INTERNATIONAL PACIFIC HALIBUT COMMISSION

Celebrating 100 Years

1924-2024

2024-26 FISS Design Evaluation

Agenda item: 4.2.2

IPHC-2023-SRB023-09

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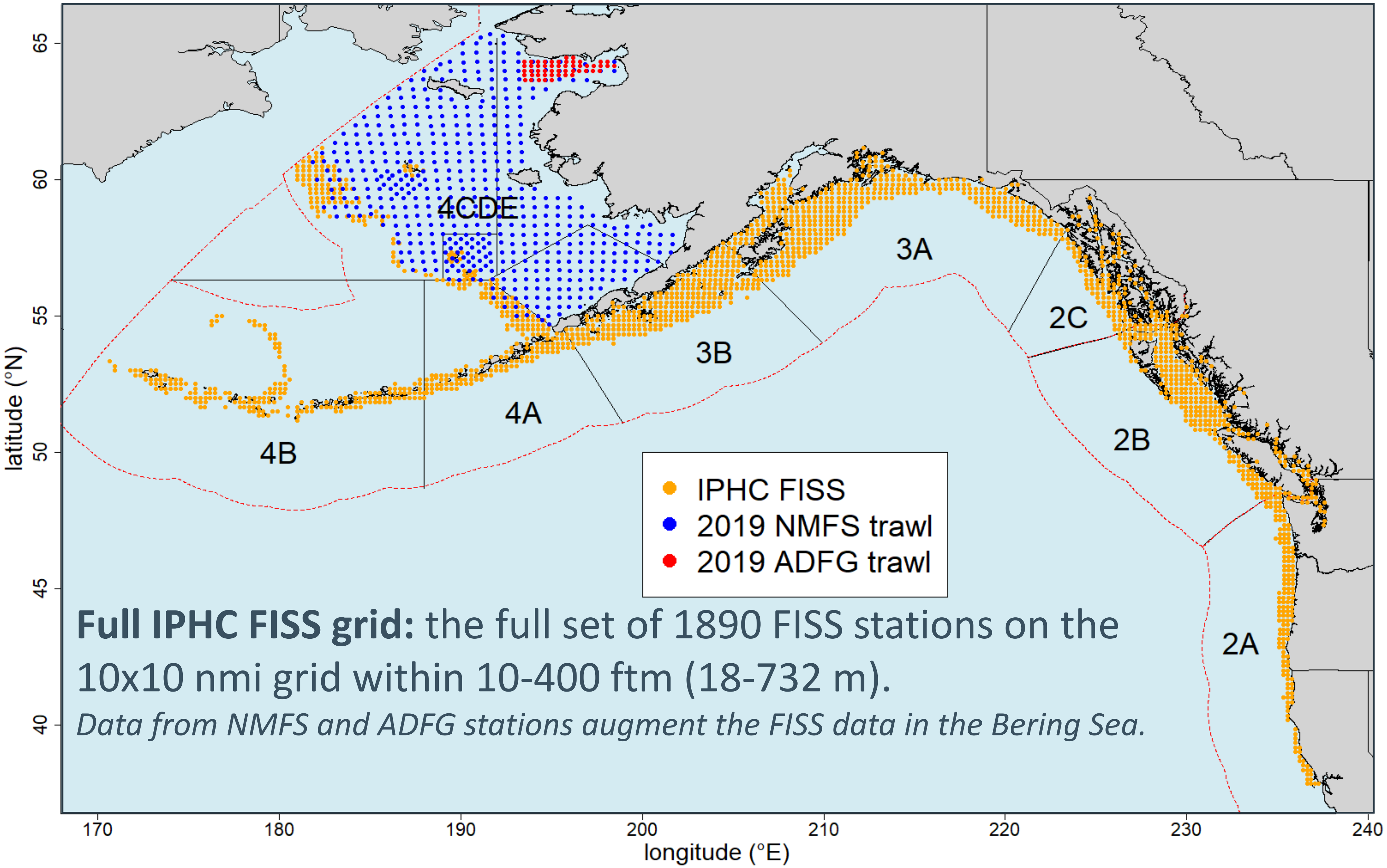
1. FISS Design Evaluation

IPHC FISS

- Our most important source of data on Pacific halibut
- Provides data for estimating weight and numbers per unit effort (WPUE and NPUE) indices of density and abundance of Pacific halibut
  - Used to estimate stock trends
  - Used to estimate stock distribution
  - Important input in the IPHC stock assessment
- Provides biological data for use in the stock assessment
- An annual FISS has been undertaken since 1993
  - Design expanded during 2011-2019 period

Full FISS grid



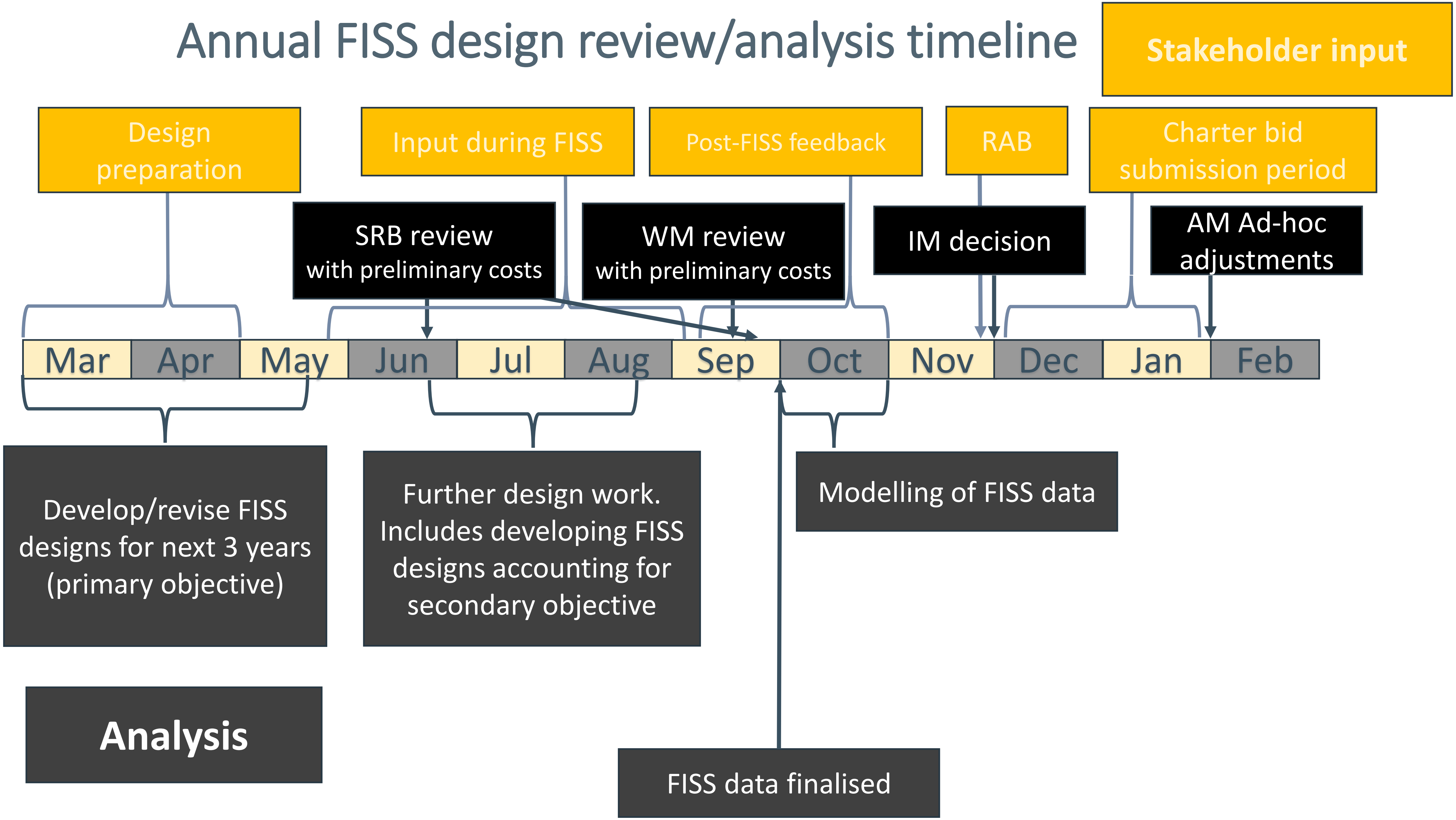
Full IPHC FISS grid: the full set of 1890 FISS stations on the 10x10 nmi grid within 10-400 ftm (18-732 m).

Data from NMFS and ADFG stations augment the FISS data in the Bering Sea.

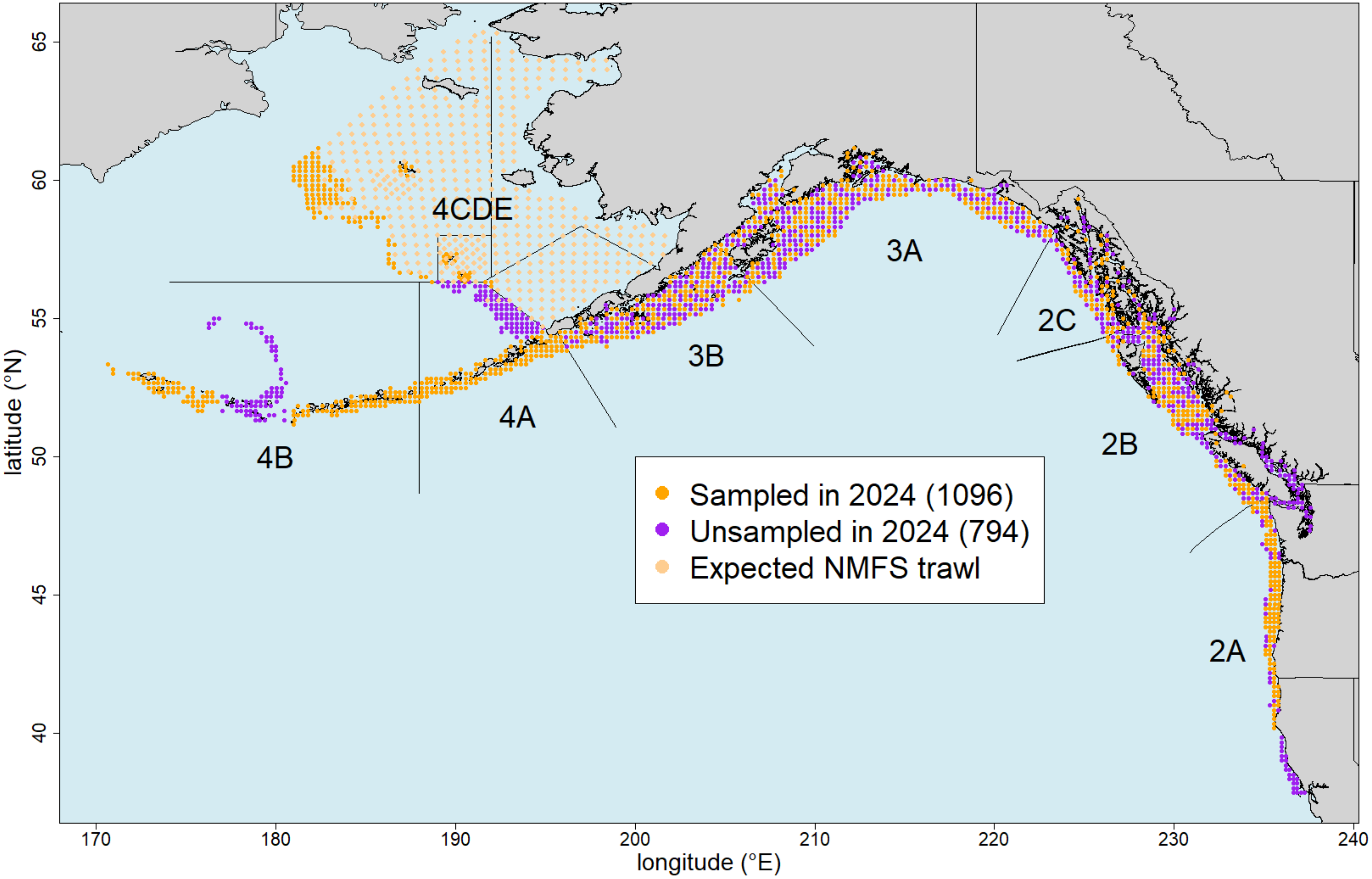
FISS objectives and design layers

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 FISS design review/analysis timeline



Design 1: Presented to SRB in June (primary objective)



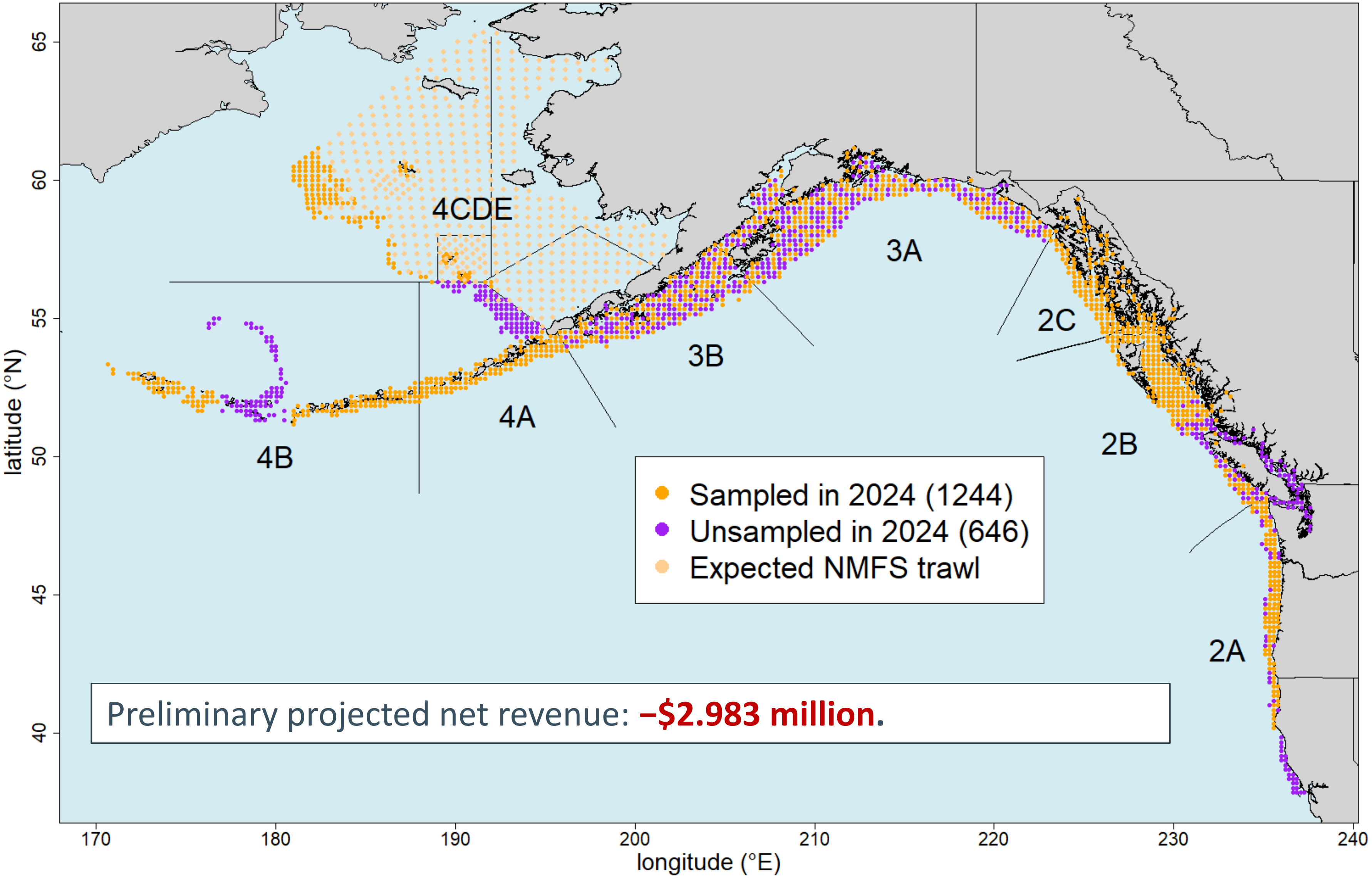
Design 1 (primary objective)

- Projected to meet data quality criteria:
  - Low risk of biased abundance indices and stock distribution estimates in all IPHC Regulatory Areas
  - CVs within target ranges (≤15% for Reg. Areas; ≤10% for Bio. Regions and Coastwide)
- Based on preliminary cost estimates, Design 1 is projected to result in a **net loss of $3.649 million**.

Designs accounting for secondary objective

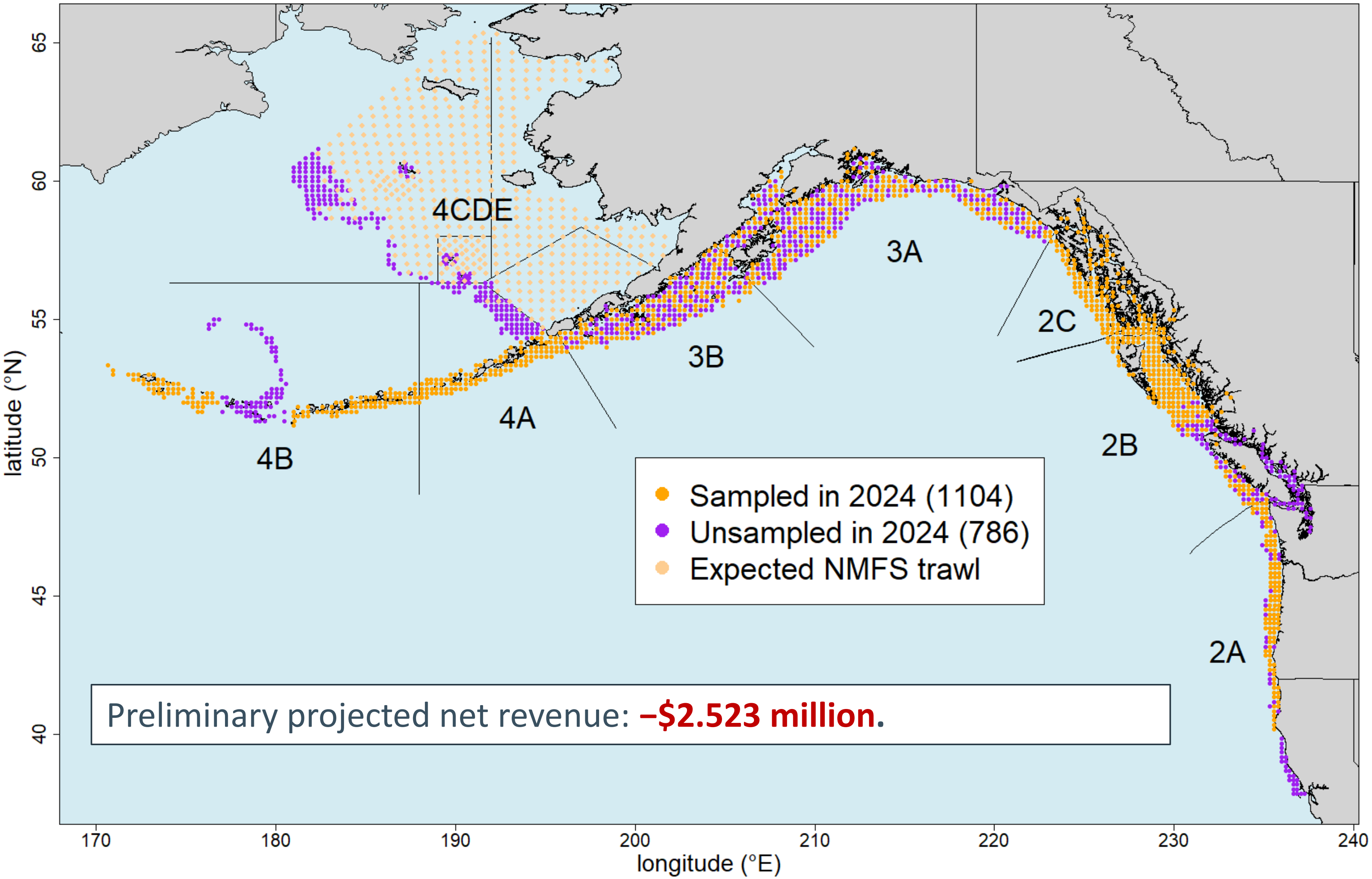
- The following designs account for the secondary objective of long-term revenue neutrality for the FISS to varying degrees.
- Cost projections are based on very preliminary values that are likely to change once the 2023 FISS is completed.

Design 2: Optimized Design 1 (stations, skates)

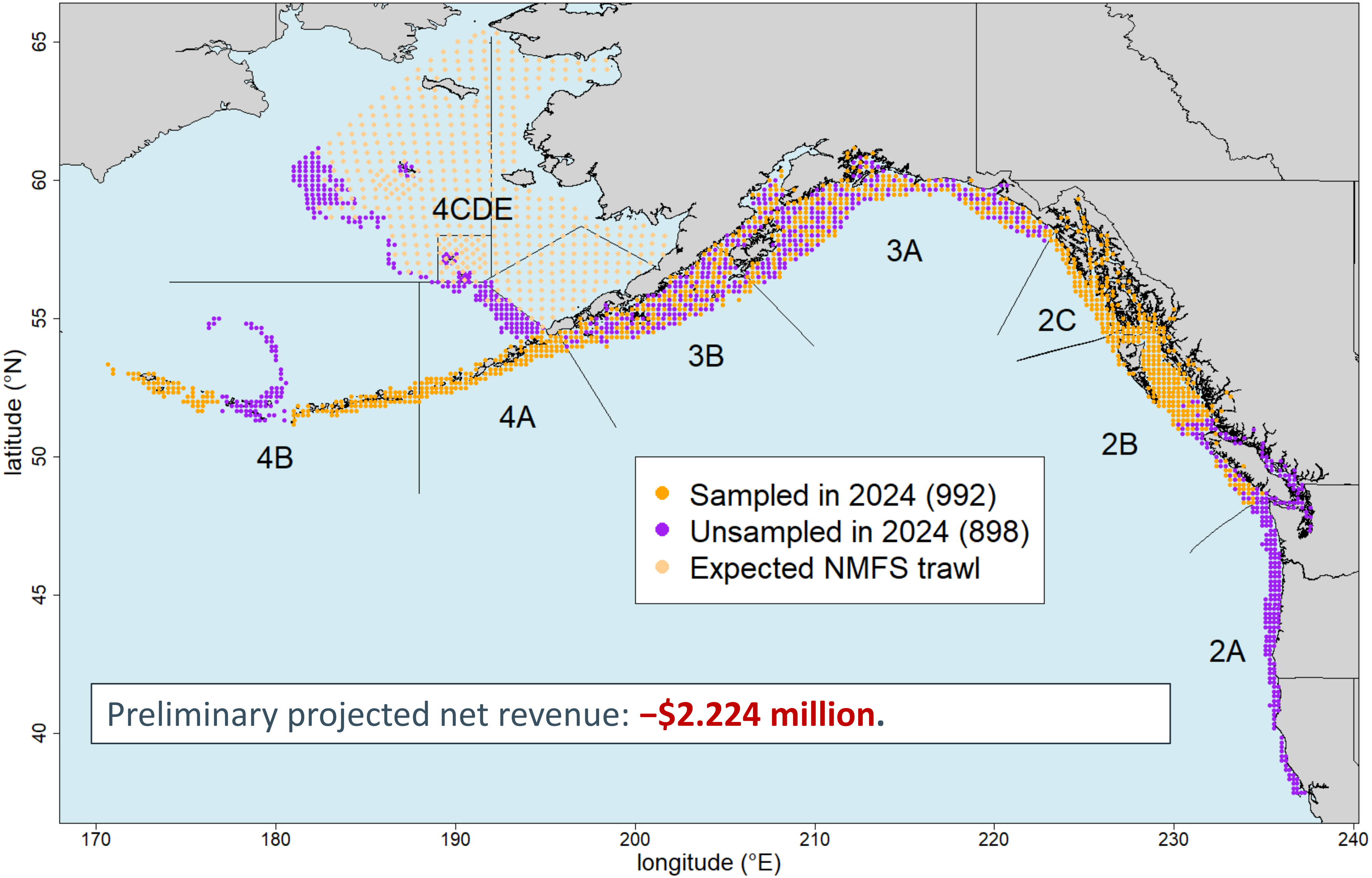


Preliminary projected net revenue: **−$2.983 million.**

Design 3: 2A-4B (no 4CDE FISS)

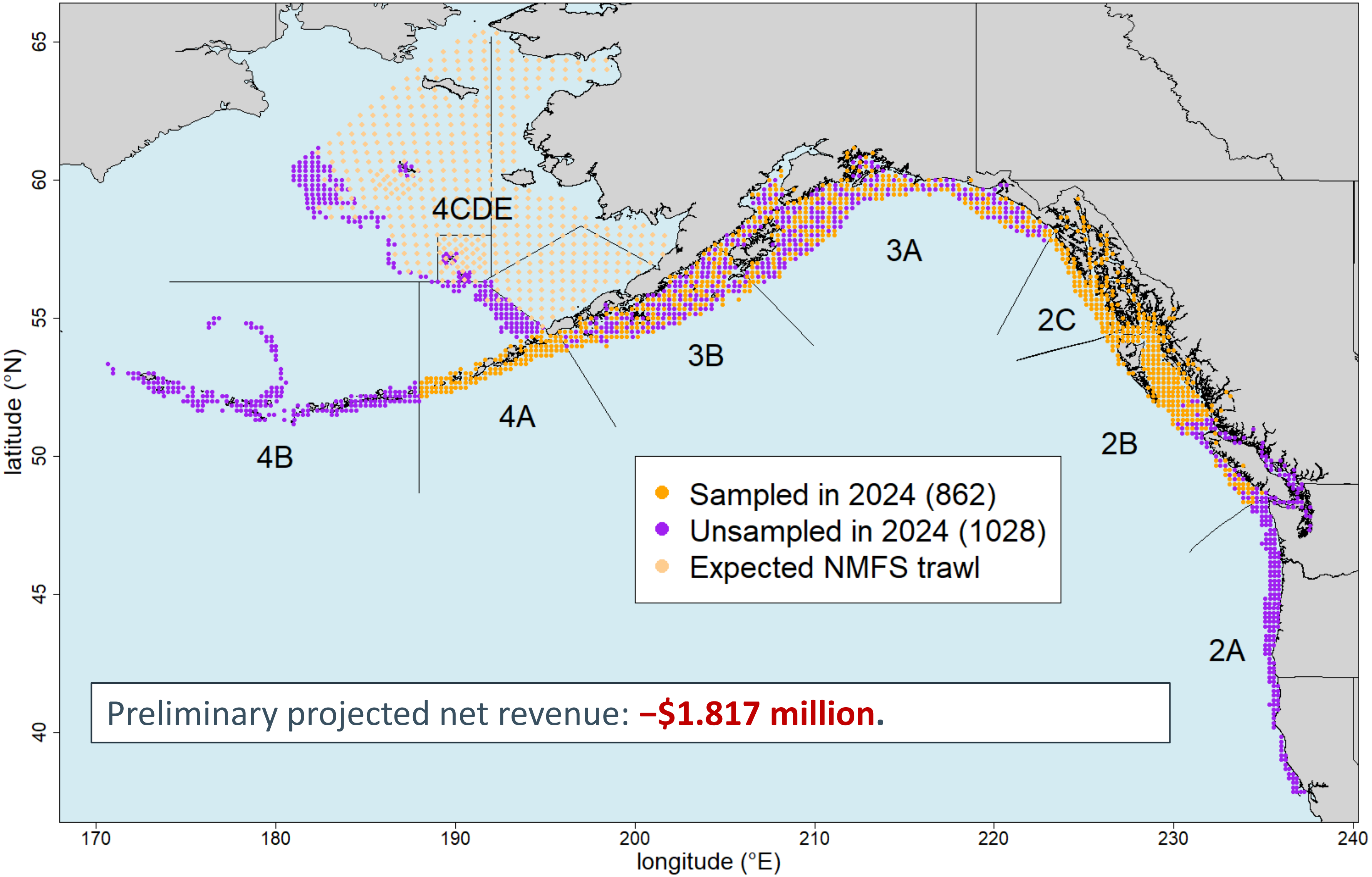


Design 4: 2B-4B



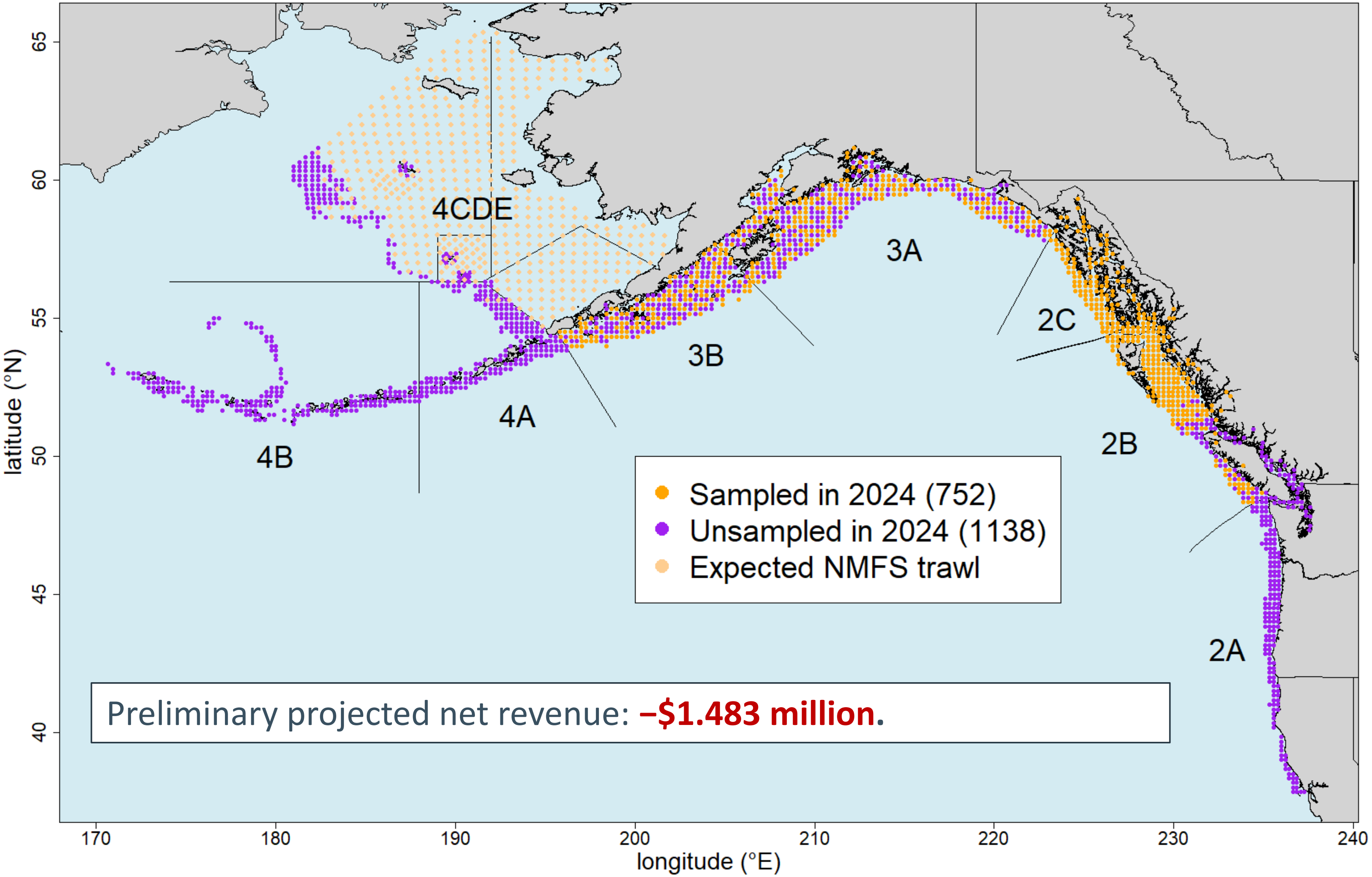
Preliminary projected net revenue: **−$2.224 million.**

Design 5: 2B-4A



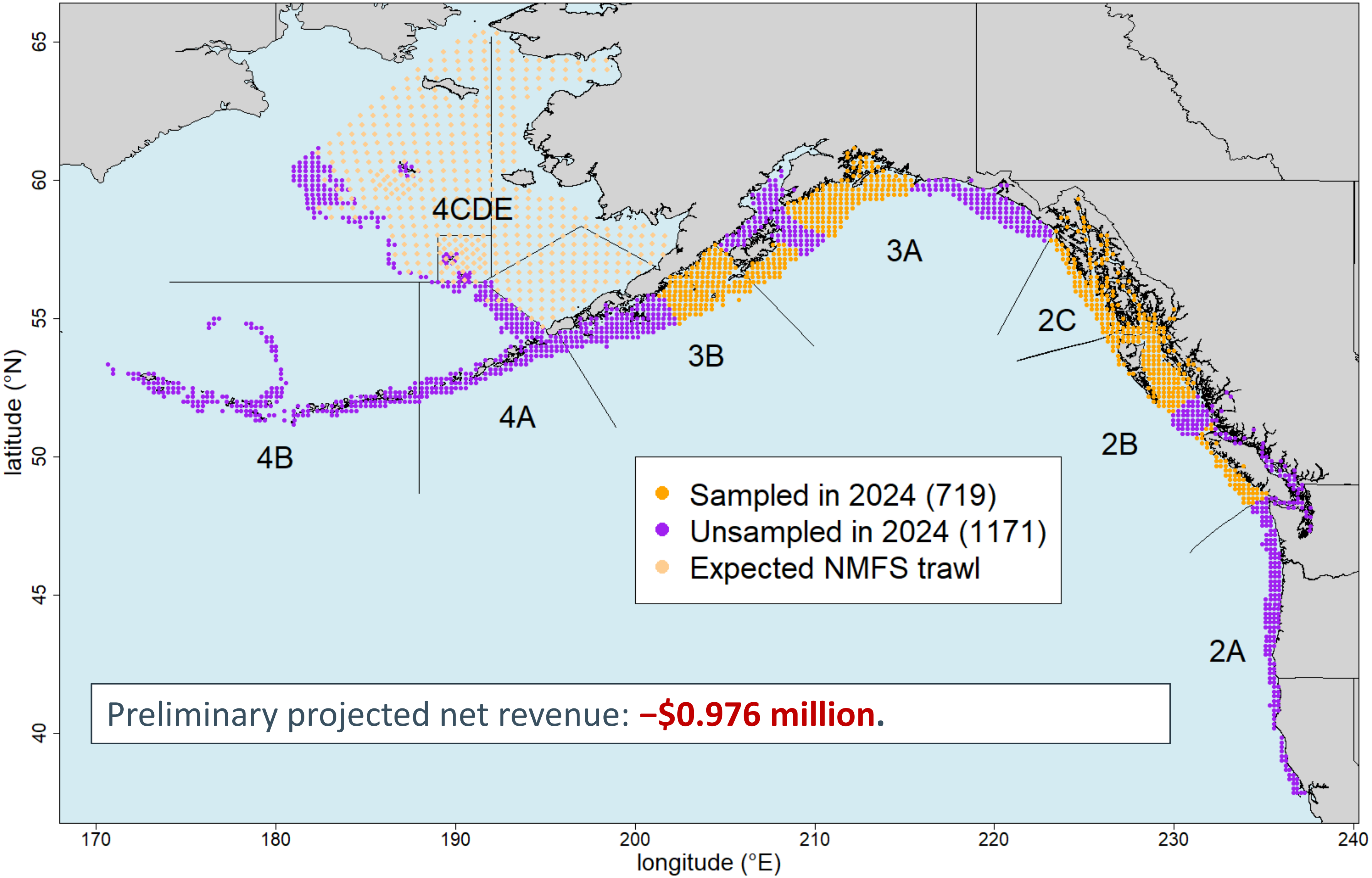
Preliminary projected net revenue: **−$1.817 million.**

Design 6: 2B, 2C, 3A and 3B



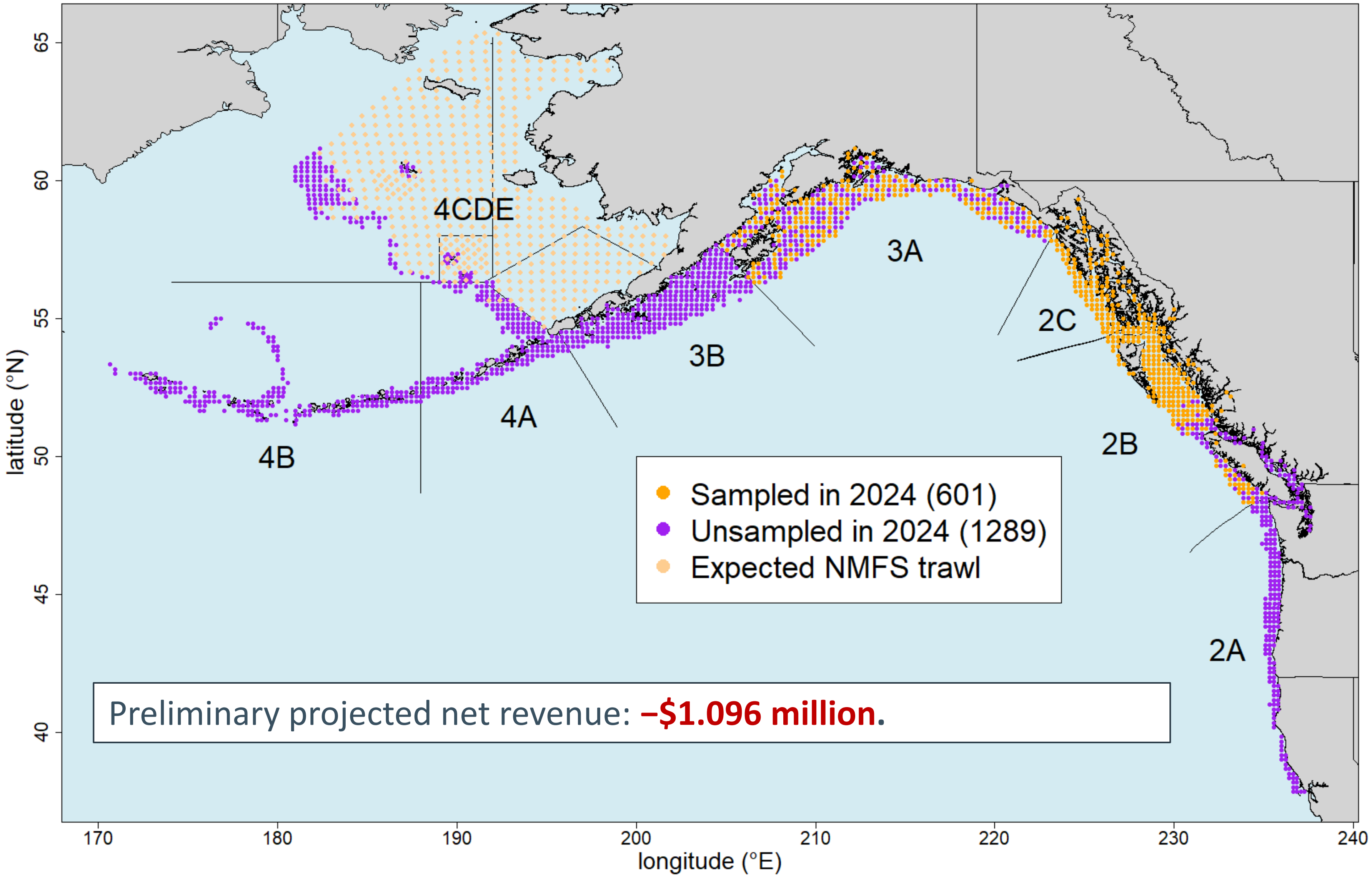
Preliminary projected net revenue: **−$1.483 million.**

Design 6b: “Best” charter regions in 2B to 3B

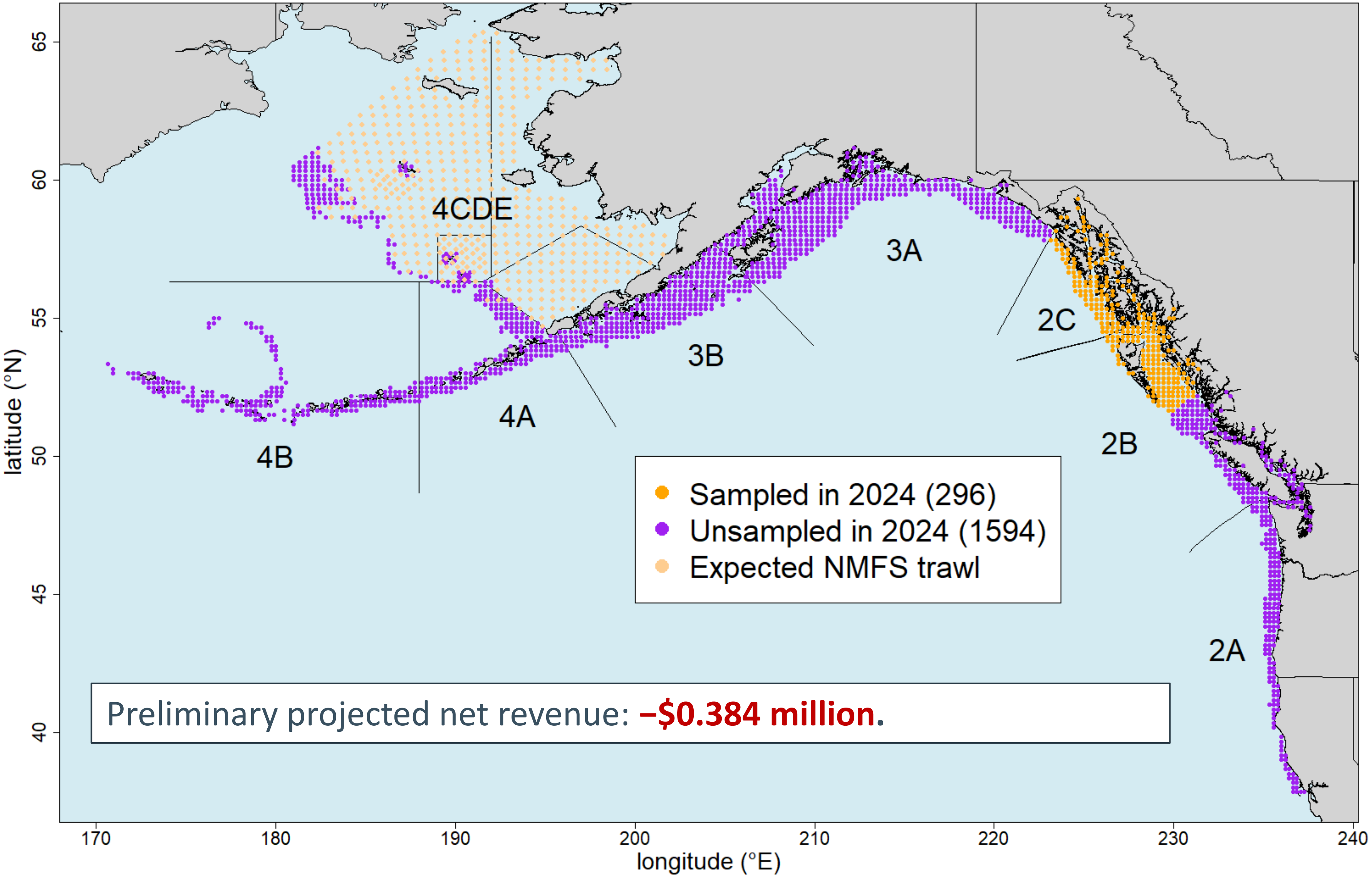


Preliminary projected net revenue: **−$0.976 million.**

Design 7: 2B, 2C and 3A

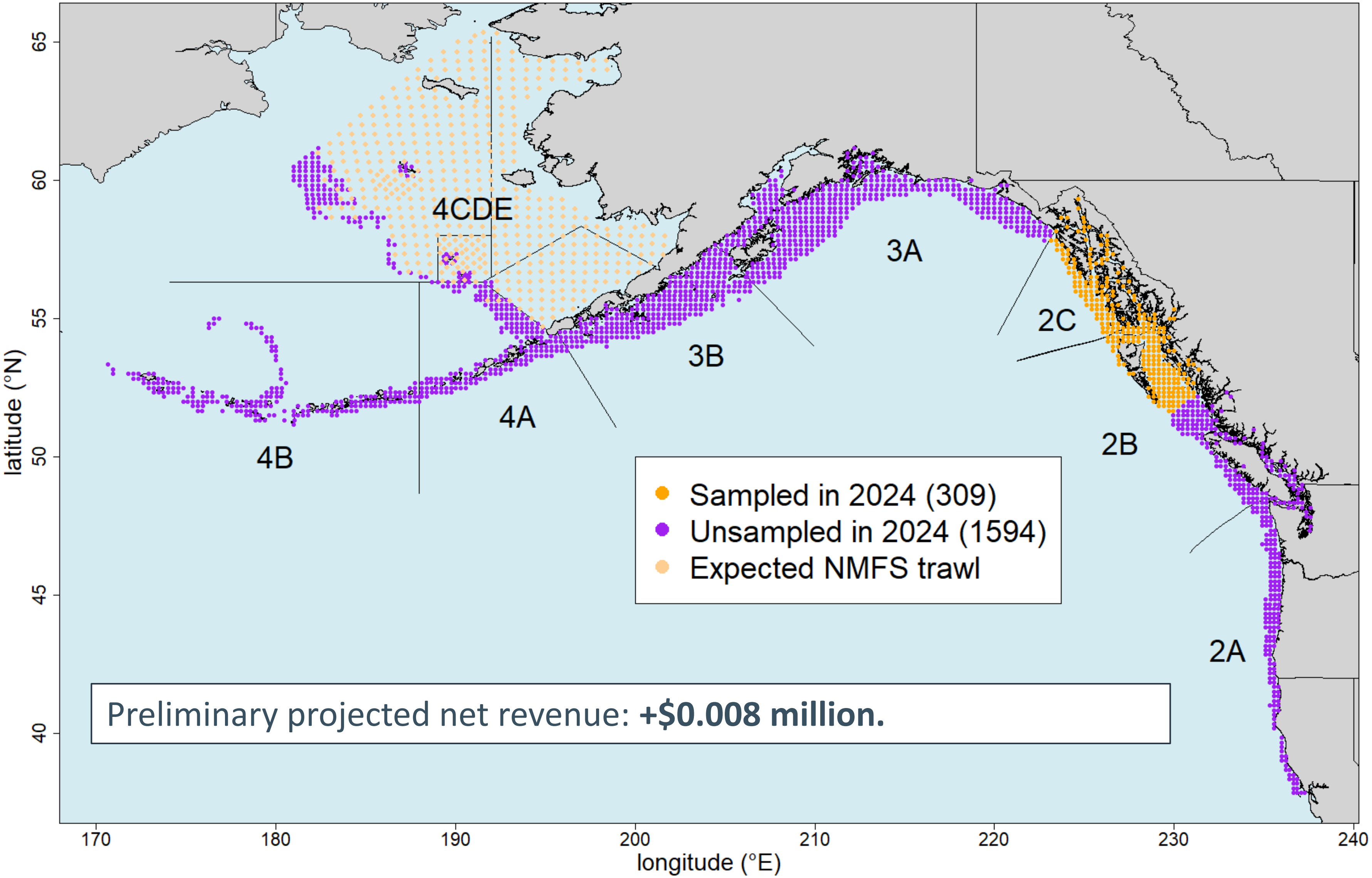


Design 8: northern 2B and 2C



Preliminary projected net revenue: **−$0.384 million.**

Design 9: Design 8 with added efficiencies



Preliminary projected net revenue: **+$0.008 million.**

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
6a	Sample 'best' charter regions in 2B-3B only	–$976,000	$507,000
7	Remove 3B, 4A, 4B, 4CDE and 2A	–$1,096,000	–$120,000
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 9: added efficiencies

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 will not be 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.

Design 9: added efficiencies

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 that these stations will achieve 120% of the average catch rate of the usual fixed-station design stations

Design 9: added efficiencies

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 current September bait comparison study will be 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 will be 60% of the price of chum salmon.

Projected CVs for mean O32 WPUE after 2024 FISS: Designs 8 & 9

IPHC Regulatory Area	Projected CV after 2024 FISS (%)	Estimated CV after 2022 FISS (%)
2A	24	16
2B	7	6
2C	5	6
3A	17	6
3B	16	14
4A	24	14
4B	33	19
4CDE	10	8

Target range: ≤15%

Projected CVs after 2024 FISS: Designs 8 & 9

IPHC Biological Region	Projected CV after 2024 FISS (%)	Estimated CV after 2022 FISS (%)
2	5	4
3	12	7
4	11	8
4B*	33	19
Coastwide	7	4

Target range: ≤10%

*4B target range: ≤15%

Projected stock distribution uncertainty after 2024 FISS: Designs 8 & 9

IPHC Regulatory Area	Projected 95% interval* after 2024 FISS (%)	Estimated 95% interval* after 2022 FISS (%)
2A	2 to 5	2 to 4
2B	10 to 14	11 to 15
2C	12 to 16	13 to 16
3A	20 to 34	23 to 29
3B	14 to 24	16 to 25
4A	4 to 9	4 to 7
4B	4 to 13	5 to 10
4CDE	10 to 15	9 to 13

* 95% percent chance that true stock % is inside interval

Implications of reduced FISS in 2024

- Estimates from unsampled IPHC Regulatory Areas will have high levels of uncertainty and increasing risk of bias due to the potential for unmonitored changes in abundance and stock distribution
- Uncertainty and bias risk also increase for Biological Regions and coastwide estimates

Implications of reduced FISS in 2024

- Limited spatial designs such as Design 8/9 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.

2. Modelling Updates

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.”*

Background

- The current ‘delta-gamma’ model accounts for the probability of zero catch and the distribution of non-zero catch rates through distinct model components, connected by a common spatio-temporal correlation structure:
  - A Bernoulli process for probability of zero
  - A gamma process for non-zero values
- Covariates are included in both model components, increasing model complexity relative to alternative parameterisations
- The Tweedie model as implemented in R-INLA is a compound Poisson-gamma model
- Zeros and non-zeros are modelled together, and it therefore requires fewer parameters when covariates are included

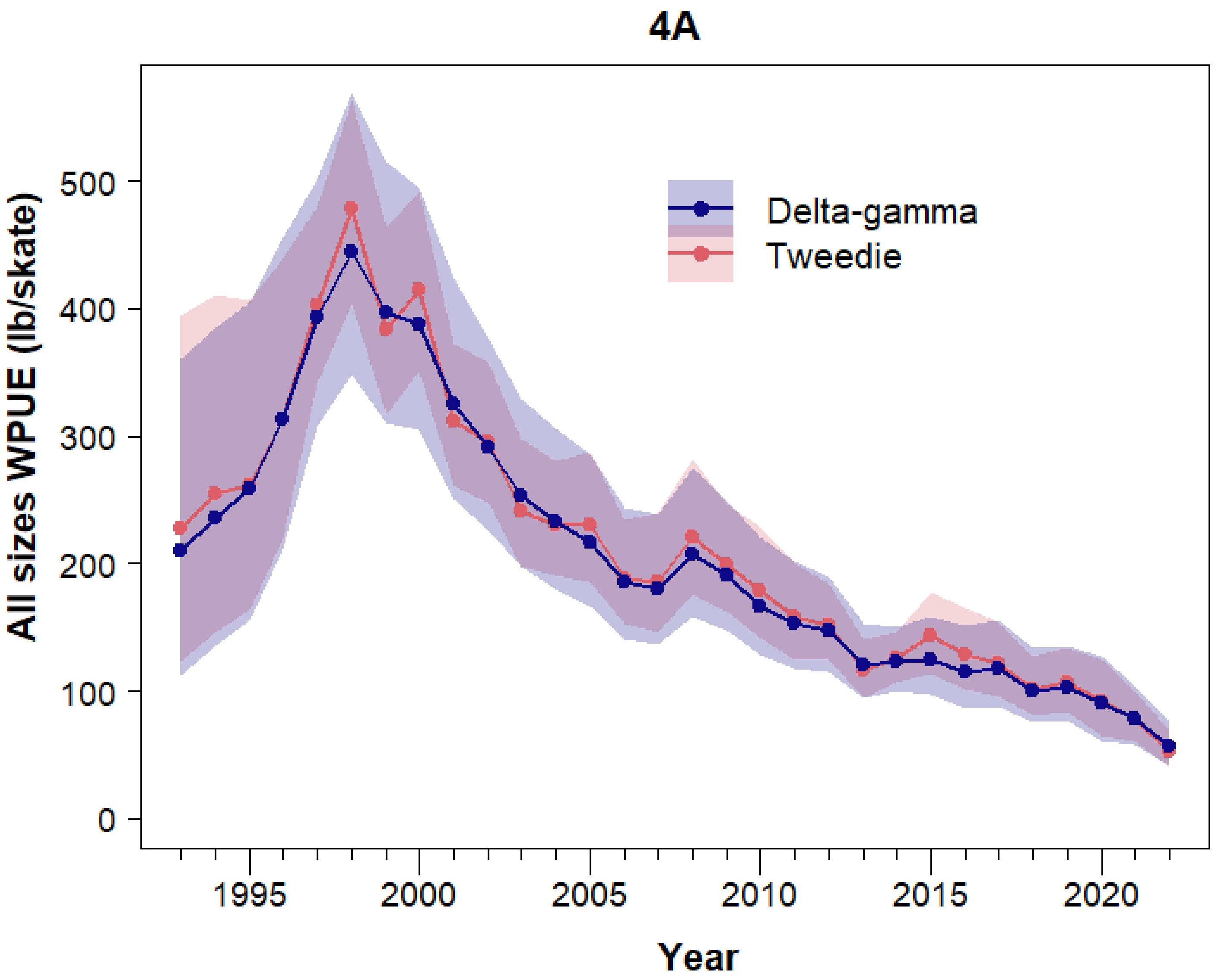
Background

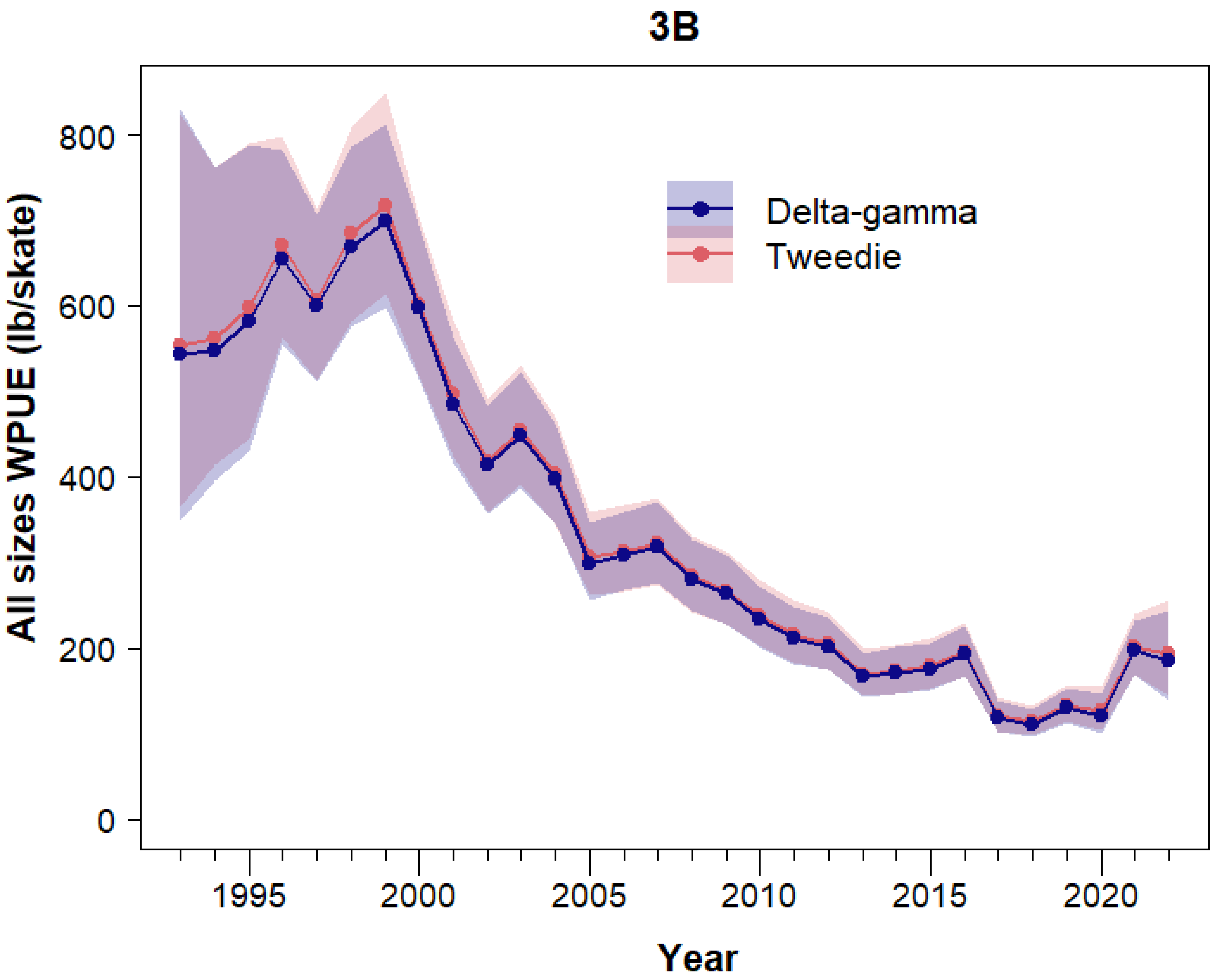
- We attempted to fit the Tweedie model to data from several IPHC Regulatory Areas
- Here we compare common model parameter estimates and model run times with those from the delta-gamma model for three areas where model convergence has been successful

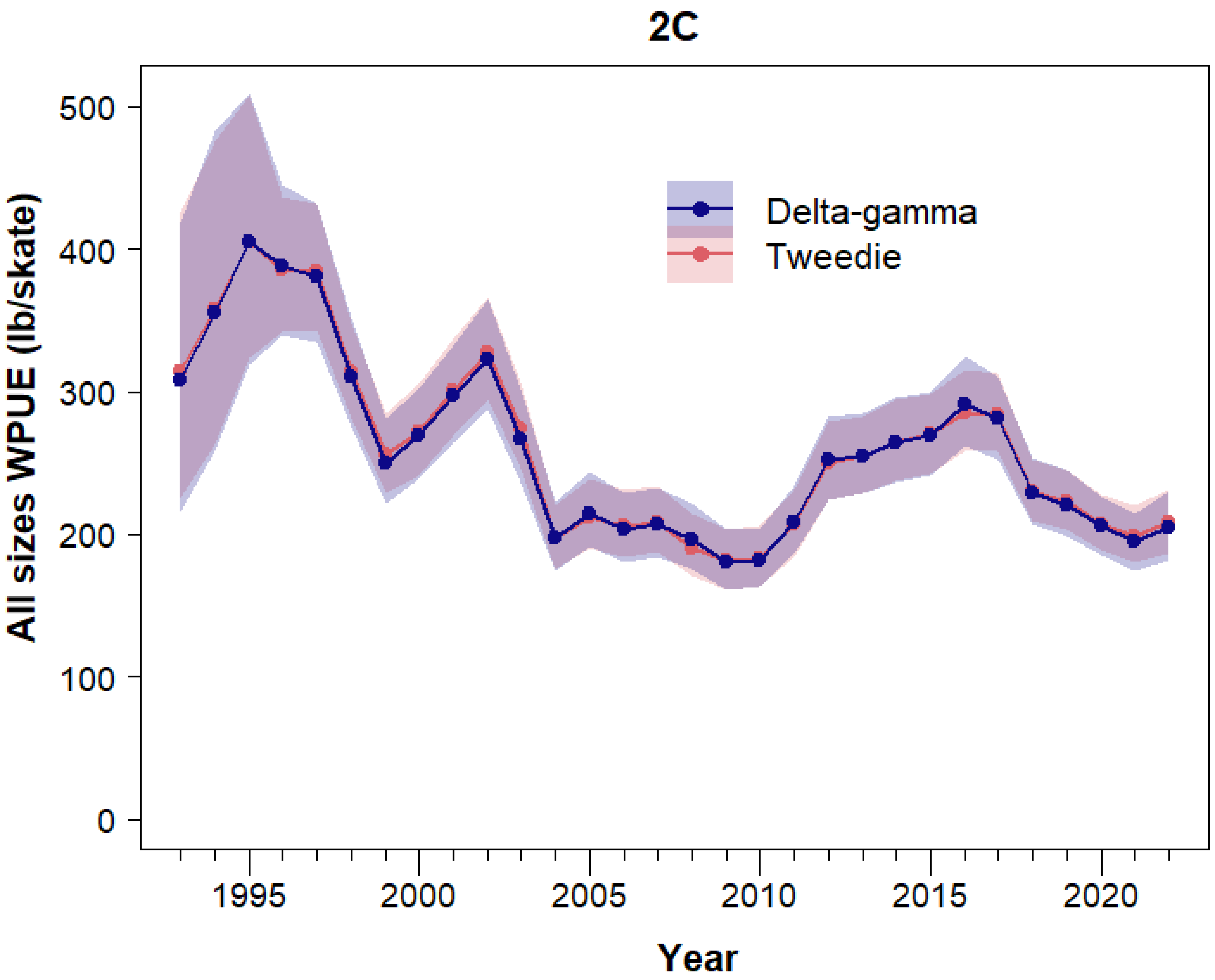
IPHC Regulatory Area	Parameter	Description	Delta-gamma	Tweedie	Difference
4A	DIC	Model fit	47 817.6	46 988.1	829.5
	Run time (s)		311	143	168
	ρ	Temporal correlation	0.952 (0.008)	0.950 (0.006)	
	θ_1	Spatial correlation	-6.84 (0.18)	-6.78 (0.11)	
	θ_2	Spatial correlation	5.07 (0.12)	5.41 (0.10)	
3B	DIC	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)	

Prediction and MCMC output times

IPHC Regulatory Area	Computations	Units	Delta-gamma	Tweedie
4A	Model prediction	seconds	1878	153
	MCMC samples	hours:minutes	4:13	0:56
3B	Model prediction	seconds	1089	117
	MCMC samples	hours:minutes	3:47	1:14
2C	Model prediction	seconds	3085	197
	MCMC samples	hours:minutes	16:47	0:45


4A
Delta-gamma
Tweedie
All sizes WPUE (lb/skate)
0
100
200
300
400
500
1995
2000
2005
2010
2015
2020
Year


3B
All sizes WPUE (lb/skate)
0
200
400
600
800
1995
2000
2005
2010
2015
2020
Year
Delta-gamma
Tweedie



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Discussion

- The Tweedie model shows great promise for modelling FISS data:
  - Spatio-temporal correlation parameters and time series estimates are close to delta-gamma values
  - Simpler model structure leads to much faster processing times
- Some convergence issues remain with data from other areas
  - We note that we did not have good starting values for Tweedie parameters
- Other outstanding modelling issues:
  - Accounting for differences between trawl and FISS gear probabilities of zero catch
  - Generating MCMC values for model projections

Recommendations

That the Scientific Review Board:

1) NOTE paper IPHC-2023-SRB023-09 (Part 1), 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;

2) NOTE paper IPHC-2023-SRB023-09 (Part 2), which presented a preliminary comparison of results from fitting the Tweedie model to FISS data with results from the current delta-gamma model.

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