Appendix A: Proposed size structured stock assessment model framework for Alaska weathervane scallops

Tyler Jackson

CPT Modelling Workshop Jan 2026

Background

Outstanding SSC request for SPT to develop model-based stock assessment for weathervane scallops

Pursued age structured model for a long time – some uncertainty surrounding age validity and error – don't need age cohort resolution anyway…

Produced simple state-space RE model on survey biomass and fishery CPUE (*rema*) – doesn't make use of all the available size data

Solution – **simple** size structured model

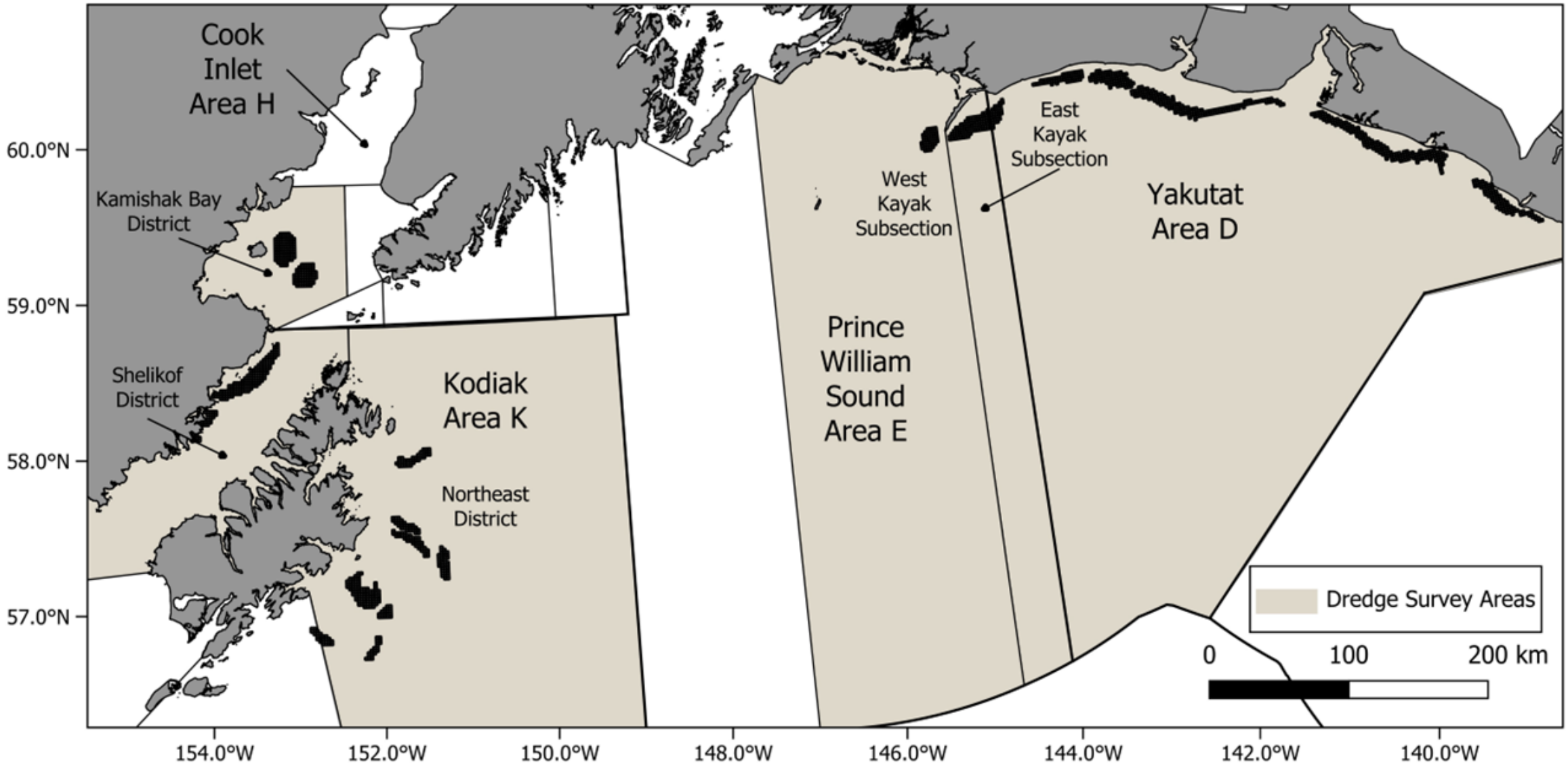
Why bold and underline ‘simple’?

Scallop fishery is not economically irrelevant, but its small (i.e., avoid over capitalizing assessment author time)

SPT has always lacked quantitative expertise, very few folks doing AK scallop science otherwise

Considered 1 stock in FMP, more likely at least 4, managed in 11 areas

Need a one-size-fits-all modelling approach


Cook
Inlet
Area H
Kamishak Bay
District
Shelikof
District
Kodiak
Area K
Northeast
District
Prince
William
Sound
Area E
West
Kayak
Subsection
East
Kayak
Subsection
Yakutat
Area D
Dredge Survey Areas
0
100
200 km
60.0°N
59.0°N
58.0°N
57.0°N
154.0°W
152.0°W
150.0°W
148.0°W
146.0°W
144.0°W
142.0°W
140.0°W

Model Dimensions

Model runs from 1990 (1997) – 2025

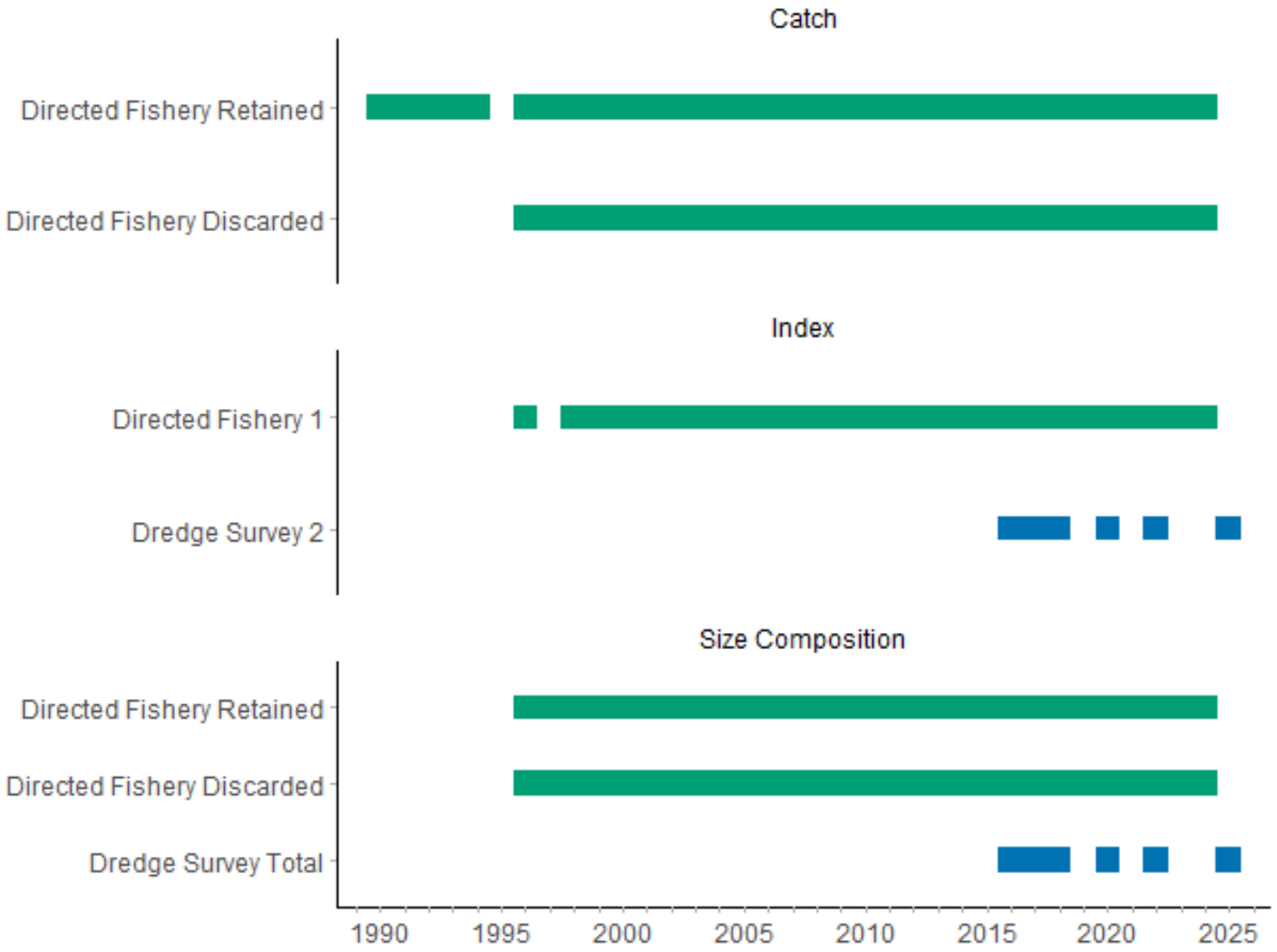
- Non-equilibrium initial conditions

Single sex (i.e., males + females combined)

10 mm size classes from 31 mm – 160+ mm

Two fleets: directed fishery, dredge survey

Data Types and Estimation



Most biological processes fixed and estimated outside of model

KSH – 98 parameters

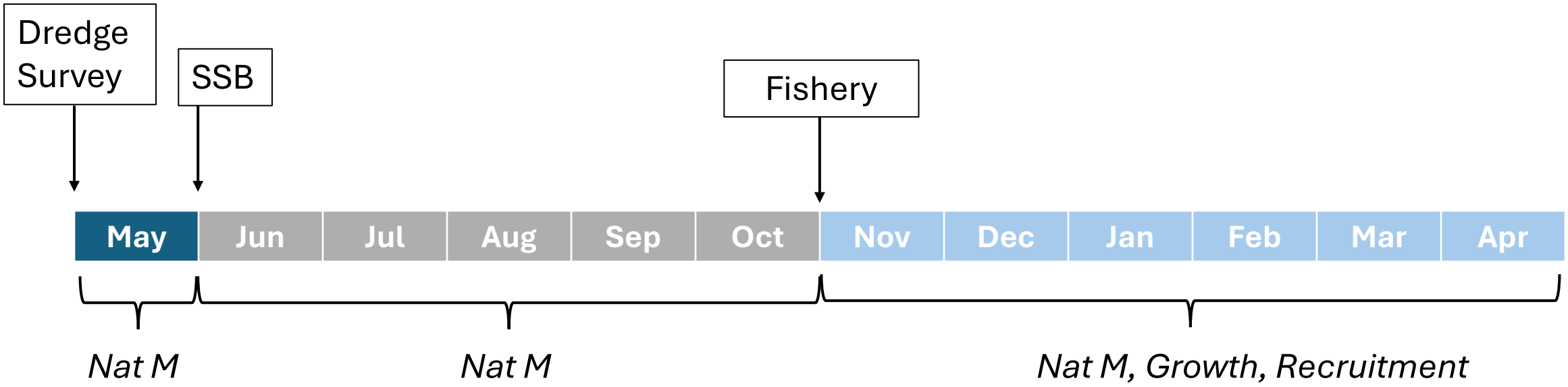
KNE – 98 parameters

WKI – 76 parameters

EKI – 71 parameters

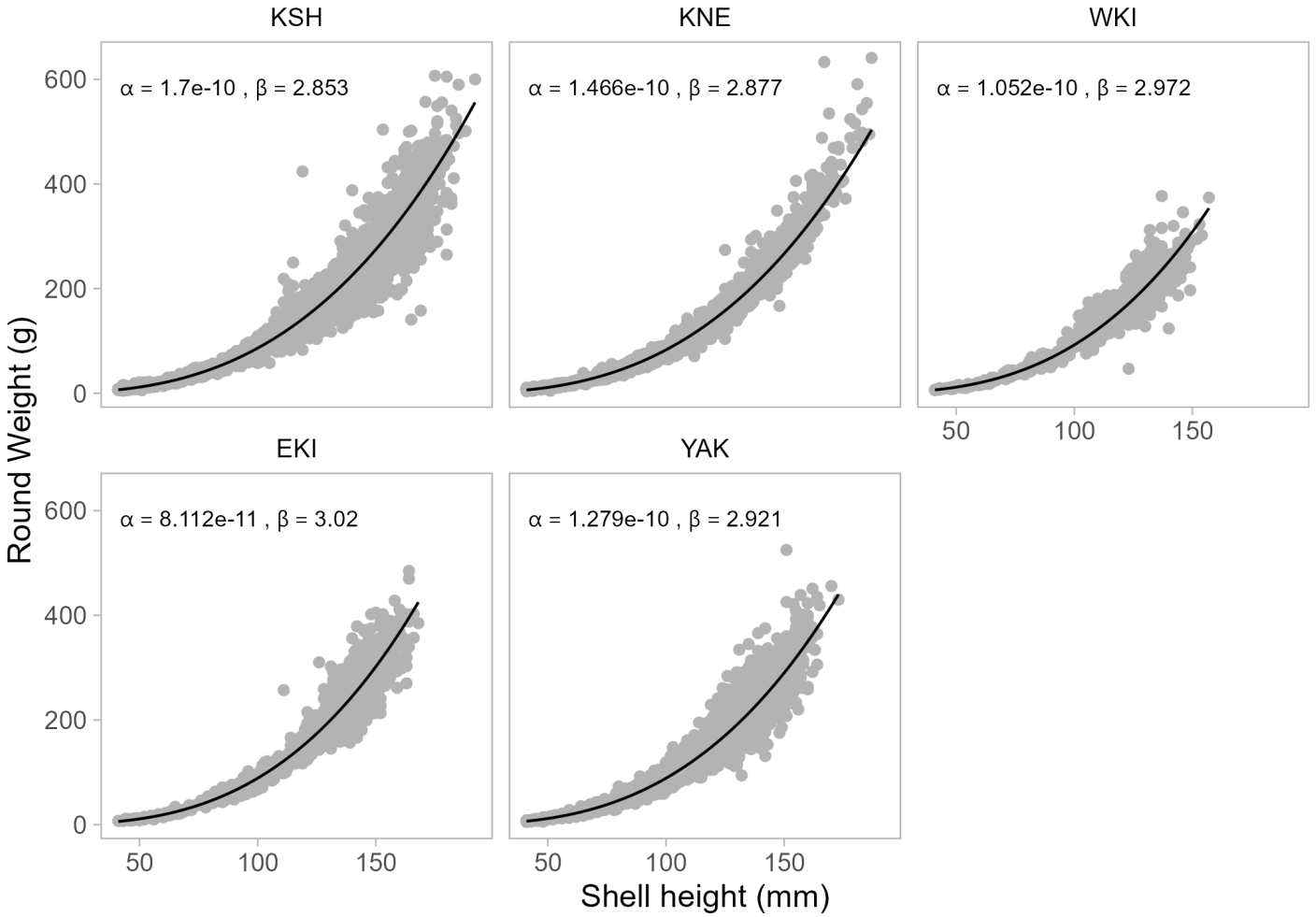
YAK – 96 parameters

Annual Structure: May 1 – Apr 30

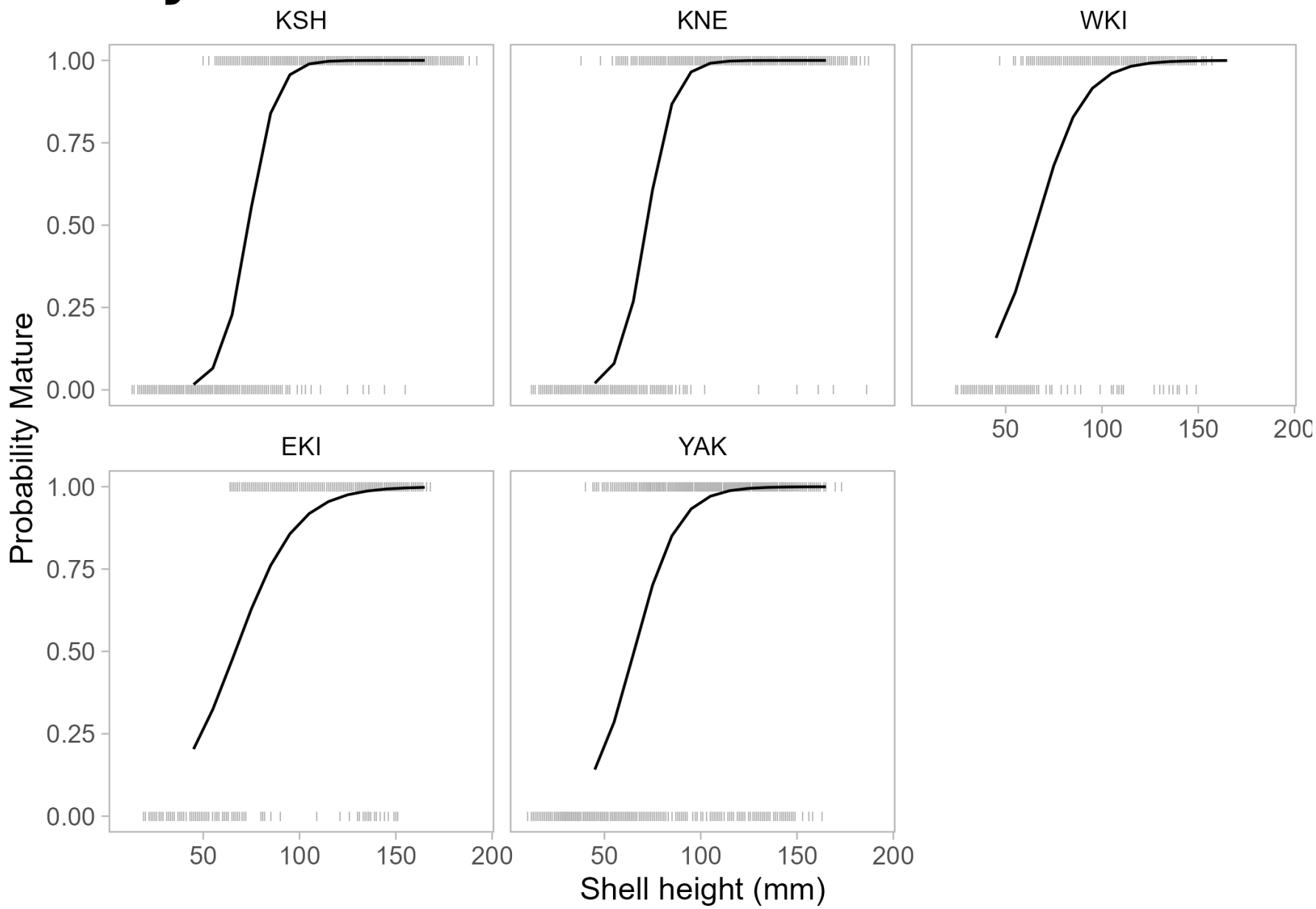


Biological Info and Natural Mortality

- Weight at length is allometric, area specific (from survey data)
- All sizes are legal
- Natural Mortality = 0.13 (FMP)



Maturity

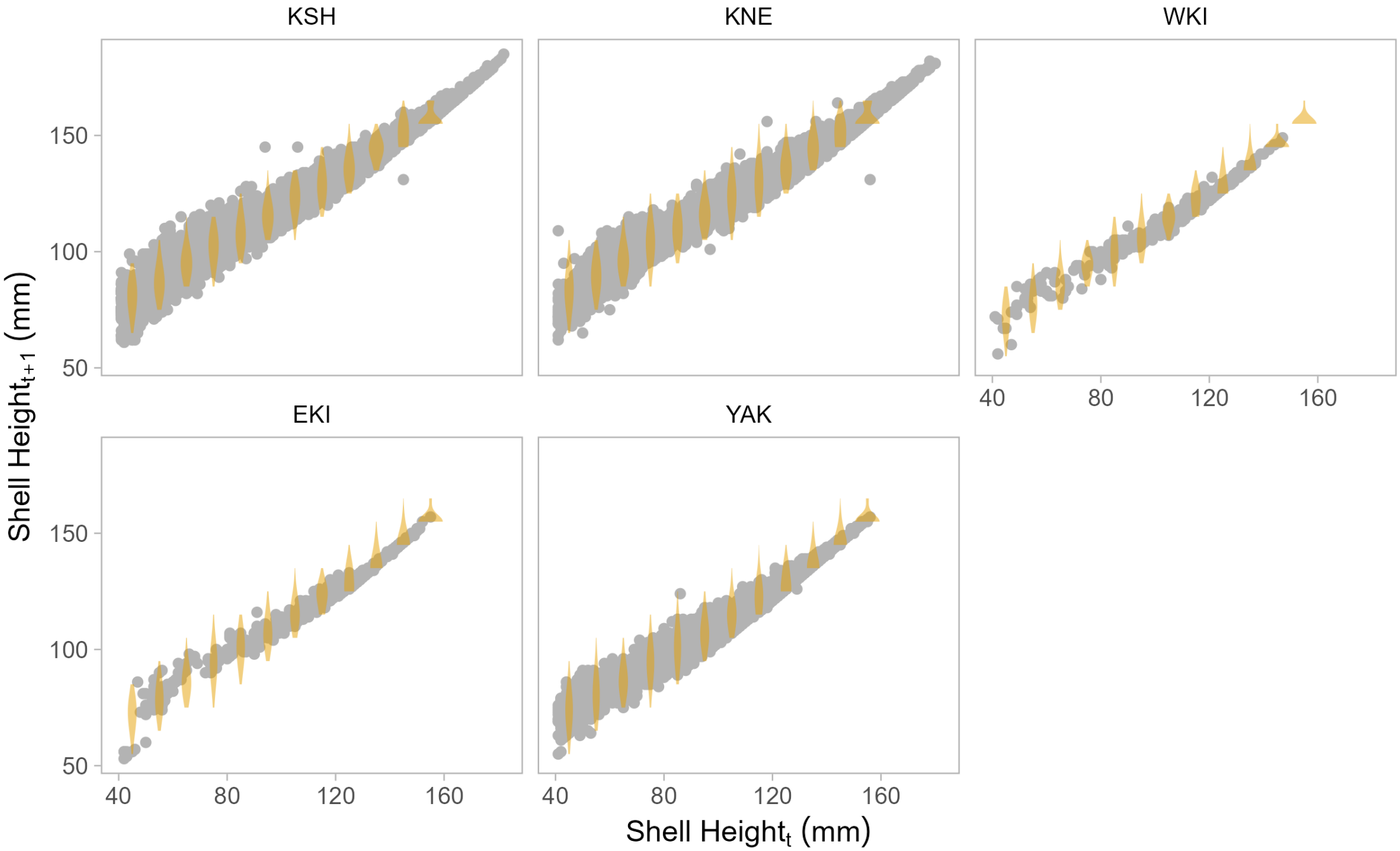

KSH
KNE
WKI
EKI
YAK
Probability Mature
1.00
0.75
0.50
0.25
0.00
50
100
150
200
Shell height (mm)

Growth Transition

- Growth occurs annually for all sizes

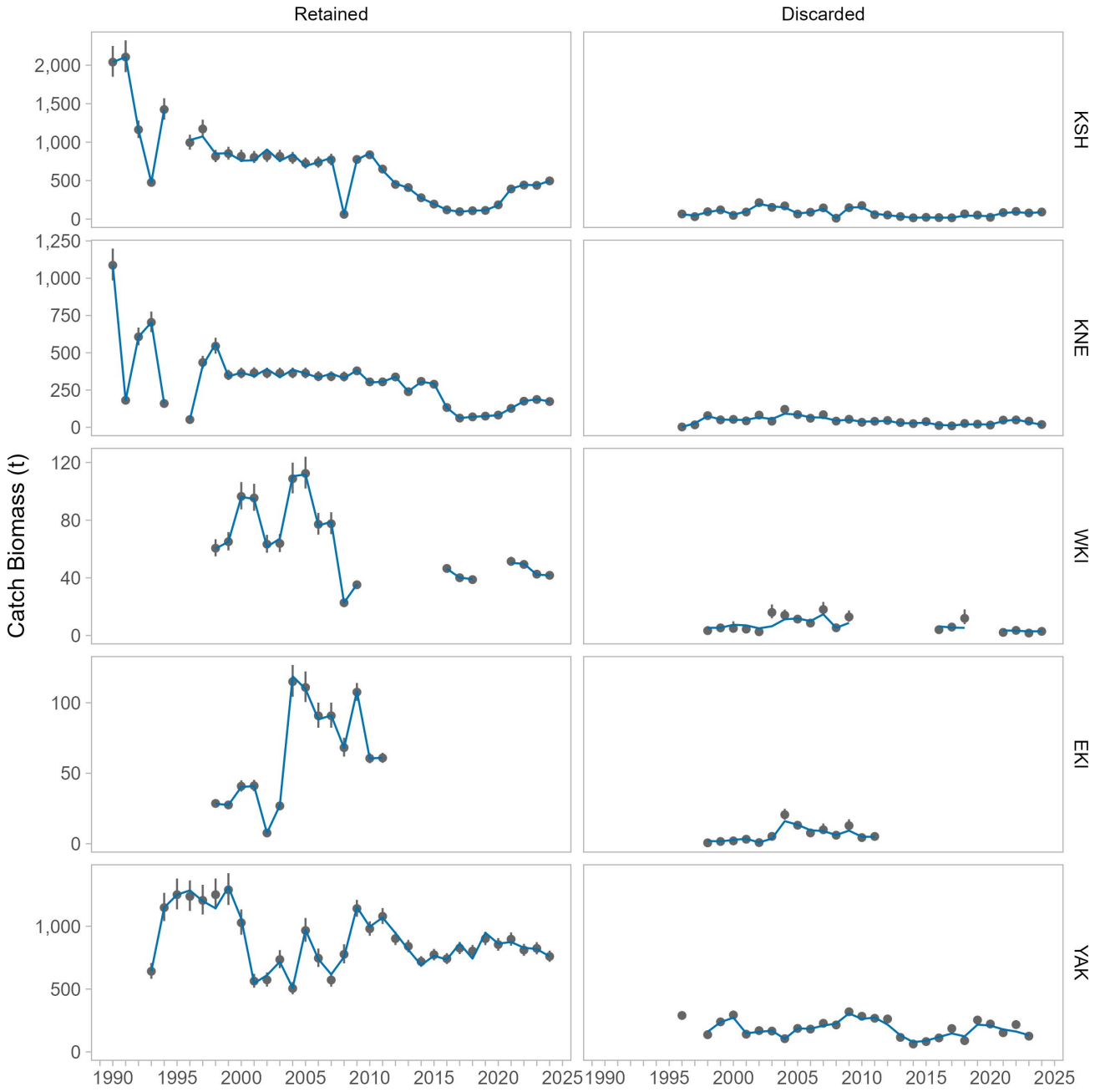
- Assumes LVB growth, w/ σ_{L_∞} (individual variation in L_{inf})(Cronin-Fine and Punt 2020)

- Mean L_{inf} and *K*, and σ_{L_∞} estimated from mixed model on growth increment data (Hart and Chute 2009)


KSH
KNE
WKI
EKI
YAK
Shell Height$_{t+1}$ (mm)
Shell Height$_t$ (mm)
50
100
150
40
80
120
160

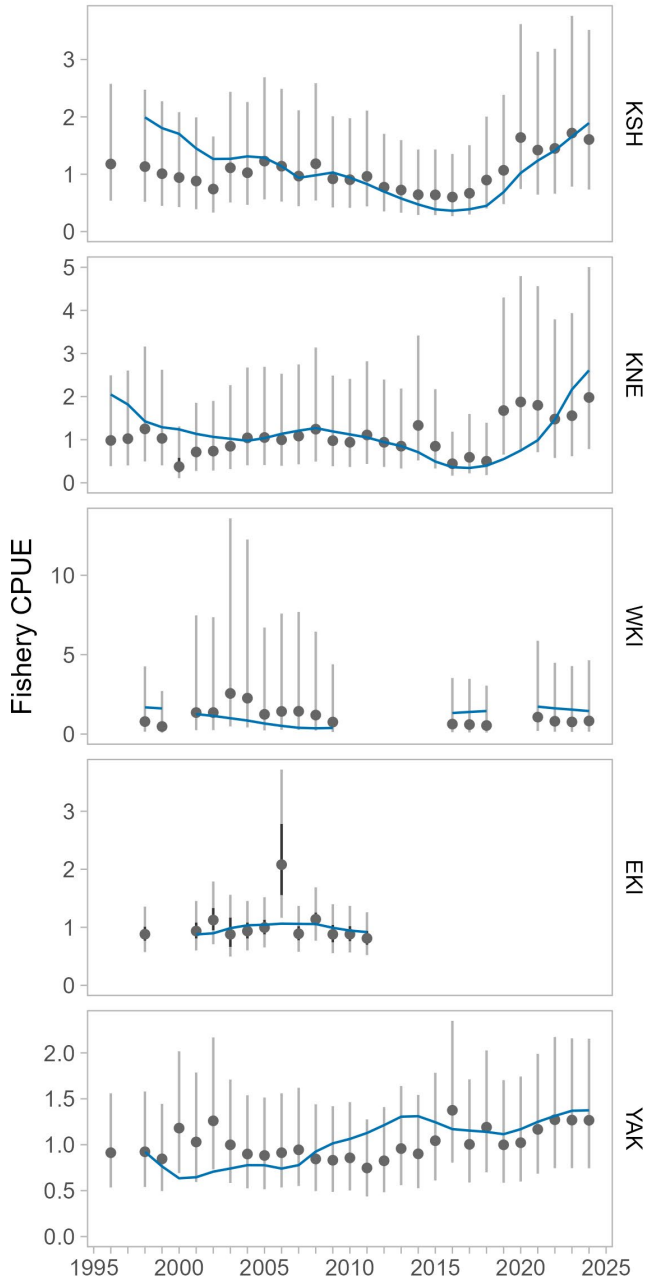
Catch Data

- Round weight
- Round weight less seasonally variable
- Fishery selectivity and retention logistic



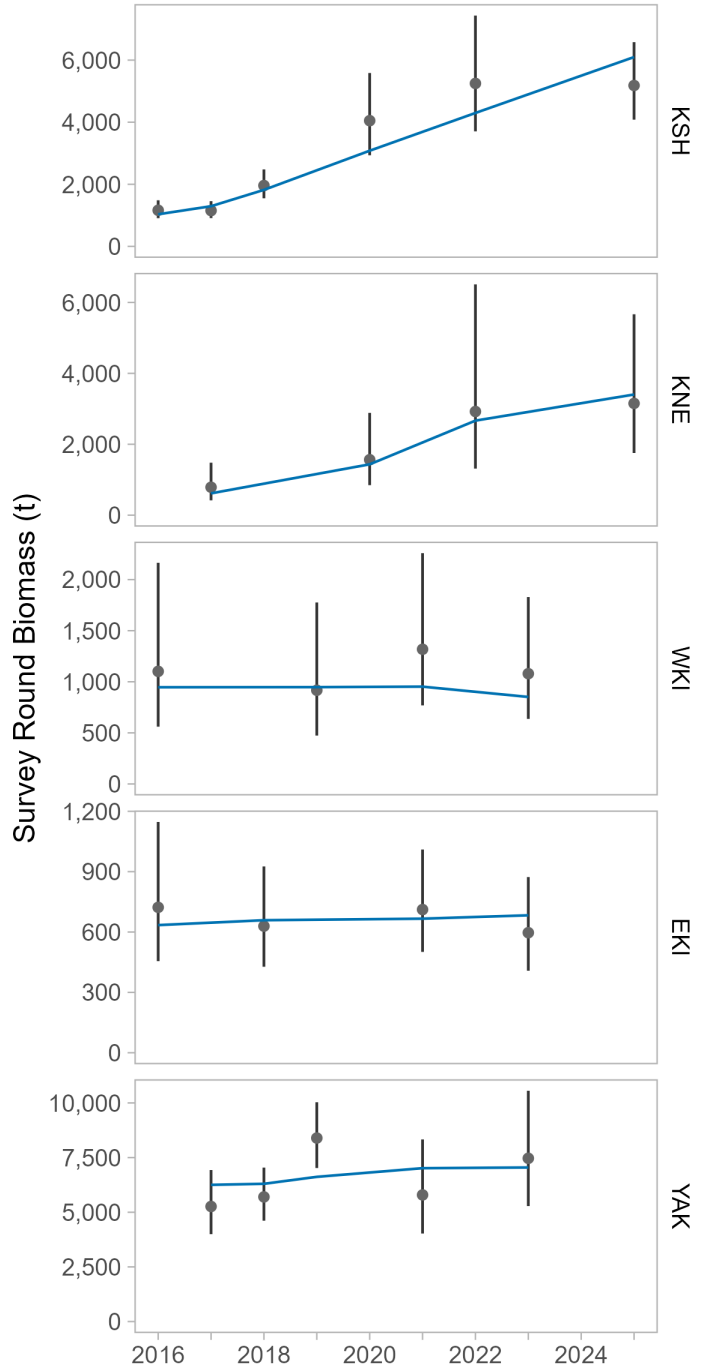
CPUE Data

- GAM CPUE standardization – *Same as last cycle see SAFE Appendix B*
- Catchability estimated, additional CV estimated
- *KNE and YAK contain multiple beds that are fished inconsistently*



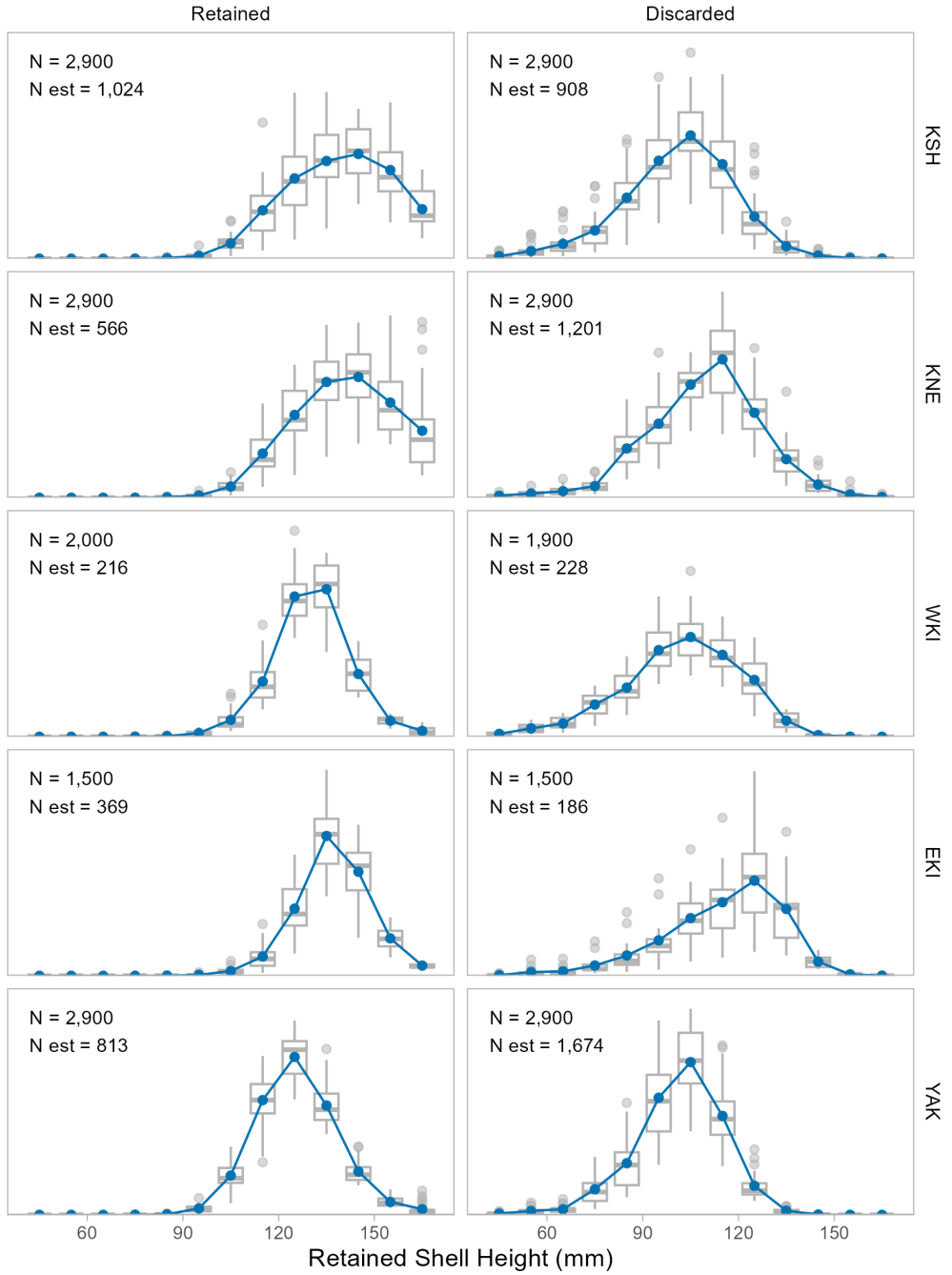
Survey Biomass

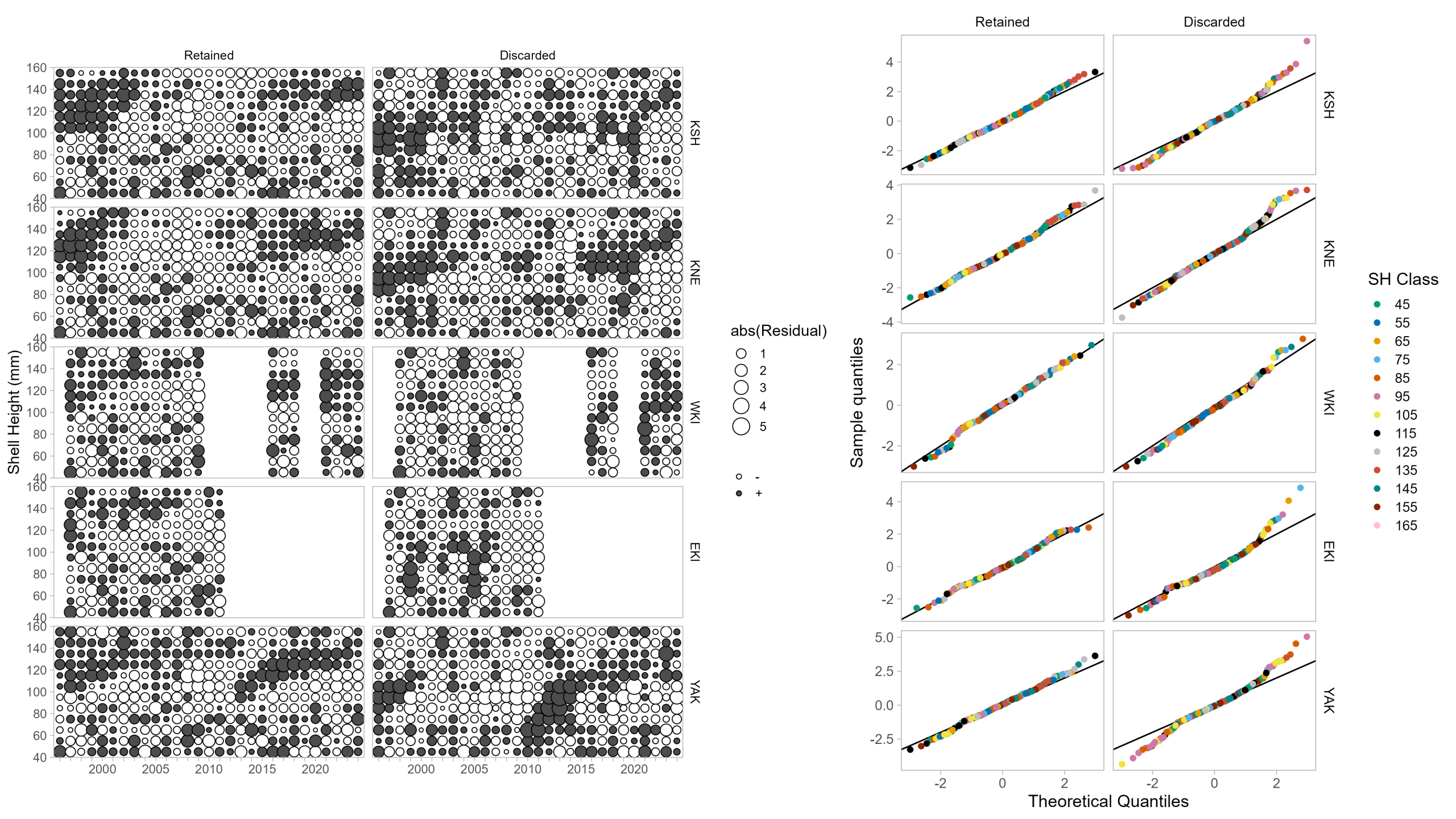
- All scallops > 41 mm SH
- No retention
- Catchability = 1
- Logistic selectivity



Fishery Size

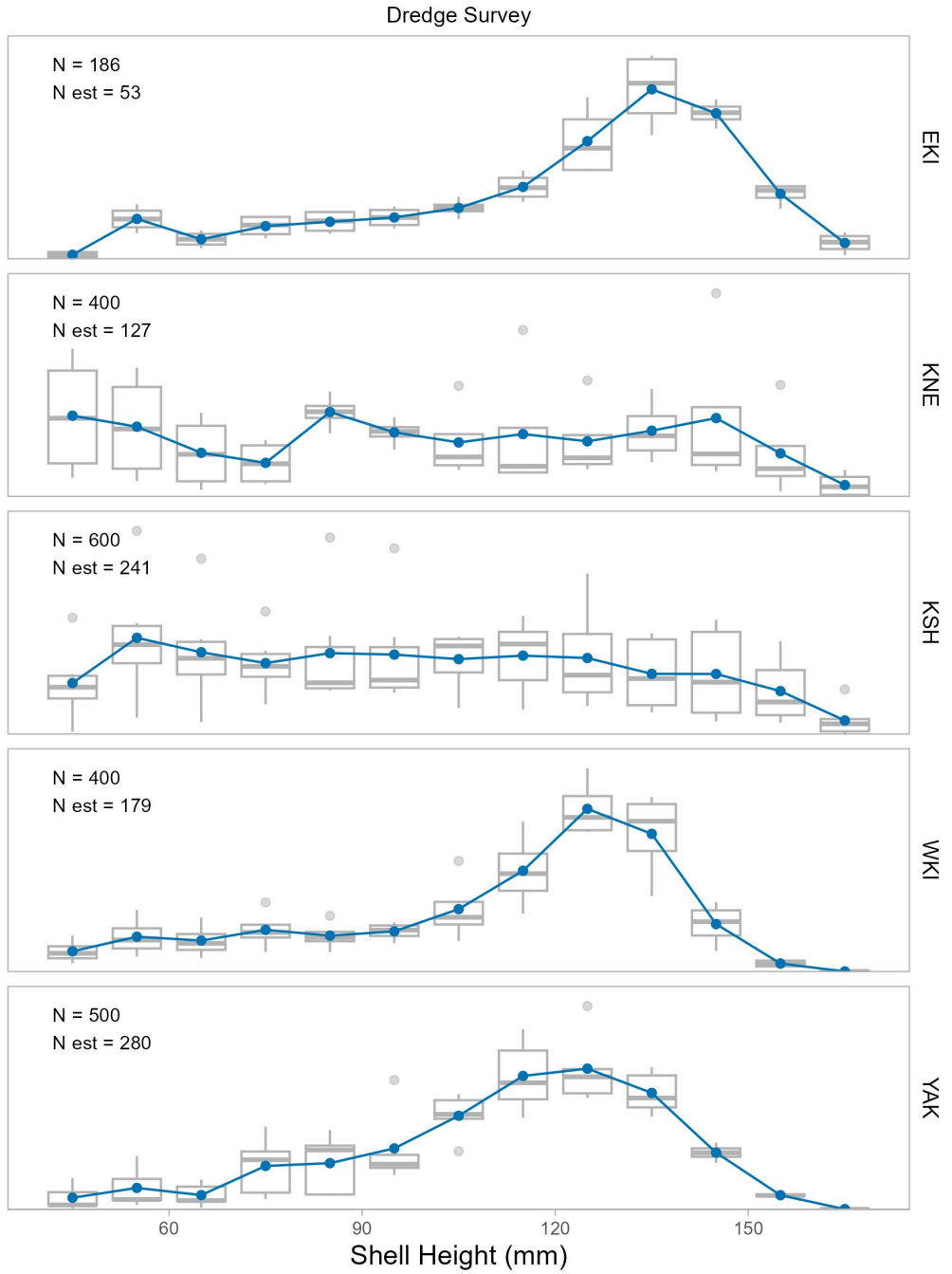
- Dirichlet multinominal
- Input N = 100
- Adequate fit overall, some misfits by year

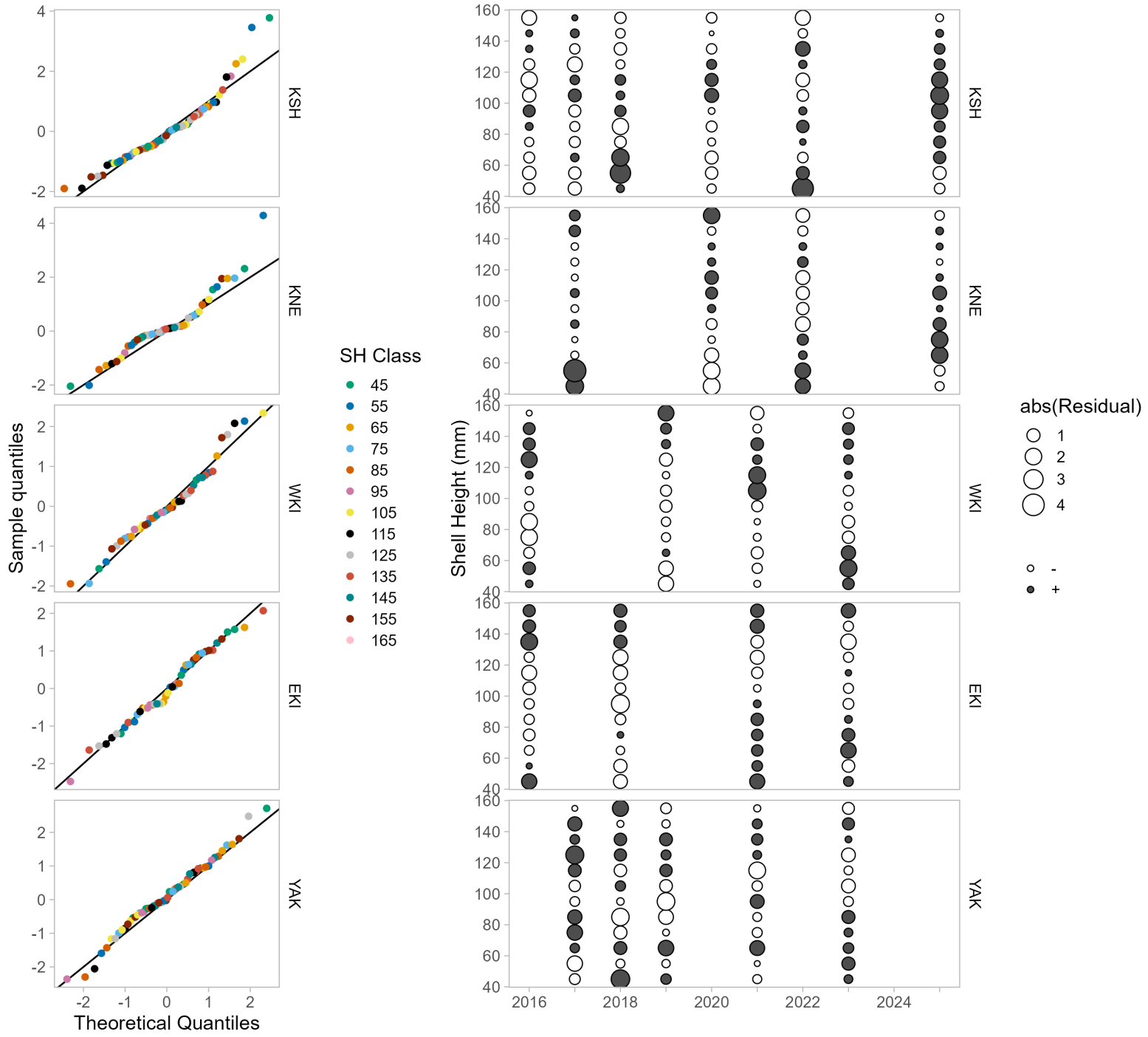



Retained
Discarded
KSH
KNE
WKI
EKI
YAK
Shell Height (mm)
160
140
120
100
80
60
40
2000
2005
2010
2015
2020
abs(Residual)
1
2
3
4
5
-
+
Sample quantiles
Theoretical Quantiles
4
2
0
-2
-4
5.0
2.5
0.0
-2.5
SH Class
45
55
65
75
85
95
105
115
125
135
145
155
165

Survey Size

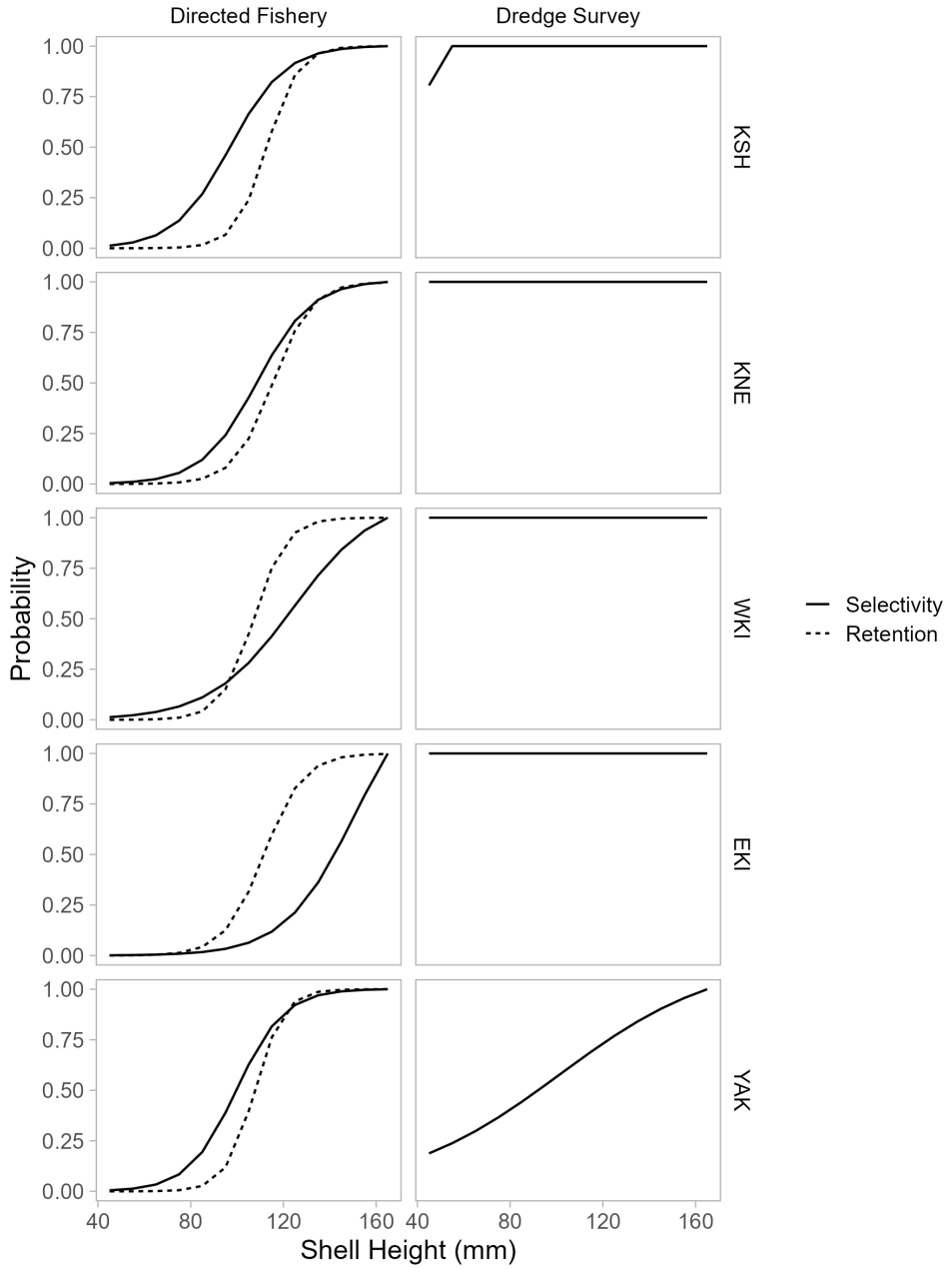
- Dirichlet multinominal
- Input N = 100
- Adequate fit overall, some misfits by year

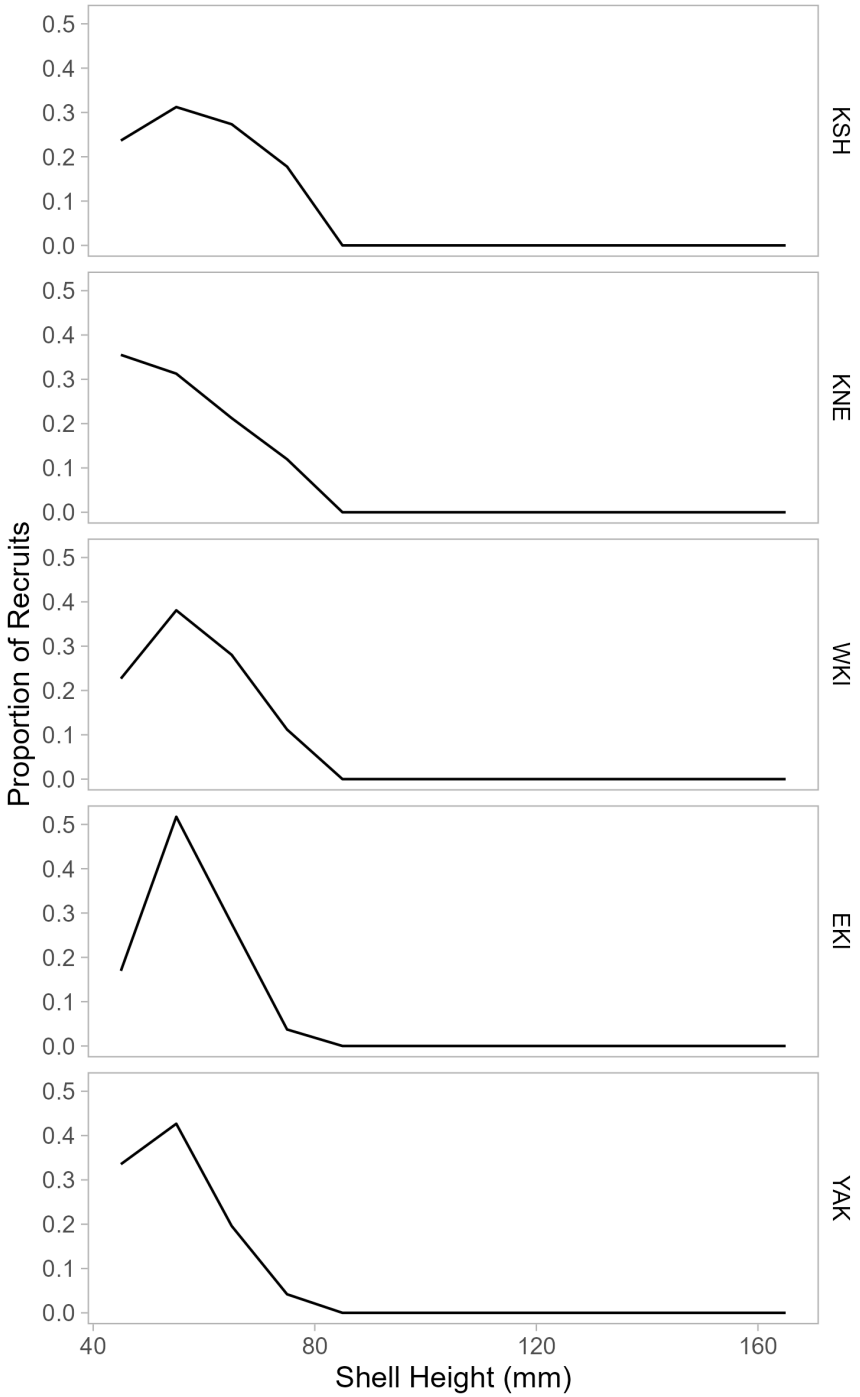


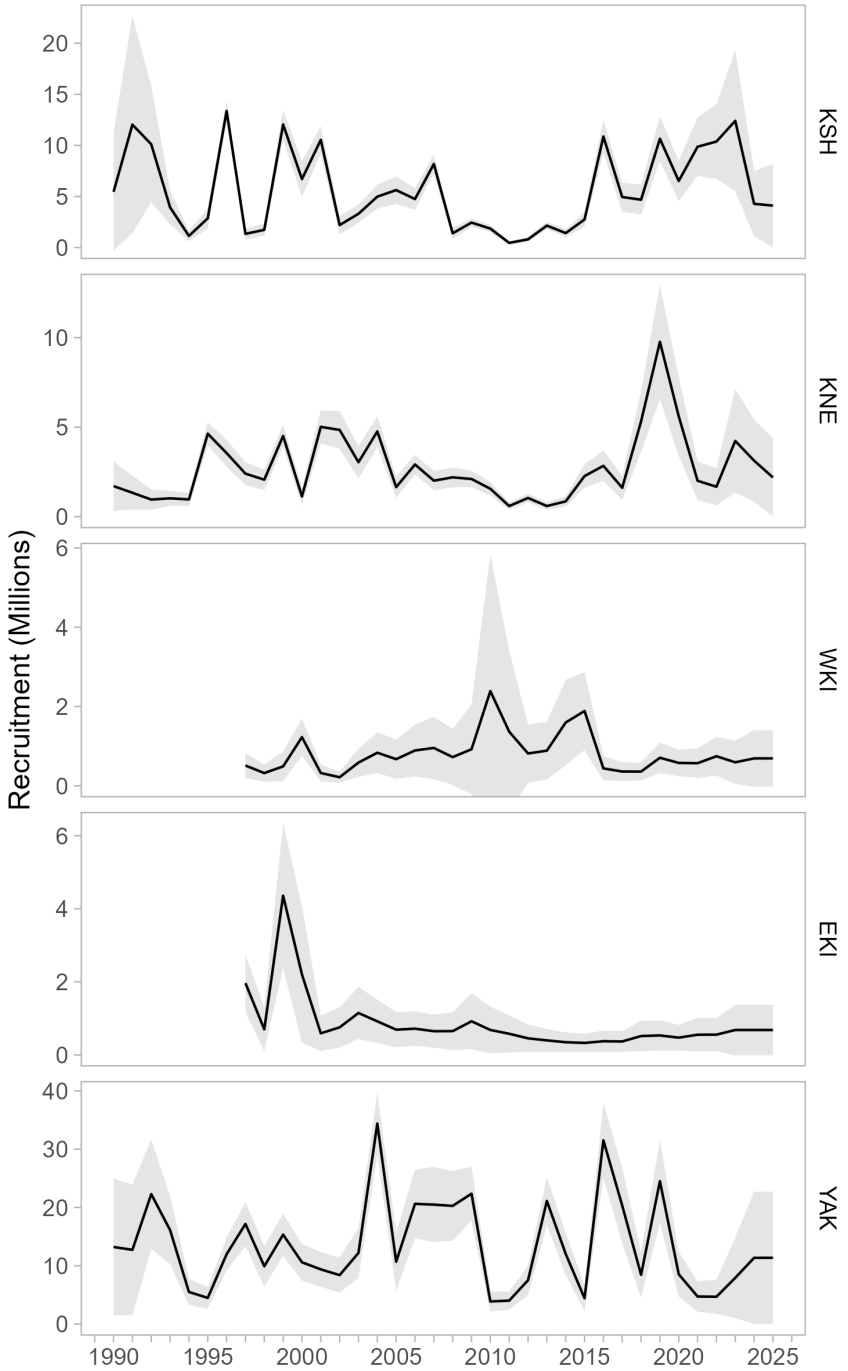

KSH
KNE
WKI
EKI
YAK
Sample quantiles
Theoretical Quantiles
Shell Height (mm)
SH Class
45
55
65
75
85
95
105
115
125
135
145
155
165
abs(Residual)
1
2
3
4
-
+
2016
2018
2020
2022
2024

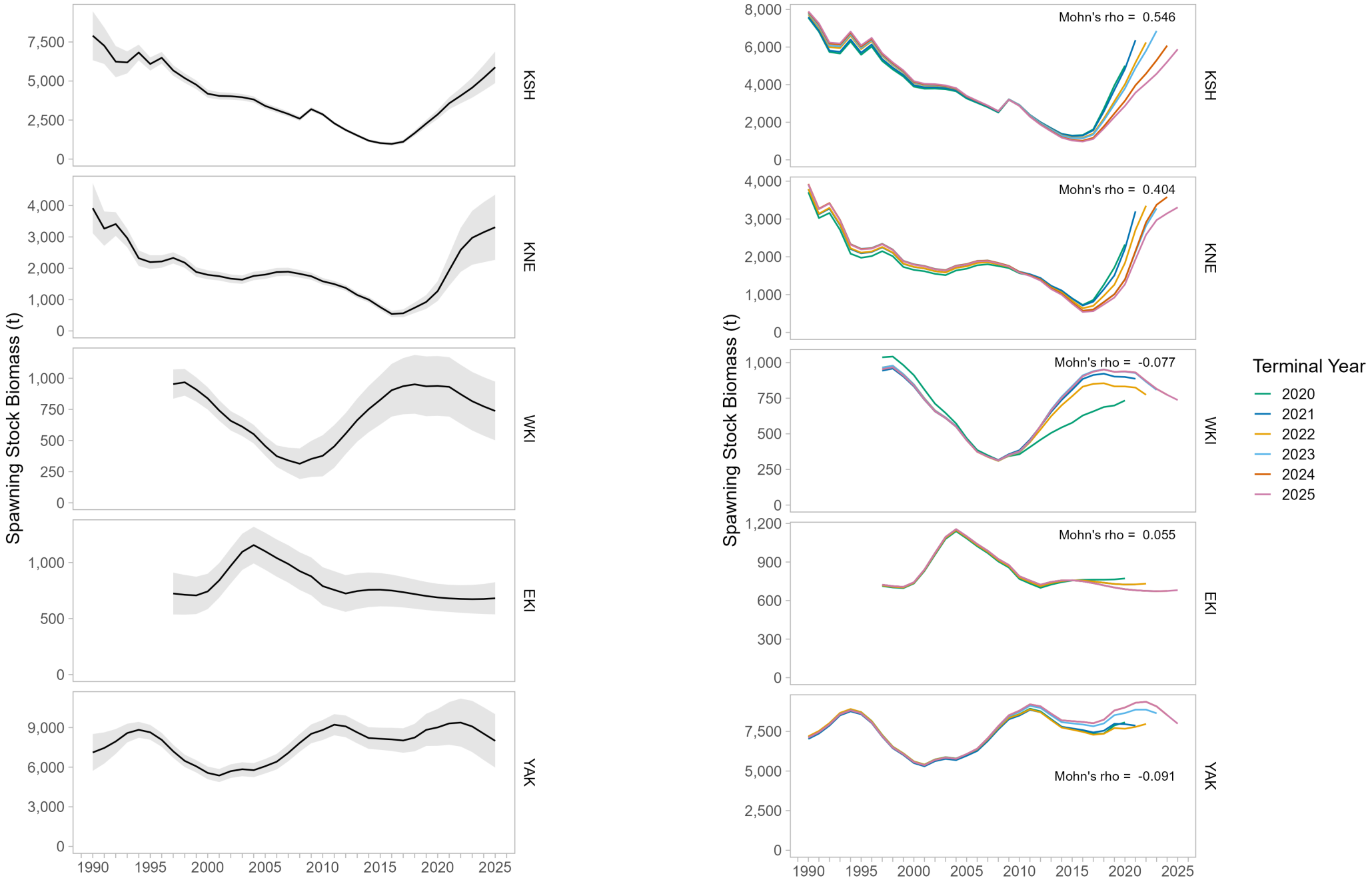
Selectivity

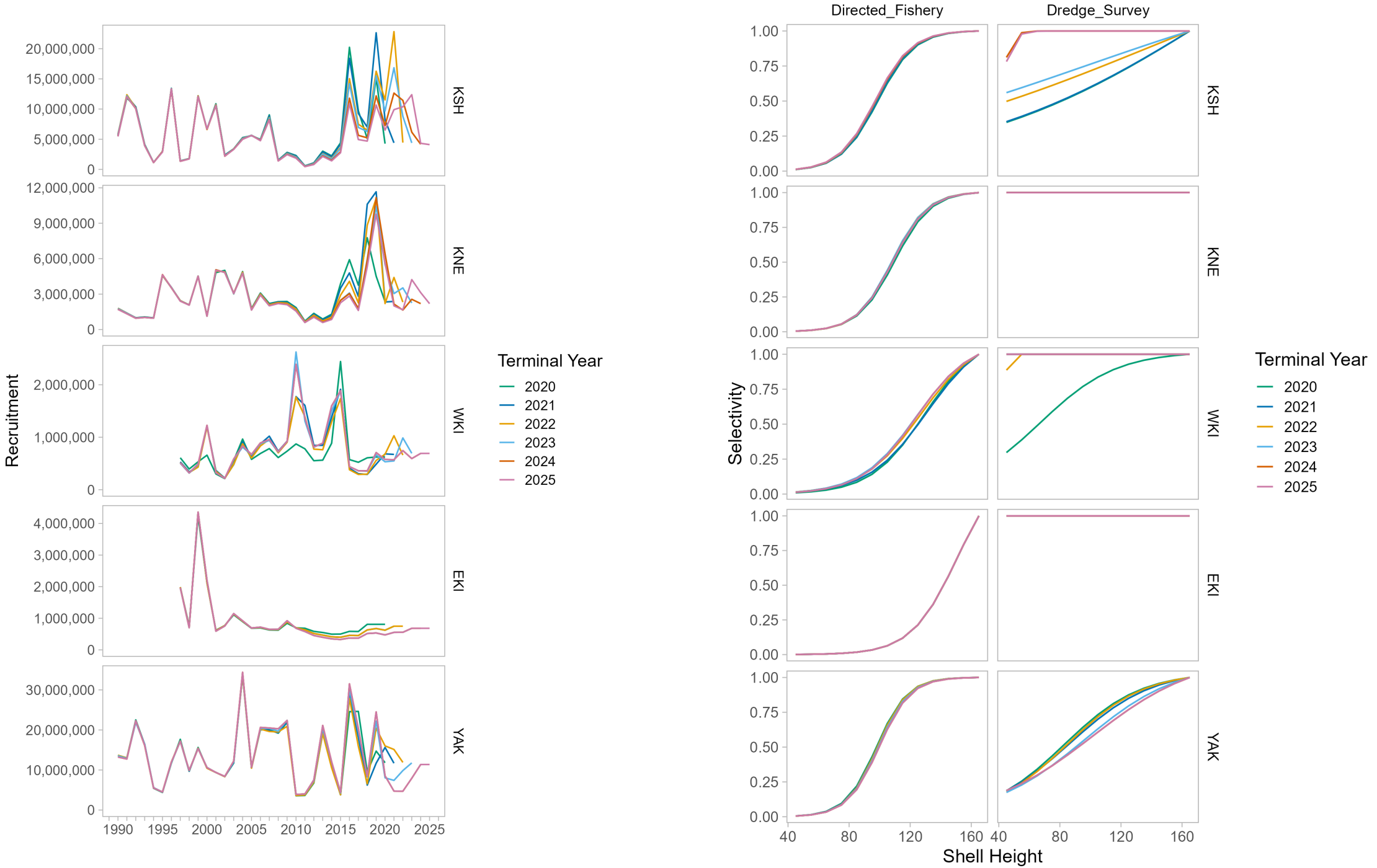
- Logistic, forced to 1 at 160+
- No retention in survey
- Survey dredge uses 1.5” (38 mm) mesh liner
- Not estimable in all districts accept YAK




Proportion of Recruits
0.0
0.1
0.2
0.3
0.4
0.5
KSH
KNE
WKI
EKI
YAK
40
80
120
160
Shell Height (mm)


Recruitment (Millions)
KSH
KNE
WKI
EKI
YAK
1990
1995
2000
2005
2010
2015
2020
2025


Spawning Stock Biomass (t)
KSH
KNE
WKI
EKI
YAK
Mohn's rho = 0.546
Mohn's rho = 0.404
Mohn's rho = -0.077
Mohn's rho = 0.055
Mohn's rho = -0.091
Terminal Year
2020
2021
2022
2023
2024
2025
1990
1995
2000
2005
2010
2015
2020
2025


Recruitment
KSH
KNE
WKI
EKI
YAK
20,000,000
15,000,000
10,000,000
5,000,000
0
12,000,000
9,000,000
6,000,000
3,000,000
2,000,000
1,000,000
4,000,000
30,000,000
1990
1995
2000
2005
2010
2015
2020
2025
Terminal Year
2020
2021
2022
2023
2024
2025
Directed_Fishery
Dredge_Survey
Selectivity
1.00
0.75
0.50
0.25
0.00
40
80
120
160
Shell Height

Jittering

‘Jitter’ parameter starting values and refit model to evaluate likelihood surface and convergence

Multiple minima identified for all models (i.e., jittering provided good view of likelihood surface near MLE)

All models have multiple runs at MLE, low maximum gradients

Survey selectivity obvious convergence issue, flat part of likelihood surface

Conclusions

Model performance seems promising

- Adequately captures population dynamics by integrating data sources without undue complexity
- Most widely applicable weathervane scallop model to date (i.e. covering all surveyed districts)

- Some clear structural misspecification – should be able to be resolved…

- Can we use it to determine OFL??? *A few things first*…

Harvest Control Rules (HCRS)

Harvest control rule needed to link biomass, stock status, and fishing mortality

Crab and Groundfish Plan Teams use similar tier system for HCRS

Scallop FMP has no tier system, but stock is effectively a Tier 5 or 6 (based on total catch during a reference period assumed to represent OY)

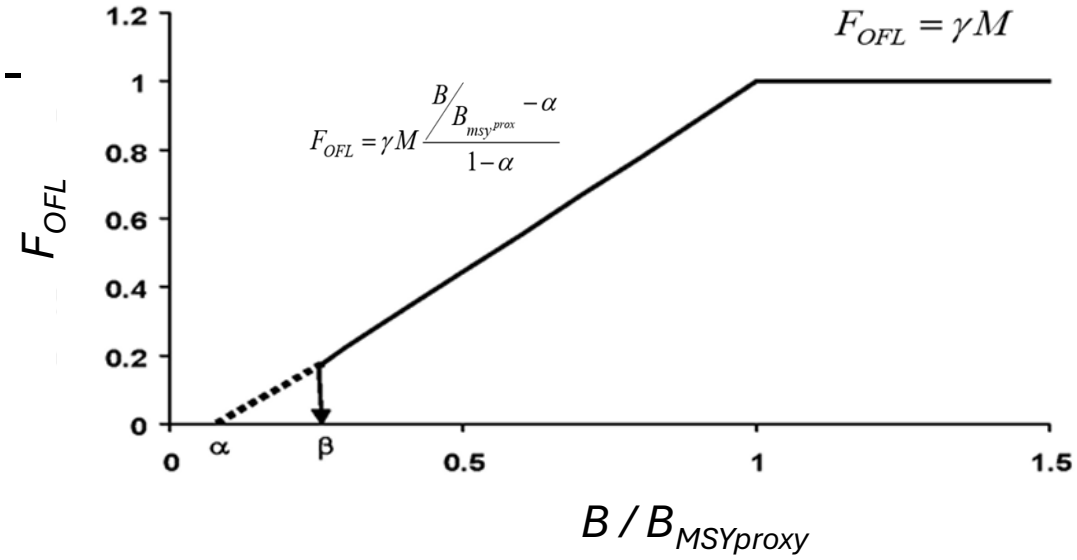
Harvest Control Rules (HCRS)

Scallop information for modelling portion of stock fits Tier 4 (Crab), Tier 5 (Groundfish)

"…sufficient information for simulation modeling that captures the essential population dynamics of the stock as well as the performance of the fisheries." (Crab FMP)

Groundfish Tier 5 – $F_{OFL} = M$

Crab Tier 4 -

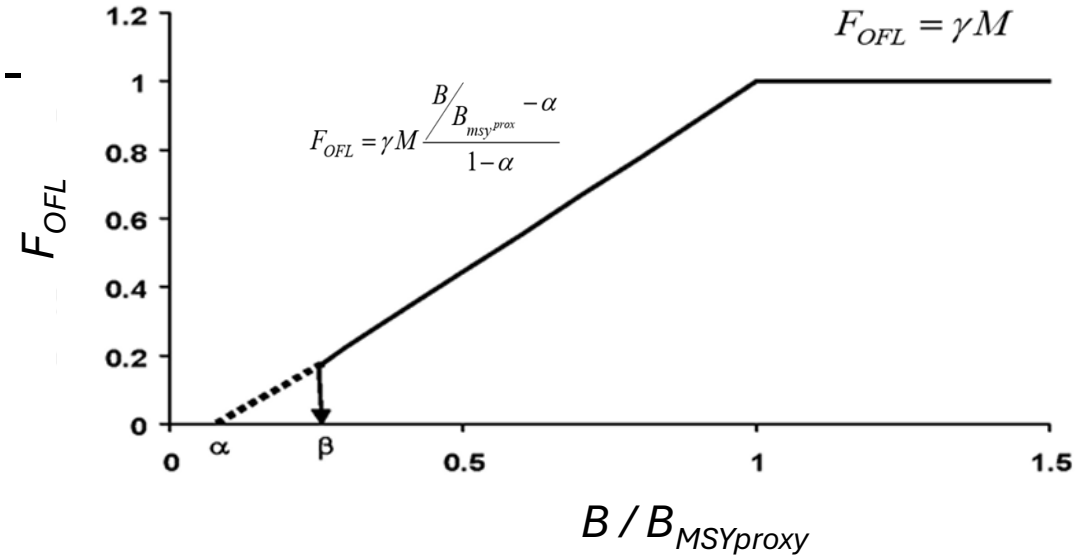


Harvest Control Rules (HCRS)

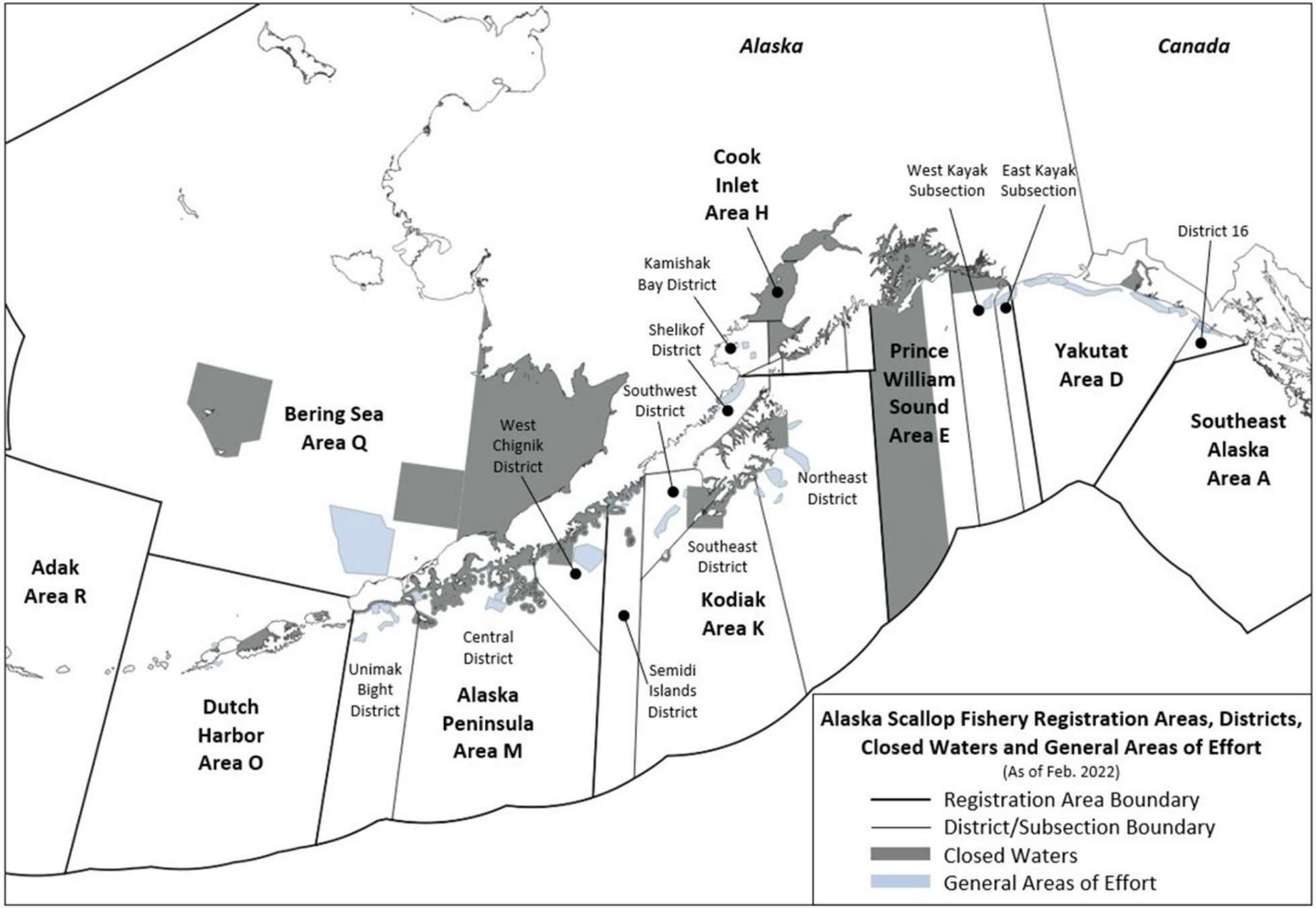
Scallop information for modelling portion of stock fits Tier 4 (Crab), Tier 5 (Groundfish)

"…sufficient information for simulation modeling that captures the essential population dynamics of the stock as well as the performance of the fisheries." (Crab FMP)

Groundfish Tier 5 – $F_{OFL} = M$ Crab Tier 4 -



Worthwhile to revisit *M*!


Alaska
Canada
Cook Inlet Area H
West Kayak Subsection
East Kayak Subsection
District 16
Kamishak Bay District
Shelikof District
Southwest District
Prince William Sound Area E
Yakutat Area D
Southeast Alaska Area A
Bering Sea Area Q
West Chignik District
Northeast District
Southeast District
Kodiak Area K
Adak Area R
Central District
Unimak Bight District
Alaska Peninsula Area M
Semidi Islands District
Dutch Harbor Area O
Alaska Scallop Fishery Registration Areas, Districts, Closed Waters and General Areas of Effort
(As of Feb. 2022)
Registration Area Boundary
District/Subsection Boundary
Closed Waters
General Areas of Effort

Split HCR – Stock delineation base on data

Core (i.e. Surveyed/Fished) Stock - KSH, KNE, WKI, EKI, YAK (model based)

Non-Core (i.e. Surveyed/Fished) Stock – H, KSW, KSE, KSEM, M, O, Q (status quo, total catch)

$$\underset{}{\mathrm{OFL}} = \underset{\text{(core)}}{\mathrm{OFL}_s} + \underset{\text{(non-core)}}{\mathrm{OFL}_{ns}}$$

Recommendation

Utility of any modelling approach relies on:

- Getting around the data disparity throughout the ‘single’ stock
- Plan Team support

If we can resolve those two issues, pursuing a model-based assessment during the next cycle is feasible, if not, let’s bag it

Potential solutions for SPT:

1) Fill vacant seats with quantitative and scallop biology expertise (unlikely)
2) Absorb SPT by either CPT or GPT

   CPT makes more sense given size-structured modelling, joint Fed-State management