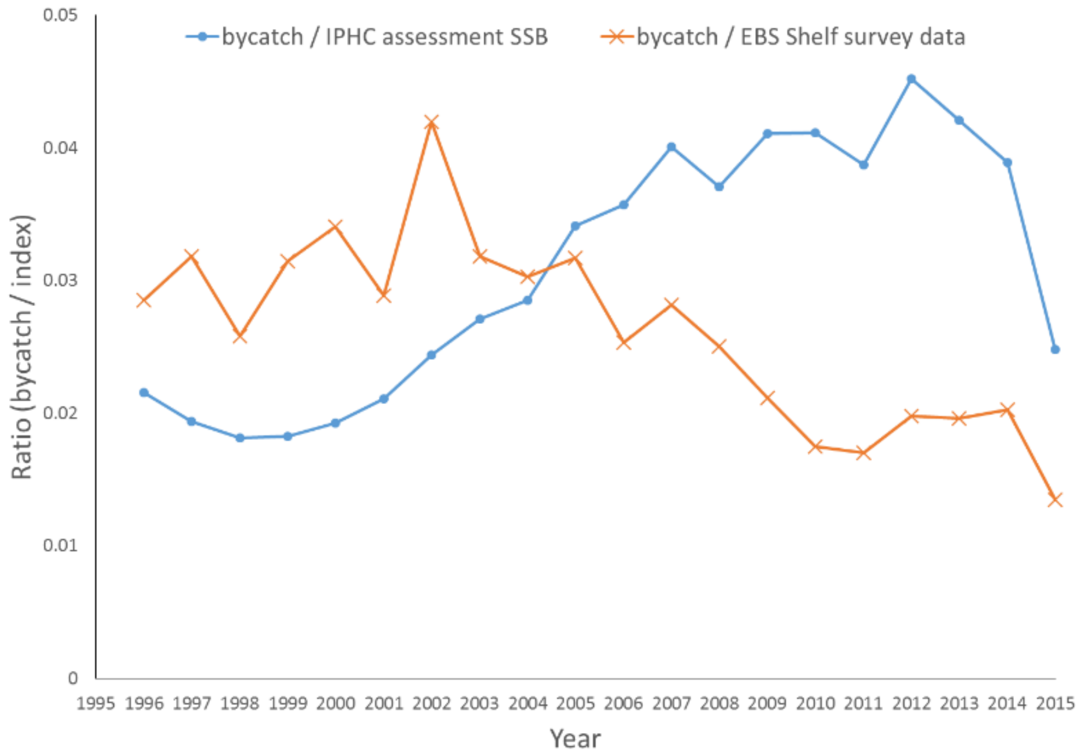


Figure 12. Historical ratios (BCR1 consideration) of the bycatch in mass divided by the EBS bottom trawl survey estimates and also the IPHC estimated spawning stock biomass (SSB); 1996-2015.

4.2.3 Threshold options vs continuous control rule

The Workgroup identified two options to structure the BSAI halibut PSC control rule: a continuous control rule or a control rule that includes thresholds at which the method for determining the PSC limit would change to meet specified objectives. A continuous control rule would establish a PSC limit that increases or decreases at a constant rate based on changes in the halibut abundance index. A continuous control rule would specify a PSC limit of zero if the halibut abundance index reaches some minimum point. It also provides for a continually increasing PSC limit corresponding with increases in the abundance index.

The second control rule option would incorporate stair-step thresholds based upon some level of abundance into a continuous control rule. The Crab PSC limits described above provide one historical example of this formulation. The Council has included stair-step thresholds in control rules to prevent significant annual variability in PSC limits from minor changes in the abundance index used for the control rule. The halibut catch sharing plan also includes stair-step thresholds to maintain stability by providing a constant allocation for the charter sector when abundance levels increase and the charter sector's proportional allocation decreases. A control rule can also include minimum (floor) and/or maximum (ceiling) PSC limits if the Council determines that these are appropriate. The Council could specify a minimum PSC limit for the groundfish fisheries at lower levels of halibut abundance as well as a maximum limit that would be maintained when halibut abundance increases.

4.2.4 Reproductive value considerations relative to different fisheries

In low abundance years, a program could consider PSC allocations based on a minimum allocation to the directed fisheries and explicitly account for the relative size distribution from each bycatch fishery/sector (or gear type) similar to proposals described in the Martell et al. (2015) paper.

This would potentially avoid explicit evaluation of assessment issues facing the IPHC yet still provide direction to the Council regarding how to best minimize impacts (without explicitly estimating the overall extent of the impacts on the halibut stock).

Issues of connectivity in general between the halibut in the BSAI and the overall coast-wide halibut stock indicates that three plausible scenarios might be considered:

1. High connectivity and direct downstream impact
2. Variable connectivity suggesting that in some years or periods and situations, the connectivity is high, in others it low or moderate
3. Low connectivity with relatively minor downstream impact (i.e., the halibut move from the EBS shelf to deeper slope areas outside of the main IPHC fishery).

Of these, tagging data suggest that scenario three is relatively implausible (which would argue against down-weighting adult stock condition for the BCR).

4.2.5 IPHC control rule

Introducing a control rule consistent with current IPHC or NPFMC practices was proposed by Martell (2015). Reviewing the current IPHC over-arching control rule the most recent assessment for Pacific halibut (RARA 2015) states that:

> "…if the stock is estimated to have fallen below 30% of the equilibrium stock size in the absence of fishing ($SB_{30\%}$; defined relative to historically good size-at-age and recruitment in a relatively unproductive environmental regime, Clark and Hare 2006), the target harvest rates are decreased linearly such that there would be no fishing mortality below 20% relative spawning biomass (Fig. 2). This policy was designed to provide a constant harvest rate that would avoid decreasing the stock below $SB_{30\%}$ with a relatively high frequency, and still provide a large fraction of the maximum sustainable yield available."

Based on results presented in this assessment, the median stock size from the ensemble model results used for the IPHC stock assessment indicates that the spawning biomass has remained above these thresholds. Nonetheless, tracking a similar policy for PSC thresholds (for setting upper and lower limits) based on Pacific halibut spawning biomass is considered important for conservation goals for the IPHC and this is considered a component for the integrated approach for PSC setting in the next section.

4.2.6 An integrated abundance based PSC control rule (BCR)

Given issues with indices (e.g., the eastern Bering Sea BTS) that seem to have a poor relationship to estimates arising from the IPHC Pacific halibut stock assessment and coupled with the desire to have an abundance-based Pacific halibut PSC limit that reflects the current stock status (i.e., spawning biomass) the working group recognized the value of developing simple but general integrated abundance indices and then exploring bycatch control rules (BCR) based on such indices. The group also discussed the desirability for the possibility of having stair-step or averaged approaches to changes in PSC to reduce inter-annual variability. Such a flexible BCR should consider potential separation of policy choices between factors affecting bycatch rates and the longer term management issues for Pacific halibut.

For example, characteristics of Pacific halibut apparent from the bottom-trawl surveys may provide a good indication of expected bycatch rates in fisheries in that region whereas this index may provide little insight on subsequent "downstream" impacts on the spawning and/or fishable Pacific halibut population. Relative to the current trend and status of the Pacific halibut resource as a whole, clearly the IPHC assessment would provide the best indicator for contributing to a BCR. Attachment 1 (developed after the workshop) provides some alternative formulations of BCRs that might warrant further consideration by the Council and SSC. Stated simply, the BCR proposals were considered to follow some basic principles:

- Adjust the PSC according to some integrated approach balancing trends in areas where bycatch occurs and in the Pacific halibut stock as a whole (i.e., evaluate allowable bycatch).
- When either the adult stock or apparent abundance (e.g., survey index) is most affecting the bycatch in the EBS and is below some target level, adjust PSC downwards
- Ability to regulate rate on the increase in PSC (relative to the decrease) when conditions in the index and/or adult stock are above some target level (e.g., via γ_u and γ_A for BCR2 in the attachment)
- Allow for a floor and ceiling for PSC (PSC_{UL} and PSC_{LL})

The amount of weight given to the factors in the BCR model are intended to provide flexibility to allow policy decisions and risks to be evaluated in the iterative selection process required to develop a robust BCR.

5 NEXT STEPS TO FORMULATE ALTERNATIVES

5.1 KEY DECISION POINTS FOR COUNCIL:

There are a number of key and likely iterative decisions for the Council in the development of alternatives for an analysis of abundance-based BSAI PSC limits. This section lays out the major assumptions embedded in moving forward with development of alternatives, the availability of pertinent analytical tools, as well as the list of decisions that the Council will make prior to launching an analysis. This process as outlined is intended to incorporate feedback from the IPHC in development of an analysis to inform respective decisions by both bodies. Recognizing that the PSC management decision resides within the Council jurisdiction, it would be desirable to have agreement of the Commission on the approaches taken to address the issue of PSC management.

5.1.1 Process for establishing new PSC limits

Revised PSC limits would be annually established in the BSAI groundfish annual specifications. Doing so requires that data to specify an abundance index as well as any modification in the PSC control rule be available ideally in time for inclusion in the proposed specifications at the October Council meeting. With the exception of abundance indices based solely on the updated Coastwide assessment from IPHC, none of the indices considered appear problematic in that respect. However the information must be publicly available, thus for some abundance indices considered solely for purpose of indexing a BSAI PSC cap, there needs to be a process in place to provide for transparent update and timely availability of these estimates.

5.1.2 Decisions in development of alternatives

There are several key decisions in the development of BCRs applied to an abundance estimate for Pacific halibut in the BSAI. These are listed below with a brief explanation of the rationale behind the decision, the potential management challenges as well as to the assessment and impacts to the Pacific halibut stock and fisheries. Any decision moving away from status quo is clearly optional for the Council (as noted for each change from status quo with "(optional' in parentheses) however the Council has already indicated an interest in pursuing such an analysis.

5.1.2.1 PSC limits in weight (t) vs numbers (optional)

The Workgroup identified two options for establishing the metric for abundance-based halibut PSC limits: weight in metric tons or numbers of halibut. Currently, PSC limits are specified in metric tons of halibut mortality. The IPHC discussion paper presented at the December 2015 Council meeting discussed the implications of weight-based halibut PSC limits. The paper suggested that PSC limits could have a disproportionate impact on the halibut stock when mortality is managed in weight instead of numbers as many more individuals can be killed in the bycatch fisheries versus the directed fisheries, which differentially impacts the spawning capital of the stock in the long run. One potential means to address this would be to specify and manage PSC limits in numbers of fish instead of mortality (as with Crab PSC limits and Chinook PSC limits). The Workgroup recommends further analysis of the impacts of specifying PSC limits in weight versus numbers. While establishing PSC limits in numbers instead of weight may address some concerns about the impacts of bycatch on the spawning capital of the halibut stock, there are a number of uncertainties and data limitations associated with estimating the impacts of bycatch and directed fisheries on spawning capital. The Workgroup agreed that further work was needed to examine the impacts of establishing PSC limits in weight versus numbers.

5.1.2.2 PSC limits managed with (status quo) and without DMRs (optional)

Currently, PSC limits are specified by in metric tons of halibut mortality, with different DMRs applied by gear type to each target fishery. The process for specifying DMRs is being re-evaluated, with revisions possible as soon as the 2016 specifications process for 2017 groundfish management. In the near term for the trawl fishery, DMRs will likely be aggregated across target fisheries, given a decrease in halibut viability sampling in recent years. The methodology for specifying DMRs may be in transition for the next several years, as the sampling program adapts and a time series under the adjusted program becomes available. Given this, the Council may wish to consider specifying PSC limits as a total amount without applying an assumed rate of mortality. The IPHC could determine an appropriate mortality rate after the fishing year to estimate bycatch mortality in its annual catch setting process. Application of PSC limits without associated DMRs however could drastically change the incentive structure for careful release and reduced mortality through deck sorting, for example.

A related issue for the alternatives, with respect to assessing historical usage, is whether to use the annual mortality estimates that are generated inseason for the groundfish fleets, by applying the specified DMRs that are based on previous years’ mortality observations, or whether to use the actual estimate of mortality in a given year back-calculated from actual DMRs observed in the fishing year. The halibut DMR discussion paper that is being prepared for the April meeting touches on this issue, and will likely provide more data to evaluate the potential difference in these respective calculations as part of the analysis being prepared for establishing DMRs during the fall harvest specifications s process.

5.1.2.3 Allocation of PSC amongst groundfish sectors (any modification from status quo is optional)

Currently PSC limits are allocated amongst the Amendment 80 cooperatives, the BSAI trawl limited access (TLA) fisheries, the BSAI non-trawl longline fisheries, and the CDQ fisheries. A policy decision in the development of alternatives will be to either retain the Status Quo sectors, allocations and structure or to modify them. Some of these considerations may include whether to retain the TLA as a sector for overall allocation with the Council selecting relative proportions in conjunction with specifications, to allocate each target and operation type (catcher vessel or catcher/processor) within the TLA category their own proportion of the annual limit, as well as to establish a hard limit for the pollock fishery.[5] Should the Council wish to modify the sector allocations and/or consider seasonal allocations amongst user groups by sectors and within the TLA group, it is likely a range of alternative formulations may be considered.

[5] The regulations include an exception for the pollock/Atka mackerel/other species fishery category. If the pollock/Atka mackerel/other species fishery category will reach its halibut PSC allowance, NMFS does not have the authority to close this fishery category. Thus, if the halibut PSC allowance for the trawl fishery category of pollock/Atka mackerel/other species will be reached, NMFS does not have authority to take additional action. The Council did not recommend, and NMFS did not propose, changes in this regulation for Amendment 111 to the BSAI FMP.

5.1.3 Summary of PSC limit alternatives and options

The following summarizes some considerations for developing alternatives for abundance-based PSC limits (the control rule) for BSAI groundfish fisheries. This represents a list of potential decision points that could be limited or expanded after additional consideration and review by the Council.

- Form of control rule
    - Slope
    - Thresholds (perhaps based upon Pacific halibut assessment benchmarks)
    - Floor and/or ceiling on harvest rate
    - Relative weights on components of the control rule
- PSC Limits based on
    - Numbers of Pacific halibut
    - Weight of Pacific halibut
- Accounting
    - With no mortality applied
    - with DMRs specified in groundfish specifications process
- Allocation
    - Status quo
        - Retain Categories and proportions
    - Retain current categories with options to modify proportions
    - Modified categories and proportions
        - Allocate PSC limit in regulations within current TLA category including:
            - Allocation to each target
            - “Hard cap” allocation to pollock fishery
            - Separate PSC allocation for BS and AI
        - Modifications to fixed gear sectors
            - separate limits to
                - Longline CP cod sector
                - Longline other targets (e.g., Greenland turbot all caught by CPs),
                - Longline CV cod.
            - PSC limit to sablefish fishery
            - PSC limit to pot fishery
        - Modified seasonal apportionments within sectors

The Workgroup did not address the potential impact of changing PSC estimation, accounting, or management on the monitoring or enforcement of the fisheries, but acknowledged that changing PSC limits or metrics could require substantial changes in the existing administration of the groundfish fisheries by changing observer sampling, in-season management, and other issues that would need to be explored in future discussion papers and analyses.

5.2 Considerations for Analysis of Alternatives

The following on-going initiatives should be coordinated with and employed in the analysis of a suite of alternatives developed by the Council in conjunction with moving forward with abundance-based PSC limits for BSAI halibut.

5.2.1 Use of MST model (AFSC MSE) in impact analysis

The AFSC has been developing an advanced toolset that includes management strategy evaluation (MSE) with a multi-species species technical interactions model to simulate the biological, management, and fleet dynamics of the Alaska groundfish fishery. Catches in the model are limited by constraints, including the 2 million t cap, halibut and salmon prohibited species catch (PSC) limits, and the constraining nature of the catch limit of one species on the catch of other species in the context of weak stock management. This work was presented at the August 2015 NSAW meeting in Portland. Subsequent work has been in refining these methods to include more species, mapping the data-driven sector-subcomponents (referred to as metíers which aggregate tows into similar categories of gear type, area, timing, and species compositions) into the current management sectors (specifically so that PSC constraints can be included effectively), and adding a BSAI component of Pacific halibut population into the model for developing and testing abundance-based PSC control rules. This project is prepared to add a Pacific halibut operating model (OM) so that testing BCR for analysis can proceed. This simplified (relative to the IPHC assessment model) will be based on fitting halibut assessment output as an approximation to what is done in reality (yet still be readily useable with the MST MSE framework). Details on how best to capture historical total fishing mortalities going forward in simulation mode (the OM is used to feed "data" to the BCR being tested) are being worked on but the project staff are confident that a reasonable approximation will be possible (and necessary to test downstream impacts on the Pacific halibut stock and fisheries). Details of the general approach for the multispecies technical interaction model (as was used for the 2005 PSEIS) and plan for establishing a function operating model for the Pacific halibut stock will be presented to the SSC at the Council's April 2016 meeting.

5.2.2 Use of IPHC MSE in impact analysis

The IPHC MSE process has been in development for several years. Initial development has focused on definition of management objectives, management procedures and scenarios to examine, metrics of performance, and development of operating models and evaluation tools. Equilibrium tools have been used to engage the Management Strategy Advisory Board (MSAB) and familiarize it with the MSE process. Much of the discussion with the MSAB has involved articulating coastwide and area-specific objectives for the halibut fishery and the stock.

The IPHC has been using a coastwide operating model for the MSE investigations, although it recognizes that many stakeholder concerns are expressed at an area-specific level because of the existing IQ management structure for the fishery. To that end, the Commission will be developing a spatially-explicit operating model or models as companions to the current process and moving away from equilibrium evaluations. The development over the next year will be to move to a closed-loop fully dynamic MSE process incorporating estimation and implementation components in the feedback process. Subsequent development will be to incorporate spatially-explicit models into the closed-loop process.

Bycatch mortality is only one of many elements of halibut management that is being examined in the MSE process. Integrating the coarser PSC management in Alaska with bycatch mortality management by Individual Bycatch Quotas practiced in other IPHC management areas is a major thread in the MSE investigations. The management procedures associated with these two forms of bycatch management afford different levels of management opportunity and precision. DMRs associated with each form of management are variables in the MSE evaluations and their evaluation forms a component of the evaluation of management procedures (such as harvest control rules, target harvest rates, fixed or variable bycatch mortality controls, minimum size limits, fishery timing, etc.) being investigated.

The Commission staff will be making an informational presentation on its MSE process to the Council at its April meeting.

5.2.3 Impact analysis to include explicit consideration of relative reductions in Pacific halibut SPR

As noted above, an age structured model conditioned on the IPHC assessment results and subsequent accounting of the relative age specific fishing mortality under different BCR will be required. This will require estimating the relative selectivity of the bycatch fisheries (and the variability of such selectivity/availability) over time. It is envisaged that this would provide a statistical basis from which an evaluation of the relative importance of different BCR options have on the impact of Pacific halibut stock and fisheries.

5.2.4 DMR working group and schedule

A workgroup of IPHC, Council, AKFIN, AFSC and Regional Office staff are working to reevaluate the methodology for determining discard mortality rates (DMRs) that are applied in-season in groundfish fisheries. A discussion paper which reviews issues associated with the current DMR methodology, some data-related analyses and proposed alternative methodologies for establishing DMRs will be provided to the Council in April 2016. The workgroup will continue to evaluate alternative DMR estimation methods and will provide a new recommended approach for consideration by the Plan Teams, SSC and Council in the fall of 2016. The intent is to use the newly estimated DMRs for the 2017 groundfish harvest specifications cycle. In the evaluation of alternatives, it may be useful to explicitly consider plausible estimates of uncertainty in the estimates of DMR values, both within the underlying viabilities and the estimation methodology within fisheries, both within the underlying viabilities and the estimation methodology within fisheries.

5.2.5 Additional analytical considerations.

The SSC made several requests in June 2015 for additional information and analyses to be included in any subsequent analysis of revising halibut PSC limits in the BSAI. Some specific data that are available to assist in the policy decisions by the Council include commercial, subsistence and recreational catch data in the Bering Sea (IPHC Area 4). Many of the analyses identified by the SSC will be addressed in any subsequent analysis initiated by the Council with respect to revising BSAI halibut PSC using some of the tools already outlined above in tandem (specifically drawing upon sensitivity analyses and projections using the IPHC MSE analysis for the Coastwide halibut stock and analyses available using the AFSC MST model and simulations developed to assess the relative constraints and impacts upon groundfish fisheries and halibut under varying PSC limit constraints, fleet behavior and halibut abundance).

Additionally, downstream aspects to the GOA, BC, and U.S. west coast of any revised management actions in the BSAI will be evaluated. Once alternatives have been adopted by the Council, an analytical workplan will be developed and reviewed by the SSC. Detailed development of this analytical outline however will be contingent on the Council articulating goals and objectives for the action as well as a developed suite of alternatives to meet these goals and objectives.

It should also be noted that largely in response to comments from the SSC on halibut management moving forward, the Council has adopted and undertaken considerable effort to formulate and revise a "Halibut Framework" as a programmatic planning tool moving forward to enhance collaboration and communication between the Council and the IPHC. This framework is being iteratively updated and remains a living document for periodic review.

5.3 Timeline

Given issues and considerations noted, a proposed timeline for work products and iterative considerations by the Council associated with such are proposed in Figure 13.

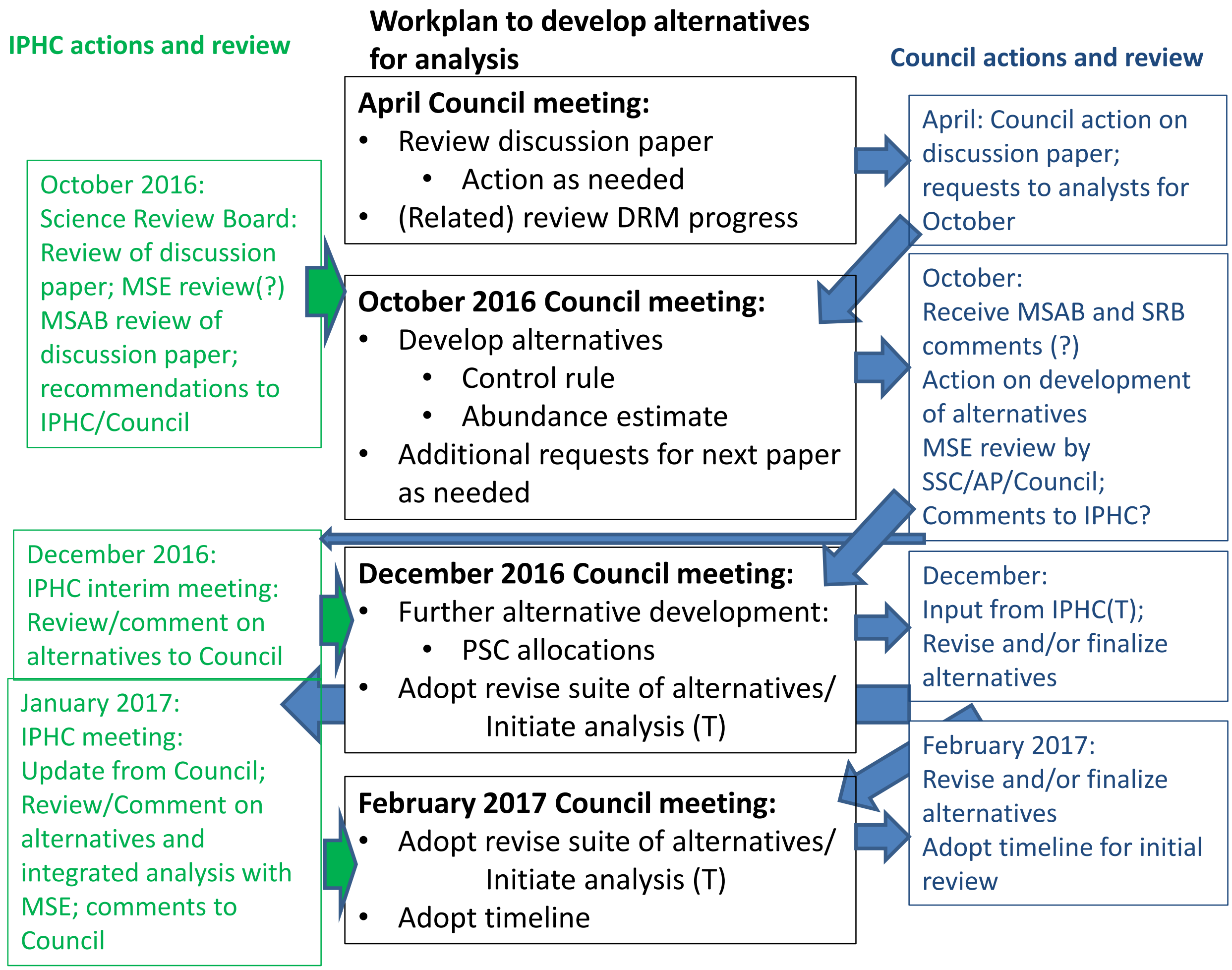


Figure 13. Timeline and workplan options for Pacific halibut abundance based PSC developments.

6 SUMMARY OF POTENTIAL COUNCIL CONSIDERATIONS/ACTION

Actions for Council in April:

- Adopt proposed workplan
- Request focused discussion papers which outline key iterative decisions by Council in stages to allow for initiation of formal (EA/EIS) analysis in 2017. Suggested topics to include in discussion papers include:
    - Additional information as needed to select a single abundance index for analysis
    - Draft control rule formulations and decision points associated with the following:
        - Single vs. multiple control rules (by gear or sector)
        - Slope of control rule and basis thereof
        - Minimum/maximum levels or thresholds associated with control rule
    - Allocation of PSC limits amongst sectors
- Draft purpose and need for analysis to aid on development of appropriate alternatives
- Other direction to Workgroup?

7 REFERENCES

Hoff, G. R. 2013. Results of the 2012 eastern Bering Sea upper continental slope survey of groundfish and invertebrate resources. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-258, 268 p.

Martell S., I. Stewart and C. Wor. 2015 Exploring index-based PSC limits for Pacific halibut by can be accessed at: http://goo.gl/hFPRpf

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ATTACHMENT 1.
SOME PROPOSED FORMS OF BYCATCH CONTROL RULES TO CONSIDER FOR ABUNDANCE-BASED PACIFIC HALIBUT PSC LIMITS

What follows is an attempt to provide an example of some options for how a Bycatch Control Rule (BCR) might be constructed. Note that there is no requirement for a BCR to be explicitly linked to specific biological or socio-economic characteristics—those aspects fall under how well the BCR behaves based on performance indicators designed to evaluate trade-offs for management and policy objectives.

.The idea is to derive a BCR that can be tested and best indexes Pacific halibut encounter rates within the groundfish fishery while accounting for current (and future) impacts on the Pacific halibut resource as a whole. Two generalized control rules are proposed, both of which define u_t and A_t as measures arising from survey index data and a measure of stock status from the IPHC coastwide assessment models (e.g., their estimated median ensemble relative spawning biomass), respectively. To either form, the Council may wish to consider an additional constraint to limit the maximum and minimum allowable PSC:

$$\text{if } PSC_{t+1} \le PSC_{LL} \text{ then } PSC_{t+1} = PSC_{LL}$$
$$\text{if } PSC_{t+1} \ge PSC_{UL} \text{ then } PSC_{t+1} = PSC_{UL}$$

Where PSC_{UL} and PSC_{LL} would need to be established through either policy or analysis.

BCR1

The following form simply specifies a rate relative to the index values with option to carry momentum from the previous year's PSC values:

$$PSC_{t+1} = PSC_t w_1 + \alpha_u u_t w_2 + \alpha_A A_t w_3 \quad \sum_{i=1}^{3} w_i = 1.0$$

The values for α_u, α_A could be specified based on historical patterns of the ratio of actual bycatch to a specified measure of biomass (e.g., Fig. 14). Based on the mean ratios from 2008-2015, and hypothetical future index trajectories, the BCR suggests that with equal weights ($w_1 = w_2 = w_3 = 1/3$), a putative PSC limit behaves reasonably (Fig. 15).

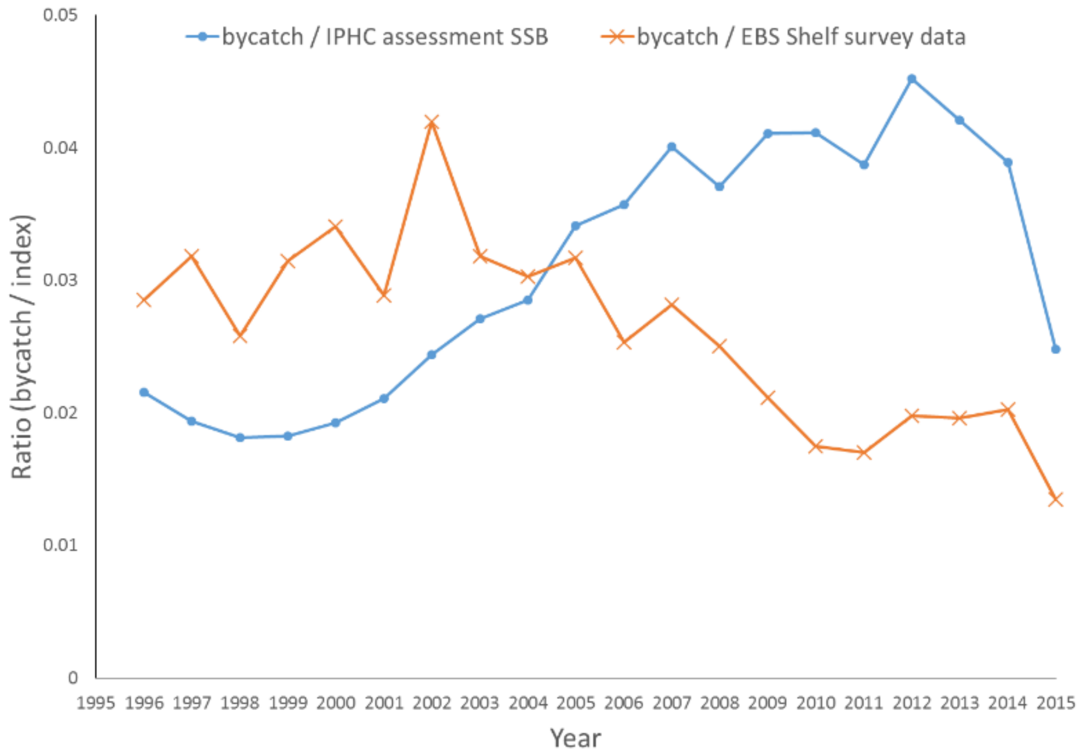

Figure 14. Historical ratios (BCR1 consideration) of the bycatch in mass divided by the EBS bottom trawl survey estimates and also the IPHC estimated spawning stock biomass (SSB); 1996-2015.

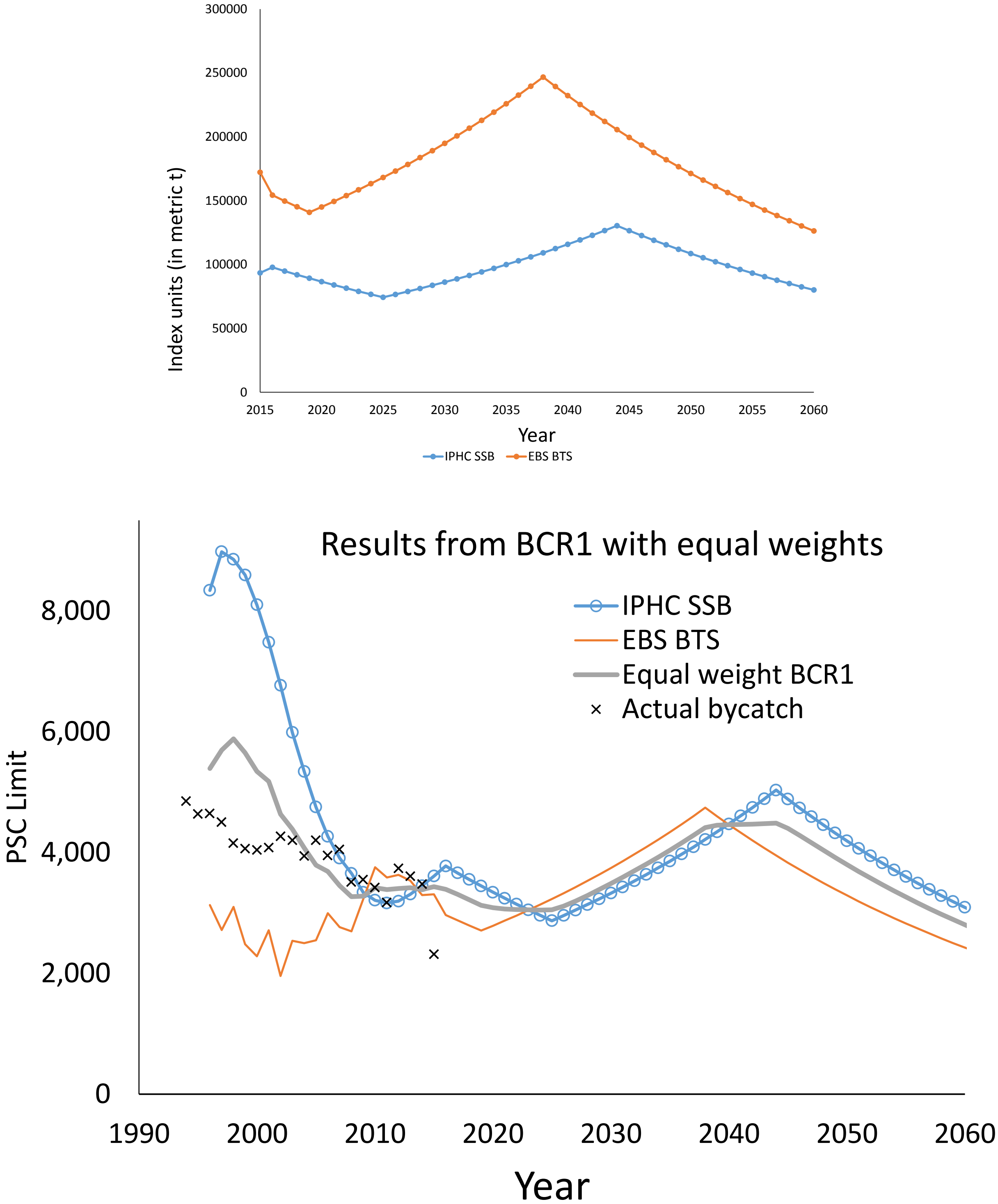

Figure 15. Example BCR1 (grey line, bottom panel) with equal weights based on hypothetical index trajectories (top panel). Note that in the bottom panel, the blue and orange lines were computed as $\alpha_A A_t$ and $\alpha_u u_t$, respectively.

BCR2

An alternative which would involve adjusting harvest rates below "target" Pacific halibut stock sizes (for both younger and say, the reproductive stock components). As above, the PSC would involve an "integrated" model of data components by weighting the juvenile index and the older-fish assessment results, and the most recent PSC limit:

$$PSC_{t+1} = PSC_t \left[w_1 + f\left(u_t\right) w_2 + g\left(A_t\right) w_3 \right], \quad \sum_{i=1}^{3} w_i = 1.0 \, .$$

The functions *f* and *g* are constructed so as to be dimensionless and PSC expressed in either numbers or biomass units of Pacific halibut. As with BCR1, this form can encapsulate many shapes and approaches, e.g., constant PSC ($w_1 = 1, w_2, w_3 = 0$) or only dependent on index data ($w_1 = 0, w_2 = 1, w_3 = 0$) etc. The functions within this form

$$g\left(A_t\right) = 1 + \min\left(0, r_{A,t} - 1\right) + \gamma_A \max\left(0, r_{A,t} - 1\right)$$

where $r_{A,t} = \frac{A_t}{A_{ref}}$ and A_t, A_{ref} are the median spawning biomass at time *t* and reference target respectively. The term γ_A is added to control the rate at which PSC is allowed to increase. To establish a reference target for presentation purposes, we selected the mean percentage of the median equilibrium spawning biomass presented in the RARA (2015) from 2008-2016. This resulted in a value for A_{ref} equal to 41%)[6].

Similarly for index data,

$$f\left(u_t\right) = 1 + \min\left(0, r_{u,t} - 1\right) + \gamma_u \max\left(0, r_{u,t} - 1\right)$$

where $r_{u,t} = \frac{u_t}{u_{ref}}$ and γ_u have analogous meanings for the index data. The selection of u_{ref} was taken to be the mean value for the index from 2008-2015 for presentation purposes only.

The amount of weight given to the prior PSC limit and the IPHC assessment in such a model would be a policy related call to how much to favor stability in favor of the trend of the overall population size. To illustrate how such a form might work, a single scenario of hypothetical increases and decreases in indices (u_t and A_t) and the resulting application of the BCR under three configurations is shown in Fig. 16.

[6] This value is something that would require more explicit consideration from the IPHC; as a BCR aspect though, performance indicator of the evaluation would be most critical rather than the actual selection of the value here. This is just for working an example for illustration.

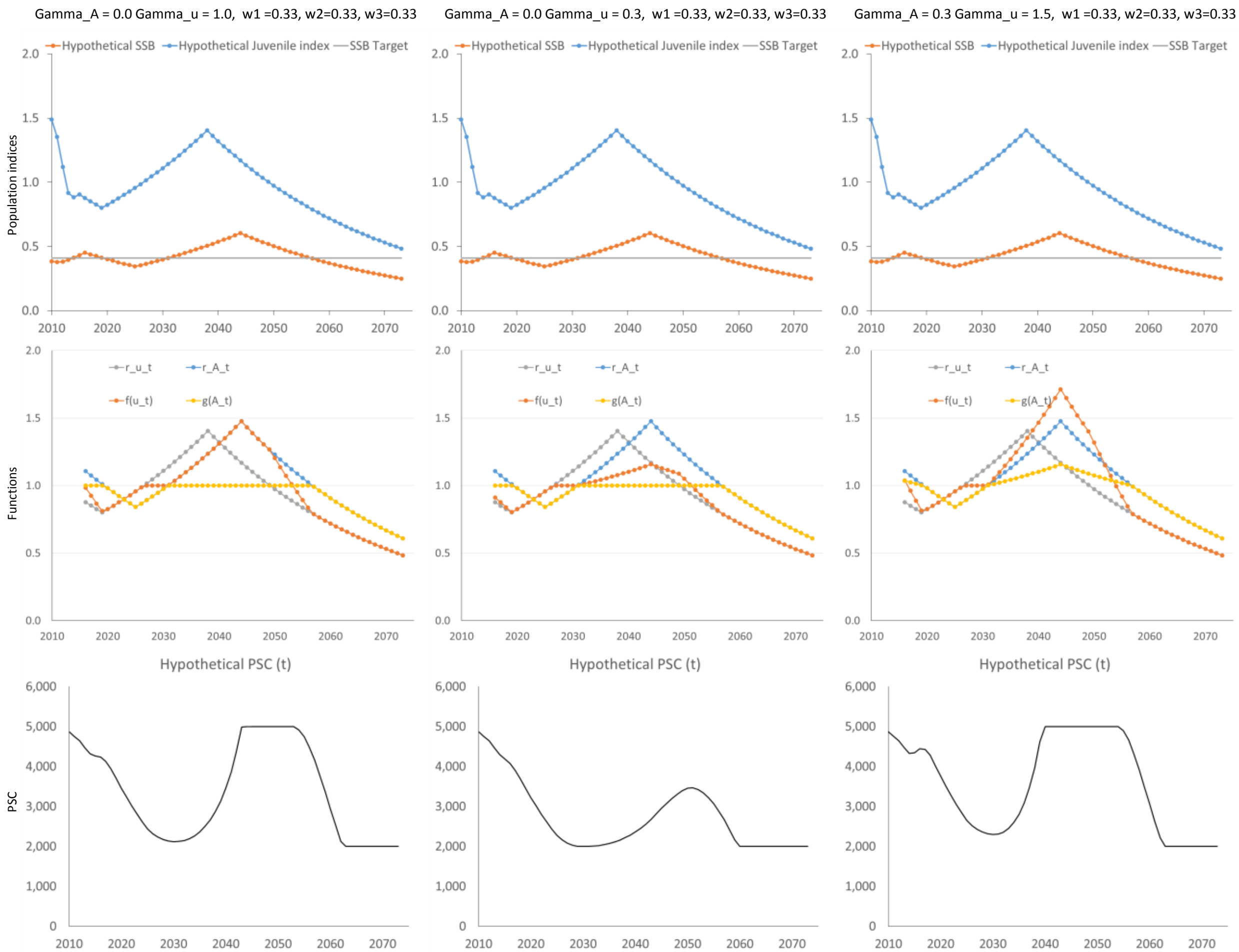

Figure 16. Example BCR2 settings and results. The first row is underlying input indices (equal in all cases here) and middle row is the function results as shown in the equations and bottom row are the resulting PSC results given upper and lower limits of 5 and 2 thousand t of PSC.