Ideas on estimating stock distribution and distributing catch for Pacific halibut fisheries

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1 PURPOSE

To update the Management Strategy Advisory Board (MSAB) on discussions and ideas related to science inputs and management procedures for distributing the Total Constant Exploitation Yield (TCEY) across the IPHC Convention Area (as of 22 September 2018).

2 INTRODUCTION

The report from the 94th Session of the IPHC Annual Meeting (AM094) included the following text related to distributing TCEY among the Regulatory Areas (IPHC-2018-AM094-R):

*37. The Commission **REQUESTED** that the objectives related to distributing the TCEY, as detailed in Circular IPHC-2017-CR022, be presented at MSAB11 for further stakeholder feedback.*

*38. The Commission **REQUESTED** that the proposed TCEY distribution methodology of the Harvest Strategy Policy reflect an understanding of both stock distribution and fishery management distribution procedures.*

*39. The Commission **RECOMMENDED** that the IPHC Secretariat consider the survey WPUE grid across the fishery as well as other biological factors (e.g. habitat configuration, size distribution in the region etc.) and provide alternatives to the current management areas (e.g. biological regions), and that the MSAB consider additional ways to incorporate biological information into TCEY distribution procedures.*

*40. The Commission **NOTED** that the current procedure to distribute the TCEY could be replaced by an interim procedure to be developed in the near term while the MSAB completes their Program of Work to deliver guidance in 2021 on scale and TCEY distribution.*

*41, The Commission **AGREED** to meet via an inter-sessional electronic meeting (soon after the AM094), along with the IPHC Secretariat, to discuss TCEY distribution procedures to use in the interim while long-term distribution procedures are being developed by the MSAB. MSAB representatives and the IPHC Secretariat will inform the Commission of what guidance the MSAB may be able to provide to help develop an interim distribution strategy, and how the development of an interim harvest procedure may affect the MSAB's current Program of Work.*

*42. The Commission **AGREED** that distributing the TCEY to regions does not necessarily need to be the first step of the TCEY distribution procedure, and other biological factors, such as habitat and size distribution, be considered.*

*43. The Commission **NOTED** that the work the MSAB has already completed on distribution procedures may help to inform the development of an interim distribution strategy. MSAB representatives and the IPHC Secretariat will advise the Commission of how this may affect their current Program of Work, and what guidance they may be able to provide to help develop an interim distribution strategy.*

The report from the 10th meeting of the Management Strategy Advisory Board (MSAB) in October 2017 included the following related to distributing the TCEY:

37. ***NOTING*** *the order of operations in the proposed TCEY distribution procedure, the MSAB AGREED that the order of stock distribution and TCEY distribution procedures is a management choice that could be evaluated.*

38. *The MSAB **NOTED** that the order of operations in the proposed TCEY distribution procedure will be subject to review at future MSAB meetings and that the specific components require further definition.*

The report from the 11th meeting of the Management Strategy Advisory Board (MSAB) in May 2018 included the following related to distributing the TCEY:

*The MSAB **NOTED** that the proposed TCEY distribution procedure contains four main components, each of which may contain multiple elements. These four components are listed below and have a computational outcome:*

a) ***Coastwide Target Fishing Intensity****: this defines the TCEY to be distributed.*

b) ***Regional Stock Distribution****: this distributes the TCEY to biological Regions to satisfy the Biological Sustainability objective of preserving biocomplexity.*

c) ***Regional Allocation Adjustment (optional)****: this adjusts the distribution of the TCEY among Regions to account for additional Biological Sustainability objectives and fishery objectives.*

d) ***Regulatory Area Allocation****: this distributes the TCEY from Regions to Regulatory Areas to satisfy fishery objectives.*

71. *The MSAB **NOTED** that the output of the TCEY distribution procedure will be a catch table describing proposed mortality (allocation) in each IPHC Regulatory Area (Appendix VI).*

72. *The MSAB **REQUESTED** that the proposed TCEY distribution framework described in paragraphs 69, 70 and 71, be reviewed by the SRB in 2018.*

73. *The MSAB **NOTED** the intent expressed by the Commission that the output from the management procedure (proposed mortality – allocation – by IPHC Regulatory Area) would then be subject to an annual Regulatory Area adjustment by the Commission, which may deviate from the harvest strategy by changing the distribution and the SPR.*

74. *The MSAB **NOTED** that the SPR is maintained after distributing the catch. A deviation from the SPR determined in the Harvest Control Rule due to distribution procedures may be useful to investigate, but there must be a minimum SPR which is not exceeded. This ensures that a maximum fishing intensity is not exceeded.*

75. *The MSAB **NOTED** some potential tools for use as distribution procedures when distributing the TCEY:*

    a) Relative harvest rates.

    b) O32:O26 ratios.

    c) trends in survey WPUE by IPHC Regulatory Area.

    d) Trends in modelled survey WPUE by biological region.

    e) trends in fishery CPUE.

    f) Smoothing algorithms on area-specific catch limits.

    g) Percentage allocation with a floor (i.e. minimums of 1.5 Mlbs in 2A and 1.7 Mlbs in 4CDE).

    h) A maximum SPR with catch distribution by IPHC Regulatory Area determined from the modelled survey WPUE.

    i) Coastwide TCEY target and maximum calculated; distribution by target, but with ability to adjust TCEY up to the maximum.

76. ***NOTING** that these tools require further discussion, the MSAB **REQUESTED** that the IPHC Secretariat provide comments, and that further stakeholder feedback is elicited.*

77. *The MSAB **NOTED** that observations of stock and catch distribution during various reference periods should be considered when defining objectives for evaluation.*

This document advances IPHC-2018-MSAB011-09 (and repeats important material) and reports progress on the topic of distributing the TCEY.

3 DISTRIBUTING THE TCEY

A considerable amount of discussion related to a description of the harvest strategy policy occurred at previous MSAB meetings. Figure 1 shows an updated depiction of the harvest strategy policy with terms describing the various components. These terms are defined in the IPHC glossary[1], but of note for this paper are TCEY distribution, stock distribution, and distribution procedures. The management procedure is the sequence of elements including the assessment, fishing intensity, stock distribution, and distribution procedures. The goal of the MSAB is to define a management procedure that will be used to output O26 mortality limits (TCEY) for each Regulatory Area that meet the long-term objectives of managers and stakeholders. The "decision" step on the right of Figure 1 is where a deviation from the management procedure may occur due to input from other sources and decisions of the Commissioners that may reflect current biological, environmental, social, and economic conditions.

In 2017, the Commission agreed to move to an SPR-based management procedure to account for the mortality of all sizes and from all fisheries. The procedure uses a coastwide fishing intensity based on spawning potential ratio (SPR), which defines the "scale" of the coastwide catch. This eliminates the use of EBio and area-specific absolute harvest rates. Therefore, there are currently two inputs to the current management procedure for distributing the TCEY among IPHC Regulatory Areas: 1) the current estimated stock distribution and 2) relative target harvest rates.

[1] https://iphc.int/the-commission/glossary-of-terms-and-abbreviations

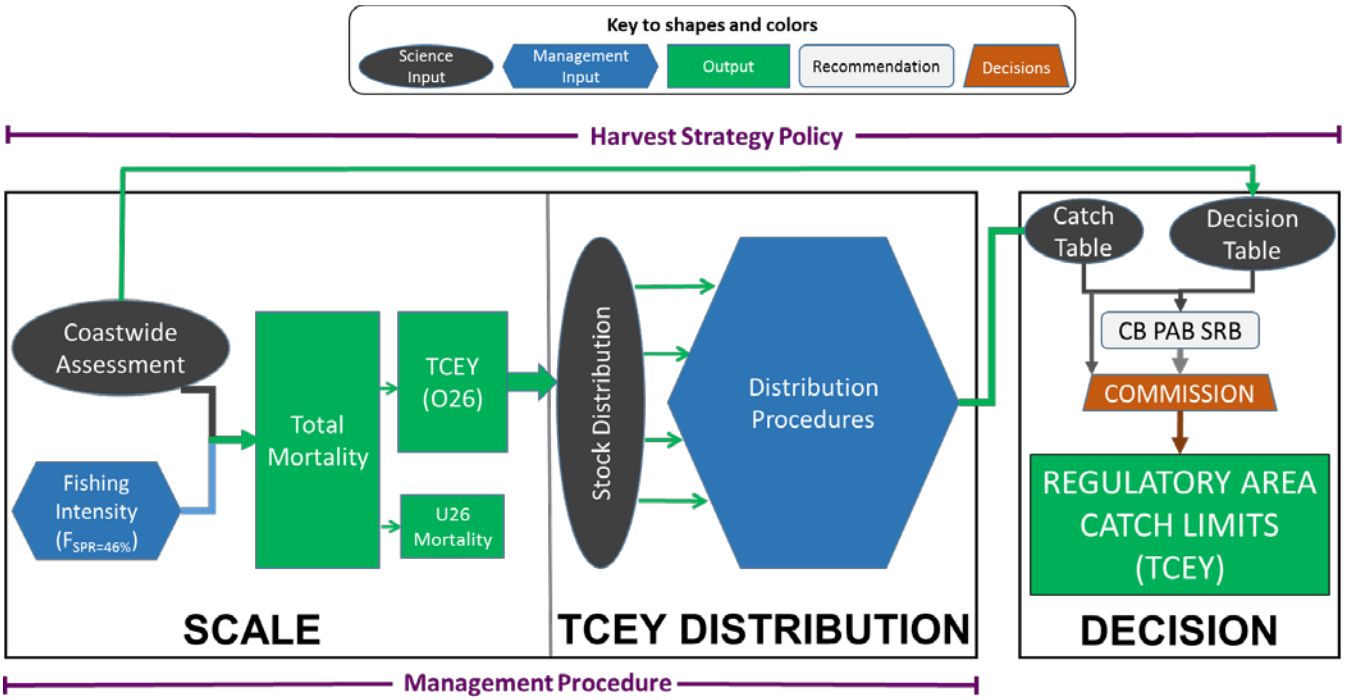

Fig. 1. A pictorial description of the interim IPHC harvest strategy policy showing the separation of scale and distribution of fishing mortality. The "decision step" is when policy and decision making (not a procedure) influences the final mortality limits.

3.1 Stock Distribution

The IPHC uses a space-time model to estimate annual Weight-Per-Unit-Effort (WPUE) for use in estimating the annual stock distribution of Pacific halibut (Webster 2018). Briefly, observed WPUE is fitted with a model that accounts for correlation between setline survey stations over time (years) and space (within Regulatory Areas). Competition for hooks by Pacific halibut and other species, the timing of the setline survey relative to annual fishery mortality, and observations from other fishery-independent surveys are also accounted for in the approach. This fitted model is then used to predict WPUE (relative density) of Pacific halibut for every setline survey station in the design (including all setline survey expansion stations), regardless of whether it was fished in a particular year. These predictions are then averaged within each IPHC Regulatory Area, and combined among IPHC Regulatory Areas, weighting by the "geographic extent" (calculated area within the survey design depth range) of each IPHC Regulatory Area. It is important to note that this produces relative indices of abundance and biomass, but does not produce an absolute measure of abundance or biomass because it is weight-per-unit-effort scaled by the geographic extent of each IPHC Regulatory Area. These indices are useful for determining trends in stock numbers and biomass, and are also useful to estimate the geographic distribution of the stock.

3.2 Using Relative Harvest Rates

The distribution of the TCEY for 2018 was shifted from the estimated stock distribution to account for additional factors related to productivity and paucity of data in each IPHC Regulatory Area. Previously, this was accomplished by applying different harvest rates in western areas (16.125% in IPHC Regulatory Areas 3B, 4A, 4B, and 4CDE)) and eastern areas (21.5% in IPHC Regulatory Areas 2A, 2B, 2C, and 3A). However, with the elimination of EBio and the use of SPR-based fishing intensity to determine the coastwide scale, the TCEY, rather than the esoteric concept of exploitable biomass, was distributed. Therefore, an absolute measure of harvest rate is not necessary, but it may still be desired to shift the distribution of the TCEY away from the estimated stock distribution to account for other factors. Consistent with the previous approach, relative harvest rates were used with a ratio of 1.00:0.75,

being equal to the ratio between 21.5% and 16.125%. This application shifted the target TCEY distribution away from the stock distribution by moving TCEY into IPHC Regulatory Areas 2A, 2B, 2C, and 3A and removing TCEY from IPHC Regulatory Areas 3B, 4A, 4B, and 4CDE (Table 1), thus harvesting at a higher rate in eastern IPHC Regulatory Areas.

Table 1. IPHC Regulatory Area stock distribution estimated from the 2017 space-time model O32 WPUE, IPHC Regulatory Area-specific relative target harvest rates, and resulting 2018 target TCEY distribution based on the IPHC's 2018 interim management procedure (reproduced from Table 1 in IPHC-2018-AM094-11 Rev_1).

	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
O32 stock distribution	1.7%	11.3%	16.6%	35.6%	10.0%	6.6%	4.8%	13.3%	100.0%
Relative harvest rates	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75	--
Target TCEY Distribution	1.9%	12.4%	18.2%	38.9%	8.2%	5.4%	3.9%	10.9%	100.0%

3.3 REDEFINING THE DISTRIBUTION OF THE TCEY

TCEY distribution is the part of the management procedure for distributing the TCEY among Regulatory Areas and is composed of a purely scientific component to distribute the TCEY in proportion to its estimated biomass in each area (stock distribution) and steps to further modify the distribution of the TCEY based on additional considerations (distribution procedures). Those two components are described below.

3.3.1 Stock Distribution

Emerging understanding of Pacific halibut diversity across the geographic range of the Pacific halibut stock indicates that IPHC Regulatory Areas should only be considered as management units and do not represent relevant sub-populations (Seitz et al. 2017). Balancing the removals against the current stock distribution is likely to protect against localized depletion of spatial and demographic components of the stock that may produce differential recruitment success under changing environmental and ecological conditions. Biological Regions, defined earlier and shown in Figure 2, are considered by the IPHC Secretariat, and supported by the SRB (paragraph 31 IPHC-2018-SRB012-R), to be the best current option for biologically-based areas to meet management needs.

The overarching conservation goal for Pacific halibut is to maintain a healthy coastwide stock, which implies an objective to retain viable spawning activity in all pertinent portions of the stock. One method for addressing this objective, without knowing what pertinent portions of the stock are, is to distribute the fishing mortality relative to the distribution of observed stock biomass. This requires defining appropriate areas for which the distribution is to be conserved. Splitting the coast into many small areas for conservation objectives can result in complications including being cumbersome to determine if conservation objectives are met, being difficult to accurately determine the proportion of the stock in that area, being subject to inter-annual variability in estimates of the proportion, forcing arbitrary delineation among areas with evidence of strong stock mixing, and not being representative of biological importance. Therefore, Biological Regions represent the most logical scale over which to consider conservation objectives related to distribution of the fishing mortality.

In addition to using Biological Regions for stock distribution, the "all sizes" WPUE from the space-time model (Figure 3), which is largely composed of O26 Pacific halibut (due to selectivity of the setline gear), is more congruent with the TCEY (O26 catch levels) than O32 WPUE. Therefore, when distributing the TCEY to Biological Regions, the estimated proportion of "all sizes" WPUE from the space-time model should be used for consistency.

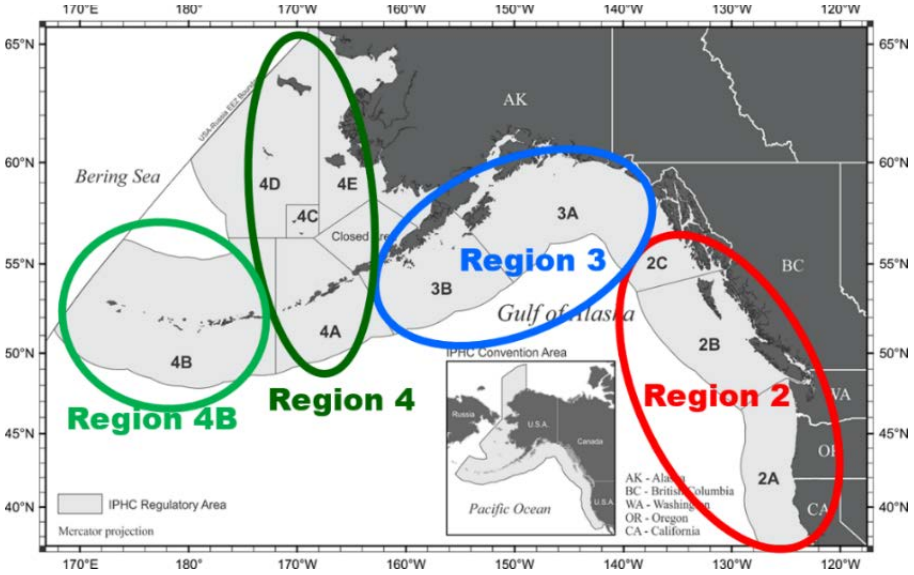

Fig. 2. Biological Regions overlaid on IPHC Regulatory Areas with Region 2 comprised of 2A, 2B, and 2C, Region 3 comprised of 3A and 3B, Region 4 comprised of 4A and 4CDE, and Region 4B comprised solely of 4B.

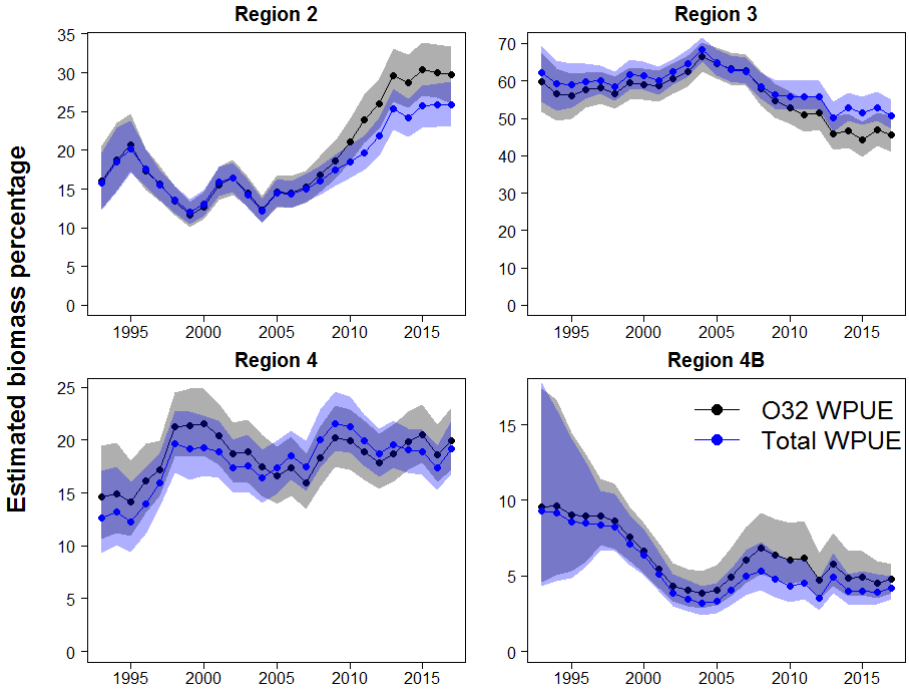

Fig. 3. Estimated stock distribution (1993-2017) based on estimate WPUE from the space-time model of O32 (black series) and all sizes (blue series) of Pacific halibut. Shaded zones indicate 95% credible intervals.

3.3.2 Distribution Procedures

Distribution Procedures contains additional steps of further modifying the distribution of the TCEY among Biological Regions and then distributing the TCEY among IPHC Regulatory Areas within Biological Regions (Figure 4). Modifications at the Biological Region or IPHC Regulatory Area level may be based on differences in production between areas, observations in each area relative to other areas (e.g. WPUE), uncertainty of data or mortality in each area, defined allocations, or national shares. Data may be used as indicators of stock trends in each Region or IPHC Regulatory Area and are included in the Distribution Procedures component because they may be subject to certain biases and include factors that may be unrelated to biomass in that Biological Region or IPHC Regulatory Area. For example, commercial WPUE is a popular source of data used to indicate trends in a population, but may not always be proportional to biomass. Types of data that could be used may include but is not limited to

- fishery WPUE,
- survey observations (not necessarily the IPHC fishery-independent setline survey),
- age-compositions,
- size-at-age, and
- environmental observations.

The steps in the Distribution Procedures may consider conservation objectives, but they will mainly be developed with respect to fishery objectives. Yield and stability in catch levels are two important fishery objectives that often contradict each other (i.e. higher yield often results in less stability). Additionally, area-specific fishery objectives may be in conflict across IPHC Regulatory Areas. Pacific halibut catch levels are defined for each IPHC Regulatory Area and quota is accounted for by those Regulatory Areas. Therefore, IPHC Regulatory Areas are the appropriate scale to consider fishery objectives.

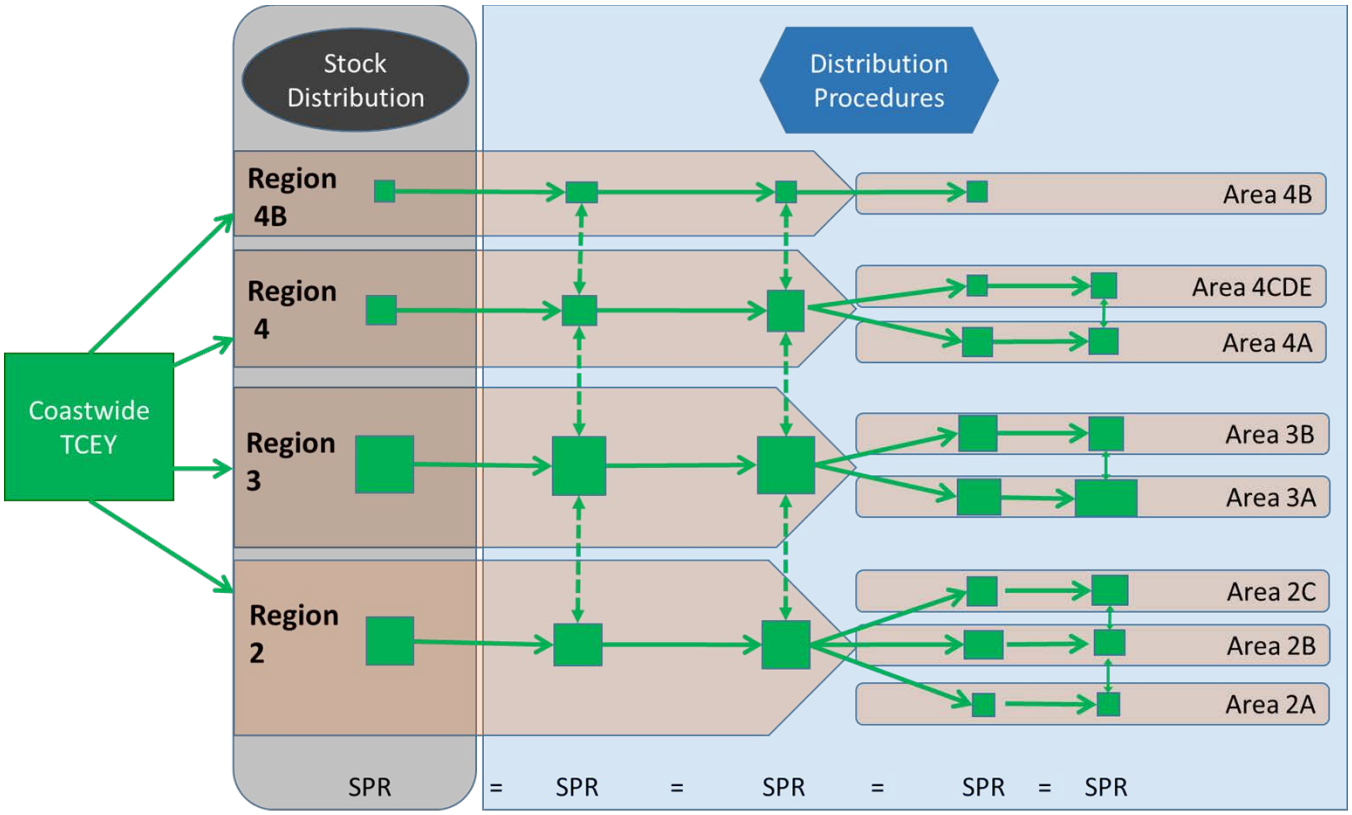

Fig. 4. The process of distributing the TCEY to Regulatory Areas from the coastwide TCEY. The first step is to distribute the TCEY to Biological Regions based on the estimate of stock distribution. Following this, a series of adjustments may be made based on observations or social, economic, and other considerations. Finally, the adjusted regional TCEY's are allocated to IPHC Regulatory Areas. The allocation to IPHC Regulatory Areas may occur at any point after regional stock distribution. The dashed arrows represent balancing that is required to maintain a constant coastwide SPR.

3.4 A SUMMARY OF THE MANAGEMENT PROCEDURE FOR DISTRIBUTING TCEY ACROSS THE COAST

The harvest strategy policy begins with the coastwide TCEY determined from the stock assessment and fishing intensity determined from a target SPR (Figure 1). When distributing the TCEY among regions, stock distribution occurs first to distribute the harvest in proportion to biomass and satisfy conservation objectives, and then is followed by adjustments across Regions and Regulatory Area based on distribution procedures to further encompass conservation objectives and consider fishery objectives. The key to these adjustments is that they are relative adjustments such that the overall fishing intensity (target SPR) is maintained (i.e. a zero sum game relative to fishing intensity). Otherwise, the procedure is broken, and it is uncertain if the defined objectives will be met.

A framework for a management procedure that ends with the TCEY distributed among IPHC Regulatory Areas and would encompass conservation and fishery objectives is described below.

1. **Coastwide Target Fishing Intensity:** Determine the coastwide total mortality using a target SPR that is most consistent with IPHC objectives defined by the Commission. Separate the total mortality in ≥26 inches (O26) and under 26 inches (U26) components. The O26 component is the coastwide TCEY.

    1.1. Target SPR is scheduled for evaluation at the 2019 Annual Meeting. The current interim target SPR is 46%.

2. **Regional Stock Distribution:** Distribute the coastwide TCEY to four (4) biologically-based Regions using the proportion of the stock estimated in each Biological Region for all sizes of Pacific halibut using information from the IPHC setline survey and the IPHC space-time model.

    2.1. Four Regions (2, 3, 4, and 4B) are defined above (**Figure 2**).

3. **Regional Allocation Adjustment:** Adjust the distribution of the TCEY among Biological Regions to account for other factors.

    3.1. For example, relative target harvest rates are part of a management/policy decision that may be informed by data and observations. This may include evaluation of recent trends in estimated quantities (such as fishery-independent WPUE), inspection of historical trends in fishing intensity, recent or historical fishery performance, and biological characteristics of the Pacific halibut observed in each Biological Region. The IPHC Secretariat may be able to provide Yield-Per-Recruit (YPR) and/or surplus production calculations as further supplementary information for this discussion. The regional relative harvest rates may also be determined through negotiation, which is simply an allocation agreement for further Regional adjustment of the TCEY.

4. **Regulatory Area Allocation:** Apply IPHC Regulatory Area allocation percentages within each Biological Region to distribute the Region-specific TCEY's to Regulatory Areas.

    4.1. This part represents a management/policy decision, and may be informed by data, based on past or current observations, or defined by an allocation agreement. For example, recent trends in estimated all sizes WPUE from the setline survey or fishery, age composition, or size composition may be used to distribute the TCEY to IPHC Regulatory Areas. Inspection of historical trends in fishing intensity or catches by IPHC Regulatory Area may also be used. Finally, agreed upon percentages are also an option. This allocation to IPHC Regulatory Areas may be a procedure with multiple adjustments using different data, observations, or agreements

The four steps described above would be contained within the IPHC Harvest Strategy Policy as part of the Management Procedure and are pre-determined steps that have a predictable outcome. The decision-making process would then occur (Figure 1).

5. **Seasonal Regulatory Area Adjustment**: Adjust individual Regulatory Area TCEY limits to account for other factors as needed. This is the policy part of the harvest strategy policy and occurs as a final step where other objectives are considered (e.g. economic, social, etc.).

    5.1. Departing from the target SPR may be a desired outcome for a particular year (short-term, tactical decision making based on current trends estimated in the stock assessment) but would deviate from the management procedure and the long-term management objectives. Departures from the management procedure may result in unpredictable outcomes but could also take advantage of current situations.

4 MANAGEMENT PROCEDURES RELATED TO DISTRIBUTION

The MSAB011 report (IPHC-2018-MSAB012-R) listed nine potential tools for use in developing distribution procedures (paragraph 75, noted above in Section 2). Each of these potential tools is discussed below.

Relative harvest rates. This was discussed above in the context of Regional Allocation Adjustment and Regulatory Area Allocation. The relative harvest rates may be justified by productivity differences, for example, or they may simply be allocation agreements between areas.

O32:O26 ratios. We interpret this tool as an indicator of the proportion of the TCEY that is under the size limit, and note that O32:U32 would likely produce a similar ratio and could be more easily understood. This ratio would give insight into the encounter rate with undersized Pacific halibut, and there may be objectives defined that are related to minimizing encounters with these undersized fish. Using this ratio to adjust allocation percentages could change the mortality on undersized Pacific halibut. This could occur in the Regional Allocation Adjustment or Regulatory Area Allocation steps.

Trends in setline survey WPUE by IPHC Regulatory Area. This tool applies to the Regulatory Area Allocation step and may be a useful method to inform the distribution to Regulatory Area. However, the Biological Regions are areas where it is likely that within-year movement may occur, and minimal movement occurs between Regions within a year. For this reason, trends from the survey within a Regulatory Area may be inconsistent with the location of Pacific halibut when the fisheries occur. In other words, Pacific halibut may occur anywhere in the Biological Region within a year, but are unlikely to move out of that Region in that year, thus the timing of the survey and the fishery are important to consider.

Trends in modelled survey WPUE by biological region. Using trends from the survey index that is already used to distribute TCEY to Biological Regions (Regional Stock Distribution) may result in some contradictions. The information from the survey is already being used. The potential benefit may be that the trend is indicative of what may occur in the future and potentially be a closer representation of stock distribution in the year when the fishery would occur.

Trends in fishery CPUE. Using trends in fishery CPUE to satisfy fishery objectives may be useful in that it is a more direct representation of what the fishery observes. However, fishery CPUE is subject to uncertainty and possibly bias which makes it inappropriate for biological objectives. Therefore, it is not useful for regional stock distribution, but is useful for Regulatory Area Allocation.

Smoothing algorithms on area-specific catch limits. A smoothing algorithm could reduce large swings in area-specific catch limits that may be a result of various uncertainties in the estimation and distribution processes. However, smoothing algorithms can slow down a sometimes-necessary response when a trend is occurring. For example, if the stock is trending downwards it may be necessary to reduce catch levels, or if the stock is increasing quickly, it may be reasonable to increase catch levels. Smoothing algorithms can be beneficial if the correct level of smoothing is used.

Percentage allocation with a floor (i.e. minimums of 1.5 Mlbs in 2A and 1.7 Mlbs in 4CDE). A simple method is to agree on pre-determined allocation percentages. However, there are often minimum amounts that a sector needs to be profitable. Defining percentage allocations can be very useful when agreed upon, and minimum amounts may also be useful. But, when the total catch to be allocated is small, there may not be enough to satisfy the minimum amounts. Therefore, agreements must be in place on where catch may be taken (i.e., the percentage allocation declines) when minimum levels are enacted.

A maximum SPR with catch distribution by IPHC Regulatory Area determined from the modelled survey WPUE. This is interpreted to be a tool similar to status quo where a SPR determines the TCEY and is distributed directly to Regulatory Areas based on survey WPUE. However, status quo also adjusts that distribution with relative harvest rates shifting TCEY to Eastern areas.

Coastwide TCEY target and maximum calculated; distribution by target, but with ability to adjust TCEY up to the maximum. This tool is interpreted to consist of a default SPR which would determine a coastwide TCEY, but also contain a higher fishing intensity (smaller SPR) that would determine a maximum TCEY. This could be viewed similar to the U.S. OFL and ABC concept, where an overfishing limit (OFL) is calculated and an ABC (allowable biological catch) is determined that is less than the OFL. However, it also differs in that the total allowable catch (TAC) is less than or equal to the ABC. This tool suggests that the TCEY could exceed the target when necessary, but not exceed the maximum. The danger of this is that it does not guarantee that the TCEY would not be set at the maximum every year, thus making this tool moot. Some clear guidelines would have to included regarding under what circumstances the default could be exceeded.

There are many other tools that could be used, some of which are mentioned in Section 3.3.2.

5 RECOMMENDATION

That the MSAB:

1) **NOTE** paper IPHC-2018-MSAB012-08 which provides the MSAB with discussions related to distributing the TCEY.
2) **NOTE** the distribution frame-work and the separation of scientific and management elements of distribution procedures.
3) **RECOMMEND** elements of management procedures for the distribution of the TCEY.

6 APPENDICES

NIL