2024 Tanner Crab Stock Assessment

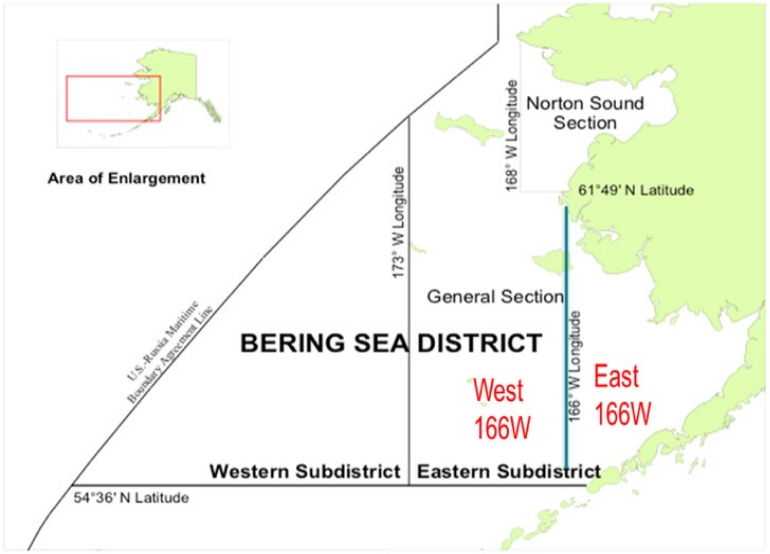
William Stockhausen

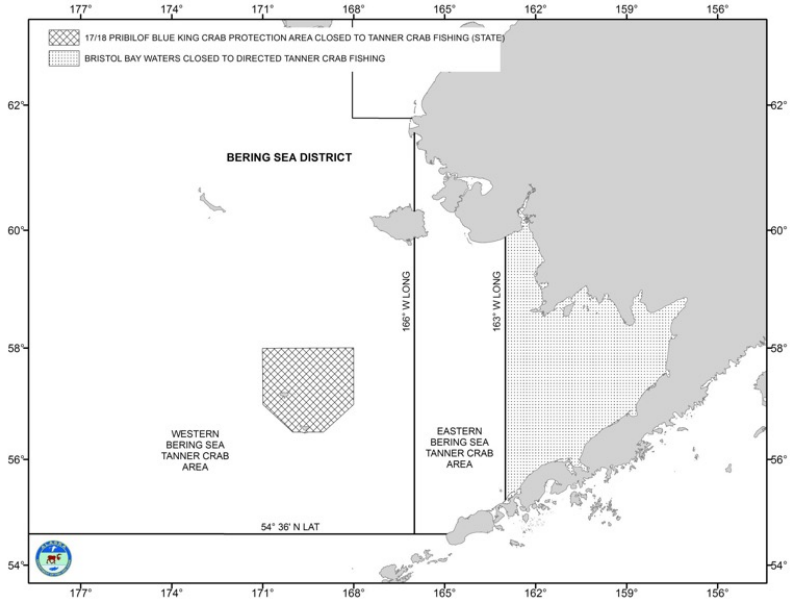
AFSC

Sept 11, 2024

Overview

- ADFG manages fishery in two areas
  - **fishery open in both areas**
  - East: TAC: 345 t. RC: 344 t
  - West: TAC: 599 t. RC: 597 t
- 2024 NMFS EBS Shelf Survey Biomass
  - male biomass: 83kt (+E,+W,+T)
  - IP male biomass: 12kt (+E,+W,+T)
  - female biomass: 44kt (+E,+W,+T)
  - **2023 recruitment moving into larger sizes**
- 2023/24 OFL: 36,200 t
  - Total catch mortality: 1,090 t
  - overfishing did not occur
- 2024 assessment
  - Tier 3a ($B>B_{MSY}$; not overfished)
  - OFL: 41,290 t; ABC: 33,030 t





Concerns

- assessment model **overly-optimistic**

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2020/21	17.97	56.34	1.07	0.66	0.96	21.13	16.90
2021/22	17.37	62.05	0.50	0.49	0.78	27.17	21.74
2022/23	18.19	74.17	0.91	0.91	1.19	32.81	26.25
2023/24	20.00	88.21	0.94	0.94	1.09	36.20	27.15
2024/25	NA	56.06	NA	NA	NA	41.29	33.03

Recent model explorations

- 1-mm size bins
- fixed growth
- fixed NMFS survey selectivity
- estimated BSFRF survey availability
- annually-varying M
- 1982 model start
- fit 2-area directed fisheries
- fit bycatch by groundfish gear type
- fit VAST time series
- fit aggregated total catch data
- use bootstrapped effective sample sizes as input sample sizes for NMFS survey size comps
- compress size composition tails
- Dirichlet-multinomial likelihood used to estimate effective size comp sample sizes

- simplified models using GMACS
- 2018 BSFRF SBS data added

Responses to Comments (Highlights)

CPT/SSC (5/6-2024): …. requested that a more complete bridging analysis [to GMACS] be undertaken for presentation to the modeling workshop in January 2025. Some features of TCSAM02 will need to be incorporated into GMACS for the CPT to make a more direct comparison between models.
Response: *the author plans to address this request in the given time frame.*

CPT/SSC (5/6-2024): …recommended that only TCSAM02 model 22.03d be brought forward to the September final assessment, **updated with the 2023/24 NMFS survey data, provided that the issues related to parameters on bounds can be resolved.**
Response: *Model 22.03d5 fulfills this request.*

SSC (6-2024): …recommends the author provide additional detail in the changes to the underlying BSFRF data from 2013-17 that caused parameters to hit bounds, including details on any possible changes to the data weighting.
Response: *Additional details associated with incorporating the 2013-2018 BSFRF SBS data into the assessment are discussed in Appendix A and Appendix B, the first bridging analysis.*

Responses to Comments (Highlights)

SSC (6-2024):…requests the authors and CPT consider coordinating the approach to analyzing the BSFRF data for the two *Chionoecetes* crab and BBRKC stocks, and specifically consider developing the results as a prior on selectivity for use in the models

Response: *With the 2018 BSFRF SBS data for Tanner crab provided this past year, the author is finishing up analyses using the BSFRF SBS data for Tanner crab and BBRKC to inform NMFS survey selectivity. Following completion, a similar approach will be applied to the snow crab data. Products from these analyses will include stock-specific priors for NMFS survey selectivity. The analysis for Tanner crab and BBRKC should be completed in time to present at the January 2025 Modeling Workshop. The analysis for snow crab will potentially be completed by the May 2025 CPT meeting.*

CPT (1-2024): …recommended that the Tanner assessment use 50% handling mortality rate for groundfish fixed gear (pot and long line) to be consistent with other crab assessments.

Response: *Done.*

CPT (1-2024): Assessments should include a history of modeling approaches, and a table of historical issues addressed.

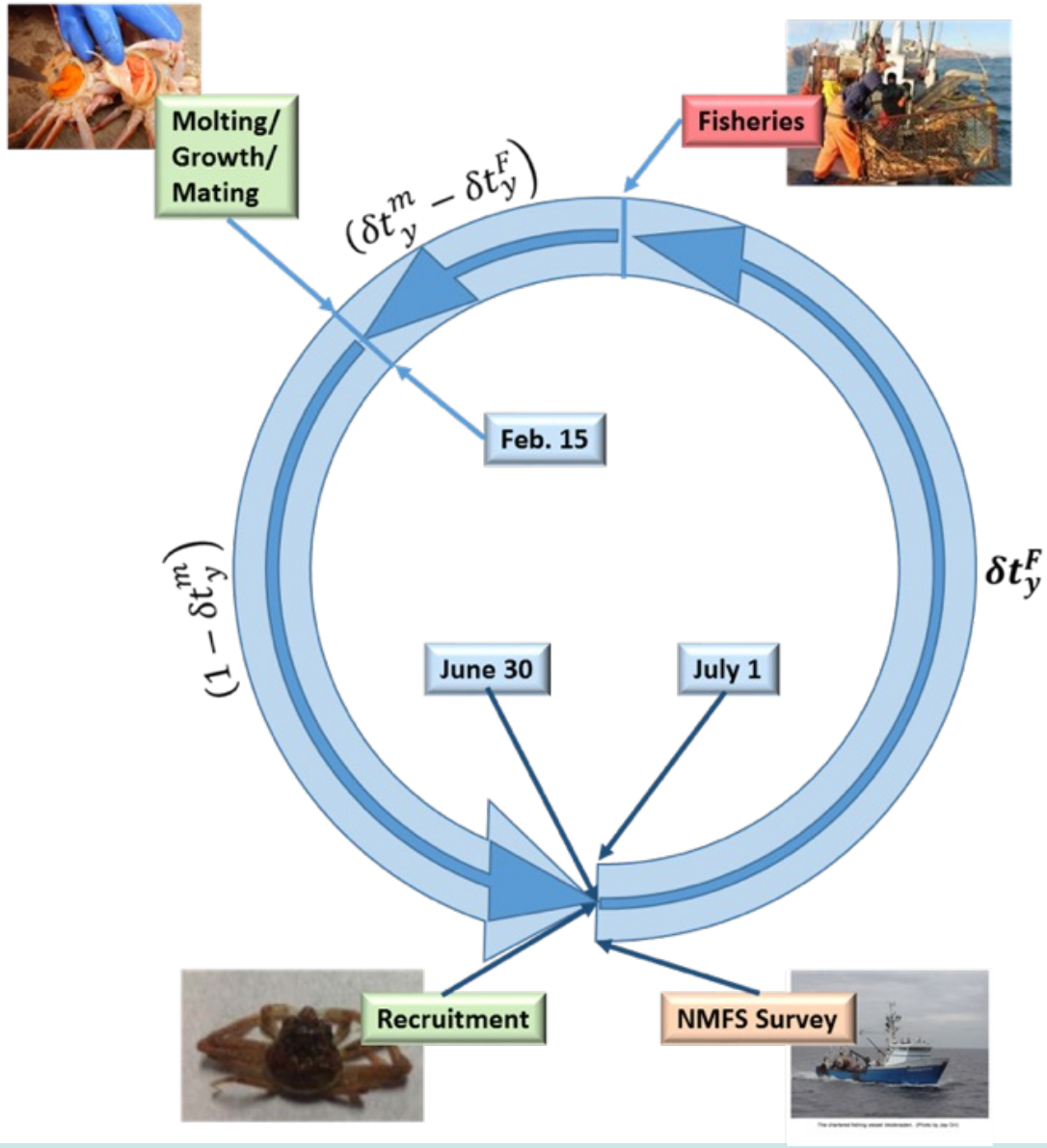
Response: *See "History of modeling approaches for this stock" section.* ***It would be helpful if the CPT could provide a template for the table of historical issues for all stocks.***

CPT/SSC (1/2-2024): …recommended the stock assessment authors that have final assessments in Sept/Oct bring forward a draft risk table for CPT review at that time.

Response: *A draft risk table is provided in Appendix D.*

Assessment Model

- Tier 3 size-structured model
  - Survey data
    - NMFS EBS shelf survey: 1975-present
    - BSFRF side-by-side haul studies
  - Fishery data
    - directed fishery (areas combined)
      - retained catch
      - total catch
    - bycatch in
      - snow crab fishery
      - BBRKC fishery
      - groundfish fisheries
  - Estimates:
    - Annual recruitment
    - Annual numbers-at-size (M,F)
    - mature biomass (MMB, MFB)
  - Determines:
    - F_{MSY}, B_{MSY}, F_{OFL}, OFL



Major Changes to Assessment from 2023

- Groundfish fixed gear handling mortality changed from 0.321 to 0.5 (CPT directive)
  - only affects overfishing determination

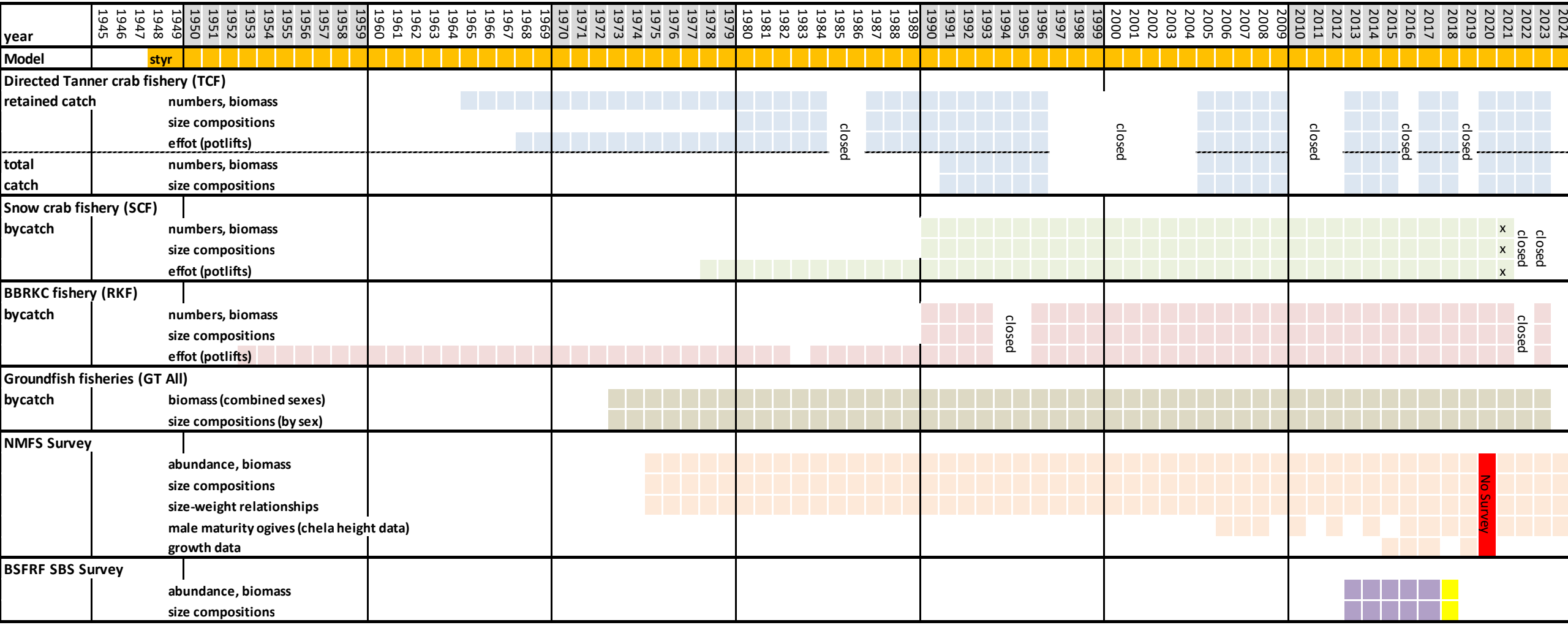
- Added 2018 BSFRF biomass index and size comps from BSFRF/NMFS selectivity study
  - slight changes to 2013-2017 BSFRF data based on additional QA/QC checks

- 2013-2017 availability curves for BSFRF SBS surveys revised, 2018 added
  - new GAM model for smoothing “raw” availability curves (fits data better)

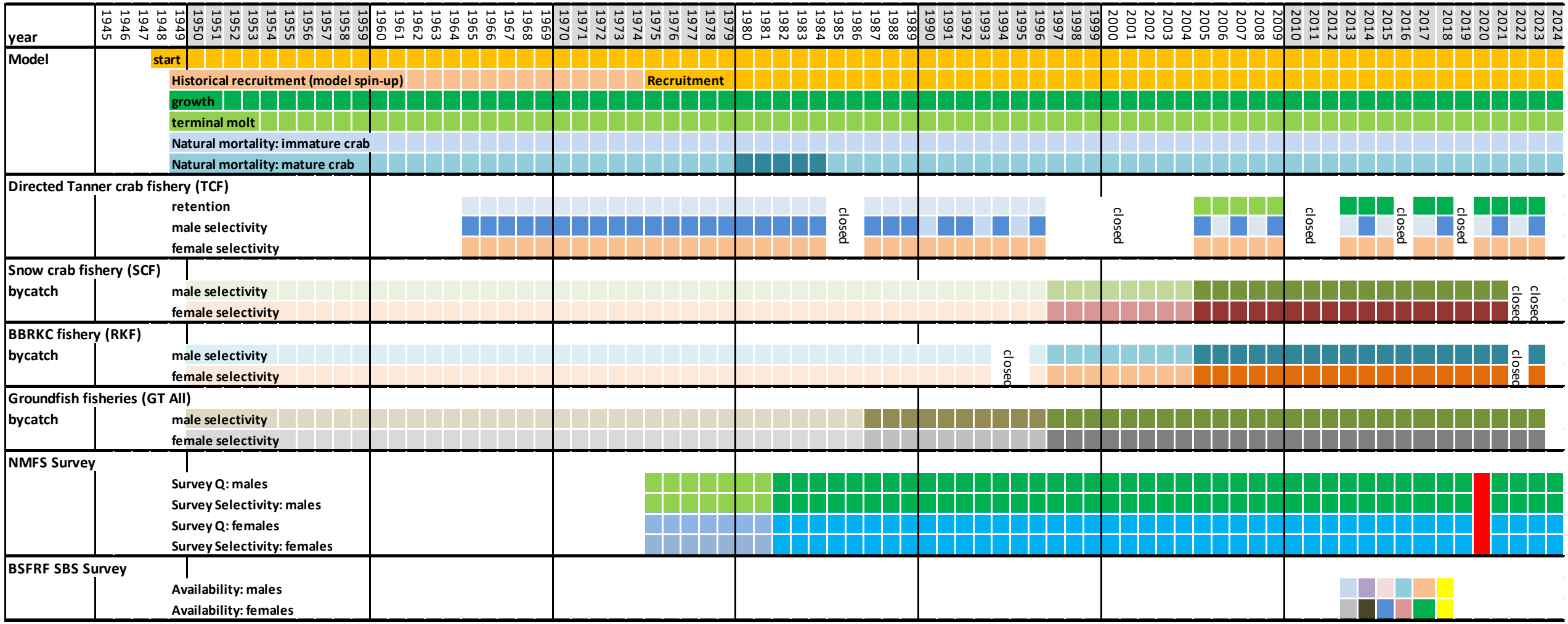
- 2023/24 data added
  - directed fisheries (combined areas) retained & total catch biomass, size comp.s
  - BBRKC Tanner crab bycatch biomass & size comp.s
  - groundfish fisheries (combined gears) Tanner crab bycatch biomass & size comp.s
  - no 2023/24 snow crab fishery: no bycatch
  - 2024 NMFS EBS survey biomass indices and size compositions
  - 2024 male maturity ogives

- Models
  - 22.03d5: Effective sample size parameters for BSFRF size comp.s Dirichlet-Multinomial likelihoods’ effective sample parameters fixed to values near upper bound

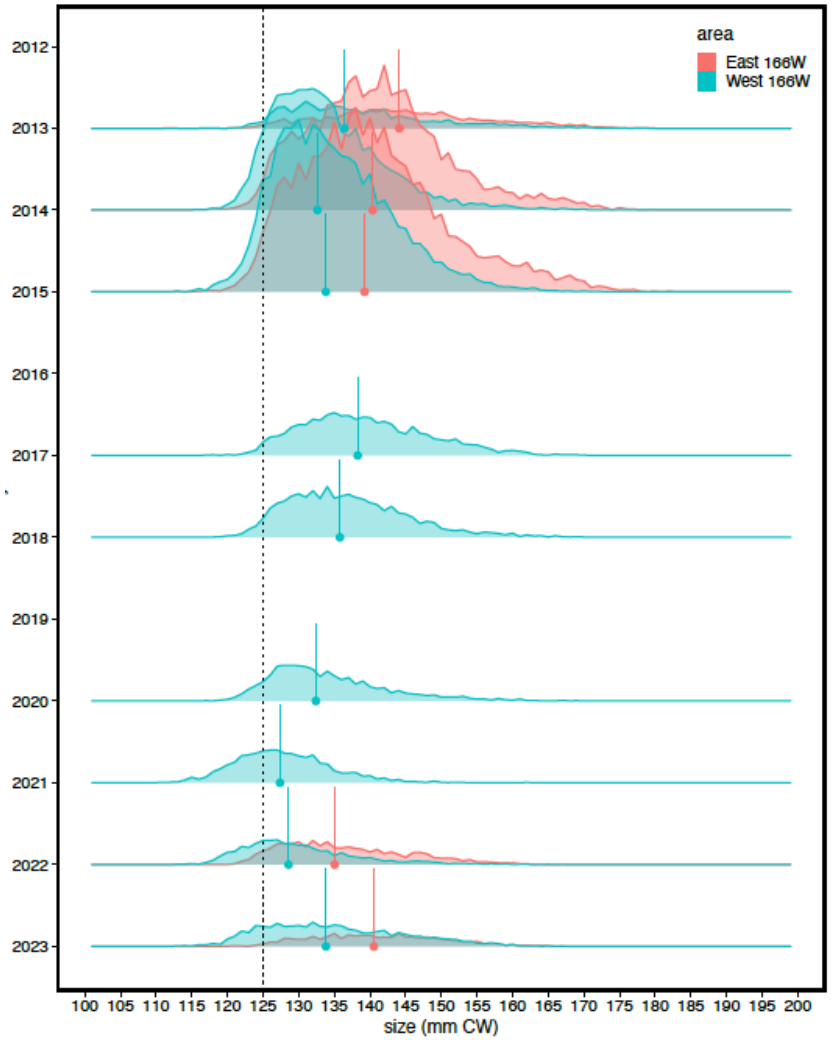
Assessment time frames: data

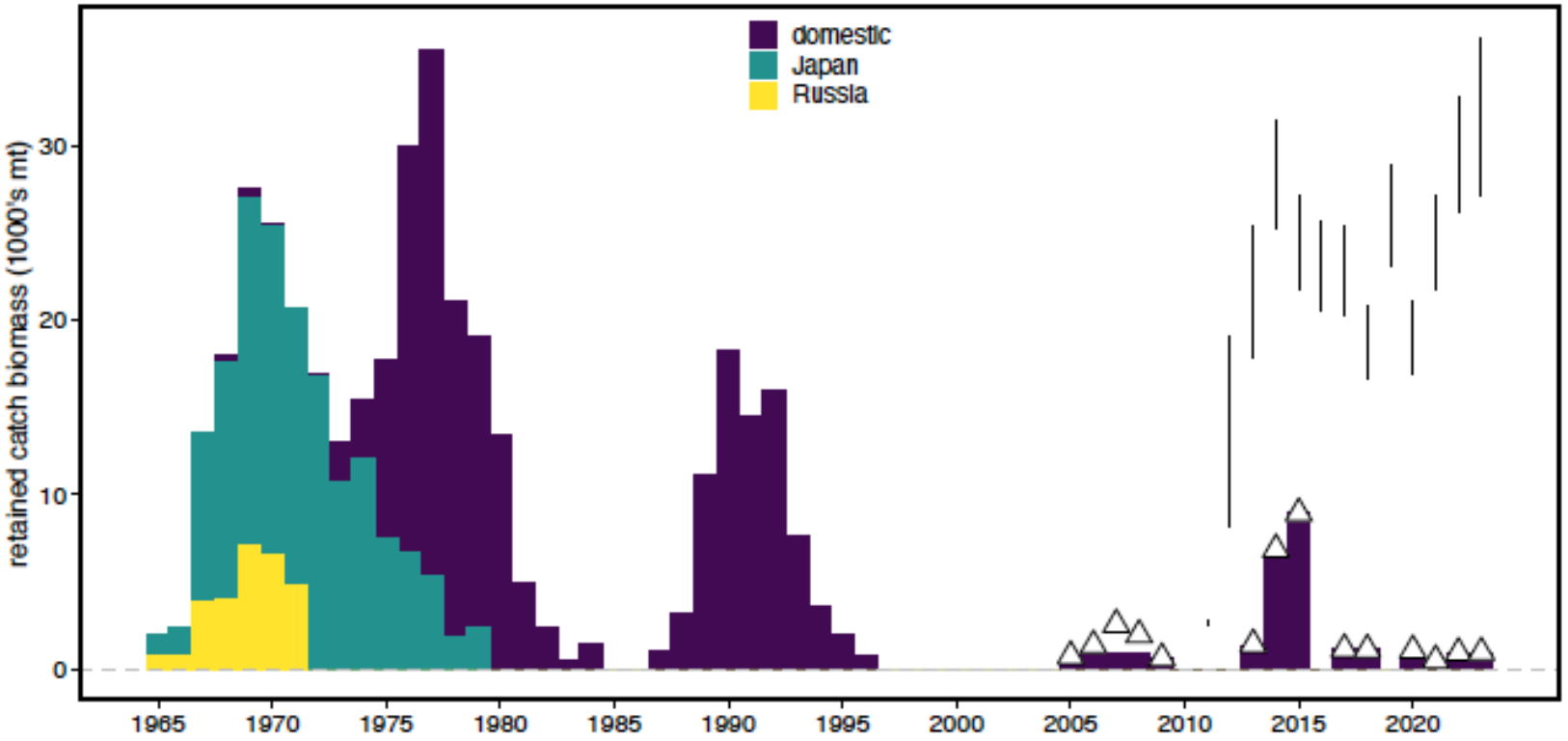


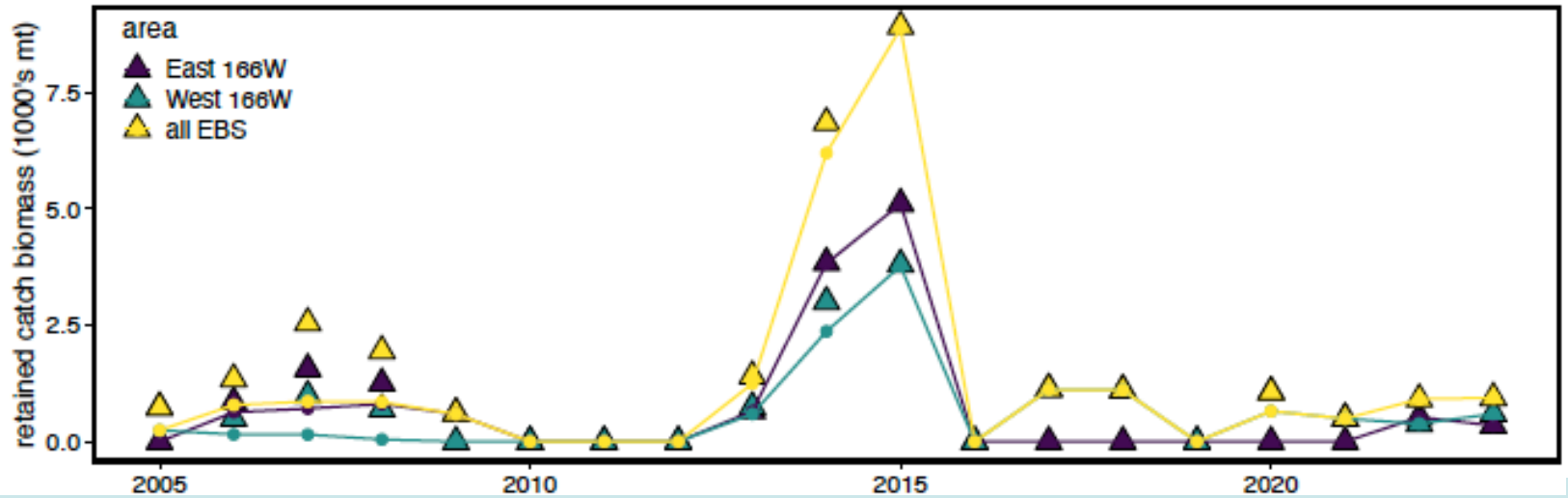
Assessment time frames: model processes



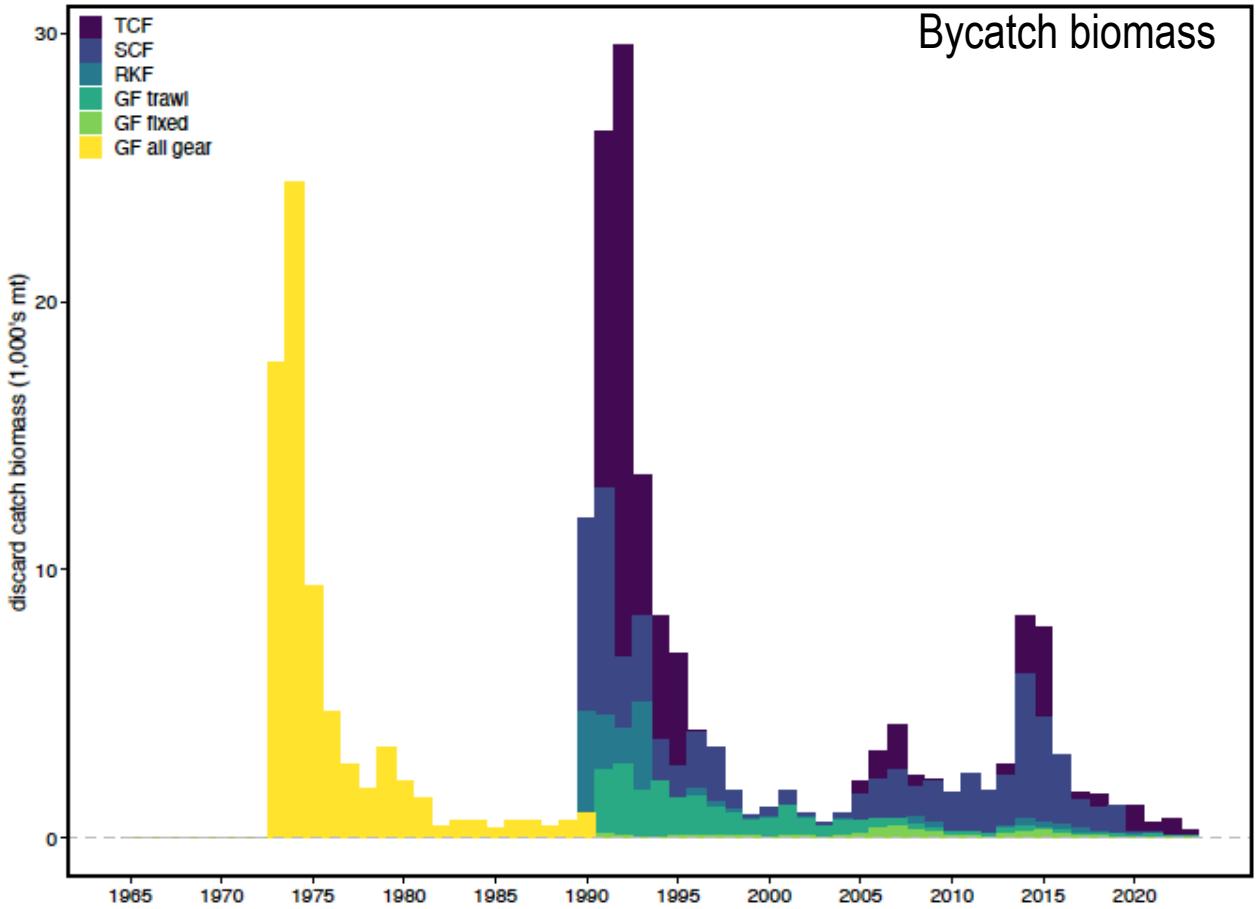
Retained catch

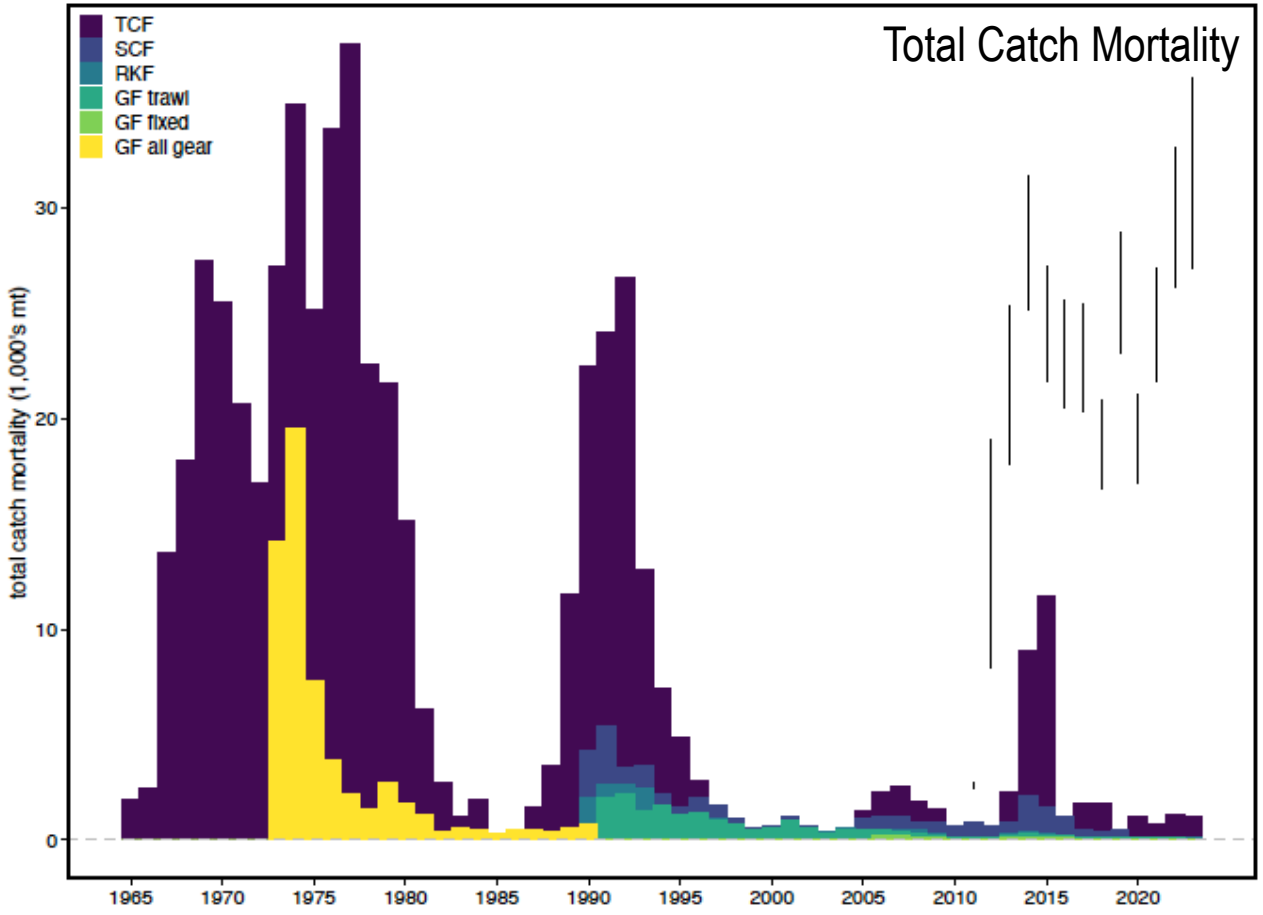






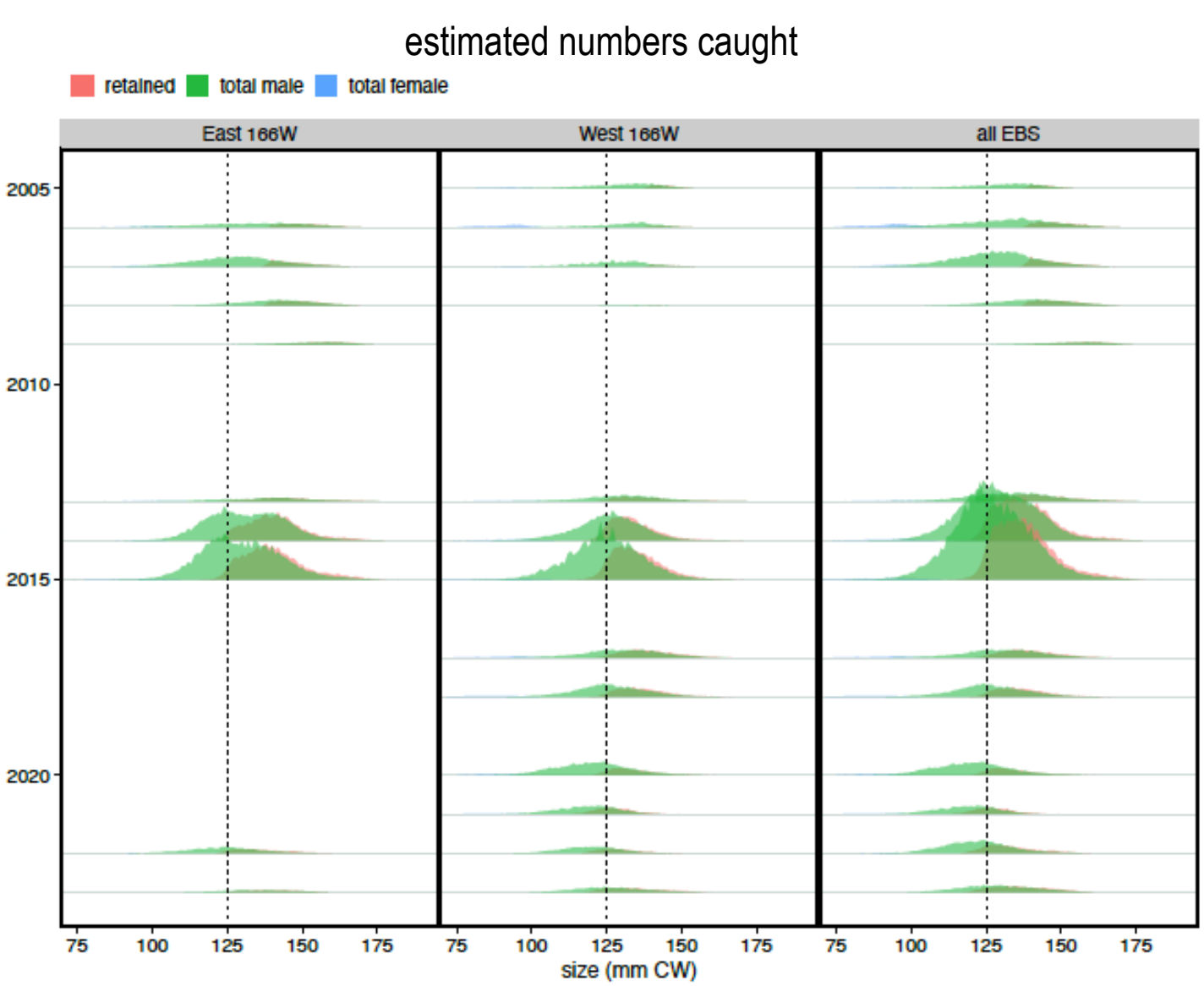
Bycatch and total catch mortality



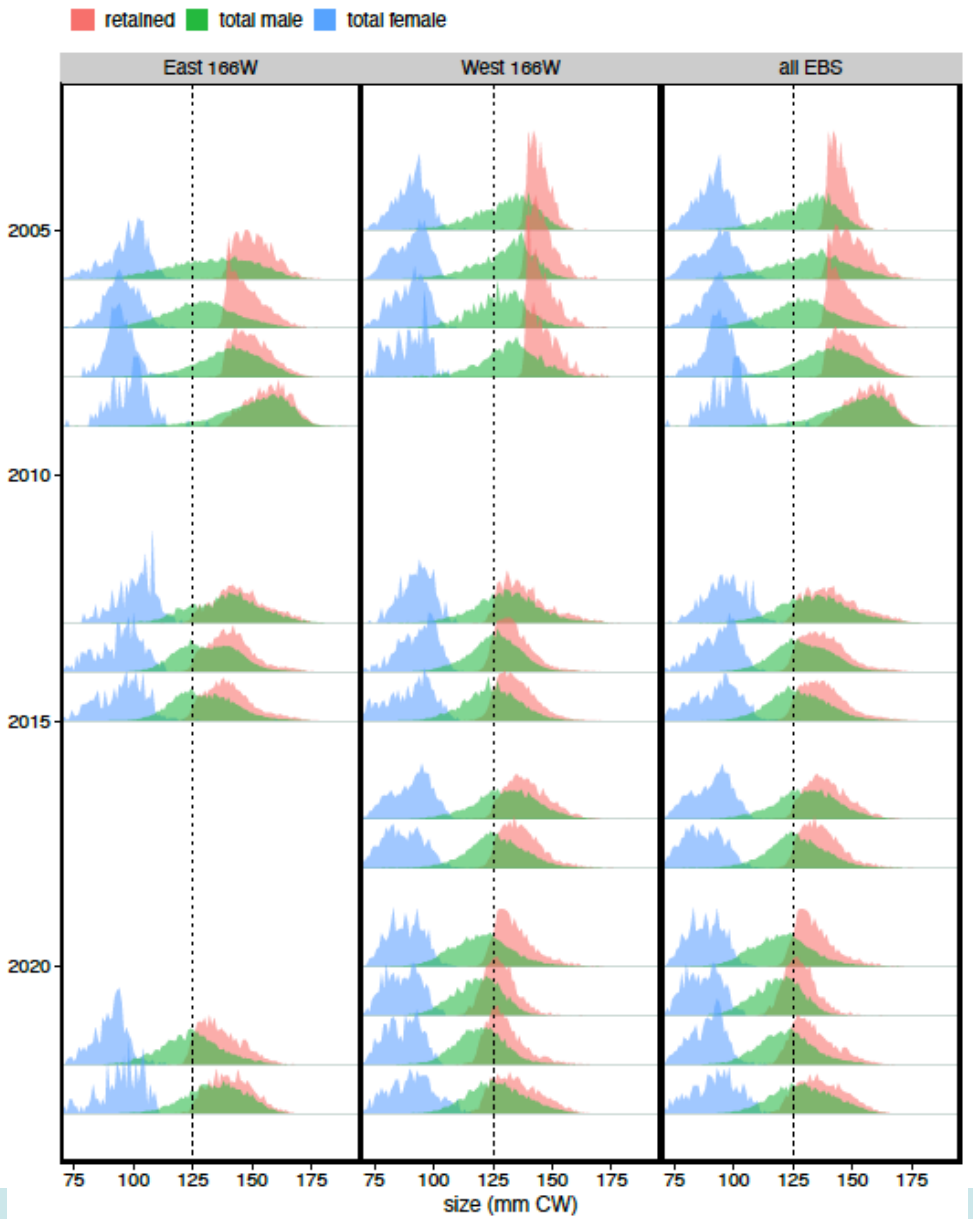


Catch in the directed fishery

estimated numbers caught



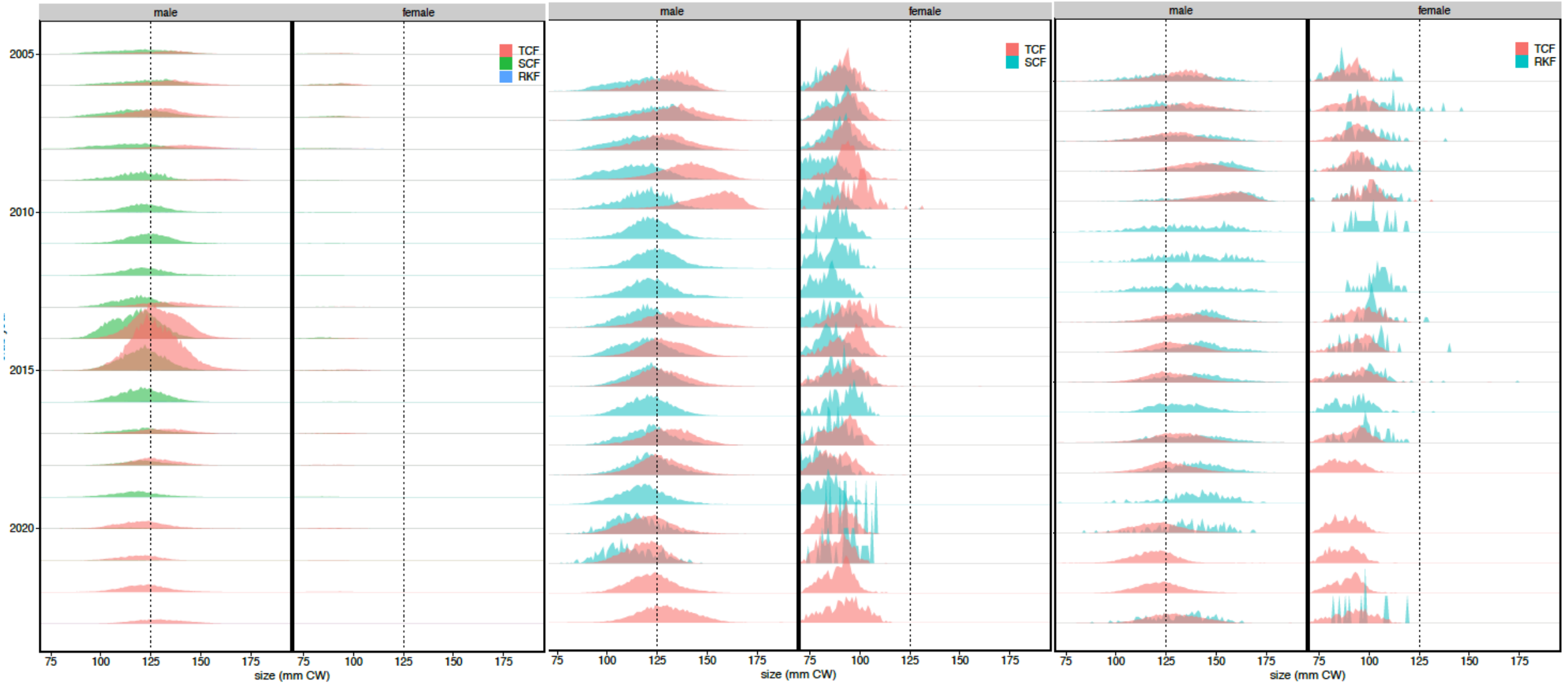
individual components normalized



Total catch comparisons: bycatch in snow crab and BBRKC fisheries

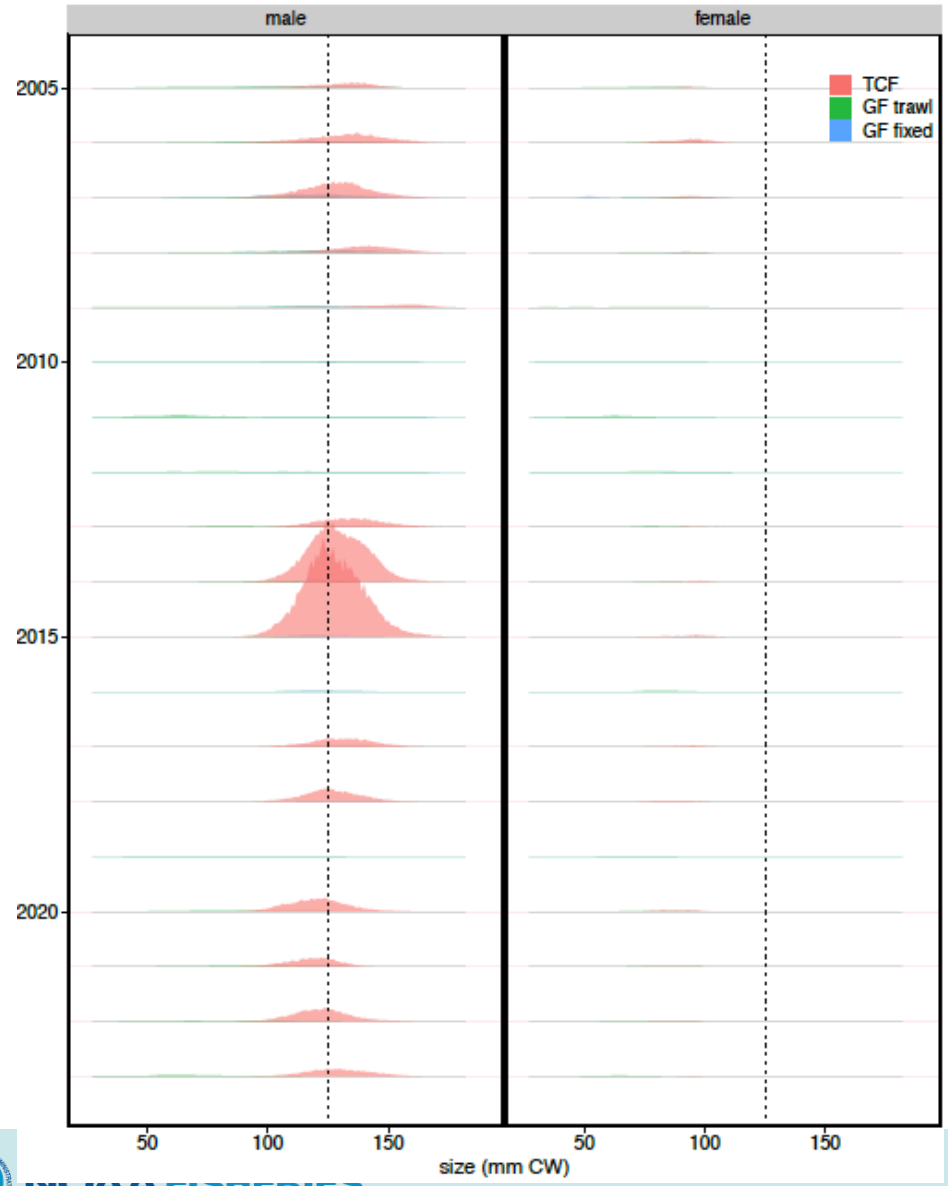
estimated numbers caught

individual components normalized

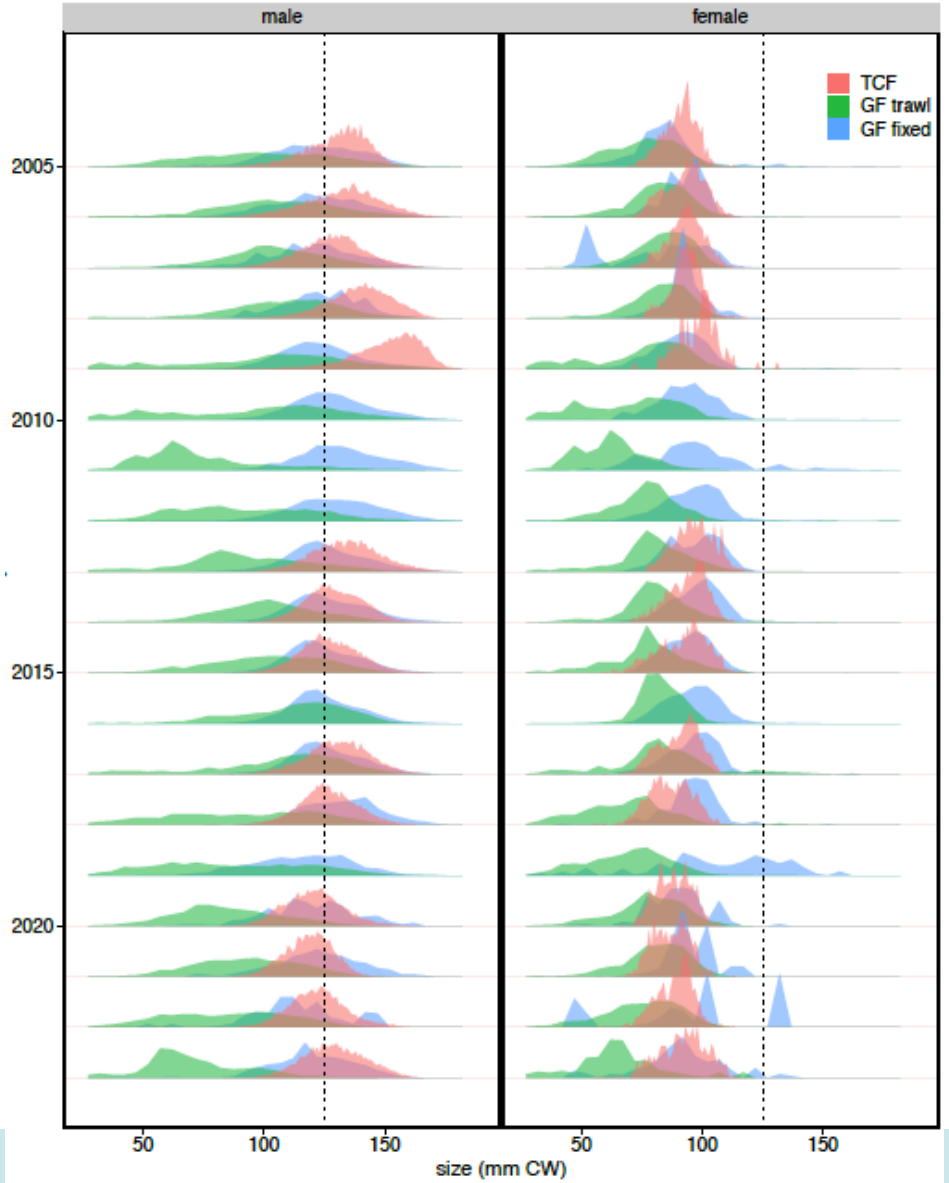


Total catch comparisons: bycatch in groundfish fisheries

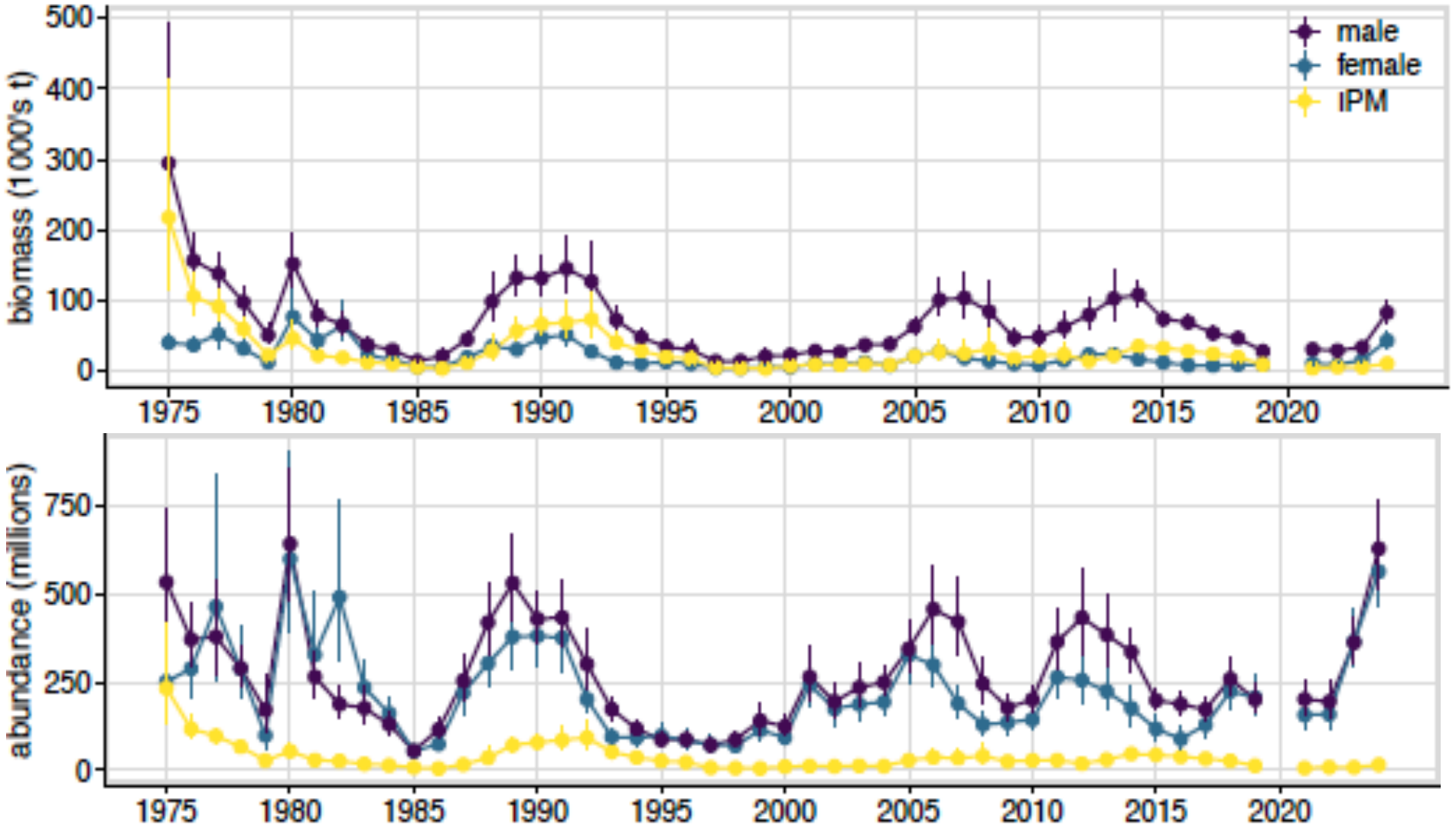
estimated numbers caught



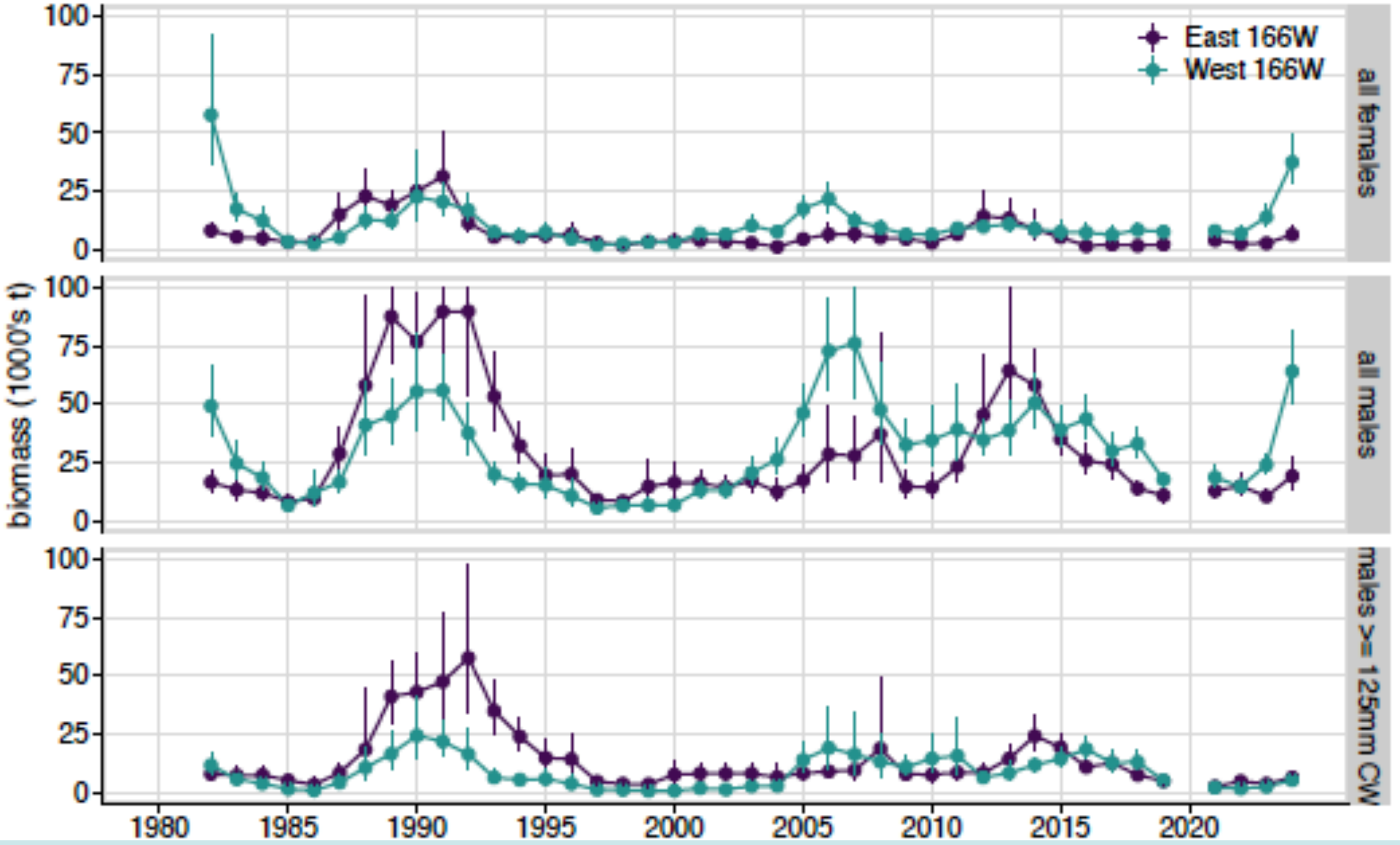
individual components normalized



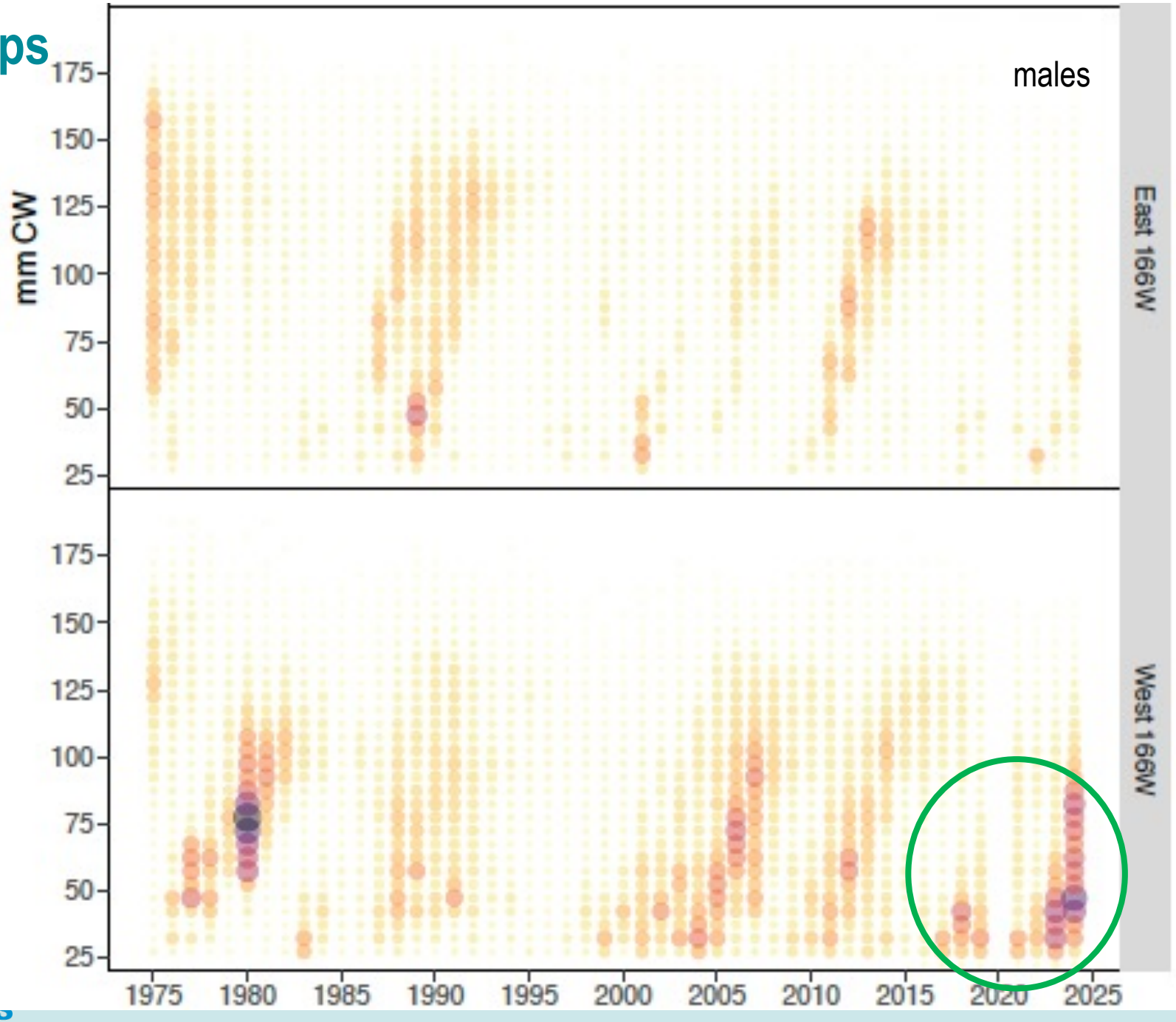
NMFS EBS Survey Data



Survey Data By Management Region



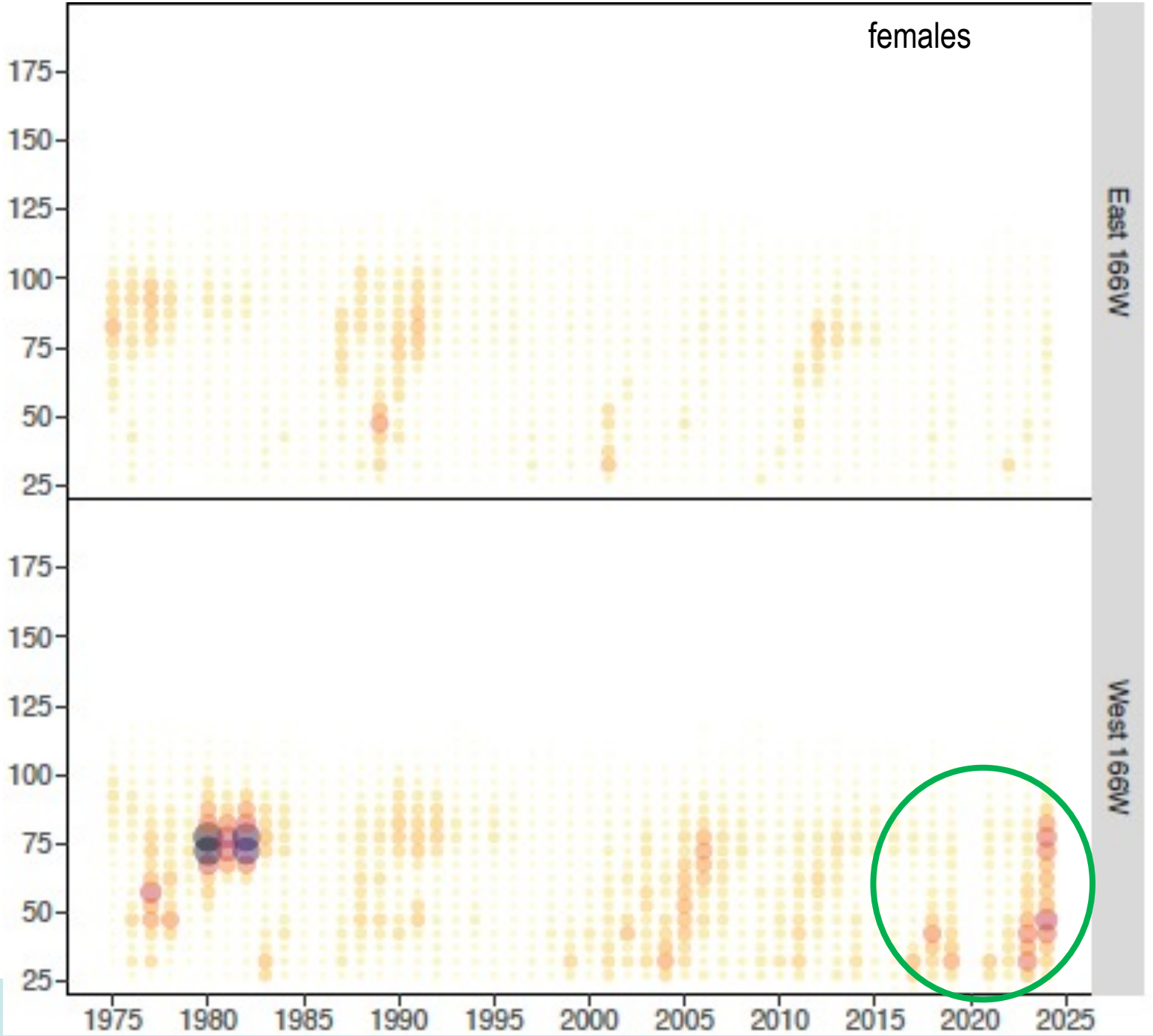
Survey Size Comps



East 166W

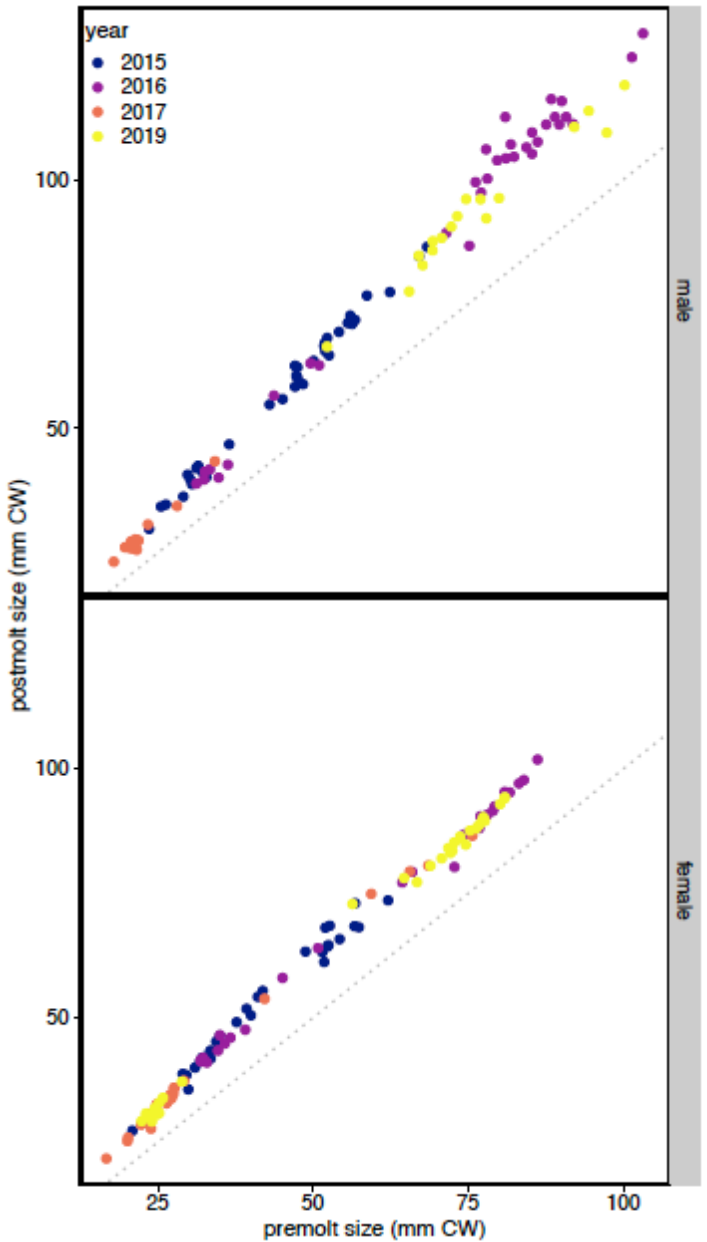
West 166W

Survey Size Comps

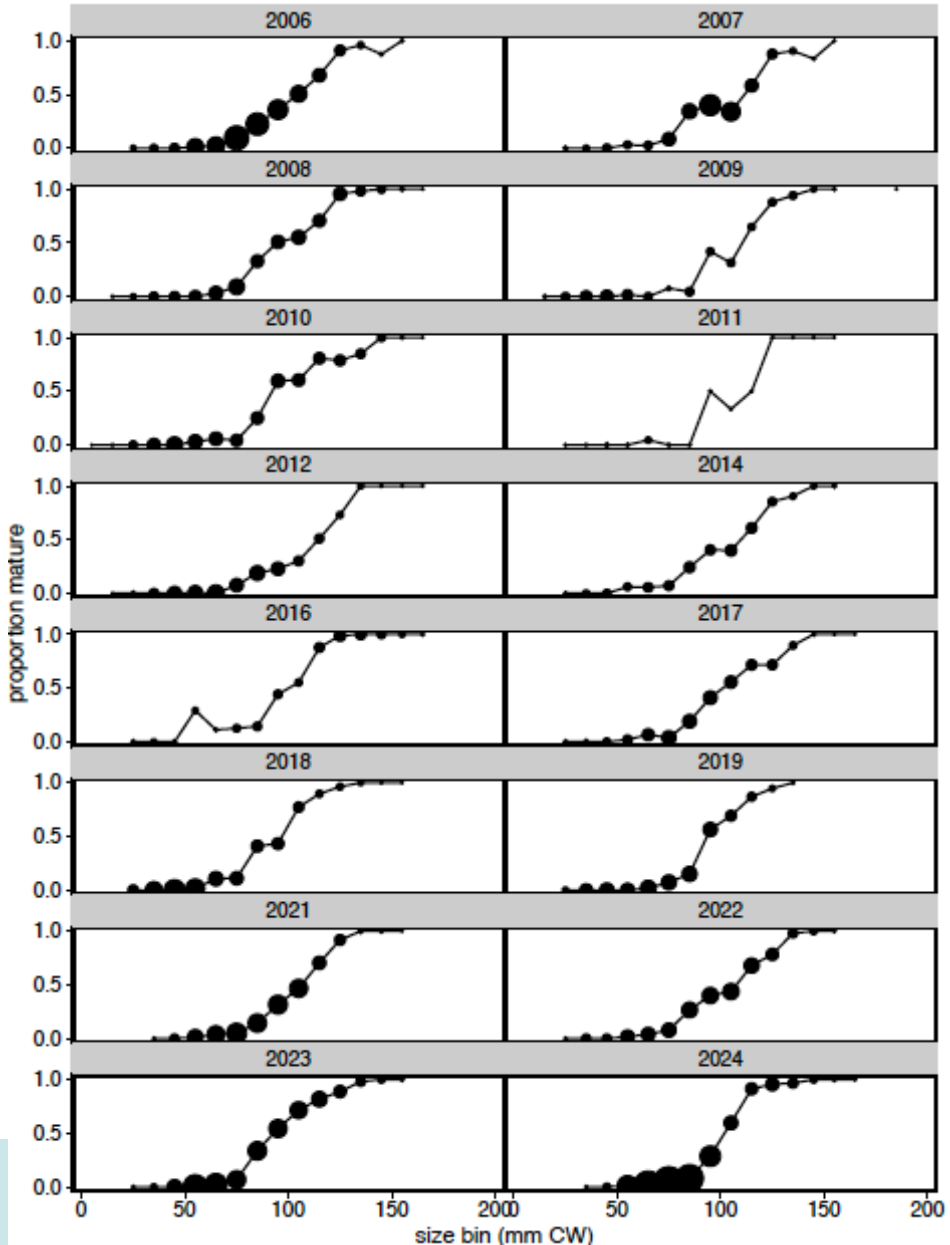


Other Data

growth

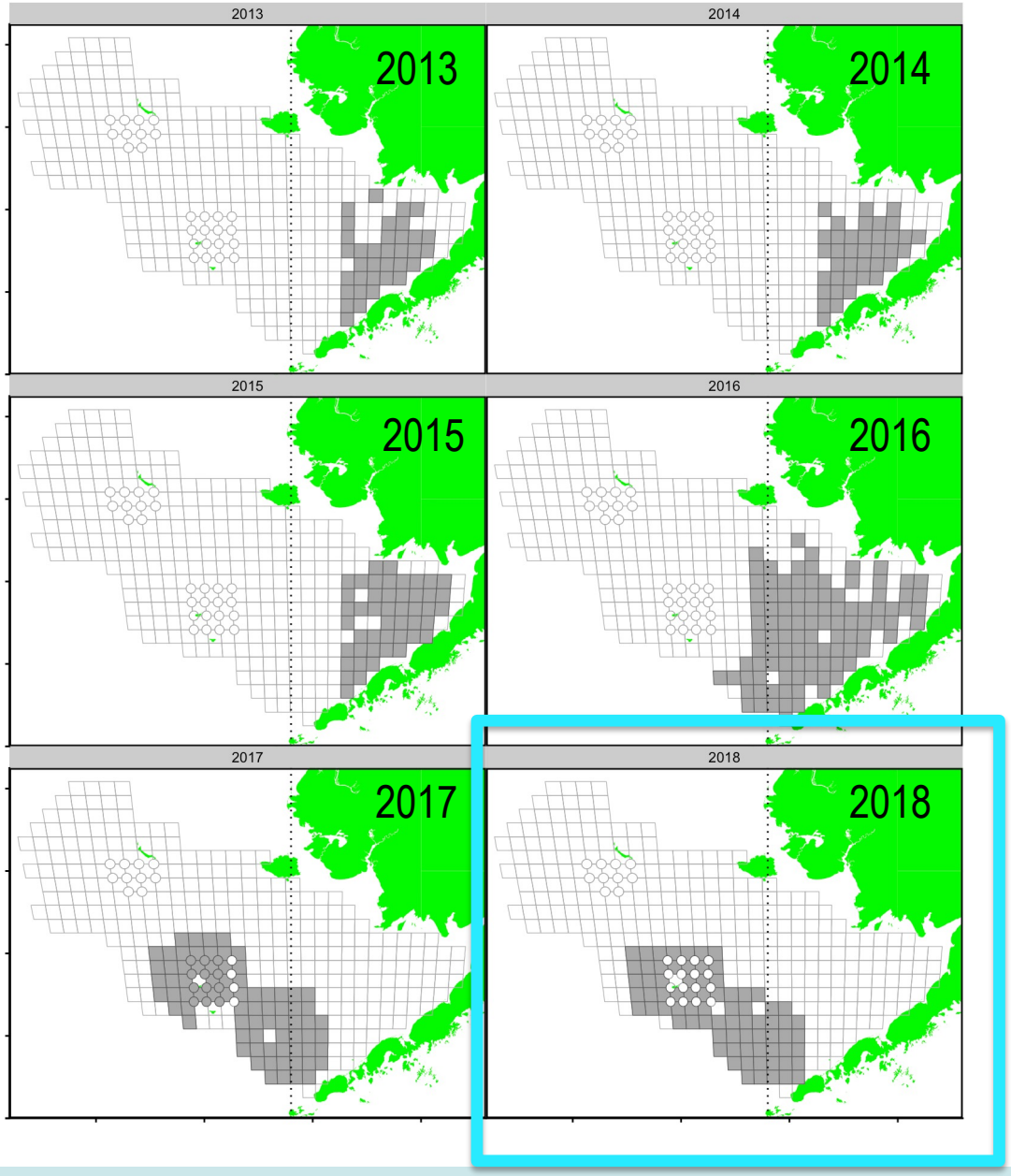


male maturity ogives



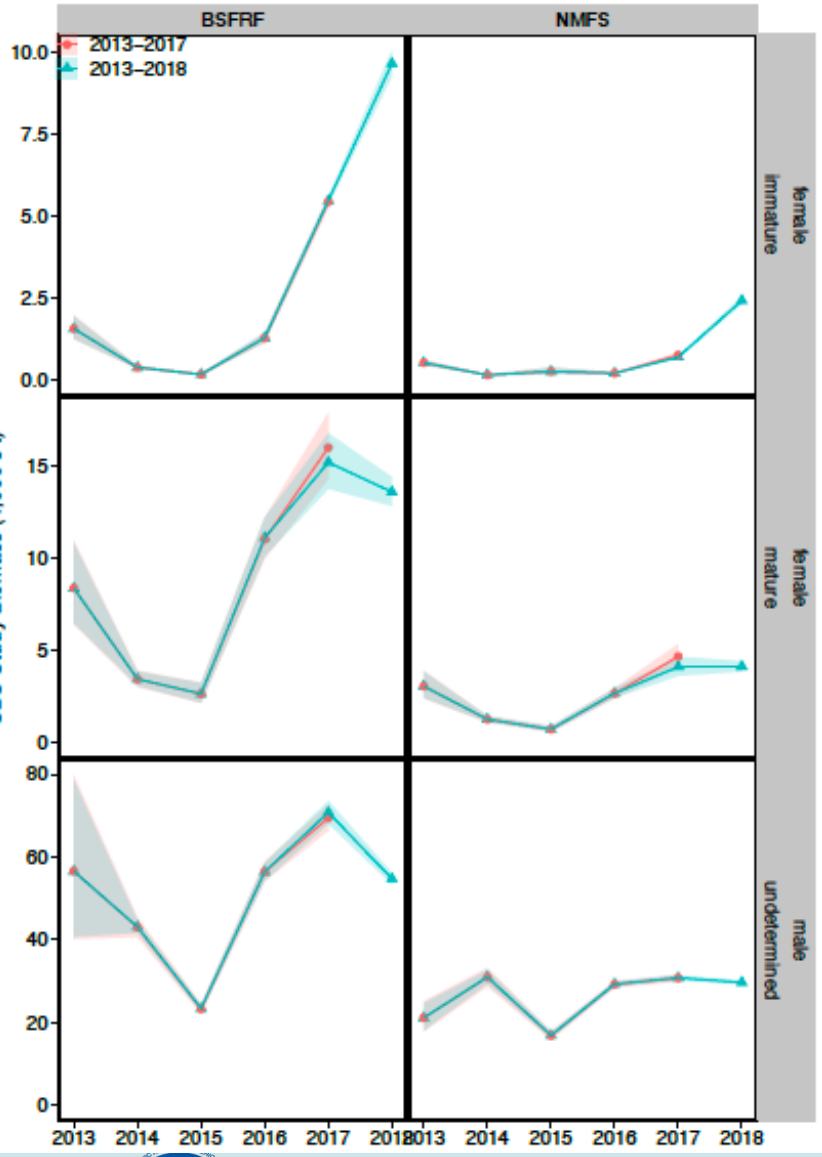
2013-2018 BSFRF SBS Data

- BSFRF-NMFS collaborative studies to estimate NMFS survey selectivity for BBRKC, Tanner crab
- BSFRF nephrops gear assumed to catch all crab in area swept; allows estimates of
  - *absolute* NMFS haul-level selectivity
- Scale up to NMFS survey-level selectivity by
  - estimating year-specific ***availability***
- **NEW for 2024:**
  - 2018 biomass indices and size comps added
  - 2013-2017 dataset slightly revised
  - smooth curves for ***availability*** re-evaluated

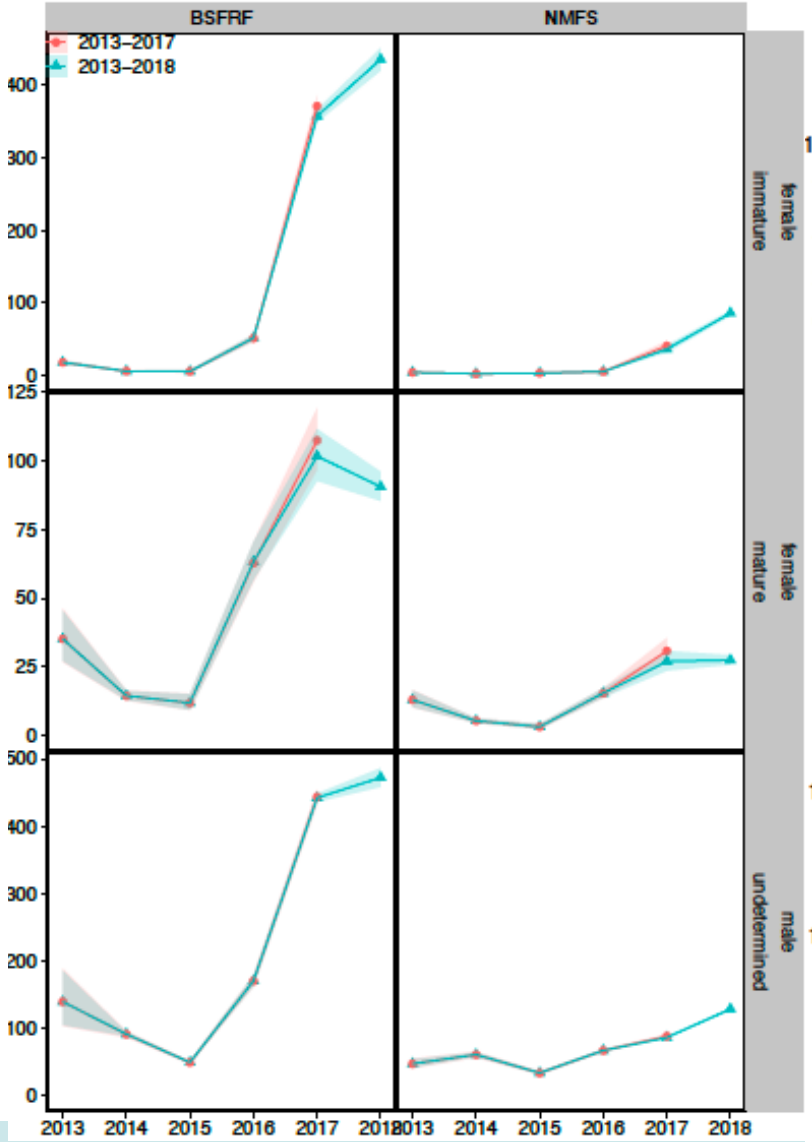


BSFRF data

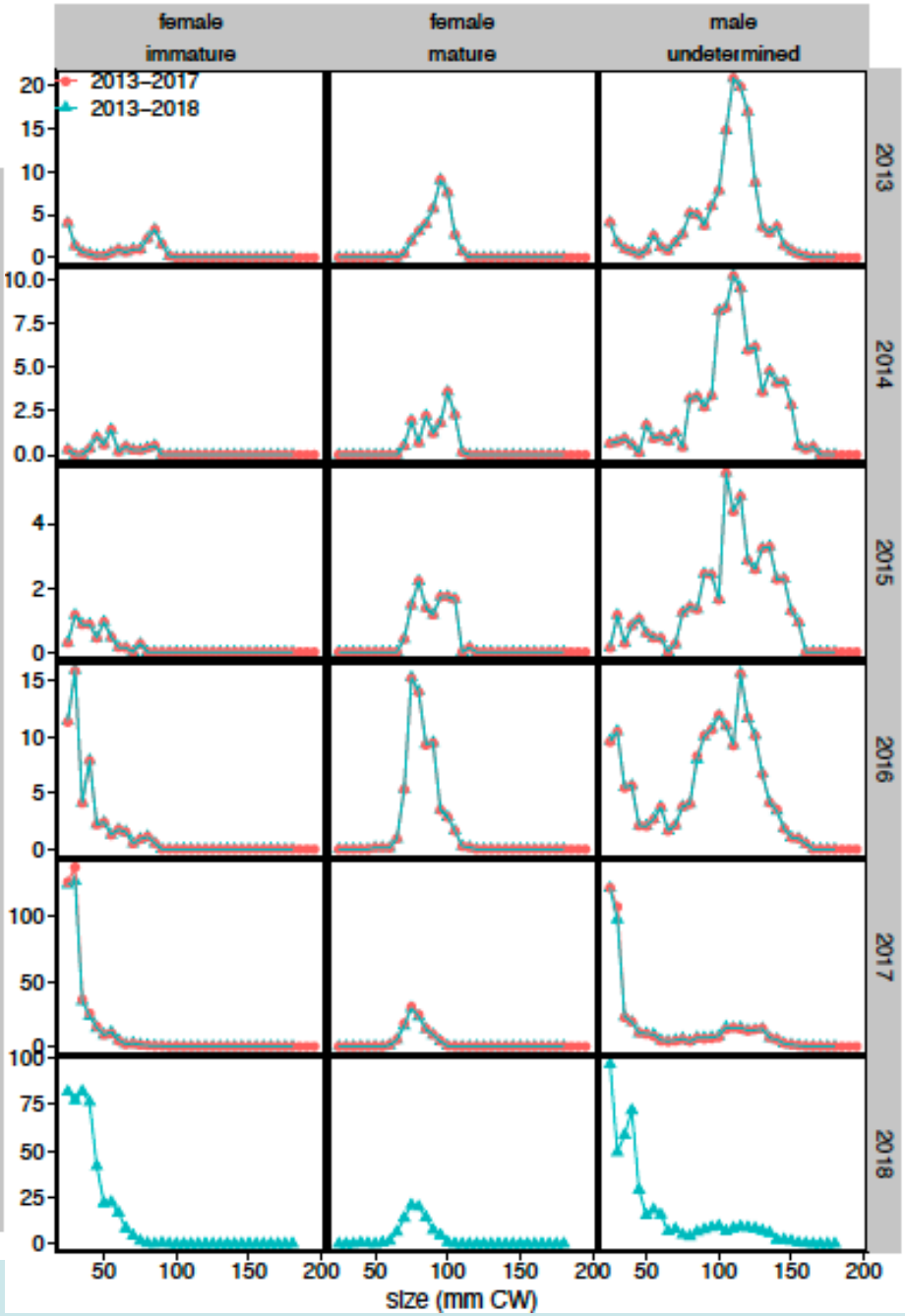
biomass



abundance



size comps



Empirical Availability: Males

$$A_x(z) = \frac{N_x^a(z)}{N_x^t(z)}$$

2013-2017

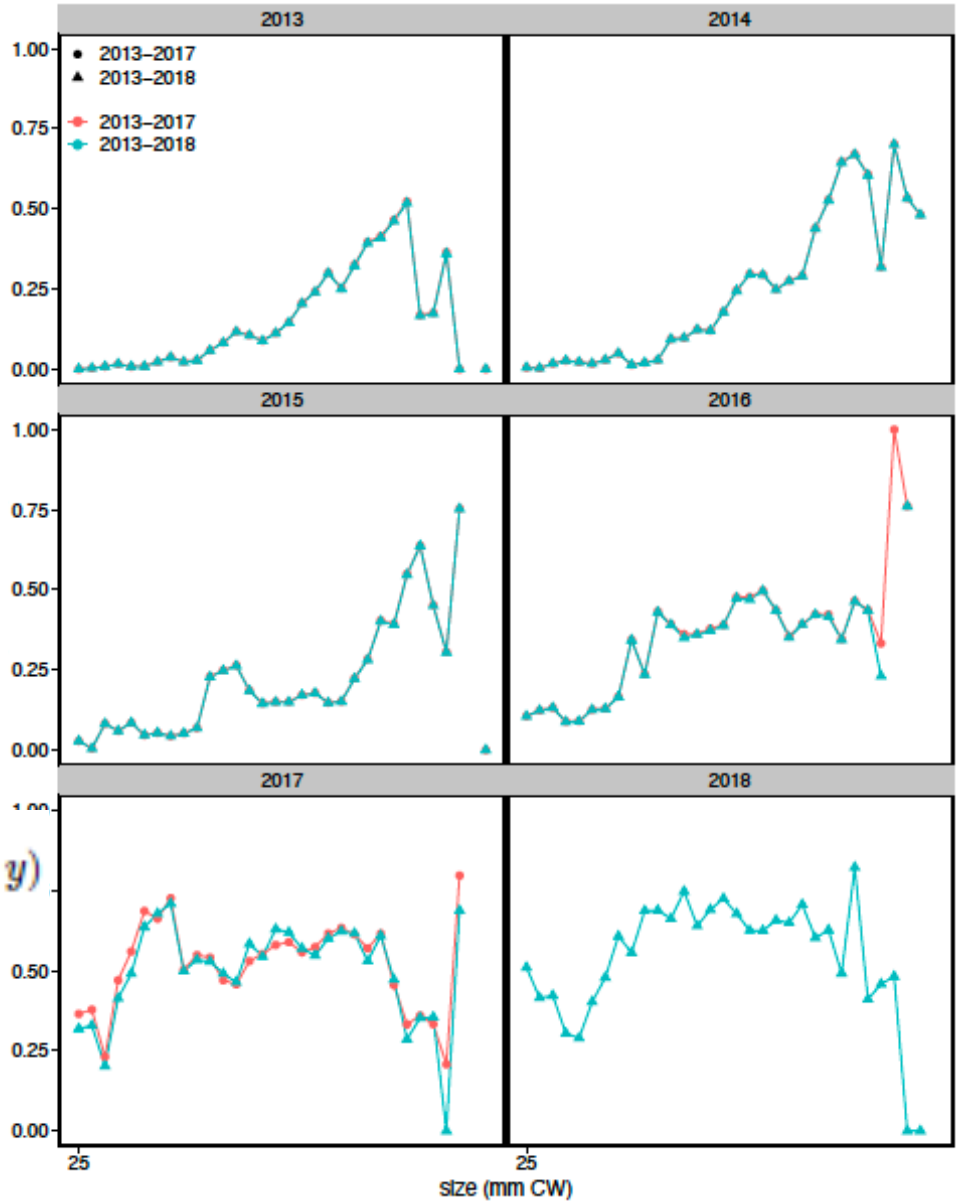
$$log(A_{y,z}) = s(z, by = y)$$

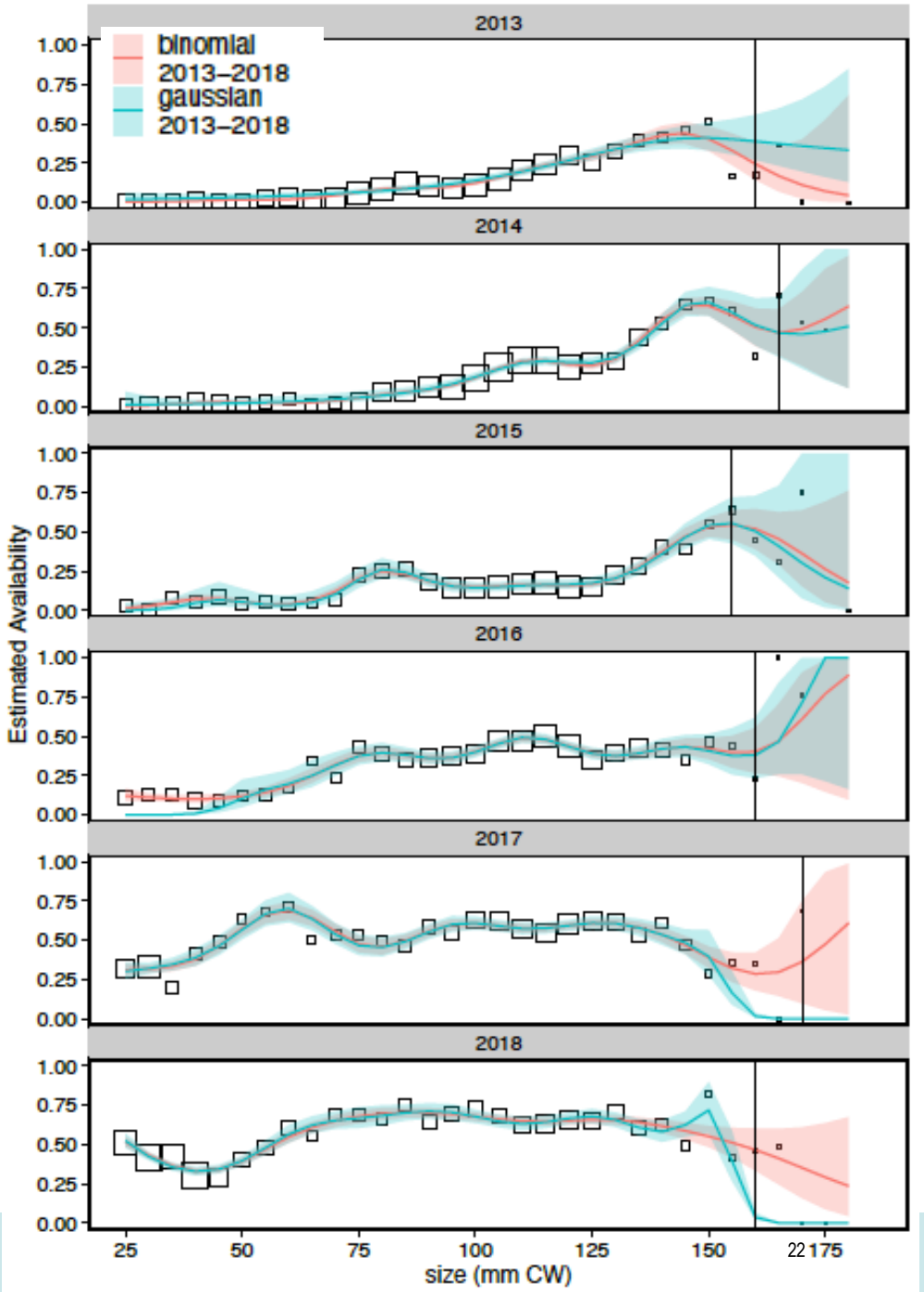
- unweighted

2013-2018

$$\frac{log(A_{y,z})}{log(1 - A_{y,z})} = c_y + s(z, by = y)$$

- weighted by number of crab





(note color switch between figures)

Empirical Availability: Females

$$A_x(z) = \frac{N_x^a(z)}{N_x^t(z)}$$

2013-2017

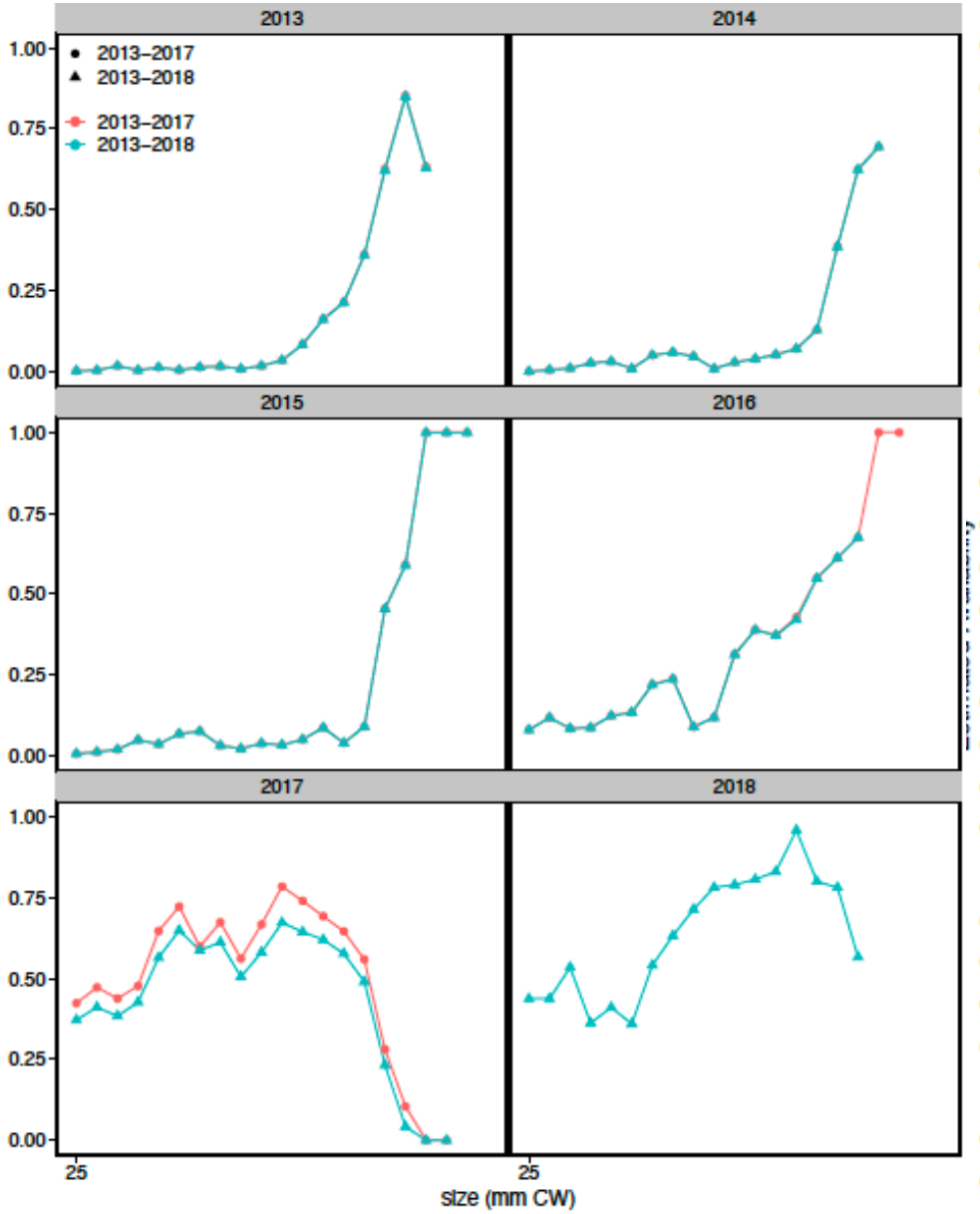
$$log(A_{y,z}) = s(z, by = y)$$

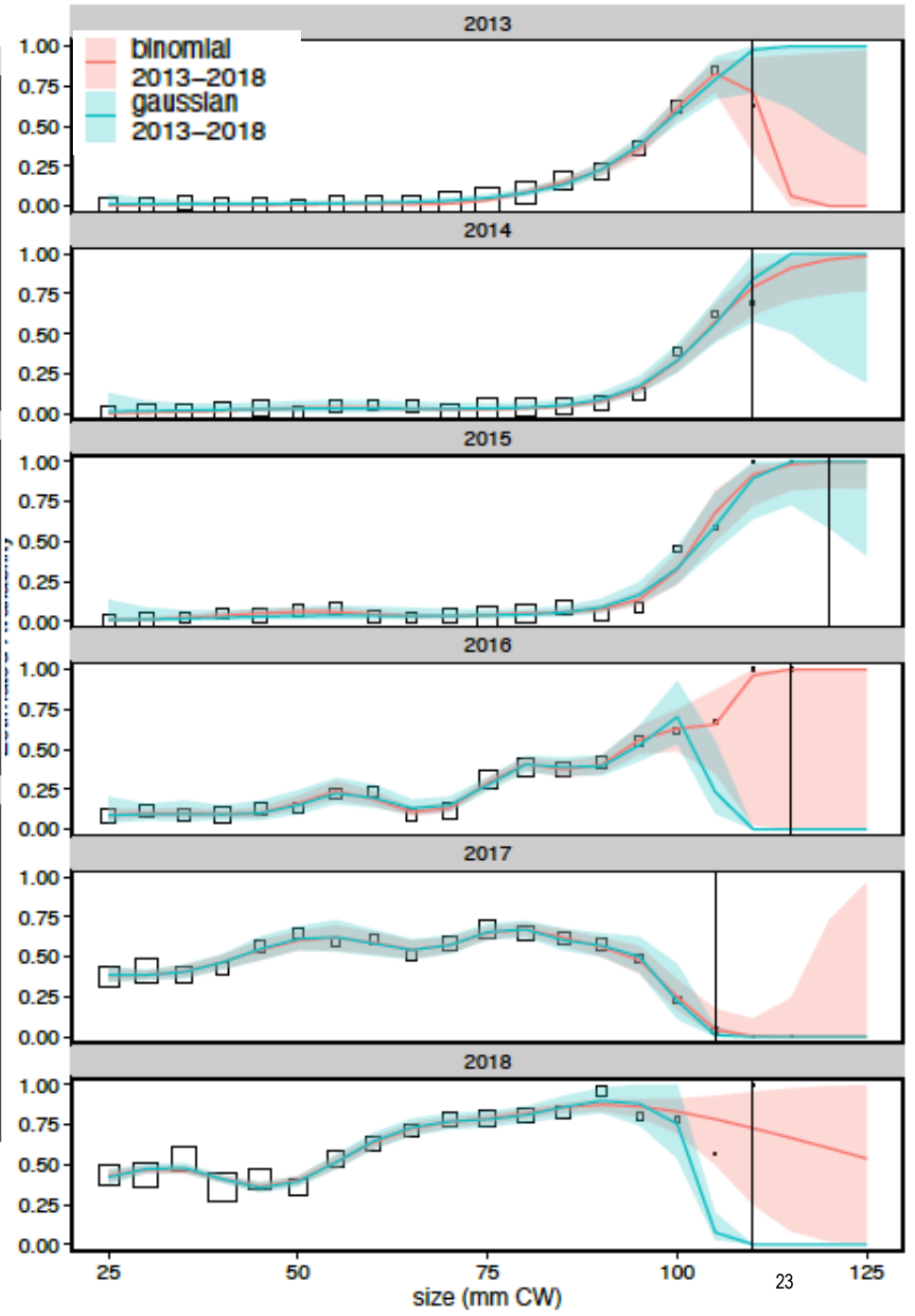
- unweighted

2013-2018

$$\frac{log(A_{y,z})}{log(1 - A_{y,z})} = c_y + s(z, by = y)$$

- weighted by number of crab





(note color switch between figures)

Bridging Analysis 1

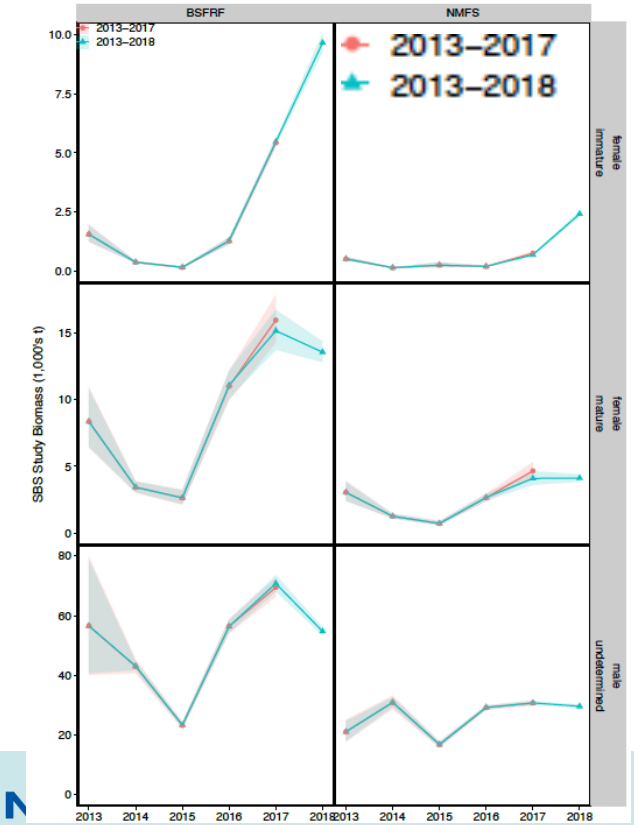
Revised BSFRF SBS data 2013-2017

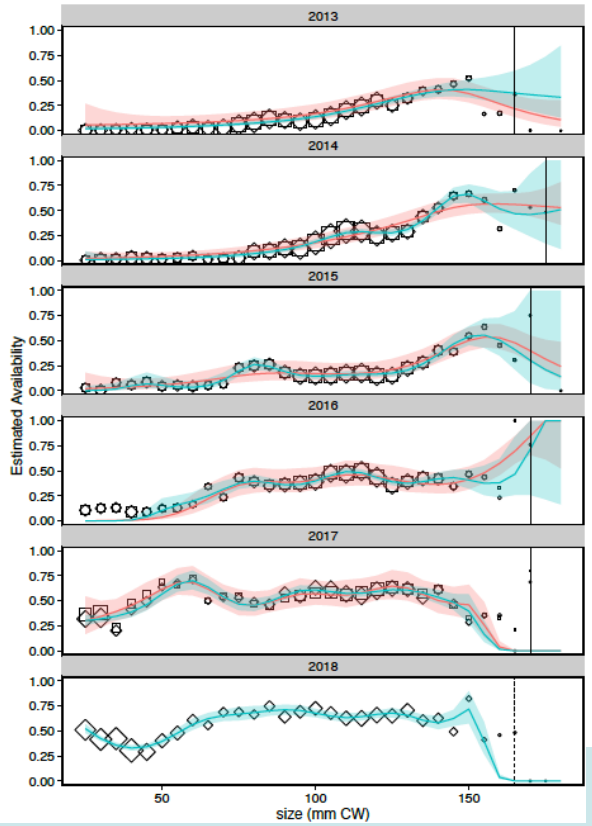
Added 2018 BSFRF SBS data; 2018 Emp. Avail.

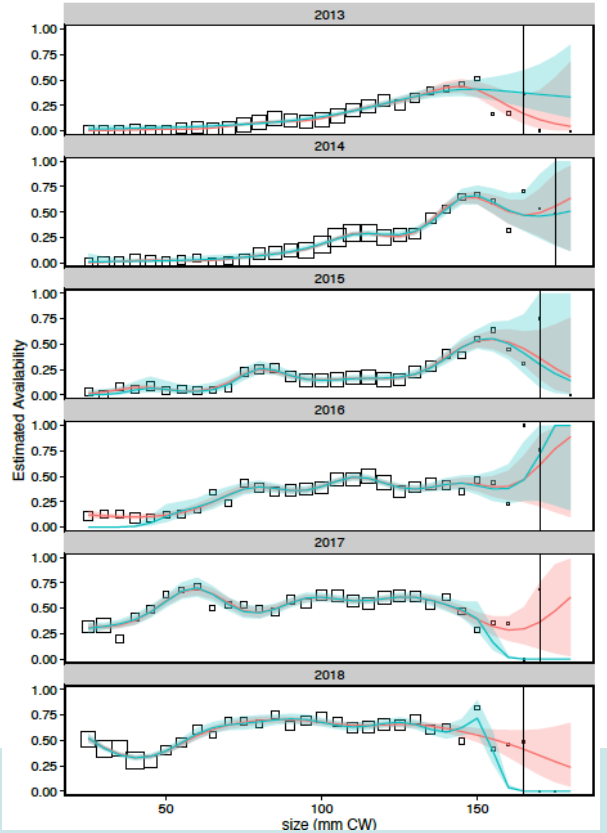
Updated 2013-2017 Emp. Avail. Curves for revised data

Revised 2013-2018 Emp. Avail. Curves w/ new model

22.03b → 22.03b 1 → 22.03b 2 → 22.03b 3 → 22.03d

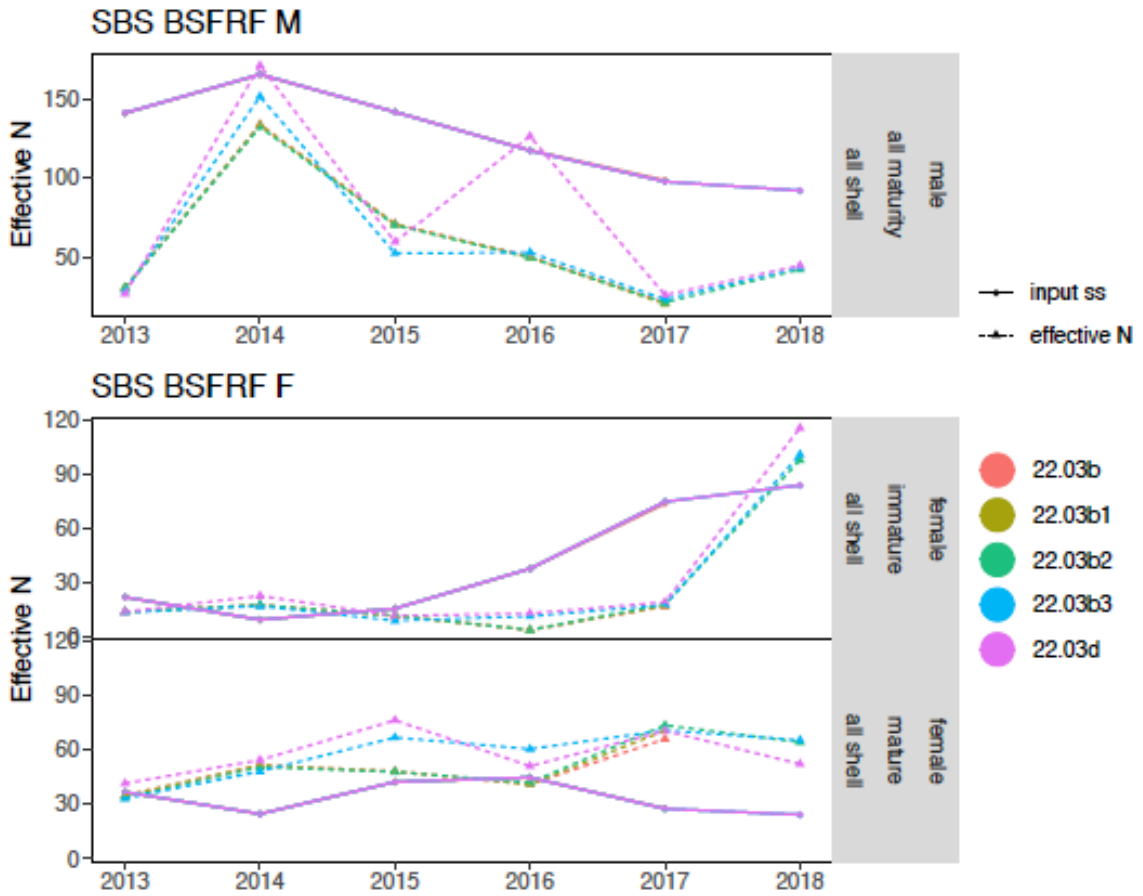


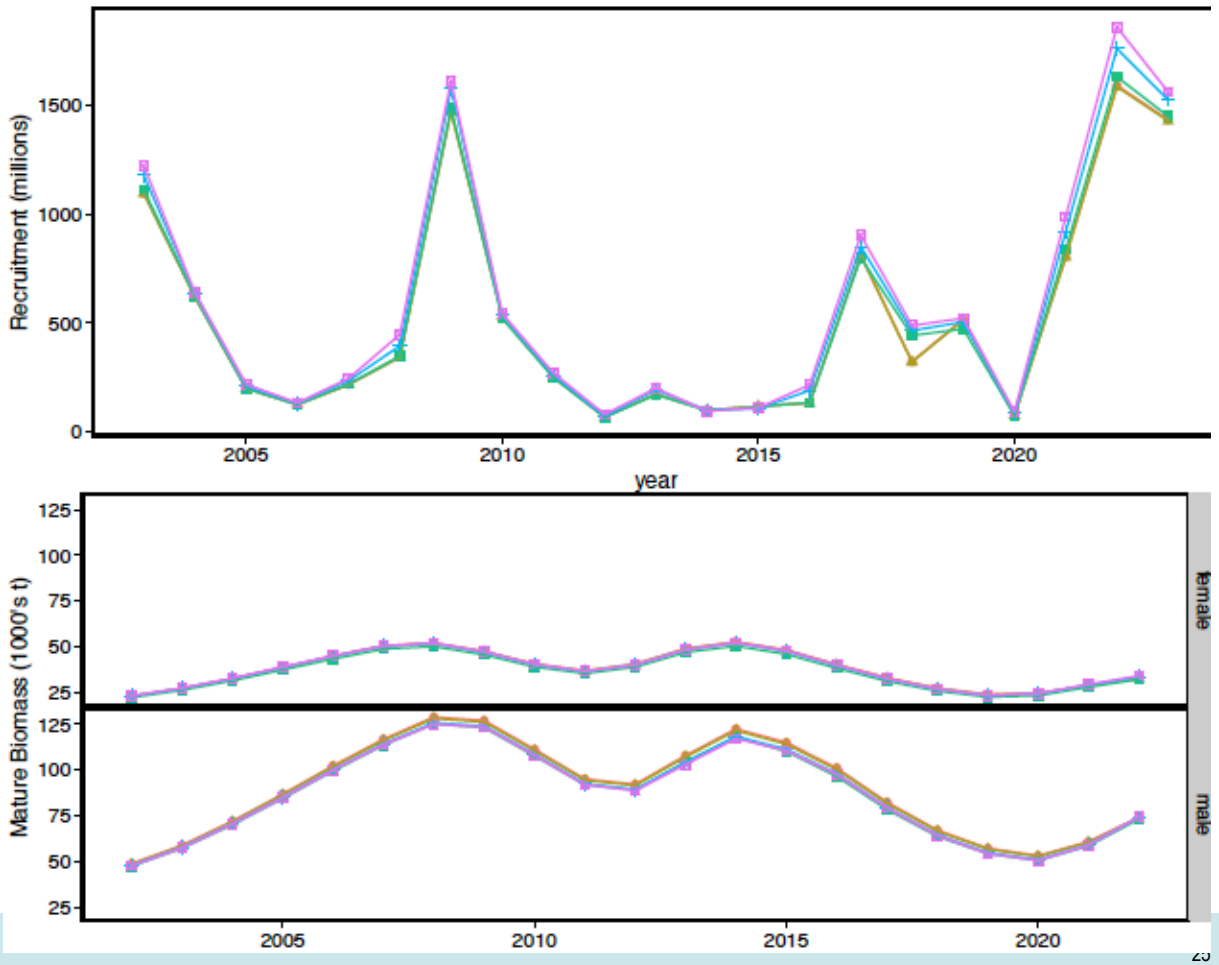




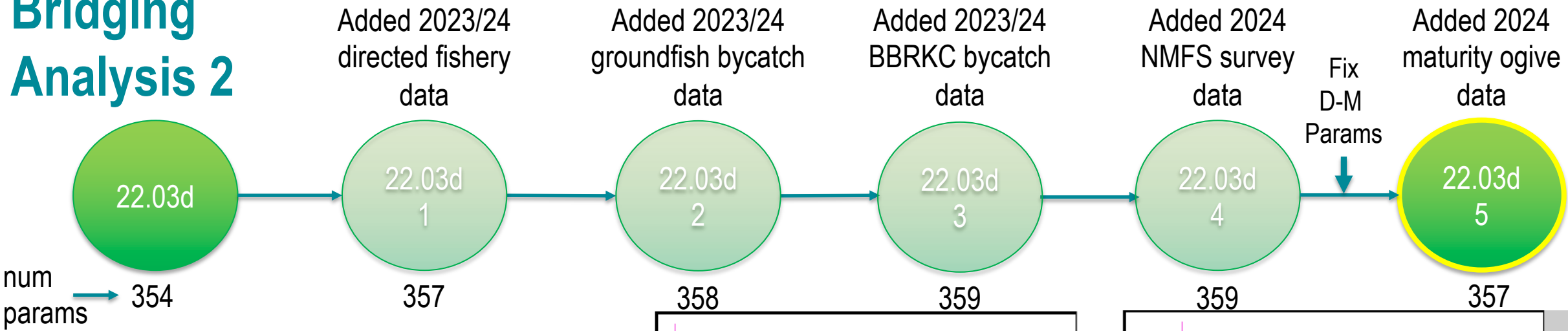
Bridging Analysis 1

case	avg recruitment	B_{100}	B_{MSY}	F_{MSY}	MSY	B
22.03b	429.5742	103.9696	36.38937	1.163916	17.25974	101.1324
22.03b1	428.1823	103.3786	36.18249	1.163943	17.18150	100.5539
22.03b2	436.4138	101.5339	35.53685	1.173097	16.95602	101.2348
22.03b3	465.1854	102.4675	35.86364	1.210361	17.26305	103.1668
22.03d	486.0105	102.3224	35.81285	1.239754	17.37937	104.1558



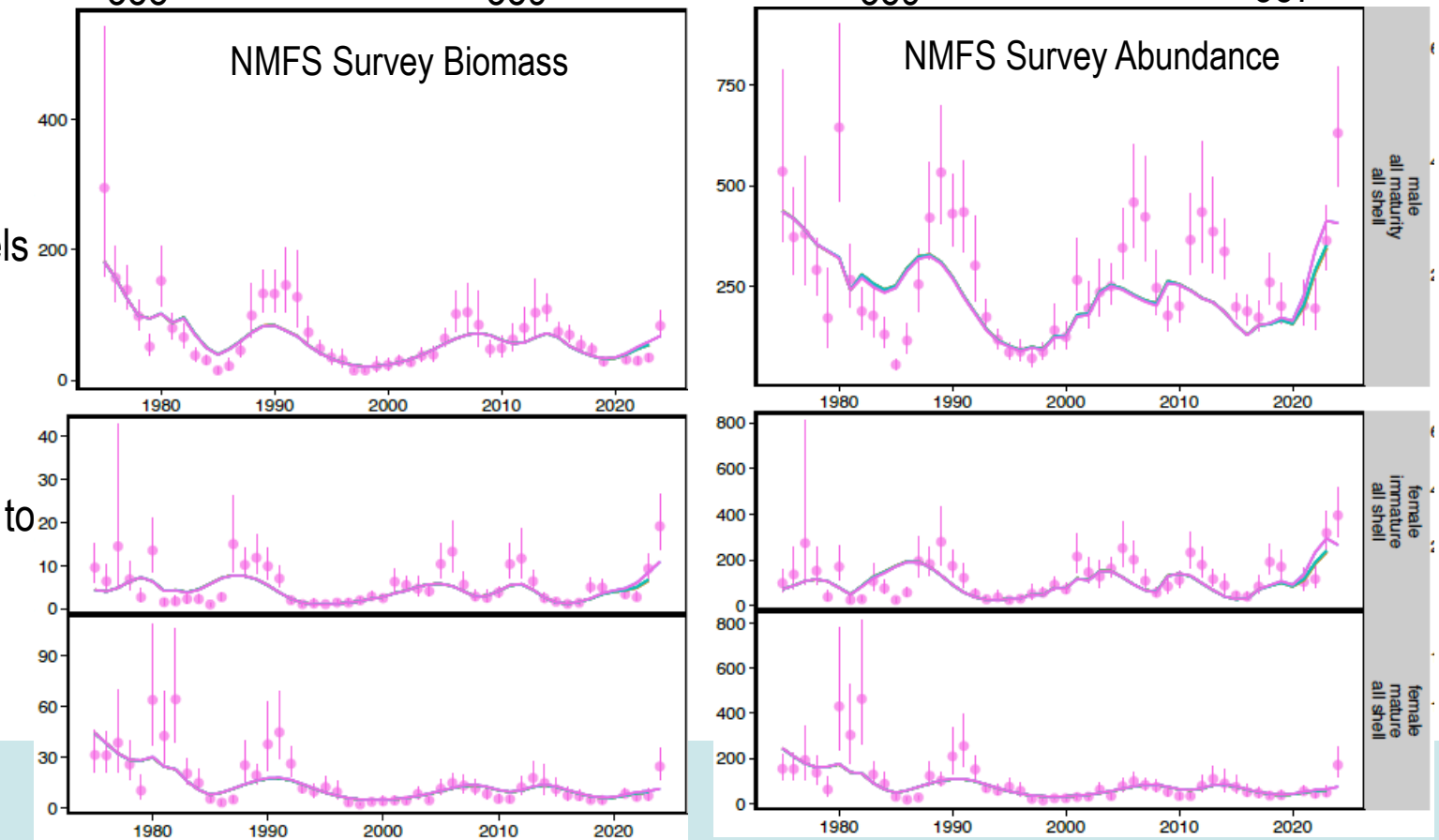


Bridging Analysis 2

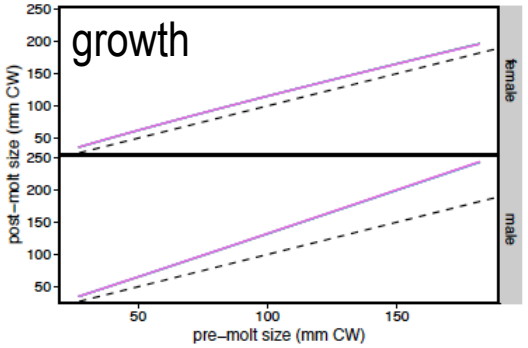


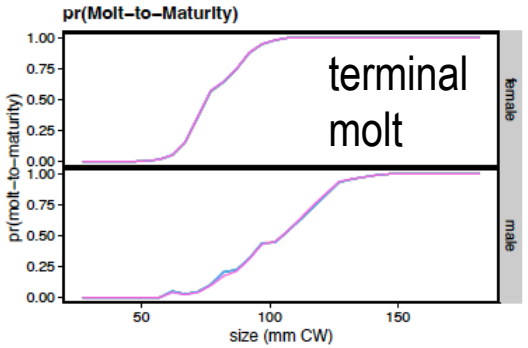
Results

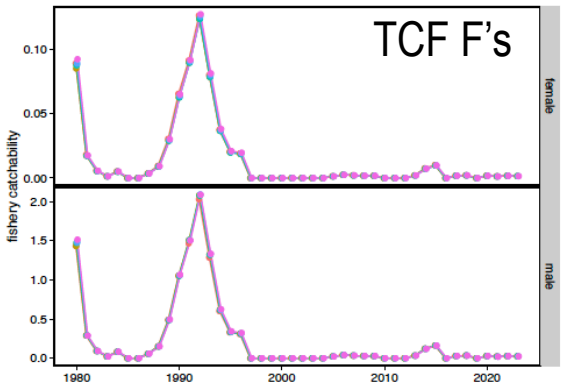
- all converged with small maximum gradients
- uncertainty estimates were obtained for all models
- D-M effective sample sizes hit upper bounds for
  - 22.03d2: female BSFRF size comps
  - 22.03d3: BSFRF size comps – both sexes
  - 22.03d4: BSFRF size comps – both sexes
- 22.03d5: fixed D-M effective sample parameters to obtain model with no parameters estimated at a bound
  - essentially multinomial likelihoods



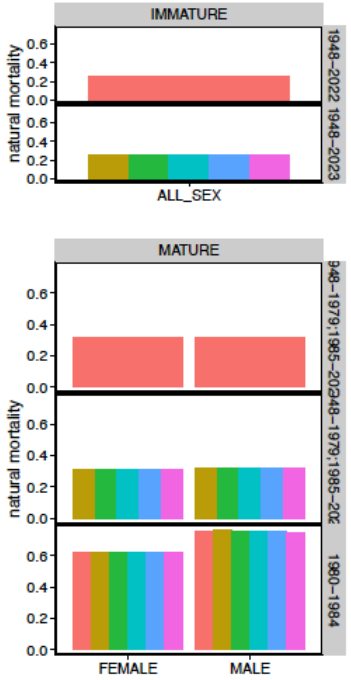
Bridging Analysis 2



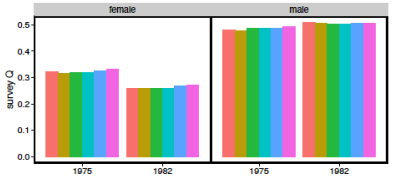




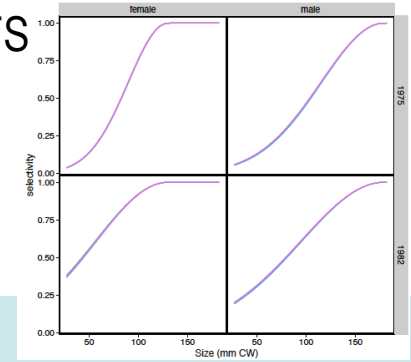
M's



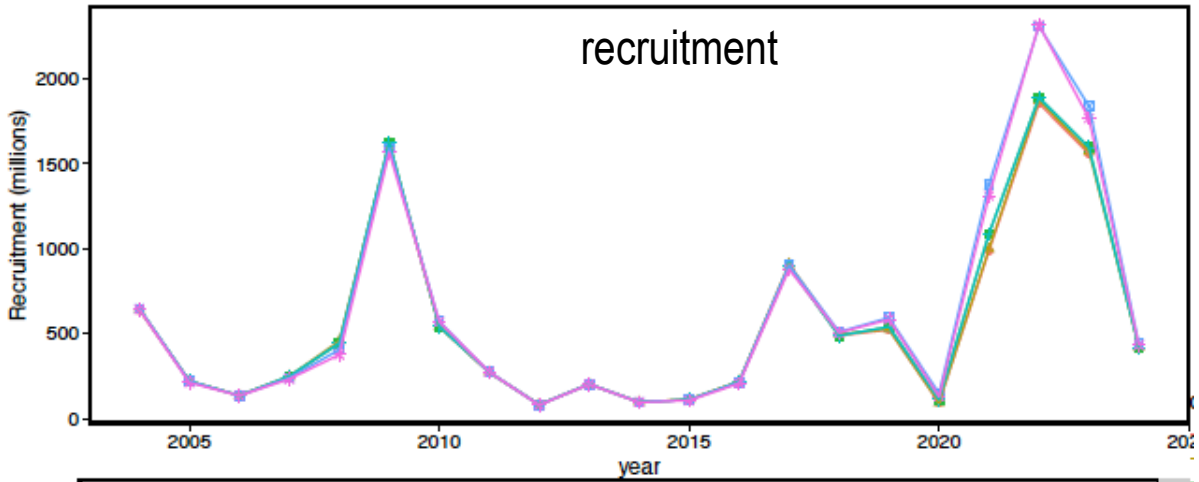
Q's

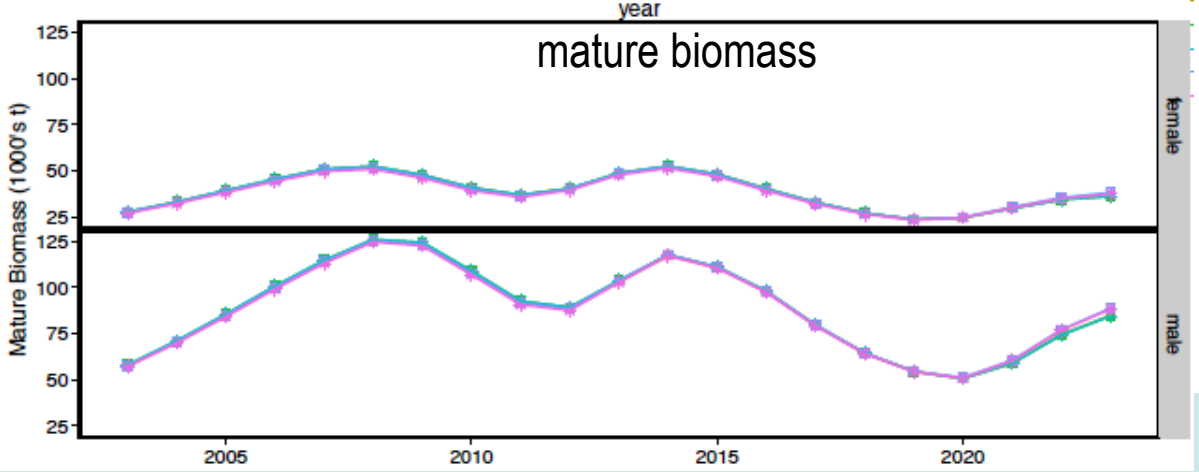


NMFS sel. fcns



case	avg recruitment	B_{100}	B_{MSY}	F_{MSY}	MSY	B
22.03d	486.0105	102.3224	35.81285	1.239754	17.37937	104.1558
22.03d1	524.0217	109.9975	38.49912	1.284085	18.70280	108.2475
22.03d2	525.9317	110.7095	38.74833	1.278229	18.81169	108.9733
22.03d3	525.9982	110.7198	38.75194	1.278426	18.81349	108.9885
22.03d4	537.4908	115.0196	40.25685	1.274491	19.57682	118.0031
22.03d5	526.0374	114.3069	40.00740	1.224960	19.52557	116.7005

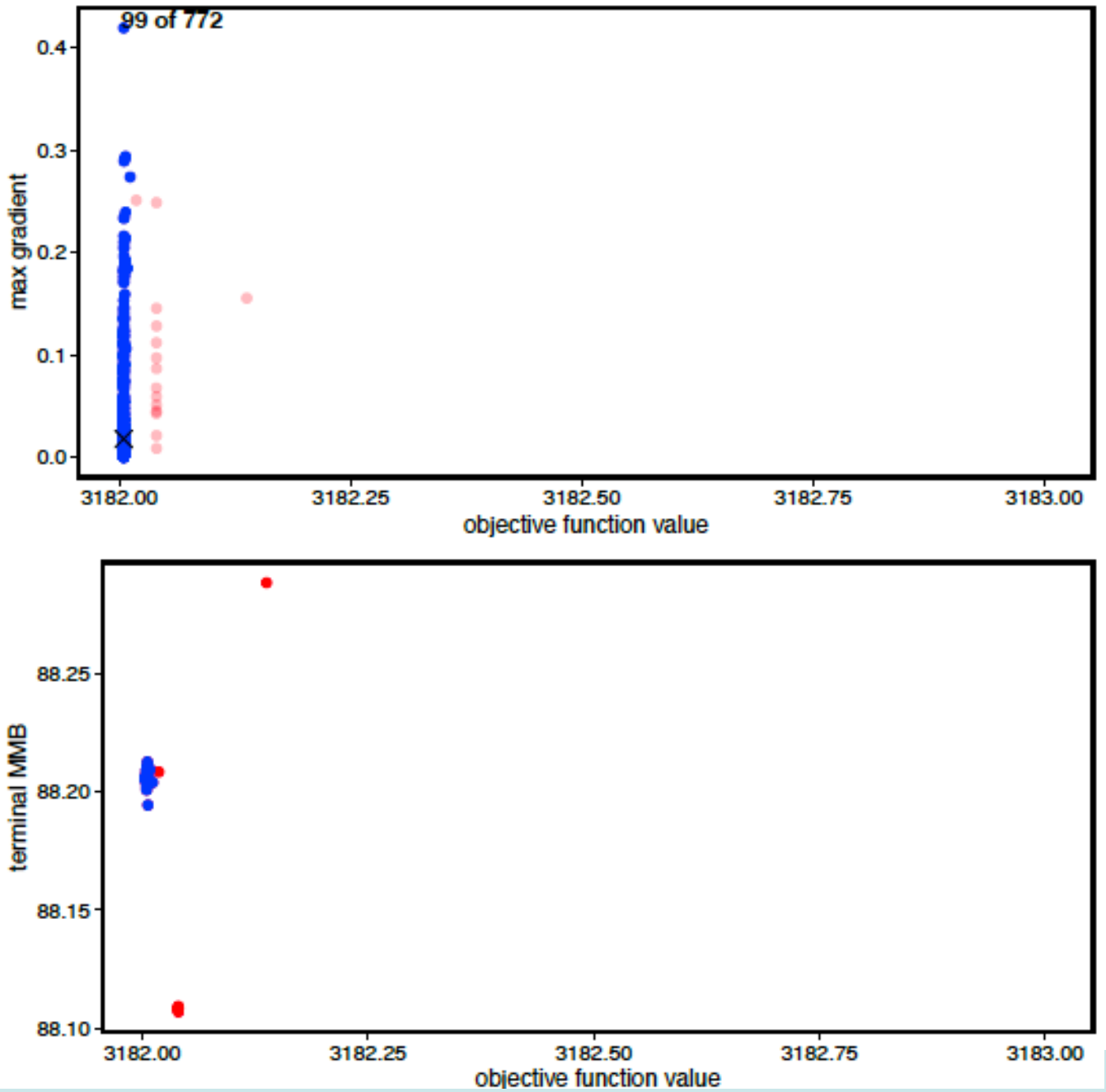




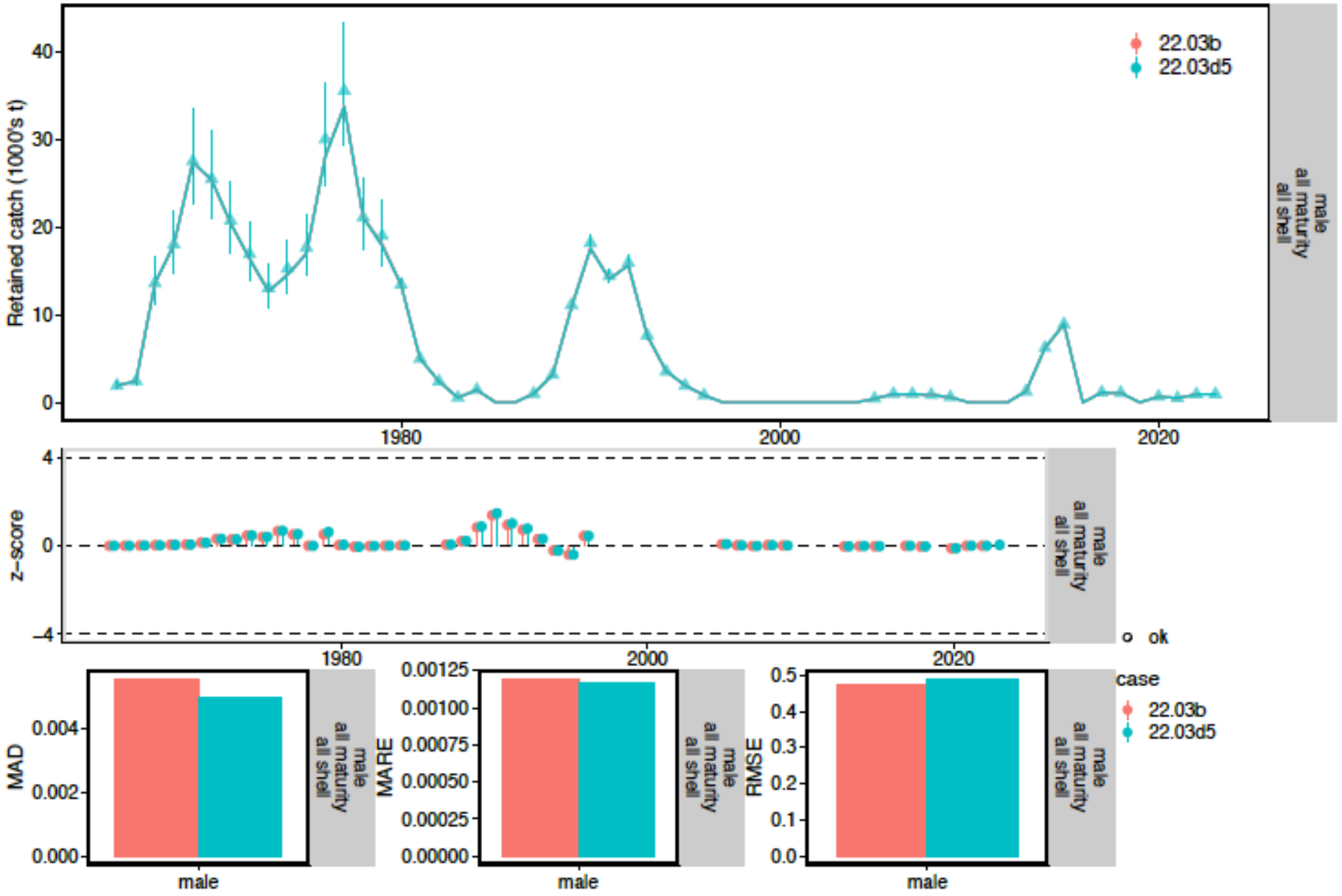
NOAA FISHERIES

Model Convergence: 22.03d5

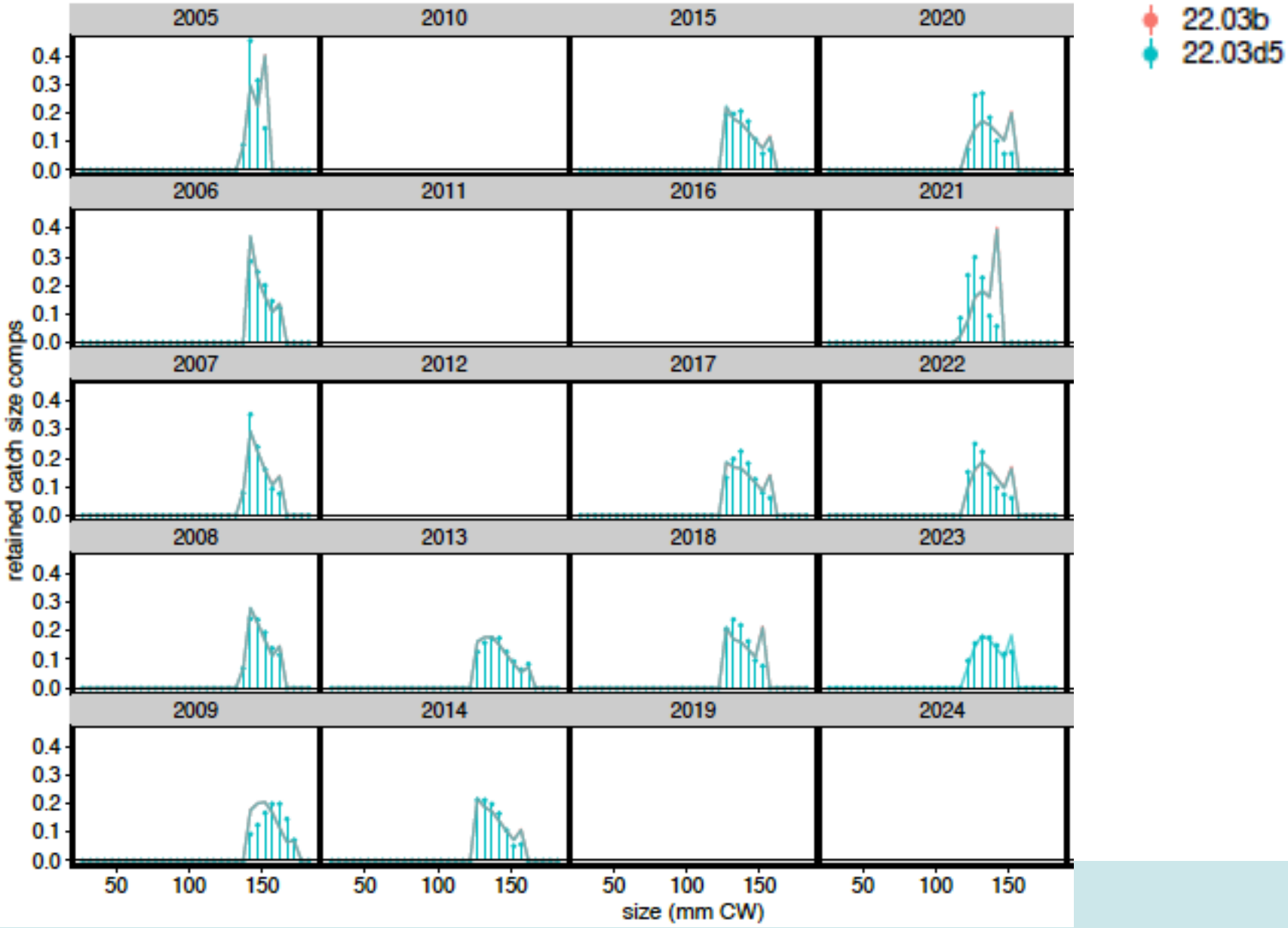
- 99 out of 800 jitter runs converged to MLE
- max. gradient at MLE: 0.0178
- no parameters at bounds



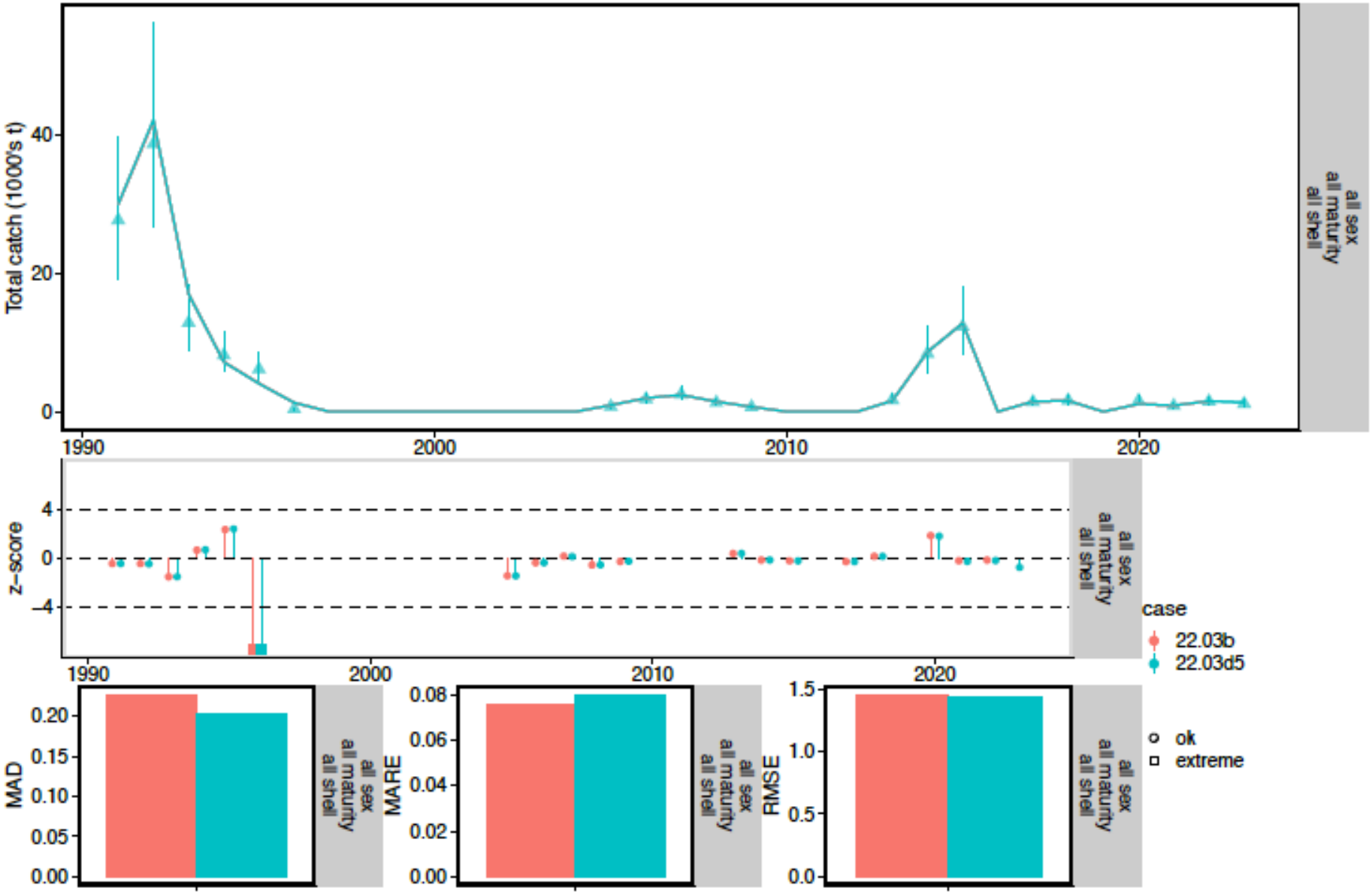
Fits to Retained Catch in Directed Fishery



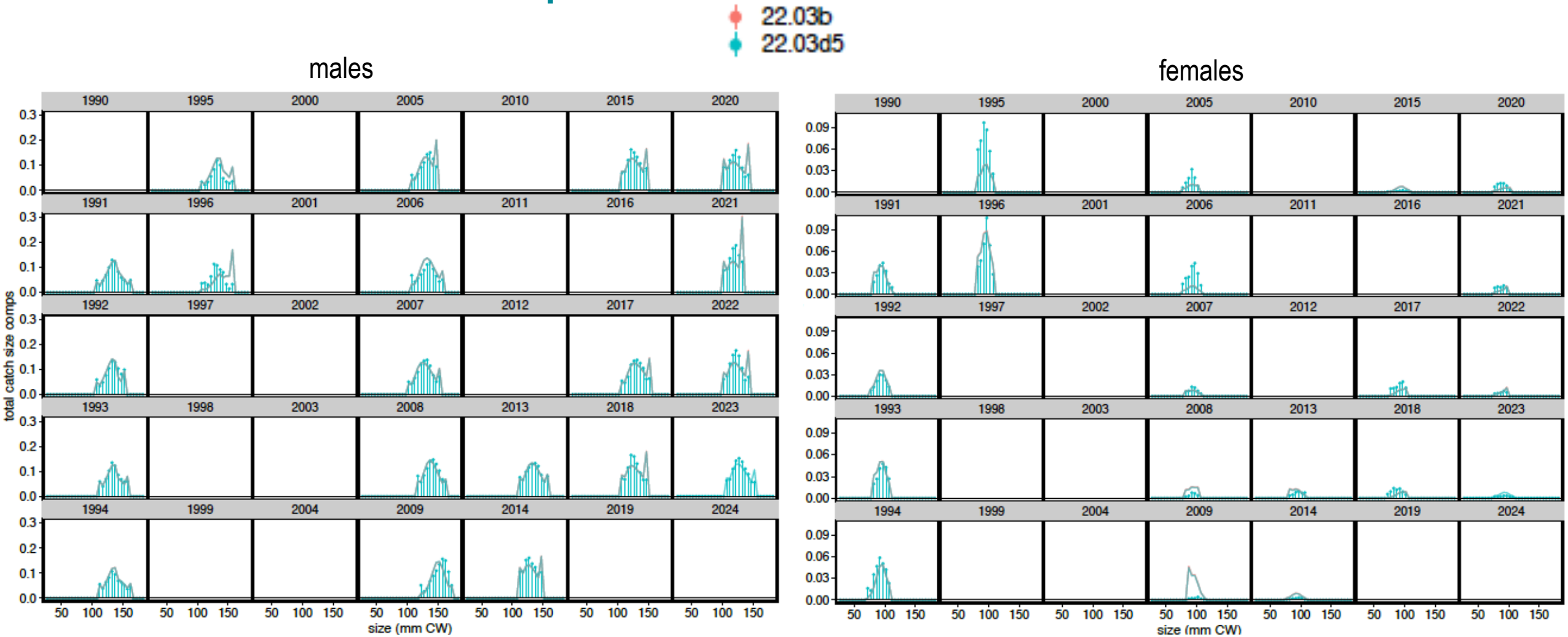
Fits to Retained Catch Size Comps



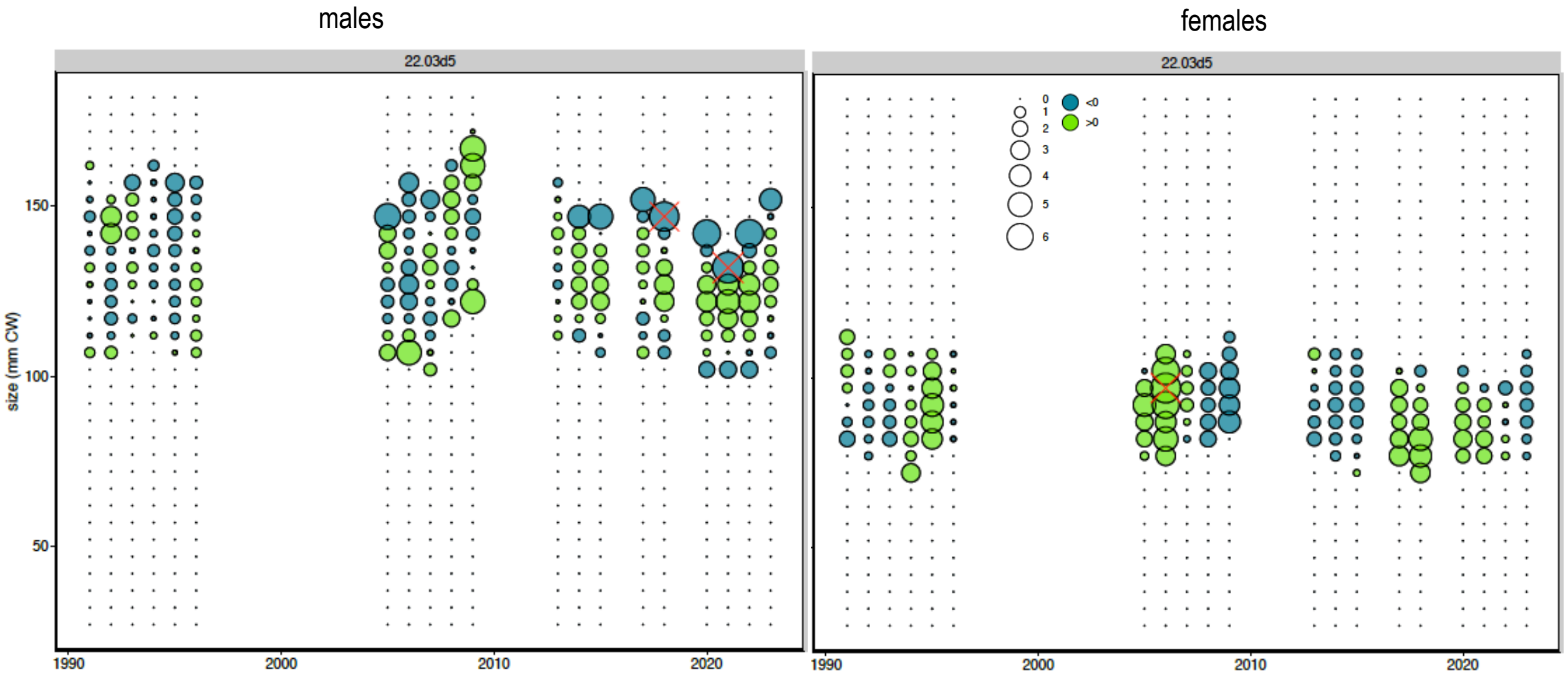
Fits to Total Catch in Directed Fishery



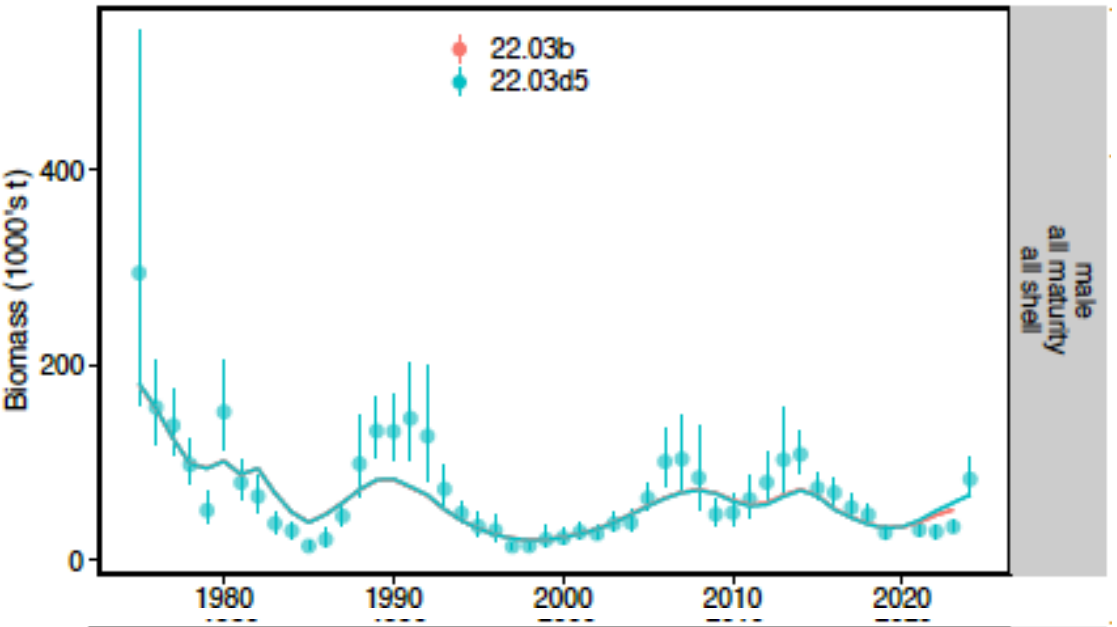
Fits to Total Catch Size Comps

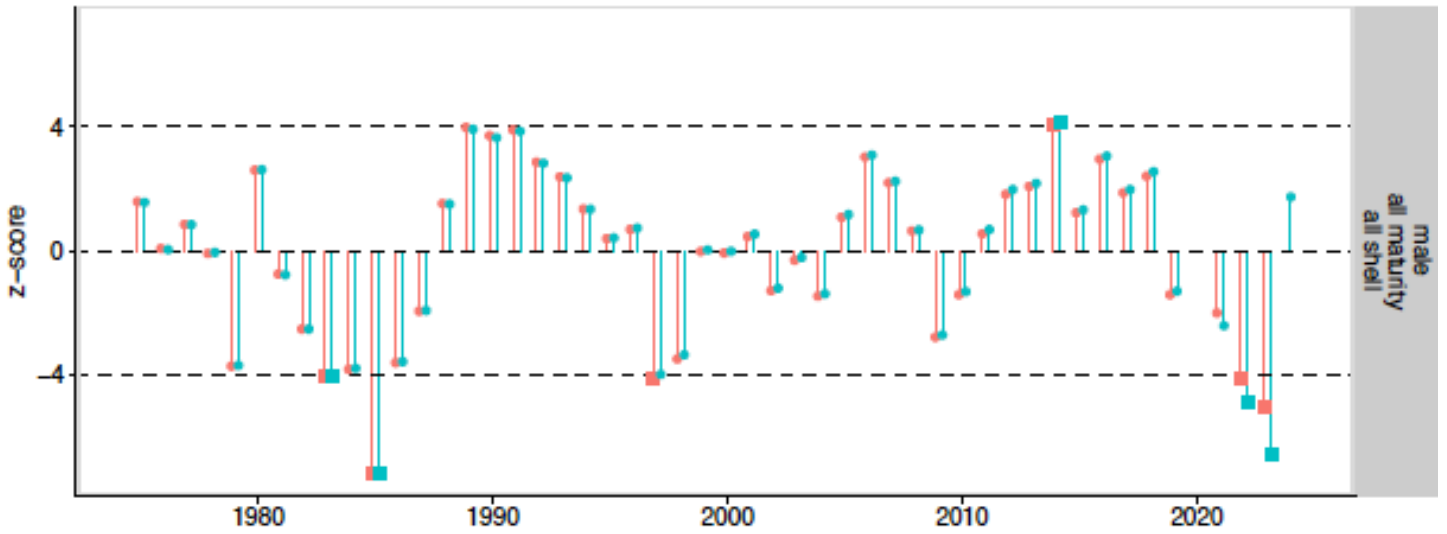


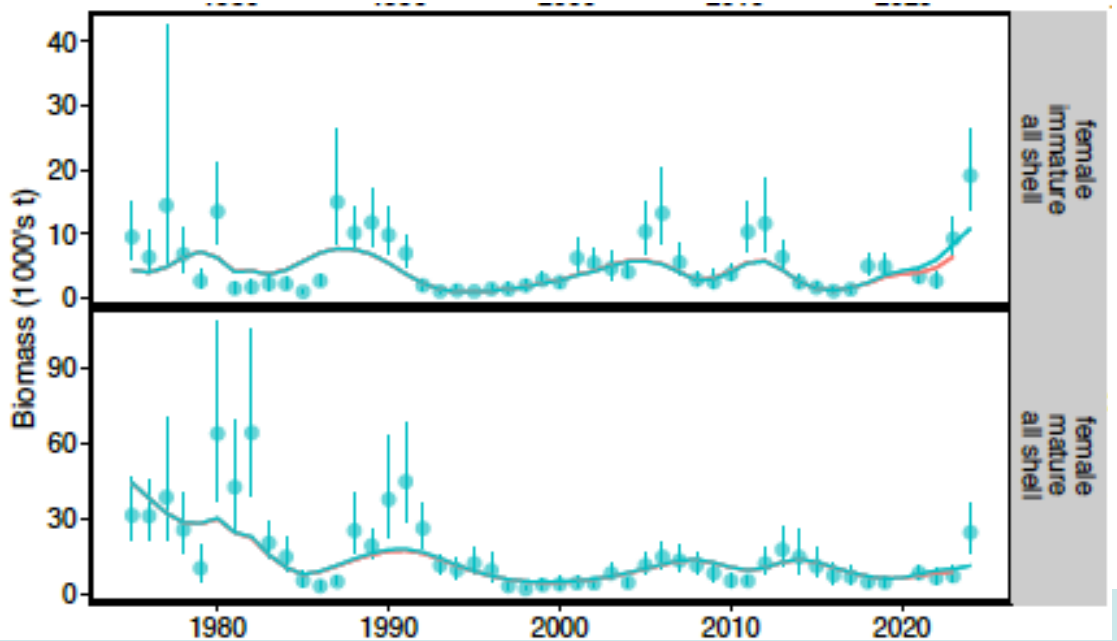
Residuals to Total Catch Size Comps

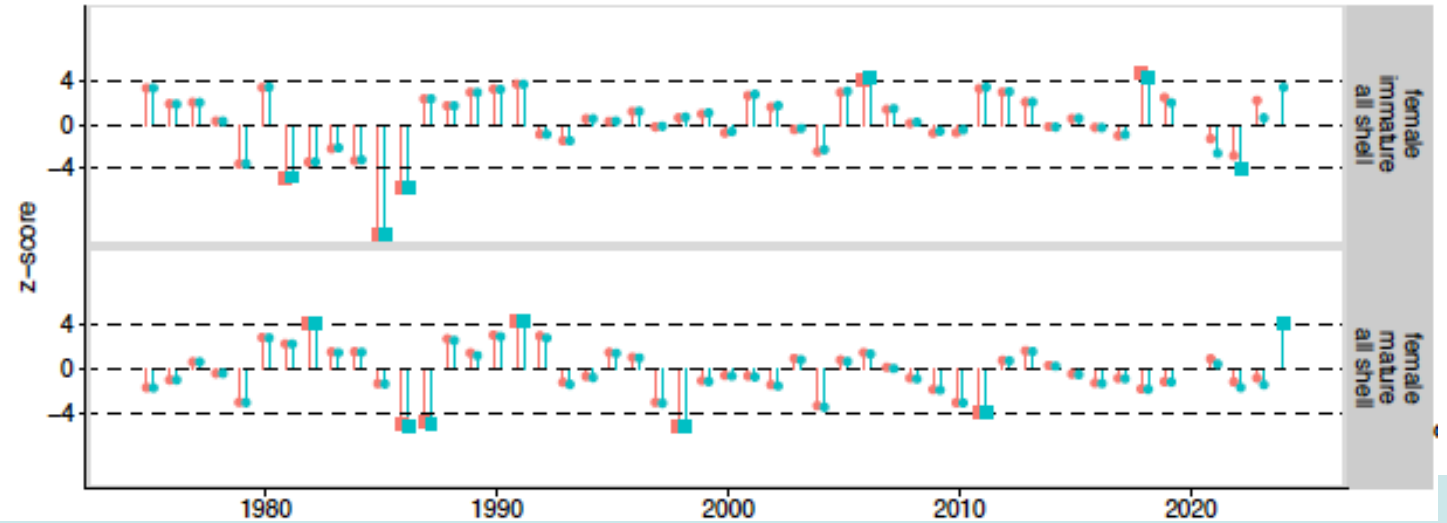


Fits to NMFS Survey Biomass

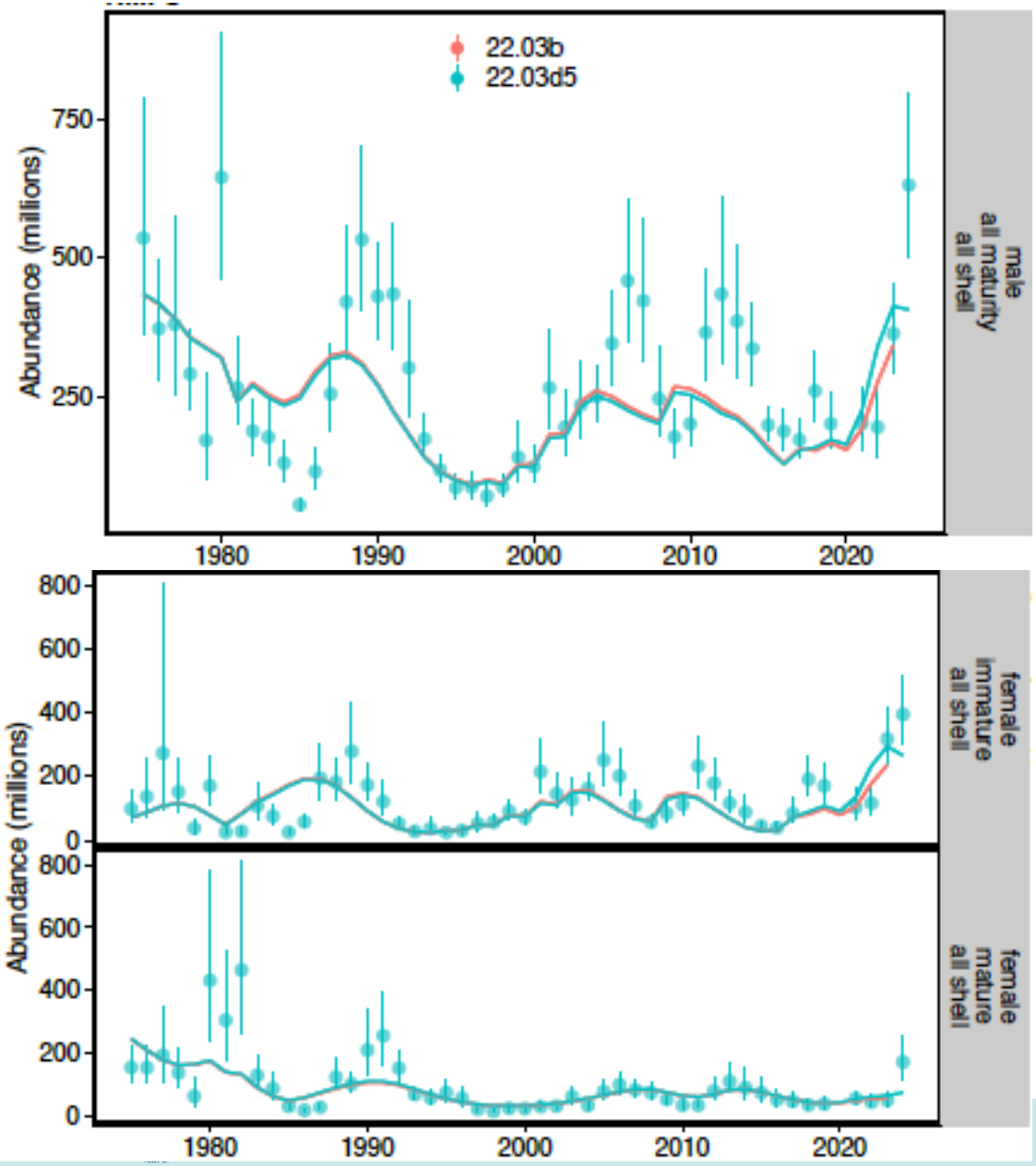


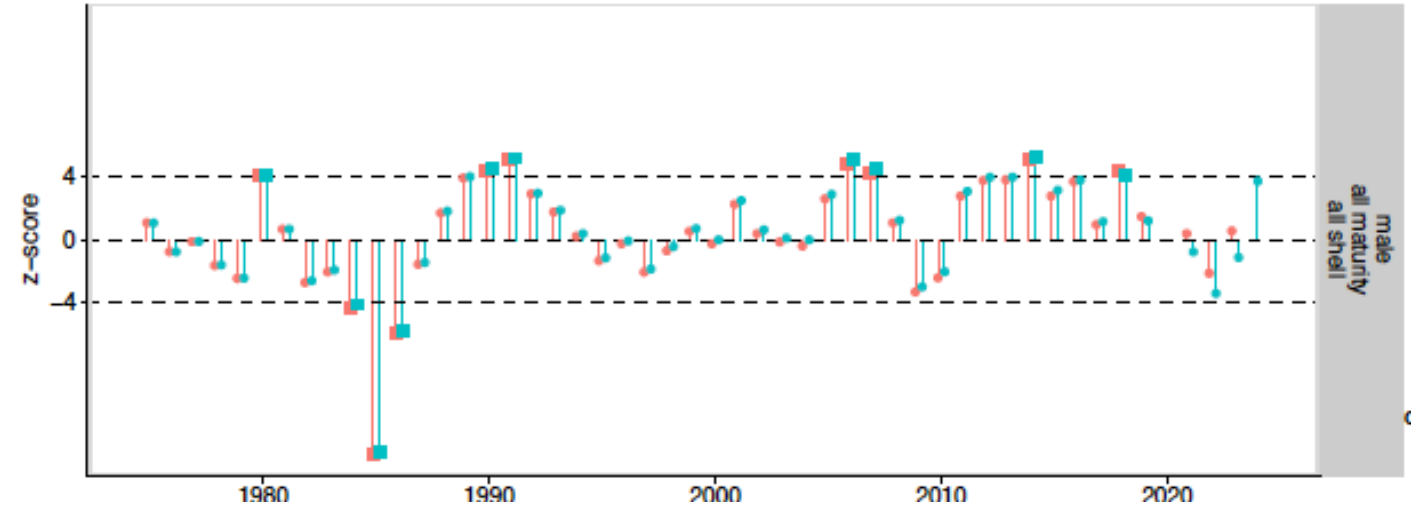


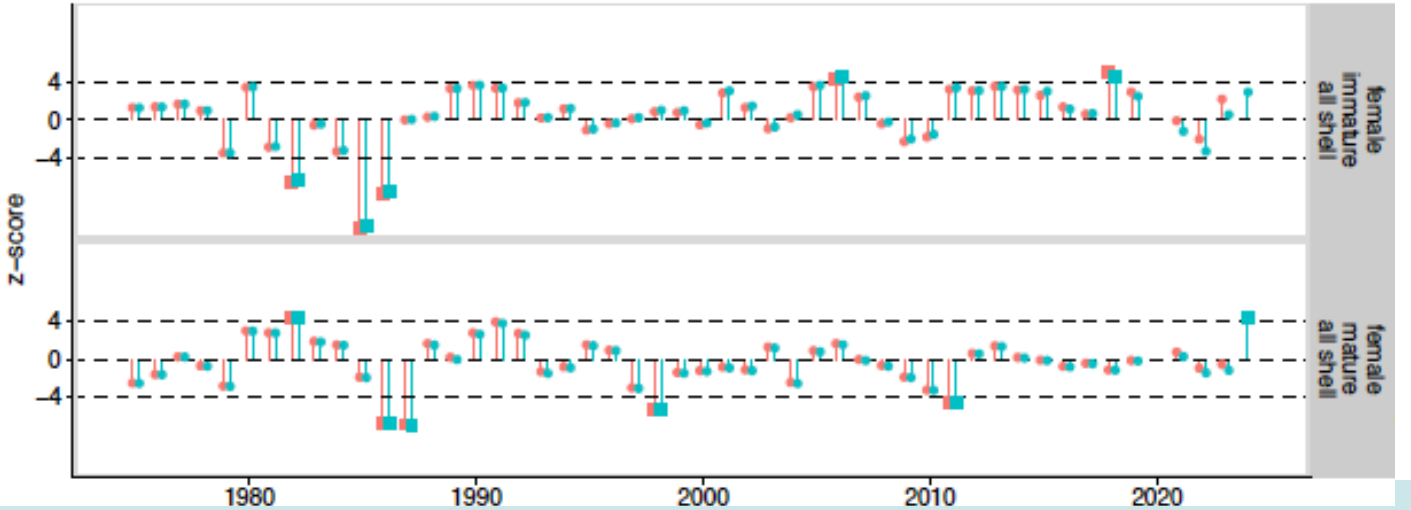




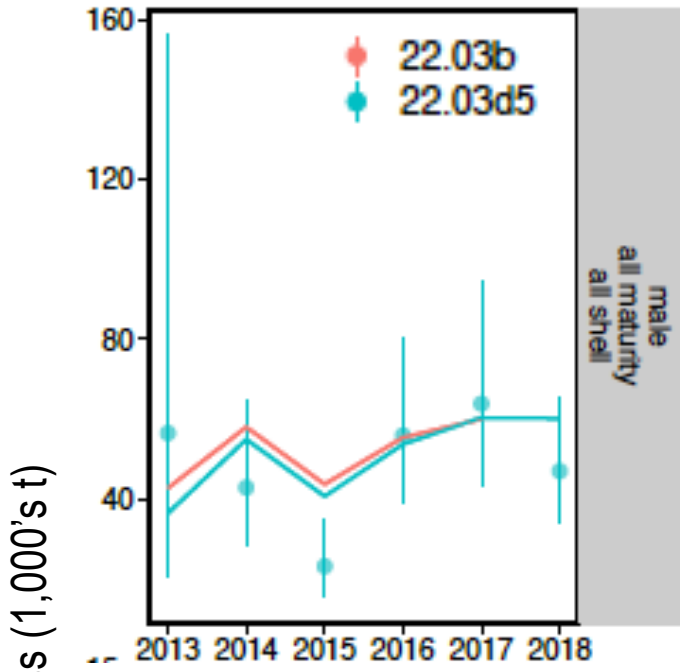
“Fits” to NMFS Survey Abundance

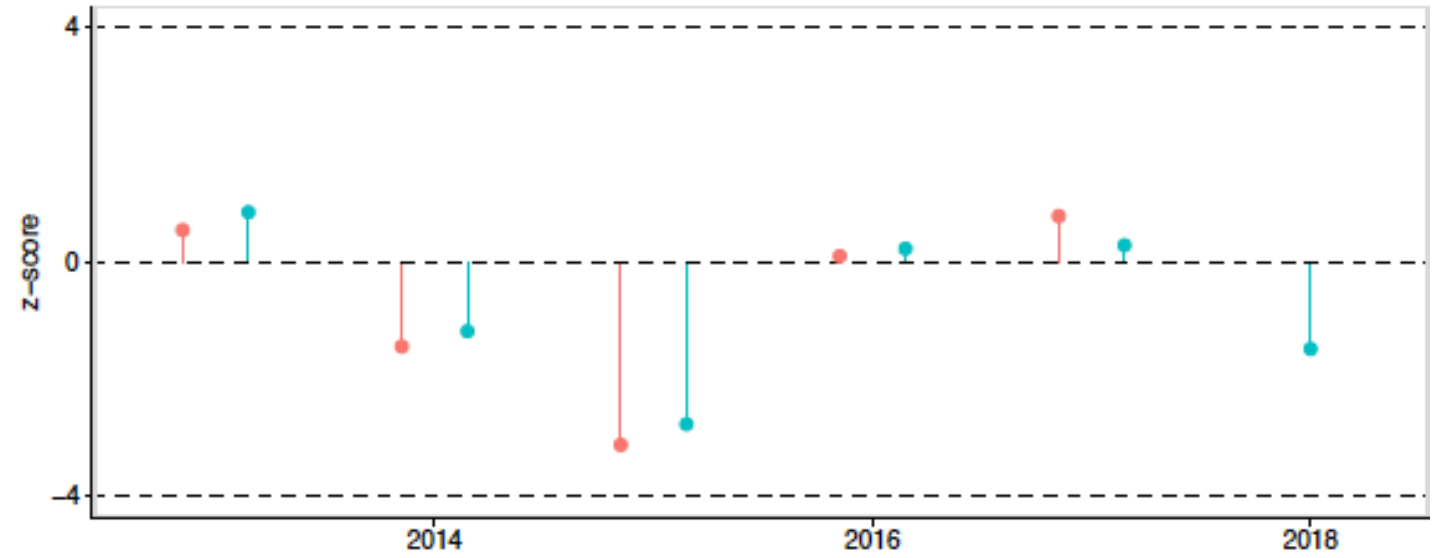


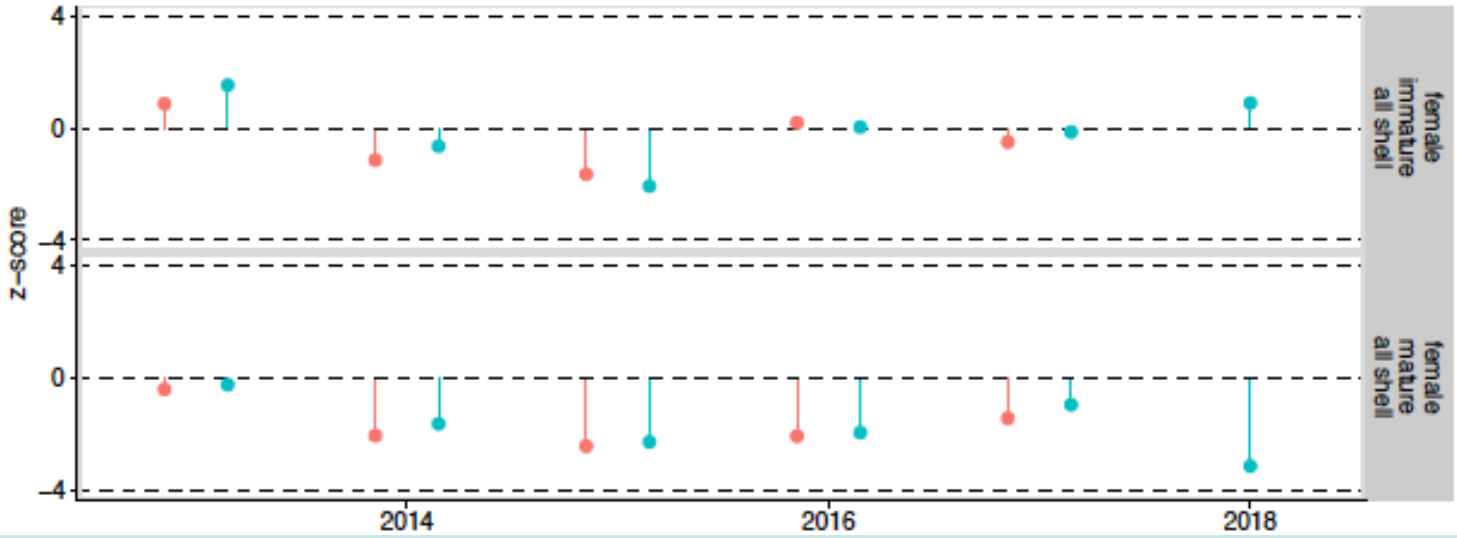




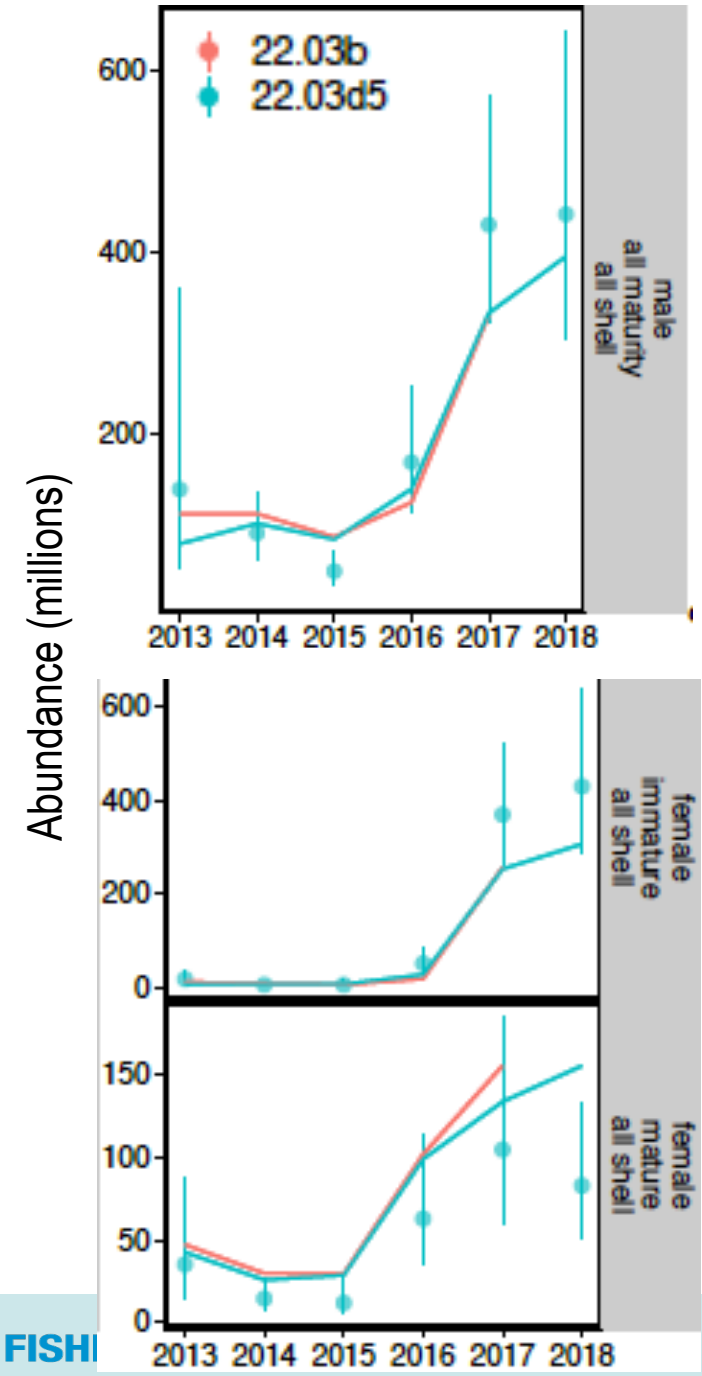
Fits to BSFRF Biomass Indices

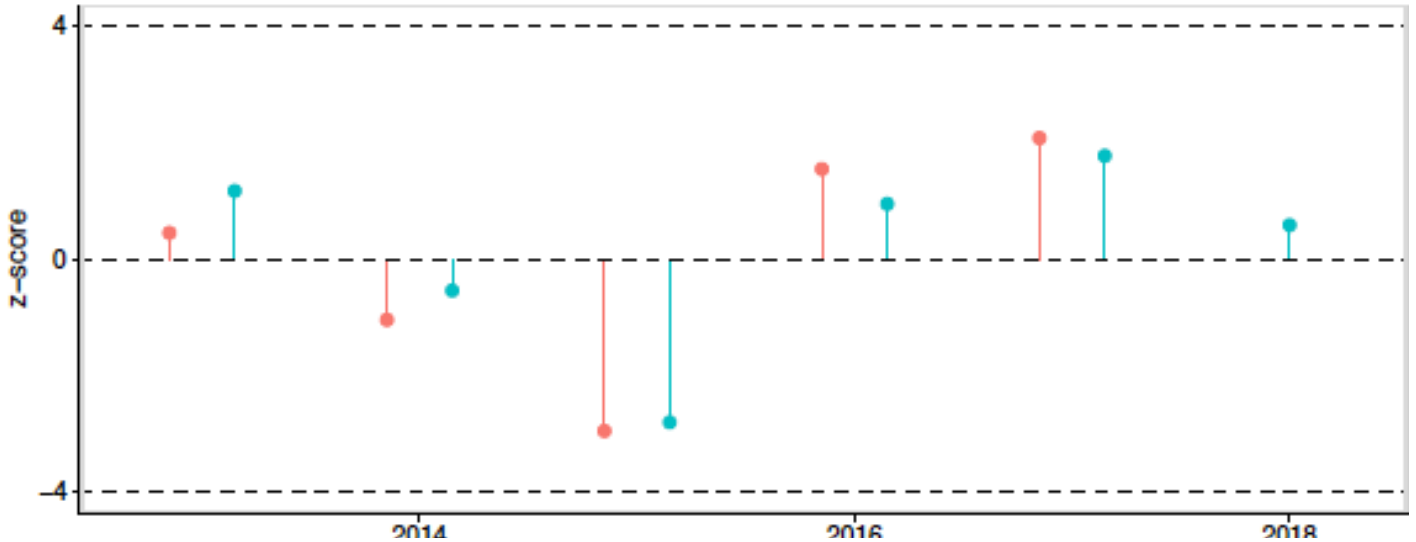


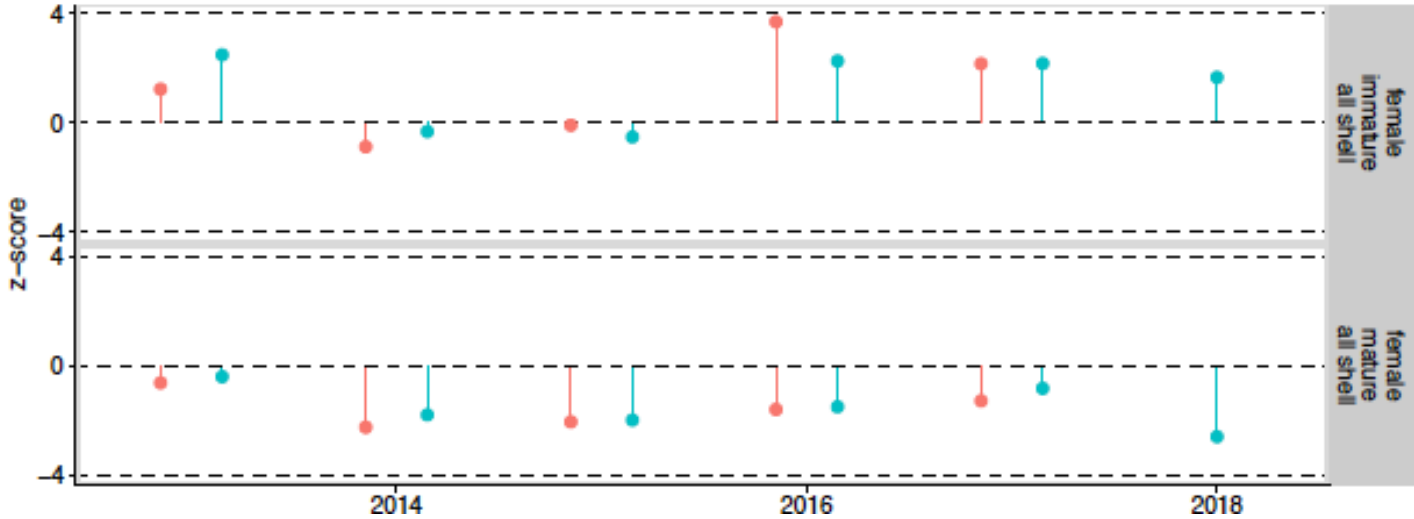




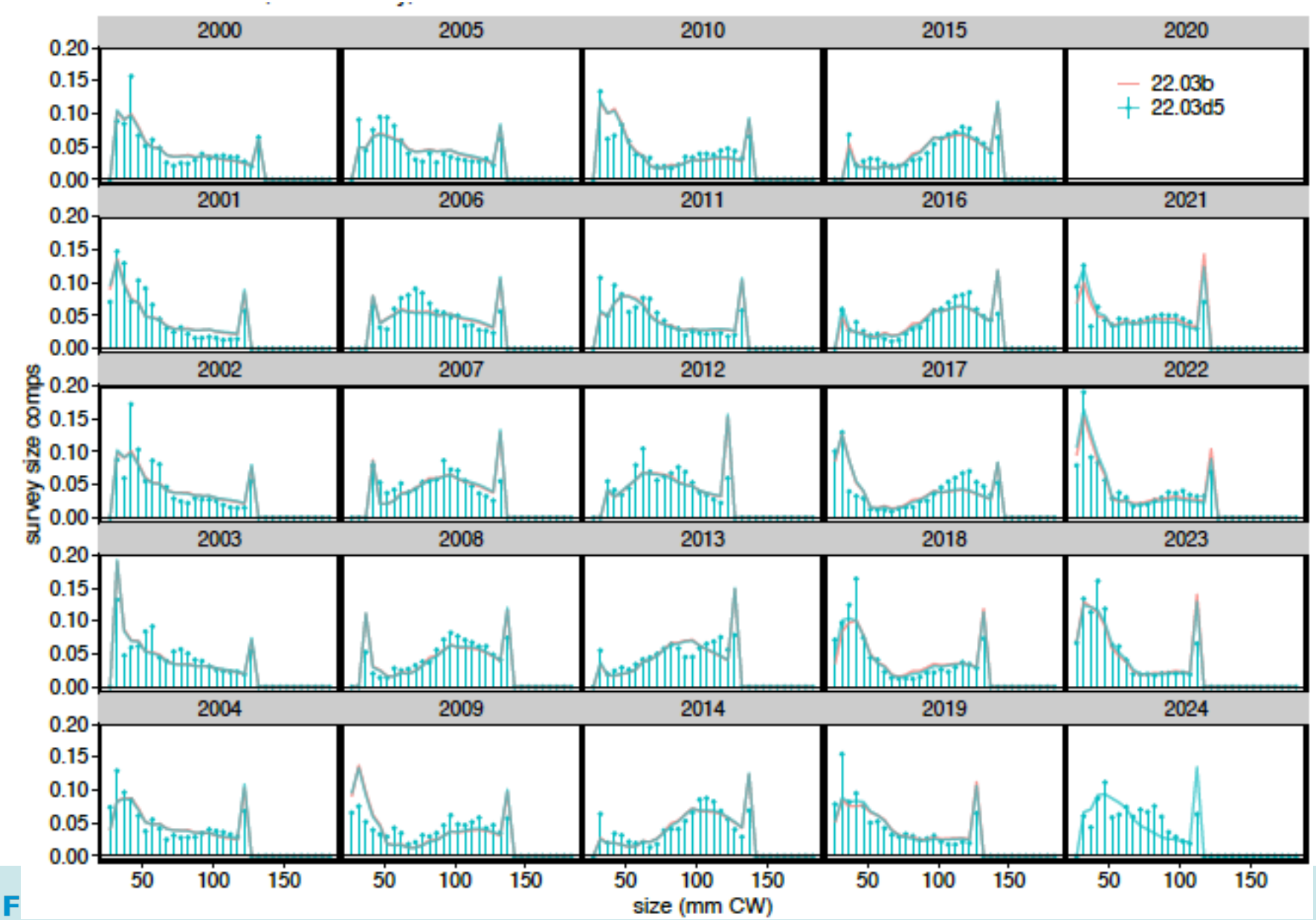
Fits to BSFRF Abundance Indices



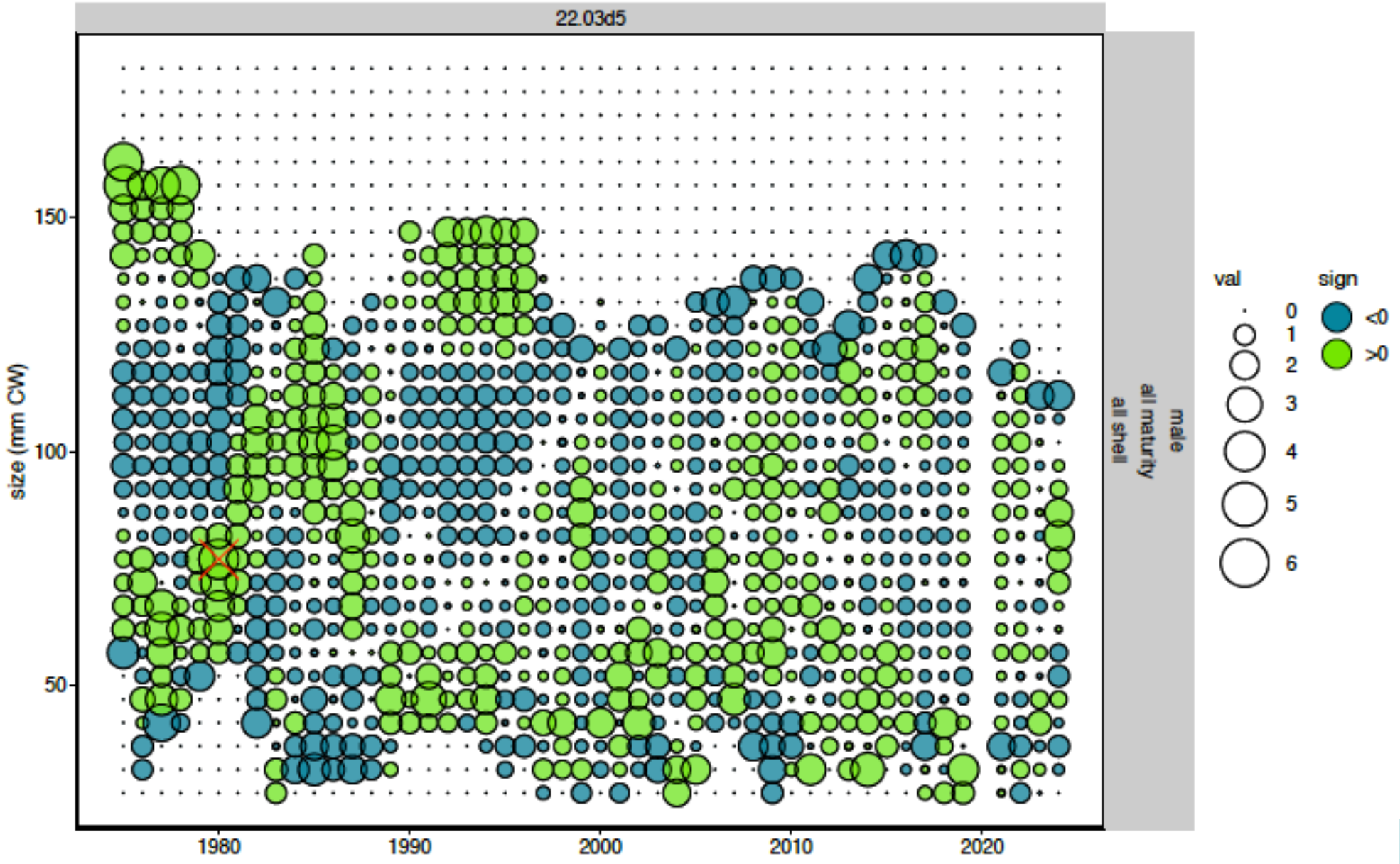




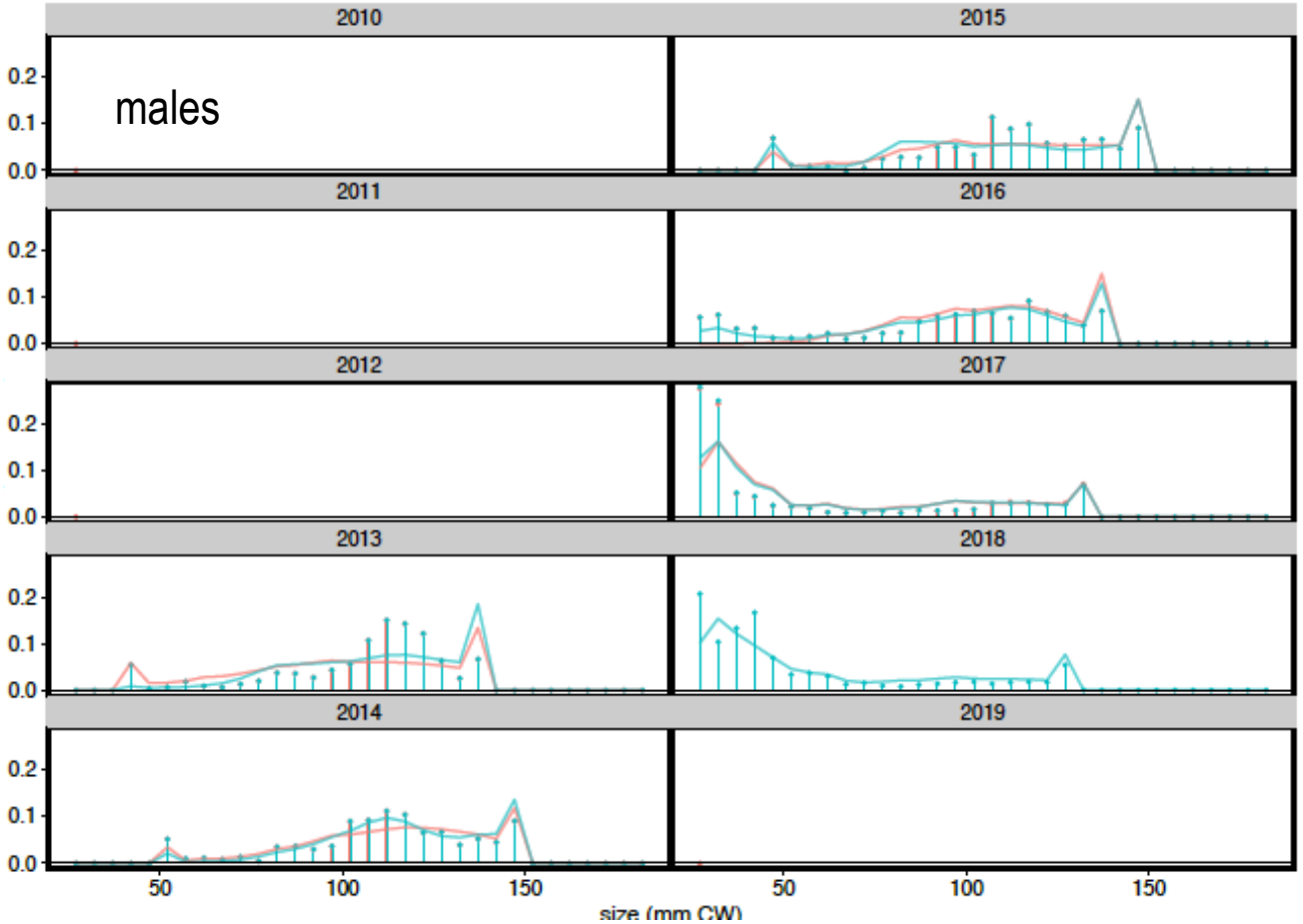
Fits to NMFS Male Survey Size Comps

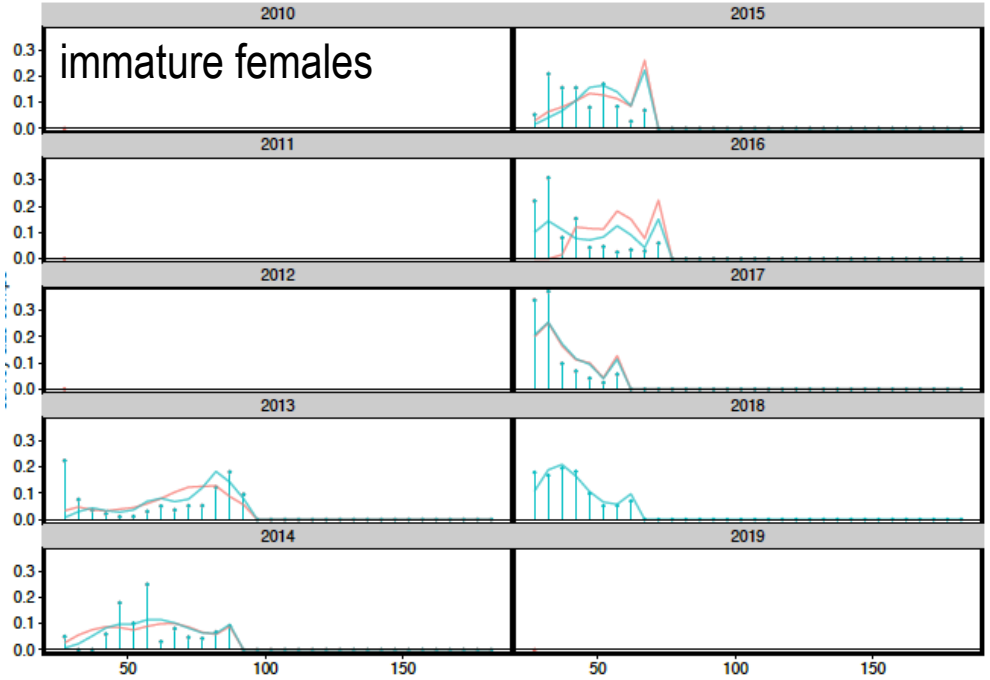


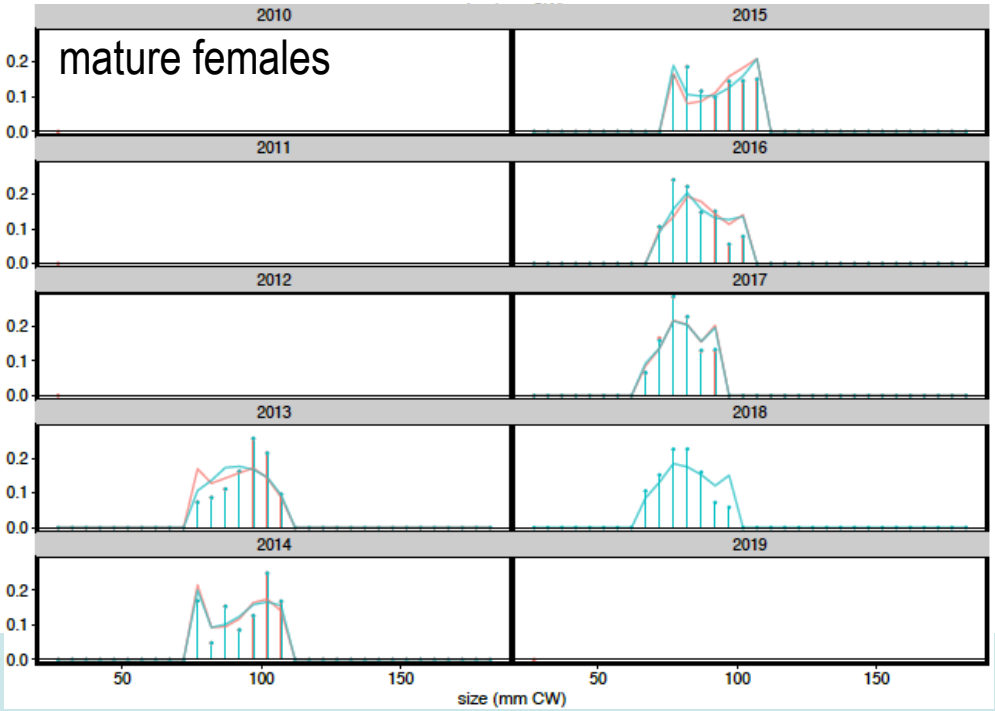
Residuals to NMFS Survey Size Comps (males)



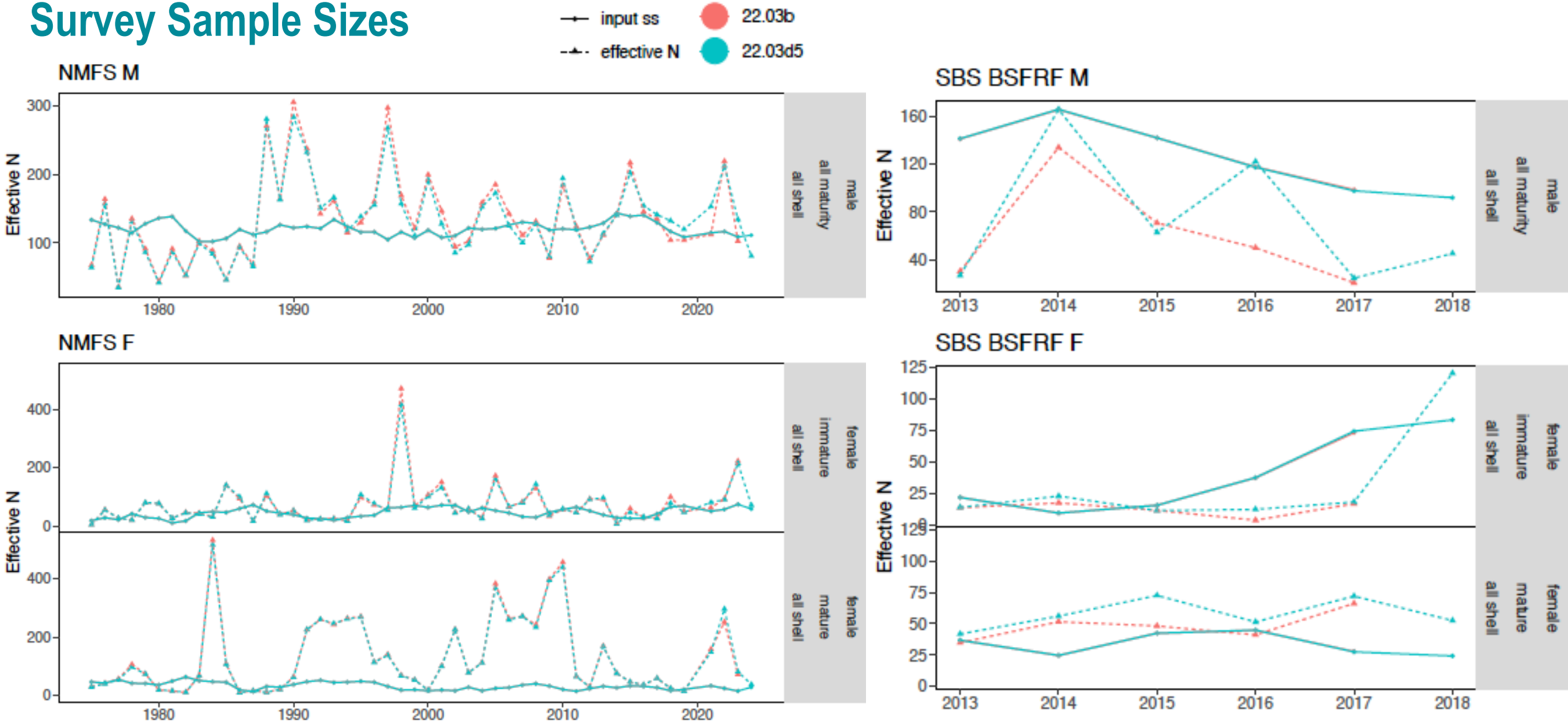
Fits to BSFRF Survey Size Comps





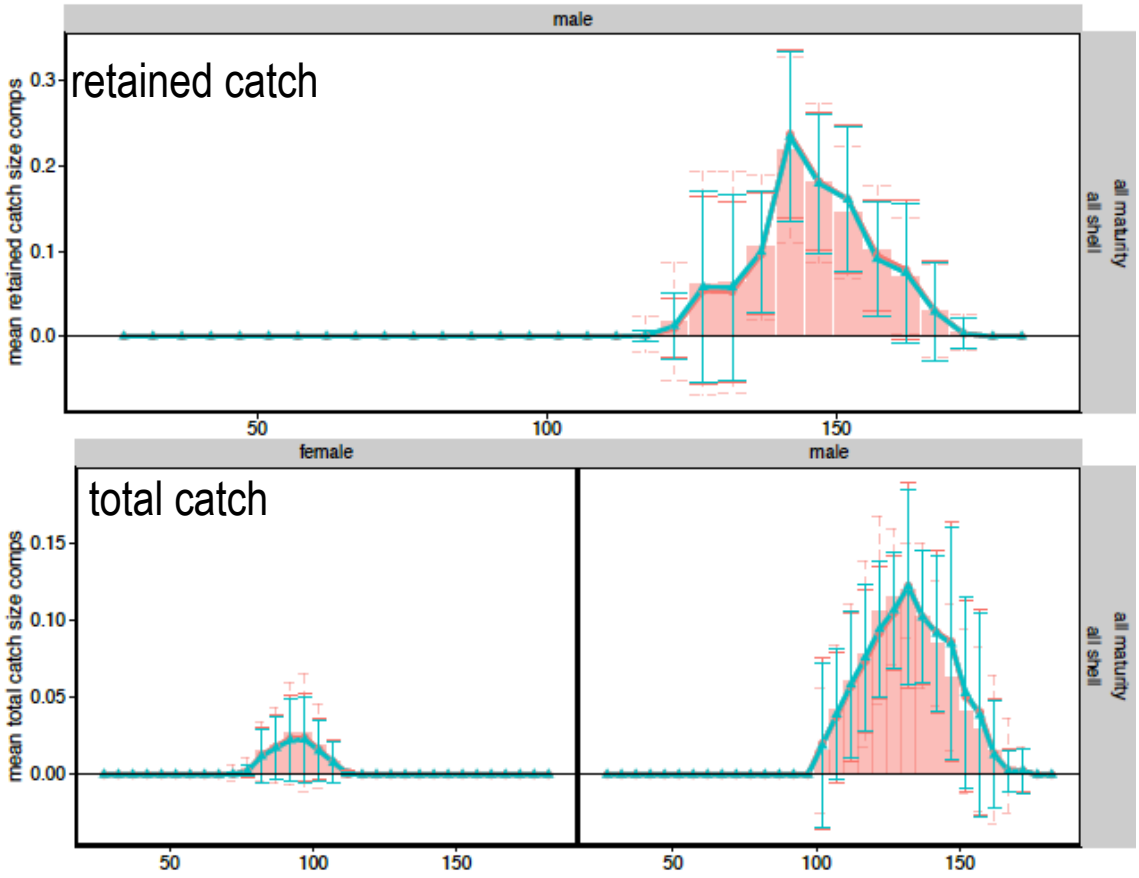


Survey Sample Sizes



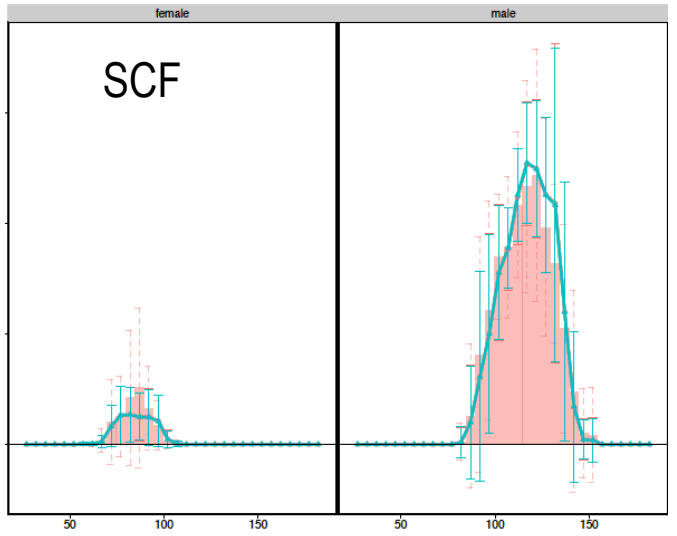
Marginal Fits to Fishery Size Comps

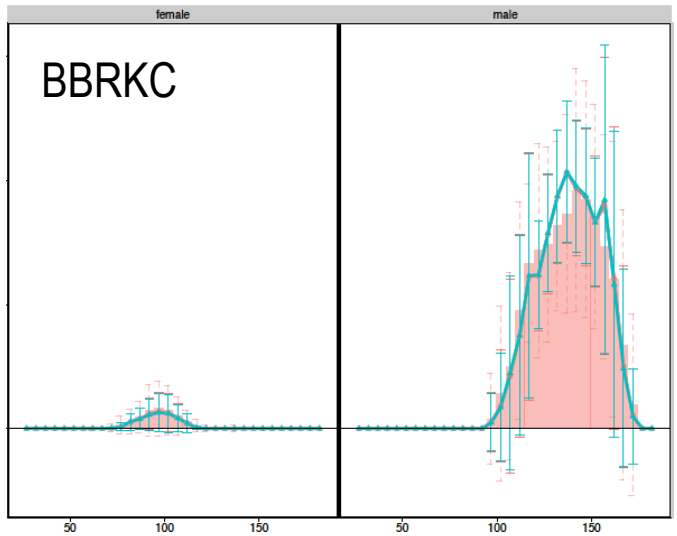
directed fishery

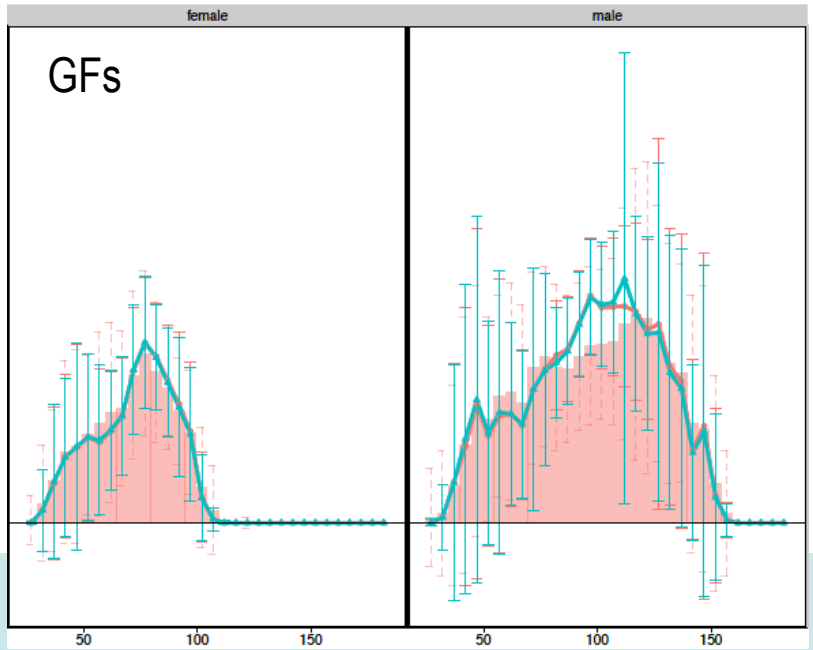


22.03b
22.03d5

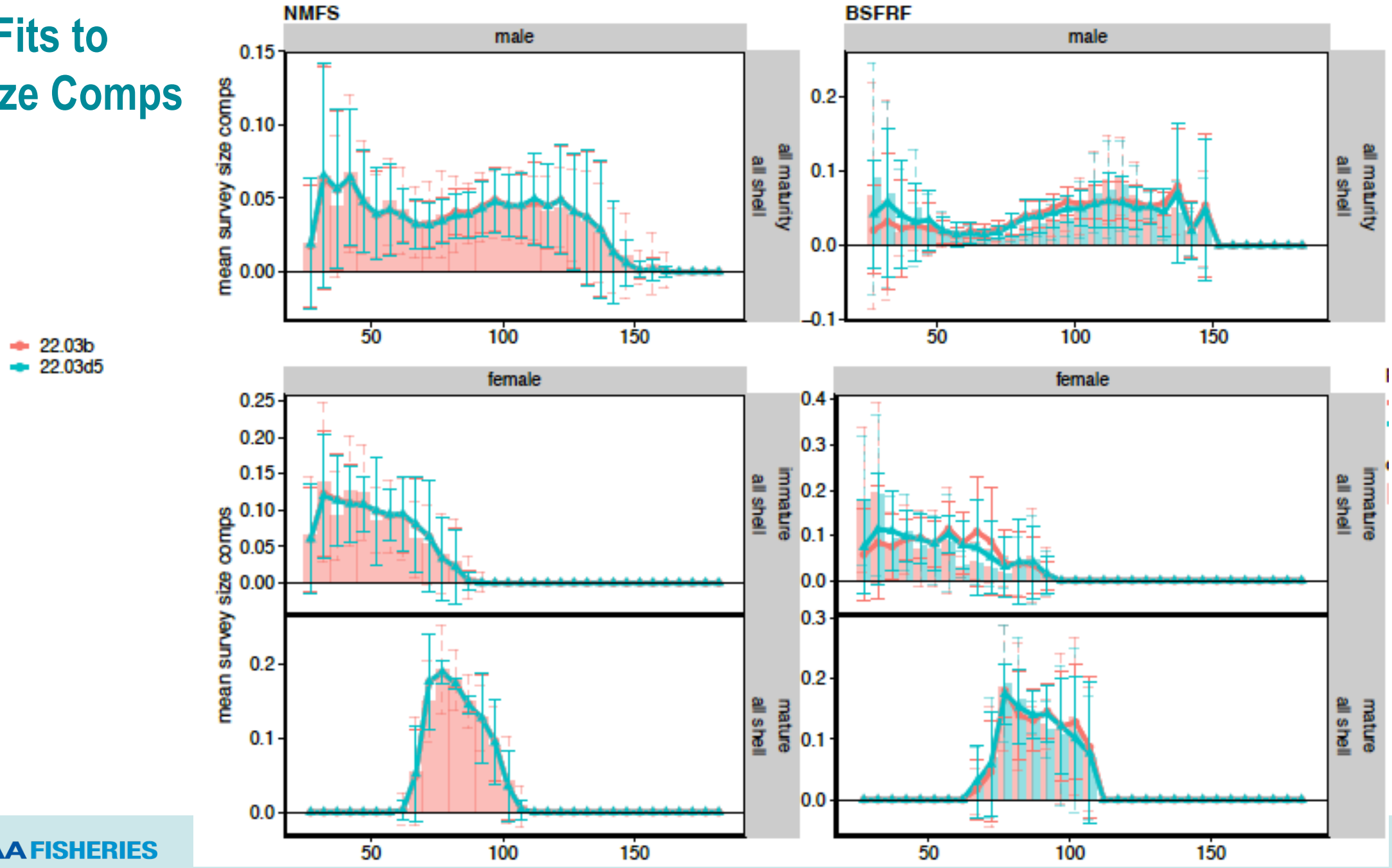
bycatch fisheries



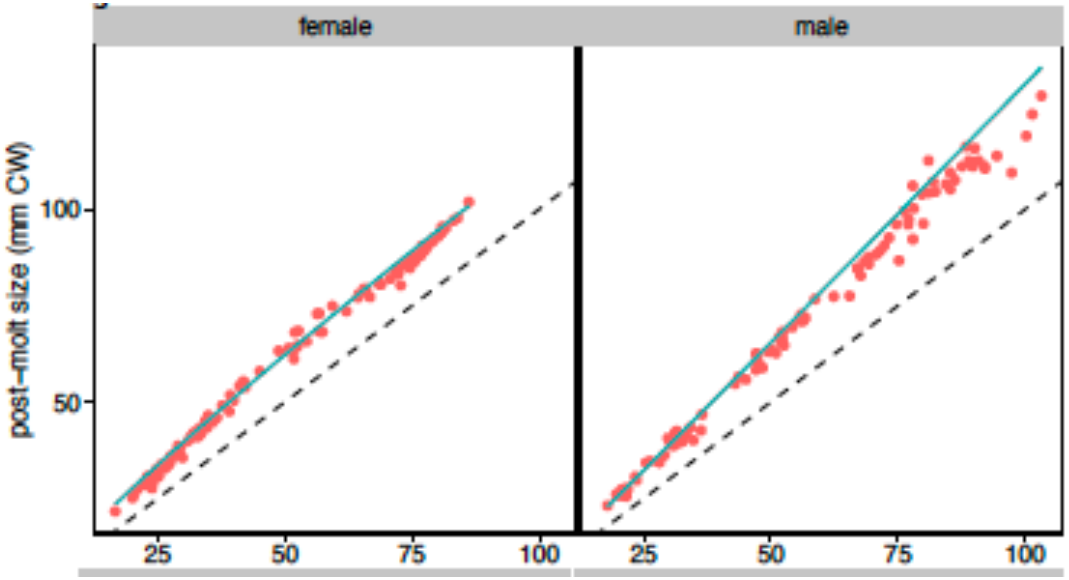


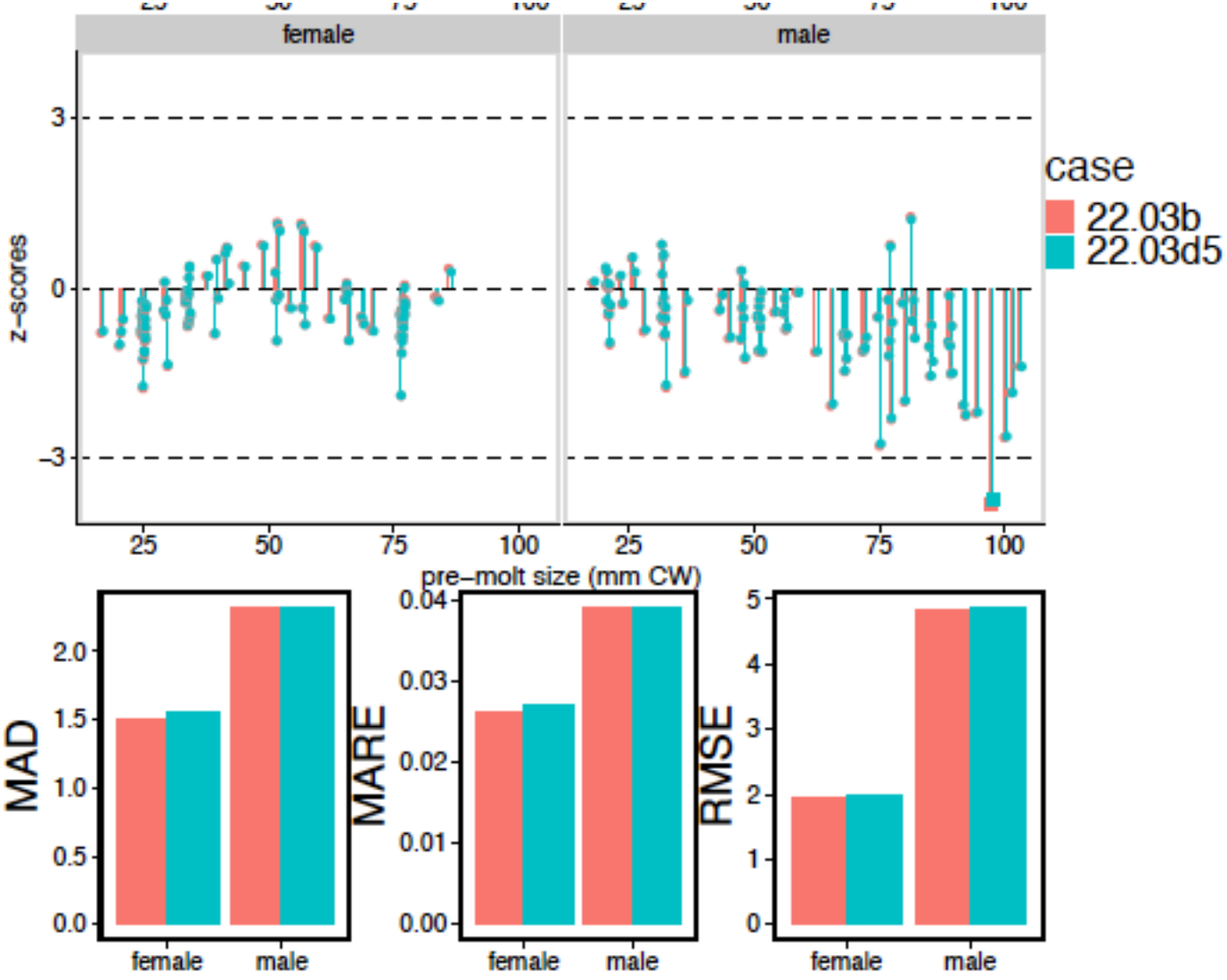


Marginal Fits to Survey Size Comps

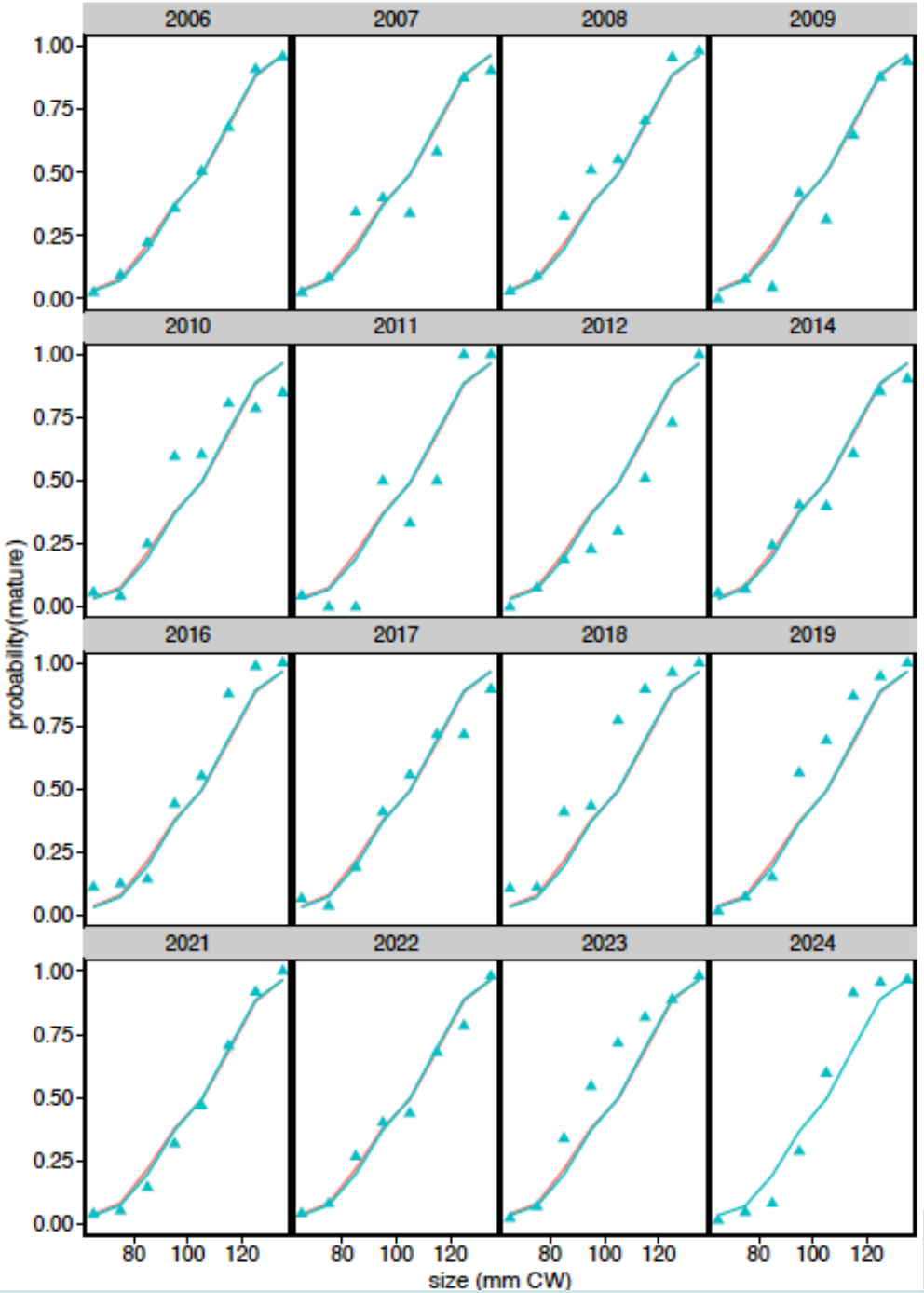


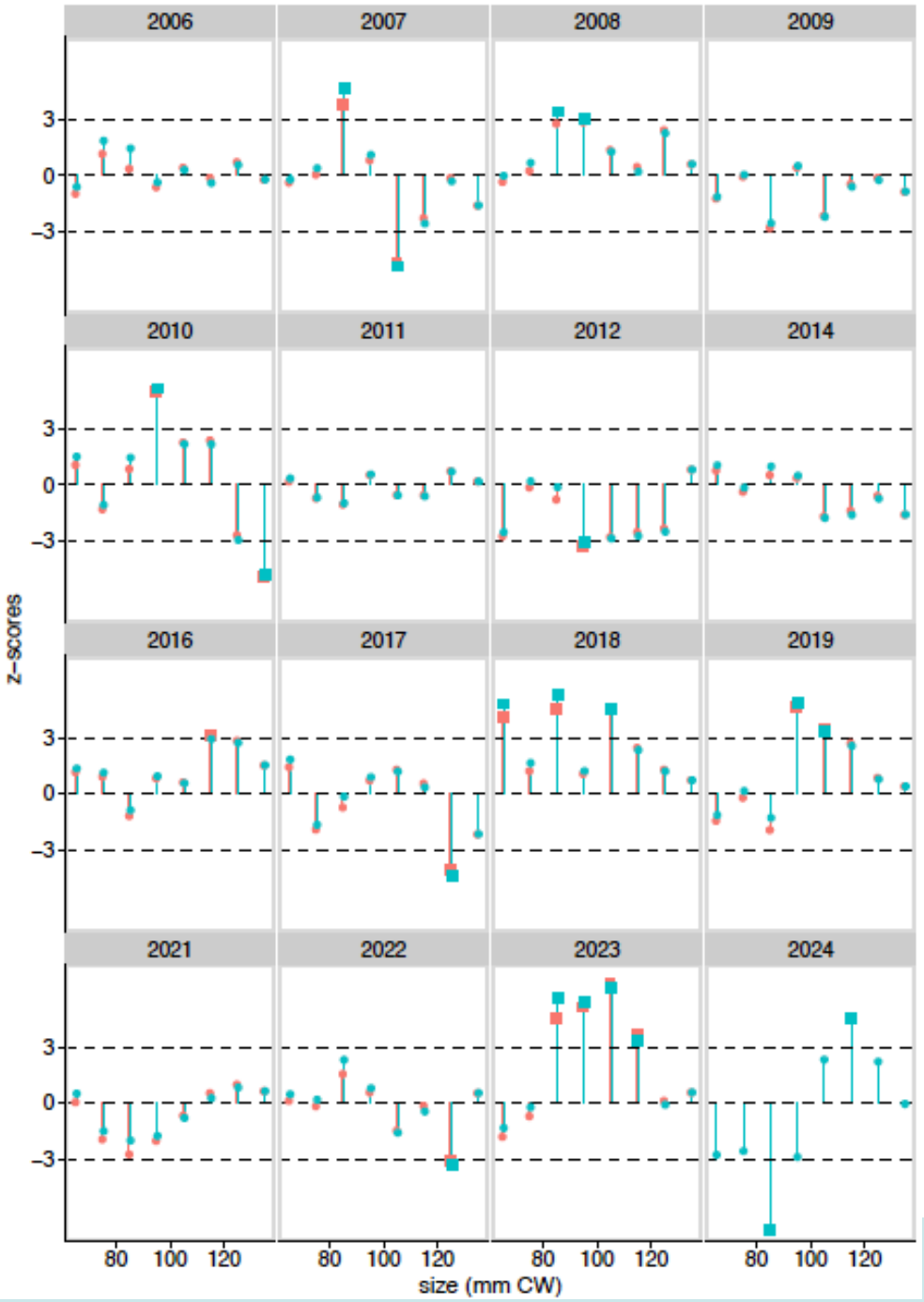
Fits to Growth Data





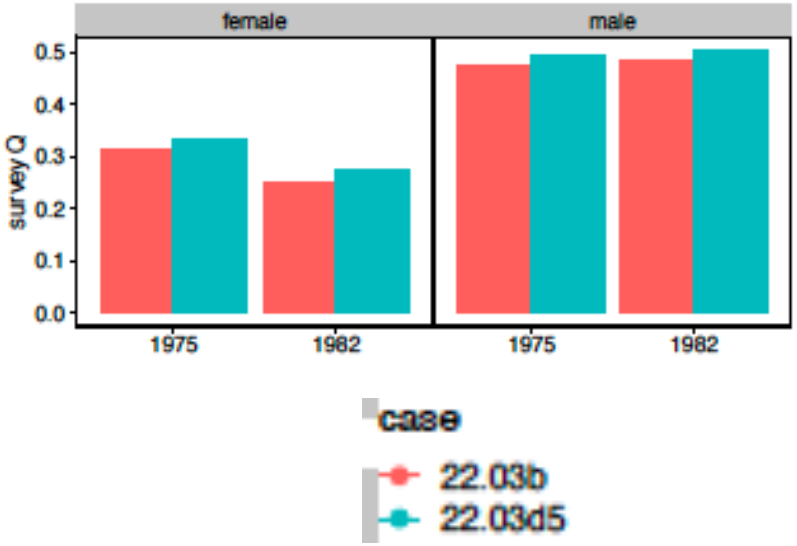
Fits to Male Maturity Ogives



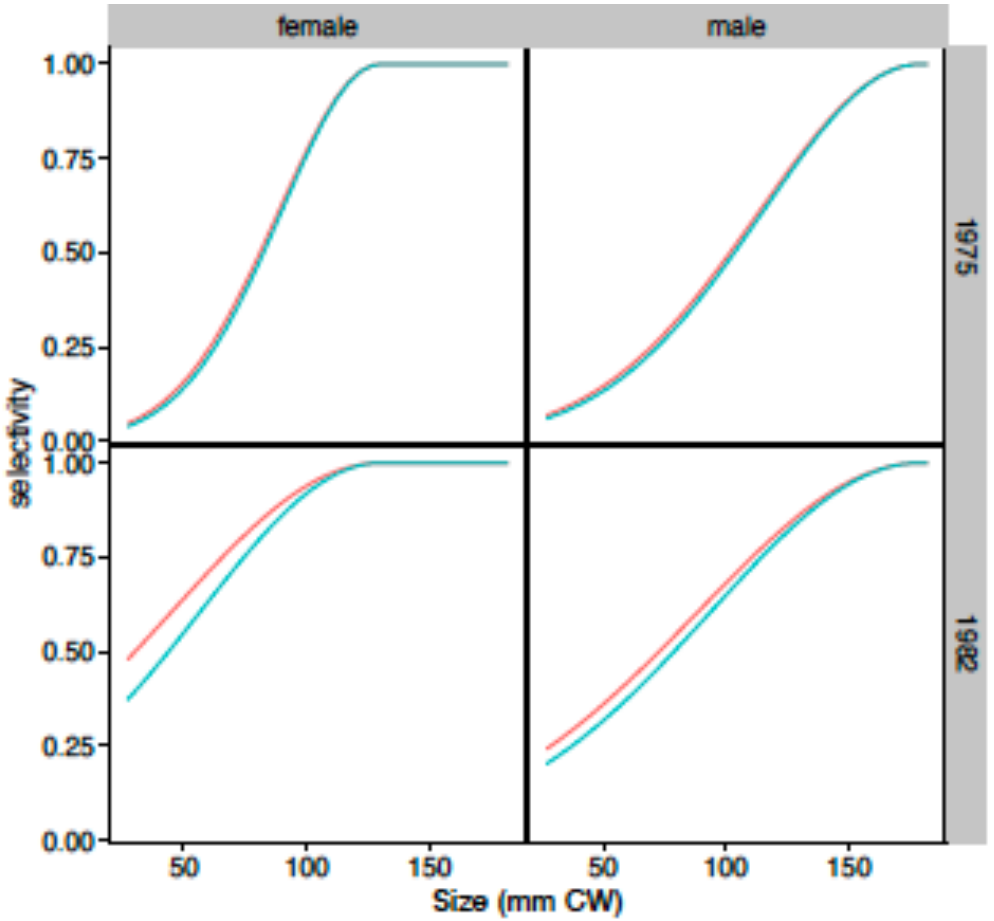


Estimated Quantities

NMFS survey Q



NMFS survey selectivity



2013-17 SBS Analysis

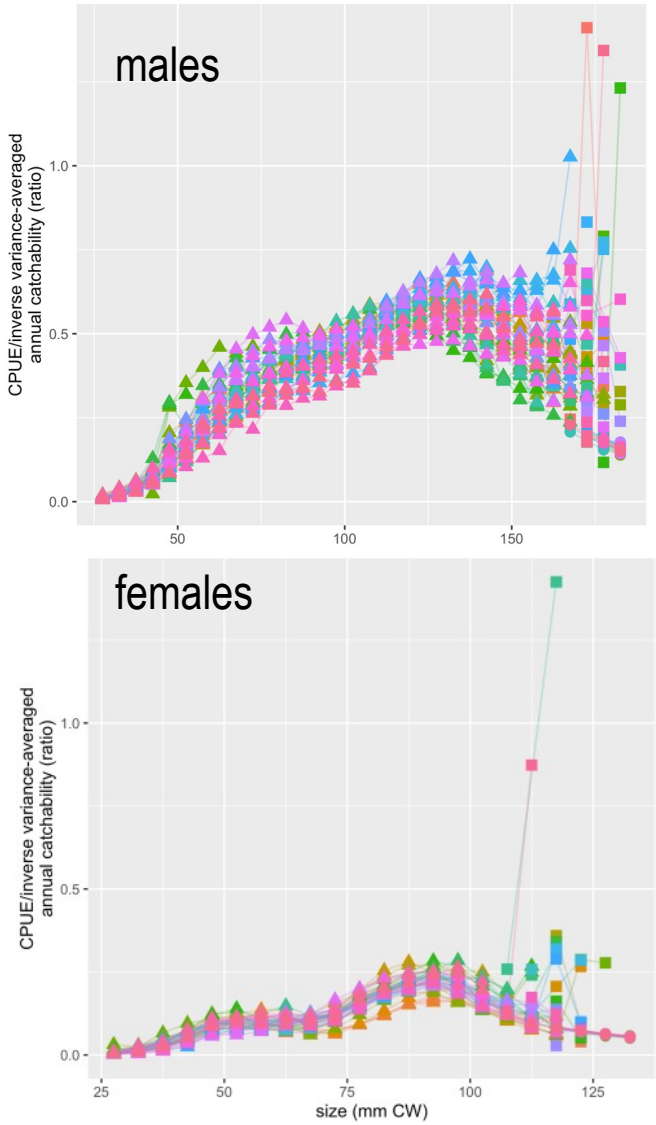


Fig. 59

Estimated Quantities: Directed Fishery

Fig. 55

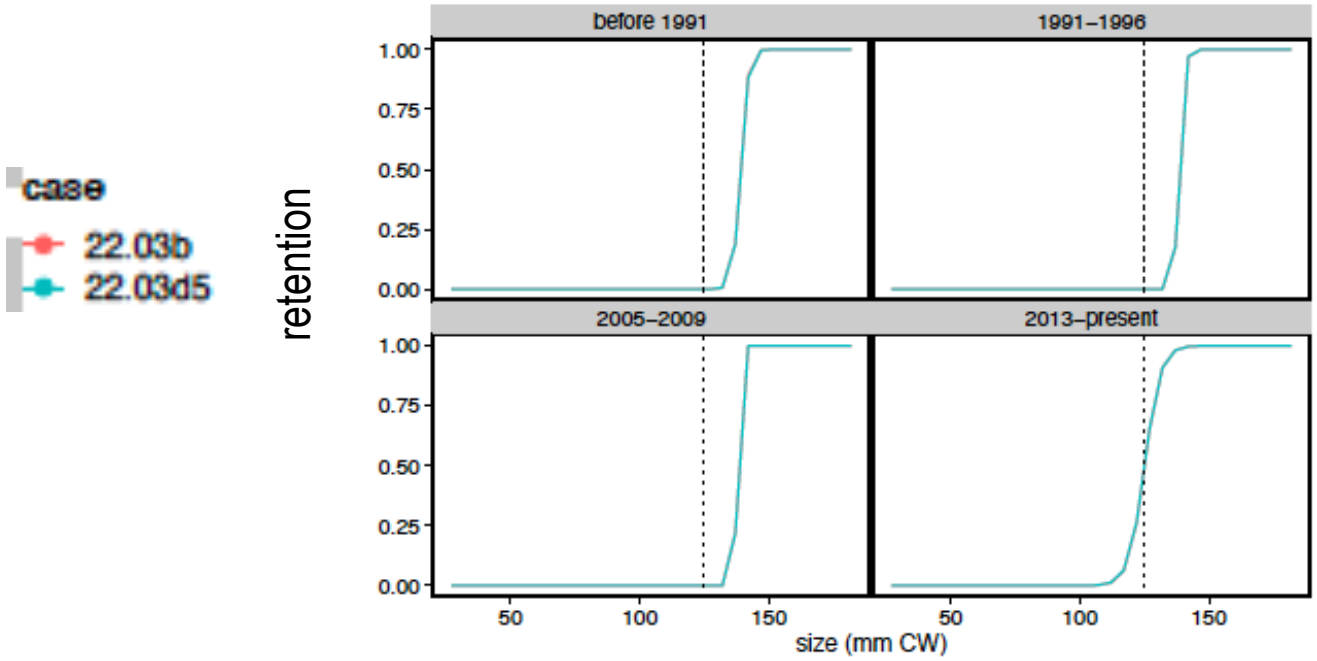
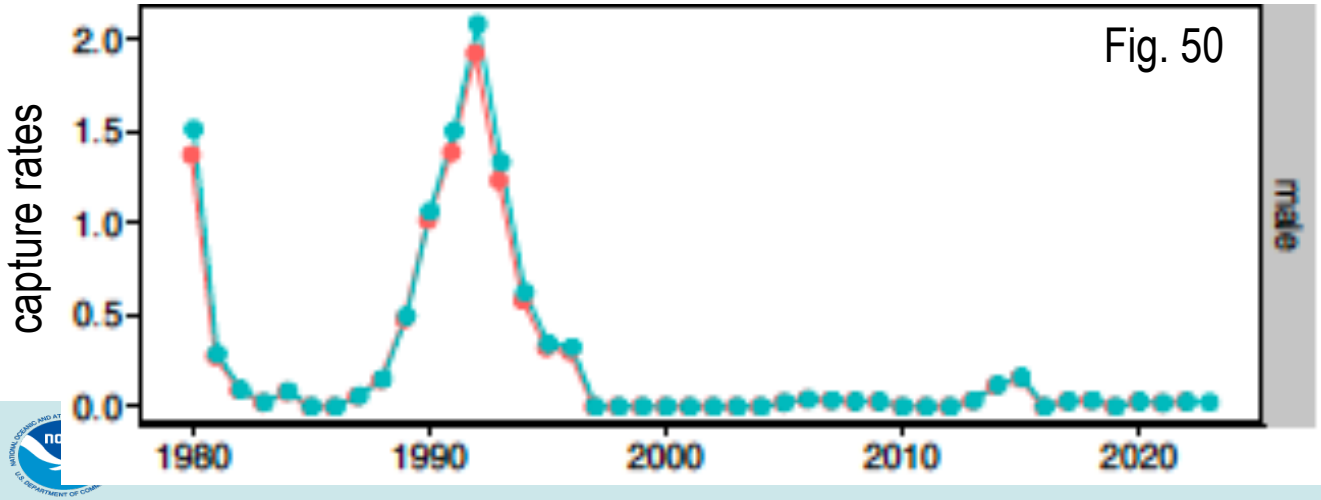


Fig. 50



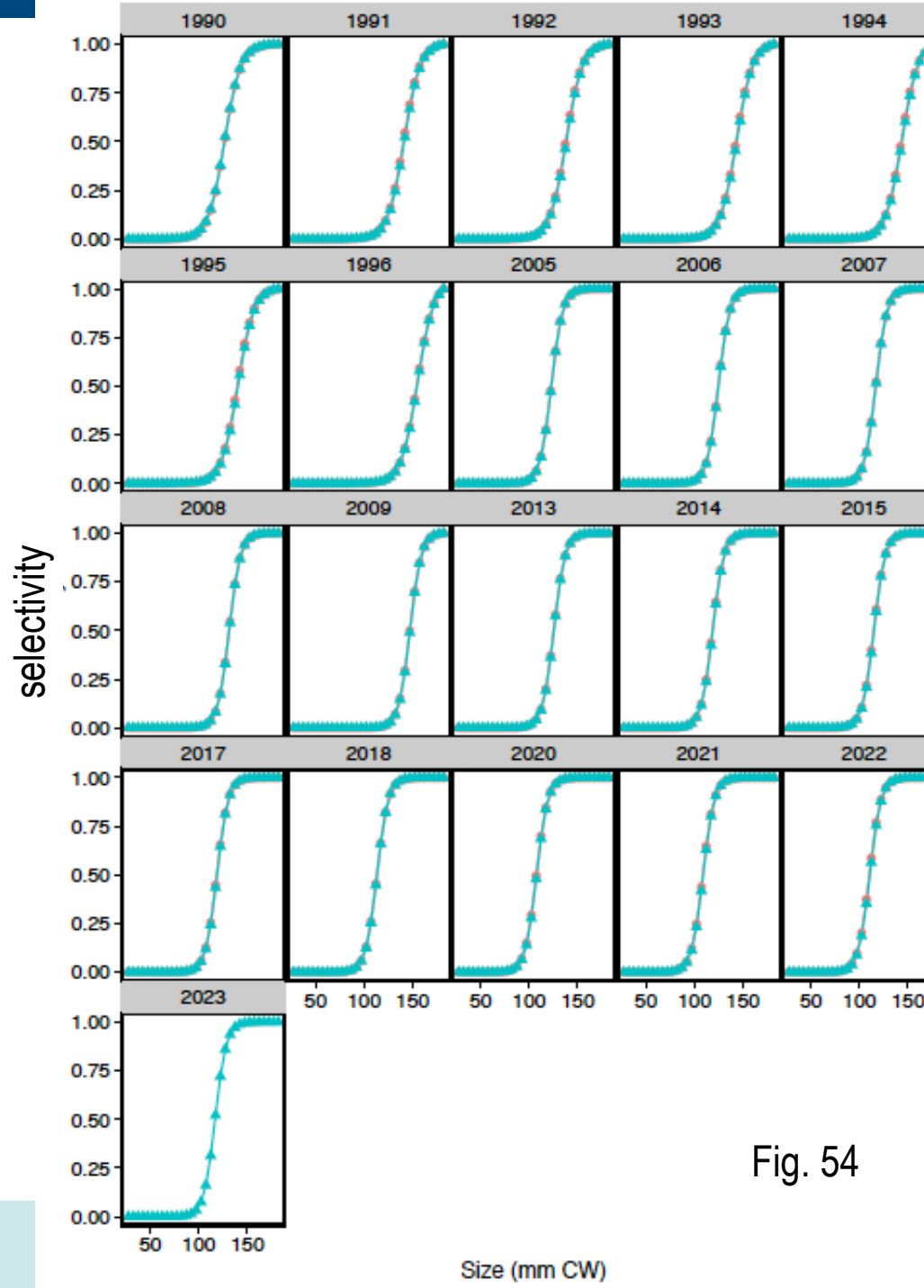
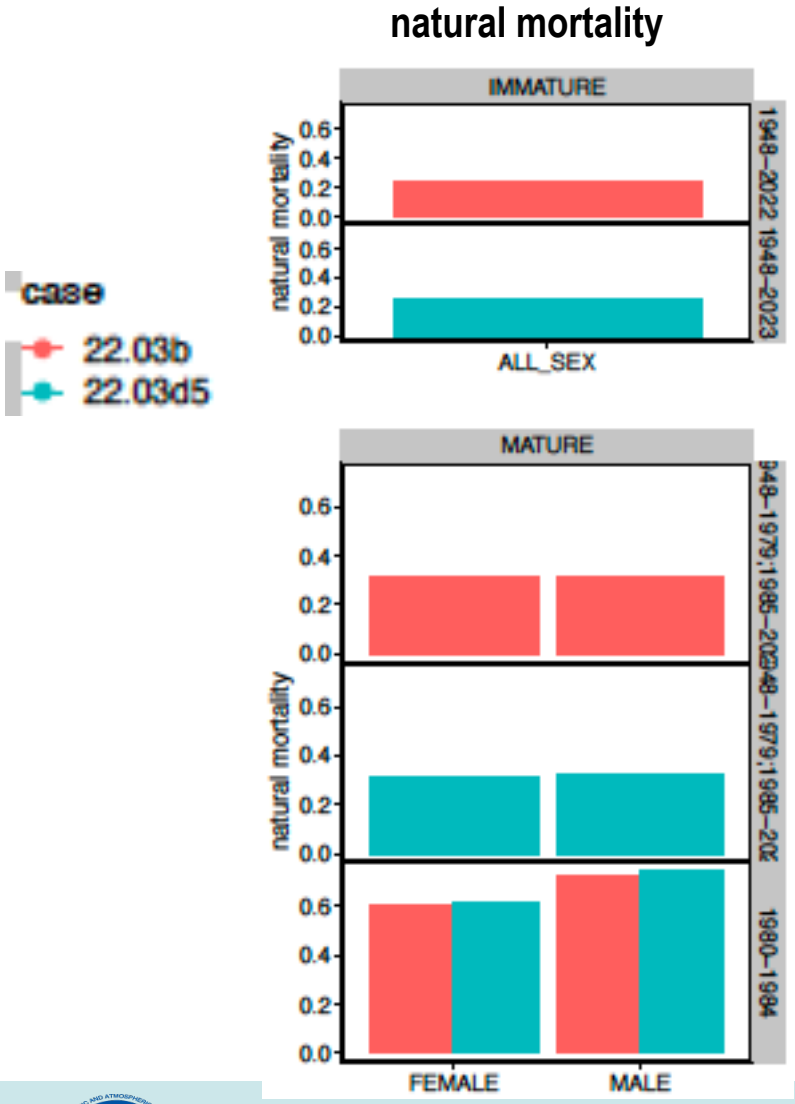


Fig. 54

Estimated Population Processes



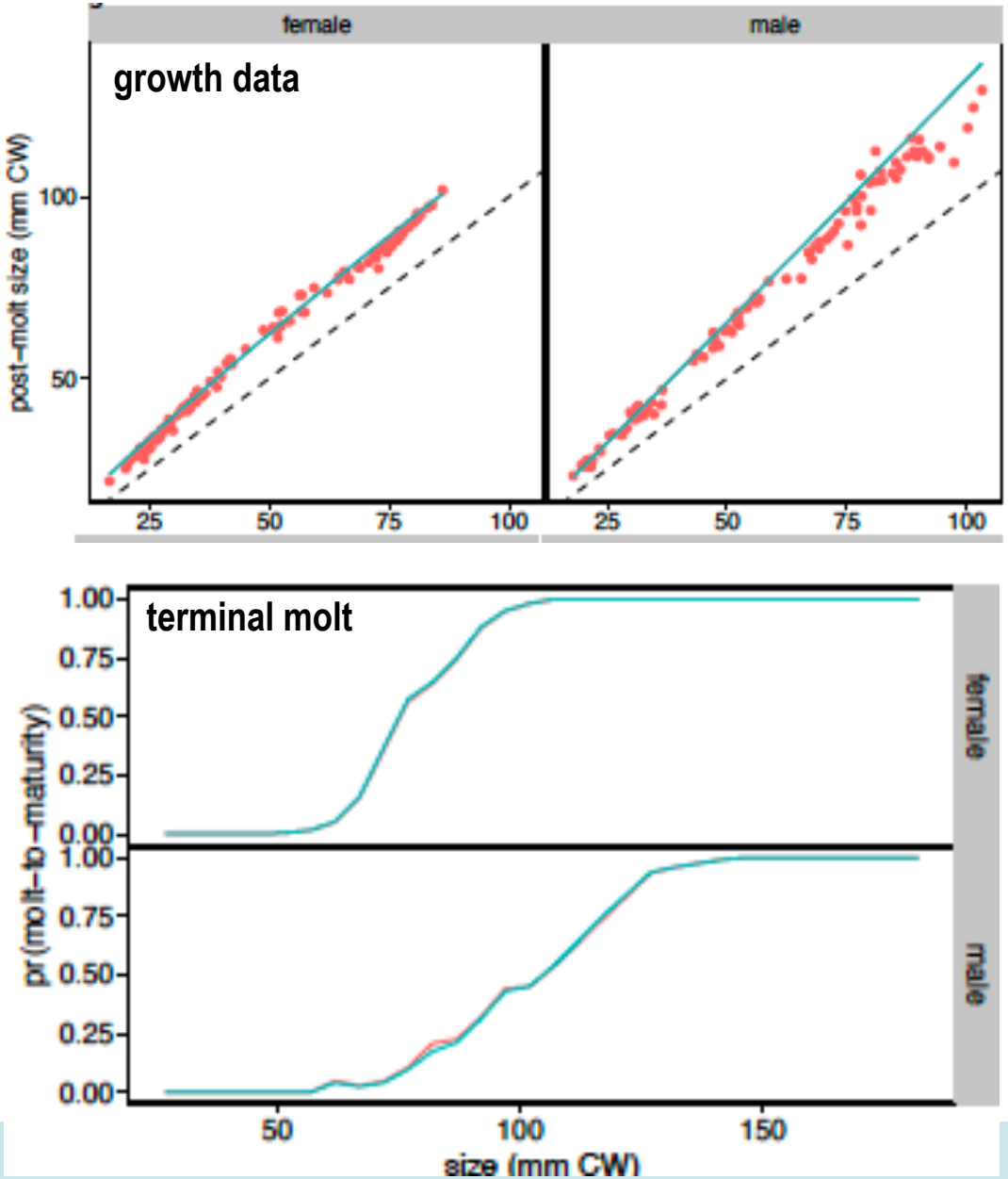
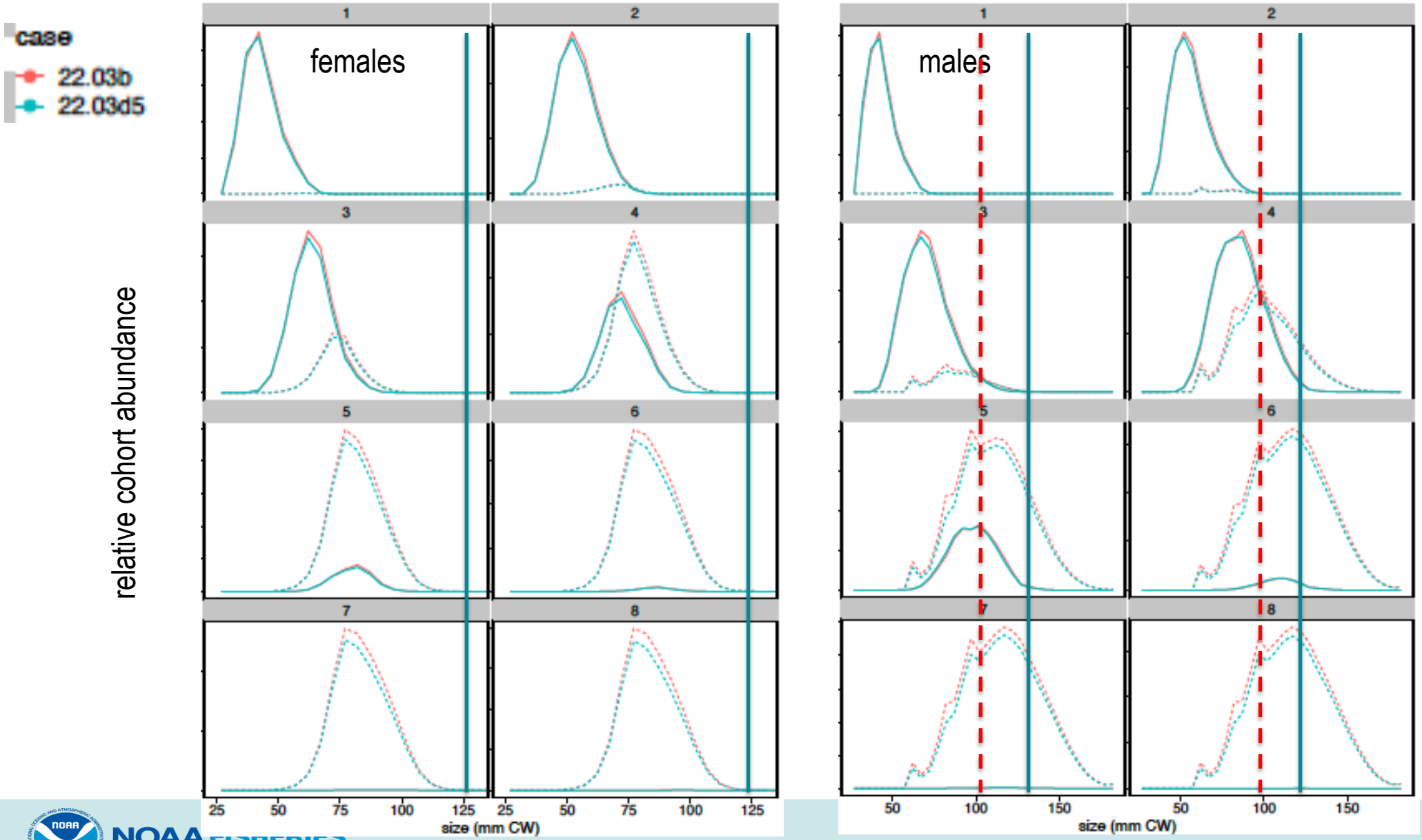


Fig. 84

Fig. 61

Estimated (Pseudo) Cohort Progression

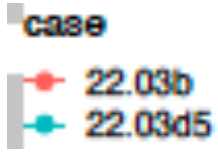
SCALES ARE RELATIVE

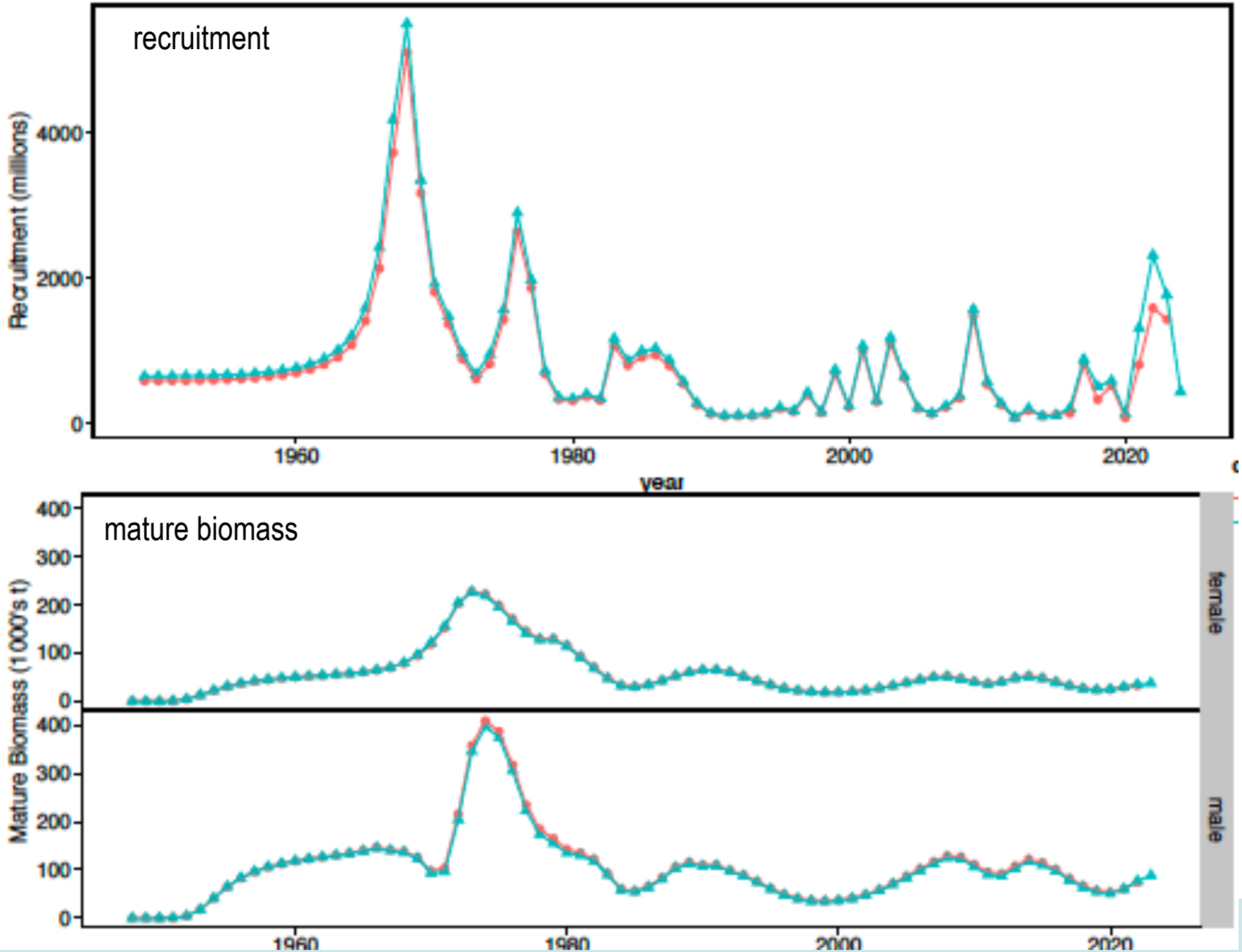


about 10% left at post-recruitment age 8

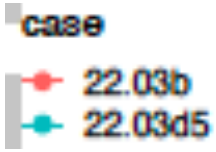
Fig.s 62 & 63

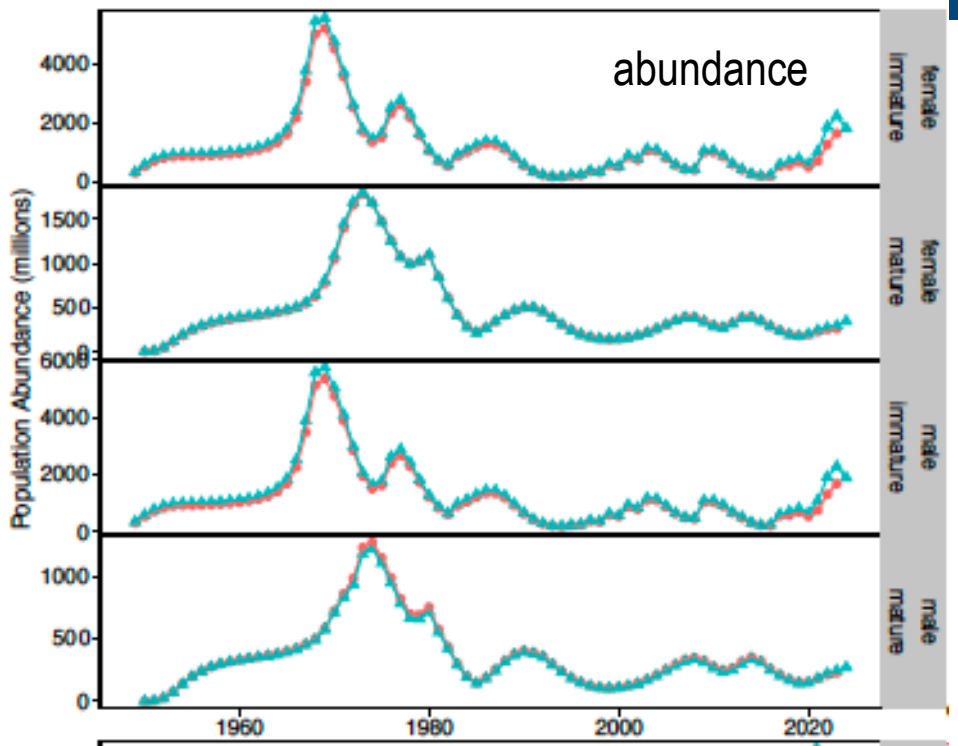
Estimated Population Quantities

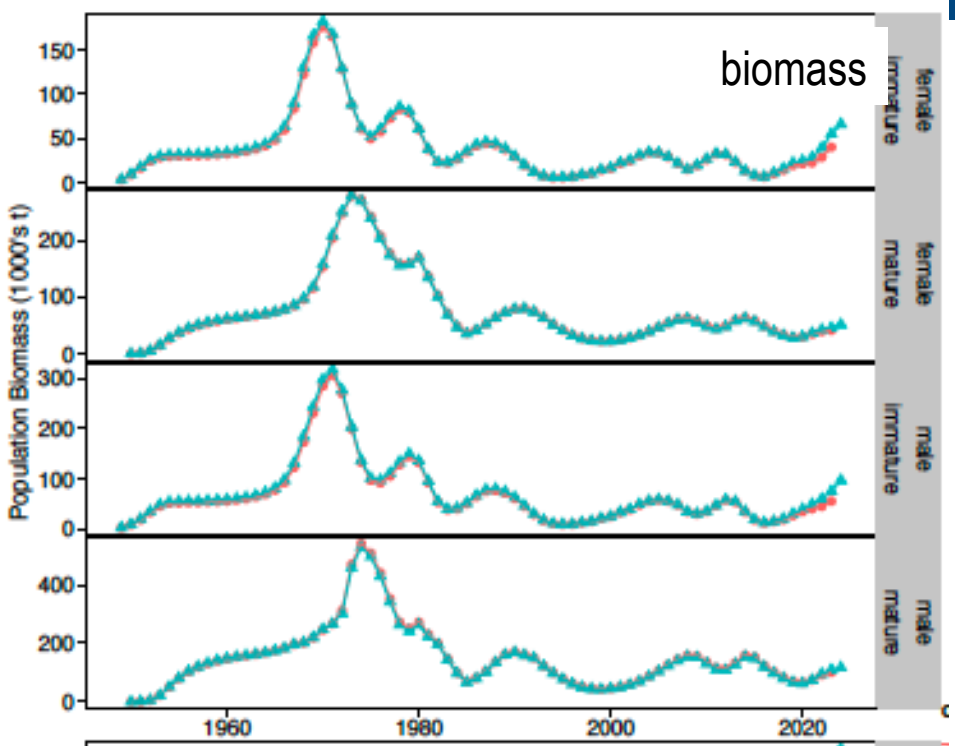


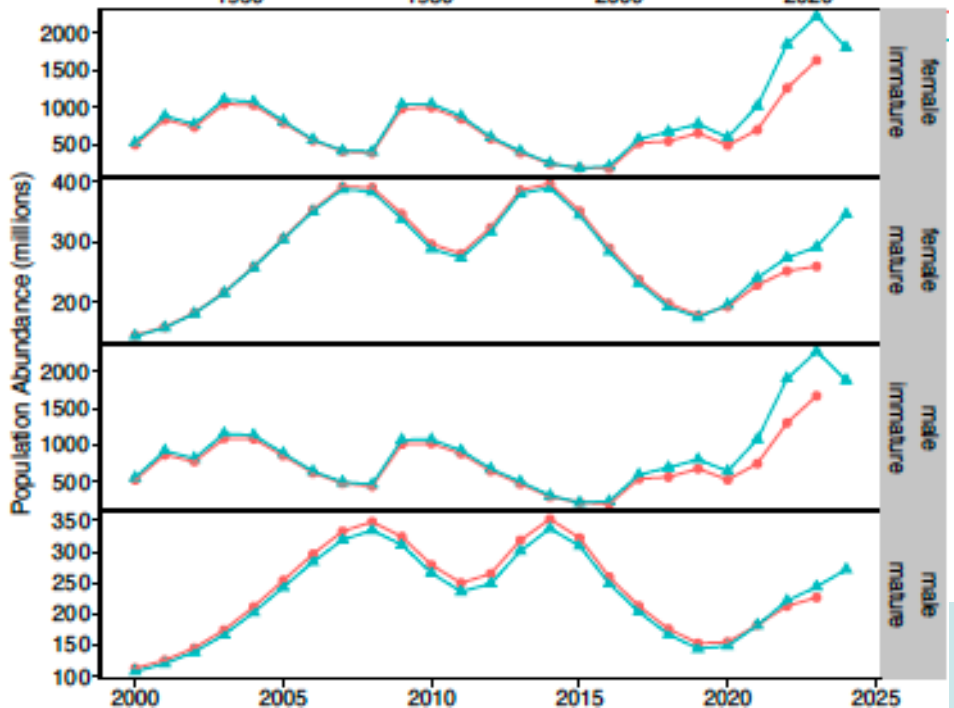


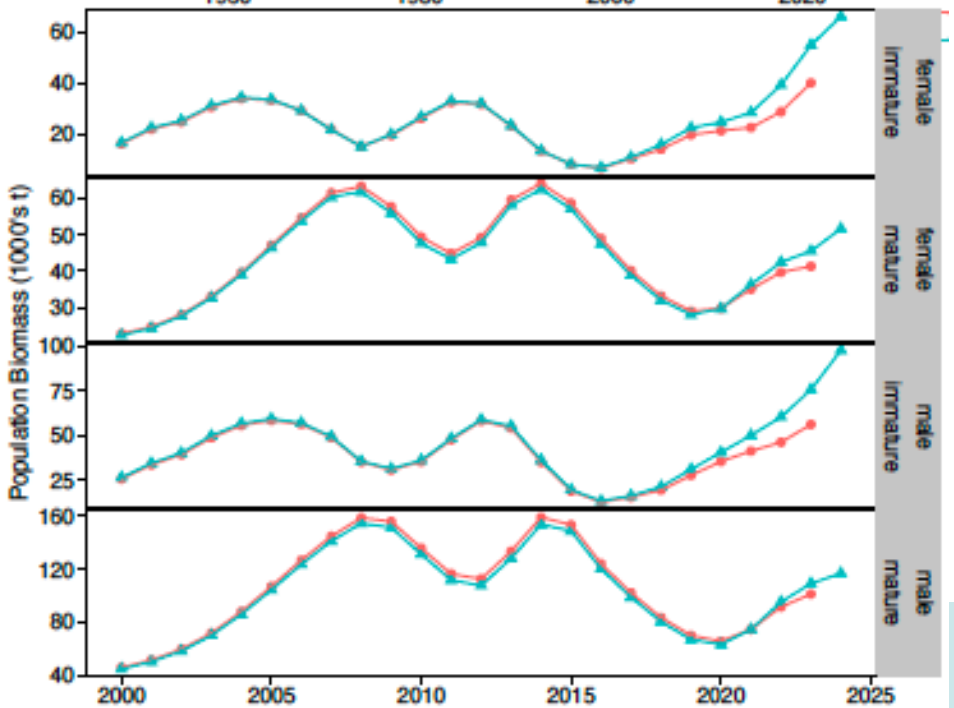
Estimated Population Quantities







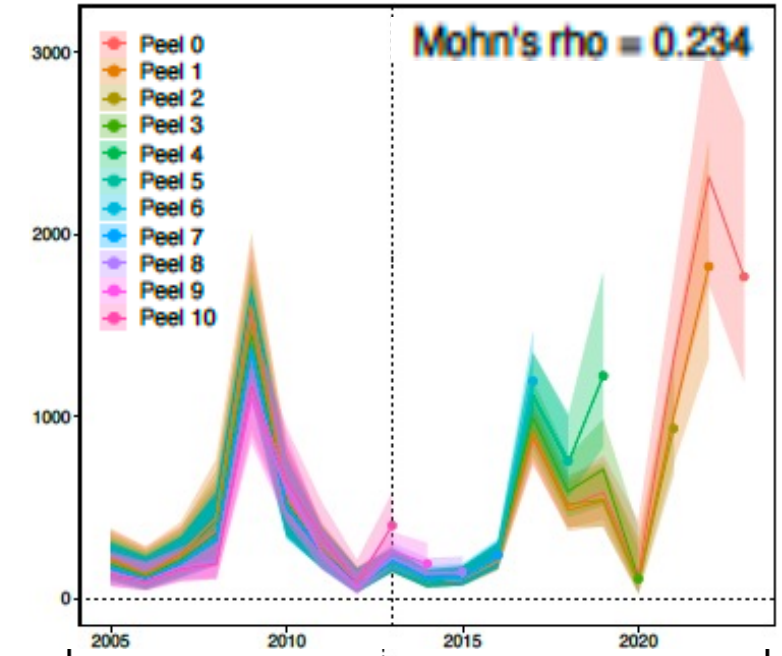




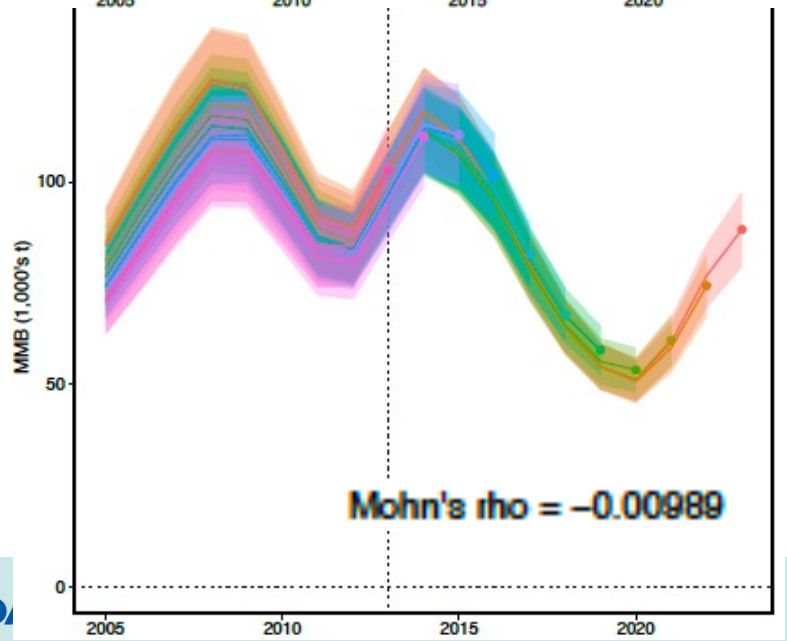
Retrospective Patterns & Historical Comparisons

retrospective comparisons

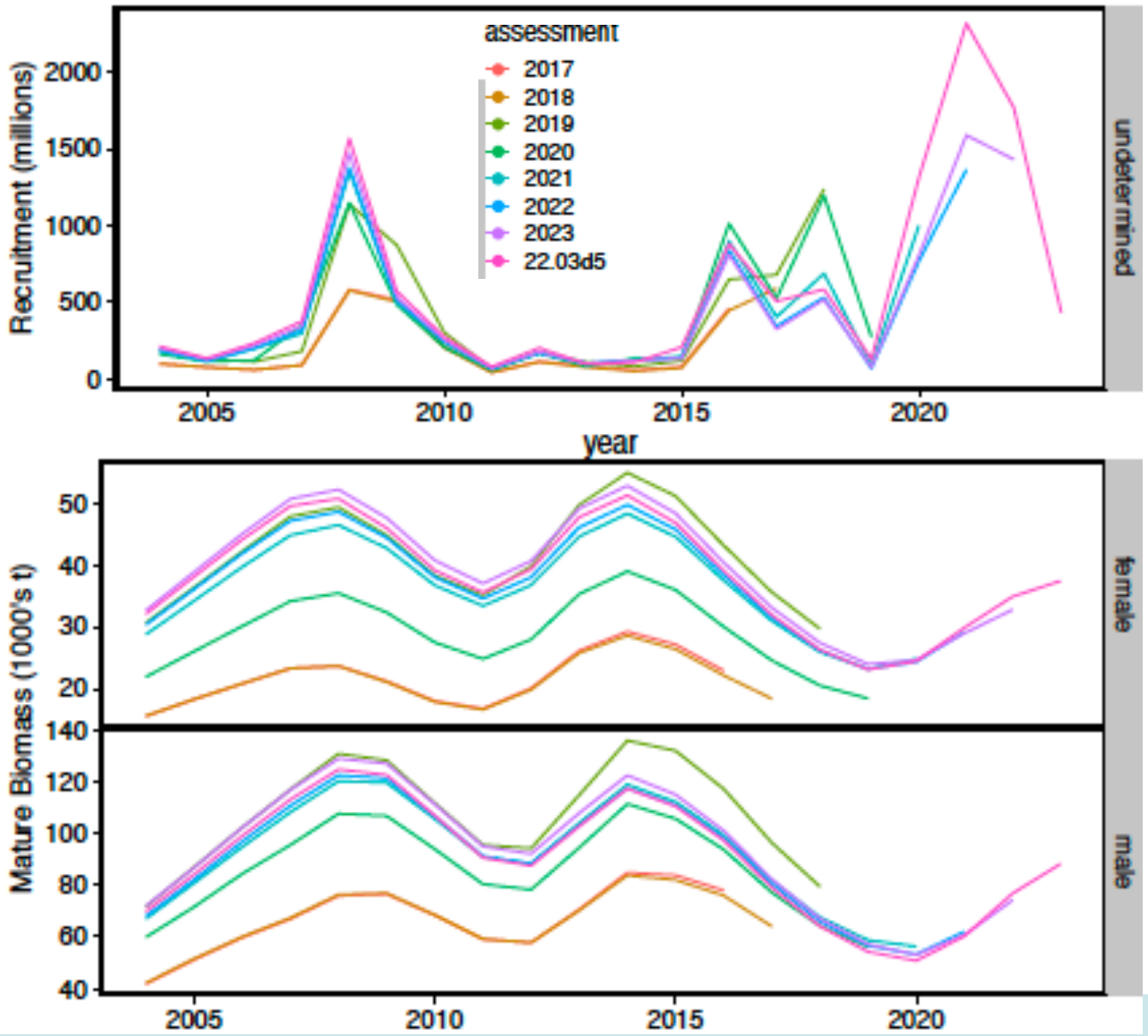
recruitment



MMB



historical comparisons (different models)

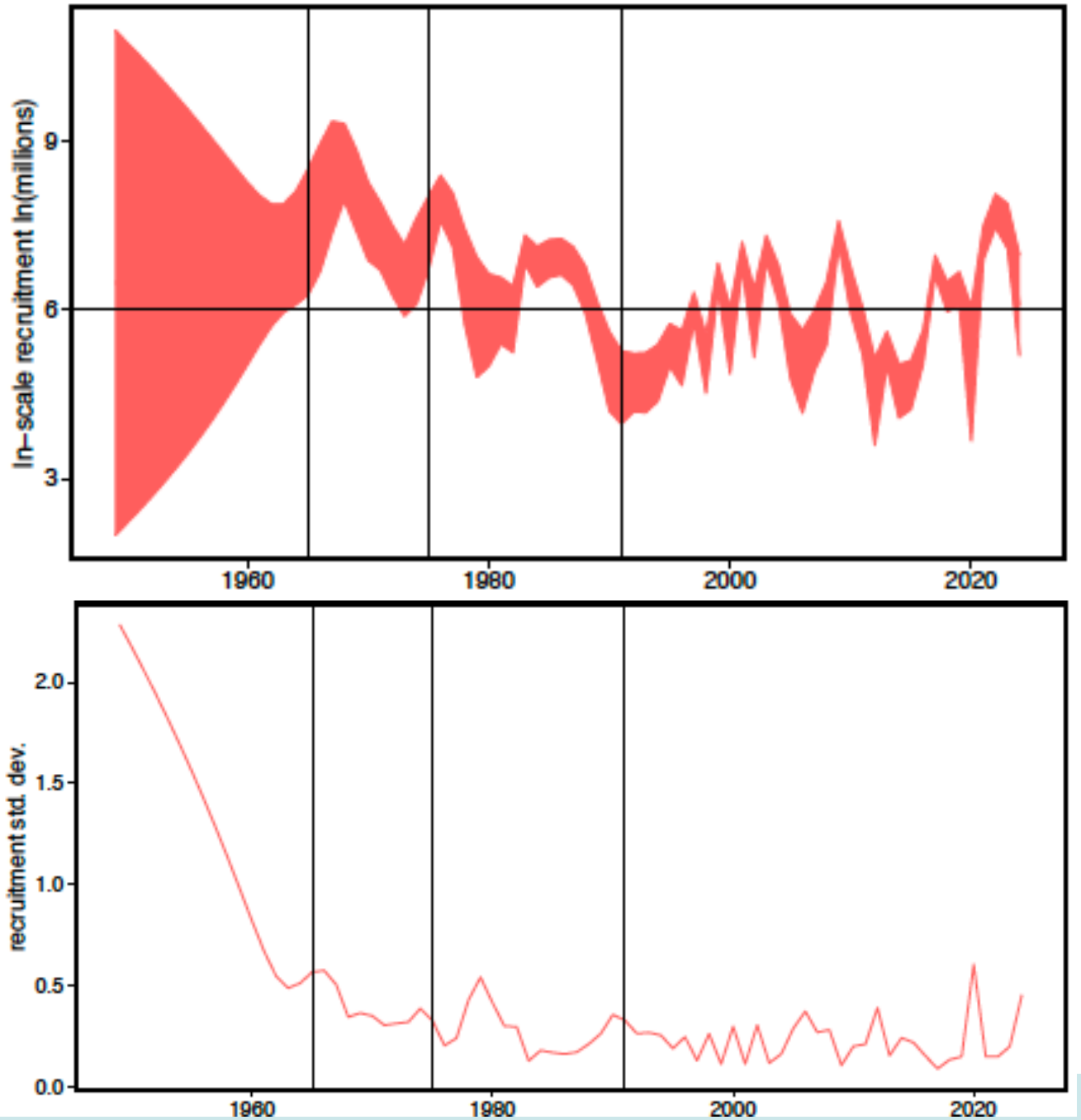


Average recruitment time period

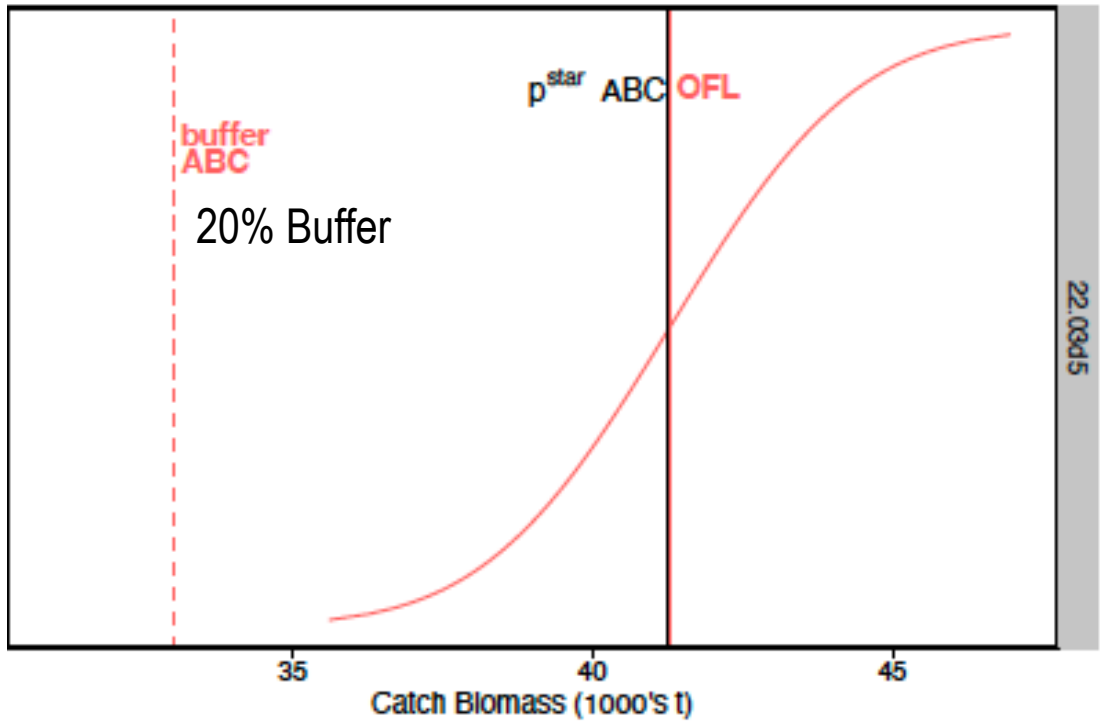
Author's recommendation

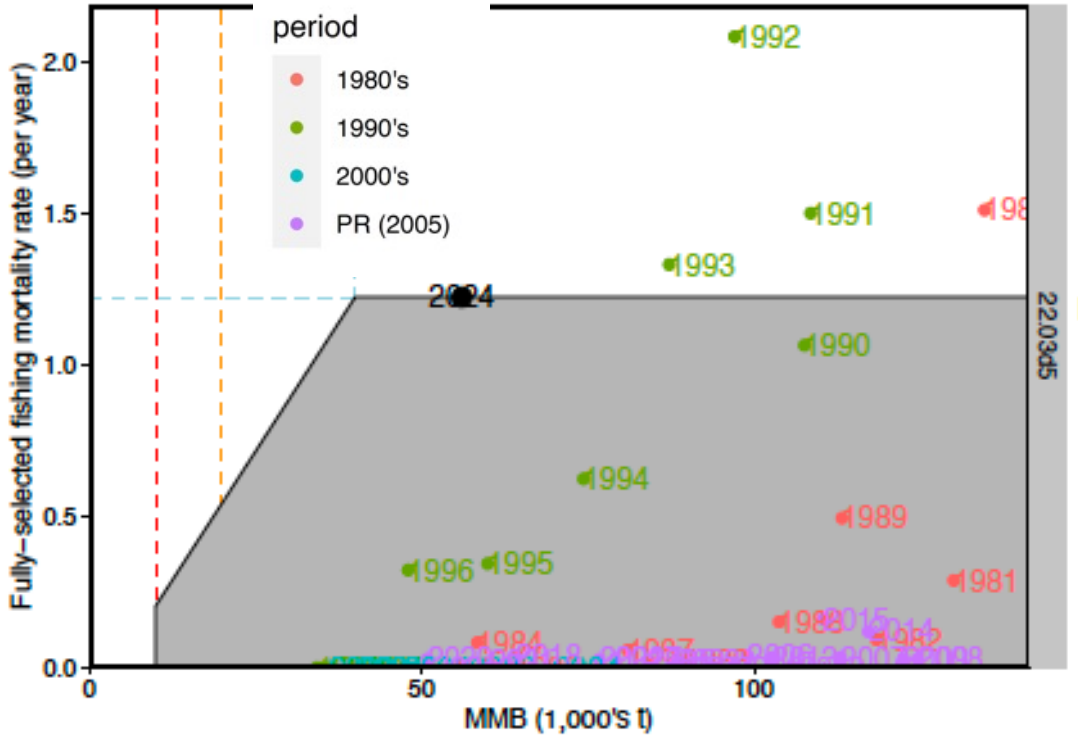
- Drop terminal year estimate
  - larger uncertainty
  - consistent with other assessments
  - consistent with last year

- time period: 1982-2023 (year of entry into population)



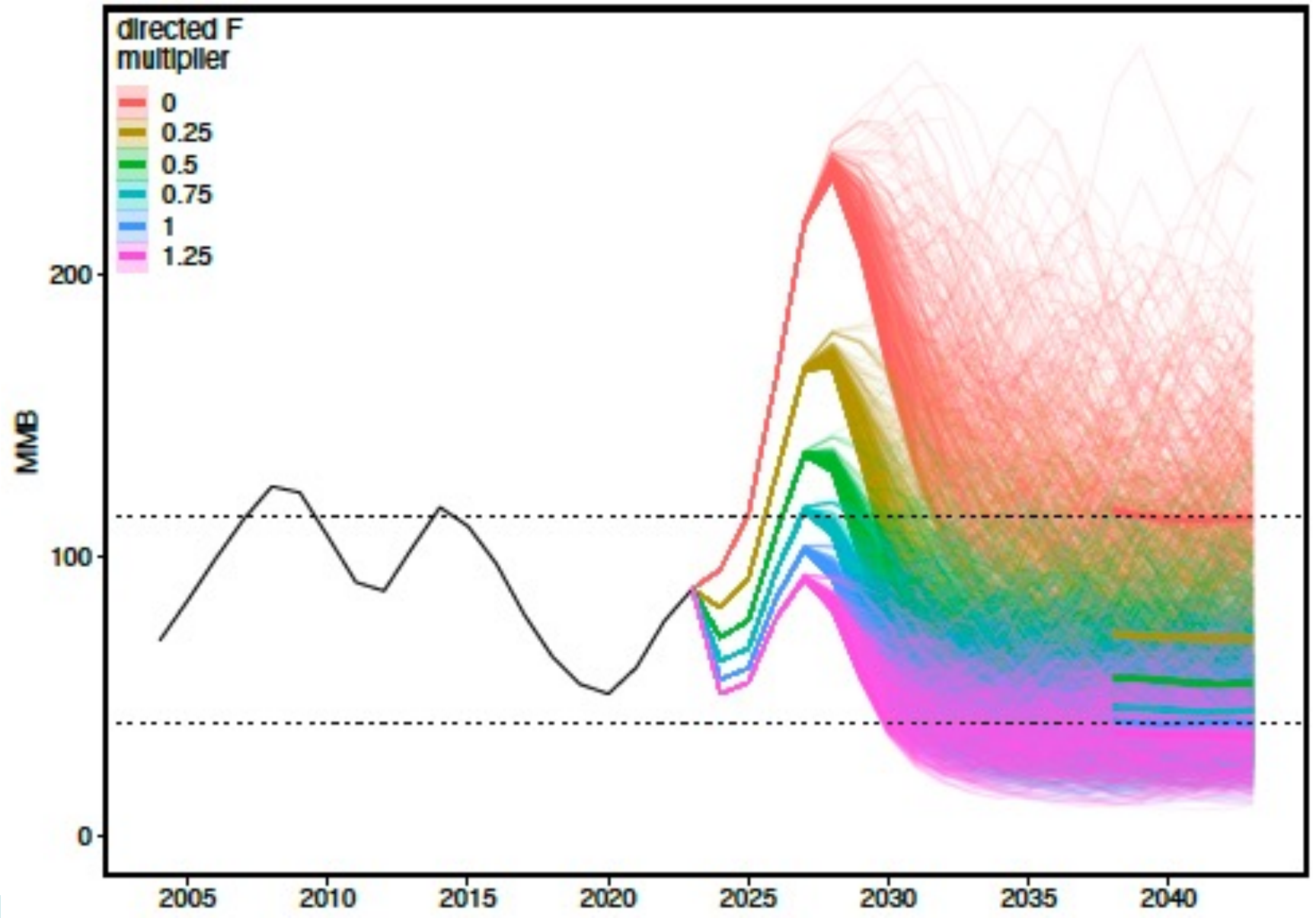
Stock Status: Tier 3a





Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2020/21	17.97	56.34	1.07	0.66	0.96	21.13	16.90
2021/22	17.37	62.05	0.50	0.49	0.78	27.17	21.74
2022/23	18.19	74.17	0.91	0.91	1.19	32.81	26.25
2023/24	20.00	88.21	0.94	0.94	1.09	36.20	27.15
2024/25	NA	56.06	NA	NA	NA	41.29	33.03

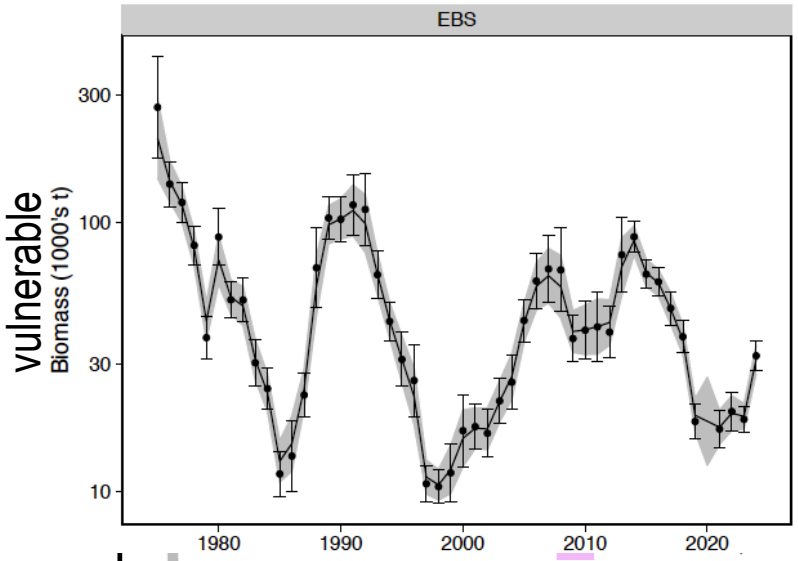
Projections from MLE

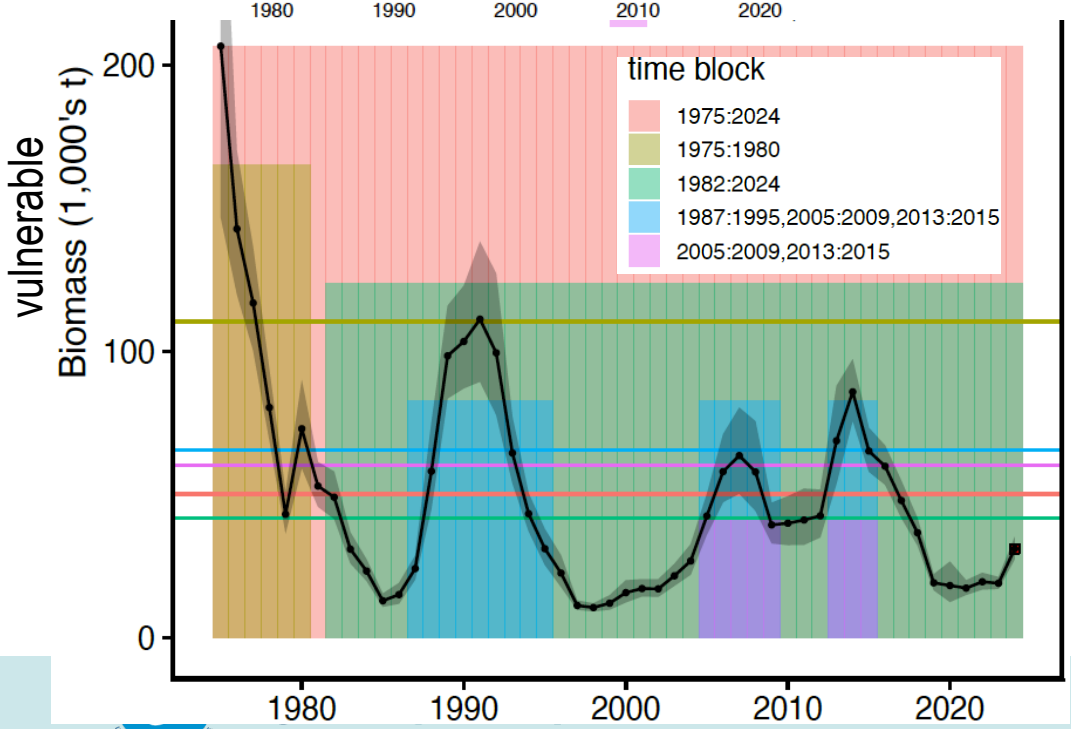


B_{100}

$B_{35\%}$

Tier 4 "Fallback"





time block	M	B	B_{MSY}	status	F_{OFL}	OFL
1975:2024	0.23	31.15	50.28	0.62	0.13	3.87
1975:1980	0.23	31.15	110.53	0.28	0.05	1.41
1982:2024	0.23	31.15	41.81	0.75	0.16	4.74
1987:1995,2005:2009,2013:2015	0.23	31.15	65.68	0.47	0.10	2.84
2005:2009,2013:2015	0.23	31.15	60.25	0.52	0.11	3.15

biomass units: 1000's t

- OFL: 4.74 thousand t
- ABC buffer
  - cv on model-estimated terminal biomass (9.7%), rounded to 5% intervals (10%), as basis
  - buffer = 90%
- ABC = 4.27 thousand t

Recommendations

- Tier 3a Model 22.03d5
  - Based on previously-adopted assessment model
  - jitter analysis successful in identifying MLE
  - small max gradient at MLE
  - no parameter-at-bounds
  - all results similar to 2023 assessment
  - but not much improvement on previous assessment
    - abundance of large crab still overestimated
    - OFL seems wildly optimistic

- ABC buffer: 20% (SSC adopted 20% last year)
  - continuing concern over model performance
  - continuing concern over $F_{35\%}$, $B_{35\%}$ as metrics for a sustainable fishery
  - reduced concern over movement of recruits into larger sizes

Future work (top priority)

- GMACS
  - ~~start simple, build complexity~~
  - develop model for head-to-head comparison with TCSAM02 assessment model
  - complete extensive comparison with assessment model
  - present comparison at January Modeling Workshop

- Complete BSFRF/NMFS *selectivity* analysis
  - 2018 BSFRF Tanner crab data provided September 2023
    - data incorporated into 2024 assessment as previously
  - selectivity analysis underway (Tech Memo in development)
  - present analysis at January Modeling Workshop

Acknowledgments

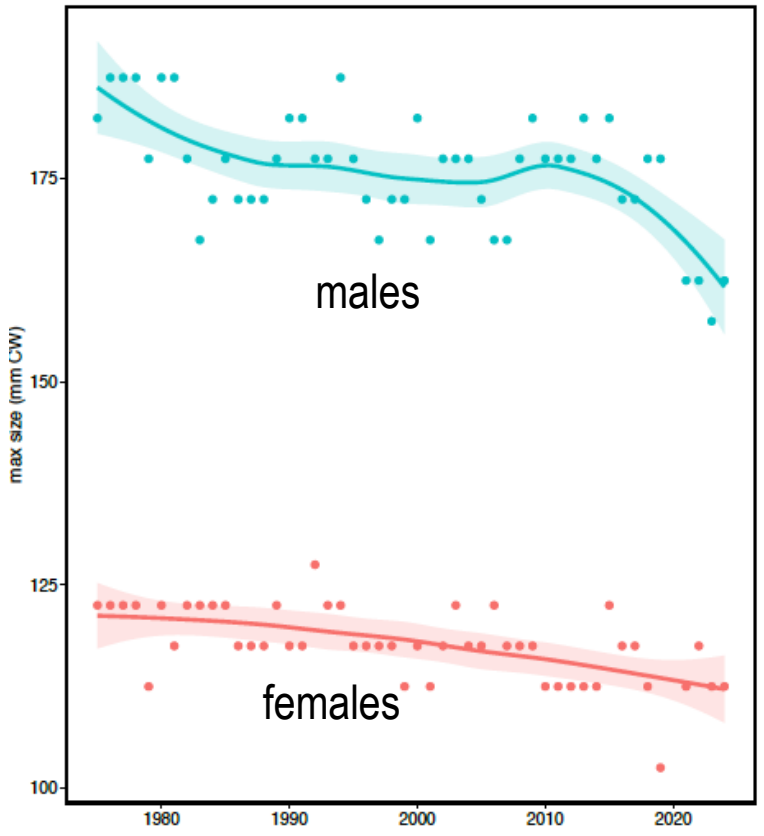
- EBS survey crews & scientific staff
- Ben Daly, Ethan Nichols
- Jon Richar
- Erin Fedewa, Kalei Shotwell, Ebett Siddon
- Scott Goodman

Risk Table-Draft

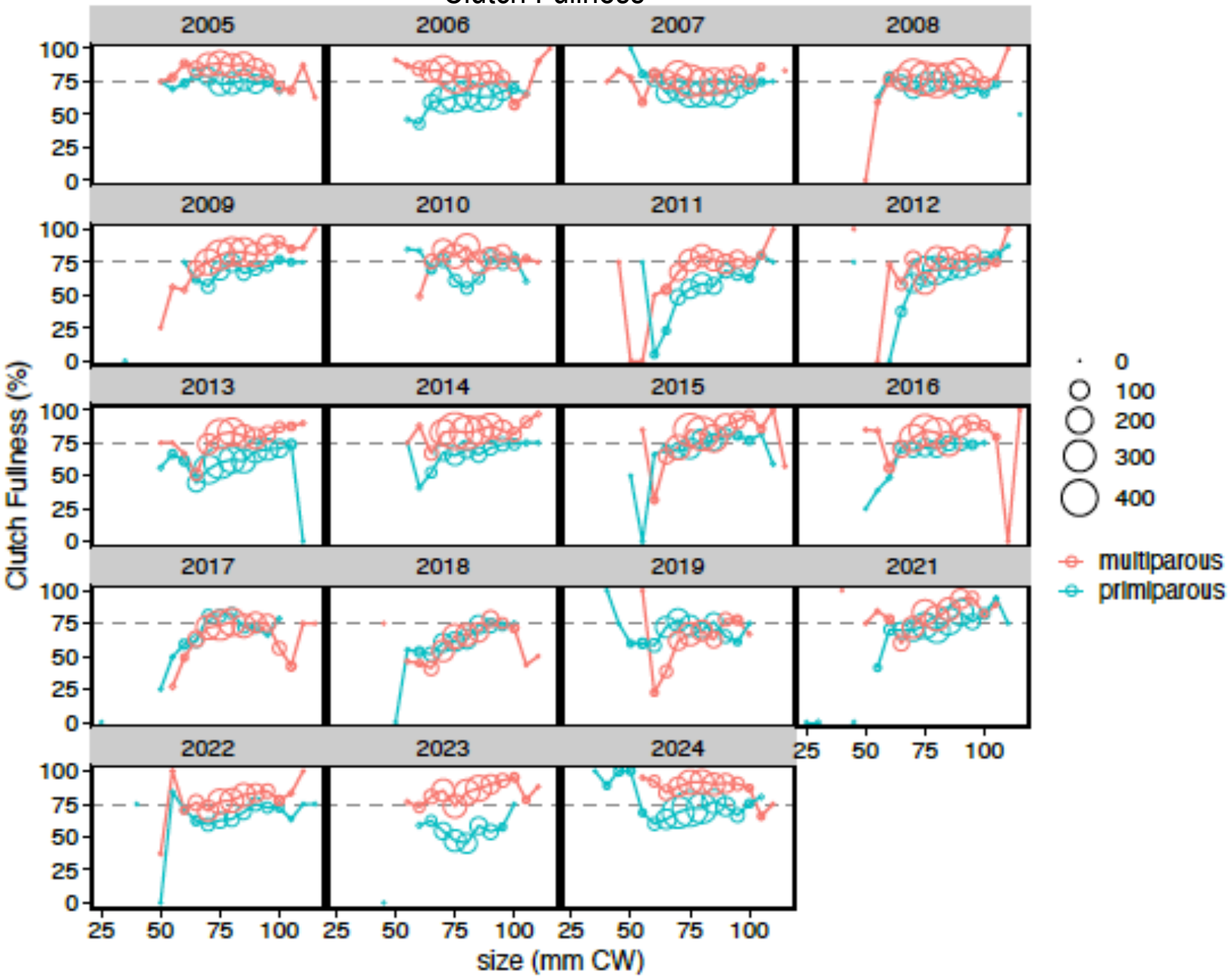
	Assessment-related considerations	*Population dynamics considerations*	*Environmental/ecosystem considerations*	*Fishery Performance*
Level 1: Normal	Typical to moderately increased uncertainty/minor unresolved issues in assessment.	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental/ecosystem concerns	No apparent fishery/resource-use performance and/or behavior concerns
Level 2: Increased concern	Major problems with the stock assessment; very poor fits to data; high level of uncertainty; strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level as the stock, and/or b) up or down trophic levels (i.e., predators and prey of the stock)	Multiple indicators showing consistent adverse signals a) across different sectors, and/or b) different gear types
Level 3: Extreme concern	Severe problems with the stock assessment; severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented; More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns.	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock; Potential for cascading effects on other ecosystem components	Extreme anomalies in multiple performance indicators that are highly likely to impact the stock

Population Dynamics

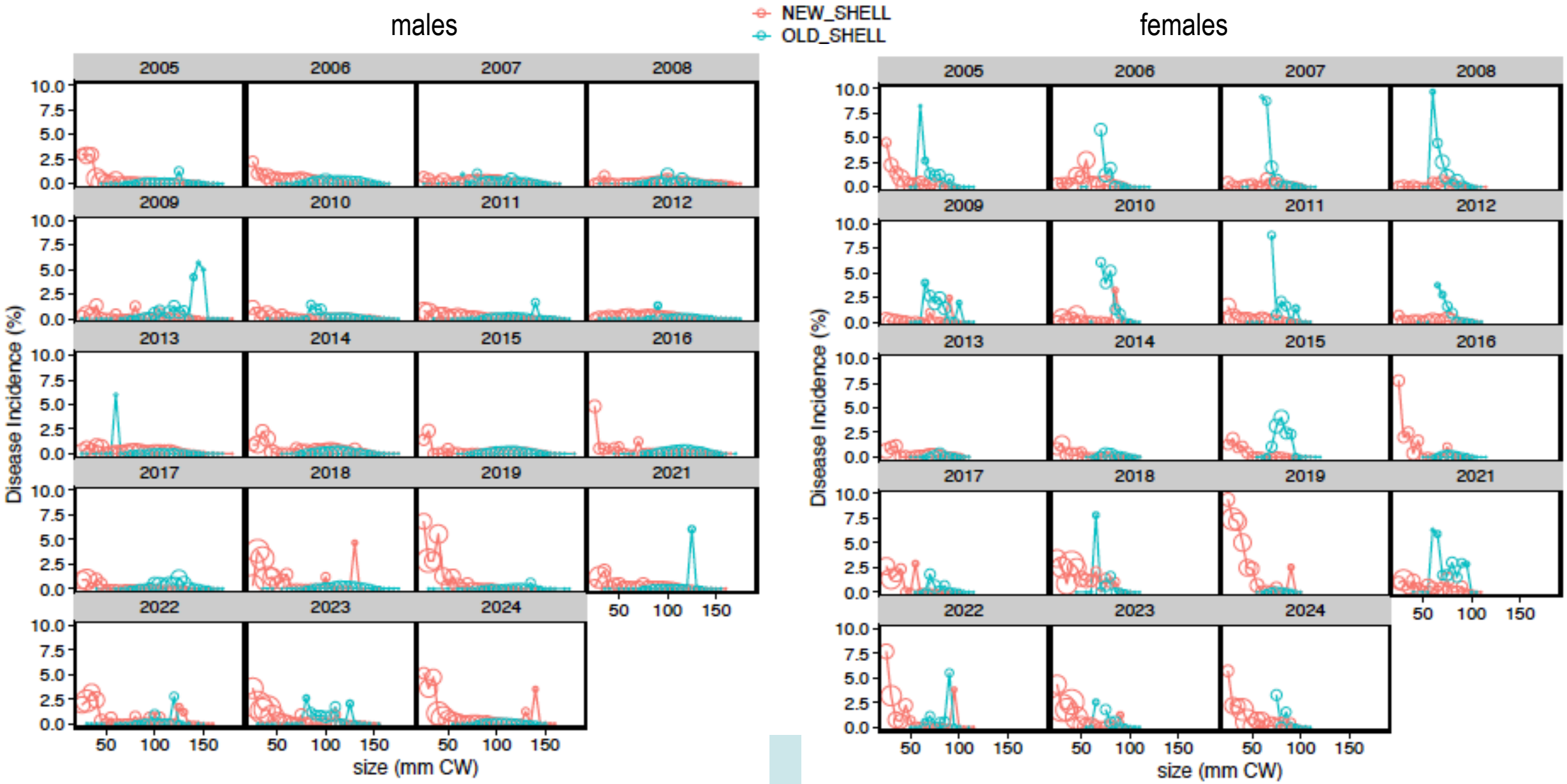
max size in survey



Clutch Fullness

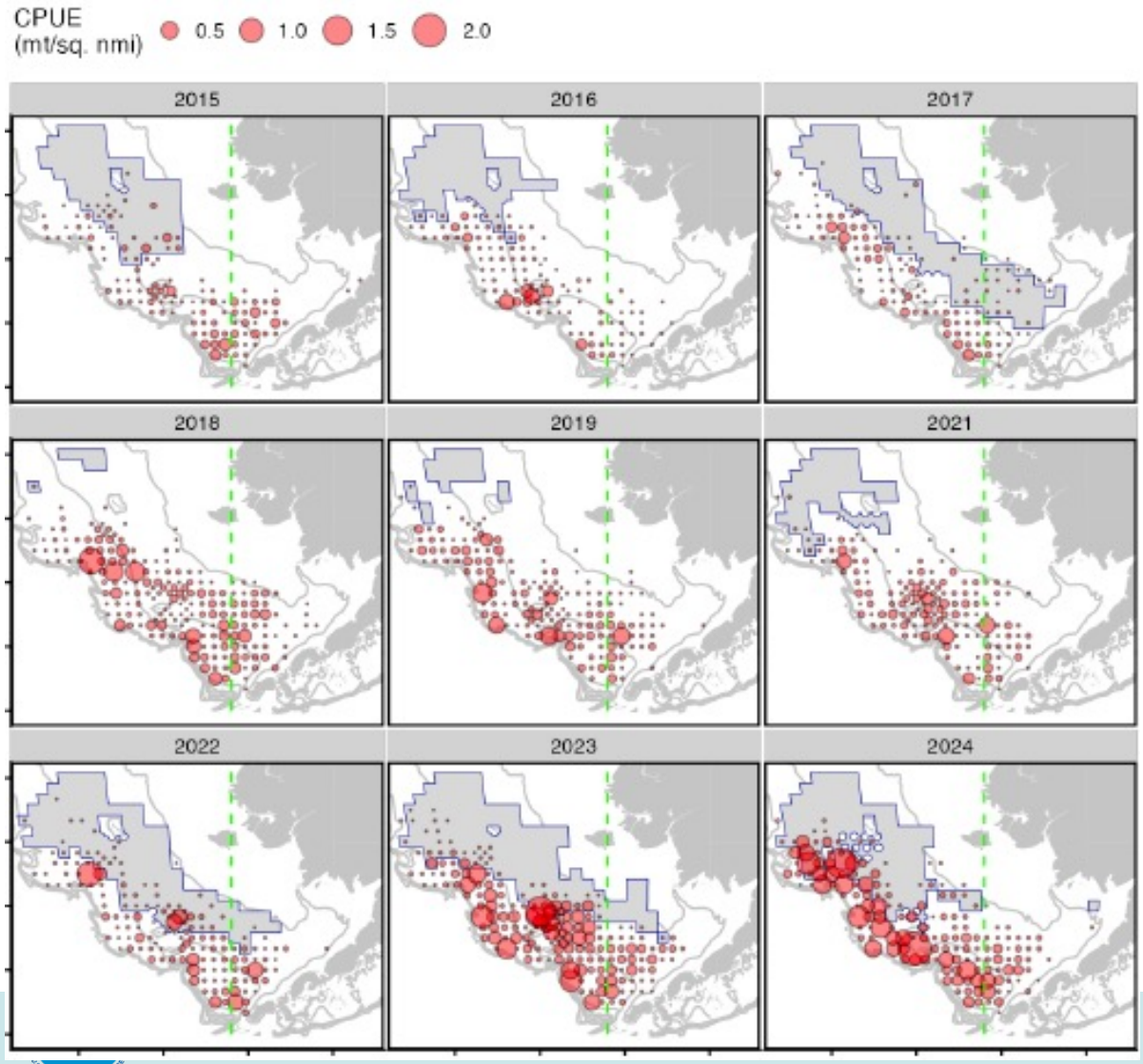


Disease prevalence in NMFS Survey

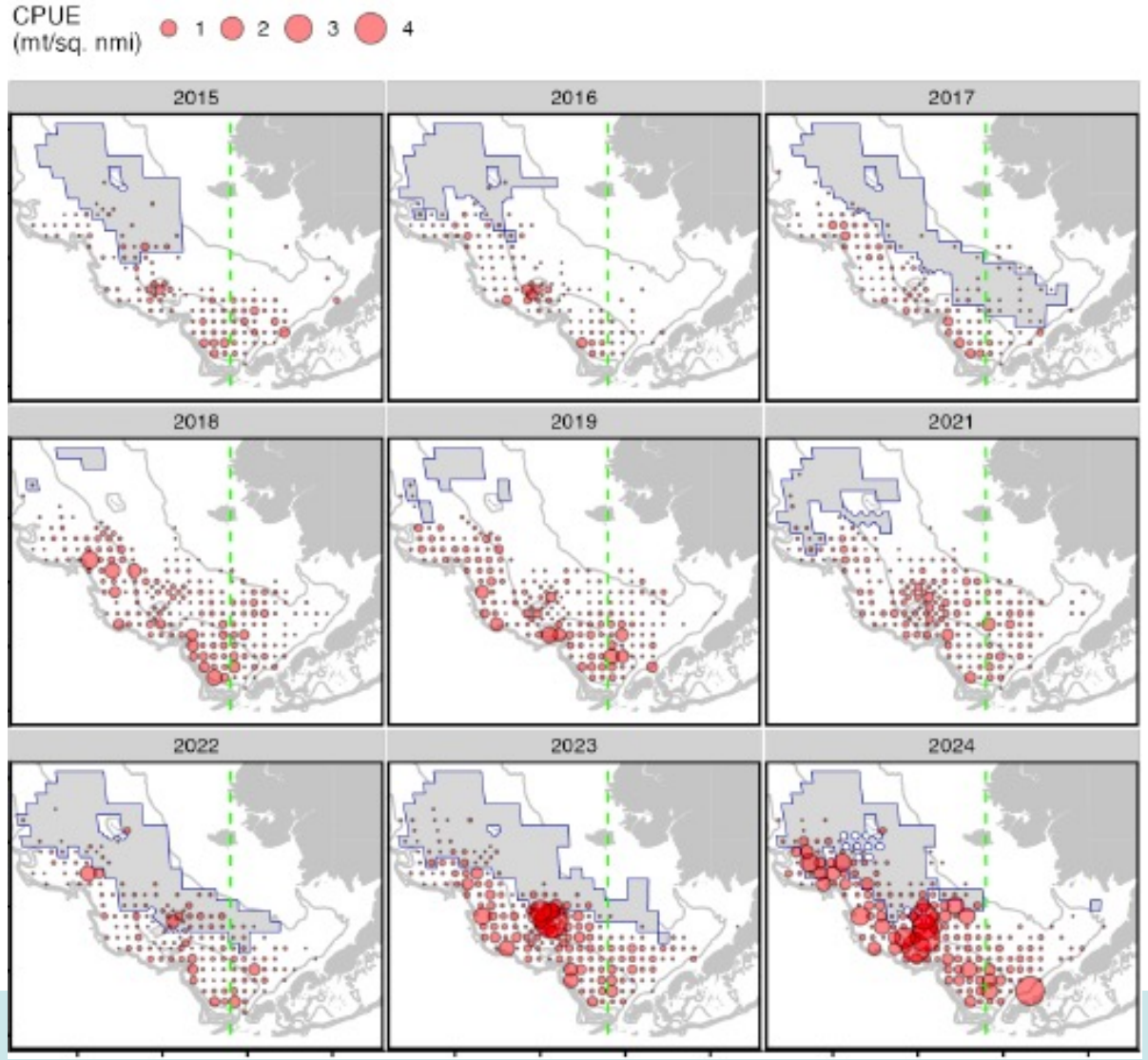


Spatial patterns

small males

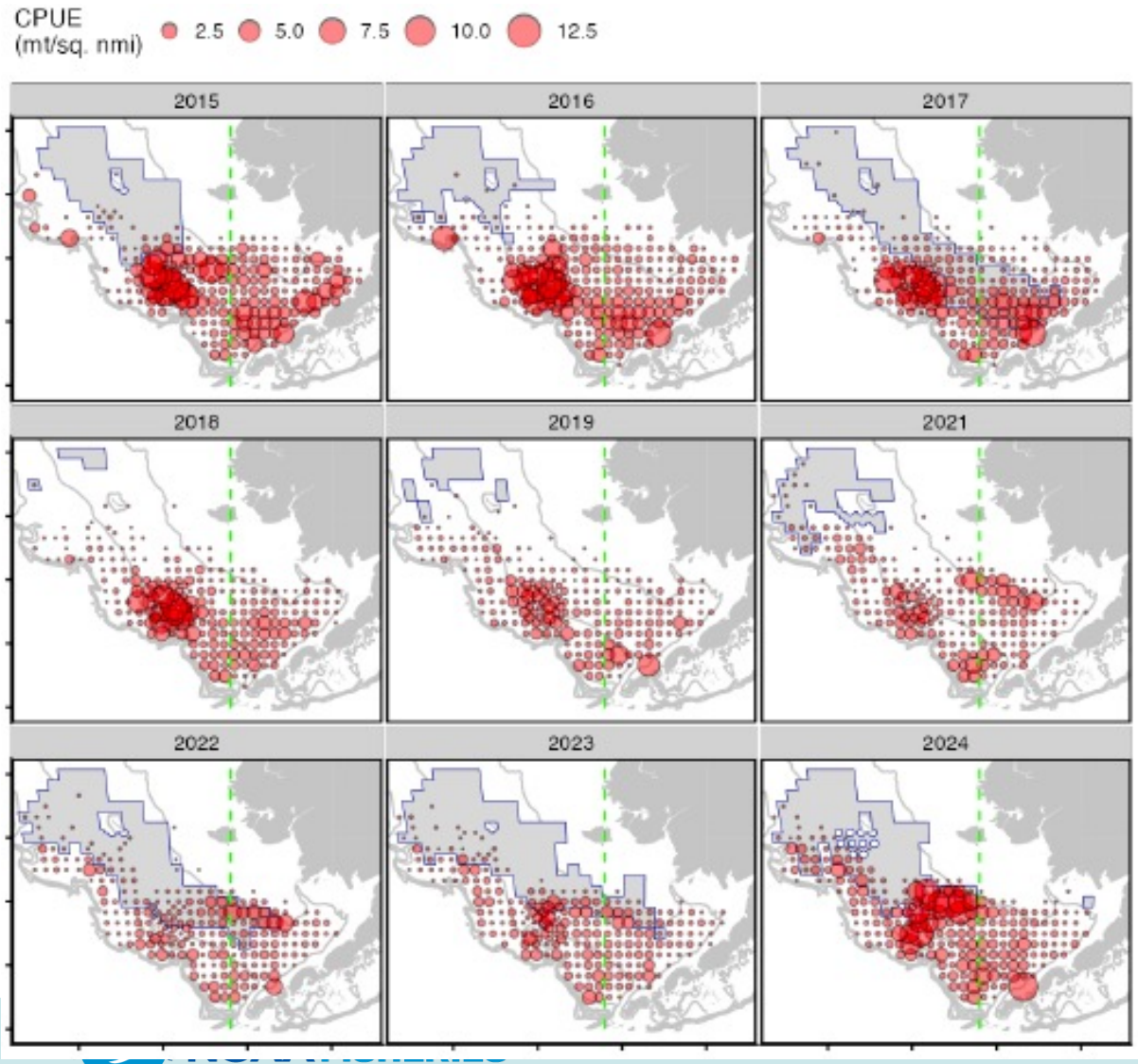


immature females

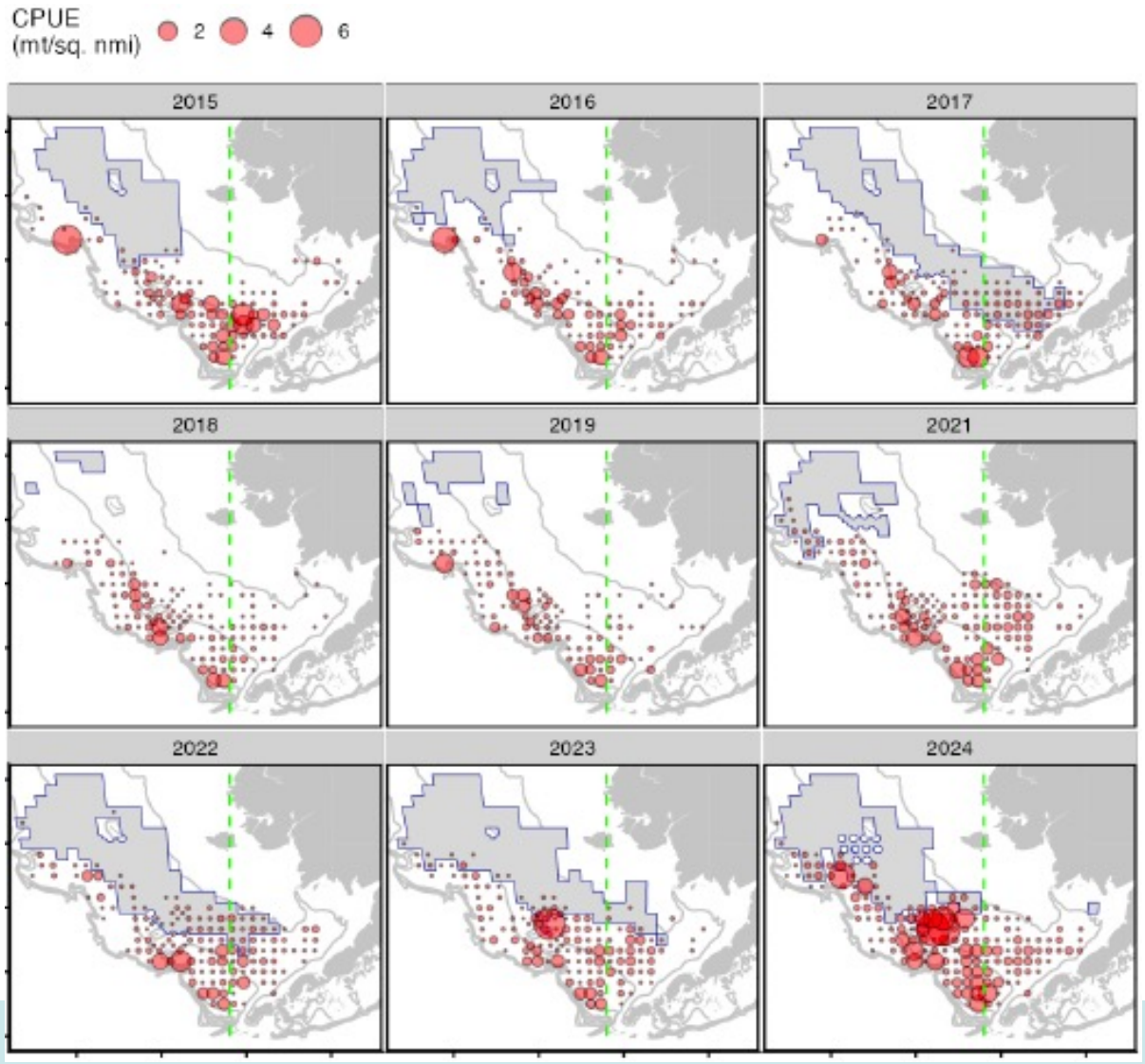


Spatial patterns

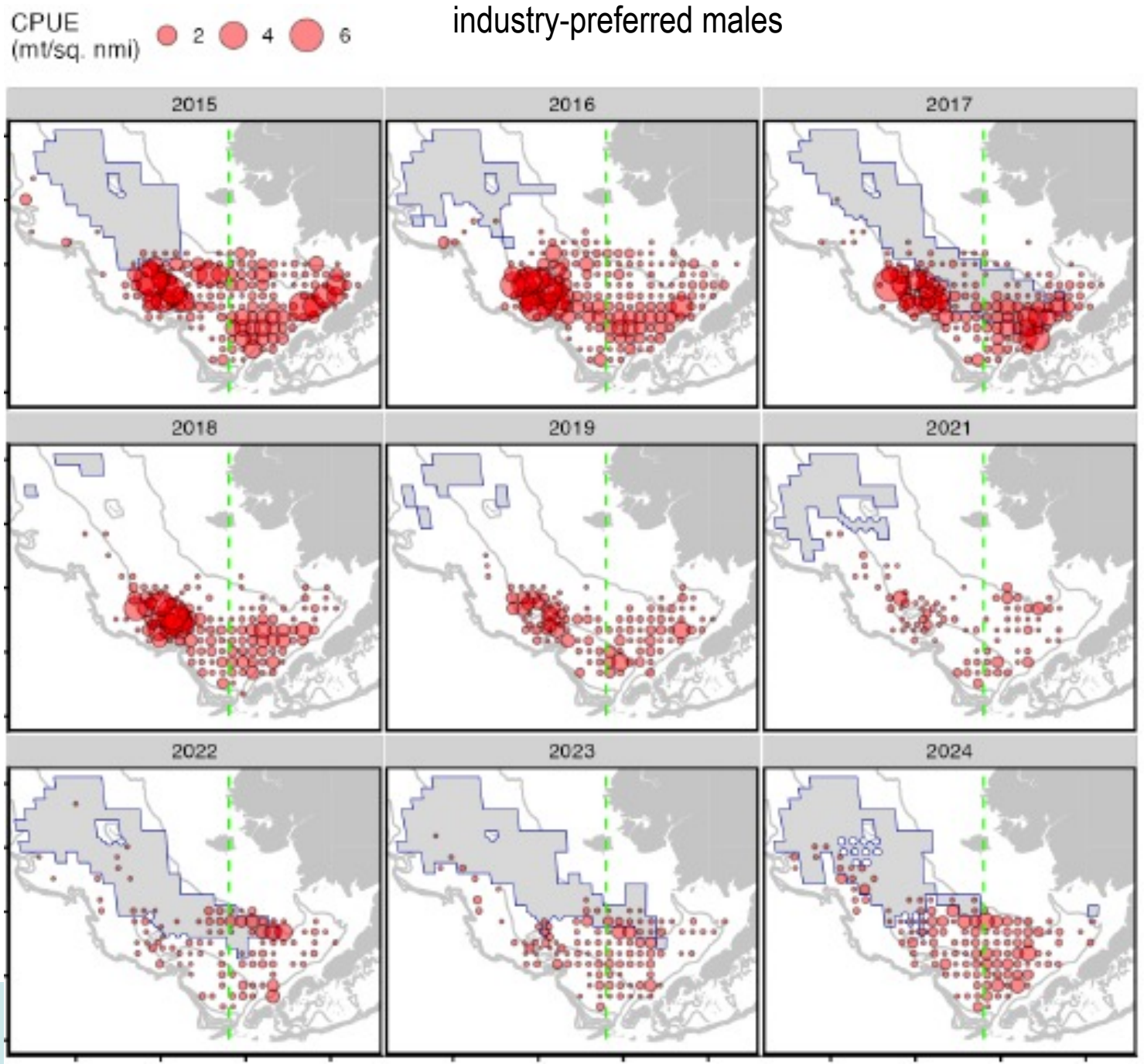
large (> 60 mm CW) males



mature females

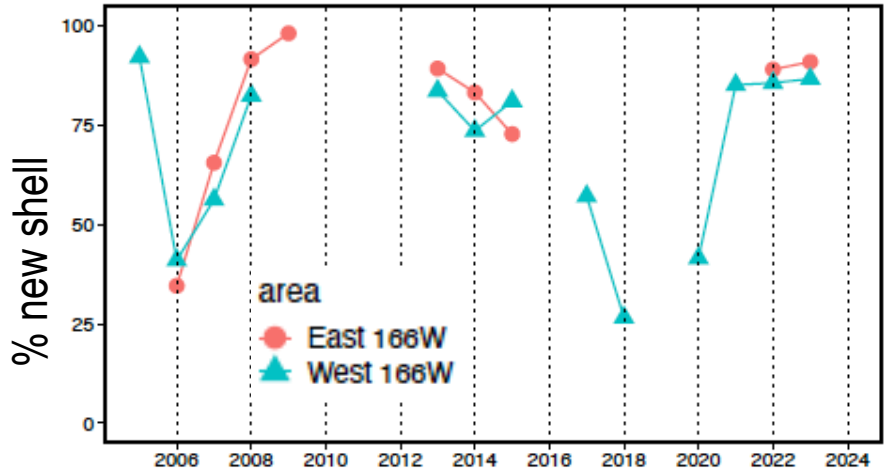


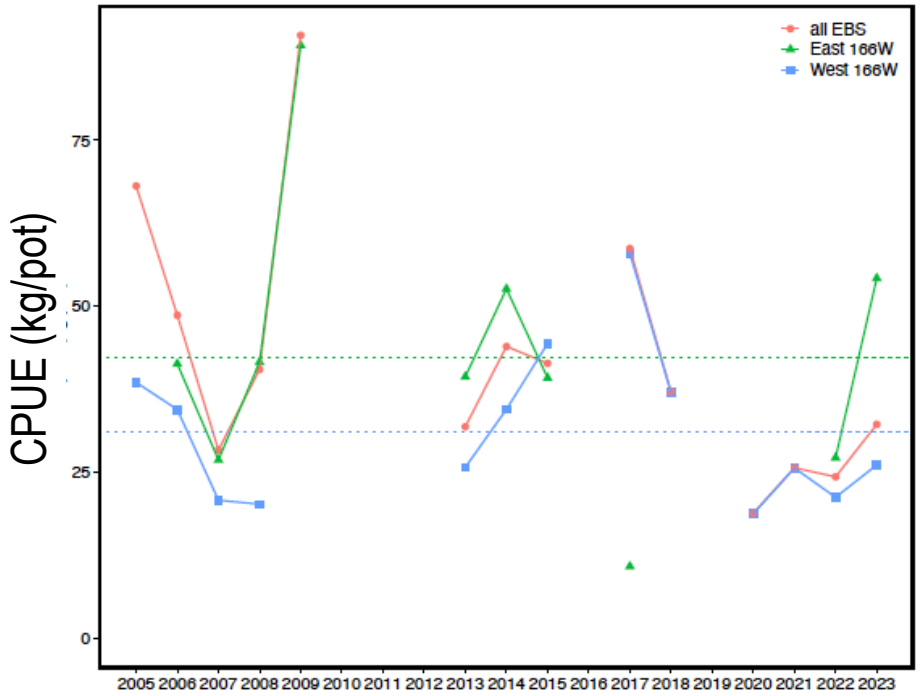
Spatial patterns

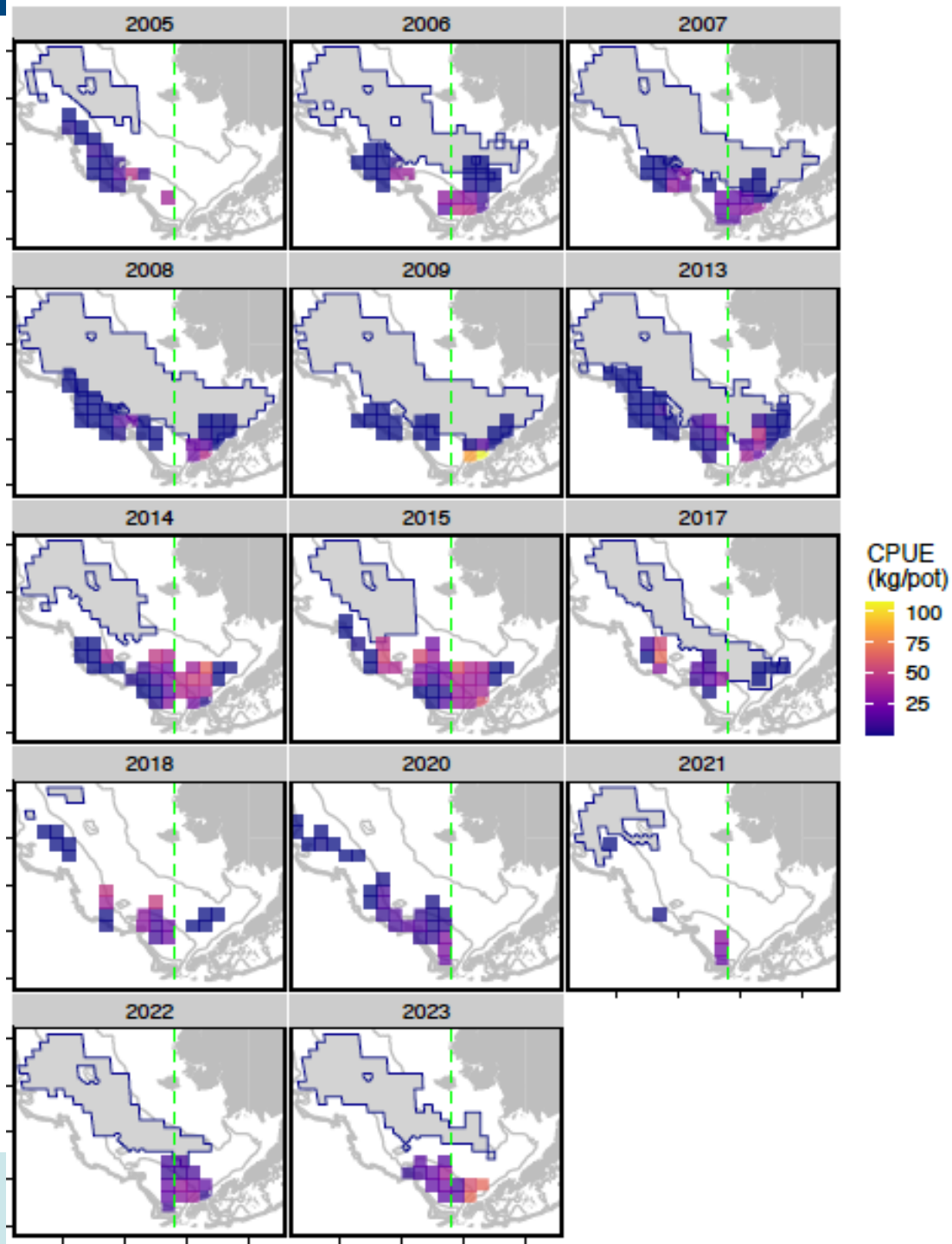


industry-preferred males

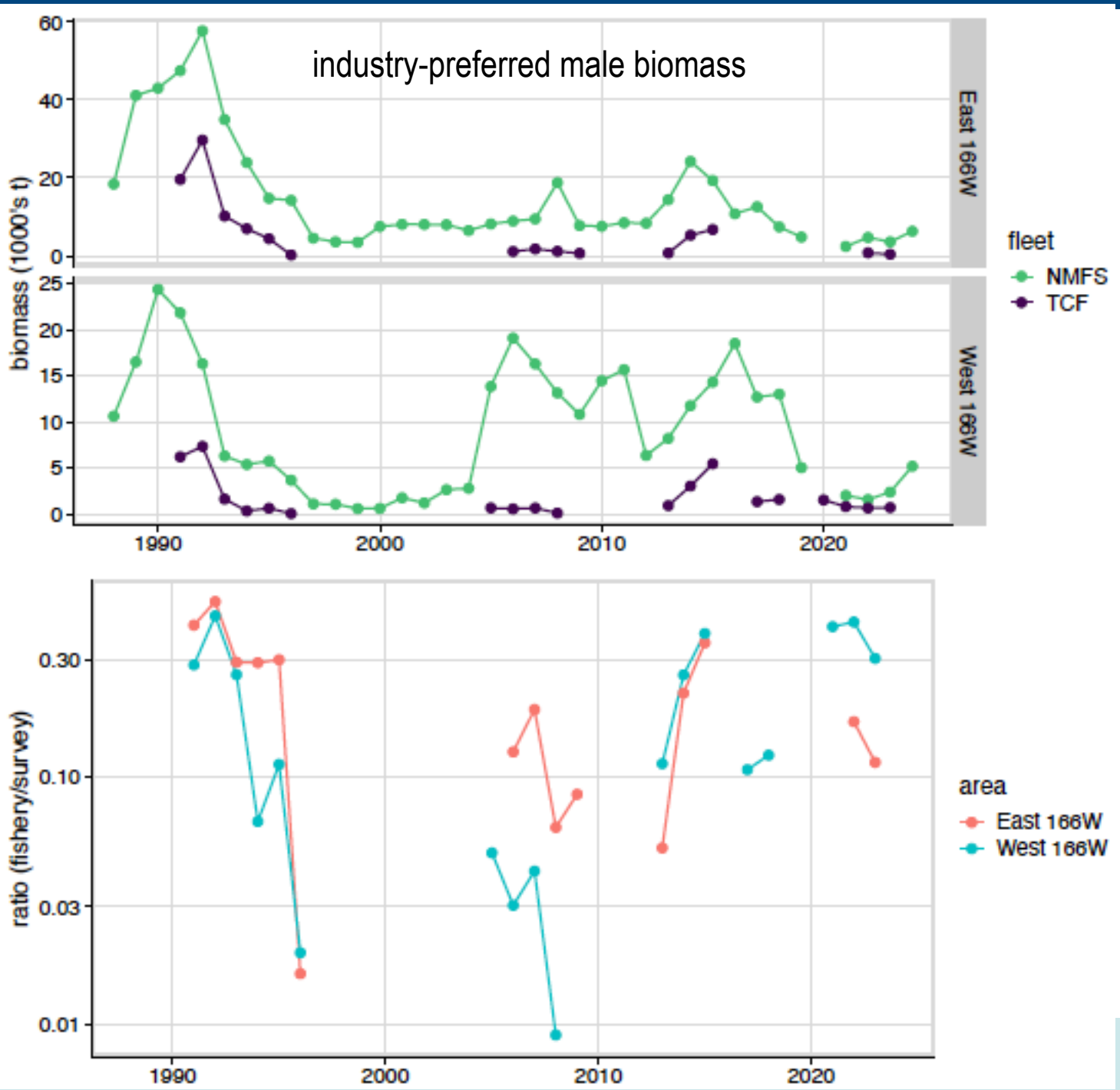
Fishery: Retained catch







Survey-Fishery Comparisons



Risk Table

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ecosystem considerations*	*Fishery Performance*
Level 1: Normal	Level 2: Increased concern	Level 1: Normal	Level 1: Normal