Options for the treatment of U26 discard mortality from non-directed fisheries (*bycatch*) within a total mortality limit

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PURPOSE

To provide the Commission with a set of options and a discussion of those options in response to:

> *"AM095–Rec.04 (para. 66) The Commission **RECOMMENDED** evaluating and redefining TCEY to include the U26 component of discard mortalities, including bycatch, as steps towards more comprehensive and responsible management of the resource, in coordination with the IPHC Secretariat and Contracting Parties. The intent is that each Contracting Party to the Treaty would be responsible for counting its U26 mortalities against its collective TCEY. This change would be intended to take effect for TCEYs established at the 2020 Annual Meeting."*

BACKGROUND

The IPHC's process for setting annual mortality limits has changed appreciably over its history. Historically, the IPHC set limits called Fishery Constant Exploitation Yields[1] (FCEYs) which constrained the retained catch of the directed commercial Pacific halibut fishery. Due to the 32 inch (81.3 cm) minimum size limit (MSL), in place since 1973 (Myhre 1973), the FCEY only applied to mortality above the MSL. In only IPHC Regulatory Areas 2A and 2B recreational mortality was also included in the FCEY. Harvest strategy calculations consisted of calculating the Total Constant Exploitation Yield (TCEY), then subtracting off the projected levels of "other removals" consisting of all recreational and subsistence mortality, as well as discard mortality from non-directed fisheries (bycatch) and directed commercial Pacific halibut fishery discard mortality estimates of fish over 32" to get the FCEY. Discussion of 'regularizing' the treatment of discard mortality from non-directed fisheries (bycatch) and directed commercial discard mortality to be consistent with the treatment of recreational and subsistence mortality began in 2006 (Hare and Clark 2007). In 2011 the mortality represented by 'other removals' was extended to add fish over 26 inches (66 cm) in length (O26), thereby adding to the deductions made from the TCEY to get to the FCEY (Hare 2011a, 2011b). Prior to the 2012 stock assessment, projections of the total mortality from all sources and sizes of Pacific halibut, and TCEYs associated with the mortality limits (FCEYs) adopted by the Commission each year were not routinely reported. In 2014, Catch Sharing Plans (CSPs) were adopted in IPHC Regulatory Areas 2C and 3A which resulted in the inclusion of the charter recreational mortality in the FCEY rather than the 'other removals'.

More recently, the Commission directed the IPHC Secretariat to provide for setting mortality limits based on the TCEY for 2018:

> *"AM093–Rec.05 (para. 30) NOTING that the Commission has indicated its interest in clearer accounting for all mortality, and that Canada has put forward catch limit allocation principles proposing that catch limits include all sources of mortality for each regulatory area, the Commission RECOMMENDED that the presentation of harvest advice be changed to be based on the TCEY, which includes all O26 commercial, sport, personal*

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

> *use/subsistence, bycatch and wastage removals, for the 2018 Annual Meeting cycle, as a step towards more comprehensive and responsible management of the resource that will result in the negotiation of Regulatory Area-specific catch limits based on TCEYs."*

This change clarified the components included in the adopted mortality limits and standardized these components across all IPHC Regulatory Areas regardless of the CSPs in place for Pacific halibut. As of 2019, all sources of Pacific halibut mortality except for discard mortality from non-directed fisheries (bycatch) of U26 fish were included in the adopted mortality limits (TCEYs).

At the 95th Session of the IPHC Annual Meeting (AM095) the Commission provided further direction on setting mortality limits on all sizes:

> AM095–Rec.04 (para. 66) *"The Commission RECOMMENDED evaluating and redefining TCEY to include the U26 component of discard mortalities, including bycatch, as steps towards more comprehensive and responsible management of the resource, in coordination with the IPHC Secretariat and Contracting Parties. The intent is that each Contracting Party to the Treaty would be responsible for counting its U26 mortalities against its collective TCEY. This change would be intended to take effect for TCEYs established at the 2020 Annual Meeting."*

This paper provides a set of options for addressing limits on U26 discard mortality from non-directed fisheries (bycatch) and a discussion of those options.

IMPORTANCE OF THE U26 DELINEATION

The historical choice of U26 (and earlier U32) on which to delineate the accounting of mortality was based on three primary considerations:

1) These young fish are highly mobile and much less likely than older fish to be found in the same IPHC Regulatory Area (or Biological Region) in the upcoming year in which mortality limits would apply. Therefore, the effects of U26 mortality on potential O26 yield are likely to be distributed broadly across the stock in subsequent years.
2) The IPHC's Fishery Independent Setline Survey (FISS) captures Pacific halibut that are approximately O26, providing an annually updated scientifically-based measure of the stock distribution across the IPHC Convention Area. There is currently no reliable tool for describing the annual distribution of U26 fish across the Convention Area.
3) Mortality of U26 fish has a different effect on the Spawning Potential Ratio (SPR; a measure of the fishing intensity describing the effect on the lifetime spawning output per recruit) than that of older fish. Although this is the case for any category of size/age delineation, previous work suggests that the effects change most rapidly around this size. This concept is further illustrated as part of the options provided below.

All three of these factors suggest that addressing U26 mortality separately from O26 mortality may in some way be warranted when setting catch limits. Therefore, the options provided below allow for consideration of both separate and partitioned limits for U26 and O26 within a total mortality limit.

USE OF THE TERMS FCEY AND TCEY

The Contracting Party CSPs (and in some cases other regulations) currently in place in many IPHC Regulatory Areas are based on the terms FCEY and TCEY. In order to provide for the time needed to adjust the wording of CSPs to match the IPHC's mortality limit setting process (noting that none have yet caught up to the change to the Commission setting TCEYs beginning in 2018), it could be beneficial to temporarily retain the calculation of FCEYs and TCEYs, and enhance these terms with a total, partitioned total or separate U26 limit per the options below.

DESCRIPTION OF OPTIONS

There are two key aspects to both the IPHC's interim management procedure and the Management Strategy Evaluation (MSE) process:

1) the scale of mortality limits is done at the coastwide level, and;

2) the distribution of those mortality limits occurs among Biological Regions and IPHC Regulatory Areas.

The options for managing U26 mortality provided below are therefore divided into those two aspects; one option will need to be selected to determine the coastwide scale of U26 mortality, and one to determine the distribution of U26 mortality.

Scale

For this initial discussion paper, three U26 mortality scale options are provided:

Scale Option 1. The *status quo* (no change to the current approach of setting TCEYs):

> Predicted U26 discard mortality from non-directed fisheries (bycatch) is currently based on the previous year's estimate (https://www.iphc.int/data/projection-tool). At the request of the Commission, in some years differing levels of projected discard mortality from non-directed fisheries (bycatch) have been used to construct alternative mortality tables for use in decision-making (Stewart 2018). This option allows for a direct evaluation of the projected effects of discard mortality from non-directed fisheries (bycatch), but offers the Commission no explicit accounting method for comparing predicted and observed U26 mortality after the limits have been set. It is important to note that O26 mortality for all fisheries (directed and non-directed) is already part of the TCEY, and therefore changes in the overall magnitude of O26 discard mortality from non-directed fisheries (bycatch) will be evident in comparisons of mortality limits with the previous year's estimates (e.g. Table 1 in https://www.iphc.int/uploads/pdf/am/2019am/iphc-2019-am095-05.pdf).

Scale Option 2. Setting a total mortality limit

> The Commission could set a single mortality limit including all sources and sizes of Pacific halibut. This approach has a potentially important shortcoming in that there will be differences in the SPR resulting from a single catch limit given varying levels/proportion of U26 discard mortality from non-directed fisheries (bycatch). To illustrate these potential effects within a single catch limit, the 2019 projected mortality levels were evaluated using the preliminary 2019 stock assessment (IPHC-2019-SRB014-07). Holding the total mortality constant at the projected magnitude, the SPR was compared under three scenarios:
>
> 1) 2019 discard mortality from non-directed fisheries (bycatch) mortality with the O26:U26 ratio exactly matching the projections;
> 2) all projected discard mortality from non-directed fisheries (bycatch) mortality taken as U26;
> 3) all projected discard mortality from non-directed fisheries (bycatch) taken as O26 (see Appendix A for a description of how this was conducted).
>
> The results of these alternative projections indicted that the change in SPR could range from –4% to 0% under current conditions (Table 1). This range represents extreme

values, as actual discard mortality from non-directed fisheries (bycatch) is unlikely to comprise all or no U26; however, discard mortality from non-directed fisheries (bycatch) is currently at a historical low which reduces the magnitude of the effect on SPR. This source of variability in projected SPR would be in addition to the considerable annual variability in realized vs. projected SPR caused by revised estimates of model parameters (biomass levels and recruitment), and differences between the projected and actual magnitude of mortality.

TABLE 1. Percent change in SPR with different treatments of recent discard mortality from non-directed fisheries (bycatch) mortality of Pacific halibut.

Discard mortality from non-directed fisheries (bycatch) scenario for 2019	Change in SPR
All mortality as U26	-4%
U26:O26 ratio as projected	0%
All mortality as O26	0%

Scale Option 3. Separate TCEY and U26 discard mortality from non-directed fisheries (bycatch) limits summing to a total mortality limit, or via a partitioned total mortality limit:

This option allows for the Commission to set limits that fully describe all sizes and sources of Pacific halibut mortality and also increases the predictability of the SPR resulting from these limits. It could consist of two limits: one for the TCEY and one for the U26 discard mortality from non-directed fisheries (bycatch), or a combined limit with an explicit partition (percentage) assigned to either the U26 discard mortality from non-directed fisheries (bycatch) or TCEY components.

It is important to note that even though these options treat the management of U26 discard mortality from non-directed fisheries (bycatch) differently, the stock assessment projections provided for management will be conducted in the same way regardless of the option chosen. For all three options, the decision-making tables presented as part of the stock assessment (decision table and mortality limits table) will have the same structure as in 2019:

- For the *status quo* option, the previous year's U26 mortality amount is predicted.
- For option 2 (total mortality limit), the percentage of U26 mortality will be predicted.
- For option 3 (separate limits) the management decision for U26 mortality will be projected.
- For all options, alternative predictions (such as full Prohibited Species Catch limit usage) can also be considered.

Distribution

For this initial discussion paper, four U26 mortality distribution options are provided:

Distribution Option 1. The *status quo* (no change to the current approach – most recent year):

Predicted U26 discard mortality from non-directed fisheries (bycatch) mortality by IPHC Regulatory Area (distributed) is currently based on the most recent year's estimates (https://www.iphc.int/data/projection-tool). This approach implicitly assumes that the effects of U26 discard mortality from non-directed fisheries (bycatch) on the Pacific halibut stock are accounted for in the coastwide SPR, and that the most recent estimates of stock

distribution reflect the most likely distribution of the U26 fish comprising the mortality in future years.

Distribution Option 2. Recent use (several years):

This option would use additional information prior to the most recent year to distribute U26 discard mortality from non-directed fisheries (bycatch) mortality. Specifically, the average U26 mortality observed over a recent period (e.g., 3- 5- or 10-years; Table 2) could be used to distribute the U26 limit among IPHC Regulatory Areas.

TABLE 2. Recent discard mortality from non-directed fisheries (fisheries that cannot legally retain Pacific halibut; bycatch) of Pacific halibut <26 inches in length (U26; million net pounds).

Year	2A	2B	2C	3A	3B	4A	4B	4CDE	Canada	U.S.	Coastwide
2009	0.04	0.02	0.01	0.87	0.37	0.67	0.14	1.56	0.02	3.65	3.67
2010	0.00	0.01	0.01	0.81	0.33	0.45	0.14	1.63	0.01	3.36	3.38
2011	0.00	0.02	0.01	0.87	0.33	0.42	0.14	1.18	0.02	2.95	2.96
2012	0.01	0.03	0.01	0.61	0.34	0.63	0.08	1.66	0.03	3.32	3.35
2013	0.00	0.02	0.00	0.48	0.33	0.38	0.02	1.81	0.02	3.01	3.03
2014	0.00	0.02	0.00	0.58	0.27	0.23	0.02	1.60	0.02	2.71	2.73
2015	0.00	0.03	0.00	0.73	0.22	0.26	0.01	1.34	0.03	2.56	2.58
2016	0.00	0.02	0.00	0.53	0.43	0.16	0.01	0.93	0.02	2.05	2.07
2017	0.00	0.02	0.00	0.32	0.21	0.14	0.01	1.03	0.02	1.71	1.73
2018	0.00	0.02	0.00	0.37	0.11	0.10	0.01	1.12	0.02	1.71	1.73
3-year average	0.00	0.02	0.00	0.41	0.25	0.13	0.01	1.03	0.02	1.82	1.84
5-year average	0.00	0.02	0.00	0.51	0.25	0.18	0.01	1.20	0.02	2.15	2.17
10-year average	0.01	0.02	0.00	0.62	0.29	0.34	0.06	1.38	0.02	2.70	2.72

Distribution Option 3. Proportions of the total mortality by IPHC Regulatory Area (set proportions):

This option would distribute the U26 discard mortality from non-directed fisheries (bycatch) limit as a set proportion of the total mortality in each IPHC Regulatory Area (Table 3). The proportions could be determined from the recent year's U26 estimate (similar to Distribution Option 1), or from the recent history of U26 mortality estimates (similar to Distribution Option 2; Table 4).

TABLE 3. Recent mortality of Pacific halibut from all sources by IPHC Regulatory Area (million net pounds).

Year	2A	2B	2C	3A	3B	4A	4B	4CDE	Canada	U.S.	Coastwide
2009	1.58	8.71	8.15	30.50	12.88	4.30	2.07	7.45	8.71	66.92	75.63
2010	1.22	8.77	7.20	28.85	12.16	3.55	2.34	7.62	8.77	62.95	71.72
2011	1.09	8.83	4.00	22.76	9.26	3.50	2.57	6.67	8.83	49.85	58.68
2012	1.22	7.85	4.81	18.23	6.75	3.19	2.03	6.71	7.85	42.93	50.79
2013	1.17	7.75	5.77	17.53	5.41	2.20	1.43	6.82	7.75	40.32	48.07
2014	1.16	7.75	6.05	13.88	4.24	1.76	1.31	6.16	7.75	34.56	42.31
2015	1.17	8.01	6.52	14.59	3.59	2.11	1.37	4.75	8.01	34.09	42.10
2016	1.32	8.13	6.73	13.57	3.84	2.03	1.32	4.84	8.13	33.66	41.79
2017	1.46	8.27	6.98	13.47	4.24	1.77	1.33	4.47	8.27	33.73	41.99
2018	1.36	7.20	6.31	13.30	3.18	1.61	1.31	4.48	7.20	31.54	38.74
3-year average	1.38	7.87	6.68	13.45	3.76	1.80	1.32	4.60	7.87	32.98	40.84
5-year average	1.29	7.87	6.52	13.76	3.82	1.85	1.33	4.94	7.87	33.52	41.39
10-year average	1.27	8.13	6.25	18.67	6.56	2.60	1.71	6.00	8.13	43.05	51.18

TABLE 4. Recent percentage of discard mortality from non-directed fisheries (fisheries that cannot legally retain Pacific halibut; bycatch) of Pacific halibut ≤26 inches in length (U26; million net pounds) relative to mortality of Pacific halibut from all sources.

Year	2A	2B	2C	3A	3B	4A	4B	4CDE	Canada	U.S.	Coastwide
2009	2.6%	0.2%	0.1%	2.9%	2.9%	15.6%	6.5%	21.0%	0.2%	5.5%	4.9%
2010	0.3%	0.2%	0.1%	2.8%	2.7%	12.8%	6.0%	21.3%	0.2%	5.3%	4.7%
2011	0.2%	0.2%	0.1%	3.8%	3.6%	11.9%	5.4%	17.6%	0.2%	5.9%	5.1%
2012	0.4%	0.4%	0.1%	3.3%	5.0%	19.8%	3.7%	24.7%	0.4%	7.7%	6.6%
2013	0.1%	0.3%	0.0%	2.7%	6.1%	17.1%	1.3%	26.5%	0.3%	7.5%	6.3%
2014	0.2%	0.3%	0.0%	4.2%	6.3%	13.2%	1.7%	26.0%	0.3%	7.8%	6.5%
2015	0.2%	0.3%	0.0%	5.0%	6.2%	12.3%	0.8%	28.1%	0.3%	7.5%	6.1%
2016	0.1%	0.3%	0.0%	3.9%	11.2%	7.9%	0.5%	19.1%	0.3%	6.1%	5.0%
2017	0.1%	0.2%	0.0%	2.4%	4.9%	7.9%	0.6%	23.0%	0.2%	5.1%	4.1%
2018	0.1%	0.3%	0.0%	2.8%	3.4%	6.0%	0.7%	25.0%	0.3%	5.4%	4.5%
3-year average	0.1%	0.3%	0.0%	3.0%	6.6%	7.3%	0.6%	22.3%	0.3%	5.5%	4.5%
5-year average	0.1%	0.3%	0.0%	3.7%	6.5%	9.6%	0.9%	24.4%	0.3%	6.4%	5.2%
10-year average	0.5%	0.3%	0.0%	3.3%	4.5%	13.2%	3.3%	23.1%	0.3%	6.3%	5.3%

Distribution Option 4. Management-based limits (Negotiated):

There is no currently available information to inform the relative value of U26 Pacific halibut occurring in one IPHC Regulatory Area over another (but see below for research avenues). Therefore, at present, the distribution of U26 discard mortality from non-directed fisheries (bycatch) represents a management decision. As long as a formulaic approach was taken, or specific distribution scenarios were provided, the IPHC Secretariat could provide mortality projections for any such decision or distribution rule. The policy implications between and within

the domestic agencies of such a decision that differed appreciably from the *status quo* are beyond the scope of this technical analysis.

POTENTIAL FUTURE RESEARCH

Additional research would be needed to provide a scientifically-based U26 stock distribution estimate (analogous to that for the O26 biomass based on the modelled FISS). Several avenues could be explored including habitat-based methods, oceanographic models linking spawning areas to settlement and areas occupied at early life-stages, as well as trawl survey-based modelling. Some previous work has investigated survey-based estimates of younger age-classes from trawl data and geostatistical models (e.g., Ono et al. 2018). However, although moderately correlated with subsequently observed recruitment, this type of approach has not proven to be a good indicator of the scale of strong year-classes (i.e., the size of the 2005 cohort is grossly overestimated by the Bering Sea trawl survey; Stewart and Webster 2019; Stewart and Hicks 2019), and therefore also may not be a good indicator of distribution. Further development consolidating all available trawl data including the Bering Sea, Aleutian Islands, Gulf of Alaska, B.C. and U.S.A. West Coast and conducting the analysis by age (rather than size, which may miss-assign strong cohorts) could be pursued. One shortcoming of these data is that comprehensive trawl data (all portions of the stock range) is not available on an annual basis.

MANAGEMENT PERFORMANCE

The IPHC's current management procedure accounts for U26 mortality, but does not actively manage its magnitude or distribution. These components could be included in the set of potential management procedures under development via the IPHC's Management Strategy Evaluation (MSE) process. MSE is the most appropriate tool for more extensive evaluation of downstream effects, specific biological implications, and effects on management performance (relative to objectives) of the scale of U26 mortality and the distribution of U26 mortality.

RECOMMENDATION/S

That the Commission:

a) **NOTE** paper IPHC-2019-IM095-10 which provides a summary of options for setting annual mortality limits.

b) **REQUEST** any modifications or additions necessary to provide for further consideration of this topic during the 96th Session of the IPHC Annual Meeting (AM096).

c) **REQUEST** which of these options (one each for scale and distribution) the IPHC Secretariat should use as the basis for the default mortality projection tool for AM096.

d) **REQUEST** that the IPHC MSE process:

   i. continue to evaluate status quo management related to discard mortality for non-directed fisheries (bycatch) under the current program of work for delivery of full MSE results at AM097 in 2021, noting that this source of mortality is currently modelled as a fixed component of the total (with variability), ***OR***

   ii. explicitly consider one or more of the options described here when evaluating management procedures.

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APPENDICES

Appendix A: Description of projections under alternative U26:O26 discard mortality in non-directed fisheries (bycatch) proportions.

APPENDIX A

Description of projections under alternative U26:O26 discard mortality in non-directed fisheries (bycatch) proportions.

In order to estimate the variability in SPR that may arise due to differences in the relative magnitude of U26 and O26 mortality, this analysis used the preliminary 2019 stock assessment models (IPHC-2019-SRB014-07). Specifically, alternative projections of the 2019 mortality from all sources were constructed under two scenarios replacing the U26 and O26 mortality projected based on the 2018 estimates: 1) all projected discard mortality in non-directed fisheries (bycatch; with the same scale and distribution) would occur as U26, and 2) all projected discard mortality in non-directed fisheries (bycatch; with the same scale and distribution) would occur as O26. In order to estimate the resulting SPR values from each of the two alternative 2019 projections the following steps were taken:

1) Approximate the U26 to O26 delineation in age at age-5.
2) For scenario 1 (all projected discard mortality in non-directed fisheries (bycatch) as U26), the selectivity for 2019 discard mortality in non-directed fisheries (bycatch) was forced to decay immediately after age-5 by setting the descending width and final selectivity parameters to extremely small values (-10 on a log scale). For scenario 2 (all projected discard mortality in non-directed fisheries (bycatch) as O26), the selectivity for all ages less than 5 was set to a value of zero directly in the model parameterization.
3) Each of the four stock assessment models was then used to project the 2019 SPR under the two alternative discard mortality in non-directed fisheries (bycatch) scenarios without changing the parameter estimates (using a .par file).
4) The results of the four models were integrated, as in the standard assessment projections to obtain a median SPR for each scenario.
5) The median projected SPR under each scenario was compared to the standard projection and the difference reported for this working paper.