2025-27 FISS design evaluation

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Part 1: 2025-27 FISS design evaluation

PURPOSE

To present the SRB with potential FISS designs for 2025-27, including a preliminary cost evaluation of the 2025 designs.

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 survey in California waters between the latitudes of 40 and 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 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 1.1). Both supplementary surveys have been conducted approximately annually in recent years.

Rationalized FISS, 2020-24

Following the 2011-2019 program of FISS expansions, rationalized FISS designs were approved for 2020 based on random selection of over 50% of stations in the core of the stock (IPHC Regulatory Areas 2B, 2C, 3A and 3B) and sampling of all stations in selected subareas of the remaining IPHC Regulatory Areas. For the latter areas, sampling priorities were determined based on maintaining precise estimates of area-specific indices of density and ensuring low bias in index estimators. That year, the COVID19 pandemic led to a reduced FISS with sampling only in the core areas. The 2021-22 FISS sampling proceeded largely as designed, although with planned stations in western IPHC Regulatory 4B in 2022 unsampled due to a lack of viable charter bids. In some charter regions in the core areas, 100% of stations were sampled in order to achieve revenue goals (see below). The 2023 FISS design (Figure 1.2) had more limited spatial coverage, with almost no FISS sampling outside of the core areas due to large projected revenue losses from designs that included extensive sampling in IPHC Regulatory Areas 2A, 4A, 4B and 4CDE. Limited sampling was carried out in northern IPHC Regulatory 2A, while planned stations around the IPHC Regulatory Area 4A/4B boundary were not sampled due to a lack of charter bids. The adopted 2024 FISS design (IPHC-2024-AM100-R) includes high sampling rates in IPHC Regulatory Areas 2B and 2C, a small number of charter regions in IPHC Regulatory Areas 3A and 3B, and sampling of the southern shelf edge and Bering Sea islands in IPHC Regulatory Area 4CDE (Figure 1.3). This design is expected to provide larger variance estimates and a relatively high risk of bias in unsampled areas but represents the maximum coverage that could be achieved given the revenue available due to projected low catch rates, increased costs and low prices.

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 (R Core Team, 2024).

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 in 2019, 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 preliminary cost projections based on prior year fiscal details (revenue) and current year vessel contract cost updates;
- Step 2: Updated 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 direct 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 2025-27

At IM099, Secretariat staff presented options for 2024 and subsequent years based on rotational block designs (IPHC-2023-IM099-13 Rev_1, Part 2). For these designs, the random selection of FISS stations in design proposals for 2020-24 for IPHC Regulatory Areas 2B, 2C, 3A and 3B were replaced with sampling complete FISS charter regions in each area, with sampled regions rotated over a two-three year period depending on area. This type of design was first proposed in 2019 (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).

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 block designs shown in Figures 1.4 to 1.6 for 2025-27 (called the **Base Block design**) were presented to Commissioners at IM099 as potential designs for 2024-26, although the Base Block design was not considered for adoption for 2024 due to high projected cost. These block designs ensure that all charter regions in the core areas are sampled over a three-year period, while prioritizing coverage in other areas based on minimizing the potential for bias and maintaining CVs below 25% for each IPHC Regulatory Area. The Base Block designs also include some sampling in all IPHC Biological Regions in each year, ensuring that data from across the spatial range of Pacific halibut are available to the stock assessment and for stock distribution estimation. We note that paragraph 72 of the AM100 report (IPHC-2024-AM100-R) states:

> *The Commission NOTED that the use of the base block design (Figures 7 to 11 of paper IPHC-2024-AM100-13) will be the focus of future planning and annual FISS proposals from the Secretariat.*

Under recent catch rates and FISS net revenues, implementation of the Base Block design had been projected to result in a substantial operating loss and would therefore require supplementary funding. For this reason, we compare the Base Block design to two alternative block designs that would involve achieve lower net costs through reductions in spatial coverage:

- **Core Block design** (Figures 1.7 to 1.9): Maintain the same rotating block coverage in the core IPHC Regulatory as the Base Block design but remove sampling outside of the core areas.

- **Reduced Core design** (Figure 1.10): Sample only the FISS charter regions in the core areas that are planned for 2024 as these are likely to result in relatively low net losses for the FISS overall. (While the more profitable charter regions will vary over time, this design is intended to be representative of similar low-coverage designs.)

Using samples generated from the fitted 2023 space-time models as simulated data for 2024-27, we projected the coefficient of variation (CV, a relative measure of precision) for mean O32 WPUE for each year of the design by area. As CVs are generally greater in the terminal year of the time series and that year is generally the most relevant for informing management, the CV values in Table 1.2 are for the final year of the modelled time series. For example, the values for 2026 were found by fitting the model to the data for 1993-2026 (with simulated data used for 2024-26).

Table 1.2. Projected coefficients of variation (CVs, %) by FISS design, terminal year of time series, and IPHC Regulatory Area or Biological Region.

Regulatory	Base Block			Core Block			Reduced Core		
Area	2025	2026	2027	2025	2026	2027	2025	2026	2027
2A	17	22	23	29	29	31	29	31	34
2B	8	10	7	8	10	7	9	9	9
2C	6	6	6	6	6	6	5	5	5
3A	9	7	7	9	7	7	11	13	15
3B	13	12	15	13	12	15	19	21	26
4A	19	13	20	26	29	33	28	31	33
4B	15	20	18	35	39	44	35	39	44
4CDE	8	8	8	8	9	9	8	9	9
Biological Region									
Region 2	5	6	5	5	6	5	5	5	6
Region 3	7	7	8	7	7	8	10	12	14
Region 4	8	7	9	11	12	14	11	14	15
Region 4B	15	20	18	35	39	44	35	39	44
Coastwide	4	4	4	5	5	6	6	7	8

Base Block design: Projected terminal year CVs for the Base Block design are all 25% or less for all IPHC Regulatory Areas. In the core areas (2B, 2C, 3A and 3B), CVs are at 15% or less (Table 1.2). All Biological Region CVs except Region 4B are below 10% while the coastwide CV is projected to be 4% in all years. The Base Block design is therefore projected to maintain precise estimates of indices of Pacific halibut density and abundance across the range of the stock. At the same time, the rotating nature of the sampled blocks means that almost all FISS stations are sampled within a 5-year period (2-3 years within the core areas) resulting in low risk of missing important stock trends and therefore a low risk of large bias in estimates of trend and stock distribution.

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 Core Block and Reduced Core designs.

Core Block design: With sampling maintain in the core areas, projected CVs for IPHC Regulatory Areas 2B, 2C, 3A and 3B remain at 15% or less with this design (Table 1.2). However, the absence of sampling outside of the core leads to CVs for 2A, 4A and 4B increasing quickly with time, which carries over to increasing CVs for Biological Regions 4 and 4B. Expected data from the NOAA trawl survey in IPHC Regulatory Area 4CDE continues to result in CVs below 10% for that area. With a large proportion of the stock unsampled for 2025-27 with this design, the risk of bias also increases in unsampled areas and regions, as well as coastwide.

Reduced Core design: In this design, only IPHC Regulatory Area 2B and 2C receive spatially extensive sampling, which maintains CVs below 10% for these areas (Table 1.2). With relatively low proportions of IPHC Regulatory Areas 3A and 3B sampled, CVs increase to 15% and 26% respectively as uncertainty grows in the unsampled parts of these areas. Regional and coastwide CVs also increase outside of Region 2. Bias risk is very high under this design, as a very large proportion of the stock is not monitored during the 2025-27 period.

Table 1.3 gives preliminary net revenue projections for all three designs for 2025. Projections include the following assumptions:

1. Designs are optimized for numbers of skates, with 4, 6 or 8 skate-sets used depending on projected catch rates and bait costs.
2. 2025 Pacific halibut price and catch rates decline by 5% per year from those used to develop the 2024 design.
3. Chum and pink salmon bait each continue to be used on approximately 50% of the stations and prices remain similar to those for 2024.

Costs for each design are given with and without oceanographic monitoring undertaken using the IPHC's Seacat water column profilers.

Cost estimates are largely based on information from the 2023 FISS and outcomes of the 2024 charter bidding process, and it is important to note there is high uncertainty in the any catch and cost projections for 2025 this far in advance. Final cost and accounting information will be available at the end of the 2024 fiscal year and will be used to refine these preliminary projections at that time.

Table 1.3. Comparison of preliminary projected net revenue for the 2025 Base Block, Core Block and Reduced Core designs.

Design	With Seacat	Without Seacat
Base Block	$1,542,000	--$1,407,000
Core Block	-$900,000	-$805,000
Reduced Core	-$644,000	-$569,000

DISCUSSION

At AM100 (IPHC-2024-AM100-13), IPHC Secretariat staff recommended that the Commission endorse block designs for all future planning as a viable alternative to the randomised sampling in use in the core of stock from 2020-23. Block designs 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 1.4 to 1.6.

The Base Block design has a projected net loss of $1,407,000 without oceanographic monitoring and therefore will rely on supplementary funding for implementation. Depending on the level of available supplementary funding and Commission priorities during Interim and Annual meeting decision making process, we can anticipate the adopted FISS design for 2025 to vary somewhat in spatial scope from the design presented in Figure 1.4.

Like the adopted 2024 FISS design, the Core Block and Reduced Core designs will result in less information available for the annual stock assessment and management supporting calculations such as stock distribution than in years prior to 2024. The increased uncertainty in the index of abundance is likely to cause the assessment model to rely more heavily on the commercial fishery catch-per-unit-effort index. Given current spatial variability and uncertainty in the magnitude of younger year classes (2012 and younger), the limited biological information from the core of the stock distribution (Biological Region 3) makes it unclear whether 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 greater portion of the actual uncertainty in stock trend and demographics will not be able to be quantified due to missing FISS data from a large fraction of the Pacific halibut stock's geographic range. The implications for the assessment would be of increasing concern if Core Block or Reduced Core designs were implemented beyond 2025 due to increasing uncertainty and risk of bias in stock trend estimates and the unrepresentativeness of the biological samples. Further, as was evident at AM100, reduced FISS designs that do not fully inform stock distribution with annual sampling in all IPHC Regulatory areas lead to reduced stakeholder confidence in the FISS results and in the aggregate scientific information from the stock assessment. This may have a strong effect on the perception of risk and on decision making by the Commission if reduced survey designs continue to be consecutively implemented.

RECOMMENDATION

That the Scientific Review Board:

1) **NOTE** paper IPHC-2024-SRB024-06, which presented an evaluation of design options for 2025-27, including options accounting for the secondary FISS objective of long-term revenue neutrality;

2) **ENDORSE** the Base Block design for 2025 (Figure 1.4) provided that sufficient supplementary funding is available to cover the projected net revenue loss.

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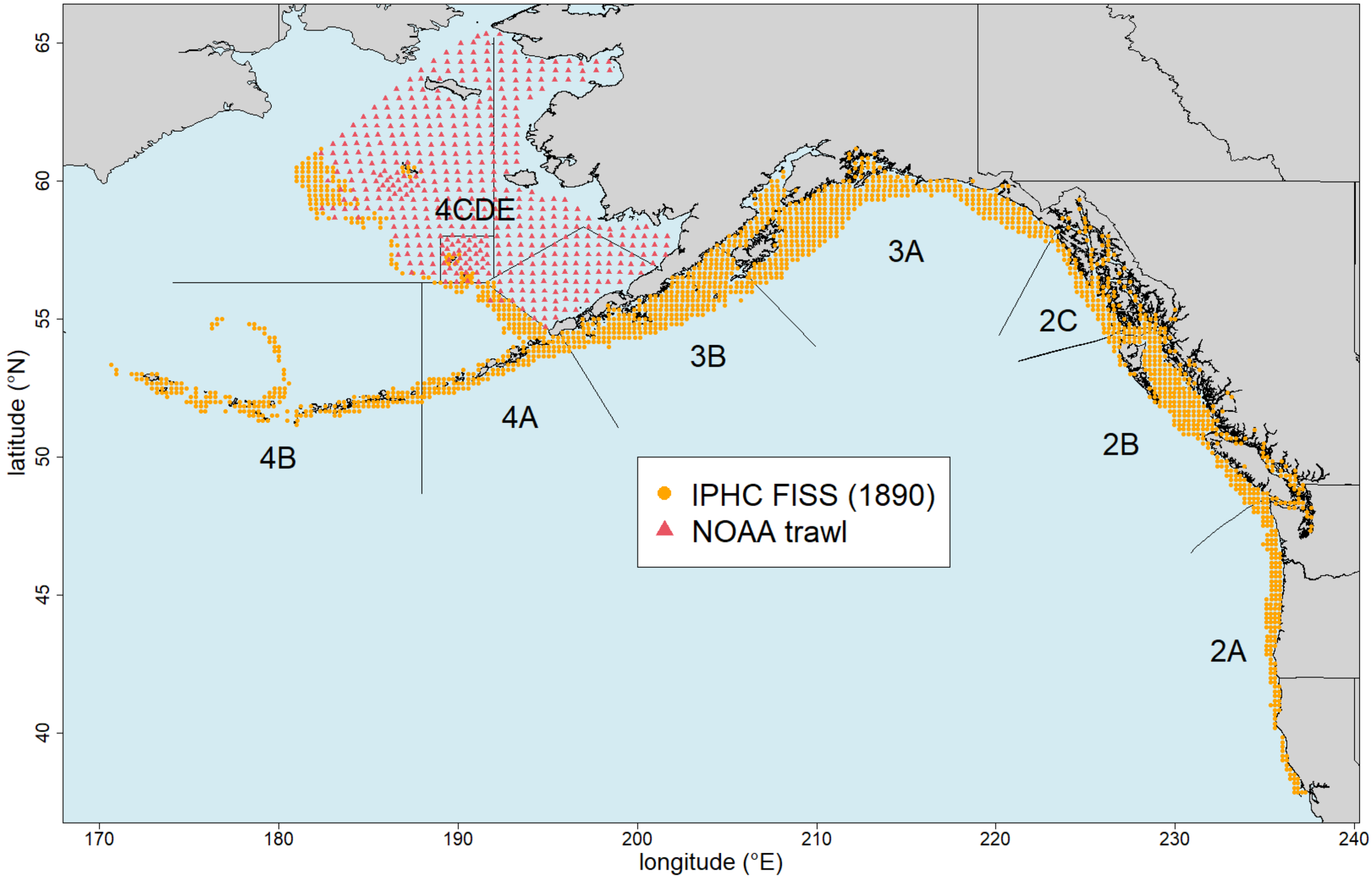

Figure 1.1. Map of the full 1890 station FISS design, with orange circles representing stations available for inclusion in annual sampling designs. Red triangles represent the locations NOAA trawl stations used to provide complementary data for Bering Sea modelling.

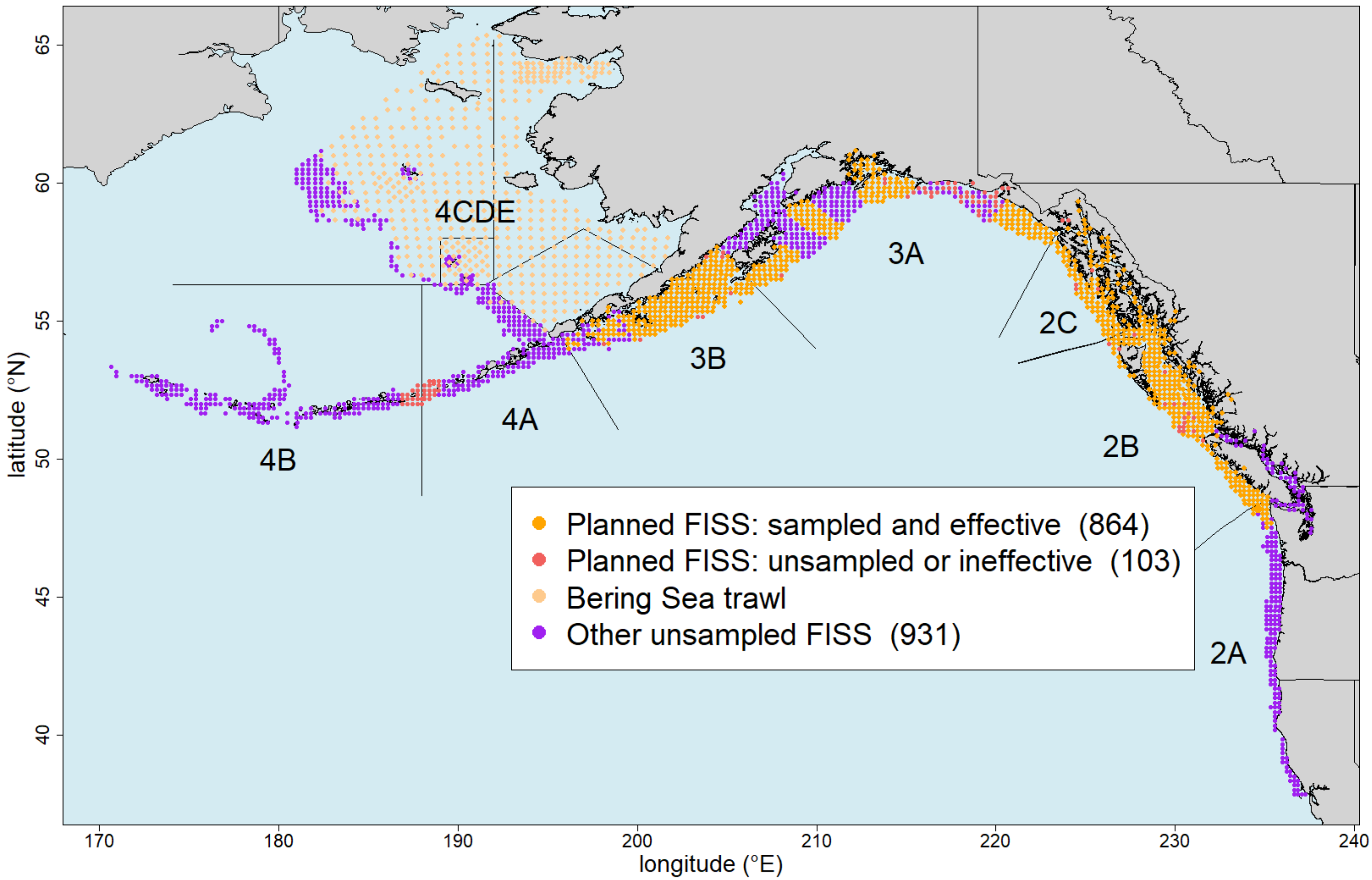

Figure 1.2. Implemented 2023 FISS design, with successfully fished (effective) stations shown in orange circles.

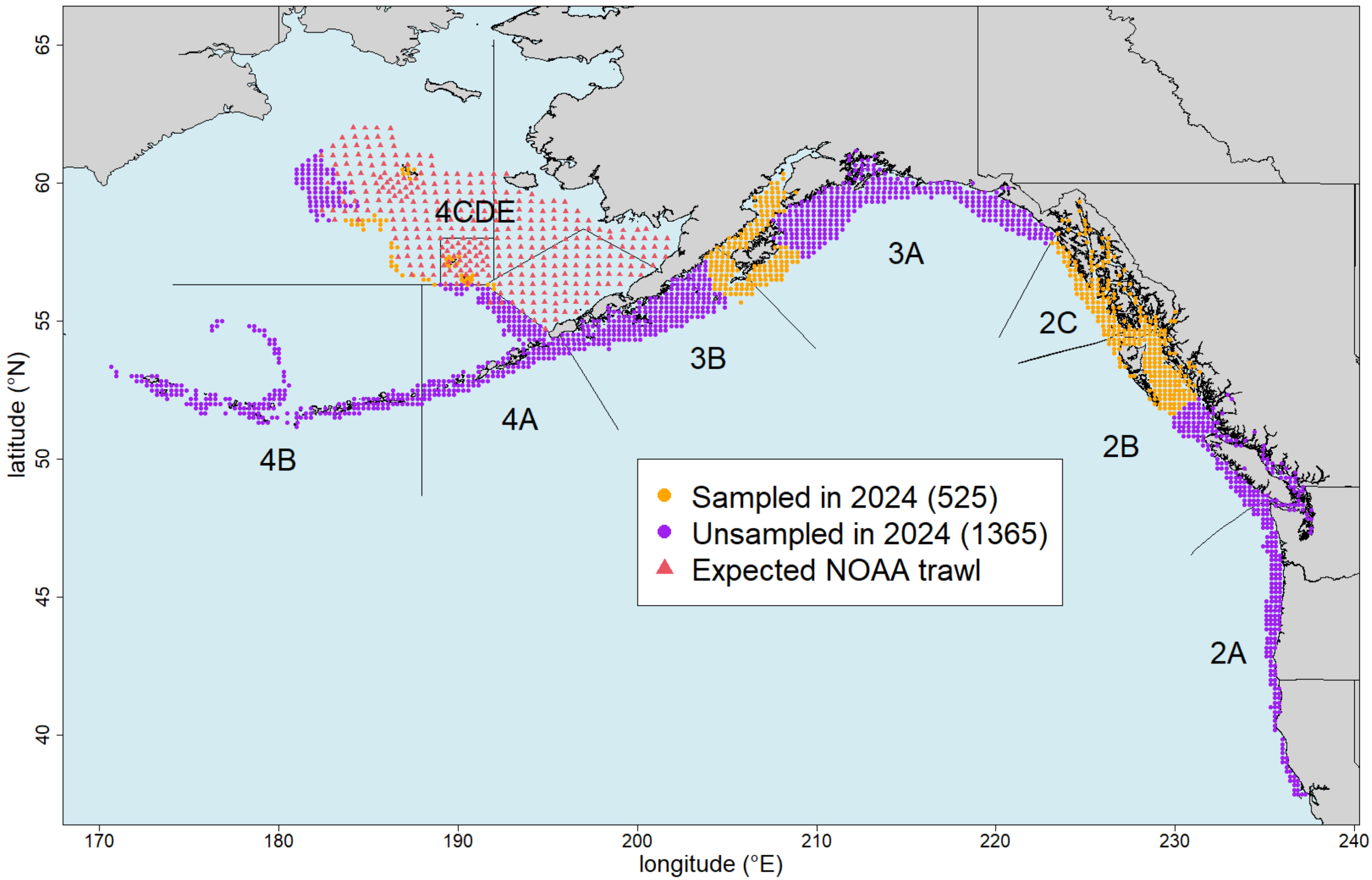

Figure 1.3. Adopted 2024 FISS design, with planned FISS stations shown as orange circles.

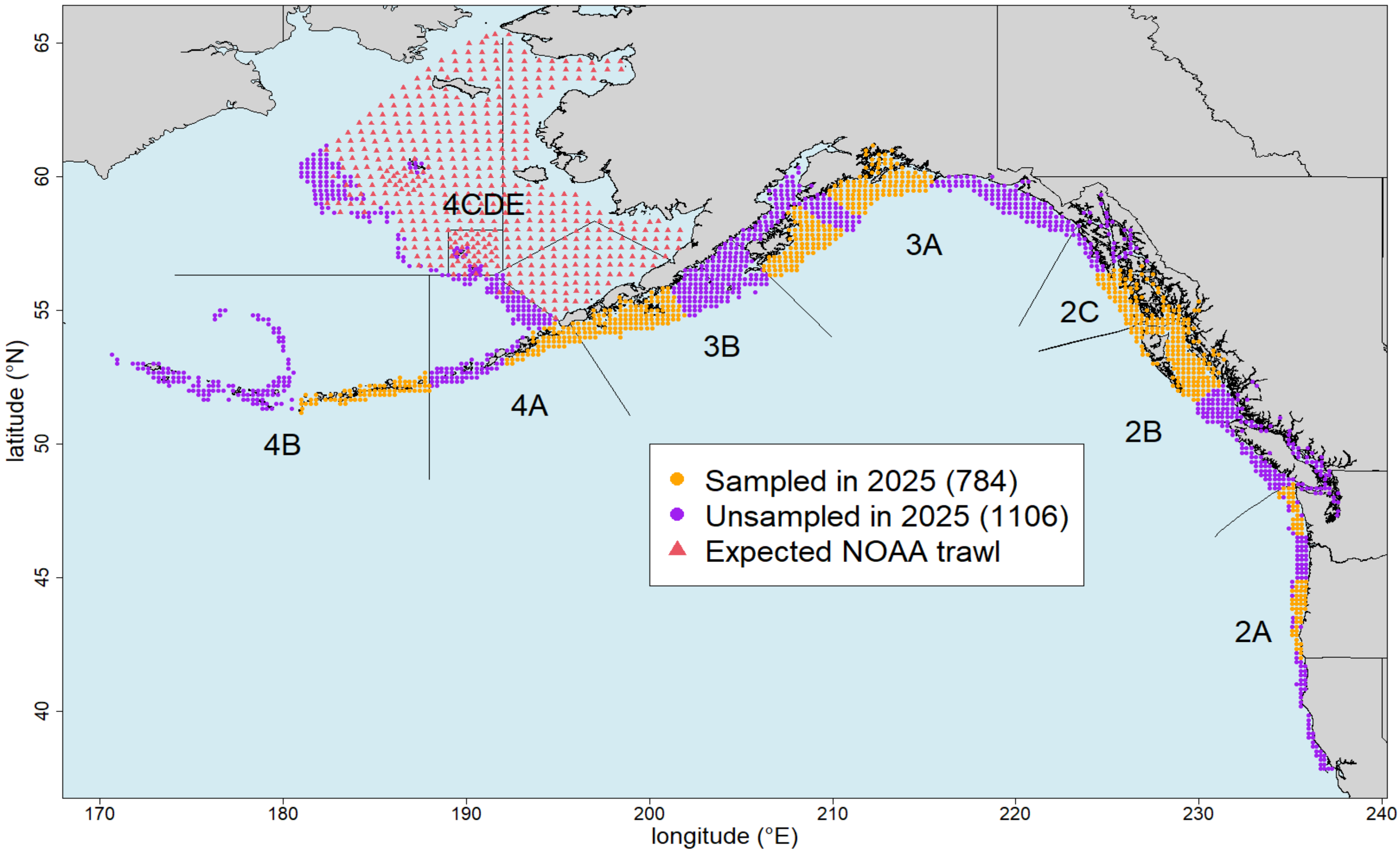

Figure 1.4. Base Block design for 2025 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

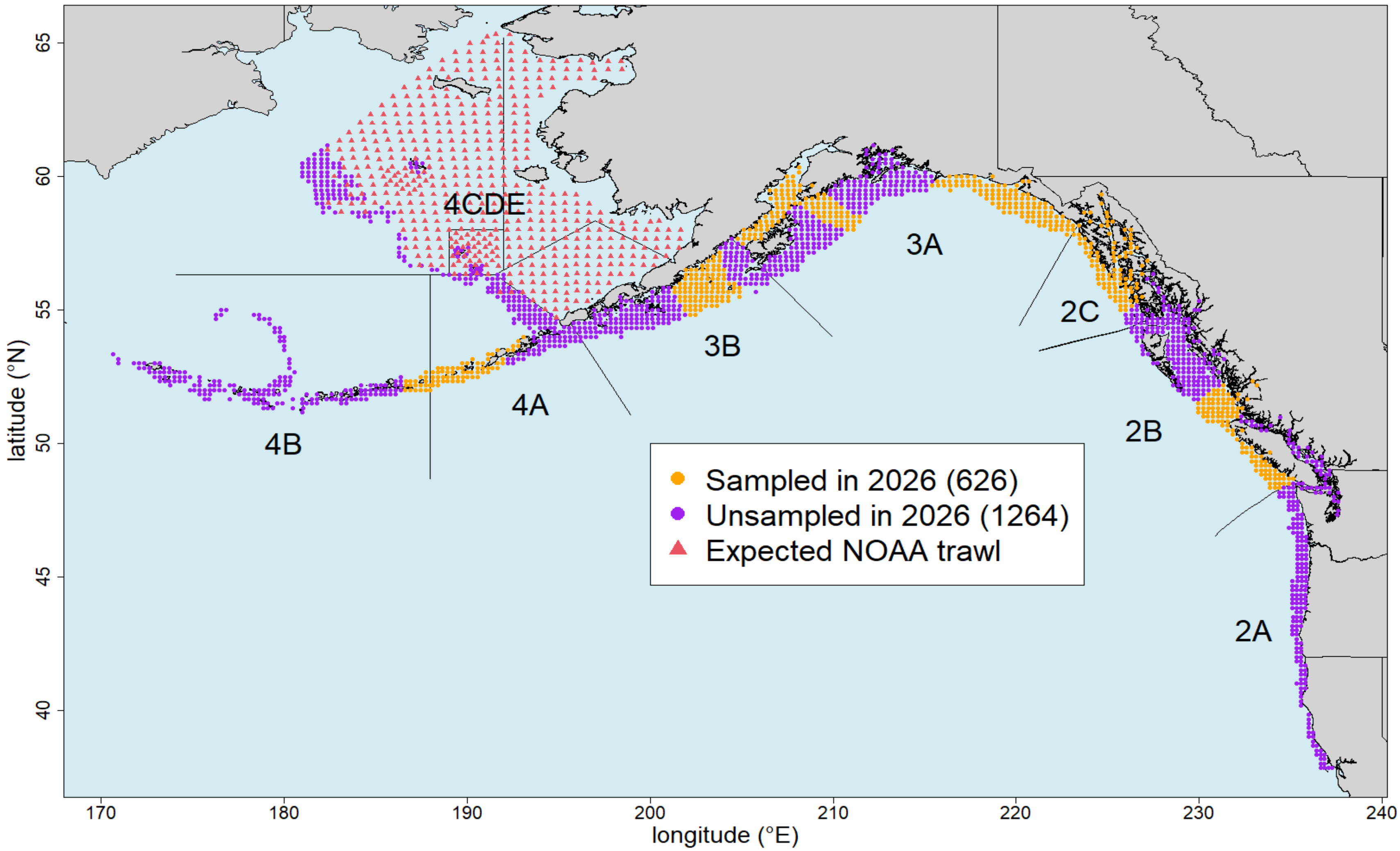

Figure 1.5. Base Block design for 2026 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

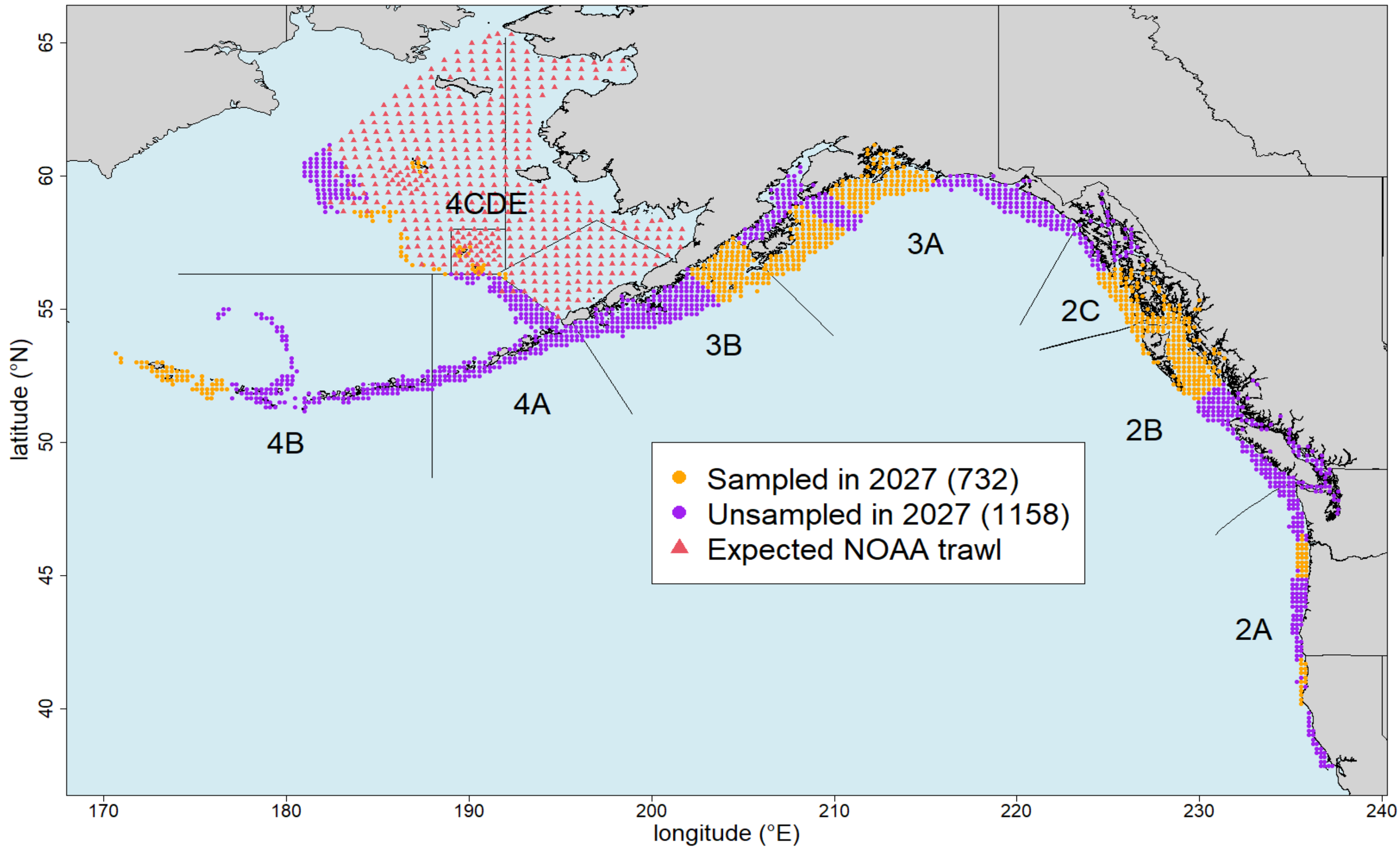

Figure 1.6. Base Block design for 2027 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

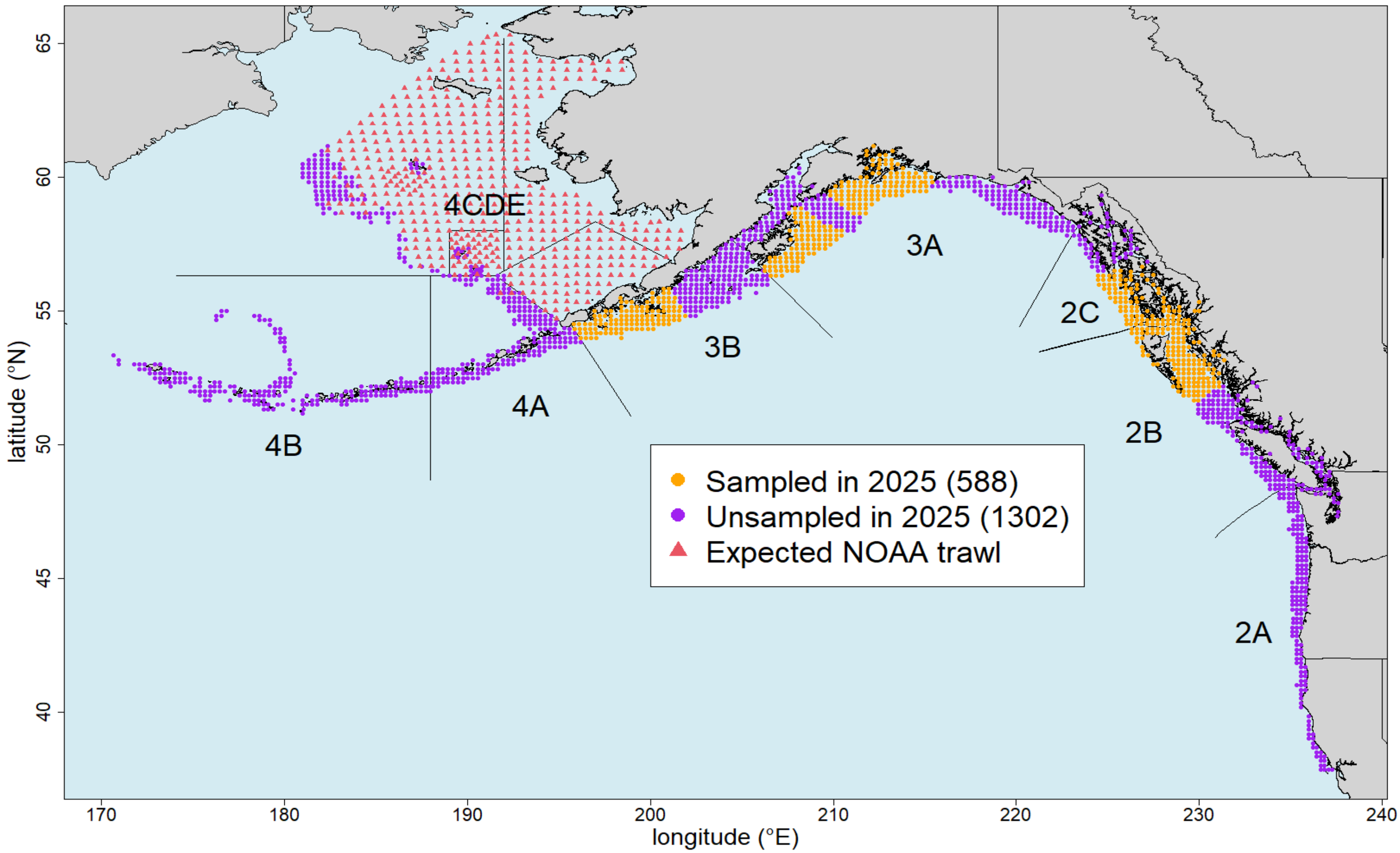

Figure 1.7. Core Block design for 2025 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and no FISS sampling elsewhere to reduce costs.

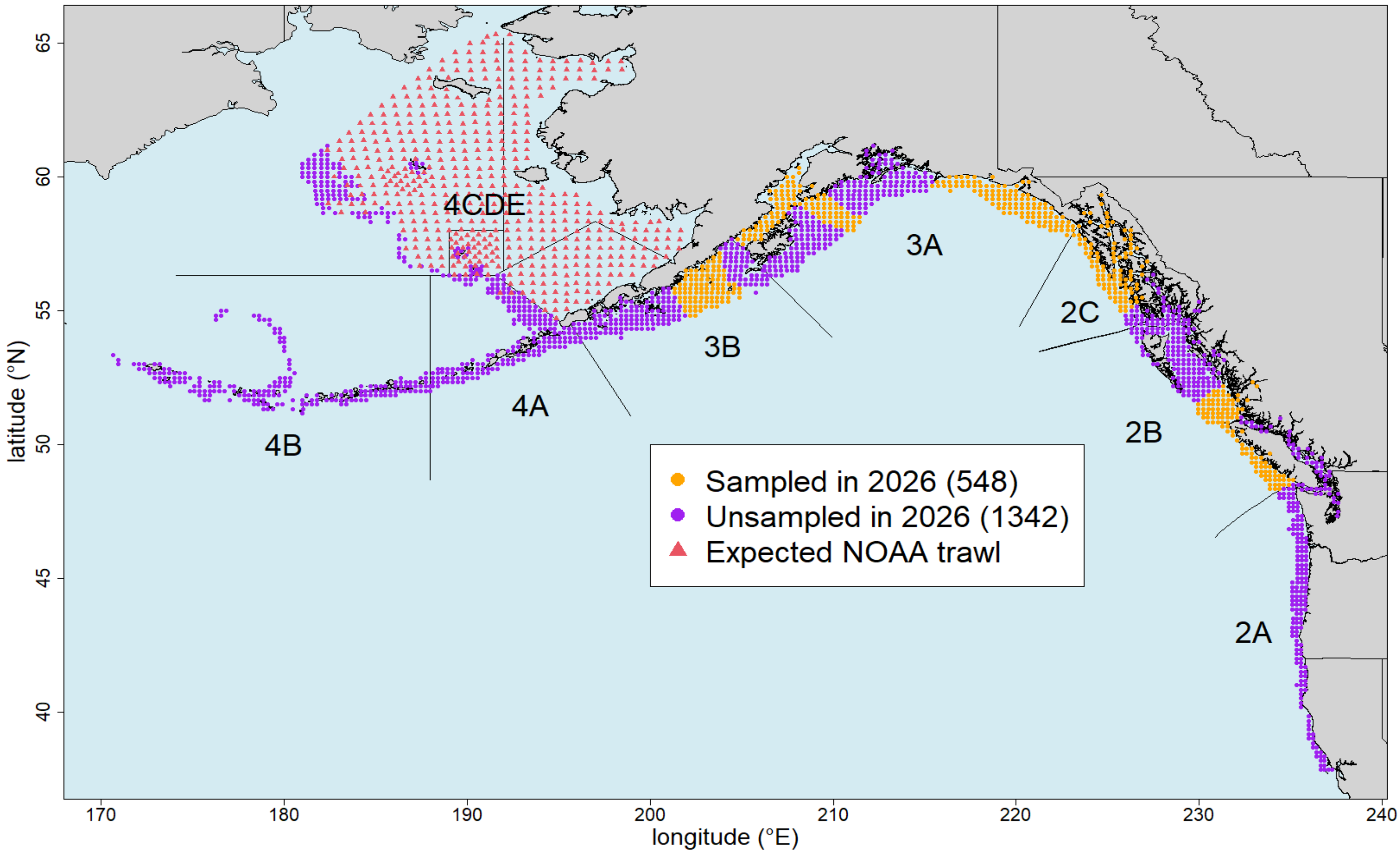

Figure 1.8. Core Block design for 2026 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and no FISS sampling elsewhere to reduce costs.

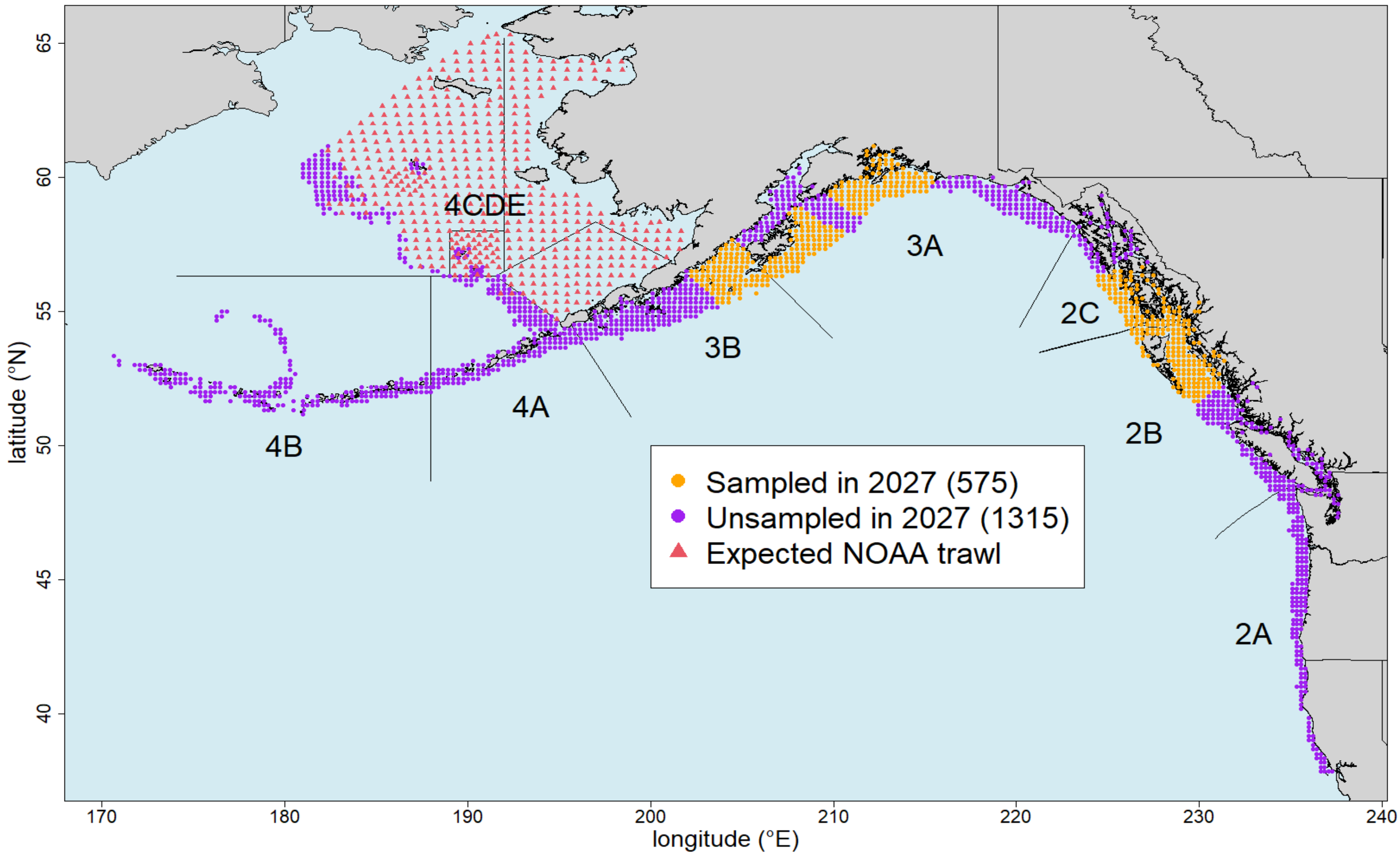

Figure 1.9. Core Block design for 2027 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and no FISS sampling elsewhere to reduce costs.

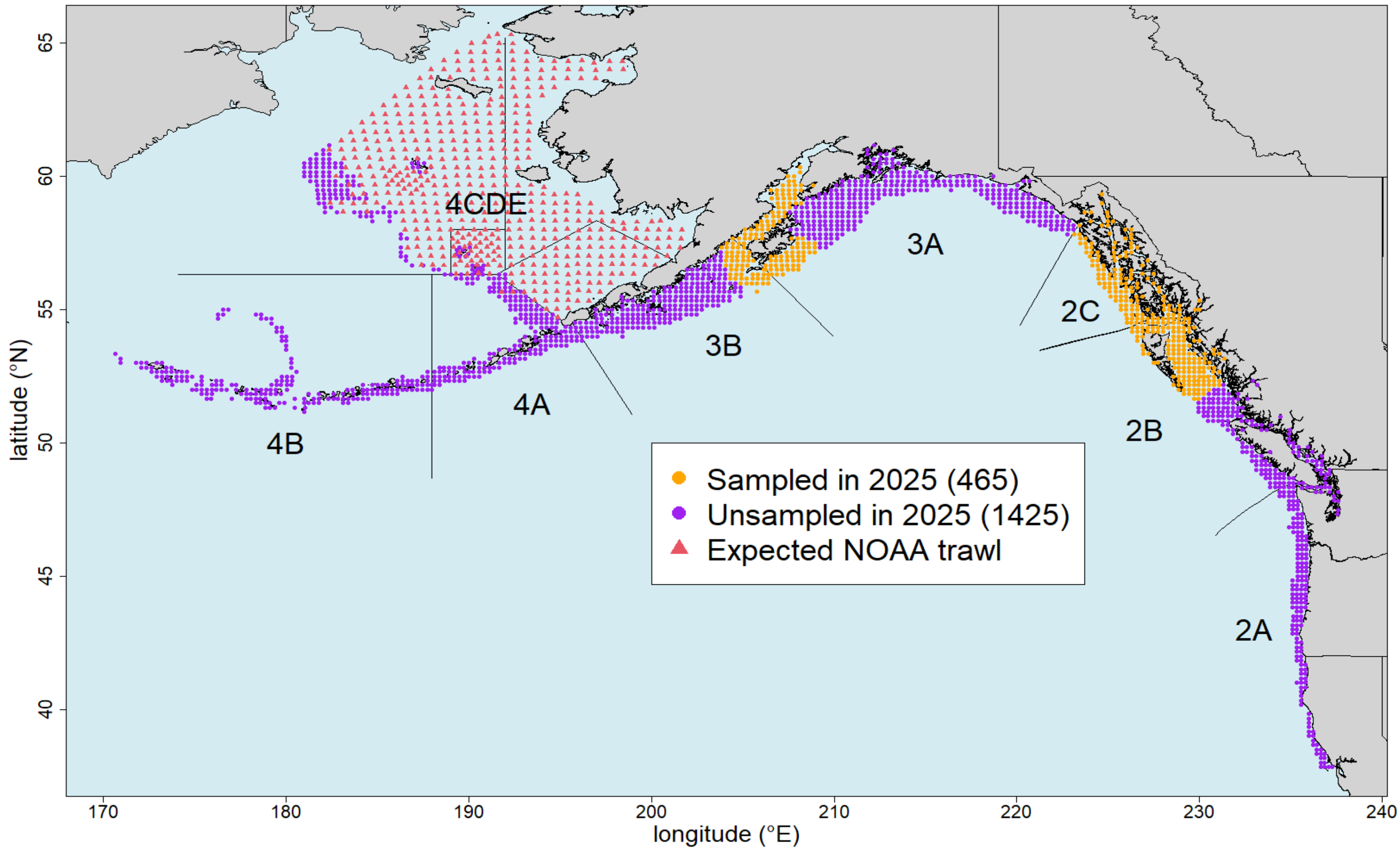

Figure 1.10. Reduced Core design for 2025-27 (orange circles). Design is based on fishing only the current highest revenue blocks of stations in the core areas (2B, 2C, 3A and 3B) and no FISS sampling elsewhere to reduce costs.

Part 2: Modelling updates

PURPOSE

To compare space-time model output from fitting a Tweedie model to survey catch data to the current model's output.

BACKGROUND

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 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).

Preliminary modelling (IPHC-2023-SRB023-09) of all-sizes WPUE data from 1993-2022 for three IPHC Regulatory Areas (2C, 3B and 4A) yielded estimates of times series that were very close to those from the existing model, but with significant reductions in model run time. In this report, we present comparisons between Tweedie and delta-gamma models for O32 WPUE data from all IPHC Regulatory Areas for 1993-2023.

RESULTS

Table 2.1 presents comparisons between the model output of the delta-gamma and Tweedie models for three IPHC Regulatory Areas. For all but IPHC Regulatory Area 3B, the DIC values imply that the Tweedie models provides a poorer fit (higher DIC), while producing similar estimates of parameters for temporal and spatial dependence.

The greatest difference in DIC was for IPHC Regulatory Area 4CDE. This is an area with many zero catches on the Bering Sea flats, and the model fits seemed to benefit from the greater flexibility in modelling the zero-generating process afforded by the delta-gamma model.

We did not compare model run times in Table 2.1 as the modelling computer was replaced between the delta-gamma and Tweedie model runs, confounding any comparisons. We note that hardware improvements together with software and coding updates mean that the delta-gamma model is now running more efficiently than in past years, and computing time improvements offered by the simpler Tweedie model are likely to be less important than implied by the preliminary results in IPHC-2023-SRB023-09.

Figures 2.1, and 2.2 compare the time series estimates by IPHC Regulatory Area and Biological Region respectively. Both model types estimate very similar values in all years except when data are sparse such as the early years in IPHC Regulatory Areas 2A, 4A, 4B time series. Our understanding of the stock trends is not meaningfully affected by the choice of model.

DISCUSSION

While initial results from fitting Tweedie models were very promising (IPHC-2023-SRB023-09), the models results presented here do not make a compelling case for changing the production version of the IPHC's space-time model from the delta-gamma to Tweedie. We note that the preliminary modelling was undertaken using all-sizes WPUE data, rather than the O32 data used here. All-sizes WPUE generally has fewer zero values and may benefit less from the more flexible structure of the delta-gamma model than O32 WPUE data.

We intend to repeat the comparisons following the 2024 FISS, potentially expanding the scope to include all three variables we routinely model (O32 WPUE, all-sizes WPUE and all-sizes NPUE). Results will be reported at SRB026.

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

IPHC Regulatory Area	Parameter	Description	Delta-gamma	Tweedie	Difference
4CDE	DIC	Model fit	72 091.8	74 157.6	−2 065.7
	ρ	Temporal correlation	0.913 (0.013)	0.897 (0.009)	
	θ_1	Spatial correlation	−6.76 (0.13)	−6.99 (0.10)	
	θ_2	Spatial correlation	5.08 (0.13)	5.23 (0.08)	
4B	DIC	Model fit	21 878.2	21 927.8	−49.6
	ρ	Temporal correlation	0.914 (0.010)	0.904 (0.012)	
	θ_1	Spatial correlation	−7.89 (0.11)	−7.57 (0.18)	
	θ_2	Spatial correlation	5.73 (0.10)	6.03 (0.13)	
4A	DIC	Model fit	41 672.5	42 188.2	−515.7
	ρ	Temporal correlation	0.954 (0.008)	0.949 (0.006)	
	θ_1	Spatial correlation	−7.73 (0.10)	−7.15 (0.12)	
	θ_2	Spatial correlation	5.51 (0.07)	5.66 (0.12)	
3B	DIC	Model fit	86 994.3	86 979.7	14.6
	ρ	Temporal correlation	0.953 (0.007)	0.933 (0.010)	
	θ_1	Spatial correlation	−6.76 (0.14)	−5.97 (0.07)	
	θ_2	Spatial correlation	4.90 (0.07)	4.88 (0.08)	
3A	DIC	Model fit	148 692.7	148 741.8	−49.1
	ρ	Temporal correlation	0.963 (0.004)	0.961 (0.004)	
	θ_1	Spatial correlation	−7.32 (0.12)	−6.72 (0.08)	
	θ_2	Spatial correlation	5.39 (0.13)	5.45 (0.08)	
2C	DIC	Model fit	55 653.8	55 816.9	−163.2
	ρ	Temporal correlation	0.959 (0.006)	0.960 (0.005)	
	θ_1	Spatial correlation	−8.57 (0.21)	−7.86 (0.29)	
	θ_2	Spatial correlation	6.46 (0.16)	6.48 (0.19)	
2B	DIC	Model fit	81 323.8	81 453.4	−129.7
	ρ	Temporal correlation	0.951 (0.005)	0.953 (0.006)	
	θ_1	Spatial correlation	−7.61 (0.18)	−7.03 (0.15)	
	θ_2	Spatial correlation	5.71 (0.11)	5.71 (0.12)	
2A	DIC	Model fit	23 582.9	23 763.9	−181.0
	ρ	Temporal correlation	0.924 (0.010)	0.924 (0.010)	
	θ_1	Spatial correlation	−8.03 (0.22)	−8.16 (0.27)	
	θ_2	Spatial correlation	5.90 (0.16)	6.21 (0.19)	

References

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Webster, R., Stewart, I., Ualesi, K. and Wilson, D. (2023). 2024-26 FISS Design Evaluation. IPHC-2023-SRB023-09. 24 p.

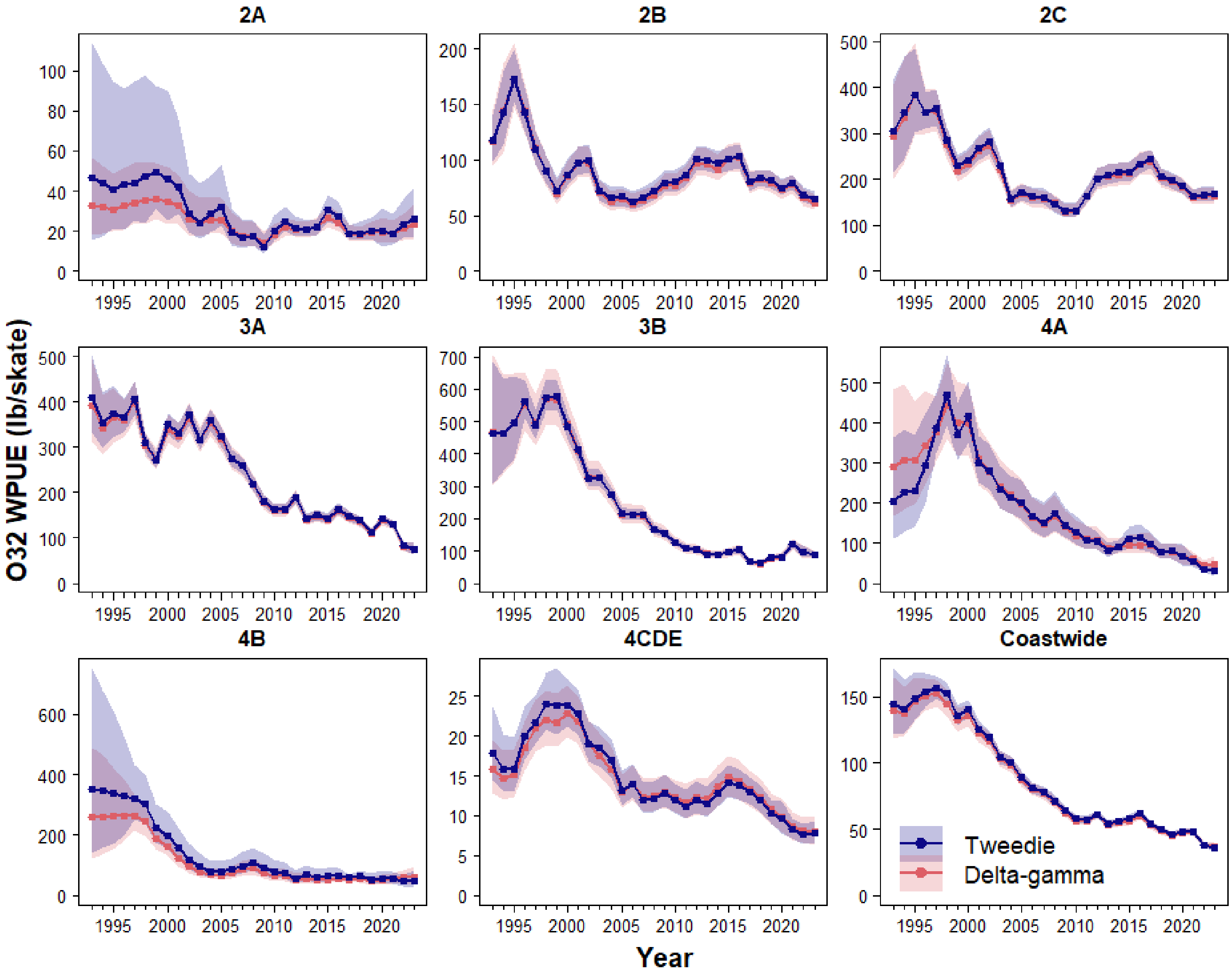

Figure 2.1. Comparison of estimated time series (posterior means by year) of O32 WPUE for the current delta-gamma model and the Tweedie model, by IPHC Regulatory Area. Shaded regions represent 95% posterior credible intervals.

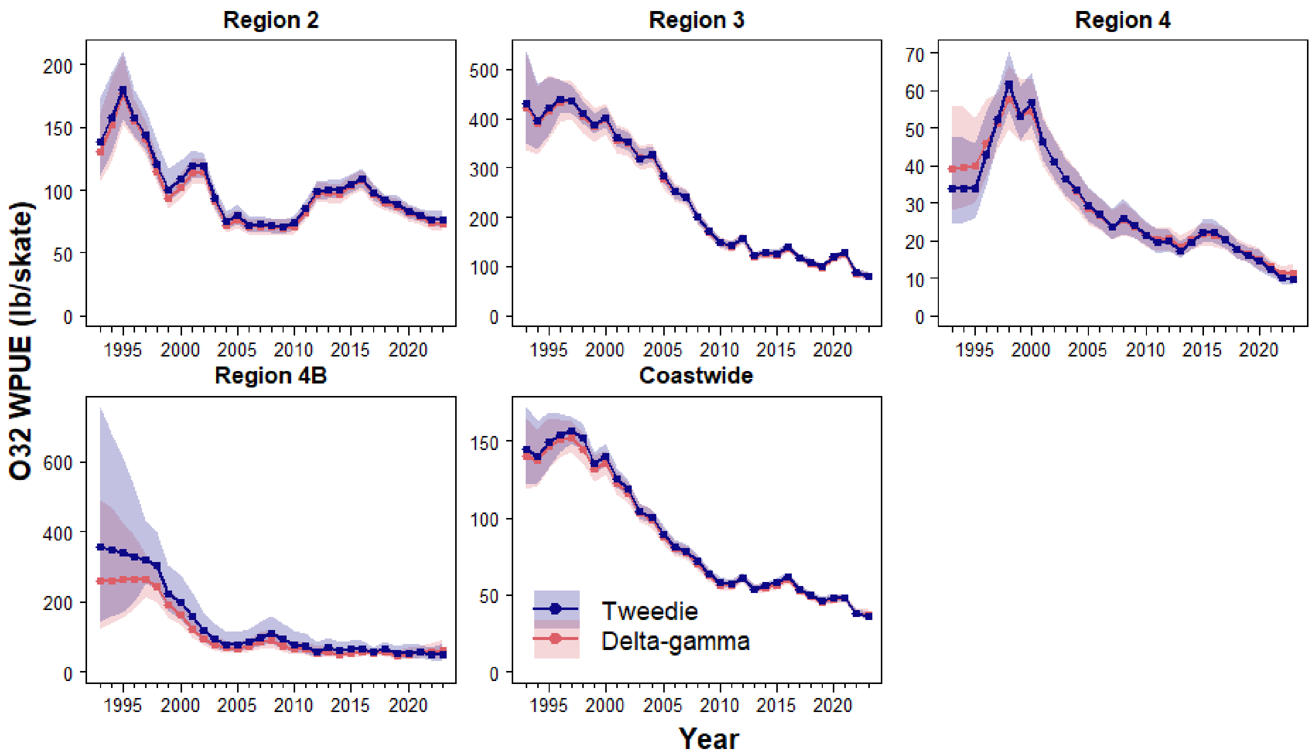

Figure 2.2. Comparison of estimated time series (posterior means by year) of O32 WPUE for the current delta-gamma model and the Tweedie model, by IPHC Biological Region. Shaded regions represent 95% posterior credible intervals.