INTERNATIONAL PACIFIC
HALIBUT COMMISSION

2022-24 FISS design evaluation

Agenda item: 4.1

IPHC-2021-SRB018-05 Rev_1

Summary

- Background
  - IPHC history of FISS, 1993-2019
  - Space-time modelling
  - FISS design objectives
  - Review process
- Proposed FISS designs for 2022-24
  - Evaluation and revision of designs
- Consideration of cost
- Stability of parameters in space-time model

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

FISS history 1993-2019

- A standardised FISS has been conducted by the IPHC each year since 1993
  - Standardised for bait and fishing gear
- From 1993-97 coverage was limited and generally restricted to IPHC Regulatory Areas 2B, 2C, 3A and 3B
- The modern FISS design on a 10 nmi grid began in 1998
- By 2001, annual coverage occurred in all IPHC Regulatory Areas
  - Depth range 20-275 fathoms in Gulf of Alaska and Aleutian Islands
  - Depth range 75-275 fathoms along Bering Sea shelf edge

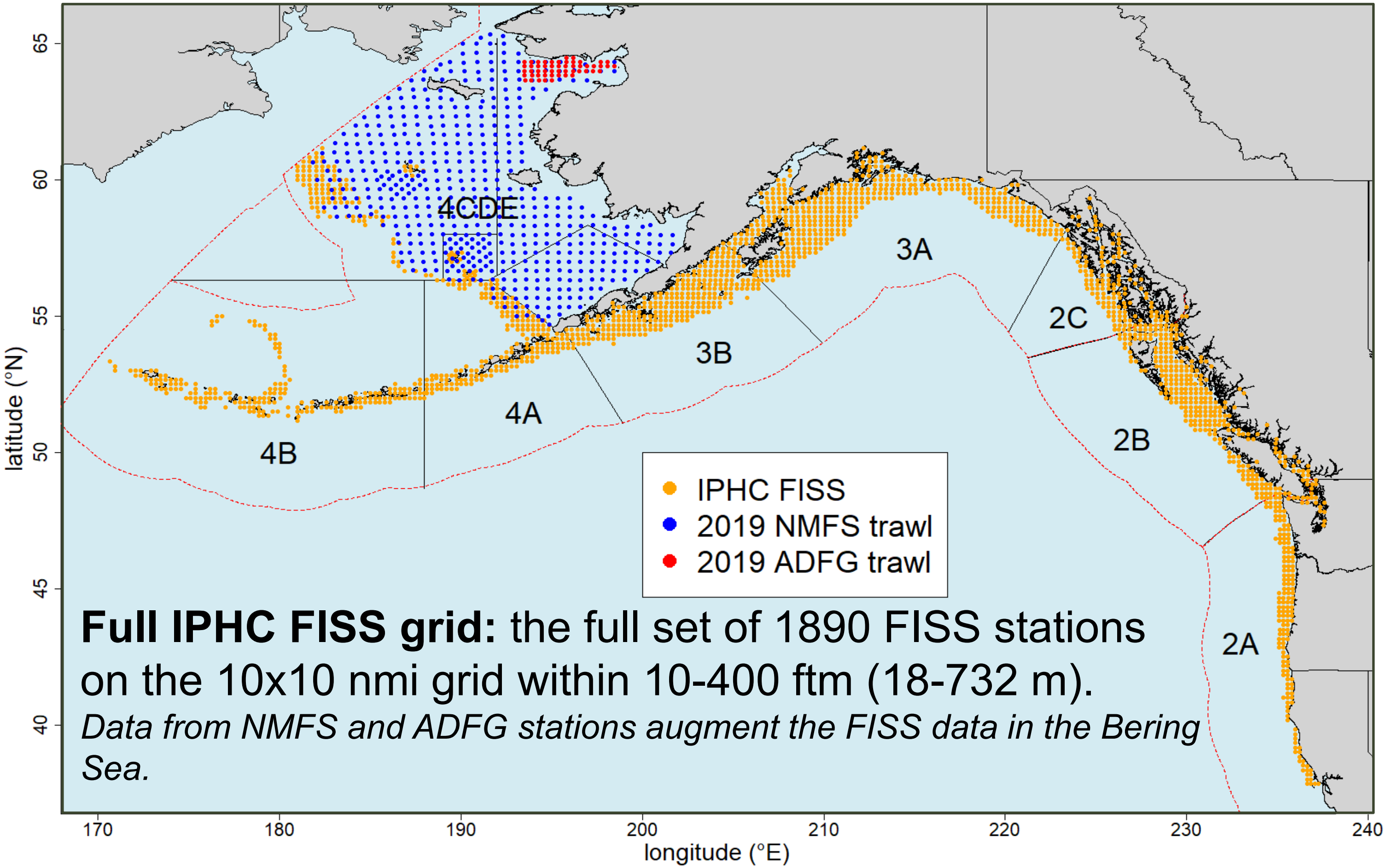
FISS history 1993-2019

- By 2010, data from other sources showed that not all Pacific halibut habitat was covered by the FISS
  - Pacific halibut were present outside the FISS depth range, in both deep and shallow waters
  - All IPHC Regulatory Areas had coverage gaps, even within the standard depth range
- Such unsampled habitat meant there was the potential for bias in estimates derived from FISS data
- Therefore, a series of FISS expansions from 2011 to 2019 were undertaken covering previously unsampled habitat in all IPHC Regulatory Areas

FISS history 2011-2019

- During the expansions, the FISS occupied for the first time 34% of the stations on the full 10 nmi FISS grid that had been previously unsampled
- The result was an improved understanding of Pacific halibut density and distribution
  - Bias was reduced, with indices for several Regulatory Areas being revised upwards or downwards
  - Uncertainty in estimates of WPUE and NPUE was reduced in most Regulatory Areas
  - These improvements were apparent throughout the time series, not only in the year of the expansion
- The resulting expanded grid of 1890 stations has provided a full FISS design from which stations can be selected for sampling in each annual FISS

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.

Space-time modelling

- Space-time modelling of survey data has been used since 2016 to produce WPUE and NPUE estimates
- The modelling has two key purposes:
  - It smooths the data in time and space
    - Makes use of information on spatial and temporal relationships among survey stations to “sort the signal from the noise”
  - It fills in gaps in survey coverage using model predictions, while accounting for uncertainty
    - Gaps previously filled using ad hoc scaling factors based on ratio of averages in surveyed and unsurveyed habitat

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

Review process

- Based on these objectives, the IPHC Secretariat staff developed methods for evaluating potential future FISS designs, and presented proposed designs for review:
  - Evaluation methods were reviewed at SRB014 and SRB016
  - Design proposals for 2020-22, and for 2021-23 were presented at SRB, Interim, and Annual Meetings in 2019/20 and 2020/21

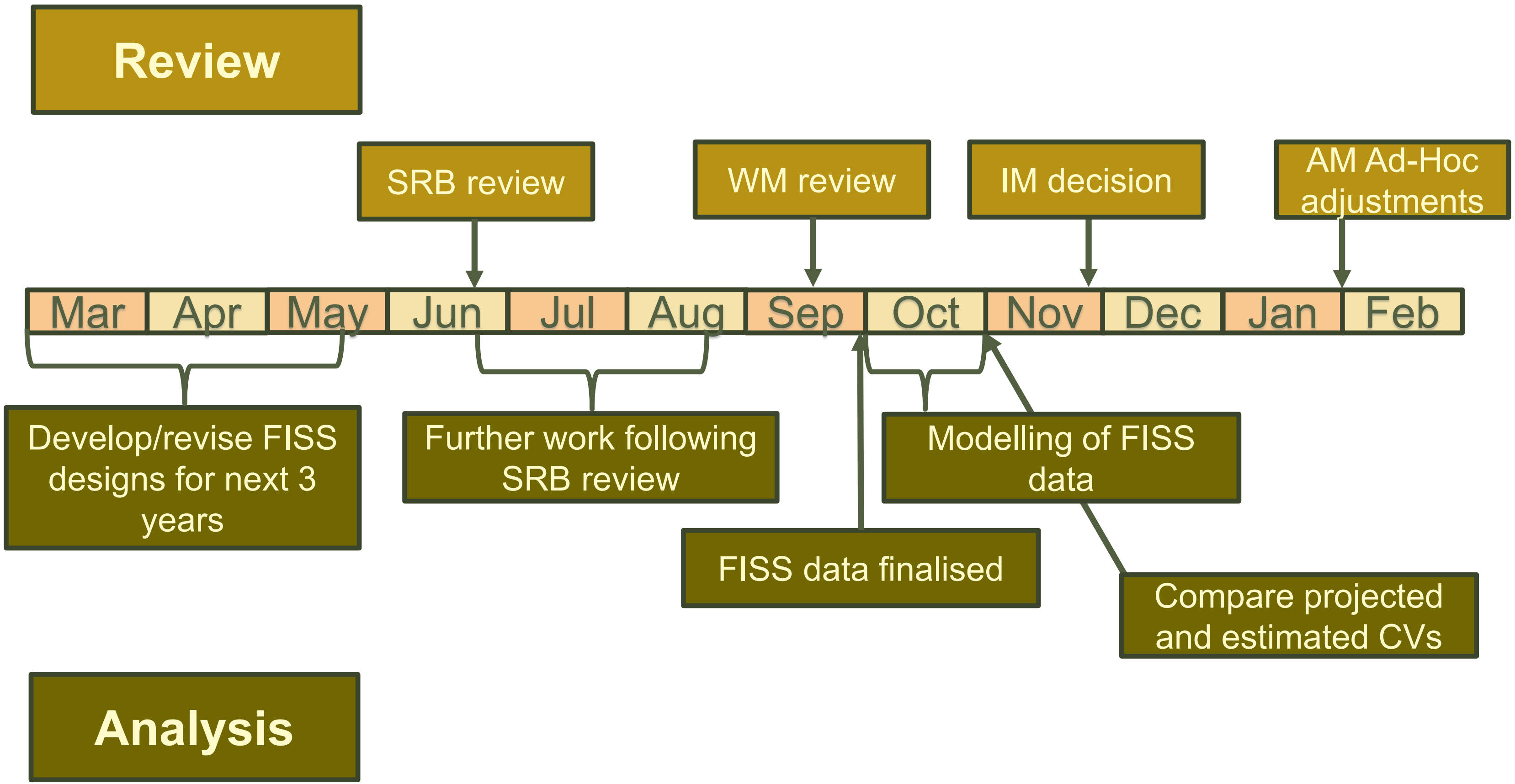
Review process

- The following design proposal and review process has now been established:
  - IPHC Secretariat staff present design proposals to the SRB for three subsequent years at the June meeting
    - Proposals based on data from prior years only
  - First review of design proposals by Commissioners at September work meeting, revised if necessary based on SRB input
  - Presentation of proposed design at the November Interim Meeting for approval
  - Ad-Hoc modifications possible at Annual Meeting (due to unforeseen issues arising).

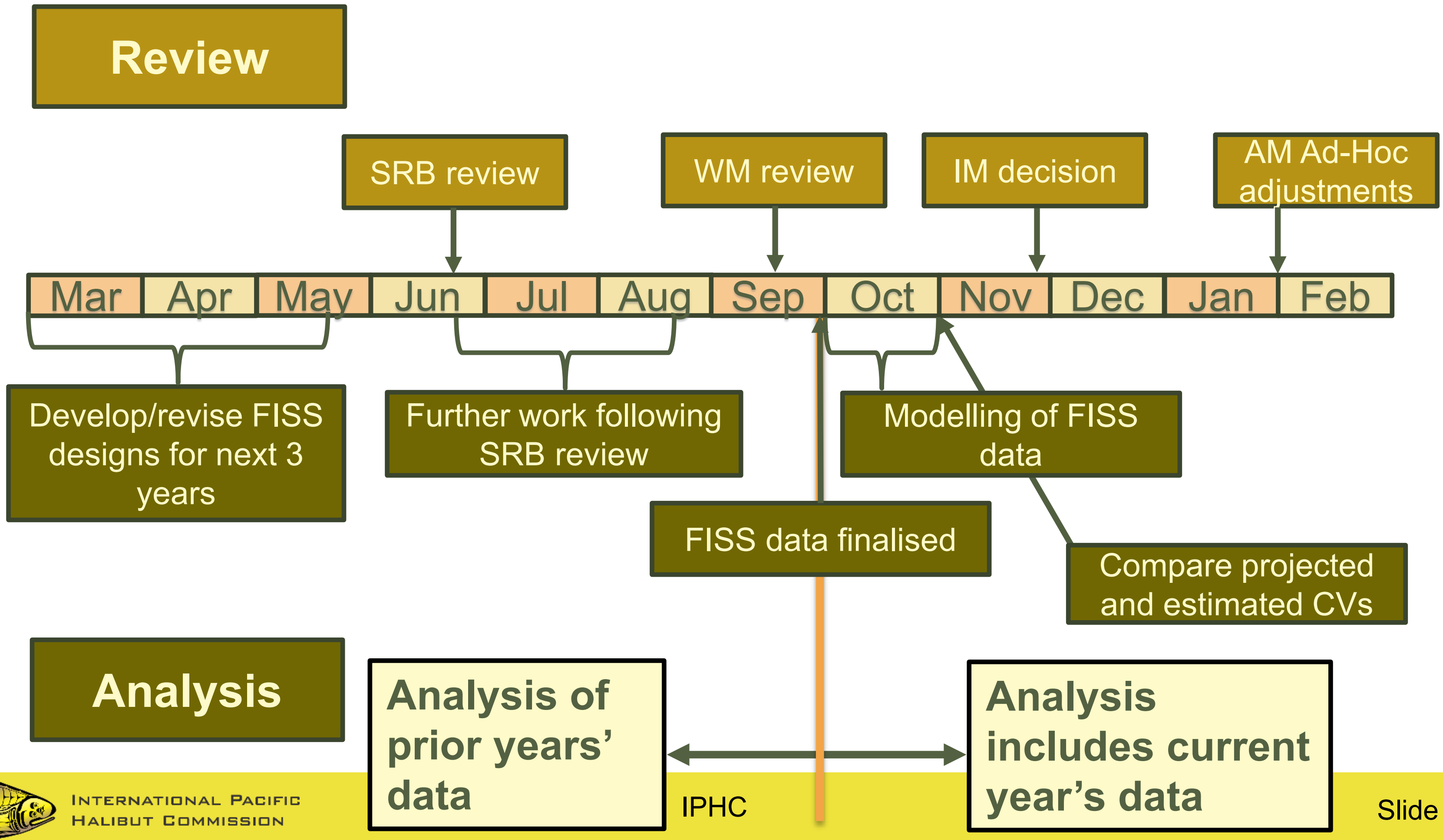
Stakeholder input

- Consultation with industry and stakeholders occurs throughout the FISS planning process
  - Input is particularly valuable in finalizing design details as part of the FISS charter bid process, when stations can be added to provide for improved logistical efficiency.
- We also note the opportunities for stakeholder input during public meetings (Interim and Annual Meetings) and through the IPHC’s Research Advisory Board.

Annual FISS design review/analysis timeline

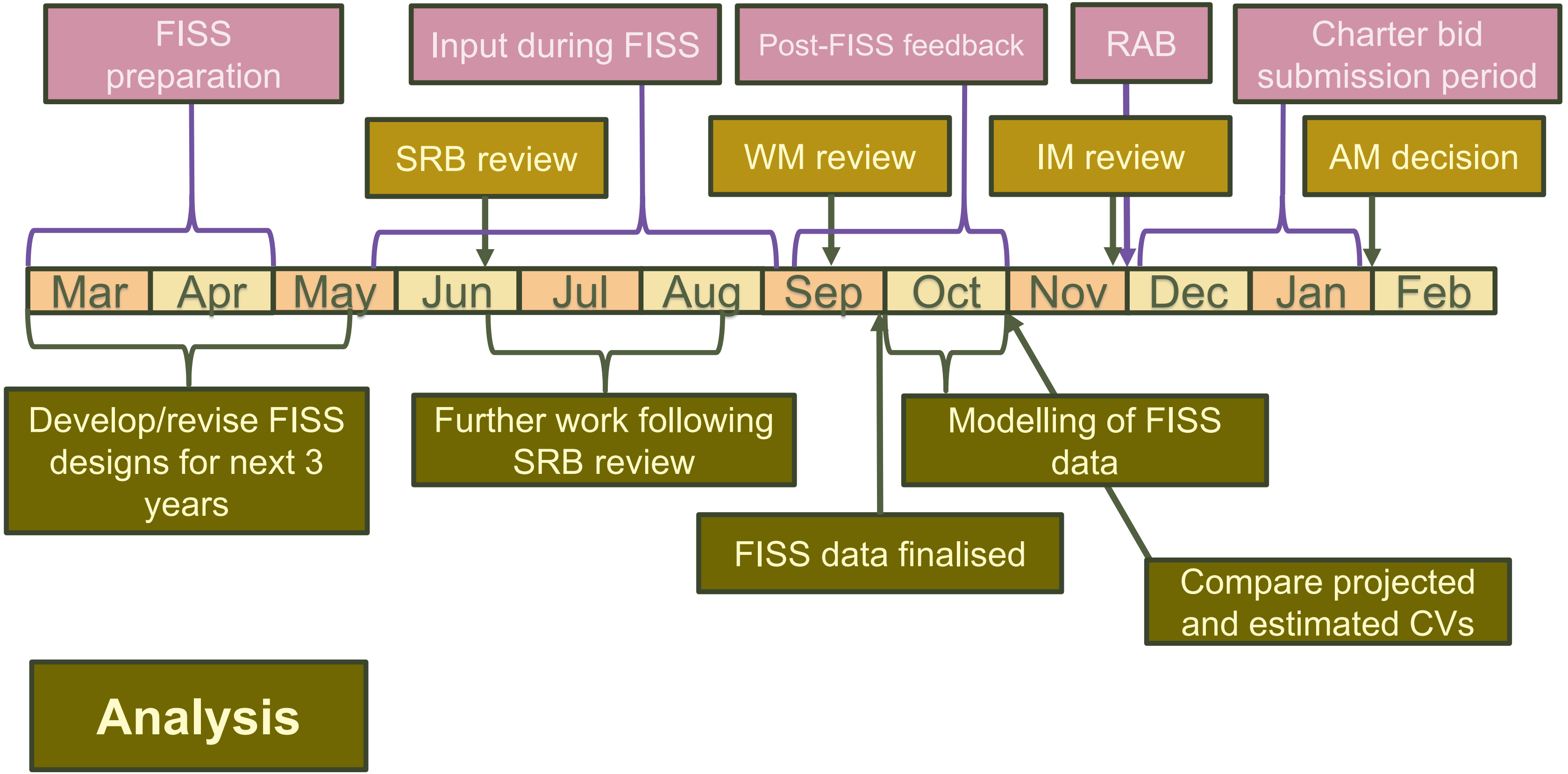


Annual FISS design review/analysis timeline



Annual FISS design review/analysis timeline

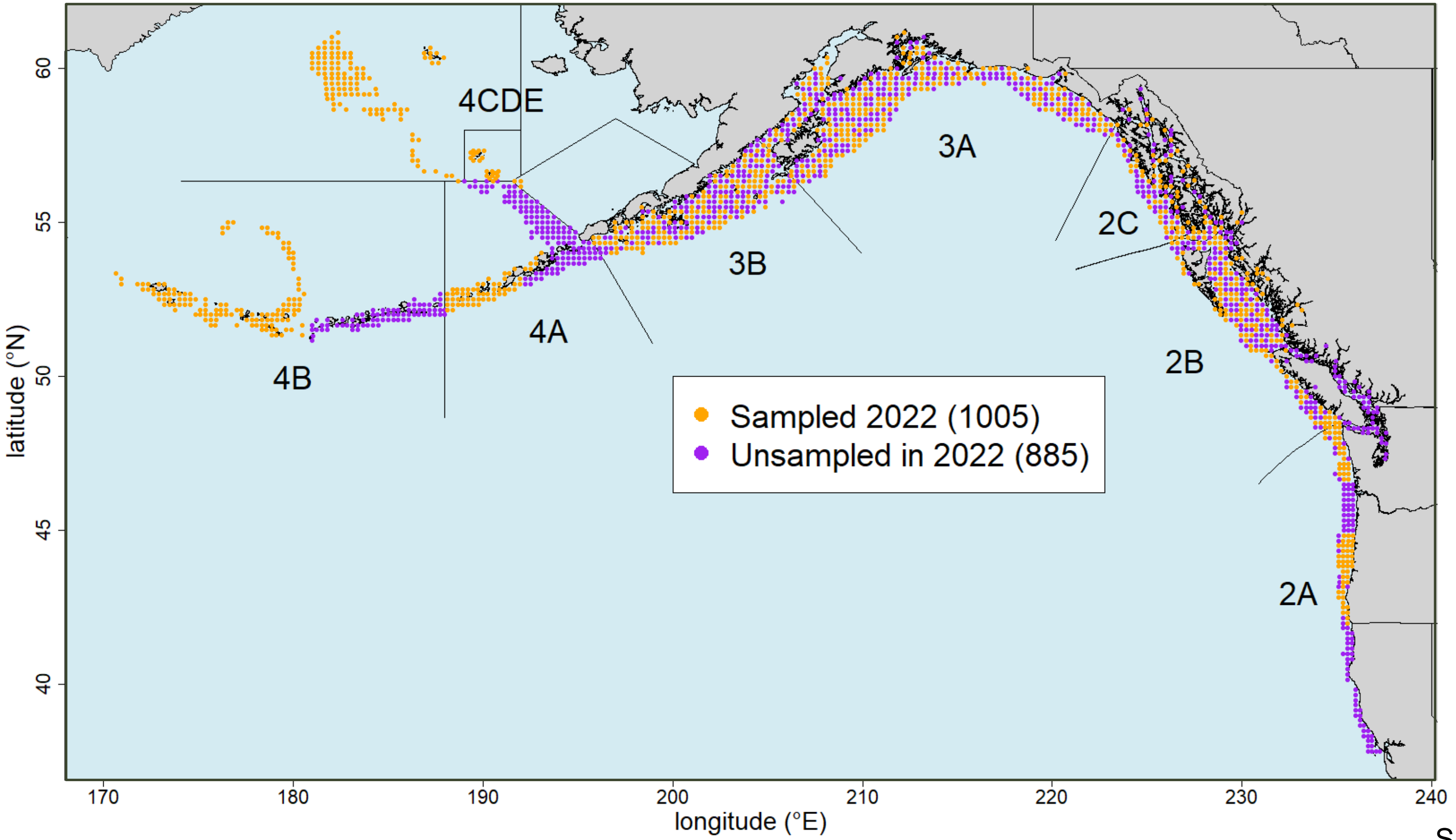
Stakeholder input



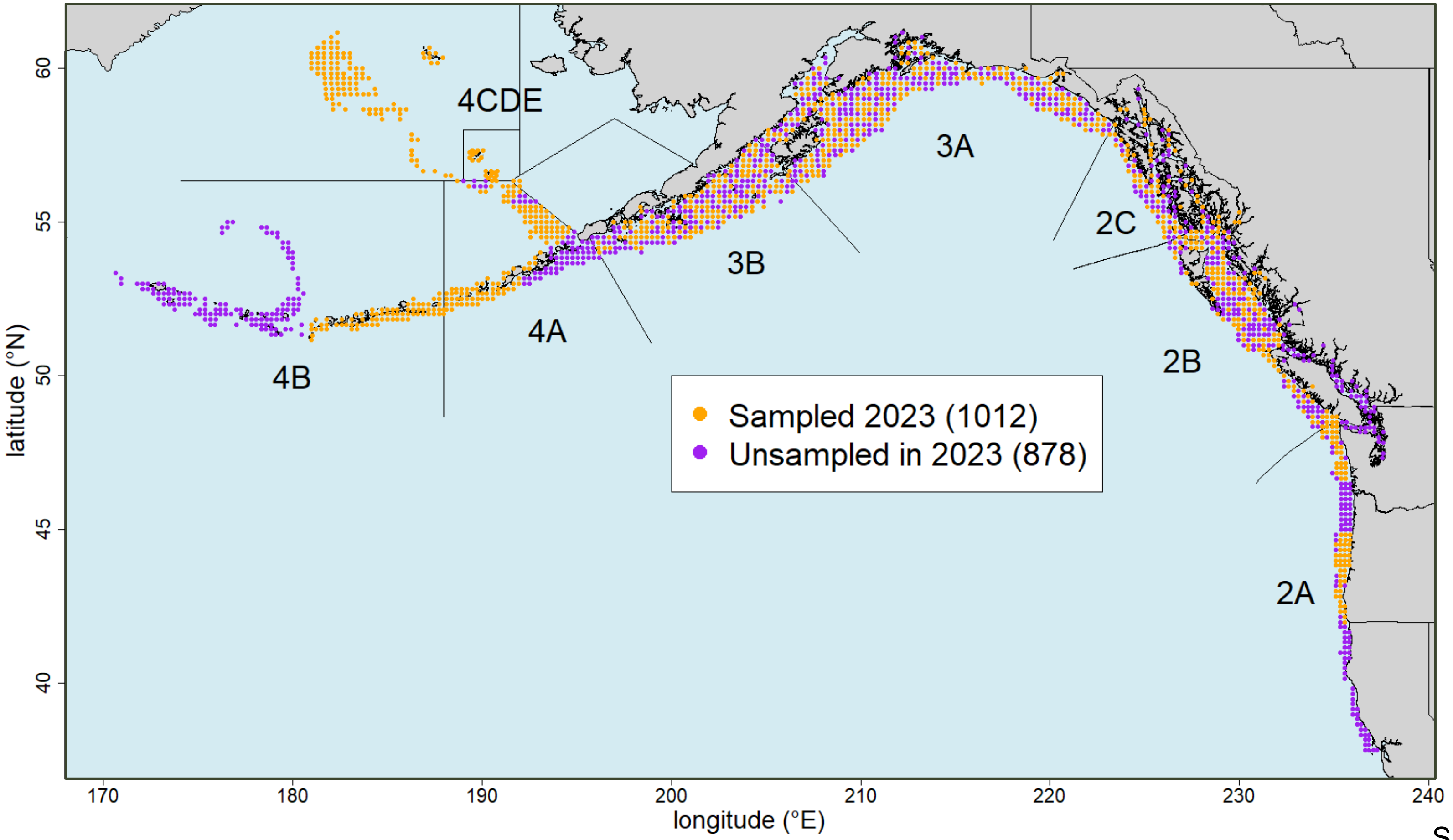
Proposed FISS designs for 2022-24

- As in 2021, the proposed designs use efficient subarea sampling in IPHC Regulatory Areas 2A, 4A and 4B, but incorporate a randomized design in IPHC Regulatory Areas 2B, 2C, 3A and 3B
- We continue to propose sampling all standard FISS stations in IPHC Regulatory Area 4CDE
  - A highly dynamic area with apparently northward-shifting distribution, and uncertainty regarding connectivity with populations near to and within in Russian waters
- It is likely that these designs represent the maximum effort that can be deployed outside the core areas in coming years, while still meeting the Secondary Objective.

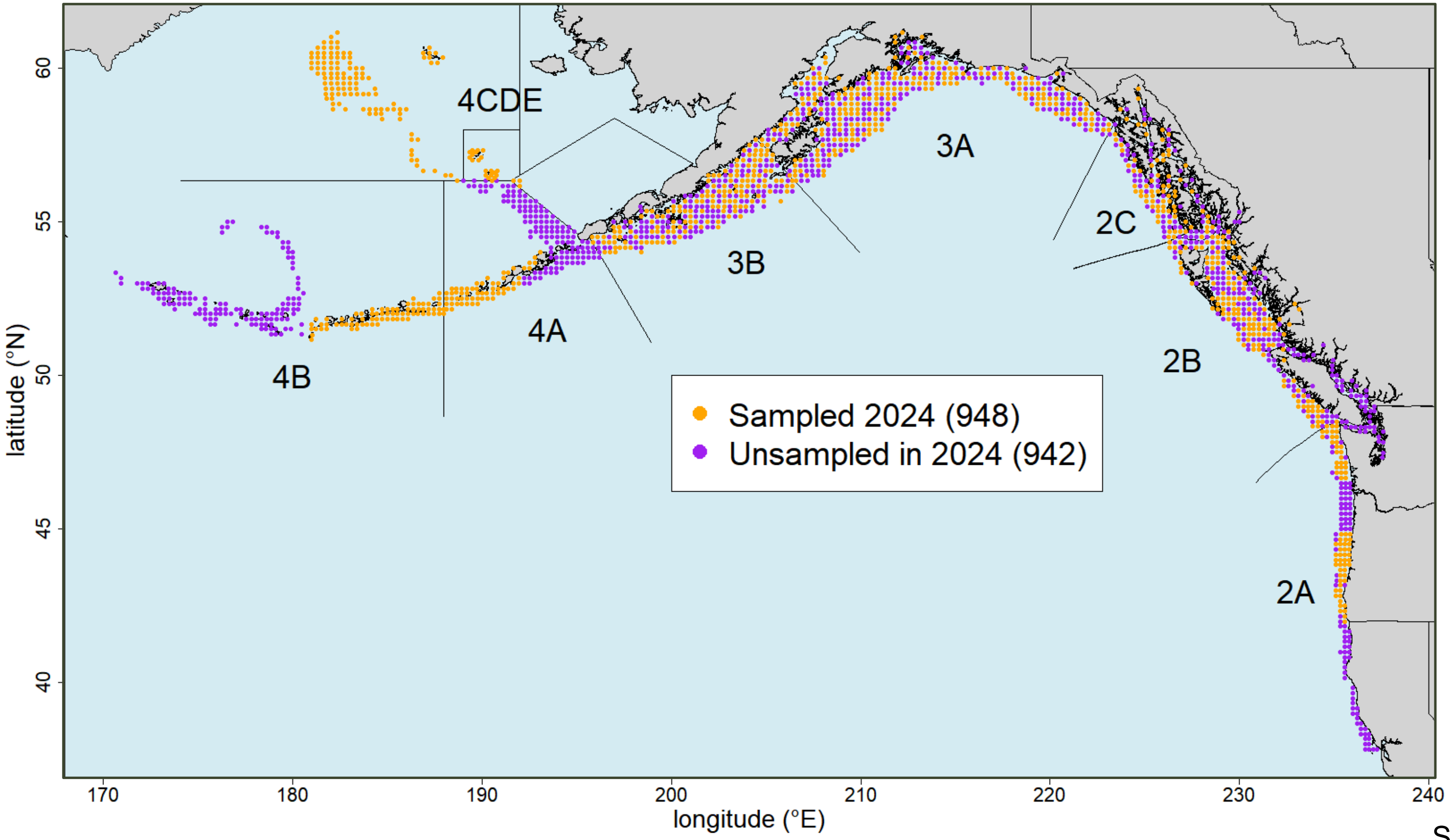
Proposed 2022 FISS design



Proposed 2023 FISS design



Proposed 2024 FISS design



Projected CVs

- The proposed designs have high sampling rates in Regulatory Areas 2B, 2C, 3A, 3B and 4CDE
  - CVs will remain well within the target range (<15% per Reg. Area)
- Randomised or full sampling designs in these areas will result in unbiased estimation
- In other Reg. Areas we project the following CVs (%) after completion of the 2024 FISS:

Reg. Area	2021	2022	2023	2024
2A	13	13	14	15
4A	10	9	9	10
4B	10	12	10	12

Projected CVs

- As CVs are typically greater in the terminal year of the time series, we also looked at projected CVs (%) following the 2022 FISS
  - Estimates from the most recent year will be used for management

Reg. Area	2022 (est. 2022)	2022 (est. 2024)
2A	**14**	13
4A	**10**	9
4B	**14**	12

Minimizing bias

- To minimize bias due to not sampling one or more subareas each year, we selected a sampling frequency that aims to keep the change in biomass proportion of each subarea within 10% between successive sampling years.
  - This is based on estimated changes in WPUE over the 1993-2020 period
- For example, if a subarea's % of its Reg. Area's biomass changed by no more than 8% over 1 or 2 years but by up to 12% over 3 years, we should sample it at least every three years.

Maximum expected unobserved change in biomass % across all subareas since previous sampling, based on proposed 2022-24 designs and assuming implementation of proposed 2021 design.

Reg. Area	2021	2022	2023	2024
2A	8%	9%	9%	9%
4A	8%	10%	6%	6%
4B	10%	9%	8%	10%

Annual revision of FISS design proposals

- As new FISS data come in each year, we revise our understanding of the spatial distribution of Pacific halibut.
- Local contraction or expansion of the distribution, or changes in inter-annual variability in subareas, can lead to revisions in the future frequency of FISS sampling in each subarea that will be incorporated into subsequent design proposals.

Projected CVs

- As part of our evaluation of the FISS design process, each year we will compare projected CVs for O32 WPUE for all sampled IPHC Regulatory Areas with those estimated from the models including the most recent data.

Reg. Area	2020 projected CV	2020 estimated CV
2A	-	22%
2B	6%	6%
2C	6%	5%
3A	4%	4%
3B	10%	10%
4A	-	25%
4B	-	25%
4CDE	-	12%

Consideration of cost

- The proposed FISS designs for 2022-24 incorporate some consideration of cost
  - Logistically efficient subarea designs are proposed in lower-density IPHC Regulatory Areas.
- The goal here was to provide statistically efficient and logistically feasible designs for consideration by the Commission
- 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 costs

Consideration of cost

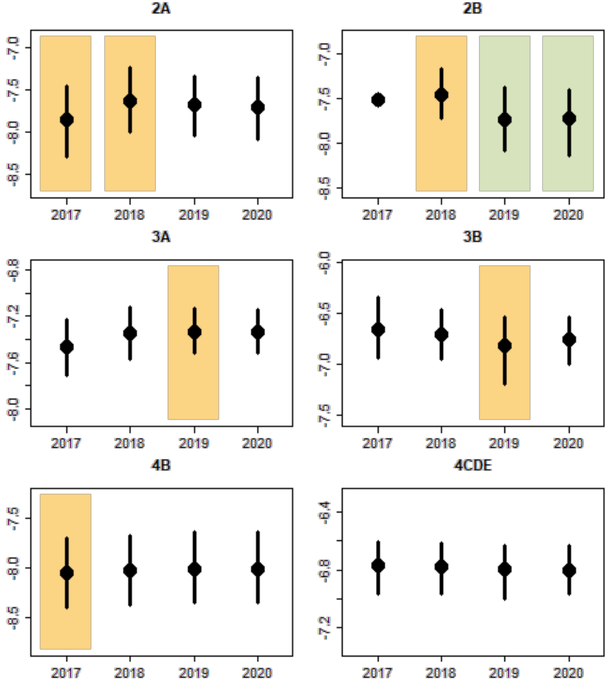
- Balancing these factors may result in modifications to the design proposals:
  - e.g., may need to increase sampling effort in high-density regions and decrease effort in low density regions
- At present, with stocks near historic lows and low prices for fish sales, the current funding model may require that some low-density habitat be omitted from the design entirely, as occurred in 2020
- This will have implications for data quality, particularly if such reductions in effort relative to proposed designs continue over multiple years.

Parameter stability

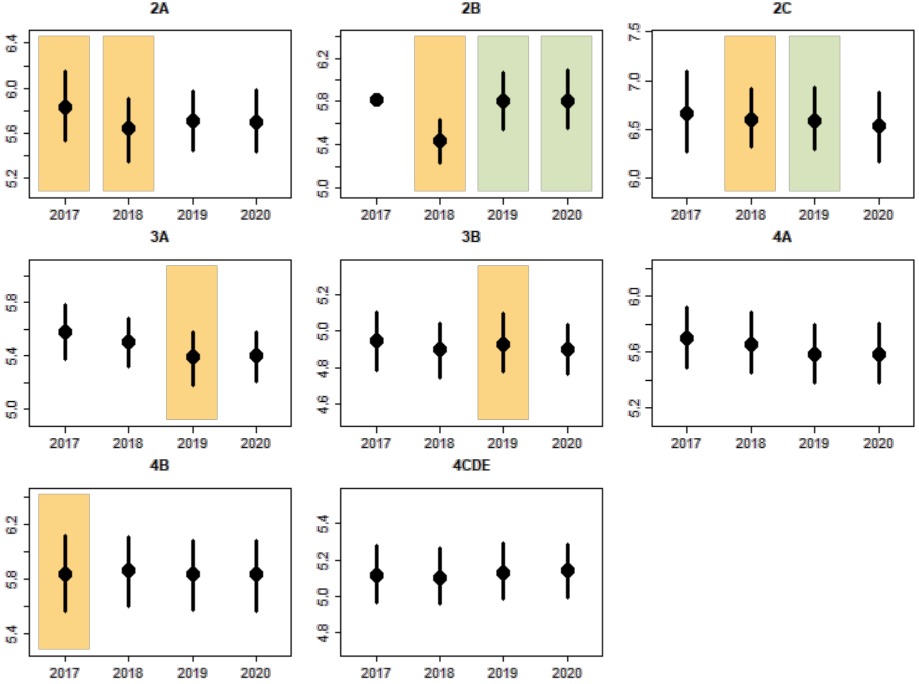
- Response to request at SRB017
- Looked at changes in space-time model parameter estimates from 2017-2020
- Over that period, several IPHC Regulatory Areas had FISS expansions into previously unsampled habitat
- New covariates were added to models in IPHC Regulatory Areas 2B and 2C
  - Binary covariate in 2B for Salish Sea (inside or outside)
  - Covariate for fixed vs snap gear in 2B and 2C

Spatial dependence parameters

θ_1

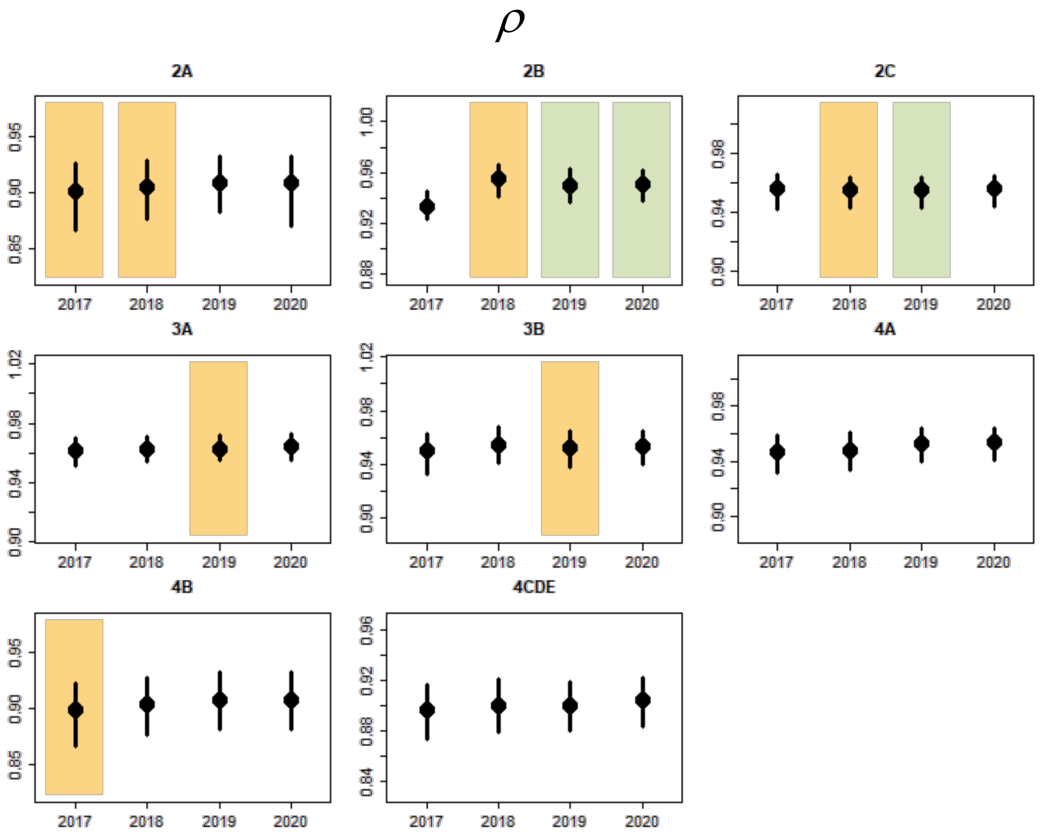


θ_2

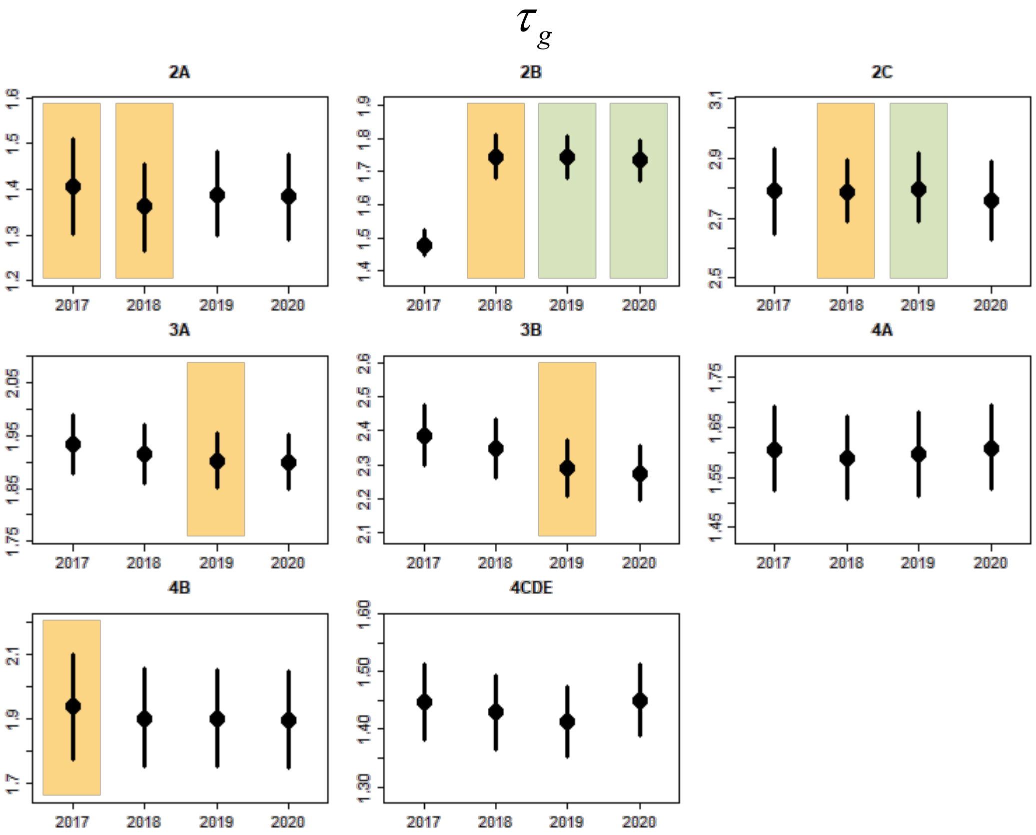


$$\sigma_\eta^2 = \frac{1}{4\pi e^{2(\theta_1+\theta_2)}} \qquad \kappa = e^{\theta_2}$$

Temporal correlation parameter

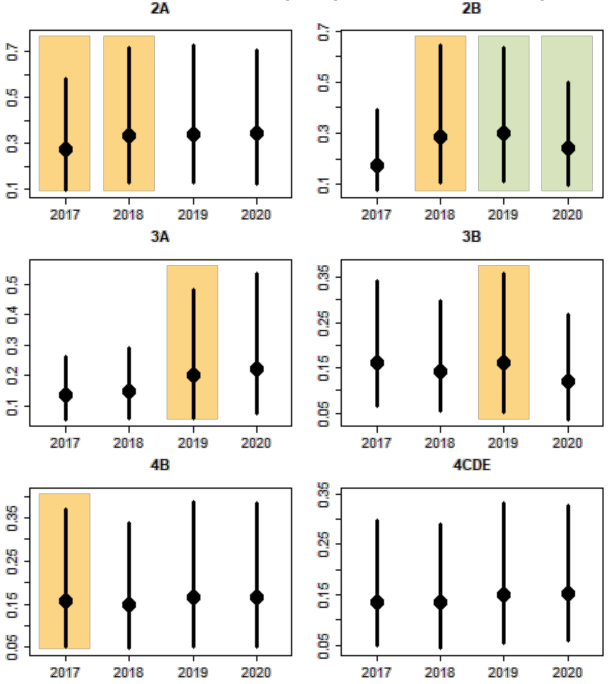


Gamma (non-zero WPUE) precision parameter

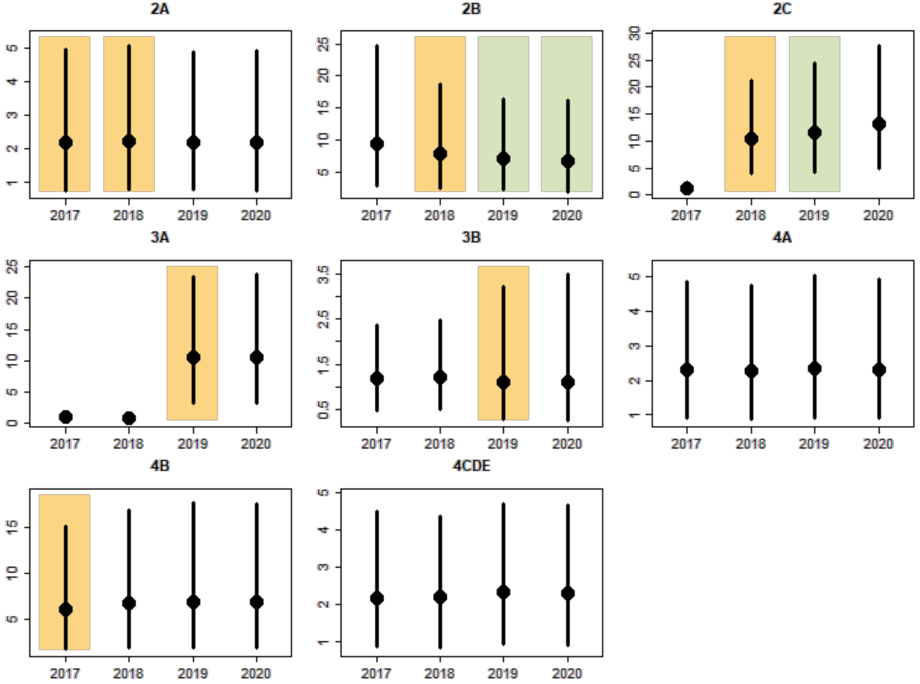


Depth random walk precision parameters

τ_u (P(WPUE=0) process)



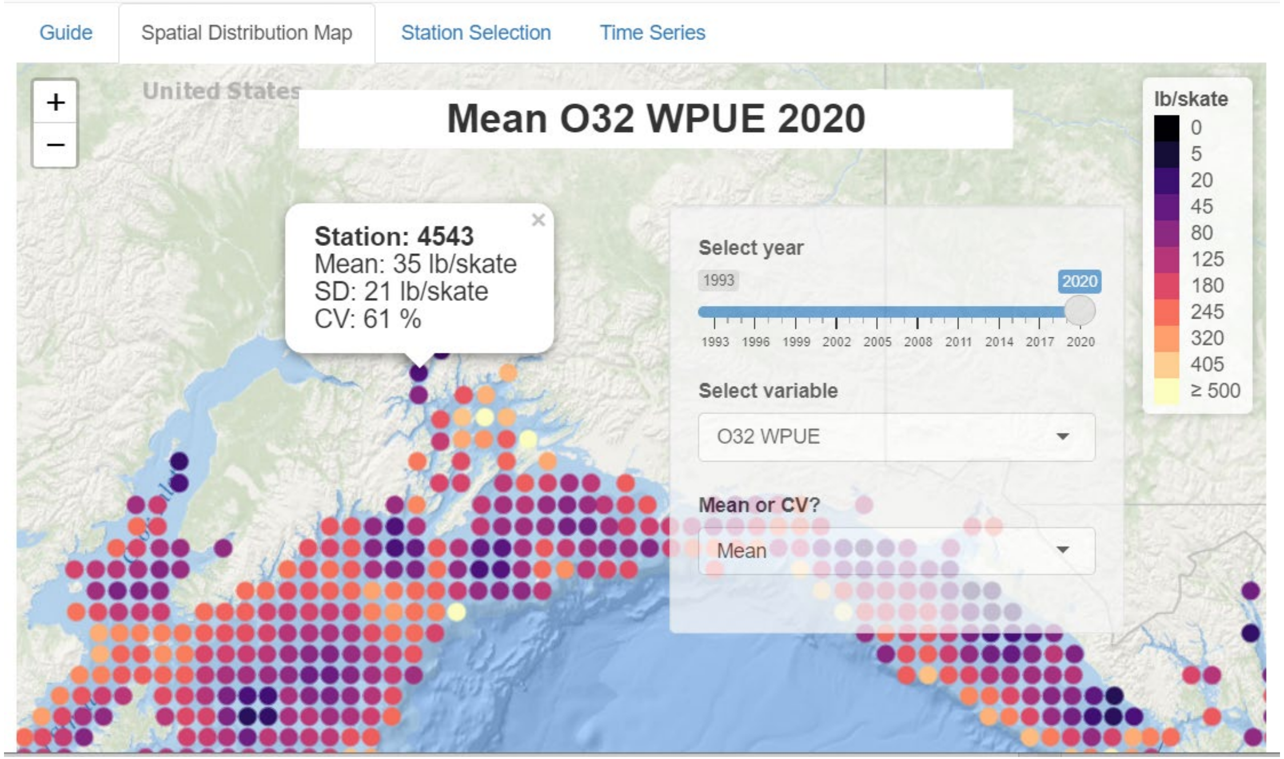
τ_v (non-zero process)



Stability of prediction of WPUE

- At individual stations and at groups of stations

Switch to Shiny tool



Recommendations

That the Scientific Review Board:

1) **NOTE** paper IPHC-2021-SRB018-05 that provides background on and a discussion of the IPHC fishery-independent setline survey design proposals for the 2022-24 period;

2) **ENDORSE** the final 2022 FISS design as presented in Figure 2 of IPHC-2021-SRB018-05, and

3) Provisionally **ENDORSE** the 2023-24 designs (Figures 3 and 4 of IPHC-2021-SRB018-05), recognizing that these will be reviewed again at subsequent SRB meetings.

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