INTERNATIONAL PACIFIC HALIBUT COMMISSION

Space-time modelling of survey data

Agenda item 6.2

IPHC-2019-AM096-07

Overview

1. Review of survey data sources and space-time modelling
2. Space-time model estimates of WPUE and NPUE
3. Regulatory Area 2C gear comparison
4. 2019 Fishery-Independent Setline Survey (FISS) expansions
   – IPHC Regulatory Areas 3A and 3B
5. FISS rationalisation
   – Methods
   – Proposals for 2020-22 FISS sampling seasons

Review of survey data sources

- IPHC fisheries-independent setline survey (FISS):
  - Primary data source for space-time modelling of WPUE and NPUE indices
  - 10 nmi grid design since 1998, with fixed FISS stations and standardised fishing methods
    - Grid design ensures all habitat is sampled in proportion to its occurrence (on average)
    - Fixed FISS stations reduces variance in trend estimates
  - Gaps in annual coverage
    - Accounted for using data from other surveys, FISS expansions, and space-time model predictions into unsurveyed habitat

Review of survey data sources

- NMFS fisheries-independent Bering Sea trawl survey:
  - Important data source for WPUE and NPUE indices in the Bering Sea (Regulatory Areas 4A and 4CDE)
  - 20 nmi grid design since 1982, with higher station density in some regions
  - Northern expansions fished in 2010, 2017-19
  - Data are calibrated with IPHC Bering Sea setline survey expansion data from 2006 and 2015
    - Provides WPUE and NPUE indices consistent with those from the IPHC setline survey
- ADFG fisheries-independent Norton Sound trawl survey:
  - Data source for WPUE and NPUE indices in the northern Bering Sea (Regulatory 4CDE)
  - Fished triennially until 2014, and annually from 2017

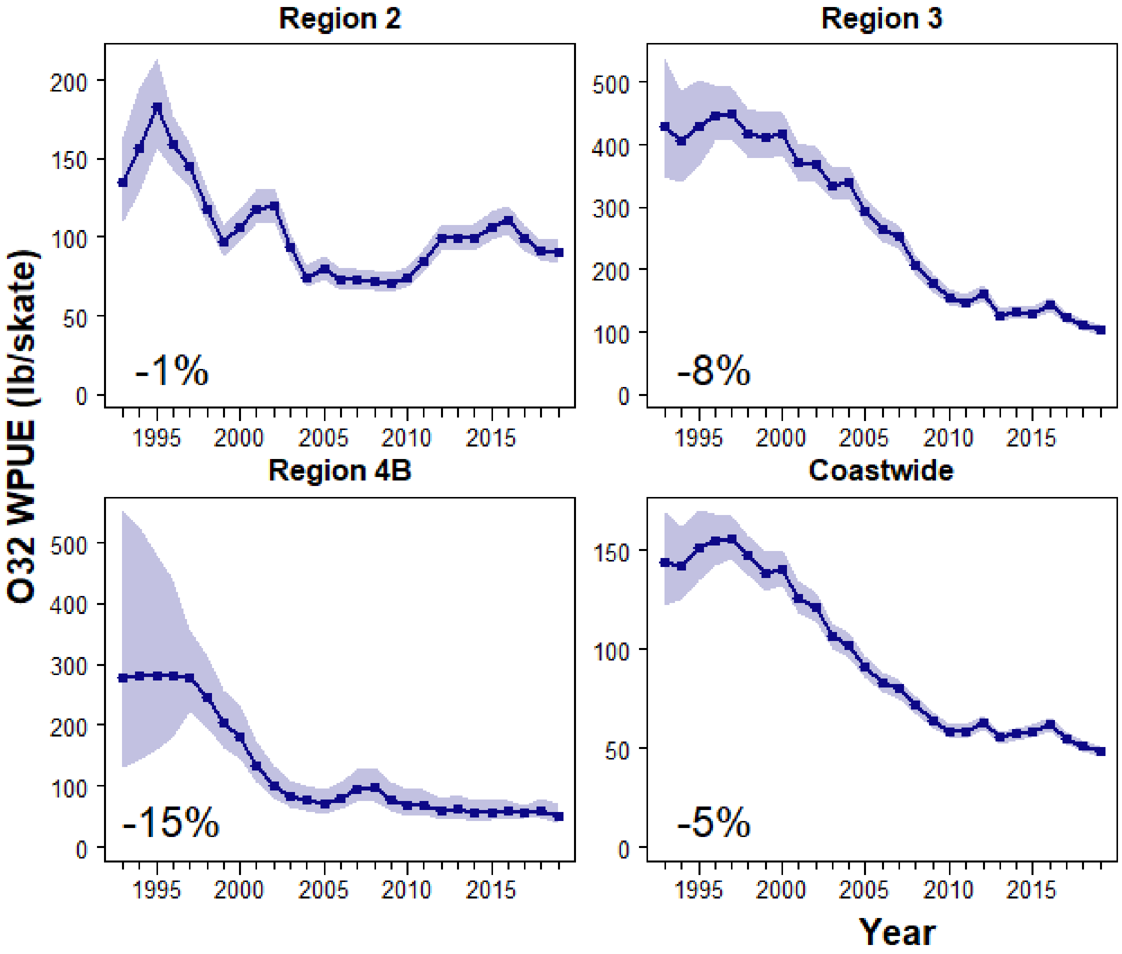
Review of space-time modelling

- 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

Space-time model estimates of WPUE and NPUE

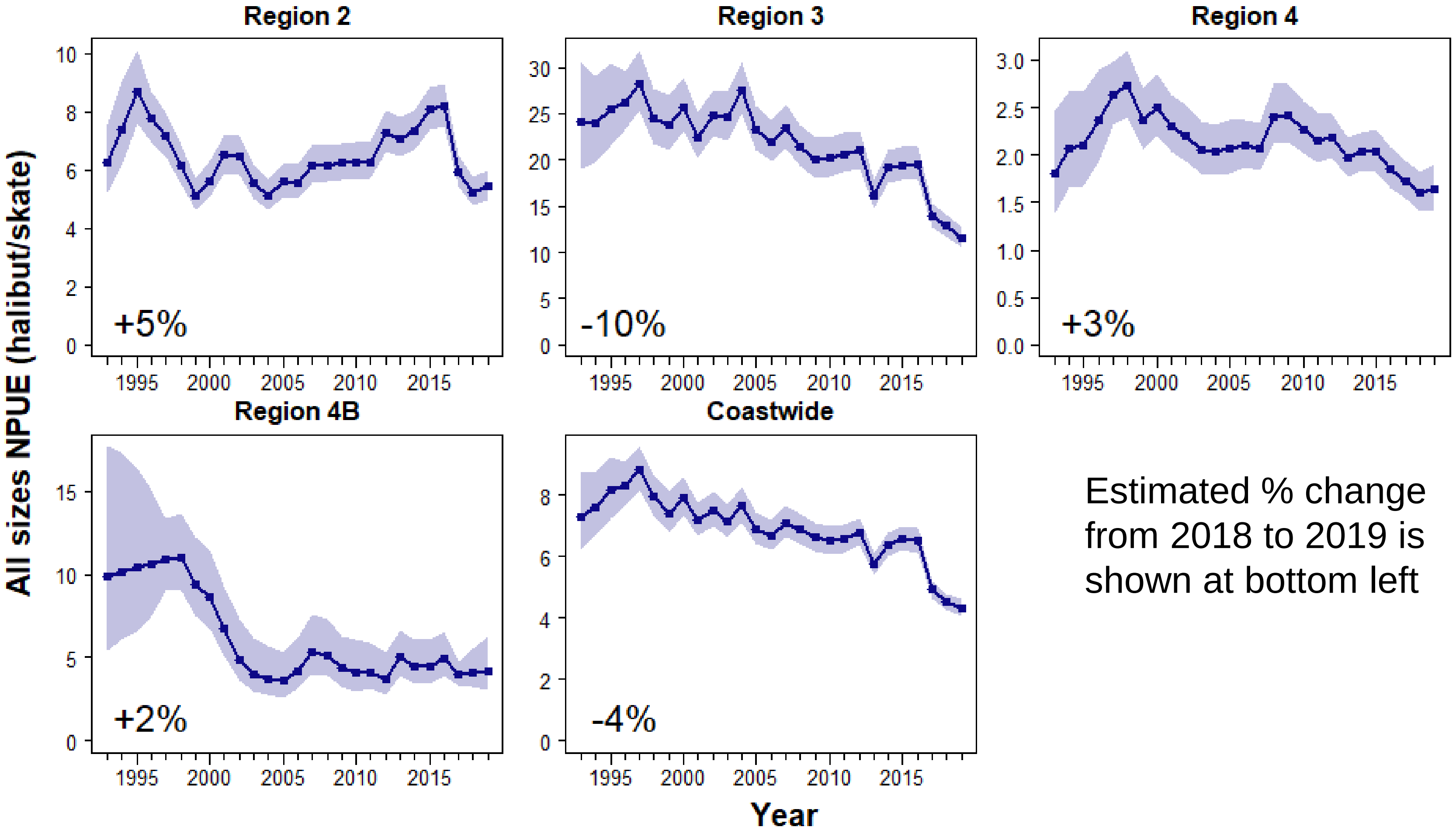
- As in 2016-18, the space-time modelling was used to estimate WPUE and NPUE indices
- Estimates computed for:
  - Biological Regions
  - IPHC Regulatory Areas
  - Coastwide IPHC Convention waters, from San Francisco Bay to Bering Strait

O32 WPUE by biological region



Estimated % change from 2018 to 2019 is shown at bottom left

All sizes NPUE by biological region



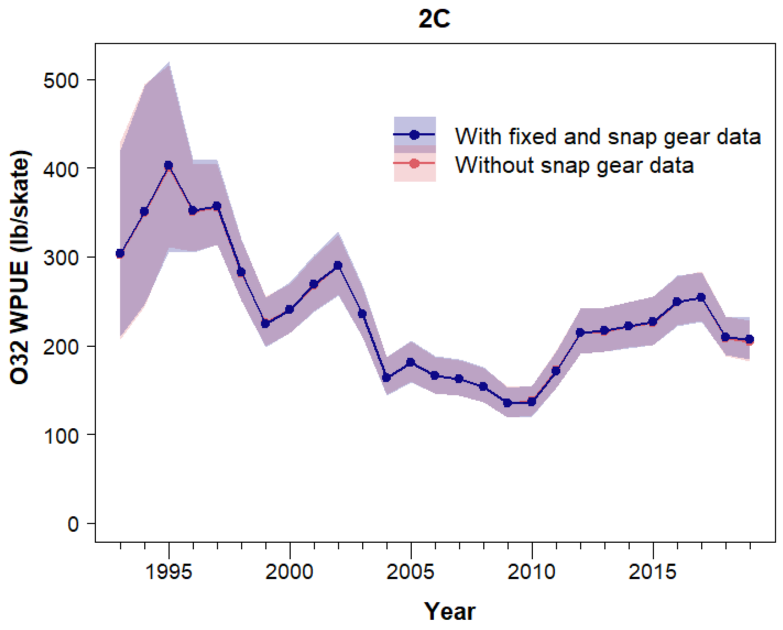
Estimated % change from 2018 to 2019 is shown at bottom left

Gear comparison study

- Each station in Regulatory Area 2C was fished twice, once with fixed gear, and once with snap gear
- Space-time modelling included parameters allowing for gear differences in catch rates
- There was some evidence that snap gear had lower catch rates than fixed gear
  - Model estimated WPUE and NPUE on snap gear was 86% of that on fixed gear
  - Uncertainty was high, with 95% intervals of 75-100%
- Results imply the need to collect additional data
  - to better understand the relative efficiency of the gears
  - to understand potential variability over time and space

Gear comparison study

- Nevertheless, with the gear calibration accounted for in the model, we did include snap gear data in the models used to produce indices for Regulatory Area 2C in 2020
- Inclusion of snap gear data together with fixed gear data had no meaningful effect on estimates of WPUE and NPUE time series
- As estimation of calibration coefficient between snap and fixed gear improves, data from both gears will likely be of equal value

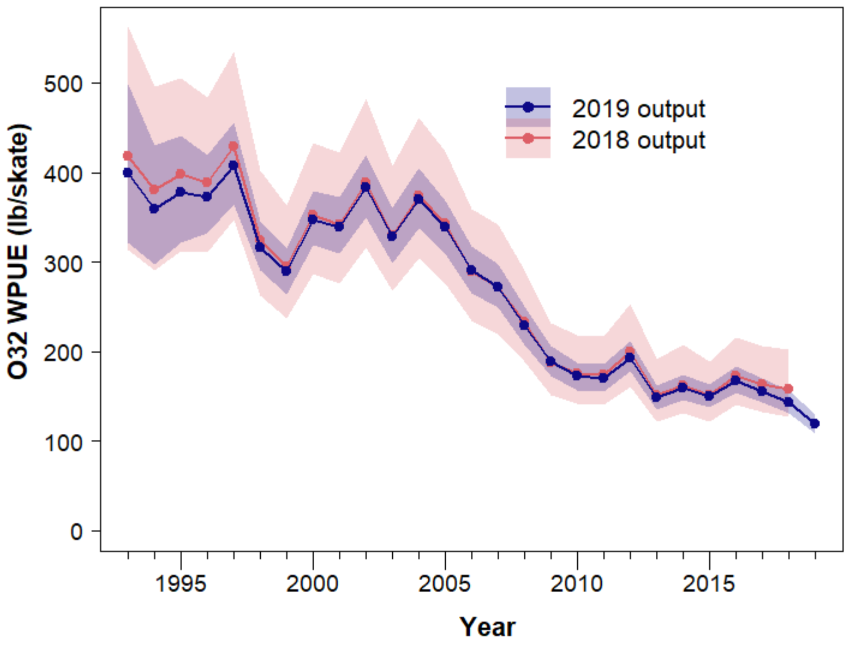


2019 setline survey expansions

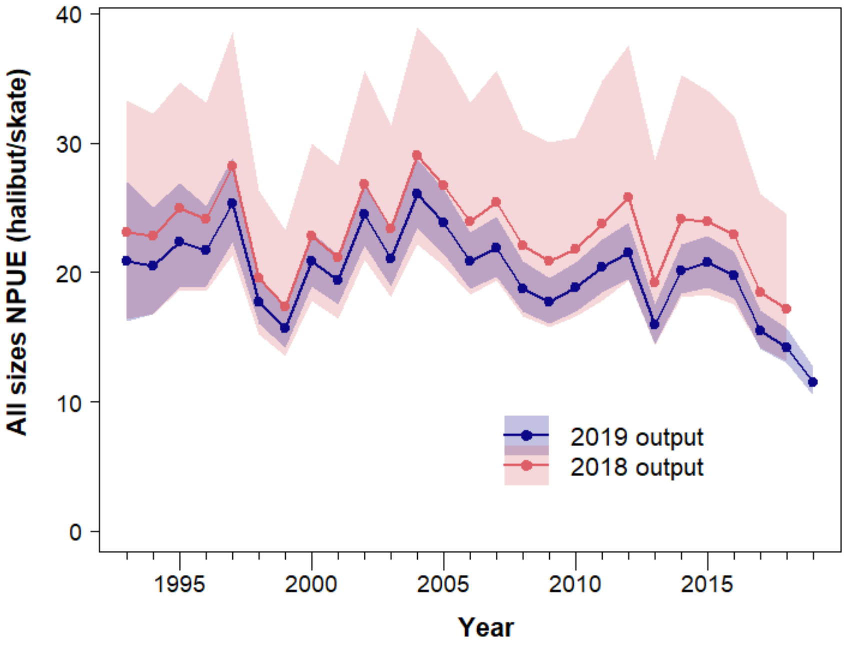
- 2019 was the 6th and final year of a program of setline survey expansions
- The goal was to collect data in previously unsurveyed regions to reduce bias and uncertainty in WPUE and NPUE indices
- Setline survey expansions to date (with previously unsampled % of stations):
  - 2014: Regulatory Areas 2A and 4A (42%)
  - 2015: Regulatory Area 4CDE eastern Bering Sea flats
  - 2016: Regulatory Area 4CDE shelf edge (62%)
  - 2017: Regulatory Areas 2A (46%) and 4B (55%)
  - 2018: Regulatory Areas 2B (42%) and 2C (25%)
  - **2019: Regulatory Areas 3A (18%) and 3B (19%)**

Regulatory Area 3A

O32 WPUE

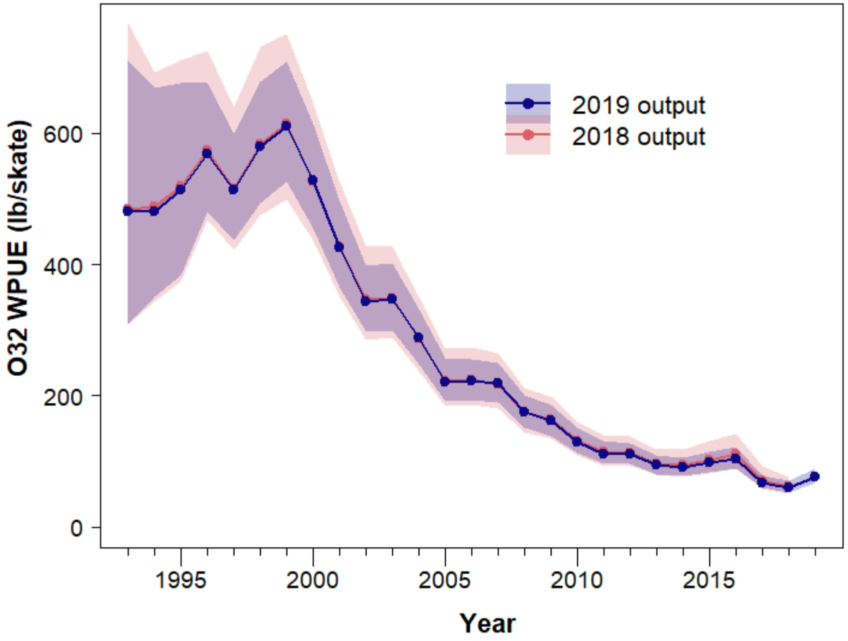


All sizes NPUE

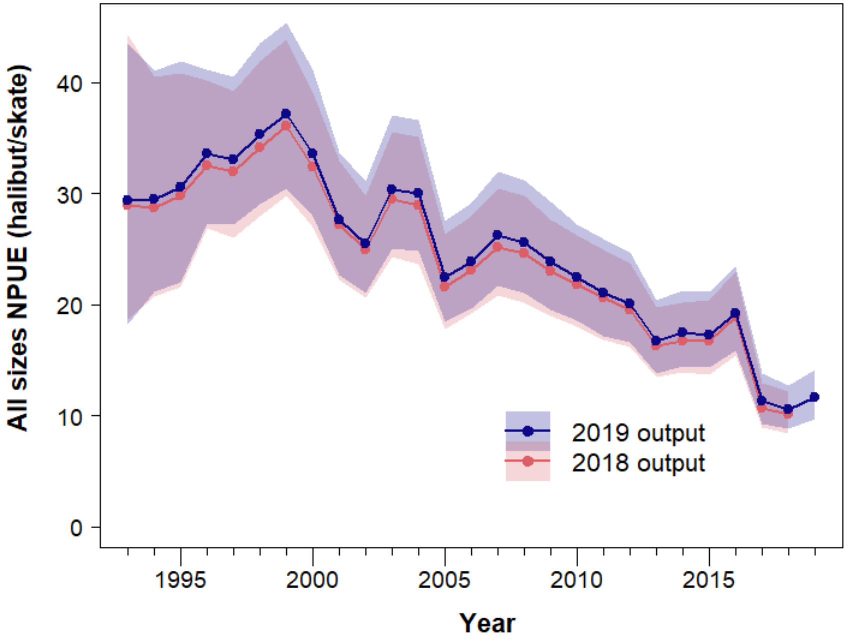


Regulatory Area 3B

O32 WPUE



All sizes NPUE



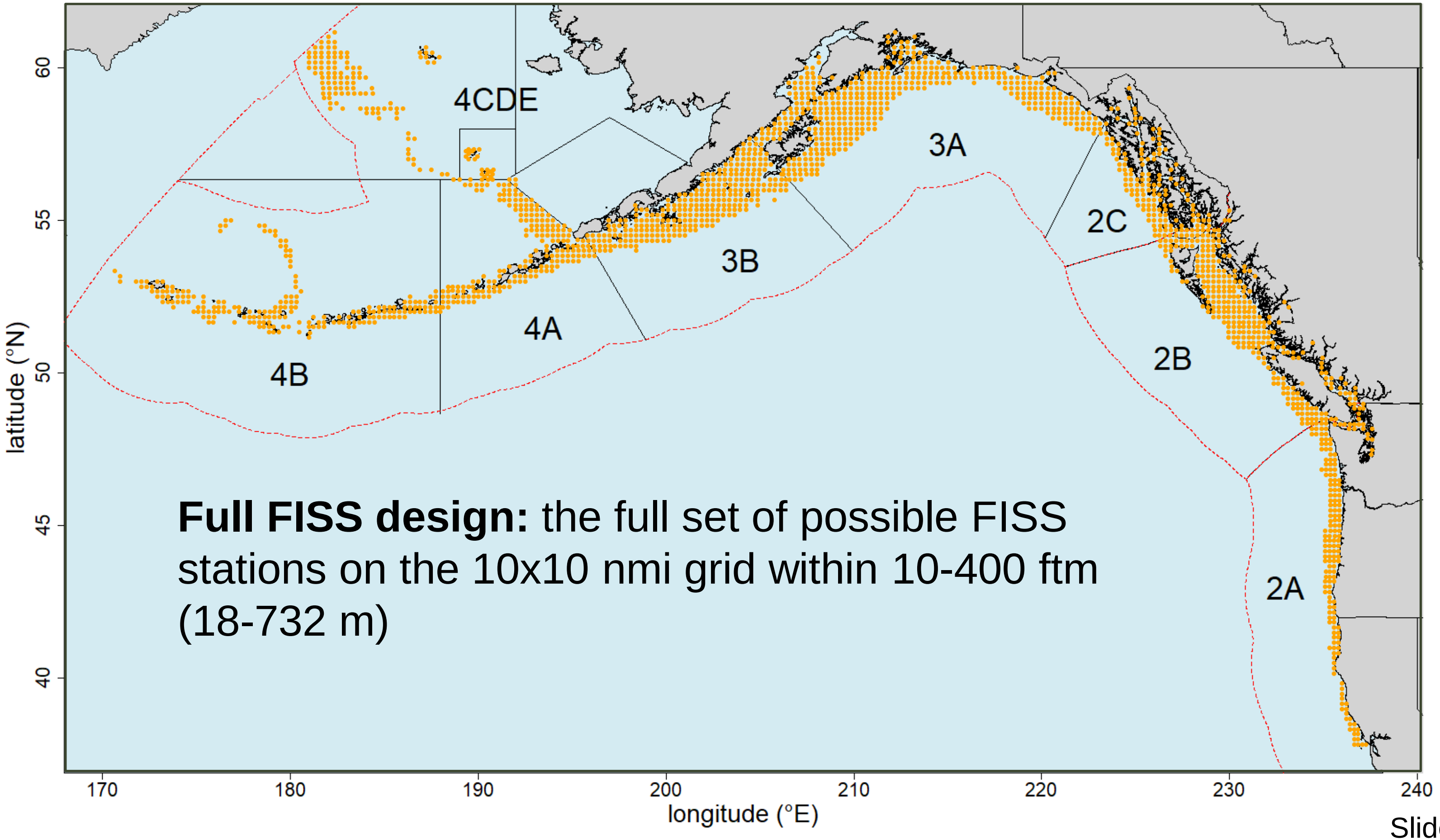
FISS expansion summary

- The FISS occupied for the first time 34% of the full grid that had previously been unsurveyed
- 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
- Moving forward, revisiting the “new” stations from the 2014-19 expansion is unlikely to have such large effects on the entire time series

FISS priorities

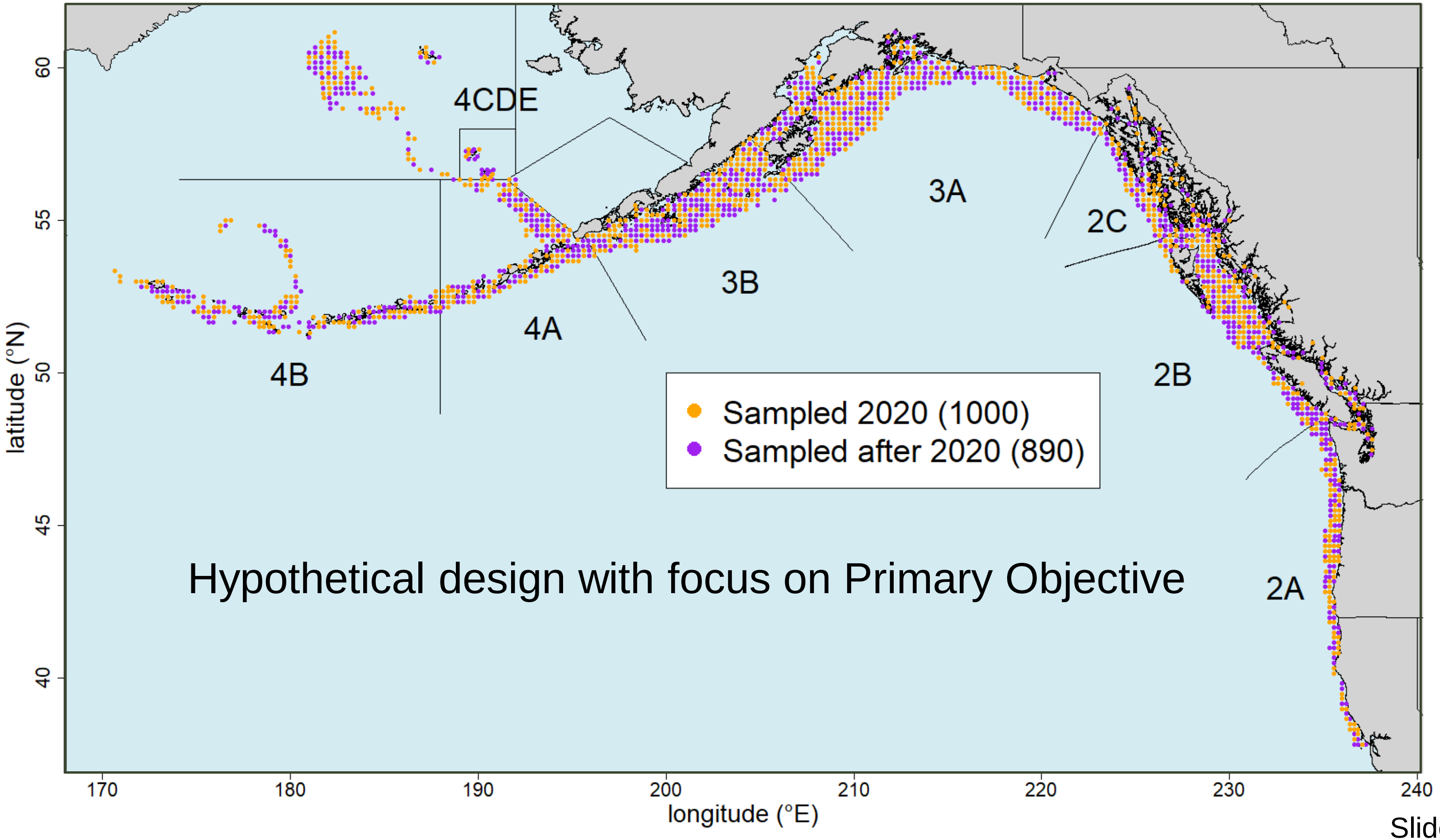
Priority	Objective	Design Layer
Primary	Sample Pacific halibut for stock assessment and stock distribution estimation	Minimum sampling requirements in terms of: • Station distribution • Station count • Skates per station
Secondary	Long term revenue neutrality	Logistics and cost: operational feasibility 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

Full FISS design

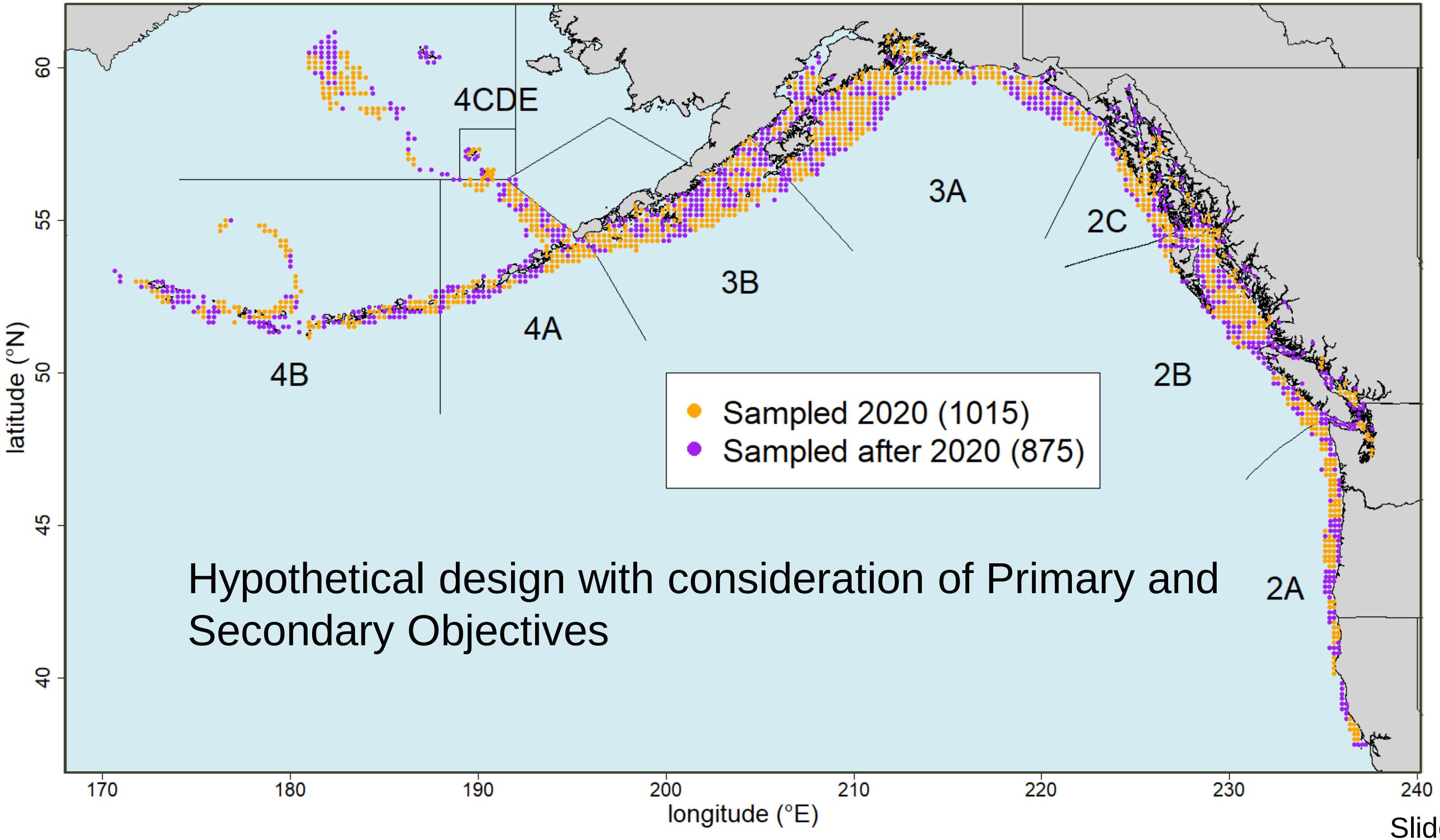


Full FISS design: the full set of possible FISS stations on the 10x10 nmi grid within 10-400 ftm (18-732 m)

Example 1: Randomised design



Example 2: Randomized cluster design



Hypothetical design with consideration of Primary and Secondary Objectives

Developing and evaluating FISS design proposals

- Set data quality targets
- Determine geographic sampling priorities and sampling frequency
- Test designs on simulated data sets
- Propose design options
- Estimate design costs

Precision targets

- To maintain data quality, we proposed the following targets on coefficient of variation (CV):

Management unit	O32 WPUE	All sizes WPUE	All sizes NPUE
Reg Area (all)	15%	15%	NA
Bio Regions 2, 3, 4	10%	10%	10%
Bio Region 4B	15%	15%	15%
Coastwide	NA	NA	10%

Potential for bias

- Failure to observe and account for changes in WPUE or NPUE in an unsurveyed subarea can lead to bias
- Therefore, it is important to undertake the FISS frequently enough to keep any bias small

Evaluation of options

- Fit models using simulated data for future years
- Models can take a long time to run: full simulation study using many data sets not practical
- Instead, for each year, single simulated sample data sets were taken from the posterior samples from the modelling

Core Regulatory Areas

- Regulatory Areas 2B to 3B comprise the current core of the Pacific halibut stock
- Generally high relative density throughout these areas
- We considered two design options:

  1) Randomised sampling

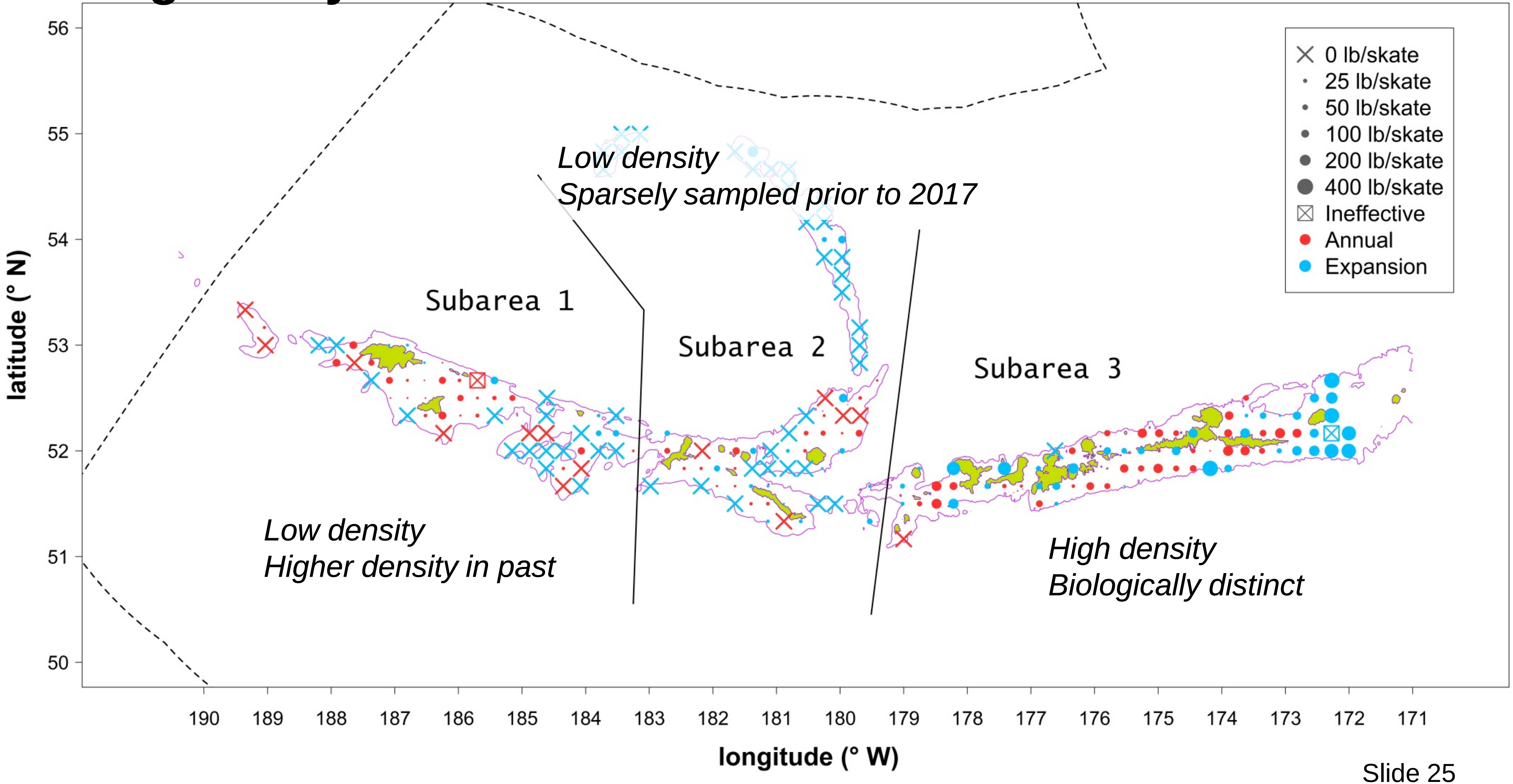
  2) Subarea sampling, in which not all FISS regions are sampled each year

     - This option places a high priority on logistics (Secondary Objective)

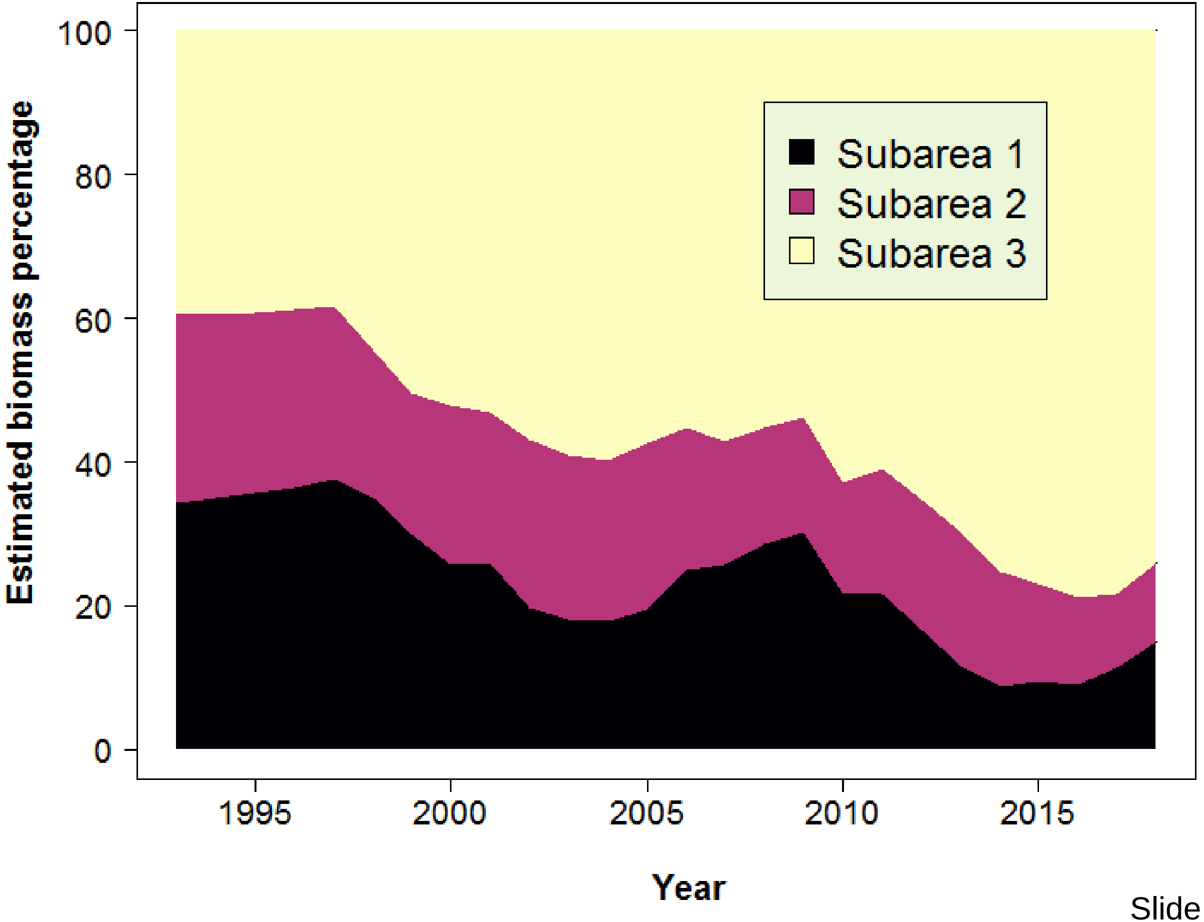
Regulatory Areas 2A, 4A and 4B

- These Regulatory Areas each contain local areas of relatively high and low densities
- Evaluations of subarea-based designs show Primary Objectives can be met by
  - Prioritising the sampling of high density, temporally variable subareas by sampling these frequently (e.g. annually)
  - Sampling other subareas less frequently

Regulatory Area 4B subareas



Regulatory Area 4B biomass % by subarea and year



Reg Area 4B sampling priorities

1. Subarea 3: 70-80% of biomass since 2013
2. Subarea 1: Frequent large changes in biomass % over short periods
3. Subarea 2: Generally low and stable biomass % (but likely affected by sparse historic sampling)

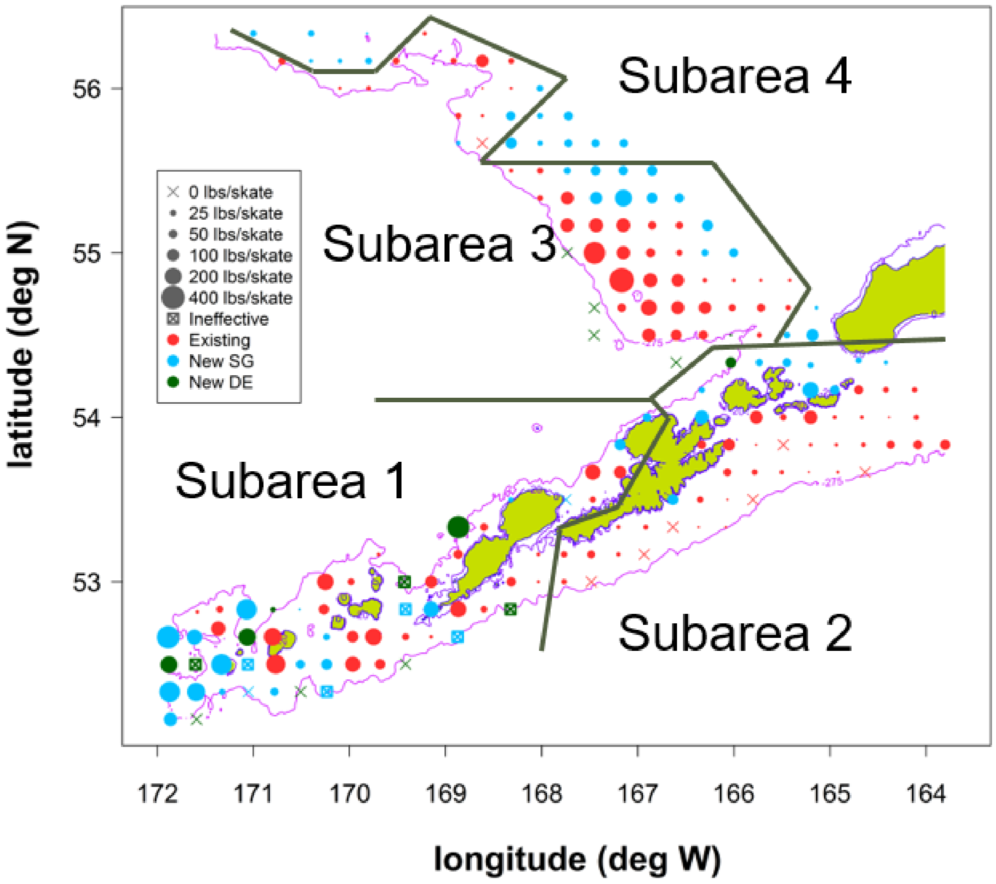
Proposal for sampling: 2020-2022

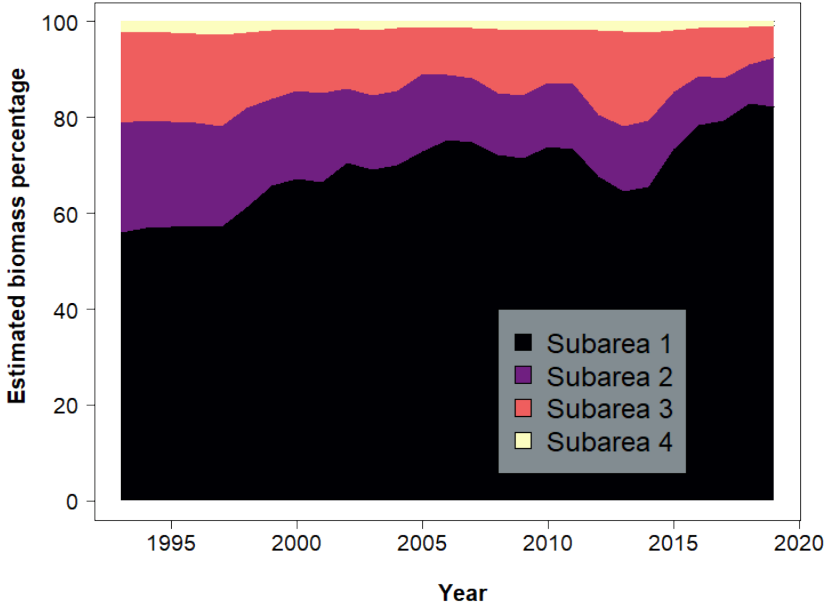
2020. Subarea 3 only (73 stations)

2021. Subarea 3 only (73 stations)

2022. Subareas 1 and 2 (130 stations)

Regulatory Area 4A subareas





Reg Area 4A sampling priorities

1. Subarea 1: 65-85% of biomass, variable biomass proportion
2. Subarea 3: Variable biomass %
3. Subarea 2: Low density, stable proportion

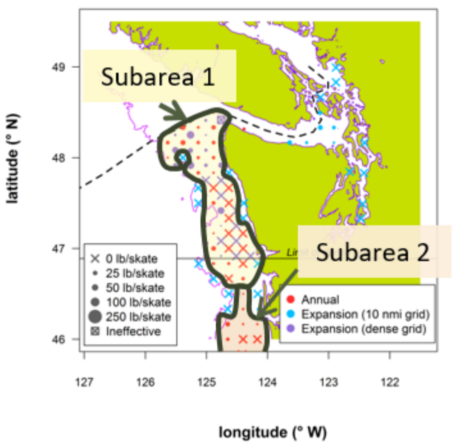
Proposal for sampling: 2020-2022

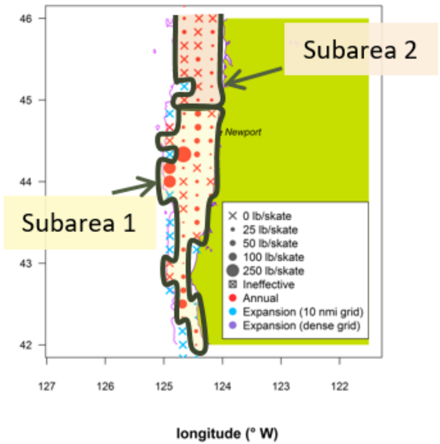
2020. Subarea 1 only (59 stations)

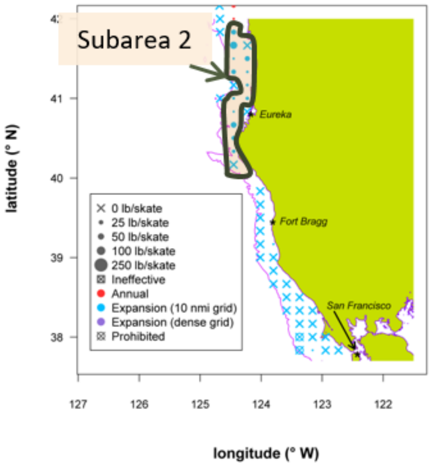
2021. Subarea 1 only (59 stations)

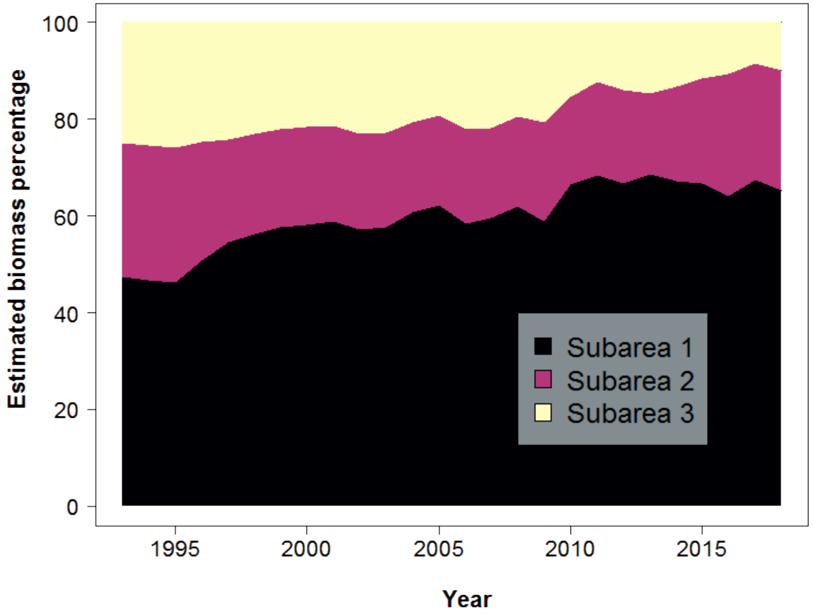
2022. Subareas 1 and 3 (122 stations)

Regulatory Area 2A subareas









Reg Area 2A sampling priorities

1. Subarea 1: 60-70% of biomass
2. Subarea 2: Moderate density, stable proportion
3. Subarea 3: Low density

Proposal for sampling: 2020-2022

2020. Subarea 1 only (72 stations)

2021. Subarea 1 only (72 stations)

2022. Subarea 1 only (72 stations)

Regulatory Area 4CDE

- Regulatory Area 4CDE estimation depends heavily on other surveys
- While it may be possible to reduce FISS sampling and still meet precision/bias targets, we note:
  - Ecosystem conditions have been anomalous in the Bering Sea for several years, making the Pacific halibut distribution more difficult to predict in unsurveyed habitat
  - The IPHC has increased interest in better understanding density trends and possible links with Russian waters
- Therefore, we propose repeating the full FISS grid on the Regulatory Area 4D shelf edge, last fished in 2016

Planning beyond three years?

- As new data become available each year, sampling priorities and bias potential for subsequent years can be re-evaluated
  - Subarea definitions and sampling priorities will evolve with changes in relative density of Pacific halibut
- Given the likely future changes in density and distribution, we did not consider evaluating sampling designs beyond three years

Biological sampling

- The IPHC also has biological sampling targets in each regulatory area.
  - 2000 otoliths/Regulatory Area
- Those targets are already difficult to meet in some areas, particularly Regulatory Areas 2A and 4CDE.
- Any reduction in the annual survey footprint will make meeting those targets more challenging
- Where possible, additional skates/set can be used to mitigate reductions in stations

Putting it all together

- Determine priorities and costs for each Regulatory Area (or Biological Region) for the next three years
  - For Bio Region purposes, whole Reg Areas could be omitted from the survey in some years
- If necessary, rearrange the annual sampling order of subareas to be fished to avoid exceeding overall budget limits
- Each year, re-evaluate priorities and projected costs following data collection on the setline survey
- Modify subsequent years' plans if necessary to reflect new data and revised cost projections

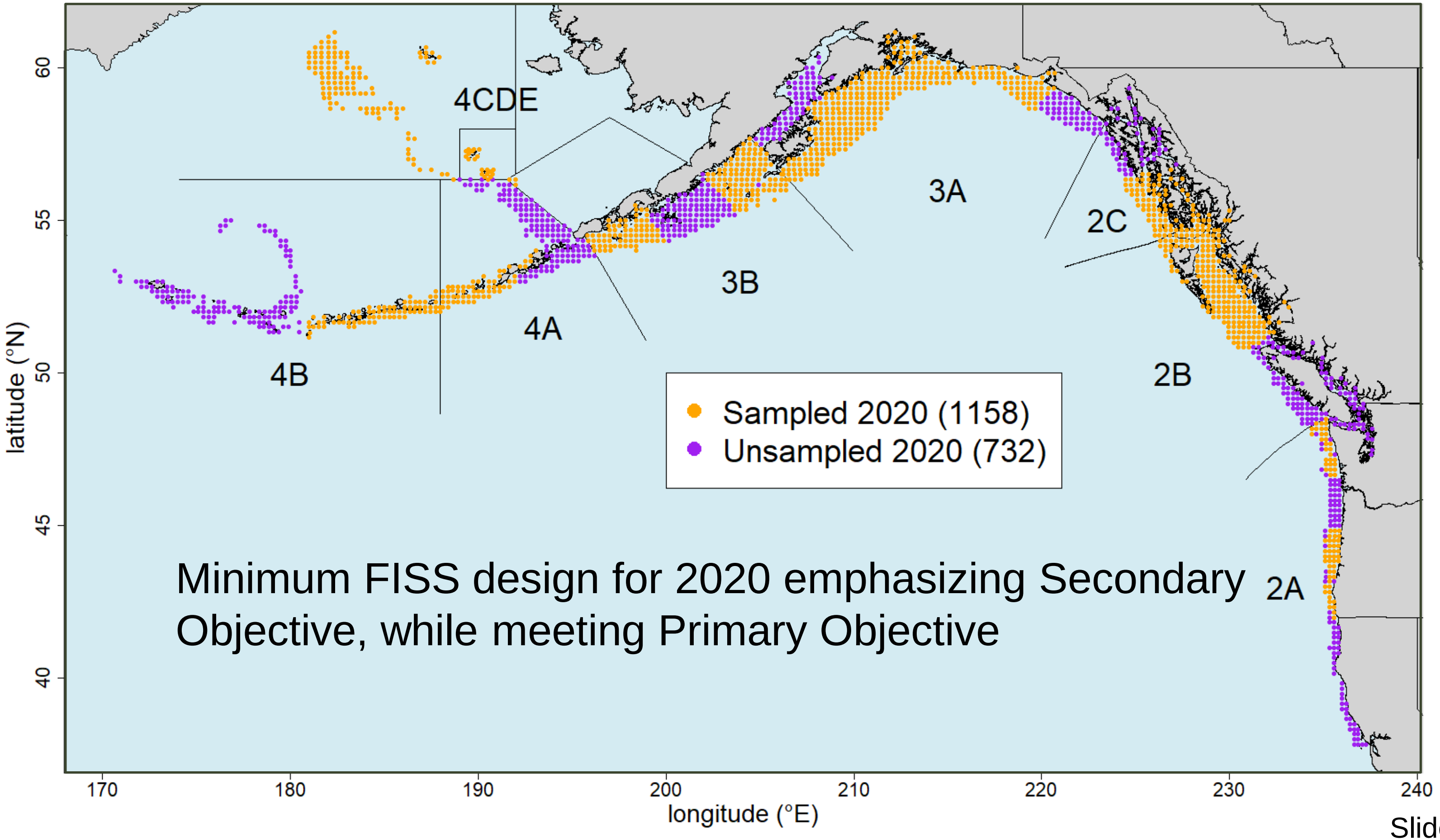
Design proposals for 2020-22

- The following designs represent minimum designs for meeting the Primary Objective of sampling Pacific halibut for the assessment/stock distribution
- They can be added to in order to meet other objectives related to science, logistics/cost, and resource extraction/policy.

Proposal 1: High Efficiency design

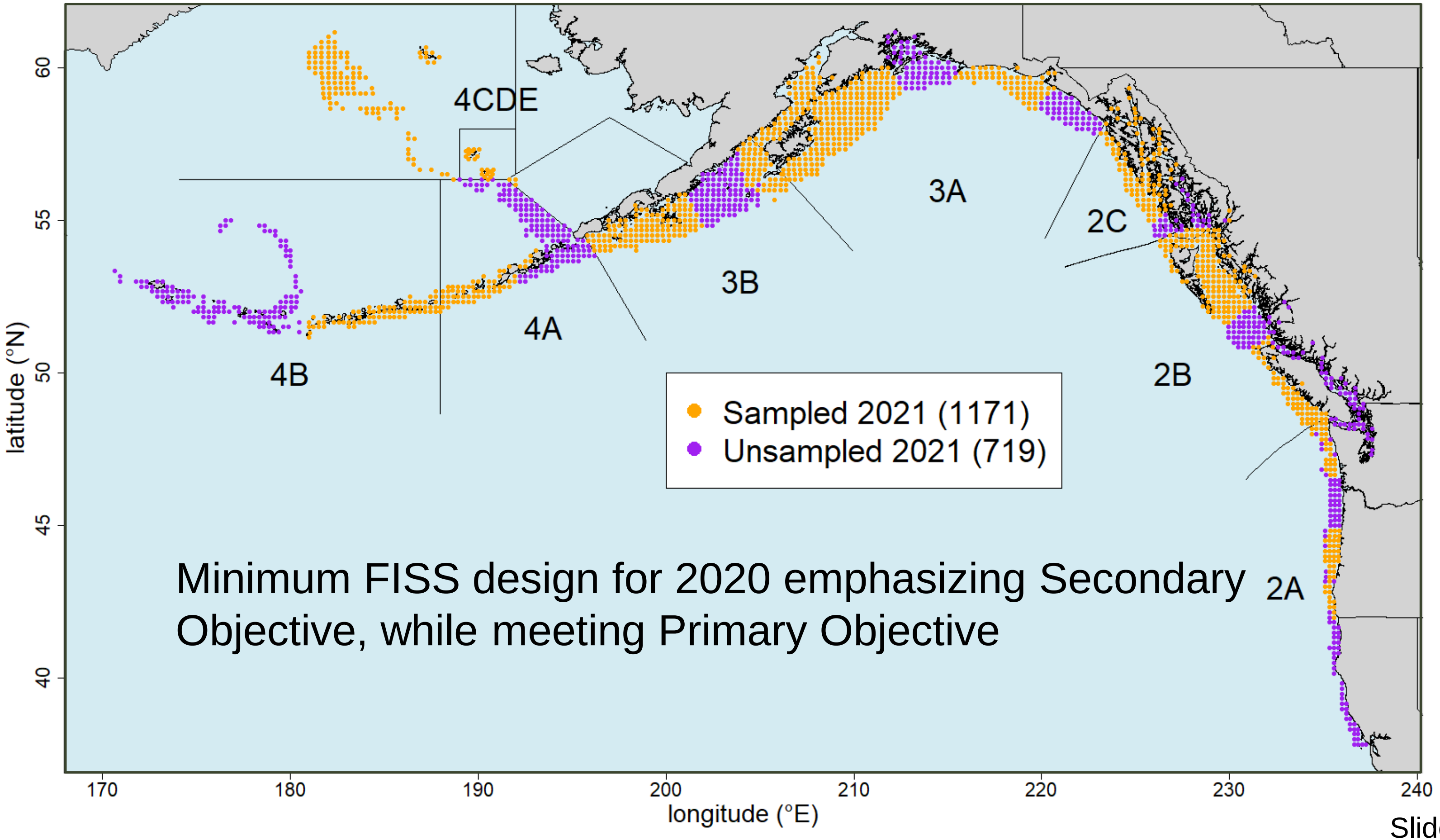
- This design depends entirely on fishing subareas, i.e. large clusters of adjacent stations
- While it meets the Primary Objective, it also heavily emphasizes the Secondary Objective by accounting for logistics and cost.

Proposal 1: High Efficiency design 2020

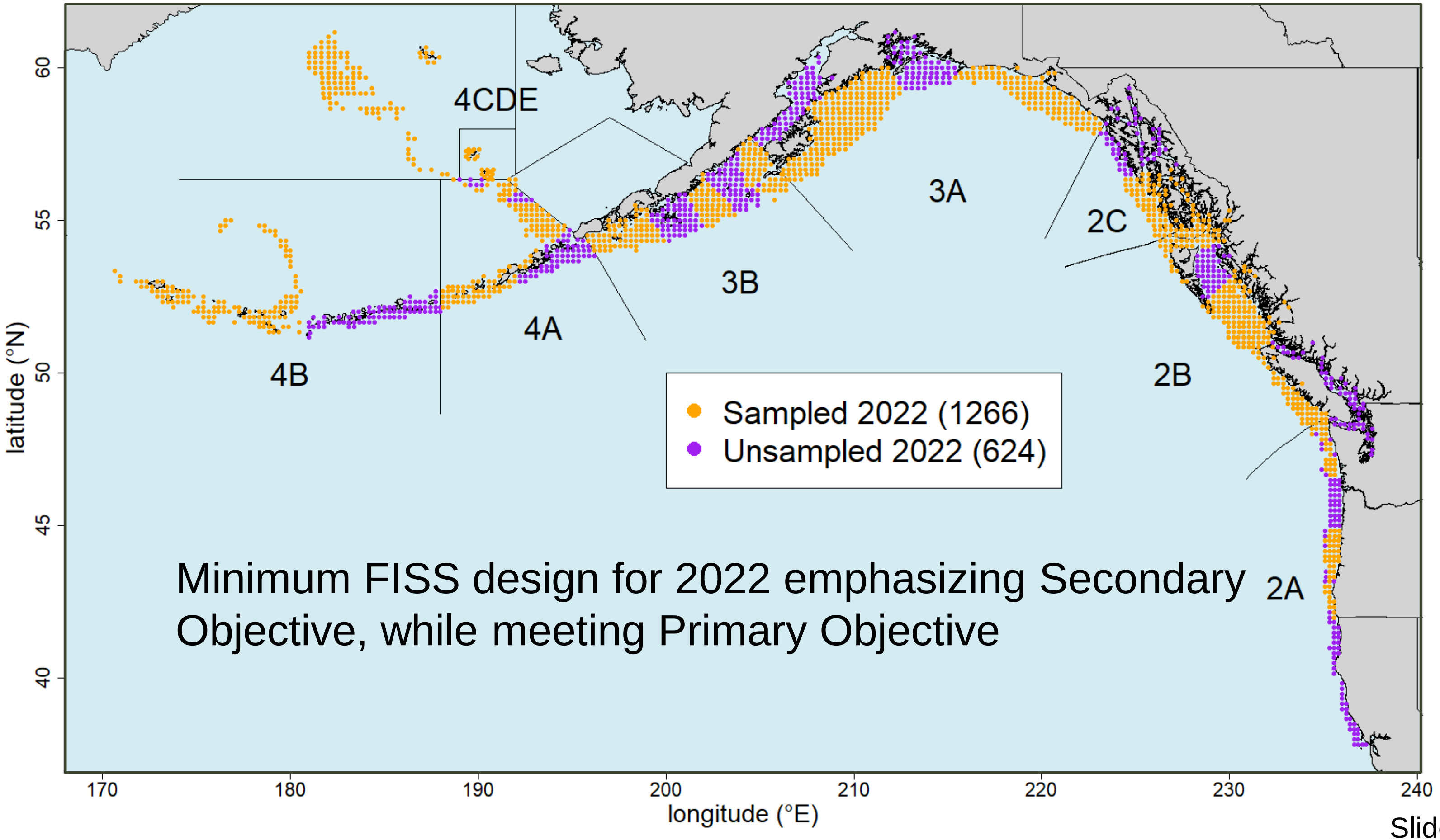


Minimum FISS design for 2020 emphasizing Secondary Objective, while meeting Primary Objective

Proposal 1: High Efficiency design 2021



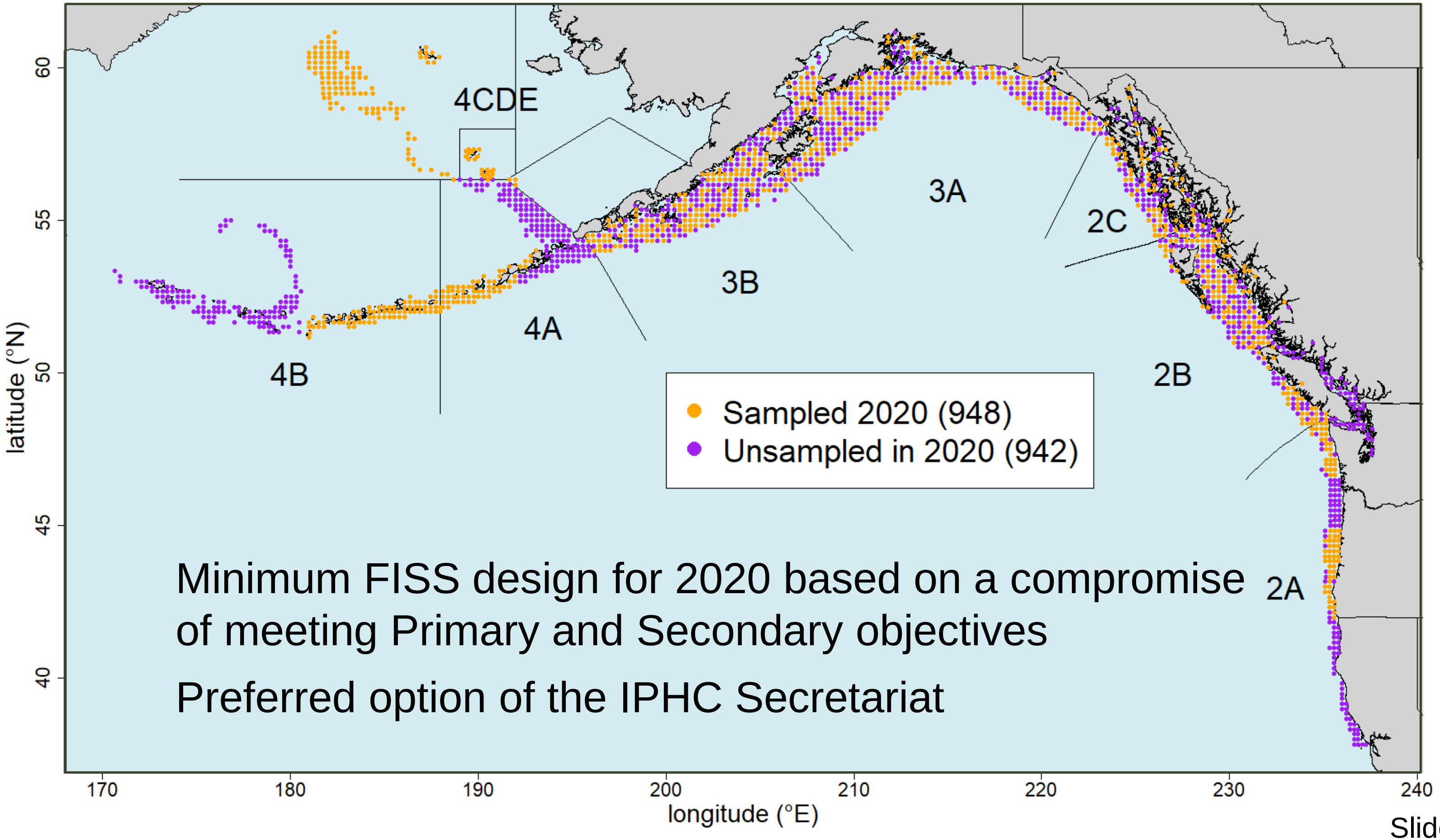
Proposal 1: High Efficiency design 2022



Proposal 2: Compromise design

- Preferred option of the IPHC Secretariat
- Uses a randomised design in the core Regulatory Areas, and a subarea design elsewhere
- The focus is on the Primary Objective, but operational efficiency is considered by fishing low-density and/or stable subareas less frequently

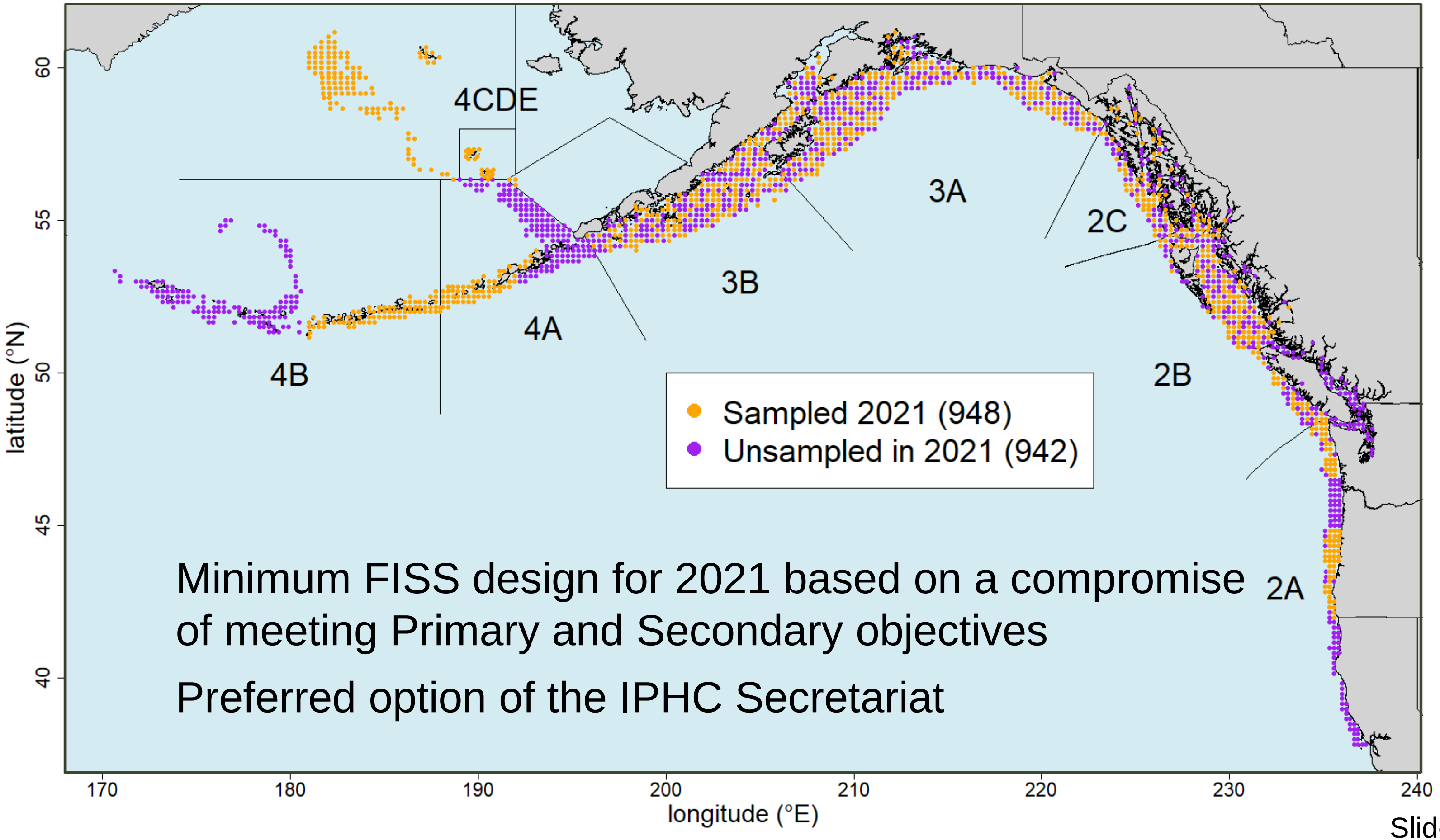
Proposal 2: Compromise design 2020



Minimum FISS design for 2020 based on a compromise of meeting Primary and Secondary objectives

Preferred option of the IPHC Secretariat

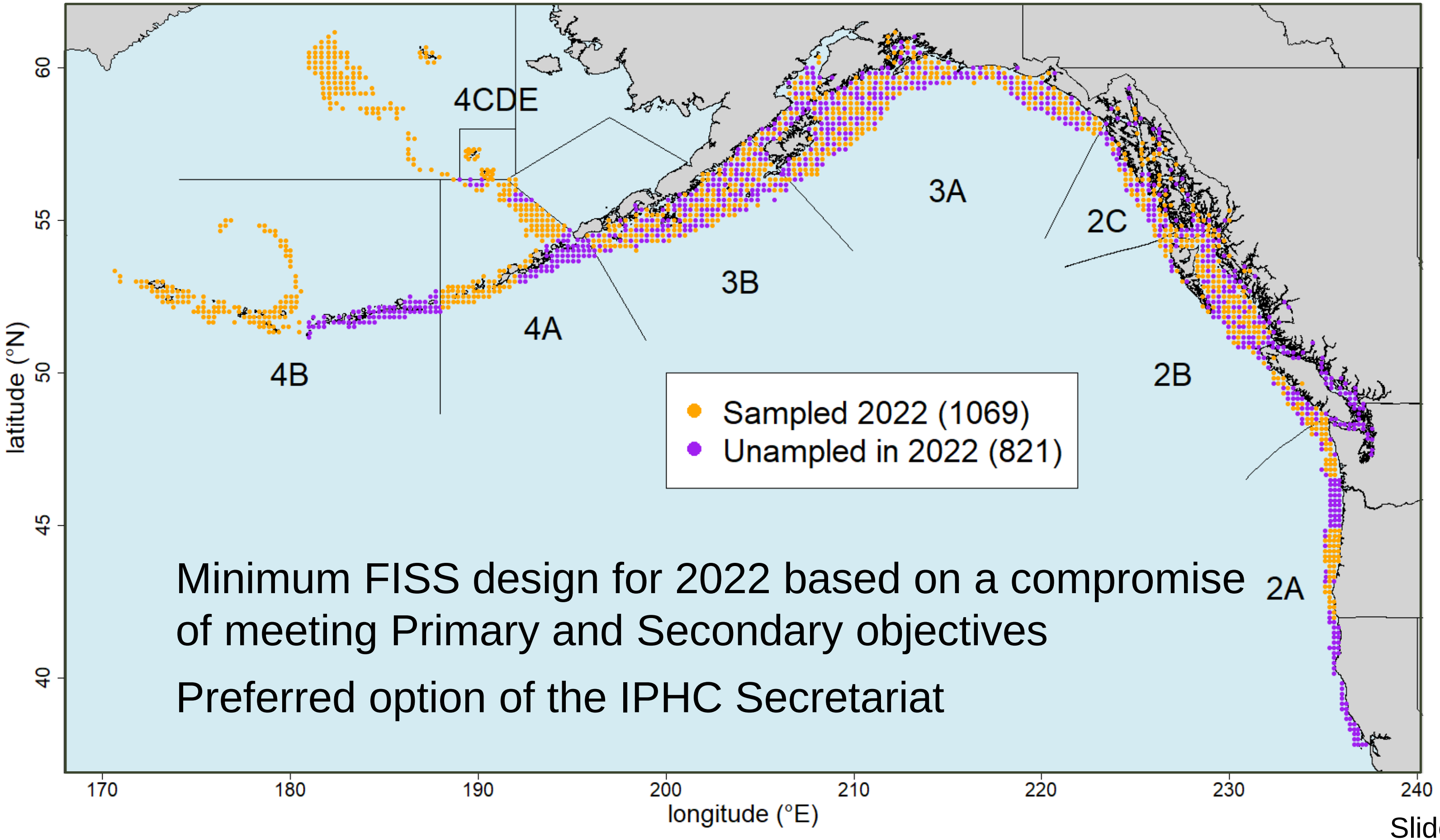
Proposal 2: Compromise design 2021



Minimum FISS design for 2021 based on a compromise of meeting Primary and Secondary objectives

Preferred option of the IPHC Secretariat

Proposal 2: Compromise design 2022



Minimum FISS design for 2022 based on a compromise of meeting Primary and Secondary objectives

Preferred option of the IPHC Secretariat

Recommendations

- That the Commission:
- **NOTE** paper IPHC-2020-AM096-07 which provides alternatives for FISS sampling in 2020 ranging from the full grid to randomised and subarea options.

- **ENDORSE** the preferred design (Proposal 2) for the IPHC Secretariat to employ, commencing in 2020.

- **PROPOSE** any specific additions or modifications to that design that the IPHC Secretariat should consider in evaluating the three design criteria: Scientific, logistical/cost, and resource extraction/policy.

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