2023-25 FISS design evaluation

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PART 1: PRIMARY OBJECTIVE - SAMPLE PACIFIC HALIBUT FOR STOCK ASSESSMENT AND STOCK DISTRIBUTION ESTIMATION (SCIENTIFIC EVALUATION)

PURPOSE

To present proposed science-based designs for the IPHC's Fishery-Independent Setline Survey (FISS) for the 2023-25 period as reviewed and endorsed by the Scientific Review Board.

BACKGROUND

The IPHC's Fishery-Independent Setline Survey (FISS) provides data used to compute indices of Pacific halibut density for use in monitoring stock trends, estimating stock distribution, and as an important input in the stock assessment. Stock distribution estimates are based on the annual mean weight per unit effort (WPUE) for each IPHC Regulatory Area, computed as the average of WPUE of all Pacific halibut and for O32 (greater than or equal to 32" or 81.3cm in length) Pacific halibut estimated at each station in an area. Mean numbers per unit effort (NPUE) is used to index the trend in Pacific halibut density for use in the stock assessment models.

FISS history 1993-2019

The IPHC has undertaken FISS activity since the 1960s. However, methods were not standardized to a degree (e.g., the bait and gear used) that allows for simple combined analyses until 1993. From 1993 to 1997, the annual design was a modification of a design developed and implemented in the 1960s, and involved fishing triangular clusters of stations, with clusters located on a grid (IPHC 2012). Coverage was limited in most years and was generally restricted to IPHC Regulatory Areas 2B through 3B. The modern FISS design, based on a grid with 10 nmi (18.5 km) spacing, was introduced in 1998, and over the subsequent two years was expanded to include annual coverage in parts of all IPHC Regulatory Areas within the depth ranges of 20-275 fathoms (37-503 m) in the Gulf of Alaska and Aleutian Islands, and 75-275 fathoms (137-503 m) in the Bering Sea (IPHC 2012). Annually-fished stations were added around islands in the Bering Sea in 2006, and in the same year, a less dense grid of paired stations was fished in shallower waters of the southeastern Bering Sea, providing data for a calibration with data from the annual National Marine Fishery Service (NMFS) bottom trawl survey (Webster et al. 2020).

Through examination of commercial logbook data and information from other sources, it became clear by 2010 that the historical FISS design had gaps in coverage of Pacific halibut habitat that had the potential to lead to bias in estimates derived from its data. These gaps included deep and shallow waters outside the FISS depth range (0-20 fathoms and 275-400 fathoms), and unsurveyed stations on the 10 nmi grid within the 20-275 fathom depth range within each IPHC Regulatory Area. This led the IPHC Secretariat to propose expanding the FISS to provide coverage of the unsurveyed habitat with United States and Canadian waters. In 2011 a pilot expansion was undertaken in IPHC Regulatory Area 2A, with stations on the 10 nmi grid added to deep (275-400 fathoms) and shallow (10-20 fathoms) waters, the Salish Sea, and other, smaller gaps in coverage. (The 10 fathom limit in shallow waters was due to logistical difficulties in standardized fishing of longline gear in shallower waters.) A second expansion in IPHC Regulatory Area 2A was completed in 2013, with a pilot California survey between latitudes of 40-42°N.

The full expansion program began in 2014 and continued through 2019, resulting in the sampling of the entire FISS design of 1890 stations in the shortest time logistically possible. The FISS expansion program allowed us to build a consistent and complete picture of Pacific halibut density throughout its range in Convention waters. Sampling the full FISS design has reduced bias as noted above, and, in conjunction with space-time modelling of survey data (see below), has improved precision and fully quantified the uncertainty associated with estimates based on partial annual sampling of the species range. It has also provided us with a complete set of observations over the full FISS design (Figure 1.1) from which an optimal subset of stations can be selected when devising annual FISS designs. This station selection process began in 2019 for the 2020 FISS and continues with the current review of design proposals for 2023-25. Note that in the Bering Sea, the full FISS design does not provide complete spatial coverage, and FISS data are augmented with calibrated data from National Marine Fisheries Service (NMFS) and Alaska Department of Fish and Game (ADFG) trawl surveys (stations can vary by year – 2019 designs are typical for recent years and are shown in Figure 1.1). Both supplementary surveys have been conducted approximately annually in recent years.

Space-time modelling

In 2016, a space-time modelling approach was introduced to estimate time series of weight and numbers-per-unit-effort (WPUE and NPUE), and to estimate the stock distribution of Pacific halibut among IPHC Regulatory Areas. This represented an improvement over the largely empirical approach used previously, as it made use of additional information within the survey data regarding the degree of spatial and temporal of Pacific halibut density, along with information from covariates such as depth (see Webster 2016, 2017). It also allowed a more complete of accounting of uncertainty; for example, prior to the use of space-time modelling, uncertainty due to unsurveyed regions in each year was ignored in the estimation. Prior to the application of the space-time modelling, these unsampled regions were either filled in using independently estimated scalar calibrations (if fished at least once), or catch-rates at unsampled stations were assumed to be equal to the mean for the entire Regulatory Area. The IPHC's Scientific Review Board (SRB) has provided supportive reviews of the space-time modelling approach (e.g., IPHC-2018-SRB013-R), and the methods have been published in a peer-review journal (Webster et al. 2020). Similar geostatistical models are now routinely used to standardise fishery-independent trawl surveys for groundfish on the West Coast of the U.S. and in Alaskan waters (e.g., Thorson et al. 2015 and Thorson 2019).

FISS design objectives

The primary purpose of the annual FISS is to sample Pacific halibut to provide data for the stock assessment (abundance indices, biological data) and estimates of stock distribution for use in the IPHC's management procedure. The priority of the current rationalised FISS is therefore to maintain or enhance data quality (precision and bias) by establishing baseline sampling requirements in terms of station count, station distribution and skates per station. Potential considerations that could add to or modify the design are logistics and cost (secondary design layer), and FISS removals (impact on the stock), data collection assistance for other agencies, and IPHC policies (tertiary design layer). These priorities are outlined in Table 1.1.

Table 1.1 Prioritization of FISS objectives and corresponding design layers.

Priority	Objective	Design Layer
Primary	Sample Pacific halibut for stock assessment and stock distribution estimation	Minimum sampling requirements in terms of: • Station distribution • Station count • Skates per station
Secondary	Long-term revenue neutrality	Logistics and cost: operational feasibility and cost/revenue neutrality
Tertiary	Minimize removals, and assist others where feasible on a cost-recovery basis.	Removals: minimize impact on the stock while meeting primary priority Assist: assist others to collect data on a cost-recovery basis IPHC policies: ad-hoc decisions of the Commission regarding the FISS design

Design review and finalisation process

Since completion of the FISS expansions, a review process has been developed for annual FISS designs created according to the above objectives:

- The Secretariat presents design proposals based only on primary objectives (Table 1.1) to the SRB for three subsequent years at the June meeting (recognizing that data from the current summer FISS will not be available for analysis prior to the September SRB meeting);
- These design proposals, revised (if necessary) based on June SRB input, are then reviewed by Commissioners at the September work meeting;
- At their September meeting, the SRB reviews revisions to the design proposals made to account for secondary and tertiary objectives

Following the review process, designs may be further modified to account for any updates based on secondary and tertiary objectives before being finalised during the Interim and Annual meetings and the period prior to implementation:

- Presentation of FISS designs for 'endorsement' by the Commission occurs at the November Interim Meeting;
- Ad hoc modifications to the design for the current year (due to unforeseen issues arising) are possible at the Annual Meeting;
- The endorsed design for current year is then modified (if necessary) to account for any additional tertiary objectives prior to summer implementation (February-April).

Consultation with industry and stakeholders occurs throughout the FISS planning process, at the Research Advisory Board meeting and particularly in finalizing design details as part of the FISS charter bid process, when stations can be added and other adjustments made to provide

for improved logistical efficiency. We also note the opportunities for stakeholder input during public meetings (Interim and Annual Meetings).
Note that while the review process examines designs for the next three years, revisions to designs for the second and third years are expected during subsequent review periods as additional data are collected. Having design proposals available for three years instead of the next year only assists the IPHC with medium-term planning of the FISS, and allows reviewers (SRB, IPHC Commissioners) and stakeholders to see more clearly the planning process for sampling the entire FISS footprint over multiple years. Extending the proposed designs beyond three years was not considered worthwhile, as we expect further evaluation undertaken following collection of data during the one to three-year period to influence design choices for subsequent years.

PROPOSED DESIGNS FOR 2023-25

The designs proposed for 2023-25 (Figures 1.2 to 1.4) use efficient subarea sampling in IPHC Regulatory Areas 2A, 4A and 4B, and incorporate a randomized subsampling of FISS stations in IPHC Regulatory Areas 2B, 2C, 3A and 3B (except for the near-zero catch rate inside waters around Vancouver Island), with a sampling rate chosen to keep the sample size close to 1000 stations in an average year, a logistically feasible footprint for the annual FISS. In 2021, designs for 2023-24 were also approved subject to later revision (IPHC-2022-AM098-R). The designs developed in 2021 have largely been carried over into the current 2023-24 proposal, with exceptions noted below.

- IPHC Regulatory Area 2A: Sample the highest-density waters of IPHC Regulatory 2A in northern Washington and central/southern Oregon each year of the 2023-25 period, and in 2023 only, add the moderate density waters of southern Washington/northern Oregon and northern California **(revision from previous 2023 design proposal)**.
- IPHC Regulatory Area 4A: Sample the higher-density western subarea of IPHC Regulatory Area 4A in all three years, the medium-density northern shelf edge subarea in 2023 only, and the historically lower-density southeastern subarea in 2025 only.
- IPHC Regulatory Area 4B: Sample the high-density eastern subarea in all three years, and the western subarea in 2023 only **(revision from previous 2023 design proposal)**.

Stations in the moderate-density waters of IPHC Regulatory 2A proposed for 2023 sampling have not been sampled since 2017 (California) or 2019 (WA/OR). This is a revision from previous proposals, which did not include these stations prior to 2025 (Webster 2021). Evaluation of potential designs in IPHC Regulatory Area 2A showed that unless these waters were sampled in 2023, we project that precision targets would not be met, with an expected 2023 coefficient of variation for mean O32 WPUE of 20% (target range is <15%). We have also received anecdotal reports of increasing recreational catch rates in northern California, providing additional motivation for bringing forward sampling in those waters.

A review of commercial catch data shows moderate catch rates in recent years in southeast IPHC Regulatory 4A. With these stations last sampled in 2019, sampling in 2025 will provide an updated understanding of Pacific halibut density in this subarea and inform future decisions on sampling frequency in IPHC Regulatory Area 4A. Note that several stations on the IPHC Regulatory Area 4A shelf edge overlap the NMFS bottom trawl survey (in purple in Figure 1.2, and are not proposed for FISS sampling in the foreseeable future.

In the most recent surveys of IPHC Regulatory Area 4B, the eastern subarea had by far the highest catch rates and is the priority for frequent sampling. The western and central subareas were approved for sampling in 2022, but only the central subarea is to be sampled due to a lack of charter vessel bids for the western subarea. Thus, the western subarea has been added to the 2023 proposal to reduce the risk of bias.

Following this three-year period, the only remaining waters unsampled since FISS rationalization began in 2020 will be:

- Zero-to-low density waters in IPHC Regulatory Area 2A comprising deep (>275 ftm) and shallow (<20 ftm) stations and northern California south of 40°N (sampled comprehensively in 2017), and low-density waters of the Salish Sea (previously sampled in 2018).
- Near-zero density waters in the Salish Sea in IPHC Regulatory Area 2B (sampled in 2018 only).

We anticipate proposing these stations for sampling in 2026-28, 9-10 years after previous FISS sampling, so that the entire 1890-station FISS grid will have been fished from 2020-28.

The design proposals again include full sampling of the standard FISS grid in IPHC Regulatory Area 4CDE. The Pacific halibut distribution in this area continues to be of particular interest, as it is a highly dynamic region with an apparently northward-shifting distribution of Pacific halibut, and increasing uncertainty regarding connectivity with populations adjacent to and within Russian waters. Ongoing oceanographic (e.g., sea ice and bottom temperatures) and ecosystem (e.g., prey species abundance and distribution) changes in this Regulatory Area highlight the potential for changes in the biology and abundance of Pacific halibut in the Bering Sea. Despite prioritizing comprehensive sampling of this Regulatory Area in 2020-22, in each year logistical challenges have precluded achieving the full design. Therefore, it is retained throughout the current three-year plan, to be re-evaluated when and if sampling is successful.

While the proposed designs continue to rely on randomised subsampling of stations within the core IPHC Regulatory Areas (2B, 2C, 3A and 3B) and logistically efficient subarea designs elsewhere, other designs have been considered and remain as options (Webster 2021, Appendix A).

We note that at SRB020 and SRB021, the SRB endorsed the final 2023 FISS design as presented in Figure 1.2, and provisionally endorsed the 2023-24 designs (Figures 1.3 and 1.4) (IPHC-2022-SRB020-R) while also recognising that the 2023 design will need to be further optimised to ensure other Commission objectives are met, including but not limited to maintaining long-term revenue neutrality (IPHC-2022-SRB021-R).

FISS DESIGN EVALUATION

Precision targets

In order to maintain the quality of the estimates used for the assessment, and for estimating stock distribution, the IPHC Secretariat has set a target range of less than 15% for the coefficient of variation (CV) of mean O32 and all sizes WPUE for all IPHC Regulatory Areas. We also established precision targets of IPHC Biological Regions and a coastwide target (IPHC-2020-AM096-07), but achievement of the Regulatory Area targets is expected to ensure that targets for the larger units will also be met.

Reducing the potential for bias

In IPHC Regulatory Areas in which stations are not subsampled randomly (IPHC Regulatory Areas 2A, 4A and 4B), sampling a subset of the full data frame in any area or region brings with it the potential for bias. This is due to trends in the unsurveyed portion of a management unit (Regulatory Area or Biological Region) potentially differing from those in the surveyed portion. Therefore, we also examine how frequently part of an area or region (subarea) should be surveyed in order to reduce the likelihood of appreciable bias. For this, we use a threshold of a 10% absolute change in biomass percentage: based on historical trends (1993-2021): how quickly can a subarea's percent of the biomass of a Regulatory Area change by at least 10% (e.g., from 15 to 25% of the area's biomass)? By sampling each subarea frequently enough to reduce the chance of its percentage changing by more than 10% between successive surveys of the subarea, we minimize the potential for appreciable bias in the Regulatory Area's index.

We examined the effect of subsampling the FISS stations for a management unit on precision as follows:

- Where a randomised design is not used, identify logistically efficient subareas within each management unit and select priorities for future sampling.
- Generate simulated data for all FISS stations based on the output from the most recent space-time modelling.
- Fit space-time models to the observed data series augmented with 1 to 3 additional years of simulated data, where the design over those three years reflects the sampling priorities identified above.
- Project precision estimates and quantify bias potential for comparison against threshold.

Table 1.2 shows projected CVs following completion of the proposed 2022-25 FISS designs. With these designs, we are projected to maintain CVs within the target range. Estimates from the terminal year are most informative for management decisions, but they also typically have the largest CVs (all else being equal; these are then reduced in subsequent years as observations are available in both adjacent years, due to the temporal correlation). The final column in Table 2 shows the CV projections immediately following the 2023 FISS, which are also within the target range.

Table 1.2 Projected CVs (%) for 2022-25 for O32 WPUE estimated after completion of the proposed 2023-25 FISS designs, and (final column) after completion of the proposed 2023 FISS design only.

Reg. Area	2022	2023	2024	2025	**2023** (Estimated in 2023)
2A	13	12	13	15	14
4A	10	9	10	10	12
4B	12	9	10	12	9

For maintaining low bias, we looked at estimates of historical changes in the proportion of biomass in each subarea, and used that to guide the sampling frequency in future designs. Thus, subareas that have historically had rapid changes in biomass proportion need to be sampled most frequently, and those that are relatively stable can be sampled less frequently. For example, if a subarea's % of its Regulatory Area's biomass changed by no more than 8% over 1-2 years but by up to 12% over three years, we should sample it at least every three years based on the 10% criterion discussed above. These criteria are updated as new data are collected and they therefore respond to updates in our understanding of the rates of change occurring in each subarea.

Based on estimates from the historical times series (1993-2021) of O32 WPUE, the proposed designs for 2023-25 would be expected to maintain low bias by ensuring that it is unlikely that biomass proportions for all subareas change by more than 10% since they were previously sampled (Table 1.3). We note that the lack of sampling in the western subarea of IPHC Regulatory 4B in 2022 means that maximum change from the historical time series for this subarea was 13%, exceeding the 10% threshold. Sampling this historically-variable subarea in 2023 again reduces values to within 10%.

Table 1.3. Maximum expected absolute changes (%) in biomass proportion since previous sampling of subareas that are unsampled in a given year, based on the estimated 1993-2021 time series.

Reg. Area	2022	2023	2024	2025
2A	9	9	9	9
4A	10	7	6	8
4B	13	5	8	10

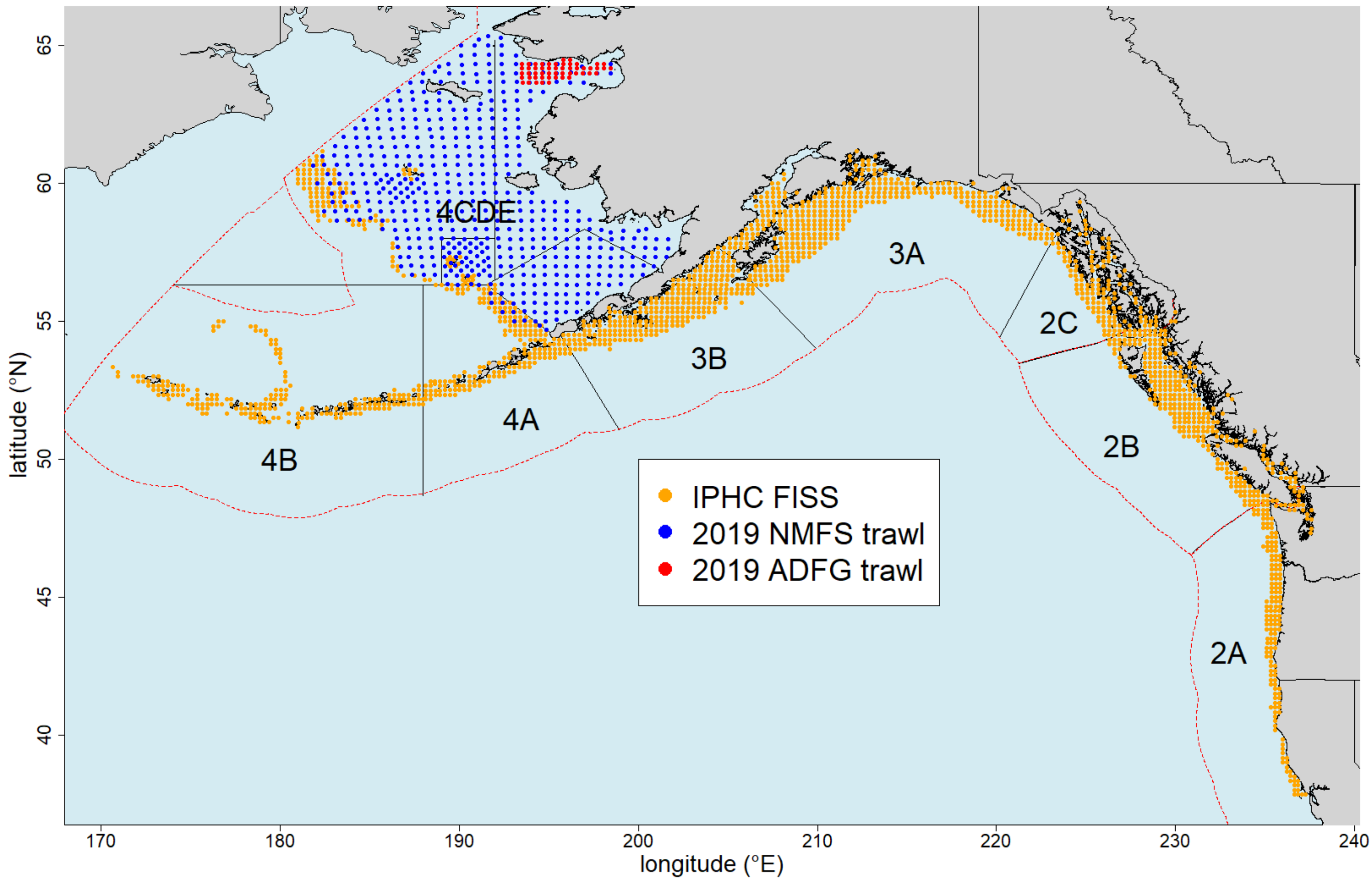

Figure 1.1. Map of the full 1890 station FISS design, with orange circles representing stations available for inclusion in annual sampling designs, and other colours representing trawl stations from 2019 NMFS and ADFG surveys used to provide complementary data for Bering Sea modelling.

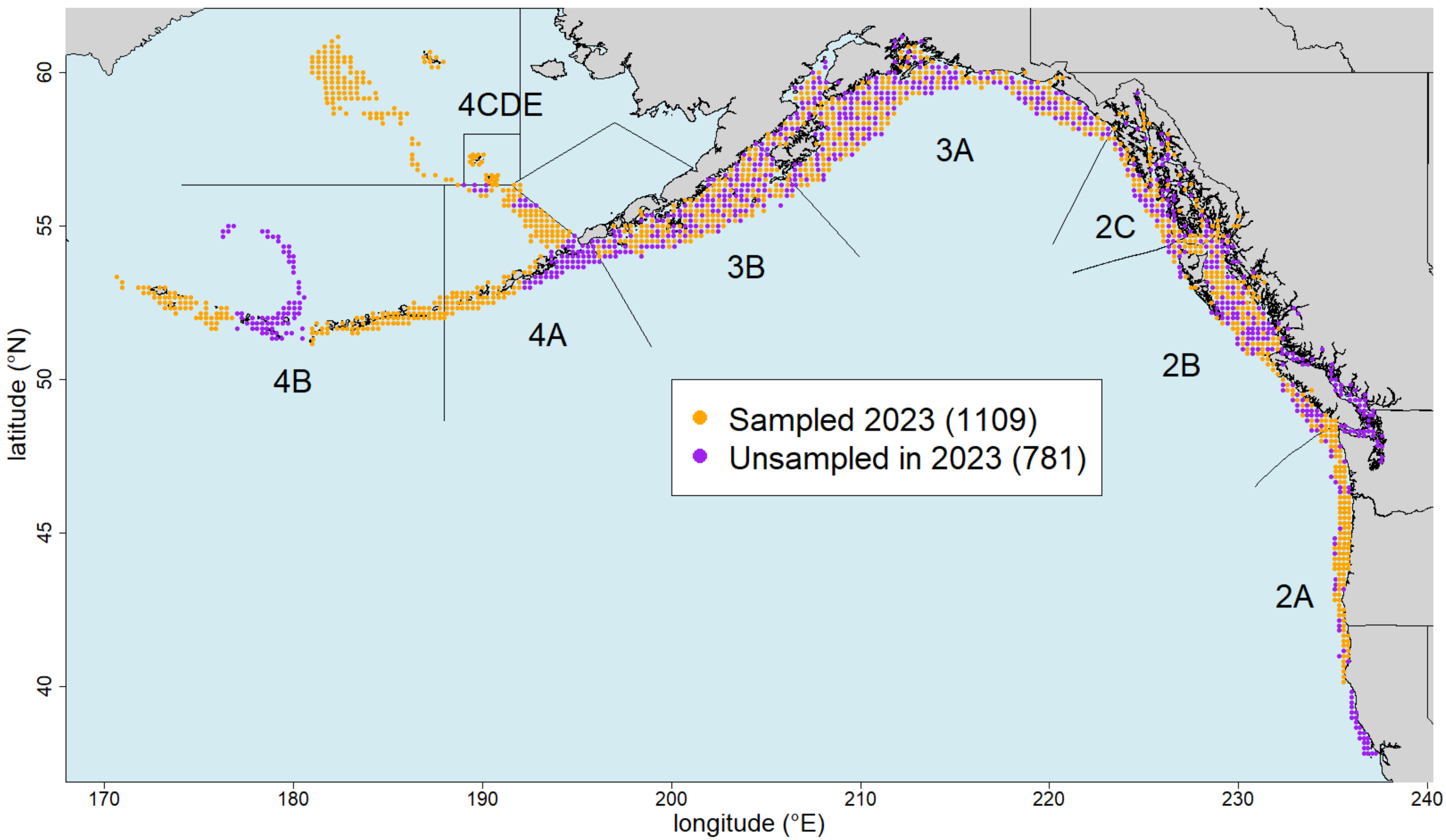

Figure 1.2. Option 1 in Table 2.1. Proposed science-based FISS design in 2023 (orange circles) based on randomized sampling in 2B-3B, and a subarea design elsewhere. Purple circles are optional for meeting data quality criteria.

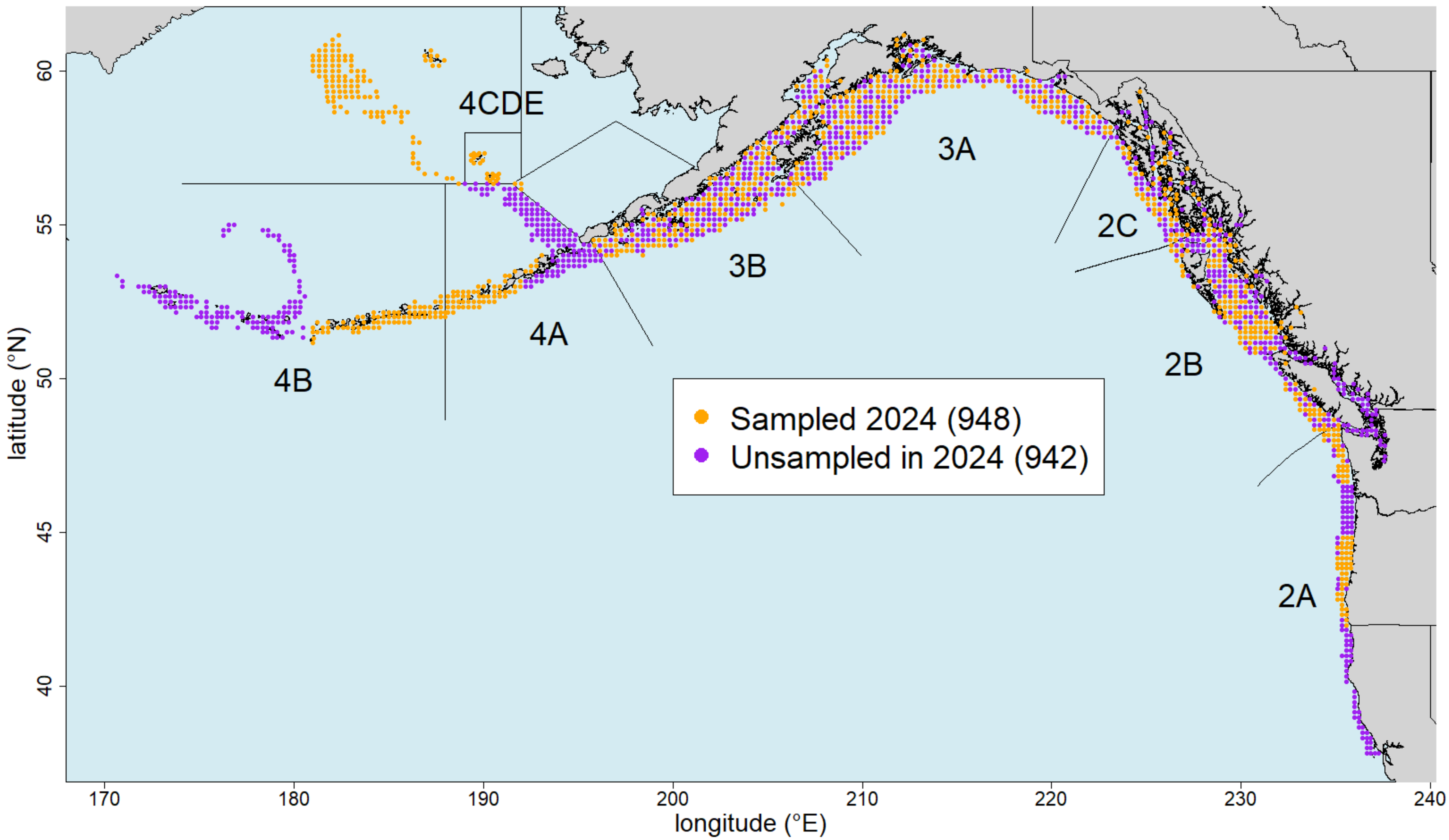

Figure 1.3. Proposed science-based FISS design in 2024 (orange circles) based on randomized sampling in 2B-3B, and a subarea design elsewhere. Purple circles are optional for meeting data quality criteria.

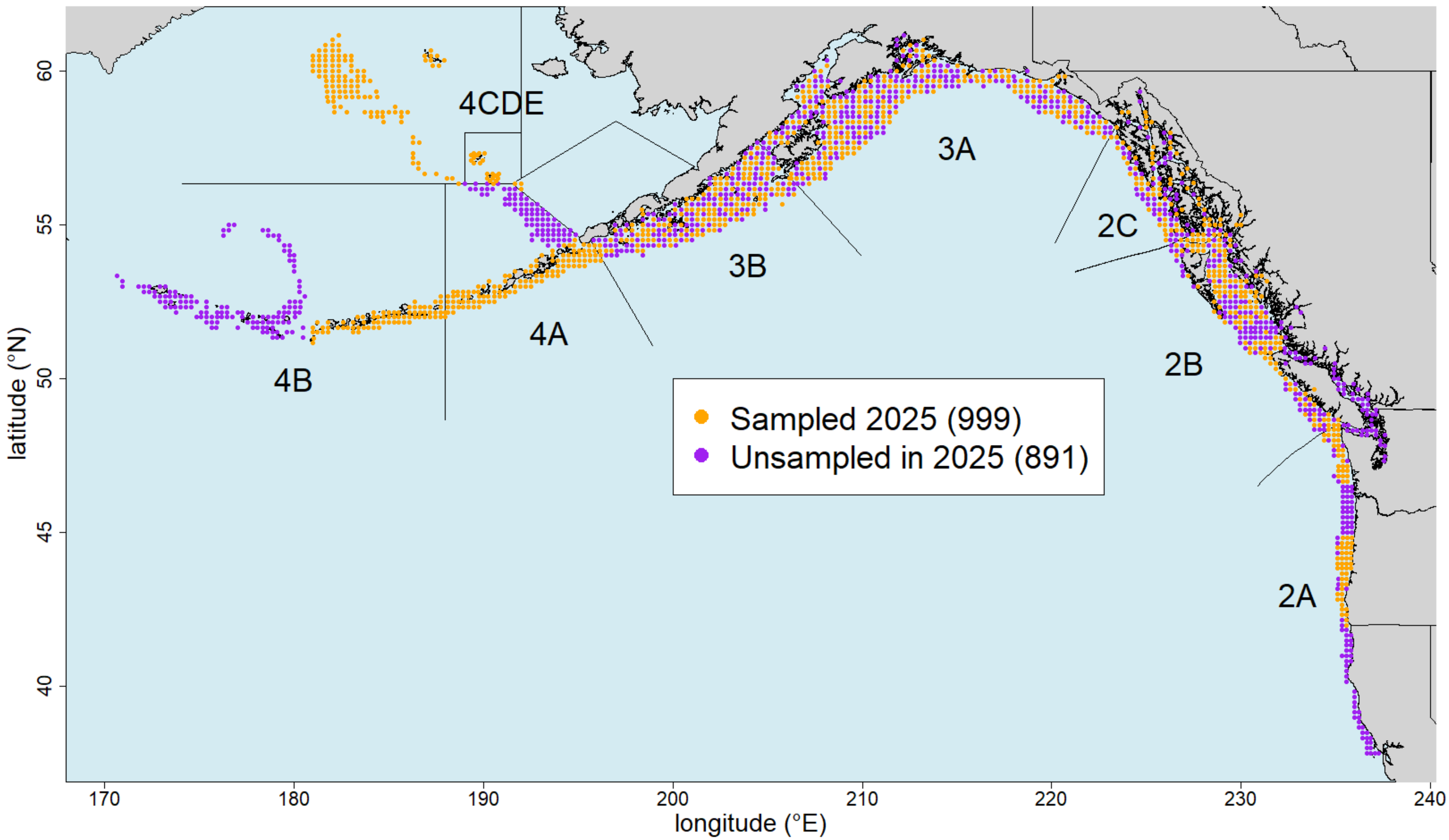

Figure 1.4. Proposed science-based FISS design in 2025 (orange circles) based on randomized sampling in 2B-3B, and a subarea design elsewhere. Purple circles are optional for meeting data quality criteria.

PART 2: OBJECTIVE 2 - LONG-TERM REVENUE NEUTRALITY (COST EVALUATION)

PURPOSE

To present and evaluate a sequence of FISS design options for 2023 optimised to varying degrees for cost.

BACKGROUND

Consideration of cost

Ideally, the FISS design would be based only on scientific needs. However, some Regulatory Areas are consistently more expensive to sample than others, so for these the efficient subarea designs were developed. The purpose of factoring in cost was to provide a statistically efficient and logistically feasible design for consideration by the Commission. During the Interim and Annual Meetings and subsequent discussions, cost, logistics and tertiary considerations (Table 1.1) are also factored in developing the final design for implementation in the current year. It is anticipated that under most circumstances, cost considerations can be addressed by adding stations to the minimum design proposed in this report. In particular, the FISS is funded by sales of captured fish and is intended to have long-term revenue neutrality, meaning that any design must also be evaluated in terms of the following factors:

- Expected catch of Pacific halibut
- Expected Pacific halibut sale price
- Charter vessel costs, including relative costs per skate and per station
- Bait costs
- IPHC Secretariat administrative costs

Balancing these factors may result in modifications to the design such as increasing sampling effort in high-density regions and decreasing effort in low density regions.

FISS design objectives

The primary objective of the annual IPHC Fishery-Independent Setline Survey (FISS) is to sample Pacific halibut to provide data for the stock assessment (abundance indices, biological data) and estimates of stock distribution for use in the IPHC's management procedure. The priority of the current rationalised FISS is therefore to maintain or enhance data quality (precision and bias) by establishing baseline sampling requirements in terms of station count, station distribution and skates per station. Potential considerations that could add to or modify the design are logistics and cost (secondary design layer), FISS removals (impact on the stock), data collection assistance for other agencies, and IPHC policies (tertiary design layer). These priorities were outlined in Table 1.1 in Part 1 of this report.

The following 2023 FISS design options are being provided to ensure that decisions required at IM098 are well informed both in terms of how they would meet the Commission's Primary and Secondary objectives for the FISS. Of these, the first five options are expected to meet data quality targets in all IPHC Regulatory Areas. Options 6 and 7 are not expected to meet all data quality targets for 2023 but to target the long-term revenue neutrality of the FISS, and thus its viability as a sampling platform. A summary of the design options is in Table 2.1.

Table 2.1. Summary of pros and cons of alternative 2023 FISS design options.

Design	Pros	Cons
Option 1 (Proposed science-based design)	• Precise, low bias estimates coastwide and for all IPHC Regulatory Areas	• Very high cost
Option 2	• Precise, low bias estimates coastwide and for all IPHC Regulatory Areas	• Very high cost
Option 3	• Precise, low bias estimates coastwide and for all IPHC Regulatory Areas	• Very high cost
Option 4	• Precise, low bias estimates coastwide and for all IPHC Regulatory Areas	• High cost
Option 5	• Precise, low bias estimates coastwide and for all IPHC Regulatory Areas	• High cost
Option 6	• Good coastwide estimates of stock trends and distribution • Overall low risk of bias	• Imprecise estimates at ends of stock • Potential for bias at ends of stock • Medium cost
Option 7	• Good coastwide estimates of stock trends • Revenue neutral	• Imprecise estimates at ends of stock with risk of bias • Less precise stock distribution estimates

Option 1: Pre-Optimization Design (science-based design proposal)

Primary objective: The IPHC Secretariat has proposed a FISS design for 2023 (Figure 1.2, discussed in Part 1 above) which is projected to achieve all data quality targets with respect to variance and bias (Webster 2022a, 2022b). The design features a random sample of FISS stations in IPHC Regulatory Areas 2B, 2C, 3A and 3B (the core areas), sampling of high-priority subareas in IPHC Regulatory Areas 2A, 4A and 4B, and full FISS sampling in IPHC Regulatory Area 4CDE.

This design was preliminarily endorsed by the Scientific Review Board (SRB) at their June meeting (SRB020 - IPHC 2022a) as follows:

> IPHC-2022-SRB020-R: (para. 12) "*The SRB ENDORSED the final 2023 FISS design as presented in Fig. 2, and provisionally ENDORSED the 2024-25 designs (Figs. 3 and 4), recognizing that these will be reviewed again at subsequent SRB meetings.*"

Subsequently, the SRB were provided with another opportunity to review the proposed design at their September meeting, with further information provided on how the design would meet both the primary and secondary Commission FISS objectives (SRB021 - IPHC 2022b). As a result, the SRB again endorsed the proposal, with caveats around long-term revenue neutrality as follows:

> IPHC-2022-SRB021-R: (para. 19) "*The SRB ENDORSED the proposed 2023 FISS design as presented in Fig. 2, and provisionally ENDORSED the 2024-25 designs (Figs. 3 and 4), while also recognising that the 2023 design will need to be further optimised to ensure other Commission objectives are met, including but not limited to maintaining long-term revenue neutrality.*"

Secondary objective: The proposed design (Option 1) detailed above, does not meet the Commission's long-term goal of achieving revenue neutrality for the FISS, as it is projected to run at a budget deficit of approximately **-$2,665,000** due to 1) the proposed number of stations to be sampled (**1,109, with an average of 5.5 skates per set**), 2) the increased operational costs to sample those stations (e.g. vessel running costs, bait, shipping, communications, insurance), and 3) expected further declines in biomass that would result in further declines in expected catch rates in 2023, as noted by the Commission at its 98th Session in January of 2022 (detailed below [*caveat*: these will be updated once the 2022 stock assessment is completed and in time for the IM098, November 2022]).

> IPHC-2022-AM098-R: (para. 43) *The Commission* ***NOTED*** *the following outlook for the stock provided by the IPHC Secretariat:*
>
> *"Outlook. The projections for this assessment are more optimistic than those from the 2019 and 2020 assessments due to the increasing projected maturity of the 2012 year-class. This translates to a lower probability of stock decline for 2022 than in recent assessments as well as a decrease in this probability through 2023-24.* ***There is greater than a 50% probability of stock decline in 2023 (55-64/100) for the entire range of SPR values from 40-46%, which include the status quo TCEY and the F43% reference level.*** *The 2022 "3-year surplus" alternative, corresponds to a TCEY of 38.0 million pounds (~17,240 t), and a projected SPR of 48% (credible interval 32-63%; [Table 2, Figure 4].* ***At the reference level (a projected SPR of 43%), the probability of spawning biomass decline from 2022 to 2023 is 59%****, decreasing to 55% in three years, as the 2012 cohort matures. The one-year risk of the stock dropping below SB30% ranges from 43% at the F46% level to 45% at the at the F40% level of fishing intensity."*

At AM098, the Commission adopted a total mortality level of 41.22 mlbs (18,697 mt), which resulted in an SPR level of ~43%.

> IPHC-2022-AM098-R: (para. 76) "*The Commission ADOPTED the distributed mortality limits for each Contracting Party, by IPHC Regulatory Area, (Table 5) and sector, as provided for in Appendix VI. [Canada: In favour=3, Against=0][USA: In favour=3, Against=0]*"

***Table 5**. Adopted TCEY mortality limits for 2022*

Contracting Party IPHC Regulatory Area	Mortality limit (TCEY) (mlbs)	Mortality limit (TCEY) (metric tonnes)
Canada Total: 2B	**7.56**	**3,429**
USA: 2A	1.65	748
USA: 2C	5.91	2,681
USA: 3A	14.55	6,600
USA: 3B	3.90	1,769
USA: 4A	2.10	953
USA: 4B	1.45	658
USA: 4CDE	4.10	1,860
United States of America Total	**33.66**	**15,268**
Total (IPHC Convention Area)	**41.22**	**18,697**

2023 FISS design alternatives:

The Secretariat has developed six (6) alternative FISS design options that have each been optimised to varying degrees for sampling precision as well as for expected fiscal viability, through the addition and/or removal of stations and the numbers of skates per station.

Option 2: Pre-optimisation Design, no 4CDE

Option 2 design (Figure 2.1) is identical to the Option 1 design (Figure 1.2) except for the removal of all IPHC Regulatory Area 4CDE stations to reduce cost. We anticipate the National Marine Fisheries Service (NMFS) will conduct their annual Bering Sea trawl survey in both the eastern and northern Bering Sea in 2023. All FISS stations in IPHC Regulatory Area 4CDE were fished in either 2021 or 2022, and together with the calibrated trawl data, we expect this to be sufficient to provide us with a precise index with low risk of bias for 2023 for this area.

Based on our analyses (Webster 2022a), we expect this design to meet data quality targets in all IPHC Regulatory Areas and to yield precise, low-bias estimates of WPUE and NPUE indices and stock distribution.

The proposed design does not meet the IPHC's long-term goal of revenue neutrality as it is also projected to run at a deficit of **-$2,202,000** due to 1) the proposed number of stations to be sampled **(969, with an average of 5.5 skates per set),** 2) the increased operational costs to sample those stations (e.g. vessel running costs, bait, shipping, communications, insurance), and 3) expected further declines in biomass that would result in further declines in expected catch rates in 2023, as noted by the Commission at its 98th Session in January of 2022 [caveat: these will be updated once the 2022 stock assessment is completed and in time for the IM098, November 2022].

Option 3: Optimised design #1

Option 3 (Figure 2.2) is identical to the Option 1 design (Figure 1.2) but with an increase in core area station density in revenue-positive FISS regions to help offset costs. As such, it will meet data quality targets in all IPHC Regulatory Areas, and comprehensively monitor the dynamic Bering Sea region.

The proposed design does not meet the IPHC's long term goal of revenue neutrality as it is also projected to run at a deficit of approximately **-$2,128,000** due to 1) the proposed number of stations to be sampled **(1,503, with an average of 5.5 skates per set)**, 2) the increased operational costs to sample those stations (e.g. vessel running costs, bait, shipping, communications, insurance), and 3) expected further declines in biomass that would result in further declines in expected catch rates in 2023, as noted by the Commission at its 98th Session in January of 2022 [caveat: these will be updated once the 2022 stock assessment is completed and in time for the IM098, November 2022].

Option 4: Optimised design #2, with a maximum 6 skates/station, no 4CDE

Option 4 (Figure 2.3) is a cost-optimised version of the Option 1 design (Figure 1.2), with greater station density in the core areas, all proposed subareas to be sampled in IPHC Regulatory Areas 2A, 4A and 4B, but no sampling of the costly FISS stations in IPHC Regulatory Area 4CDE. As with Option 2, we expect this design to meet data quality targets in all IPHC Regulatory Areas and to yield precise, low-bias estimates of WPUE and NPUE indices and stock distribution.

The proposed design does not meet the IPHC's long term goal of revenue neutrality as it is also projected to run at a deficit of approximately **-$1,665,000** due to 1) the proposed number of stations to be sampled **(1,363, with an average of 5.6 skates per set)**, 2) the increased operational costs to sample those stations (e.g. vessel running costs, bait, shipping, communications, insurance), and 3) expected further declines in biomass that would result in further declines in expected catch rates in 2023, as noted by the Commission at its 98th Session in January of 2022 [caveat: these will be updated once the 2022 stock assessment is completed and in time for the IM098, November 2022].

Option 5: Optimised design #2, with a maximum 6 skates/station, no 4CDE

Option 5 (Figure 2.3) has the same station design as Option 4 (based on Option 1), but with a higher maximum number of skates/set to maximise revenue. As such, it is also expected to meet data quality targets in all IPHC Regulatory Areas and to yield precise, low-bias estimates of WPUE and NPUE indices and stock distribution.

The proposed design does not meet the IPHC's long term goal of revenue neutrality as it is also projected to run at a deficit of approximately **-$976,000** due to 1) the proposed number of stations to be sampled **(1,363, with an average of 7.1 skates per set)**, 2) the increased operational costs to sample those stations (e.g. vessel running costs, bait, shipping, communications, insurance), and 3) expected further declines in biomass that would result in further declines in expected catch rates in 2023, as noted by the Commission at its 98th Session in January of 2022 [caveat: these will be updated once the 2022 stock assessment is completed and in time for the IM098, November 2022].

Summary Options 1-5: In any given year, the IPHC Secretariat takes the base design endorsed by the SRB and then optimizes it to target revenue neutrality, the Commission's adopted secondary objective for the FISS. Thus, we are not asking the Commission to consider Options 1-4, but rather, to commence discussions based on Option 5.

Option 5 is expected to meet data quality targets in all IPHC Regulatory Areas and to yield precise, low-bias estimates of WPUE and NPUE indices and stock distribution, while running at a projected deficit of approximately **-$976,000**.

2023 FISS designs that do not meet data quality targets in one or more IPHC Regulatory Areas for 2023 (and implications for future) but aim to move the design towards achieving the secondary objective: revenue neutrality.

Option 6: Design to achieve revenue loss of <$0.5M

Option 6 (Figure 2.4) removes the California and Oregon FISS regions from IPHC Regulatory Area 2A along with all 4CDE FISS stations but retains the highest density subareas of IPHC Regulatory Areas 4A and 4B. For this reason, this design offers a greater probability that variance and bias goals will be met for these areas than Option 7 below. In IPHC Regulatory Area 2A, only stations in the Washington FISS charter region are included, and our analysis (Webster 2022a) implies that this would not be sufficient to meet data quality targets for IPHC Regulatory Area 2A. However, this design includes at least some FISS sampling in all IPHC Regulatory Areas except 4CDE (where NMFS will sample), and we can expect it to yield highly quality estimates of coastwide and bioregion trends, and of the distribution of the stock among Regulatory Areas.

The proposed design does not meet the IPHC's long term goal of revenue neutrality as it is also projected to run at a deficit of approximately **-$469,000** due to 1) the proposed number of stations to be sampled **(1,178, with an average of 7.1 skates per set)**, 2) the increased operational costs to sample those stations (e.g. vessel running costs, bait, shipping, communications, insurance), and 3) expected further declines in biomass that would result in further declines in expected catch rates in 2023, as noted by the Commission at its 98th Session in January of 2022 [caveat: these will be updated once the 2022 stock assessment is completed and in time for the IM098, November 2022].

Option 7: Revenue neutral design

Option 7 (Figure 2.5), like previous designs, increases station density in the high-density core areas above that of the science-based design to improve revenue and thus offset losses in other areas. To reduce overall costs and achieve revenue neutrality, no sampling is proposed in IPHC Regulatory Areas 2A, 4A, 4B and 4CDE.

Approximately 70-80% of the Pacific halibut stock by weight is estimated to occur in the core areas to be sampled, and with a sample size of 998 FISS stations, this design will continue to provide a precise estimate of the coastwide time series with relatively low bias.

However, it is anticipated that precision targets will not be met in IPHC Regulatory Areas 2A, 4A and 4B, which failed to meet these targets in 2020-21 due a combination of no sampling (2020), sparse sampling (4A, 4B in 2021) and higher than expected variability (2A in 2021). All three areas contain a designated sampling subarea with relatively high density and potential large year-to-year variability in density: in each case, not sampling these subareas in particular leads to high risk of bias in estimates of WPUE and NPUE indices and stock distribution.

This design is likely to result in indices and biological data that maintain the basic stock assessment inputs but with somewhat higher uncertainty for 2023. Direct stock distribution estimates would be uninformed by new survey data for IPHC Regulatory Areas 2A, 4A and 4B and this would create additional uncertainty in the application of management procedures that rely on annual estimates of stock distribution.

Planning for 2024 and 2025: If there is no FISS sampling at the ends of the stock in 2023, the Secretariat's proposal for 2024 will include fishing all subareas of IPHC Regulatory Areas 2A, 4A and 4B that were originally proposed for 2023 (Figure 1.2). A clearer picture will emerge once the 2022 data are included in the space-time modelling, but in one or more of those areas it may be necessary to propose sampling additional stations earlier than previously planned to help bring estimates closer to our precision and bias targets. This may mean adding more stations in 2024 than those in Figure 1.3, or sampling some subareas in both 2024 and 2025 when they otherwise may have been sampled just once in that period. Given the costs and logistical challenges of sampling at the ends of the stock's range, we recognize that implementing such 'catch up' sampling in practice may be difficult without supplemental ad-hoc funding.

The proposed design does meet the IPHC's long term goal of revenue neutrality as it is projected to run at a nominal surplus, effectively neutral at approximately **$15,000** due to 1) the proposed number of stations to be sampled **(998, with an average of 7.3 skates per set)**, 2) the increased operational costs to sample those stations (e.g. vessel running costs, bait, shipping, communications, insurance), and 3) expected further declines in biomass that would result in further declines in expected catch rates in 2023, as noted by the Commission at its 98th Session in January of 2022 [caveat: these will be updated once the 2022 stock assessment is completed and in time for the IM098, November 2022].

Discussion

All designs except Option 7 are expected to provide high quality data for estimation of coastwide stock trends and distribution (Table 2.1). In previous years, the IPHC Secretariat would simply go through this 'optimisation' process internally, and take the design endorsed at the SRB and optimise station density and skate numbers to target revenue neutrality. This would have resulted in us implementing either Option 5 or (most likely) Option 6, with additional input from the Commission.

However, given the highly unpredictable nature of the fishery (with high costs, lower catch rates and associated fish sale revenue) – experienced in 2022 and expected to continue in 2023 – combined with a lack of alternative funding sources for the FISS, **IPHC Secretariat is recommending Commission endorsement of Option 7 for 2023:** Option 7 will maximise the likelihood of achieving revenue neutrality in 2023 and reduce the risks that ongoing deficits pose to funding the FISS in subsequent years.

Proceeding with Option 7 in 2023 would allow for 'normal' stock assessment and management procedure inputs and results, except for annual stock distribution for management use. However, if such coverage gaps persist in subsequent years, then the risk of unmonitored changes in density or distribution occurring increases and estimates from the ends of the stock will become increasingly unreliable. IPHC Regulatory Areas 2A, 4A, 4B and 4CDE are challenging areas to sample, but ongoing sampling reductions will have implications for our overall understanding of stock trends and distribution. Importantly, the Pacific halibut stock and fishery are currently in transition between a strong 2005 year-class and more recent 2011 and 2012 year-classes. While the distribution of these year-classes is likely to become more uniform as they age, a multiple-year sampling gap at the ends of the geographic range (particularly 4A-4CDE) increases the likelihood that stock distribution and therefore realized harvest rates may differ appreciably from those intended by the IPHC's interim management procedure. With reduced precision, the ability of the stock assessment model to update currently predicted trends based on new information is much more limited: increases or decreases in overall stock trend may not be tracked by the assessment model, which relies heavily on the trend information provided by the annual FISS.

Reductions in the FISS in 2023 will have implications for the 2024-2026 FISS designs as well. Current design planning spreads the most challenging charter regions (logistically and financially) over a three-year time-horizon. To 'catch-up' from the much larger variance estimates that would be produced in 2023, an increased level of sampling would be required in subsequent years, including the regions omitted in 2023 as well as at least some of those currently proposed for 2024-25. The longer such gaps in coverage persist, the more difficult it becomes to maintain the quality of time series estimates, and the result may be a period in the time series with permanently high uncertainty around our understanding of stock trends and distribution.

RECOMMENDATION

That the Commission:

1) **NOTE** paper IPHC-2022-IM098-10 that presents the FISS design proposals for 2023-25 together with scientific evaluations of the designs, and cost evaluations of additional 2023 design options;
2) **ENDORSE** revenue neutral design Option 7 for the 2023 FISS, as presented in Figure 2.5 or make modifications with associated funding adjustments;
3) Provisionally **ENDORSE** the proposed designs for 2024-25, as endorsed by the Scientific Review Board at SRB021, recognizing that the 2024-25 designs are expected to be modified in subsequent years.

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IPHC (2022b) Report of the 21st Session of the IPHC Scientific Review Board (SRB021) IPHC-2022-SRB21-R. 22 p.

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Webster RA (2022b) 2023-25 FISS design evaluation. IPHC-2022-SRB021-06

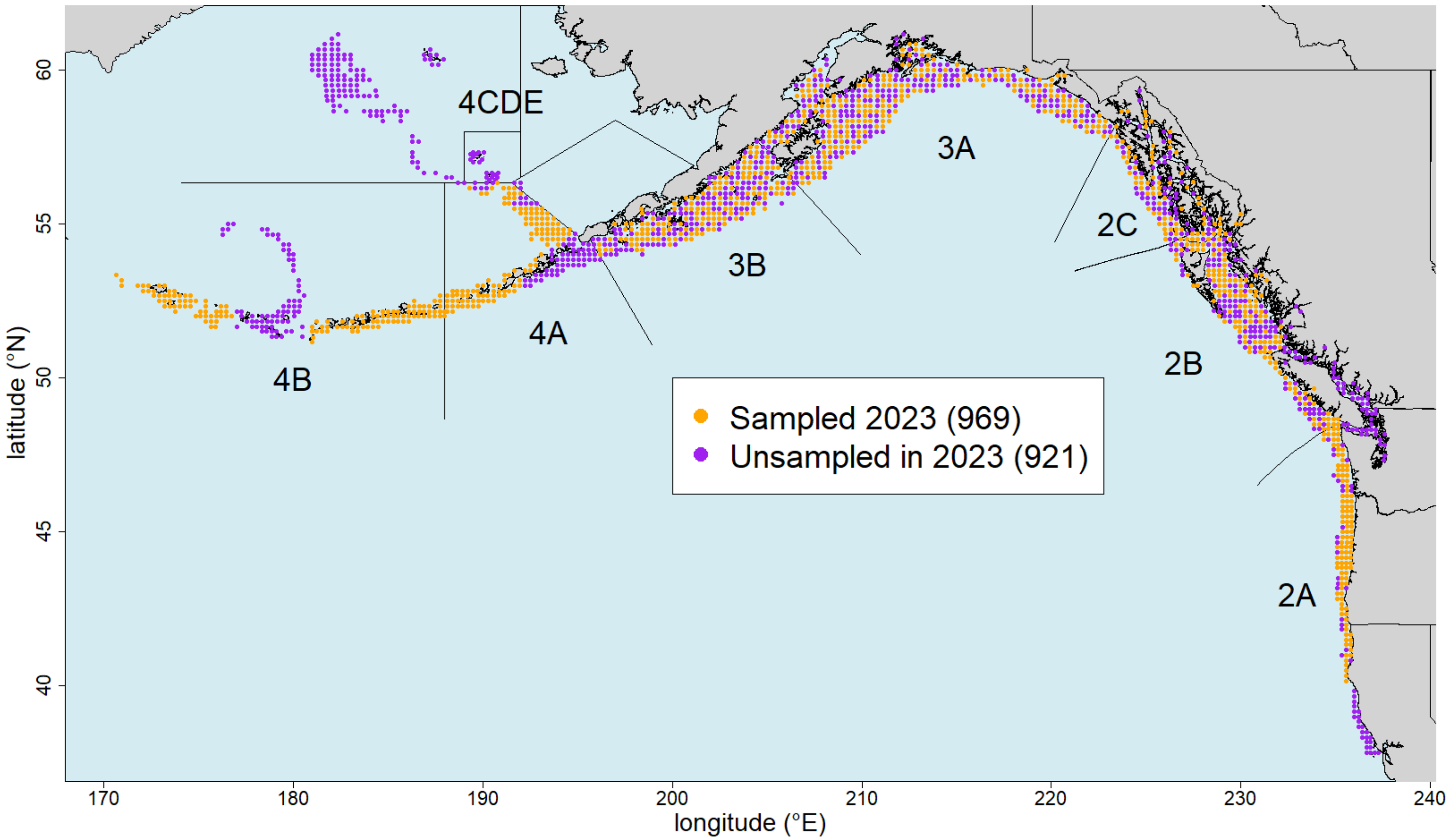

Figure 2.1. Option 2, the science-based design omitting stations in IPHC Regulatory Area 4CDE (Pre-cost optimisation, no 4CDE).

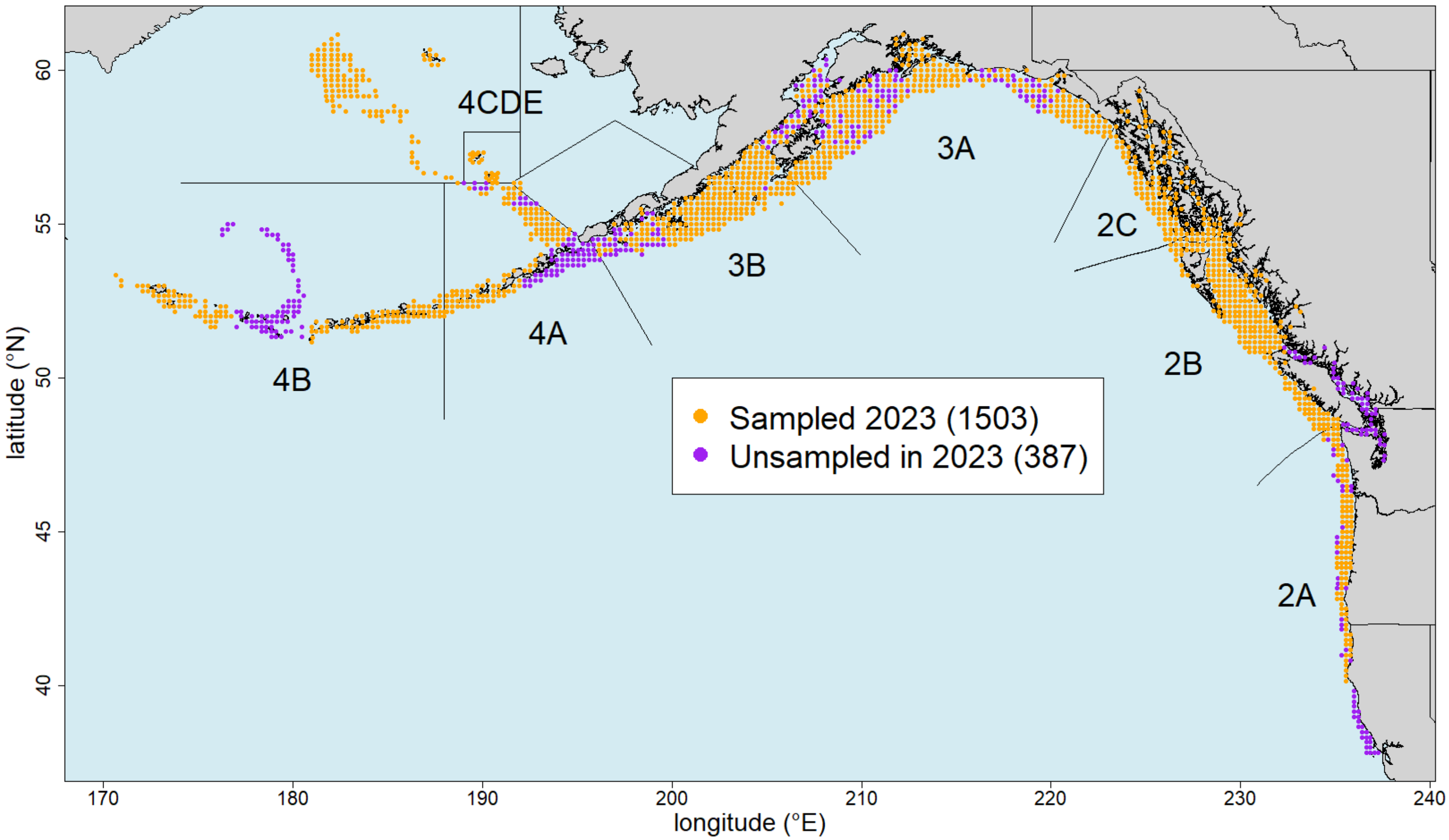

Figure 2.2. Option 3, the science-based design optimised for revenue through increased station density in the core IPHC Regulatory Areas.

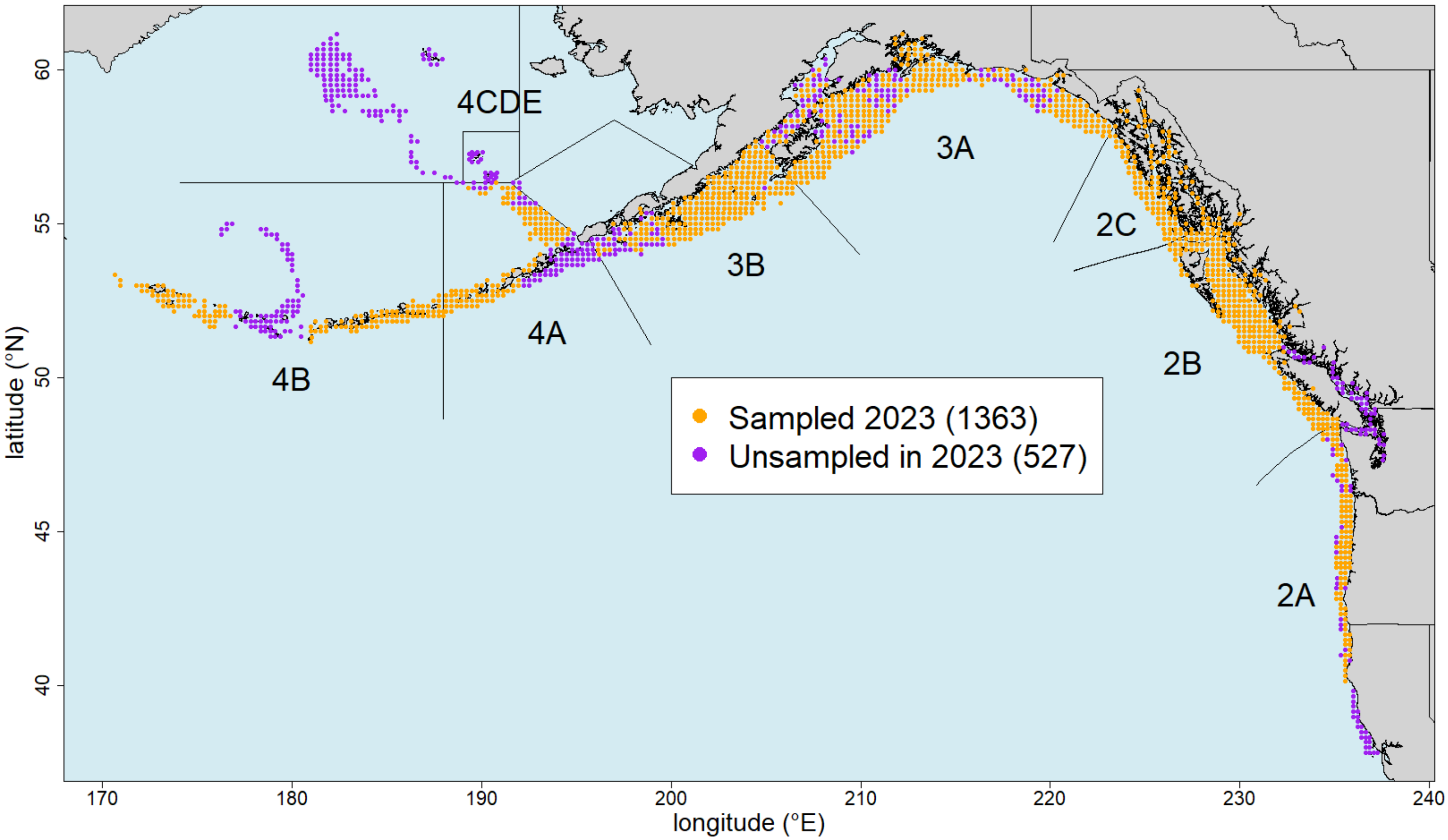

Figure 2.3. Options 4 and 5, optimized for revenue through increased station density in the core IPHC Regulatory Areas but omitting FISS stations from IPHC Regulatory Area 4CDE. Options 4 and 5 differ in terms of the maximum number of skates fished per station (6 vs 8 respectively).

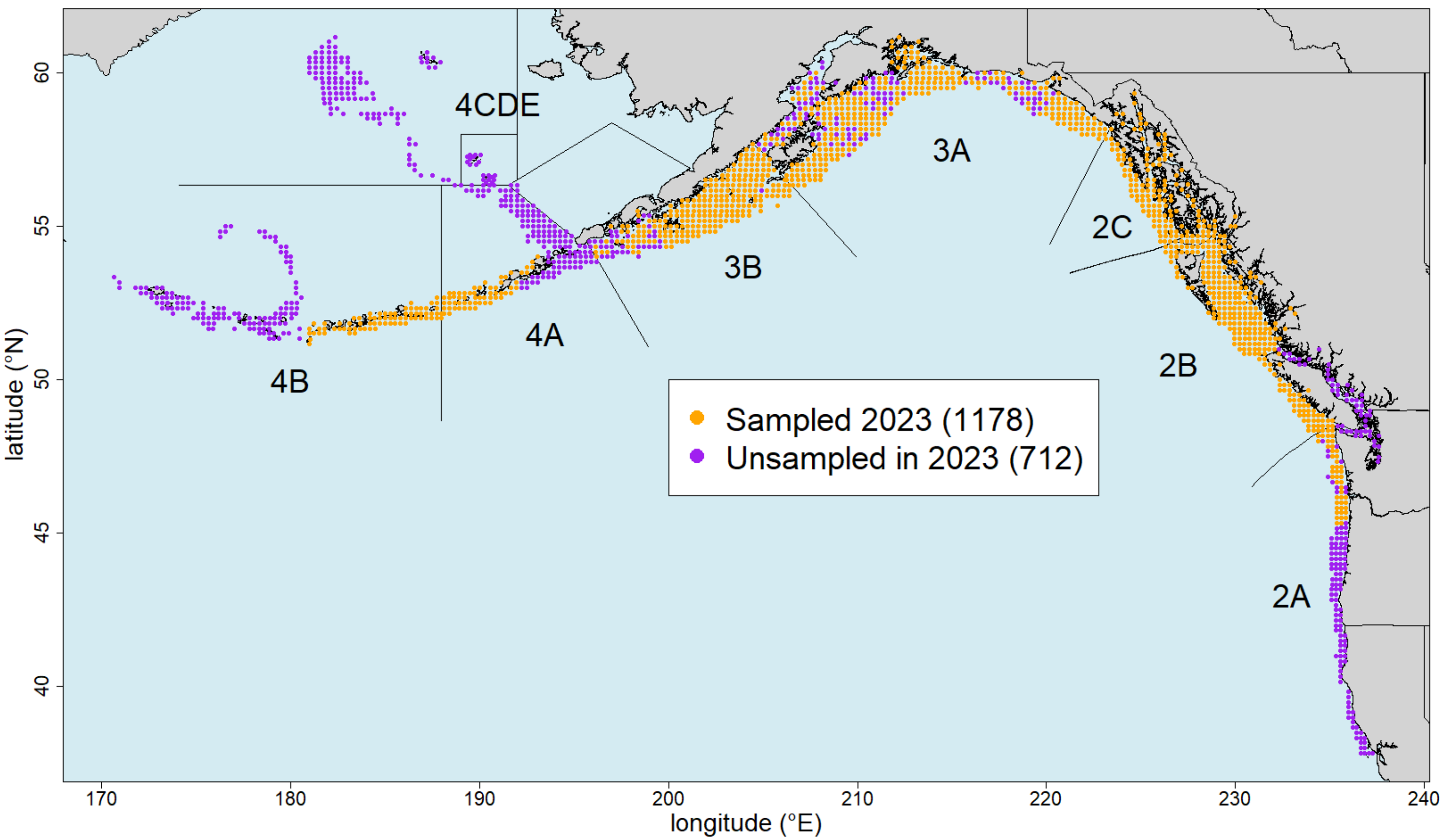

Figure 2.4. Option 6, with core area stations as in Options 3 and 4, but also omitting low-density subareas from IPHC Regulatory Areas 4A and 4B along with stations in Oregon and California (Designed to achieve revenue loss of <$0.5M).

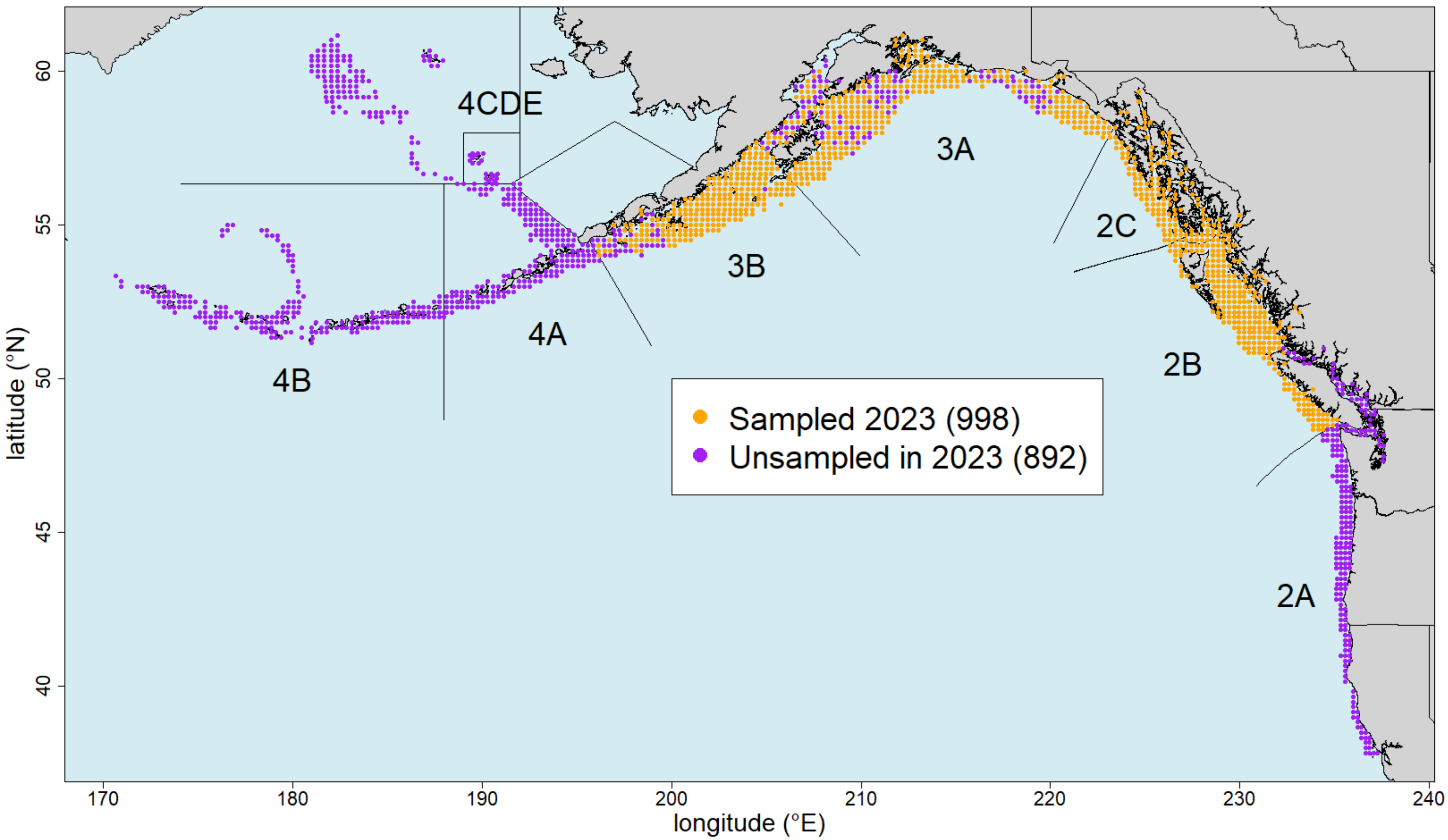

Figure 2.5. Option 7, with FISS sampling in core IPHC Regulatory Areas only (Revenue neutral design).

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IPHC 2012. IPHC setline charters 1963 through 2003 IPHC-2012-TR058. 264p.

IPHC 2018. Report of the 13th Session of the IPHC Scientific Review Board (SRB) IPHC-2018-SRB013-R. 17 p.

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IPHC 2022. Report of the 20th Session of the IPHC Scientific Review Board (SRB) IPHC-2022-SRB020-R. 19 p.

IPHC (2022b) Report of the 21st Session of the IPHC Scientific Review Board (SRB021) IPHC-2022-SRB21-R. 22 p.

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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. Can. J. Fish. Aquat. Sci. 77(8): 1421-1432.

Webster, R. A. (2021) 2022-24 FISS design evaluation. IPHC-2021-SRB018-05 Rev_1. 18 p