2024 and 2025-28 FISS design evaluation

Part 1: Potential 2024-26 designs

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PURPOSE

To present potential design options for the IPHC's Fishery-Independent Setline Survey (FISS) for the 2024-26 period, and a cost evaluation of the 2024 designs proposed.

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. Annual FISS designs are developed by selecting a subset of stations for sampling from the full 1890-station FISS footprint (Figure 1.1).

Further background information on FISS history and space-time modelling is in Appendix A.

FISS DESIGN OBJECTIVES (Table 1.1)

Primary objective: *To sample Pacific halibut for stock assessment and stock distribution estimation.*

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 rationalized 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.

Secondary objective: *Long-term revenue neutrality.*

The FISS is intended to have long-term revenue neutrality, and therefore any implemented design must consider both logistical and cost considerations.

Tertiary objective: *Minimize removals and assist others where feasible on a cost-recovery basis.*

Consideration is also given to the total expected FISS removals (impact on the stock), data collection assistance for other agencies, and IPHC policies.

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

Annual design review, endorsement, 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:

- Step 1: The Secretariat presents preliminary design options based on the primary objective (Table 1.1) to the SRB for three subsequent years at the June meeting based on analysis of prior years' data. Commencing in 2024, this will include prior year fiscal details (revenue) and current year vessel contract cost updates;
- Step 2: Design options for the following year that account for both primary and secondary objectives (Table 1.1) are reviewed by Commissioners at the September work meeting, recognising that revenue and cost data from the current year's FISS are still preliminary at this time;
- Step 3: At their September meeting, the SRB reviews design options accounting for both primary and secondary objectives (Table 1.1) for comment and advice to the Commission (recommendation);
- Step 4: Designs are further modified to account for updates based on secondary and tertiary objectives before being finalized 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 of the Commission;
    - The endorsed design for current year is then modified (if necessary) to account for any additional tertiary objectives or revision to inputs into evaluation of secondary objectives prior (i.e. updated cost estimates) prior to summer implementation (February-April).

Consultation with industry and stakeholders occurs throughout the FISS planning process, at the Research Advisory Board meeting (late November) 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 Secretariat with medium-term planning of the FISS, and allows reviewers (SRB, Commissioners) and stakeholders to see more clearly the planning process for sampling the entire FISS footprint over multiple years.

POTENTIAL DESIGNS FOR 2024-26

IPHC Secretariat began the design process in early 2023 with the development of design options based on the Primary Objective (Table 1.1) for 2024-26 (Figures 1.2 to 1.4). These designs were presented to the Scientific Review board at their June meeting (IPHC-2023-SRB022-06).

During the operation of the 2023 FISS, it became apparent that low prices for Pacific halibut and lower than expected catches in some charter regions were likely to result in a substantial net operating loss for the FISS in 2023. Preliminary estimates of net revenue for the 2024 design in Figure 2 projected a net operating loss of over $3 million. Optimizing the design for revenue by adding stations in revenue-positive charter regions and adjusting the number of skates still led to a projected loss of almost $3 million. For this reason, neither version of the design was considered feasible (IPHC-2023-SRB023-09).

Projected revenue-positive design for 2024

The IPHC Secretariat developed a series of designs that improved revenue and reduced cost to different degrees. These were presented to the SRB in September 2023 (IPHC-2023-SRB023-09) as well as at the Commissioner Work Meeting that same month. Included in these potential designs was a design that was projected to be slightly revenue-positive. This design has since been revised based on improved cost projections, and includes sampling only in IPHC Regulatory Areas 2B, 2C and one charter region in IPHC Regulatory 3A (Figure 1.5).

In order to achieve a revenue-positive design, several aspects of the standard FISS procedures were removed:

- No oceanographic monitoring will take place;
- NOAA Fisheries trawl surveys are not staffed by IPHC;
- All FISS training will be conducted virtually;
- Reduce field staff on each vessel from two to one in two charter regions; only basic biological information (length, weight and sex) would be collected.

Additional changes were required to the standard FISS design in sampled areas:

- Allow for "Vessel captain stations", in which vessel captains can choose to fish up to one third of their sets at a location that is optimal in terms of catch rates or revenue. It is assumed pending further evaluation these stations will achieve 120% of the average catch rate of the usual fixed-station design stations

Further, the following assumptions regarding FISS bait were made:

- That the price of chum salmon is projected to be US$2.00/lb in 2024 and pink salmon US$1.30/lb.

With these modifications and assumptions, this design (Figure 1.5) has **a projected net operating profit of $3,000**.

Base HQ staff costs (incurred even if no survey is conducted) are projected to be US$490,000 for 2024. These costs are fully offset, along with all variable costs, in the revised revenue-positive design (Table 1.2 and Figure 1.5).

Variable FISS costs

Due to concerns about the implications of the reduced sampling in the revenue-positive design (see below), IPHC Secretariat also projected costs of additional sampling and monitoring effort should supplementary funding become available. These are presented as a series of modular options that can be added to the revenue positive design (Table 1.2). All modular options (Table 1.2, options 2-6) were designed to include an entire charter region or comprise at least 60 stations to increase the likelihood of obtaining one or more competitive bids.

Individual charter regions were added to the revenue neutral design one at a time, selecting the charter region that was closest to net revenue neutrality for each IPHC Regulatory Area (Table 1.2). The exceptions to this were in IPHC Regulatory Area 2A, where 60 stations were selected to encompass higher catch-rate areas in both Washington and Oregon, and in IPHC Regulatory Areas 4A/4B where 60 adjacent stations were clustered around the boundary between these areas. The choice of 60 stations was motivated by the lack of bids for the 32 stations proposed in 2023 and intended to provide sufficient work to make the travel required for most vessels to reach 4A/4B worthwhile. No charter regions were evaluated for IPHC Regulatory Area 4CDE as the NOAA Fisheries trawl surveys are anticipated to provide a solid baseline of Pacific halibut density information even in the absence of direct FISS sampling.

The net cost projected for each of these additional charter regions ranged from $47,000 for IPHC Regulatory Area 3A (Shelikof), to $245,000 for the 60 stations IPHC Regulatory Areas 4A/4B.

Staffing of the NOAA Fisheries trawl survey allows for much more extensive biological sampling (age, length, and weight) of Pacific halibut than is possible otherwise, and also provides a platform for wire-tagging of juvenile halibut in this area to provide long-term monitoring of migratory pathways. These data are used in the annual stock assessment to inform weight-at-age for young Pacific halibut (up to approximately age 6) that are not captured in large numbers by the FISS. As there is not considerable variability in weight-at-age, missing a year of this sampling (as was the case when the NOAA Fisheries trawl survey was cancelled in 2020) would not be a critical problem for subsequent analyses.

Oceanographic monitoring during FISS operations provides a valuable long-term monitoring data set that is used by both IPHC and external fisheries scientists. In some years (e.g. 2017) it has provided valuable supporting information for better interpreting anomalous catch-rates due to hypoxic events (observed periodically, primarily off the coasts of Oregon and Washington). Missing a single year of this time series, although unfortunate for long-term monitoring, would not be problematic for standard stock assessment and management supporting analyses provided for the Commission unless unexpected oceanographic conditions were encountered.

Table 1.2. Comparison of design alternative costs for the 2024 FISS; see text for additional details on each design. Each of options 2-8 can be added in any combination by summing the additional costs for each option selected.

Option	Design	IPHC Regulatory Areas sampled (charter regions)	Additional net cost
1	Revenue neutral with efficiencies	2B (2), 2C (3), 3A (1)	--
2	Add additional 3A to Option 1	2B (2), 2C (3), 3A (**2**)	($47,000)
3	Add 3B to Option 1	2B (2), 2C (3), 3A (1), **3B (1)**	($62,000)
4	Add 4A/4B to Option 1	2B (2), 2C (3), 3A (1), **4A+4B (1)**	($245,000)
5	Add 2A to Option 1	2B (2), 2C (3), 3A (1), **2A (1)**	($134,000)
6	Add additional 2B to Option 1	2B (**3**), 2C (3), 3A (1)	($68,000)
7	Add oceanographic monitoring to Option 1	2B (2), 2C (3), 3A (1)	($55,000)[1]
8	Add trawl survey staffing to Option 1	2B (2), 2C (3), 3A (1)	($120,000)

[1] The estimated expense for adding oceanographic monitoring would scale according to the number of regions included in the design. It is projected that with each additional region, expenses would increase by approximately $10,000.

Implications of FISS reductions in 2024

Proceeding with the reduced sampling in the revenue positive design (Figure 1.5) would have implications for data quality that affect estimates of stock trends and distribution together with biological inputs into the stock assessment.

The lack of sampling in IPHC Regulatory Areas 2A, 4A and 4B will lead to further increases in uncertainty above those projected for 2023 (first column, Table A.1), and we anticipate CVs between 20 and 35% for these areas. With no sampling in IPHC Regulatory Areas 3A and 3B, uncertainty in estimates from these areas will also increase, and we expect a CV outside the target range of ≤15% for IPHC Regulatory Area 3B (given that with reduced sampling in 2022, the CV was 14%). With a NOAA Fisheries trawl survey expected to take place in the Bering Sea in 2024, the CV for IPHC Regulatory Area 4CDE is not expected to increase outside the target range. Increased uncertainty in most areas will carry through into coastwide estimates, although at present we anticipate the coastwide WPUE and NPUE indices to have CVs that remain in the target range of ≤10%. Estimates of stock distribution will also have higher levels of uncertainty, and the lack of data from most of the range of Pacific halibut also increases the potential for bias in estimates of overall stock trends from 2023 to 2024.

This very limited spatial design will result in much less information available for the annual stock assessment and management supporting calculations such as stock distribution. The increased uncertainty in the index of abundance is likely to cause the assessment model to rely much more heavily on the commercial fishery catch-per-unit-effort index. Given current variability and uncertainty in the magnitude of younger year classes (2012 and younger), missing biological information in the core of the stock distribution (Biological Region 3) makes it unlikely that the stock assessment will detect a major change in year class abundance, either up or down. Although the basic stock assessment methods can remain unchanged, a much greater portion of the actual uncertainty in stock trend and demographics will not be able to be quantified due to missing FISS data from such a large fraction of the Pacific halibut stock's geographic range.

RECOMMENDATIONS

That the Commission:

1) **NOTE** paper IPHC-2023-IM099-13 Rev_1, (Part 1) that presents potential FISS design options for 2024-26 and preliminary cost evaluations of 2024 potential designs;
2) **ENDORSE proceeding with the revenue neutral design for 2024 proposed here,** in order to cover all fixed headquarters costs, and to provide data for basic trend estimation and biological data for use in the 2024 stock assessment. Specifically, the Secretariat recommends fishing two charter regions in IPHC Regulatory Area 2B, three regions in IPHC Regulatory Area 2C and one region in IPHC Regulatory Area 3A (Option 1, Table 1.2; Figure 1.5), with added efficiencies as described above.

In addition, a minimum of two extensions are also recommended, dependent on the Commission's weighting of the corresponding objectives:

1) Further **prioritizing the collection of biological data** representing all four biological regions and reducing the potential for bias in trend estimates: Add modular options 4 and 3, which would provide minimal sampling in 4A/4B and in 3B (supplementing the single charter region included for 3A). This extension would require supplemental funding of US$307,000.
2) Further **prioritizing reliable estimates of stock distribution** for all IPHC Regulatory Areas, as well as biological data: Add modular options 2-5, which would allow for directly informed estimates of trend, demographics and stock distribution for all IPHC Regulatory Areas in 2024. This extension would require supplemental funding of US$488,000.

Part 2: Evaluation of block-based designs for 2024-28

PURPOSE

To provide the Commission with information and advice regarding potential Fishery-Independent Setline Survey (FISS) designs based on using blocks of stations with different target ranges of precision.

BACKGROUND

At the 2023 Work Meeting (WM2023), the Commission provided the following directive to the IPHC Secretariat relevant to this paper:

*The Commission **DIRECTED** the Secretariat to provide a five-year (2025-29) FISS design options paper, that includes the following elements for initial consideration at IM099:*

a. *Surveying using a 'block' design (rather than randomized within large areas) that would facilitate a rotational FISS of charter regions/Regulatory Areas, with some areas to be sampled more intensively but less frequently than in the past (perhaps realizing efficiencies that could decrease overall costs);*
b. *FISS that alternates year-on, year-off – analysis and implications;*
c. *Options that would maintain CVs at 15% and also other less conservative levels while maintaining the scientific integrity of the FISS;*
d. *Provide advice on the risks and bias that may result from the design described above, and what are considered tolerable levels of bias and risk, both by the Secretariat and other surveys.*

The coefficient of variation (CVs) is a relative measure of variability, calculated as the standard deviation of an estimate divided by the mean. In recent years, the IPHC has used a target range of CVs of ≤15% by IPHC Regulatory Area. To project CVs for mean O32 weight per unit effort (WPUE) for potential future designs, space-time models are fitted to observed survey data augmented with data generated from terminal year of the most recent space-time model run (in this case from 2022 as 2023 modelling is still in progress at the time of writing). As variability can change over time, projections become less reliable the further into the future we try to project. For this reason, we have projected CVs for potential designs for the three-year period 2024-26 period (2024-27 for alternating year designs) and inferred likely CVs for designs in subsequent years based on these results.

BLOCK DESIGNS

In 2019, IPHC Secretariat proposed a rotational block design (using FISS charter regions as blocks) for the following year for the core IPHC Regulatory Areas (2B, 2C, 3A and 3B) (IPHC-2019-IM095-07 Rev_1, Figure 4) to complement the similar subarea design proposed and adopted for areas at the ends of the stock (2A, 4A and 4B). The design recognized that complete spatial coverage was not necessary every year in order to maintain precision and bias goals, particularly given the ability of the space-time model to make predictions in unsampled regions that are informed by data collected nearby in time (especially the previous year) and space (that is, adjacent sampled regions). Each core area omitted 1-2 charter regions from sampling each year, with the intention being to rotate the unsampled regions over time. The block design was not adopted, and a randomized design (with random selection of over 50% of stations from the full grid) was selected to maintain comprehensive spatial coverage in the core areas.

Block designs are potentially more efficient from an operational perspective than a randomized design, as they involve less running time between stations, possibly leading to cost reductions on a per station basis. The efficiency benefits are an important consideration in bringing forward the option of using block designs for the FISS in coming years.

As in 2019, the designs considered here will use IPHC FISS charter regions for the core areas (2B-3B) and efficient sub-areas for the ends of the range (2A, 4A-4CDE).

BASE BLOCK DESIGNS

We begin with a base block design which reduces sampling in the core areas of the stock to two charter regions per year for IPHC Regulatory Areas 2B, 2C and 3B (out of five, three and five regions respectively) and four charter regions in IPHC Regulatory Area 3A (out of eight regions). This represents somewhat fewer stations than in recent randomized designs, and the reduced annual spatial coverage is expected to lead to higher CVs than in recent years. Blocks in the core areas are rotated each year so that all blocks are sampled at least once over a three-year period. The repeating design makes it easy to infer approximate CVs by area in subsequent years as they will be similar to CVs in the terminal year once a full rotation has been completed.

A subarea design is maintained at the ends of the stock, but with less frequent sampling than previously proposed to allow CVs to exceed the ≤15% target range. All potential designs maintain some FISS sampling in each Biological Region in each year to provide at least some biological data for the annual stock assessment from each region.

The base block designs for 2024-26 are shown in Figures 2.1 to 2.3. Projected CVs for the terminal year (2026) of these designs are presented in Table 2.1 (the terminal year typically has the greatest CVs but is also most important for informing management decisions). Additional potential designs for 2027-28 are presented in Figures 2.4 and 2.5 to complete the five-year design period.

For the core areas, projected CVs were generally higher than in recent years (Table 2.1), but remain below 15% for IPHC Regulatory Areas 2B, 2C and 3A while reaching 16% for IPHC Regulatory Area 3B. Even with reduced spatial coverage, sampling all stations in the core over a three-year period is projected to provide sufficient information to the space-time model to ensure precise estimates of the O32 WPUE index. At the ends of the stock, CVs for IPHC Regulatory Areas 2A, 4A and 4B were projected to be between 15 and 20%, similar to recent years in which not all planned sampling was able to be undertaken. Biological Region CVs are projected to be 5-9% (with 4B at 16%), with a 5% CV for the coastwide mean.

REDUCED BLOCK DESIGNS

In order to allow for CVs closer to 20-25% by IPHC Regulatory Area, sampling would need to be reduced further from the base block designs described above. In particular, fewer charter regions would be sampled annually in core areas, or some IPHC Regulatory Areas would go unsampled each year (see below). Such sampling reductions would further reduce the representativeness of the data, increasing the likelihood that estimates of trends and stock distribution would be biased. Some Biological Regions would have no biological data in some years, making it more difficult for the assessment to detect a major change in year class abundance, either up or down.

To see what such designs might look like, Figures 2.6 to 2.8 show maps of designs in which either one (2B, 2C and 3B) or two (3A) charter regions are fished annually, meaning that a full rotation requires at least five years to complete. For simplicity, sampling in other IPHC Regulatory Areas was unchanged from the base block design.

Projected CVs for the reduced block design are given in Table 2.1. For the core areas, CVs are projected to be 2-3 times what has been typical in recent years, and higher than projected for the base block design (with a slight exception for 3B). Biological Region CVs are projected to be 8-10% (except 4B at 17%), with a 5% CV for the coastwide mean.

Table 2.1. Projected CVs by IPHC Regulatory Area for mean O32 WPUE under alternative block designs discussed in this report, compared to CVs from recent implemented designs.

IPHC Regulatory Area	2019-23 CV (%)[¥]		Projected CV (%)		
	Range	Median	Base block design 2026	Reduced block design 2026	Alternating year design 2027
2A	13-22	18	19	19	31
2B	6-7	6	7	14	19
2C	4-6	5	6	10	16
3A	4-8	4	7	11	18
3B	7-14	8	16	15	21
4A	14-20	18	18	19	21
4B	16-26	19	16	17	26
4CDE	10-12	10	10[‡]	10[‡]	10

[¥] CV in terminal year of time series.

[‡] Inferred from other design evaluations.

ALTERNATING YEAR FISS DESIGNS

In alternating year designs, FISS sampling would occur only every other year, for example in 2024 and 2026, but not 2025 or 2027. For this exercise we took the base block designs in Figures 2.1 to 2.3 and assumed that they would be fished over 2024-28, with no sampling in odd years (including 2029). CVs were projected for the 2024-2027 period. CVs will be highest in unsampled terminal years, and therefore the projections for 2027 are shown in Table 2.1. Projected CVs are all greater than 15% except for IPHC Regulatory 4CDE which is assumed to have annual trawl sampling data. CVs for IPHC Regulatory Areas 2A and 4B and projected to exceed 25% in unsampled years. Biological Region CVs are projected to be 10-14% (except 4B at 26%), with an 8% CV for the coastwide mean.

It is important to note that fixed HQ staff costs of around $480,000 are incurred annually regardless of the actual survey design. This means that in unsampled years in an alternating year design such costs would be incurred without any FISS revenue to offset those costs. This implies that revenue would need to be greater in years when sampling does occur to meet the FISS objective of long-term revenue neutrality (Table 1.1).

TOLERABLE LEVELS OF RISK AND BIAS

The base block design maintains good spatial coverage each year and complete spatial coverage in the core of the stock over a three-year period. While CVs are generally higher than recent values, estimates of O32 WPUE indices remain precise in the core and have acceptable precision elsewhere. Estimates of stock distribution computed from these indices would be expected to have similar levels of precision, sufficient for management decision making. Biological data used as input to the IPHC stock assessment will come from throughout the stock over a relatively short time frame, reducing the likelihood that the relative strength of important cohorts is estimated imprecisely or inaccurately. The indices of abundance by Biological Region and coastwide that are used in the stock assessment would continue to provide a reliable estimate of stock trend.

The reduced block design results in less precise estimates of density indices and stock distribution and provides poor spatial coverage in the core of the stock over short time periods. Such a design will lead to a high risk of bias in estimates of stock trends and distribution and a poorer understanding of changes in year class abundance from the stock assessment due to the reduced biological sampling.

In unsampled years, the alternating year design provides the least reliable estimates of the designs considered here, with no information on stock changes from the previous year and no biological data for the annual stock assessment. Thus, risk of bias in unsampled years in expected to be higher than the two alternative block designs which maintain some annual sampling in each Biological Region.

The 'global average' research survey CVs has been estimated to be approximately ~20%; however, this value includes estimated observation and process error (based on lack of fit in the stock assessments), and so is larger than the survey-only observation CVs projected in this report (Francis et al. 2003). In NOAA Fisheries trawl survey results in the Bering Sea (roughly analogous to one Biological Region for Pacific halibut), commercially important species showed a range of average annual model-based CVs, including: Pacific cod (5%), Walleye pollock (7%), Northern rock sole (6%), and yellowfin sole (5%) over 1982-2019 (DeFilippo et al. 2023). These values are comparable to the projected 5-9% CVs for IPHC Biological Regions that would be expected from the base block design (with the exception of Biological Region 4B), but lower than corresponding values for the reduced block and alternating year designs.

DISCUSSION

The IPHC Secretariat staff recommends using block designs for all future planning as a viable alternative to the randomised sampling currently in use in the core of stock. Block designs will increase efficiency by reducing vessel travel time among stations. Sampling effort should not be lower than the levels presented in the base block design in Figures 2.1 to 2.5. We note the general need for a base level of funding to ensure a minimally adequate scientific design and therefore do not recommend alternating year surveys, instead deploying at a minimum the revenue-neutral design to cover fixed costs and maintain staff. There may be additional data quality costs to an alternating year design due to higher anticipated turnover of staff and therefore reduced availability of highly experienced staff capable of training new samplers in the field.

Revenue projections beyond one year are highly speculative. Therefore, base block design cost projections have been made as if each design were to be applied in 2024. Even modest changes in costs, price, or catch-rates can have a large effect on the net revenue of future FISS activity, as observed in the rapid changes from 2021 to 2023. The base block designs reported here reduce sampling in some high-cost areas, but also in some revenue positive areas. Therefore, **the Secretariat recommends that consistent supplementary funding of approximately $1.5 million per year would be needed to allow implementation of the base block designs reported here over 2024-2026.** We note that the revenue-positive design discussed in Part 1 of this report (Figure 1.5) is also a block design, but one that is not projected to require supplementary funding (allowing for the added efficiencies) in 2024.

The Secretariat notes that planned changes to the design and gear used for the NOAA Fisheries trawl survey in the Bering Sea will likely require additional calibration studies with the FISS, potentially beginning in 2026.

RECOMMENDATIONS

That the Commission:

1) **NOTE** paper IPHC-2023-IM099-13 Rev_1, (Part 2) that presents evaluation and discussion of potential block designs for the FISS;
2) **ENDORSE** the use of the base block design (Figures 2.1 to 2.5) or a block design with similar sampling effort as an alternative to FISS designs based on random sampling in the core of the stock;
3) **ENDORSE** maintaining sufficient FISS sampling to ensure a maximum annual CV of 25% in each IPHC Regulatory Area, decreasing to 15% as financial considerations allow, and including FISS biological sampling in all Biological Regions each year;
4) **NOTE** that stock assessment and MSE simulation analyses will be conducted in 2024 to further explore the effect on annual tactical and strategic decision-making of reduced FISS designs in the future. The Secretariat also requests clarification on whether the Commission has interest in supporting FISS designs that would provide IPHC Regulatory Area CVs comparable to the historical target (≤15%) to inform potential management procedures that rely on annual stock distribution estimates.

REFERENCES

DeFilippo, L., Kotwicki, S., Barnett, L., Richar, J., Litzow, M.A., Stockhausen, W.T., and Palof, K. 2023. Evaluating the impacts of reduced sampling density in a systematic fisheries-independent survey design. Frontiers in Marine Science **10**. doi:10.3389/fmars.2023.1219283.

Francis, R.I.C.C., Hurst, R.J., and Renwick, J.A. 2003. Quantifying annual variation in catchability for commercial and research fishing. Fishery Bulletin **101**: 293-304.

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.

IPHC 2020. Report of the 96th Session of the IPHC Annual Meeting (AM096) IPHC-2020-AM096-R. 51 p.

IPHC 2022. Report of the 98th Session of the IPHC Interim Meeting (IM098) IPHC-2022-IM098-R. 30 p.

Thorson, J. T., Shelton, A. O., Ward, E. J., and Skaug, H. J. 2015. Geostatistical delta-generalized linear mixed models improve precision for estimated abundance indices for West Coast groundfishes. ICES Journal of Marine Science 72(5): 1297-1310. doi:10.1093/icesjms/fsu243.

Thorson, J. T. 2019. Guidance for decisions using the Vector Autoregressive Spatio-Temporal (VAST) package in stock, ecosystem, habitat and climate assessments. Fisheries Research 210: 143-161. doi:10.1016/j.fishres.2018.10.013.

Webster R. A. 2016. Space-time modelling of setline survey data using INLA. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2015: 552-568.

Webster R. A. 2017. Results of space-time modelling of survey WPUE and NPUE data. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2016: 241-257.

Webster, R. 2019. Space-time modelling of IPHC Fishery-Independent Setline Survey (FISS) data. IPHC-2023-IM095-07 Rev_1. 19 p.

Webster R. 2019. Space-time modelling of IPHC Fishery-Independent Setline Survey (FISS) data. IPHC-2020-AM096-07. 32 p.

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.

Webster, R. A. 2022. 2023-25 FISS design evaluation. IPHC-2022-SRB020-05. 19 p.

Webster, R. A. 2022. 2023-25 FISS design evaluation. IPHC-2022-SRB021-06. 12 p.

Webster, R. A. 2023. 2024-26 FISS design evaluation. IPHC-2023-SRB022-06. 22 p.

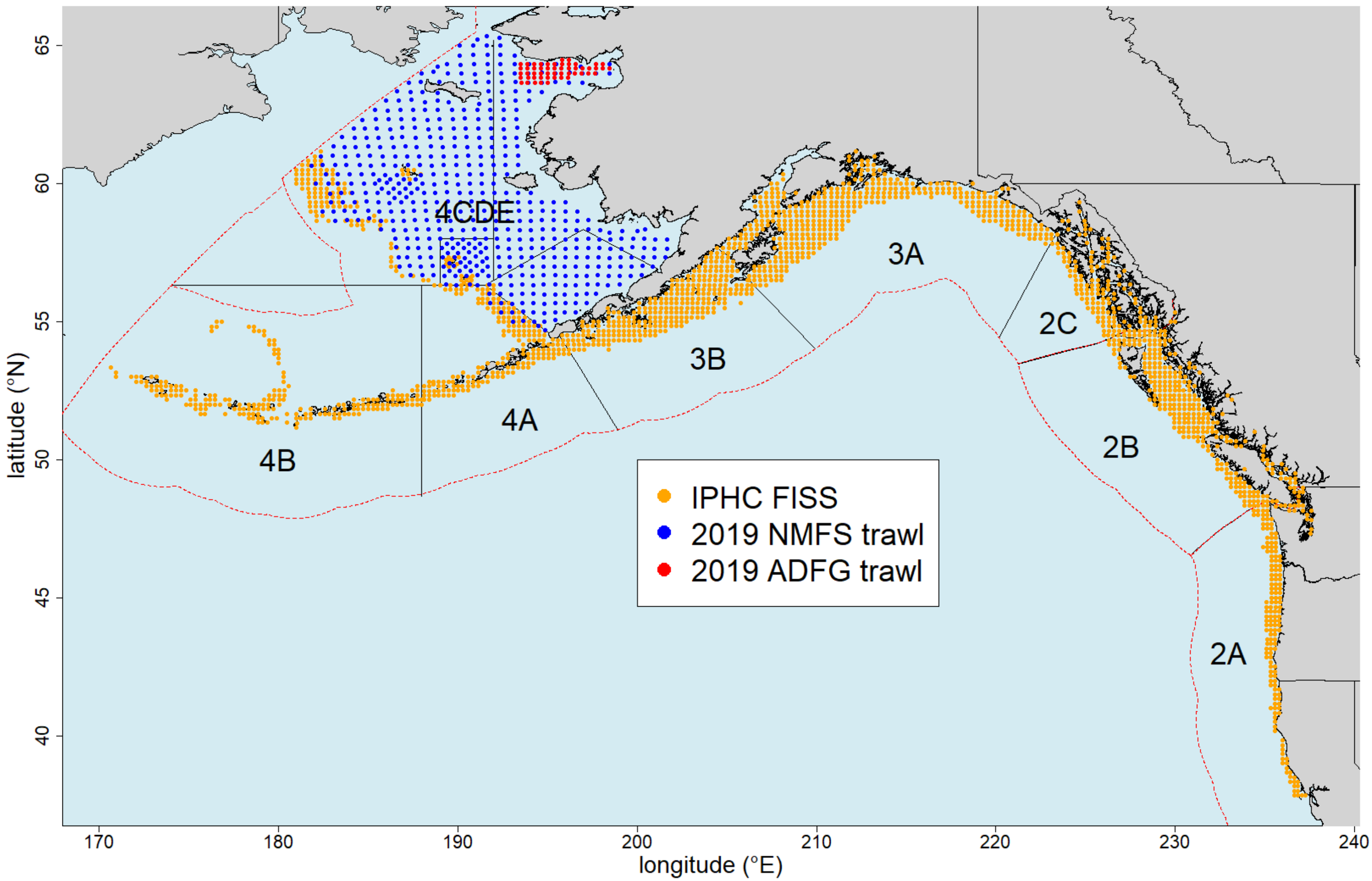

Figure 1.1. Map of the full 1890 station FISS design, with orange circles representing stations available for inclusion in annual sampling designs, and other colours representing trawl stations from 2019 NOAA and ADFG surveys used to provide complementary data for Bering Sea modelling.

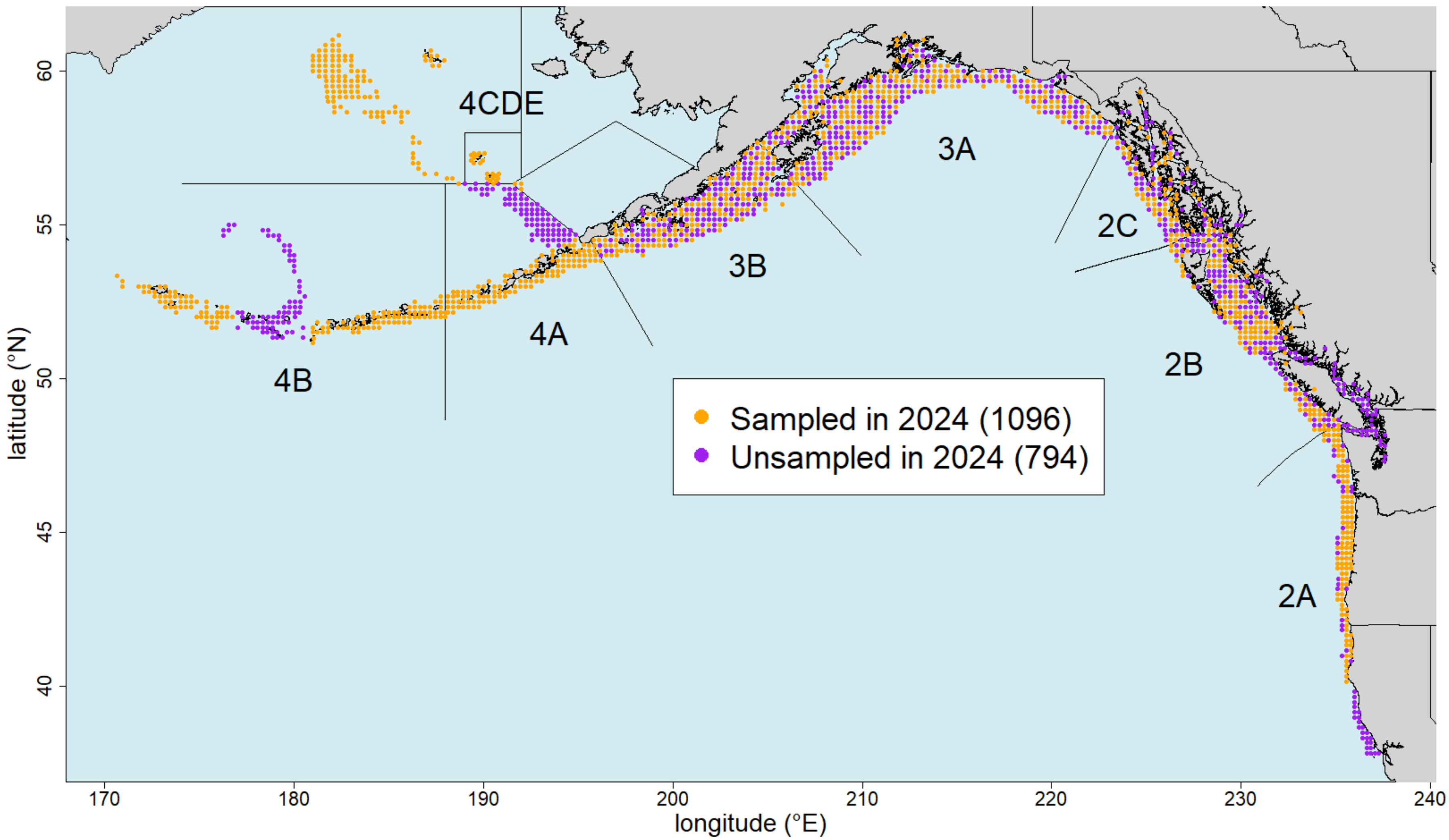

Figure 1.2. Potential FISS Design 1 in 2024 (orange circles) based on prioritization of the Primary Objective in Table 1. The design relies on randomized sampling in 2B-3B, and a subarea design elsewhere. Purple circles are optional for meeting data quality criteria.

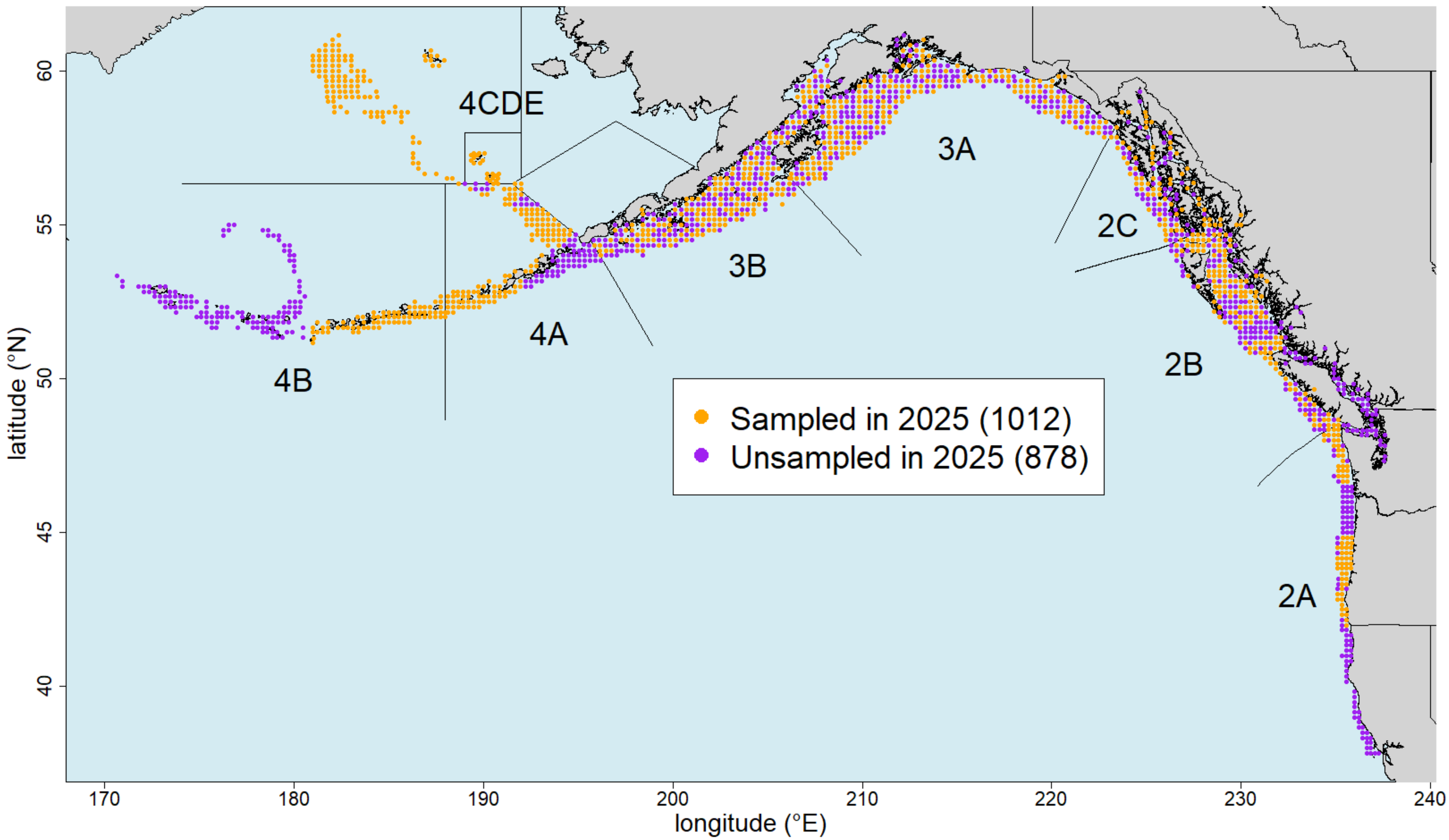

Figure 1.3. Potential FISS design in 2025 (orange circles) based on prioritization of the Primary Objective in Table 1. The design relies on randomized sampling in 2B-3B, and a subarea design elsewhere. Purple circles are optional for meeting data quality criteria.

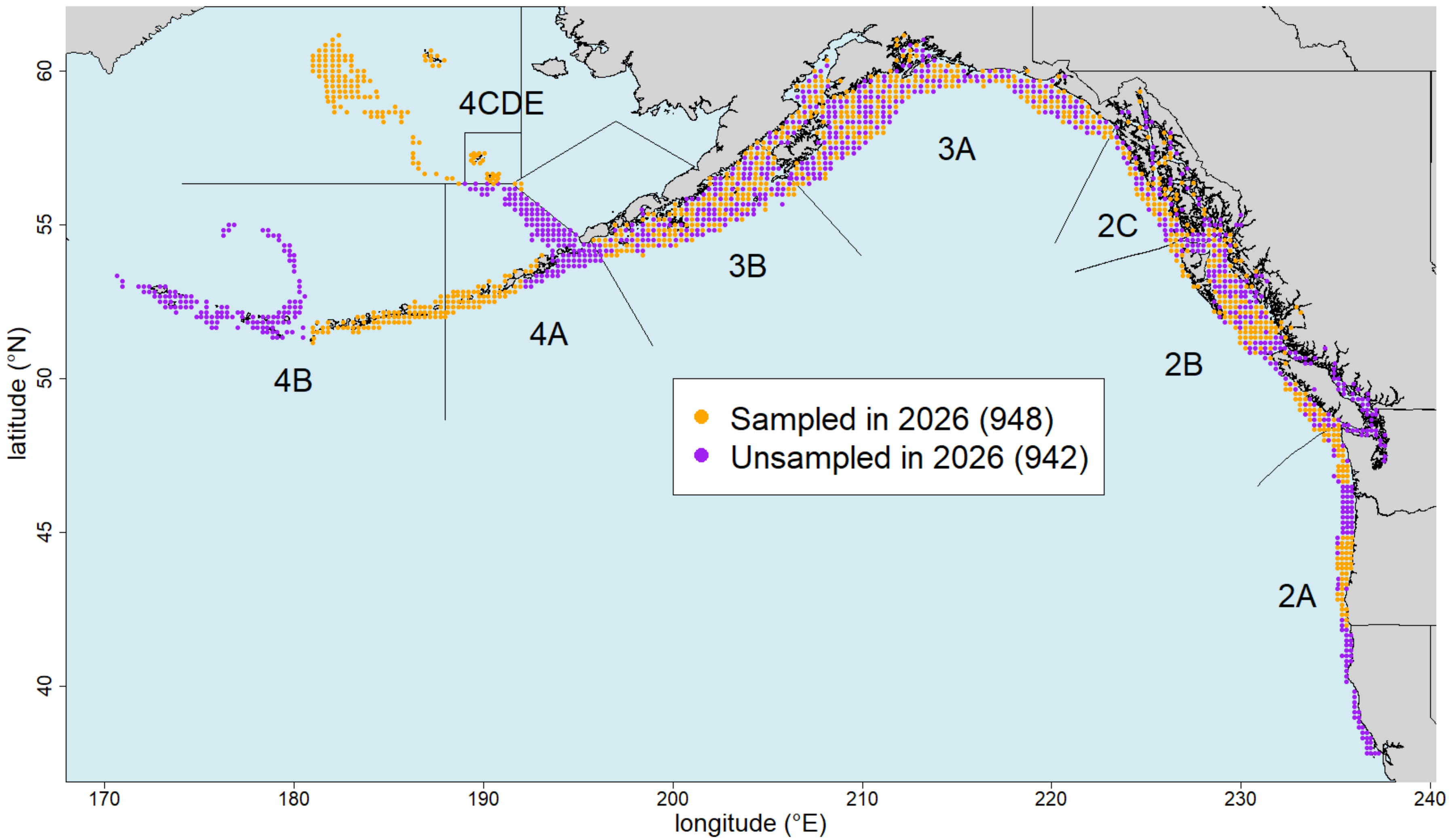

Figure 1.4. Potential FISS design in 2026 (orange circles) based on prioritization of the Primary Objective in Table 1. The design relies on randomized sampling in 2B-3B, and a subarea design elsewhere. Purple circles are optional for meeting data quality criteria.

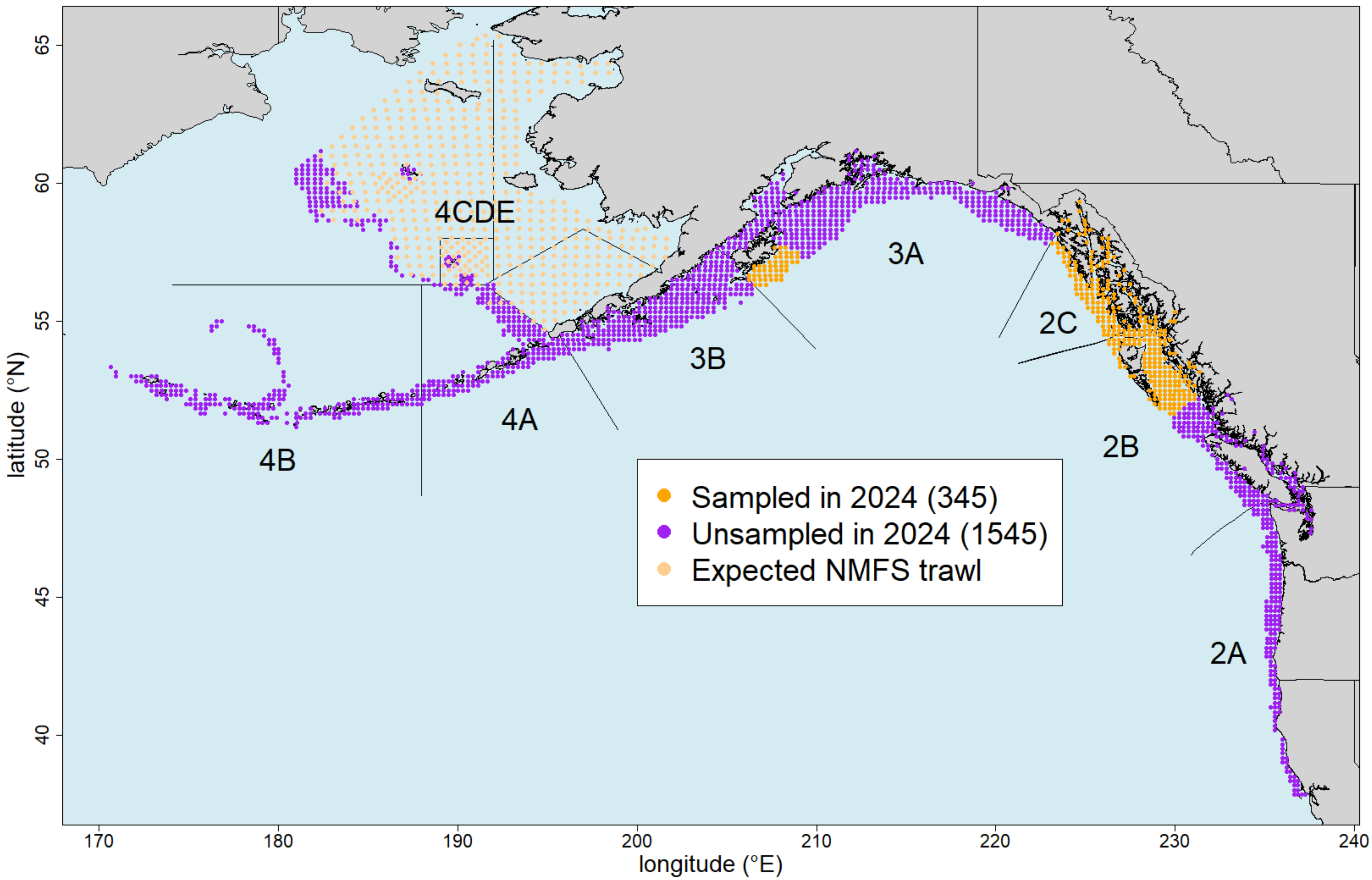

Figure 1.5. FISS design in 2024 (orange circles) based on prioritization of the Secondary Objective in Table 1. See text for more information.

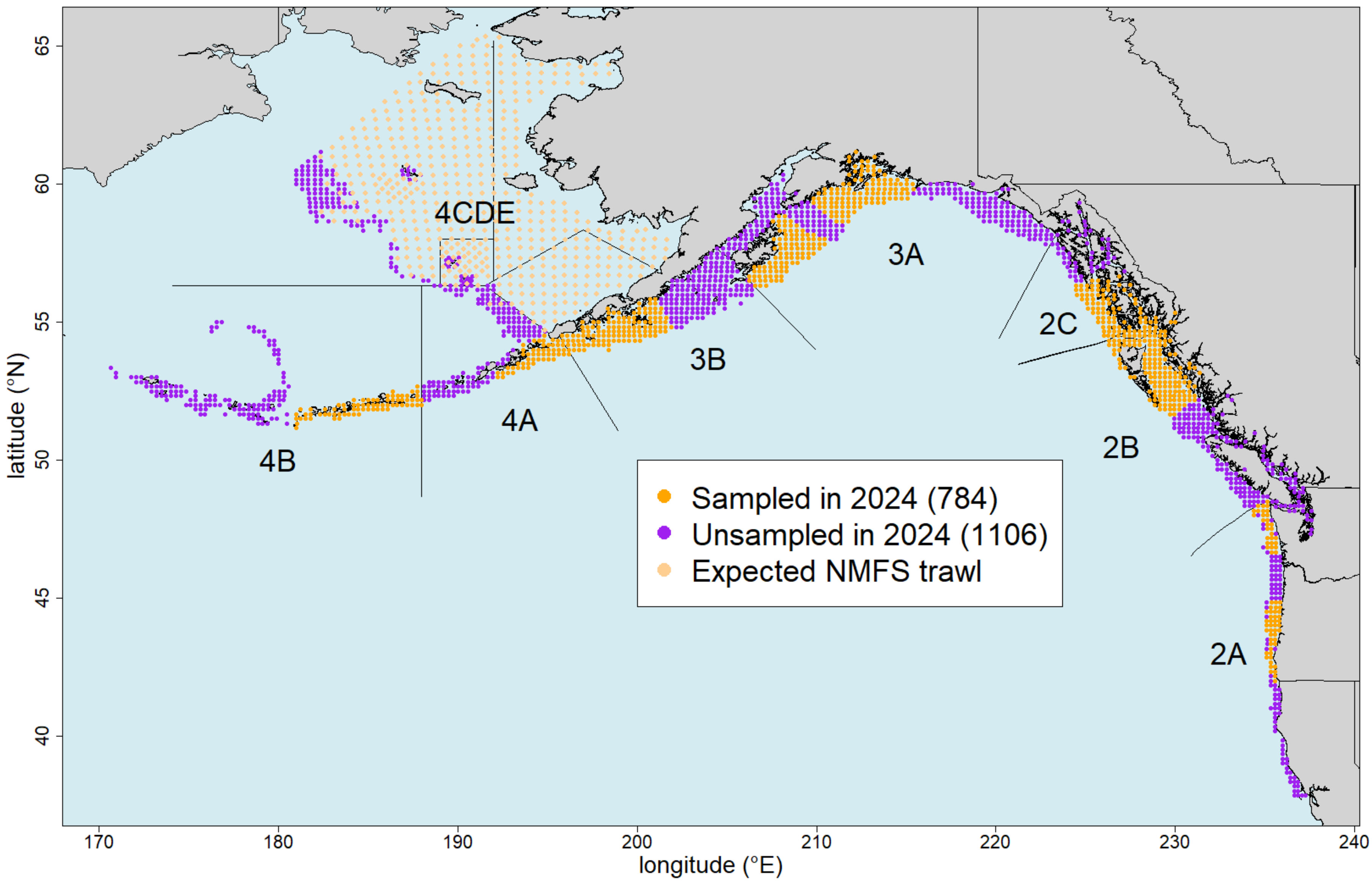

Figure 2.1. Base block design in 2024 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

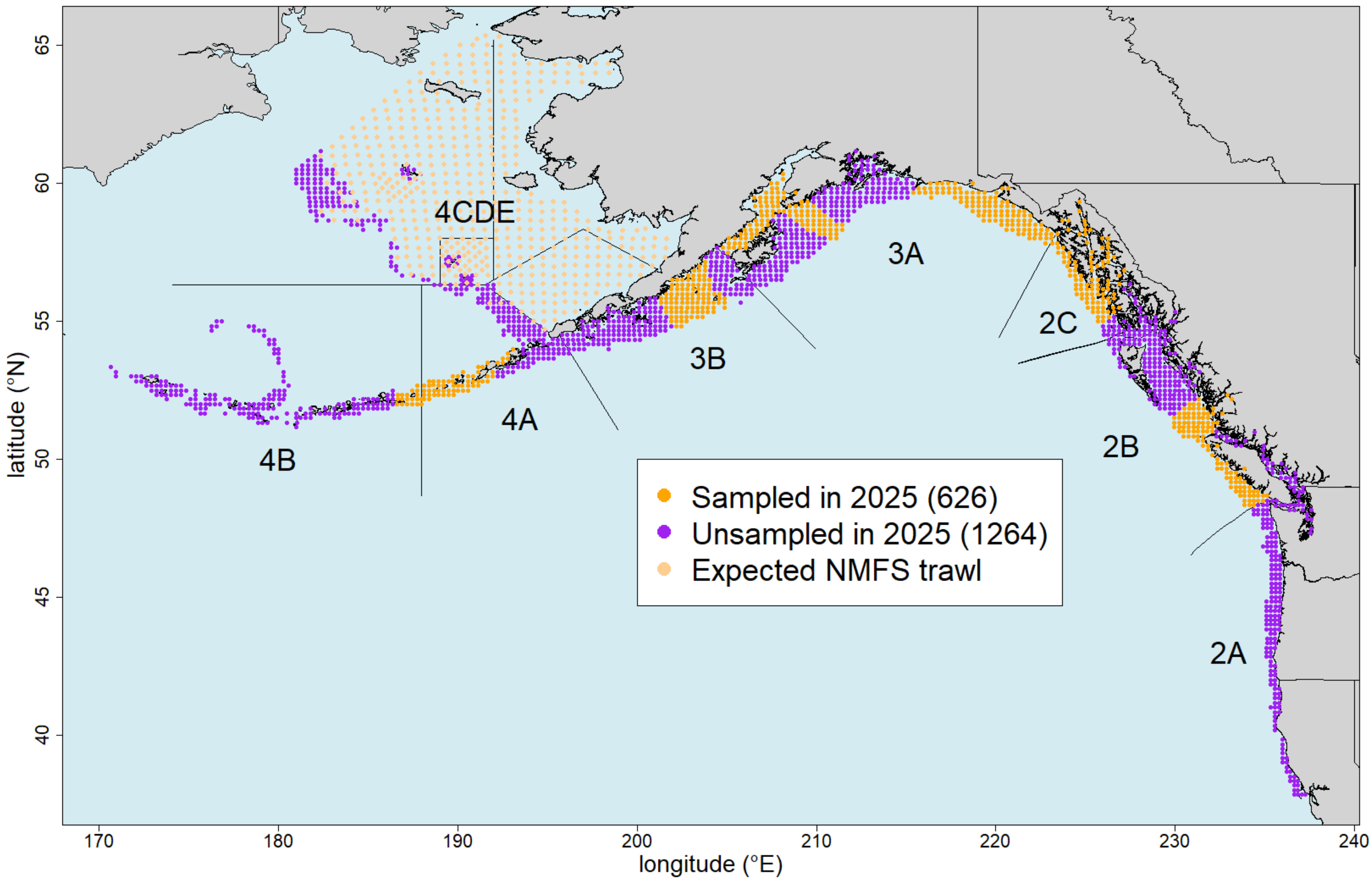

Figure 2.2. Base block design in 2025 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

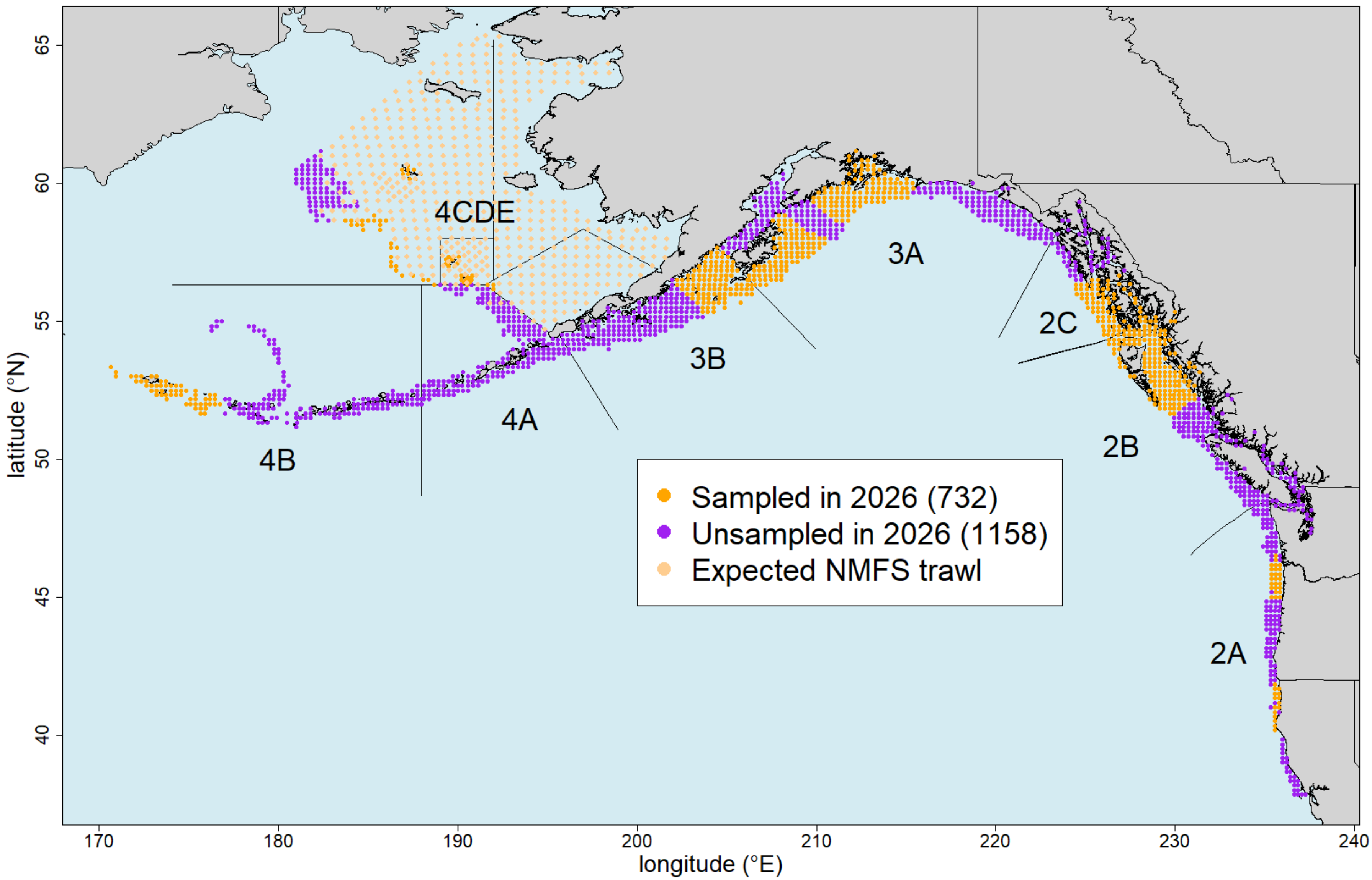

Figure 2.3. Base block design in 2026 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

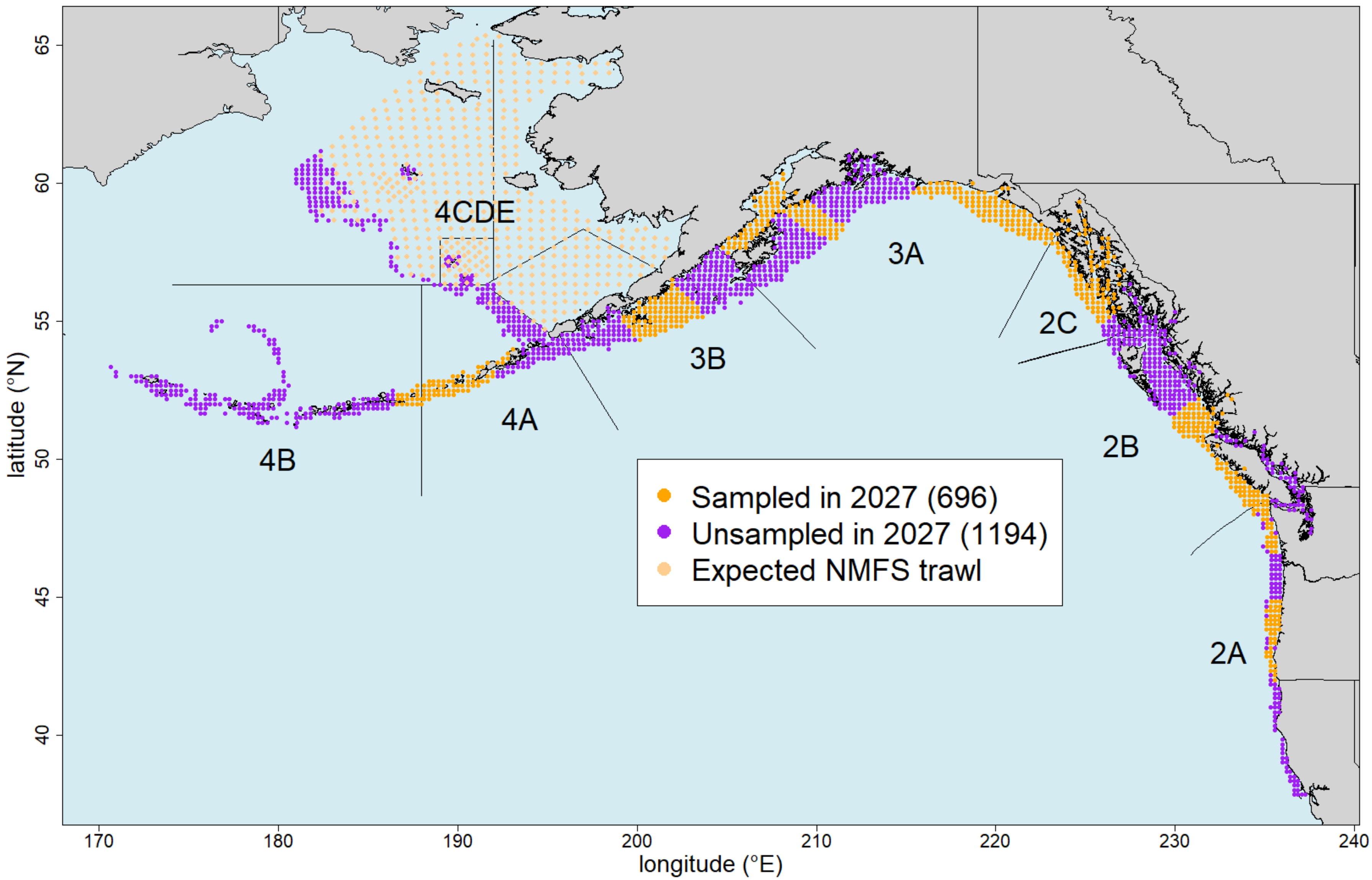

Figure 2.4. Base block design in 2027 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

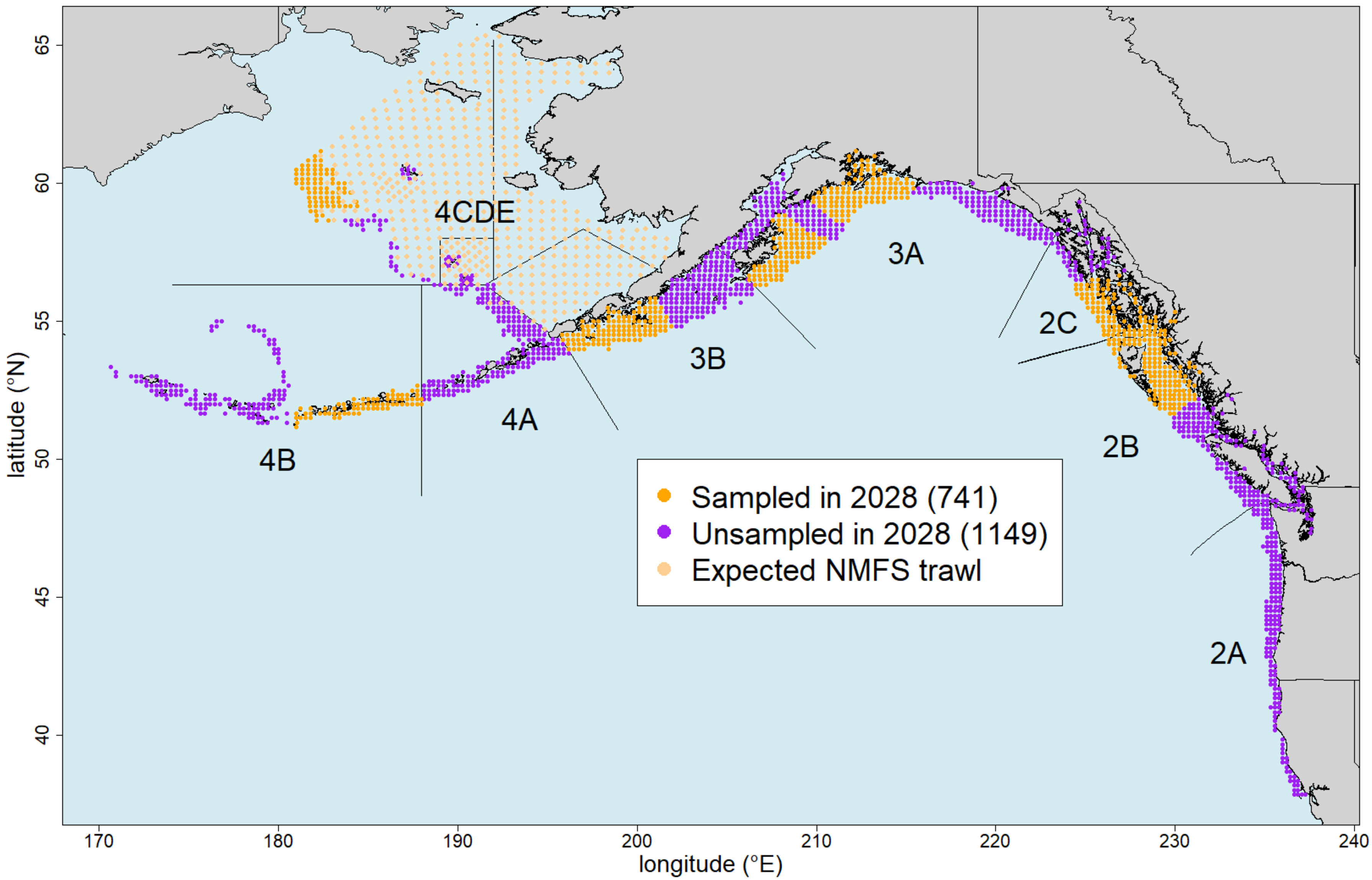

Figure 2.5. Base block design in 2028 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

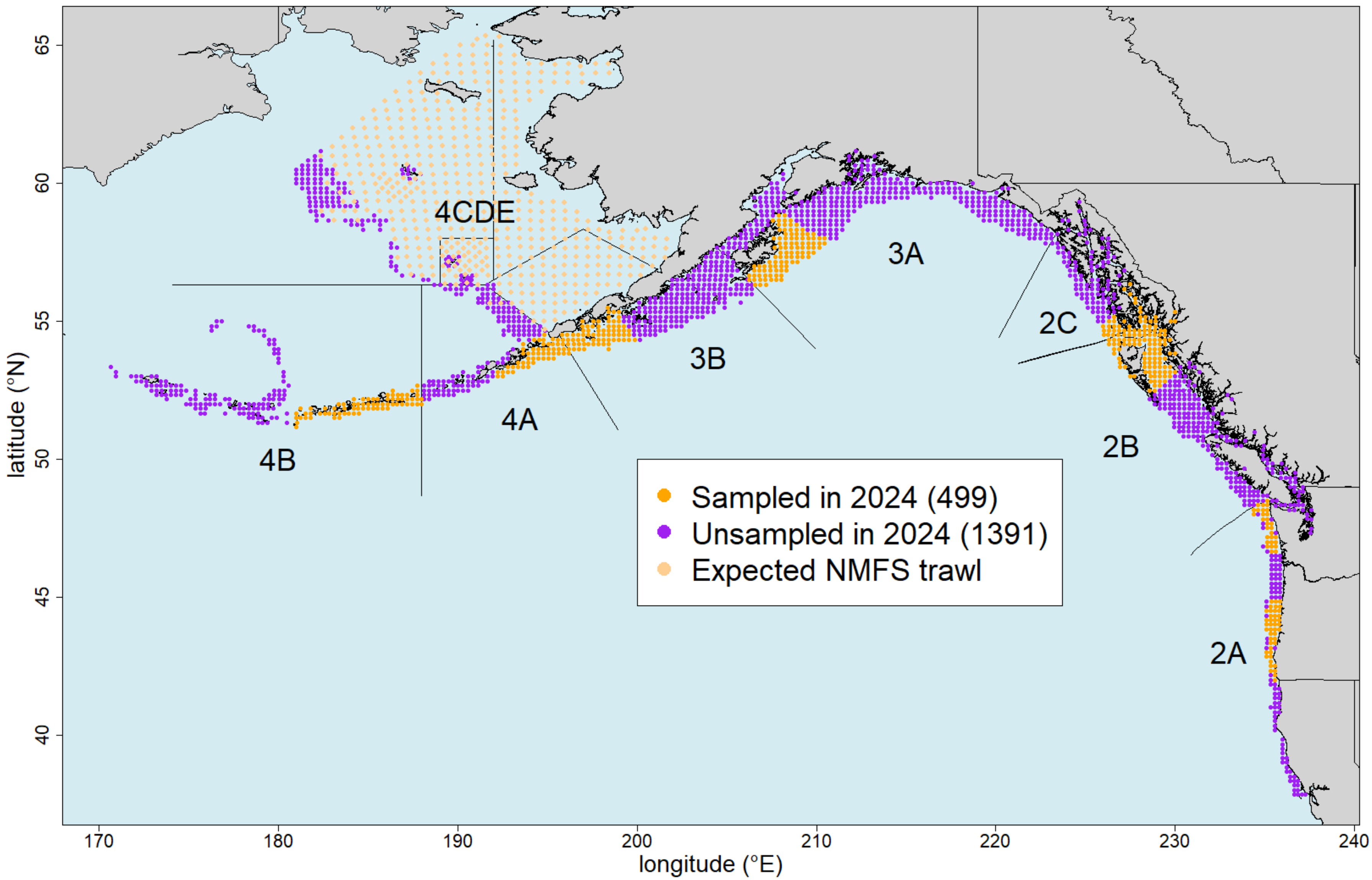

Figure 2.6. Reduced block design in 2024 (orange circles). Design is based on fishing 1-2 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

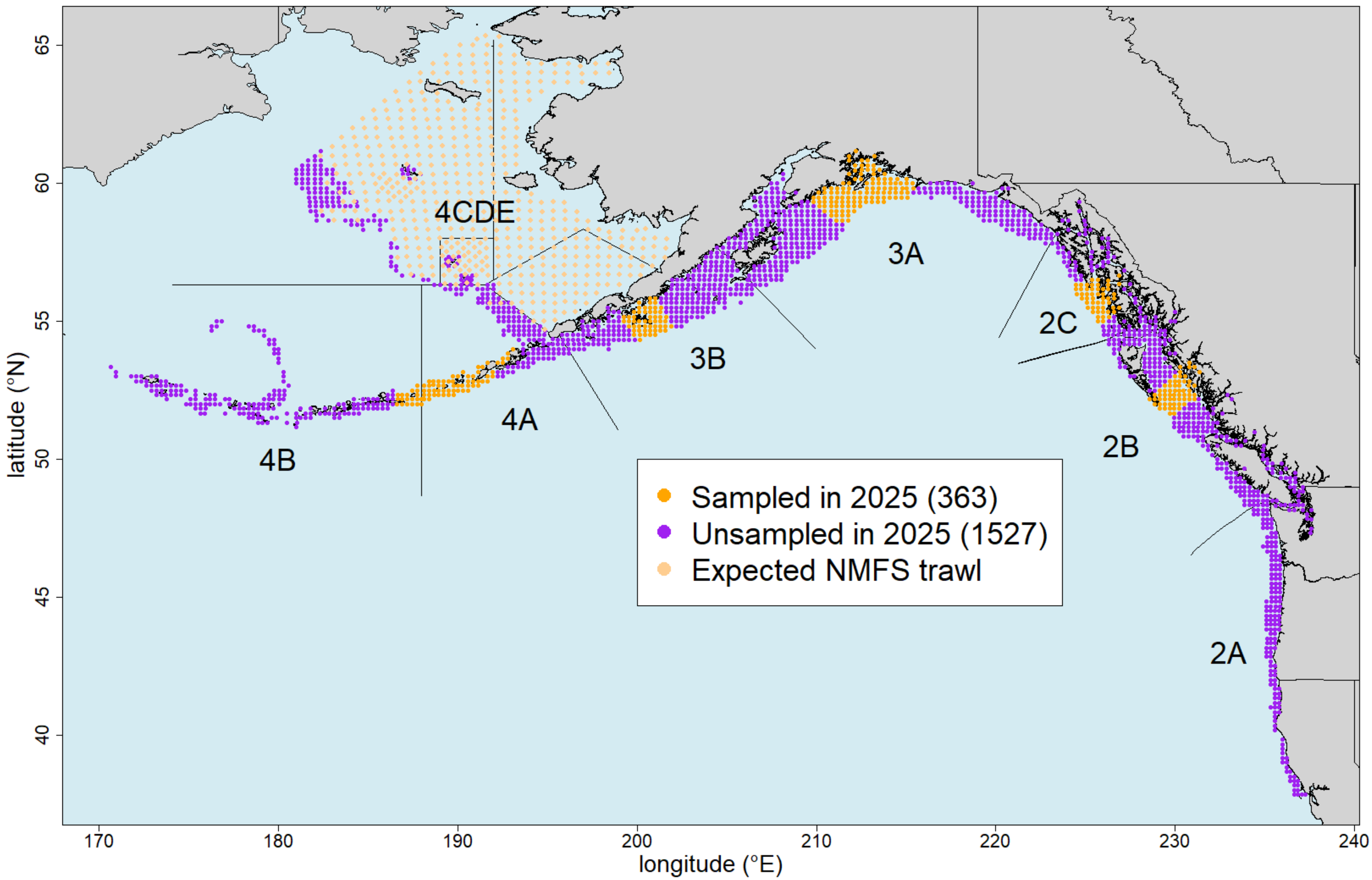

Figure 2.7. Reduced block design in 2025 (orange circles). Design is based on fishing 1-2 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

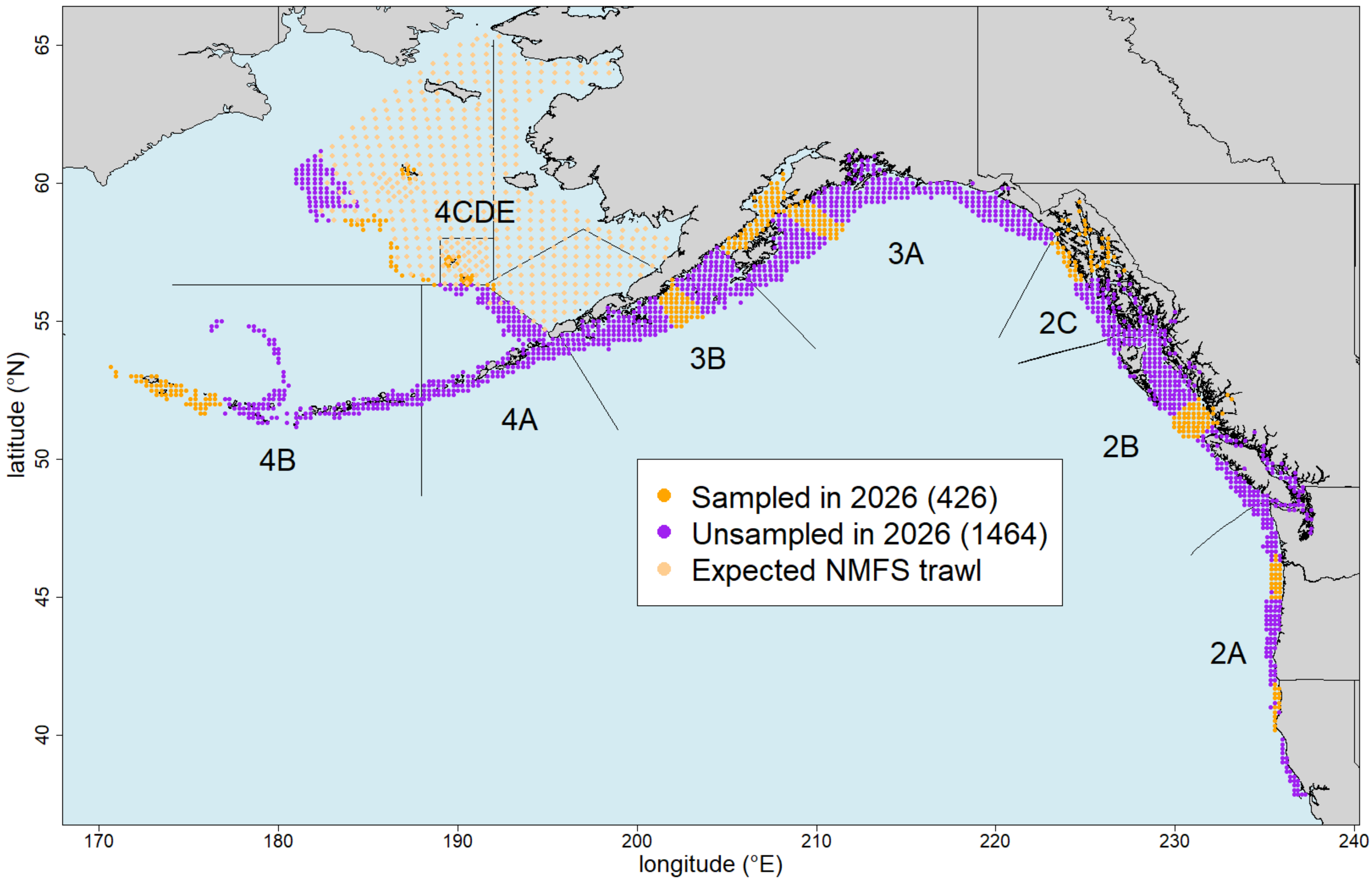

Figure 2.8. Reduced block design in 2026 (orange circles). Design is based on fishing 1-2 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

Appendix A: Additional background information and scientific evaluation

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) 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 2024-26. 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 shown in Figure 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 correlation in 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 standardize 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). The IPHC space-time models are fitted through the R-INLA package in the R software.

FISS DESIGN SCIENTIFIC EVALUATION

Precision targets

In order to maintain the quality of the estimates used for the assessment and for estimating stock distribution to be consistent with historical performance, 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 has resulted in meeting targets for the larger geographic units.

The Commission-endorsed 2023 FISS design in IPHC Areas 4A and 4B did not receive viable bids, and our analysis therefore assumed a design with no 2023 sampling in these areas.

Table A.1 shows projected CVs following the implemented 2023 FISS, the potential 2024 FISS design, and following the full 2024-26 proposed designs. The reduced 2023 FISS in IPHC Regulatory Area 2A and the lack of a 2023 FISS in IPHC Regulatory Areas 4A and 4B will lead to CVs outside of the target range this year (19-26%, first column). However, if the potential 2024 design is implemented, CVs for these areas are projected to return to within the target range (9-12%, second column) following the 2024 FISS. If the full set of proposals for 2024-26 are implemented, we are projected to achieve CVs within the target range in all years after 2023.

Table A.1. Projected CVs (%) for 2023-26 for O32 WPUE estimated after completion of the implemented 2023 FISS, completion of the potential 2024 FISS design only, and completion of all potential FISS designs for 2024-26.

Reg. Area	**2023** (After 2023 FISS)	**2024** (After 2024 FISS)	**2023** (After 2026 FISS)	**2024** (After 2026 FISS)	**2025** (After 2026 FISS)	**2026** (After 2026 FISS)
2A	19	12	12	11	12	14
4A	21	10	14	9	9	12
4B	26	9	16	9	10	12

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 (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: our goal is to sample frequently enough so that each subarea's biomass proportion has a low chance of changing by more than 10% between successive surveys of the subarea. The 10% value was chosen to provide a threshold that was meaningful in terms of bias without either resulting in large unmonitored change - e.g., 20% or more - or change so small it would require annual sampling of all stations – e.g., 5% or less - to detect reliably.

At SRB021, we presented a new method for quantifying the risk of bias due to not sampling a particular subregion of an IPHC Regulatory Area for a specified number of years (see IPHC-2022-SRB021-06). The method uses samples from the posterior predictive distribution from the space-time modelling to estimate the probability of at least a 10% absolute change in a subarea's biomass proportion over a period of time equal to the number of years since it was last sampled. A detailed description of the analysis results is presented in IPHC-2023-SRB022-06. Results are summarized in Table A.2.

Table A.2. Summary of results of analysis of bias risk for IPHC Regulatory Areas that are sampled using subareas.

Reg Area	Subarea	Description	Last sampled	Risk of ≥10% change since last sampled	Recommendation
2A	1	High density north WA/central OR	2022	NA*	Annual sampling (core of 2A stock)
	2	Moderate density, south WA/north and south OR/north CA	2017-19	High	Sample 2024
	3	Deep and shallow/Salish Sea/south CA	2017-19	Low	Sample after 2026
4A	1	Western AI	2022	NA*	Annual sampling (core of 4A stock)
	2	Eastern AI	2019	High	Sample 2024
	3	Shelf Edge	2019	Low	Sample 2025
4B	1	West	2019	Moderate	Sample 2024
	2	Central	2022	Low	Sample after 2026
	3	East	2021	NA*	Near-annual sampling (core of 4B stock)

*Not evaluated for bias risk as annual or near-annual sampling is required to maintain CVs within target range.

To evaluate how well this subarea approach to projecting CVs has been working, a comparison was made between pre-FISS projections and post-sampling estimates for IPHC Regulatory Areas 2A, 4A and 4B. Projected CVs in all three areas were lower than those estimated once the observed 2022 data were incorporated into the modelling (Table A.3). The projections for 2022 were made prior to the start of the 2021 FISS. As noted in IPHC-2022-SRB020-05, the 2021 FISS in IPHC Regulatory Areas 4A and 4B did not complete all planned stations due to logistical issues. In both areas, the unfished stations covered some of the most productive habitat in recent years. This affected both the projections for 2021 and 2022, which assumed a complete FISS. Further, the western subregion of IPHC Regulatory Area 4B was planned to be sampled in 2022 but due to lack of viable charter bids, the FISS did not sample there.

Table A.3. Comparison of projected (in 2021) and estimated CVs (%) for O32 WPUE for 2022 by IPHC Regulatory Area.

Regulatory Area	2022 projected CV (%)	2022 estimated CV (%)
2A	14	16
4A	10	14
4B	14	19

The difference between projected and estimated CVs in IPHC Regulatory Area 2A was relatively small. Last year (IPHC-2022-SRB020-05) we noted an apparent increase in the underlying variability of Pacific halibut density in this area. The 2022 data did not show evidence for higher variability than other recent years, and the combined effect of 2021 and 2022 data was an estimated CV that was closer to the projection than last year.

Projected CVs were not calculated for other IPHC Regulatory Areas as they are not at present used to evaluate design proposals and all have been within the target range (≤15%) in recent years. Estimated CVs for O32 WPUE for the core IPHC Regulatory Areas of 2B, 2C, and 3A were all 6% in 2022, with a CV of 10% in IPHC Regulatory 4CDE. The CV for IPHC Regulatory Area 3B was 14%, but this was anomalous as it was due to unforeseen logistical issues leaving many stations unsampled. Typically, the CV is around 7% in this area.