Examining biological processes in the assessment for eastern Bering Sea snow crab

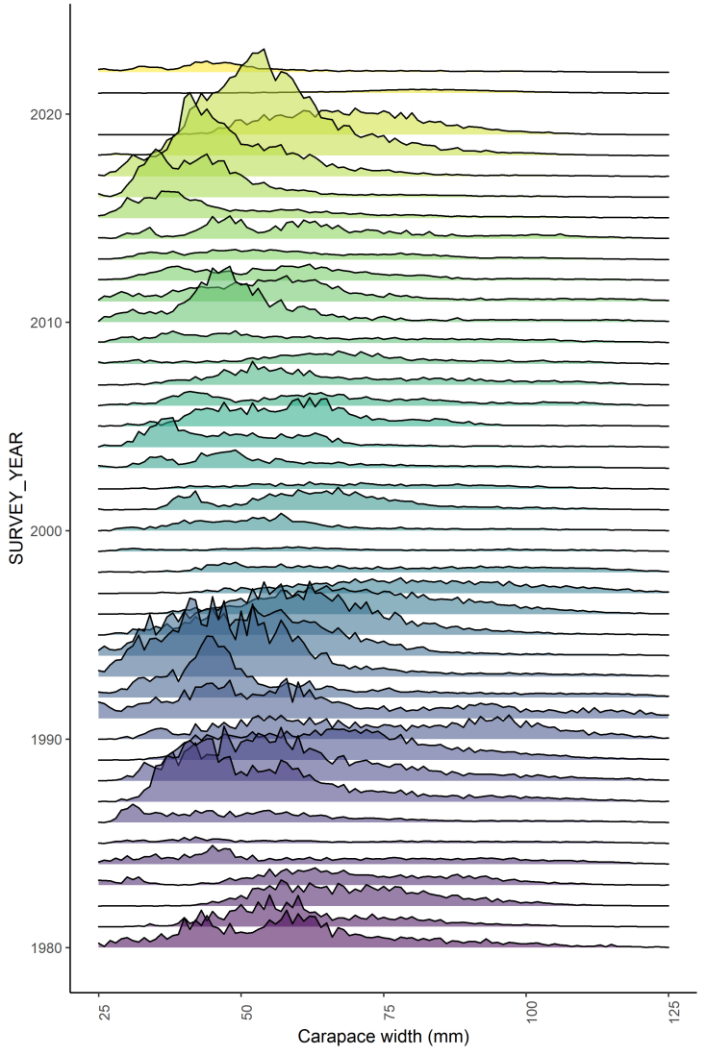
Cody Szuwalski

- March meeting guidance
  - Recent problems
  - Let biology lead
  - Think outside of historical decisions made
- First step in larger revision
  - Few tables, likelihoods, residuals, etc.
  - Big picture questions
- Models
  - Status quo
  - Research model
  - Bridging models
  - Simplest
- What happened updates
  - Still in review

Build from biology first

- Snow crab data are impressive
  - NMFS survey (abundance indices, size comps, chelae height etc.)
  - BSFRF survey selectivity experiments
  - Growth increment data
- Terminal molt to maturity is important to capture appropriately because of its impacts on growth
- Survey selectivity is important to capture because it scales the index
- Natural mortality is a tricky parameter

We need to represent these processes appropriately in the model to ensure good estimates of biomass at the time of the next fishery to provide catch advice.



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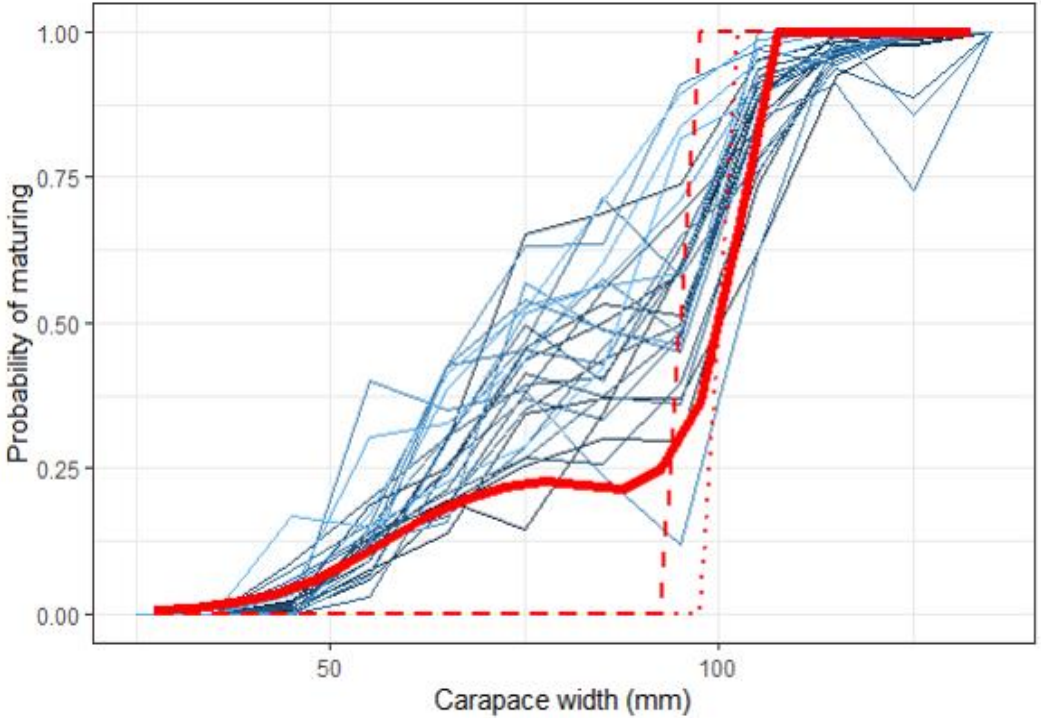

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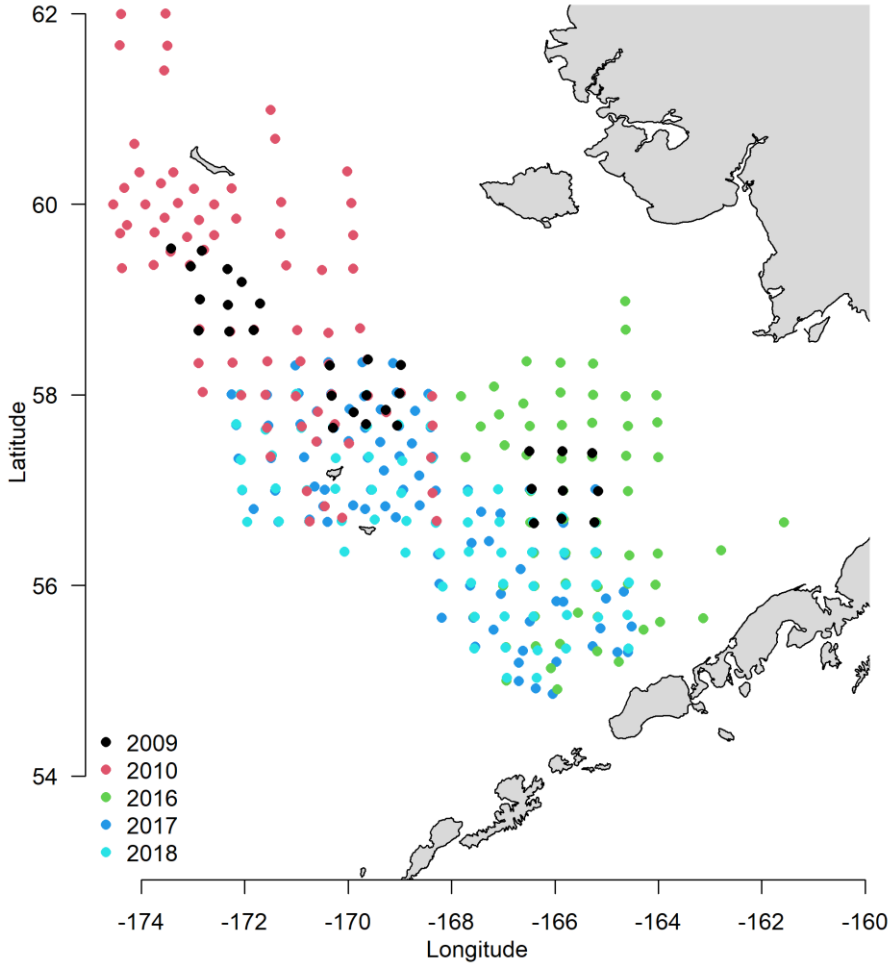

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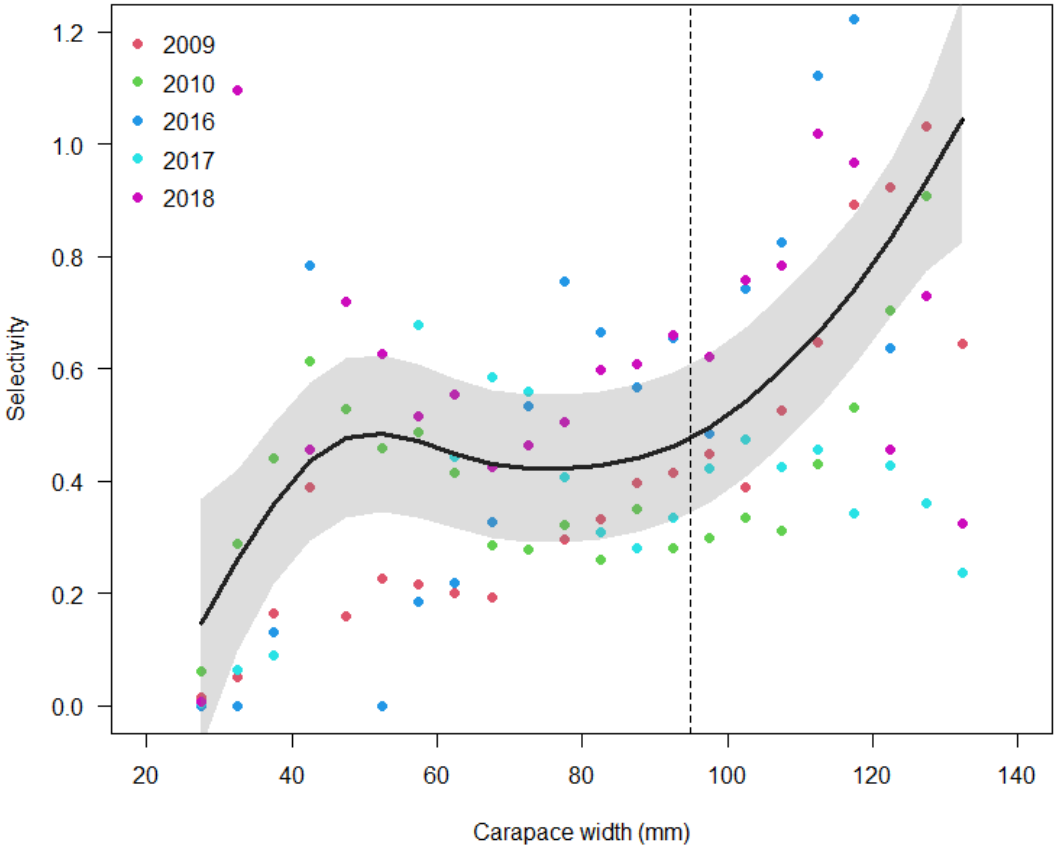
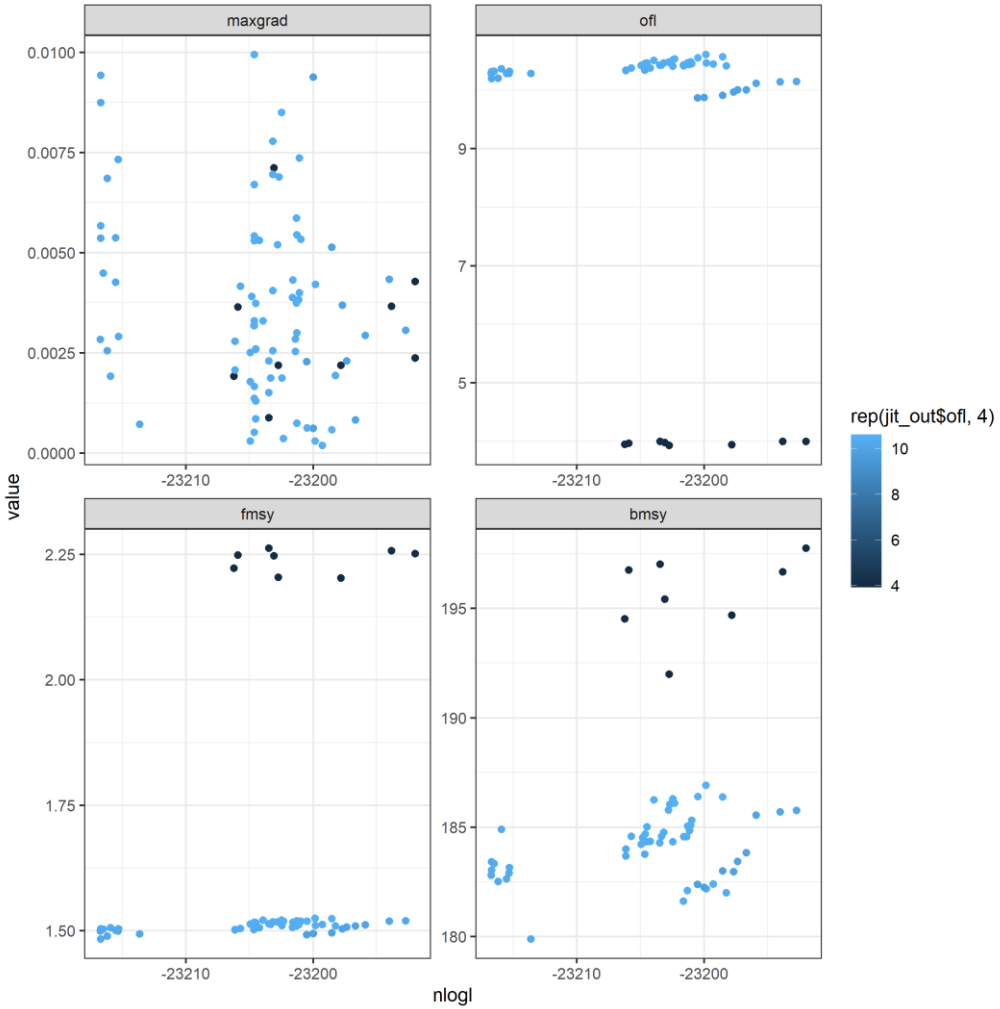


Past problems

- Convergence issues and bimodality in management quantities
- Retrospective patterns
- Undesirably high target fishing mortality rates
- Unrealistic catch advice



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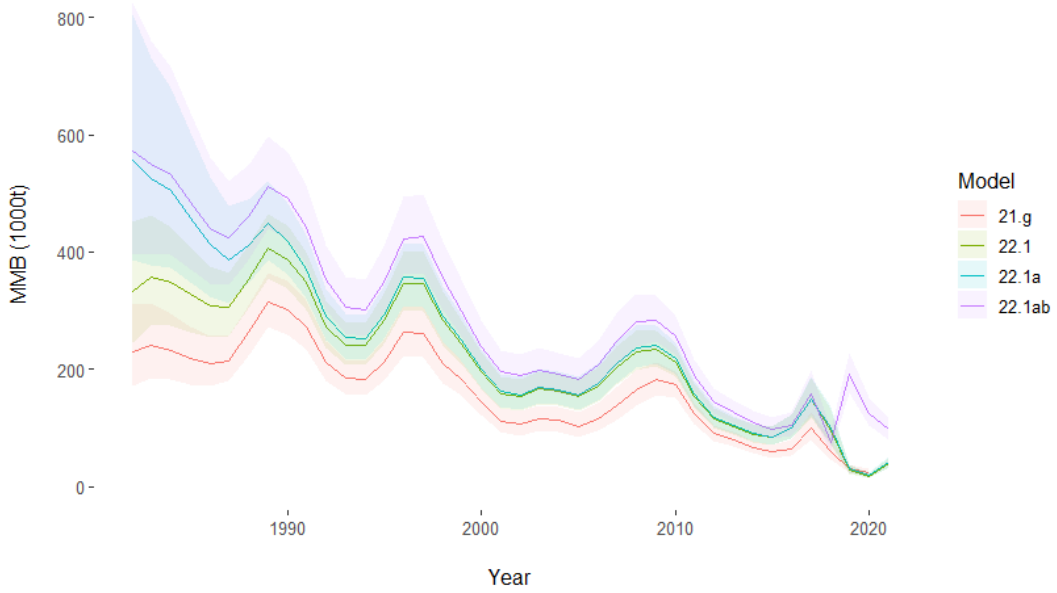

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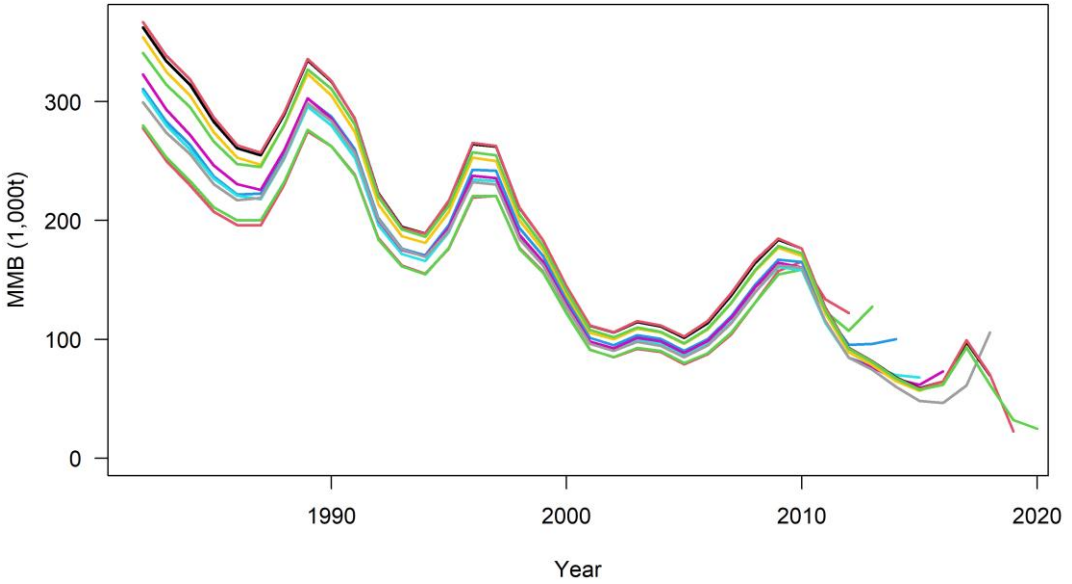

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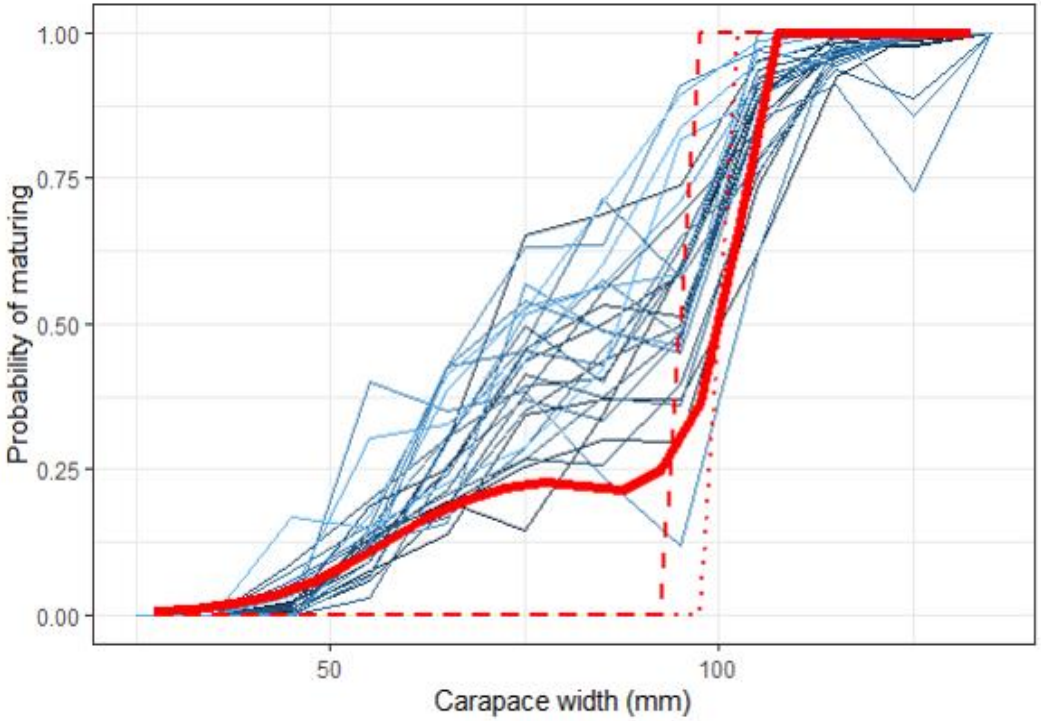

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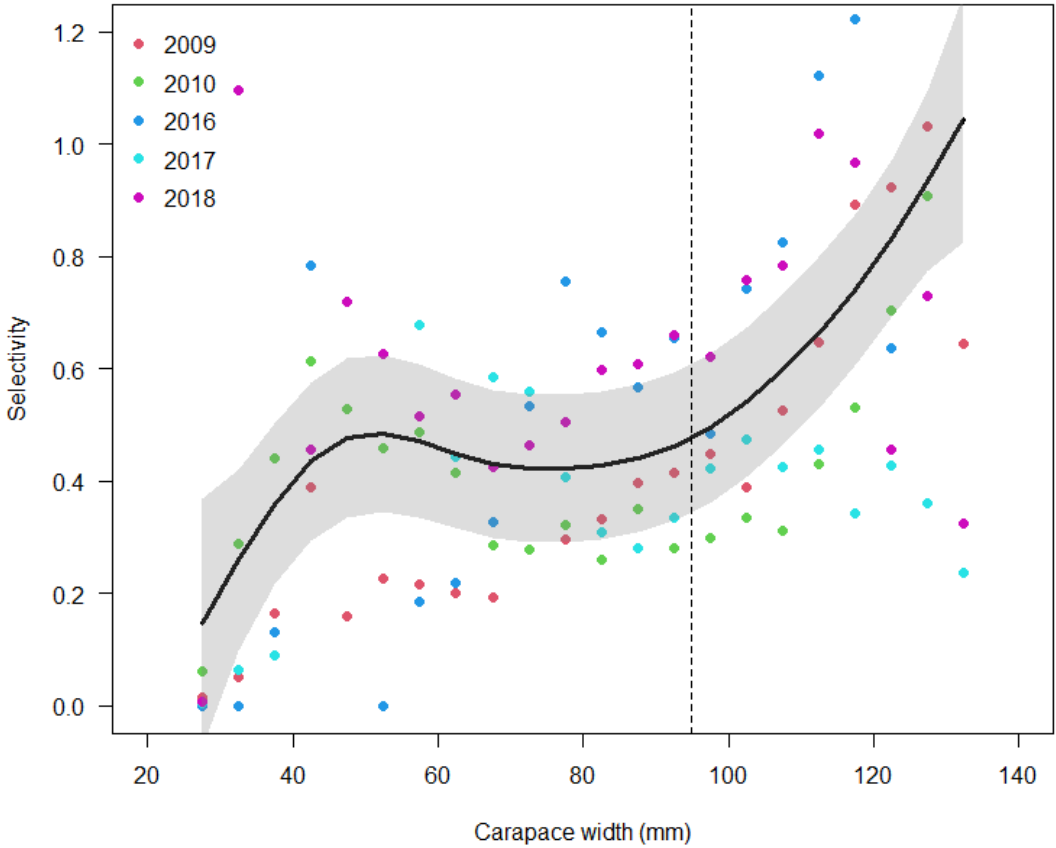


	Status quo	Research model	Bridge
Sex	Male + female	Male	Male + female
Maturity	Single estimated ogive	Input as yearly data	Input as yearly data
BSFRF.data	Treated as an additional survey with estimated availability	Treated as prior on survey selectivity	Treated as prior on survey selectivity
Survey.sel.	Logistic by sex (1982-1988; 1989-present	Non-parametric	Non-parametric; shared by sex 1982-present
Growth	Linear estimated	Linear specified	Linear estimated
Natural.M	Immature + Mature by sex; offset in 2018 and 2019	Immature + Mature; time-varying	Immature + Mature by sex; offset in 2018 and 2019

1. *How should the 'reference' biological process be defined?*
2. *Should natural mortality vary annually or only large mortality events delineated?*
3. *How should estimated parameters be chosen? (Andre's sufficient statistics)*
4. *How to define B_{MSY} when using Tier 4?*
5. *What data should be fit? Both indices and time span.*
7. *What is the relative confidence in each data set available?*

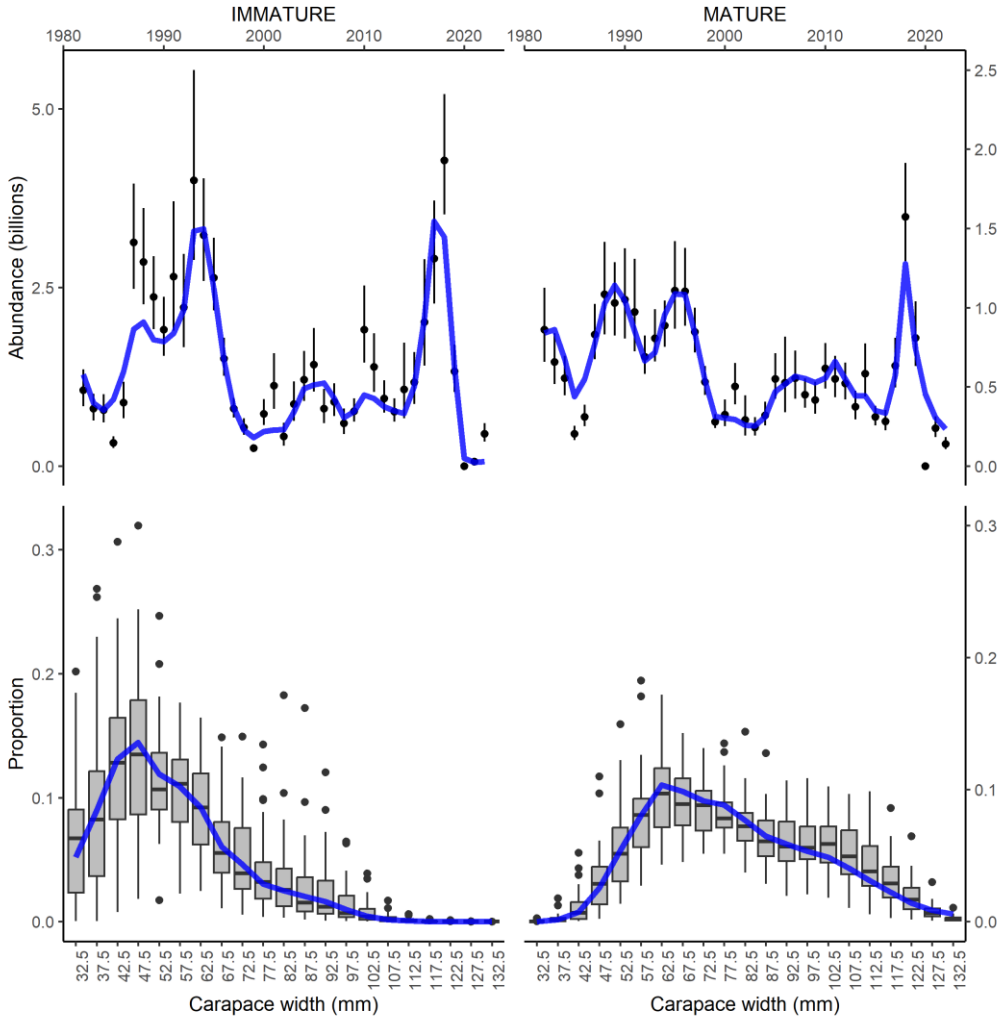
RESEARCH MODEL

- Simple sandbox for ideas
- Simpler version simulation tested—shows time-varying M might be reasonably estimated under some circumstances
- Why bother doing something out of GMACS?
  - Out growth of “What happened?” project

- Biggest differences from status quo:
  - Male only
  - BSFRF data as priors on non-parametric survey selectivity
  - Maturity and growth data are input
  - Estimates annually varying natural mortality
  - Fits to abundances, not biomass

Research model

- Fits immature and mature indices of abundance well
- Aggregate size composition data well fit



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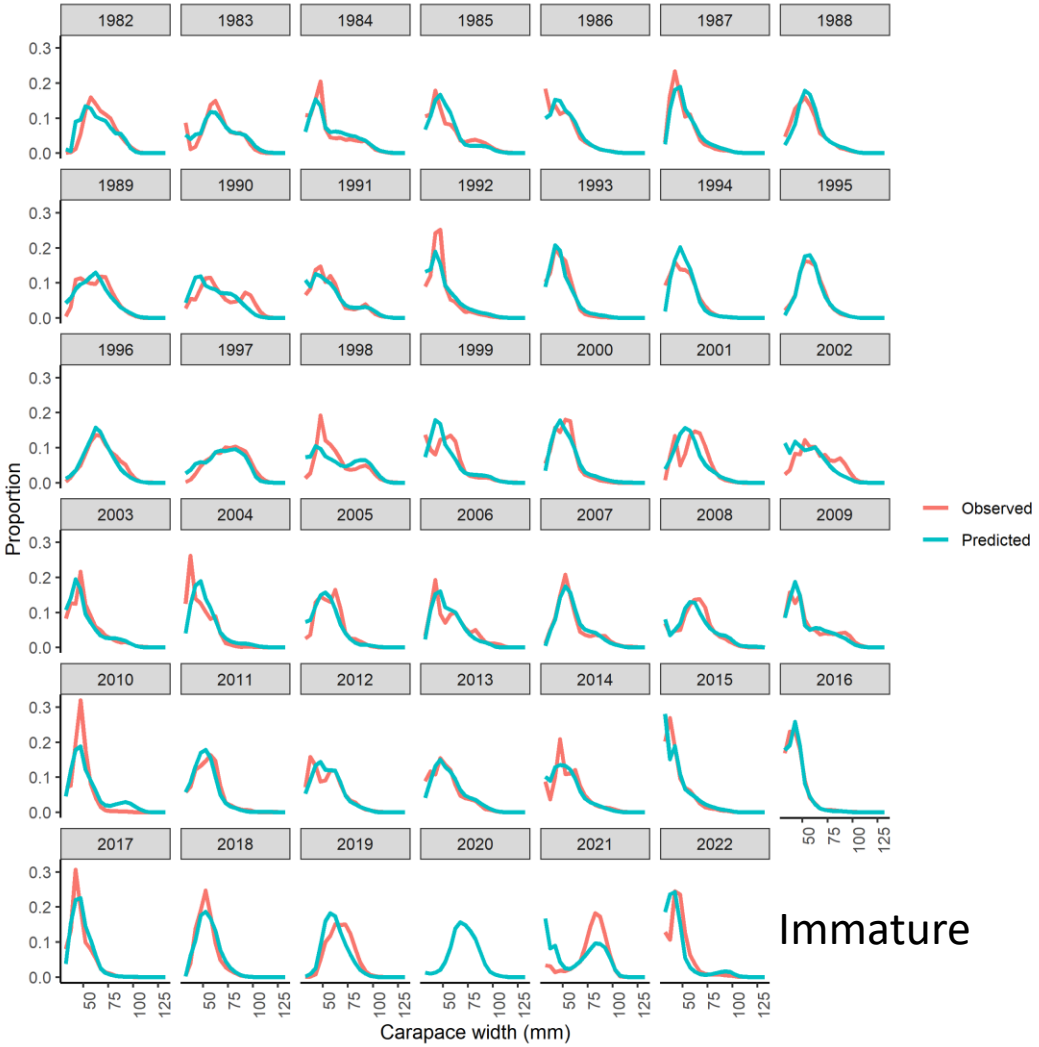

Immature

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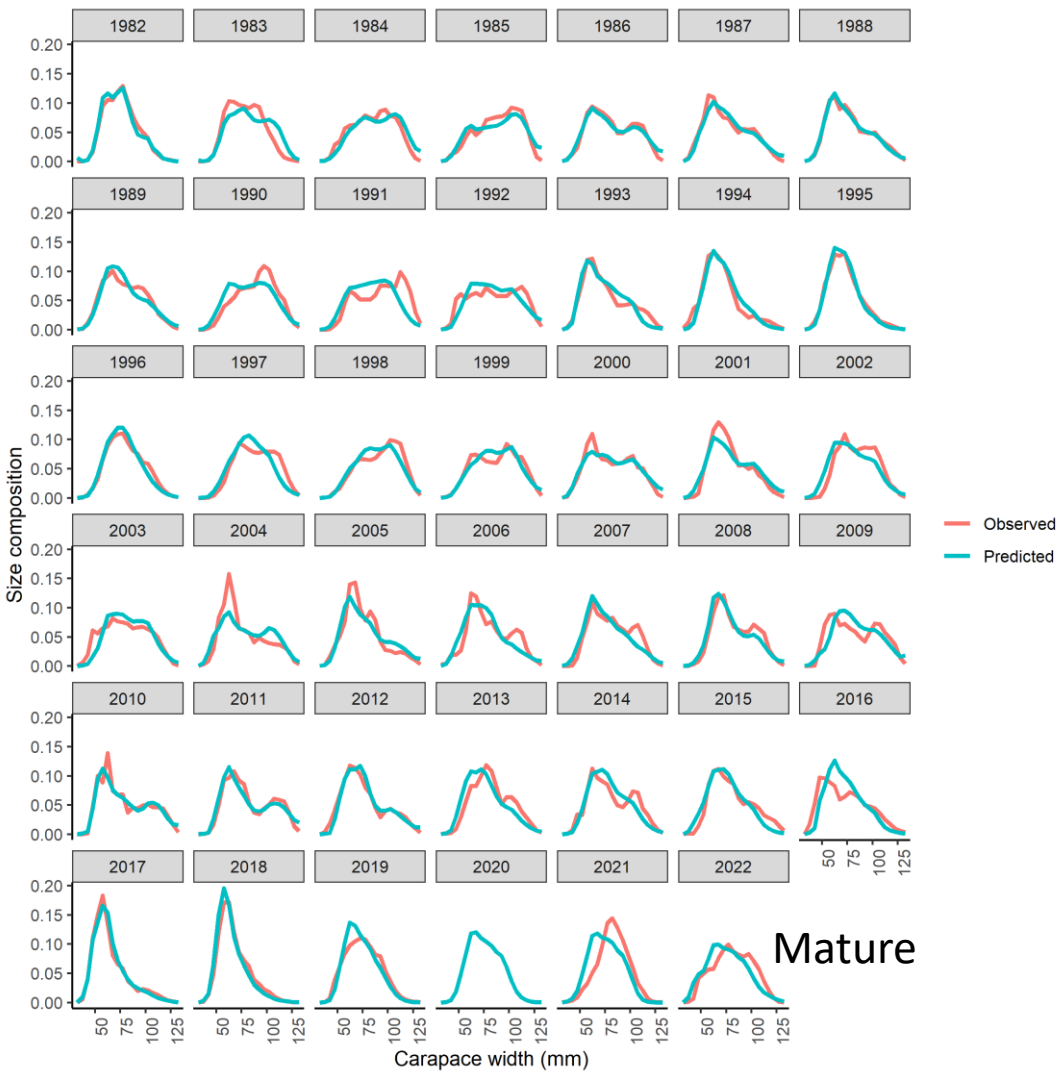

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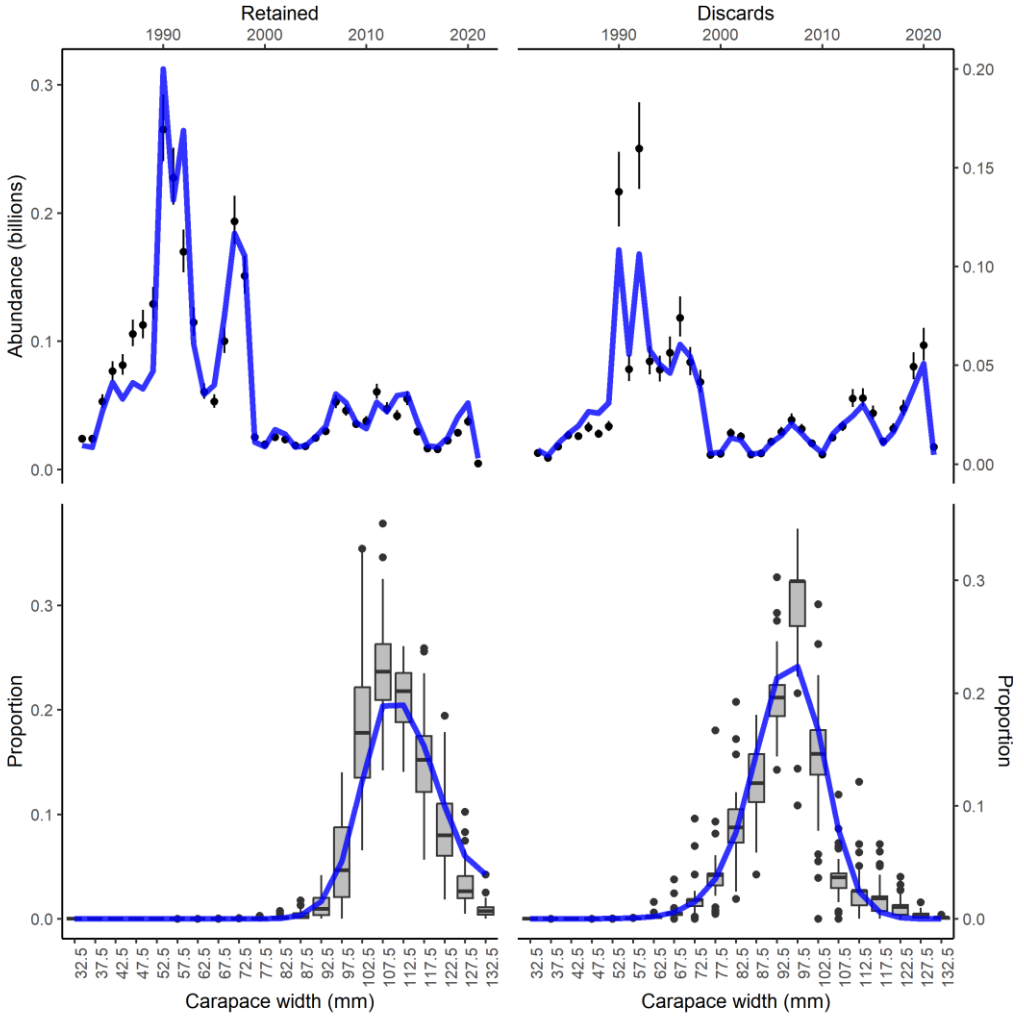
- Fits immature and mature indices of abundance well
- Aggregate and annual size composition data also well fit
- Retained and discard catches well fit, save a couple of years of discard
- Largest males overrepresented in retained catch (growth?)



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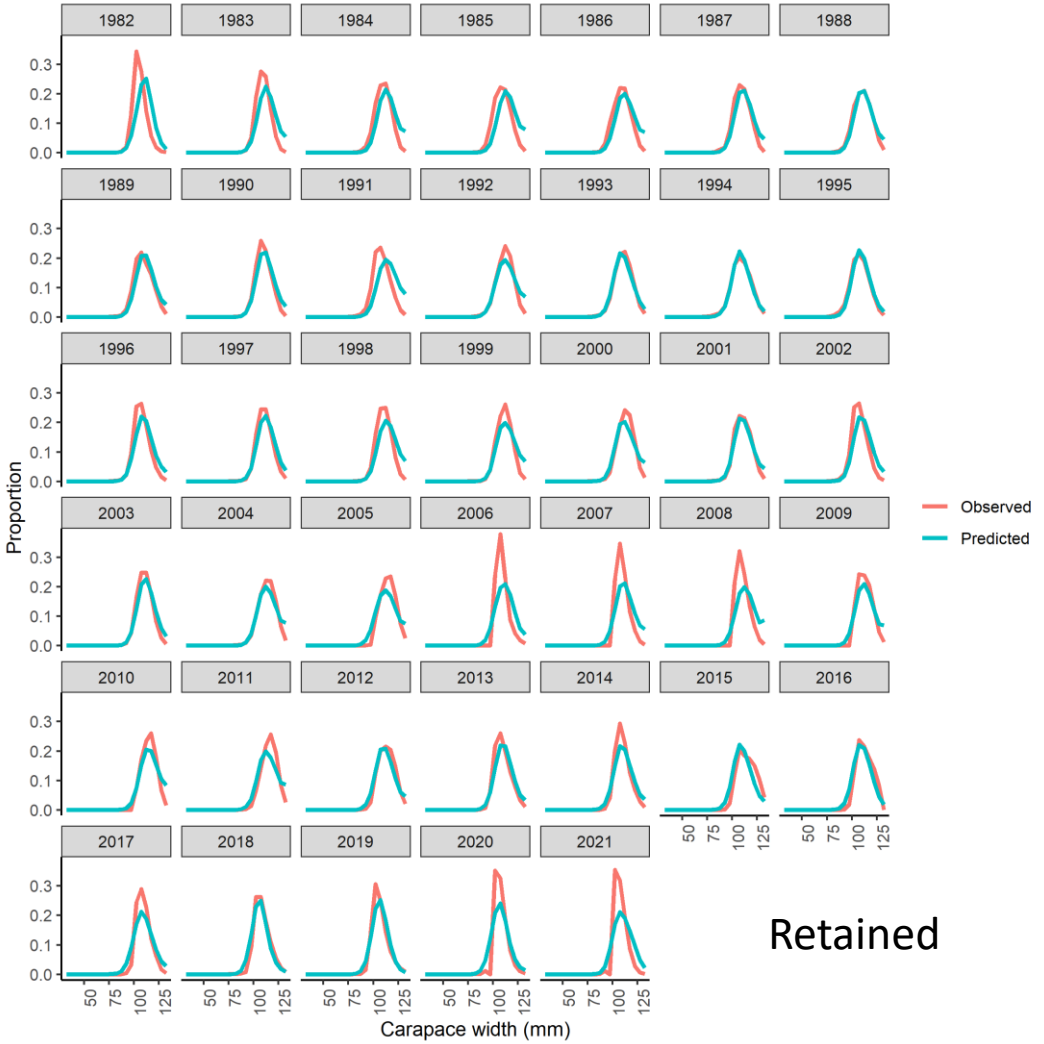

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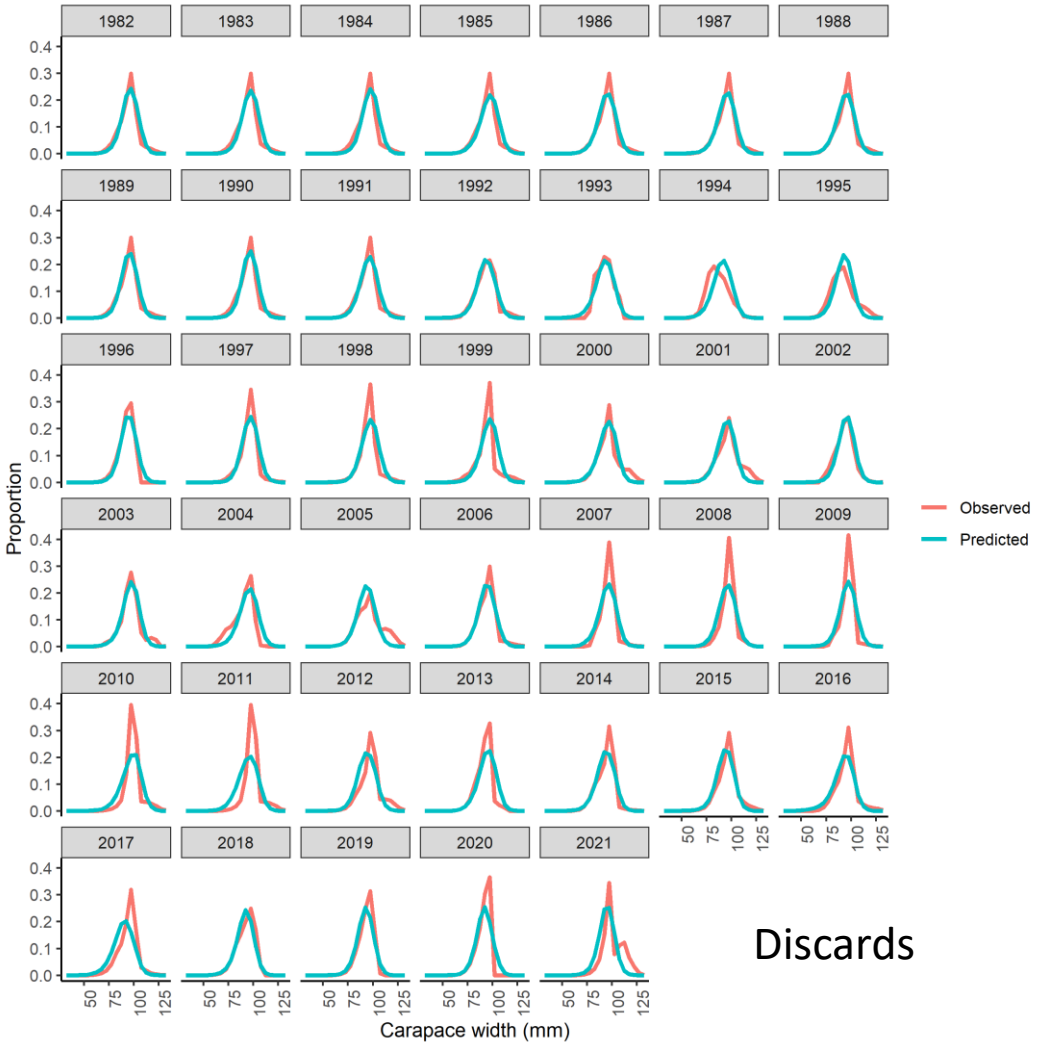
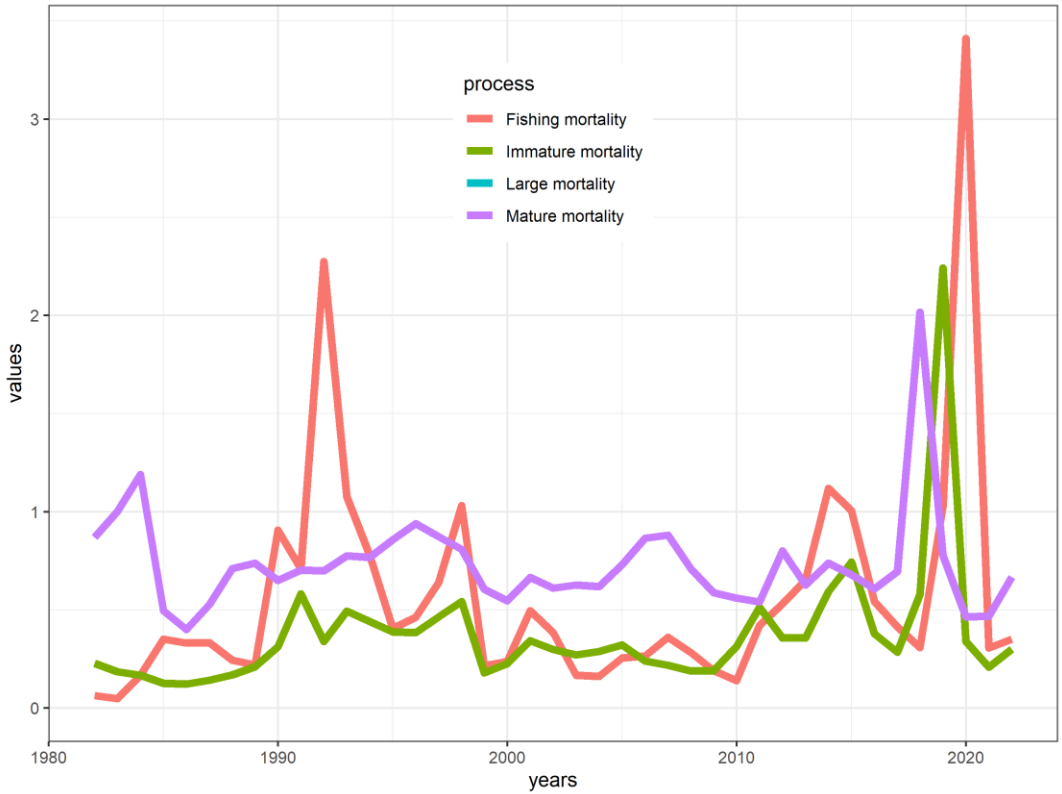


Discards

Research model

- Estimate mature mortality higher than immature
- Peaks in natural mortality in 2018 and 2019
- Peaks in fishing mortality in the early 1990s and 2020



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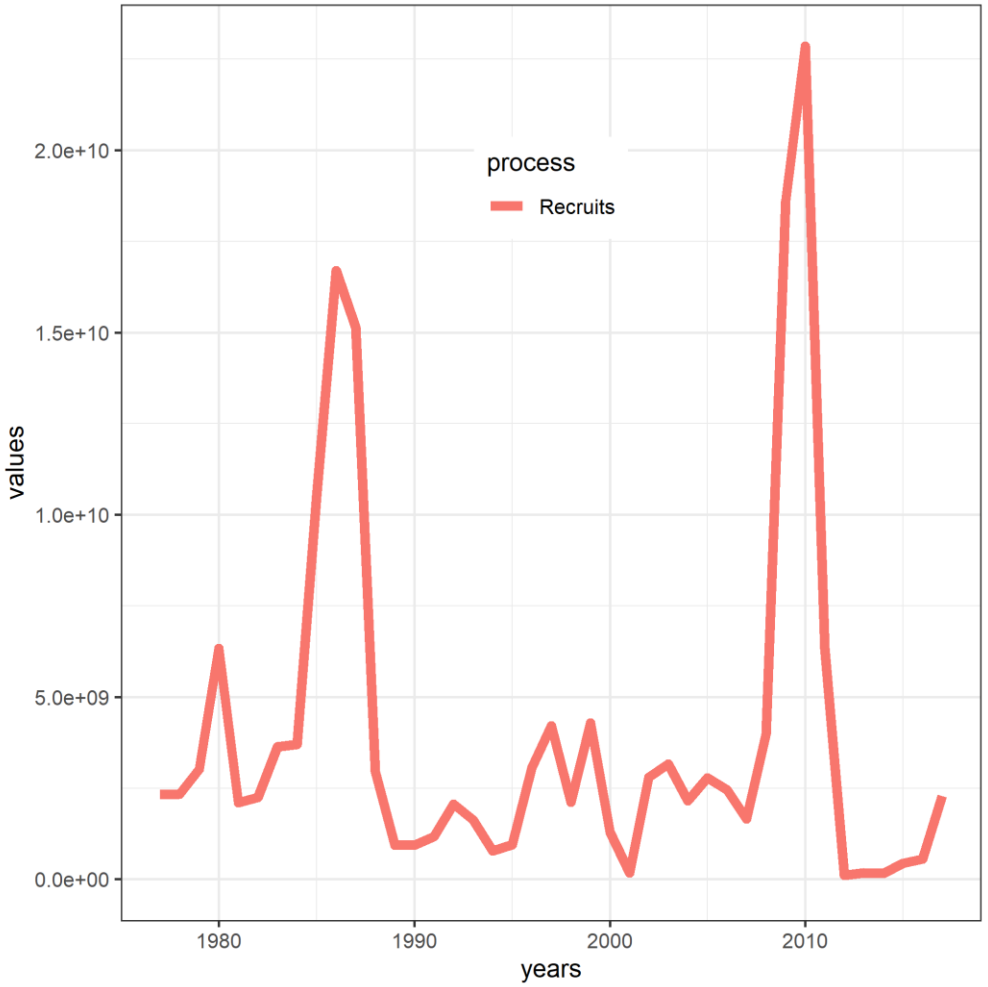

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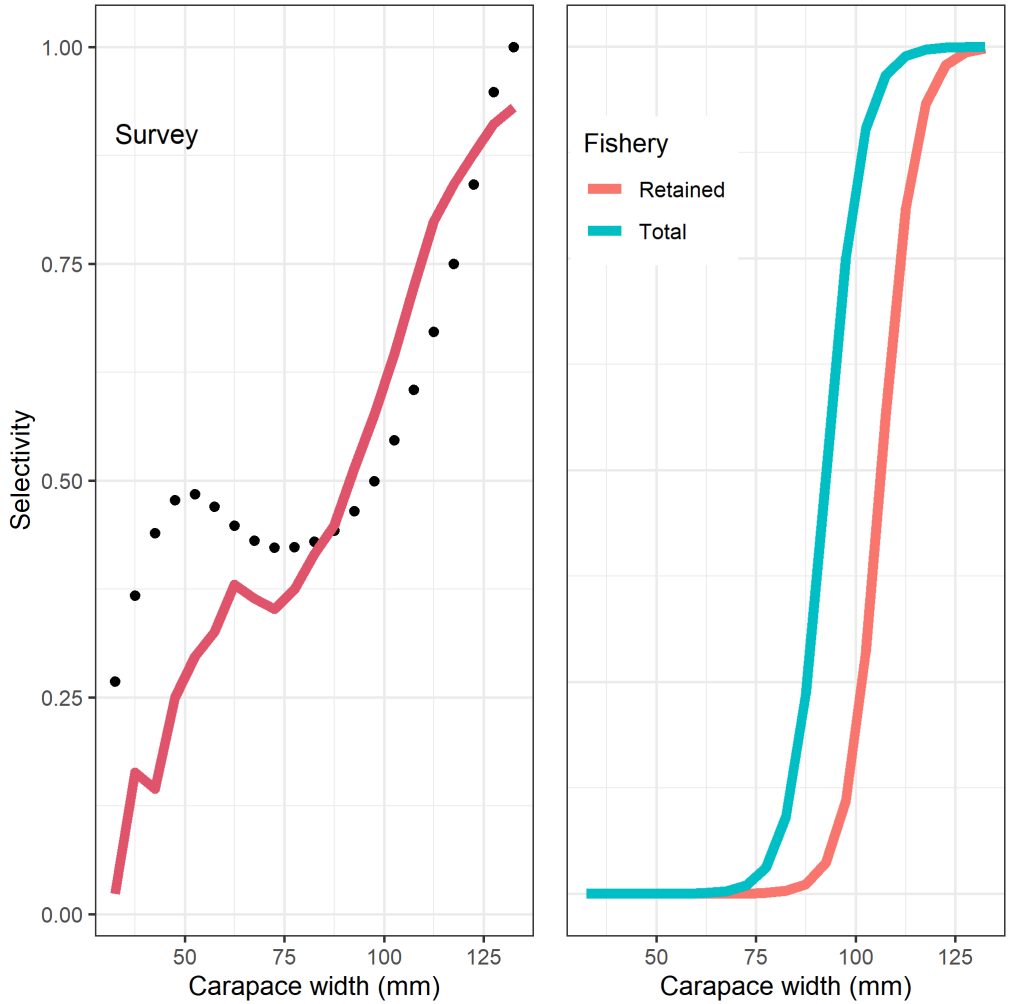
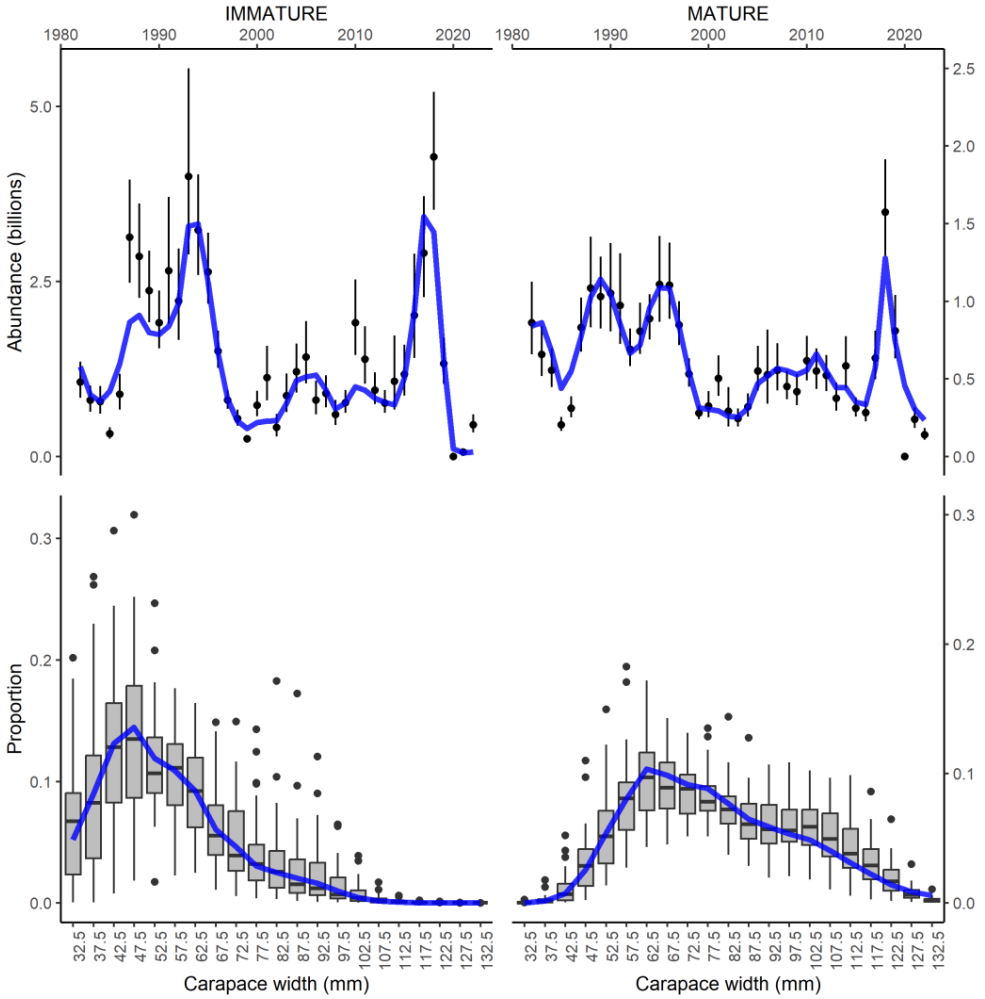
- Peaks in natural mortality in 2018 and 2019
- Peaks in fishing mortality in the early 1990s and 2020
- Recent estimated recruitment largest in 2010
- Estimated survey selectivity less than prior for small crab and larger than prior for most large crab



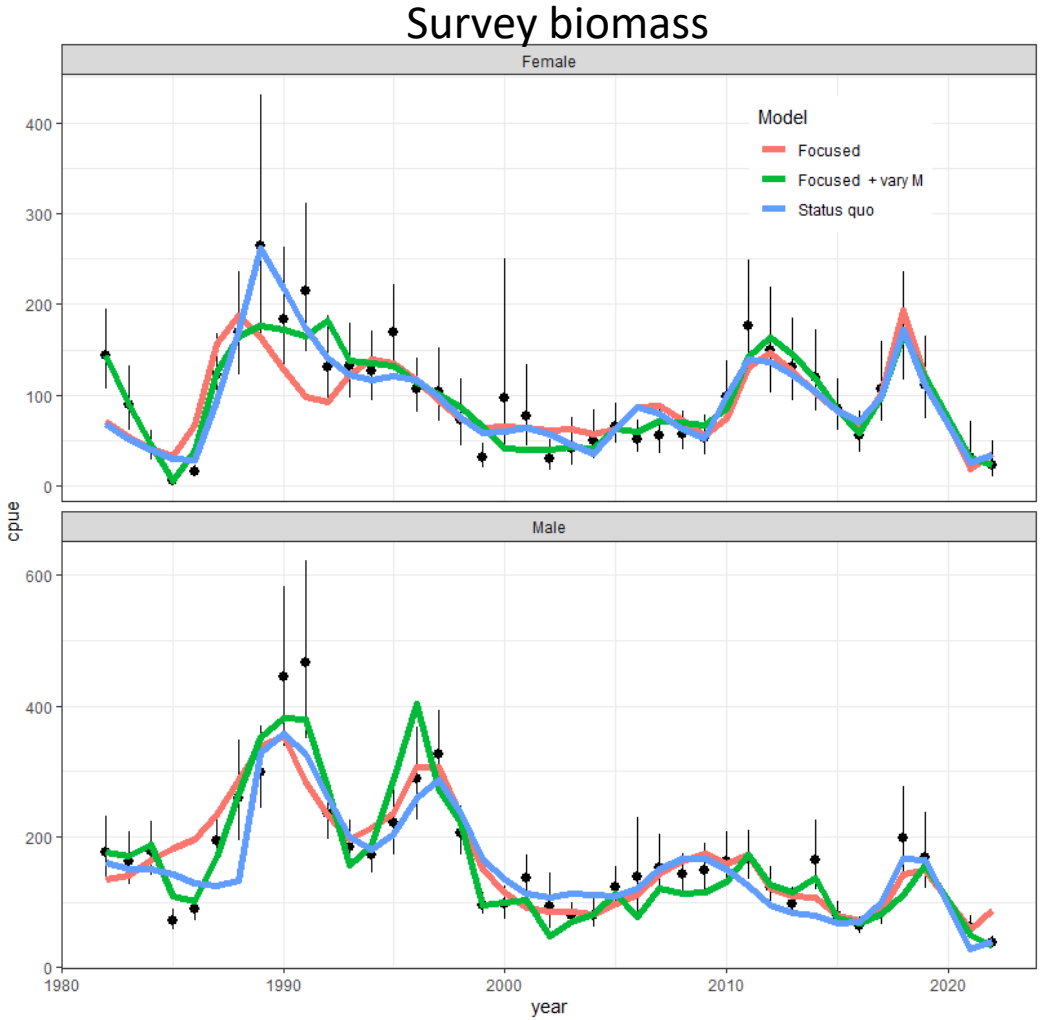
Research model summary

- Fits the data well
- Estimated population process mostly reasonable
- Good example that a focused model with the desired characteristics can ‘work’
- Not having females eliminates some linkages that appear to be influential



Status quo and bridge models

- Research assumptions included:
  - BSFRF as prior on non-parametric survey selectivity
  - Maturity data input
  - ‘Focused + vary M’ has time-varying M



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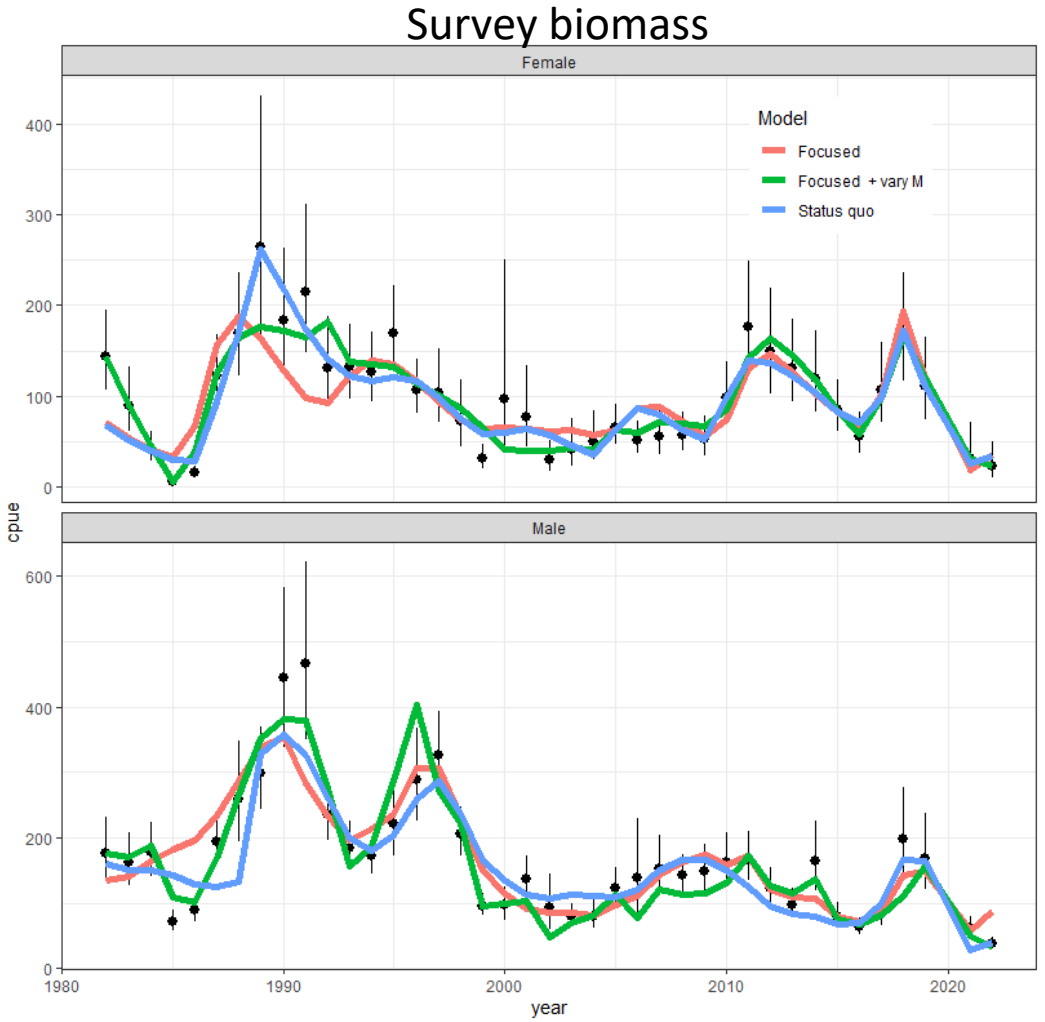

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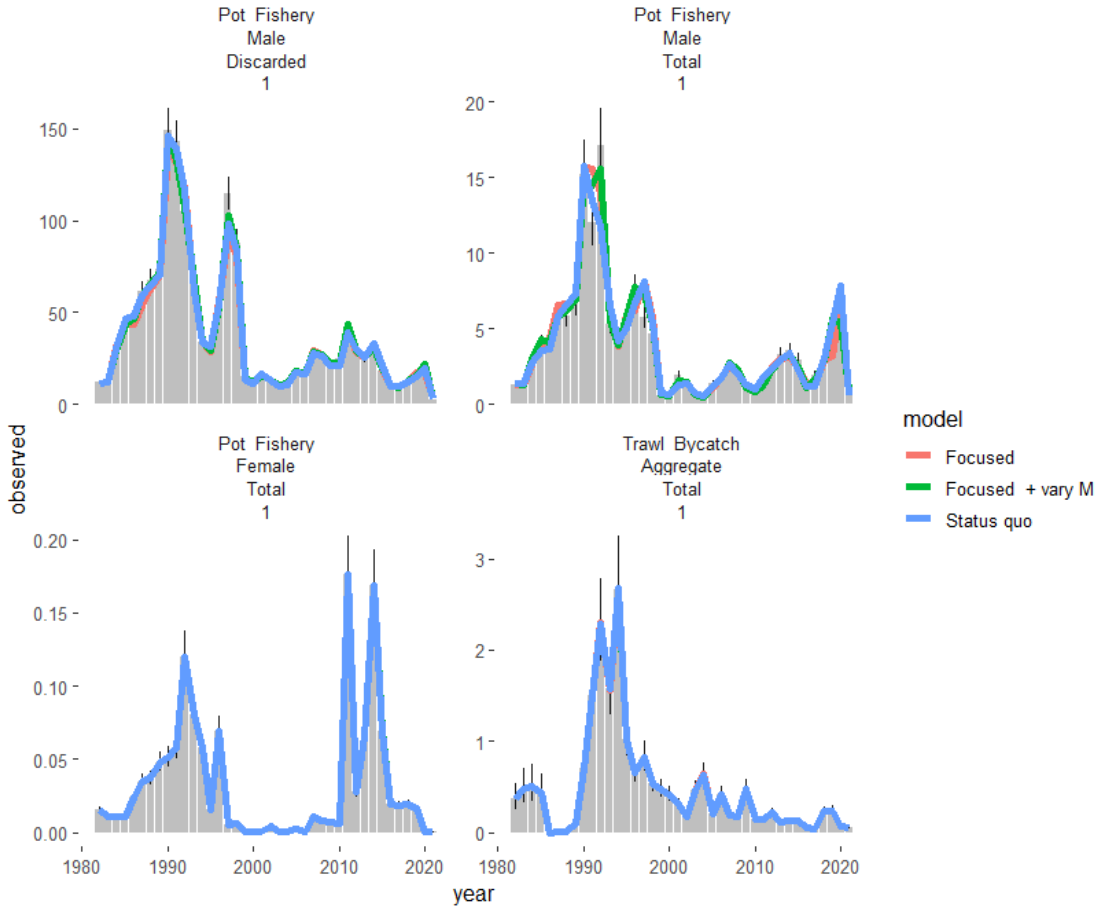
Catch (labels wrong)



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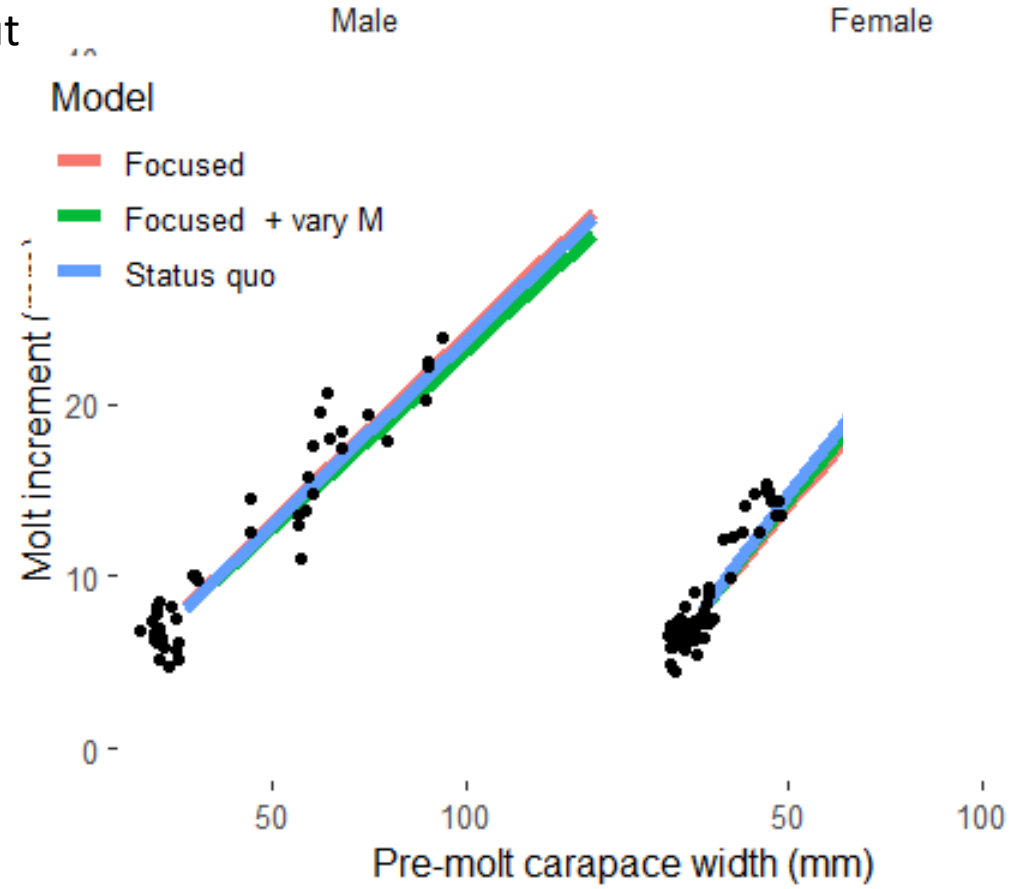

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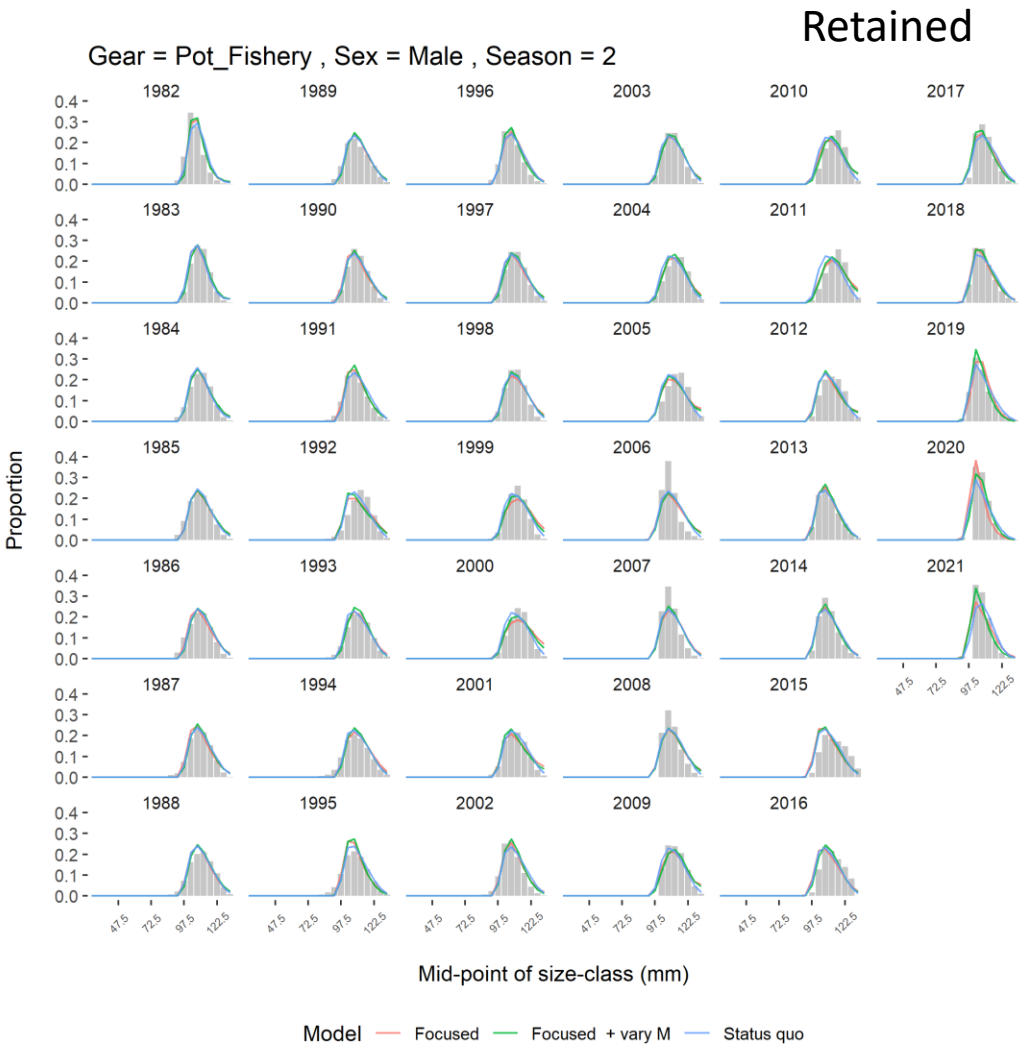

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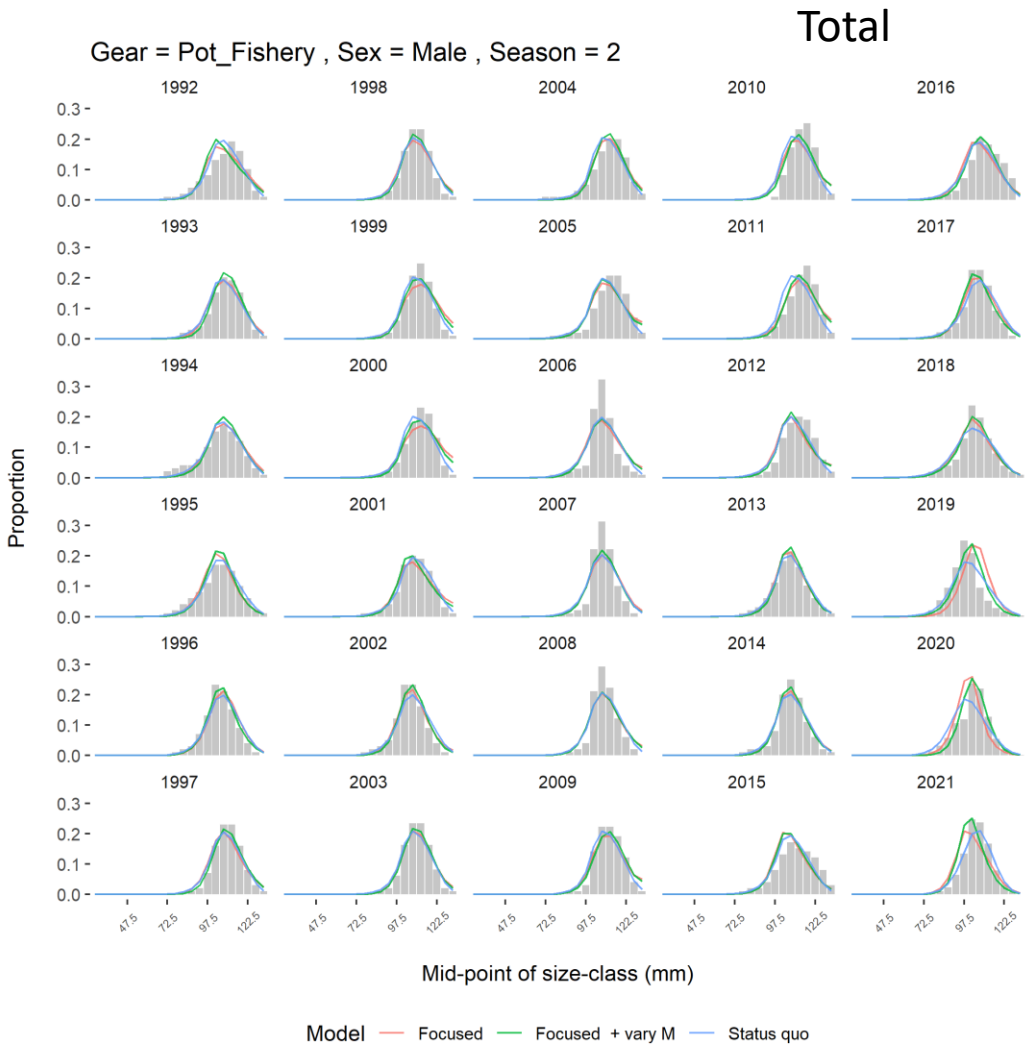

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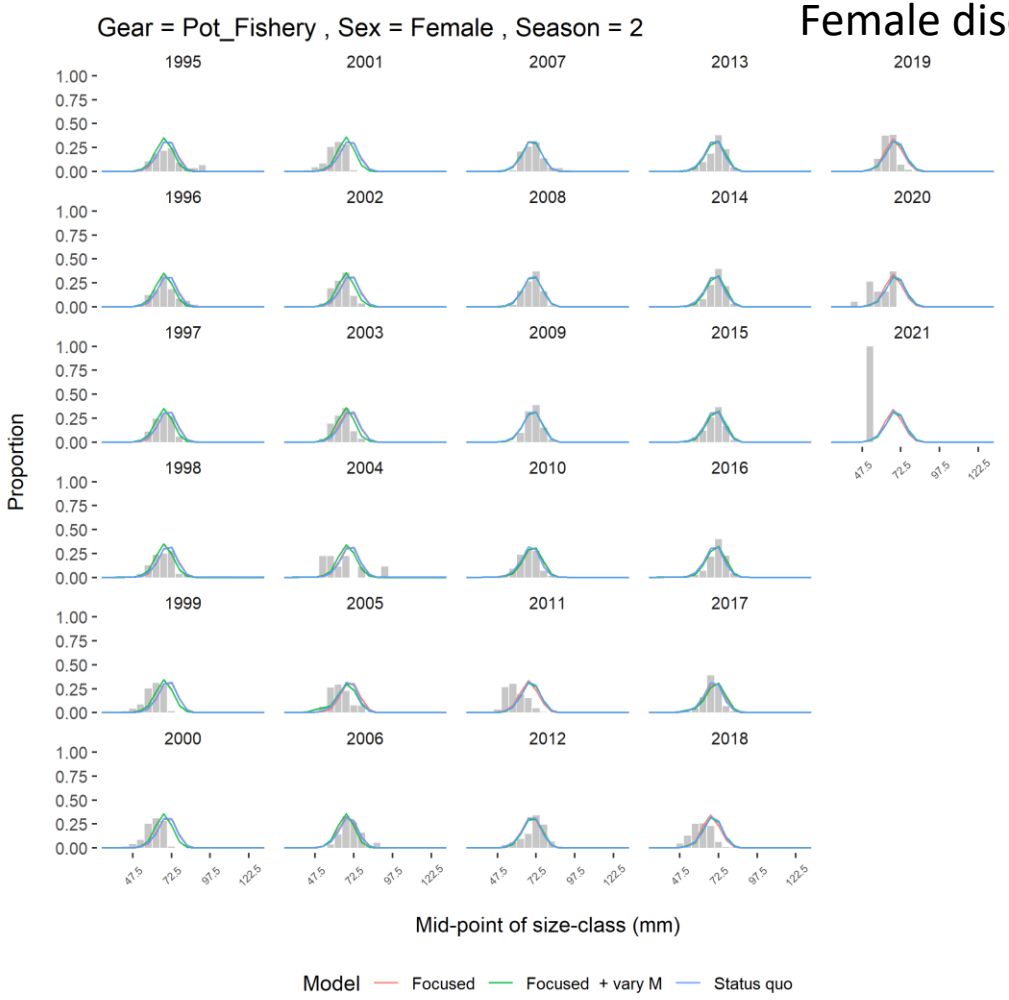

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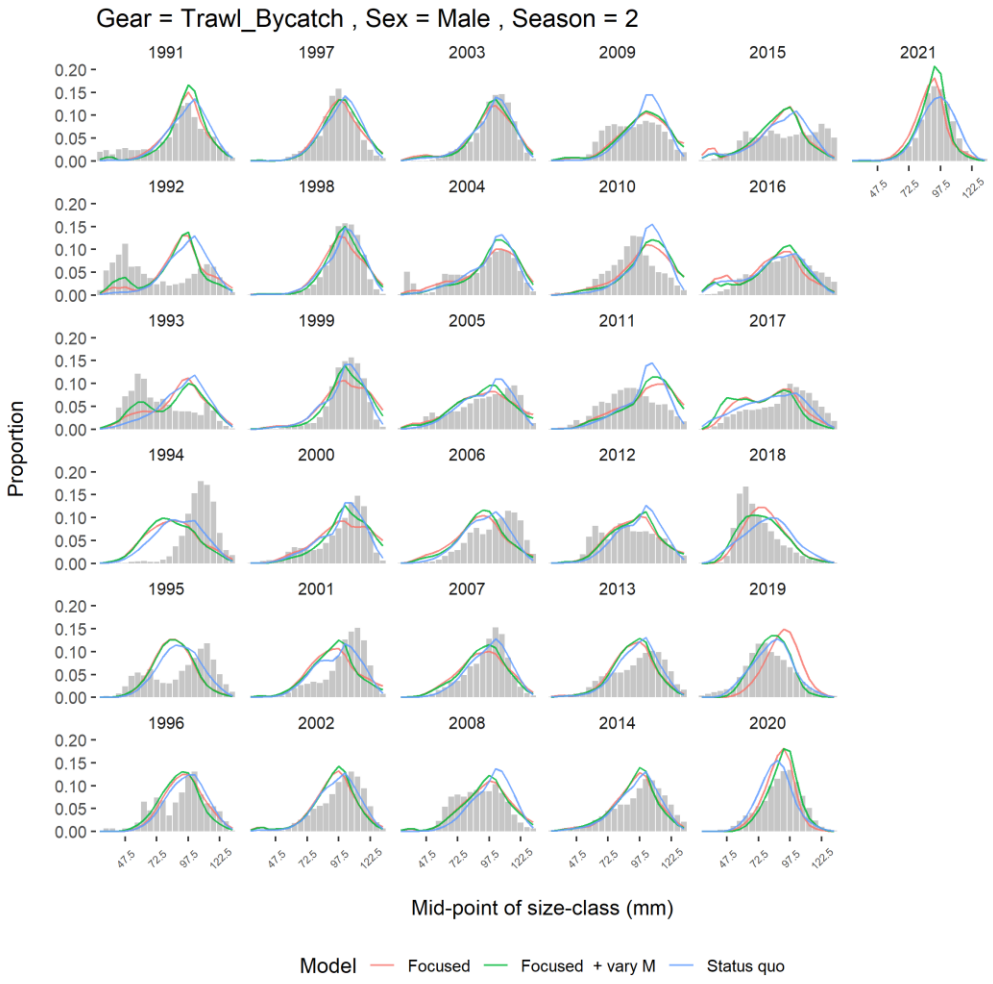

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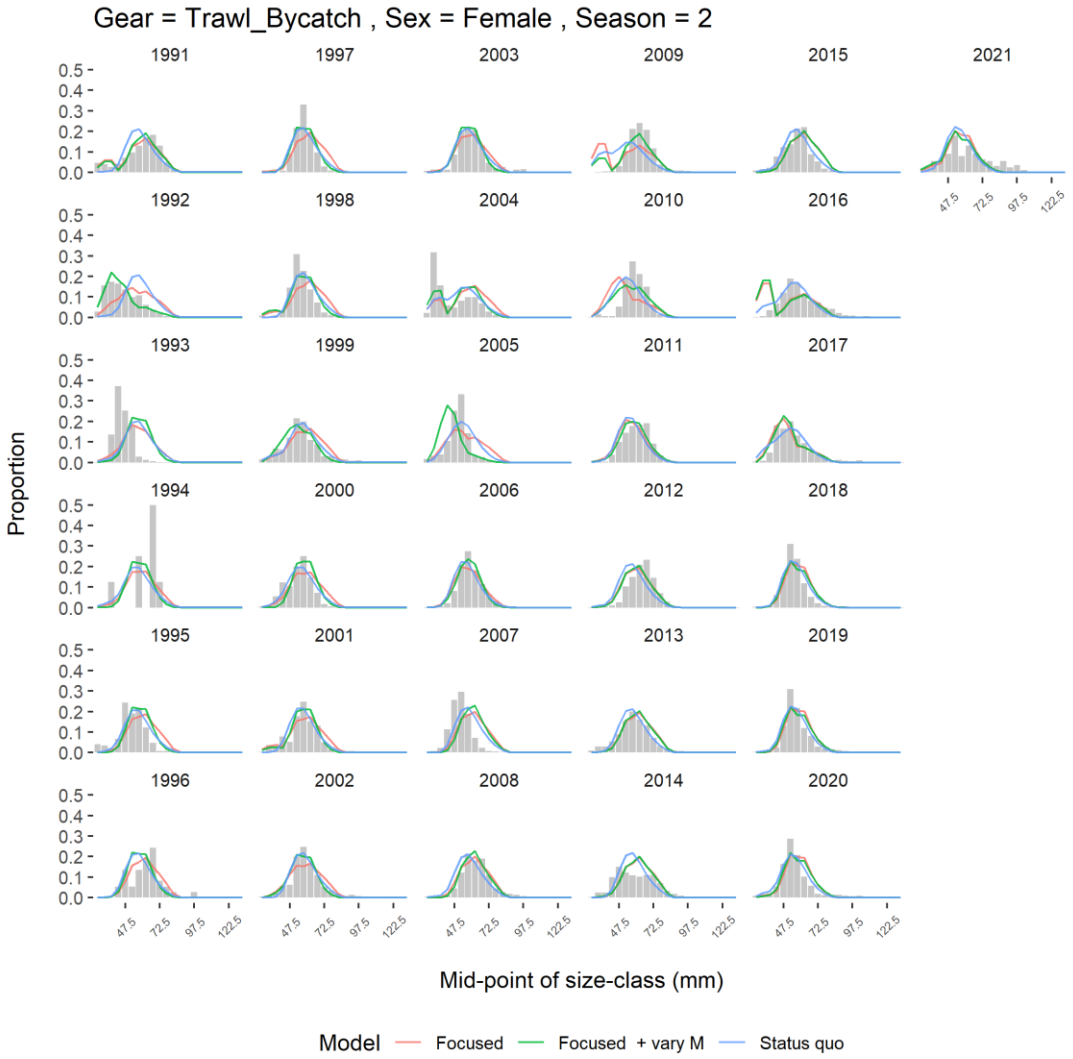

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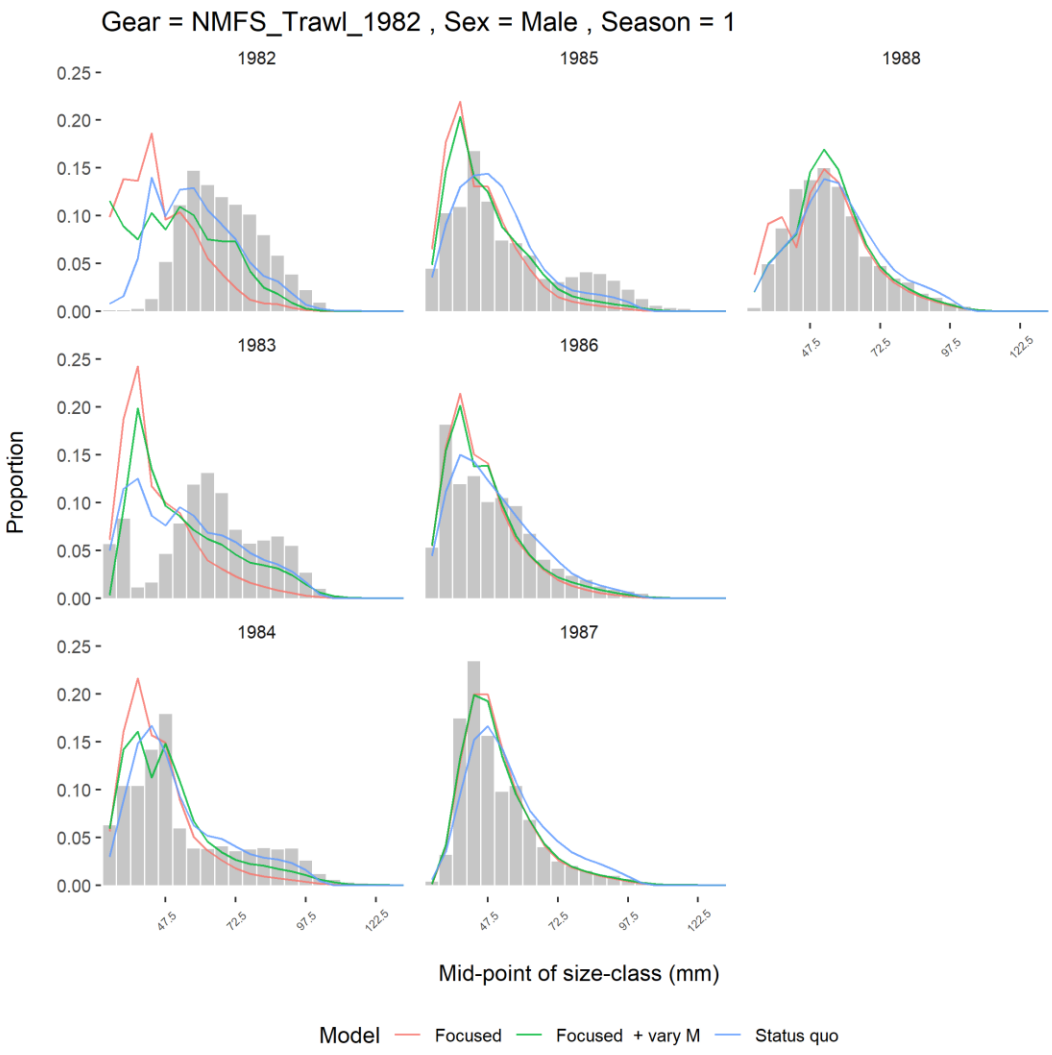

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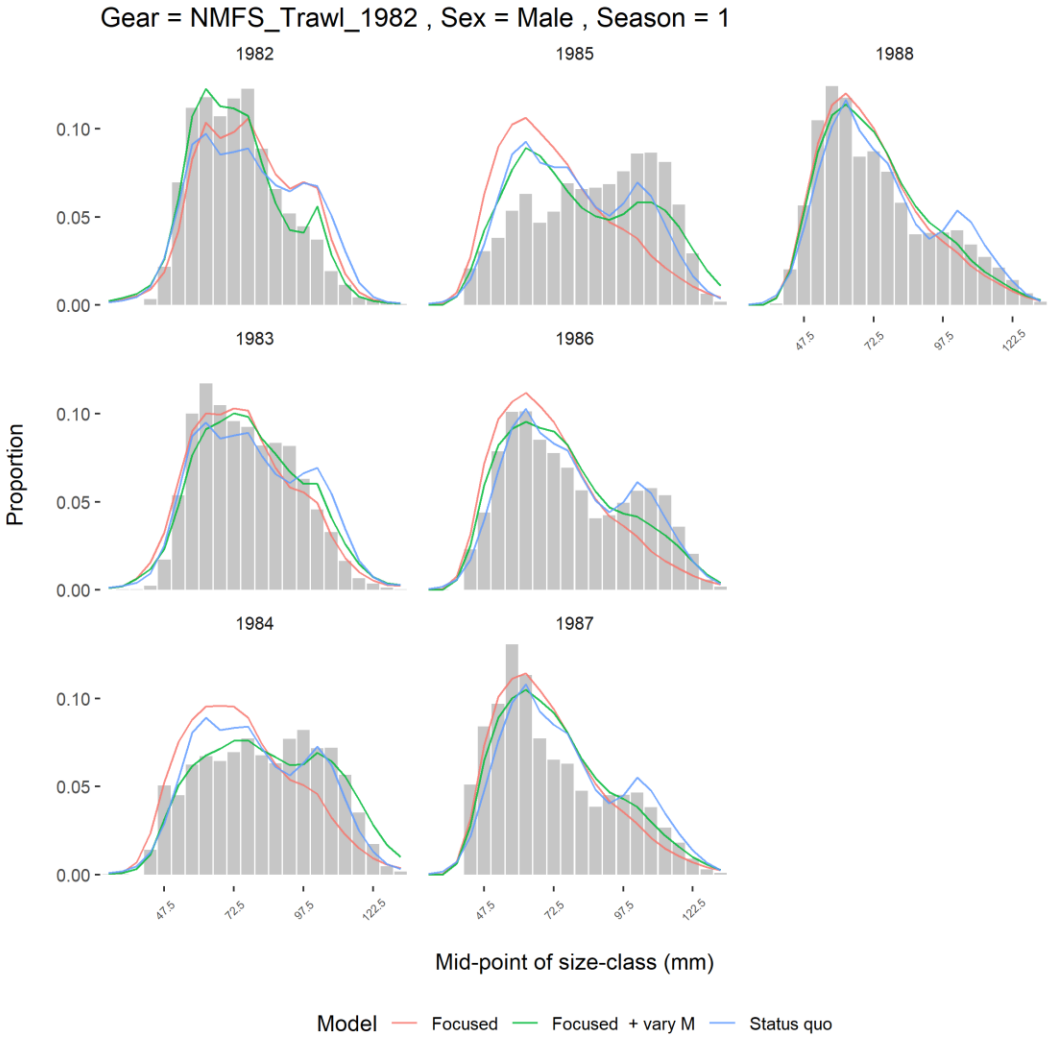

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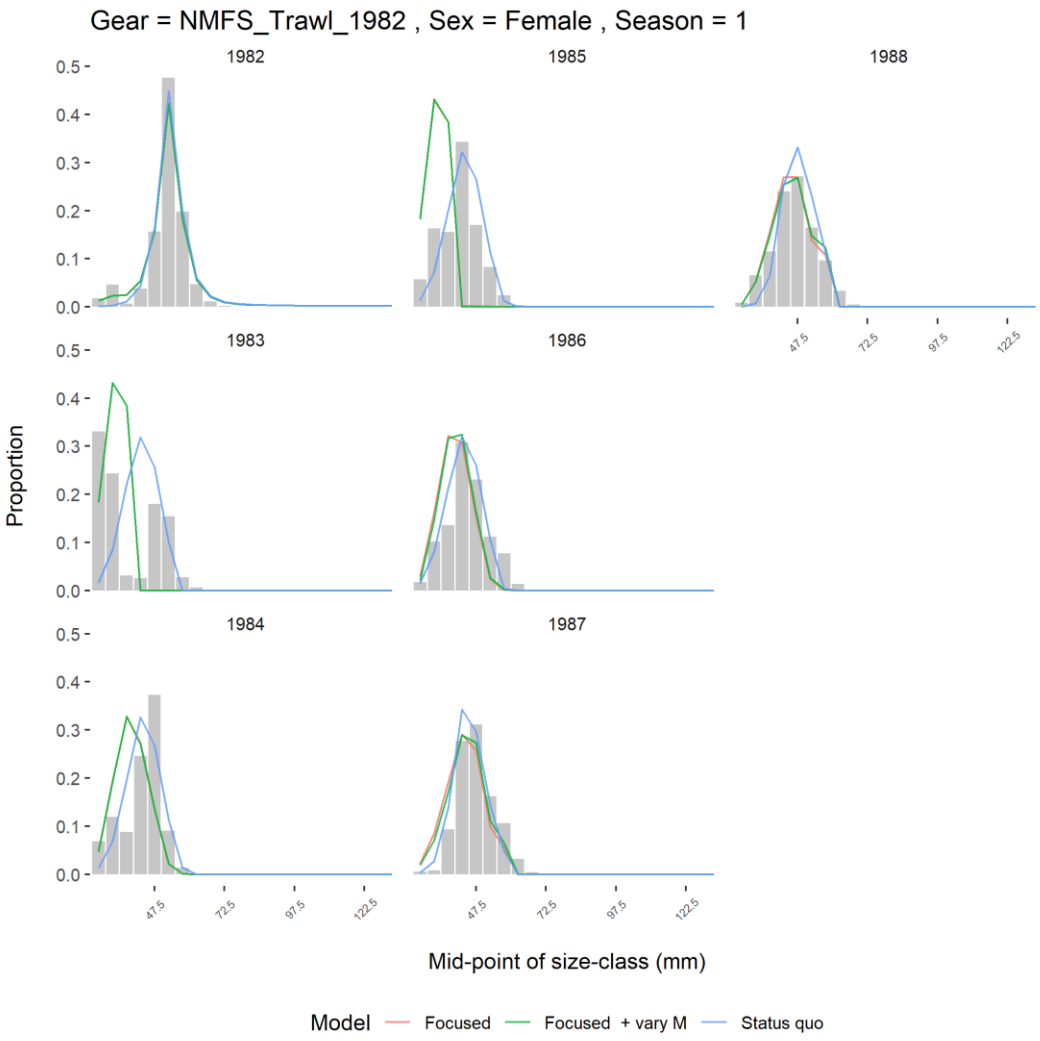

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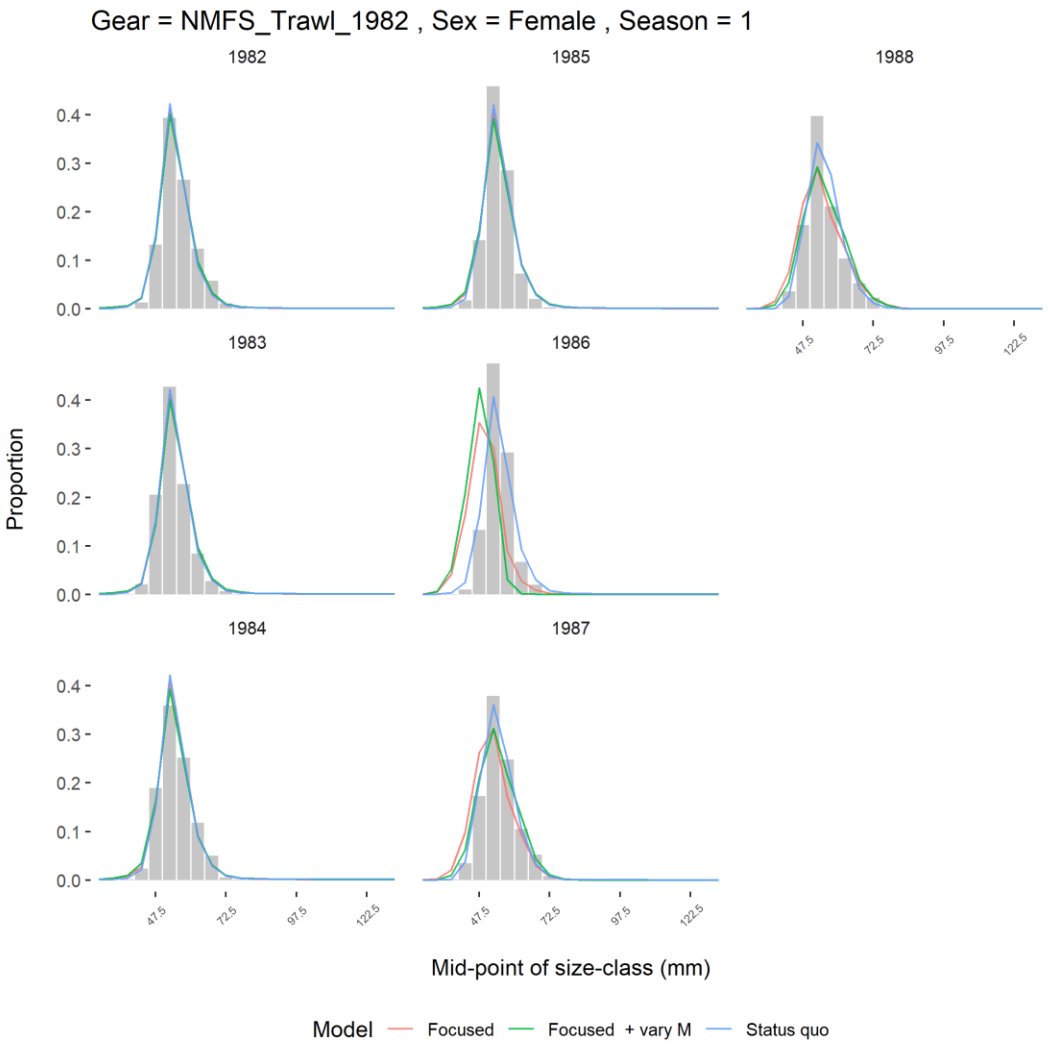

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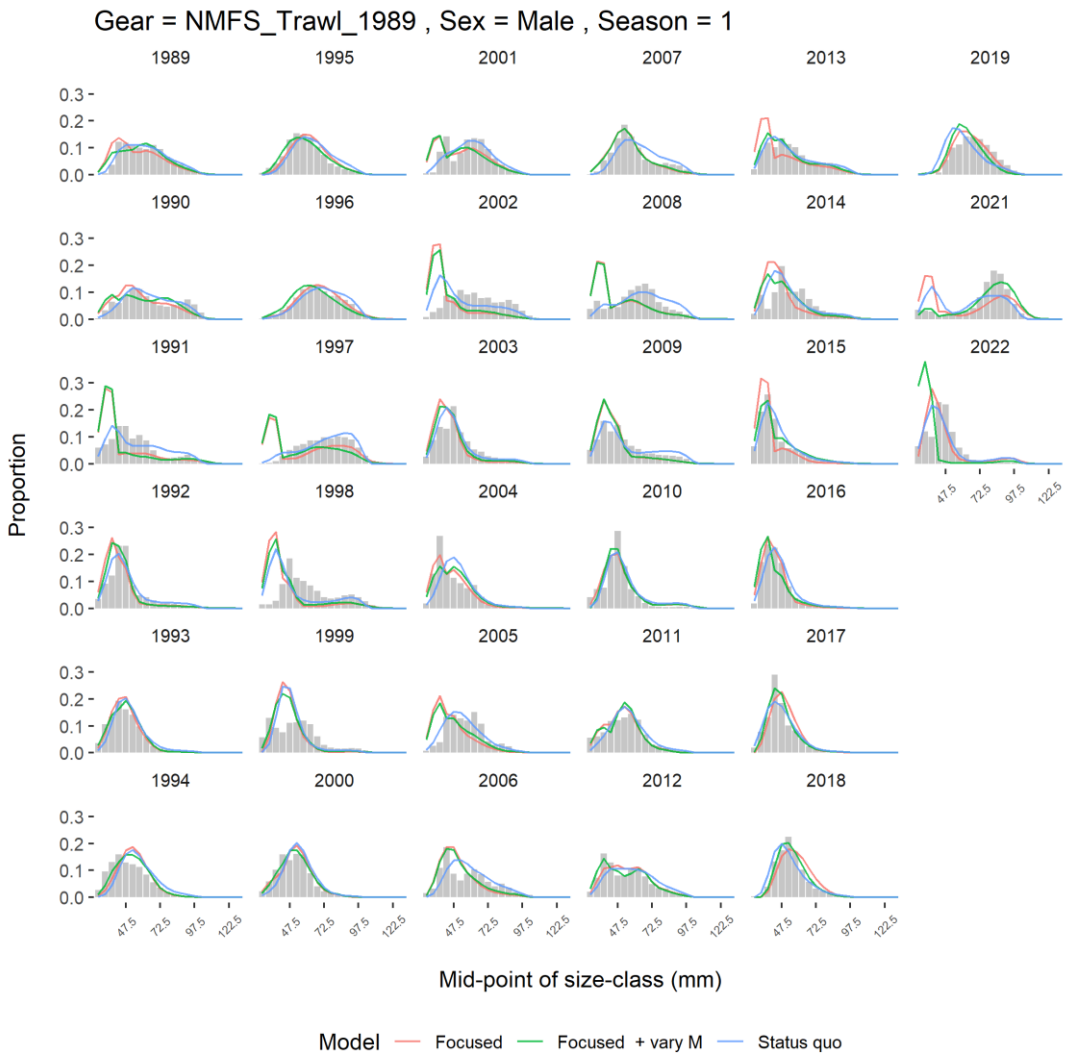

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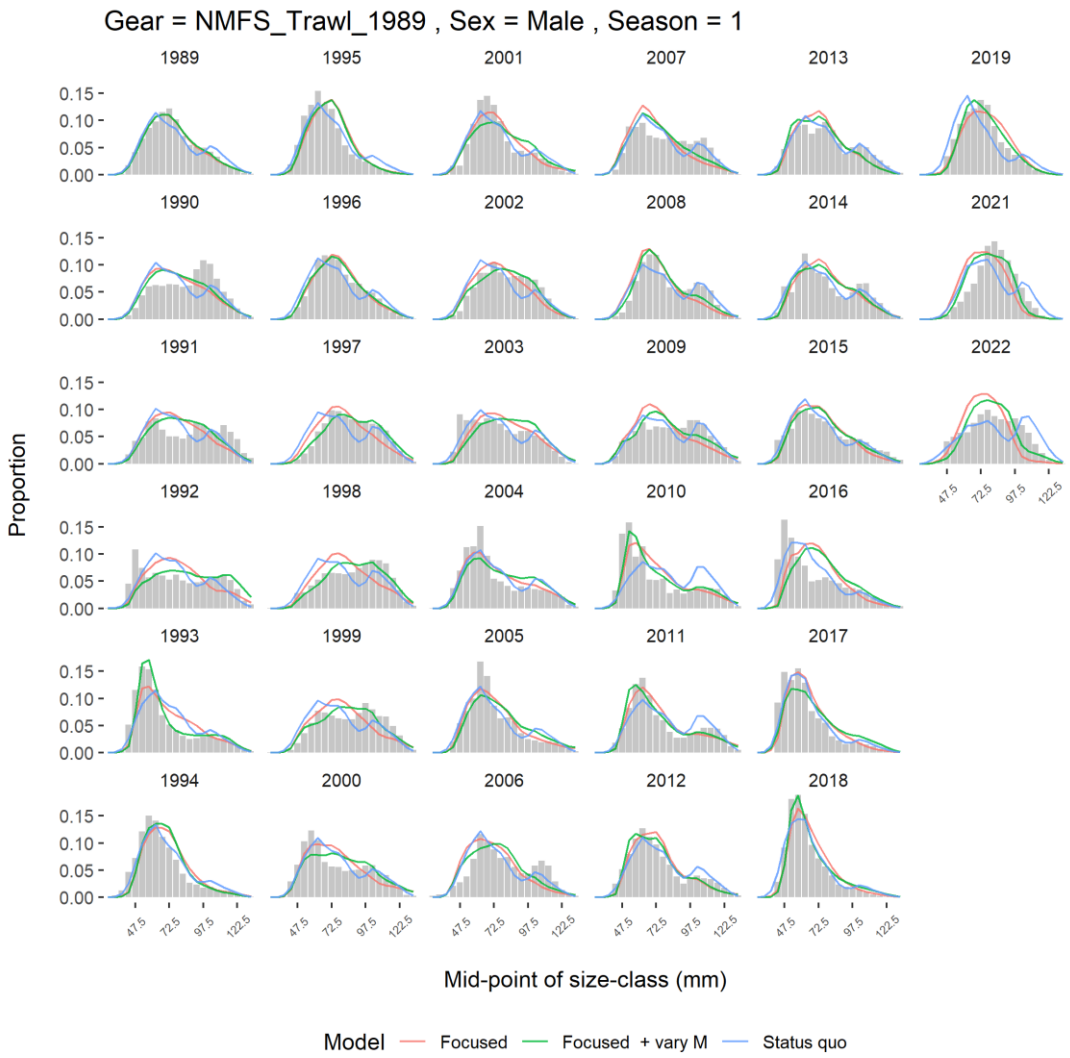

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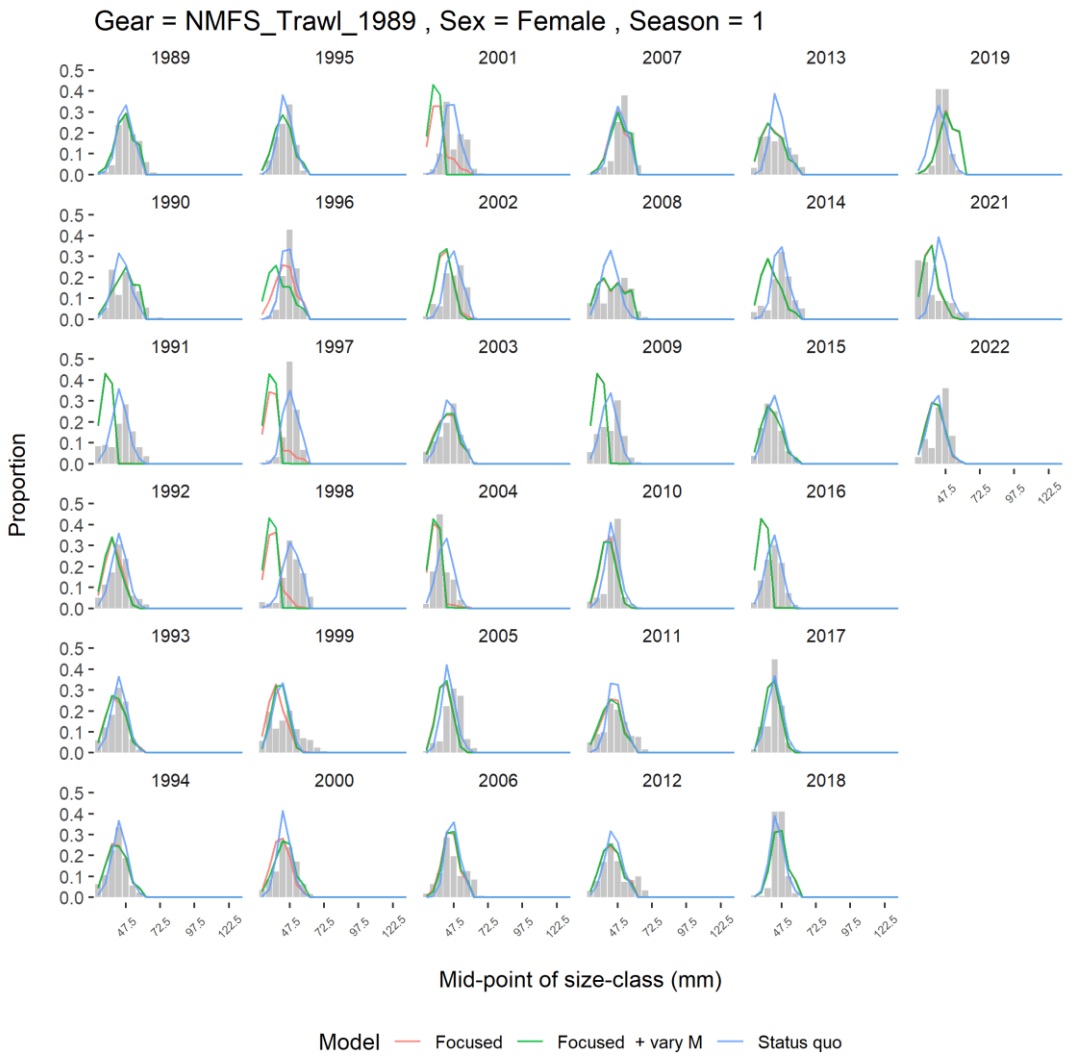

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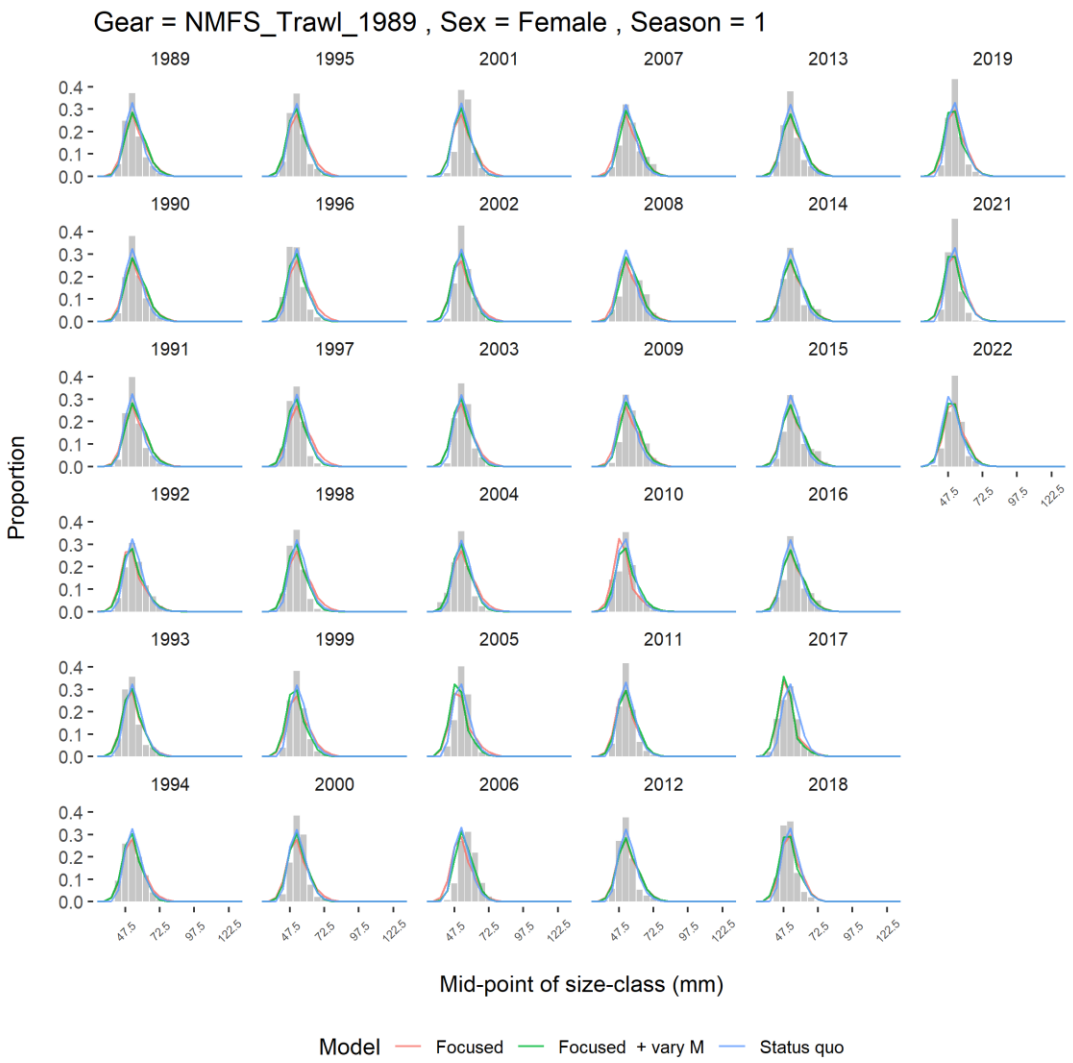

Status quo and bridge models

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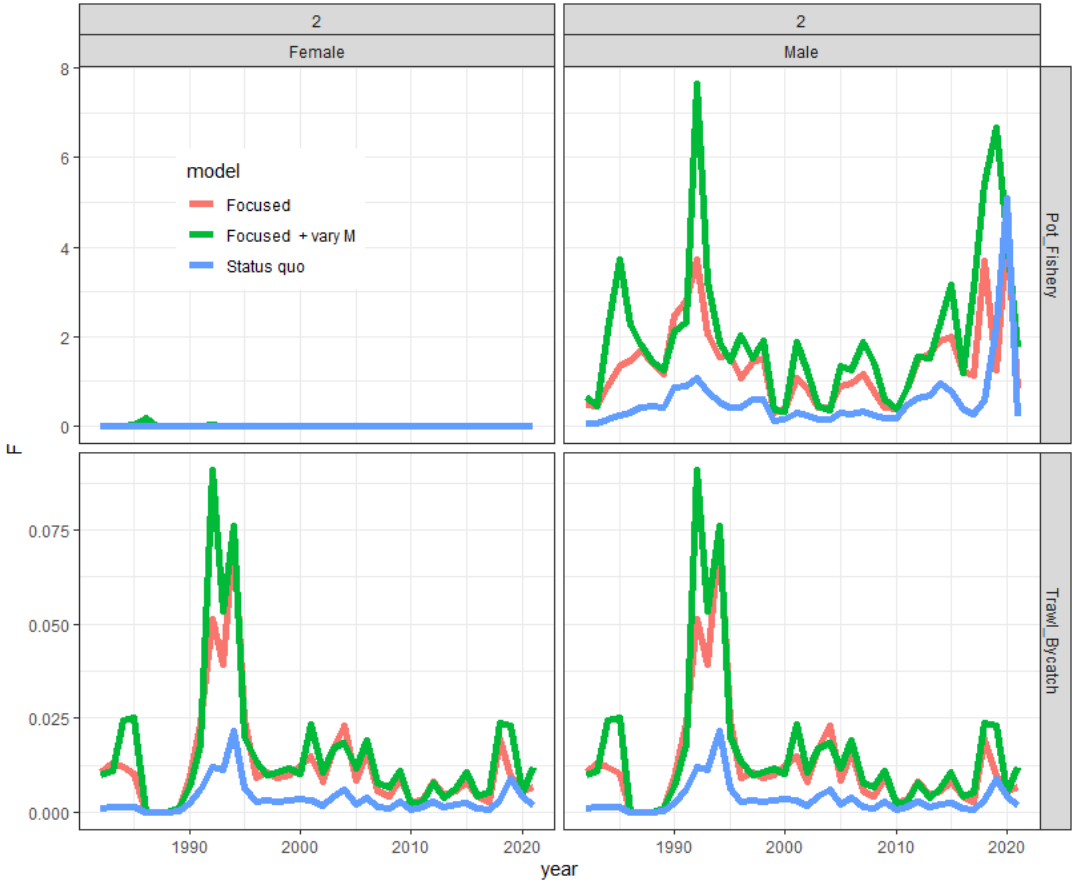

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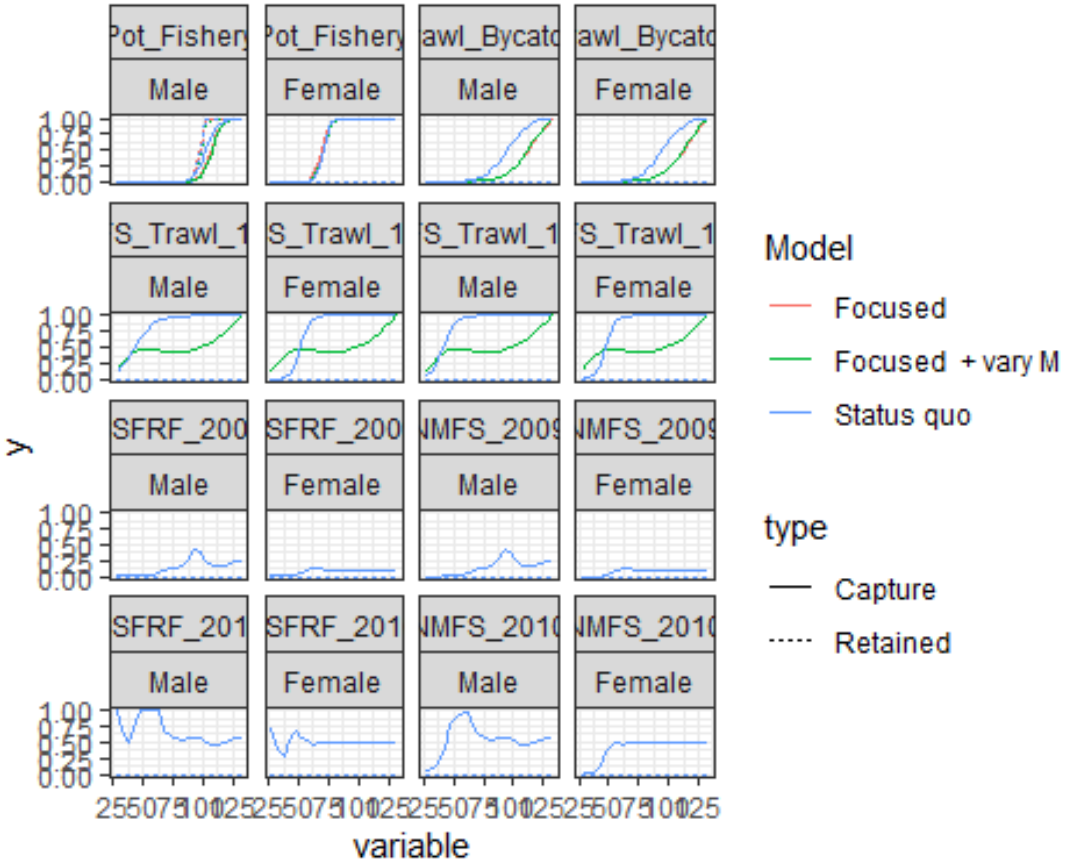

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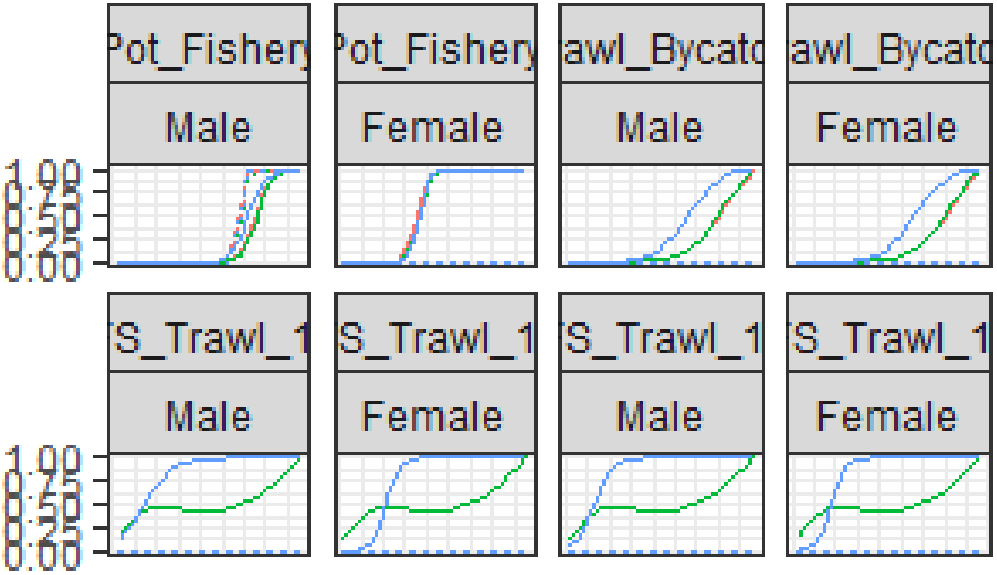

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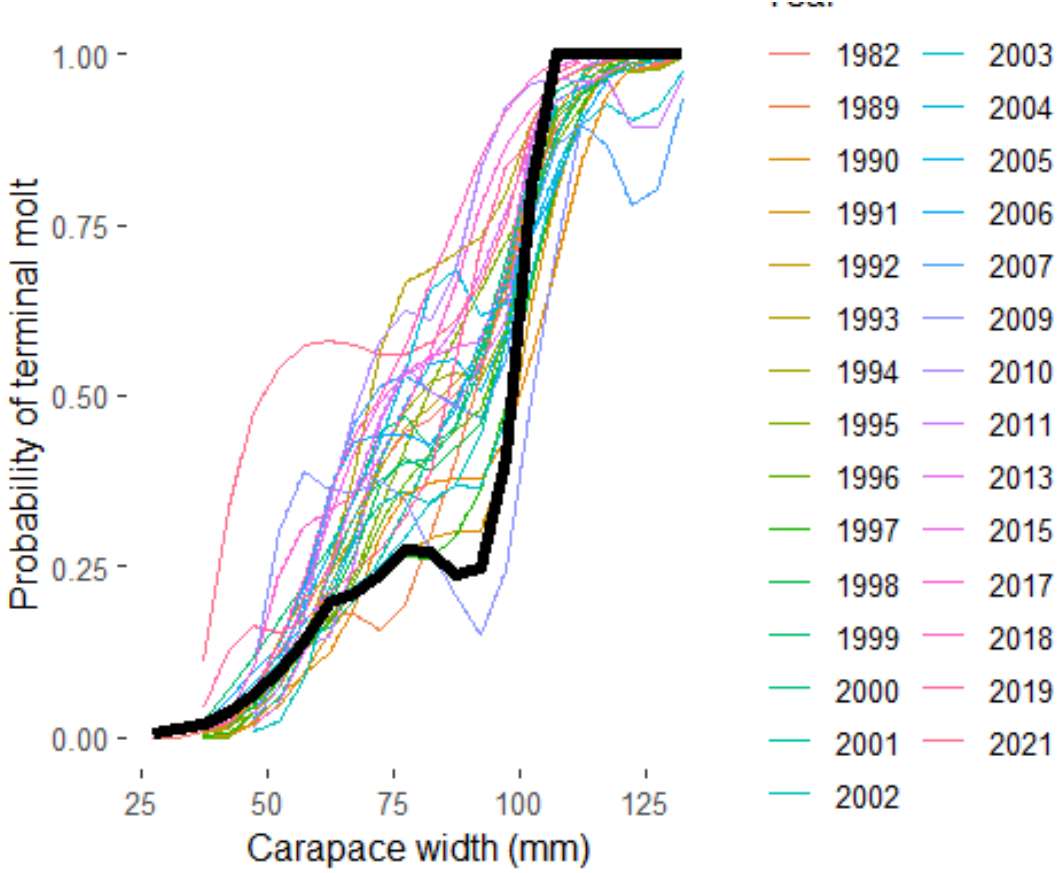
- Status quo model has a much lower probability of terminal molt



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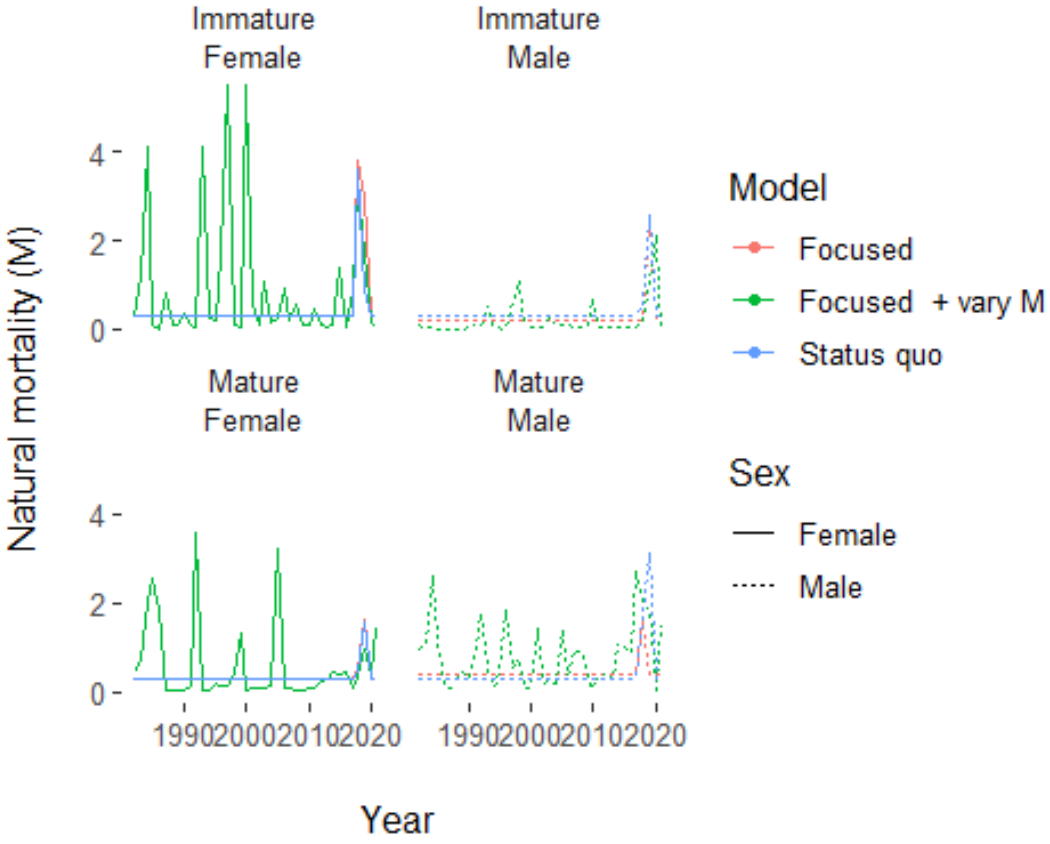

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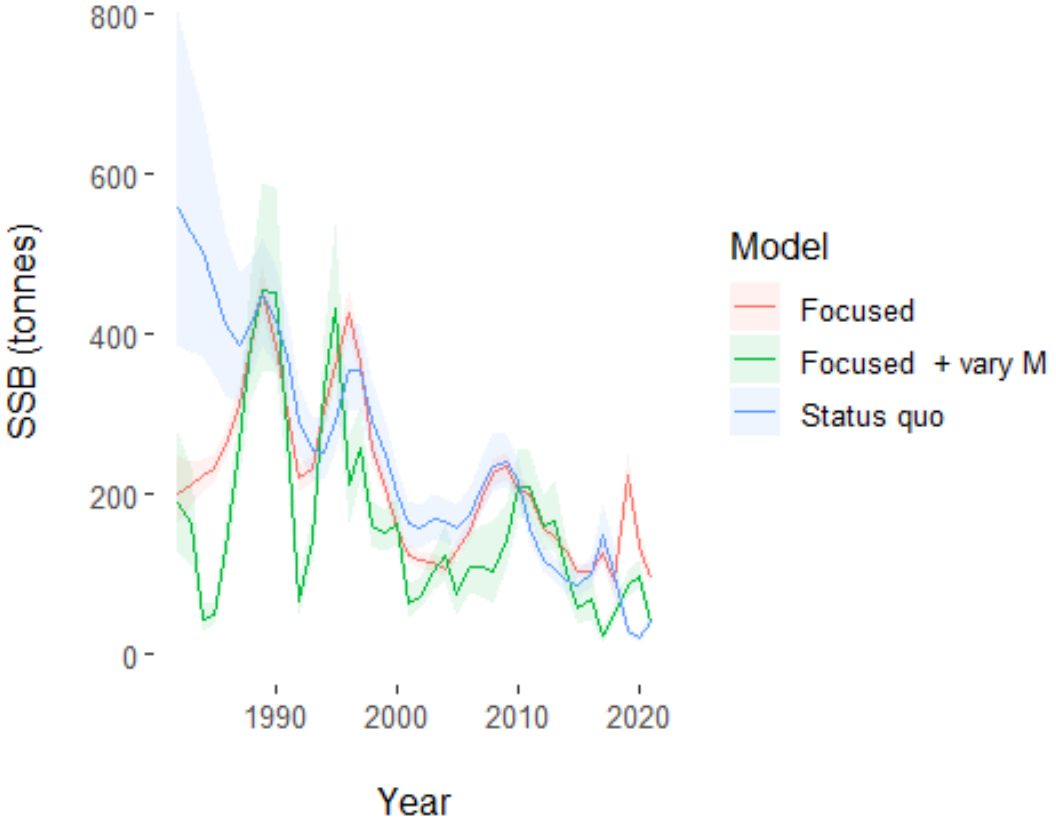

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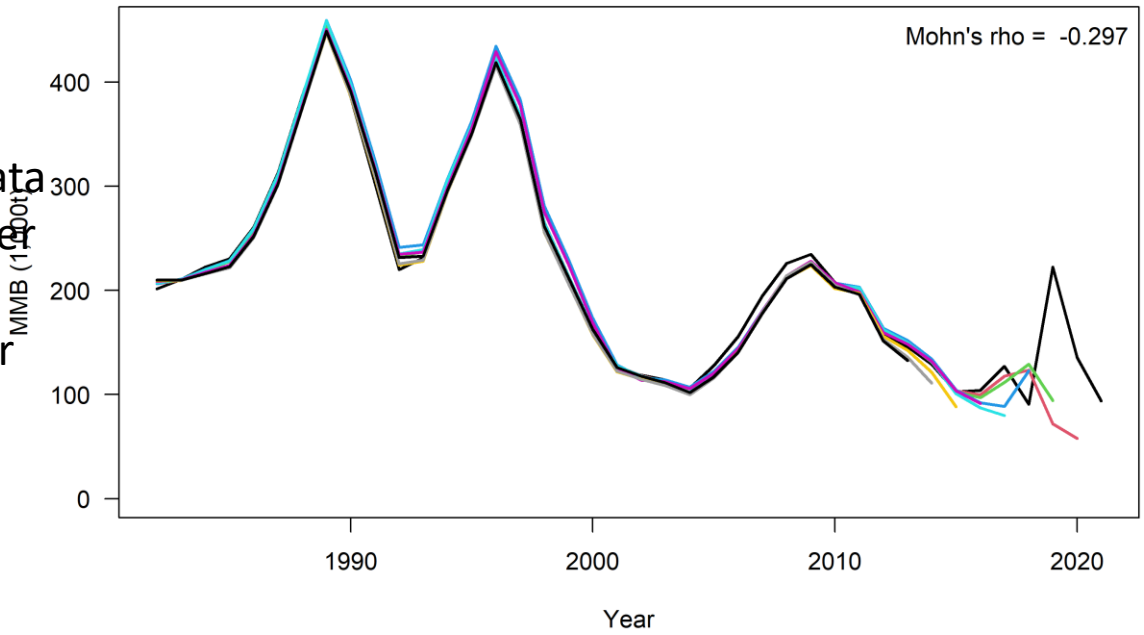

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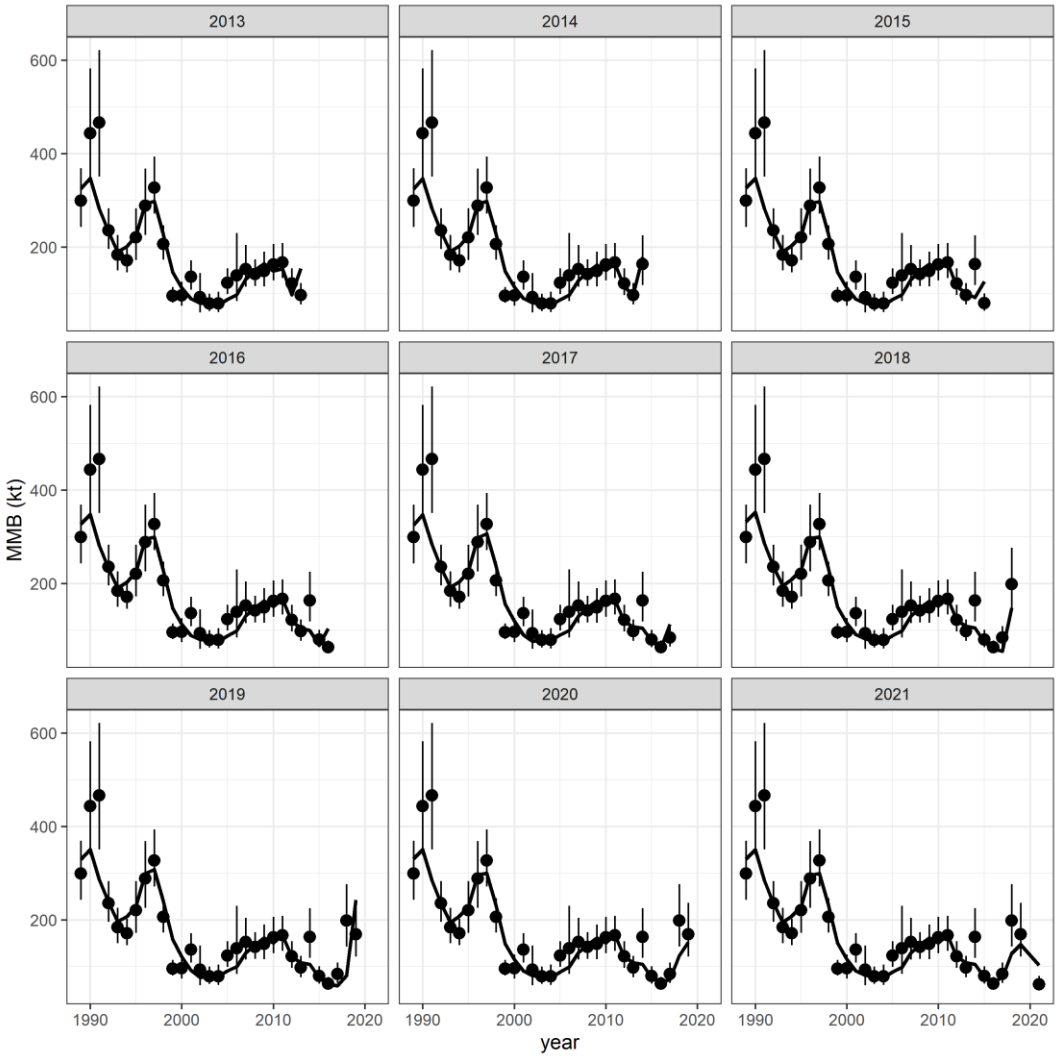

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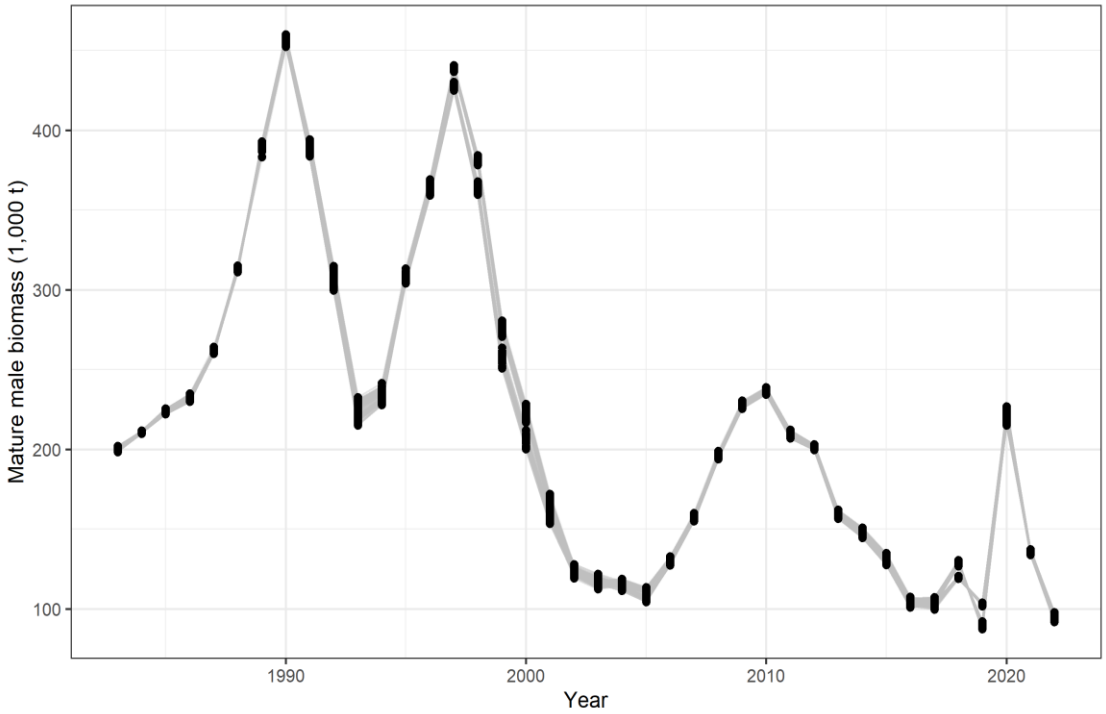
- Bimodality no longer seen



Why didn't the bridging work as well as the research model?

- Unrealistic population processes (fishing mortality in particular)
- Lack of convergence when trying to estimate survey selectivity

- Different data sets fit (biomass vs. abundance…immature indices added in research)
- Linkages between females and males may still be influencing estimation, particularly of fishery processes

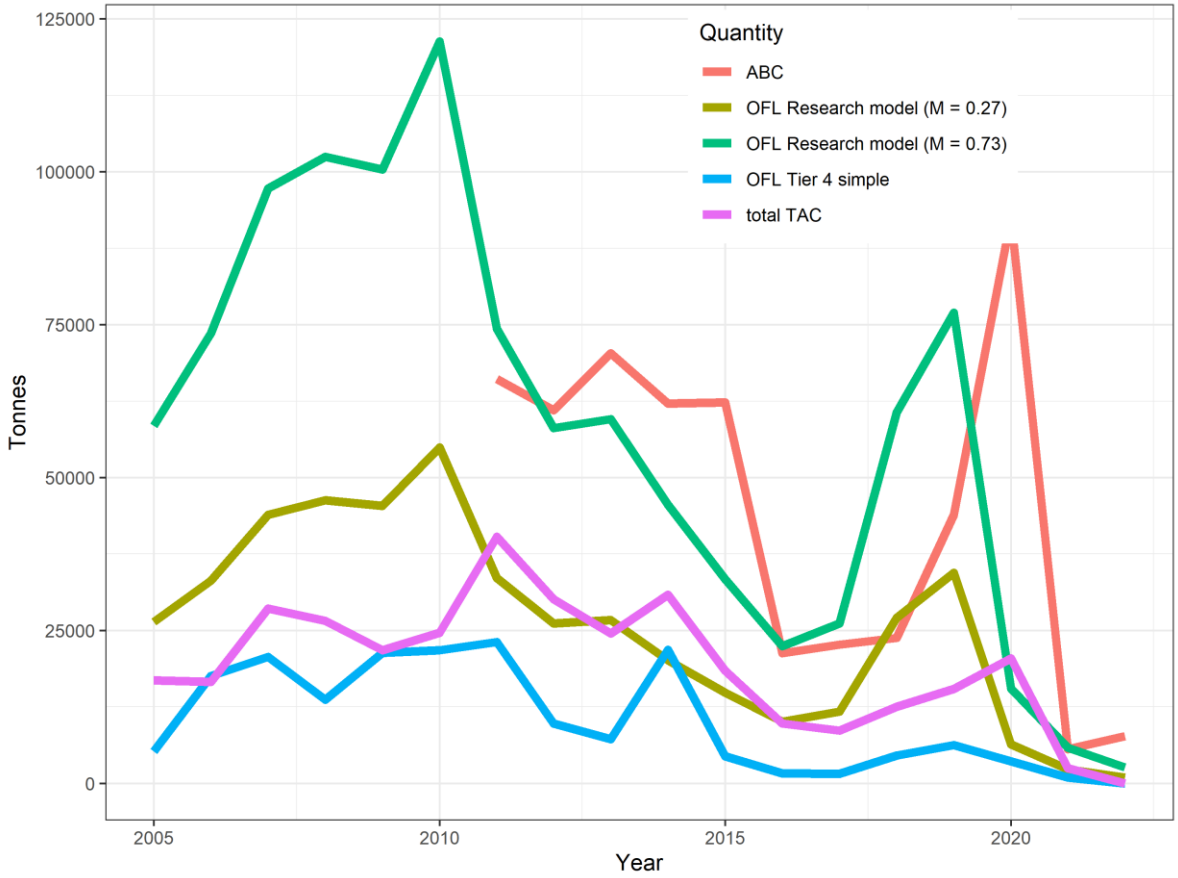
- Fit different indices?
- Remove females?

Reference points

- Tier 4 is the only available option in the tier system that makes sense when maturity is specified appropriately

Model	MMB	B35	F35	FOFL	OFL
Status quo	41.2	183.1	1.5	0.32	10.32
Focused	93.9	80.3	83.8	41.43	21.87
Focused + vary M	39.4	44.9	127.8	21.13	8.19
Status quo (tier 4)	41.4	249.1	0.28	0.000	0.11
Focused (tier 4)	93.9	215.3	0.41	0.092	0.50
Focused + vary M (tier 4)	39.4	162.4	0.19	0.000	0.03

- TAC is ~40% of the ABC on average.
- OFLs from research were comparable to the TAC when the F_{MSY} proxy was 0.27
- OFLs were more comparable to the ABCs when using average M.
- tier 4 produced the most conservative management advice.



September models

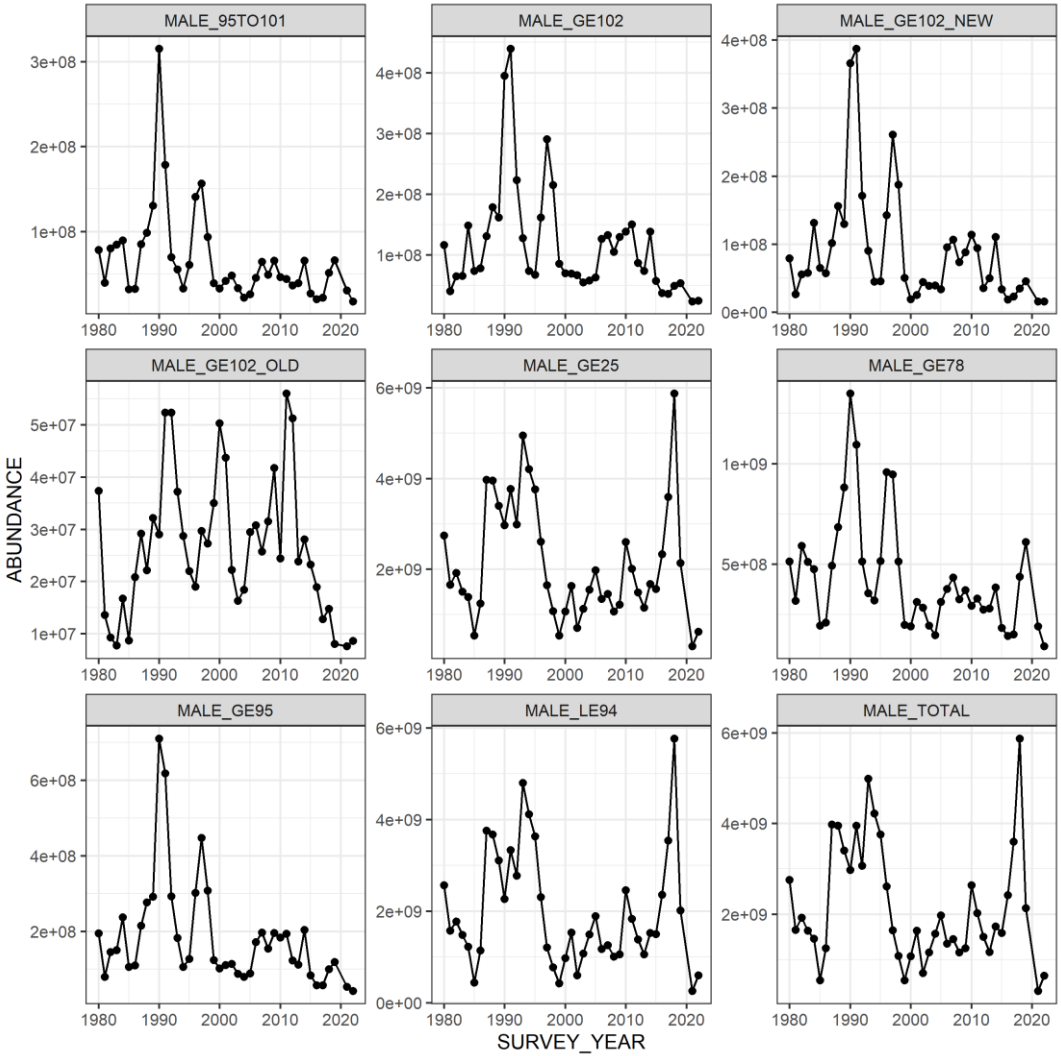
Status quo

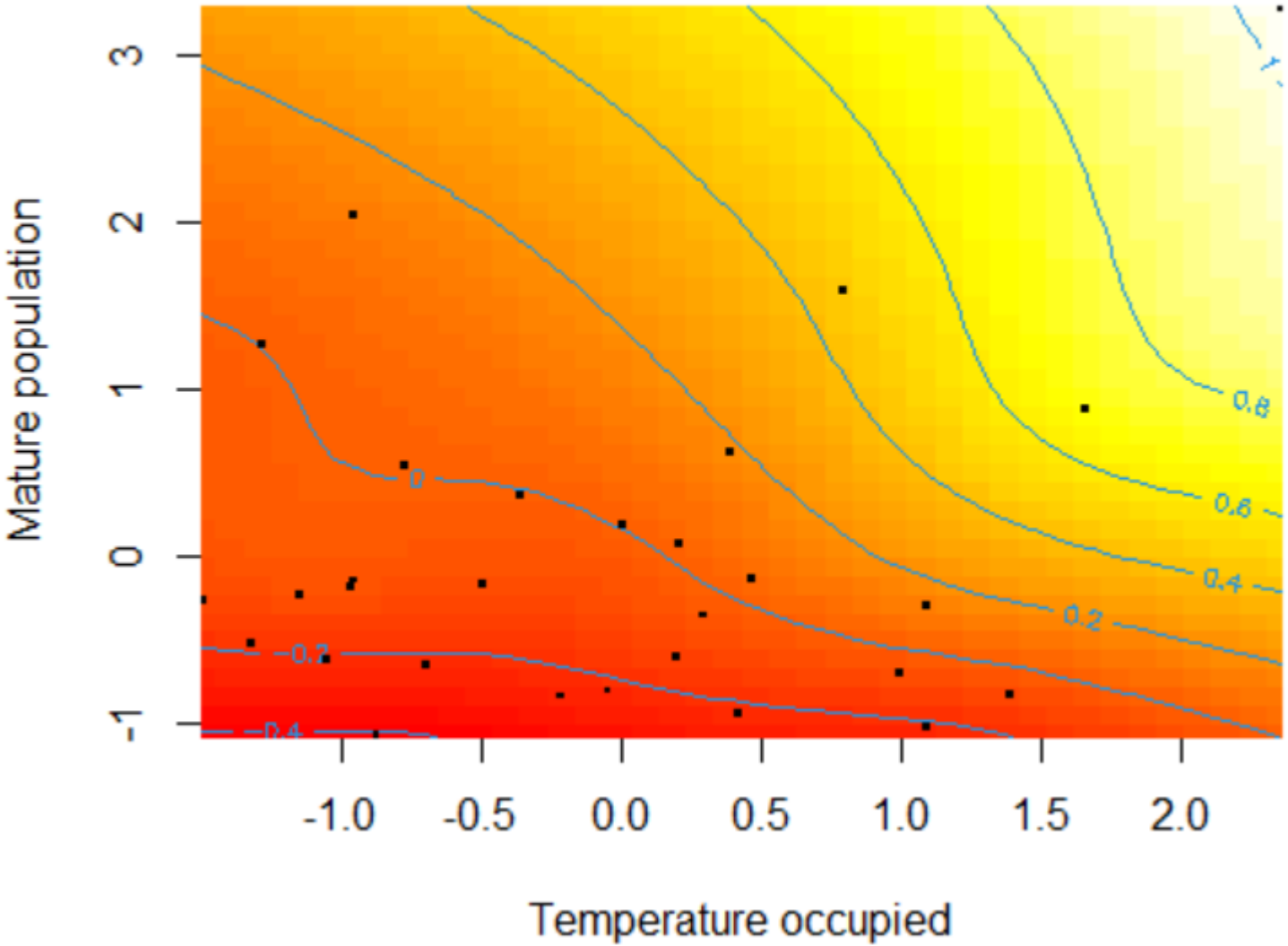
A working bridge model

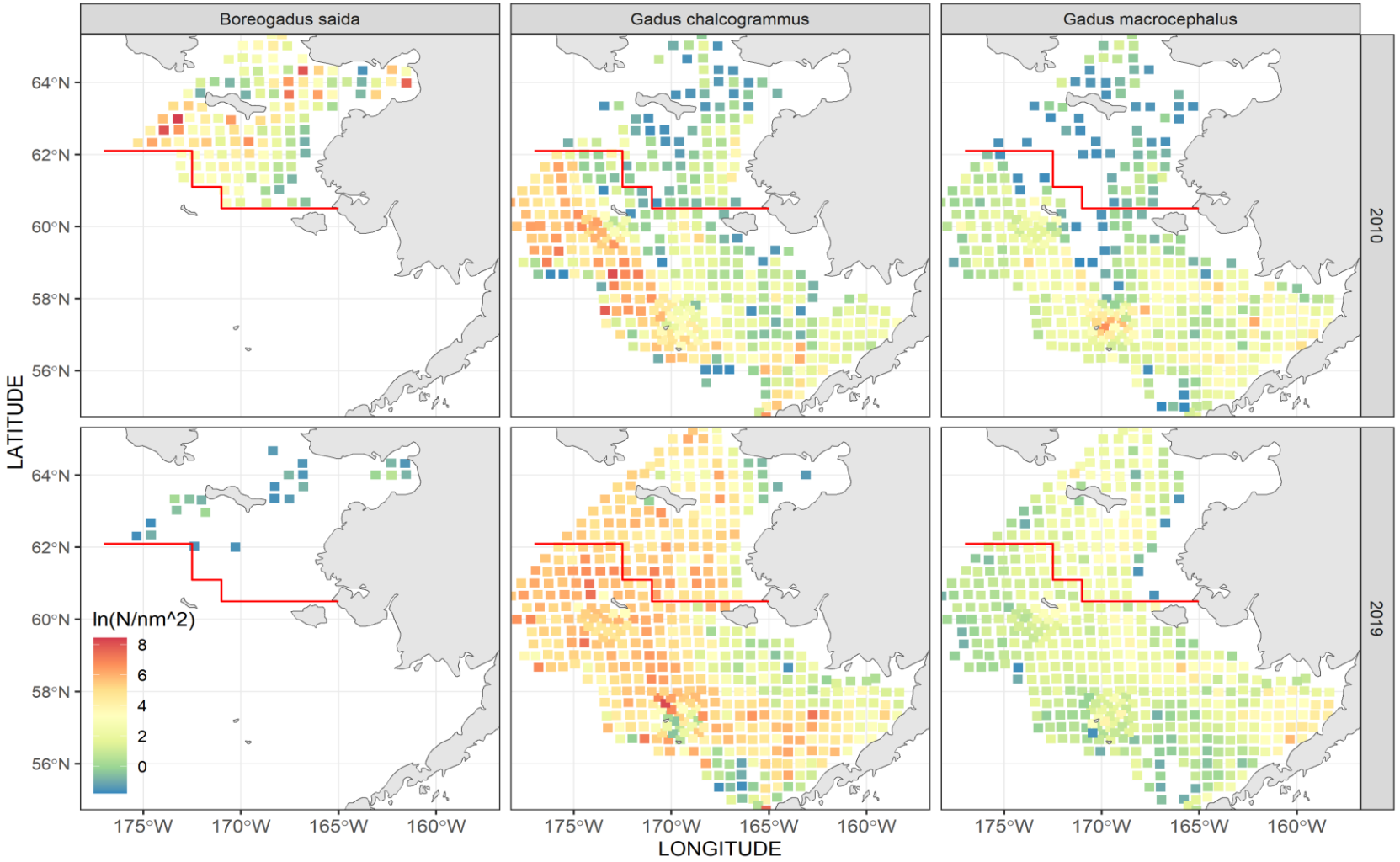
Tier 4

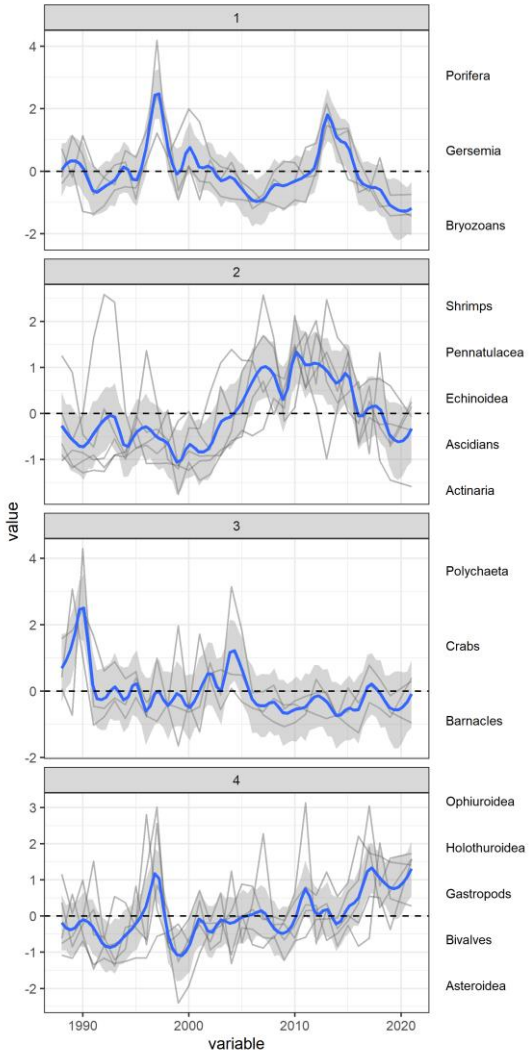
1. *How should the 'reference' biological process be defined?*
2. *Should natural mortality vary annually or only large mortality events delineated?*
3. *How should estimated parameters be chosen? (Andre's sufficient statistics)*
4. *How to define B_{MSY} when using Tier 4?*
5. *What data should be fit? Both indices and time span.*
6. *What is the relative confidence in each data set available?*

1. *How should the 'reference' biological process be defined?*
    1. *Natural mortality and terminal molting*
2. *Should natural mortality vary annually or only large mortality events delineated?*
    2. *What would be sufficient rationale for choosing annually varying?*
    3. *How does the longevity assumption for M apply when there are life transitions like terminal molt?*
3. *How should estimated parameters be chosen? (Andre's sufficient statistics)*
    3. *Growth? Maturity? Selectivity?*
4. *How to define B_{MSY} when using Tier 4?*
    4. *Hard to know when the stock was 'fished at FMSY"*
5. *What data should be fit? Both indices and time span.*
    5. *Abundance or biomass? Both maturity states? Should an index of commercially sized males be included? Should the early part of the survey be excluded?*
7. *What is the relative confidence in each data set available?*
    7. *Is everyone convinced that the BSFRF data should be used as priors? How to make sure these data 'speak' loudly enough?*


MALE_95TO101
MALE_GE102
MALE_GE102_NEW
MALE_GE102_OLD
MALE_GE25
MALE_GE78
MALE_GE95
MALE_LE94
MALE_TOTAL
ABUNDANCE
SURVEY_YEAR
1980
1990
2000
2010
2020


Mature population
3
2
1
0
-1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Temperature occupied


Boreogadus saida
Gadus chalcogrammus
Gadus macrocephalus
2010
2019
LATITUDE
LONGITUDE
64°N
62°N
60°N
58°N
56°N
175°W
170°W
165°W
160°W
ln(N/nm^2)
8
6
4
2
0


1
2
3
4
Porifera
Gersemia
Bryozoans
Shrimps
Pennatulacea
Echinoidea
Ascidians
Actinaria
Polychaeta
Crabs
Barnacles
Ophiuroidea
Holothuroidea
Gastropods
Bivalves
Asteroidea
value
variable
1990
2000
2010
2020