Summary of the data, stock assessment, and harvest decision table for Pacific halibut (*Hippoglossus stenolepis*) at the end of 2017

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PURPOSE

To provide the Commission with a summary of the data, stock assessment, and harvest decision table at the end of 2017.

INTRODUCTION

In 2017 the International Pacific Halibut Commission (IPHC) undertook its annual coastwide stock assessment of Pacific halibut (*Hippoglossus stenolepis*) using a range of updated data sources. This summary provides an overview of the data sources available for the Pacific halibut stock assessment and related analyses including the population trends and distribution among Regulatory Areas based on the IPHC fishery-independent setline survey, the 2017 stock assessment methodology, and results of the stock assessment. Catch tables detailing Regulatory Area-specific projections are provided separately in paper IPHC-2018-AM094-11.

STOCK AND MANAGEMENT

The stock assessment reports the status of the Pacific halibut (*Hippoglossus stenolepis*) resource in the IPHC Convention Area. As in recent stock assessments, the resource is modelled as a single stock extending from northern California to the Aleutian Islands and Bering Sea, including all inside waters of the St rait of Georgia and Puget Sound, but excludes known extremities in the western Bering Sea within the Russian Exclusive Economic Zone (Figure 1).

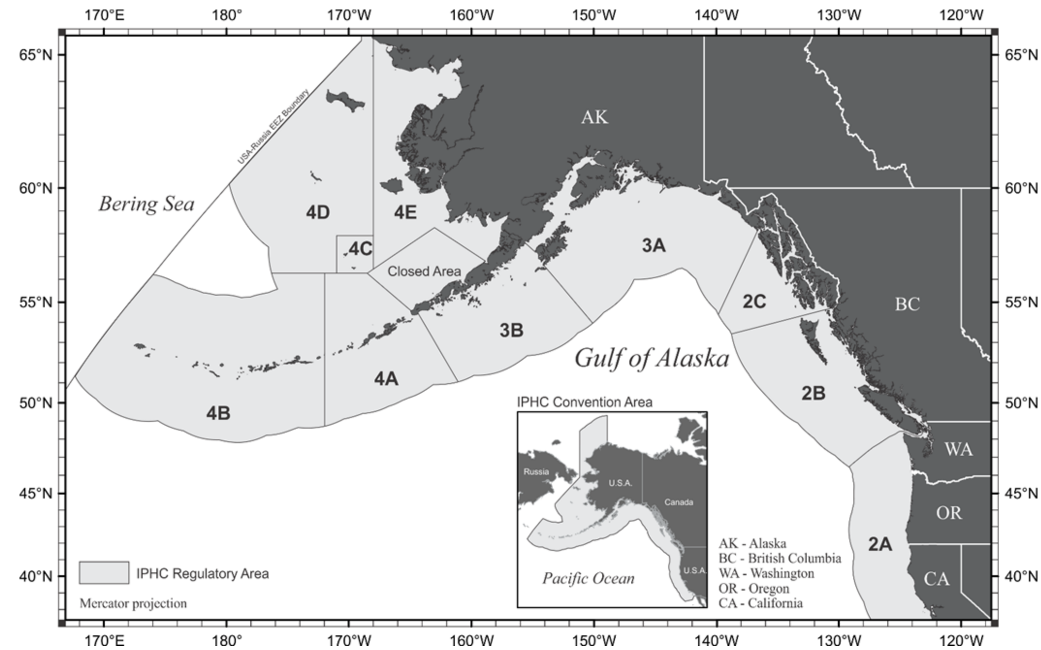

FIGURE 1. IPHC Regulatory Areas and the Pacific halibut geographical range within the territorial waters of Canada and the United States of America.

The Pacific halibut fishery has been managed by the IPHC since 1923. Catch limits for each of eight management Regulatory Areas[1] are set each year by the Commission. The stock assessment provides a summary of recently collected data, and model estimates of stock size and trend. Specific management information is summarized via a decision table reporting the estimated risks associated with alternative management actions and catch tables projecting the level of mortality for fisheries in each Regulatory Area indicated by the IPHC's interim management procedure, as well as other alternatives.

DATA

Historical removals

Known Pacific halibut removals (mortality) consist of target fishery landings and discard mortality (including research), recreational fisheries, subsistence, and bycatch mortality in fisheries targeting other species (where Pacific halibut retention is prohibited). Over the period 1918-2017 removals have totaled 7.2 billion pounds (~3.2 million metric tons, t), ranging annually from 34 to 100 million pounds (16,000-45,000 t) with an annual average of 63 million pounds (~29,000 t; Figure 2). Annual removals were above this long-term average from 1985 through 2010 and have been relatively stable near 42 million pounds (~19,000 t) since 2014.

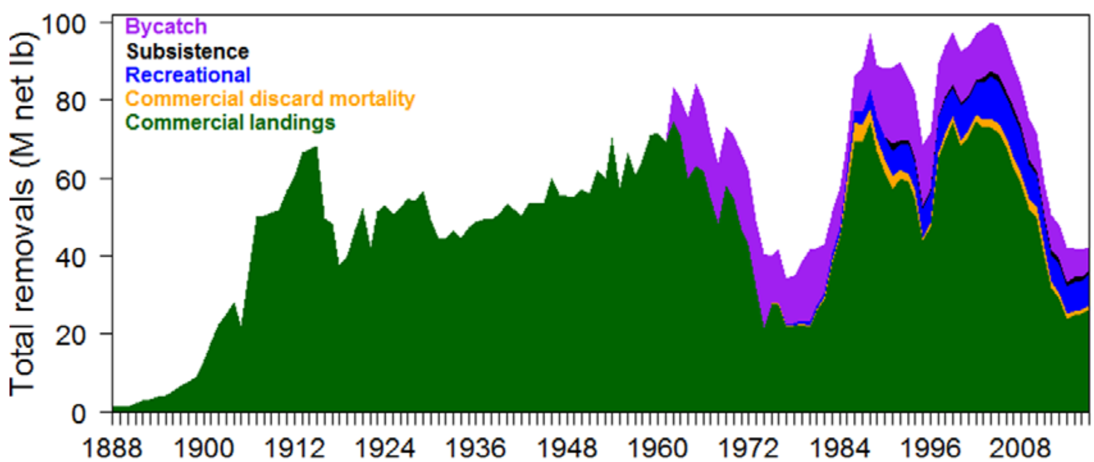

FIGURE 2. Summary of estimated historical mortality by source (colors), 1888-2017.

2017 Fishery and IPHC fishery-independent setline survey statistics

Coastwide commercial Pacific halibut fishery landings in 2017 were approximately 26.2 million pounds (~11,900 t), up from a low of 23.7 million pounds (~10,700 t) in 2014. Bycatch mortality was estimated to be 6.0 million pounds in 2017 (~2,720 t)[2], the lowest level in the estimated time series, beginning with the arrival of foreign fishing fleets in 1962, and just over one million pounds (~450 t) less than estimated for 2016. The total recreational removals was estimated to be 8.1

[1] The IPHC recognizes sub-Areas 4C, 4D, 4E and the Closed Area for use in domestic catch agreements but manages the combined Area 4CDE.

[2] The IPHC receives a preliminary estimate of the current year's bycatch mortality from the National Marine Fisheries Service Alaska Regional Office in early November.

million pounds (~3,675 t), up 10% from 2016. Removals from all sources in 2017 were estimated to be 42.4 million pounds (~19,200 t), up slightly from 41.8 million pounds in 2015 (~18,960 t).

Data are initially compiled by IPHC Regulatory Area and then aggregated to the coastwide level and to four biological Regions: Region 2 (Areas 2A, 2B, and 2C), Region 3 (Areas 3A, 3B), Region 4 (4A, 4CDE) and Region 4B (Figure 1). In addition to the removals (including all sizes of Pacific halibut), the assessment includes data from both fishery dependent and fishery independent sources as well as auxiliary biological information collected over the last 10 years, with the most spatially complete data available since the late-1990s. Primary sources of information for this assessment include indices of abundance from the IPHC's annual fishery-independent setline survey (numbers and weight) and commercial Catch-Per-Unit-Effort (weight), and biological summaries (length-, weight-, and age-composition data).

Efforts to improve the data sources included in the assessment have been ongoing since 2013, with a complete reprocessing of all inputs completed for 2015. Further improvements in 2016 included the transition to model-based setline survey indices (Webster 2017b). For 2017, additional data was included in the form of age data from setline survey expansions and additional stations sampled historically, individual Pacific halibut weights collected during port sampling of commercial fishery landings as well as an extended time-series (1993-2017) from the setline survey modelling (Webster 2017a) making use of 6 additional years of data (1993-1997 and 2017). As is standard practice, all mortality estimates and existing time-series were updated for 2016 and extended to include 2017 observations. All available information was finalized on 9 November 2017 in order to provide adequate time for analysis and modeling. As has been the case in all years, some data are incomplete, or include projections for the remainder of 2017. These include commercial fishery WPUE, commercial fishery age-composition data, and 2017 removals for all fisheries still operating after late-October 2016.

The 2017 IPHC's fishery-independent setline survey detailed a coastwide aggregate legal (O32) WPUE which was 10% lower than the value observed in 2016, with individual IPHC Regulatory Areas varying from a 1% increase (Regulatory Area 2C) to a 32% decrease (Regulatory Area 3B; Figure 3). Setline survey NPUE showed a more pronounced decrease from 2016 to 2017 (24% coastwide), with individual Regulatory Areas ranging from a 1% increase (Regulatory Area 4A) to a 44% decrease (Area 2A; Figure 4). Commercial fishery WPUE (based on extensive, but still incomplete logbook records available for this assessment) was slightly increased (5%) at the coastwide level with mixed trends among Regulatory Areas (Figure 5). Based on review by the IPHC's Scientific Review Board (SRB), a bias correction for each Regulatory Area was developed using the last five years of post-assessment revisions resulting from additional logbooks available after the assessment deadline in early November. Applying these corrections reduced the increase in coastwide commercial fishery WPUE to only 3% and negative trends were predicted for all Regulatory Areas except Area 4D (+71%), Area 4C (+20%) and Regulatory Area 3A (+6%). Tribal and non-tribal commercial fishery trends in Regulatory Area 2A are reported separately this year in response to important differences in the timing and spatial extent of the two components. Tribal fishery WPUE has been increasing since 2014 in that Area, and non-tribal WPUE has been declining over the same period, although a small increase (5%) from 2016 to 2017 was observed. The very large increase in WPUE observed in Regulatory Area 4D appears to be a function of much higher catch-rates around St. Matthew Island (also observed in the setline survey) and a shift of 25% of the catch previously occurring along the shelf-edge to the waters around that island in 2017. Age distributions in 2017 show a 2005 cohort somewhat stronger than those in adjacent years, and weak recruitments from 2006 onward. At the coastwide level, individual size-at-age continues to be very low relative to the rest of the time-series, although there has been little change over the last several years.

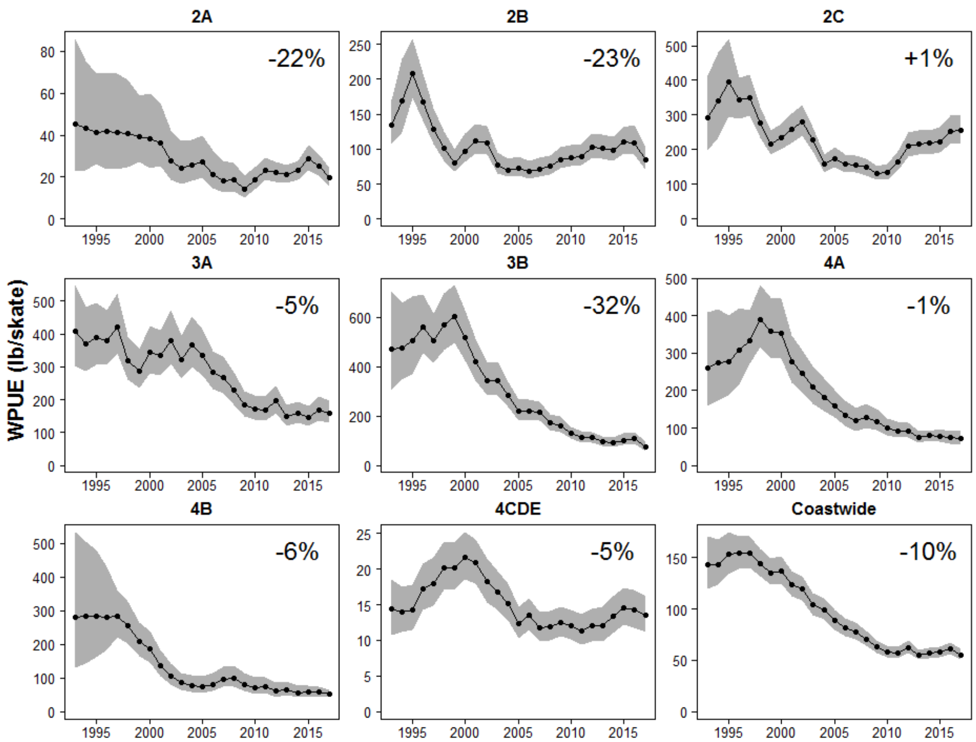

FIGURE 3. Trends in setline survey legal (O32) WPUE by IPHC Regulatory Area, 1993-2017. Percentages indicate the change from 2016 to 2017. Shaded zones indicate approximate 95% credibility intervals.

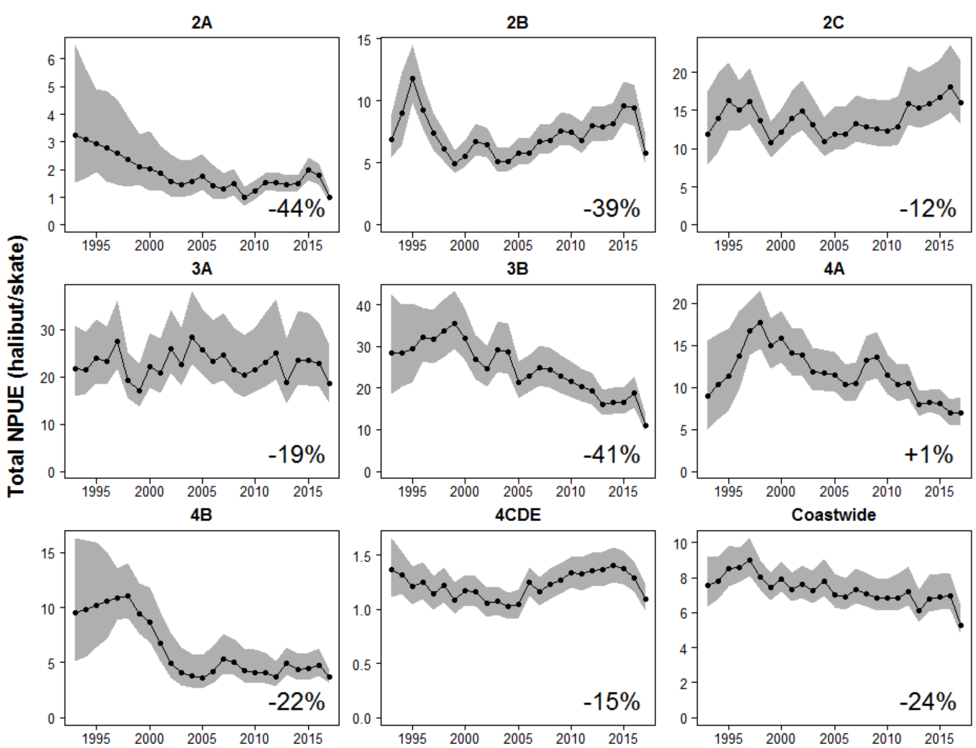

FIGURE 4. Trends in setline survey all-sizes NPUE by IPHC Regulatory Area, 1993-2017. Percentages indicate the change from 2016 to 2017. Shaded zones indicate approximate 95% credibility intervals.

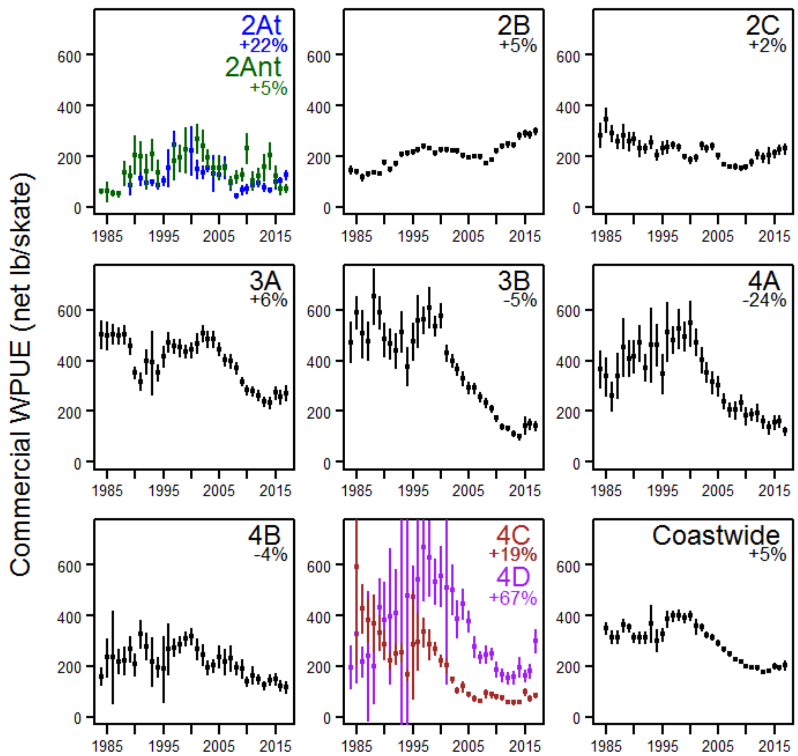

FIGURE 5. Trends in commercial fishery WPUE by Regulatory Area, 1984-2017. Percentages indicate the uncorrected change from 2016 to 2017 (see text above). Vertical lines indicate approximate 95% confidence intervals.

Stock distribution

During 2017, there was extensive consideration by the IPHC Secretariat of what constitutes a biologically-based stock distribution estimate (Hicks and Stewart 2017). Although IPHC Regulatory Areas have been used for distributional summary historically, there is no biological basis for that level of resolution. Instead, population-level information suggests that broader regions (with the exception of Regulatory Area 4B) are more biologically meaningful (Seitz et al. 2017).

Trends over the last five years indicate that population distribution, measured either via the O32 component of the setline survey catch or all sizes has been relatively stable (Figure 1, Table 2). However, over a decadal time-period (setline survey data prior to 1993 is insufficient to provide stock distribution estimates) there has been an increasing proportion of the coastwide stock occurring in Region 2 and a decreasing proportion occurring in Region 3. It is unknown to what degree either of these periods corresponds to historical distributions from the mid-1900s or to the average distribution likely to occur in the absence of fishing mortality.

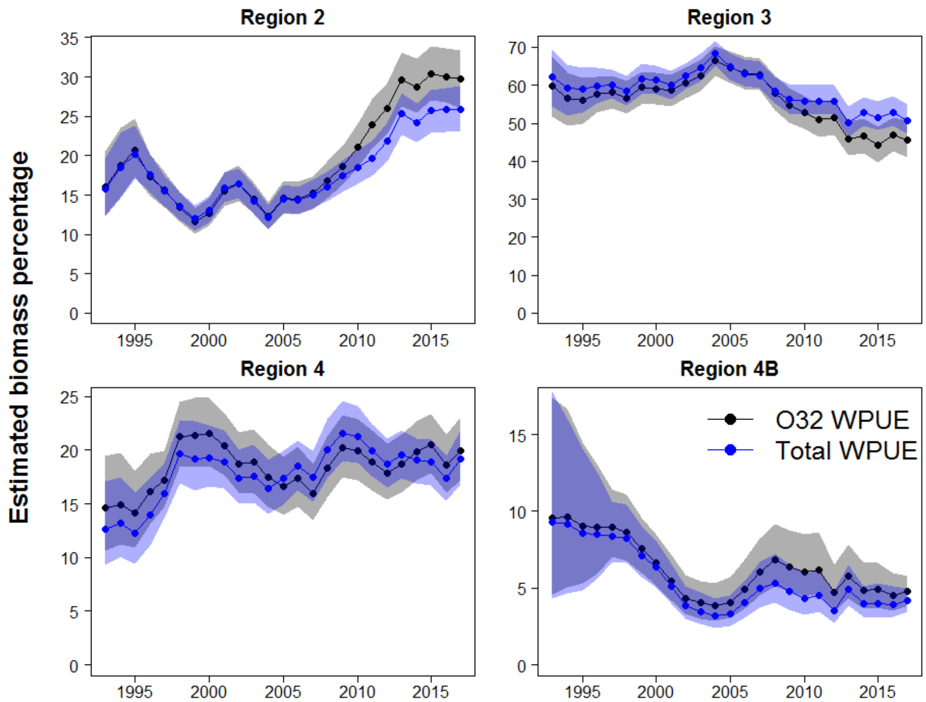

FIGURE 6. Estimated stock distribution (1993-2017) based on setline survey catch of O32 (black series) and all sizes (blue series) of Pacific halibut. Shaded zones indicate approximate 95% credibility intervals.

TABLE 1. Recent regional stock distribution estimates based on modelling of the fishery-independent setline survey data.

	O32 stock distribution				All sizes stock distribution			
Year	**Region 2 (2A, 2B, 2C)**	**Region 3 (3A, 3B)**	**Region 4 (4A, 4CDE)**	**Region 4B**	**Region 2 (2A, 2B, 2C)**	**Region 3 (3A, 3B)**	**Region 4 (4A, 4CDE)**	**Region 4B**
2013	29.6%	45.9%	18.7%	5.8%	25.4%	50.1%	19.6%	4.9%
2014	28.8%	46.5%	19.8%	4.9%	24.2%	52.8%	19.1%	4.0%
2015	30.4%	44.2%	20.5%	4.9%	25.7%	51.4%	18.9%	4.0%
2016	30.0%	46.8%	18.6%	4.5%	25.9%	52.8%	17.4%	3.9%
2017	29.7%	45.6%	20.0%	4.8%	25.9%	50.7%	19.2%	4.2%

STOCK ASSESSMENT

This stock assessment is implemented using the generalized software stock synthesis (Methot Jr and Wetzel 2013), and consists of an ensemble of four equally-weighted models; the basic approach remains unchanged since 2014.The ensemble is comprised of two long time-series models, reconstructing historical dynamics back to the beginning of the modern fishery, and two short time-series models incorporating data only from 1996 to the present when all sources of removals and surveys are available for all regions. For each time-series length there are two models: one fitting to coastwide aggregate data, and one to data disaggregated into the four geographic regions. This combination of models also includes uncertainty in natural mortality rates (estimated in the long time-series models, fixed in the short time-series models), environmental effects on recruitment (estimated in the long time-series models), and other model parameters.

As has been the case since 2012, this stock assessment is based on the approximate probability distributions derived from the ensemble of models, thereby incorporating the uncertainty within each model as well as the uncertainty among models. This approach reduces the potential for abrupt changes in management quantities as improvements and additional data are added to individual models, and provides a more realistic perception of uncertainty than any single model, and therefore a stronger basis for risk assessment. For 2017, the four models were equally weighted, as work-to-date on retrospective and predictive performance continues to suggest that each can be considered approximately equally plausible. Within-model uncertainty from each model was propagated through to the ensemble results via an asymptotic approximation. Point estimates reported in this stock assessment correspond to median values from the ensemble, and can therefore be described probabilistically.

BIOMASS AND RECRUITMENT TRENDS

The results of the 2017 stock assessment indicate that the Pacific halibut stock declined continuously from the late 1990s to around 2010 (Figure 7). That trend is estimated to have been largely a result of decreasing size-at-age, as well as somewhat weaker recruitment strengths than those observed during the 1980s. Since the estimated female spawning biomass (SB) stabilized near 200 million pounds (~90,100 t) in 2010, the stock is estimated to have increased gradually to 2017. The SB at the beginning of 2018 is estimated to be 202 million pounds (~91,600 t), with an approximate 95% confidence interval ranging from 148 to 256 million pounds (~67,100-116,100 t; Figure 8). Comparison with previous stock assessments indicates that the 2017 results are very consistent (although slightly lower) with estimates from 2012 through 2016, all of which lie inside the 50% interval (Figure 9.). The 2017 SB estimate from the 2017 stock assessment is only 2% below the estimate from the 2016 stock assessment.

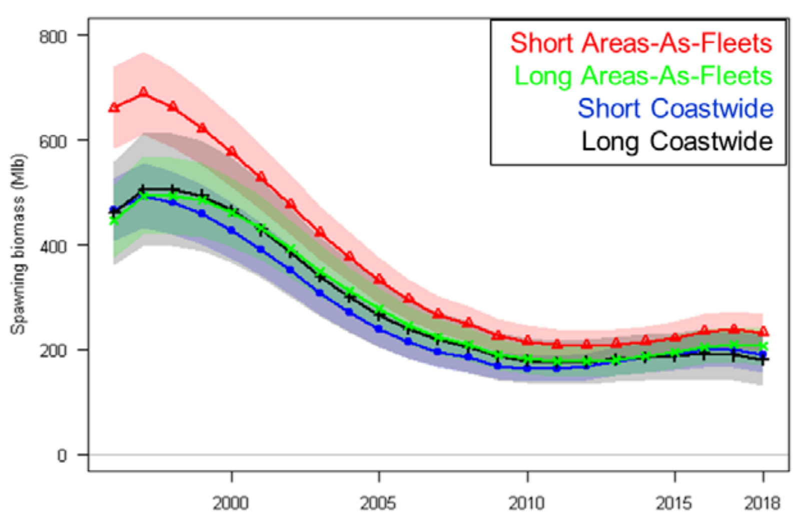

FIGURE 7. Estimated spawning biomass trends (1996-2018) based on the four individual models included in the 2017 stock assessment ensemble. Series indicate the maximum likelihood estimates; shaded intervals indicate approximate 95% confidence intervals.

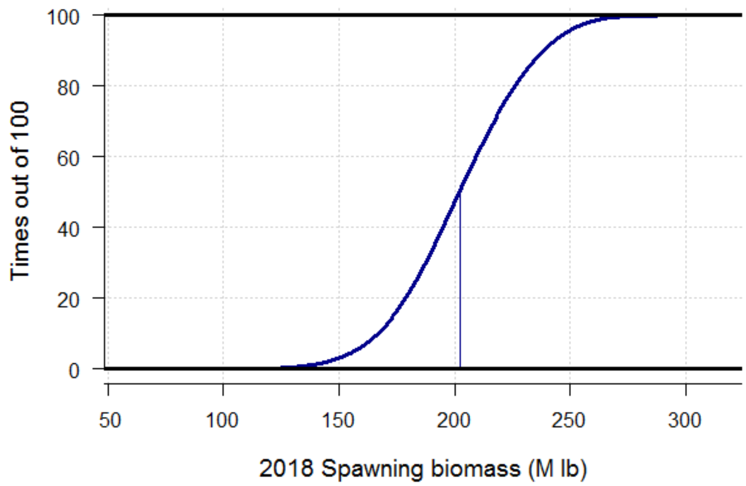

FIGURE 8. Cumulative distribution of the estimated spawning biomass at the beginning of 2018. Curve represents the estimated probability that the biomass is less than or equal to the value on the x-axis; vertical line represents the median (202 million pounds; ~91,600 t).

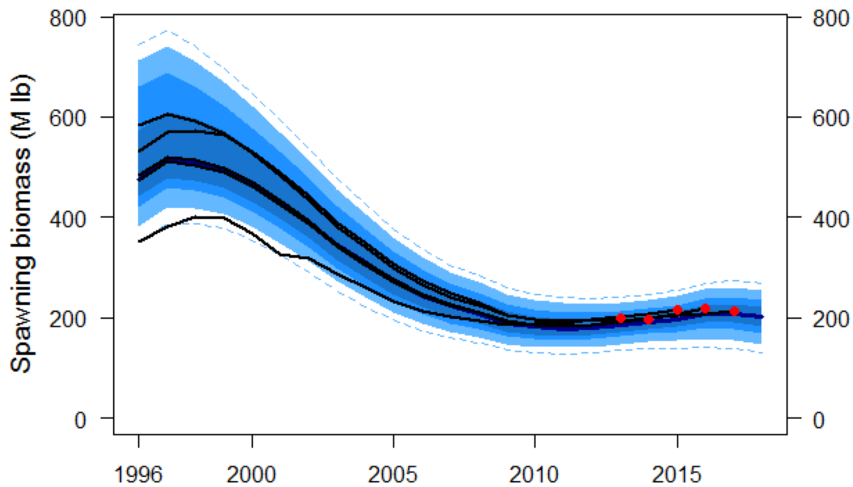

FIGURE 9. Retrospective comparison among recent IPHC stock assessments. Black lines indicate estimates of spawning biomass from assessments conducted from 2012-2016 with the terminal estimate shown as a point, the shaded distribution denotes the 2017 ensemble: the dark blue line indicates the median (or “50:50 line”) with an equal probability of the estimate falling above or below that level; colored bands moving away from the median indicate the intervals containing 50/100, 75/100, and 95/100 estimates; dashed lines indicating the 99/100 interval.

Based on the two long time-series models, average Pacific halibut recruitment is estimated to be higher (41 and 76% for the coastwide and AAF models respectively) during favorable Pacific Decadal Oscillation (PDO) regimes, a widely used indicator of productivity in the north Pacific. Historically, these regimes included positive conditions prior to 1947, poor conditions from 1947-77, positive conditions from 1978-2006, and poor conditions from 2007-13. Annual averages from 2014 through October 2016 have been positive; however, many other environmental indicators, current and temperature patterns have been anomalous relative to historical periods. Further, observed declines in Pacific cod (*Gadus macrocephalus*) in the Gulf of Alaska, seabird mortality events and other conditions suggest that historical patterns of productivity related to the PDO may not be relevant to the most recent few years. Pacific halibut recruitment estimates show the largest recent cohorts in 1999 and 2005. Cohorts from 2006 through 2013 are estimated to be smaller than those from 1999-2005 (Figure 10). This indicates a high probability of decline in both the stock and fishery yield as recent recruitments become increasingly important to the age range over which much of the harvest and spawning takes place.

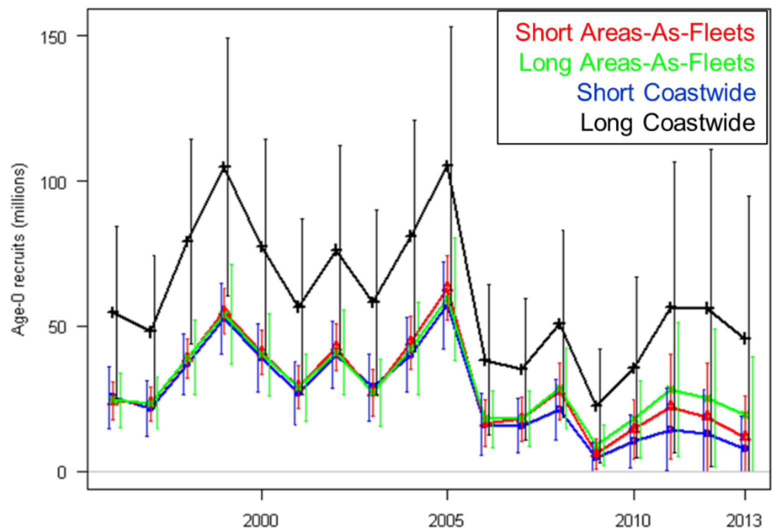

FIGURE 10. Estimated age-0 recruitment trends (1996-2013) based on the four individual models included in the 2017 stock assessment ensemble. Series indicate the maximum likelihood estimates; vertical lines indicate approximate 95% confidence intervals.

HARVEST POLICY AND OTHER REFERENCE POINTS

A comparison of the median 2018 ensemble SB to reference levels specified by the interim management procedure suggests that the stock is currently at 40% (approximate 95% credible range = 26-60%) of specified unfished levels (relative to the SB specified by the current management procedure). The probability that the stock is below the $SB_{30\%}$ level is estimated to be 6%, with less than a 1% chance that the stock is below $SB_{20\%}$ (Table 2). Consistent with the interim management procedure (while improvements are ongoing), estimates of spawning biomass are compared to equilibrium values representing poor recruitment regimes and relatively large size-at-age. Alternative reference points include the spawning biomass estimated to have occurred at the lowest point in the historical time-series (1977-78), as well as the spawning biomass that would be estimated to occur at present (given recent recruitment and biology) in the absence of fishing (dynamic SB0; Hicks and Stewart 2017). The two long time-series models provide a comparison with SB levels estimated to have occurred during the historically low stock sizes of the 1970s: the AAF model suggests that recent stock sizes are at 96% of those levels, and the coastwide model at 215%. The estimates of current spawning biomass relative to the dynamic reference point range from 26-43% among the four stock assessment models, with an average value of 33%. Relatively large differences among models reflect both the uncertainty in historical dynamics as well as the importance of spatial patterns in the data and population processes, for which all of the models represent only simple approximations.

MAJOR SOURCES OF UNCERTAINTY

This stock assessment includes uncertainty associated with estimation of model parameters, treatment of the data sources (e.g., short and long time-series), natural mortality (fixed vs. estimated), approach to spatial structure in the data, and other differences among the models included in the ensemble. Although this is an improvement over the use of a single assessment model, there are important sources of uncertainty that are not included.

Two uncertainties in our current understanding of the Pacific halibut resource are:

1) The sex-ratio of the commercial catch (not sampled due to the dressing of fish at sea), which serves to set the scale of the estimated female abundance in tandem with assumptions regarding natural mortality. Voluntary marking in tandem with genetic sampling of all Pacific halibut sampled from the commercial landings will allow an estimate of the 2017 landings to be available for the next stock assessment. It will take several years to generate enough information on the sex ratio of the landings to begin to meaningfully inform the stock assessment models; however, this represents a crucial step toward addressing this source of uncertainty for future stock assessments. The uncertainty in the historical time-series will remain.

2) The treatment of spatial dynamics and movement rates among Regulatory Areas, which are represented via the coastwide and AAF approaches, and have large implications for the current stock trend. In addition, movement rates for adult and younger Pacific halibut (roughly ages 0-6, which were not well-represented in the PIT-tagging study), particularly to and from Area 4, are necessary for parameterizing a spatially explicit stock assessment. Current understanding of these rates has now been summarized, but remains problematic for tactical stock assessment modelling.

Other important contributors to assessment uncertainty and potential bias include recruitment, size-at-age, and fishery removals. The link between Pacific halibut recruitment strengths and environmental conditions remains poorly understood, and there is no guarantee that observed correlations will continue in the future. Therefore, recruitment variability remains a substantial source of uncertainty in current stock estimates due to the lag between birth year and direct observation in the fishery and survey data (6-10 years). Reduced size-at-age relative to levels observed in the 1970s is the most important driver of recent stock trends, but its cause also remains unknown. The historical record suggests that size-at-age changes relatively slowly; therefore, although projection of future values is highly uncertain, near-term values are unlikely to be substantially different than those currently observed. Data suggest that the decreasing trend in size-at-age has slowed and coastwide values have been relatively stable over the last decade. Like most stock assessments, estimated removals from the stock are assumed to be accurate. Therefore uncertainty due to bycatch mortality estimation (observer sampling and representativeness), discard mortality rates, and any other unreported sources of removals in either directed or non-directed fisheries could create bias in this assessment. Ongoing research on these topics may help to inform our understanding of these processes in the long-term, but in the near-future it appears likely that a high degree of uncertainty in both stock scale and trend will continue to be an integral part of the annual management process.

This stock assessment contains a broader representation of uncertainty in stock levels relative to analyses for many other species. Although the data available for this stock assessment has narrowed both the historical and projected confidence intervals for stock size and trend relative to last year’s assessment and projections, the considerable remaining uncertainty can be seen in the distribution for spawning biomass estimated at the beginning of 2017 (Figure 8), such that the small differences between the estimate from the 2017 and recent assessments (Figure 9) are not statistically significant.

OUTLOOK

Stock projections were conducted using the integrated results from the stock assessment ensemble, summaries of the 2017 directed fisheries and other sources of mortality. The harvest decision table (Table 3) provides a comparison of the relative risk (in times out of 100), using stock and fishery metrics (rows), against a range of alternative harvest levels for 2018 (columns). The orientation of this table has changed from previous analyses in order to make the comparison of additional metrics easier (the second year of projection is now explicitly included), and to increase consistency with the results produced from the Management Strategy Evaluation (Hicks & Stewart 2017). The block of rows entitled “Stock Trend” provides for evaluation of the risks to short-term trend in spawning biomass, independent of all harvest policy calculations. The remaining rows portray risks relative to the spawning biomass reference points (“Stock Status”) and fishery performance identified in the interim management procedure. The alternatives (columns) provided include several coarsely spaced levels of mortality intended to provide for evaluation of stock dynamics including:

- No mortality (useful to evaluate the stock trend due solely to population processes),
- A 10 million pound (~4,500 t) 2018 Total Constant Exploitation Yield (TCEY[3])
- A 50 million pound (~22,700 t) 2018 TCEY
- A 60 million pound (~27,200 t) 2018 TCEY
- The removals consistent with the reference SPR ($F_{46\%}$) level.

A finer grid of alternative TCEY values is provided around the column corresponding to the reference level of fishing intensity (SPR=46%; for 2018 a TCEY of 31 million pounds, ~14,060 t).

For each row of the decision table, the total mortality of all sizes and from all sources, the coastwide TCEY and the associated level of fishing intensity (median value with the 95% credible range below; measured via the Spawning Potential Ratio) are reported. Fishing intensity reflects the relative reduction in equilibrium (long-term) spawning biomass per recruit from all sources and sizes of removals, reported as $F_{x\%}$, (where x = the SPR) for comparison to other management processes in both nations where harvest rate targets and limits are commonly reported in these units. As in previous years, it is expected that additional alternatives will be produced during the IPHCs annual process such that all management alternatives considered for 2018 can be directly evaluated in terms projected total mortality and risk.

The stock is projected to decrease gradually over the period from 2018-20 for removals around the reference SPR level (Figure 11). The risk of stock declines begins to increase rapidly for TCEYs above 31 million pounds (~14,060 t), becoming more pronounced by 2020 (Table 3). The reference SPR corresponds to a 78/100 (78%) chance of stock decline through 2019, and a 46% chance of at least a 5% decline through 2021 at that constant level of TCEY. TCEYs

[3] The TCEY corresponds approximately to the mortality comprised of Pacific halibut greater than 26 inches (66 cm) in length.

corresponding to recent levels of fishing mortality correspond to probabilities of stock decline over the next one to three years greater than 95%. There is a relatively small chance (<21/100; 21%) that the stock will decline below the threshold reference point (SB30%) in projections for all the levels of TCEY up to 40 million pounds (~18,100 t) evaluated over three years; for TCEYs exceeding that level, the probability begins to increase rapidly.

TABLE 3. Harvest decision table for 2018. Columns correspond to yield alternatives and rows to risk metrics. Values in the table represent the probability, in "times out of 100" (or percent chance) of a particular risk.

		2018 Alternative	No removals							*Reference: SPR=46%*								
		Total removals (M lb)	0.0	11.8	21.8	28.8	29.8	30.8	31.8	32.8	33.8	34.8	35.8	37.3	41.8	51.8	61.9	
		TCEY (M lb)	0.0	10.0	20.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.5	40.0	50.0	60.0	
		Fishing intensity	$F_{100\%}$	$F_{73\%}$	$F_{58\%}$	$F_{50\%}$	$F_{49\%}$	$F_{48\%}$	$F_{47\%}$	$F_{46\%}$	$F_{45\%}$	$F_{44\%}$	$F_{43\%}$	$F_{42\%}$	$F_{39\%}$	$F_{32\%}$	$F_{27\%}$	
		Fishing intensity interval	--	61-84%	45-73%	37-67%	36-66%	36-65%	35-65%	34-64%	33-63%	32-63%	32-62%	31-61%	28-58%	23-53%	19-48%	
Stock Trend (spawning biomass)	in 2019	is less than 2018	1	3	24	59	64	69	74	78	81	85	87	91	98	>99	>99	a
		is 5% less than 2018	<1	<1	<1	2	2	3	4	5	7	9	11	14	29	69	96	b
	in 2020	is less than 2018	<1	1	14	46	52	57	62	67	71	76	80	85	95	>99	>99	c
		is 5% less than 2018	<1	<1	1	9	11	14	18	21	25	29	34	41	61	94	>99	d
	in 2021	is less than 2018	<1	2	23	59	63	68	72	76	79	83	86	90	97	>99	>99	e
		is 5% less than 2018	<1	<1	5	27	32	36	41	46	50	55	59	66	83	99	>99	f
Stock Status (Spawning biomass)	in 2019	is less than 30%	3	4	5	6	6	7	7	7	7	7	7	8	9	11	15	g
		is less than 20%	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	h
	in 2020	is less than 30%	2	2	4	6	6	6	7	7	8	8	9	9	12	21	32	i
		is less than 20%	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	1	j
	in 2021	is less than 30%	1	1	4	7	8	8	9	10	11	12	13	15	21	37	54	k
		is less than 20%	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	2	7	l
Fishery Trend (TCEY)	in 2019	is less than 2018	<1	<1	7	33	38	43	49	55	60	64	68	71	78	89	97	m
		is 10% less than 2018	<1	<1	3	23	26	30	34	38	43	48	53	59	72	82	92	n
	in 2020	is less than 2018	<1	<1	10	38	43	49	54	59	63	67	70	73	79	91	98	o
		is 10% less than 2018	<1	<1	6	27	31	36	40	45	50	54	59	64	74	84	95	p
	in 2021	is less than 2018	<1	<1	14	44	50	55	59	63	67	69	72	74	81	93	>99	q
		is 10% less than 2018	<1	<1	9	34	38	43	48	52	56	60	63	67	75	86	99	r
Fishery Status (Fishing intensity)	in 2018	is above $F_{46\%}$	0	<1	4	29	33	38	43	50	54	60	64	69	77	87	95	s

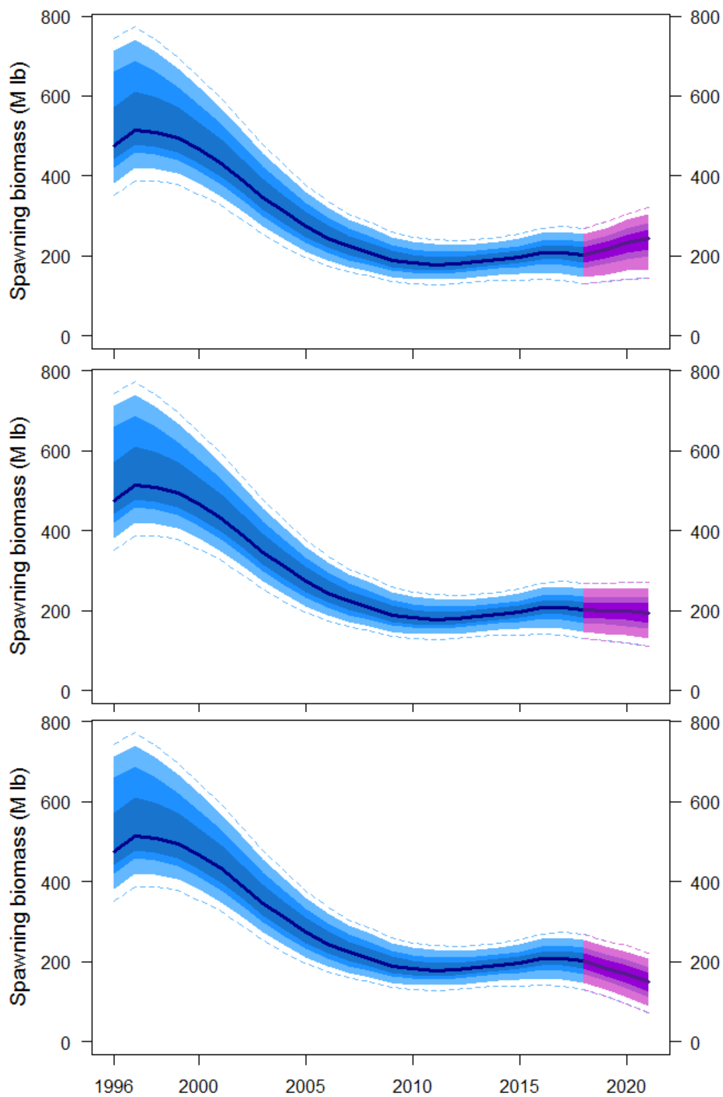

FIGURE 11. Three-year projections of stock trend under alternative levels of mortality: no removals (upper panel), Reference SPR=46% (32.8 million pounds, ~14,900 t; middle panel) and a TCEY of 60 million pounds (~27,200 t; lower panel).

SCIENTIFIC ADVICE

Sources of mortality: In 2017, total removals were below the 100-year average, and have been stable near 42 million pounds (19,050 t) from 2014-17 (Figure 2). In 2017, 83% of the total removals from the stock were retained compared to 80% in 2016.

Fishing intensity: The 2017 mortality from all sources corresponds to a point estimate of SPR = 40% (there is a 75% chance that fishing intensity exceeded the IPHC's reference level of 46%; Table 2). In order to reach the interim reference level, catch limits would need to be reduced for 2018. The Commission does not currently have a coastwide limit fishing intensity reference point.

Stock status (spawning biomass): Current female spawning biomass is estimated to be just above 200 million pounds (90,700 t), which corresponds to only a 6% chance of being below the

IPHC threshold (trigger) reference point of $SB_{30\%}$, and less than a 1% chance of being below the IPHC limit reference point of $SB_{20\%}$. Therefore, no adjustment to the target fishing intensity is required, and the stock is not considered to be '**overfished**'. Projections indicate that the target fishing intensity is likely to result in similar, but declining biomass levels in the near future (Figure 11).

Stock distribution: Regional stock distribution has been stable within estimated credibility intervals over the last five years (Figure 6). Region 2 currently represents a greater proportion, and Region 3 a lesser proportion of the coastwide stock than observed in previous decades.

TABLE 2. Status summary of Pacific halibut in the IPHC Convention Area at the end of 2017.

Indicators	Values	Trends	Status
Total mortality 2017: Retained mortality 2017: Average mortality 2013-17:	42.44 Mlbs, 19,250 t[1] 35.29 Mlbs, 11,864 t 43.34 Mlbs, 19,659 t	Mortality stable 2014-17	**2017 MORTALITY BELOW 100-YEAR AVERAGE**
SPR_{2017}: P(SPR<46%): P(SPR<limit):	40% (29-58%)[2] 75% Limit not specified	Fishing intensity increased from 2016 to 2017	**FISHING INTENSITY HIGHER THAN REFERENCE LEVEL**[3]
SB_{2018} (Mlb): SB_{2018}/SB_0: $P(SB_{2018}<SB_{30})$: $P(SB_{2018}<SB_{20})$:	202 Mlbs (148–256) 40% (26-60%) 6% <1%	SB decreased from 2017 to 2018	**NOT OVERFISHED**[4]
O32 stock distribution: All stock distribution:	See Table 1 and Figure 6	Distribution stable 2013-17	**REGION 2 ABOVE, REGION 3 BELOW HISTORICAL VALUES**

[1] Weights in this document are reported as 'net' weights, head and guts removed; this is approximately 75% of the round (wet) weight).
[2] Ranges denote approximate 95% confidence intervals from the stock assessment ensemble.
[3] Status determined relative to the IPHC's interim reference Spawning Potential Ratio level of 46%.
[4] Status determined relative to the IPHC's interim management procedure biomass limit of $SB_{20\%}$.

RESEARCH PRIORITIES

Research priorities for the stock assessment and related analyses can be delineated into two broad categories: gaps in biological understanding and technical development.

Biological understanding: During the last several years, the IPHC Secretariat has developed a comprehensive five-year research program (Planas 2017). The development of the research priorities has been closely tied to the needs of the stock assessment and harvest strategy policy analyses, such that each of the IPHC's ongoing projects (e.g., determining the sex-ratio of the commercial landings, updating estimates of the maturity schedule for Pacific halibut, better understanding of recruitment processes and stock structure, etc.) will provide data, and hopefully knowledge, about key biological and ecosystem processes that can then be incorporated directly into analyses supporting the management of Pacific halibut.

Technical development: The IPHC's stock assessment, Management Strategy Evaluation (MSE), and harvest strategy policy methods is ongoing, and responds to new developments in the data or analyses necessary each year. New approaches are tested, reported to the IPHC's SRB (generally in June), refined (and reviewed again in October, as needed), and ultimately incorporated in the development of the best scientific information available for the annual management process. Current technical research priorities include:

1) Maintaining consistency and coordination between MSE, and stock assessment data, modelling and methodology.

2) Continued refinement of the ensemble of models used in the stock assessment.

3) Continued development of weighting approaches for models included in the ensemble, potentially including fit to the survey index of abundance, retrospective, and predictive performance.

4) Exploration of methods for better including uncertainty in discard mortality and bycatch estimates in the assessment (now evaluated only via alternative catch tables or model sensitivity tests) in order to better include these sources uncertainty in the decision table.

5) Bayesian methods for fully integrating parameter uncertainty may provide improved uncertainty estimates within the models contributing to the assessment, and a more natural approach for combining the individual models in the ensemble.

RECOMMENDATION/S

That the Commission:

a) **NOTE** paper IPHC-2018-AM094-08 which provides a summary of data, the stock assessment and the harvest decision table for 2018.

References

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