Standardizing sablefish catch-per-unit-effort (CPUE) across gear types and data sources

September Groundfish Plan Team 2023

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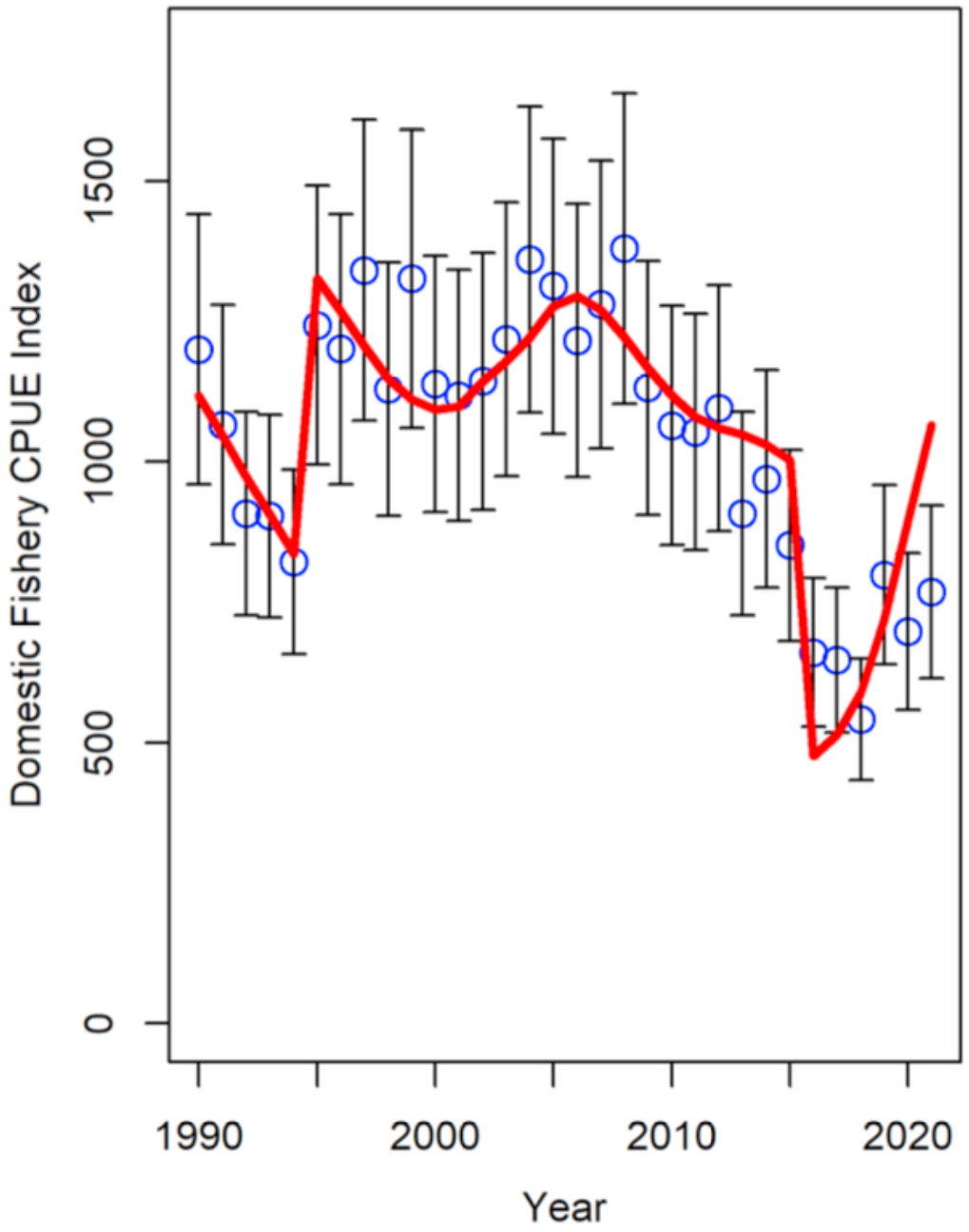
Motivation

- Current assessment assumes a single fishery fleet, combining HAL and pot gear data
  - However, the fishery index associated with the fleet only uses HAL data.
    - Assumes a nominal CPUE index
    - Time-series: 1990 – 2019
      - Uses data pre-IFQ



Objective

Assimilate hook-and-line and pot gear data from both observer and logbook records to develop a standardized index of abundance for Alaska sablefish

Methods: Data sources

- Vessel Logbooks – Joint NMFS IPHC program
  - n = 116,987
- Onboard observers – North Pacific Observer Program
  - n = 43,518
- HAL: n = 123,699; Pot: n = 36,806
- Model index time-series = 1995 – 2022
  - Does not use data during pre-IFQ period

Methods: Analysis

- Hierarchical cluster to define target strategies (included as a covariate)
- Generalized Additive Models (GAMs)
- Model selection:
  - BIC
  - AIC
  - 5-fold cross validation
    - Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and R^2

Methods: Model Structure

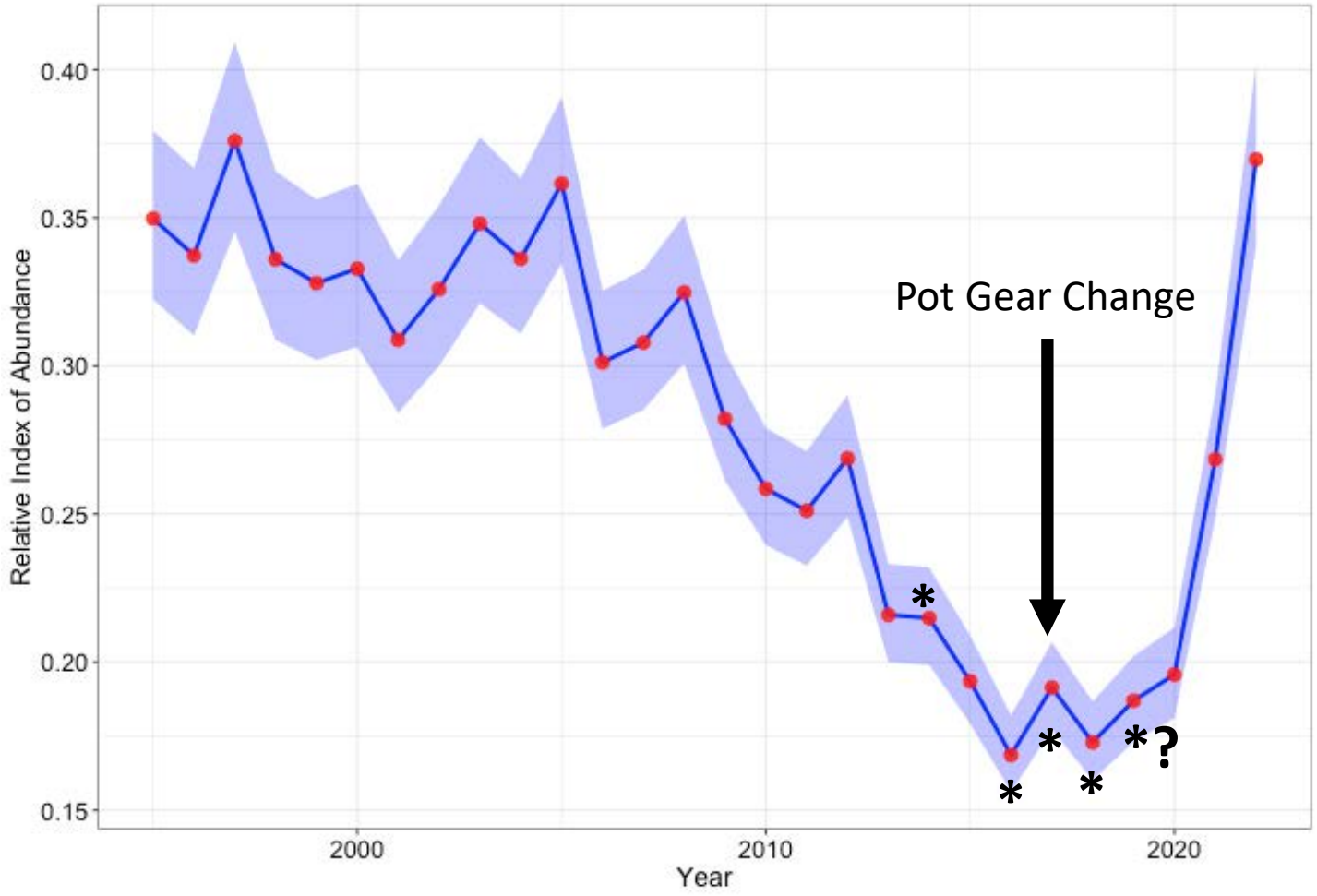
- Incorporates catch and effort data from **BOTH hook-and-line and pot gear**
- Tweedie-distributed errors
- Effort treated as an offset
  - HAL CPUE = catch-per-hook
  - Pot CPUE = catch-per-pot

Full model considered:

$$\log(weight) = \text{Year} + \text{Gear type} + \text{Data type} + \text{Vessel length} + \text{Area} + + \text{Target Strategy} + \text{Processed Type} + f(\text{Day of year}) + f(\text{Bottom depth}) + f(Longtiude, Latitude) + f_{Gear\ type}(Longitude, Latitude) + \text{offset}[\log(\text{effort})] + \epsilon$$

Updated Abundance Index

Lag in increases in abundance following recruitment events, presumably due to selectivity effects



* = Recruitment events well above average

Next step: Incorporate index into 2023 assessment

Exploring alternative parameterizations to account for the emerging pot gear fleet in the sablefish stock assessment

2023 September Groundfish Plan Team

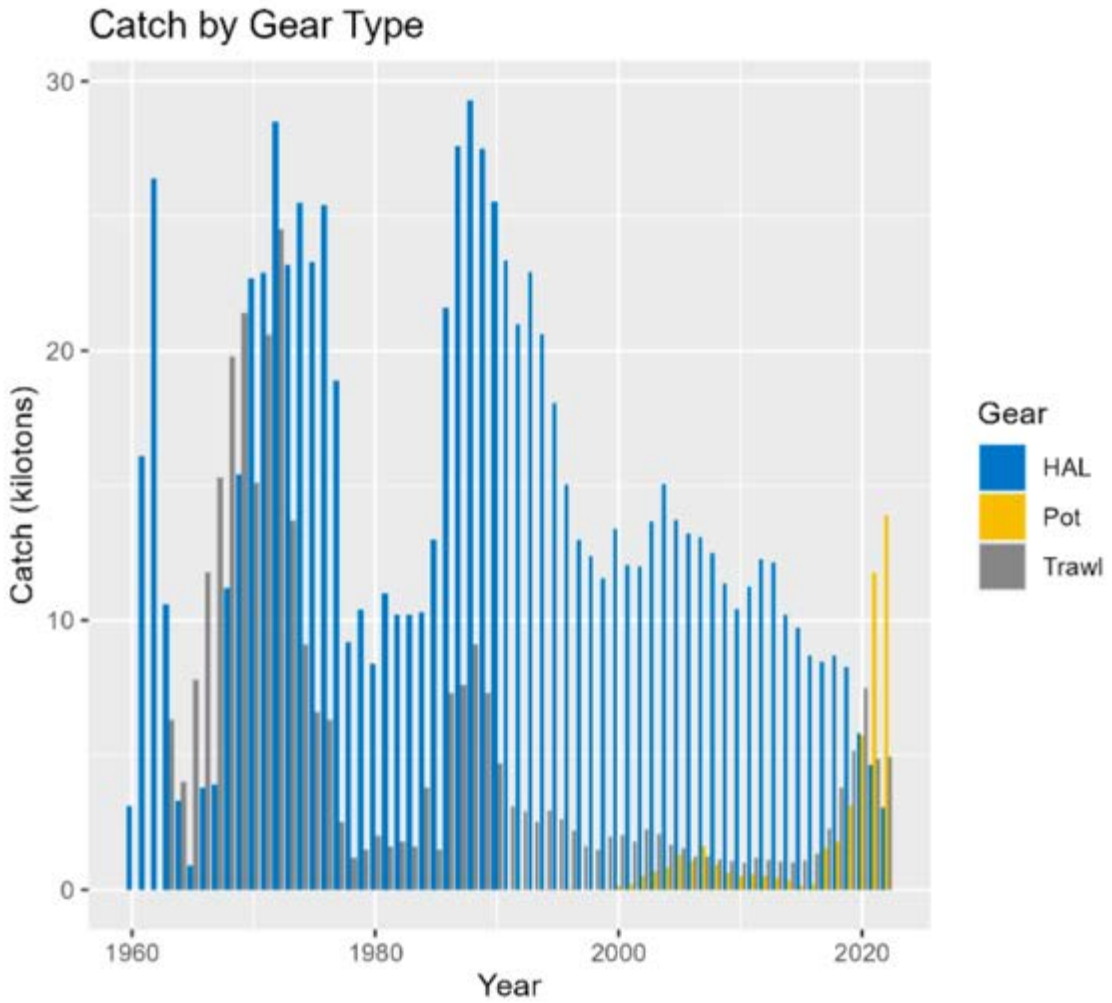
Matt Cheng, Dan Goethel, Curry Cunningham

Outline

- Background
- Objectives
- Results
- Conclusions

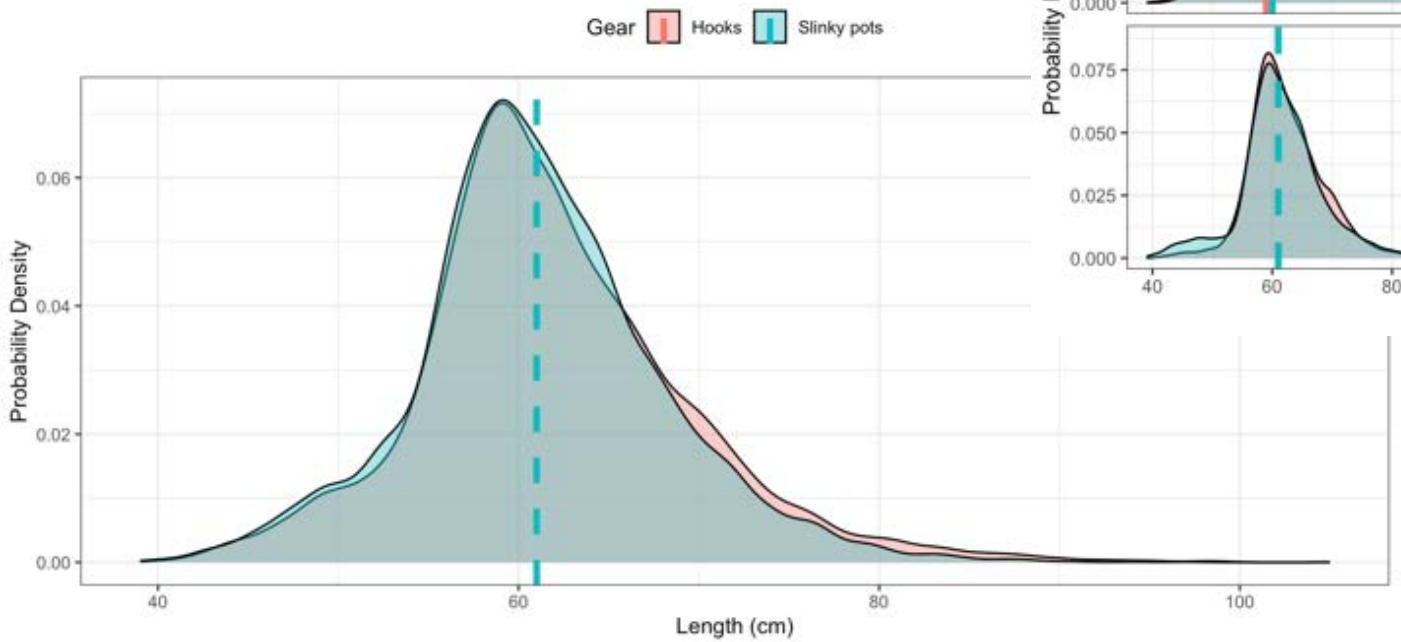
Background

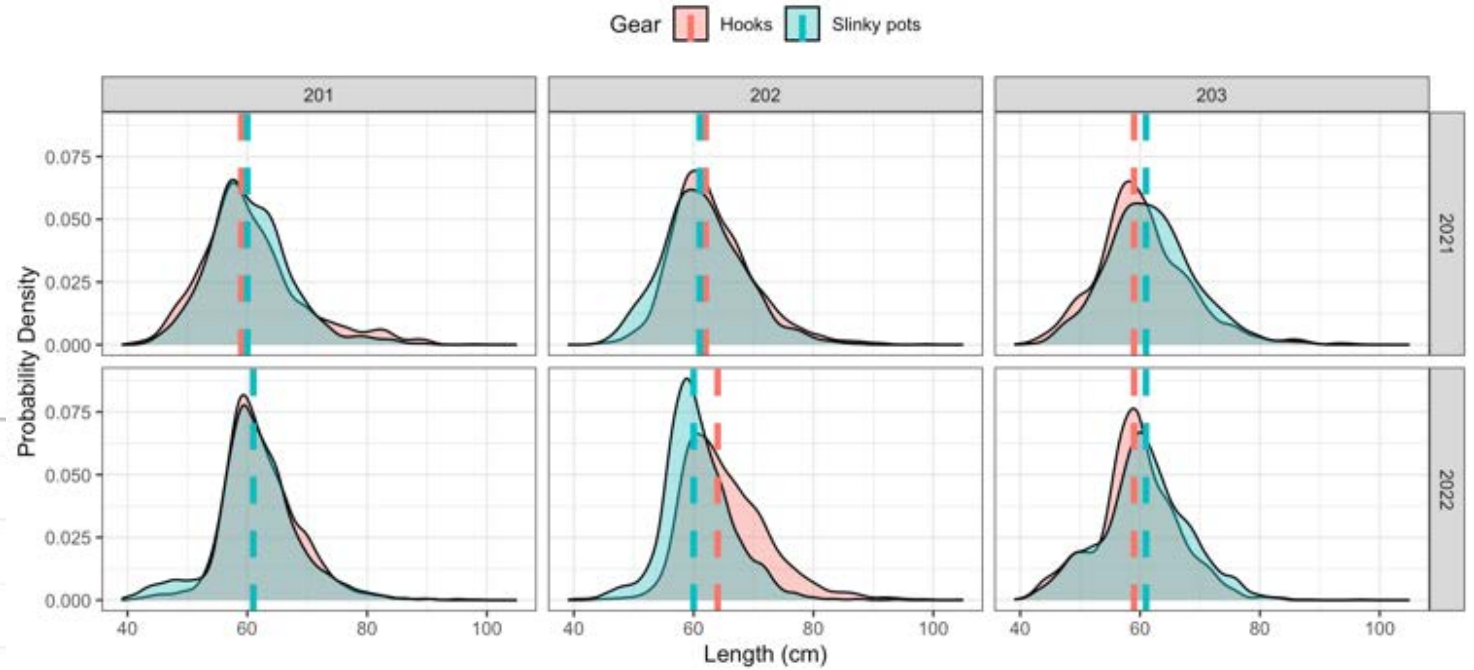
- Adoption of pot gear fishing (GOA)
  - Removals from pots have surpassed hook-and-line (HAL)
- Assessment treats the fixed-gear fleet as a single-fleet
  - Selectivity is time blocked to account for changes in fishery fleet structure



What do we know about pot selectivity?

- NMFS Sablefish Longline Survey (Experimental Leg)
  - Experiments comparing HAL gear and pot gear

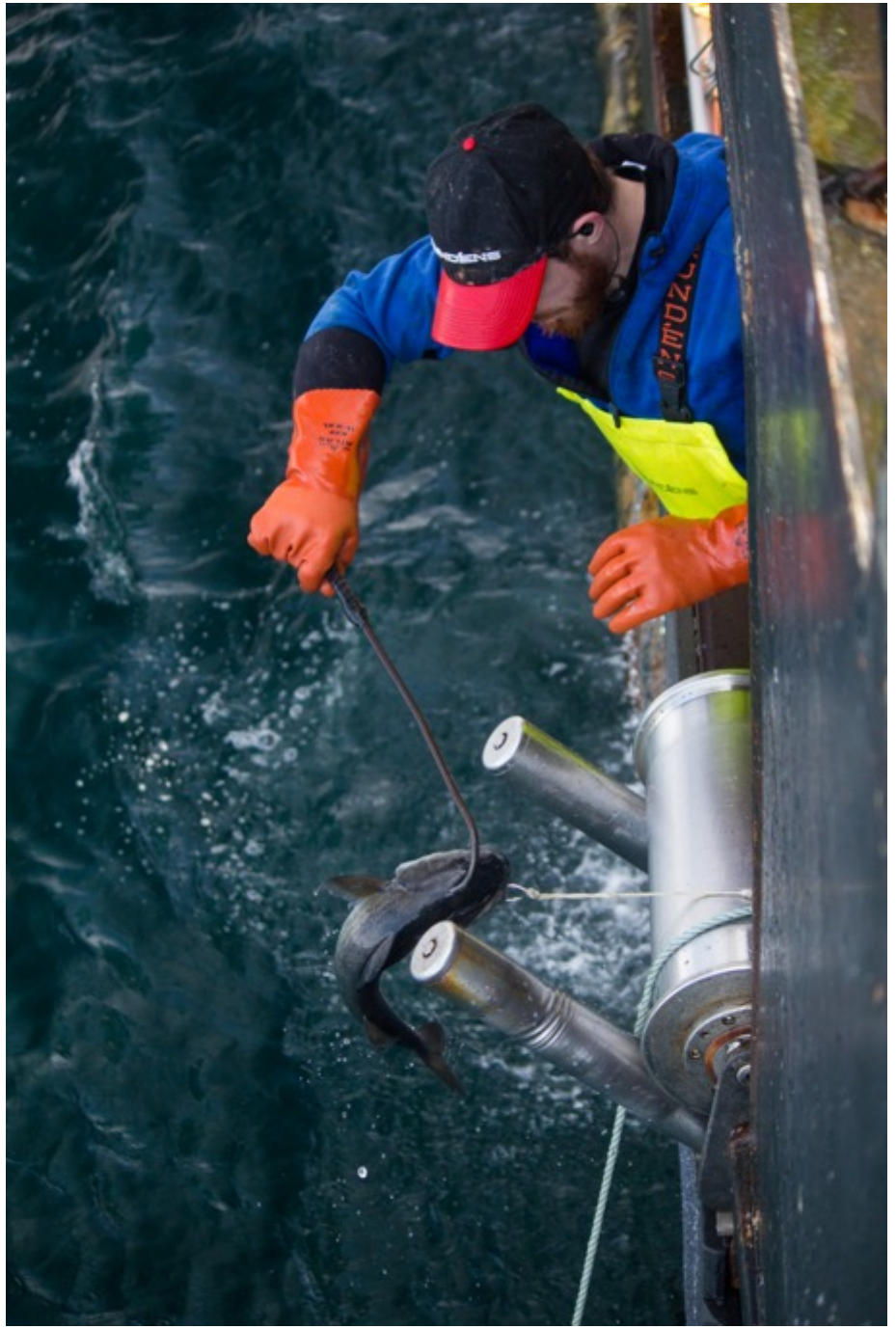




The SSC appreciates the analyses to date investigating the rapid transition from longline to pot gear in the sablefish fishery and the possible ways in which this shift can be best modeled in the stock assessment. There was considerable discussion on the relative merits of including a calibrated fishery CPUE series, separating the two gears into different fleets, allowing for changes in selectivity to reflect the change in gear types, or some combination of these approaches. The SSC recommends side-by-side comparisons of size and age distributions from the two gear types to better understand potential differences in selectivity. **As recommended last year, the SSC would also like to see a model that allows for separate fleets, even if compositional data are sparse, to evaluate how important differences in selectivity might be to assessment results.** The SSC recommends that this investigation be a high priority for the next assessment.

Key Question(s)

- Is time blocked selectivity an adequate approach for accounting for changes in fleet structure?
- Is disaggregating the fixed-gear fleet necessary to account for the rapid adoption of pot gear?
  - Is it feasible to incorporate an additional pot gear fleet into the assessment given data limitations (length of time series and sample sizes)?



Objectives

Compare model variants and investigate implications of:

1) addition of a new pot fishery fleet

2) assumed fleet selectivity (i.e., logistic or dome-shaped)

Study Design

- Operational Sablefish Assessment (2021)
- Evaluate models based on:

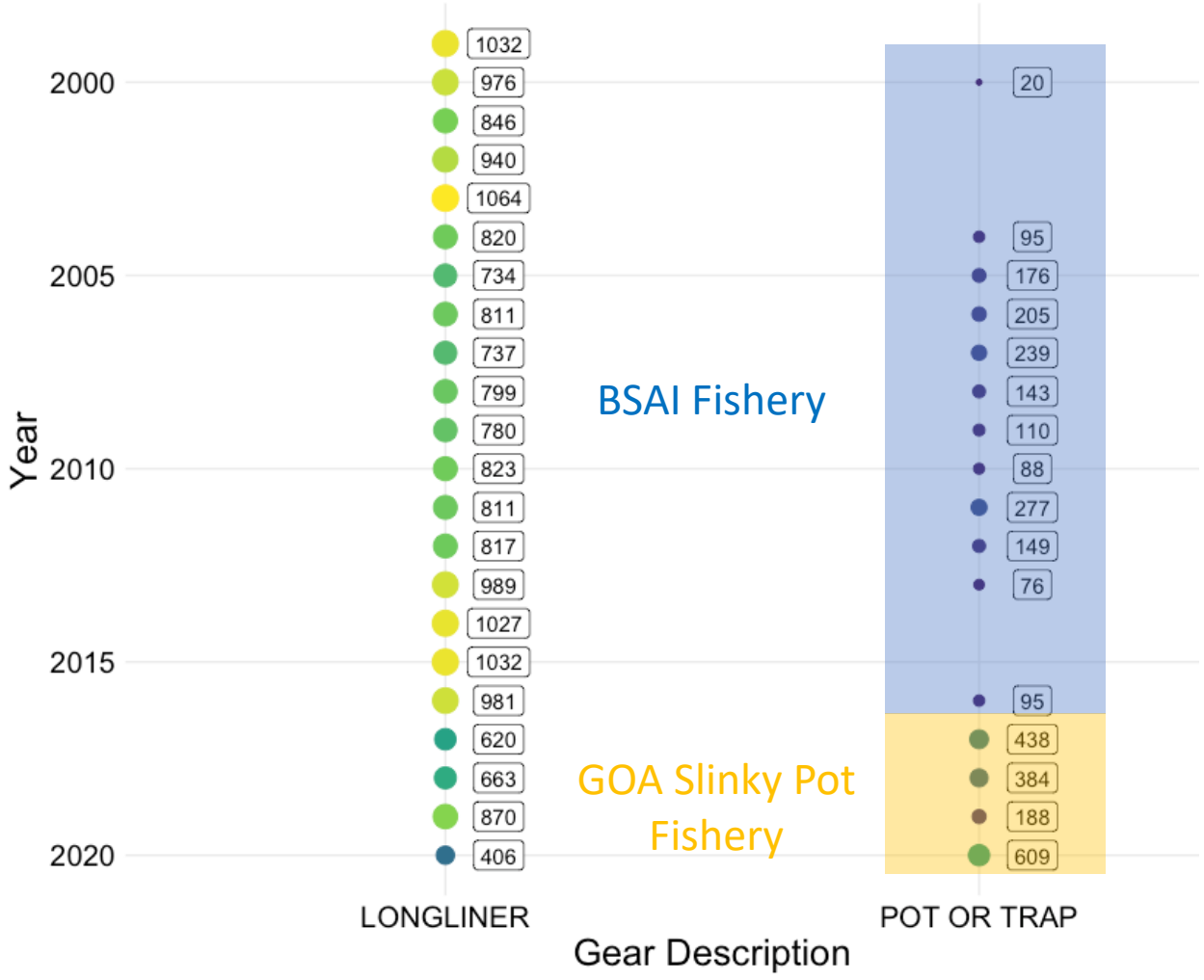
1) Model fit
2) Key management quantities
3) Expert judgement

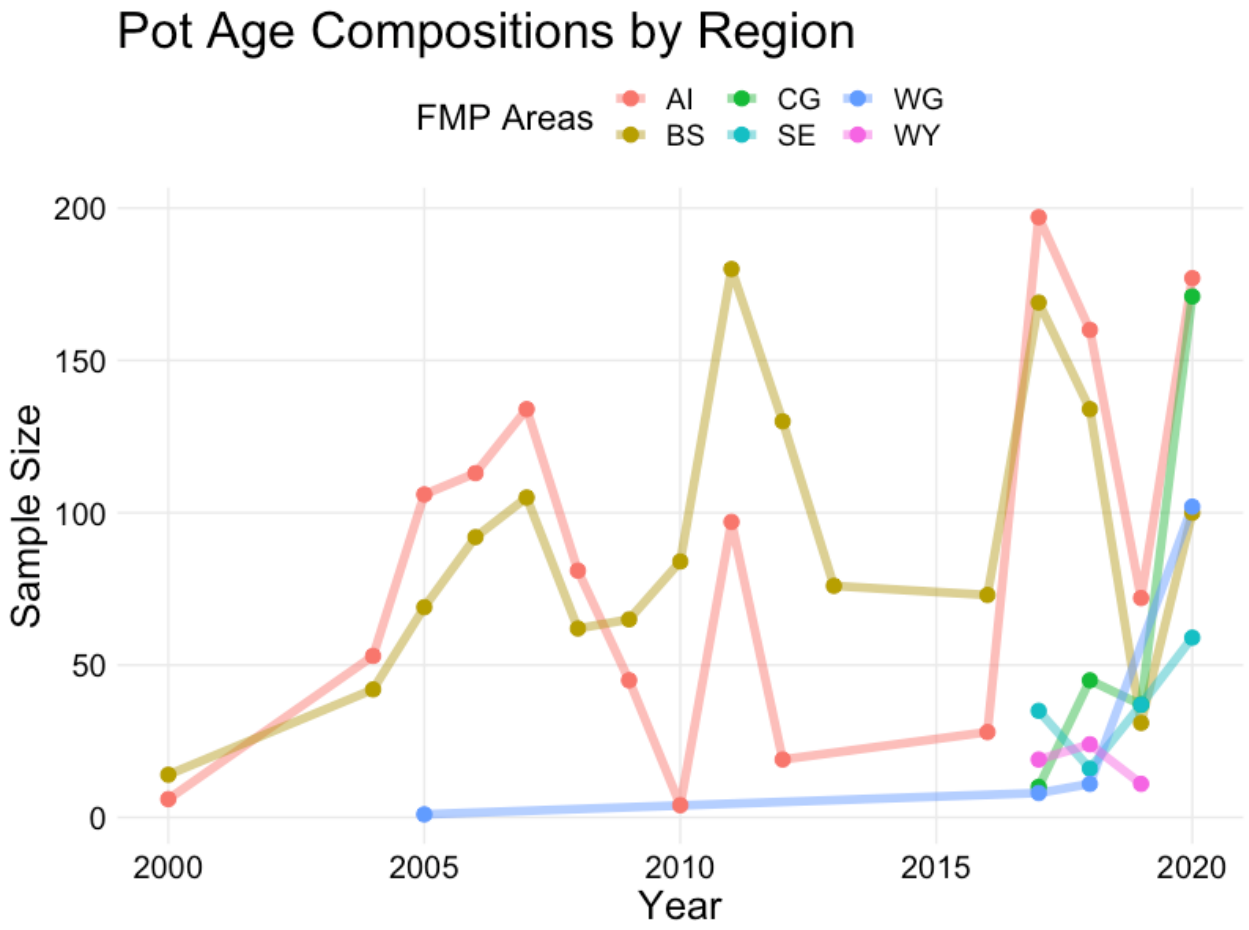
- Single pot fleet modelled; data from historical BSAI pot fishery and slinky pot fishery in GOA are treated as 1 fleet

Alternative selectivity parameterizations attempted, BUT failed to converge: (Exponential Logistic, Double Logistic, Double Normal)
Blocks were also explored for the pot fleet, but also failed to converge

Model Name	Fleet Structure	Selectivity	Time-variation in selectivity
Comb_Logist (Status-quo)	Combined	Combined Fleet: Logistic	Time-block (n = 3) 1960 – 1994 1995 – 2015 2016 - 2021
Pot_Logist	Disaggregated	HAL Fleet: Logistic Pot Fleet: Logistic	Time blocks same as Comb_Logist for HAL Fleet None for pot fleet
Pot_Gamma	Disaggregated	HAL Fleet: Logistic Pot Fleet: Gamma	Time blocks same as Comb_Logist for HAL Fleet None for pot fleet

Sample Sizes (Age Compositions)

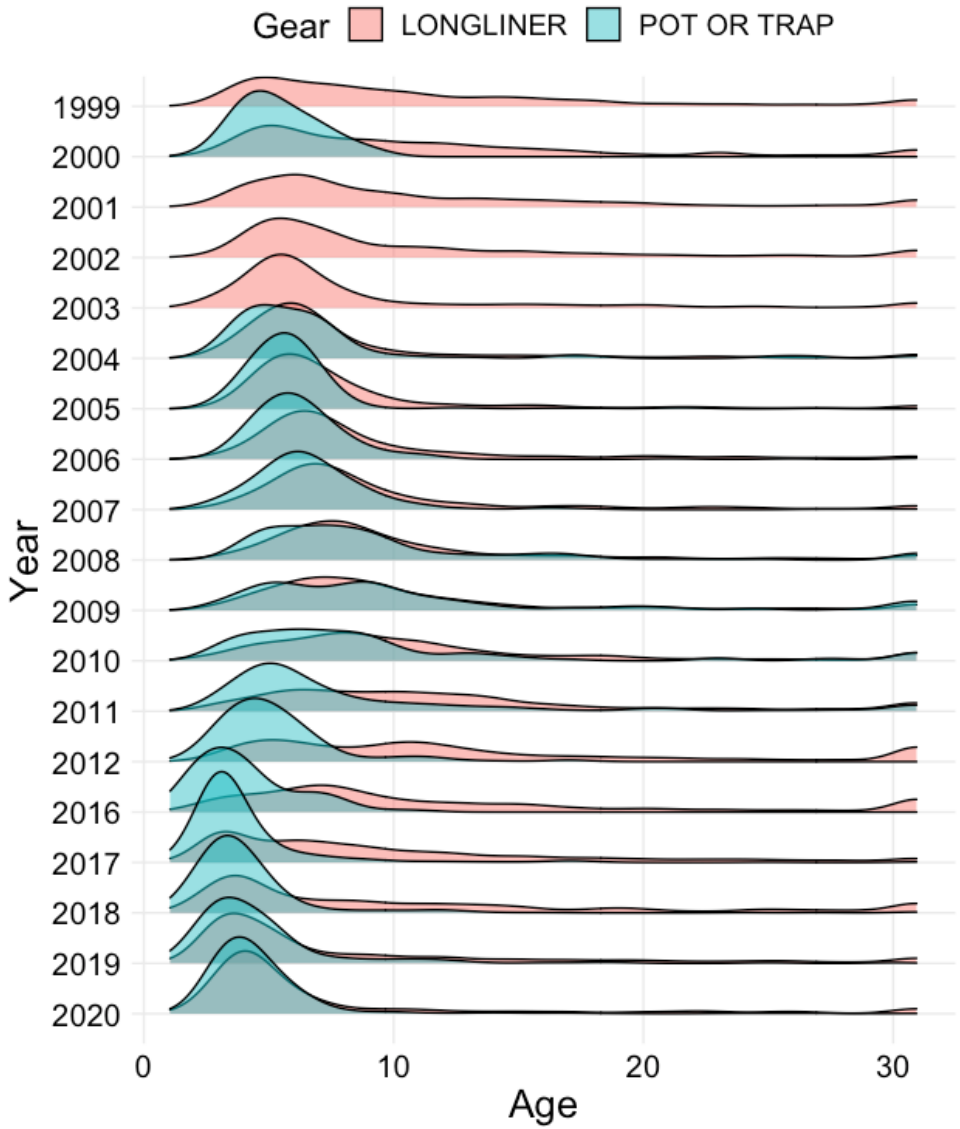




Sample sizes are predominately BSAI pre-2017

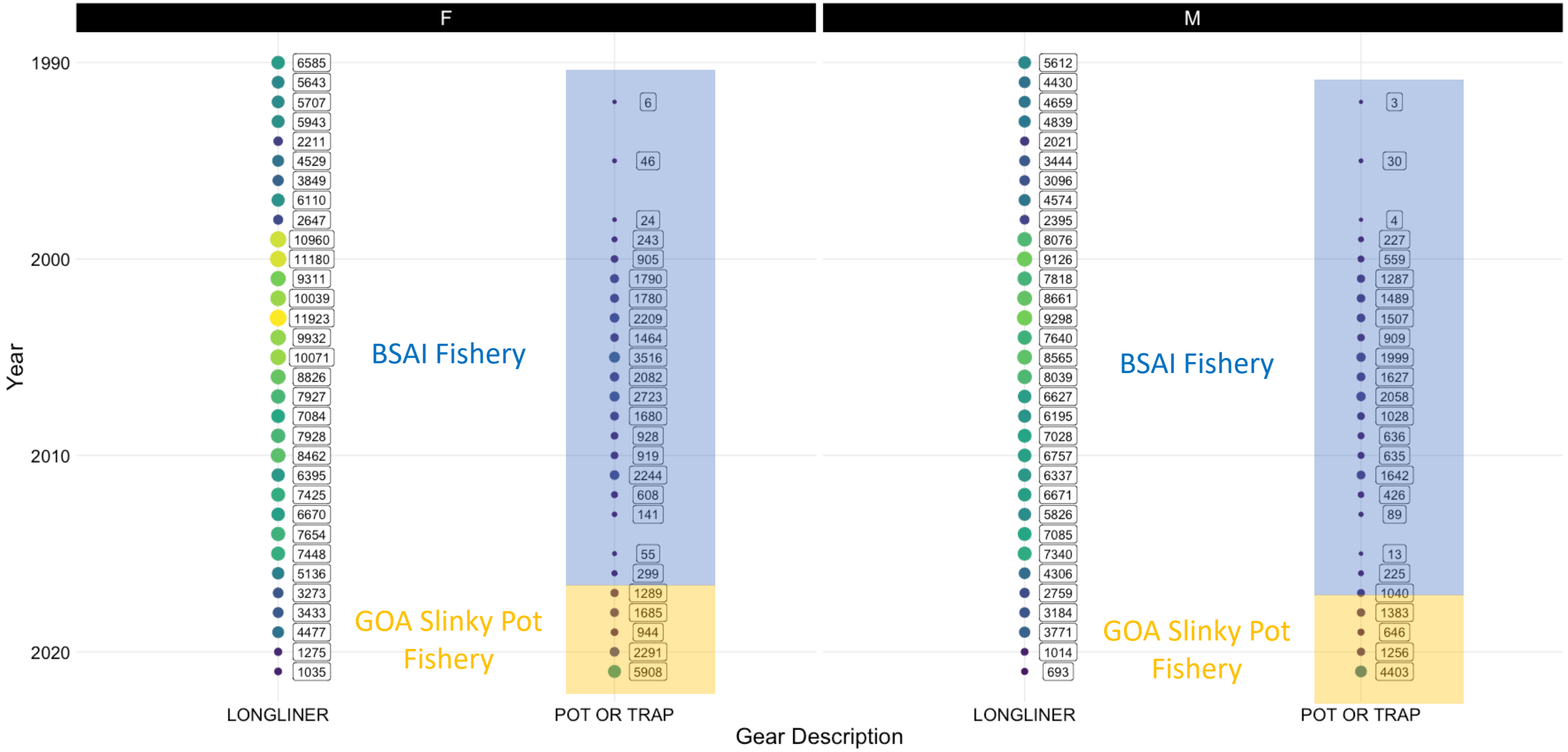
Fairly patchy spatial distribution and not a ton of data, except for recent years

Age Composition Distributions

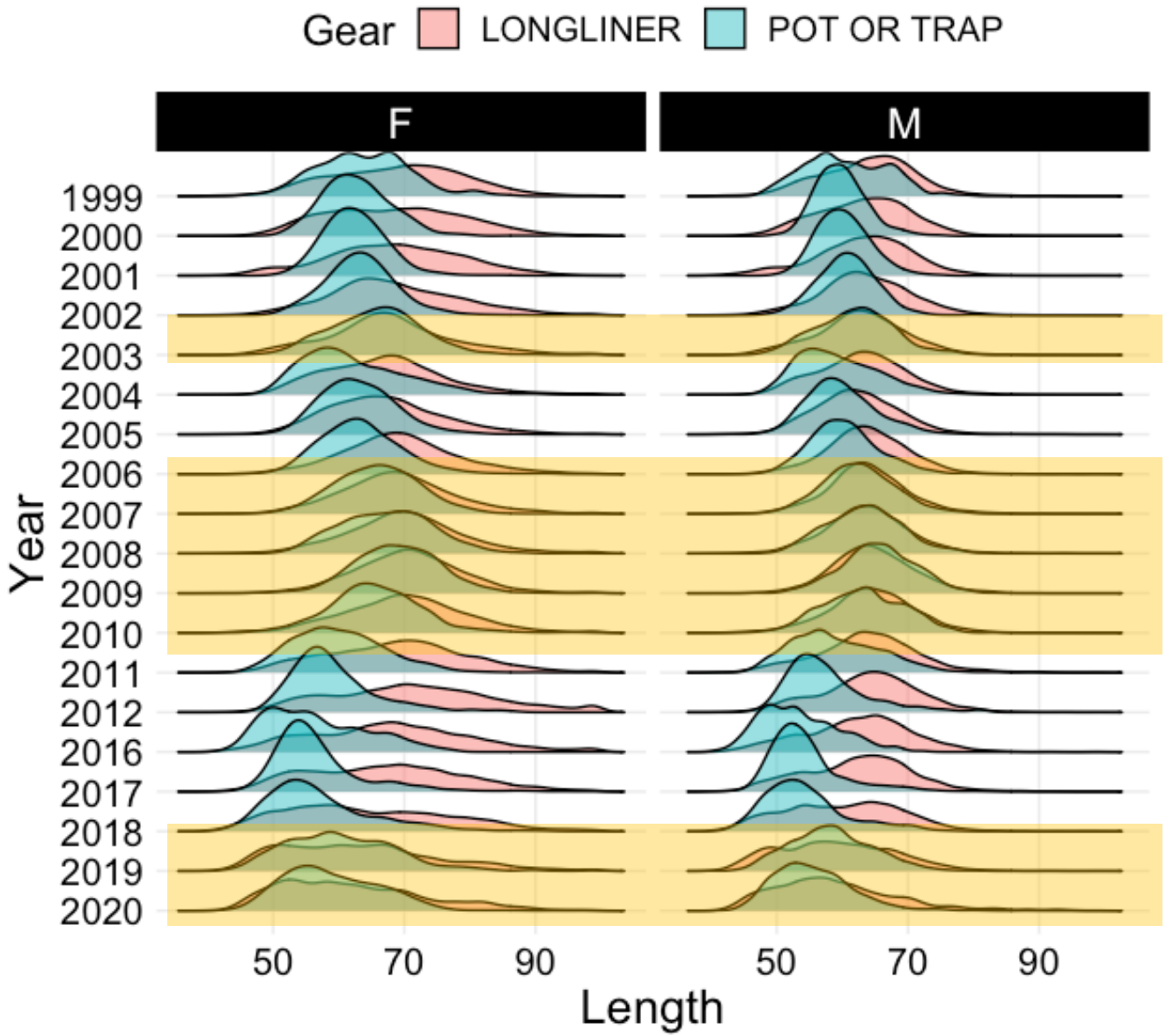


- Age compositions don’t look too different between gears (aggregated across sexes)
- HAL appears to select larger fish, but not by much.

Sample Sizes (Length Compositions)



Length Composition Distributions

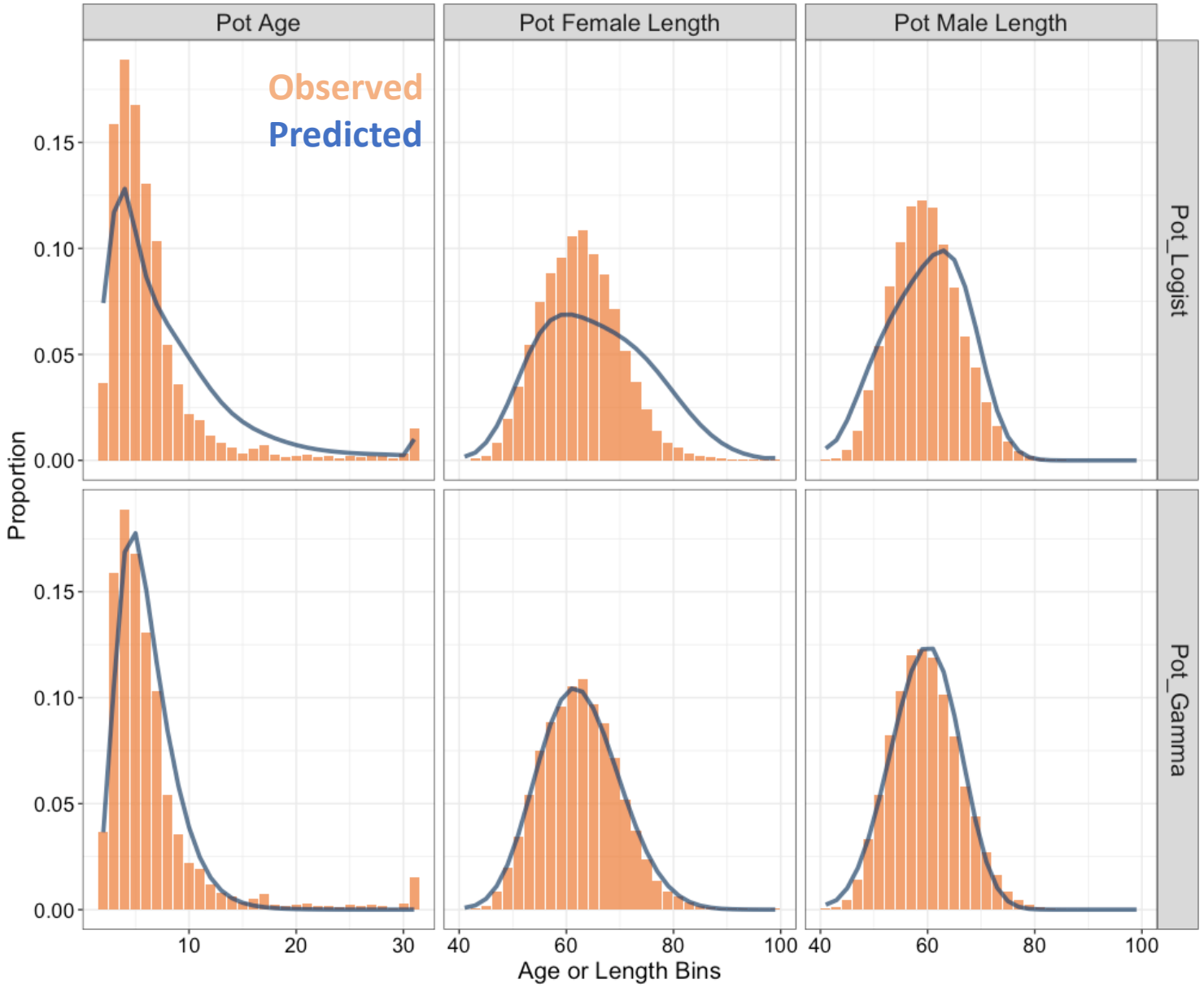


- Fairly similar length compositions among sexes and gears for some years.
- Length compositions for years 2010 – 2018 are fairly different (could be attributed to lower sample sizes)
  - Note: Pot fishery occurred in BSAI region during these earlier periods, where more small fish are often observed in these areas

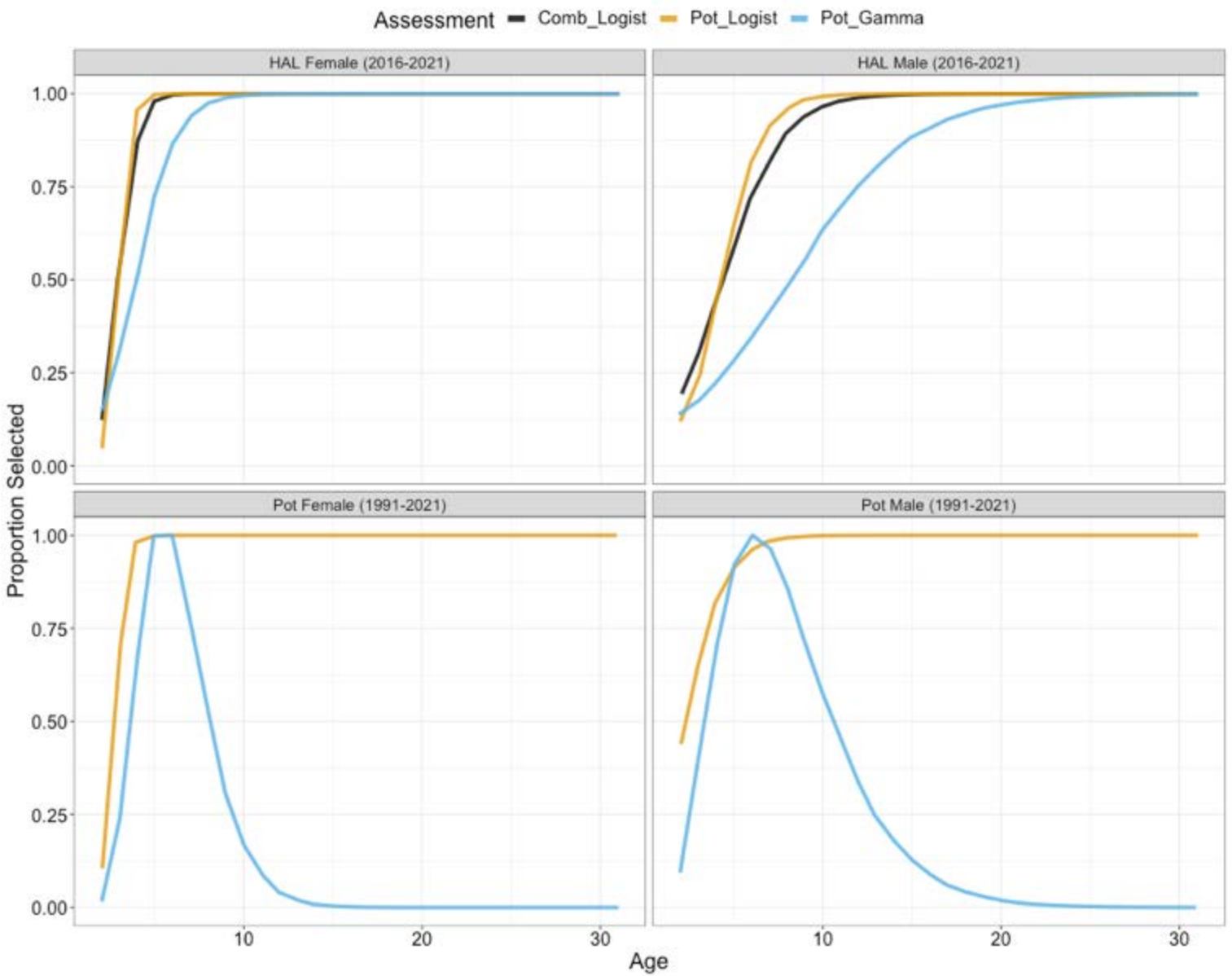
Model Fits to Aggregated Compositions

Logistic selectivity doesn't fit data well

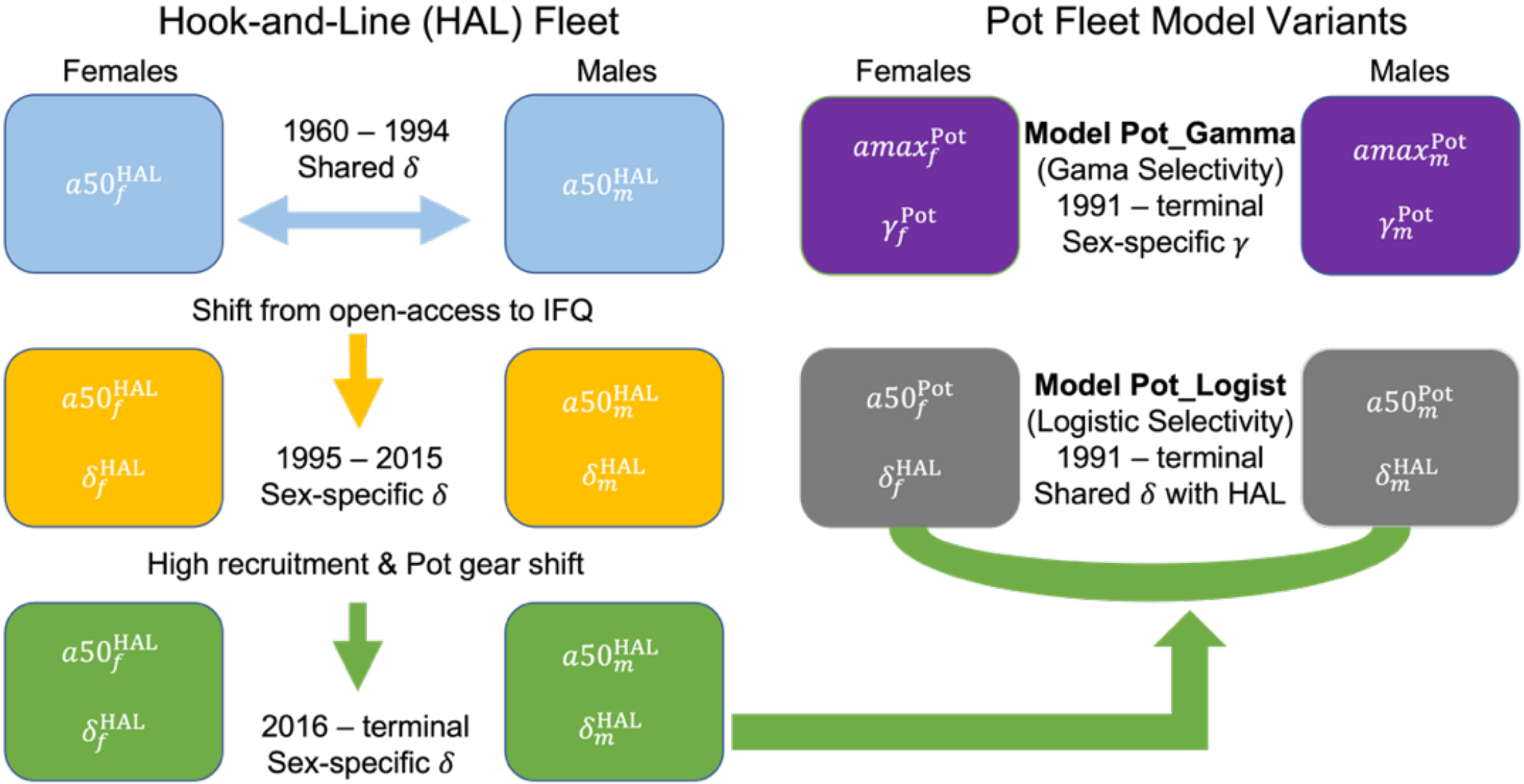
Gamma selectivity fits way better



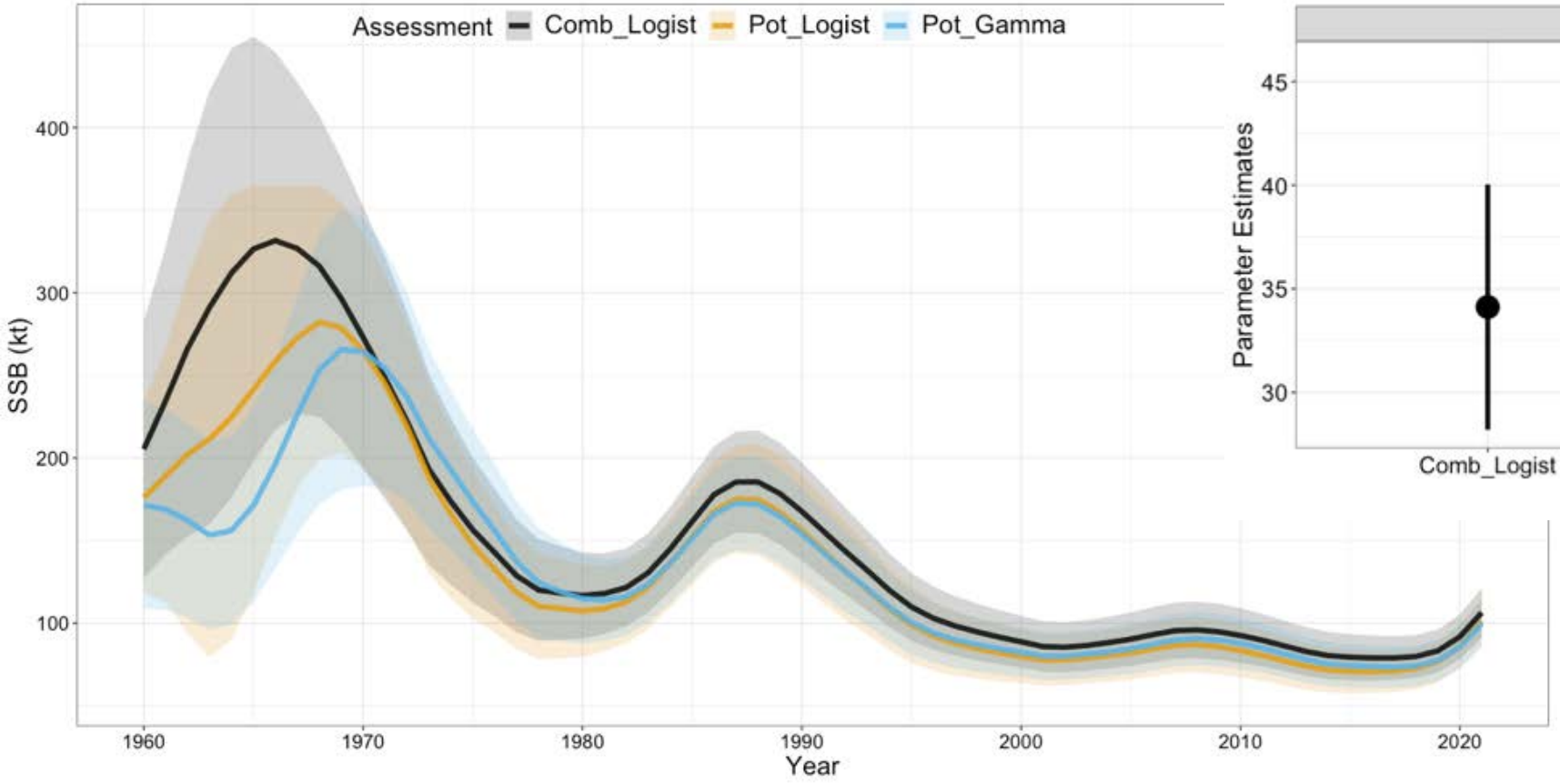
Estimated pot selectivities

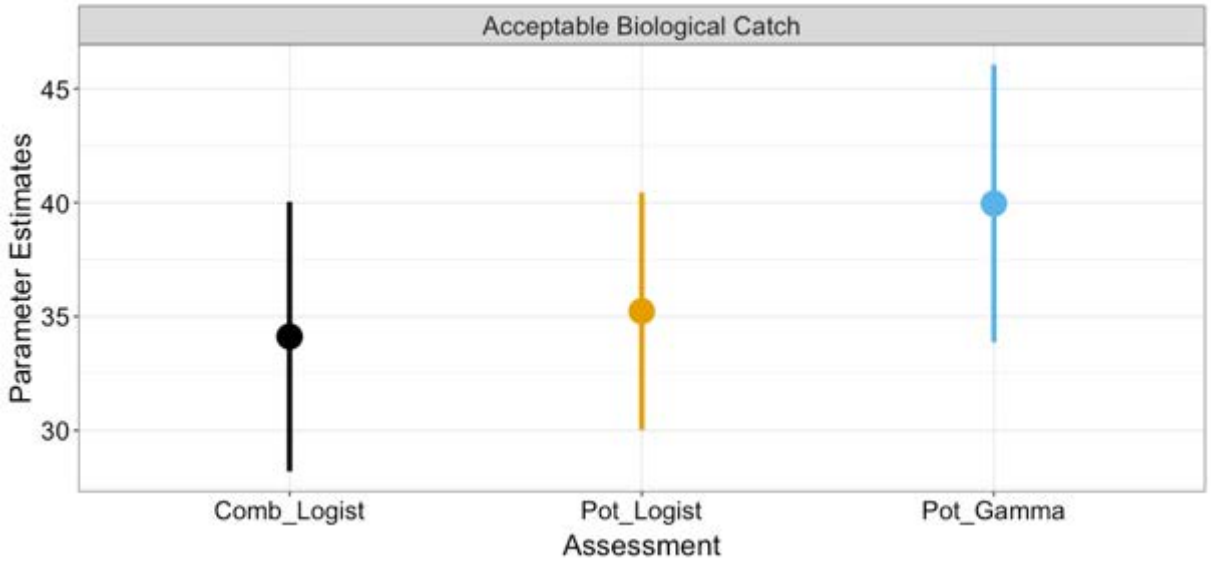


For logistic selectivity, the delta parameters had to be shared w/ the sex-specific parameters from the HAL time block in 2016, to achieve adequate model performance (knife-edged selectivity estimated otherwise)


Hook-and-Line (HAL) Fleet
Females
Males
$a50_f^{HAL}$
1960 – 1994
Shared δ
$a50_m^{HAL}$
Shift from open-access to IFQ
$a50_f^{HAL}$
δ_f^{HAL}
1995 – 2015
Sex-specific δ
$a50_m^{HAL}$
δ_m^{HAL}
High recruitment & Pot gear shift
$a50_f^{HAL}$
δ_f^{HAL}
2016 – terminal
Sex-specific δ
$a50_m^{HAL}$
δ_m^{HAL}
Pot Fleet Model Variants
Females
Males
$amax_f^{Pot}$
γ_f^{Pot}
Model Pot_Gamma
(Gama Selectivity)
1991 – terminal
Sex-specific γ
$amax_m^{Pot}$
γ_m^{Pot}
$a50_f^{Pot}$
δ_f^{HAL}
Model Pot_Logist
(Logistic Selectivity)
1991 – terminal
Shared δ with HAL
$a50_m^{Pot}$
δ_m^{HAL}

Estimates of key management quantities





ABC higher for Gamma b/c of strong dome-shaped selectivity, which assumes older individuals become invulnerable such that more cryptic biomass develops

Why ***strong*** dome-shaped selectivity is unlikely

1) Limited time-series for pot fishery
   - More flexible forms failed to achieve model convergence
     - Double Logistic, Exponential Logistic, Double Normal
   - Resulted in the need to parameterize selectivity with inflexible forms (Gamma)

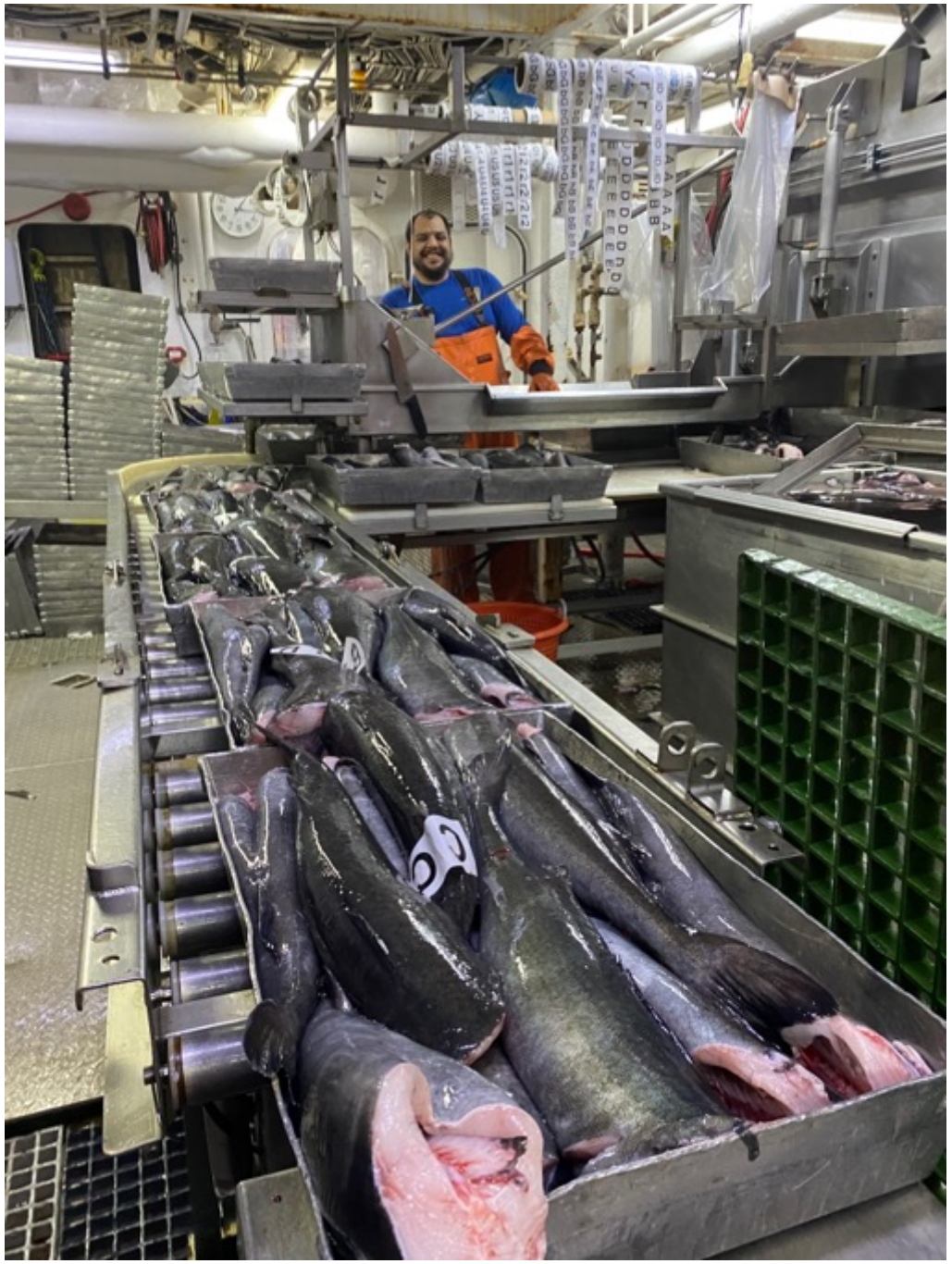
2) Limited experiments suggest contact selectivity is similar
   - Comparisons of size distributions between HAL and slinky pots are fairly similar

3) High recruitment events coincide with pot gear shift in 2017
   - Estimation of selectivity is likely confounded by availability given limited time series
   - Signal of removals for older-aged individuals are likely obscured given dominance of younger-individuals in the compositional data

Bottom Line

- **Is the time-block an adequate approach?**
  - Treatment of fleet structure had minimal impacts on estimates
  - Assumed selectivity had substantial impacts on recommended harvest levels

- Model estimates from multi-fleet models can be useful in validating the assumption of a single-fleet model



Future work

- **Ongoing:** Simulations exploring best practices for the treatment of fleet structure and selectivity
  - Explore influence of data availability on best practice following gear change
    - i.e., what is the minimum number of years before a new selectivity pattern can be identified?
  - Explore parsimonious parameterizations of selectivity and fleet structure following changes in gear
- Explore alternative selectivity parameterizations as pot time-series increases

Ongoing work: Study Design

Operating Model: Sex-and age-structured model

- 2 Fishery Fleets
- Sablefish-like life-history
- 3 combinations of selectivity patterns for fishery fleets (Logistic-Logistic, Logistic-Gamma-Old, Logistic-Gamma-Young)
- 2 fishing history patterns (Fast vs. Slow)
- 2 data quality and quantity scenarios (Low vs. High)

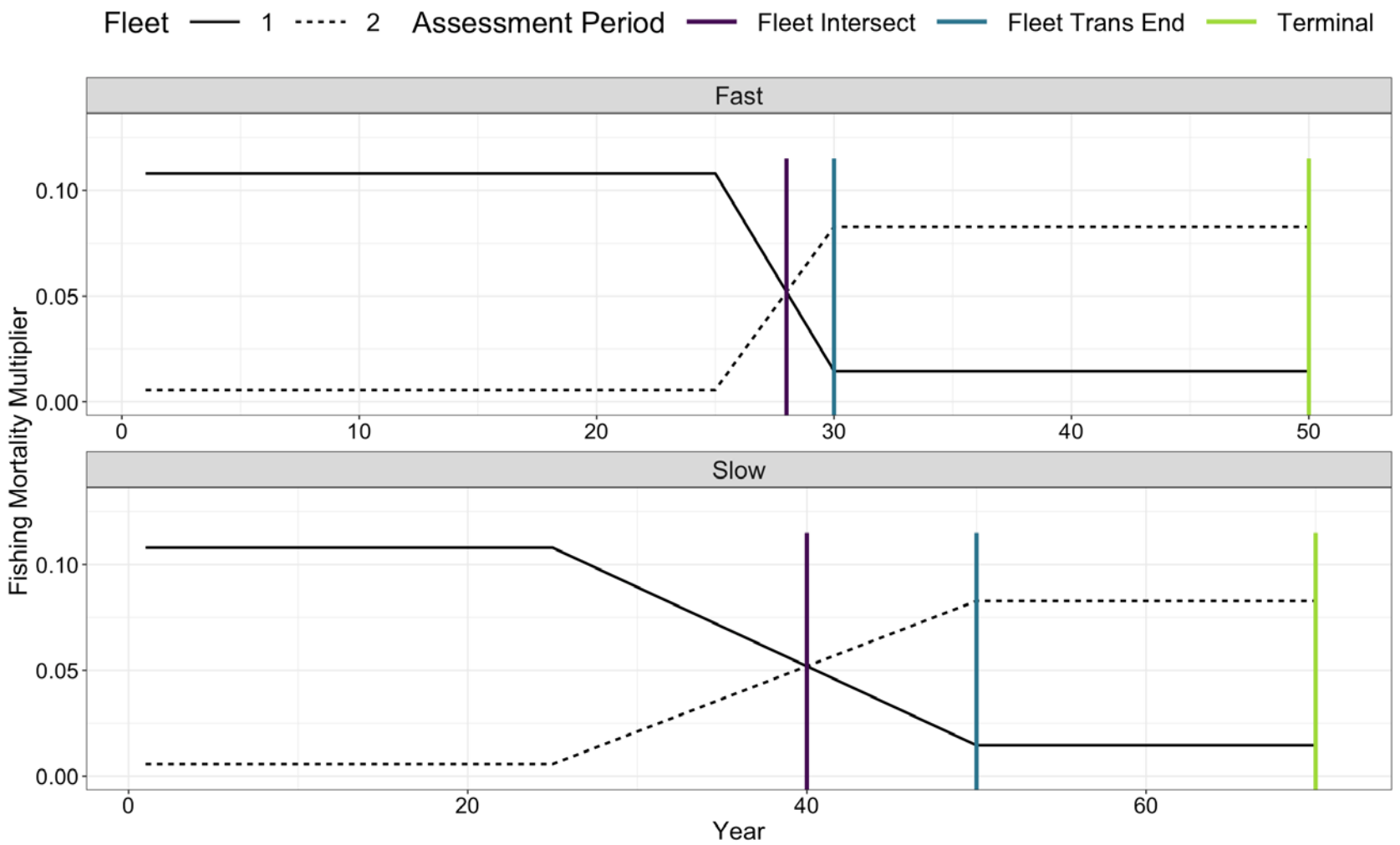
Estimation Models: Sex-and age-structured model

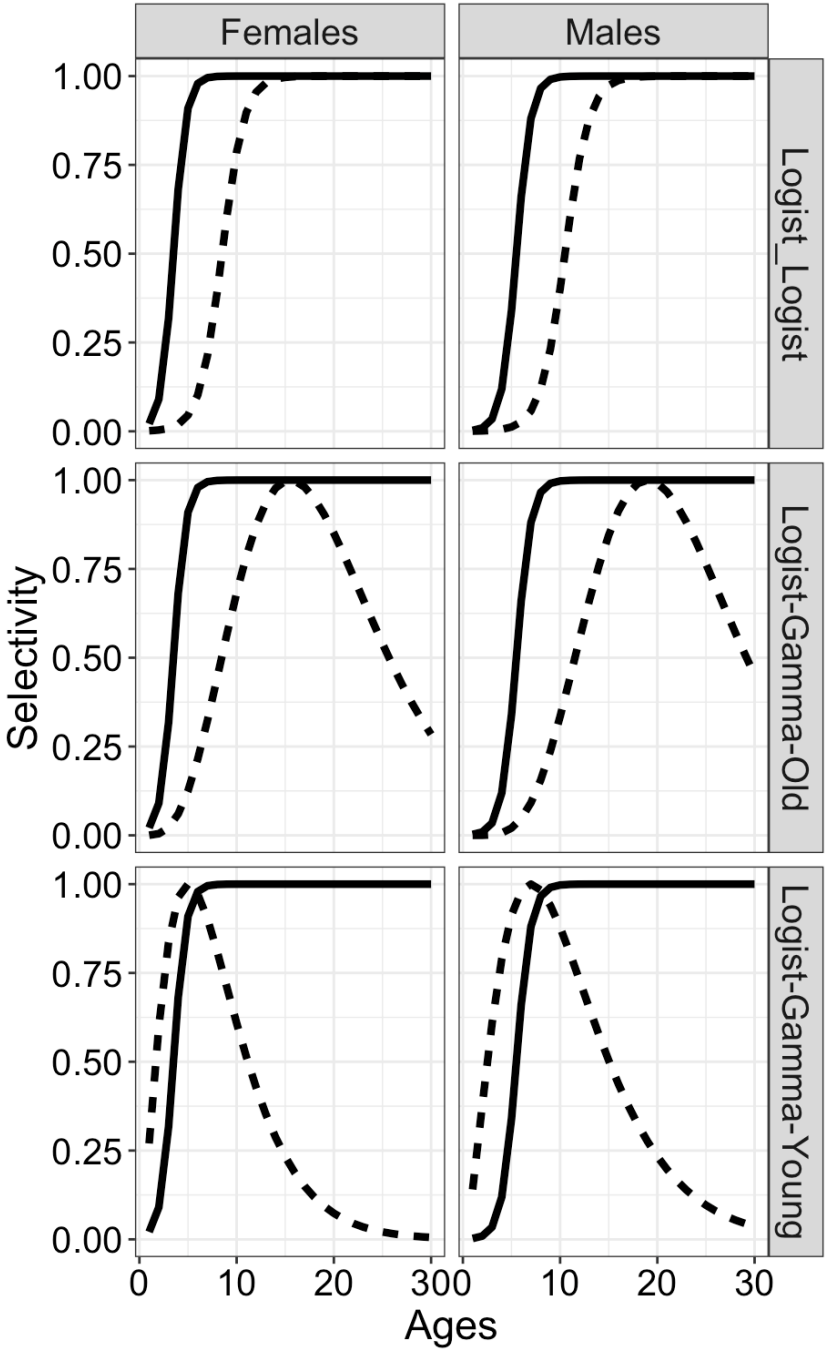
2 Fleets (Base Case, Matching OM)

1 Fleet (Selectivity patterns: Logistic, Gamma, Exponential Logistic)

- Time-invariant
- Time-block
- Time-varying random walk on selectivity parameters

Ongoing work

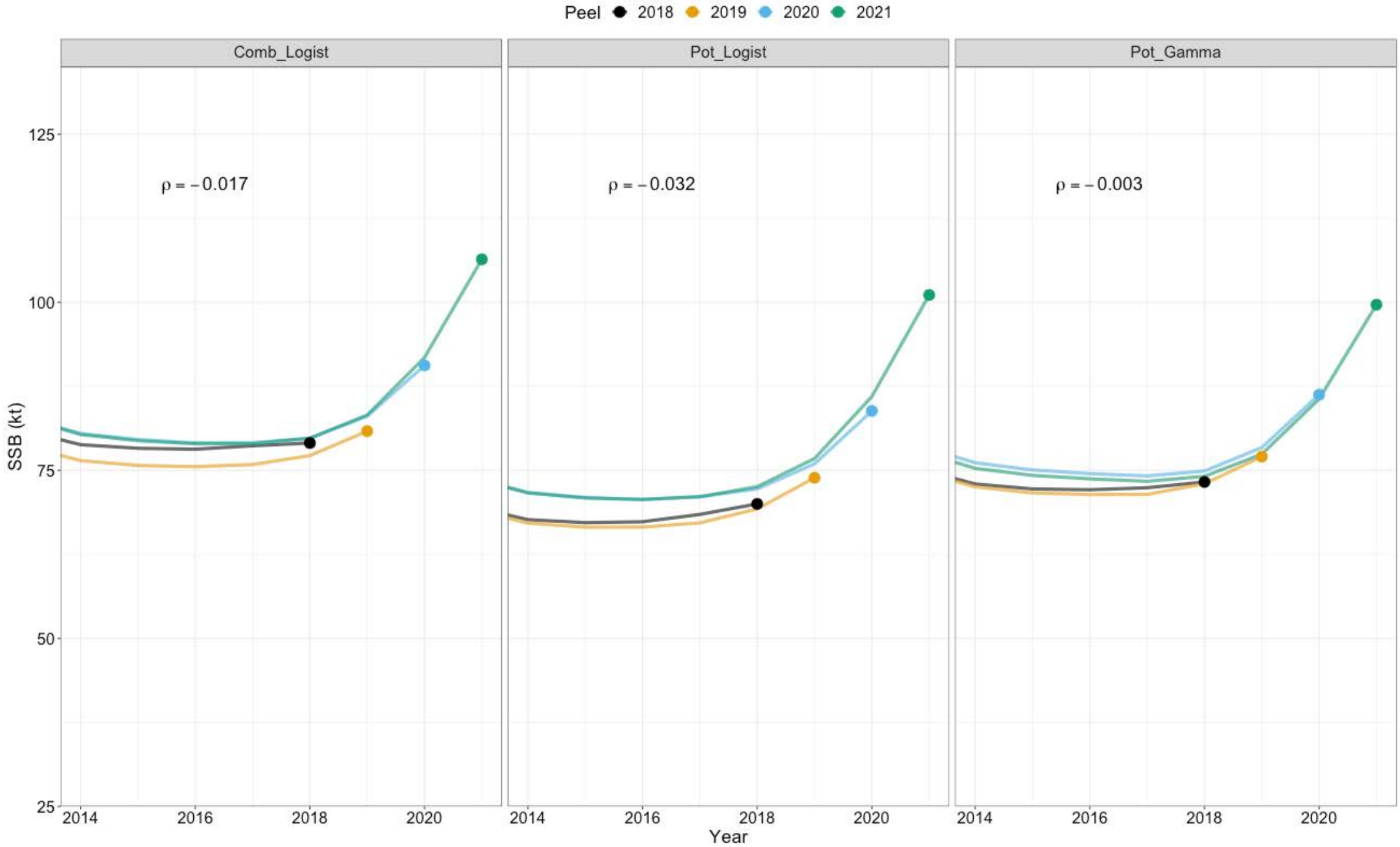


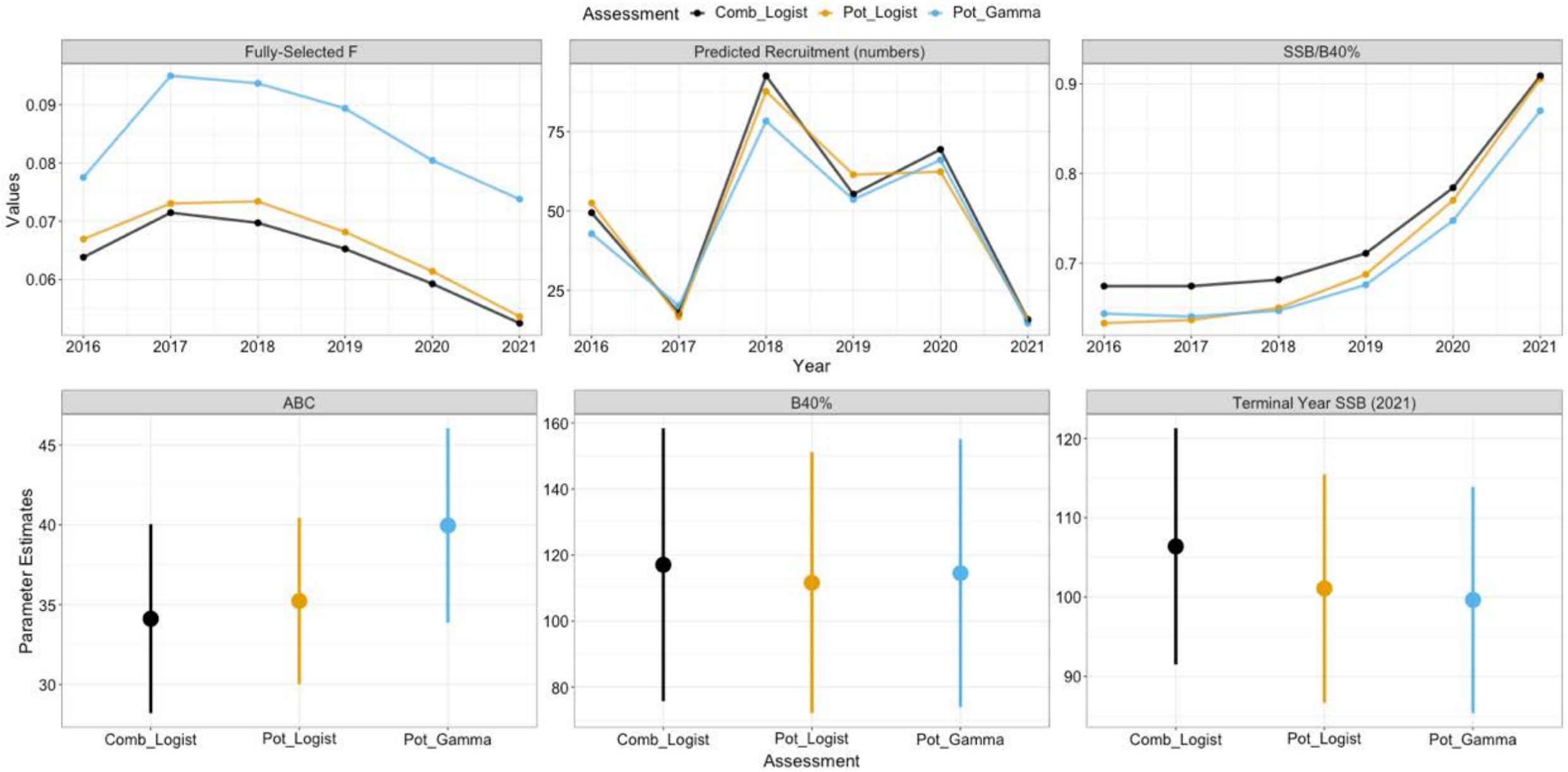


https://github.com/chengmatt/Fleet_Selex_Sim

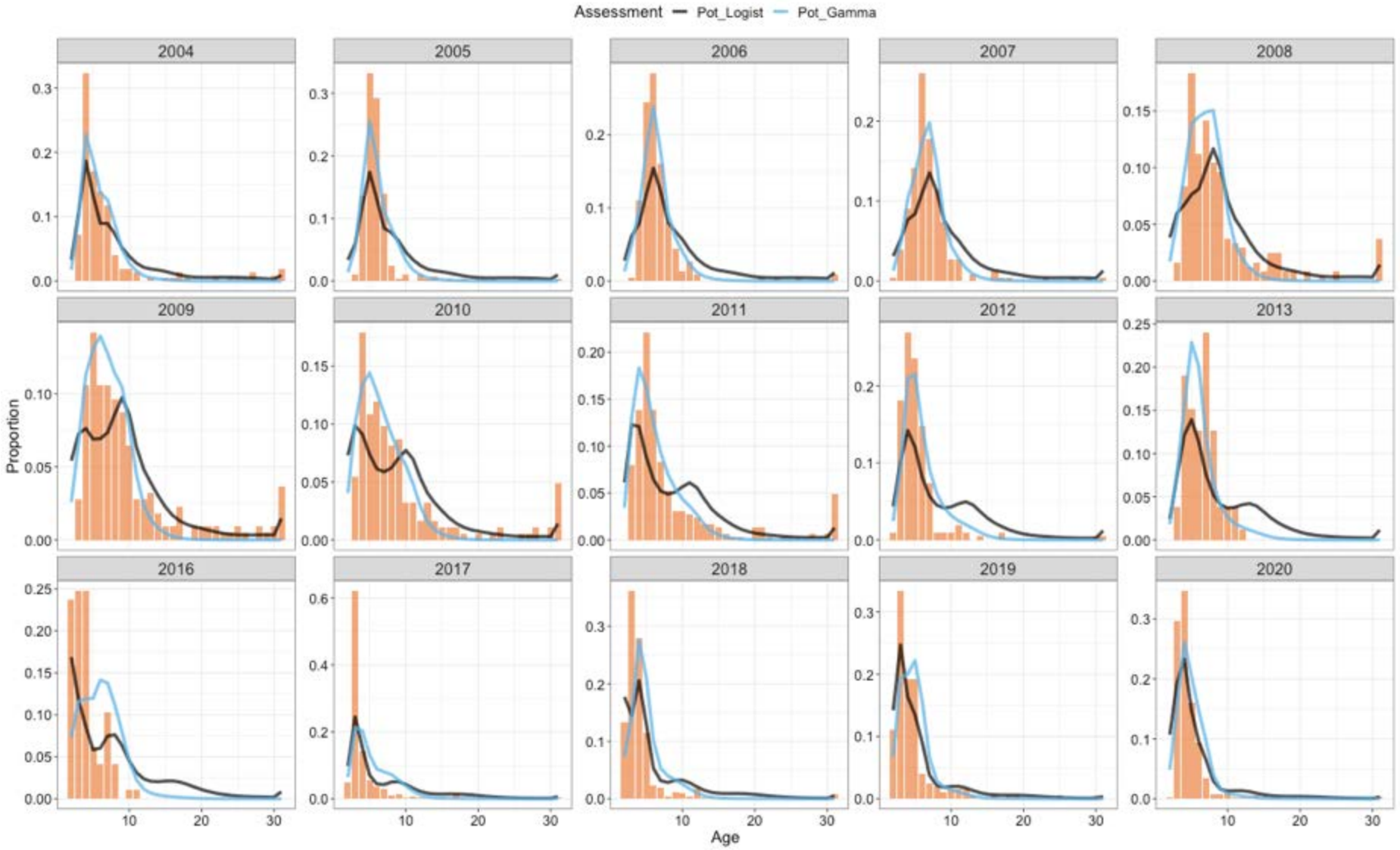
Questions?

Email: **lhcheng@alaska.edu**

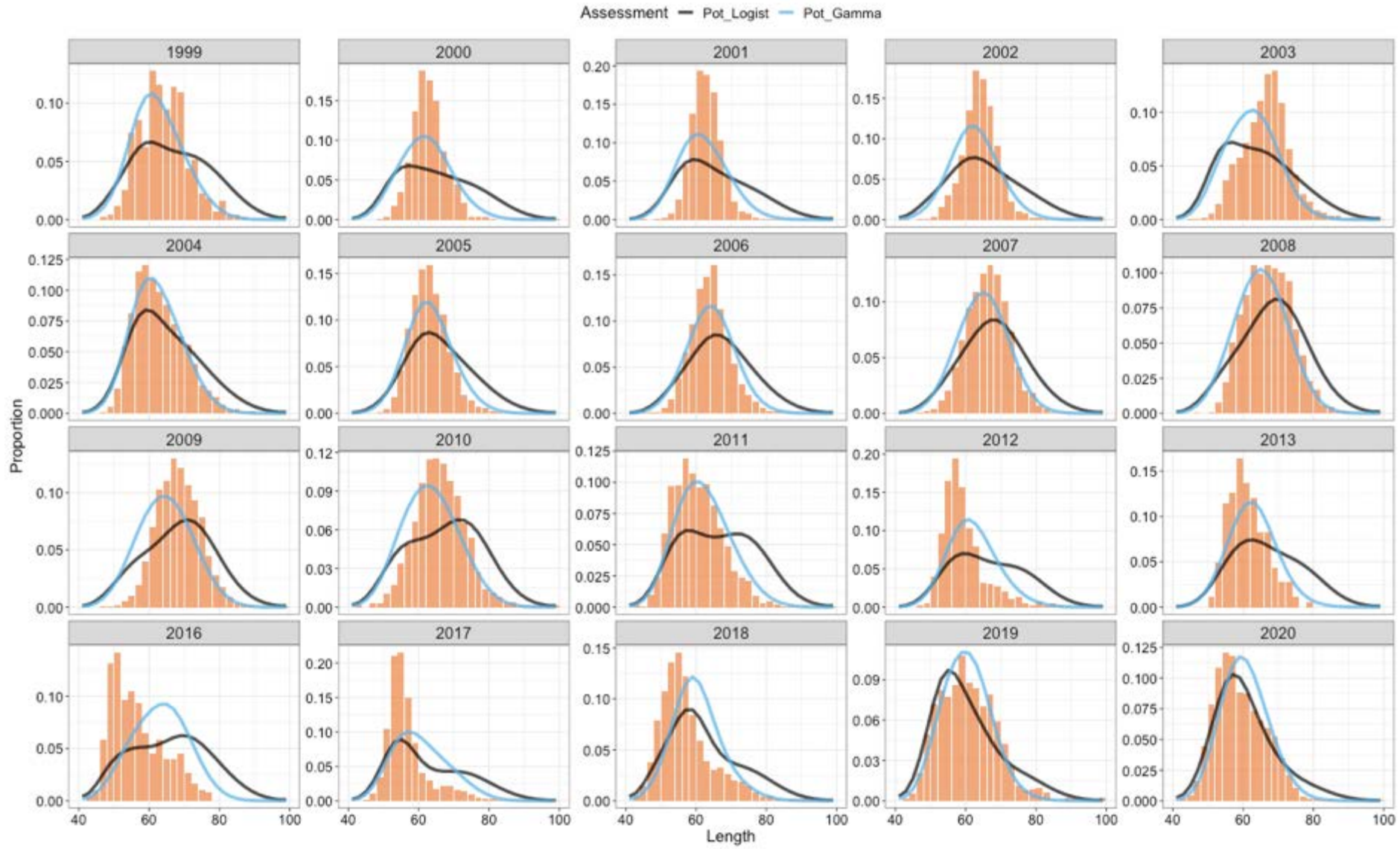

Peel 2018 2019 2020 2021
Comb_Logist
Pot_Logist
Pot_Gamma
ρ = −0.017
ρ = −0.032
ρ = −0.003
SSB (kt)
125
100
75
50
25
2014
2016
2018
2020
Year


Assessment
Comb_Logist
Pot_Logist
Pot_Gamma
Fully-Selected F
Predicted Recruitment (numbers)
SSB/B40%
Values
Year
ABC
B40%
Terminal Year SSB (2021)
Parameter Estimates
Assessment

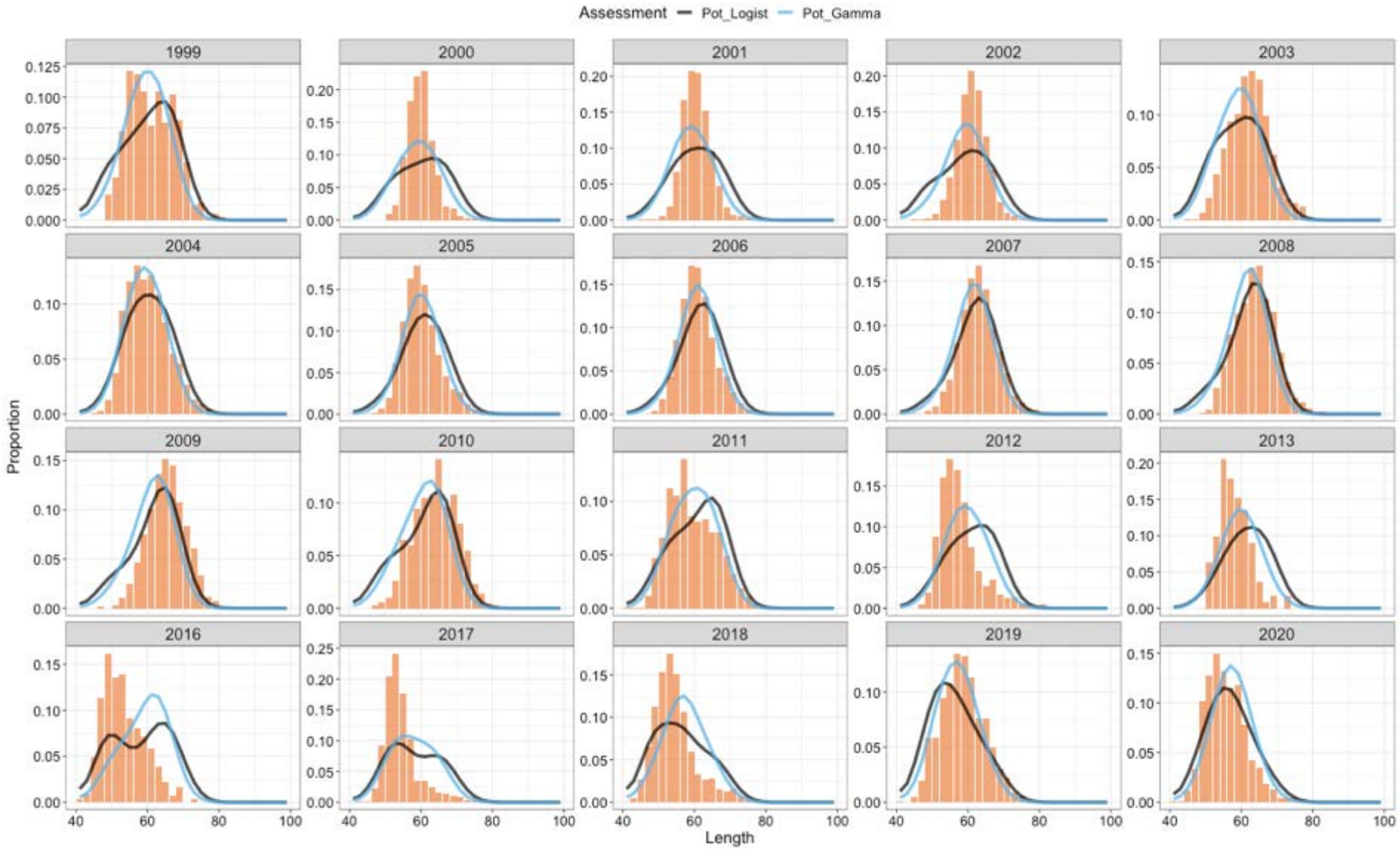
Pot Age Compositions



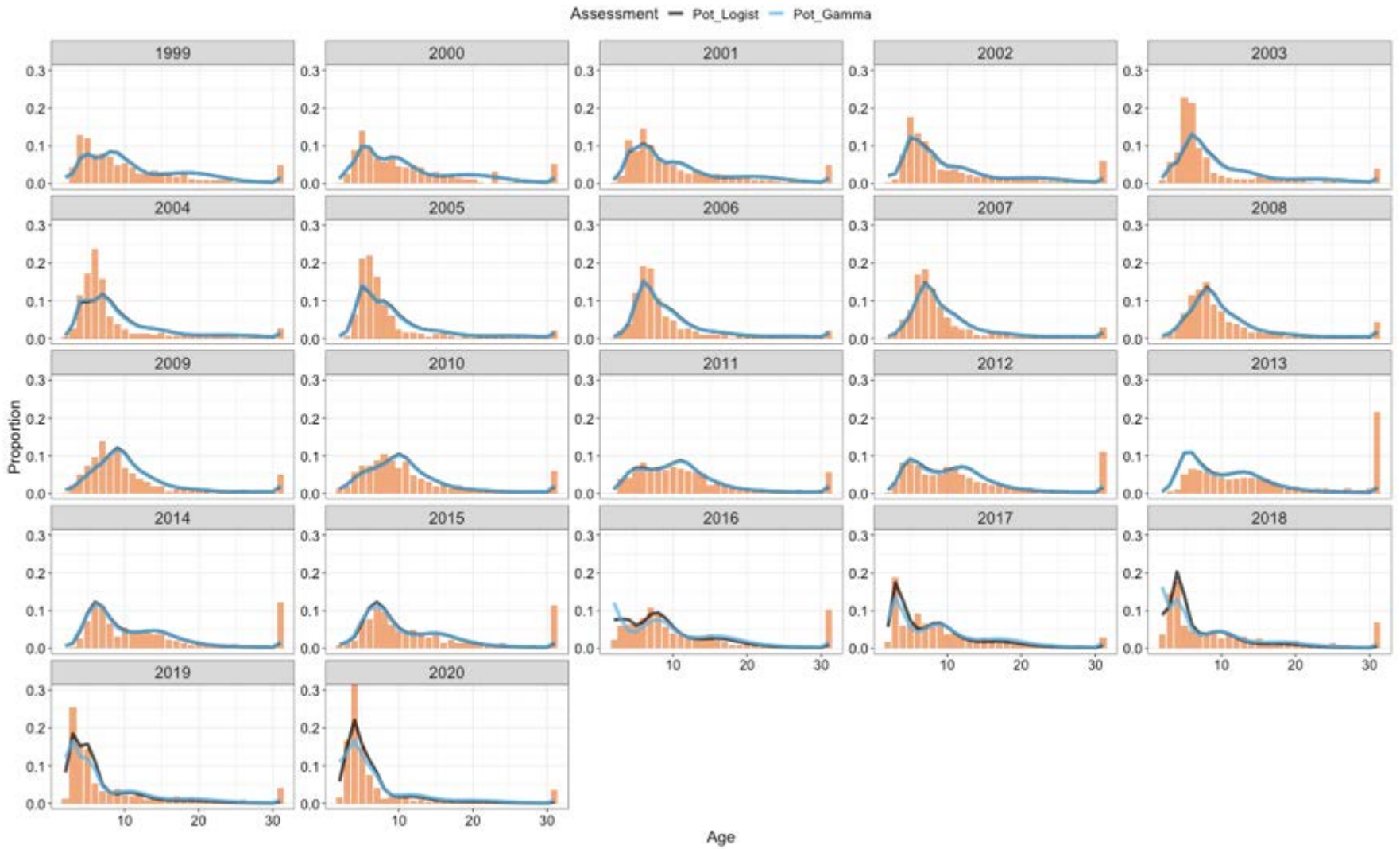
Pot Female Length Compositions



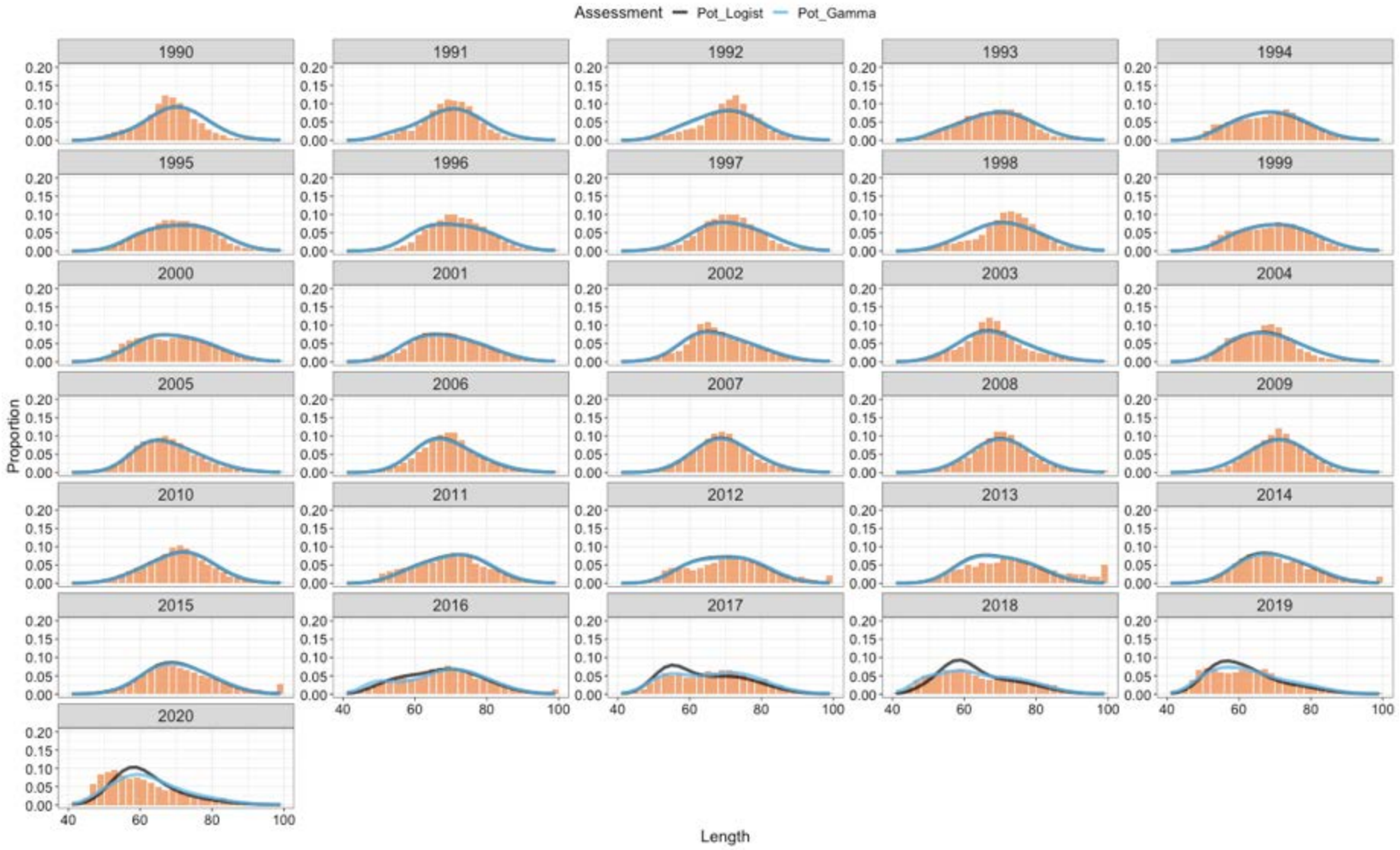
Pot Male Length Compositions



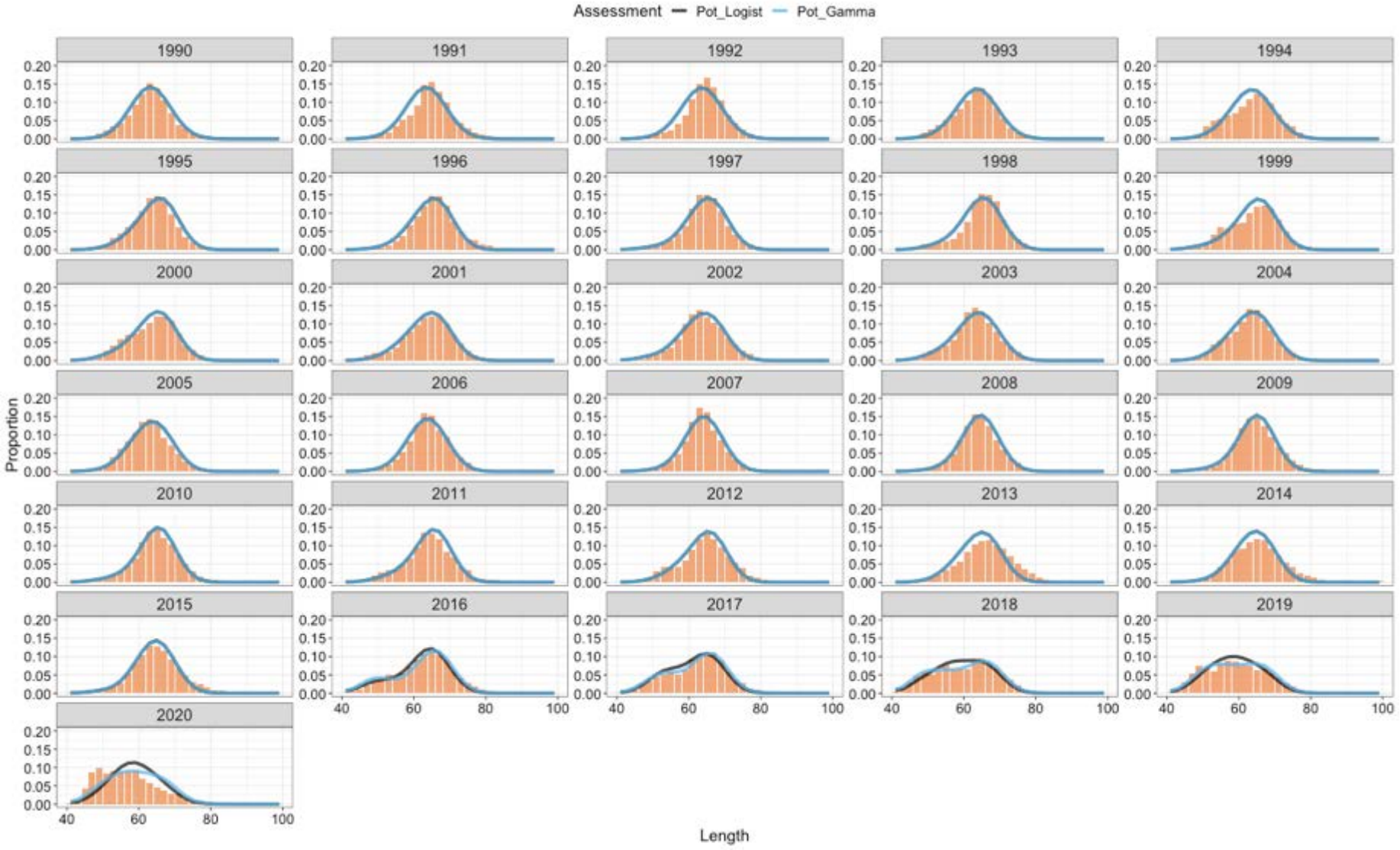
HAL Age Compositions

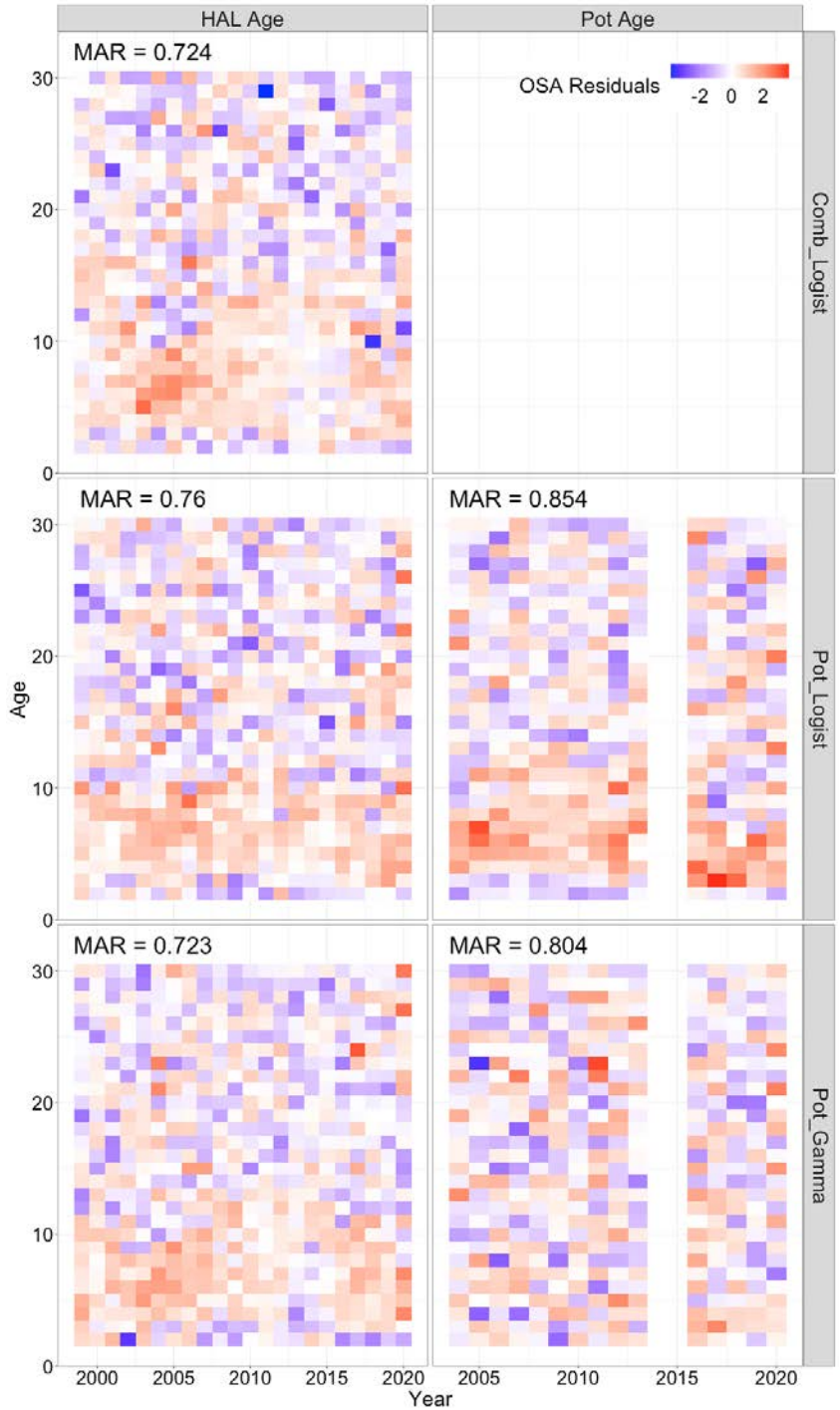


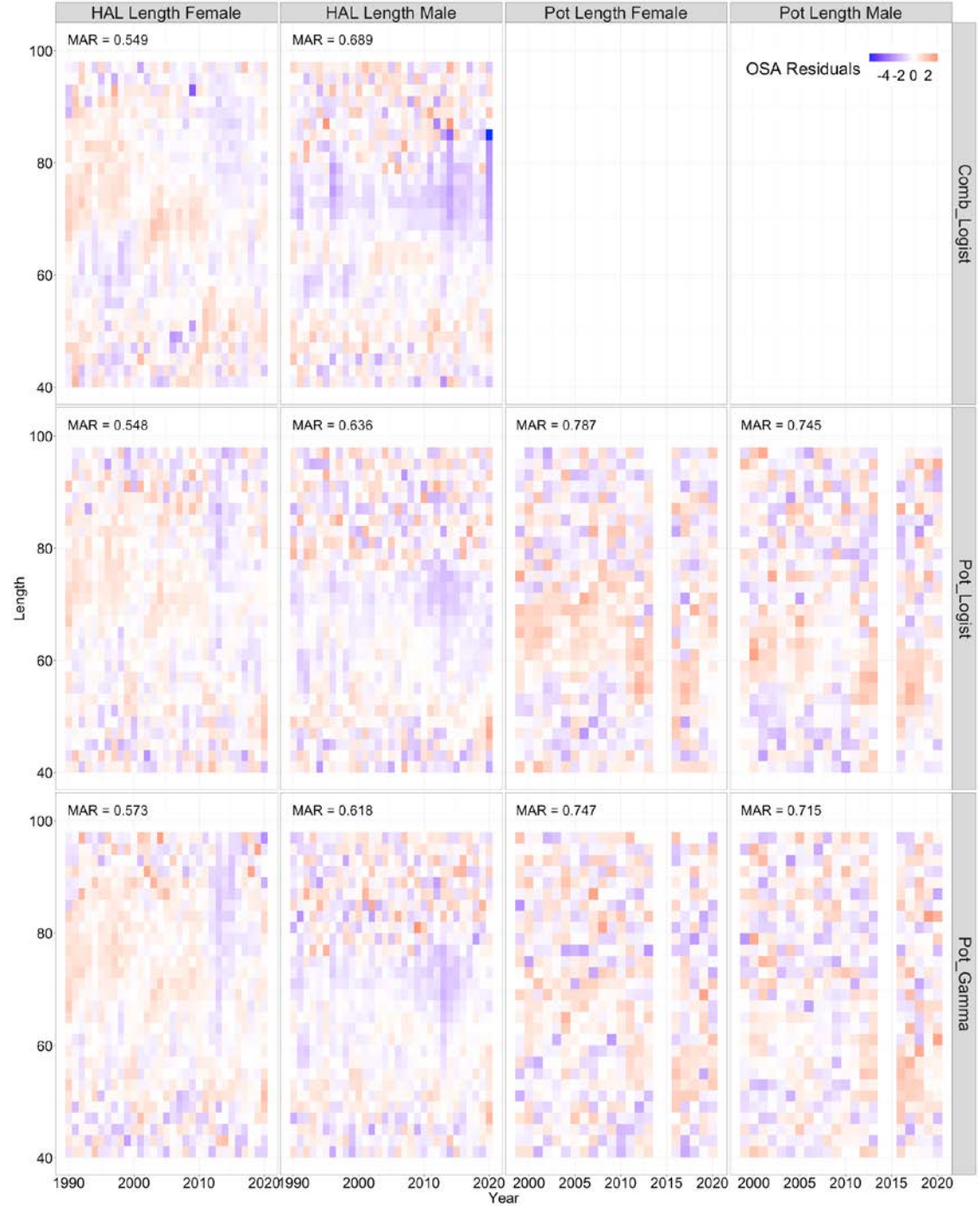
HAL Female Length Compositions

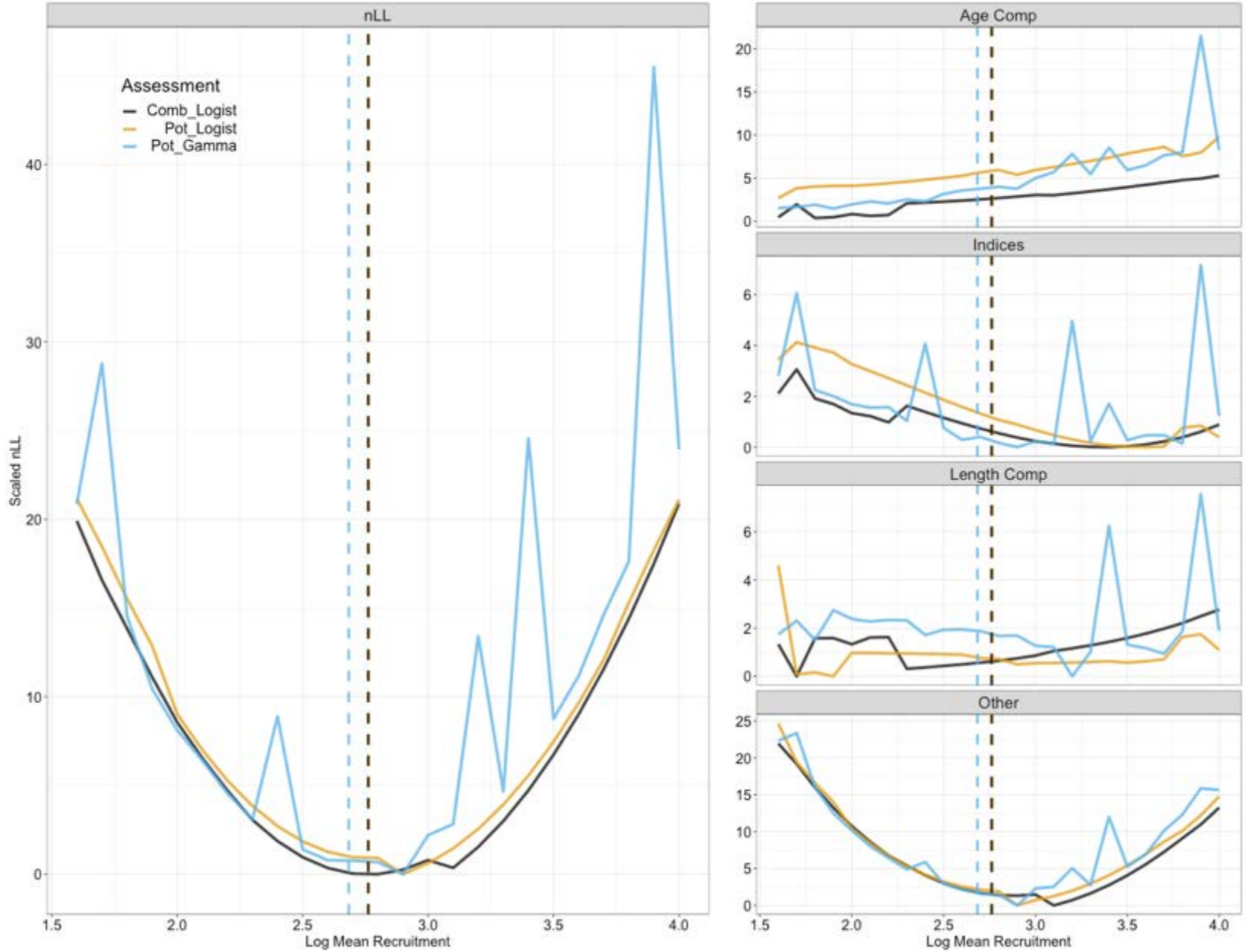


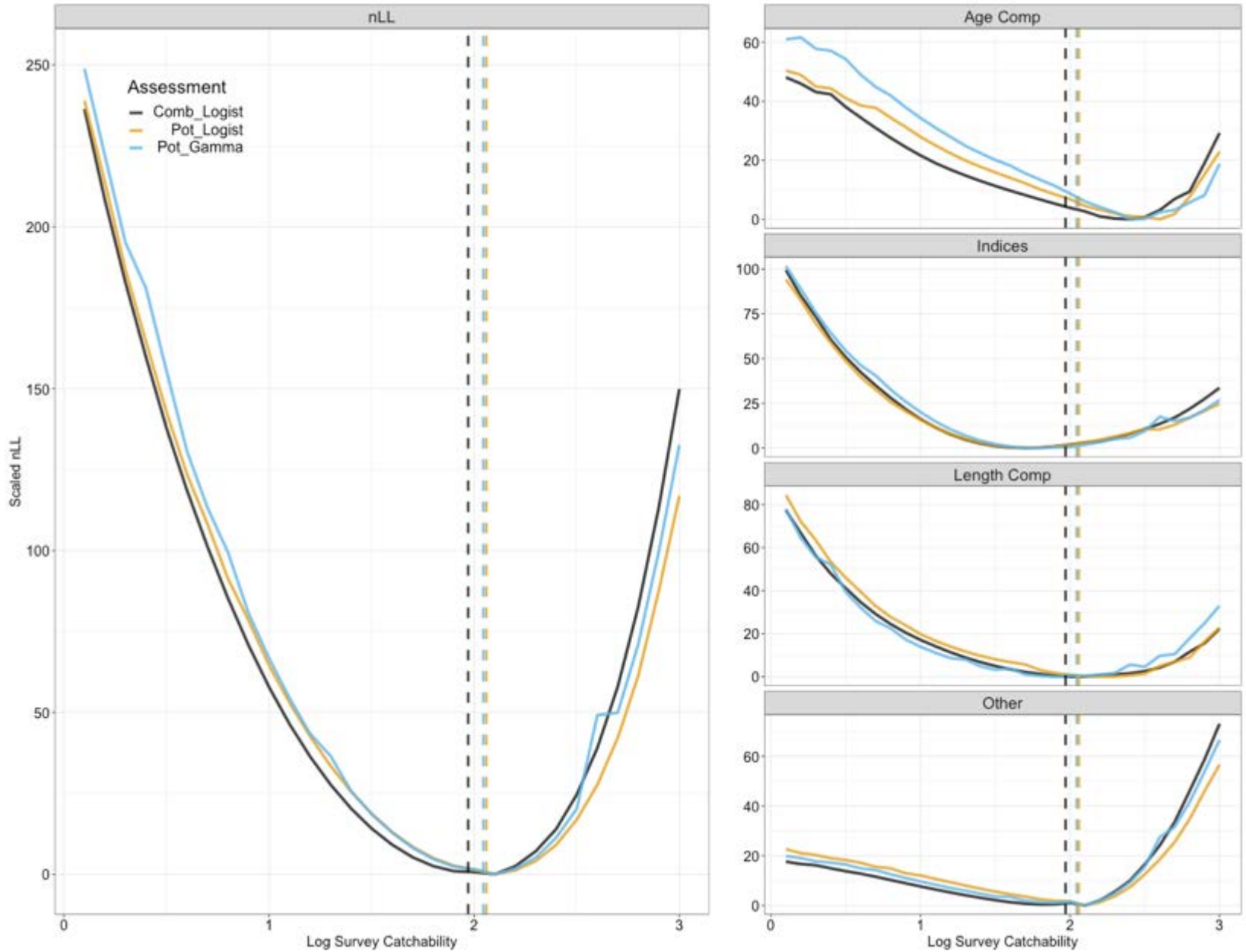
HAL Male Length Compositions

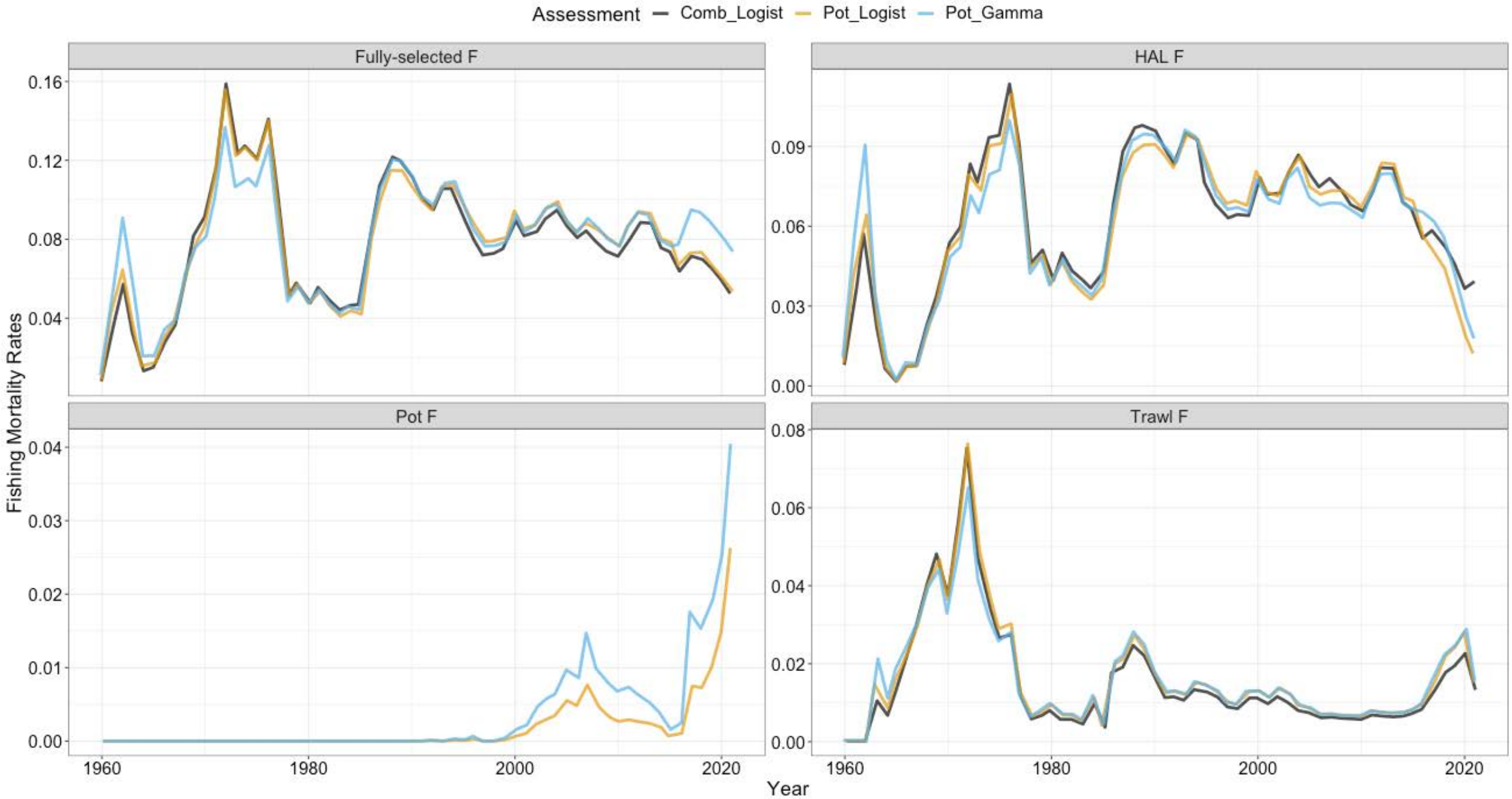



HAL Age
Pot Age
MAR = 0.724
OSA Residuals
-2 0 2
MAR = 0.76
MAR = 0.854
MAR = 0.723
MAR = 0.804
Comb_Logist
Pot_Logist
Pot_Gamma
Age
Year
0
10
20
30
2000
2005
2010
2015
2020


HAL Length Female
HAL Length Male
Pot Length Female
Pot Length Male
MAR = 0.549
MAR = 0.689
OSA Residuals
-4 -2 0 2
MAR = 0.548
MAR = 0.636
MAR = 0.787
MAR = 0.745
MAR = 0.573
MAR = 0.618
MAR = 0.747
MAR = 0.715
Comb_Logist
Pot_Logist
Pot_Gamma
Length
Year
40
60
80
100
1990
2000
2005
2010
2015
2020


nLL
Assessment
Comb_Logist
Pot_Logist
Pot_Gamma
Scaled nLL
Log Mean Recruitment
Age Comp
Indices
Length Comp
Other
Log Mean Recruitment


nLL
Assessment
Comb_Logist
Pot_Logist
Pot_Gamma
Scaled nLL
Log Survey Catchability
Age Comp
Indices
Length Comp
Other
Log Survey Catchability


Assessment
Comb_Logist
Pot_Logist
Pot_Gamma
Fully-selected F
HAL F
Pot F
Trawl F
Fishing Mortality Rates
Year
0.16
0.12
0.08
0.04
0.09
0.06
0.03
0.00
0.04
0.03
0.02
0.01
0.00
0.08
0.06
0.04
0.02
0.00
1960
1980
2000
2020