INTERNATIONAL PACIFIC HALIBUT COMMISSION

2024-26 FISS design evaluation

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Part 1: 2024-26 FISS design evaluation

PURPOSE

To review the potential 2024-26 FISS designs presented previously at SRB022, along with 2024 design options accounting for the FISS objective of long-term revenue neutrality.

BACKGROUND

At SRB022, the Secretariat presented proposed FISS designs for 2024-26 together with a scientific evaluation of those designs (IPHC-2023-SRB022-06). Based on the evaluation, it is expected that the proposed designs would lead to estimated indices of density that would meet bias and precision criteria in the 2024-26 period.

The designs presented at SRB022 were evaluated only using criteria based on the primary FISS objective of sampling Pacific halibut for stock assessment and stock distribution estimation (Table 1). The IPHC Secretariat has developed a sequence of additional designs that account to varying degrees for the secondary FISS objective of long-term revenue neutrality. The estimate of net revenue for each design is based on preliminary information from the current FISS, which at the time of writing is not yet complete. Cost projections for 2024 designs are therefore subject to later revision.

For at least some of the design options below, projected coefficients of variation (CVs) will be calculated to help understand the impact of a reduced FISS footprint on data quality in 2024. It is our intention to present this information to the SRB in a Rev_1 version of this document and/or as part of the meeting presentation.

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

POTENTIAL DESIGNS FOR 2024-26

1) ***Options based on the primary objective (Table 1.1)**, to sample Pacific halibut for stock assessment and stock distribution estimation.*

Design options based on the Primary Objective for 2024-26 (Figures 1.1 to 1.3) 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, historically a logistically feasible footprint for the annual FISS.

In 2022, designs for 2024-25 were also endorsed subject to later revision (IPHC-2022-IM098-R). However, the original proposed design for 2023 (IPHC-2022-SRB020-05) was not endorsed by the Commissioners. To meet the secondary objective of long-term revenue neutrality, they instead endorsed a spatially-reduced design with minimal sampling in IPHC Regulatory Areas 2A, 4A and 4B (16 FISS grid station per area), and no sampling in IPHC Regulatory Area 4CDE (IPHC-2022-IM098-R). For this reason, almost all stations in IPHC Regulatory Areas 2A, 4A, 4B and 4CDE that were proposed but not endorsed for 2023 are again included in the design for the 2024 FISS presented at SRB022. The one exception is in IPHC Regulatory Area 4A, where the sample timing of two subareas has been switched.

Thus, the following changes from the previous 2024 proposal presented at SRB020 have been made (see Figure 1.1):

- IPHC Regulatory Area 2A: Sample the highest-density waters of IPHC Regulatory 2A in northern Washington and central/southern Oregon and add the moderate density waters of southern Washington/northern Oregon and northern California **(original 2023 SRB proposal)**.
- IPHC Regulatory Area 4A: Sample both the higher-density western subarea of IPHC Regulatory Area 4A and the lower-density southeastern subarea in 2024 **(previous 2025 SRB proposal)**.

- IPHC Regulatory Area 4B: Sample the high-density eastern subarea and the western subarea in 2024 **(original 2023 SRB proposal)**.

One change was made to last year's 2025 proposal (Figure 1.2):

- IPHC Regulatory Area 4A: Sample both the higher-density western subarea of IPHC Regulatory Area 4A and the medium-density Bering Sea shelf subarea in 2025 **(previous 2023 SRB proposal)**.

The 2026 design (Figure 1.3) includes sampling in the high-density subareas of IPHC Regulatory Areas 2A, 4A, and 4B, along with full sampling of FISS stations in IPHC Area 4CDE. Further details were presented at SRB022 and can be found in IPHC-2023-SRB022-06.

The potential 2024 design in Figure 1.1 is designated as Design 1 of nine potential designs considered here. Each of the design options presented in this document was evaluated assuming that the average price in each charter region for Pacific halibut remains unchanged from 2023 to 2024 and that the landings in each charter region decrease by 5% on average across all stations.

DESIGN 1: Using preliminary information from the 2023 FISS, the potential 2024 design in Figure 1.1 based on primary objectives (Table 1.1) is projected to result in **a net loss of between 3.649 million dollars** (Table 1.2) and is therefore **not feasible**. **NOT RECOMMENDED**

2) ***Options accounting for the secondary objective (Table 1.1),*** *long term revenue neutrality.*

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 is to provide a fiscally viable FISS design.

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 support costs (staffing, travel, training, gear transport etc.).

Balancing these factors results in modifications to designs such as increasing sampling effort in high-density regions and decreasing effort in low density regions. It had been anticipated that under most circumstances, cost considerations could be addressed by increasing effort (adding stations, increasing the number of skates set) in revenue-positive regions in the designs proposed in this report. However, with stocks near historic lows and extremely low prices for fish sales, the current funding model requires that some low-density habitat be omitted from the design entirely (as occurred in 2020 and 2023).

This has implications for data quality, particularly if such reductions in effort relative to proposed designs continue over multiple years. In the 2021 and 2022 FISS, it was sufficient to include additional stations in core IPHC Regulatory Areas to generate a revenue-neutral coastwide design and so there were no planned reductions in coverage. The 2023 FISS balanced the primary objective with the secondary objective by greatly reducing sampling outside of the core areas of the stock (IPHC-2022-IM098-R). The result will be increased uncertainty in estimates of WPUE and NPUE indices following the 2023 FISS, with projected 2023 CVs of 19-26% for IPHC Regulatory Areas 2A, 4A and 4B which received little or no sampling in 2023.

The 2023 FISS is expected to be completed at a substantial operating loss, due primarily to lower than expected catch rates and lower prices for Pacific halibut than projected. The Secretariat recognises that the FISS cannot continue in 2024 under similar pressures, and as such, we propose the following sequence of 2024 FISS design options that balance data collection and fiscal viability to varying degrees. The preliminary estimates of net cost for all 2024 design options are in Table 1.2.

Cost estimates are based on preliminary information from the 2023 FISS and it is important to note that data and accounting are not yet complete. Fish sales revenue and catch rates in some areas are still pending completion of work this summer (IPHC charter region Sanak and Sitka). Therefore, in preparing the 2024 projections, values for these regions were estimated factoring in the projected values as well as current patterns seen in surrounding regions. Final cost and accounting information will be available at the end of the fiscal year and will be used to refine these preliminary projections at that time.

Table 1.2. Comparison of preliminary design option costs for the 2024 FISS. Each design modifies the previous alternative as noted; see text for additional details.

Design	Description	Preliminary projected net revenue	Change in revenue from previous design
1	Pre-optimized design	-$3,649,000	--
2	Optimized design (adding stations and skates)	-$2,983,000	$666,000
3	Remove 4CDE	-$2,523,000	$460,000
4	Remove 4CDE and 2A	-$2,224,000	$299,000
5	Remove 4B, 4CDE and 2A	-$1,817,000	$407,000
6	Remove 4A, 4B, 4CDE and 2A	-$1,483,000	$334,000
7	Remove 3B, 4A, 4B, 4CDE and 4A	-$1,096,000	$387,000
8	Remove parts of 2B and all of 3A, 3B, 4A, 4B, 4CDE and 2A	-$384,000	$712,000
9	Design 8 with added efficiencies	$8,000	$392,000

DESIGN 2: This option adds stations and uses sets of 8 skates in revenue-positive charter regions in IPHC Regulatory Areas 2B and 2C (Figure 1.4). The station design in other IPHC Regulatory Areas is the same as Design 1 above. Design 2 is projected to result in **a net loss of 2.983 million dollars** (Table 1.2) and is therefore **not feasible**. **NOT RECOMMENDED**

DESIGN 3: Removes IPHC Regulatory Area 4CDE from Design 2 (Figure 1.5). Design 3 is projected to result in **a net loss of 2.523 million dollars** (Table 1.2) and is therefore **not feasible**. **NOT RECOMMENDED**

DESIGN 4: Removes IPHC Regulatory Area 2A from Design 3 (Figure 1.6). Design 4 is projected to result in **a net loss of 2.224 million dollars** (Table 1.2) and is therefore **not feasible**. **NOT RECOMMENDED**

DESIGN 5: Removes IPHC Regulatory Area 4B from Design 4 (Figure 1.7). Design 5 is projected to result in **a net loss of 1.817 million dollars** (Table 1.2) and is therefore **not feasible**. **NOT RECOMMENDED**

DESIGN 6: Removes IPHC Regulatory Area 4A from Design 5 (Figure 1.8). Design 6 is projected to result in **a net loss of 1.483 million dollars** (Table 1.2) and is therefore **not feasible**. **NOT RECOMMENDED**

DESIGN 7: Removes IPHC Regulatory Area 3B from Design 6 (Figure 1.9). Design 7 is projected to result in **a net loss of 1.096 million dollars** (Table 1.2) and is therefore **not feasible**. **NOT RECOMMENDED**

DESIGN 8: Removes IPHC Regulatory Area 3A and southern charter regions of IPHC Regulatory Area 2B from Design 7 (Figure 1.10). Design 8 is projected to result in **a net loss of 0.384 million dollars** (Table 1.2) and is therefore **not feasible**. **NOT RECOMMENDED**

As none of the above 2024 design options is preliminarily projected to be revenue neutral, an additional design was developed based on modifying Design 8 to further reduce costs and increase revenue.

DESIGN 9: The IPHC Secretariat has developed an alternative preliminary design for 2024 that is currently projected to be slightly revenue positive (Figure 1.11) by adding a series of cost-saving efficiencies to design 8. In order to achieve projected positive net revenue, sampling would only take place in the northern portion of IPHC Regulatory Areas 2B and in IPHC Regulatory Area 2C. Sampling in any other IPHC Regulatory Area is projected to lead to an overall operating loss for the 2024 FISS.

Several aspects of the standard FISS procedures were removed to achieve a revenue-positive design:

- 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:

- Add a further 13 stations in high density regions to increase revenue.
- 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 there will be a decrease in price of chum salmon bait of approximately 25% from 2023;
- That data from the planned September bait comparison study is supportive of using pink salmon as bait, that pink salmon will comprise 25% of all FISS bait (used at 50% of the stations in 2C), and is 60% of the price of chum salmon.

With these modifications and assumptions, Design 9 (Figure 1.11) has **a preliminary projected net operating profit of $8,000** (Table 1.2). If the 2023 bait calibration study in IPHC Regulatory Area 2C is successful, it may be desirable to add a similar bait calibration in IPHC Regulatory Area 2B in 2024. Such an effort may further increase net revenue and generate sufficient information to proceed with the use of both pink and chum salmon in that area in 2025.

The lack of sampling in IPHC Regulatory Areas 2A, 4A and 4B will lead to further increases in uncertainty above those projected for 2023, 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.

This is the first time the Secretariat has attempted to evaluate FISS projections at this time of the year; therefore, these projections should be considered highly preliminary. With the 2023 FISS data still incomplete it is not currently possible to understand how the decline in catch rates observed in 2023 will interact with the estimated age structure of the population potentially leading to a larger or smaller projected decline in landings based on the pending stock assessment results. Further, budget estimates are incomplete and will not be fully reconciled until the end of the fiscal year; adjustments to 2023 costs will translate to changes in projected costs for 2024. Finally, the 2023 FISS still has vessels fishing and pending fish sales which may further adjust the basis for 2024 projections when completed.

RECOMMENDATION

That the Scientific Review Board:

1) **NOTE** paper IPHC-2023-SRB023-09, which reviewed the 2024-26 FISS designs presented at SRB022 and presented an evaluation of design options for 2024 accounting the secondary FISS objective of long-term revenue neutrality;

References

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

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

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

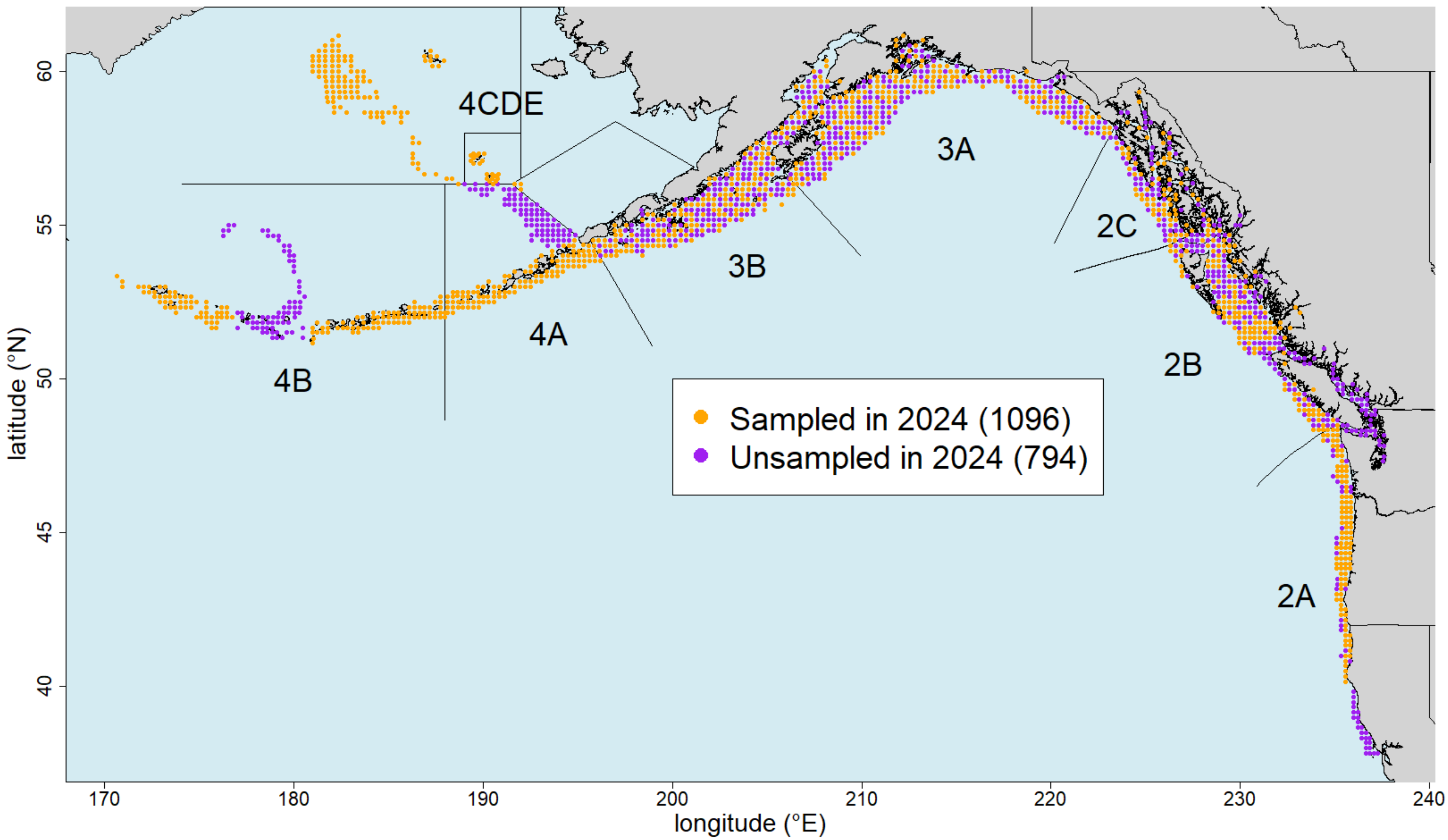

Figure 1.1. Potential FISS Design 1 in 2024 (orange circles) based on prioritization of the Primary Objective in Table 1.1. The design relies on randomized sampling in 2B-3B, and a subarea design elsewhere. Purple circles are optional for meeting data quality criteria.

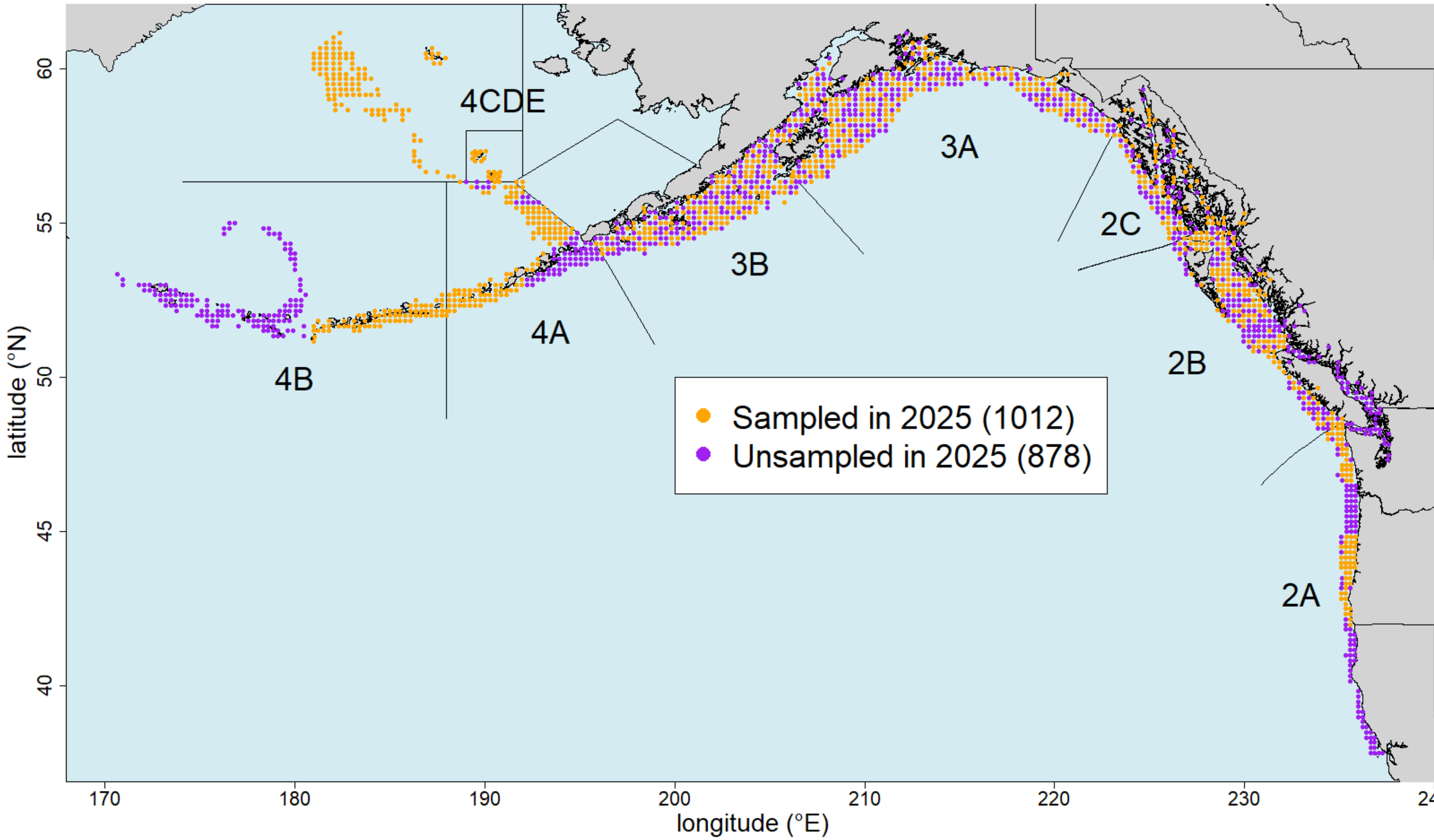

Figure 1.2. Potential FISS design in 2025 (orange circles) based on prioritization of the Primary Objective in Table 1.1. The design relies on randomized sampling in 2B-3B, and a subarea design elsewhere. Purple circles are optional for meeting data quality criteria.

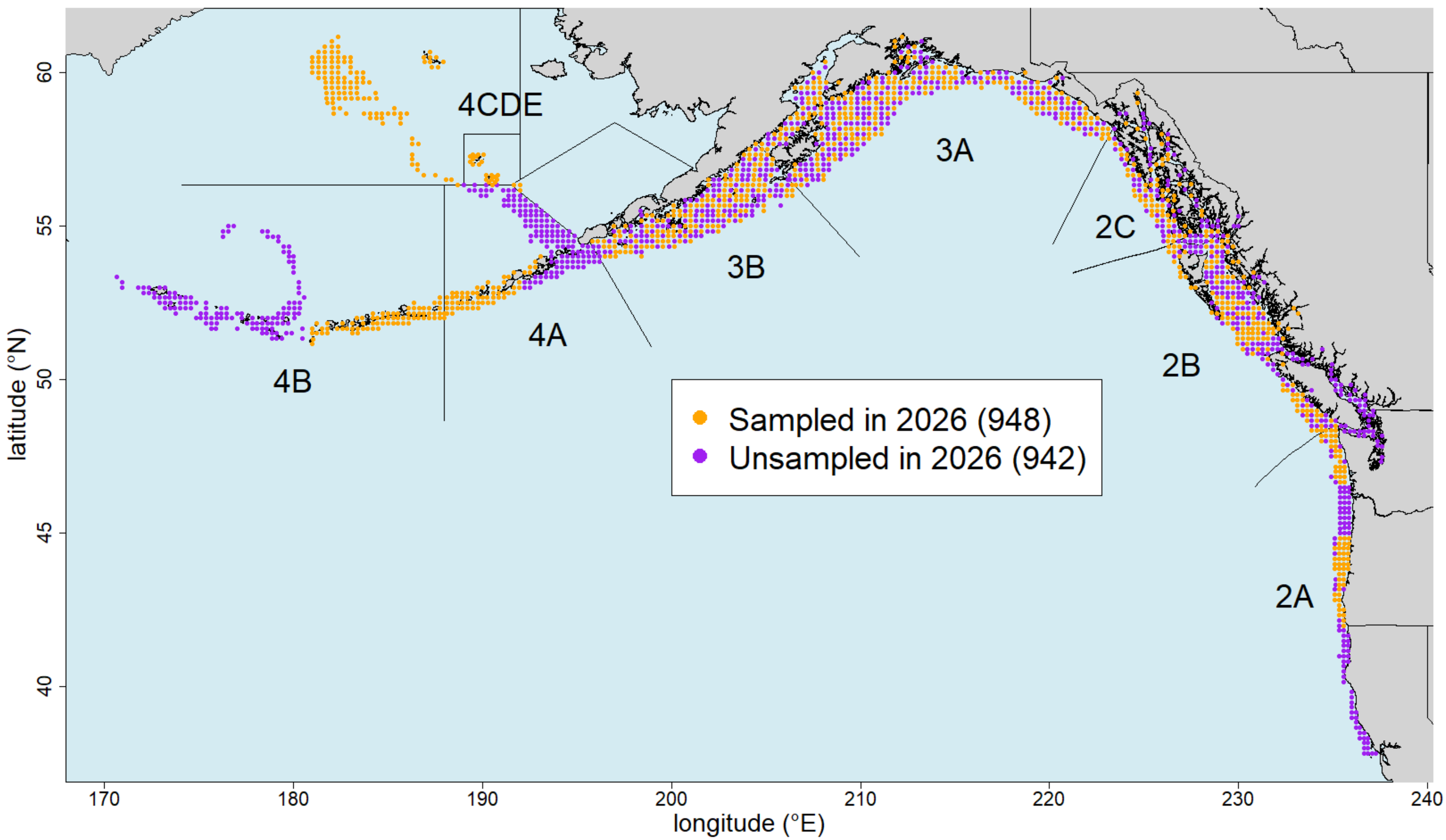

Figure 1.3. Potential FISS design in 2026 (orange circles) based on prioritization of the Primary Objective in Table 1.1. The design relies on randomized sampling in 2B-3B, and a subarea design elsewhere. Purple circles are optional for meeting data quality criteria.

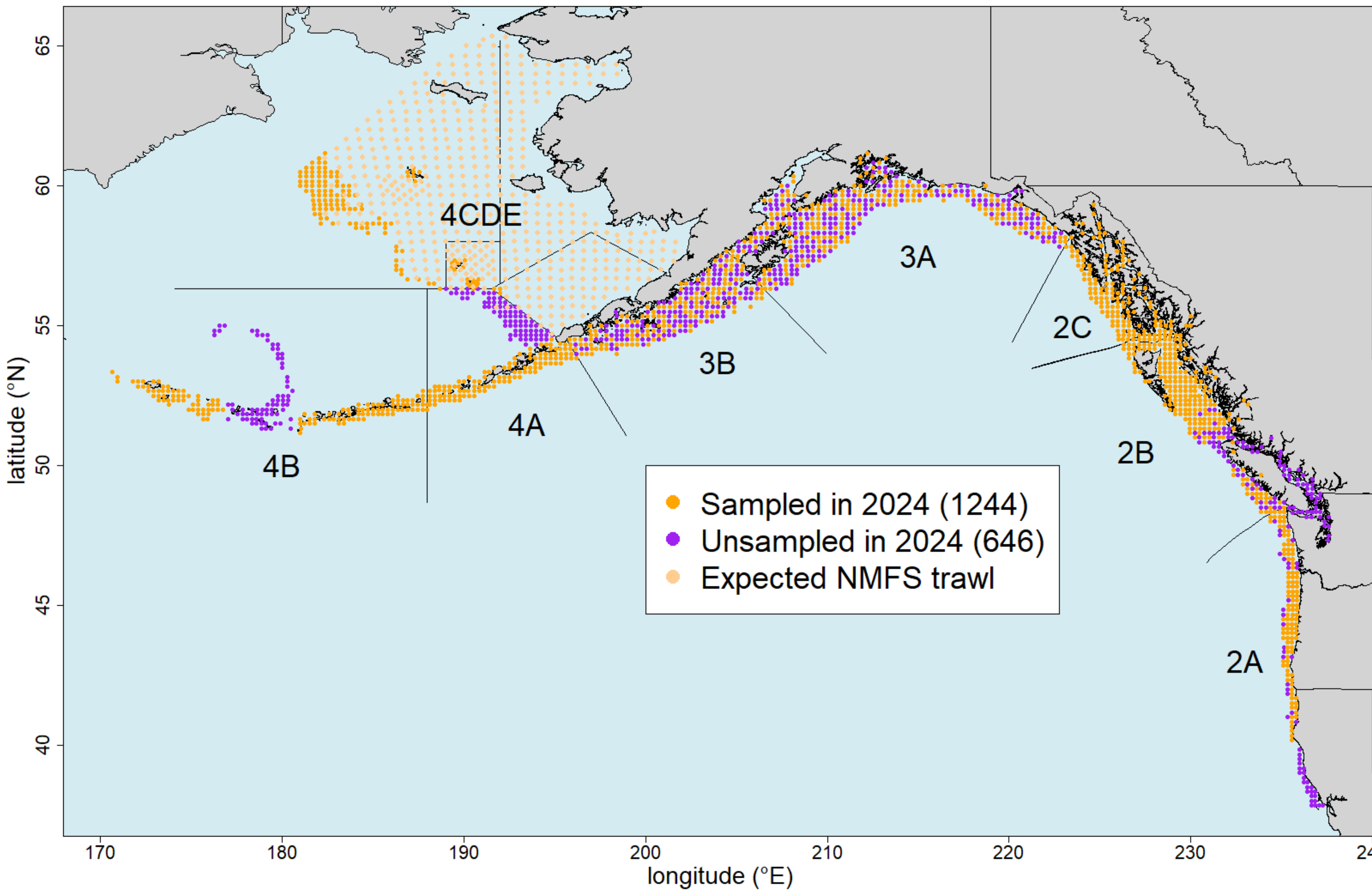

Figure 1.4. Potential FISS **Design 2** in 2024 (orange circles). See text and Table 1.2 for more information.

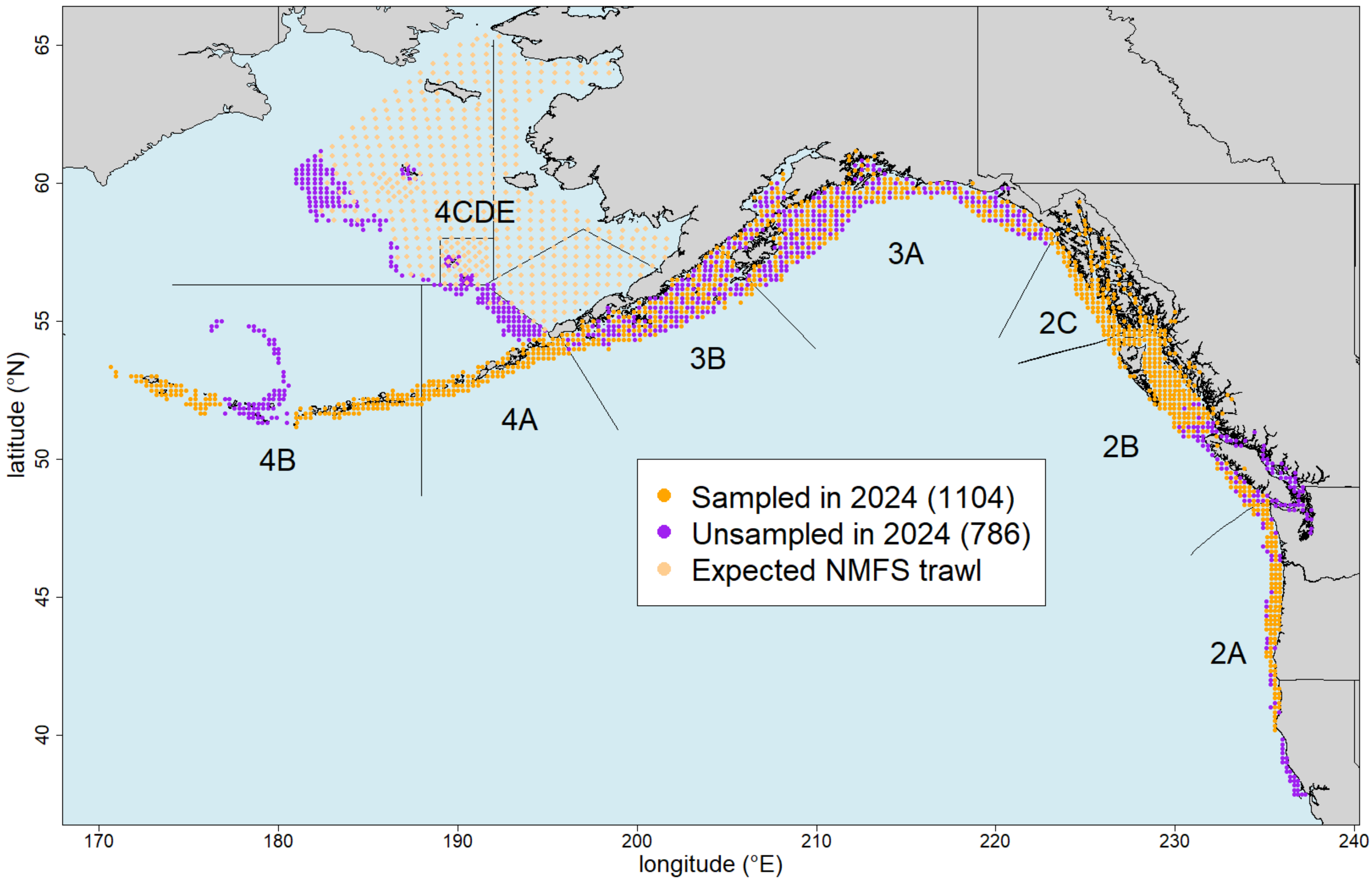

Figure 1.5. Potential FISS **Design 3** in 2024 (orange circles). See text and Table 1.2 for more information.

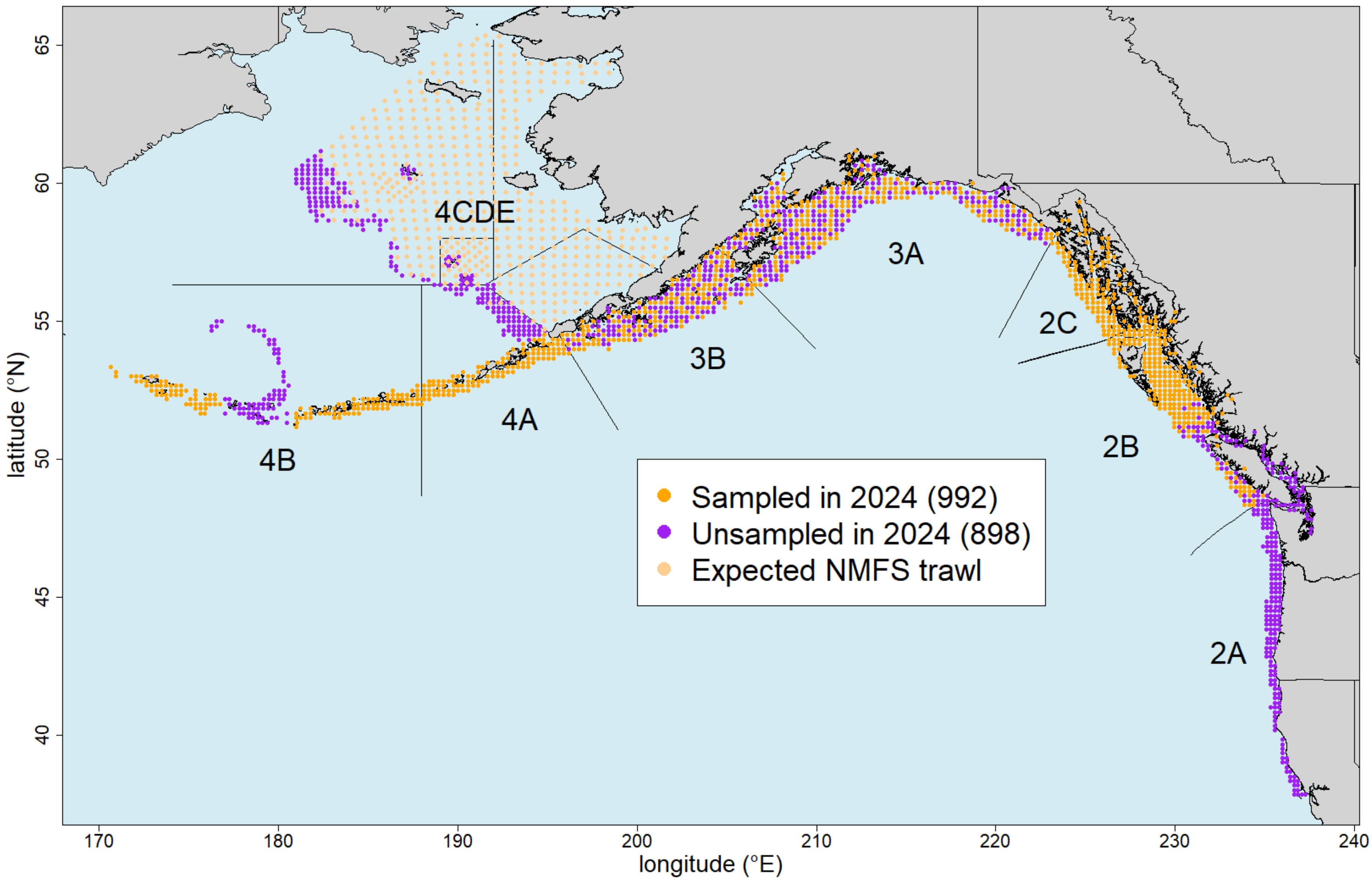

Figure 1.6. Potential FISS **Design 4** in 2024 (orange circles). See text and Table 1.2 for more information.

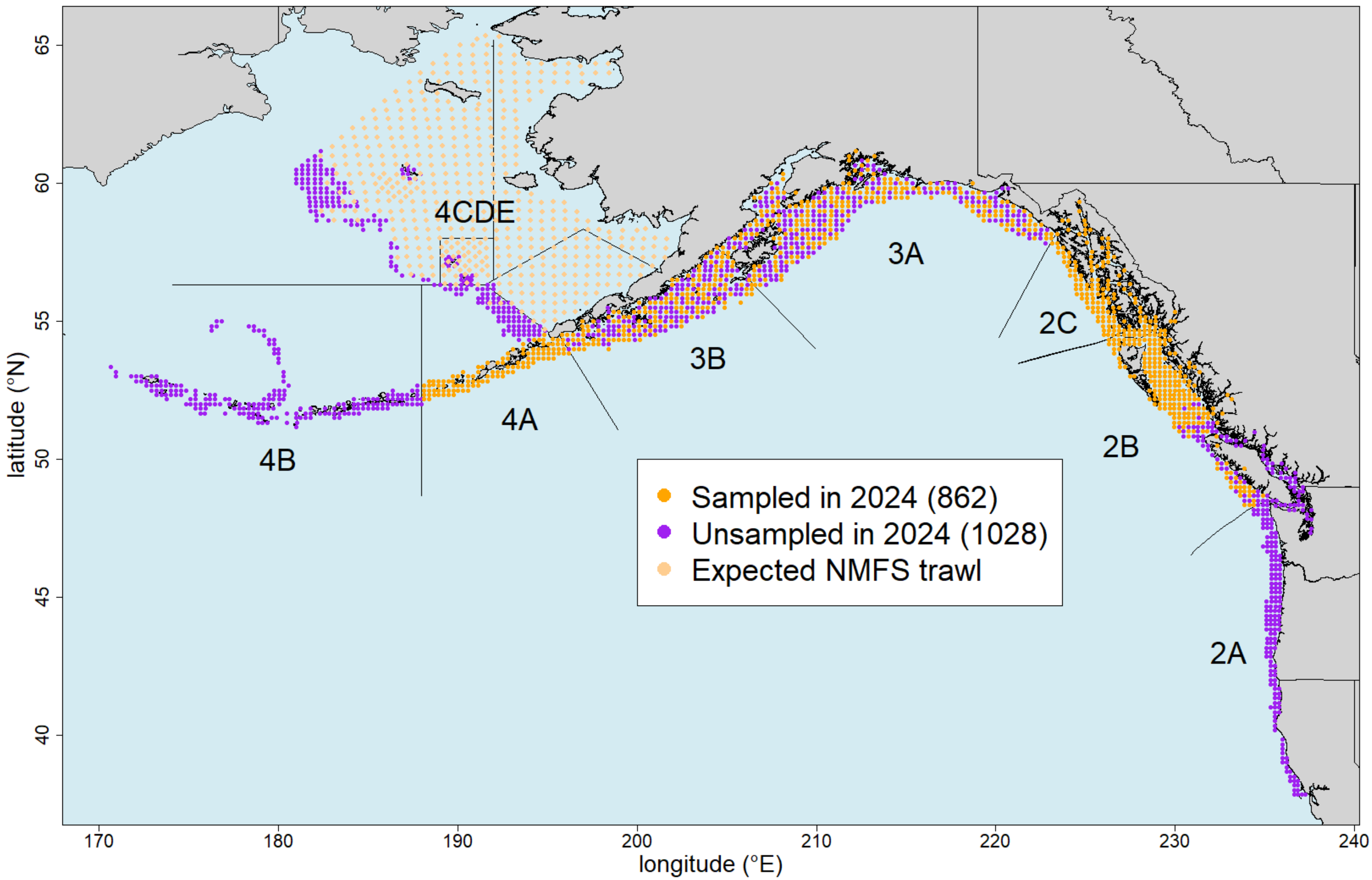

Figure 1.7. Potential FISS **Design 5** in 2024 (orange circles). See text and Table 1.2 for more information.

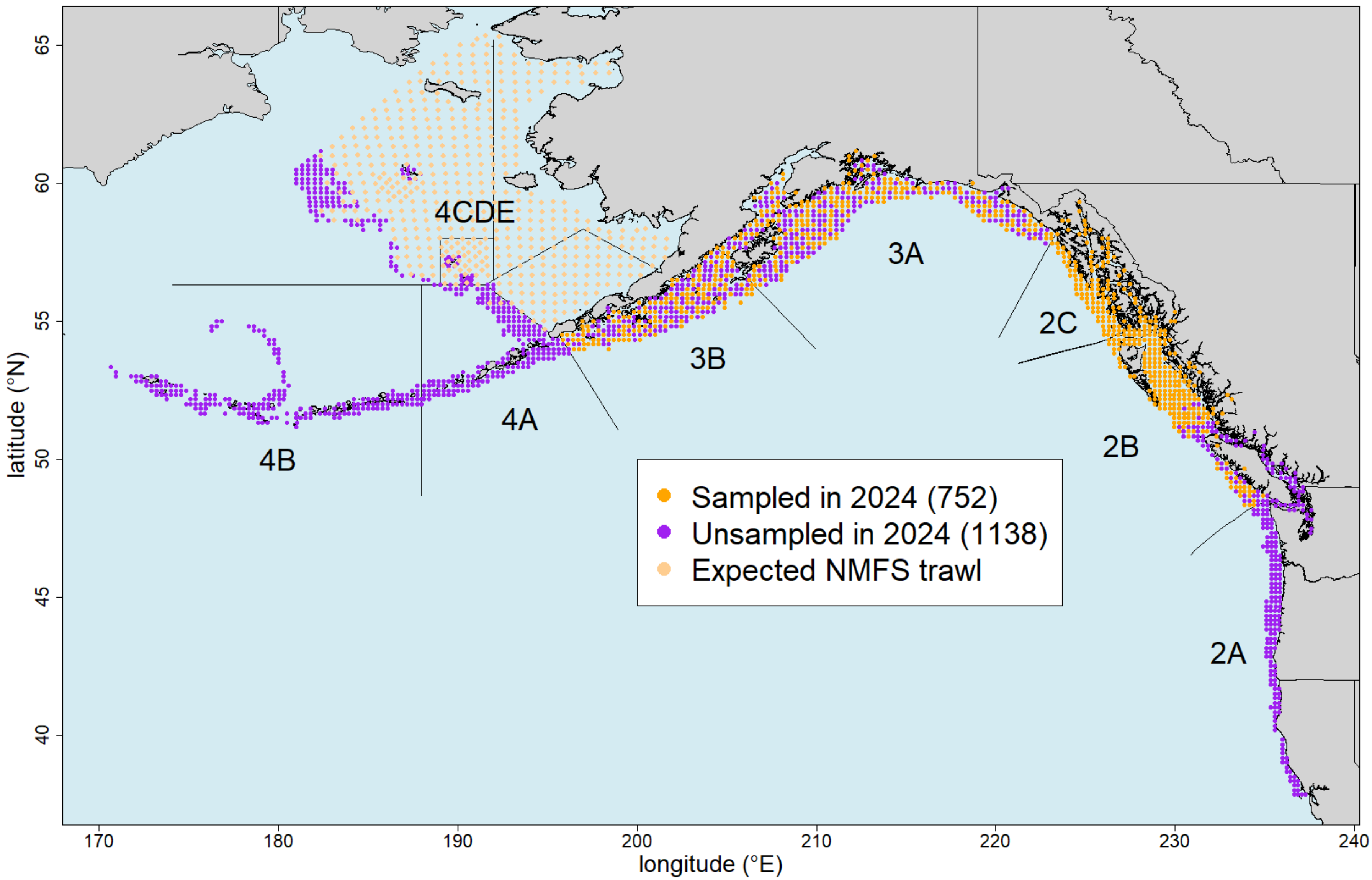

Figure 1.8. Potential FISS **Design 6** in 2024 (orange circles). See text and Table 1.2 for more information.

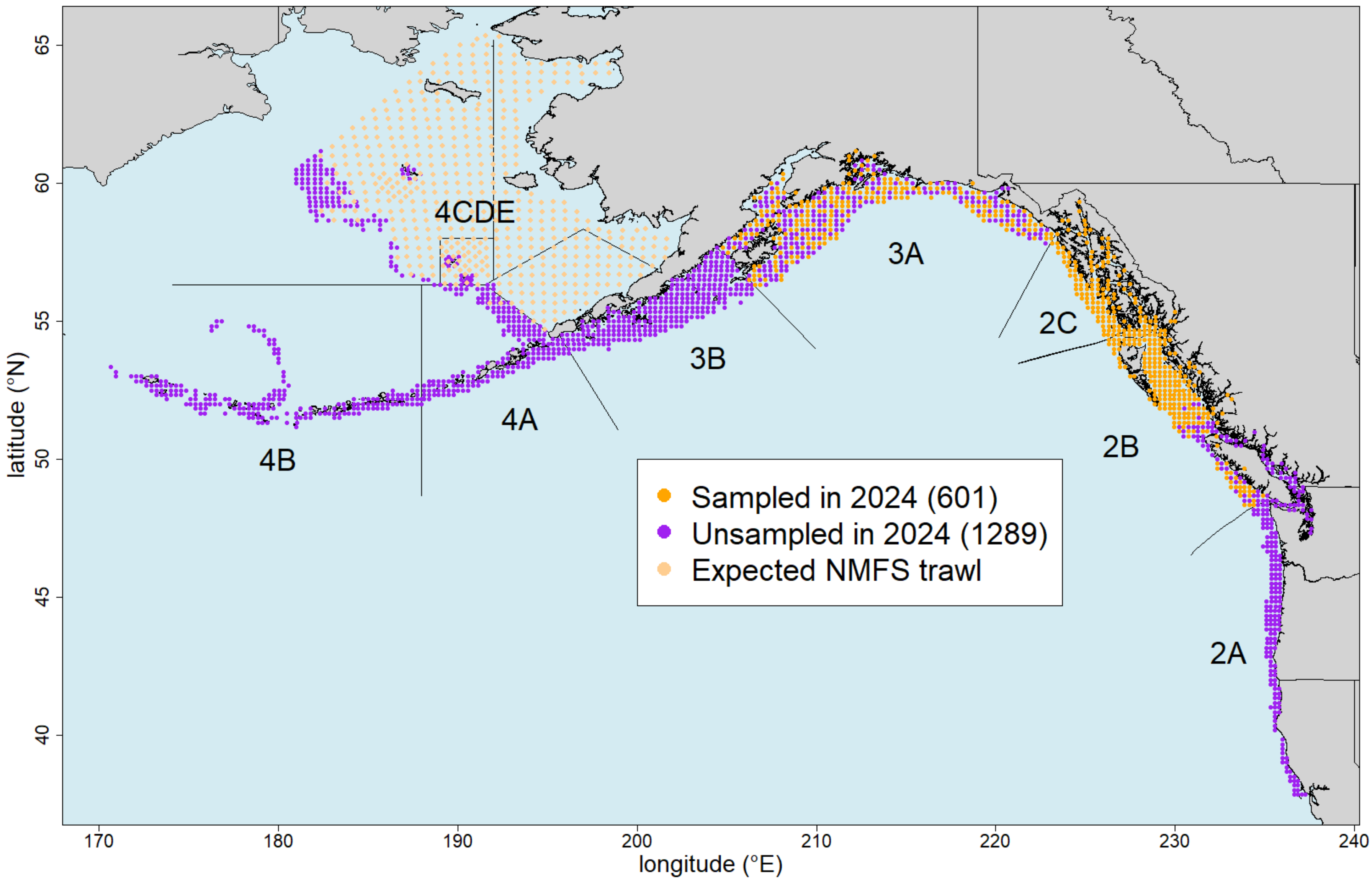

Figure 1.9. Potential FISS **Design 7** in 2024 (orange circles). See text and Table 1.2 for more information.

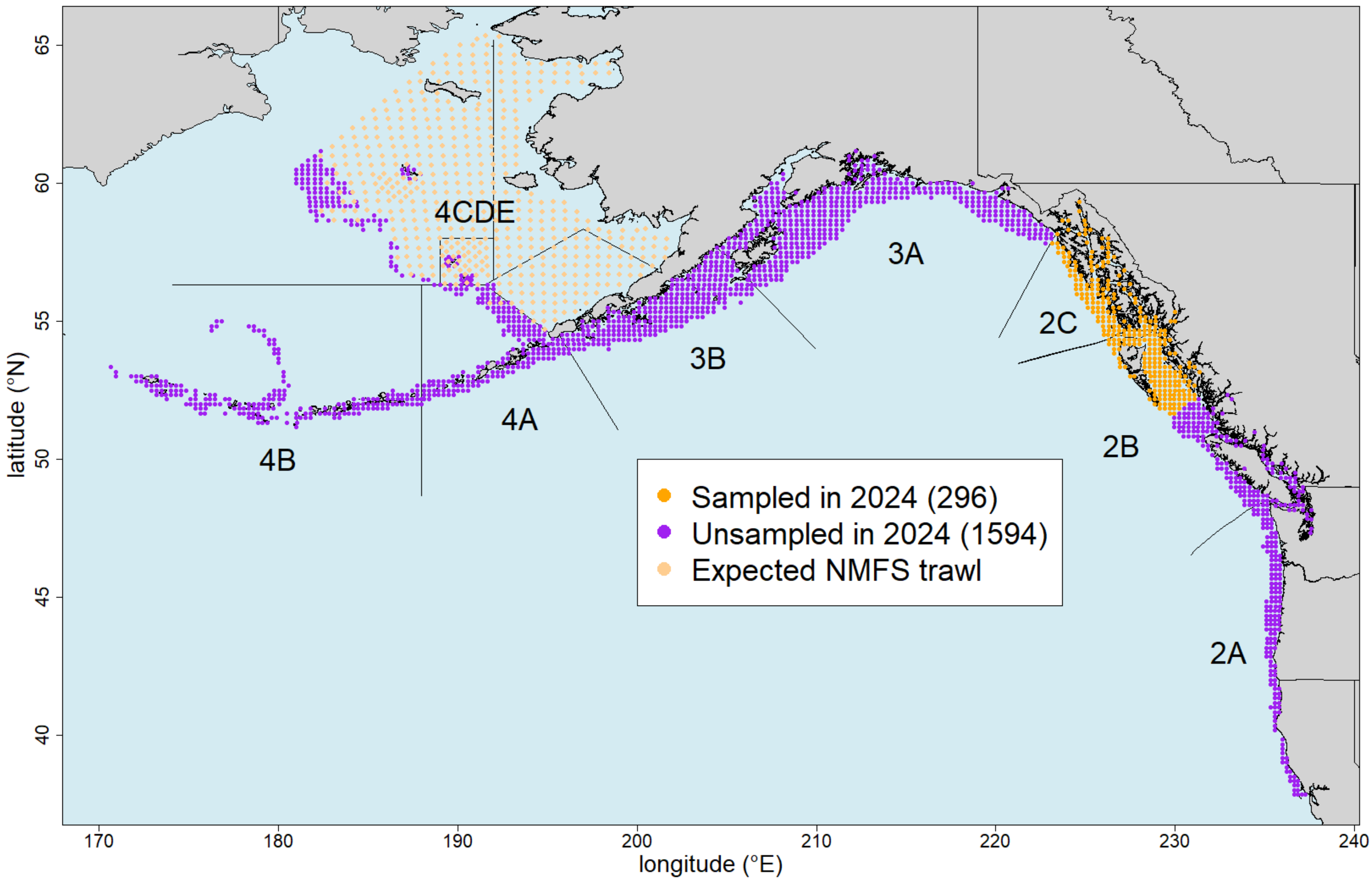

Figure 1.10. Potential FISS **Design 8** in 2024 (orange circles). See text and Table 1.2 for more information.

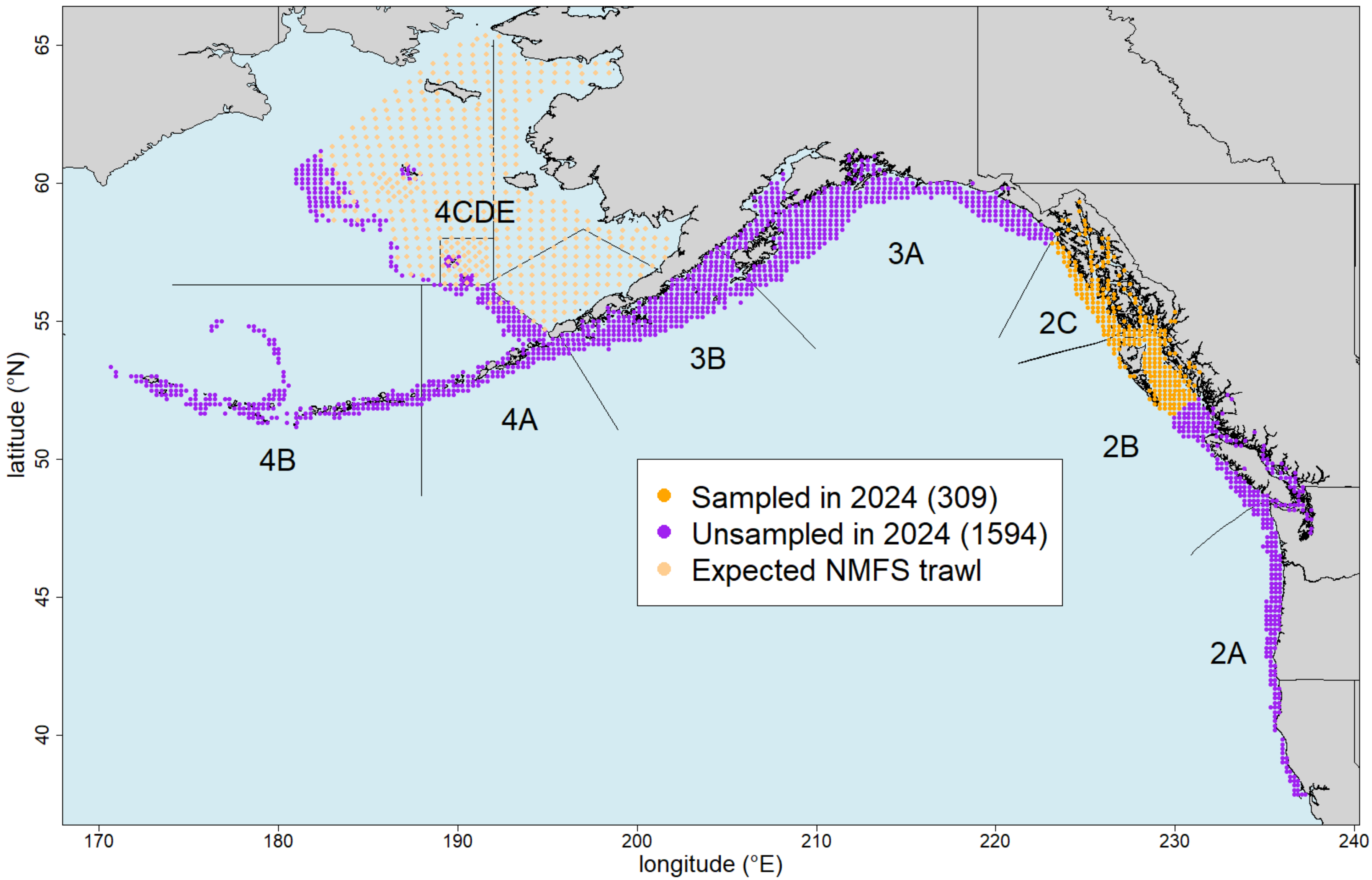

Figure 1.11. Preliminary FISS **Design 9** in 2024 (orange circles) based on prioritization of the Secondary Objective in Table 1.1. An additional 13 revenue-positive stations are not shown on the map, while the location of proposed "skipper stations" are represented by stations on the standard grid. See text for more information.

Part 2: Modelling updates

PURPOSE

To present a potential revision to the space-time model for Pacific halibut survey data in response to an SRB request.

BACKGROUND/INTRODUCTION

At SRB021, the Scientific Review Board recommended that the Secretariat explore other parameterizations of the space-time model used for modelling Pacific halibut survey catch rates. From paragraph 20 in IPHC-2022-SRB021-R:

> *"**NOTING** that the 'hurdle' model structure (separate modeling of presence/absence and abundance conditional on presence) of the space-time model used to analyze the FISS may not be the most efficient approach, the SRB **RECOMMENDED** that the Secretariat explore other approaches such as the use of mixture models or the 'Tweedie' distribution."*

The 'hurdle' (or semi-parametric or delta) model structure is described in Webster et al. (2020), and involves specifying separate model components for the probability of a catch rate (weight or numbers per unit effort) of zero (a Bernoulli process) and for the non-zero observations (a gamma process). For this document, we refer to this as the "delta-gamma" model. While the two components share a common spatio-temporally correlated error structure, model covariates are generally included in both model components (zeros and non-zeros), increasing model complexity and likely leading to longer times for model fitting than simpler models.

The Tweedie model as implemented in R-INLA (the R package currently used for space-time modelling of FISS data) is a compound Poisson-gamma model (see https://inla.r-inla-download.org/r-inla.org/doc/likelihood/tweedie.pdf). The model has two hyperparameters, p and φ ("dispersion") compared to one hyperparameter for the delta-gamma model currently in use (the gamma variance or precision parameter) but as noted requires fewer covariate parameters. Both models have the same two parameters specifying spatial dependence and a single temporal correlation parameter. However, the current model has two hyperparameters for the random walk models of depth (one for each model component) and a scalar parameter linking the space-time model errors between the model components. Thus, the Tweedie model has one fewer hyperparameter, along with a reduction in the number of fixed effects parameters present in some models (e.g., distance from shelf edge in IPHC Regulatory Area 4CDE, gear effect in areas with recent snap/fixed gear comparisons).

We have fitted the Tweedie model to all-sizes WPUE data from several IPHC Regulatory Areas and compared model output in the form of posterior means and standard deviations of hyperparameters shared by both models, the deviance information criterion (DIC) as a measure of relative model fit, and the resulting model run time. Modelling of data from other IPHC Regulatory Areas is ongoing.

RESULTS

Table 2.1 presents comparisons between the model output of the delta-gamma and Tweedie models for three IPHC Regulatory Areas. In all cases, the Tweedie models provides a better fit (lower DIC) and faster run time, while producing very similar estimates of parameters for temporal and spatial dependence.

Table 2.1. Comparison of DIC, model run time, and model parameter estimates (posterior means with standard deviations in parentheses) between the current delta-gamma model and the Tweedie model.

IPHC Regulatory Area	Parameter	Description	Delta-gamma	Tweedie	Difference
4A	DIC	Model fit	47 817.6	46 988.1	829.5
	Run time (s)		311	143	168
	ρ	Temporal correlation	0.952 (0.008)	0.950 (0.006)	
	θ_1	Spatial correlation	-6.84 (0.18)	-6.78 (0.11)	
	θ_2	Spatial correlation	5.07 (0.12)	5.41 (0.10)	
3B	DIC	Model fit	89 677.3	89 509.9	167.4
	Run time (s)		758	148	610
	ρ	Temporal correlation	0.928 (0.011)	0.933 (0.010)	
	θ_1	Spatial correlation	-6.17 (0.08)	-5.97 (0.07)	
	θ_2	Spatial correlation	4.82 (0.04)	4.88 (0.08)	
2C	DIC	Model fit	55 304.0	55 233.7	70.3
	Run time (s)		2145	223	1922
	ρ	Temporal correlation	0.963 (0.004)	0.962 (0.005)	
	θ_1	Spatial correlation	-8.97 (0.27)	-8.37 (0.36)	
	θ_2	Spatial correlation	6.69 (0.16)	6.78 (0.21)	

Figures 2.1, 2.2 and 2.3 compare the time series estimates for each area. The Tweedie time series for IPHC Regulatory Area 4A has more temporal variability but narrower 95% credible intervals than the delta-gamma time series (Figure 2.1). Time series for the other two areas are very similar between the two models.

DISCUSSION

The initial results from fitting Tweedie models are very promising, with little to no effect on our understanding of trends or the strength of temporal or spatial dependence, but with much faster run times. It is worth noting that while delta-gamma models were fitted with good starting values (based on past model output) this wasn't the case with the Tweedie models. This implies we may expect further improvements in run times in the future. Not all Tweedie models converged with initial starting values: the model for IPHC Regulatory Area 2C had to be run twice after it failed to converge to a sensible solution the first time, and this appears to be an issue with the model for IPHC Regulatory Area 4B currently in progress. The model for IPHC Regulatory Area 3A is also in progress after crashing with an error regarding starting values. Similar issues arose the first year we used space-time modelling in 2016 and we expect them to be resolved without much difficulty. Work still needs to be done on creating the output MCMC values used for projection of coefficients of variation in FISS design evaluation, along with adapting the model to account for different probabilities of zeros between gear types (setline and trawl) in the Bering Sea (see IPHC-2022-SRB021-06, page 7).

While we looked at model run times for fitting the model, the greatest computing times occur when re-fitting the model for prediction and generating the posterior samples from the prediction model run. We will update the SRB with that information once it has been compiled. Our intention is to have a full coastwide comparison of the two models for the SRB to review at SRB024 based on the 1993-2023 data.

References

IPHC 2022. Report of the 21st Session of the IPHC Scientific Review Board (SRB021), IPHC-2022-SRB021-R.

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.

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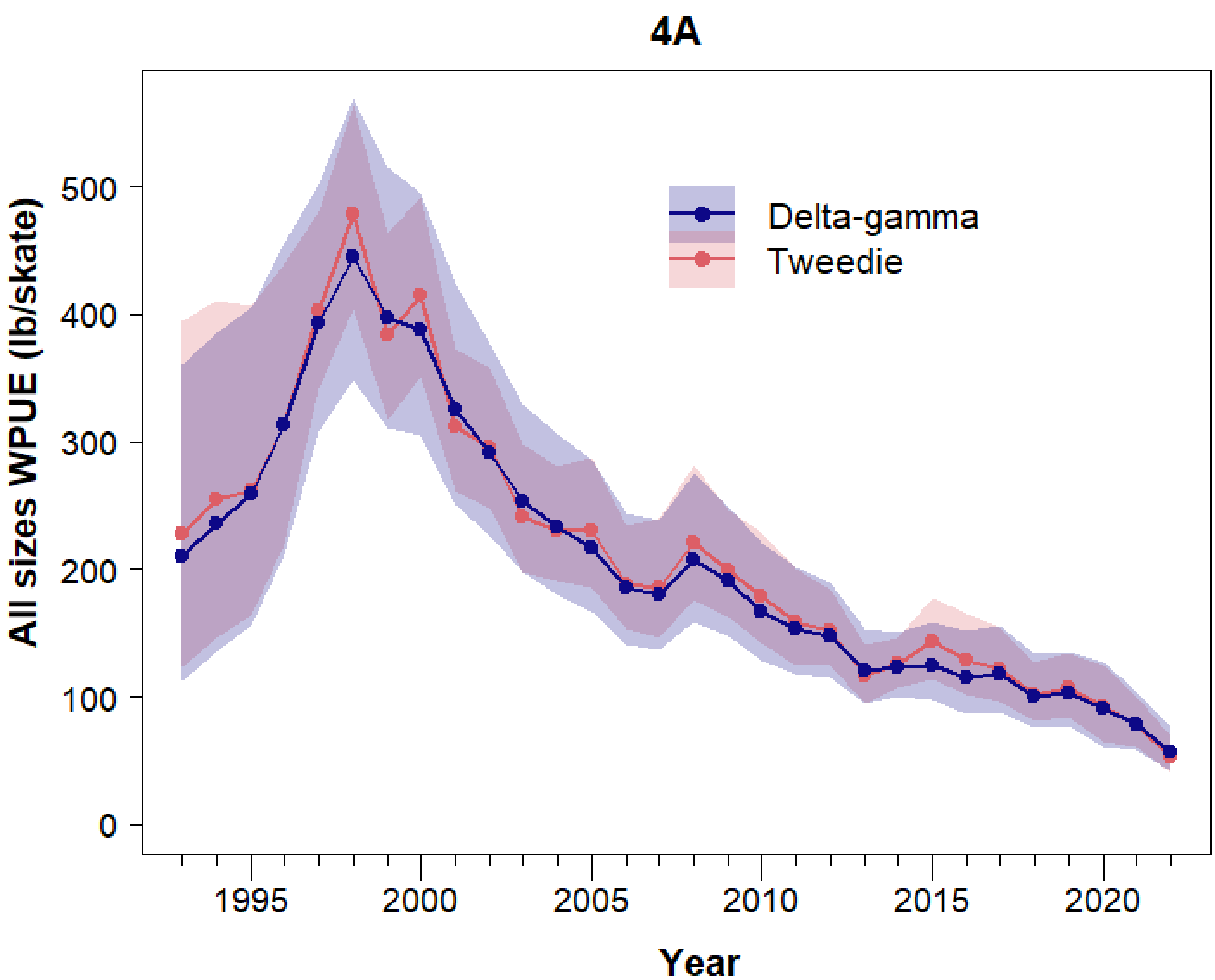

Figure 2.1. Comparison of estimated time series (posterior means by year) of all-sizes WPUE for the current delta-gamma model and the Tweedie model, for IPHC Regulatory Area 4A. Shaded regions represent 95% posterior credible intervals.

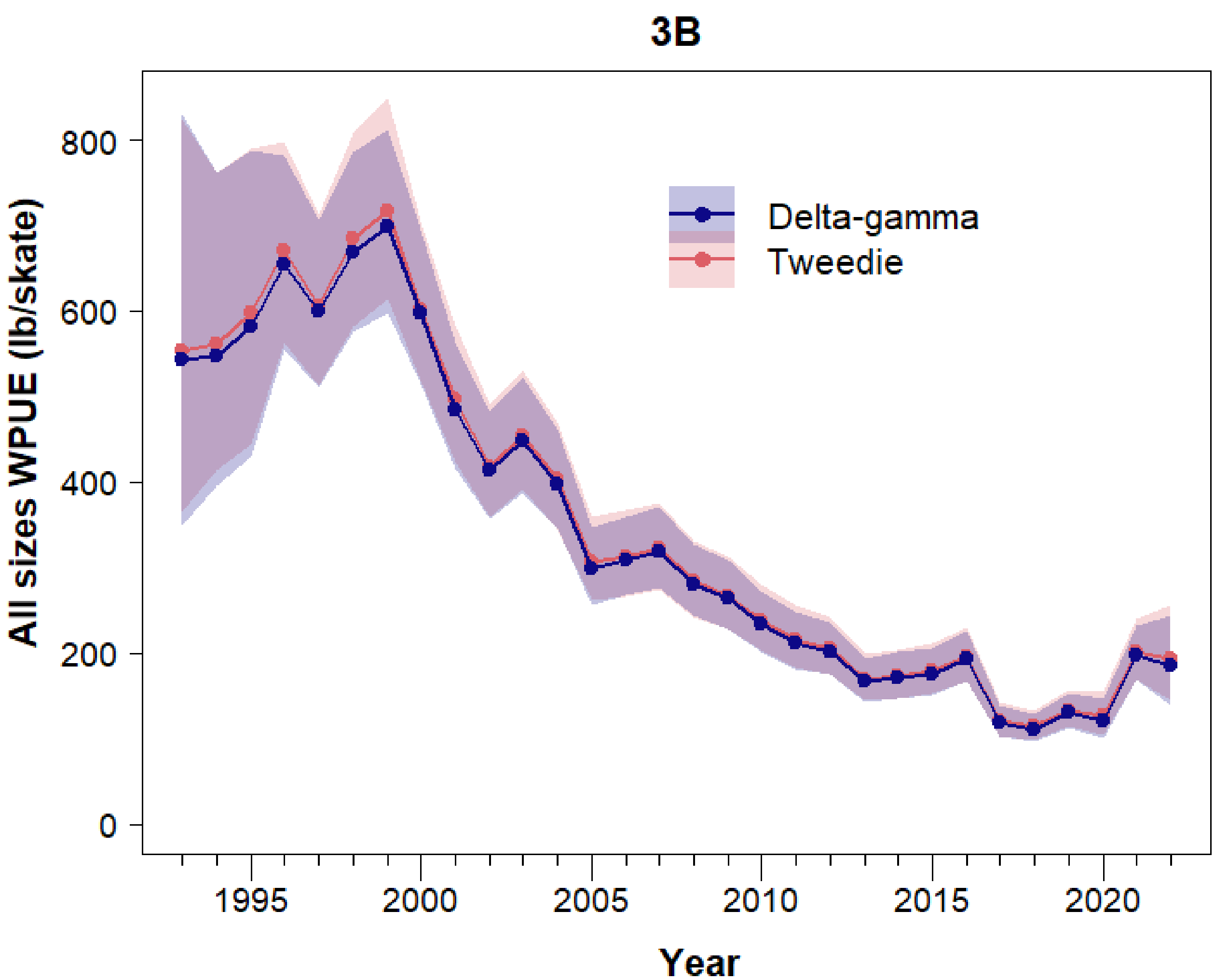

Figure 2.2. Comparison of estimated time series (posterior means by year) of all-sizes WPUE for the current delta-gamma model and the Tweedie model, for IPHC Regulatory Area 3B. Shaded regions represent 95% posterior credible intervals.

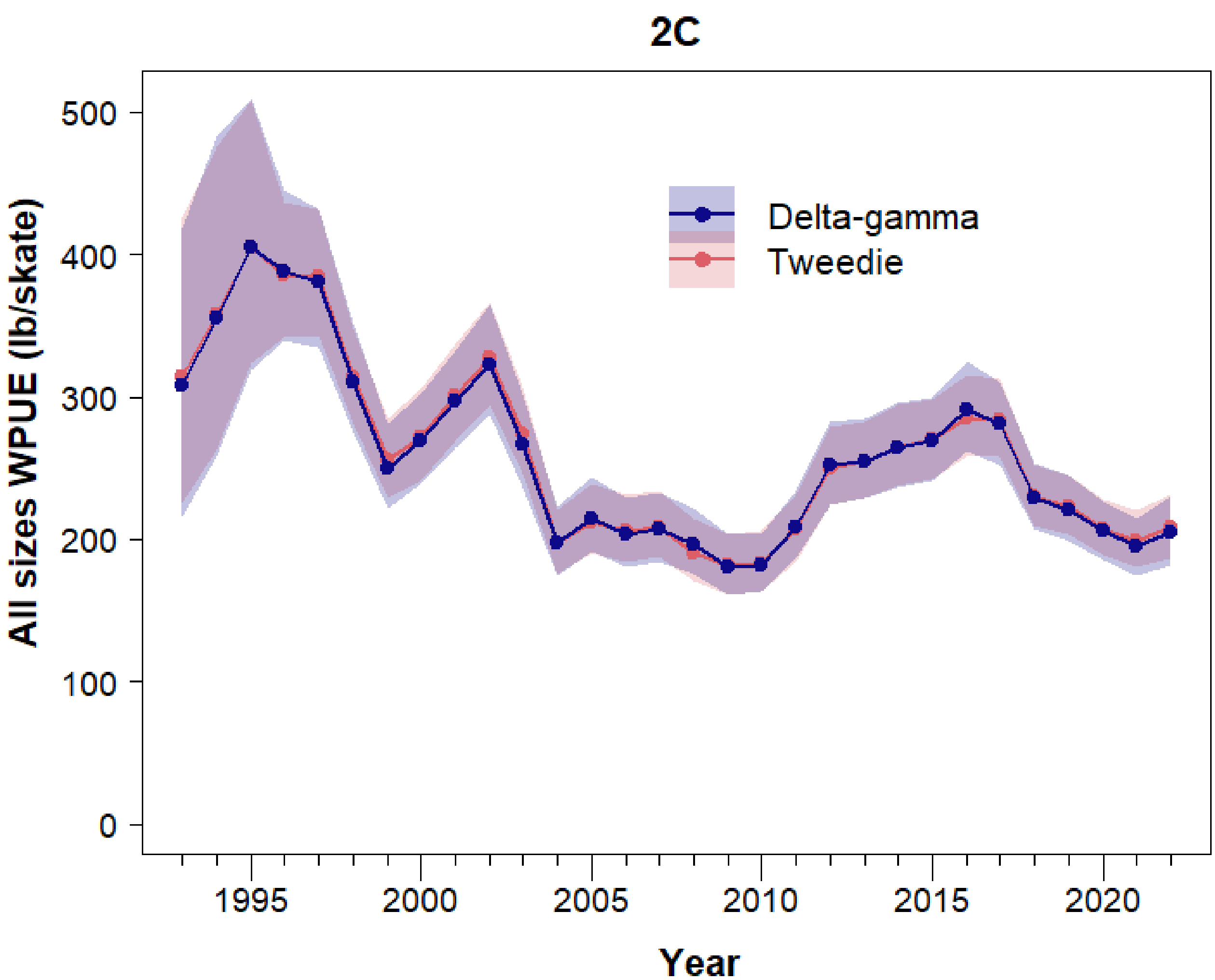

Figure 2.3. Comparison of estimated time series (posterior means by year) of all-sizes WPUE for the current delta-gamma model and the Tweedie model, for IPHC Regulatory Area 2C. Shaded regions represent 95% posterior credible intervals.