INTERNATIONAL PACIFIC HALIBUT COMMISSION

Development of the 2025 stock assessment

Agenda item: 4.1.2
IPHC-2025-SRB026-07
(I. Stewart and A. Hicks)

Outline

- IPHC process and recent SRB requests
- Existing data
  - Data sources included
  - Mortality
  - Indices
  - Age data
  - Other information
- New/revised information
  - Improved bootstrapping of sample sizes
  - Pacific Decadal Oscillation (PDO) indices
  - Updated maturity

Outline

- Modelling
  - Multi-model approach
  - Structural assumptions/Technical configuration
  - Changes from 2024
  - Diagnostics and results
- Evaluation of uncertainty
  - Sensitivity analyses
  - Retrospective analyses
- Ensemble
  - Methods
  - Preliminary results for 2025
- Research priorities and future development

IPHC Assessment and review process

- Annual assessments
  - Full analyses ~ every 3 years (… 2019, 2022, 2025)
  - Updates in between
    - Include all new data available and limited model changes
- Annual improvements reviewed by the SRB in June
- Refined and finalized for the September SRB
- Final data added in early November
- Results first presented at Interim Meeting (late November/early December)
- Results and management decision-making at Annual Meeting (late January)

Documentation

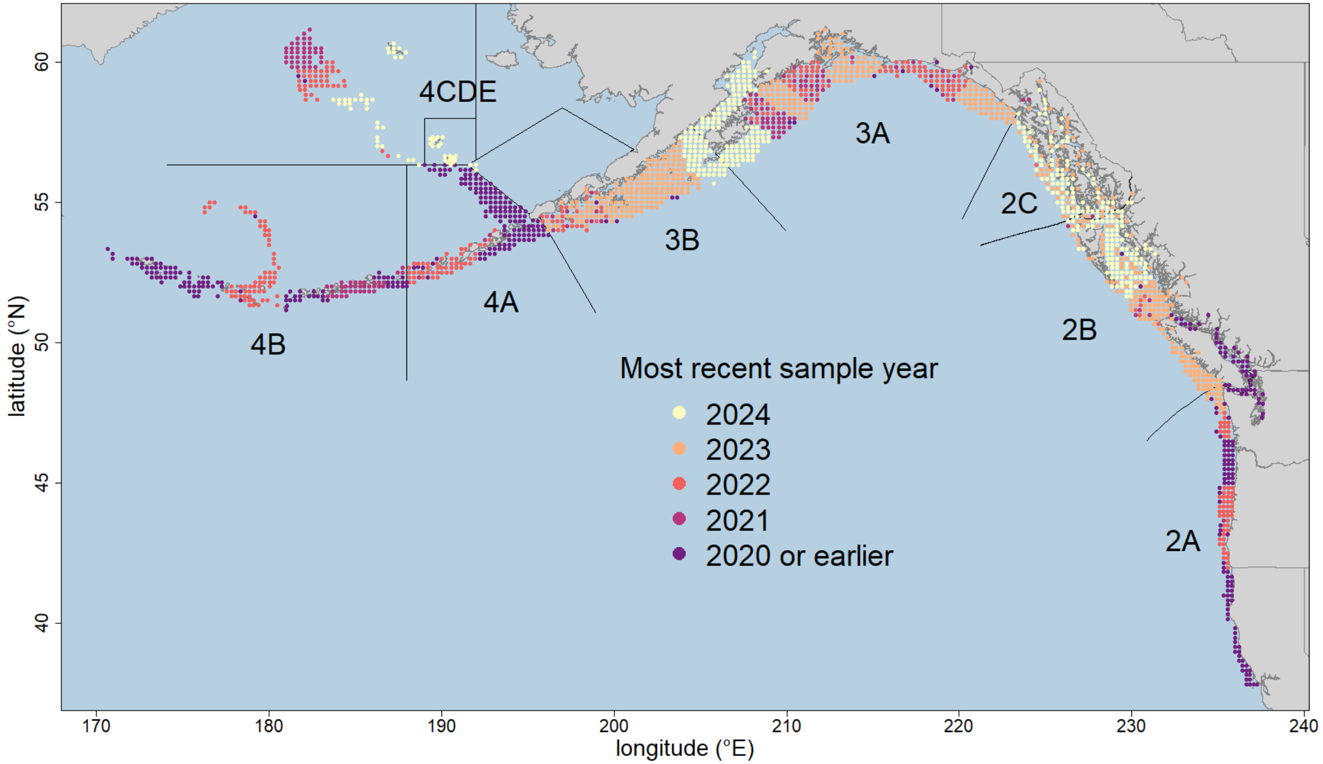
- The 2025 preliminary assessment document (IPHC-2025-SRB026-07)
- Additional files (Appendix A), available via Sharepoint:
  - Input files for each model
  - Output files and graphics for each model
  - Software documentation
  - Recent data overview and stock assessments
  - Relevant manuscripts
  - Full history of assessment and review (assessment web site)

SRB025 Requests and Recommendations

- Para. 18: *The SRB* ***RECOMMENDED*** *considering the impact of alternative FISS designs not only on the coast-wide abundance estimates but also on our understanding of the stock distribution across regions.*
- Para. 20: *The SRB* ***REQUESTED*** *an analysis of the relationship between commercial CPUE and the FISS WPUE at the coastwide and regional levels to investigate the strength of hyperstability/hyperdepletion in CPUE for the stock assessment in 2025. This analysis should include two scenarios: (i) the historical FISS WPUE estimates and (ii) FISS WPUE estimates calculated from reduced designs (i.e. subset the historical FISS data and recalculate WPUE from the reduced data set). The statistical model used for the analysis should account for uncertainty in the FISS index (the X-axis variable) using, for example, an error-in-variables approach like that in Harley et al. 2001 (CJFAS). This analysis represents a first step in including presumed hyperstability in scenarios that investigate the impacts of reduced FISS designs.*
- Para. 22: *RECALLING previous discussions at SRB020 (IPHC-2022-SRB020-R) and SRB021 (IPHC-2022- SRB021-R) regarding stock assessment research priorities and that several of the smaller topics have been addressed, the SRB* ***REQUESTED*** *an update on the list of larger topics larger topics that may require moving to a three-year schedule for stock assessment. Examples of such topics include the following: a) Exploration of alternative stock assessment model frameworks, e.g. state-space models like the Woods Holde Assessment Model (WHAM), Bayesian models, and spatially structured models beyond the Areas as Fleets model.*

SRB025 Requests and Recommendations

- Para. 18: *The SRB* ***RECOMMENDED*** *considering the impact of alternative FISS designs not only on the coast-wide abundance estimates but also on our understanding of the stock distribution across regions.*



SRB025 Requests and Recommendations

- Para. 18: *The SRB **RECOMMENDED** considering the impact of alternative FISS designs not only on the coast-wide abundance estimates but also on our understanding of the stock distribution across regions.*

Presented at AM101

	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
Low 95% CI	2.1%	11.2%	13.8%	18.3%	11.5%	4.6%	5.4%	9.3%	
O32 Stock distribution	3.3%	13.6%	16.4%	22.6%	15.4%	7.4%	9.8%	11.4%	100%
High 95% CI	5.1%	16.4%	19.2%	27.1%	19.9%	11.2%	16.3%	13.9%	
Low 95% CI	0.81	4.43	5.47	7.27	3.42	1.37	1.59	2.76	
TCEY	1.33	5.39	6.50	8.95	4.59	2.21	2.92	3.40	35.28
High 95% CI	2.04	6.50	7.60	10.75	5.91	3.35	4.86	4.14	

SRB025 Requests and Recommendations

- Para. 20: *The SRB* ***REQUESTED*** *an analysis of the relationship between commercial CPUE and the FISS WPUE at the coastwide and regional levels to investigate the strength of hyperstability/hyperdepletion in CPUE for the stock assessment in 2025. This analysis should include two scenarios: (i) the historical FISS WPUE estimates and (ii) FISS WPUE estimates calculated from reduced designs (i.e. subset the historical FISS data and recalculate WPUE from the reduced data set). The statistical model used for the analysis should account for uncertainty in the FISS index (the X-axis variable) using, for example, an error-in-variables approach like that in Harley et al. 2001 (CJFAS). This analysis represents a first step in including presumed hyperstability in scenarios that investigate the impacts of reduced FISS designs.*

No progress on this topic to date.

SRB025 Requests and Recommendations

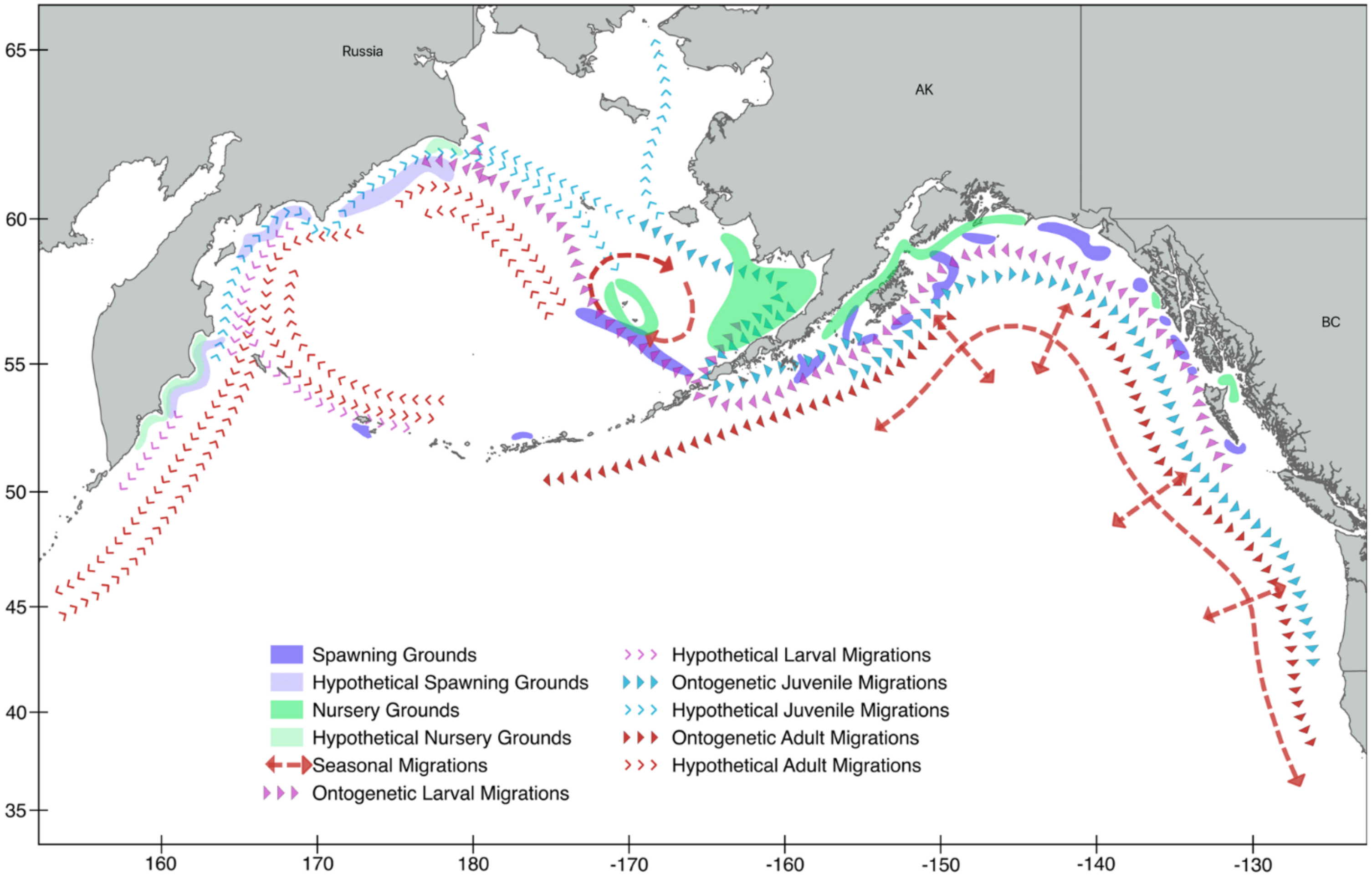
- Para. 22: *RECALLING previous discussions at SRB020 (IPHC-2022-SRB020-R) and SRB021 (IPHC-2022- SRB021-R) regarding stock assessment research priorities and that several of the smaller topics have been addressed, the SRB* ***REQUESTED*** *an update on the list of larger topics larger topics that may require moving to a three-year schedule for stock assessment. Examples of such topics include the following: a) Exploration of alternative stock assessment model frameworks, e.g. state-space models like the Woods Holde Assessment Model (WHAM), Bayesian models, and spatially structured models beyond the Areas as Fleets model.*

An updated and revised list of research topics is included in this assessment.

Outline

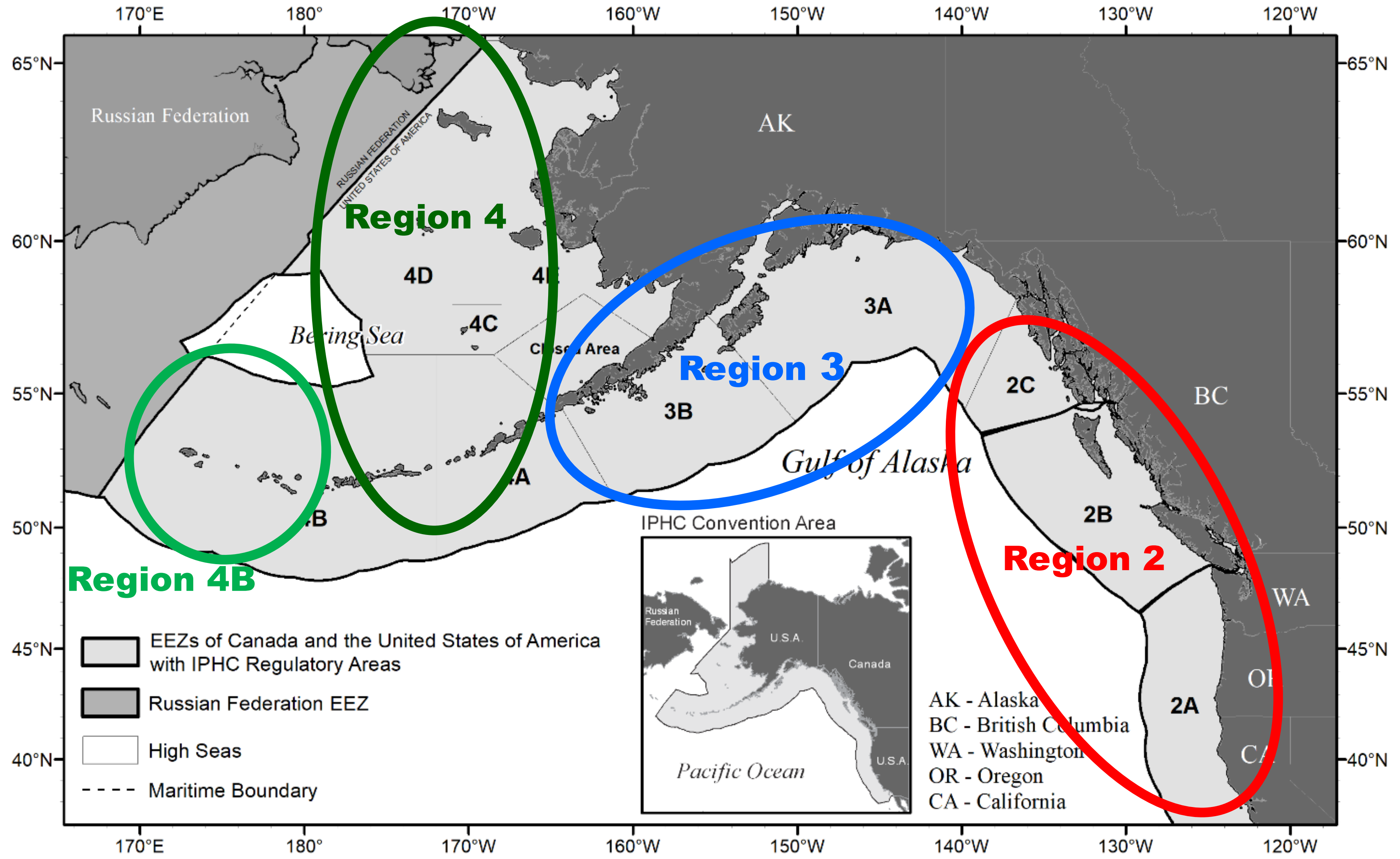
- IPHC process and recent SRB requests
- Existing data
  - Data sources included
  - Mortality
  - Indices
  - Age data
  - Other information
- New/revised information
  - Improved bootstrapping of sample sizes
  - Pacific Decadal Oscillation (PDO) indices
  - Updated maturity

Basic life history

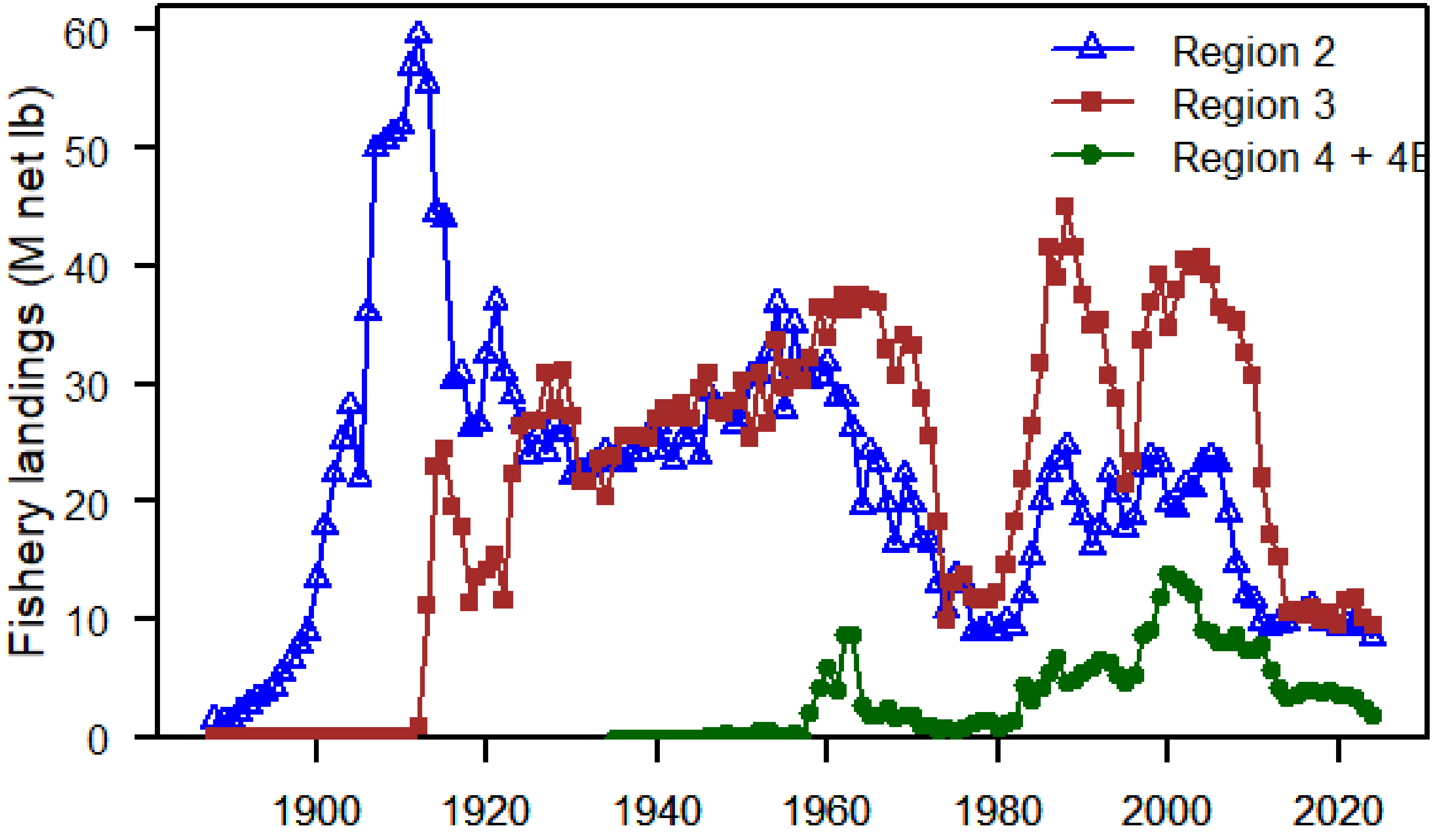


Carpi, P., Loher, T., Sadorus, L.L., Forsberg, J.E., Webster, R.A., Planas, J.V., Jasonowicz, A., Stewart, I.J., and Hicks, A.C. 2021. Ontogenetic and spawning migration of Pacific halibut: a review. Reviews in Fish Biology and Fisheries. doi:10.1007/s11160-021-09672-w.

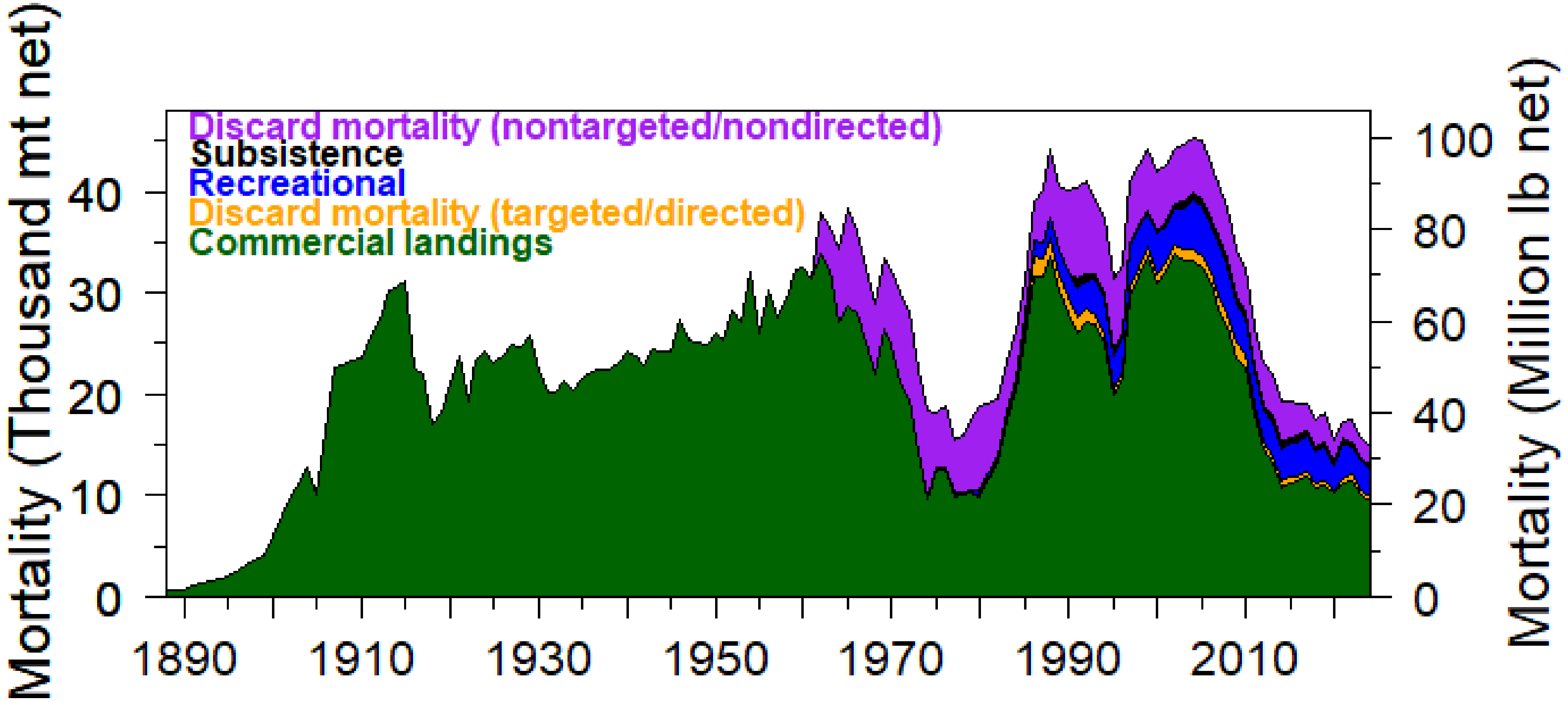
One stock, four Biological Regions



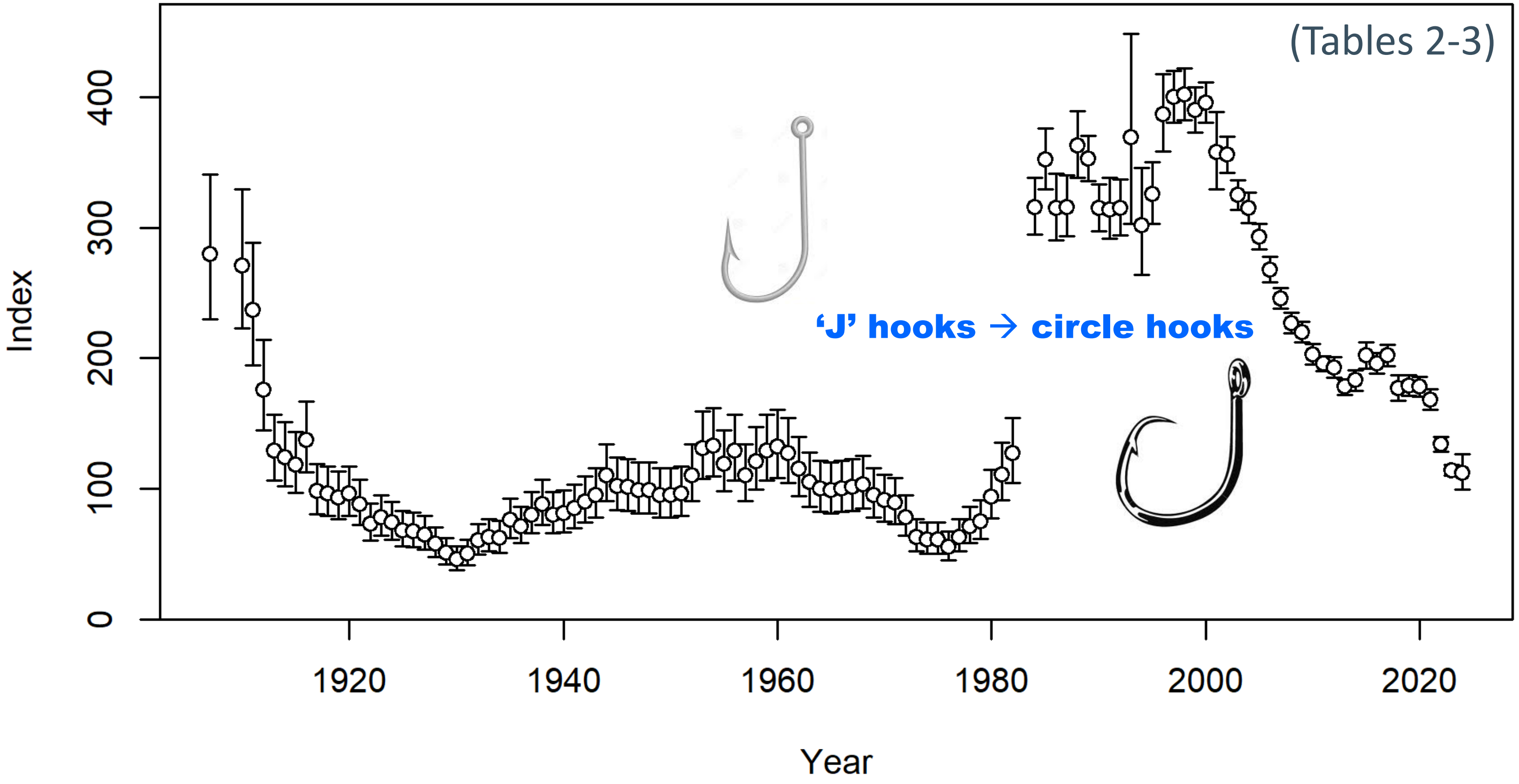
Sequential fishery development East to West/North



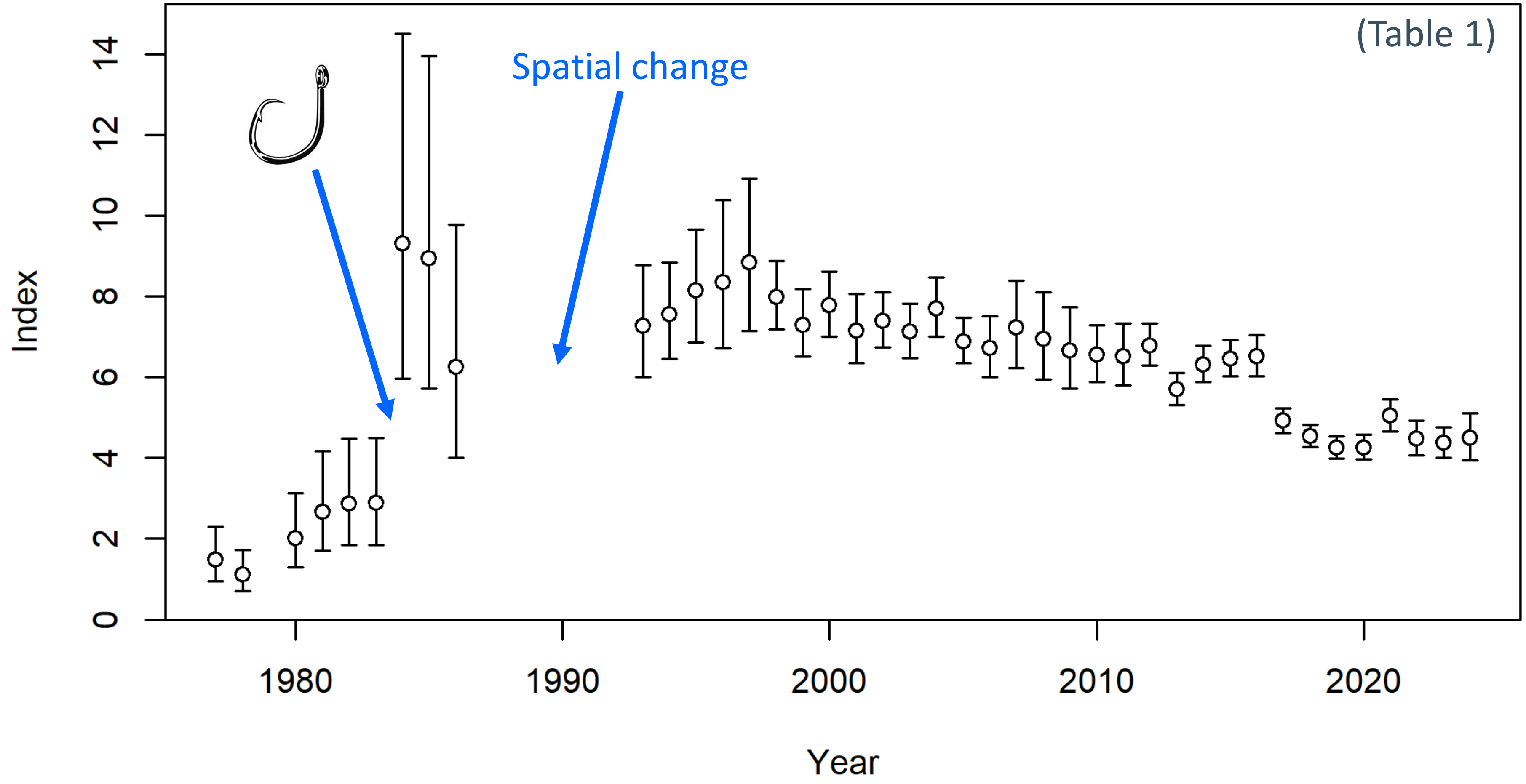
Historical mortality by sector



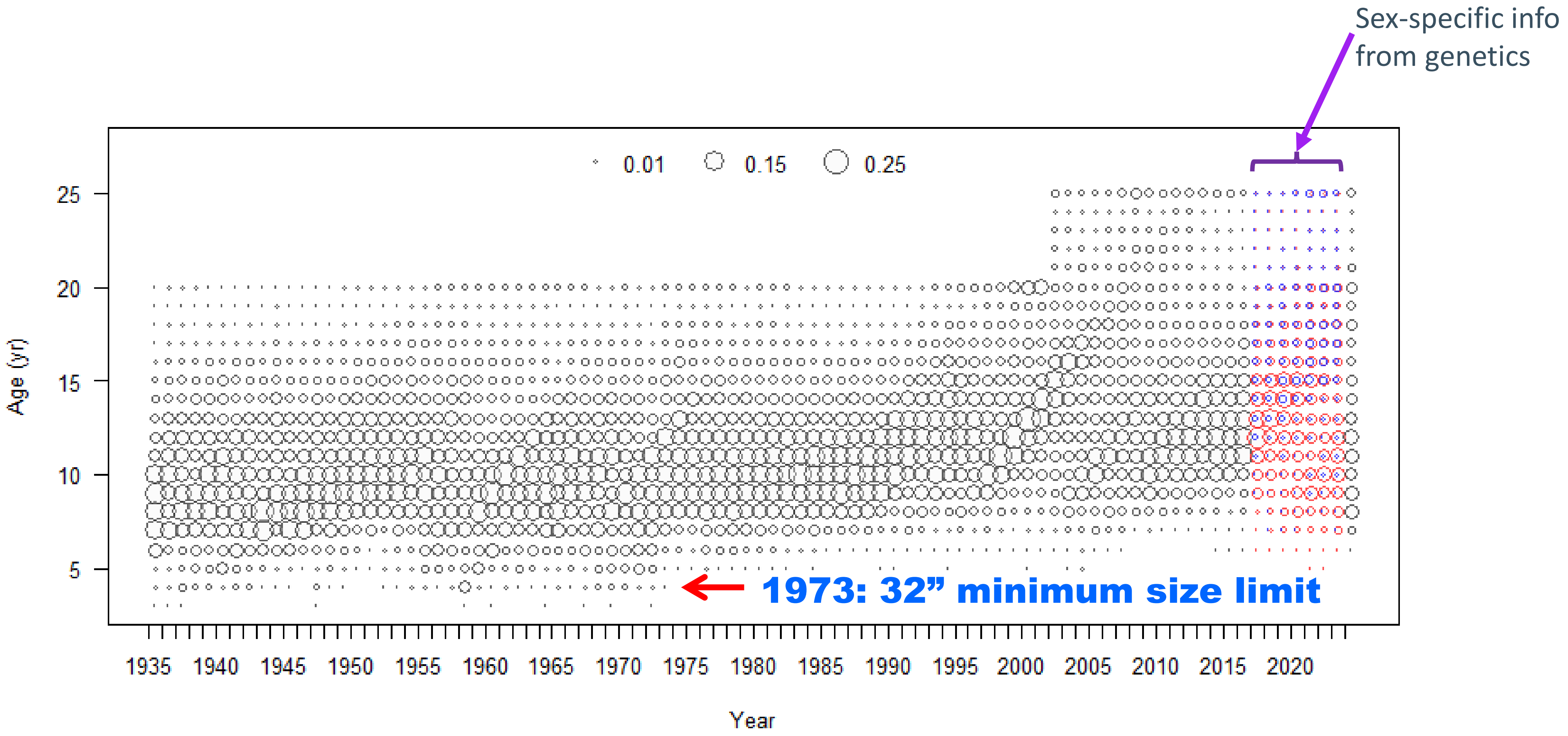
Coastwide commercial CPUE



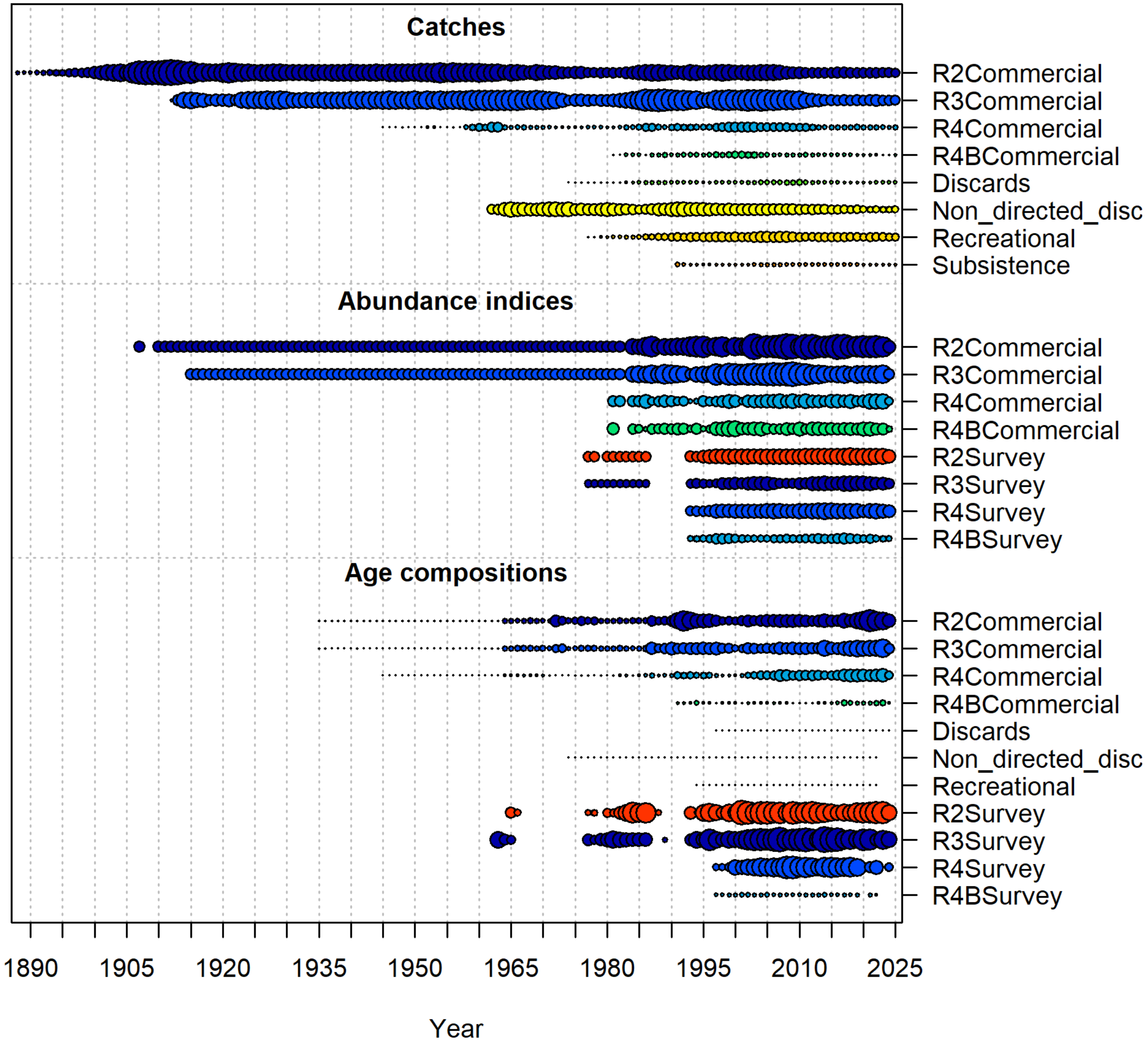
Coastwide FISS NPUE



Fishery ages

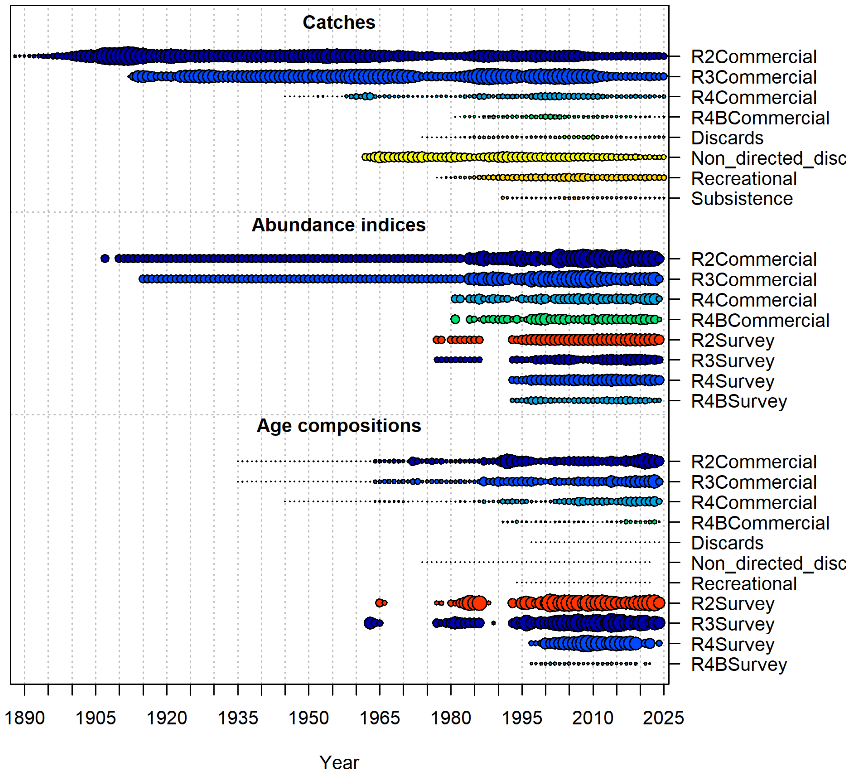


Summary of available data



Summary of available data

- Mortality series relatively complete
  - Uncertainty in discard mortality rates
  - Uncertainty in whale depredation
- Primarily only fishery data before 1992
- High quality age data after 1992
  - Change in methods from surface to break-and-bake in 2002
- Poor biological information on directed discards, recreational, subsistence and non-directed discards



Other data inputs (Table 8)

- PDO index – <u>updated this year</u>
- Maturity ogive – <u>updated this year</u>
- Priors on natural mortality
- Fecundity assumed proportional to bodyweight – <u>pending ongoing research</u>
- Weight-at-age
- Length-weight relationship
- Ageing error (bias and imprecision)
- ‘Priors’ on bycatch, discard and recreational selectivity

Management summary

- 32” Commercial minimum size limit
- Commercial seasons: March-December
  - FISS: June-August
- IFQ/ITQ in AK and BC (Derby in WA/OR/CA)
- Longline and pot gear legal
  - Trawl gear must discard all Pacific halibut
- Recreational, personal use/subsistence managed differently by IPHC Regulatory Area
  - Size, bag, temporal and possession limits
- Discard mortality rates vary from 4-100% by fishery

Outline

- IPHC process and recent SRB requests
- Existing data
  - Data sources included
  - Mortality
  - Indices
  - Age data
  - Other information
- New/revised information
  - Improved bootstrapping of sample sizes
  - Pacific Decadal Oscillation (PDO) indices
  - Updated maturity

Bootstrapping age composition sample sizes

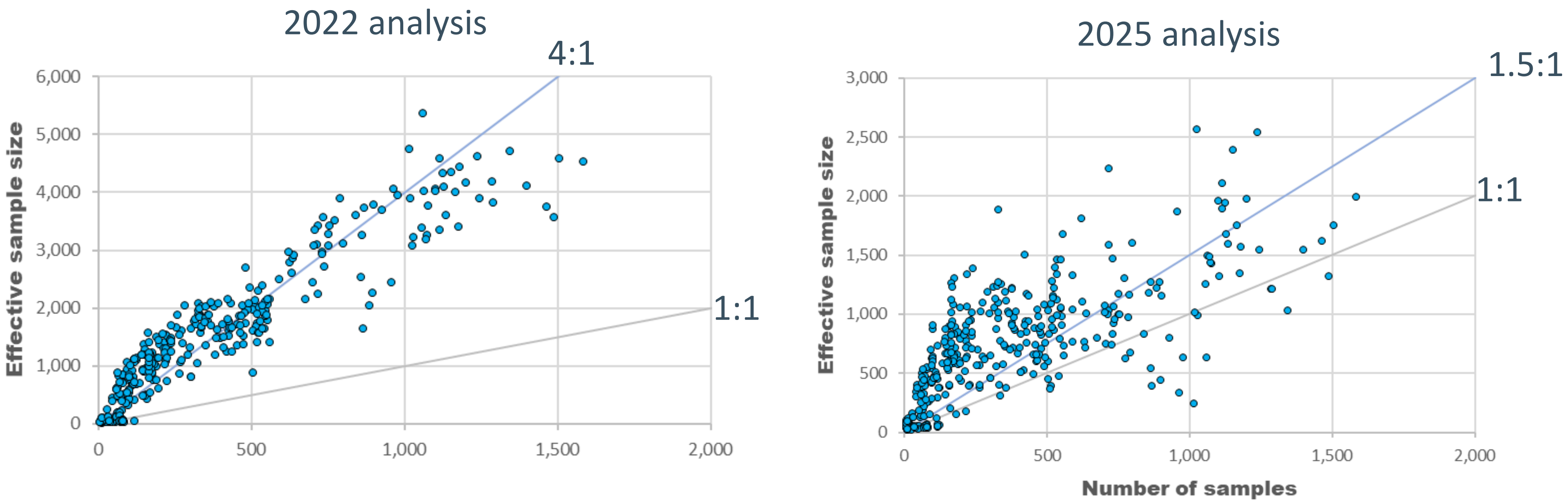
- Improved via the approach of Hulson and Williams (2024)
  - Bootstrapping the sampling design per Stewart and Hamel (2014)
    - Ages within sets/trips within Regulatory Areas
  - Adds draws from empirical ageing imprecision matrix (double reads)

		Second read																						
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
First read	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	79	9	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	-	26	411	44	5	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	5	-	1	216	931	63	11	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	-	-	8	450	1,122	166	18	6	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7	-	-	1	17	1,004	1,849	332	48	10	2	1	-	2	-	-	-	-	-	-	-	-	-	-	-
	8	-	-	-	4	38	735	2,572	451	86	20	10	1	1	-	1	-	-	-	-	-	-	-	-	1
	9	-	-	-	-	7	74	680	2,753	496	115	25	8	3	1	3	-	-	1	-	-	-	-	-	-
	10	-	-	-	-	2	7	112	749	2,961	513	123	38	9	5	2	1	-	1	1	-	-	-	-	-
	11	-	-	-	-	-	2	11	119	683	2,678	595	104	33	11	3	2	2	1	1	-	-	-	-	1
	12	-	-	-	-	2	-	6	26	134	709	2,527	540	132	63	13	4	2	3	2	-	-	-	-	-
	13	-	-	-	1	-	1	1	7	34	154	676	1,872	417	132	22	9	4	2	1	-	-	-	-	-
	14	-	-	-	-	-	-	-	4	13	42	146	483	1,377	436	112	32	8	5	1	-	1	1	-	1
	15	-	-	-	-	-	-	1	13	16	67	153	262	623	1,414	356	141	51	10	5	1	3	1	-	-
	16	-	-	-	-	-	-	2	1	4	4	13	40	110	349	822	230	68	18	13	-	2	-	1	-
	17	-	-	-	-	-	-	1	1	2	7	20	26	43	119	295	646	173	62	16	4	-	2	1	1
	18	-	-	-	-	-	-	2	3	2	4	20	26	34	42	118	226	510	159	55	27	8	2	1	2
	19	-	-	-	-	-	-	1	-	-	1	-	3	7	13	19	72	176	336	107	33	9	3	1	-
	20	-	-	-	-	-	-	-	-	-	2	10	13	23	25	30	67	135	189	420	121	24	19	7	5
	21	-	-	-	-	-	-	-	-	-	1	-	1	1	2	2	7	12	34	86	183	66	13	7	8
	22	-	-	-	-	-	-	1	-	-	-	-	1	-	1	-	-	8	14	38	91	128	38	22	17
	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	9	14	22	59	113	39	35
	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	2	4	8	26	42	88	50
	25+	-	-	-	-	-	-	-	-	-	2	1	1	1	-	3	5	17	19	17	28	30	48	82	801

(Tables 9-10)

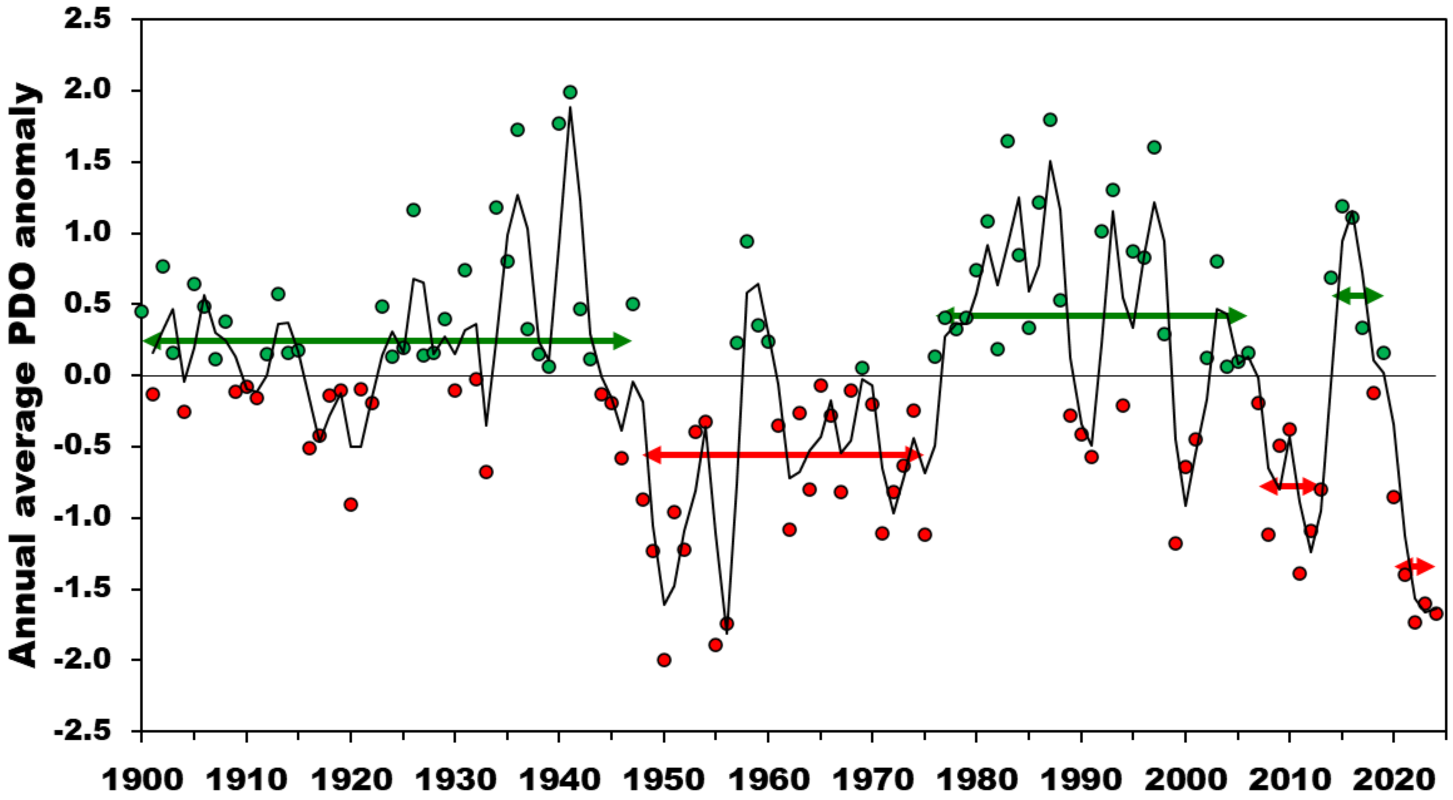
Bootstrapping age composition sample sizes

- Results in reduced input (maximum) sample sizes, especially for historical data



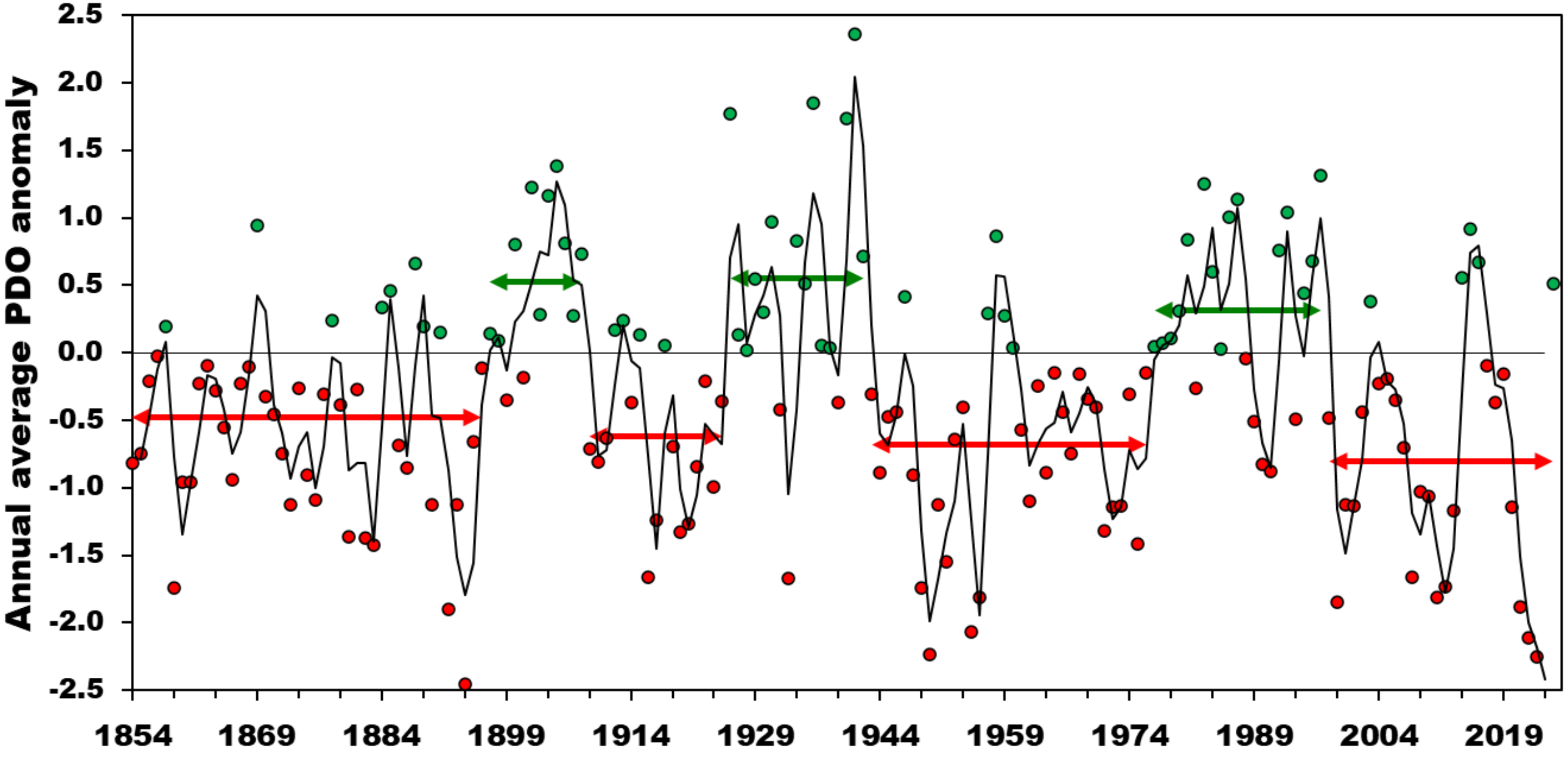
Pacific Decadal Oscillation (PDO)

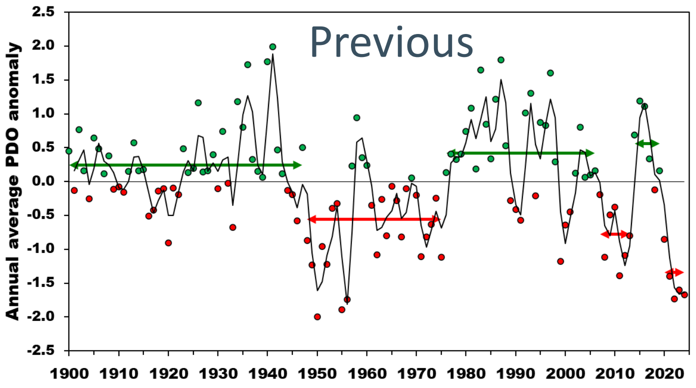
- Index used in previous assessments



Pacific Decadal Oscillation (PDO)

- Updated for 2025
- Longer time-period; different regime changes

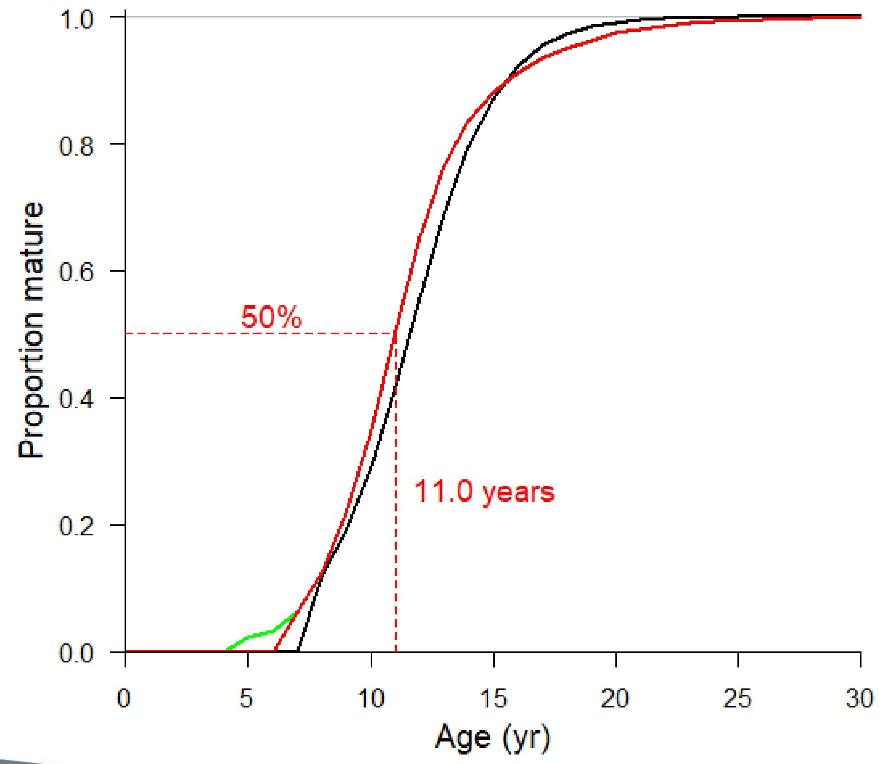




INTERNATIONAL PACIFIC HALIBUT COMMISSION

Updated maturity

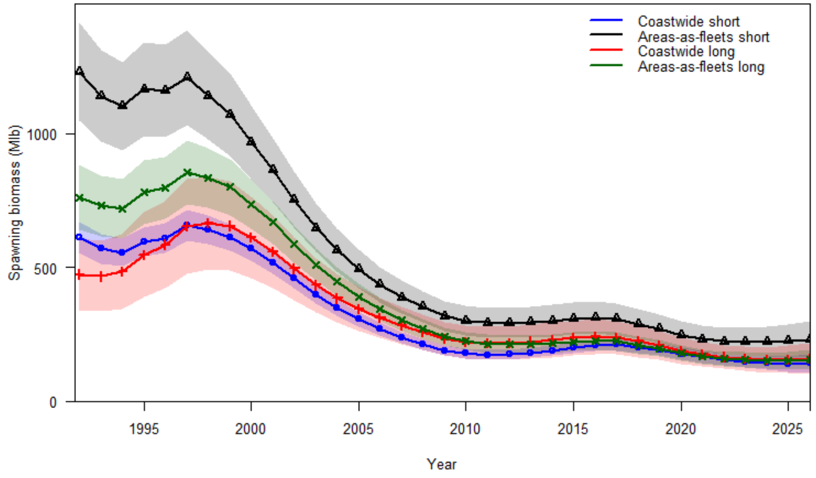
- Change toward younger maturing fish (*IPHC-2025-SRB026-06*)
- Implies larger spawning biomass, particularly when age structure is truncated

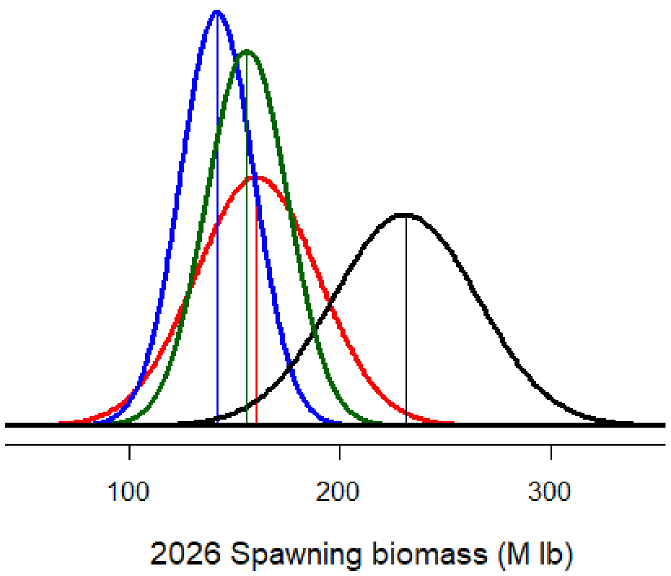


Outline

- Modelling
  - Multi-model approach
  - Structural assumptions/Technical configuration
  - Changes from 2024
  - Diagnostics and results
- Evaluation of uncertainty
  - Sensitivity analyses
  - Retrospective analyses
- Ensemble
  - Methods
  - Preliminary results for 2025
- Research priorities and future development

Ensemble approach: four individual models





- Four ways to aggregate the data
- Respond differently to trend and age data by Region
- Provides stability from year to year as individual model results change

Ensemble basis

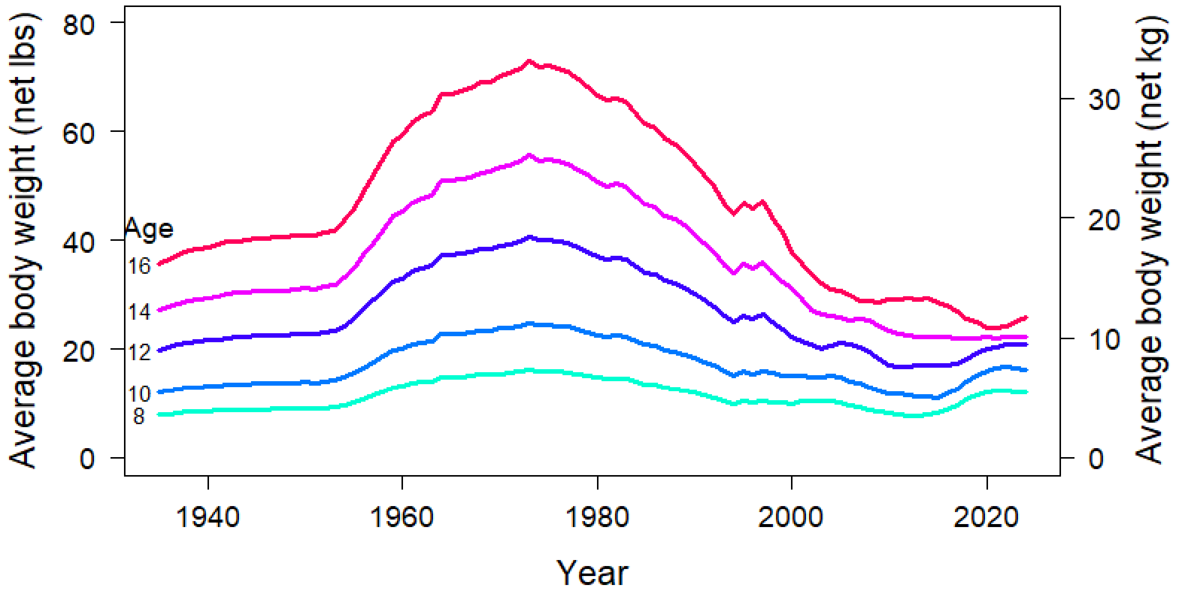
- 2 x 2 cross of Coastwide (CW) and Areas-As-Fleets (AAF) models with short (1992+) vs long (1888+) time-series’
- All four model types are commonly used to assess groundfish in the NE Pacific
- Each model represents an internally consistent approach that could be a stand-alone assessment but represents a different hypothesis about how the population dynamics operate and how best to approximate them with a model

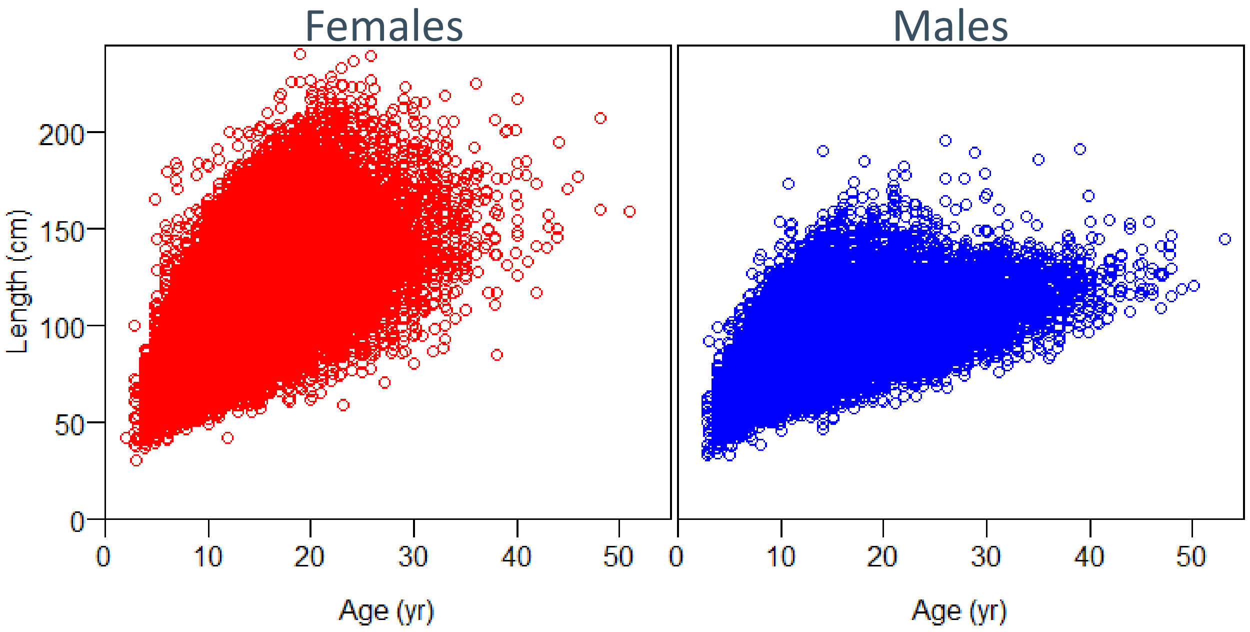
Ensemble basis

- 2 x 2 cross of Coastwide (CW) and Areas-As-Fleets (AAF) models with short (1992+) vs long (1888+) time-series'
- All four model combinations are commonly used to assess groundfish in the NE Pacific
- Each model represents a different hypothesis about how the population dynamics operate and how best to approximate them
- Each model is an internally consistent approach that could be a stand-alone assessment

Basic structural assumptions

- Age based models with empirical weight-at-age
  - Growth is highly variable among individuals and time-varying
  - Length data carries little information on population dynamics and is very technically costly to model



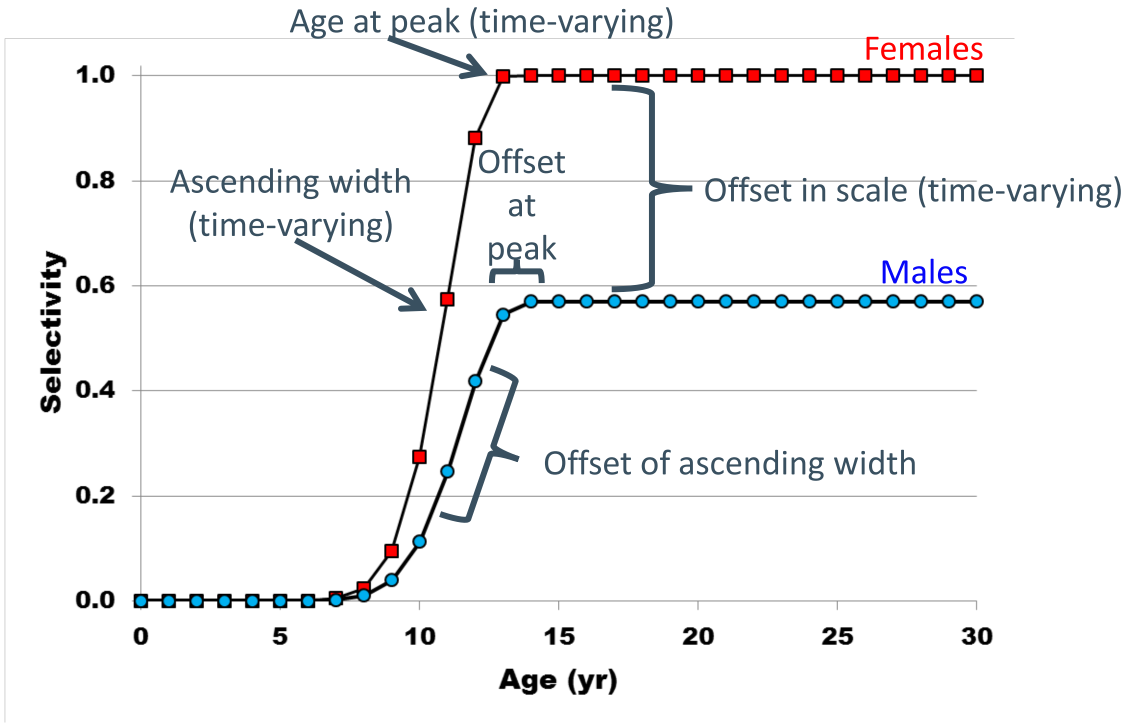


Basic structural assumptions

- Beverton-Holt Stock-recruitment relationship
  - Annual recruitment deviations
  - Steepness fixed at 0.75
  - Estimated initial offset (short models)
  - Estimated PDO coefficient (long models)
- Natural mortality separated for females and males
  - Both estimated in all but the coastwide short model (females fixed at 0.15)
- Asymptotic fishery and survey selectivity (coastwide models)
- Domed selectivity except Biological Regions 4 and 4B (AAF models)

Time-varying selectivity

- Accounts for changes in spatial availability of different size fish
- Accounts for growth interacting with gear selectivity and the 32" minimum size limit



Internally consistent process errors

- Time-varying selectivity, catchability (fishery), recruitment
  - Tuned to reflect process and estimation variance
  - Internally consistent and unbiased estimates of the variance (e.g., Methot and Taylor 2011):

$$\sigma_{tuned} \sim \sqrt{SE_{devs}^2 + \bar{\sigma}_{dev}{}^2}$$

Treatment of the PDO

- Estimated link coefficient (β) adjusting the scale of the S-R relationship:

$$R_0' = R_0 * e^{\beta * PDO_{regime}}$$

$$R_y = f\left(SB_y, R_0', SB_0, h\right) * e^{r_y - \frac{\sigma^2}{2}}$$

- If no relationship exists β → 0 and there is no effect on the stock-recruitment function.

'Priors' on selectivity

- Down-weighted age data used as a prior for recreational/subsistence, directed discards, and non-directed discards
  - Non-directed discards – lengths converted to ages based on trawl survey age-length keys; incomplete coverage and weighting among sectors
  - Recreational – age-data from IPHC Regulatory Area 3A only
  - Directed discards – ages from FISS sublegal catch used as a proxy for discards (comparison only available in 2B)

Bridge of changes from 2024 (Figures 10-15)

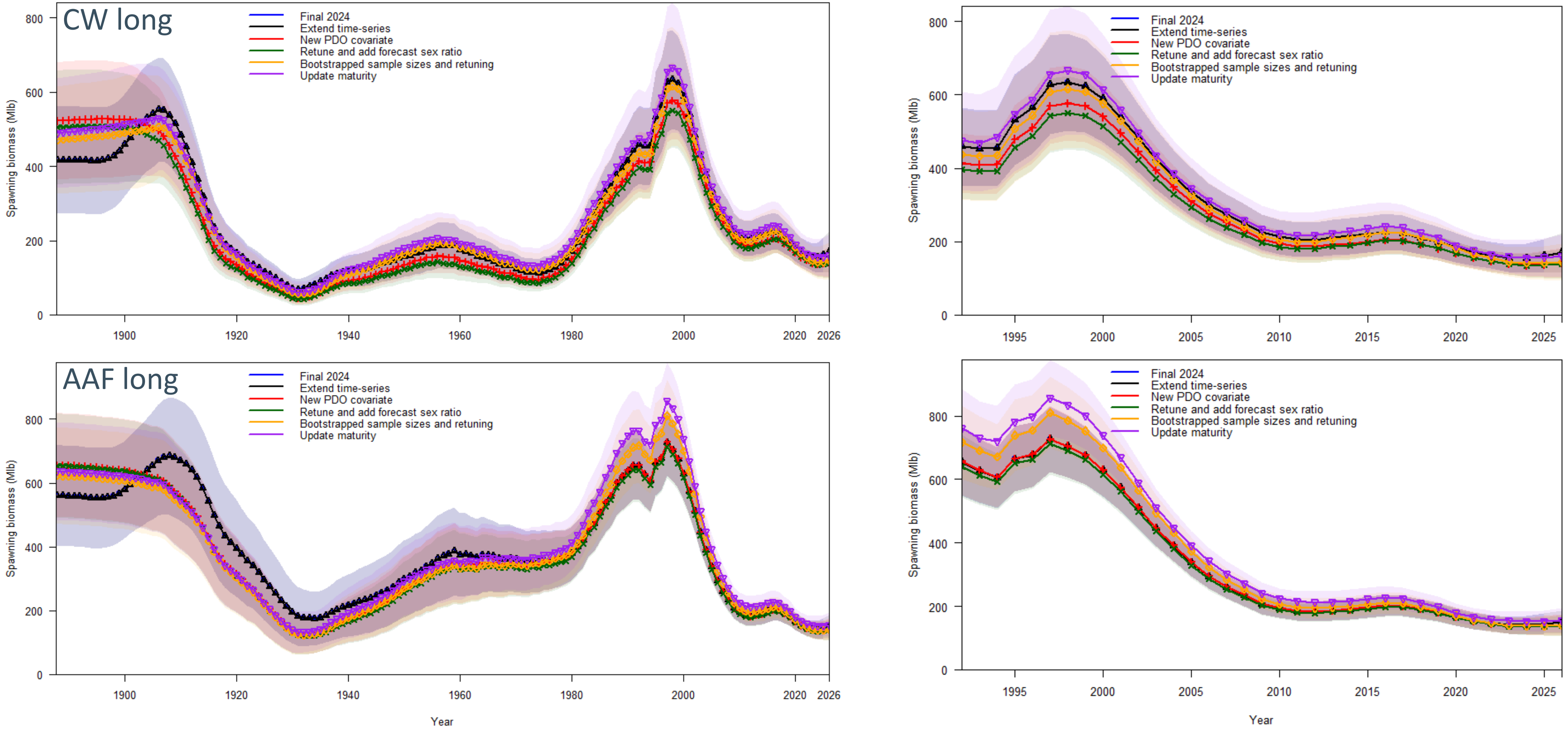
1) Extend the time series using projected mortality for 2025 (*does not change the model estimates*)
2) Update the stock synthesis software (*identical results*)
3) Updating to the new PDO time-series (long models only)
4) Retuning and extending the estimated male time-varying fishery selectivity offset in scale (~ the sex-ratio)
5) Adding the new bootstrapped input (maximum) sample sizes and retuning process and observation errors
6) Updating the maturity ogive

Updated PDO

- Similar estimated relationship strength
- Similar residual (unexplained) recruitment variability

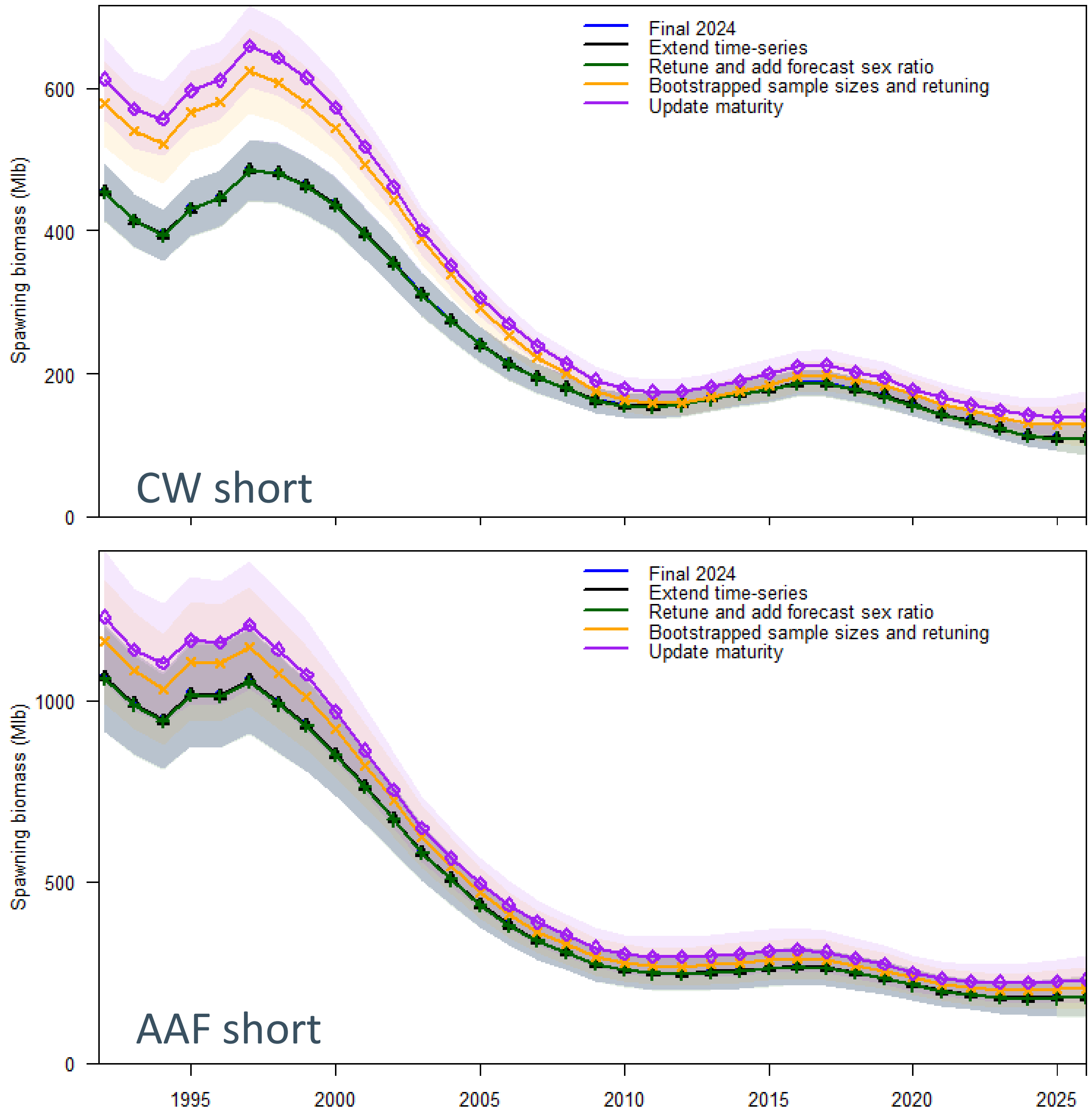
	Positive regime effect (increase)		SD of recruitment deviations	
Model	AAF long	CW long	AAF long	CW long
Previous index	53%	59%	0.322	0.375
Updated index	50%	62%	0.322	0.364

Updated PDO (black to red)

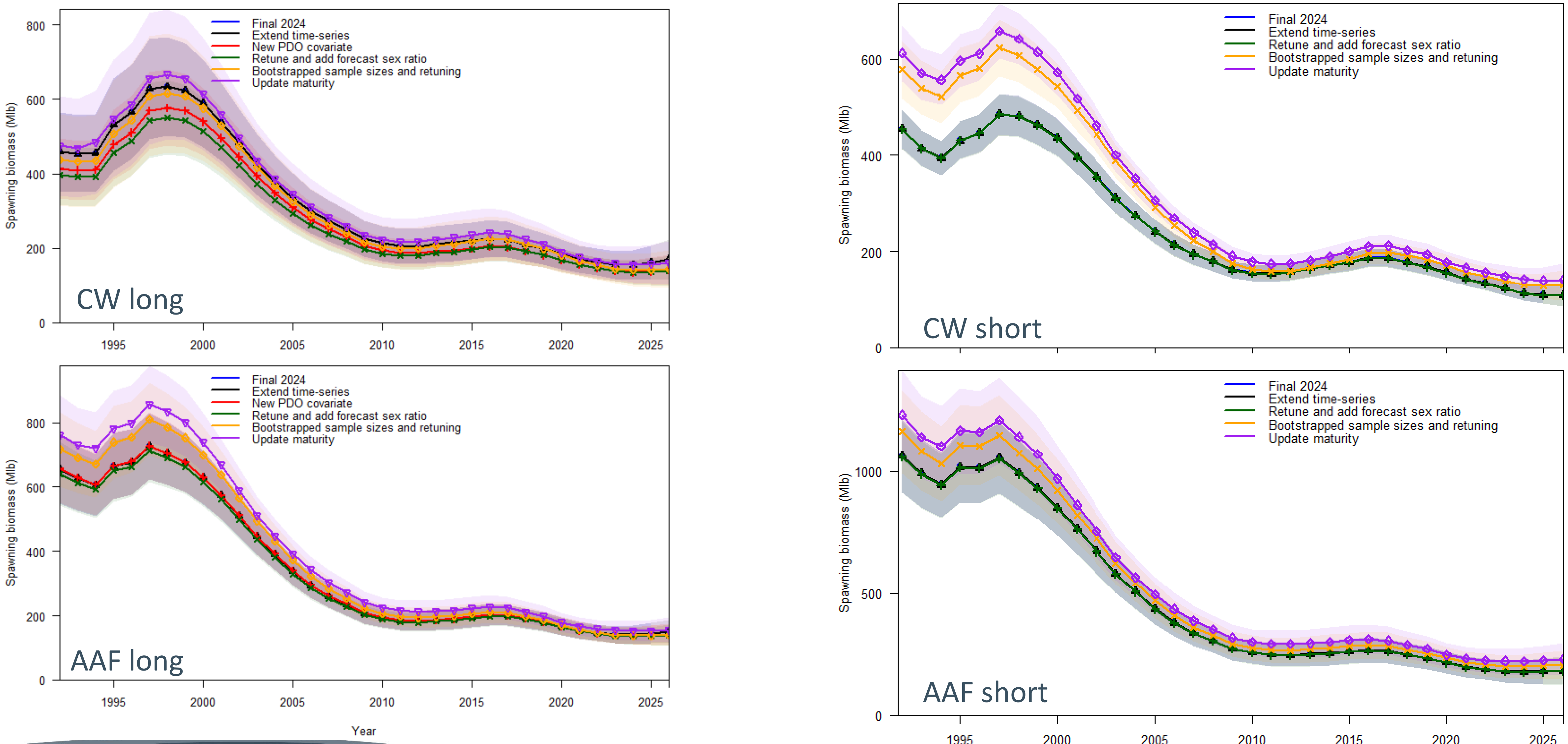


Retune sex-ratio (black to green)

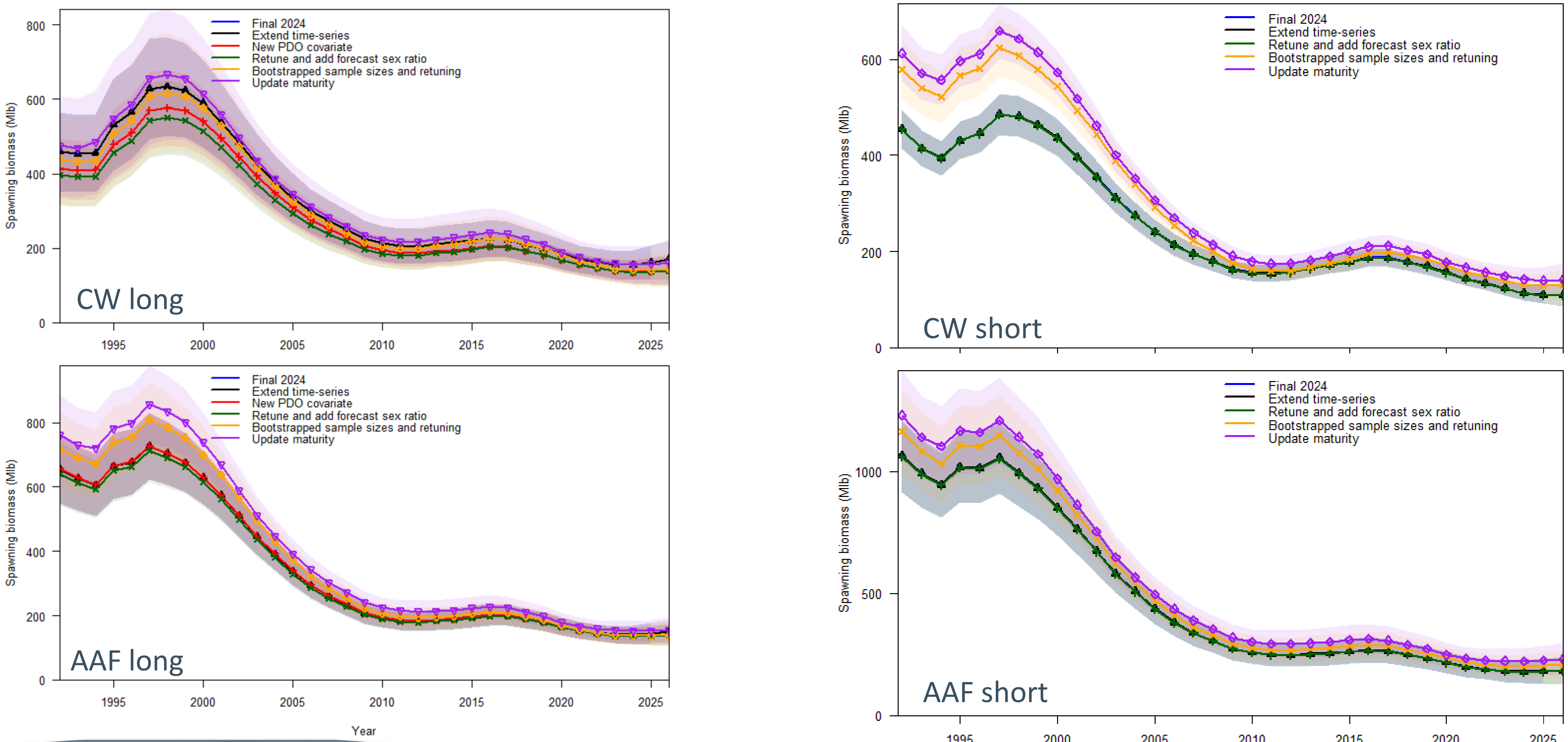
- Little change in any of the four models



Sample sizes and process errors (green to gold)



Updated maturity (gold to purple)



International Pacific Halibut Commission

Model diagnostics and results

- Convergence criteria – no issues identified
- AAF long and short models perform better with good starting values
- Jitter analyses did not indicate any minima better than the base case MLE

Model diagnostics and results

- All models generally fit the FISS and fishery indices well
- Age data down-weighted from maximum sample sizes (except 4B)

	Average iterated input	Harmonic mean effective	Francis weight effective	Maximum Pearson residual
Coastwide short				
Fishery	159	423	174	2.08
Discards[1]	6	221	116	0.67
Non-directed discards[1]	3	51	56	1.61
Recreational[1]	3	104	24	0.63
FISS	164	810	163	2.78
Coastwide long				
Fishery	144	318	148	3.01
Discards[1]	6	213	100	0.65
Non-directed discards[1]	3	38	7	1.30
Recreational[1]	3	131	20	0.61
FISS	97	208	97	4.18

	Average iterated input	Harmonic mean effective	Francis weight effective	Maximum Pearson residual
AAF short				
Region 2 fishery	456	600	825	4.91
Region 3 fishery	599	609	733	4.10
Region 4 fishery	58	85	61	2.08
Region 4B fishery[2]	49	130	65	2.43
Discards[1]	6	198	80	0.66
Non-directed discards[1]	3	49	28	0.84
Recreational[1]	3	128	21	0.56
Region 2 FISS	7	77	5	1.06
Region 3 FISS	27	317	28	1.33
Region 4 FISS	86	156	90	2.68
Region 4B FISS[2]	41	147	38	2.56
AAF long				
Region 2 fishery	256	293	563	4.87
Region 3 fishery	319	286	468	3.93
Region 4 fishery	47	65	49	2.50
Region 4B fishery[2]	49	122	58	2.34
Discards[1]	6	157	85	1.22
Non-directed discards[1]	3	39	8	1.30
Recreational[1]	3	103	20	0.65
Region 2 FISS	5	63	5	1.35
Region 3 FISS	23	145	21	1.44
Region 4 FISS	114	158	121	2.80
Region 4B FISS[2]	34	147	35	2.00

Comparison of results (Table 19)

	Model			
	Coastwide Short	Coastwide Long	AAF Short	AAF Long
Biological				
Female M	0.150 (Fixed)	0.221 (0.185-0.257)	0.220 (0.204-0.236)	0.186 (0.169-0.204)
Male M	0.164 (0.155-0.172)	0.198 (0.181-0.216)	0.179 (0.169-0.189)	0.163 (0.154-0.171)
Log(R_0)	11.43 (11.19-11.67)	11.91 (11.51-12.32)	12.30 (12.06-12.54)	11.56 (11.32-11.79)
Initial log(R_0) offset	-1.512 (-1.746--1.278)	NA	-0.193 (-0.411-0.019)	NA
Environmental Link (β)	NA	0.456 (0.238-0.675)	NA	0.430 (0.225-0.636)
Survey Log(q) Δ1984 (transition to circle hooks)	NA	0.933 (0.485-1.381)	NA	R2: 1.344 (0.756-1.513) R3: 1.876 (1.631-2.120)
Fishery Log(q) Δ1984	NA	0.823 (0.647-0.999)	NA	R2: 0.562 (0.373-751) R3: 0.942 (0.751-1.133) R4: 0.850 (0.645-1.055) R4B: 0.381 (0.187-0.575)
2012 Age-0 recruitment (Millions)	67 (48-94)	164 (96-282)	195 (139-273)	115 (86-153)
2025 SB (Million lb)	139 (111-167)	156 (105-208)	226 (165-287)	153 (119-187)

Model diagnostics and results

- Switch to document and output files as needed.

Coastwide short model

Strengths:

- Lowest technical overhead (complexity) of the four models in the ensemble
- Fit the fishery and FISS indices very well
- Fit the survey age data (males and females) relatively well
- Parameter estimates are derived from the most recent time-period
- Internally consistent data weighting
- Similar weighting of commercial fishery and FISS age composition data

Weaknesses:

- Basis for fixed female *M* is unclear
- Does not include uncertainty in female *M* (see sensitivity analyses below)
- Does not include extensive historical data
- May lose Region-specific trends and biological patterns due to aggregation
- Does not use environmental information to inform recruitment

AAF short model

Strengths:

- Parameter estimates are derived from the most recent time-period
- Avoids aggregating data over Biological Regions with differing trends and biological patterns
- Fits the Regional fishery and FISS indices well
- Fits Regions 2 and 3 fishery age data well
- Internally consistent data weighting
- Propagates uncertainty in female and male *M* estimates

Weaknesses:

- Does not include environmental information to inform recruitment
- Increased technical overhead (complexity)
- Residual patterns in Region 4 and 4B fishery and survey age data
- Fits Region 2 FISS age data poorly
- Does not include extensive historical data

Coastwide long model

Strengths:

- Includes uncertainty in female natural mortality
- Includes extensive historical data
- Uses environmental information to inform recruitment
- Modest technical overhead (complexity)
- Fits the fishery and survey indices well
- Fits both the survey and fishery age data well
- Internally consistent data weighting

Weaknesses:

- May lose Region-specific trends and biological patterns due to aggregation
- Relies heavily on only fishery trends over the historical period
- Implicitly assumes stationarity in some processes (e.g. the stock-recruitment function after accounting for the PDO, *M*) over the long historical period
- Implicitly assumes that availability to the fishery did not change over the historical period, despite known patterns in geographical expansion prior to the 1960s

AAF long model

Strengths:

- Includes uncertainty in female and male *M*
- Includes extensive historical data
- Uses environmental information to inform recruitment
- Fits the fishery and survey indices well
- Fits both the Regions 2, 3 and 4B fishery age data well
- Fits Region 4 and 4B FISS age data well
- Internally consistent data weighting

Weaknesses:

- Highest technical overhead (complexity) of the four models
- Most challenging model to check and ensure reliable convergence
- Relies heavily on only fishery trends over the historical period
- Implicitly assumes stationarity in some processes (e.g., the stock-recruitment function, *M*) over the long historical period
- Fit Biological Regions 2 and 3 survey age data poorly

Outline

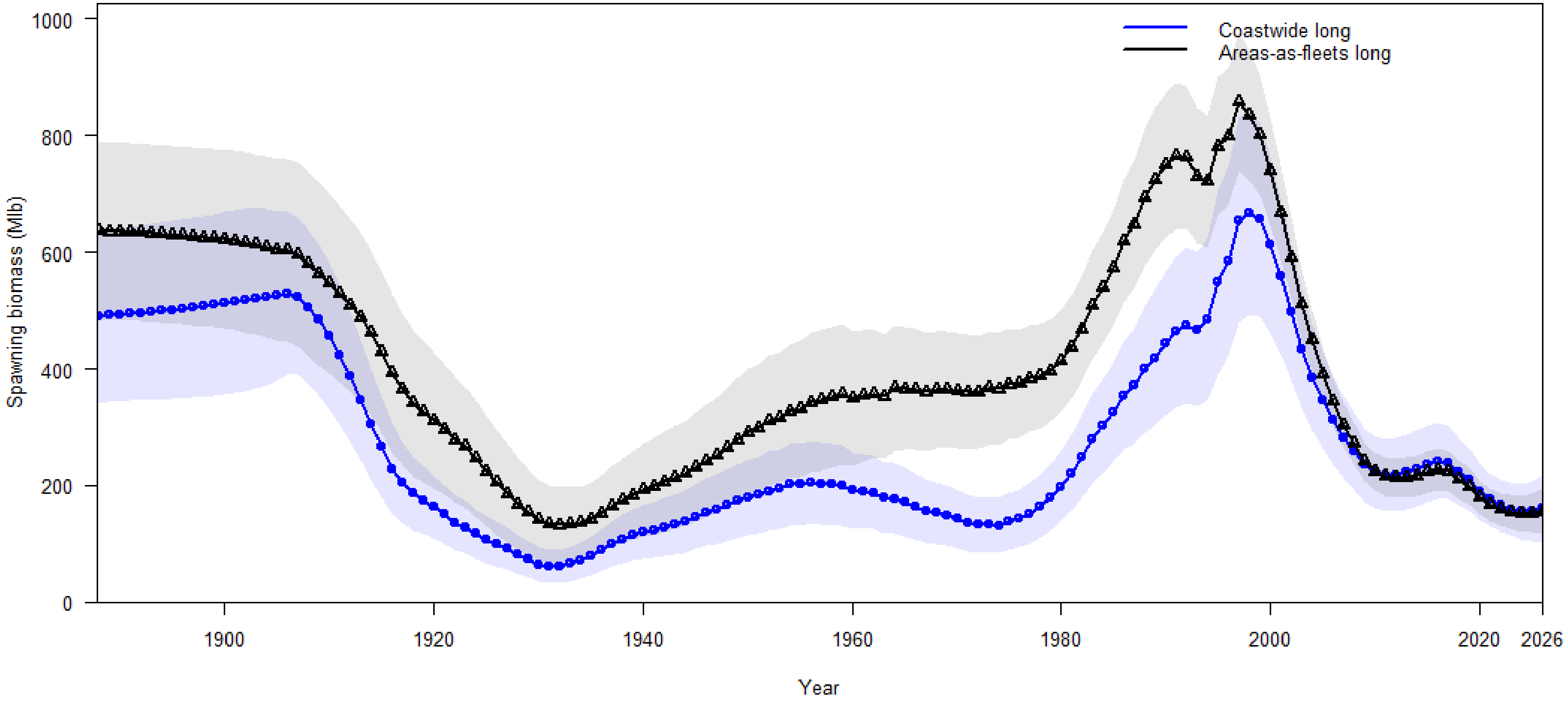
- Modelling
  - Multimodel approach
  - Structural assumptions/Technical configuration
  - Changes from 2024
  - Diagnostics and results
- Evaluation of uncertainty
  - Sensitivity analyses
  - Retrospective analyses
- Ensemble
  - Methods
  - Preliminary results for 2025
- Research priorities and future development

Historical sensitivity analyses

- 2015: *Ensemble*, fishery *q*, M:F selectivity, *M*, *h*, historical selectivity
- 2016: *Ensemble, m*aturity, M:F selectivity, directed fishery DMRs
- 2017: *Ensemble, m*aturity, M:F selectivity, unobserved mortality (e.g., depredation)
- 2018: *Ensemble, m*aturity, M:F selectivity, unobserved mortality
- 2019: *Ensemble, M*, *h*, data weighting
- 2020: *Ensemble*, bridging
- 2021: *Ensemble*, unobserved mortality, PDO, maturity
- 2022: *Ensemble*, PDO, *M*
- 2023: *Ensemble,* fishery CPUE
- 2024: *Ensemble,* fishery CPUE, maturity
- 2025: *Ensemble,* PDO, *h*, *M*, maturity, whale depredation

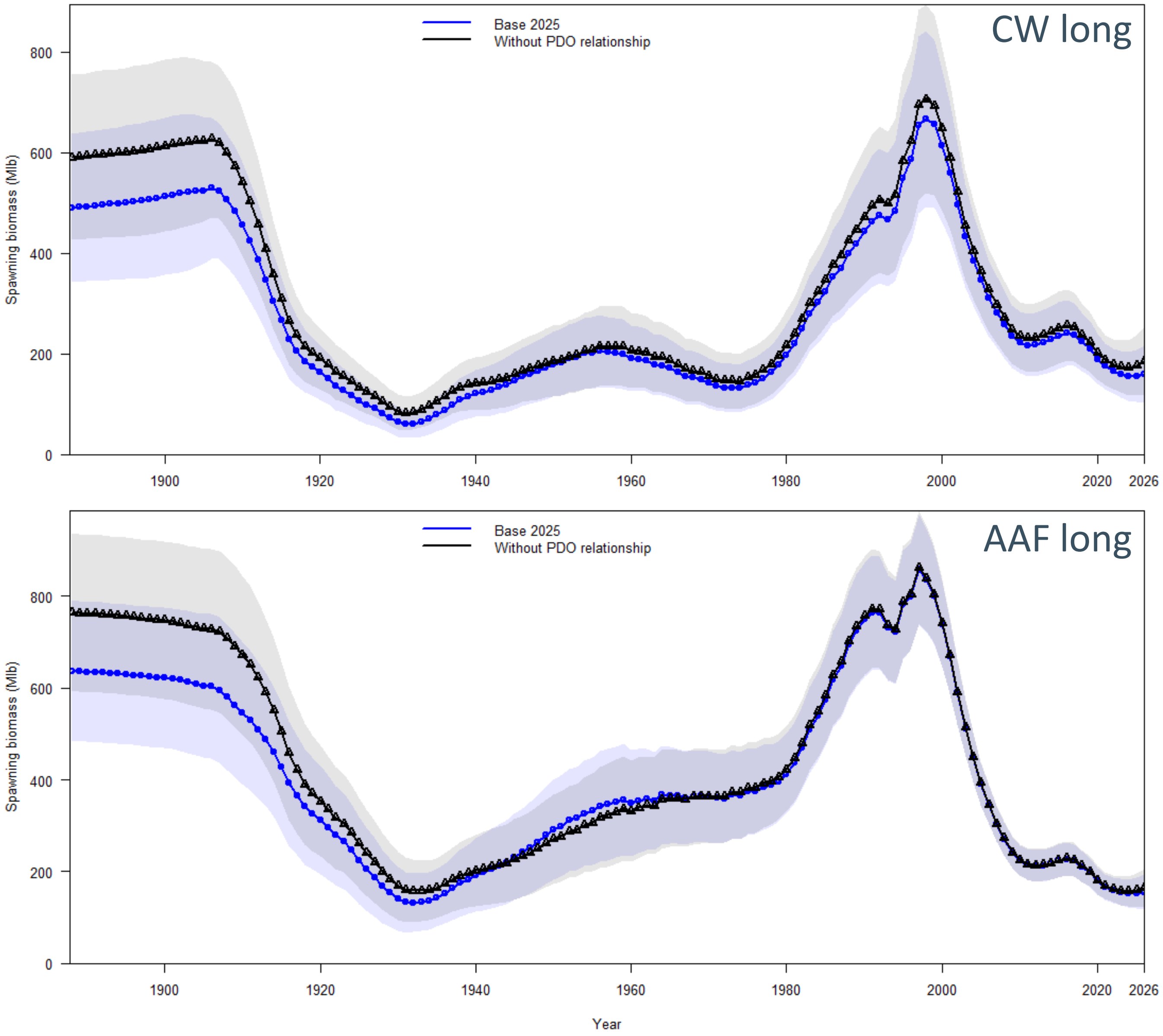
Sensitivity analyses

- Historical connectivity of Regions 4 and 4B with Regions 2 and 3
  - CW long vs. AAF long



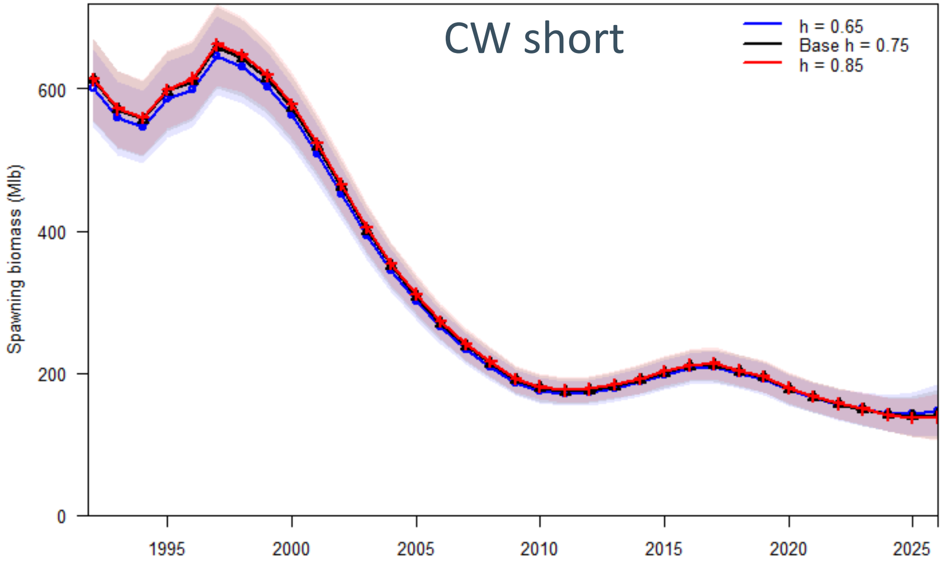
Sensitivity analyses: PDO

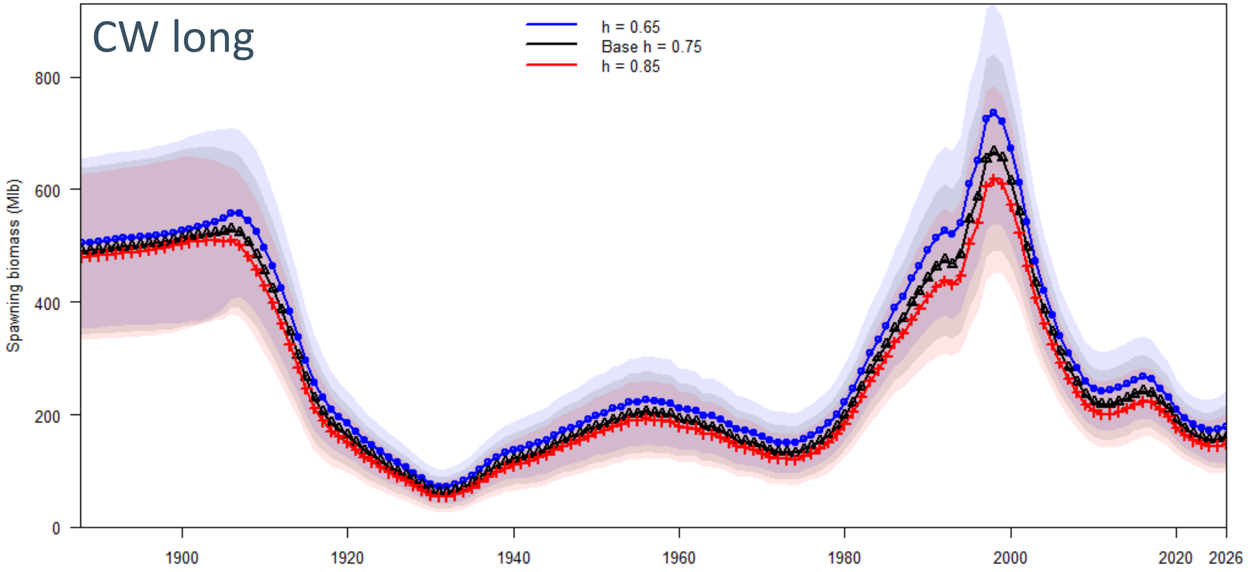
- Slightly higher estimated biomass without the PDO relationship



Sensitivity analyses: steepness (*h*)

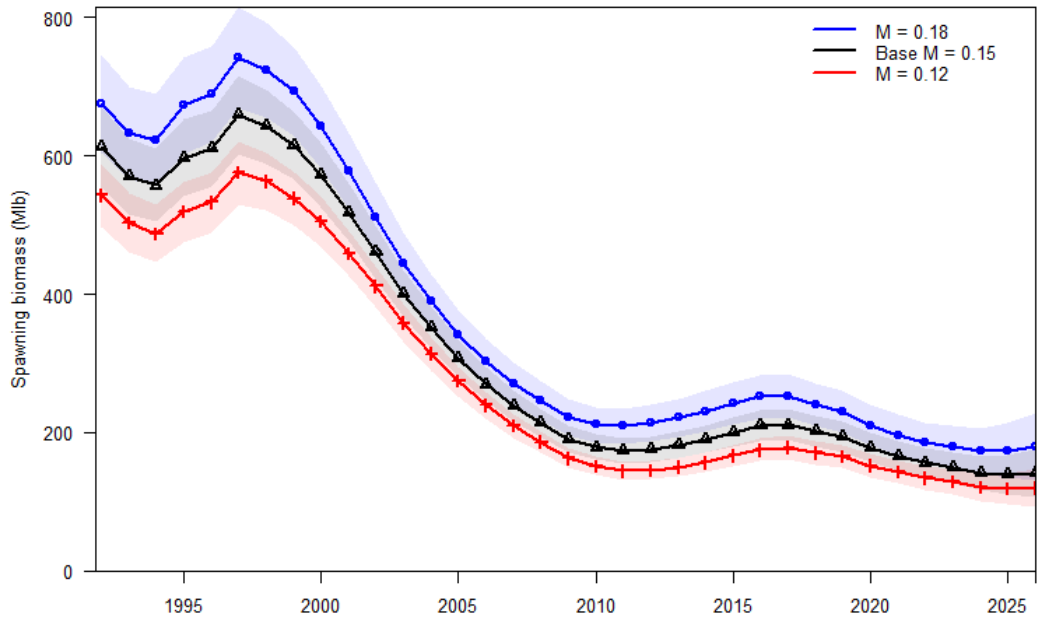
- Slightly higher estimated biomass at lower steepness values (CW long)
- Other models almost unchanged





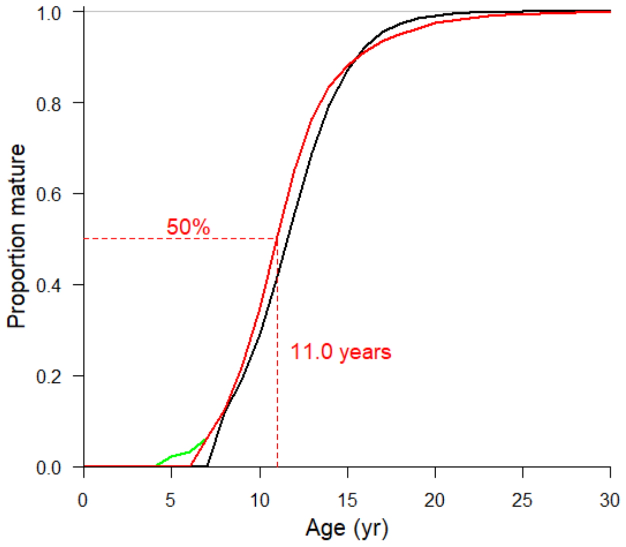
Sensitivity analyses: natural mortality (*M*)

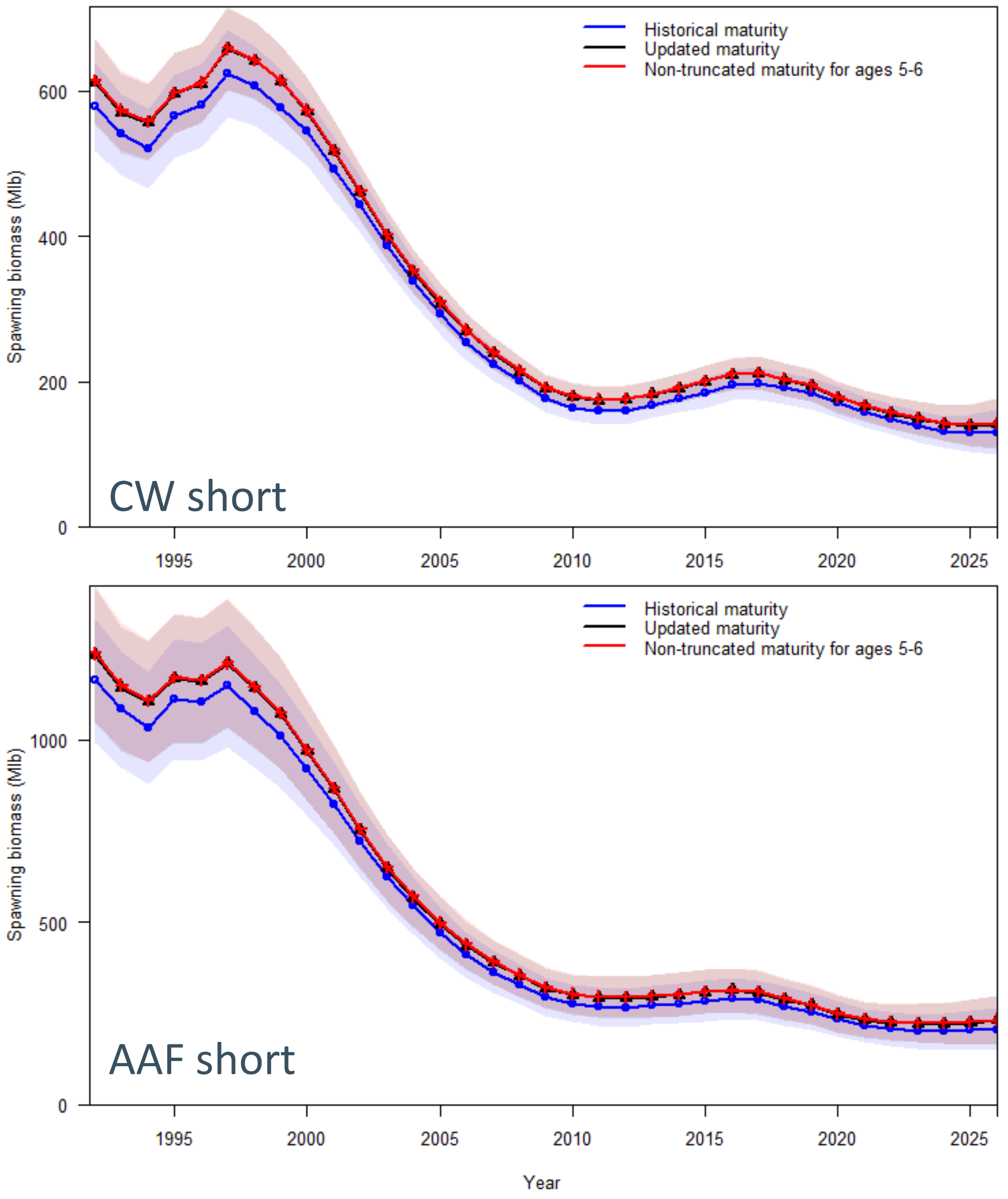
- CW short model only
- Direct scalar with estimated biomass
- Potential additional source of uncertainty that could be added to the ensemble



Sensitivity analyses: maturity

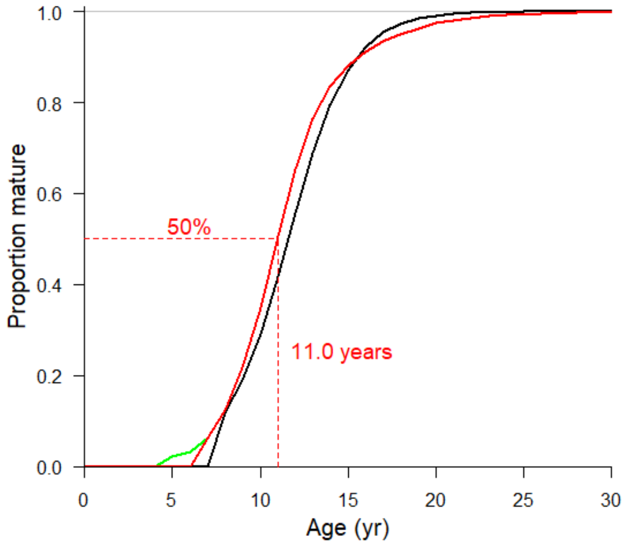
- Historical, updated, updated but not truncated at age 7
- Similar trend, modest increase in estimated spawning biomass across all models

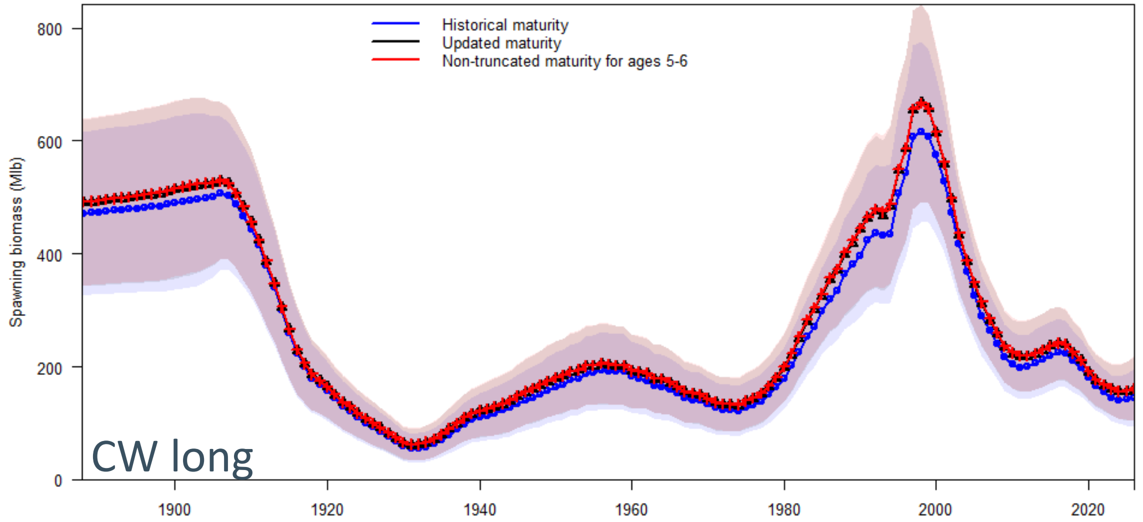


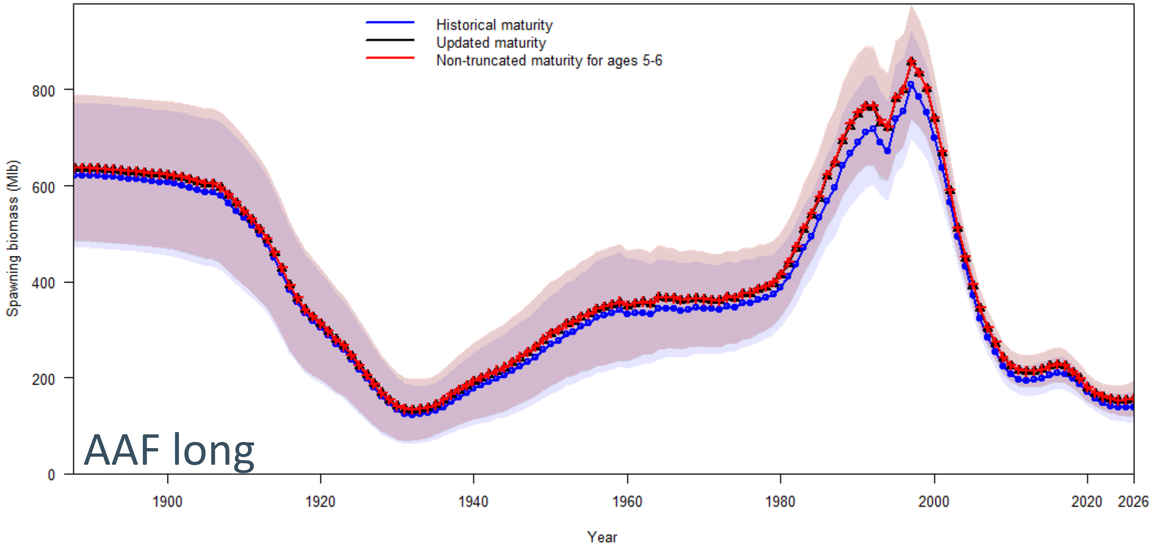


Sensitivity analyses: maturity

- Historical, updated, updated but not truncated at age 7
- Similar trend, modest increase in estimated spawning biomass across all models





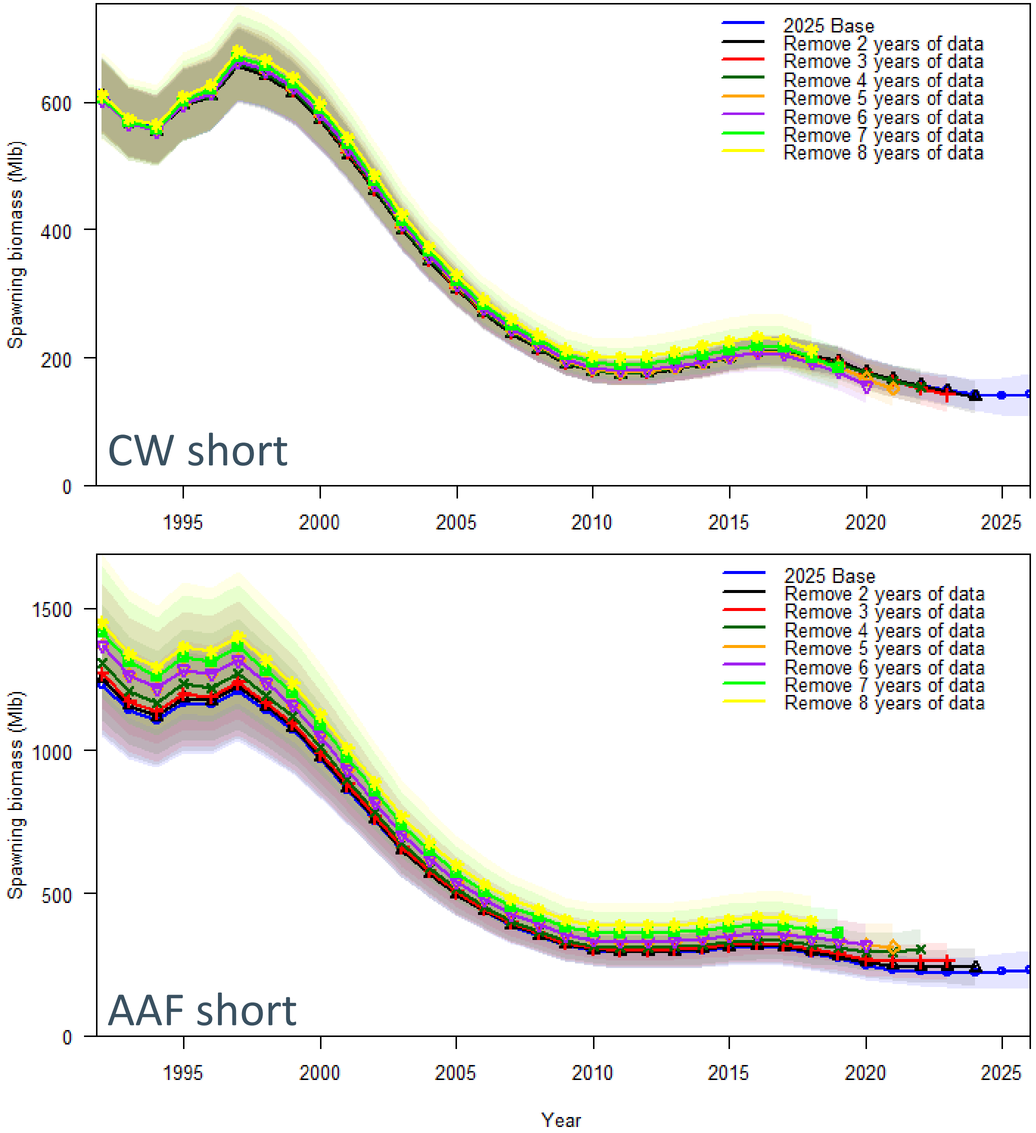


Other sensitivity analyses

- Lack of fit to Region 2 age data (AAF short model)
  - Catchability change from early to late data suggests spatial availability not fully represented by the AAF approach
- Increased whale depredation in recent period (2010+)
  - Does not explain the reduced recruitment/productivity of the stock
  - Change in recruitment strengths is ‘etched in’ to the observed composition data regardless of the level of mortality
  - Observed indices reflect the true mortality, regardless of whether mortality is estimated accurately

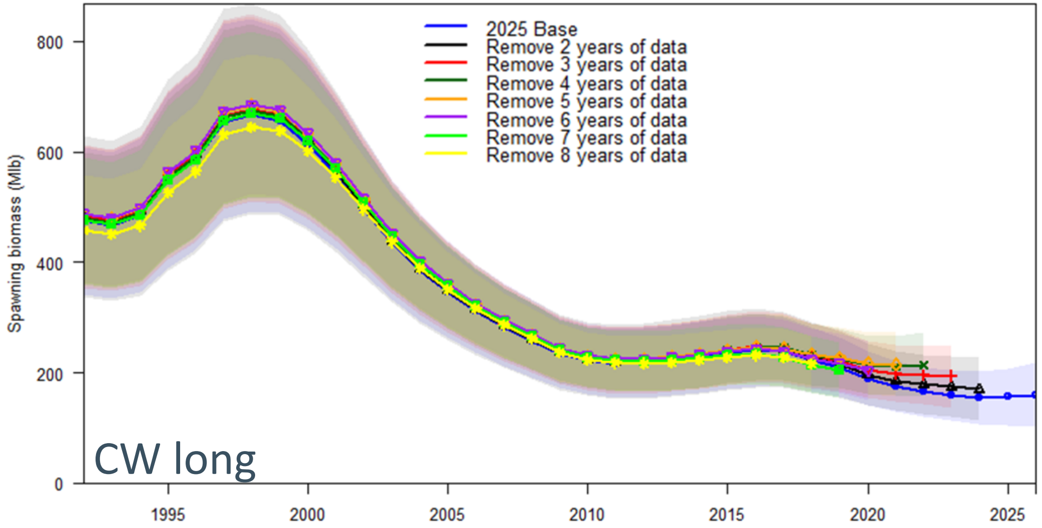
Retrospective analyses

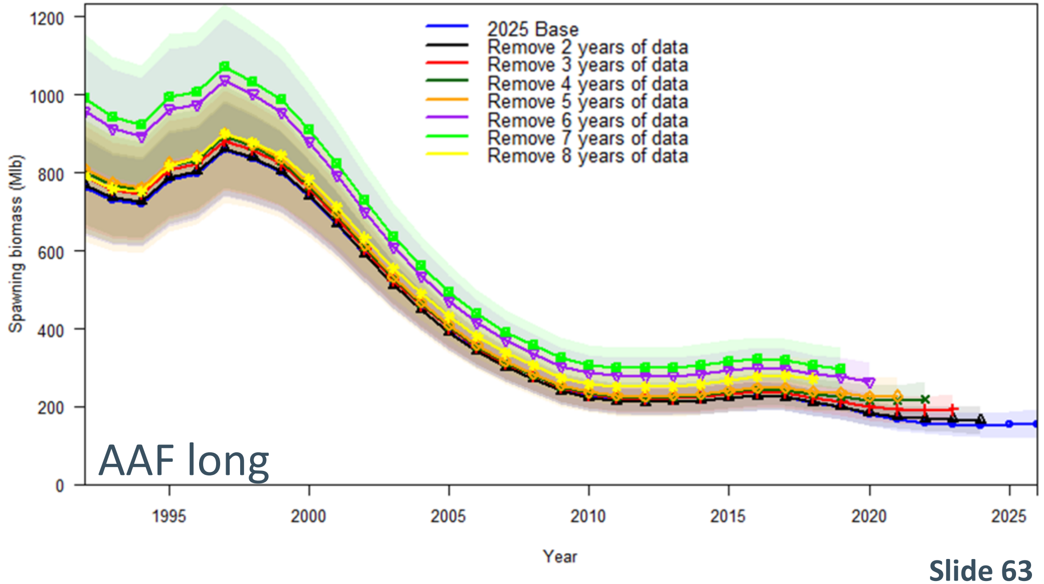
- Sequential data removed back to 2018 (no data in 2025, 2017 is the first year with fishery sex-specific age compositions)
- Slight increasing trend in CW short
- Decreasing scale in AAF short



Retrospective analyses

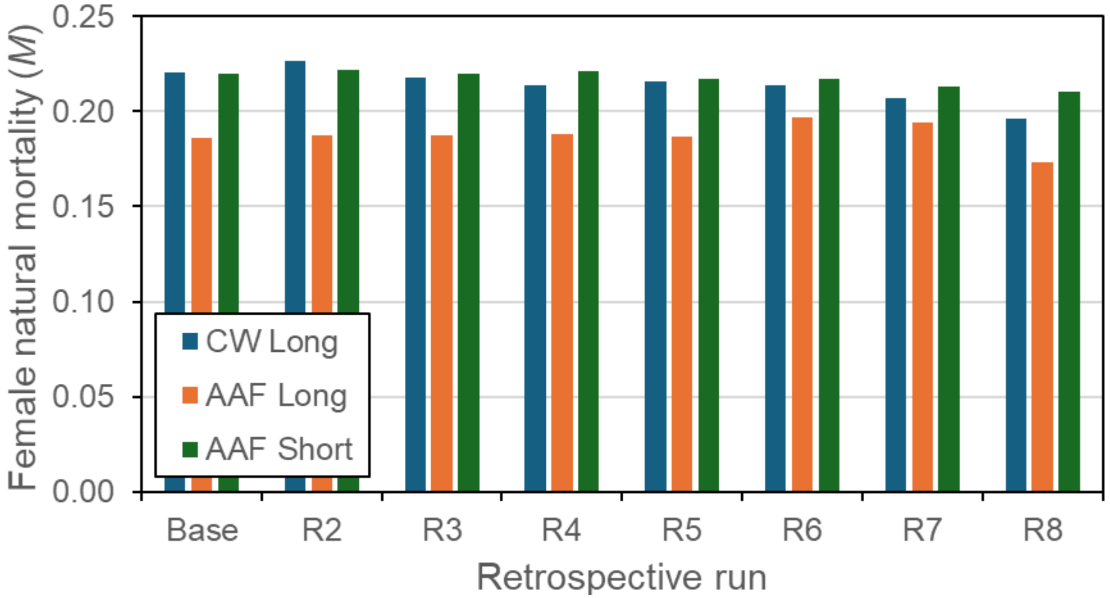
- Sequential data removed back to 2018 (no data in 2025, 2017 is the first year with fishery sex-specific age compositions)
- Largest change in trend in CW long model
- Largest change in scale in AAF long model





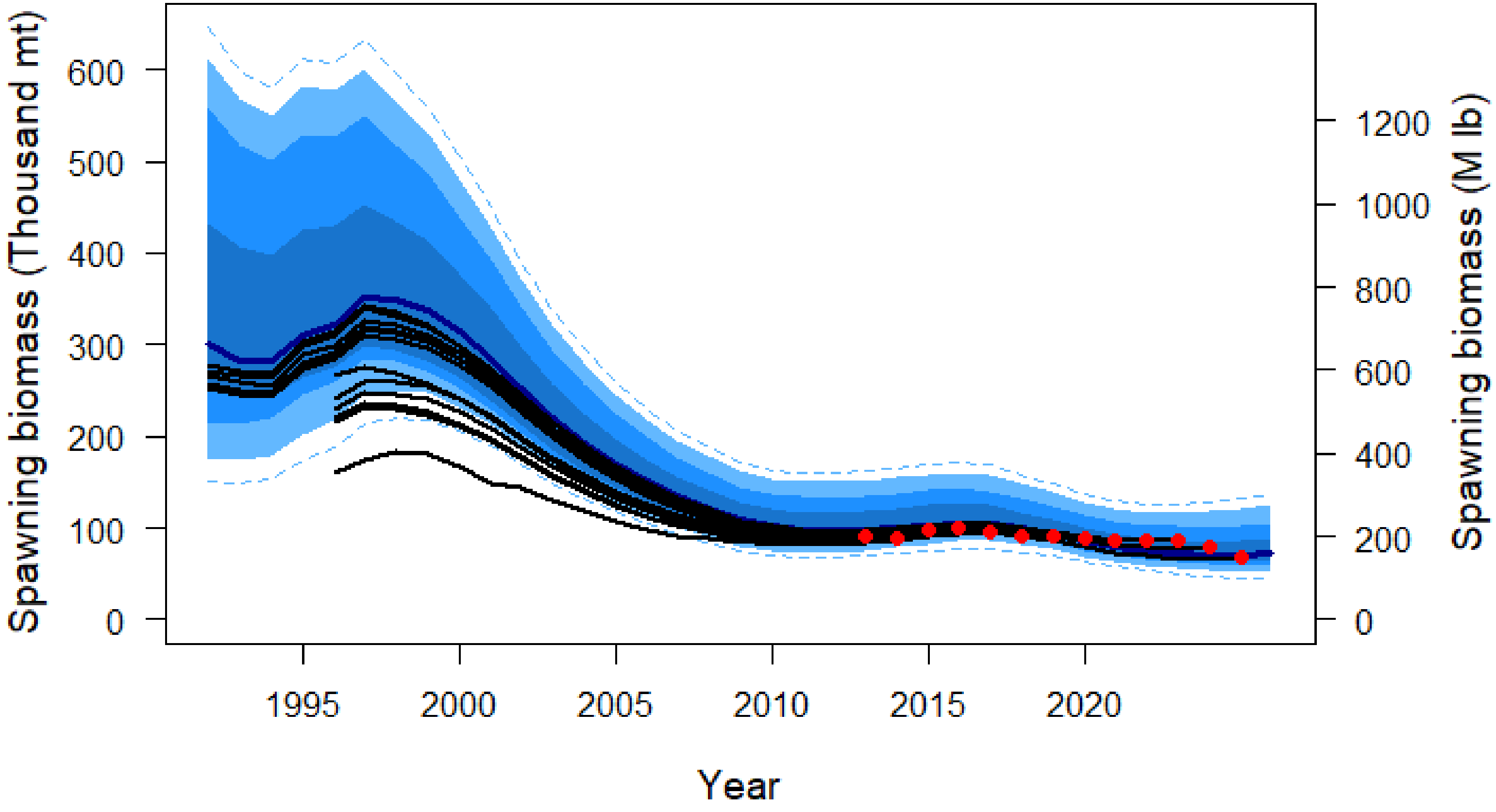
Retrospective analyses

- Retrospective changes in scale are not related to estimated natural mortality



Retrospective analyses

- Ensemble has shown a retrospective pattern only in the last 2 years. Driven almost entirely by the fishery data.



Outline

- Modelling
  - Multimodel approach
  - Structural assumptions/Technical configuration
  - Changes from 2024
  - Diagnostics and results
- Evaluation of uncertainty
  - Sensitivity analyses
  - Retrospective analyses
- Ensemble
  - Methods
  - Preliminary results for 2025
- Research priorities and future development

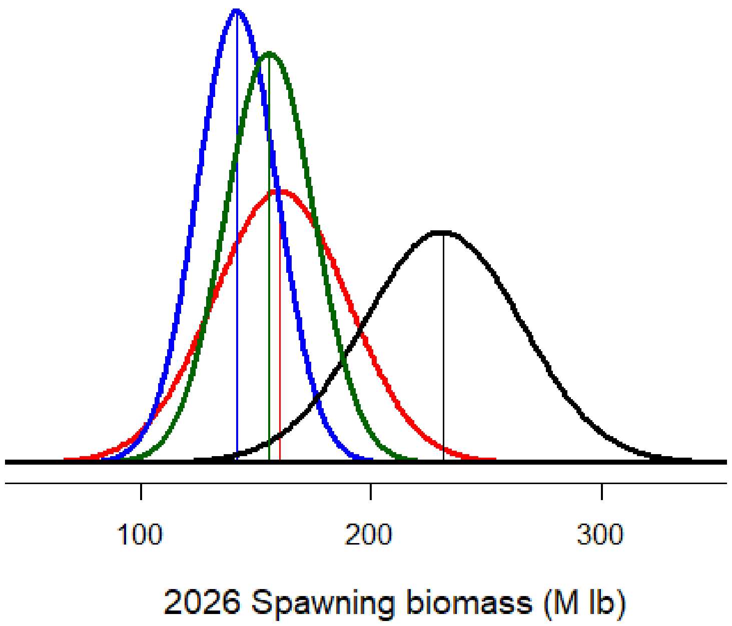
Ensemble methods

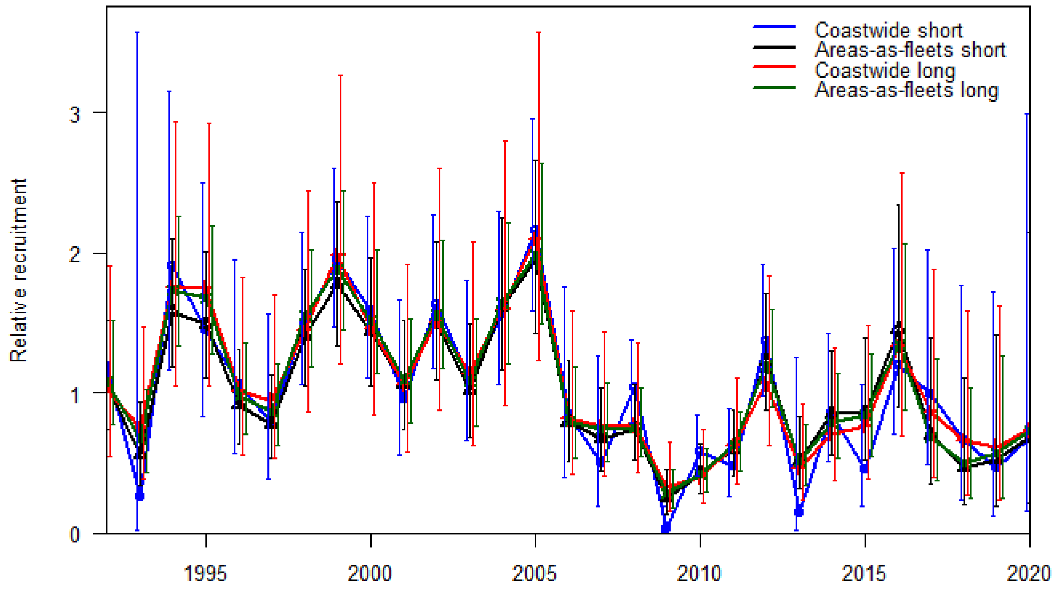
- Random draws from each model for quantities of interest, including variance and covariance estimates
- Number (*n*) of replicates from each model (*m*) determines the weight (*w*) within the set of models:

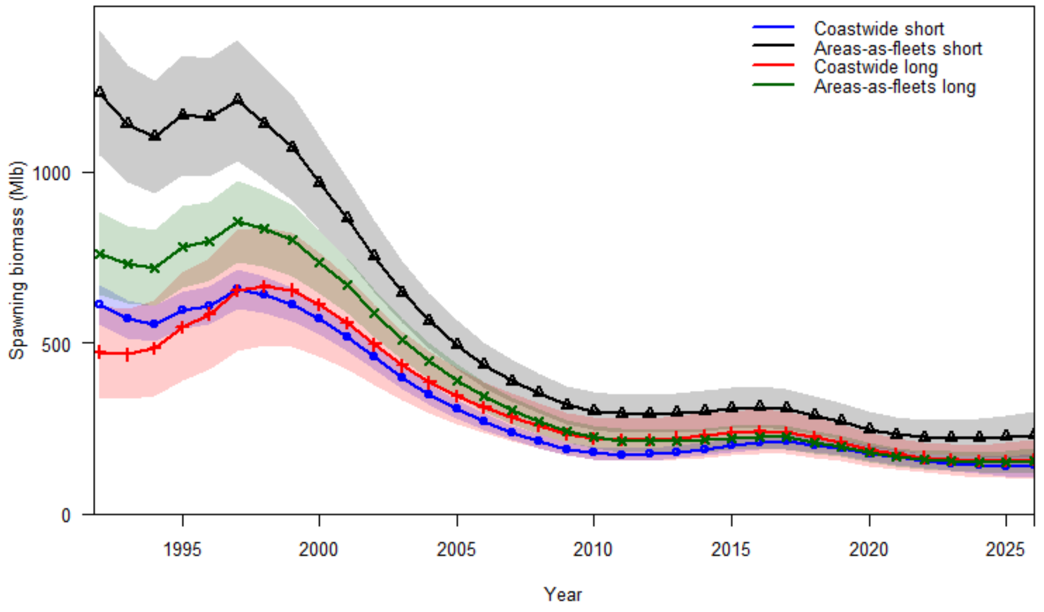
$$w_m = \frac{n_m}{\sum_m n_m}$$

Ensemble considerations

- Four models capture more uncertainty than any single approach
- No weighting method has emerged that is appreciably better than equal







Ensemble considerations

- Genetic studies provide no support for separating Biological Region 4B
- Exchange with Russian waters is an unquantified uncertainty, but no clear avenue to add this to the ensemble
- No substantial work done since the 2019 assessment on Bayesian models
- One or more state-space models could be developed and added to the ensemble
- Uncertainty in poorly quantified sources of mortality (discard mortality rates, whale depredation) generally addressed through sensitivity analyses; however, these could be integrated into the ensemble

Outline

- Modelling
  - Multimodel approach
  - Structural assumptions/Technical configuration
  - Changes from 2024
  - Diagnostics and results
- Evaluation of uncertainty
  - Sensitivity analyses
  - Retrospective analyses
- Ensemble
  - Methods
  - Preliminary results for 2025
- Research priorities and future development

Research priorities

- Updated to reflect progress made
- Highest priorities are elevated to the 5-year research plan
- Longer list in the document provides a record of items which could benefit from further work, even if not immediately high priority

Research priorities

- Biological understanding:
  - *Highest priority*: Updating the fecundity-weight relationship and the presence and/or rate of skip spawning.
  - *Highest priority*: The relative role of potential factors underlying changes in size-at-age is not currently understood. Delineating between competition, density dependence, environmental effects, size-selective fishing and other factors could allow improved prediction of size-at-age under future conditions.
- Data related research:
  - *Highest priority*: Continued collection of sex-ratio from the commercial landings will provide valuable information for determining relative selectivity of males and females, and therefore the scale of the estimated spawning biomass, and the level of fishing intensity as measured by SPR.
  - *Highest priority*: Evaluation of the magnitude of marine mammal depredation and tools to reduce it.
- Technical development:
  - *Highest priority*: Maintaining consistency and coordination between MSE, and stock assessment data, modelling and methodology.
  - *Highest priority*: Exploration of state-space models for Pacific halibut allowing for direct estimation of the variance in time-varying processes.
  - *Highest priority*: Continued exploration into the estimation of M in the short coastwide model.

Further development in 2025

- Responses to suggestions and comments generated from SRB026 and SRB027.
- Addition of all 2025 data, extending existing time series (mortality, indices, ages, etc.).
- The sex-ratio of the 2024 commercial fisheries landings based on the IPHC's genetic assay will be available by late summer.

Recommendations

That the SRB:

a) **NOTE** paper IPHC-2025-SRB026-07 which provides an overview of model development for 2025.

b) **RECOMMEND** any changes to be made and reviewed at SRB027.

c) **RECOMMEND** any additional analyses for SRB028 and beyond.

INTERNATIONAL PACIFIC

HALIBUT COMMISSION

https://www.iphc.int/