Eastern Bering Sea Survey Modernization

Project leads:

Lewis Barnett, Lyle Britt, Meaghan Bryan, Nicole Charriere, Rebecca Haehn-Tam, Ned Laman, Mike Litzow, Stan Kotwicki, Zack Oyafuso, Sean Rohan, Shawn Russell, Paul Spencer, Duane Stevenson

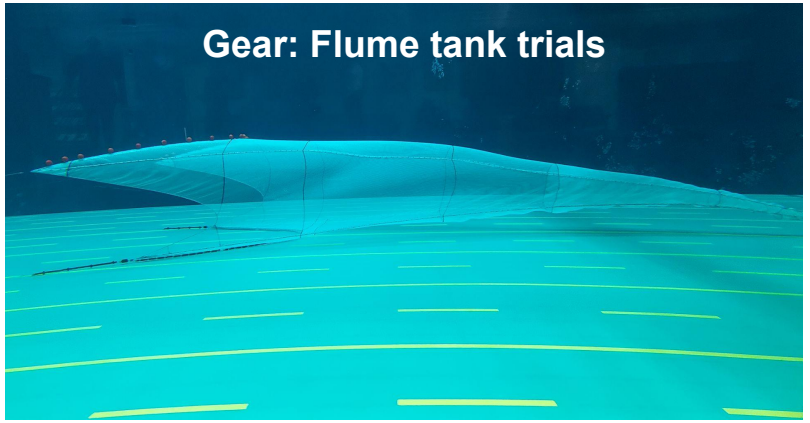
EBS modernization Steering Committee:

Mike Litzow (co-chair), Duane Stevenson (co-chair), Lyle Britt, Melissa Haltuch, Stan Kotwicki, Chris Lunsford, Shawn Russell

NPFMC Crab Plan Team
May 14, 2025

Survey modernization working groups

1. **Sampling design (L. Barnett)**
2. **Reducing tow duration to 15 minutes (S. Rohan & R. Haehn-Tam)**
3. Extending survey coverage to the EBS Slope (S. Rohan & R. Haehn-Tam)
4. Survey gear redesign (S. Russell & N. Charriere)
5. Gear calibration (TBD)
6. Survey design transition (M. Bryan & P. Spencer)



Note: Working group lead(s) in parentheses.

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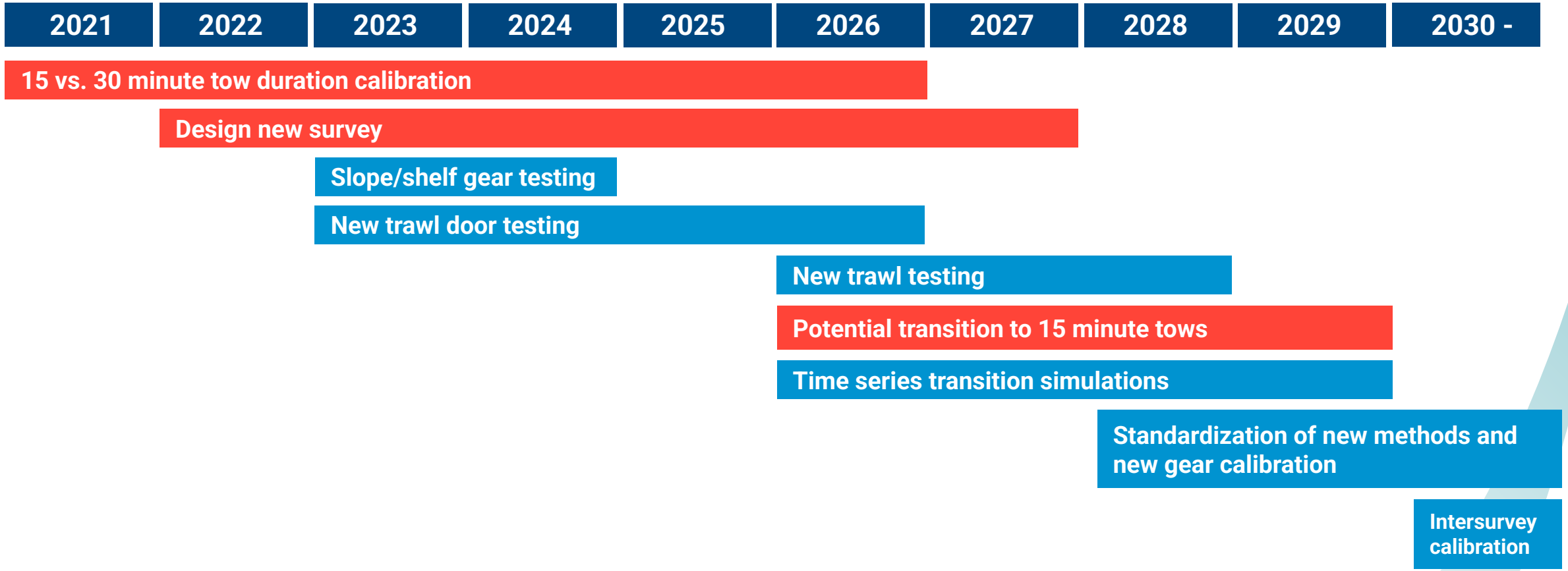
Timeline (extremely optimistic)



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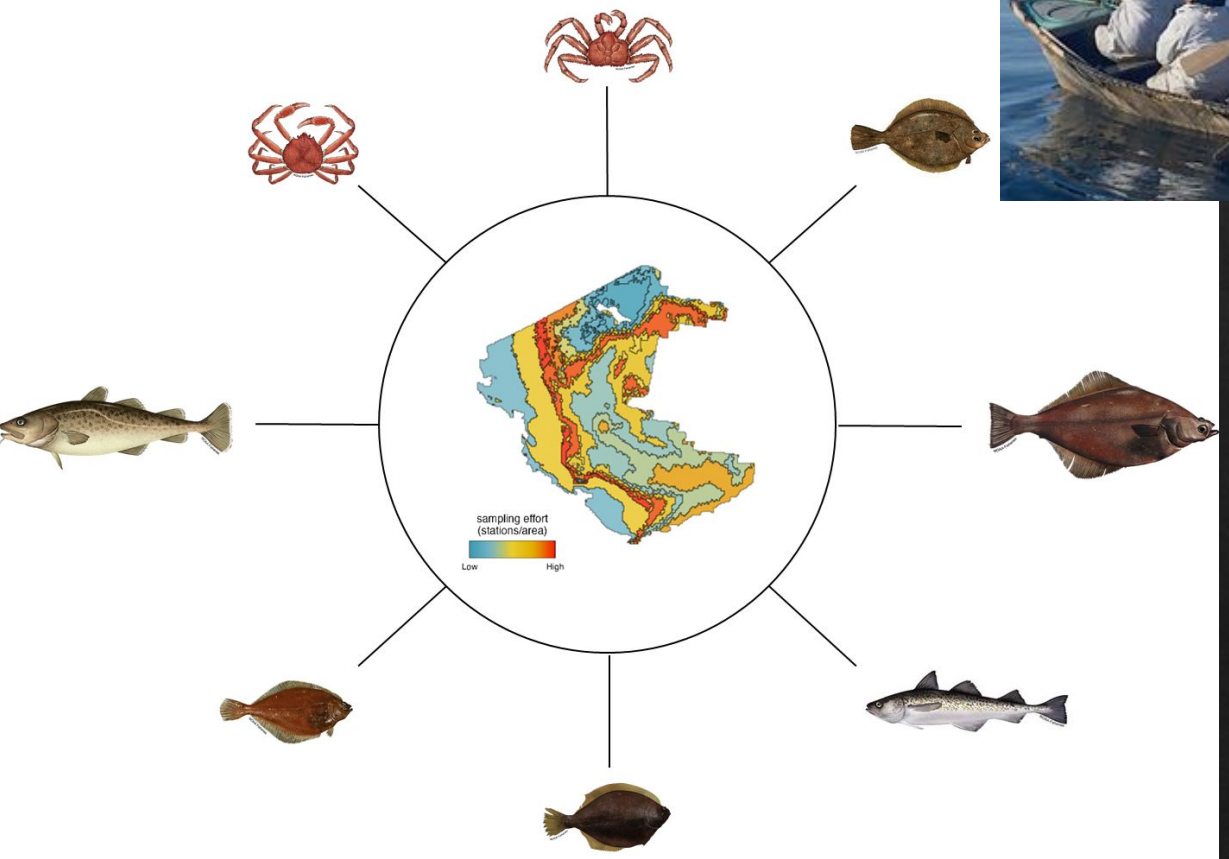
Bering Sea Survey Modernization: Sampling Design

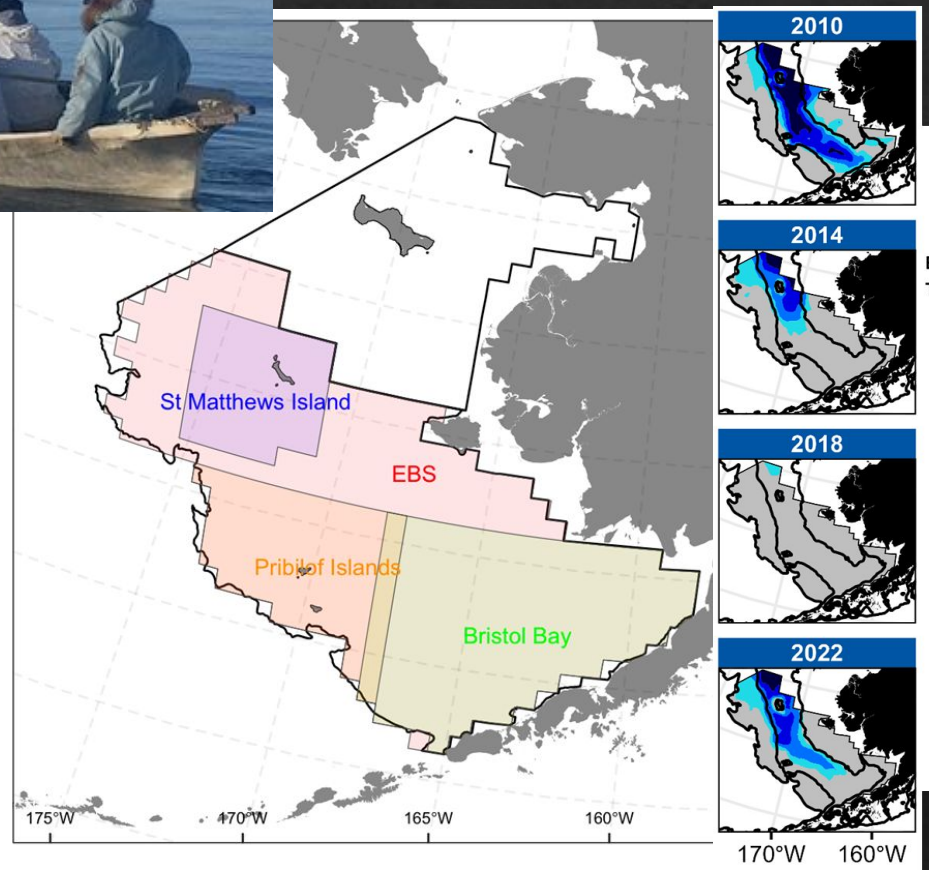
*Lewis Barnett, Daniel Vilas, Zack Oyafuso, Lukas DeFilippo, Leah Zacher, Shannon Hennessey, Margaret Siple, Stan Kotwicki, André Punt

NPFMC Crab Plan Team
May 14, 2025

Survey Design Goals and Background

- Goals
  - Unify Bering surveys in a flexible and efficient design
  - Obtain accurate and precise design-unbiased estimates of abundance across FMP species and management regions (e.g., full Bering, EBS, shelf, crab areas)



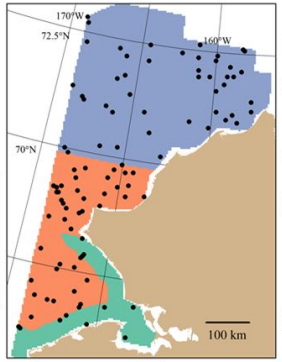


Survey Design Goals and Background

- Motivation and guidance for the approach
  - ICES WKUSER 2020, 2023
  - GOA redesign (Oyafuso et al., 2021, 2022) with GPT feedback
  - Chukchi design (Oyafuso et al. 2023)
  - Feedback from stock assessment leads

Simulation approach

Oyafuso et al. 2021 ICES JMS



Find designs that limit abundance estimate CV

Genetic algorithm: stratification

Bethel algorithm: sample allocation

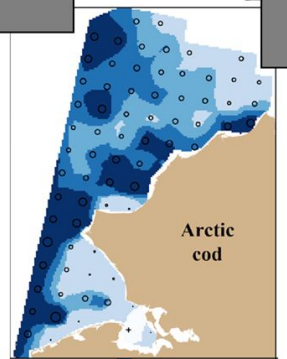
Optimize design

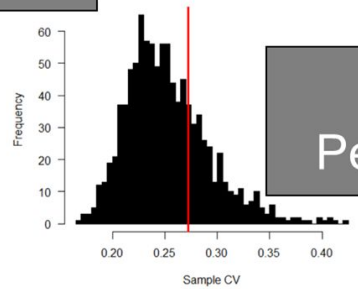
Spatiotemporal model conditioned on historical data

Simulate Densities

Simulate Surveys

Survey Performance

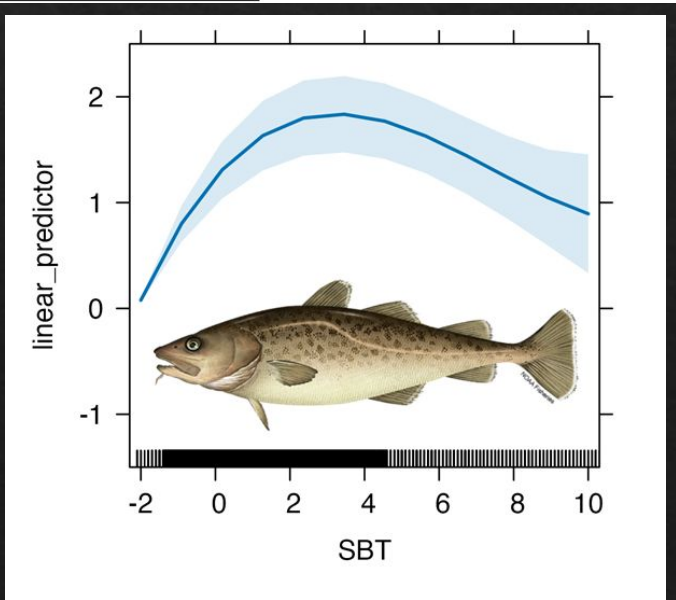




CV Constraints

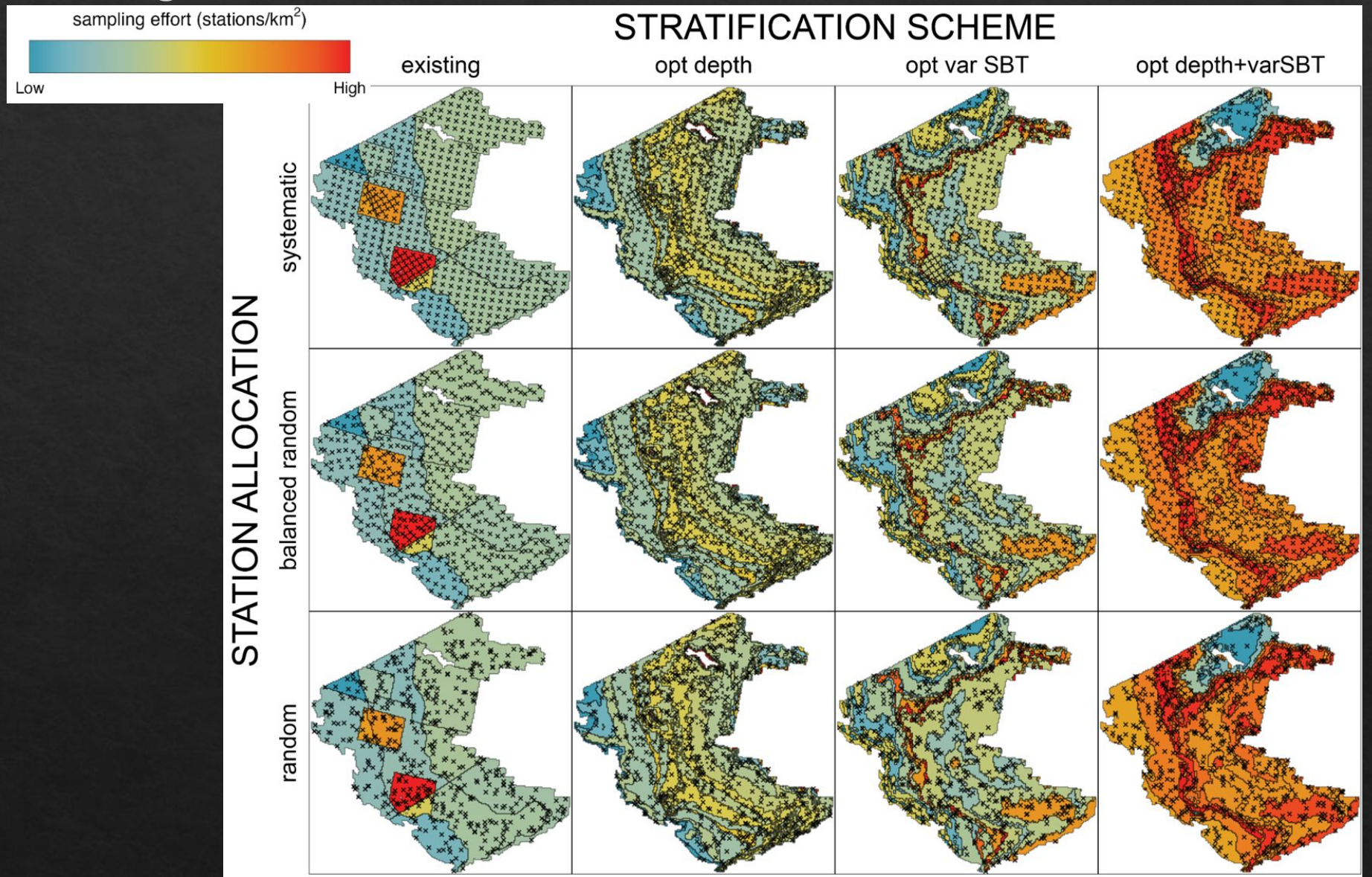
Stratification

Bethel Algorithm



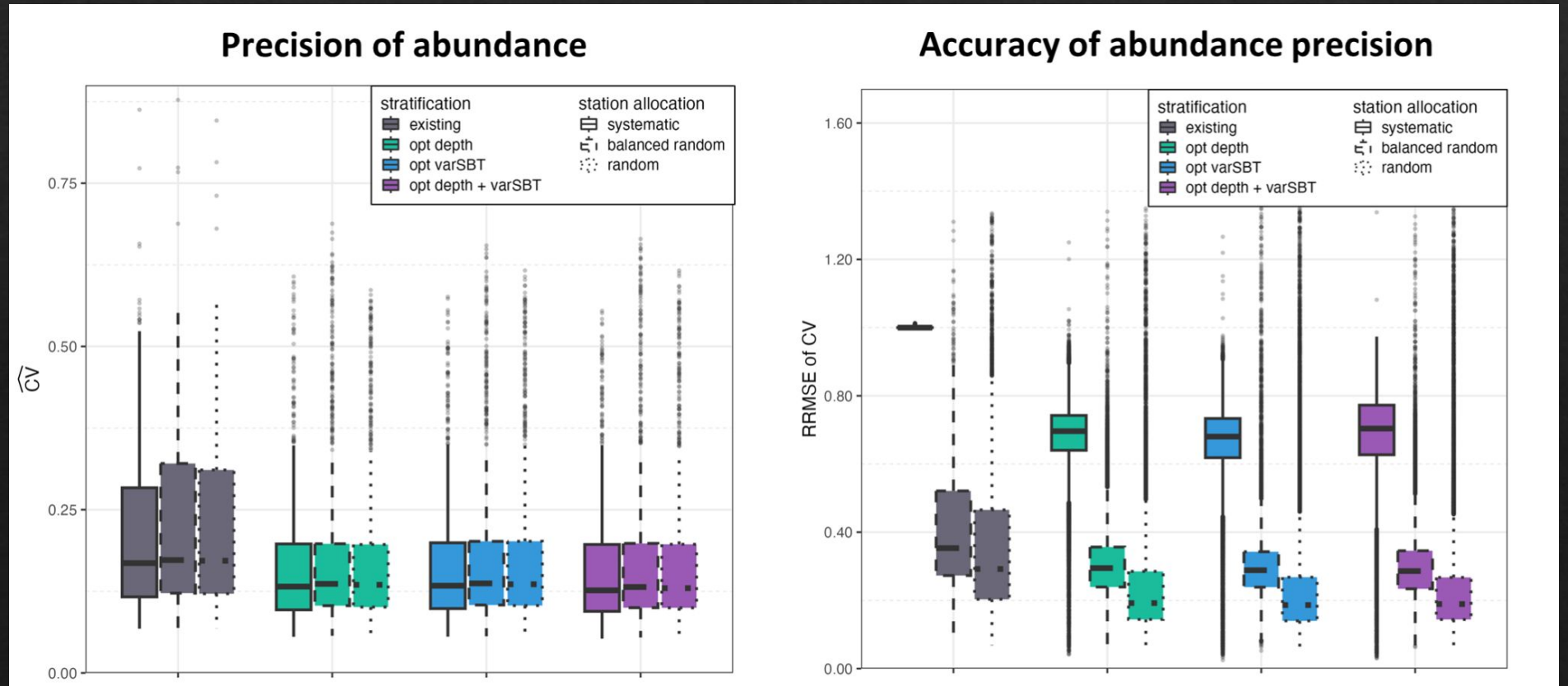
Survey Design Methods

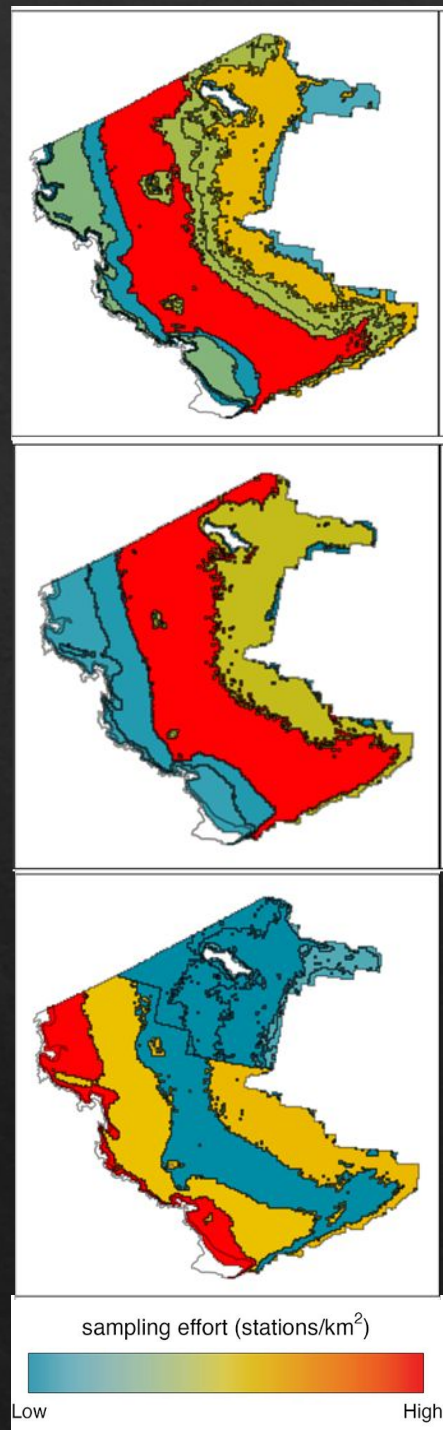
- Optimizing shelf strata and allocation (Vilas et al. 2024)



Survey Design Progress

- Optimizing shelf strata and allocation (Vilas et al. 2024)
  - Best designs were stratified random or spatially balanced stratified random sampling
    - Precision similar or better than existing design for most species, with much more accurate estimates of the variance



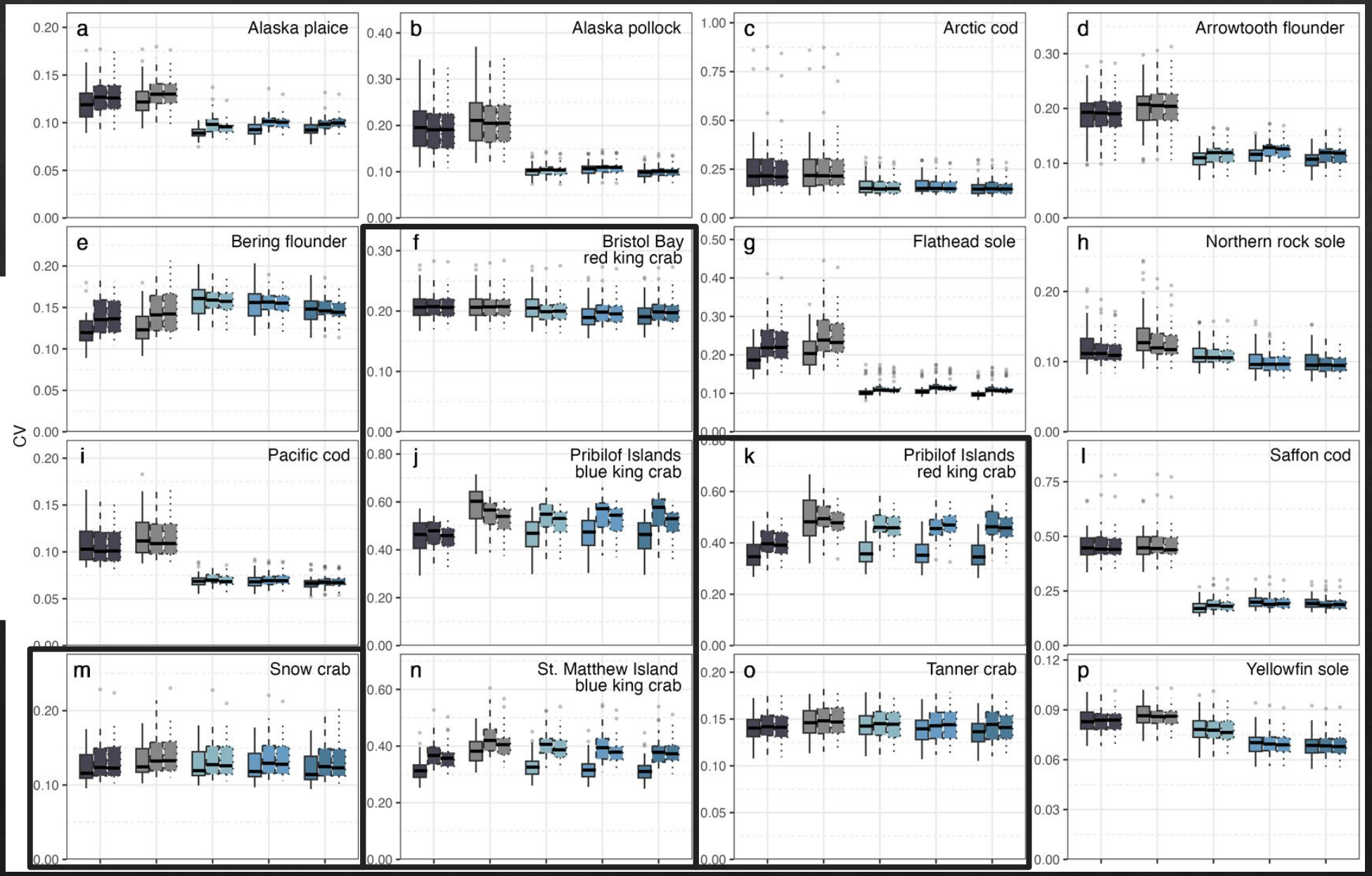


Survey Design Progress: species-specific

HISTORICAL

Index CV

Over all years

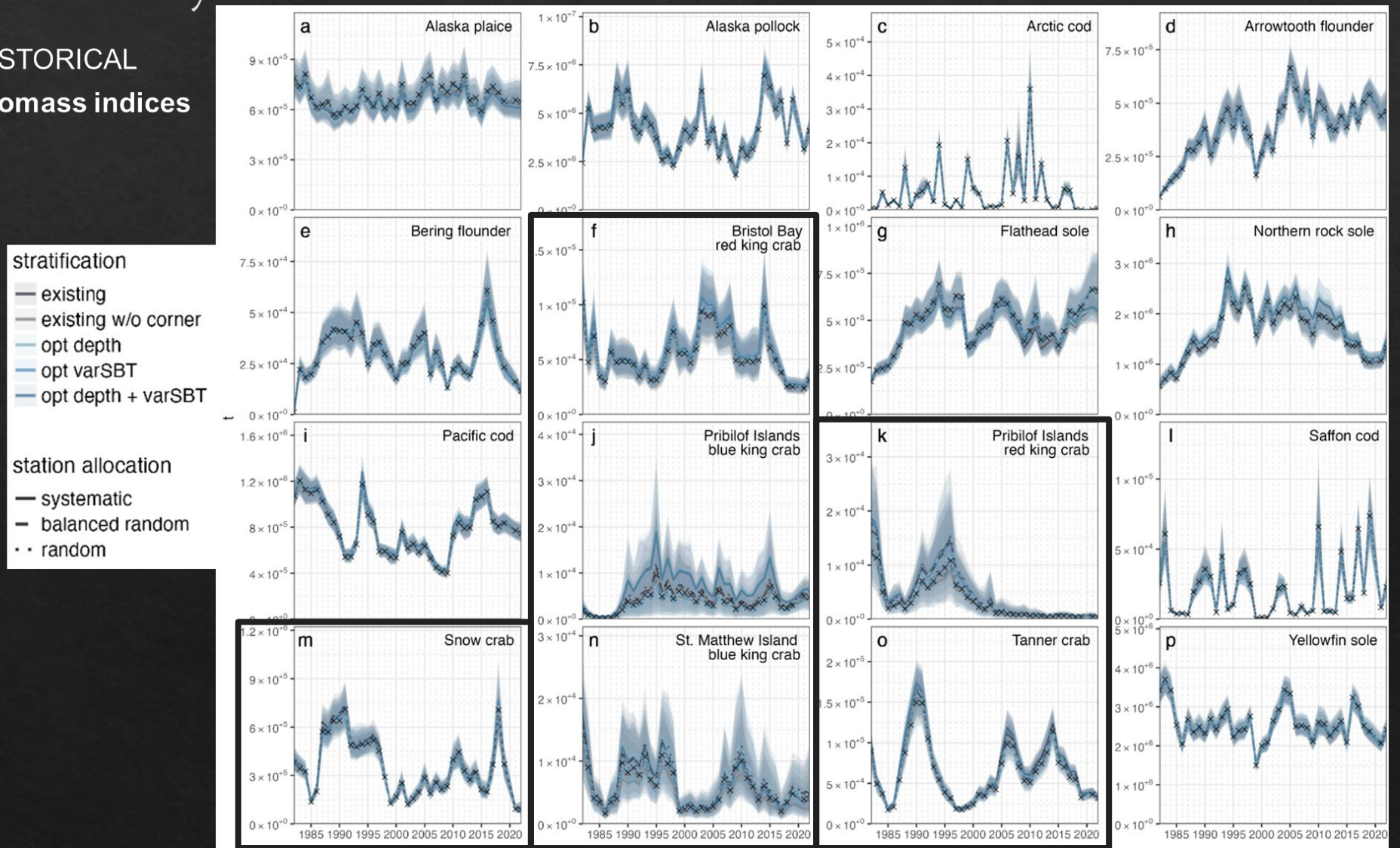


Survey Design Progress: species-specific

- Abundance estimate scale and trends were very similar across designs, indicating continuity with historical time series

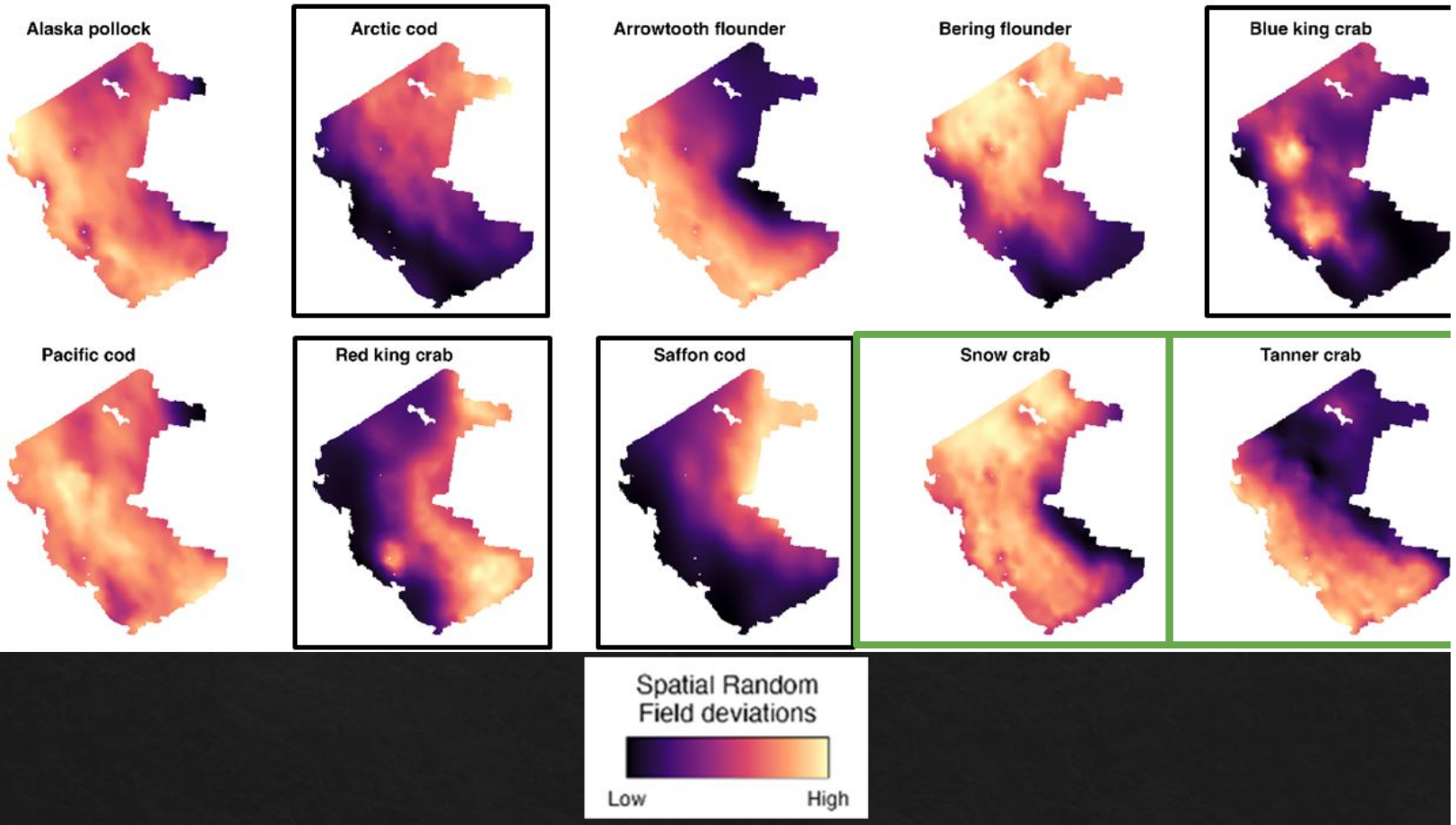
HISTORICAL

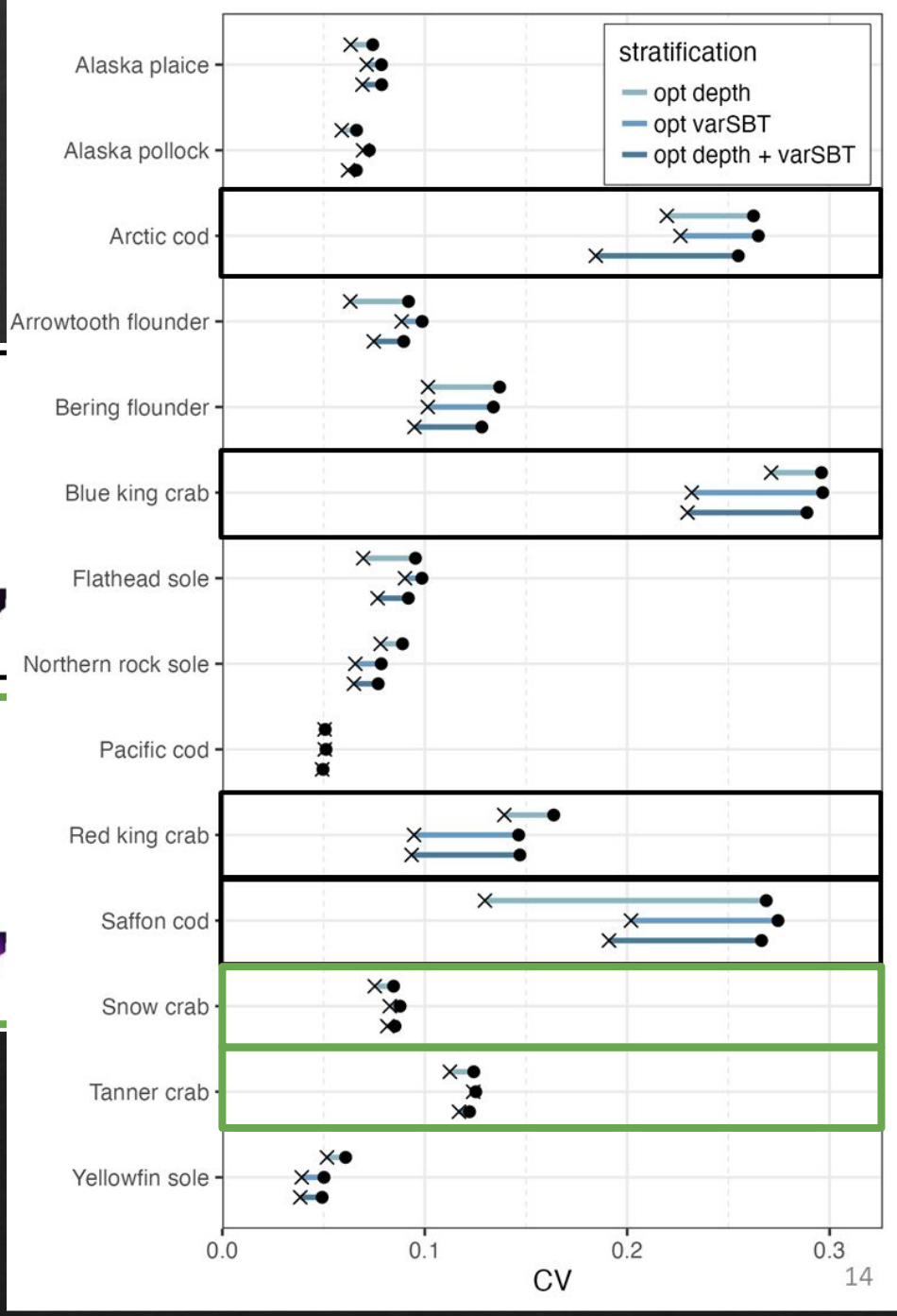
Biomass indices



Survey Design Progress

- Tradeoffs among stocks in precision and accuracy

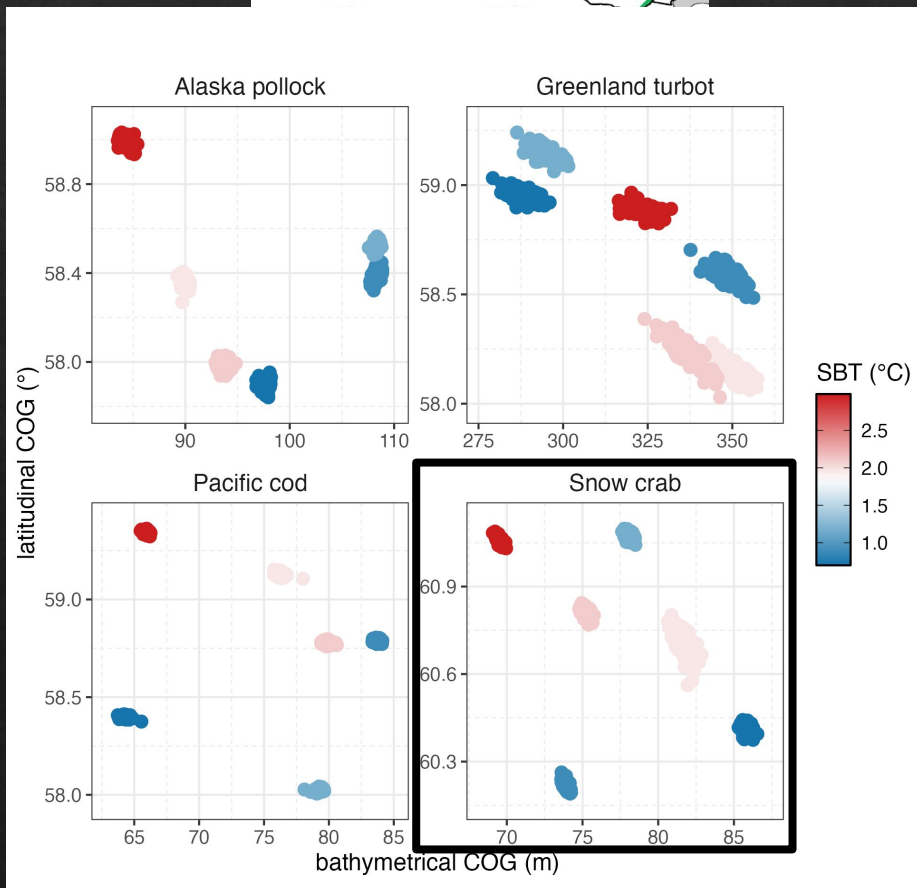




Survey Design Progress: Fresh Results

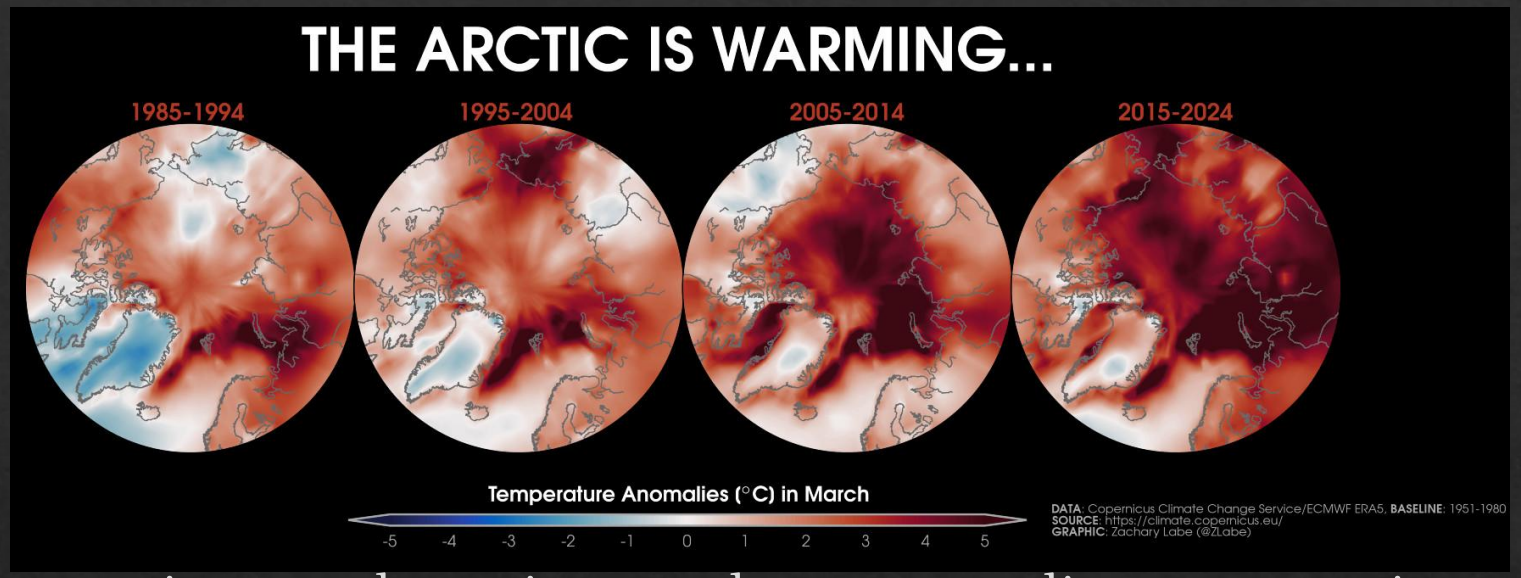
- Including upper slope in design optimization
  - Shelf and slope integrated abundance estimates
    - Integrating selectivity ratios from gear calibration

- Dynamic allocation: Do estimates improve when sample allocations among strata are optimized for cold vs warm years?
  - Detected poleward distribution shifts
  - Did not detect deeper distributions with warming



Survey Design Forward Outlook

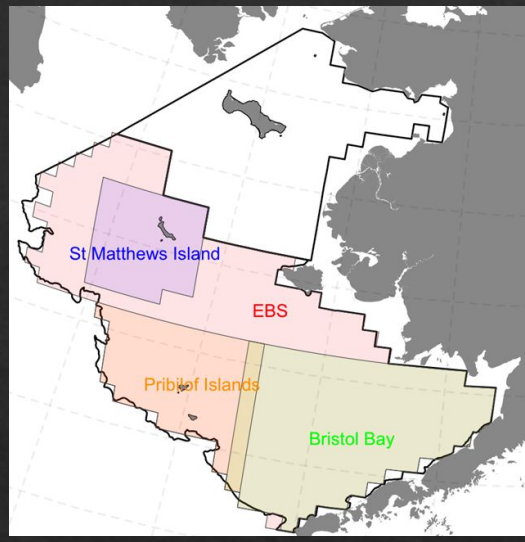
- Challenges
  - Changing environment



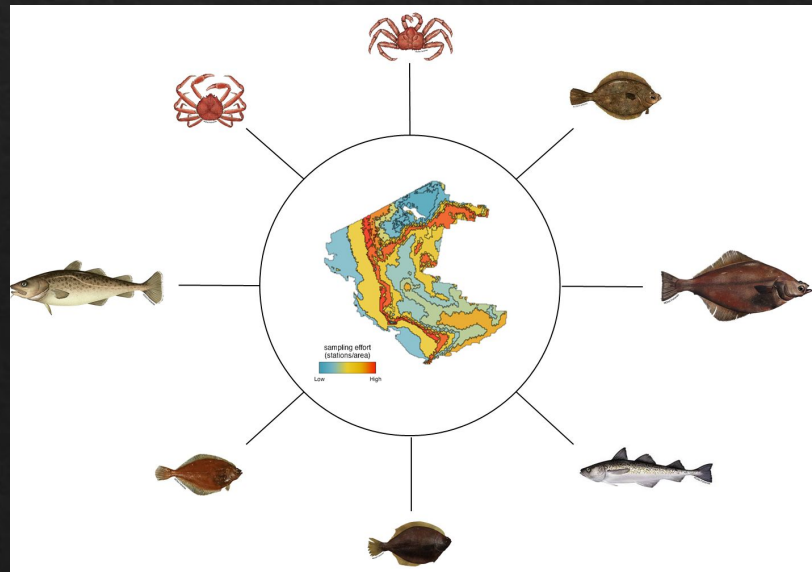
  - Potential unforseen increases in sample variances due to sampling new stations
- Timeline: ~2 years for main results if postdoc funding proceeds
  - Research on static vs dynamic sample allocation
  - Incorporating new shelf/slope gear calibrations
  - Evaluating effects on sampling timing and distance traveled
  - Refining OM and candidate designs
    - Incorporating feedback from Plan Teams, Council, stakeholders, Alaska Natives

Topics requested for feedback

- How to approach misalignment of optimal stratum boundaries relative to sub-regional (crab) management areas?
  - Evaluate performance at domain-scale or sub-regional scale?



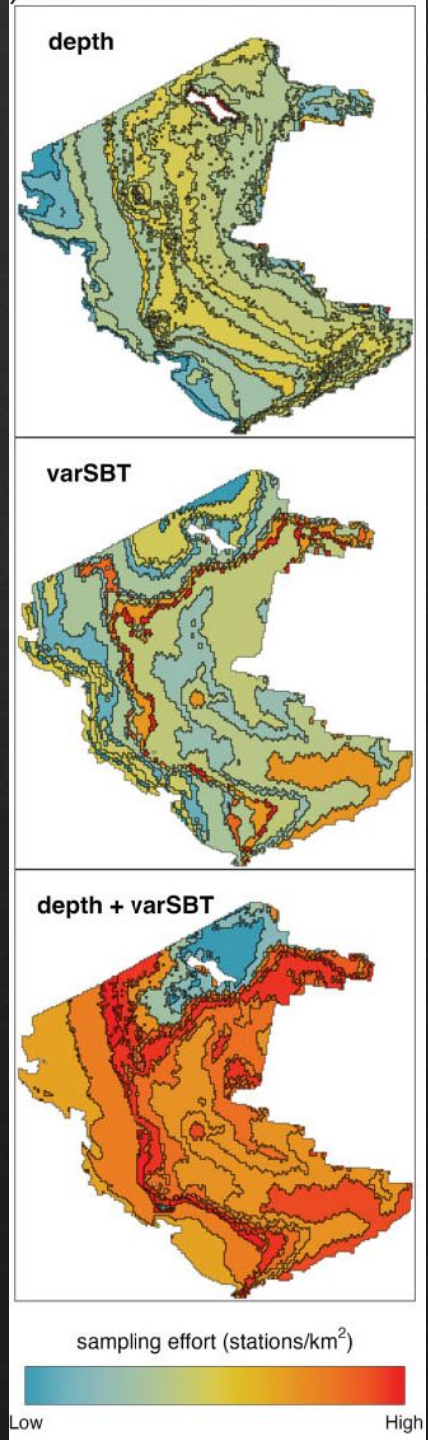
- Multispecies and multiobjective scope and prioritization
  - Should we consider optimizing over size/sex-specific quantities rather than total biomass for crab stocks?
  - Do we want to weight the optimization toward further minimizing uncertainty for some stocks at the cost of others? In what way(s)?



Survey Design Extra slides

On the right are the original stratification and allocation solutions from which performance measures on previously slides were derived, demonstrating differences among stratifying variables

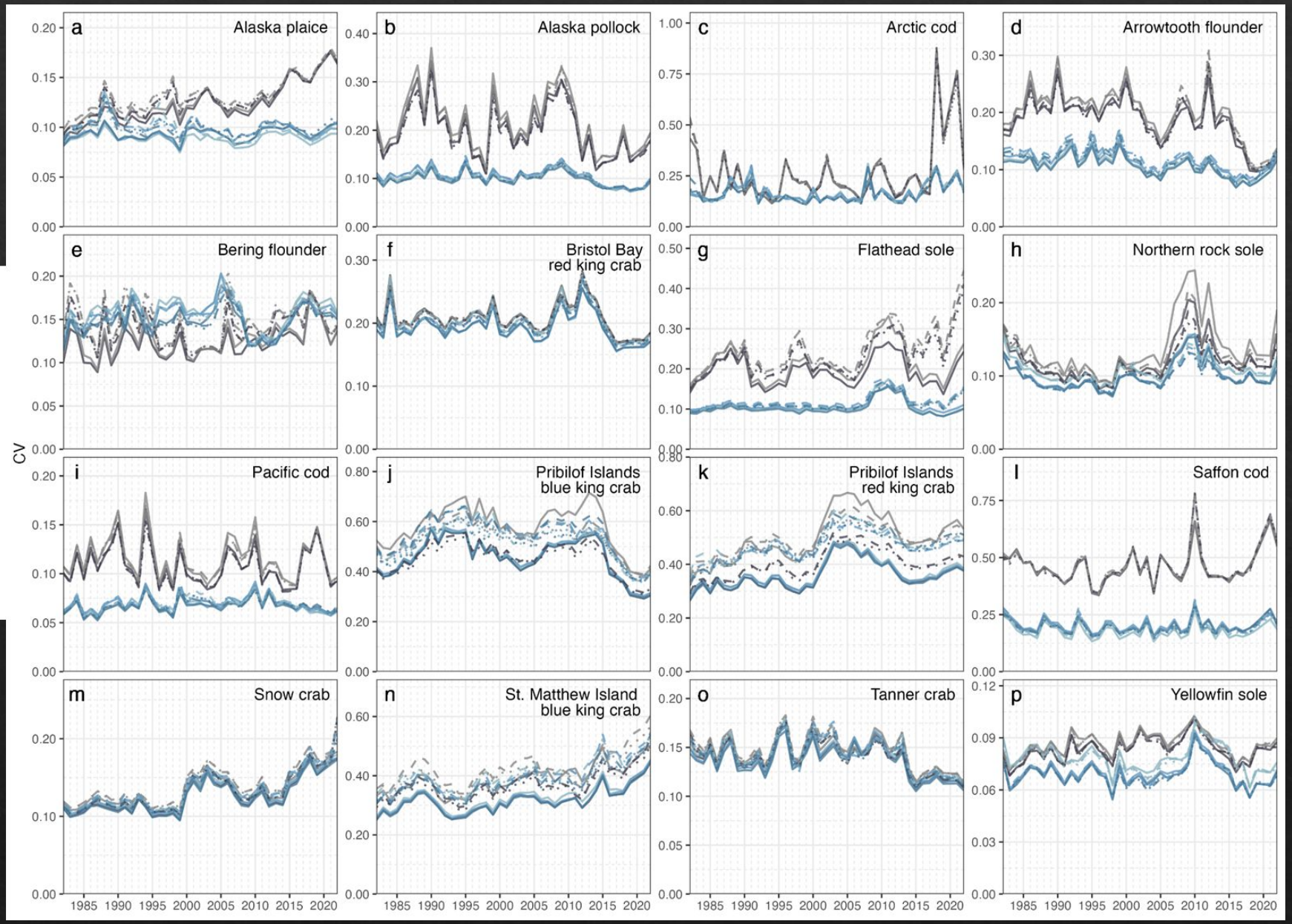
More recent example solutions are shown in slide 8, representing solutions with reduced number of strata [top: 10, middle: 5, bottom: 5 per domain (EBS, NBS optimized as independent domains)], as recommended by the SSC



Survey Design Extra slides

HISTORICAL

Index CV

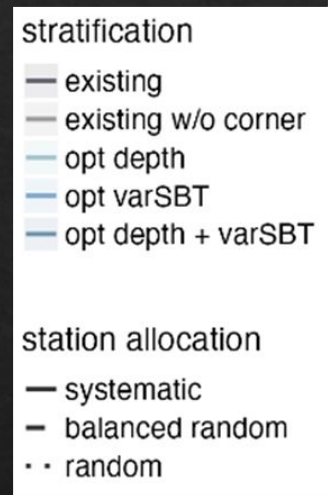


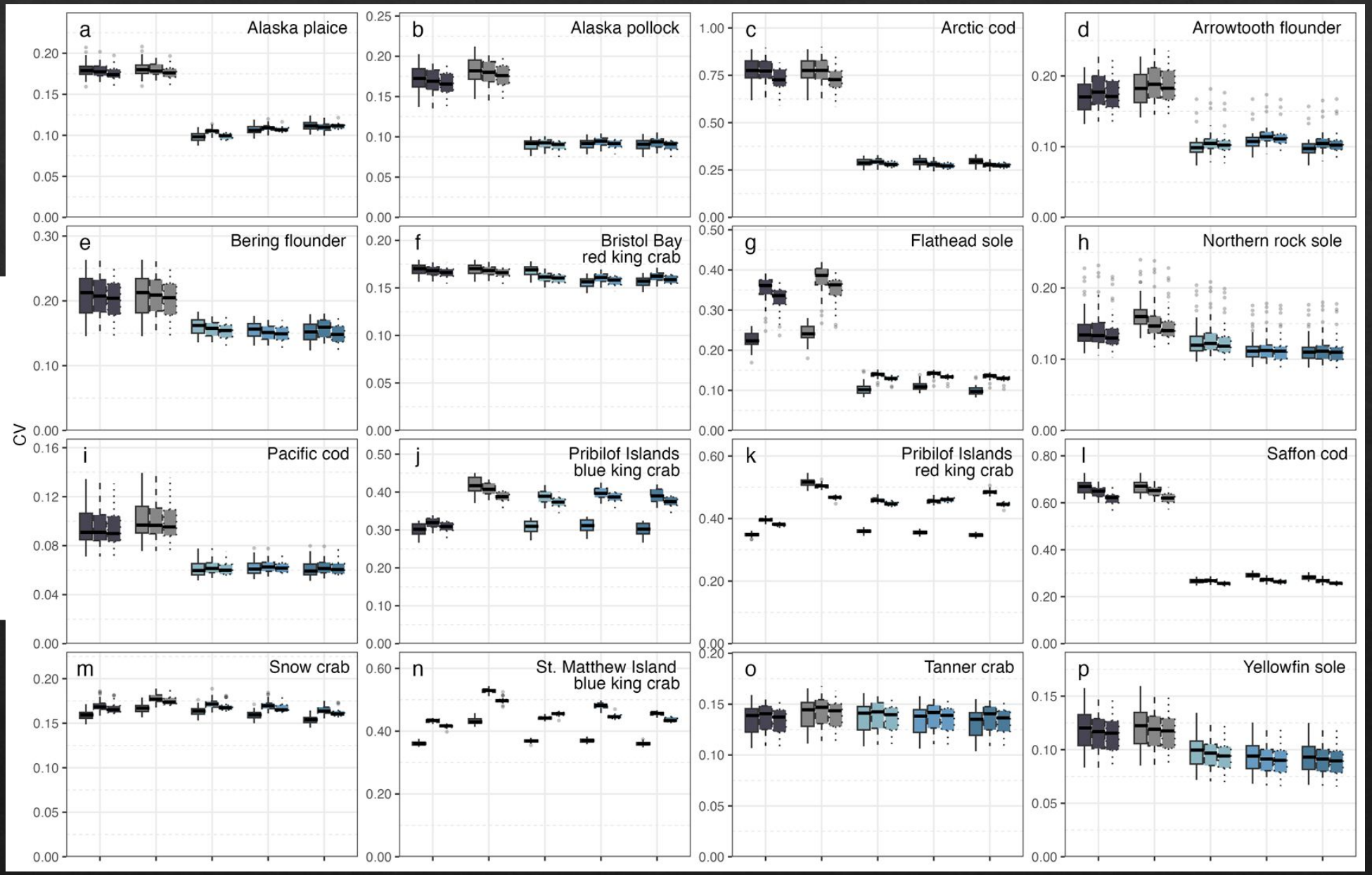
Survey Design Extra slides

FUTURE

Index CV

Over all years, scenarios





Bering Sea Survey Modernization: Reducing tow duration to 15 minutes (“15/30”)

Sean Rohan, Rebecca Haehn-Tam, Emily Ryznar, Chris Long, Zack Oyafuso, and Stan Kotwicki

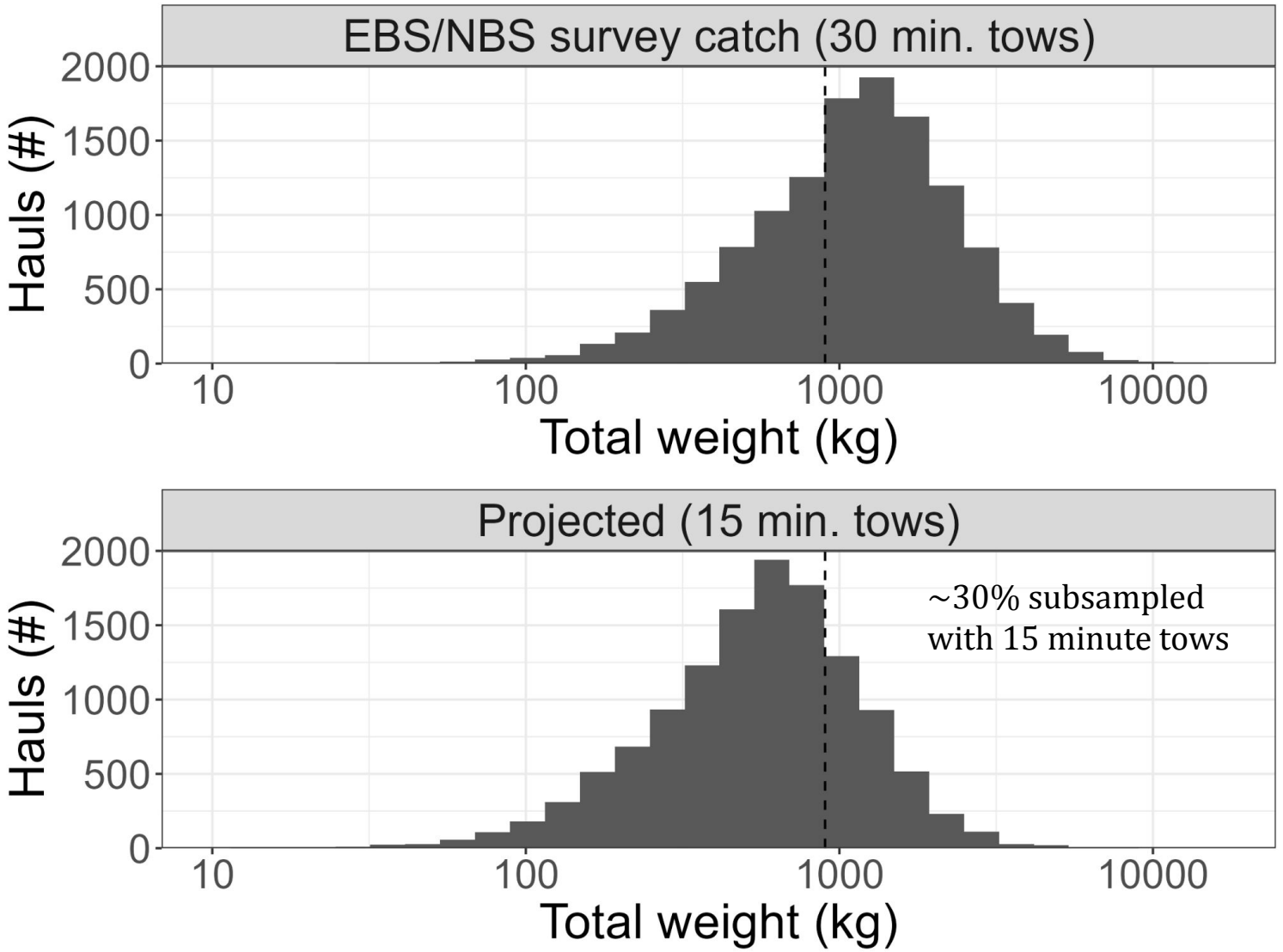
NPFMC Crab Plan Team

May 14, 2025

Why reduce tow duration to 15 minutes?

- Reduce potential errors associated with subsampling large catches
- Enable additional data collection
  - Time to collect other types of data
    - e.g., visual maturity, genetics, environment
  - Shorter duration necessary for future stratified-random design
- Reduce ergonomic injuries

Approximately 70% of catches are subsampled



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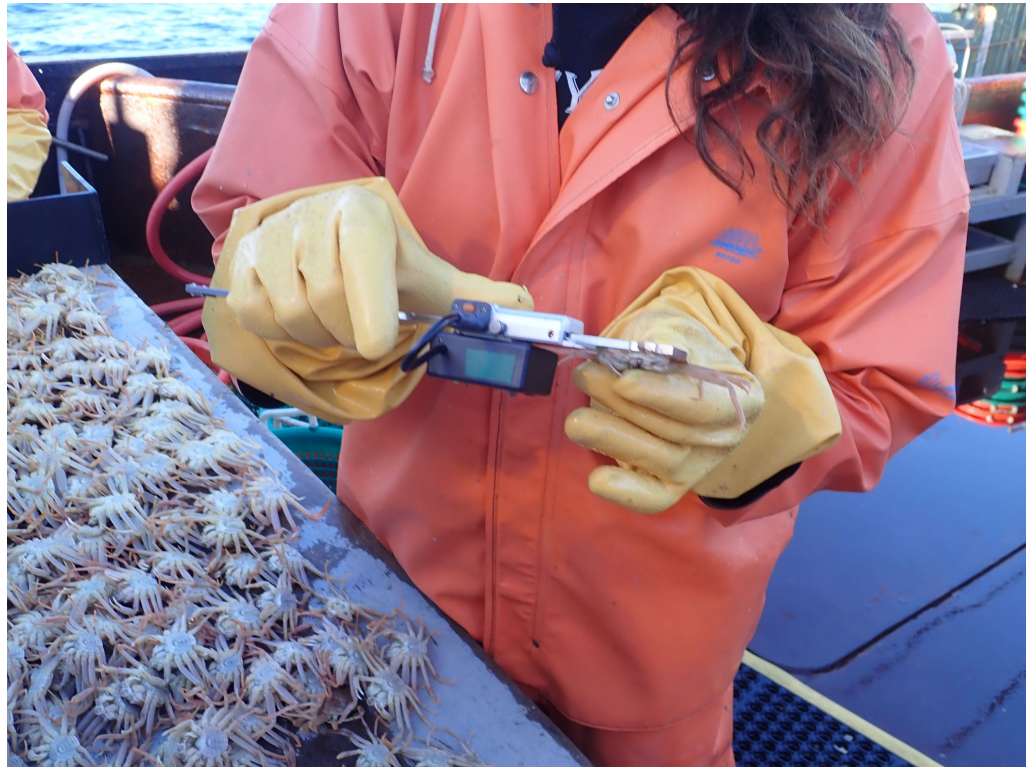
FIRE
HOSE


FLATFISHES
ALASKA PLAICE
ARROWTOOTH FLOUNDER
BERING FLOUNDER
BUTTER SOLE
FLATHEAD SOLE
GREENLAND TURB
KAMCHATKA
LONGHEA
NO
FLOUNDER
OWFIN SOLE


MITTEMAIER
MITTEMAIER
STRODL
STRODL



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2012 CIE Review recommended approach

1. Conduct side-by-side tow experiments to evaluate effects of reduced tow duration.
2. Evaluate impact of change in tow duration on assessment outcomes (e.g. through simulations).
3. Implement transition to 15 minute tows using one of the recommended options.

Chen, Y (2012). CIE Independent Peer Review Report: Eastern Bering Sea Crab and Groundfish Bottom Trawl Surveys. 29 pp. Link
Hall, NG (2012). Review of the eastern Bering Sea crab and groundfish bottom trawl surveys. Center of Independent Experts, May 24, 2012. 37 pp. Link
Volstad, JH (2012) CIE Independent Peer Review Report: Eastern Bering Sea Crab and Groundfish Bottom Trawl Surveys. Center of Independent Experts, May 24, 2012. 26 pp. Link

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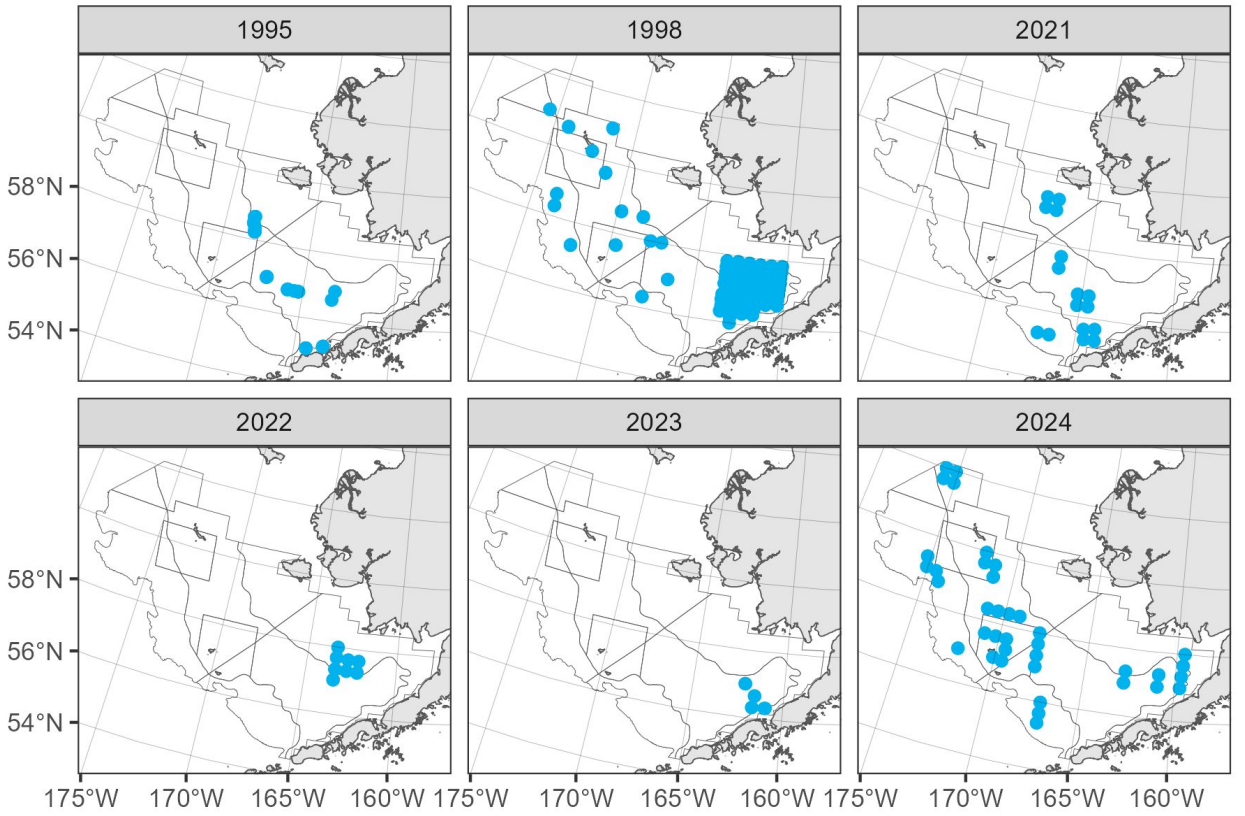
15/30 research and implementation plan

1. Conduct side-by-side catch comparison tows.
2. Evaluate effects of shorter tow duration on survey catch.
3. Develop calibrated design-based indices that can be used to simulate effects of shorter tow duration on assessment outcomes.
4. Transition/begin phasing in to 15 minute tows in 2026.

15/30 status

- Completed 38 paired tows in 2024 (161 total from 1995 to 2024).
- Selectivity/catchability calibration analyses underway, to be completed in FY25.
- Evaluating multiple methods for estimating selectivity/catchability ratios.



Note: Progress on this project has been delayed due to the Department of Commerce's pause in grant funding for a UW postdoc.

Why has the change not been implemented in the past?

- Idea to reduce tow duration is not new (e.g. 2012 CIE review, tow duration experiments in the 90s).
- Heavily influenced by Somerton et al's (2002) fishing power comparison for numerical CPUE:
  - Snow crab: 78% higher in 15 minute tows
  - Tanner crab: 68% higher in 15 minute tows
  - Red king crab: No difference

Preliminary results: snow crab CPUE ~20% higher in 15 minute tows; Tanner crab CPUEs ~14% higher in 15 minute tows; red king crab CPUE ~12% higher in 30 minute tows.

Somerton, D.A., Otto, R.S., Syrjala, S.E., 2002. Can changes in tow duration on bottom trawl surveys lead to changes in CPUE and mean size? Fish. Res. 55, 63–70. https://doi.org/10.1016/S0165-7836(01)00293-4

Options for implementation

1. **Replicated (CIE)**: Conduct 30 and 15 minute tow duration surveys in parallel for several years then transition. *Not feasible.*
2. **Augmented (CIE)**: Augment survey with a large number of randomly positioned 15-minute tows for several years. Transition to 15-minute tows with a large number of randomly positioned 30-minute tows. *Not feasible.*
3. **Phased (CIE)**: Replace 30 minute tows with 15 minute tows over time; progressively increase the proportion of 15 minute tows. *Feasible.*
4. **"Rip the band-aid off"**: Transition to 15 minute tows to maximize contrast in the time series; continue calibration tows to the extent possible. *Feasible.*

Options for implementation

1. **Replicated (CIE)**: Conduct 30 and 15 minute tow duration surveys in parallel for several years then transition. *Not feasible.*
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4. **"Rip the band-aid off"**: Transition to 15 minute tows to maximize contrast in the time series; continue calibration tows to the extent possible. *Feasible.*

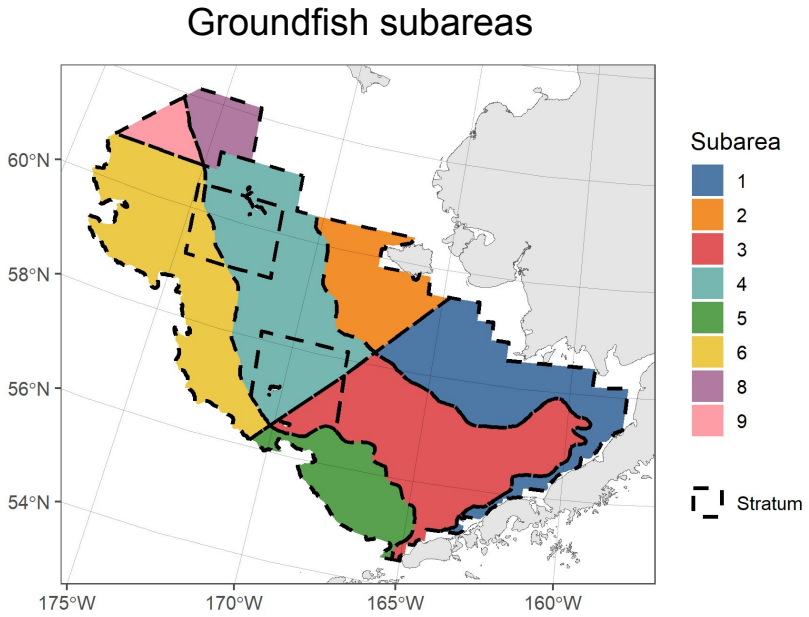
Phased transition

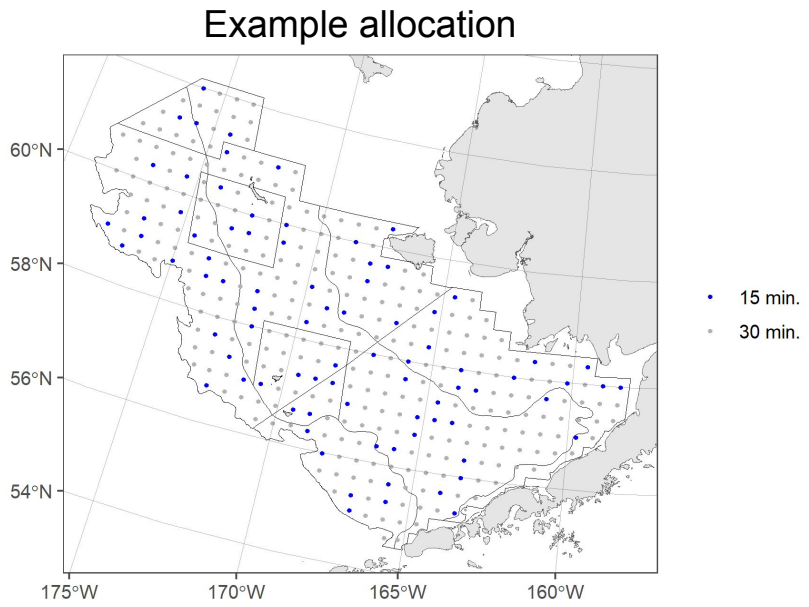
2026

Transition 25% of stations to 15 minutes (randomly by groundfish subarea).

2027-

Continue increasing proportion of 15 minute stations.





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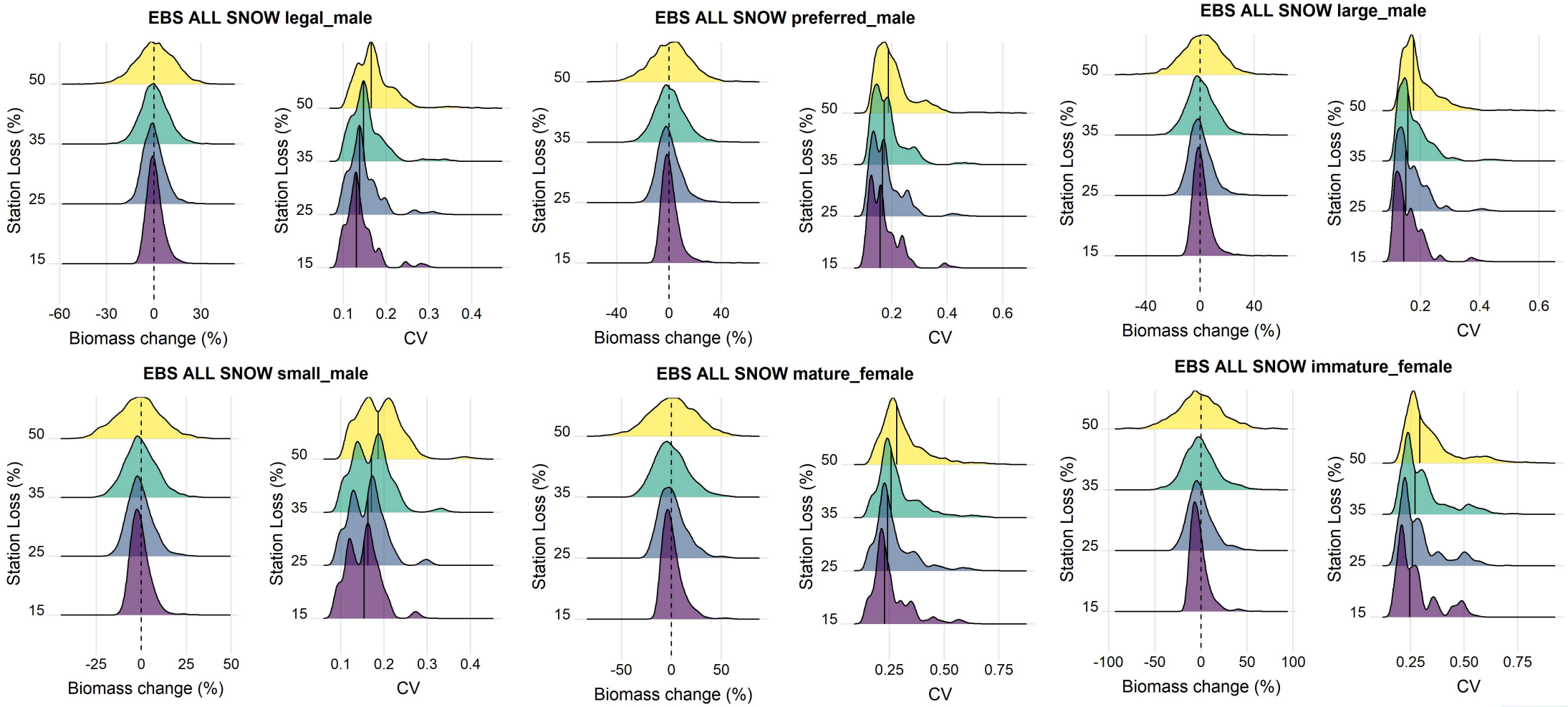
Example: Simulated effect of station loss on BTS crab biomass indices and CVs (worst case scenario for phased transition)



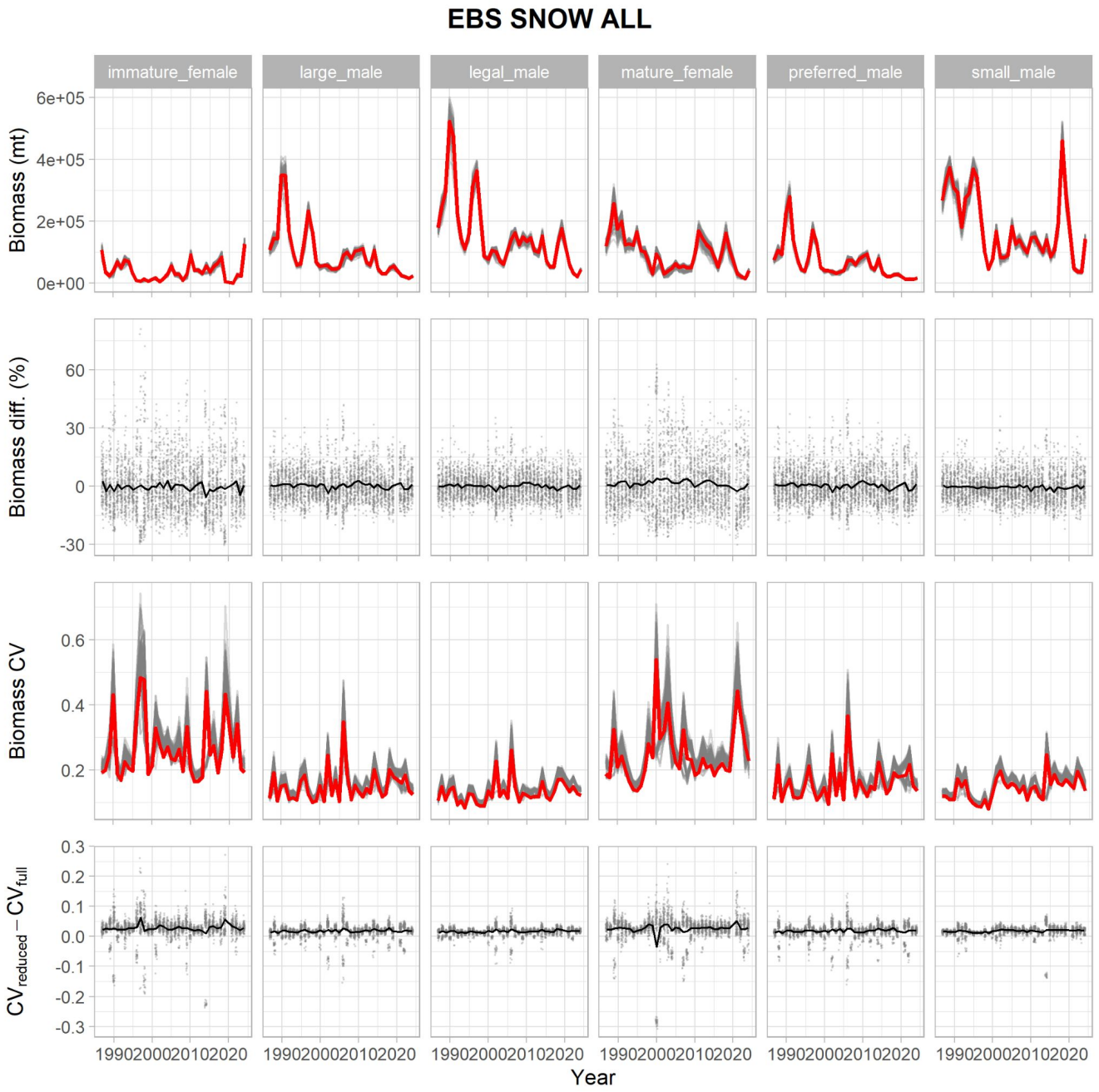
Simulation: 100 draws for each station loss %; all years since 1987.

Example: Simulated 25% station loss time series

Red = mean

Grey = individual draw

Note: Slides for additional stocks at the end.



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“Ripping the band-aid off”

2026-

15 minute tow duration at all stations

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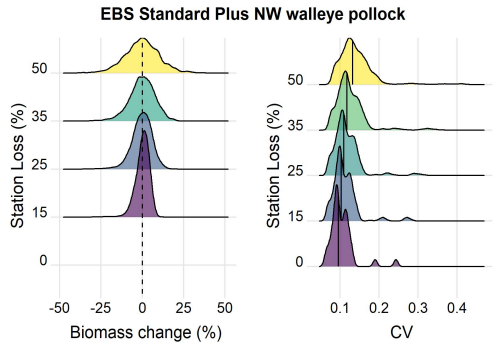
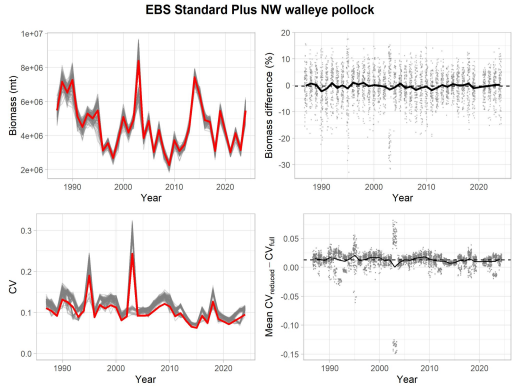
Questions

1. If the EBS survey begins transitioning to 15 minute tows in 2026, which approach to transition would be preferable? Phased transition or knife-edge ("ripping the band-aid off")?
2. If the survey uses a phased transition, what criteria would be useful for evaluating whether to phase in more stations?
3. When selectivity and catchability ratio estimates are available, how would you use the estimates in a stock assessment (e.g. use the raw values, as catchability/selectivity priors, not at all)?

Extra slides: Effect of station loss on crab indices



Density plots show 15-50 % loss



Time series plots show 25% loss

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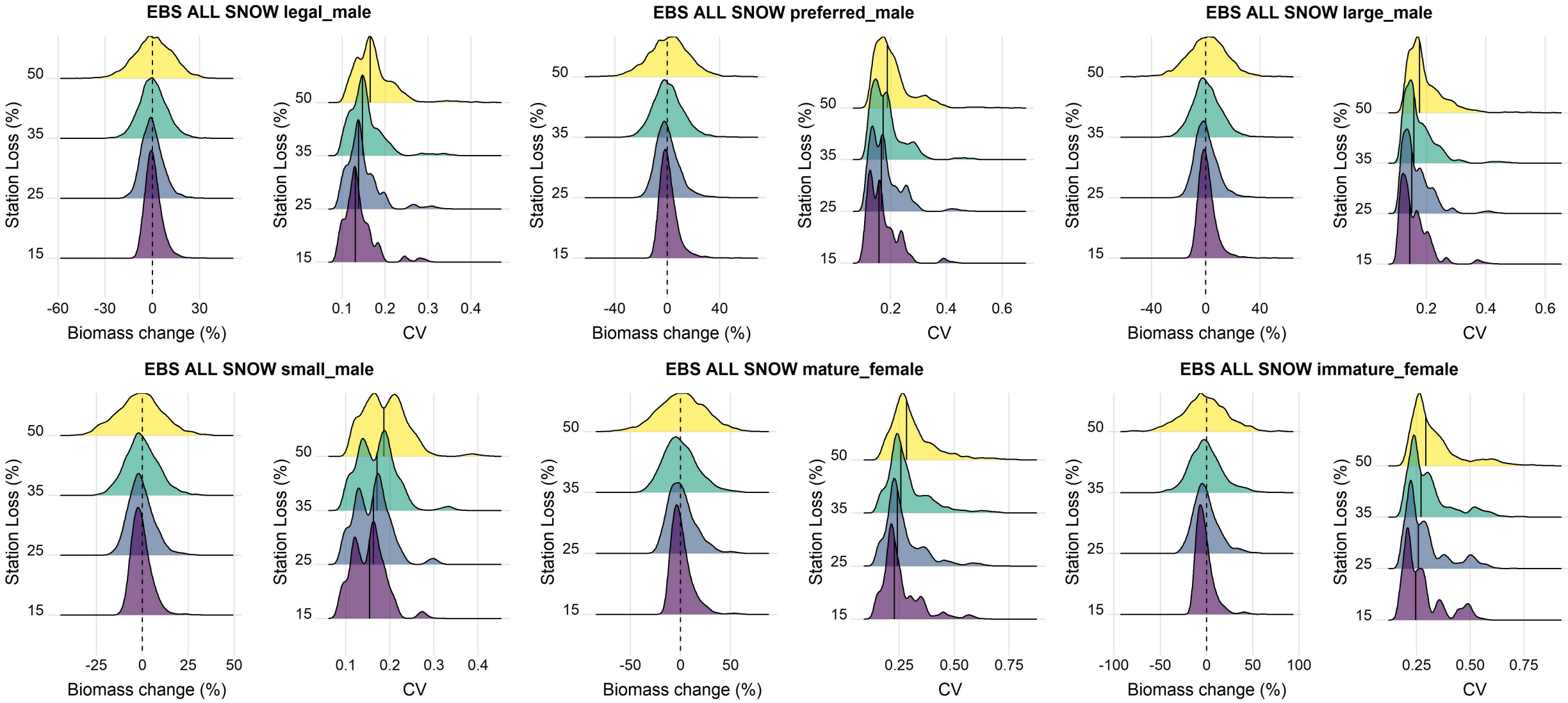
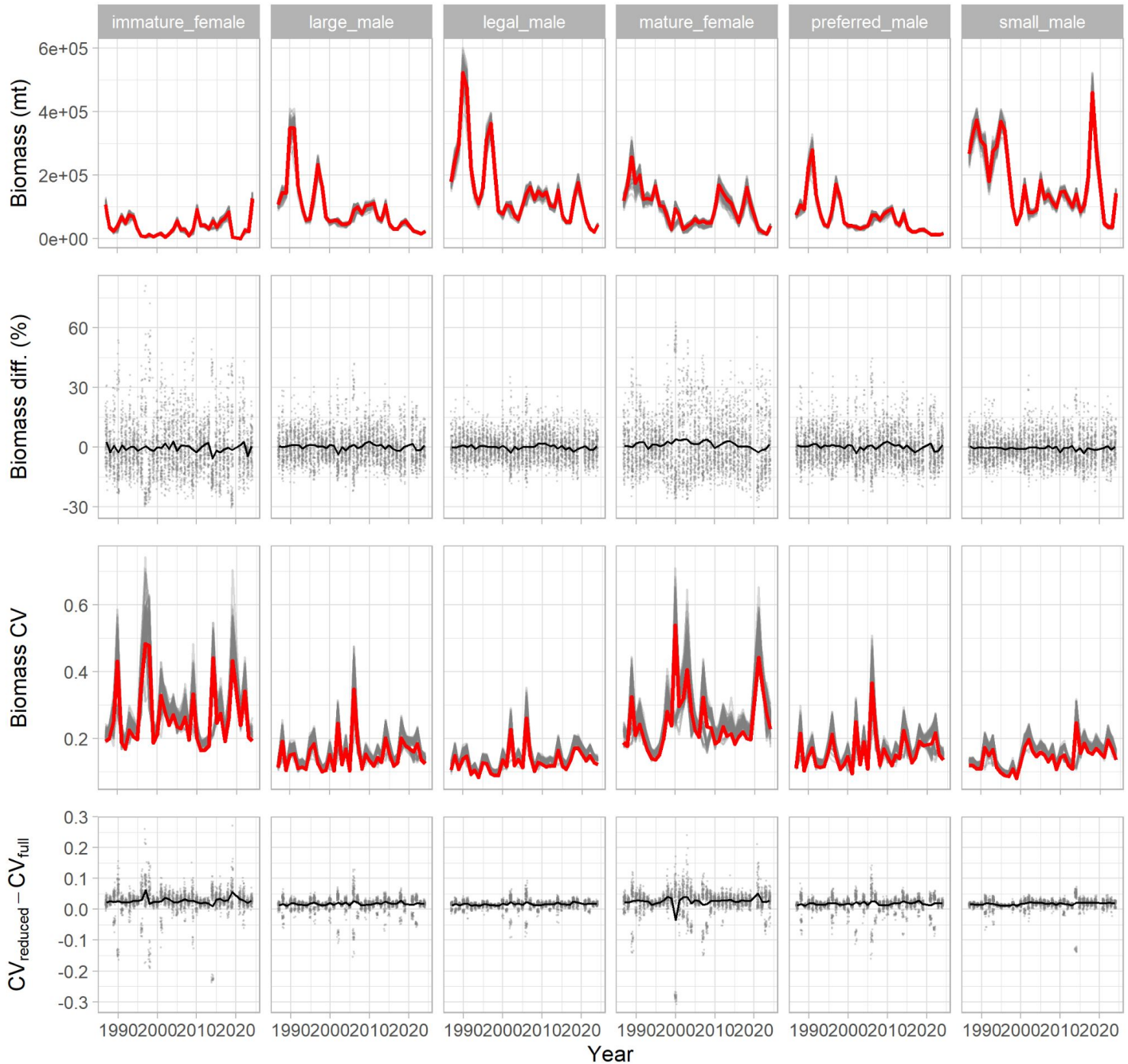
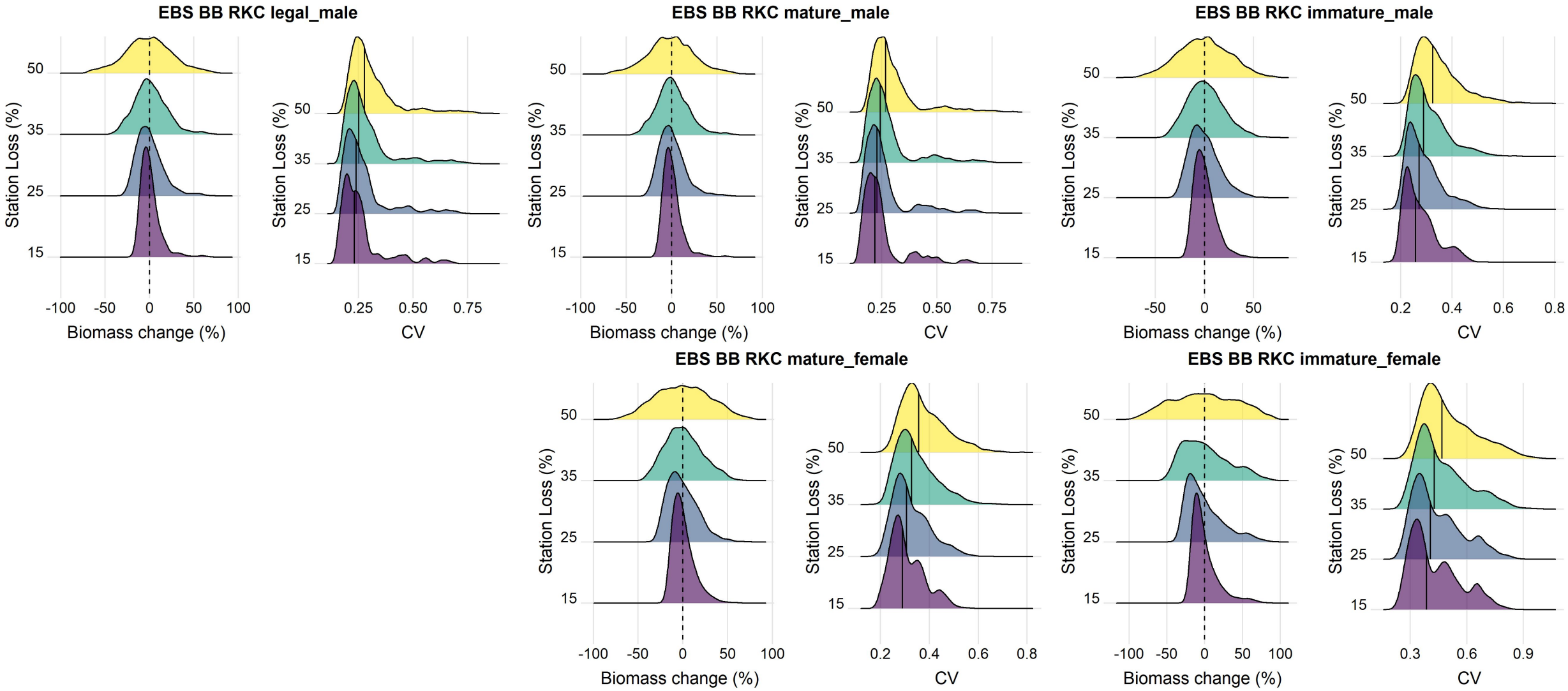
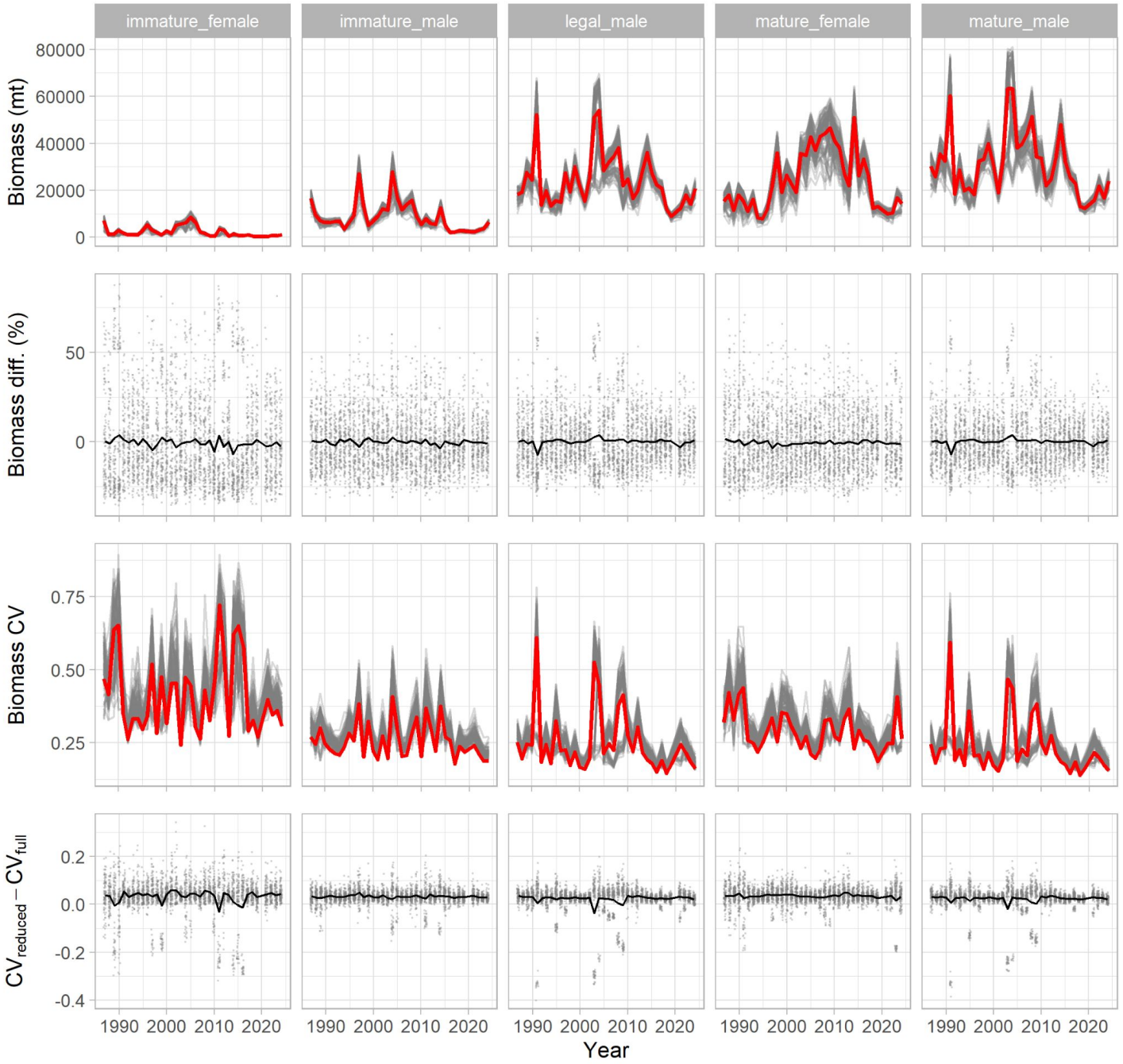
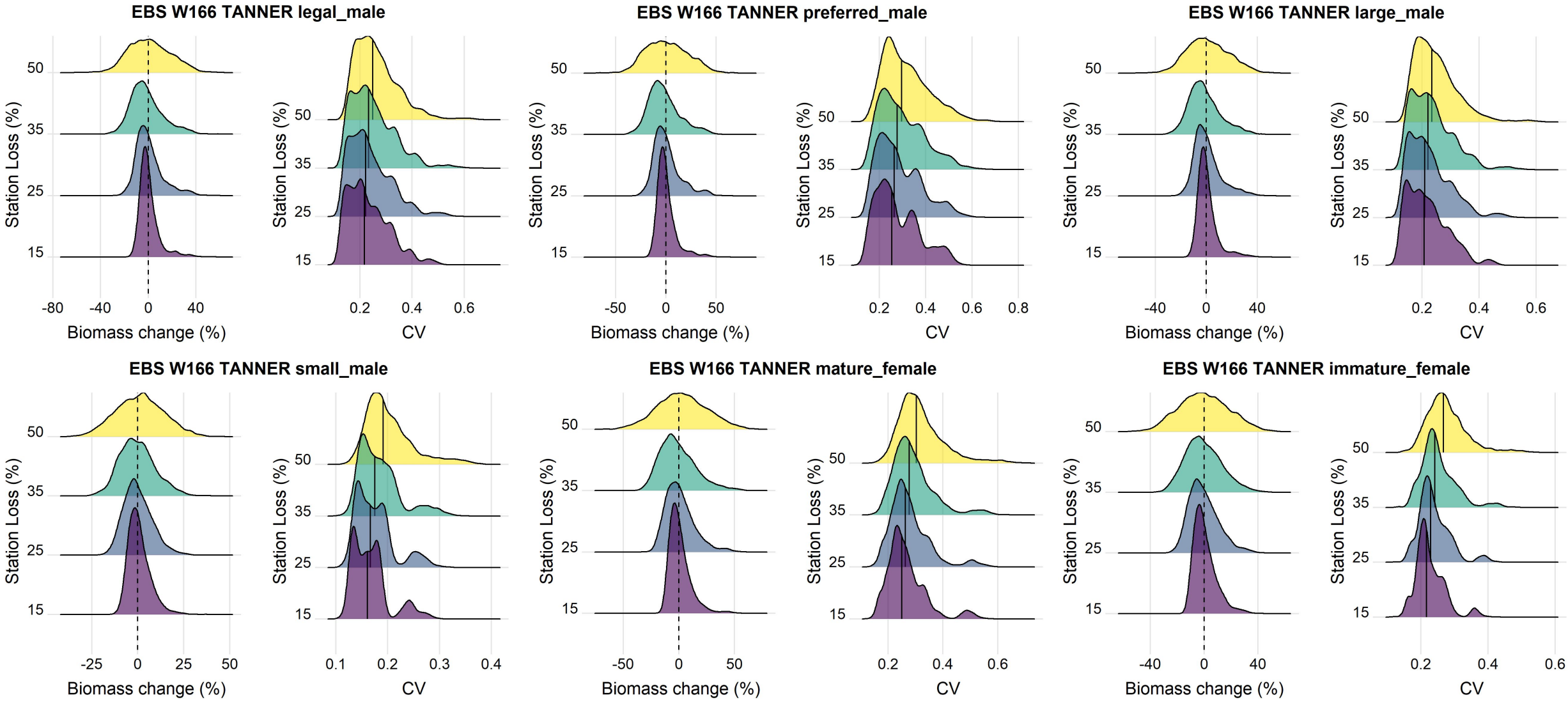
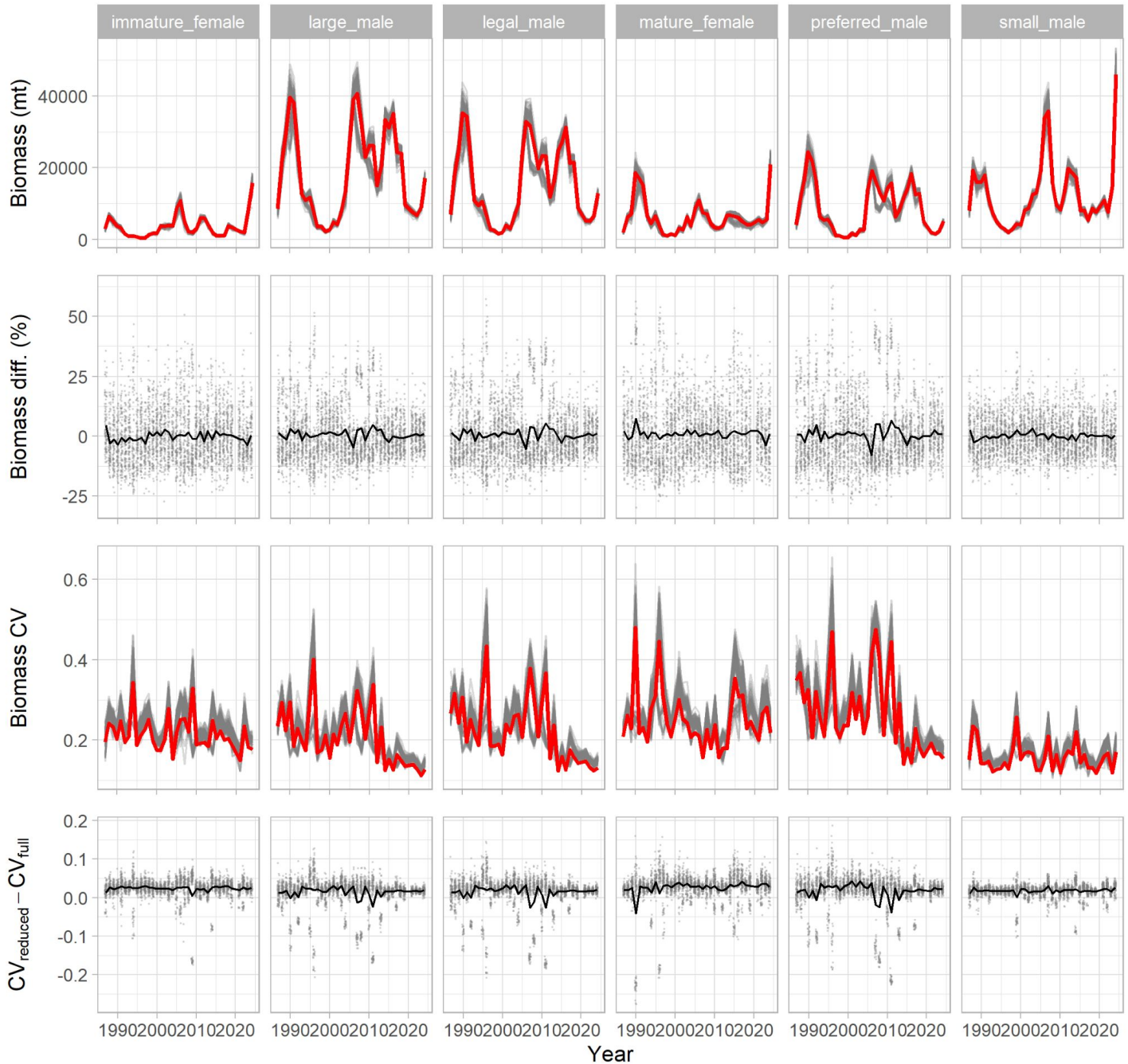

EBS ALL SNOW legal_male
EBS ALL SNOW preferred_male
EBS ALL SNOW large_male
EBS ALL SNOW small_male
EBS ALL SNOW mature_female
EBS ALL SNOW immature_female
Station Loss (%)
50
35
25
15
Biomass change (%)
CV

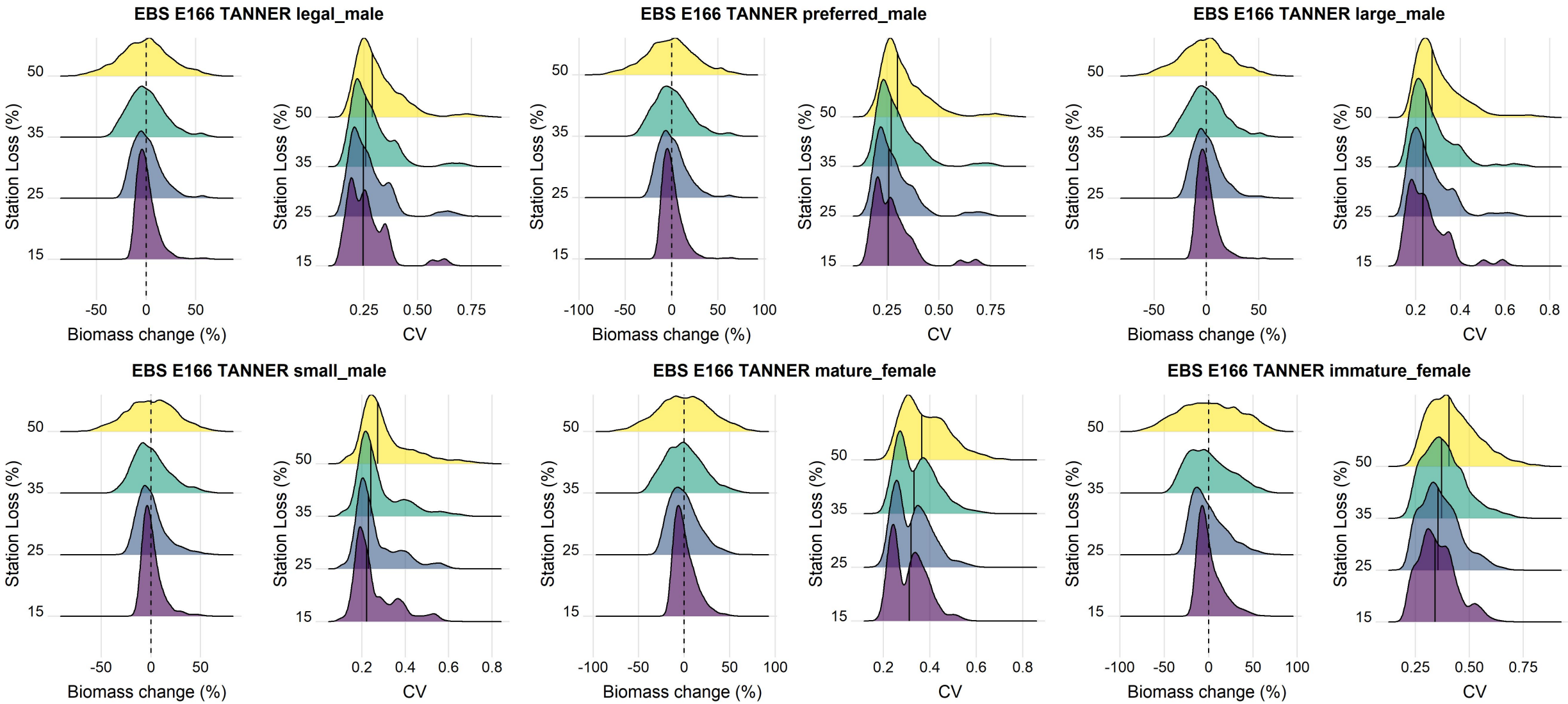

EBS SNOW ALL
immature_female
large_male
legal_male
mature_female
preferred_male
small_male
Biomass (mt)
6e+05
4e+05
2e+05
0e+00
Biomass diff. (%)
60
30
0
-30
Biomass CV
0.6
0.4
0.2
CV_reduced − CV_full
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
1990
2000
2010
2020
Year


EBS BB RKC legal_male
EBS BB RKC mature_male
EBS BB RKC immature_male
EBS BB RKC mature_female
EBS BB RKC immature_female
Station Loss (%)
50
35
25
15
-100 -50 0 50 100
Biomass change (%)
0.25 0.50 0.75
CV
-50 0 50
0.2 0.4 0.6 0.8
0.3 0.6 0.9

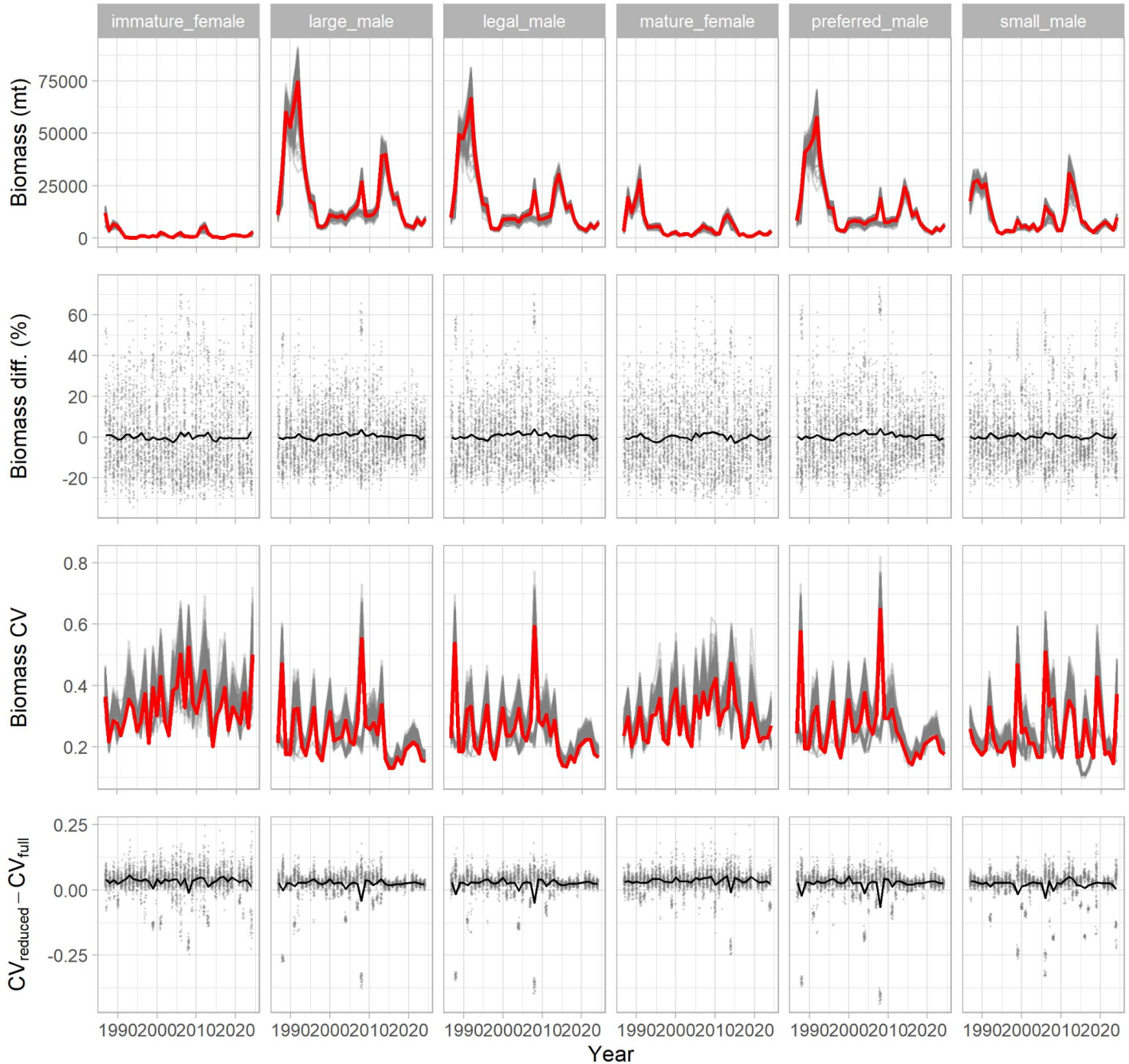

EBS RKC BB
immature_female
immature_male
legal_male
mature_female
mature_male
Biomass (mt)
80000
60000
40000
20000
0
Biomass diff. (%)
50
0
Biomass CV
0.75
0.50
0.25
CV_reduced − CV_full
0.2
0.0
-0.2
-0.4
1990 2000 2010 2020
Year

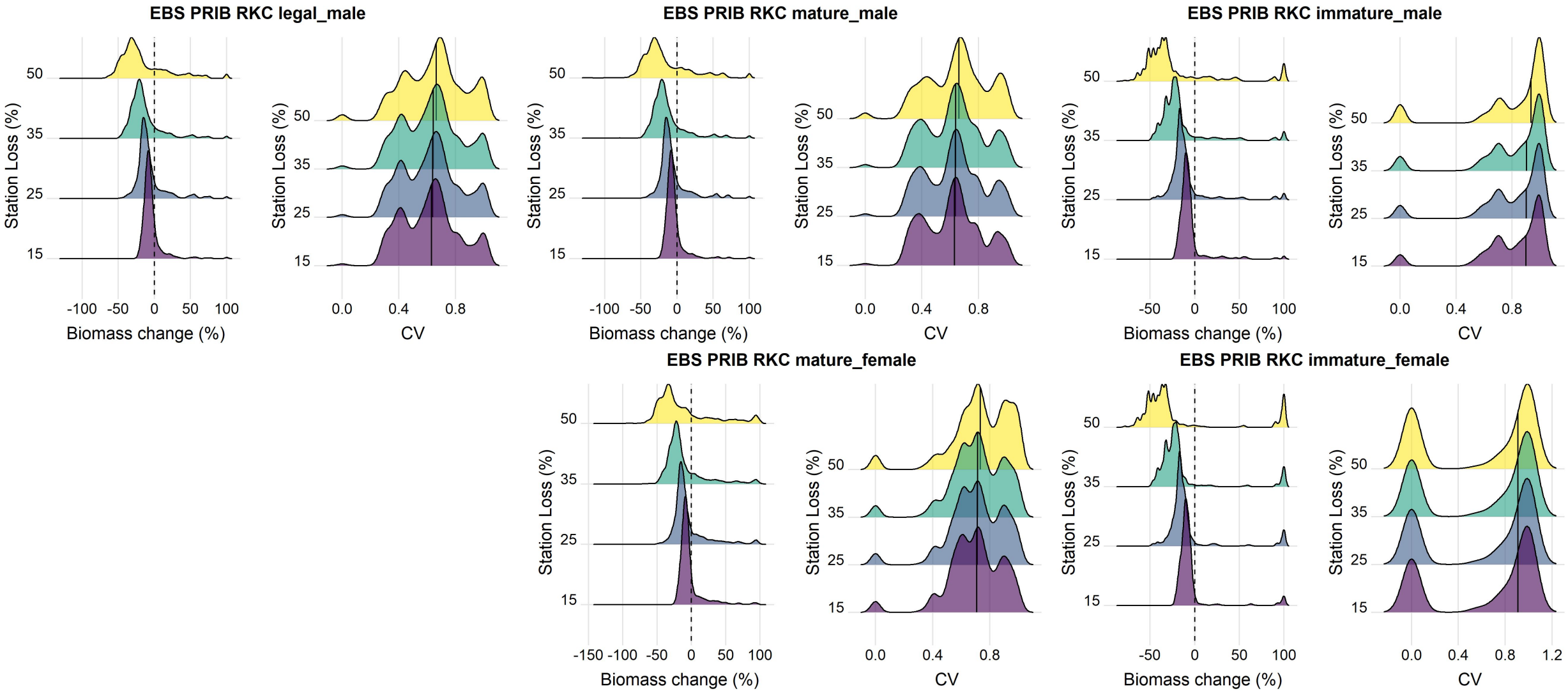

EBS W166 TANNER legal_male
EBS W166 TANNER preferred_male
EBS W166 TANNER large_male
EBS W166 TANNER small_male
EBS W166 TANNER mature_female
EBS W166 TANNER immature_female
Station Loss (%)
Biomass change (%)
CV
50
35
25
15
-80
-40
0
40
-50
50
-25
0.2
0.4
0.6
0.8
0.1
0.3

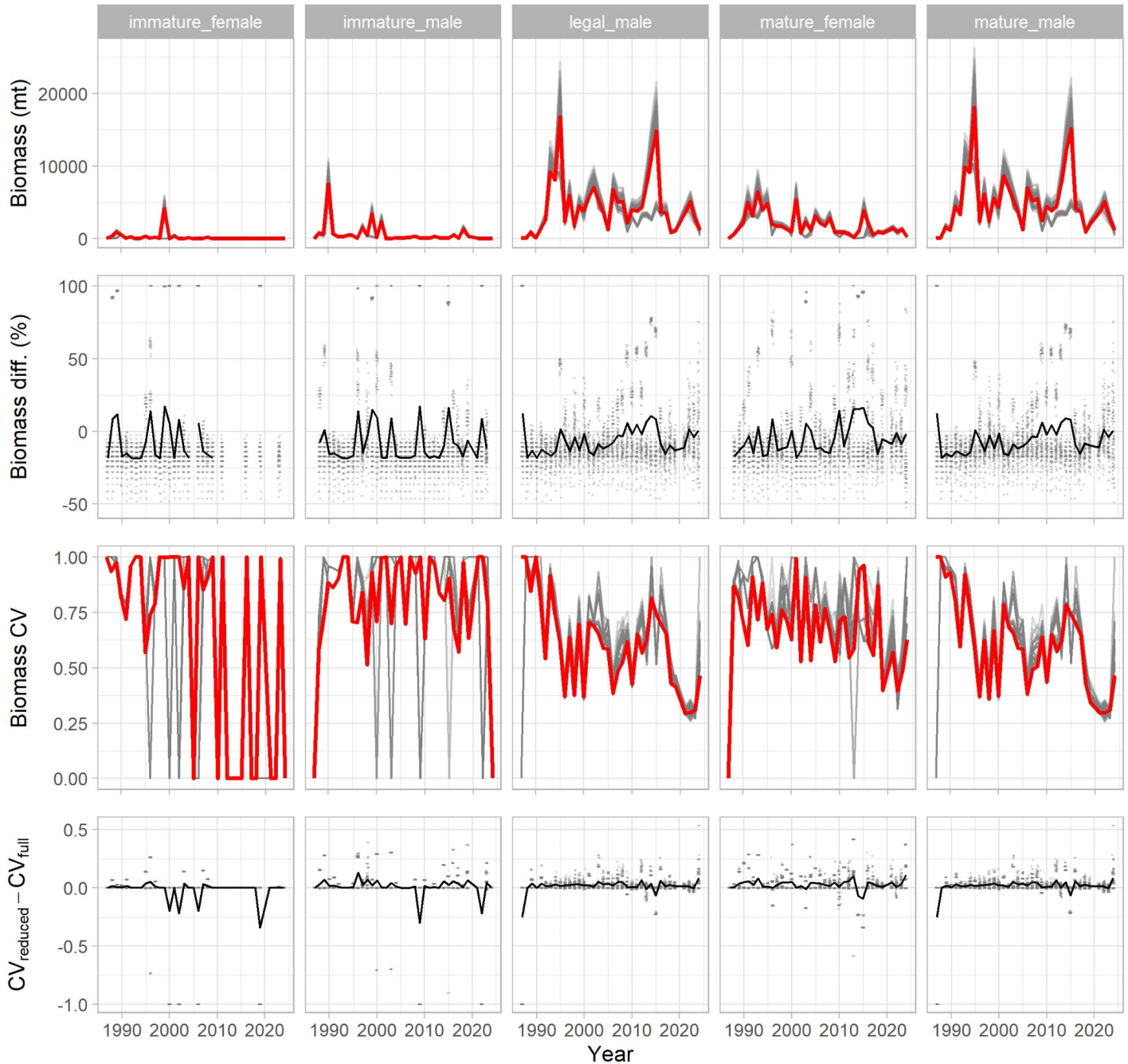

EBS TANNER W166
immature_female
large_male
legal_male
mature_female
preferred_male
small_male
Biomass (mt)
40000
20000
0
Biomass diff. (%)
50
25
0
-25
Biomass CV
0.6
0.4
0.2
CV_reduced − CV_full
0.2
0.1
0.0
-0.1
-0.2
1990200020102020
Year

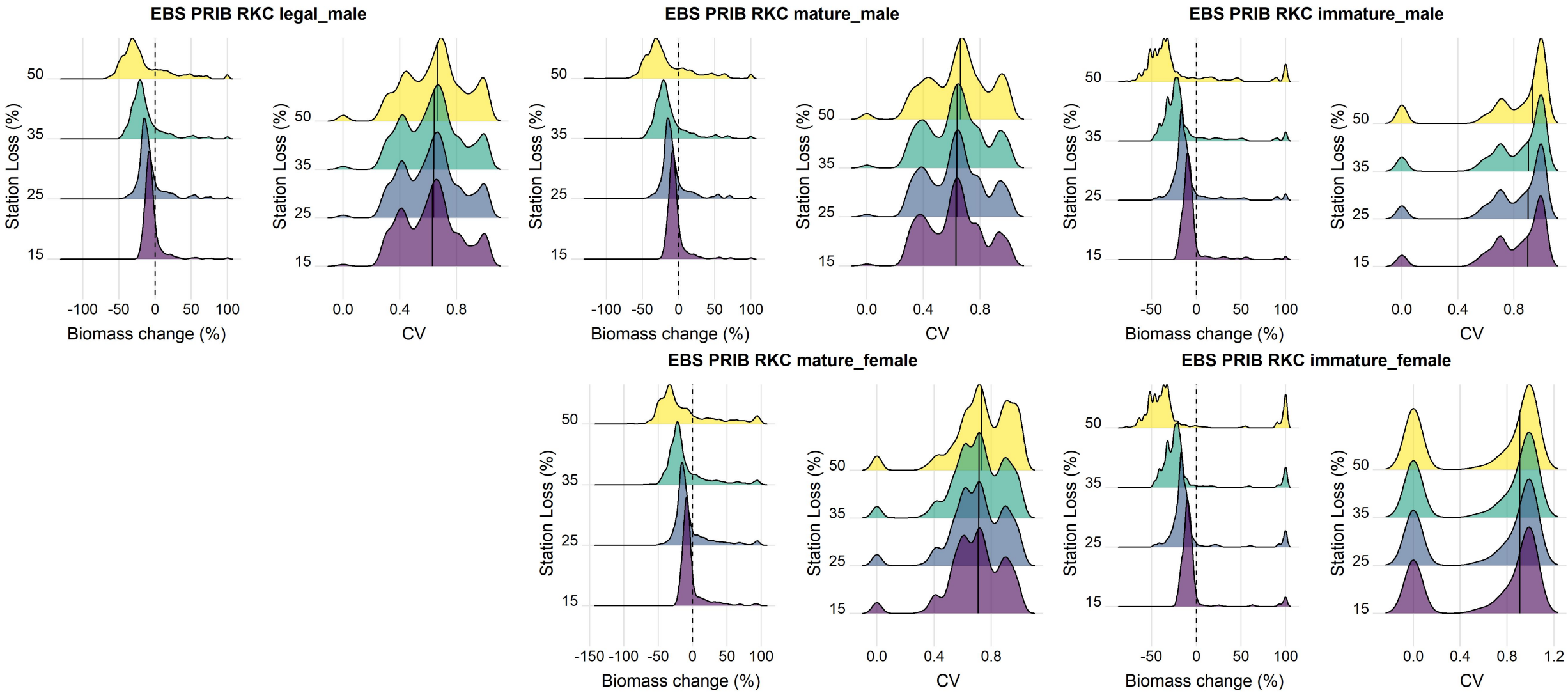

EBS E166 TANNER legal_male
EBS E166 TANNER preferred_male
EBS E166 TANNER large_male
EBS E166 TANNER small_male
EBS E166 TANNER mature_female
EBS E166 TANNER immature_female
Station Loss (%)
50
35
25
15
Biomass change (%)
-100
-50
0
50
100
CV
0.25
0.50
0.75
0.2
0.4
0.6
0.8

EBS TANNER E166

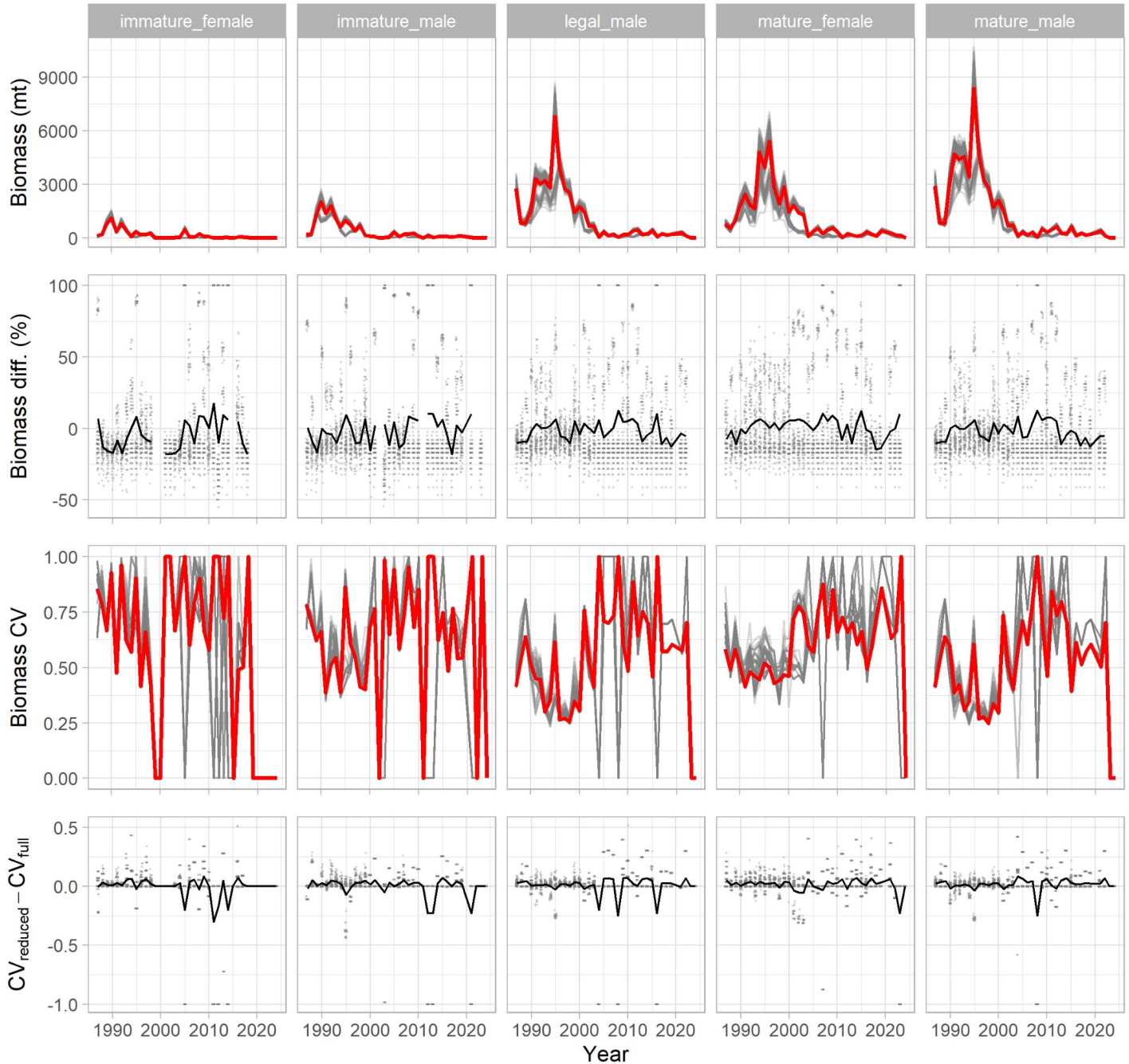


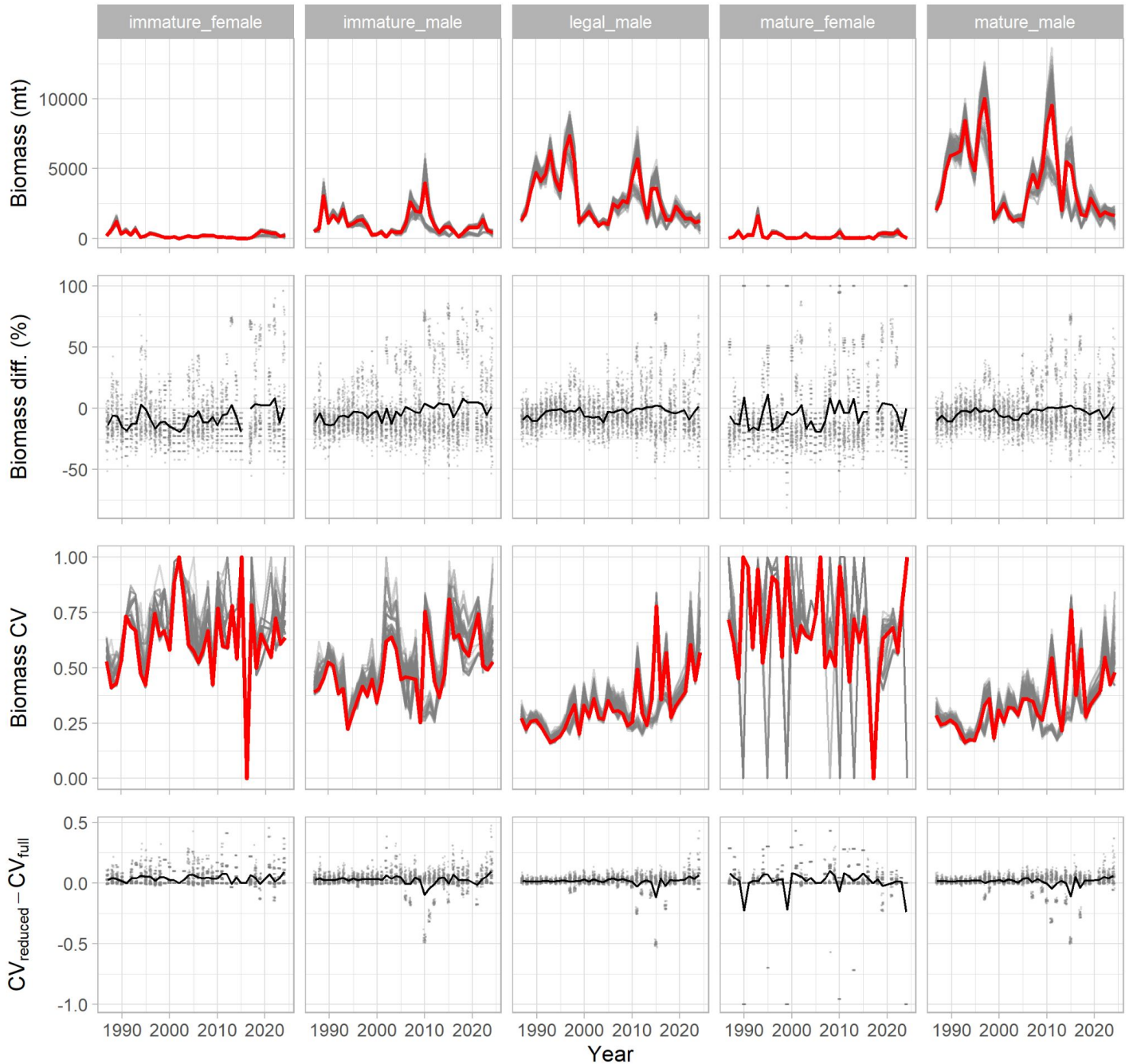

EBS PRIB RKC legal_male
EBS PRIB RKC mature_male
EBS PRIB RKC immature_male
EBS PRIB RKC mature_female
EBS PRIB RKC immature_female
Station Loss (%)
50
35
25
15
Biomass change (%)
CV


EBS RKC PRIB
immature_female
immature_male
legal_male
mature_female
mature_male
Biomass (mt)
20000
10000
0
Biomass diff. (%)
100
50
0
-50
Biomass CV
1.00
0.75
0.50
0.25
0.00
CV_reduced − CV_full
0.5
0.0
-0.5
-1.0
1990 2000 2010 2020
Year


EBS PRIB RKC legal_male
EBS PRIB RKC mature_male
EBS PRIB RKC immature_male
EBS PRIB RKC mature_female
EBS PRIB RKC immature_female
Station Loss (%)
50
35
25
15
-100 -50 0 50 100
Biomass change (%)
0.0 0.4 0.8
CV
-150 -100 -50 0 50 100
0.0 0.4 0.8 1.2

EBS BKC PRIB


immature_female
immature_male
legal_male
mature_female
mature_male
Biomass (mt)
9000
6000
3000
0
Biomass diff. (%)
100
50
0
-50
Biomass CV
1.00
0.75
0.50
0.25
0.00
$CV_{reduced} - CV_{full}$
0.5
0.0
-0.5
-1.0
1990 2000 2010 2020
Year


EBS BKC STMATT
immature_female
immature_male
legal_male
mature_female
mature_male
Biomass (mt)
10000
5000
0
Biomass diff. (%)
100
50
0
-50
Biomass CV
1.00
0.75
0.50
0.25
0.00
CV_reduced − CV_full
0.5
0.0
-0.5
-1.0
1990 2000 2010 2020
Year