INTERNATIONAL PACIFIC HALIBUT COMMISSION

2026-28 FISS Design Evaluation

Agenda item 4.2.2

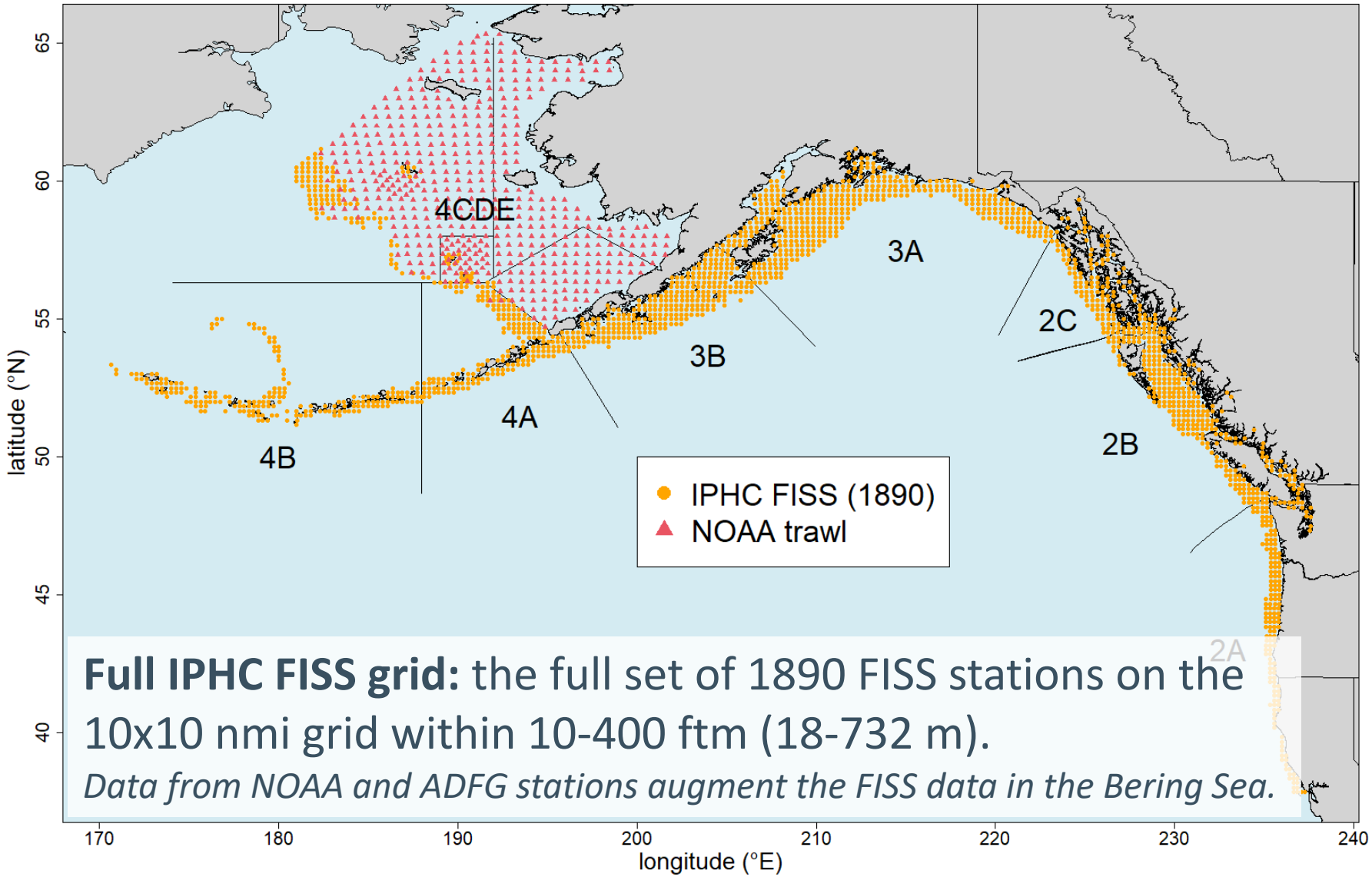
IPHC-2025-SRB027-09

(R. Webster, I. Stewart, K. Ualesi, T. Jack, & D. Wilson)

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 from 1993-2000 to include sampling in all IPHC Regulatory Areas
  - Further expansion into previously unsampled waters 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 NOAA and ADFG stations augment the FISS data in the Bering Sea.

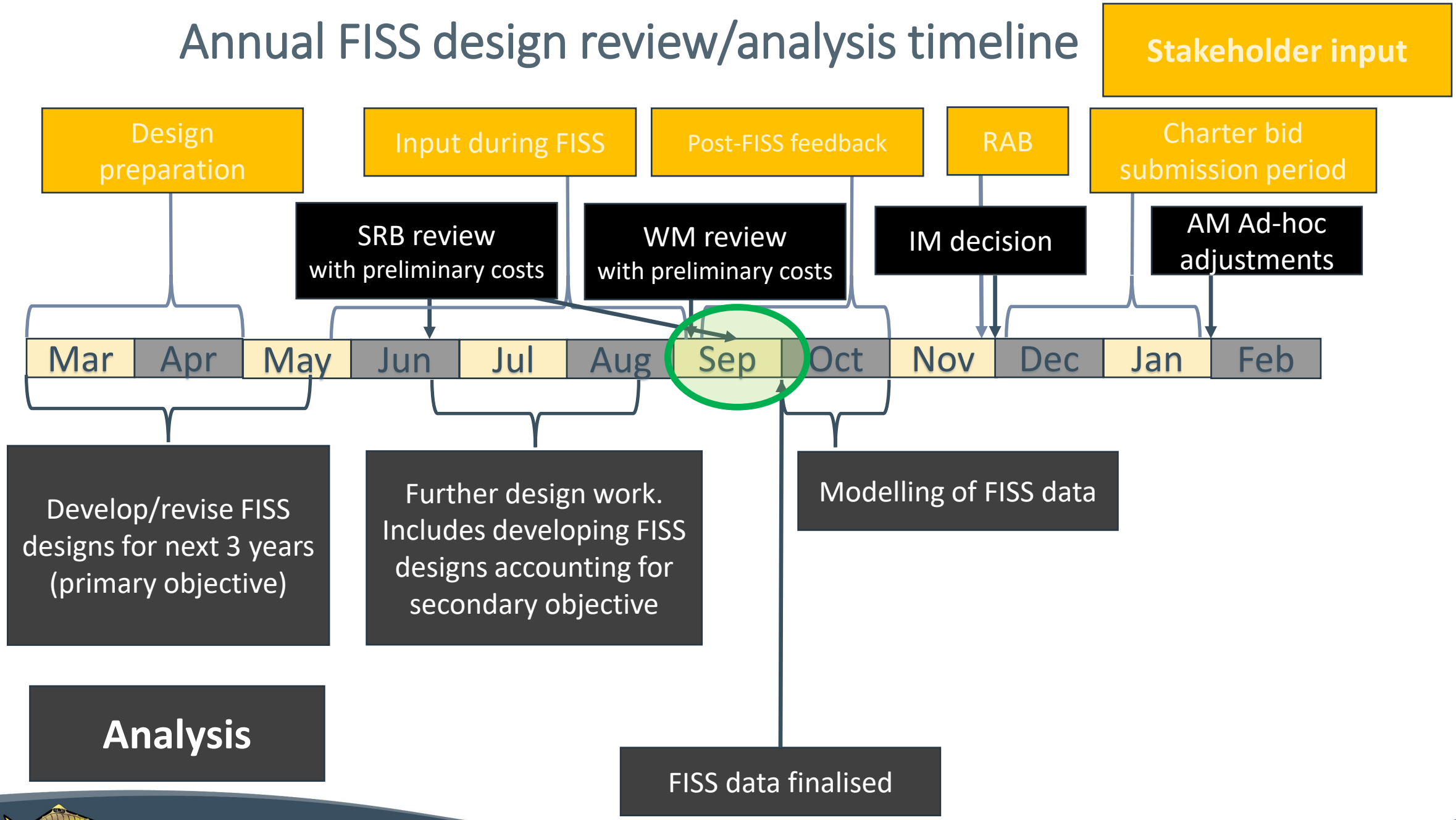
Finite survey resources

- The full FISS grid cannot be sampled each year
  - Logistically challenging and cost prohibitive
- We prioritize sampling effort based on:
  1. **Scientific needs:**
     - Precise estimates of indices of abundance and stock distribution with low potential for bias
     - Requires more frequent sampling in areas with higher variability
  2. **Cost effectiveness:**
     - Balance operational feasibility and logistics, cost and revenue, and scientific needs

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	Cost effectiveness without compromising the scientific integrity of the FISS design.	Balance operational feasibility/logistics, cost/revenue, and scientific needs. Includes an aspirational target reserve of US$2,000,000.
Tertiary	Minimize removals, assist others where feasible on a cost-recovery basis, address specific Commission informational needs.	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

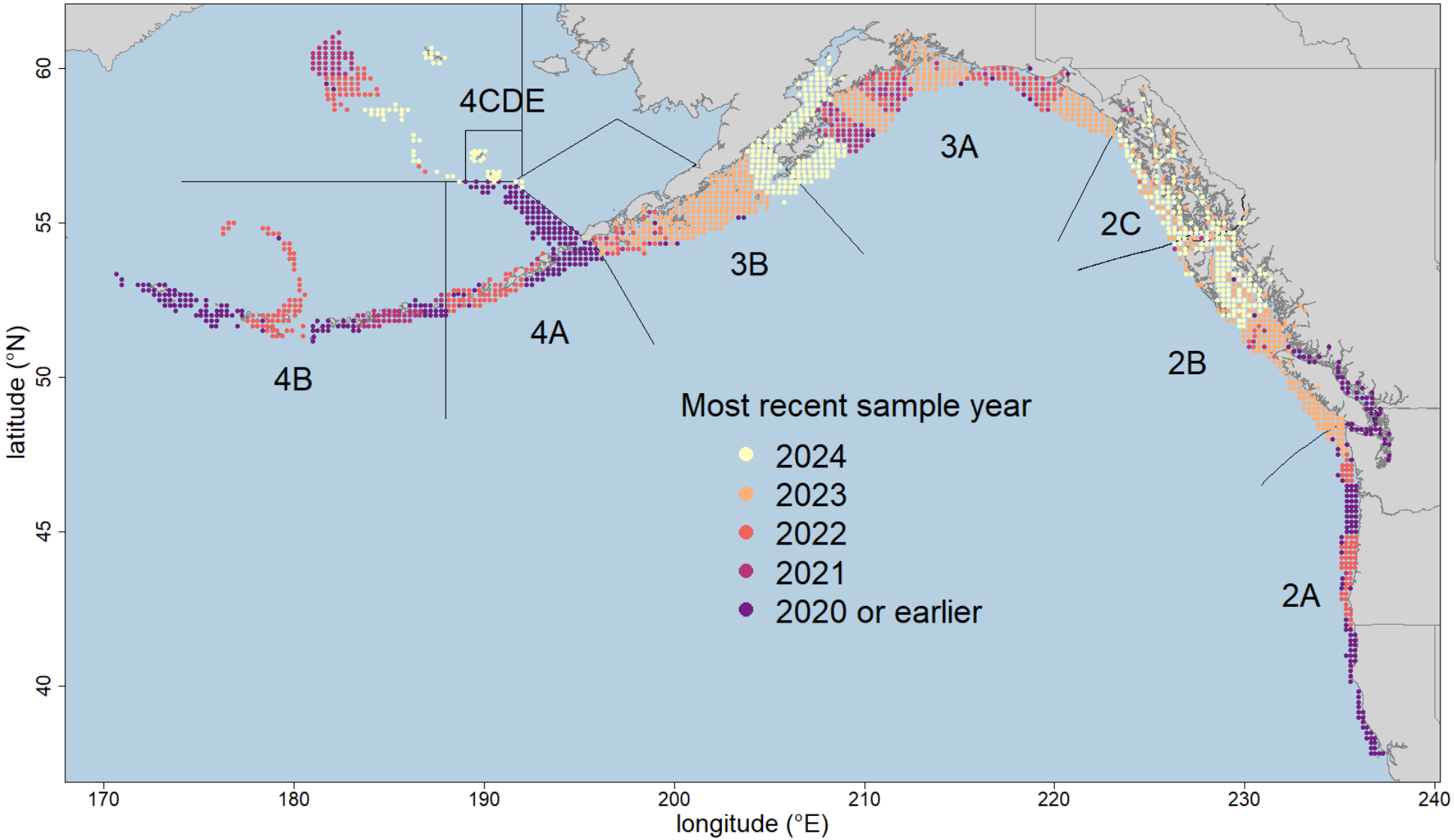
Annual FISS design review/analysis timeline



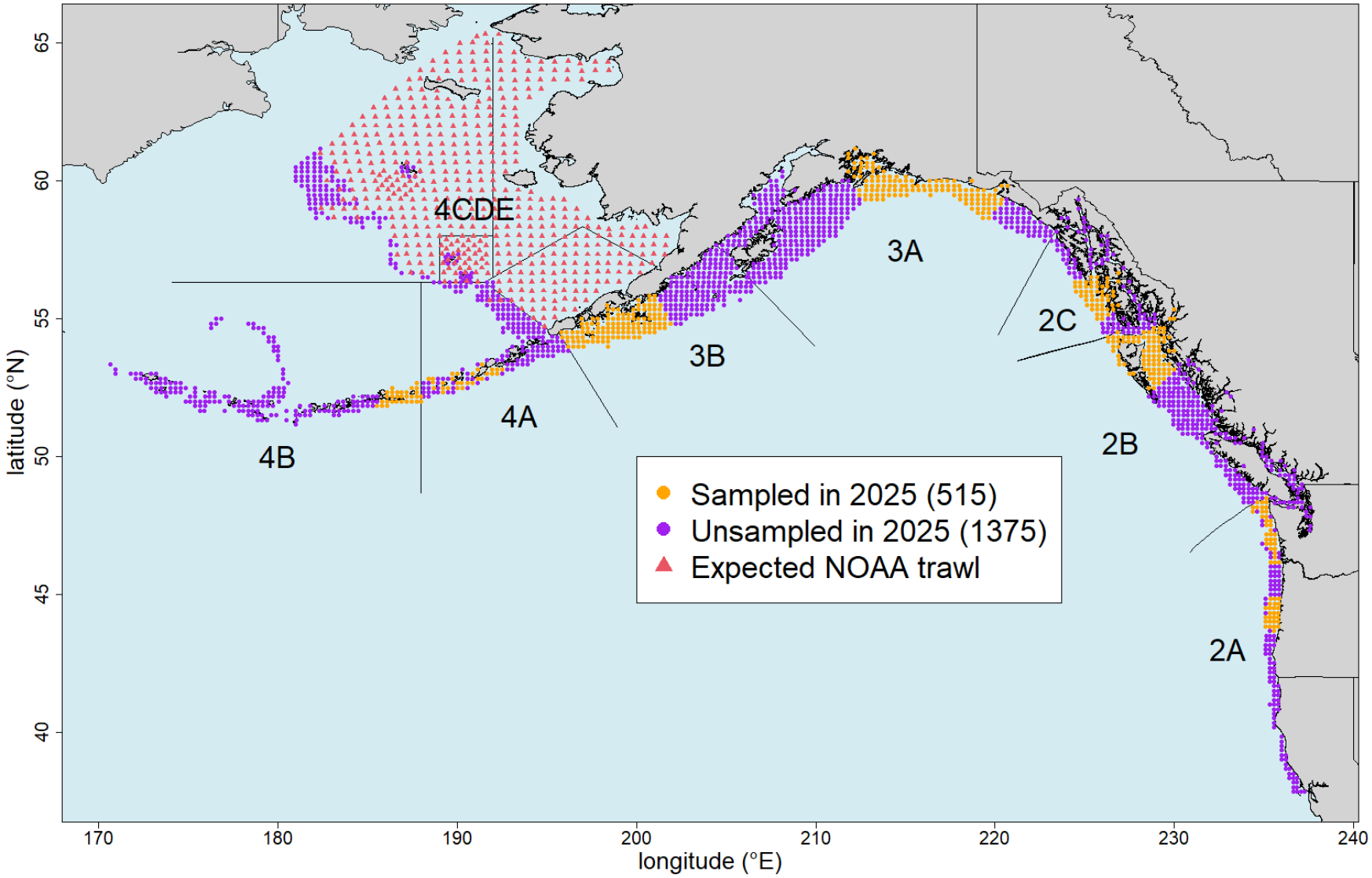
IPHC FISS 2020-25

- 2020: Rationalized FISS design approved
  - Random sampling in core areas (2B, 2C, 3A, 3B)
  - Sampling of blocks of stations elsewhere prioritized to maintain precise estimates with low bias
  - FISS reduced to core areas only due to COVID19
- 2021-22: Proposed design largely implemented
  - Western 4B not sampled in 2022 due to lack of viable bids
- 2023-25: Reduced designs implemented to lower costs
  - Little sampling outside core areas in 2023, with no FISS sampling in 4A, 4B or 4CDE
  - Further reductions in 3A and 3B in 2024, but some sampling in 4CDE
  - 2025 sampling in 3A and 3B to complement 2023-24 sampling; sampling higher density parts of 2A and 4A/4B for first time since 2022

Most recent sampling year by station



2025 design


4CDE
3A
2C
3B
4A
2B
4B
2A
Sampled in 2025 (515)
Unsampled in 2025 (1375)
Expected NOAA trawl
latitude (°N)
longitude (°E)
65
60
55
50
45
40
170
180
190
200
210
220
230
240

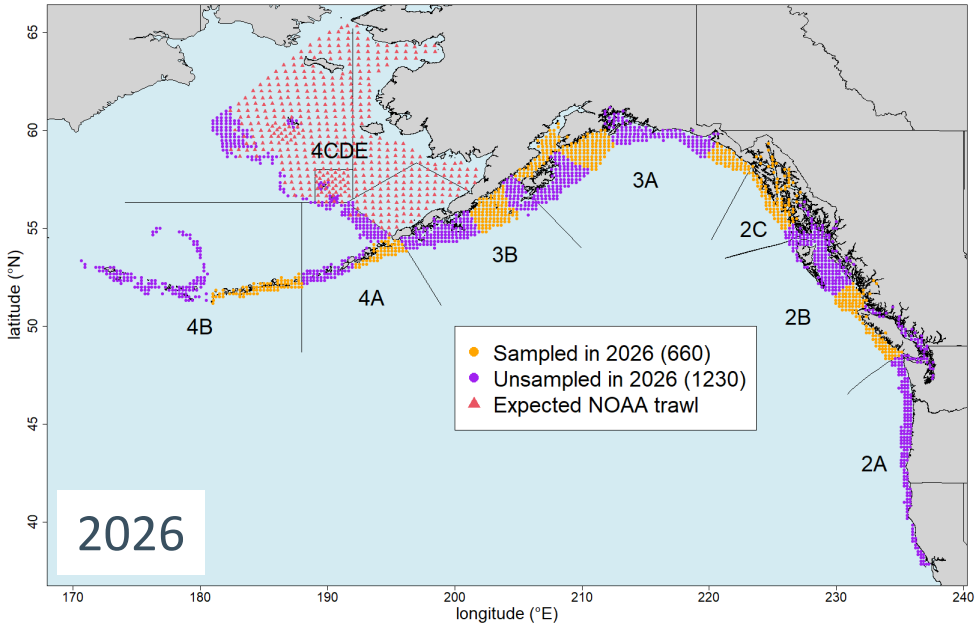
Potential designs for 2026-28

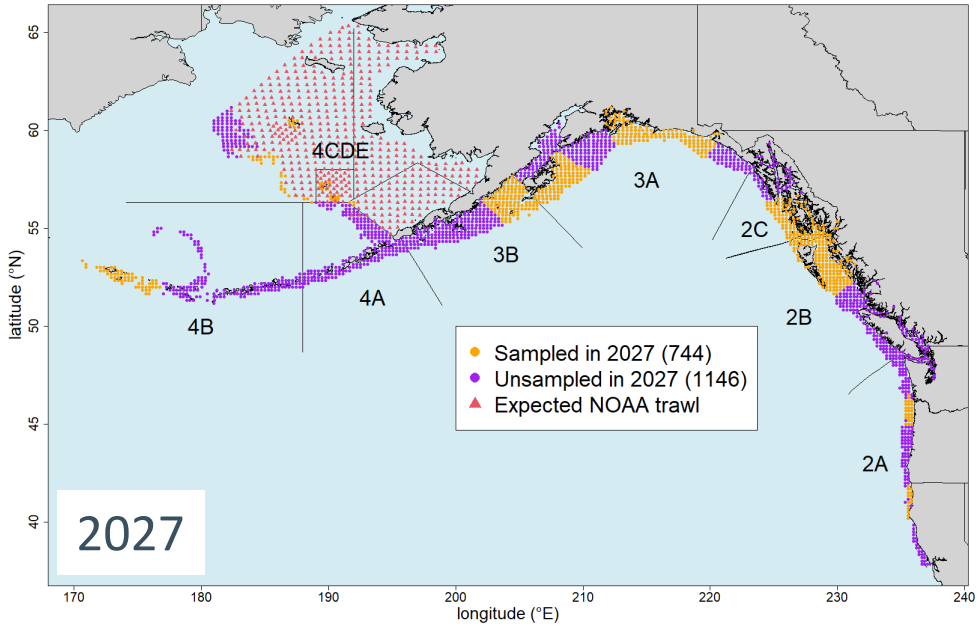
- Until 2024, initial FISS designs targeted a random selection of stations in the core IPHC Regulatory Areas (2B, 2C, 3A and 3B).
- This method for station selection was chosen in 2019 over a proposal to instead fish a selection of charter regions as blocks of stations.
- In September 2023, the Commission directed IPHC Secretariat to evaluate potential block designs for future FISS sampling
  - Reduced running time between stations in a block design leads to greater operational efficiency, an important consideration in bringing these designs forward.

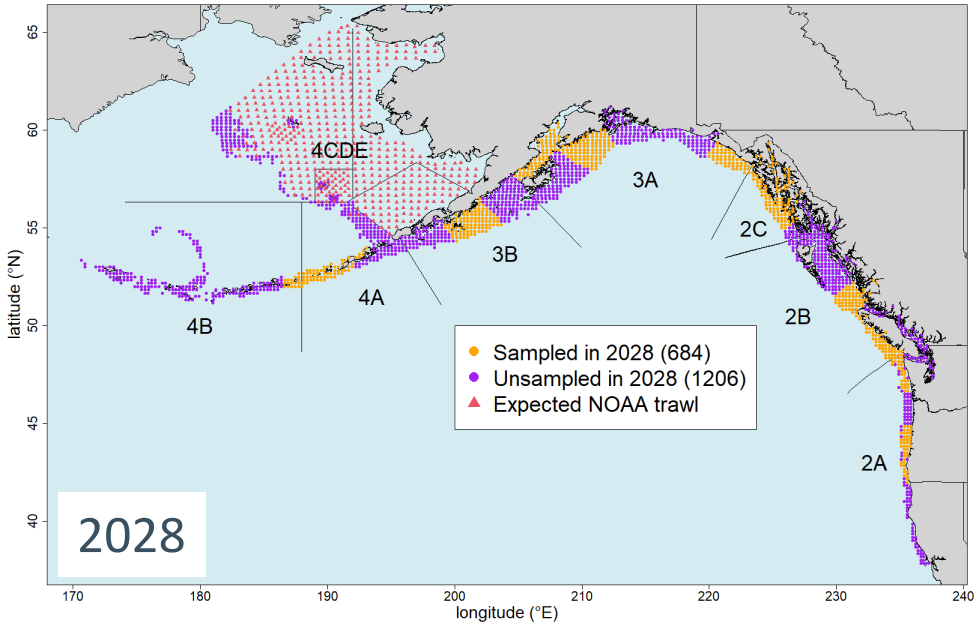
Potential designs for 2025-27

- In 2023-24, a **Base Block design** was evaluated for the Commission's consideration for the subsequent three-year period:
  - Prioritizes some annual sampling in each Biological Region for stock assessment purposes.
  - Ensures all charter regions in the core of the stock (2B, 2C, 3A and 3B) are sampled over a three-year period
  - Coverage in other areas is prioritized to minimize bias potential and maintain CVs below 25%
- The sampled blocks (charter regions) would be rotated over time.

Potential Base Block designs 2026-28





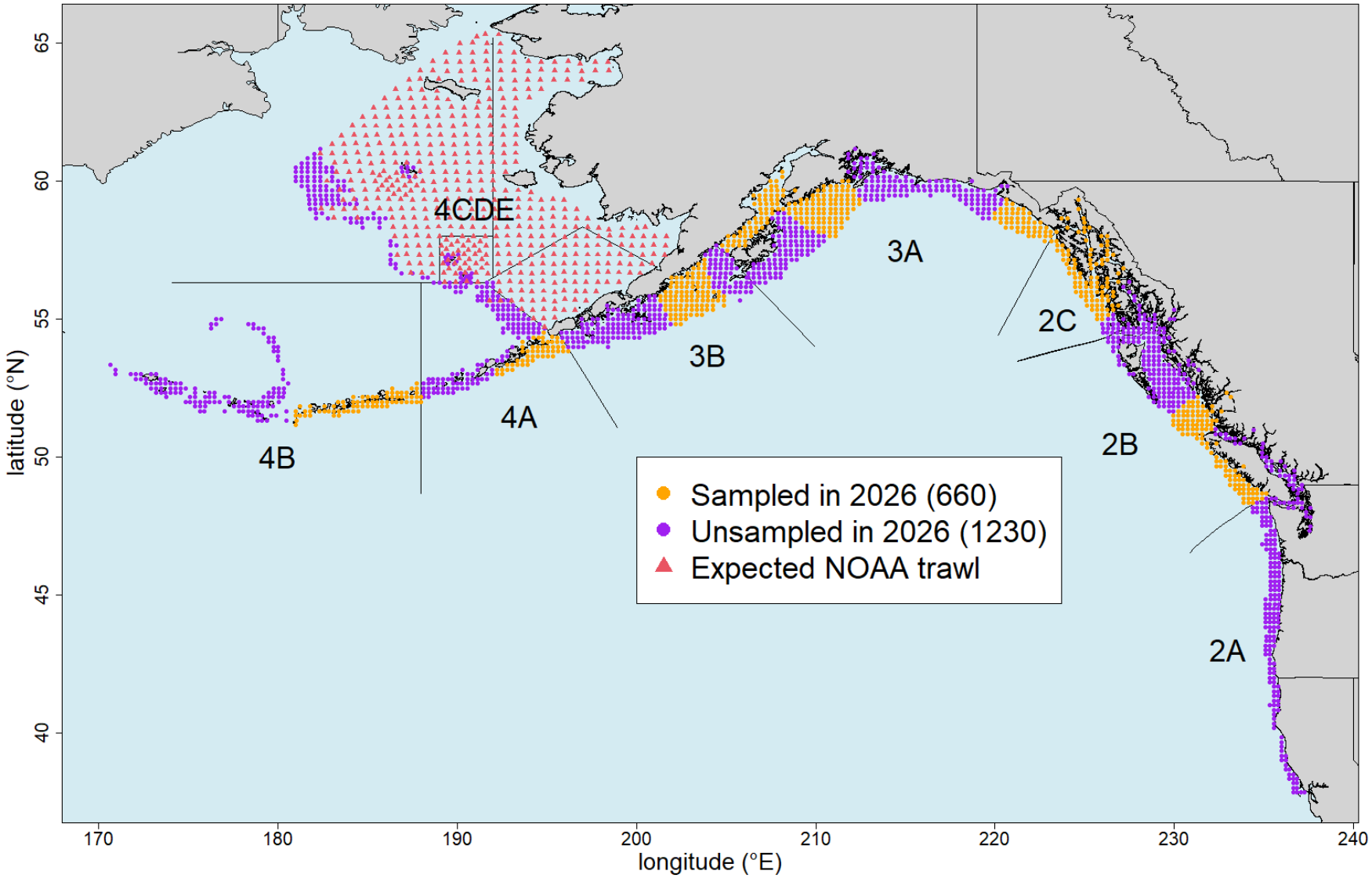


Projected coefficients of variation* (CVs)

Regulatory Area	Base Block		
	2026	2027	2028
2A	21	22	14
2B	11	7	10
2C	6	6	6
3A	8	7	8
3B	11	15	11
4A	18	22	13
4B	15	16	17
4CDE	9	9	8
Biological Region			
Region 2	6	5	5
Region 3	7	7	7
Region 4	9	10	7
Region 4B	15	16	17
Coastwide	4	4	4

* For terminal year of time series. Projected using IPHC's space-time modelling.

2026 Base Block design



Preliminary projected net revenue (US$):
($1,887,000)

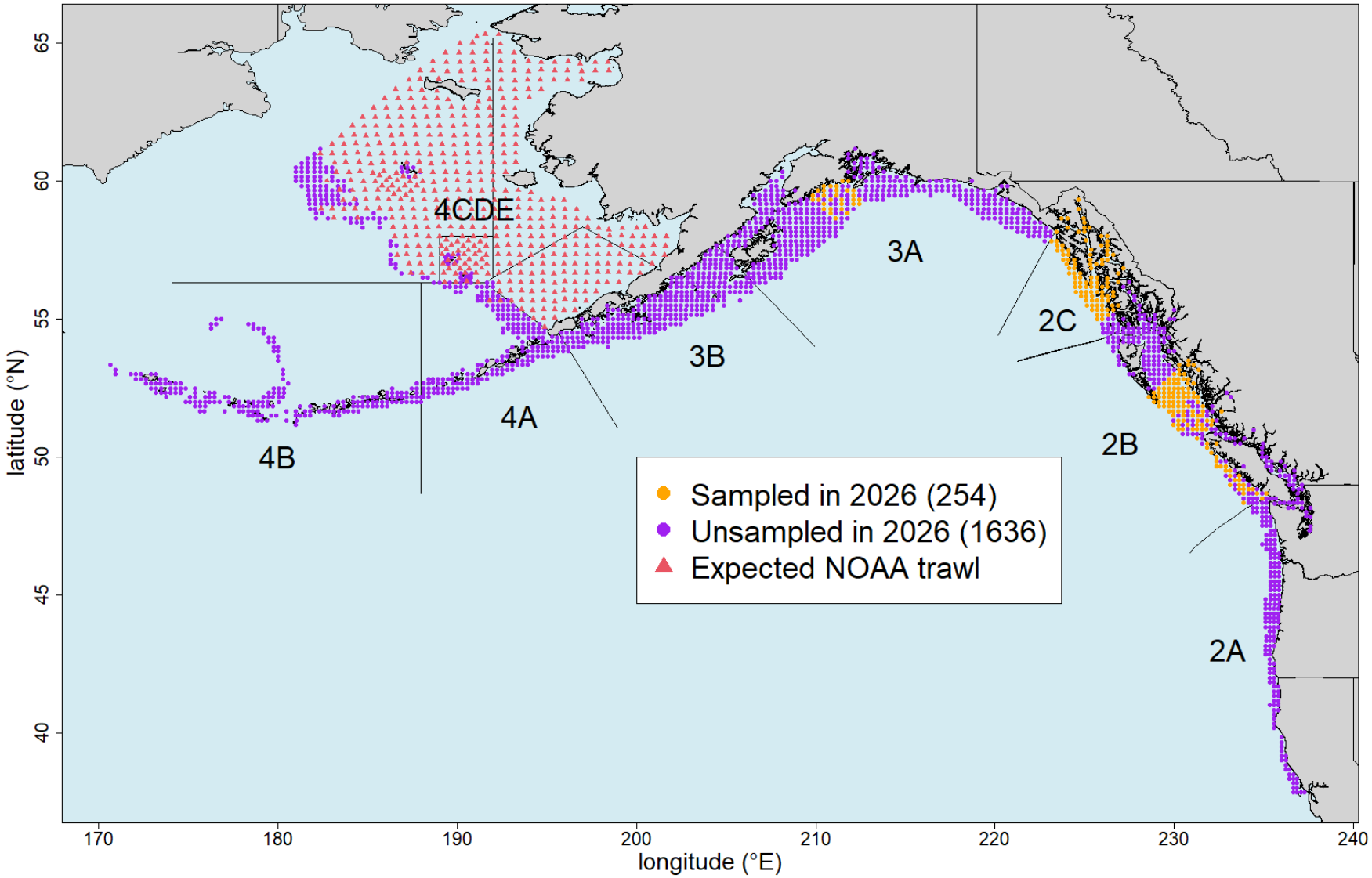
Evaluation of potential Base Block design

- Projected terminal year CVs 25% or less for all IPHC Regulatory Areas; 15% or less for core areas (2B, 2C, 3A and 3B).
- All Biological Region CVs except Region 4B projected below 10%.
- Coastwide CV is projected to be 4% in all years.
- Therefore, this design is **projected to maintain precise estimates** of indices of Pacific halibut density and abundance across the range of the stock.
- By rotating the sampled blocks, almost all FISS stations are sampled within a 5-year period (2-3 years within the core areas) resulting in **a low risk of large bias** in estimates of trend and stock distribution.

Reduced Loss design

- The Base Block design is preliminarily projected to result in a **substantial operating loss** for the FISS and would require supplementary funding
- Therefore, we developed an alternative design with a more feasible preliminary projected net operating loss of close to US$0.5 million
- This **Reduced Loss design** includes:
  - A projected revenue-positive charter region in IPHC Regulatory Area 2B
  - Three other charter regions, one in each of IPHC Regulatory Areas 2B, 2C and 3A, with 30 stations subsampled per region (53-58% of total stations in each region)
  - The three subsampled charter regions were prioritized as they were among the regions not sampled in the most recent 1-2 years

2026 Reduced Loss design



Preliminary projected net revenue (US$):
($537,000)

Note: stations shown in partially-sampled charter regions (2B and 3A) are only for the purpose of illustrating the spatial extent of the design.

Evaluation of potential Reduced Loss design

- Limited spatial coverage leads to increased risk of bias relative to Base Block design
  - Greater risk that important stock changes are unobserved
  - Space-time model estimates for unsampled regions begin to drift towards long-term mean in the absence of data
- Increased uncertainty in estimates of density indices
  - Assessment model will rely more heavily on commercial CPUE index, as it did in 2023 and 2024
- Unclear if the assessment model will detect a major change in year class abundance due to:
  - Current spatial variability and uncertainty in magnitude of younger year classes (2016 and younger)
  - Limited biological information from Biological Region 3 in the stock's core

Preliminary costs and revenue

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. 2026 Pacific halibut price and landings **decline 15% and 5%** respectively from 2025 values.

Design		Base Block	Reduced Loss
Projected costs	**Base HQ**	(534,000)	(534,000)
	(incurred even with no FISS)		
	Vessel bids	(1,306,000)	(436,000)
	Field staff expenses	(492,000)	(246,000)
	Bait	(409,000)	(195,000)
	Non-IPHC fish sales	(182,000)	(147,000)
	Other costs*	(471,000)	(279,000)
	Total costs	**(3,394,000)**	**(1,838,000)**
Projected revenue	**Total Pacific halibut sales**	1,460,000	1,260,000
	Total byproduct sales	46,000	41,000
	Total sales	**1,507,000**	**1,302,000**
Projected net revenue		**($1,887,000)**	**($537,000)**
Estimated water column profiler costs		(66,000)	(39,000)
Projected net revenue including water column profilers		**($1,953,000)**	**($576,000)**

*Other costs include staff training, personnel expenses, mailing and shipping, travel, technology, gear replacement, customs fees, bait storage fees, field supplies and equipment, equipment maintenance fees, facility rental fees, and communication fees.

Intermediate 2026 designs

- Secretariat staff prepared several designs intermediate to the Base Block and Reduced Loss designs
- Together with the Reduced Loss (Option 1) and Base Block (Option 7) designs, these designs comprised seven preliminary FISS design options for 2026
- These designs were also presented as a series of modular changes to the Reduced Loss design to assist Commissioners in selecting sampling priorities if additional funding could be committed to the FISS.

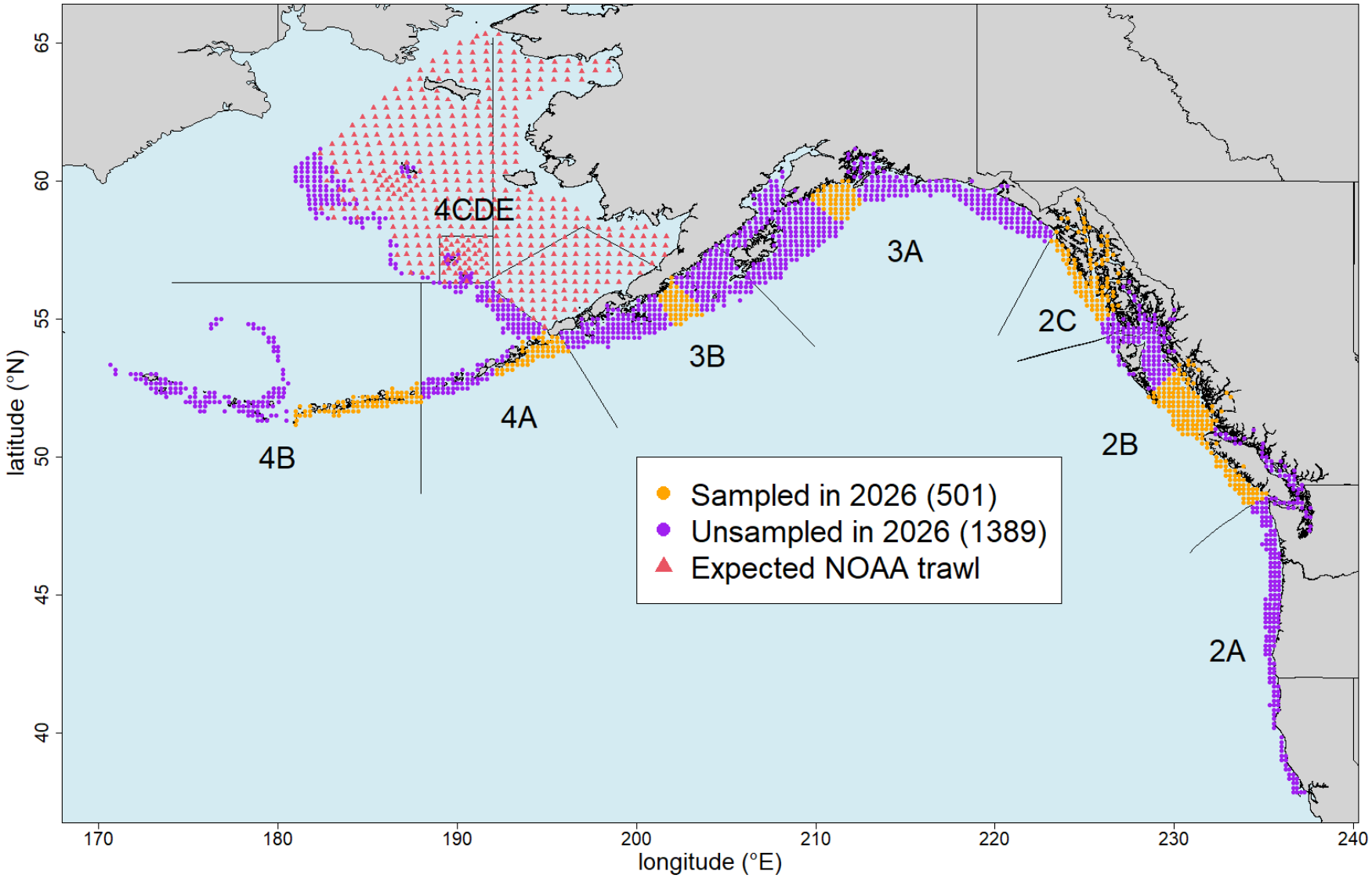
Voluntary contribution from USA

As per US State Department letter of 19 August 2025, the USA intends to make a **$513,000 voluntary contribution** to subsidize the FISS:

- $265,000 to fund the IPHC Regulatory Area 4B survey
- $163,000 to fund one charter region in IPHC Regulatory Area 3B
- $85,000 to partially fund the survey in IPHC Regulatory Area 4A

Option	Design or design change	Sampled IPHC Regulatory Areas (Option 1) (with FISS charter regions) or change from previous options (Options 2 to 7)	Net cost (Option1) or additional cost (Options 2 to 7)	Benefit/rationale
1	Reduced Loss	2B(1 full, 2 partial), 2C(2), 3A(1 partial)	($537,000)	
2	Add full sampling in all charter regions to Option 1	**2B(+2 partial)**, **3A(+1 partial)**	($54,000)	Fully sampled regions may more easily attract bids
3	Add east Adak	**4B(+1)**	($265,000)	Adds sampling in Biological Region 4B
4	Add Chignik	**3B(+1)**	($163,000)	Adds 3B sampling. Last sampled 2023.
5	Add east Unalaska	**4A(+1)**	($233,000)	Adds 4A sampling. Last sampled 2019.
6.1	Add Gore Pt	**3A(+1)**	($136,000)	Improves 3A coverage. Last sampled 2023.
6.2	Add Fairweather	**3A(+1)**	($153,000)	Improves 3A coverage. Last sampled 2023.
6.3	Add Semidi	**3B(+1)**	($159,000)	Improves 3B coverage. Last sampled 2023.
6.4	Add Shelikof	**3A(+1)**	($141,000)	Improves 3A coverage. Last sampled 2024.
7	Remove St James (Base Block)	**2B(−1)**	($44,000)	Removes lower-priority revenue positive region. Last sampled 2024.

2026 preliminary Option 5: revised cost



Updated preliminary projected net revenue (US$), including voluntary contribution from USA: **($739,000)**

Requires additional funding to fully sample proposed stations in 4A ($148,000) and other regions with partial sampling under Reduced Loss design ($54,000).

Discussion

- If adopted, Option 5 would include FISS sampling in all IPHC Biological Regions, and some sampling in all IPHC Regulatory Areas except 4CDE (sampled by NOAA trawl) and 2A
- Option 5 differs from the Base Block design as follows:
  - Has three fewer charter regions in IPHC Regulatory Area 3A
  - Has one fewer charter region in IPHC Regulatory Area 3B
  - Has one additional revenue-positive charter region in IPHC Regulatory Area 2B
- While the reduced spatial coverage in IPHC Biological Region 3 relative to the Base Block design increases the chance of bias in estimates for that region, Option 5 represents a substantial improvement over the Reduced Loss design in terms of both bias and precision.
- This will result in more representative biological data, more precise indices of abundance and stock distribution, and an assessment model that is less reliant on commercial data.

Discussion

- We note that some information remains to be finalized following completion of the 2025 FISS, including:
  - Final catch rates for all regions
  - Average sales prices of Pacific halibut
  - Final realized costs
- Sampling priorities for subsequent years may also be revised based on the results of updated space-time modelling that includes 2025 survey data
- Decisions remain to be made regarding internal funding, including the application of general funds or the 2025 FISS surplus to cover any projected losses for 2026

Recommendation

That the Scientific Review Board **NOTE** paper IPHC-2025-SRB027-09 (Part 1), which presents an evaluation of design options for 2026-28, including a preliminary option accounting for the secondary FISS objective of cost effectiveness.

Modelling updates: coastwise modelling

- At present, the IPHC models Pacific halibut survey data by fitting a spatio-temporal model to data from each individual IPHC Regulatory Area
- Model output is aggregated to produce estimates for larger geographical units (Biological Regions, coastwide waters).
- The advantages of area-level modelling include:
  - Smaller modelling regions allow for finer meshes without leading to prohibitively long runtimes
  - Faster model runtimes due to both smaller datasets and smaller modelling regions
  - Easily allows model parameters to differ among areas
- The drawbacks of splitting modelling into smaller components include:
  - Potential discontinuities at area boundaries due to differences in model parameter values between adjacent areas
  - Samples drawn from posterior predictive distributions (used to create time series of variables of interest) will not be spatially correlated across boundaries as each area's samples are drawn independently from each other

Coastwide modelling

- In recent years, there have been substantial improvements in the runtime of the spatio-temporal models (fitted via the R package, R-INLA, www.r-inla.org)
- Fitting models to coastwide data sets has therefore become more feasible
- Potential applications of coastwide models:
  - Modelling of FISS WPUE and NPUE data as a single data set, with parameters that vary across space
  - Modelling of biological data on individual fish, which may have shorter time series or larger spatial gaps than FISS catch rate data
  - Modelling of environmental data collected on FISS water column profilers

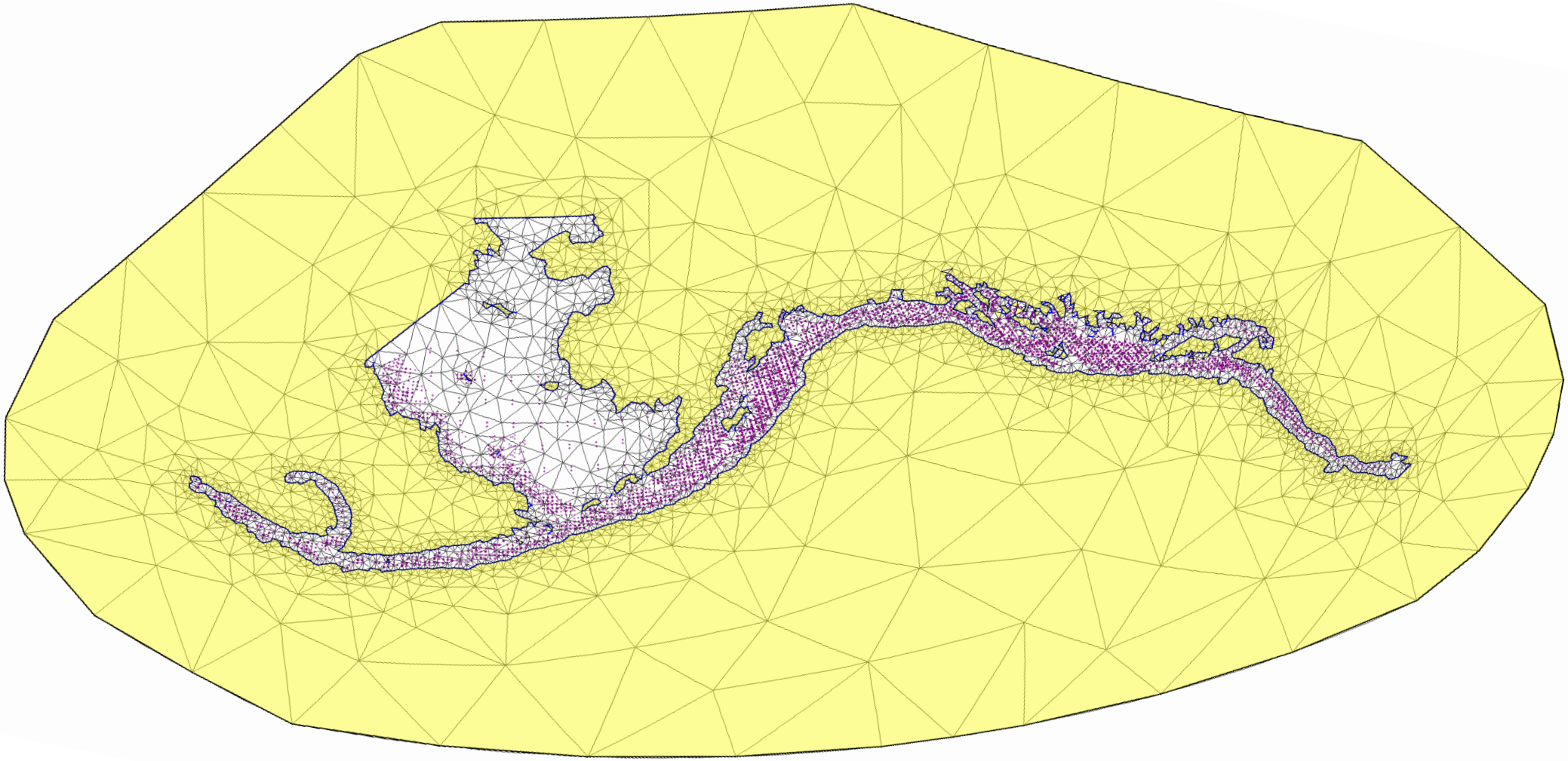
Defining a mesh for the modelling region

- The INLA approximation uses a set of basis functions defined on a triangulated mesh covering the region of interest (Lindgren and Rue 2015).
- IPHC data imply that Pacific halibut do not inhabit depths greater than 732 m (400 fathoms) at non-negligible densities during the summer survey period
  - To provide an additional buffer, we extended the region to a depth of 800 fathoms and further into Russian waters in the Bering Sea
- Other offsets were made to the mesh boundaries to smooth the edge and avoid narrow inlets, reducing the dimensionality of the modelling problem.
  - We selected values that preserved major islands and peninsulas as much as possible to ensure that nonexistent pathways were not created in the mesh space.
- The coarseness of the mesh itself was defined so that the number of vertices allowed comprehensive spatial coverage without being so numerous that the model processing would become prohibitively slow.

Barrier models

- Functions in R-INLA were used to define the land and deeper waters as barriers, which were used implement a non-stationary barrier model (Bakka et. al, 2019)
  - Ensures that the model's correlation structure cuts off pathways through land, including large islands and peninsulas, along with areas of deeper water that Pacific halibut do not inhabit.
- Barrier models define the range parameter (the distance at which the correlation between two points is small, i.e., ≈0.1) on land to be a small fraction of the value on water (e.g., 10%), and add little additional computational cost

Mesh for modelling with R-INLA using barrier models

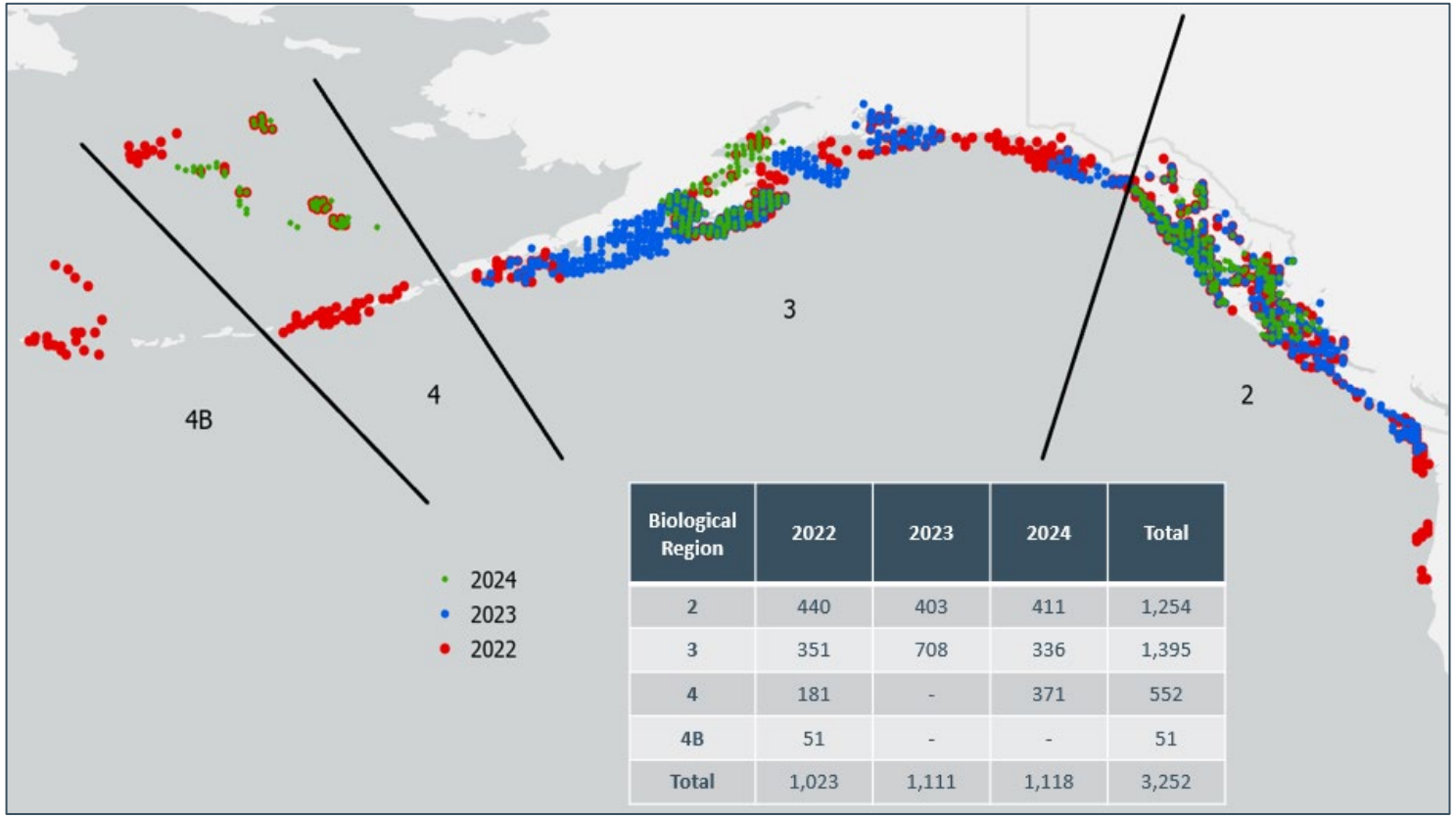


Application to histological maturity data

- The IPHC has collected histological data on Pacific halibut maturity on the FISS since 2022 (see Planas et al, 2025, for details).
- Maturity is assessed on individual female Pacific halibut, and each fish has an approximate capture location given by the midpoint of the location of the FISS set on which it was captured.
- Recent modelling of the relationship of maturity probability and age has used statistical methods that assume each fish is sampled independently
  - Ignores the likelihood of spatial correlation in the probability of maturity and the fact that fish are sampled in clusters on each set.
  - Spatial (or spatio-temporal) modelling can account for this lack of independence.

Application to histological maturity data

Spatial models can also account for uncertainty due to gaps in coverage when estimating relationships for Biological Regions or coastwide.

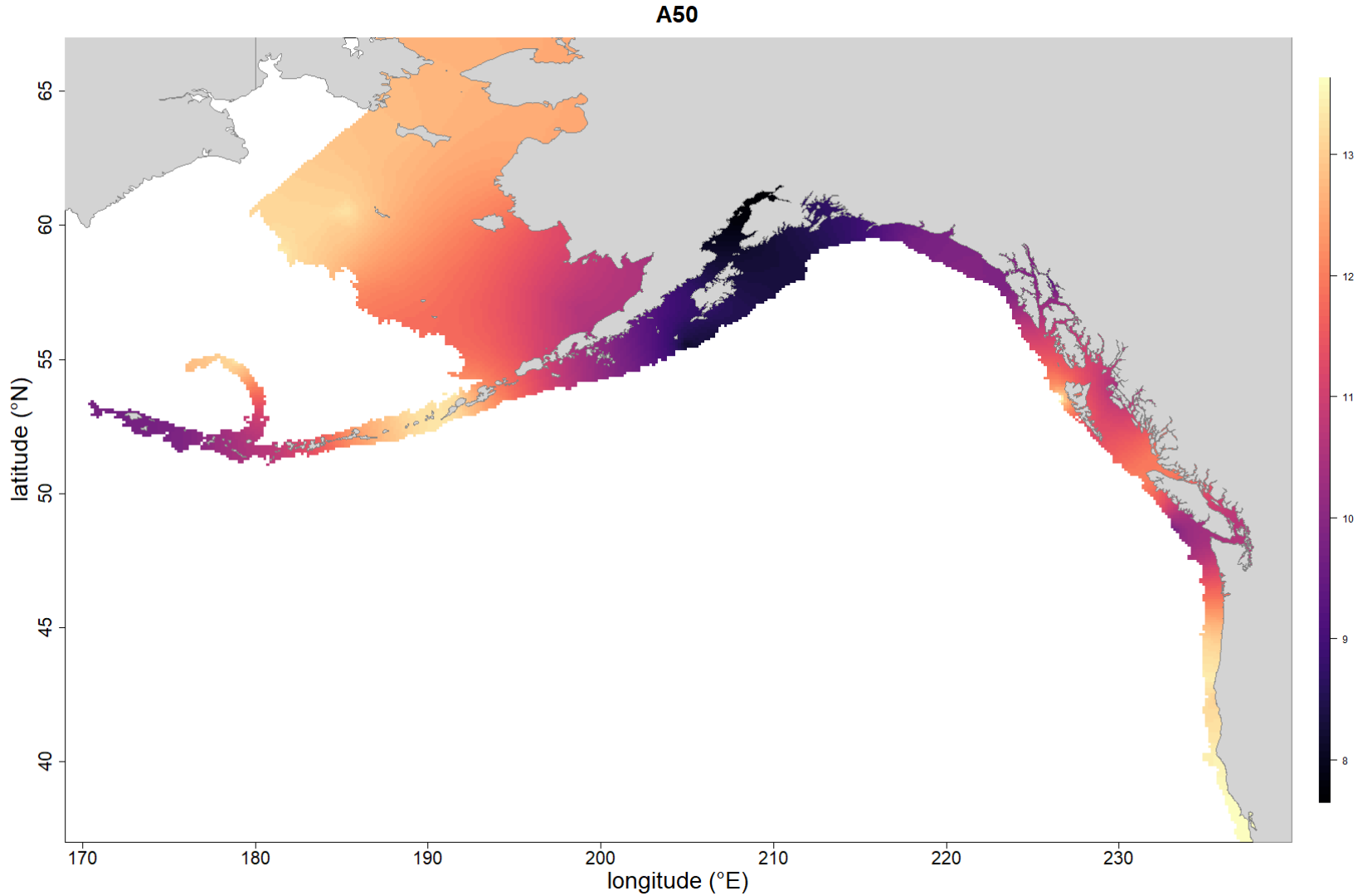


Biological Region	2022	2023	2024	Total
2	440	403	411	1,254
3	351	708	336	1,395
4	181	-	371	552
4B	51	-	-	51
Total	1,023	1,111	1,118	3,252

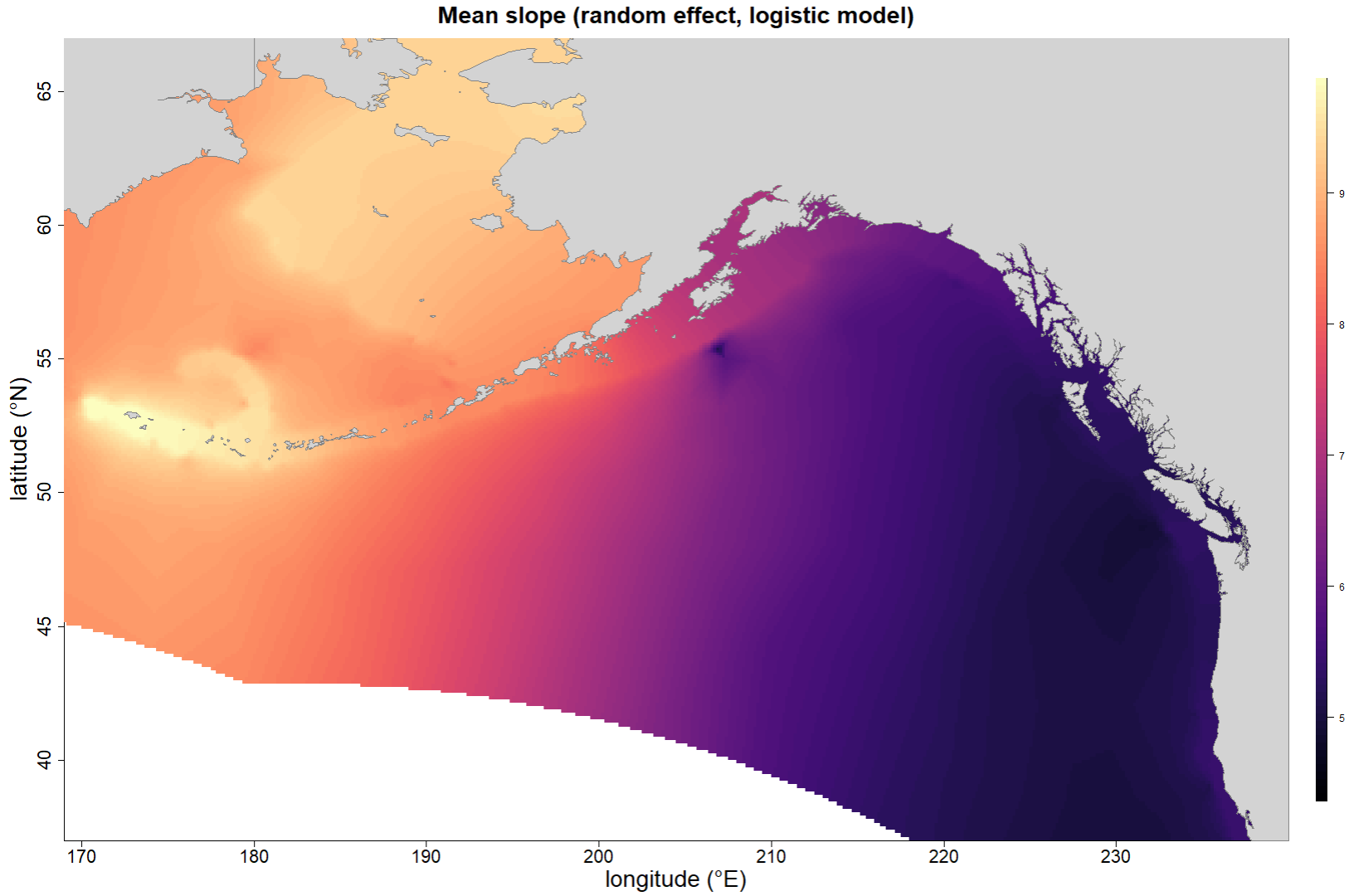
Preliminary spatial modelling

- At present, generalized additive models (GAMs) are used to estimate the relationship between maturity probability and age by IPHC biological region.
- Standard GAM models allow flexibility from a strict logistic model (i.e., linear on the logit scale) but still require the assumption of independent observations.
- To date we have fitted several spatial models of differing complexity for modelling the relationship of maturity probability and age, including:
  - Logistic models, with fixed effects for intercept and slope that vary by IPHC Biological Region, with spatially-dependent errors (Matérn covariance function)
  - Logistic models with spatially-varying intercept and slope (i.e., slope and intercept are spatially-dependent random effects)
  - Versions of the models above with added “GAM-like” flexibility through a random walk term in the age relationships.

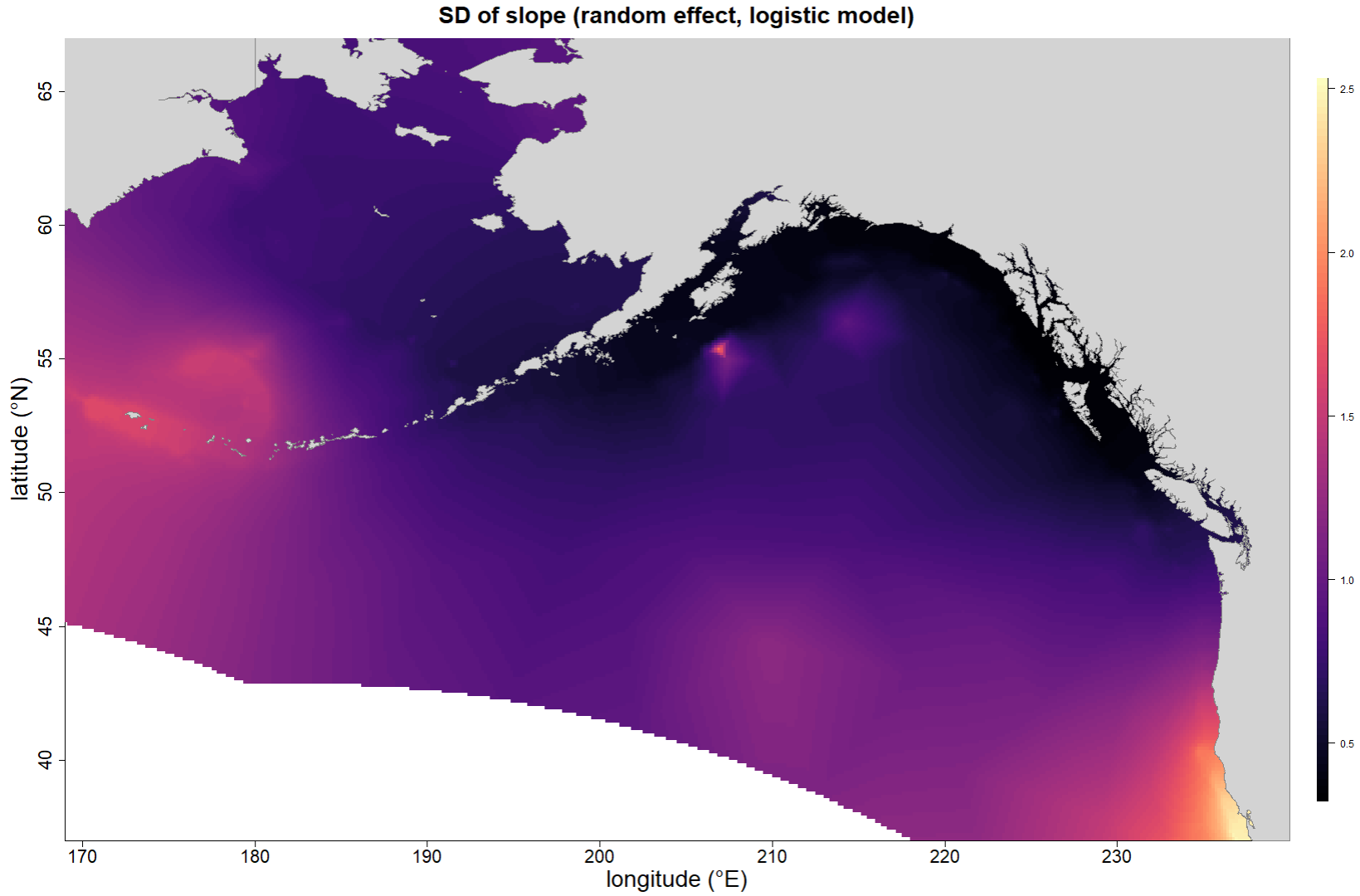
A50: logistic model with random intercept and slope



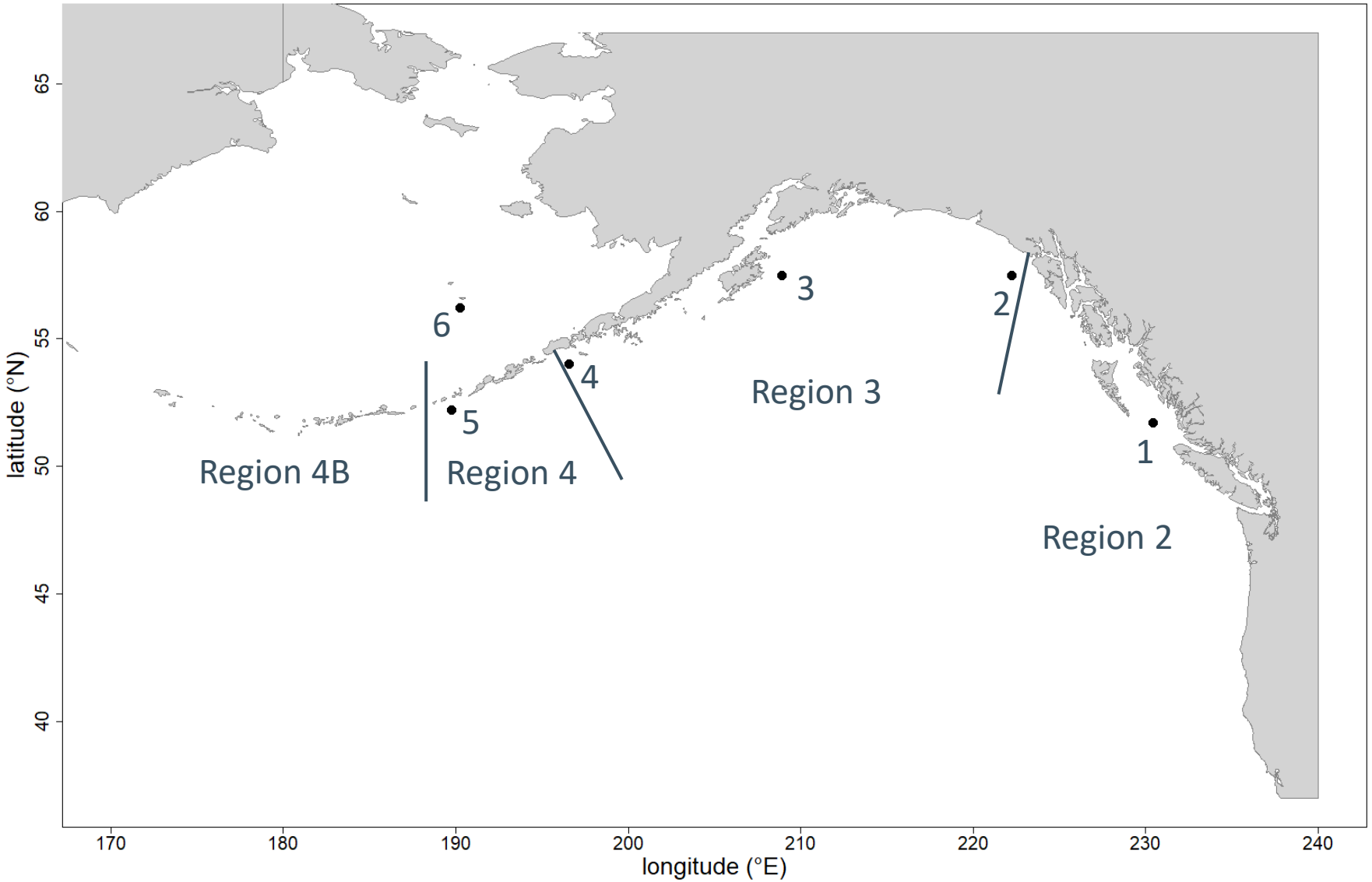
Slope random effect: logistic model

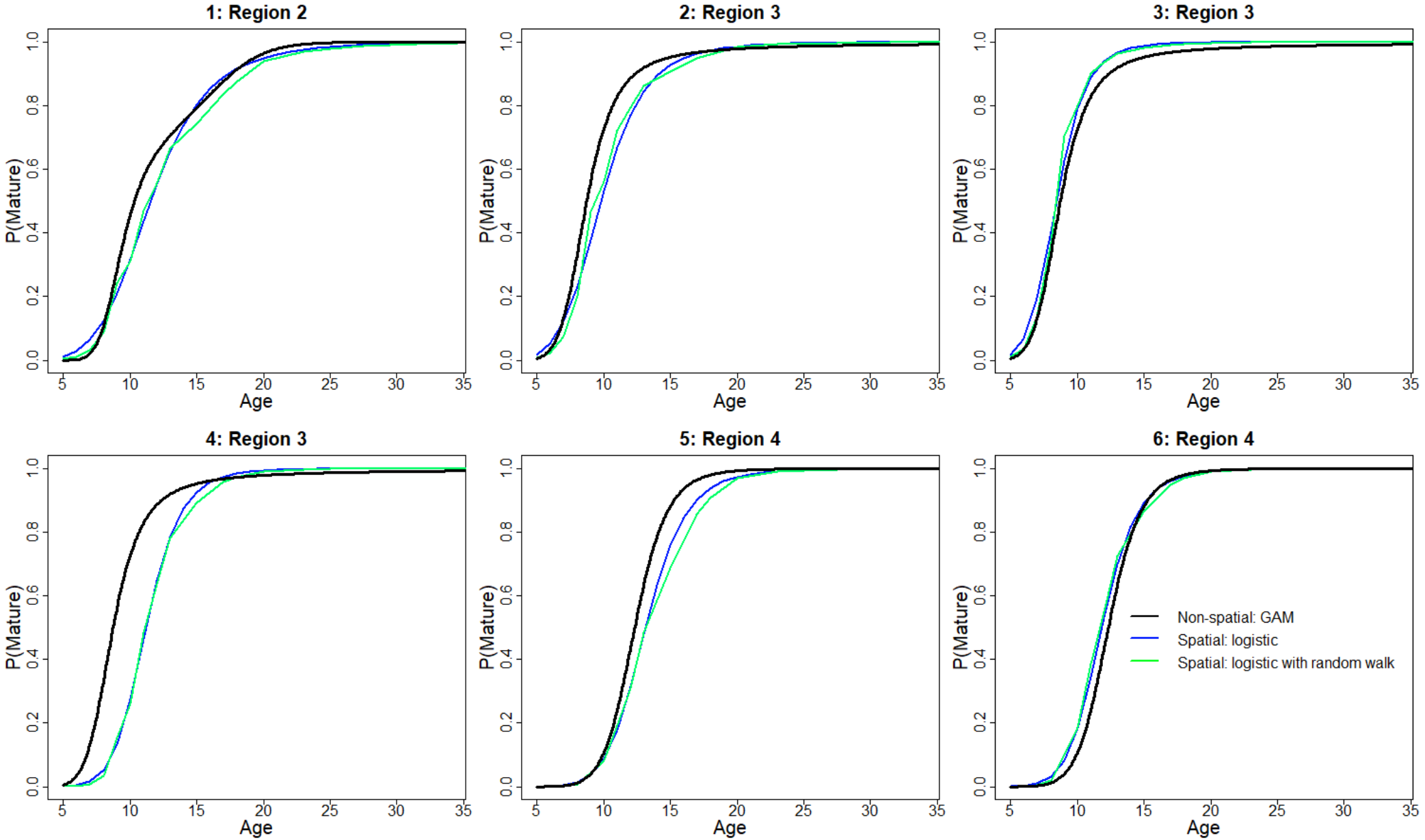


SD of slope

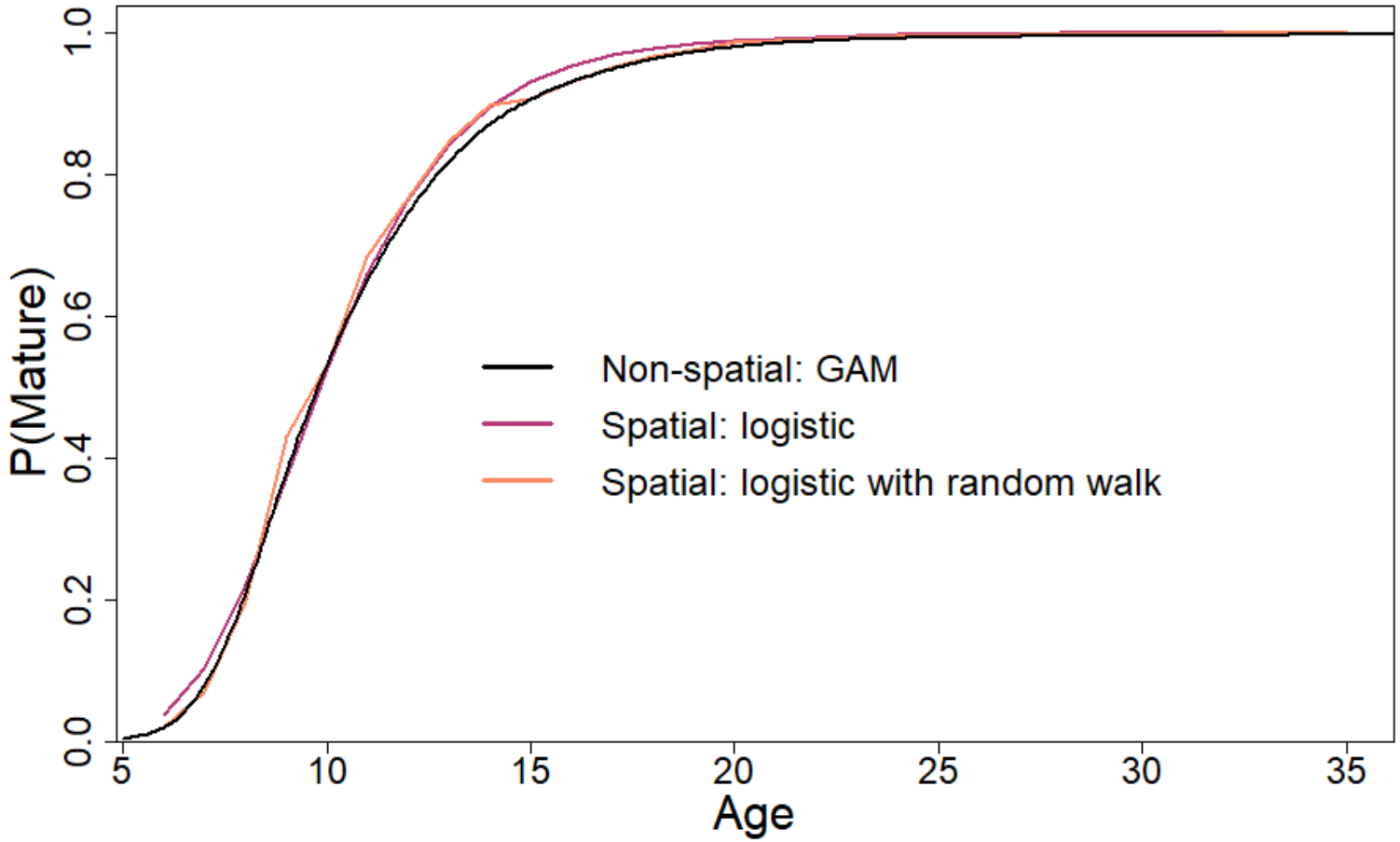

SD of slope (random effect, logistic model)
latitude (°N)
65
60
55
50
45
40
longitude (°E)
170
180
190
200
210
220
230
2.5
2.0
1.5
1.0
0.5

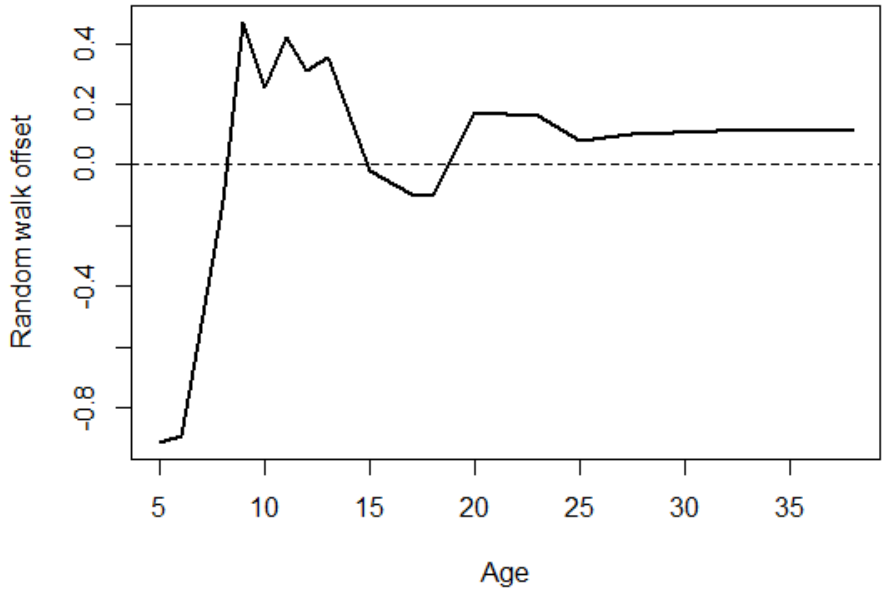
Comparison of maturity curves by location




1: Region 2
2: Region 3
3: Region 3
4: Region 3
5: Region 4
6: Region 4
P(Mature)
Age
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
25
30
35
Non-spatial: GAM
Spatial: logistic
Spatial: logistic with random walk

Coastwide maturity curves

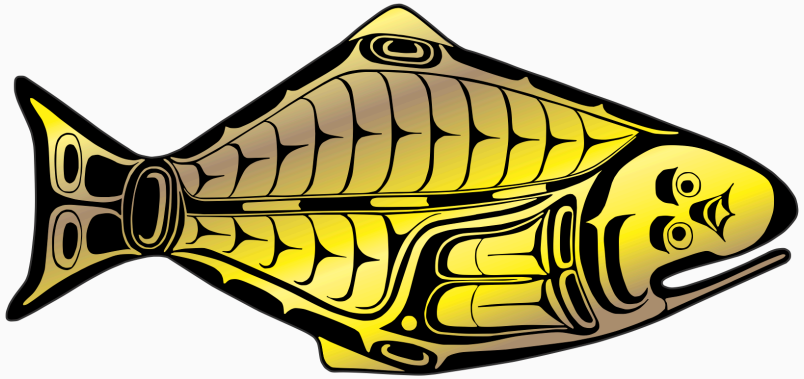




Ongoing work

- Examine other options for including GAM-like flexibility in the spatial modelling
- Generalise models to include year effects and temporal correlation
- Compute cross-validation statistics for model evaluation and comparison
- Apply coastwide models to FISS WPUE and NPUE data (2026)

INTERNATIONAL PACIFIC



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https://www.iphc.int/