A description of the IPHC fishery-independent setline survey (FISS) abundance-based management (ABM) index

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PURPOSE

This document provides a description of the abundance-based management (ABM) index developed from the IPHC Fishery-Independent Setline Survey (FISS).

BACKGROUND

Abundance-based management (ABM) of the Pacific halibut Prohibited Species Catch (PSC) limit is currently being evaluated by the North Pacific Fishery Management Council (NPFMC). The alternatives being evaluated include two-dimensional look-up tables to determine the PSC limit dependent on the Eastern Bering Sea (EBS) trawl survey index and the International Pacific Halibut Commission (IPHC) Fishery-Independent Setline Survey (FISS)[1] index. Breakpoints for these two survey indices define categories from which the PSC limit is determined (Figure 1). The EBS trawl survey index is categorized as low or high, and the IPHC FISS index is categorized into a low, medium, or high category along with a very low category for two of the three alternatives.

Alternative 3		EBS shelf trawl survey index (t)	
		Low < 150,000	**High** ≥ 150,000
IPHC setline survey index in Area 4ABCDE (WPUE)	**High** ≥ 11,000	1,745 mt (current limit)	2,007 mt (15% above current)
	Medium 8,000 – 10,999	1,396 mt (20% below current)	1,745 mt (current limit)
	Low 6,000-7,999	1,309 mt (25% below current)	1,396 mt (20% below current)
	Very Low < 6,000	1,222 mt (30% below current)	1,309 mt (25% below current)

Figure 1. Alternative #3 being considered by the NPFMC for determination of Pacific halibut PSC limits. This is one of three alternatives being considered.

This document describes the IPHC FISS index, how it is calculated, and provides some insights and potential alternative calculations. It updates the index to include the 2021 estimate.

[1] https://iphc.int/management/science-and-research/fishery-independent-setline-survey-fiss

METHODS

The methods used to calculate the ABM index are provided below. The ABM index is calculated from model outputs provided by IPHC. Three different calculations of the ABM index are provided for consideration. They are exactly the same in trends, but have different units associated with them.

Space-Time model

The IPHC FISS data are analysed using a spatiotemporal model (called the space-time model) to account for correlations between observations in space and time (IPHC-2021-IM097-08 Rev_1, Webster et al 2020). This has a number of benefits, one of which is the ability to predict unobserved stations. This improves the consistency between years and reduces concerns regarding the influence of missed stations in some years.

The model parameters are estimated for the entire time-series with the addition of new data. Therefore, when a new year is available, the index values for all years are updated. Years farther back in time are typically less affected unless the new data provide a significant update to the model parameters or provide information on a region that was unsampled or sparsely sampled in the past. The use of additional data to update the understanding of the entire time-series is a very useful outcome of this approach and these types of methods are being adopted in many analyses of fisheries and survey data.

Timing of FISS and space-time model output

The FISS is conducted annually from late May until mid-September. Collected data are immediately vetted and finalized for analysis in early October. The space-time modelling takes several weeks to complete, and the space-time results are typically available in November.

The space-time model output consists of weight-per-unit-effort (WPUE) in the units of net[2] pounds per standardised skate (100 hooks, 1800 feet in length) for each IPHC Regulatory Area (Figure 2). The ABM index uses all sizes encountered by the FISS and combines observations across IPHC Regulatory Area 4A, 4B, and 4CDE. Station-level WPUE values are standardized to account for the effects of hook competition on catch rates using adjustments calculated from the proportion of returned baits (e.g. greater % of returned baits implies less competition, IPHC-2021-SRB019-05).

[2] Net pounds refer to the weight with the head and entrails removed; this is approximately 75% of the round (wet) weight.

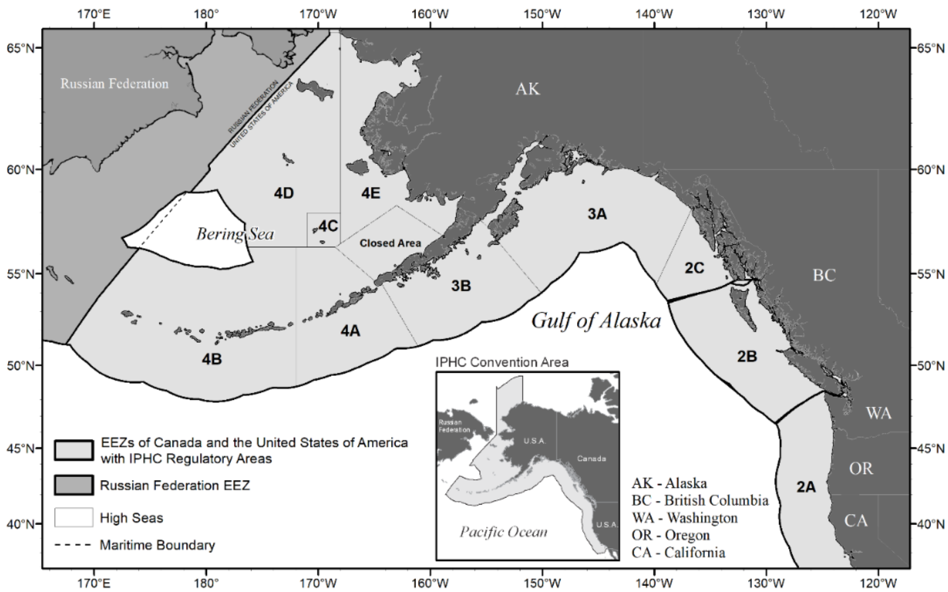

Figure 2. IPHC Convention Area (inset) and IPHC Regulatory Areas.

For each Regulatory Area, bottom area multiplied by mean WPUE provides a biomass index for that area. Therefore, an appropriate index combined across these IPHC Regulatory Areas uses the bottom area within the 0 to 400 fathom depth range (the assumed range of Pacific halibut habitat) to weight the mean WPUE from each IPHC Regulatory Area. Thus, this index is determined as follows.

$$I_{ABM,y} = \sum_{i \in \{4A,4B,4CDE\}} WPUE_{i,y} * A_i \qquad (1)$$

where A_i is the bottom area (nm^2) within the IPHC Regulatory Area (which is subject to occasional revision as new bathymetry data become available). The resulting units of this index are net pounds*nm^2/skate which is not intuitive. More intuitive outputs may be to standardise the index to a specific year or to divide equation (1) by the total bottom area, thus yielding a weighted average in the original WPUE units of net pounds per skate.

Standardising the index to a particular year has been considered during the development of ABM approaches. For example, standardising the index to the value predicted for 2019 or 2021 would provide an indication of whether the index is above or below that year and by what amount. This calculation, standardising to 2019 for example, would simply be

$$I^{s}_{ABM,y} = \frac{I_{ABM,y}}{I_{ABM,2019}} \qquad (2)$$

where $I_{ABM,y}$ is the year-specific index from equation (1) above. There are no units on this standardised index, as it is relative to a specific year. The value for 2019 ($I^{s}_{ABM,2019}$) would always be 1.0 regardless of changes to the time-series predicted from the space-time model. The benefit of this is that the variability due to re-analysis of the data each year is reduced and the index is more reflective of relative changes in the Pacific halibut abundance.

Another approach is to simply use the bottom areas as weights in a weighted mean. This is analogous to equation (1) except that the sum of the bottom areas is used as a divisor.

$$I^{w}_{ABM,y} = \frac{\sum_{i\in\{4A,4B,4CDE\}} WPUE_{i,y} * A_i}{\sum_{i\in\{4A,4B,4CDE\}} A_i} \quad (3)$$

The units on this index are net pounds per skate, which is more intuitive than those from equation (1).

ABM index

The three versions of the index are presented in Table 1 along with the resulting units of each version. Two different standardisations are provided for index version (2): one is standardised to 2019 as has been suggested at previous ABM discussions, and the other is standardised to 2021 which is the most recent year that an index is available. They all show the exact same trends, but provide different absolute numbers reflective of the resulting units.

For each version of the index, the breakpoints for the look-up table are provided in Table 2. These breakpoints are simply mapped from the breakpoints provided in the current Council alternatives. Given these breakpoints and the appropriate version of the index (Table 1) the outputs from the lookup table (i.e. PSC limit) would be exactly the same for the year of interest.

DISCUSSION

The IPHC FISS data are analysed using a state-of-the-art space-time model that has been peer reviewed and accepted by the International Pacific Halibut Commission. The ABM index uses these model outputs to calculate an index over IPHC Regulatory Areas 4A, 4B, and 4CDE. This includes appropriately weighting by the bottom area in each IPHC Regulatory Area.

Two alternative version of the index are provided for consideration. All three versions show the exact same trends, but each has different units associated with it and thus differs only in scale. This simply provides different interpretations of the index without changing the output PSC limit based on the index in a particular year. The currently accepted ABM index has units of net pounds times nm^2 per skate, which is complicated and unfamiliar to most stakeholders. A simple change to the calculation of the index, which only changes the absolute scale of the index but not the trends, leads to units of average net pounds per skate. This has a clear meaning and can be easily interpreted by many stakeholders. Another alternative method standardises the index to a specific year, such as its 2019 or 2021 value, providing an interpretation relative 2019 and the additional benefit of reducing interannual variability in the index due to revisions in the space-time model output with each additional year of data.

All three versions of the index presented here would result in the same PSC limit when the breakpoints of the lookup table are appropriately mapped to the index. However, the standardised index is the only one that reduces interannual variability and the potential confusion that updating the index in each year may bring. For example, the 2019 index value was calculated as 7,104 in 2019, 7,460 in 2020 (with the addition of 2020 space-time model outputs produced in the absence of Bering Sea IPHC and NMFS surveys), and 7,227 in 2021 (using data through 2021 as presented in Table 1). The interannual variability in the index is minimised by standardising the index to a specific year. The clearest example is that the index for 2019 would be 1.0 regardless of which year it was calculated in. The trend between years may change interannually, resulting in a change to the standardised version of the index, but that interannual variability would be less than the other versions of the index. For example, the 2018 ABM index was 7,228 in 2019, 7,709 in 2020, and 7,550 in 2021, thus increased by 6.7% then decreased by 2.1%. The standardised version of the index for 2018 was 1.02, 1.03, and 1.04 in 2019, 2020, and 2021, respectively, thus increased by 1% in each year. Another benefit of the standardised version of the index is that the breakpoints can be clearly presented as a percentage difference from 2019. For example, a breakpoint of 1.51 means that the index would be 51% higher than in 2019. The standardised version of the index may lose some interpretability if a specific measure such as net pounds per skate is desired for setting breakpoints in the lookup table. Therefore, the third version of the index is presented as an option.

Any of the three versions of the index can be easily calculated once the modelling is completed at IPHC and is expected to be available before the December NPFMC meeting in any given year.

References

Webster, R.A., Soderlund, E., Dykstra, C.L., and Stewart, I.J. 2020. Monitoring change in a dynamic environment: spatio-temporal modelling of calibrated data from different types of fisheries surveys of Pacific halibut. Canadian Journal of Fisheries and Aquatic Sciences **77**: 1421-1432.

Table 1. The ABM index for the years 1998–2021 along with two alternative versions.

Year Equation Units	ABM index (1) net pounds*nm²/skate	Standardised index (2) Relative to 2019	Standardised index (2) Relative to 2021	Weighted average index (3) net pounds/skate
1998	18,254	2.526	2.625	70.6
1999	16,069	2.223	2.310	62.1
2000	15,859	2.194	2.280	61.3
2001	13,538	1.873	1.947	52.4
2002	12,025	1.664	1.729	46.5
2003	10,988	1.520	1.580	42.5
2004	10,366	1.434	1.490	40.1
2005	10,182	1.409	1.464	39.4
2006	10,472	1.449	1.506	40.5
2007	10,481	1.450	1.507	40.5
2008	11,081	1.533	1.593	42.9
2009	10,338	1.430	1.486	40.0
2010	9,725	1.346	1.398	37.6
2011	9,340	1.292	1.343	36.1
2012	8,858	1.226	1.274	34.3
2013	8,514	1.178	1.224	32.9
2014	8,457	1.170	1.216	32.7
2015	8,638	1.195	1.242	33.4
2016	8,469	1.172	1.218	32.8
2017	7,819	1.082	1.124	30.2
2018	7,550	1.045	1.086	29.2
2019	7,227	1.000	1.039	28.0
2020	7,134	0.987	1.026	27.6
2021	6,955	0.962	1.000	26.9

Table 2. The breakpoints of the setline survey index for the lookup table in different units reflective of the units for each version of the ABM index.

Classification	ABM index	Standardised index	Standardised index	Weighted average index
Equation	**(1)**	**(2)**	**(2)**	**(3)**
Units	**net pounds*nm²/skate**	**Relative to 2019**	**Relative to 2021**	**net pounds/skate**
High	≥ 11,000	≥ 1.52	≥ 1.58	≥ 42.5
Medium	8,000–10,999	1.11–1.51	1.15–1.57	30.9–42.49
Low	6,000–7,999	0.83–1.10	0.86–1.14	23.2–30.89
Very Low	< 6,000	< 0.83	< 0.86	< 23.2