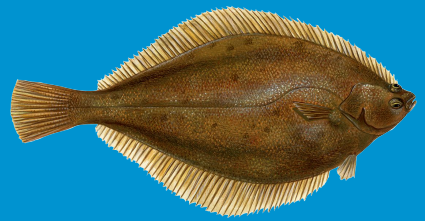
NOAA FISHERIES
Northeast Fisheries Science Center

Cape Cod-Gulf of Maine Yellowtail ToRs 4,5 & 6

Research Track Peer Review Meeting
November 18-22



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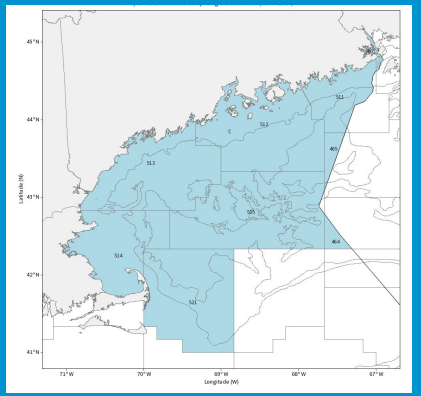
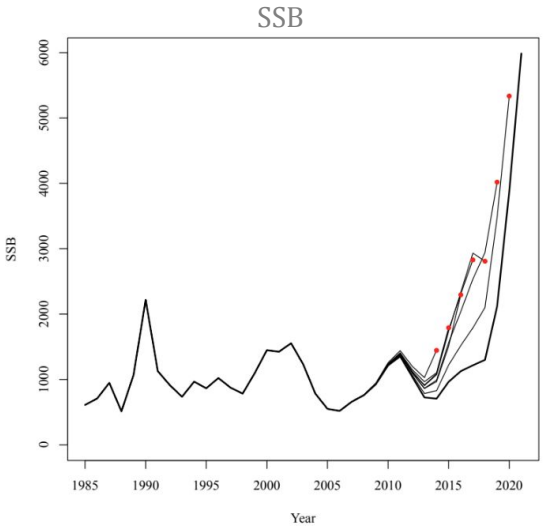


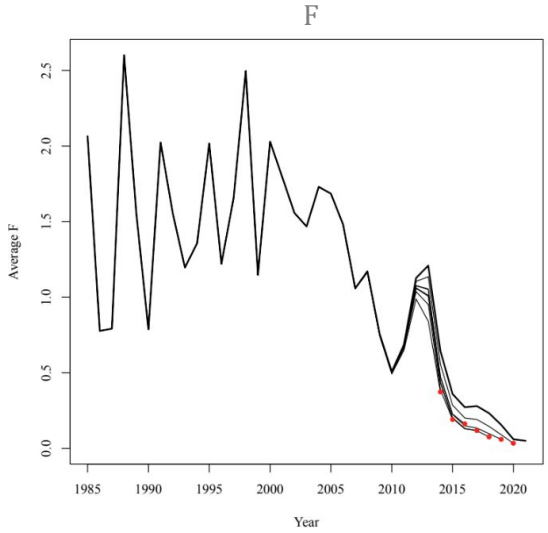
Overview

- Part 1: Bridge Building from VPA
- Part 2: Model Selection Process
- Part 3: Candidate Model Diagnostic
- Part4: Candidate Model Results
- Part5: Biological Reference Points
- Part6: Projections

Last Assessment - 2022 Management Track

- Model - Virtual Population Analysis (VPA)
- Ages 1-6+
- Catch (1985 - 2021)
- Six Surveys
  - NEFSC Spring (ages 1-6+)
  - NEFSC Fall (ages 1-5)
  - MADMF Spring (ages 1-6+)
  - MADMF Fall (ages 2-5)
  - MENH Spring (ages 2-5)
  - MENH Fall (ages (2-4)
- M = 0.2
- Major retrospective Pattern - SSB (0.96) , F (-0.52)





Brief Data Overview Research Track

- Years in the model: 1985-2022
- Ages 1-6+
- Single Aggregate Fleet (Commercial landings and Discards)
- Started with eight surveys (4 Federal Surveys and 4 Inshore State Surveys)
- Six Surveys (4 Federal Surveys and two Inshore State Surveys):
  - NEFSC Spring and Fall
    - NEFSC Spring Albatross years (1985-2008)
    - NEFSC Spring Bigelow years (2009 - 2022)
    - NEFSC Fall Albatross years (1985-2008)
    - NEFSC Fall Bigelow years (2009 - 2022)
  - MADMF Fall Only (1985-2022)
  - MEDMR Fall Only (2000-2022)

Part One

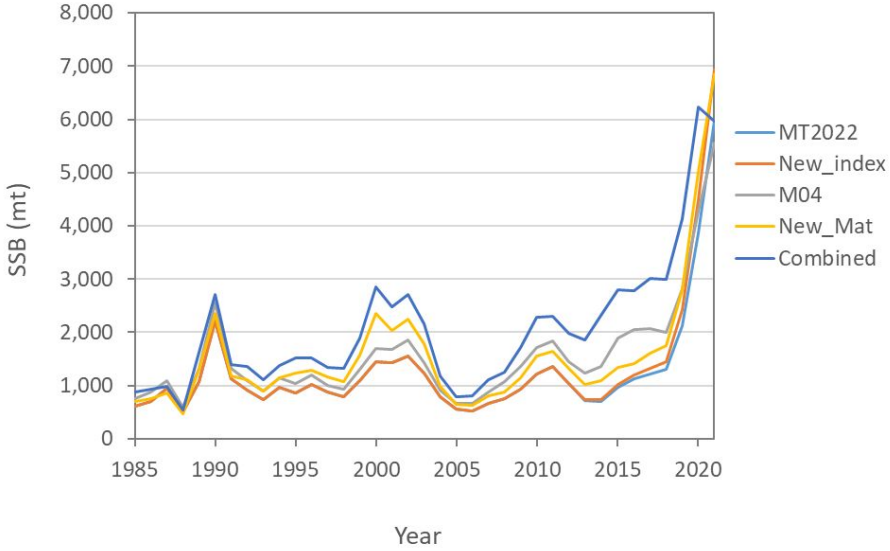
Building the Bridge from VPA to WHAM

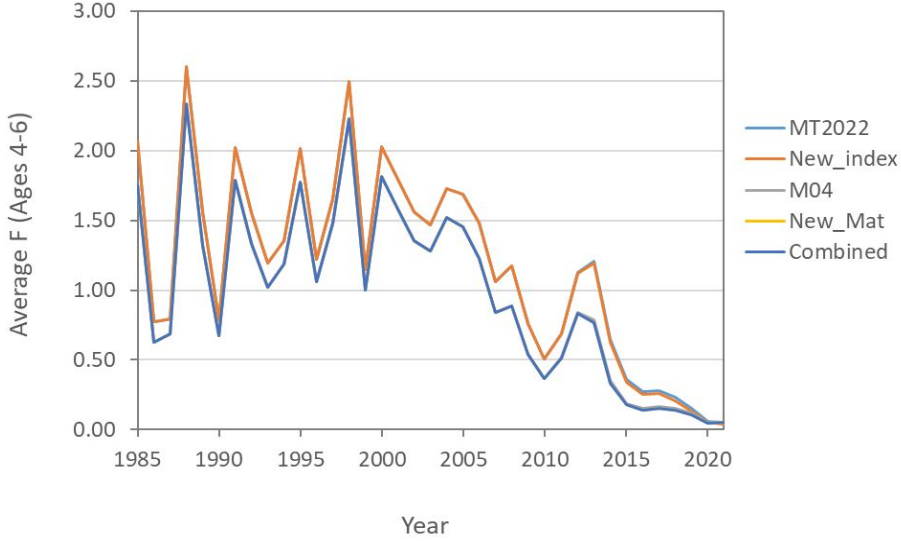
Building a Bridge from VPA to WHAM

Data Revisions in VPA

- **Survey Indices Update**: NEFSC and MADMF survey indices changed from absolute biomass to relative indices, improving consistency over time.
- **Natural Mortality Adjustment**: M rate was increased from **0.2 to 0.4**, based on recent life history studies.
- **Maturity Ogive Refinement**: 3yr MA from annual proportions-at-age were applied instead of a time-series average, capturing temporal variation in maturity.
- **Length-Weight Update**: Revised catch-at-age data from 1994–2022 with updated length-weight relationships.

Building a Bridge from VPA to WHAM





VPA Results: The “Combined” run with all adjustments produced the highest SSB and lowest F values, underscoring the cumulative impact of these data improvements.

Building a Bridge from VPA to WHAM

ASAP "Pit Stop"

- A preliminary setup in ASAP was conducted to facilitate importing data inputs into the WHAM framework, bridging from VPA to WHAM.
- The Working Group prioritized developing a robust WHAM model over refining the ASAP model, using ASAP mainly as a transitional tool.
- ASAP was configured to align with VPA assumptions, with fixed CVs and sample sizes to mimic known catch and index weighting.
- The initial ASAP model (ASAP_BridgeRun1) faced convergence issues, leading the WG to discontinue further ASAP runs.
- WHAM development became the primary focus, enabling more refined assessment methods for CCGOM yellowtail flounder.

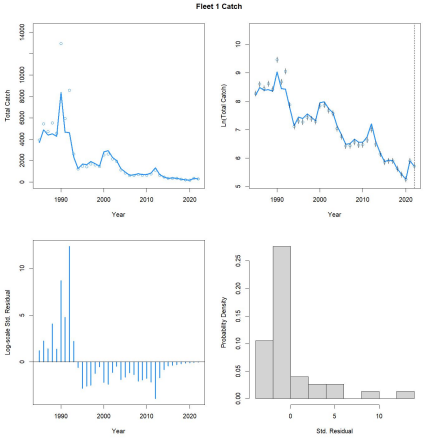
Initial WHAM Parameterization (model m0)

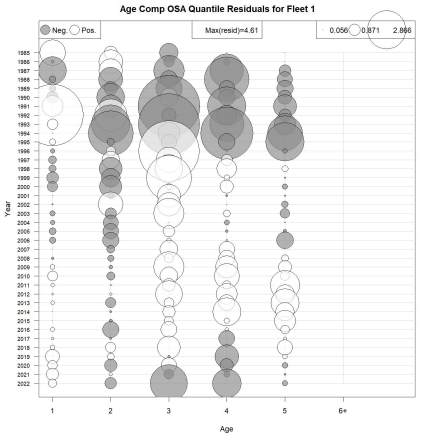
- Initial WHAM setup emulated an ASAP-like non-state-space model with age classes (1-6+) and a fixed CV on fleet landings (0.05).
- The model met both first-order and second-order convergence criteria, with a maximum gradient of 1.45e-11 and an invertible Hessian matrix.
- Diagnostics showed strong residual patterns, improved Mohn's rho over VPA
- Over 800 model variations were tested, examining assumptions on fleet/survey selectivities, recruitment, age compositions, life history, and environmental factors.
- Model development was iterative, revisiting earlier decisions as new insights emerged from each model variation.

Initial WHAM Parameterization ("Fixed Effects")

M0 Formulation

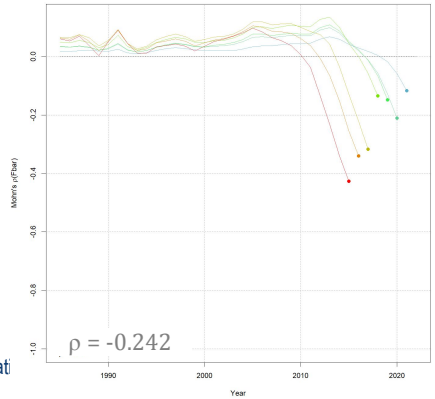
- Age 6+ Formulation
- Six Survey Indices
  - NEFSC Fall/Spring
  - MADMF Fall/Spring
  - MEDMR Fall/Spring
- Recr. = Random about Mean
- Selectivity
  - Fleet = Age-specific (RE = None)
  - Survey indices = Age-Specific (RE = None)
- Age Comp
  - Fleet = Multinomial
  - Indices = Multinomial
- NAA RE = None

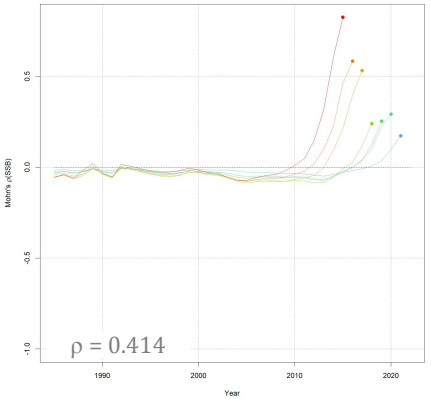




Fixed Effect Explorations

- Moderate Retrospective patterns
- However, Lack of model fit to aggregate catch and majority of the survey indices remains an issue to be explored
- Strong residual patterns





Part Two

The Model Selection Process

Non-ECOV: ~ 817 WHAM Runs
NEFSC Survey (“*To split or Not to Split*”)
Fleet Selectivity
Survey Selectivity
Numbers-at-age
Recruitment Assumption
Age Composition
Survey Inclusion/Exclusion
Natural Mortality
Ecov Effects on Recr. and M
Fleet Selectivity - Revisited
Final Candidate Model

The WHAM (Woods Hole Assessment Model)

Model development generally follows this process

ECOV: ~ 16 WHAM Runs
Environmental Covariate effect on R
Environmental Covariate effect on M

Non-ECOV: ~ 817 WHAM Runs
NEFSC Survey (*To split or Not to Split"*)
Fleet Selectivity
Survey Selectivity
Numbers-at-age
Recruitment Assumption
Age Composition
Survey Inclusion/Exclusion
Natural Mortality
Ecov Effects on Recr. and M
Fleet Selectivity - Revisited
Final Candidate Model

Model m1
Maintained similar settings to the previous Model m0 with No random effects.

Here we examined whether to split time series in 2009 when the BTS underwent a significant transition from Albatross to the Bigelow.

Splitting the survey led to some improvement in Retrospective pattern. Residual pattern still remains

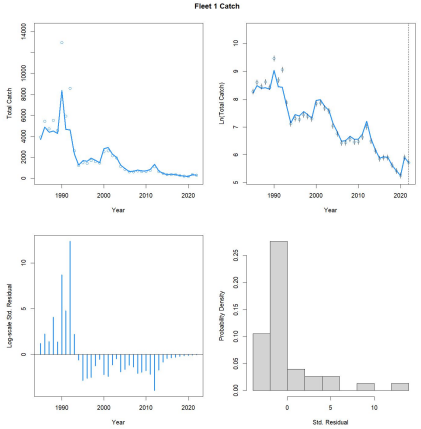
NEFSC Survey ("To split or Not to Split")

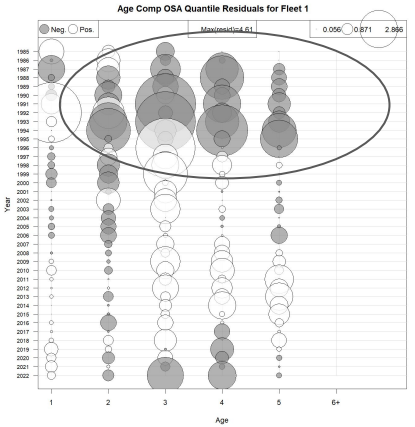
m1 Formulation

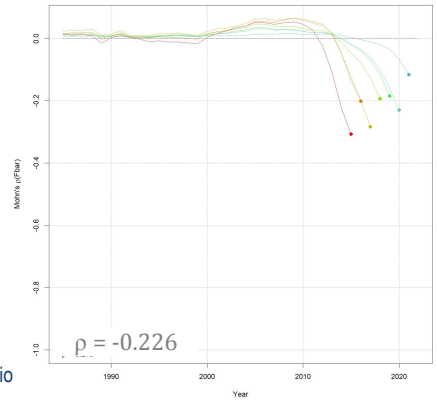
- Age 6+ Formulation
- Eight Survey Indices
  - NEFSC Fall/Spring (1985-2008)
  - NEFSC Fall/Spring Bigelow (2009-2022)
  - MADMF Fall Spring
  - MEDMR Fall/Spring
- Recr. = Random about Mean
- Selectivity
  - Fleet = Age-specific (RE = None)
  - Survey indices = Age-Specific (RE = None)
- Age Comp
  - Fleet = Multinomial
  - Indices = Multinomial
- NAA RE = None

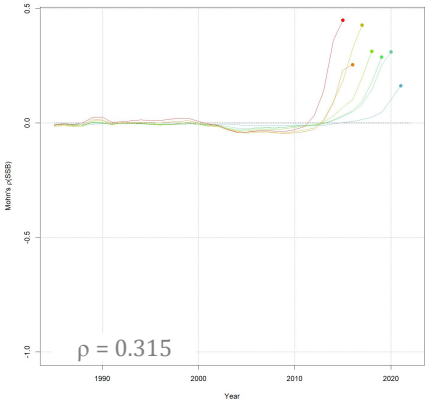
Model Summary:

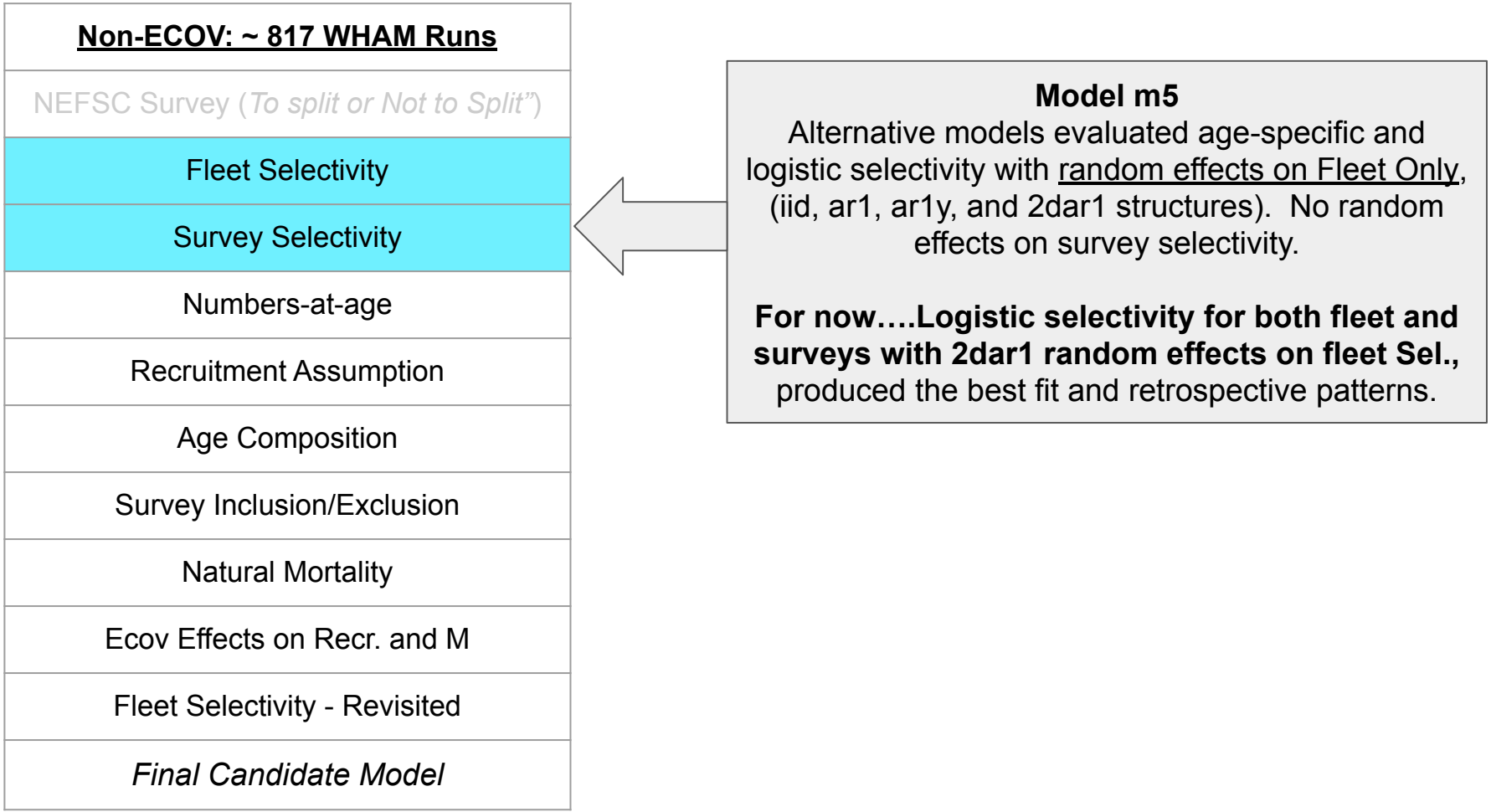
- Moderate improvement in retrospective Mohn's Rho
- Strong residual patterns in catch and survey










Non-ECOV: ~ 817 WHAM Runs
NEFSC Survey (To split or Not to Split")
Fleet Selectivity
Survey Selectivity
Numbers-at-age
Recruitment Assumption
Age Composition
Survey Inclusion/Exclusion
Natural Mortality
Ecov Effects on Recr. and M
Fleet Selectivity - Revisited
Final Candidate Model
Model m5
Alternative models evaluated age-specific and logistic selectivity with random effects on Fleet Only, (iid, ar1, ar1y, and 2dar1 structures). No random effects on survey selectivity.
For now….Logistic selectivity for both fleet and surveys with 2dar1 random effects on fleet Sel., produced the best fit and retrospective patterns.

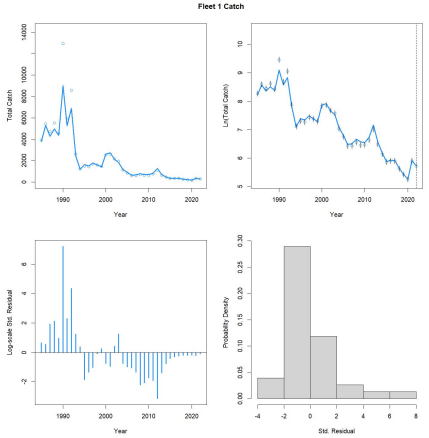
Fleet and Survey Selectivity

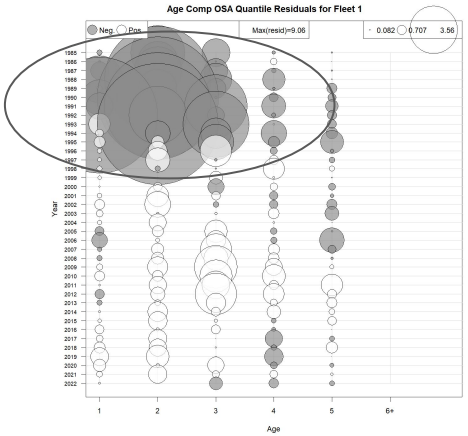
m5 Formulation

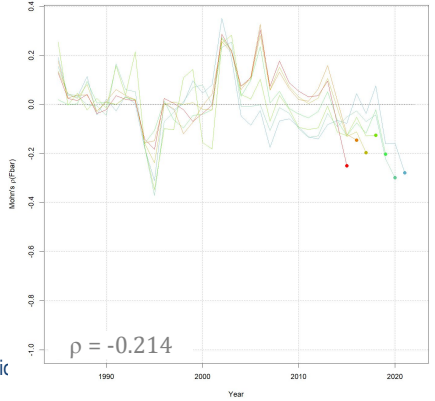
- Age 6+ Formulation
- Eight Survey Indices
  - NEFSC Fall/Spring (1985-2008)
  - NEFSC Fall/Spring Bigelow (2009-2022)
  - MADMF Fall Spring
  - MEDMR Fall/Spring
- Recr. = Random about Mean
- Selectivity
  - Fleet = Logistic (RE = 2dar1)
  - Survey indices = Logistic (RE = None)
- Age Comp
  - Fleet = Multinomial
  - Indices = Multinomial
- NAA RE = None

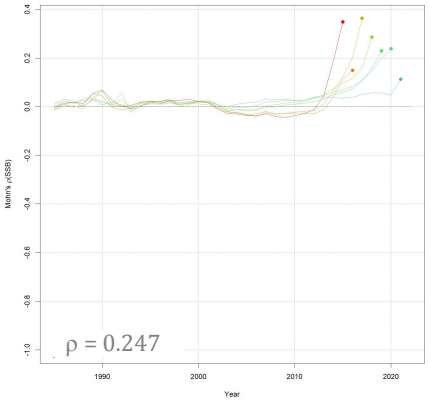
Model Summary:

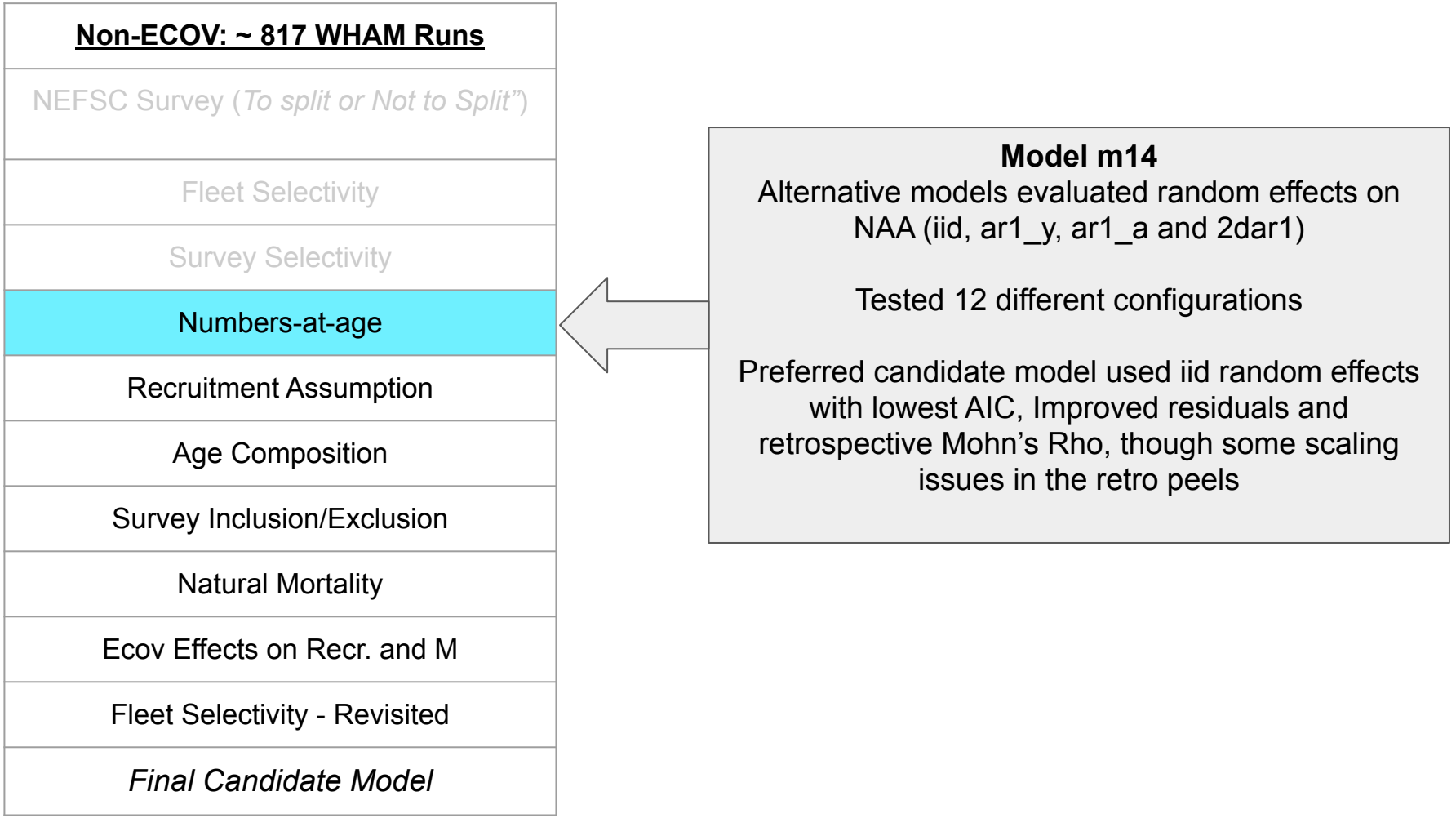
- Lowest AIC among Logistic functional forms
- Improved retrospective Mohn's rho across (Age-specific vs Logistic)
- Improved fit to some survey indices. Emergence of large residuals in early part of catch age comp.







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NEFSC Survey (To split or Not to Split")
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Survey Selectivity
Numbers-at-age
Recruitment Assumption
Age Composition
Survey Inclusion/Exclusion
Natural Mortality
Ecov Effects on Recr. and M
Fleet Selectivity - Revisited
Final Candidate Model
Model m14
Alternative models evaluated random effects on NAA (iid, ar1_y, ar1_a and 2dar1)
Tested 12 different configurations
Preferred candidate model used iid random effects with lowest AIC, Improved residuals and retrospective Mohn's Rho, though some scaling issues in the retro peels

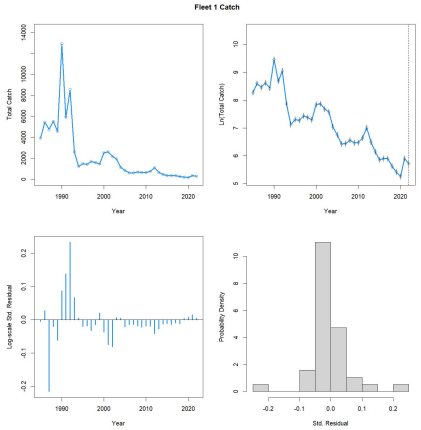
Numbers-at-age

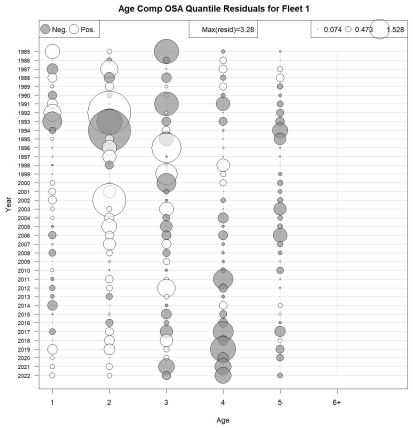
m14 Formulation

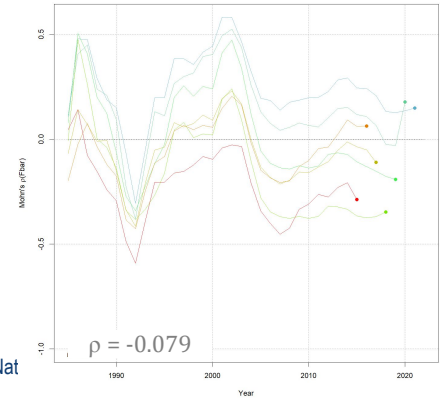
- Age 6+ Formulation
- Eight Survey Indices
  - NEFSC Fall/Spring (1985-2008)
  - NEFSC Fall/Spring Bigelow (2009-2022)
  - MADMF Fall Spring
  - MEDMR Fall/Spring
- Recr. = Random about Mean
- Selectivity
  - Fleet = Logistic (RE = 2dar1)
  - Survey indices = Logistic (RE = None)
- Age Comp
  - Fleet = Multinomial
  - Indices = Multinomial
- NAA RE = iid

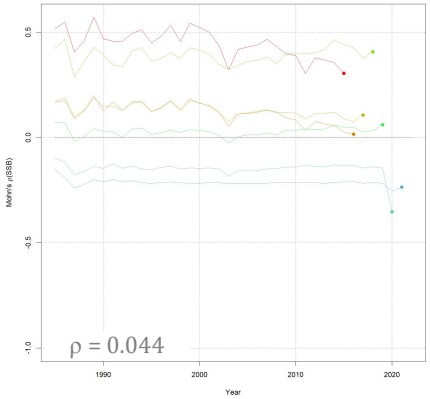
Model Summary:

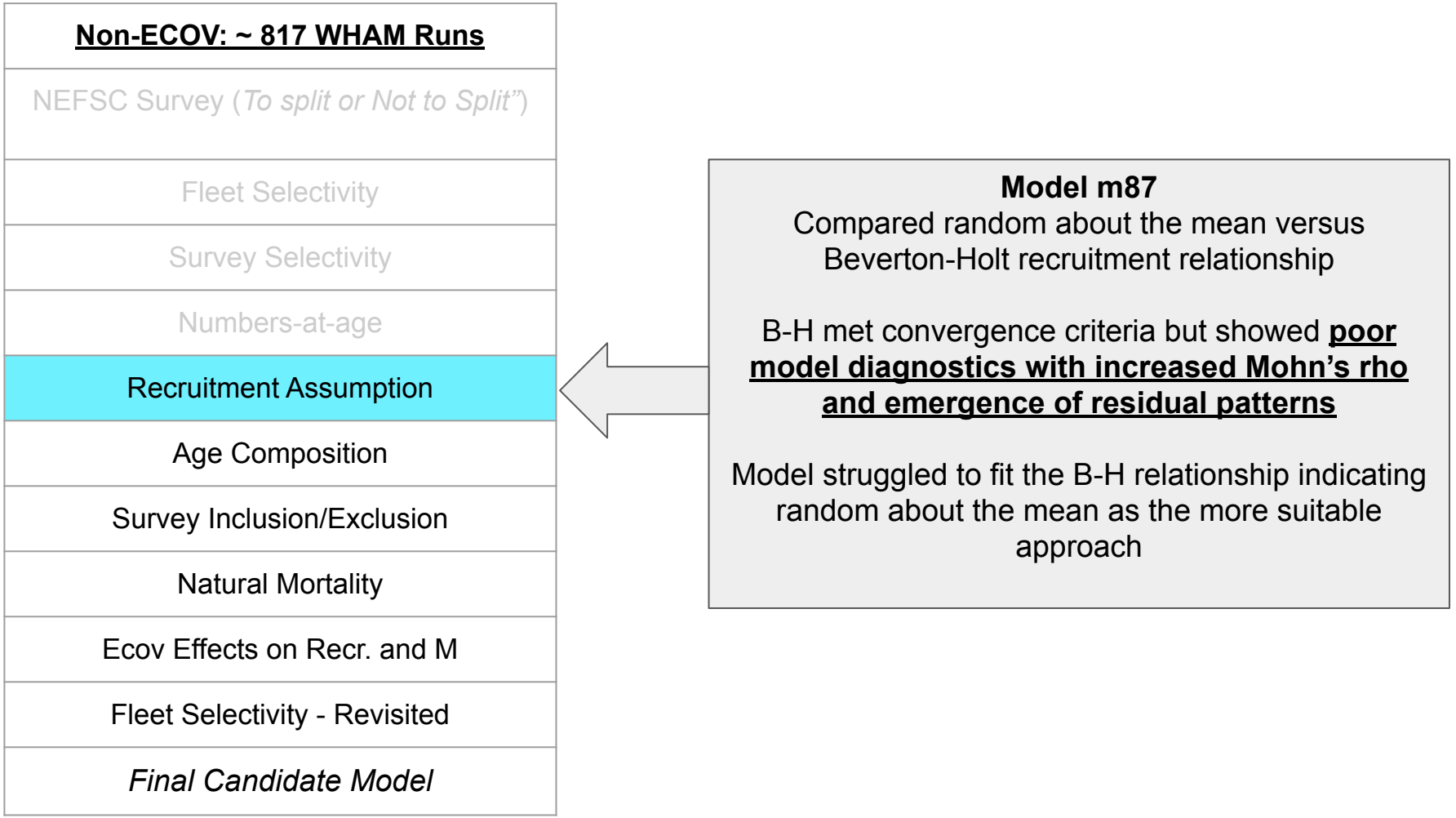
- Lowest AIC
- Improved residual pattern
- Improved retrospective Mohn's rho
- Emergence of retrospective scaling in the peels







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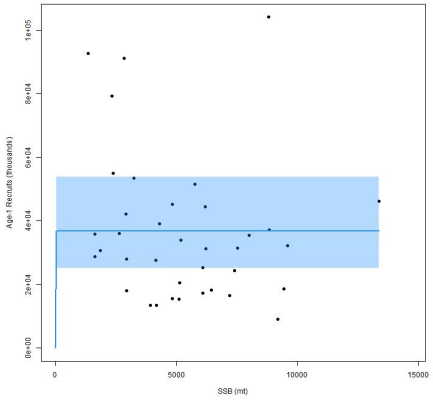
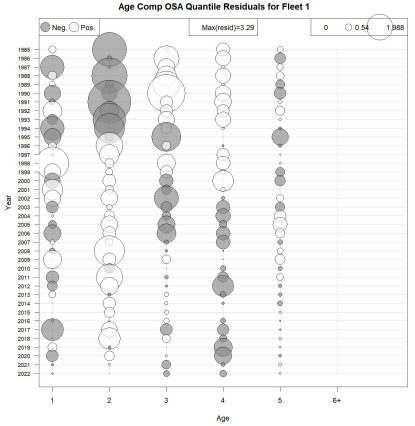
NEFSC Survey (To split or Not to Split")
Fleet Selectivity
Survey Selectivity
Numbers-at-age
Recruitment Assumption
Age Composition
Survey Inclusion/Exclusion
Natural Mortality
Ecov Effects on Recr. and M
Fleet Selectivity - Revisited
Final Candidate Model
Model m87
Compared random about the mean versus Beverton-Holt recruitment relationship
B-H met convergence criteria but showed poor model diagnostics with increased Mohn's rho and emergence of residual patterns
Model struggled to fit the B-H relationship indicating random about the mean as the more suitable approach

Recruitment Assumption

m87 Formulation

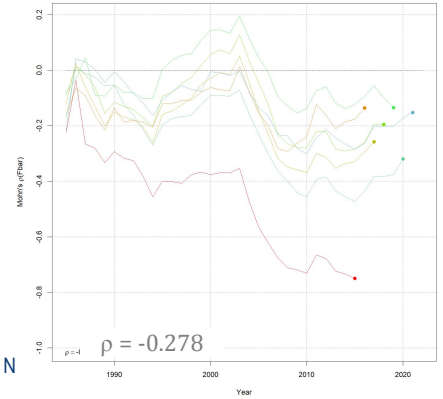
- Age 6+ Formulation
- Eight Survey Indices
  - NEFSC Fall/Spring (1985-2008)
  - NEFSC Fall/Spring Bigelow (2009-2022)
  - MADMF Fall Spring
  - MEDMR Fall/Spring
- Recr. = Beverton-Holt
- Selectivity
  - Fleet = Logistic (RE = 2dar1)
  - Survey indices = Logistic (RE = None)
- Age Comp
  - Fleet = Multinomial
  - Indices = Multinomial
- NAA RE = iid

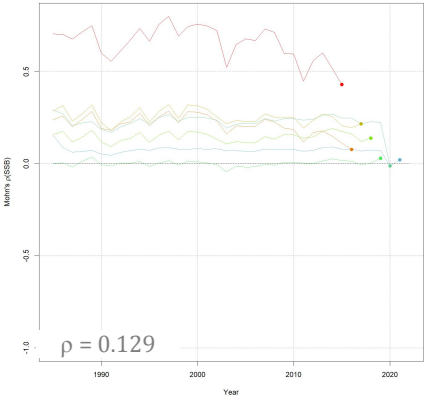


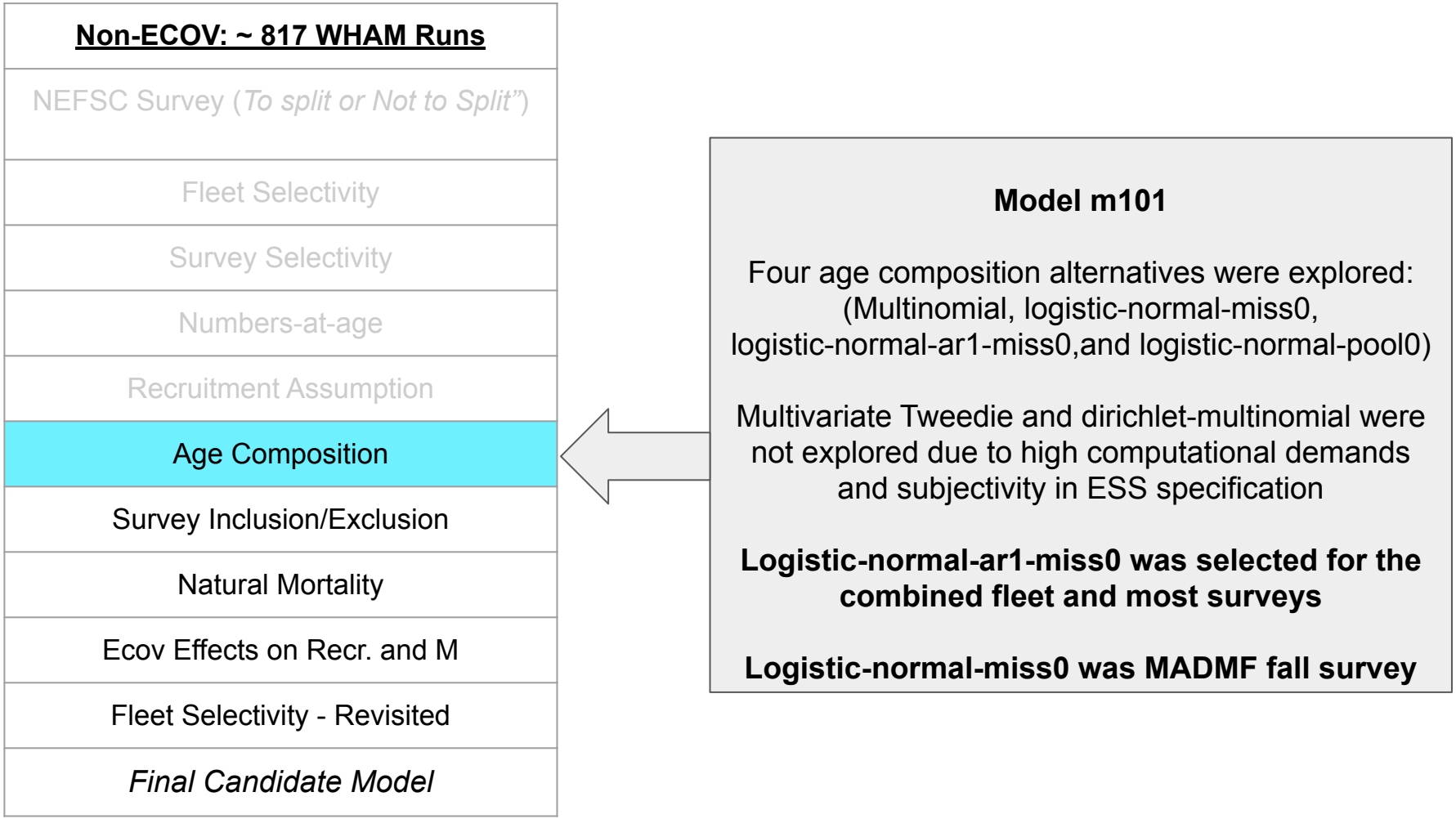


Model Summary:

- No improvement in retro diagnostic
- Stronger scaling in retro peels
- Emergence of patterning in residuals
- Poor S-R relationship



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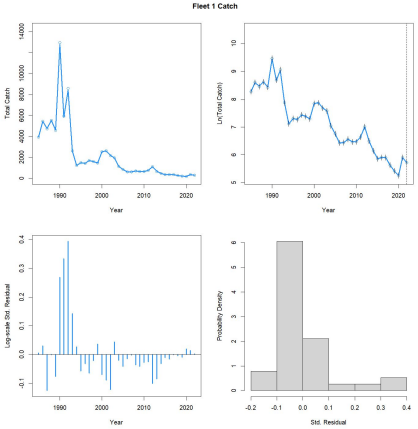
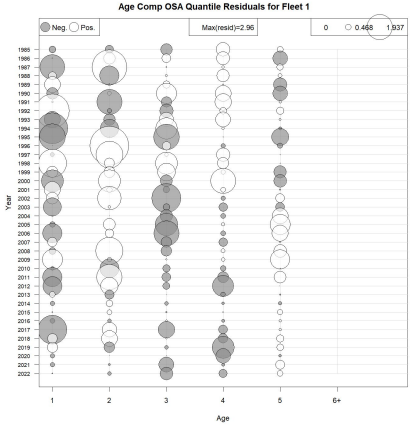
Fleet Selectivity
Survey Selectivity
Numbers-at-age
Recruitment Assumption
Age Composition
Survey Inclusion/Exclusion
Natural Mortality
Ecov Effects on Recr. and M
Fleet Selectivity - Revisited
Final Candidate Model
Model m101
Four age composition alternatives were explored: (Multinomial, logistic-normal-miss0, logistic-normal-ar1-miss0,and logistic-normal-pool0)
Multivariate Tweedie and dirichlet-multinomial were not explored due to high computational demands and subjectivity in ESS specification
Logistic-normal-ar1-miss0 was selected for the combined fleet and most surveys
Logistic-normal-miss0 was MADMF fall survey

Fleet and Survey Age-Composition

m101 Formulation

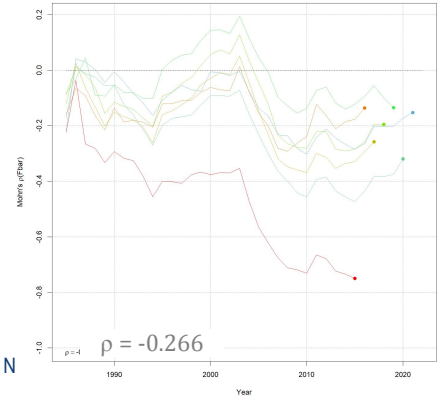
- Age 6+ Formulation
- Eight Survey Indices
  - NEFSC Fall/Spring (1985-2008)
  - NEFSC Fall/Spring Bigelow (2009-2022)
  - MADMF Fall Spring
  - MEDMR Fall/Spring
- Recr. = Random about Mean
- Selectivity
  - Fleet = Logistic (RE = 2dar1)
  - Survey indices = Logistic (RE = None)
- Age Comp
  - Fleet & 7 indices = logistic-normal-ar1-miss0
  - Indices (MADMF Fall) = logistic-normal-miss0
- NAA RE = iid

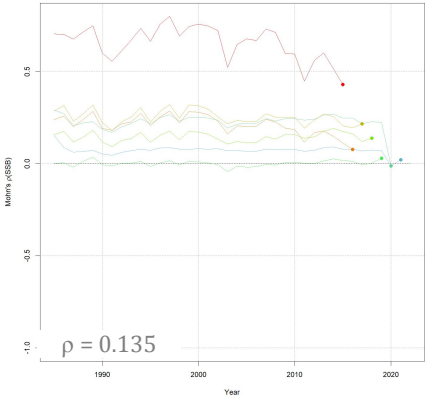




Model Summary:

- Preferred model based on lowest AIC
- Deterioration retro diagnostic
- Retro Scaling remains an issue
- Residual patterns continue to improve





Non-ECOV: ~ 817 WHAM Runs

NEFSC Survey (*To split or Not to Split"*)

Fleet Selectivity

Survey Selectivity

Numbers-at-age

Recruitment Assumption

Age Composition

Survey Inclusion/Exclusion

Natural Mortality

Ecov Effects on Recr. and M

Fleet Selectivity - Revisited

Final Candidate Model

Model m304

Initial candidate model showed scaling issues in retrospective peels, suggesting difficulty in resolving population scale.

Hypothesized that survey inclusion choices influenced scaling due to differences in geographic and temporal coverage among surveys.

Conducted 255 model runs with various survey combinations, excluding up to seven surveys to identify those affecting retrospective consistency.

Excluding MADMF and MENH spring state Inshore surveys significantly improved retrospective scaling, reducing bias and improving Mohn's Rho diagnostics.

Exclusion of these surveys was based on hypothesis that survey timing and spatial coverage could potentially change availability over time

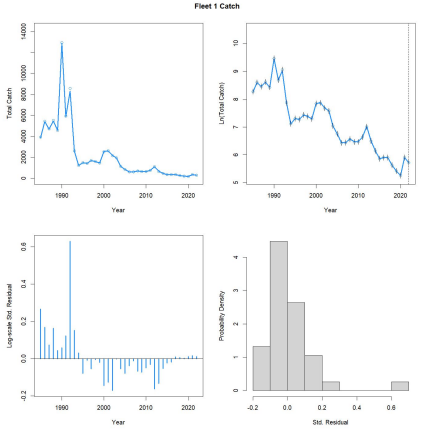
Survey Inclusion/Exclusion

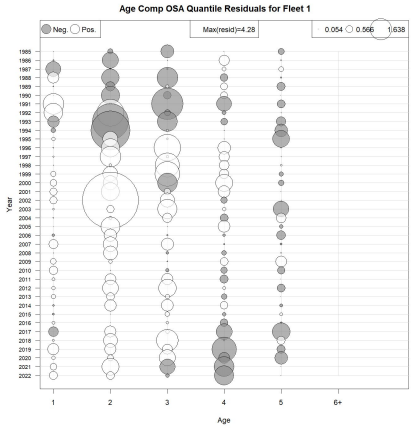
m406 Formulation

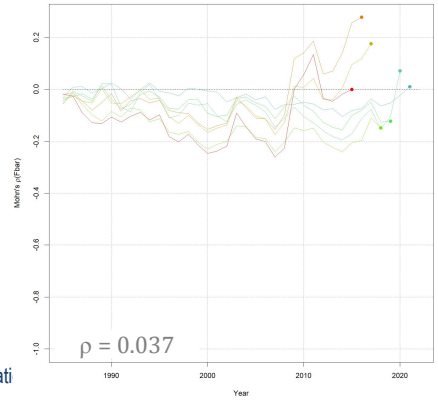
- Age 6+ Formulation
- Six Survey Indices
  - NEFSC Fall/Spring (1985-2008)
  - NEFSC Fall/Spring Bigelow (2009-2022)
  - MADMF Fall ONLY
  - MEDMR Fall ONLY
- Recr. = Random about Mean
- Selectivity
  - Fleet = Logistic (RE = 2dar1)
  - Survey indices = Logistic (RE = None)
- Age Comp
  - Fleet & 5 indices = logistic-normal-ar1-miss0
  - Indices (MADMF Fall) = logistic-normal-miss0
- NAA RE = iid

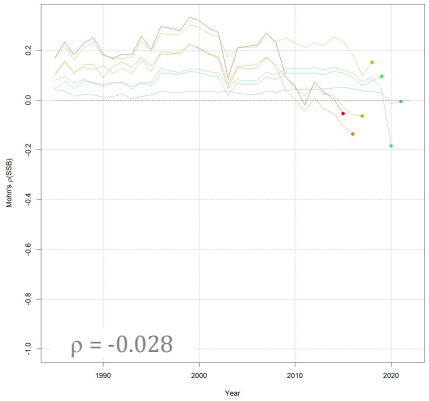
Model Summary:

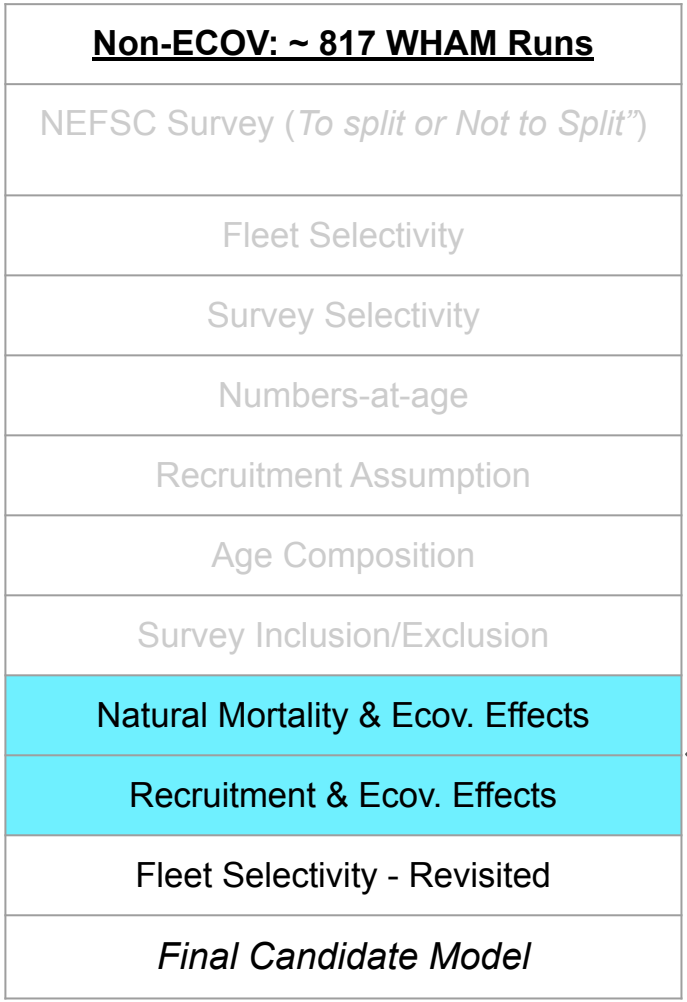
- Improvement retro diagnostic in terms of scaling and Mohn's rho
- Some slight indication of residual patterning (age-2 for the catch age composition)











Ecov. Effects WHAM Runs

- Deviations on Recruitment
  - Atlantic Multidecadal Oscillation (AMO)
  - Spring Bottom Temperature
- Ecov on R was modeled with rw or ar1 process
  - Controlling Factor
  - Limiting Factor
- Deviations on Natural Mortality
  - Atlantic Multidecadal Oscillation (AMO)
  - Bottom Temperature
- All Evaluations are lagged by one year effects
  - Ex. Ecov in year *t* is linked to year *t+1* (rec or M)

Environmental Covariate Effects on Rec and M

R

- Atlantic Multidecadal Oscillation
- Spring Bottom Temperature

(All lagged 1 year effects)

M

- Atlantic Multidecadal Oscillation
- Spring Bottom Temperature

All based on work done for ToR 1

Recruitment: AMO

Rec	Ecov Process	Ecov how	Conv	pdHess	NLL	dAIC	AIC	rho_R	rho_SSB	rho_Fbar
Random	none	---	TRUE	TRUE	-325.796	0	-483.6	0.2809	-0.0635	0.0727
Random	rw	Controlling	TRUE	TRUE	-326.042	1.5	-482.1	0.2255	-0.0637	0.0741
Random	ar1	Controlling	TRUE	TRUE	-324.815	6	-477.6	0.2388	-0.0643	0.0764
Bev-Holt	rw	---	TRUE	TRUE	-325.797	2	-481.6	0.2809	-0.0635	0.0727
Bev-Holt	rw	Controlling	TRUE	TRUE	-326.042	3.5	-480.1	0.2255	-0.0637	0.0741
Bev-Holt	rw	Limiting	TRUE	TRUE	-326.042	3.5	-480.1	0.2255	-0.0637	0.0741
Bev-Holt	ar1	Controlling	TRUE	TRUE	-324.815	8	-475.6	0.2388	-0.0643	0.0764
Bev-Holt	ar1	Limiting	TRUE	TRUE	-324.815	8	-475.6	0.2388	-0.0643	0.0764

Recruitment: Spring B.Temp

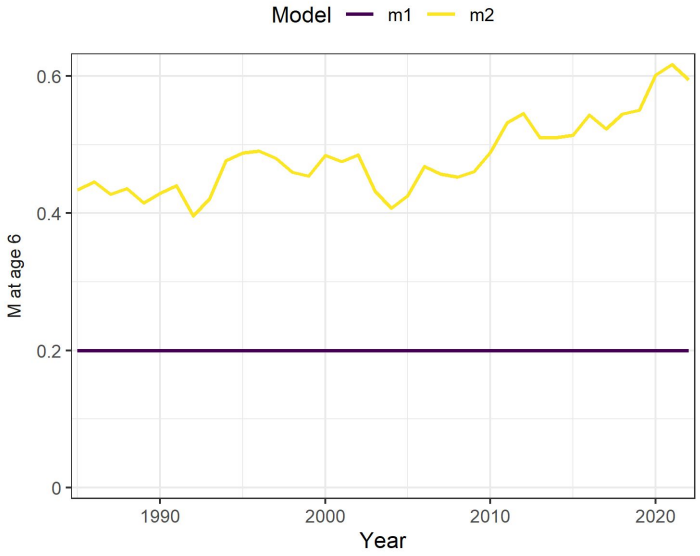
Rec	Ecov Process	Ecov how	Conv	pdHess	NLL	dAIC	AIC	rho_R	rho_SSB	rho_Fbar
Random	rw	---	TRUE	TRUE	-268.662	0	-367.3	0.2809	-0.0635	0.0727
Random	rw	Controlling	TRUE	TRUE	-269.127	1	-366.3	0.2777	-0.0597	0.0576
Random	ar1	Controlling	TRUE	TRUE	-268.154	5	-362.3	0.2441	-0.0535	0.0507
Bev-Holt	rw	---	TRUE	TRUE	-268.662	2	-365.3	0.2809	-0.0635	0.0727
Bev-Holt	rw	Controlling	TRUE	TRUE	-269.127	3	-364.3	0.2777	-0.0597	0.0576
Bev-Holt	rw	Limiting	TRUE	TRUE	-257.797	25.7	-341.6	0.3138	-0.0471	0.0403
Bev-Holt	ar1	Controlling	TRUE	TRUE	-268.154	7	-360.3	0.2441	-0.0535	0.0507
Bev-Holt	ar1	Limiting	TRUE	TRUE	-268.154	7	-360.3	0.2441	-0.0535	0.0507

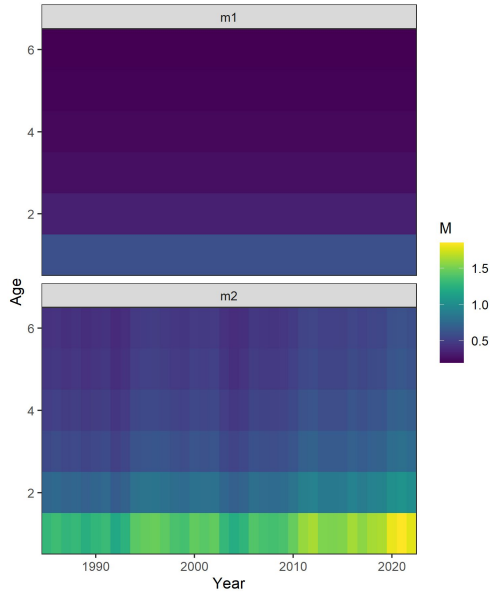
Time Varying M: AMO

Model	M model	Ecov link	M re	Conv.	pdHess	NLL	dAIC	AIC	Rho R	Rho SSB	Rho Fbar
m1	---	None	none	TRUE	TRUE	-312.072	140.5	-454.1	0.340	-0.018	0.032
m2	---	Controlling	none	TRUE	TRUE	-317.357	131.9	-462.7	0.217	-0.069	0.093
m3	---	Limiting	none	NC							
m4	age-specific	None	none	TRUE	TRUE	-369.967	36.7	-557.9	1.36E05	97233.8	-0.660
m5	weight-at-age	None	none	NC							
m6	constant	None	none	TRUE	TRUE	-352.083	62.4	-532.2	5.24E07	2.38E07	-0.703
m7	constant	None	Ar1_y	TRUE	TRUE	-366.776	37	-557.6	2.84E06	1.49E06	-1.000
m8	age-specific	None	2dar1	NC							
m9	constant	Controlling	none	TRUE	TRUE	-356.159	56.3	-538.3	0.643	-0.155	0.439
m10	constant	Limiting	none	NC							
m11	---	None	2dar1	TRUE	TRUE	-385.315	0	-594.6	**52.046**	**8.378**	**1.687**

Time varying M: Spring Bottom Temperature

Model	M model	M re	Ecov process	Ecov link	conv	pdHess	NLL	daic	aic	Rho R	Rho SSB	Rho Fbar
m1	---	none	ar1	None	TRUE	TRUE	-255.44	10.4	-338.9	0.340	-0.0179	0.032
m2	---	none	ar1	Controlling	TRUE	TRUE	-261.63	0	-349.3	5.827	0.509	-0.188





Summary Results of Ecov runs

- Based on AIC and Retros
- All Ecov effects on Natural mortality and recruitment did not enhance model performance over the base model with almost 30% of the runs for M not converging
- Effects of Bottom temp and AMO on recruitment performed worse than base model.
- In summary, NONE of the Ecov model runs were moved forward to the candidate model
- Hence, Candidate model treats recruitment as random about the mean and natural mortality will assume time and age invariant M = 0.4

Non-ECOV: ~ 817 WHAM Runs

NEFSC Survey (*To split or Not to Split"*)

Fleet Selectivity

Survey Selectivity

Numbers-at-age

Recruitment Assumption

Age Composition

Survey Inclusion/Exclusion

Natural Mortality & Ecov. Effects

Recruitment & Ecov. Effects

Fleet Selectivity - Revisited

Final Candidate Model

Model m452

Initial evaluation of base model m406 showed unusual high F reference proxy values driven by reduced selectivity for younger fish (ages 4-5)

Declining Selectivity led to only 6+ being fully selected in recent years

Re-evaluated fleet selectivity configurations with blocks in 1994 and 2010,and various random effects

Revised NAA random effects from iid to ar1_a

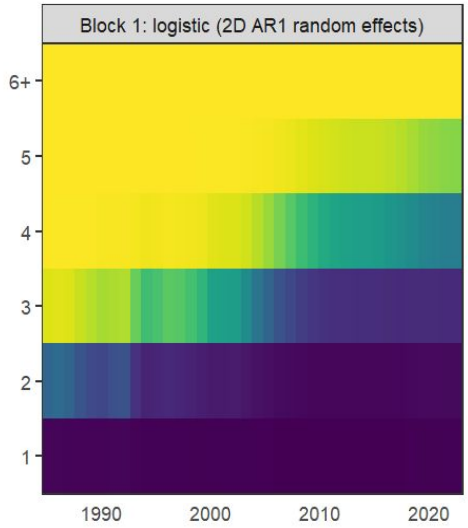
Turning off random effects on fleet selectivity and applying a two-block sel. structure improved model diagnostics (AIC, residuals and Retros.)

Model 452 was chosen as the proposed base model for CCGOM research Track

Revisit Fleet Selectivity

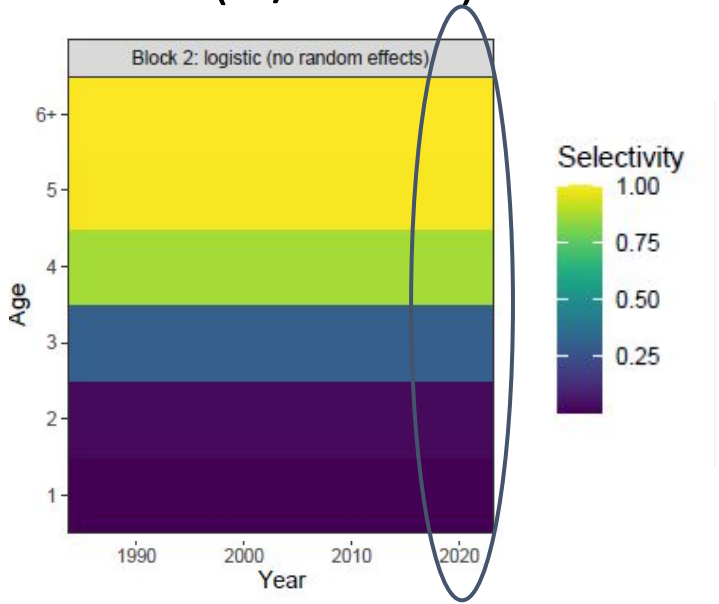
Fleet Selectivity by age and year

M304 (w/ 2dar1 RE)



F40% = 3.00

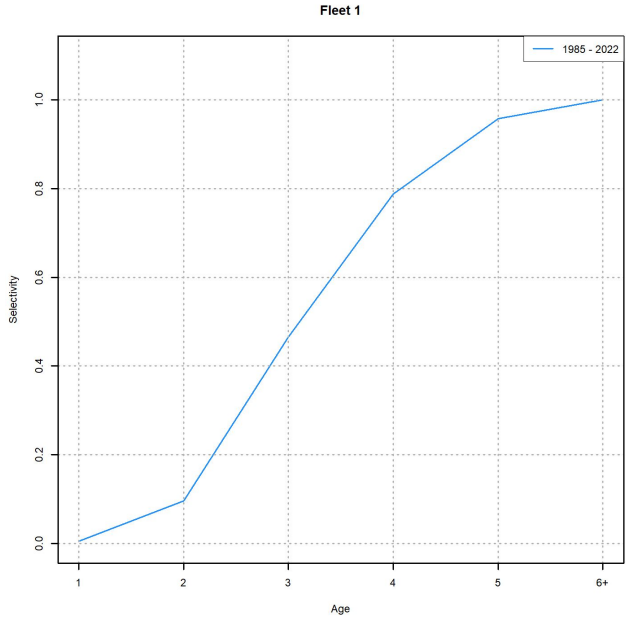
M452 (w/ No RE)



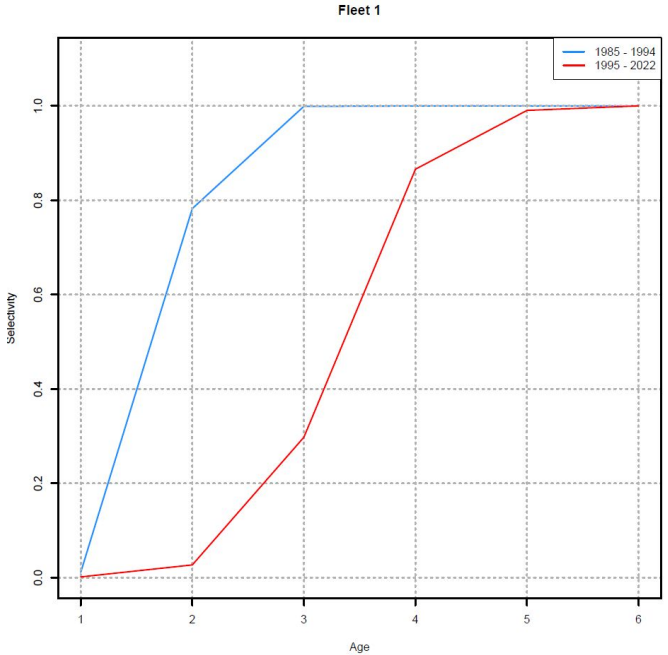
F40% = 1.64

Average Fleet Selectivity by age

m304



m452



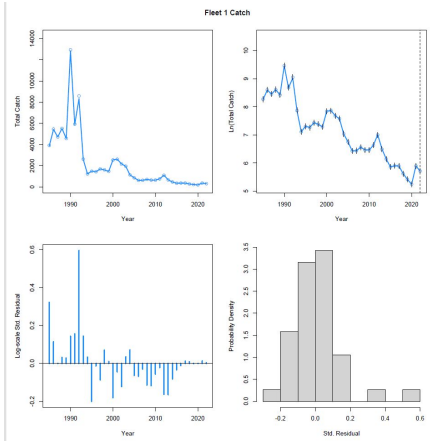
Fleet Selectivity Revisited

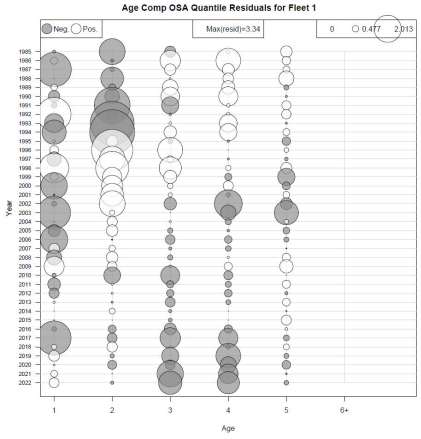
m452 Formulation

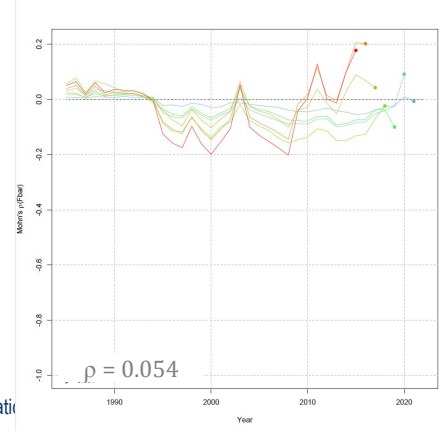
- Age 6+ Formulation
- Six Survey Indices
  - NEFSC Fall/Spring (1985-2008)
  - NEFSC Fall/Spring Bigelow (2009-2022)
  - MADMF Fall ONLY
  - MEDMR Fall ONLY
- Recr. = Random about Mean
- Selectivity
  - Fleet
    - Block (1985-1994; 1995-2022)
    - Logistic (RE = None)
  - Survey indices = Logistic (RE = None)
- Age Comp
  - Fleet & 5 indices = logistic-normal-ar1-miss0
  - Indices (MADMF Fall) = logistic-normal-miss0
- NAA RE = ar1_a

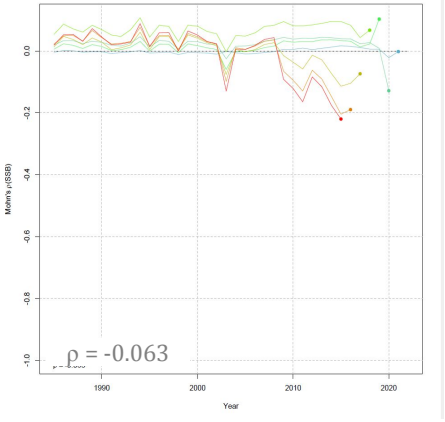
Model Summary:

- Improvement retro diagnostic in terms of scaling.
- Slight increase in Mohn's rho, but still < 10%
- Improved residual pattern
- AIC not comparable to previous model









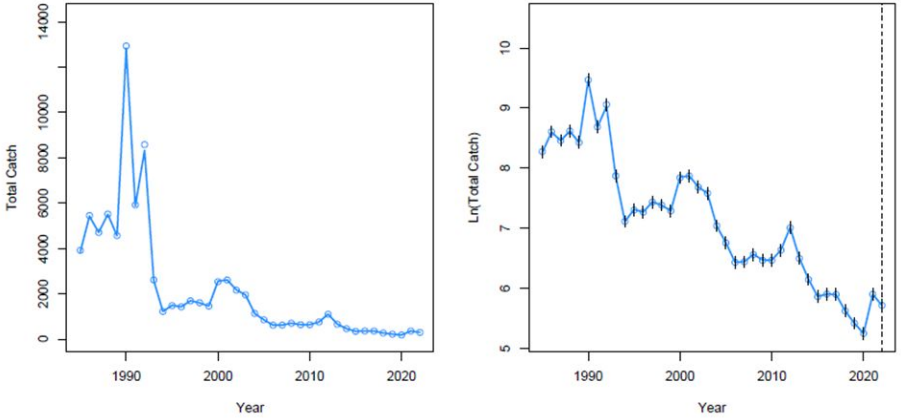
THE CANDIDATE MODEL

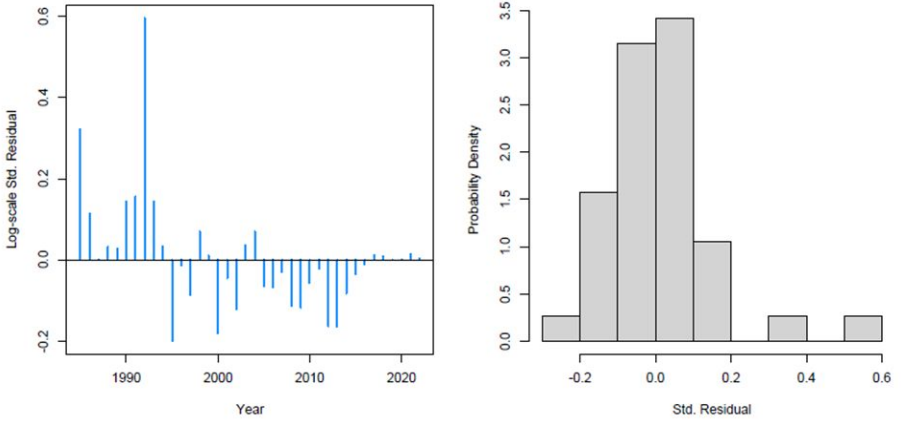
- Codename: m452
- Recruitment (Not decoupled) - Random about mean
- Selectivity: Logistic for Fleet and surveys (NEFSC Spring & Fall survey; MADMF & MEDMR Inshore Fall surveys)
- AgeComp: Fleet and Indices- Logistic-normal-ar1-miss0 age comp; MADMF Fall index - Logistic-normal-miss0
- NAA random effects modelled as ar1_a
- M = 0.4
- Ecov = None

Part Three

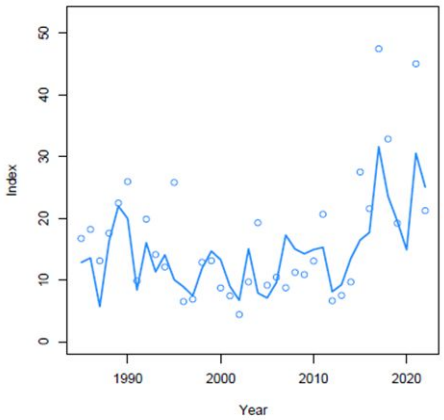
Candidate Model Diagnostics

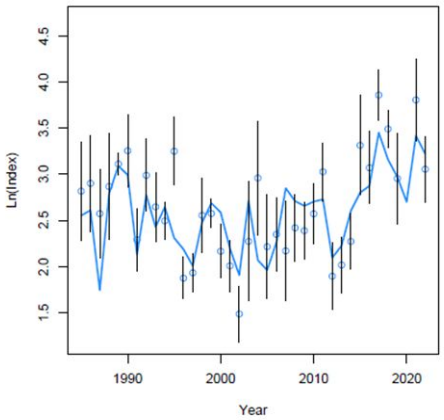
FLEET

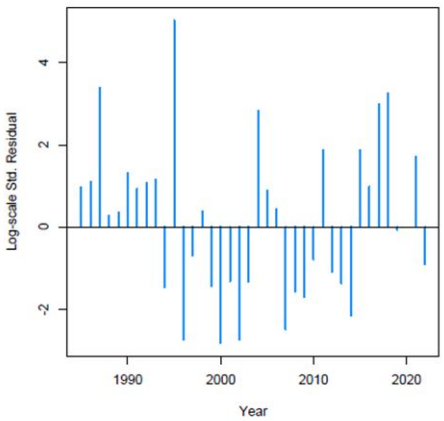


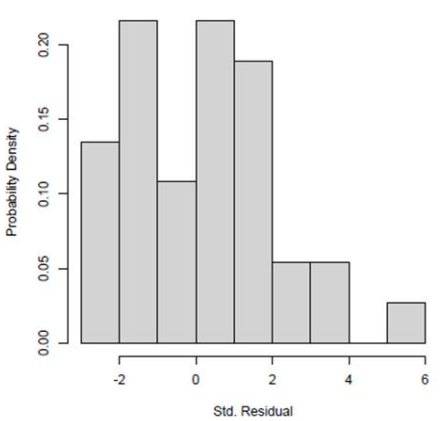


MADMF Fall

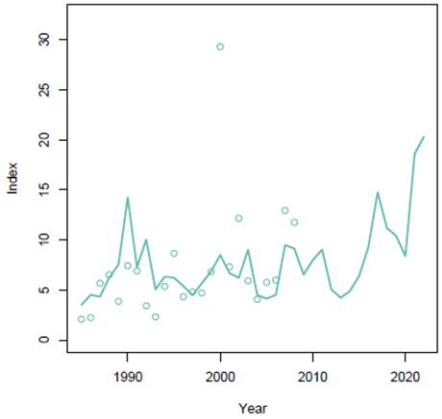


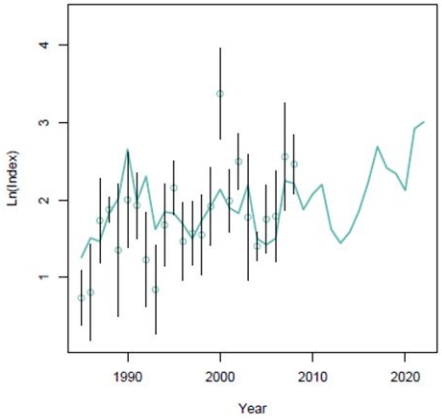


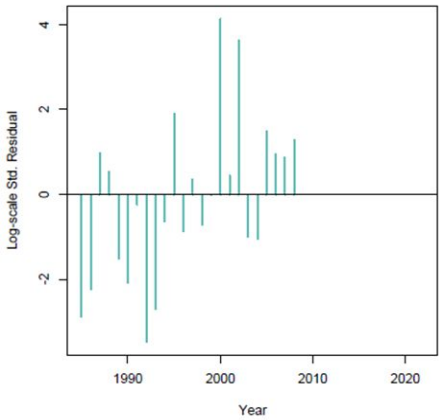


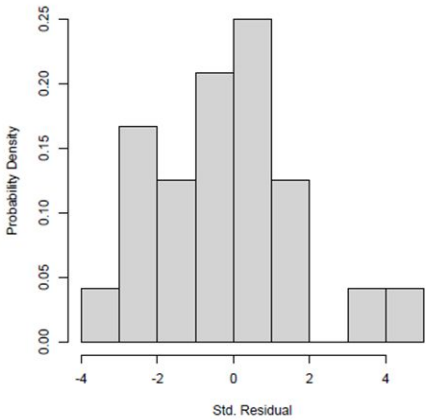


NEFSC Spring Albatross

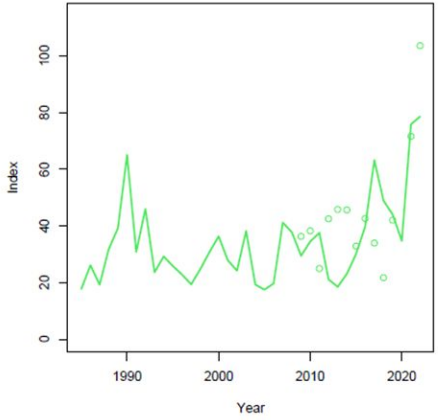


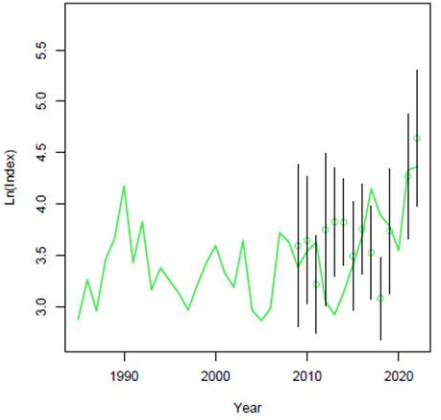


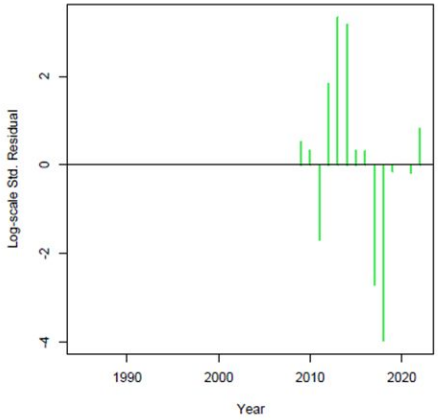


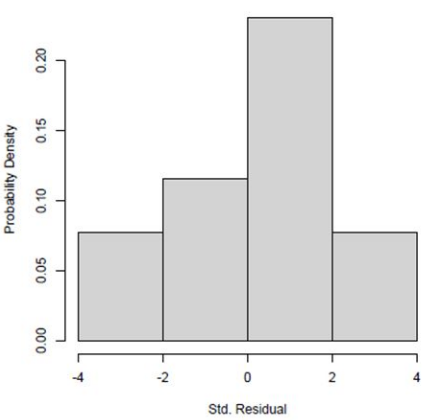


NEFSC Spring Bigelow

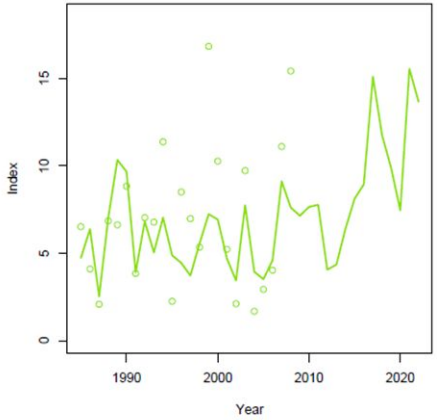


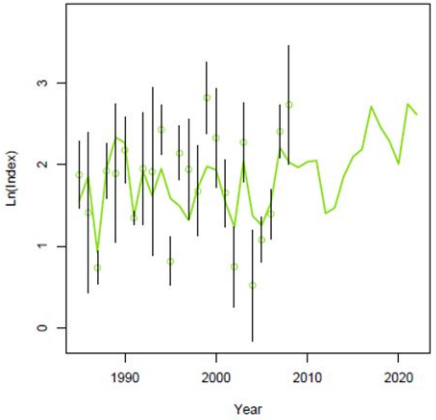


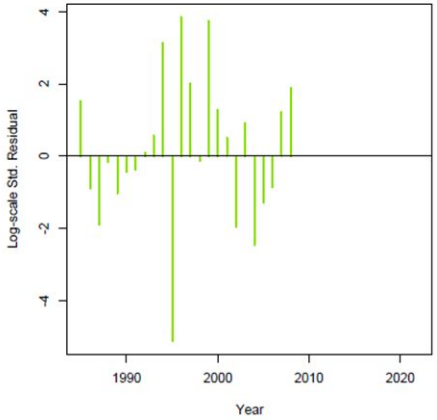


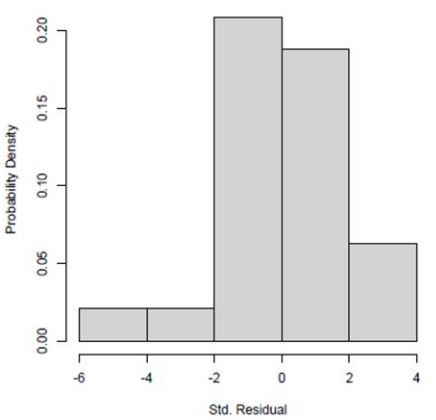


NEFSC Fall Albatross

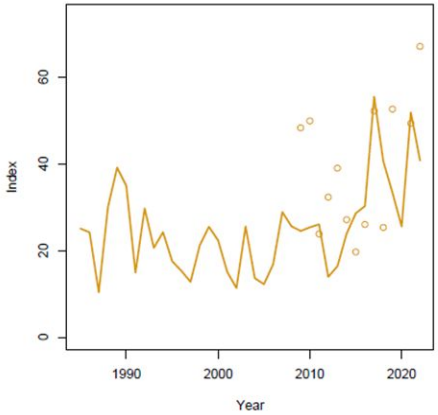


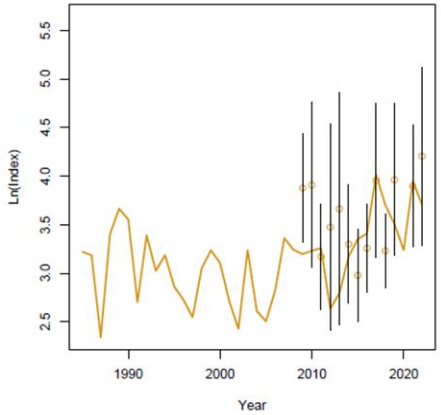


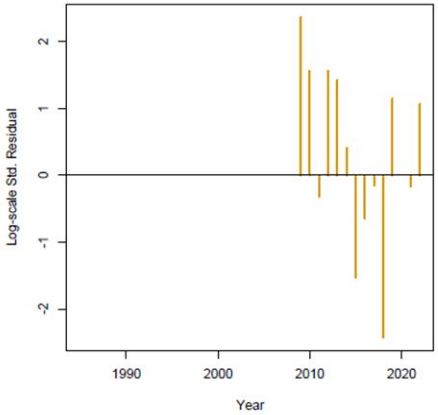


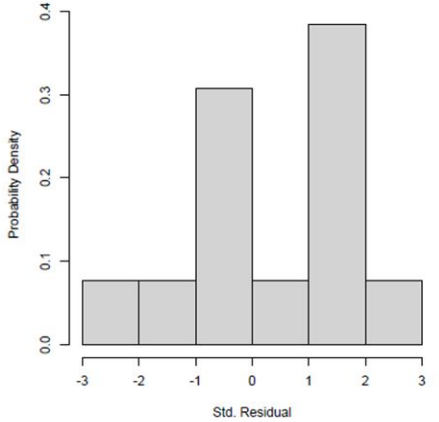


NEFSC Fall Bigelow

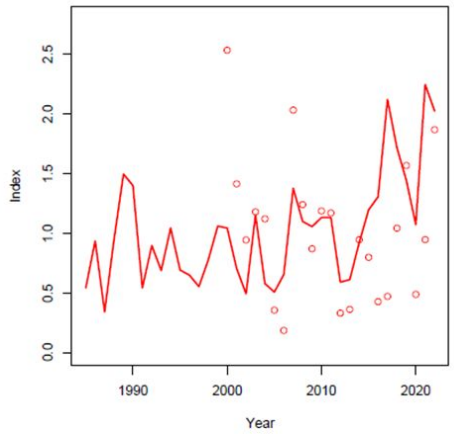








MEDMR Fall


Index
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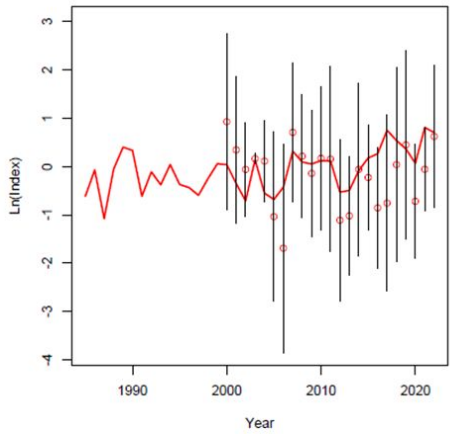
0.5
1.0
1.5
2.0
2.5
1990
2000
2010
2020


Ln(Index)
Year
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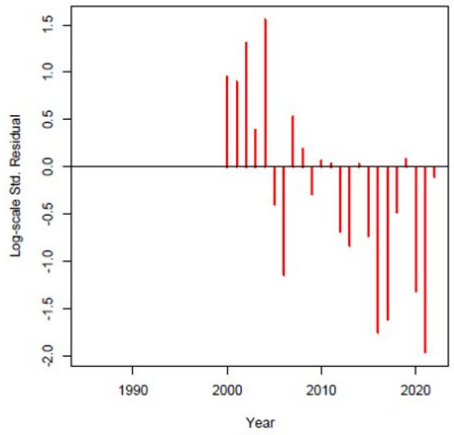
-2
-1
0
1
2
3
1990
2000
2010
2020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1.5
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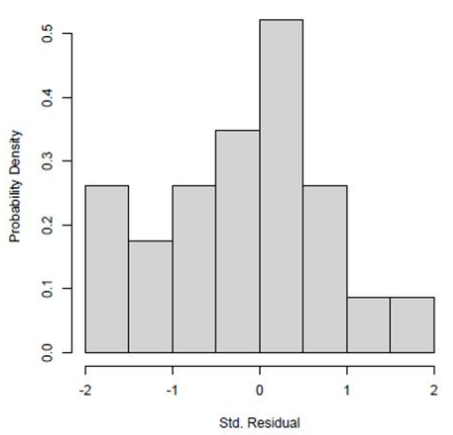
2000
2010
2020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Std. Residual
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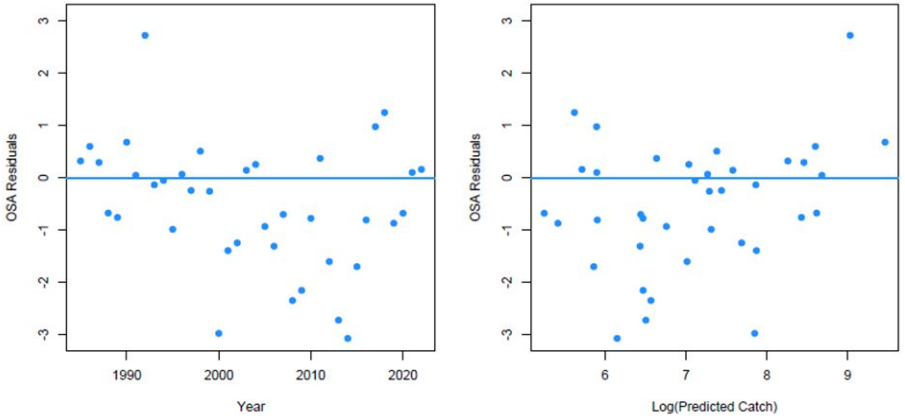
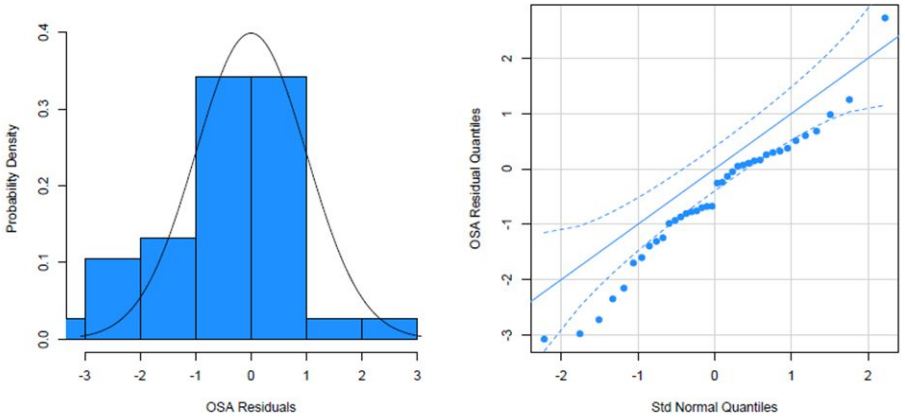
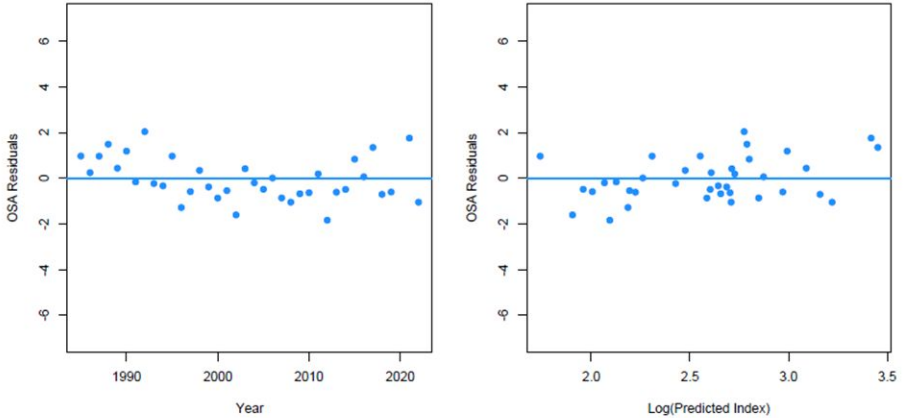
-1
0
1
2

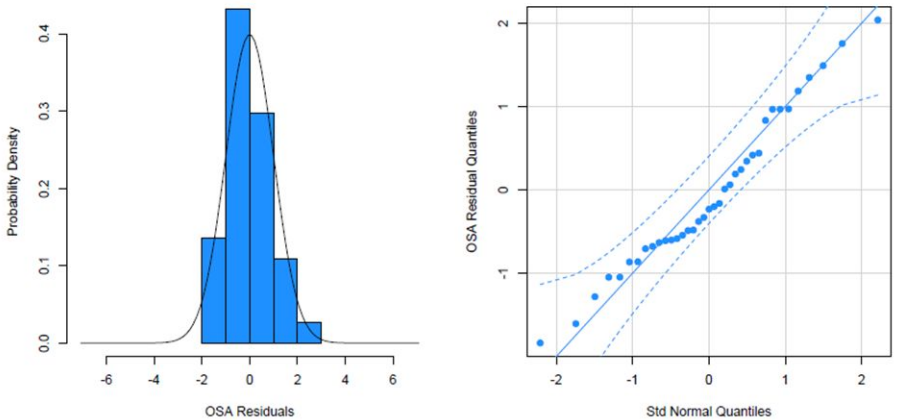
FLEET



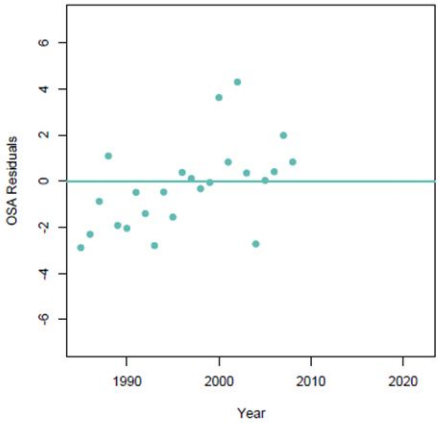


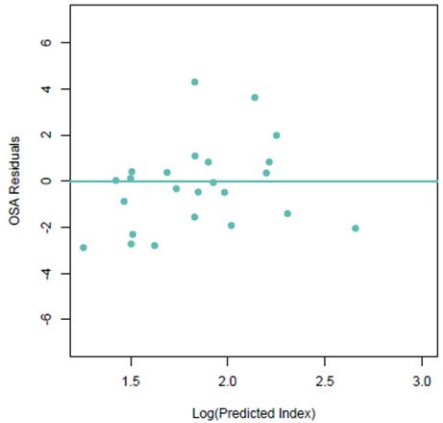
MADMF Fall

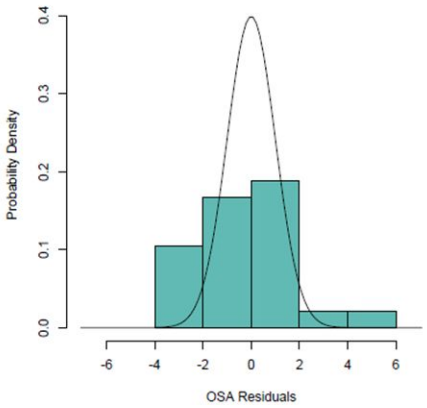


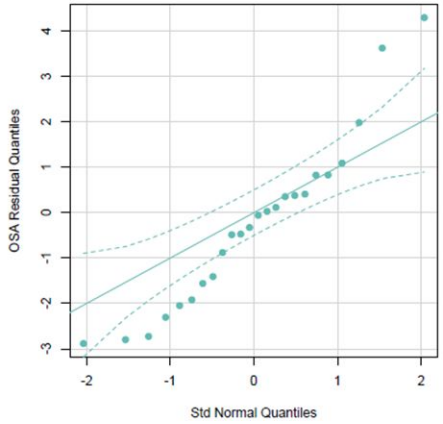


NEFSC Spring Albatross

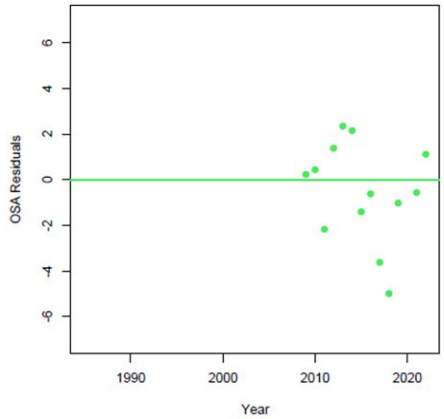


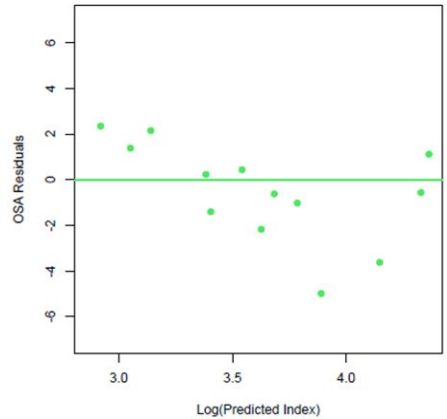


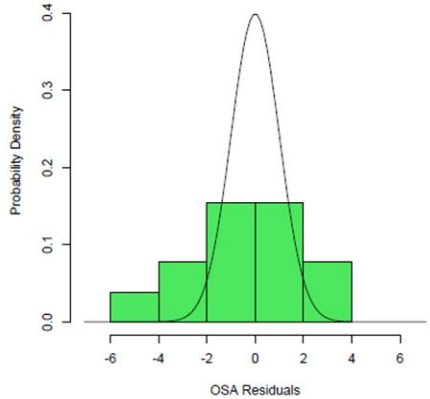


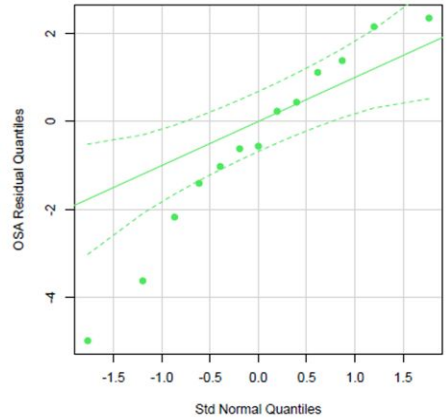


NEFSC Spring Bigelow

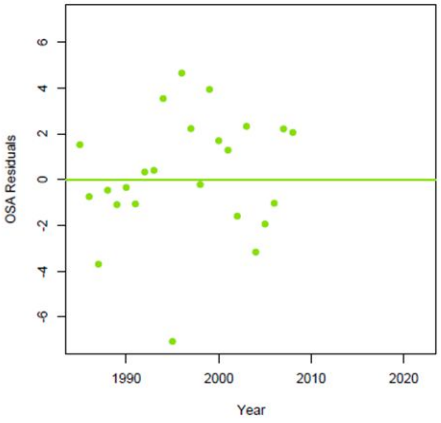


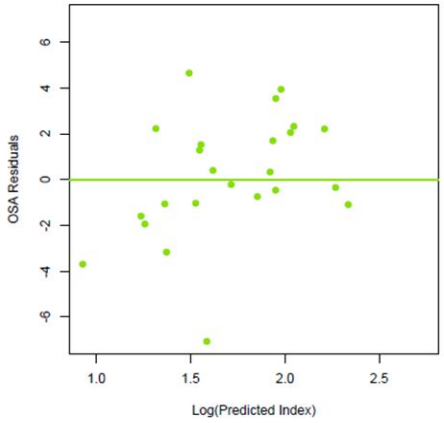


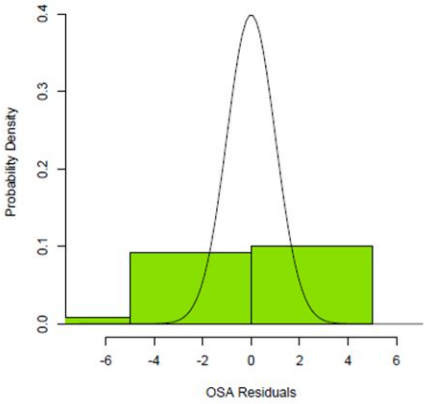


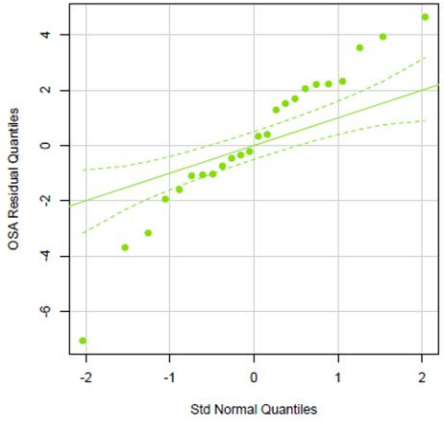


NEFSC Fall Albatross

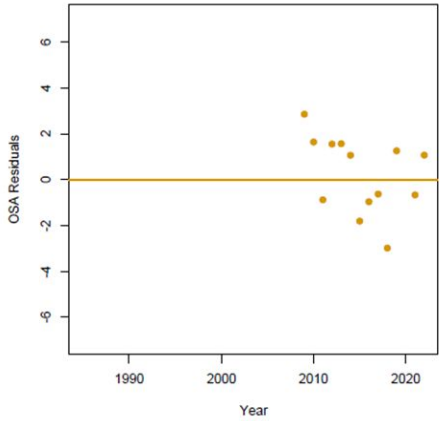


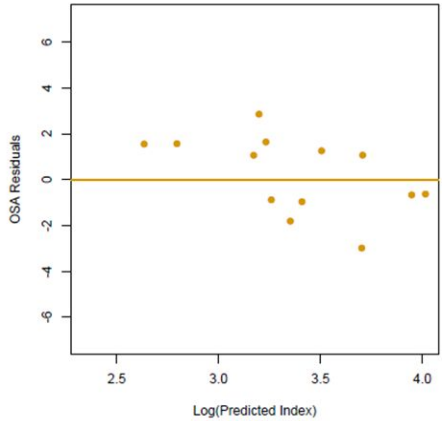


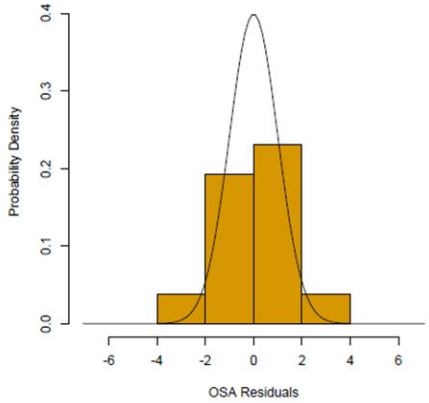


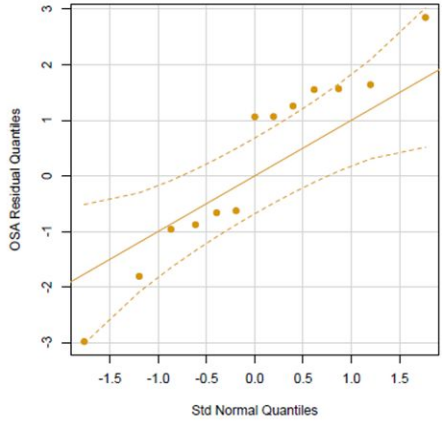


NEFSC Fall Bigelow

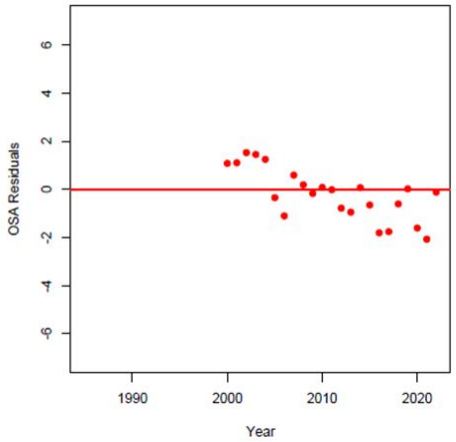


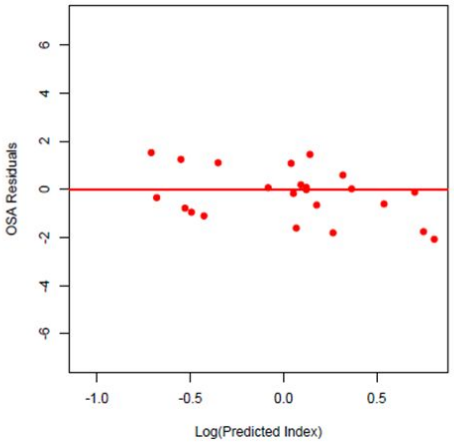


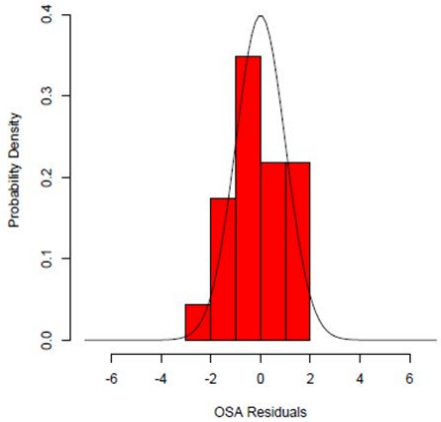


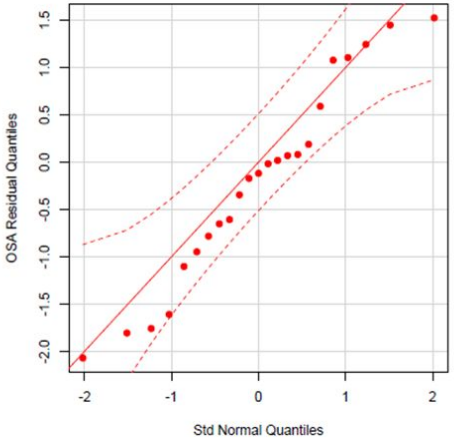


MEDMR Fall


OSA Residuals
6
4
2
0
-2
-4
-6
1990
2000
2010
2020
Year

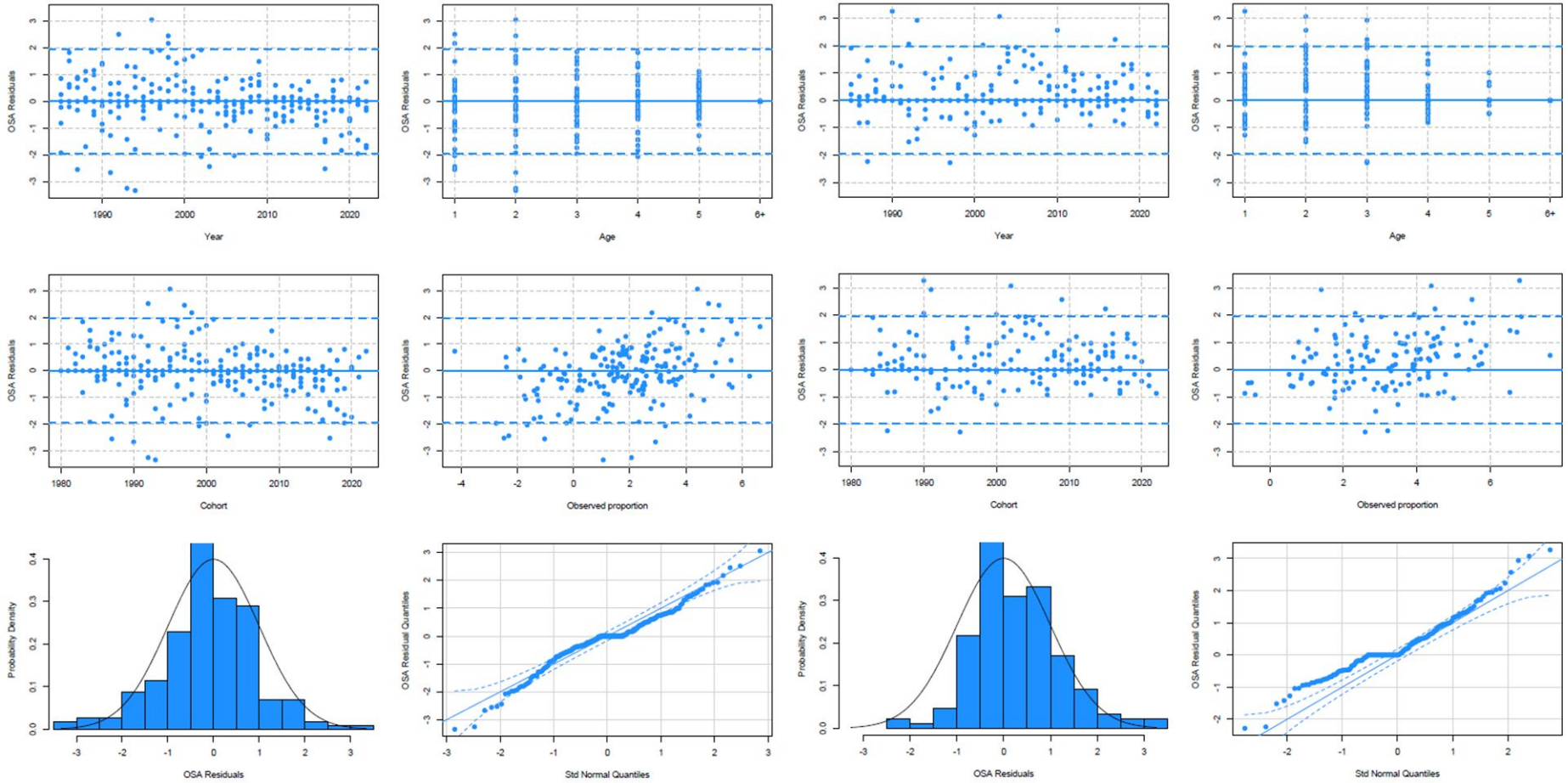

OSA Residuals
6
4
2
0
-2
-4
-6
-1.0
-0.5
0.0
0.5
Log(Predicted Index)


Probability Density
0.4
0.3
0.2
0.1
0.0
-6
-4
-2
0
2
4
6
OSA Residuals

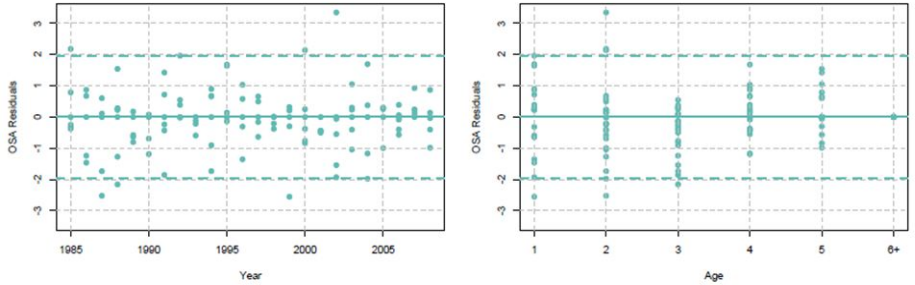

OSA Residual Quantiles
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2
-1
0
1
2
Std Normal Quantiles

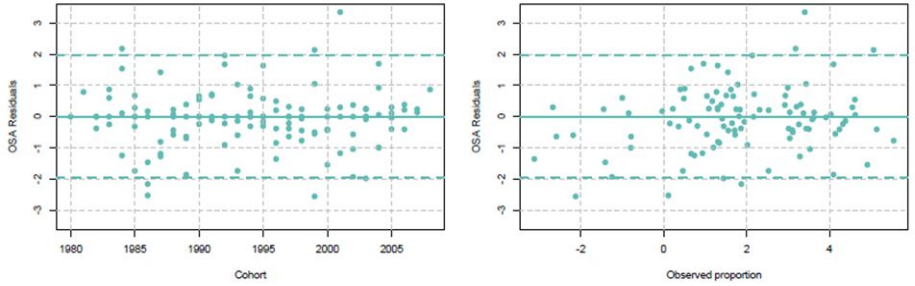
FLEET

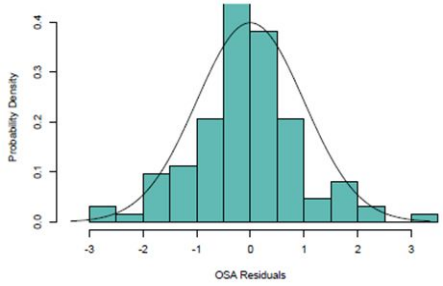
MADMF Fall

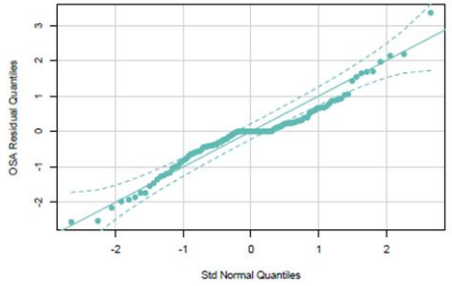


NEFSC Spring Albatross

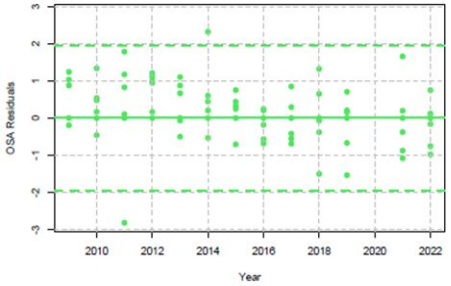


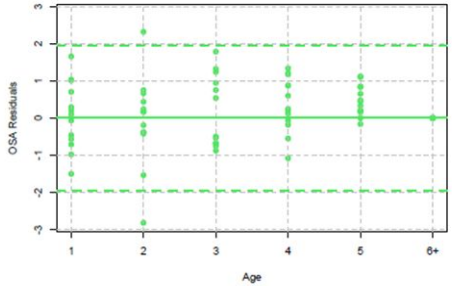


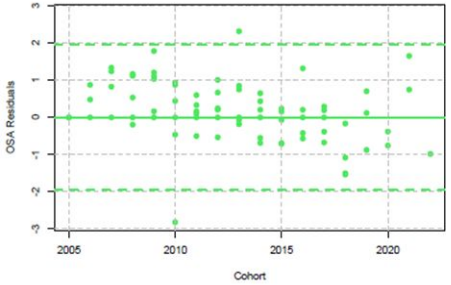


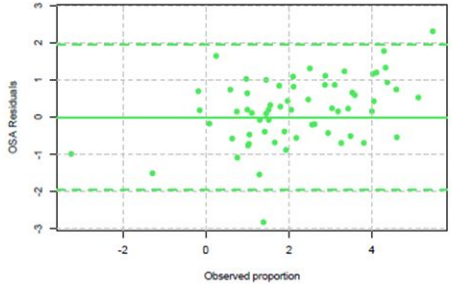


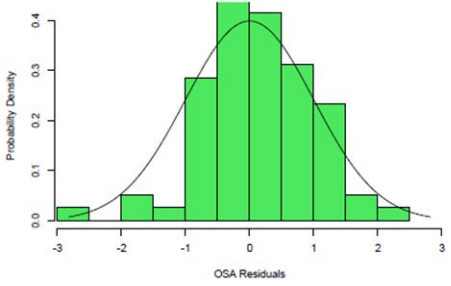
NEFSC Spring Bigelow

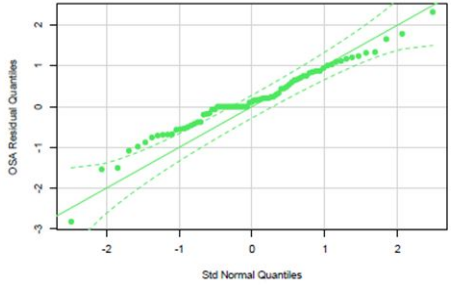




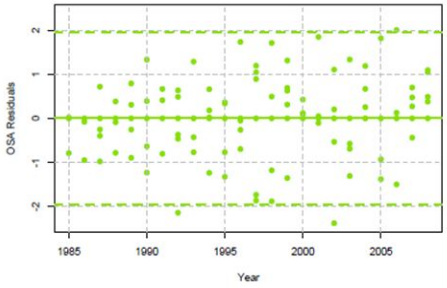


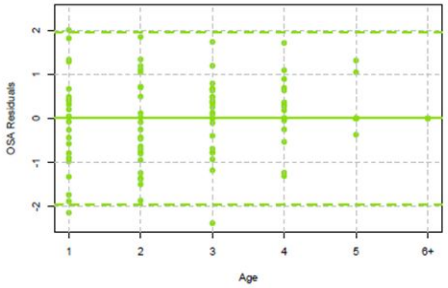


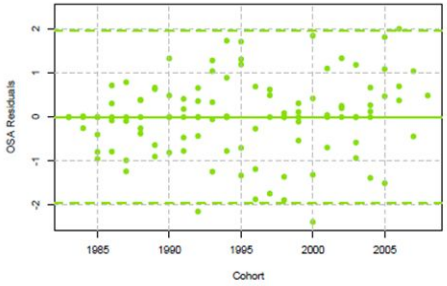


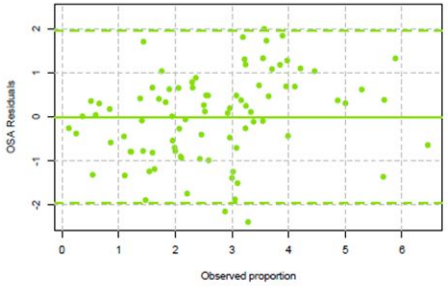


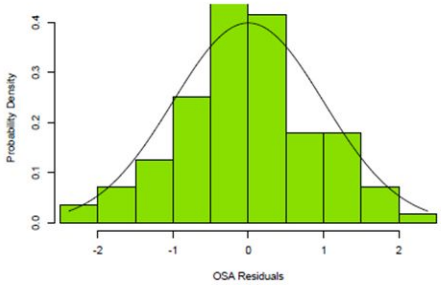
NEFSC Fall Albatross

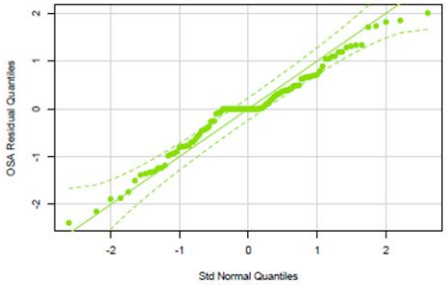




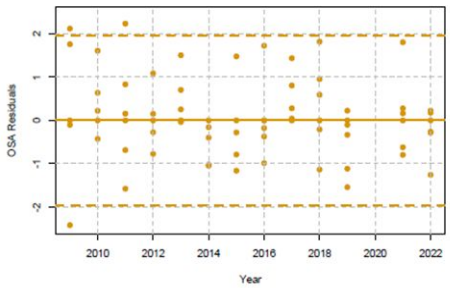


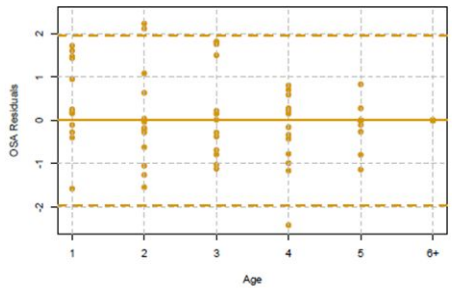


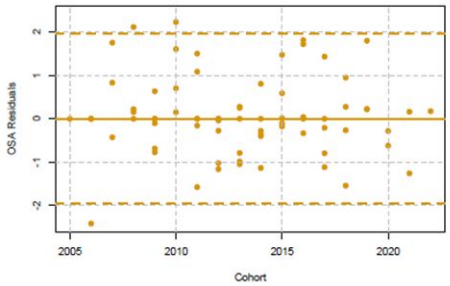


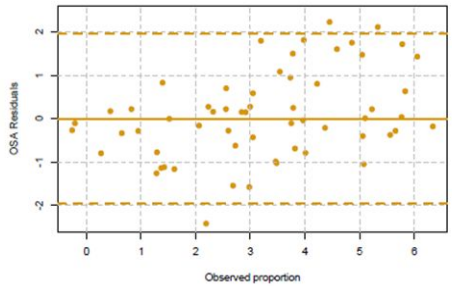


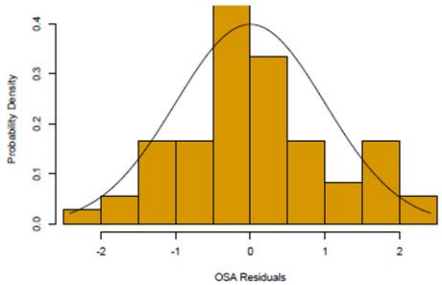
NEFSC Fall Bigelow

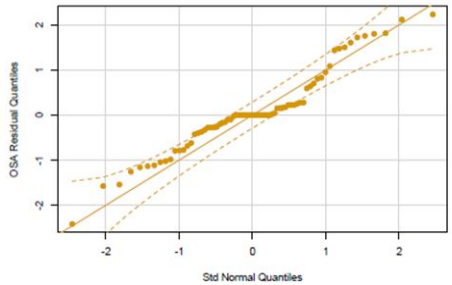




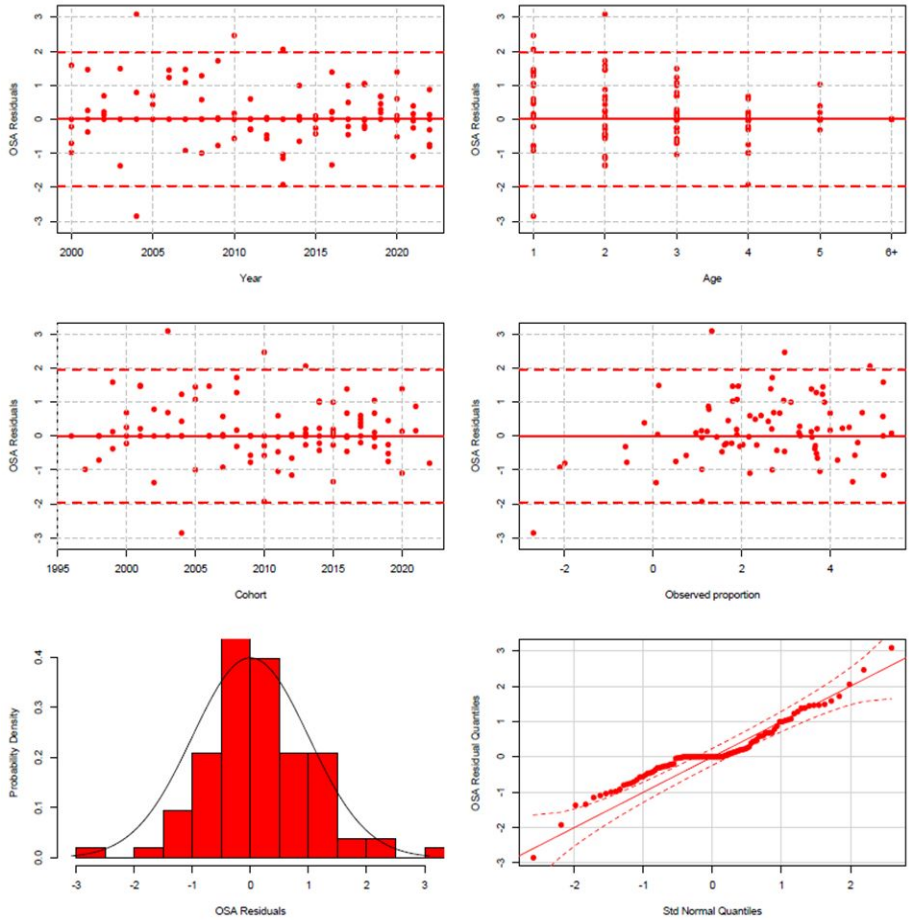




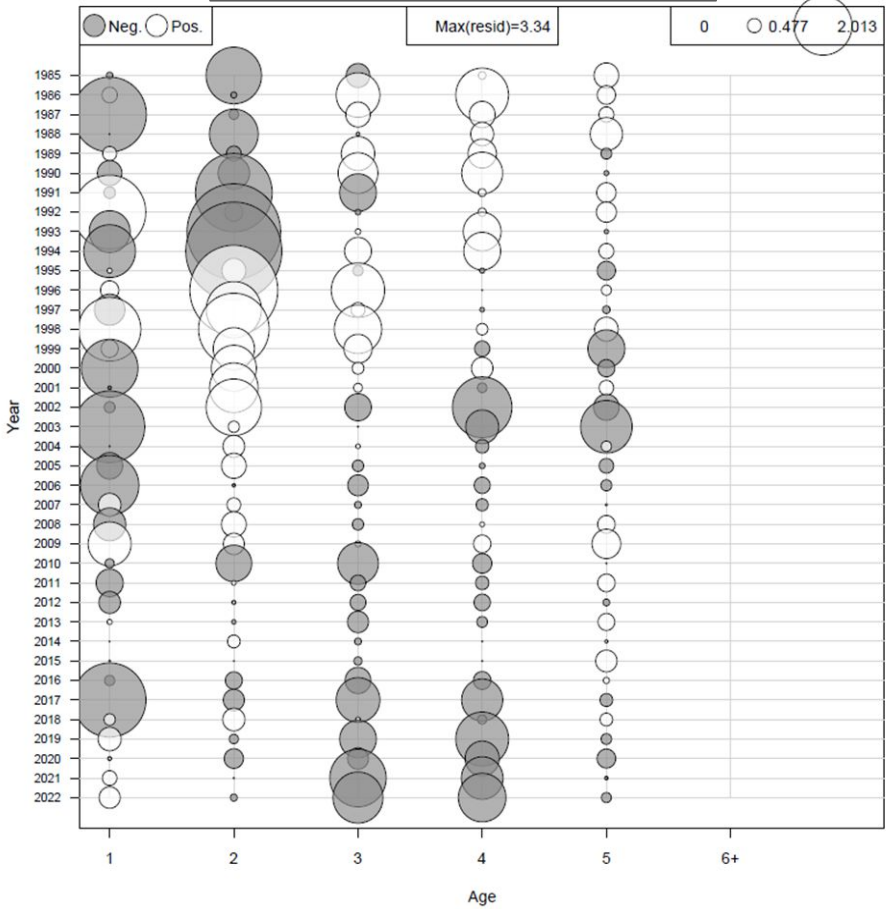




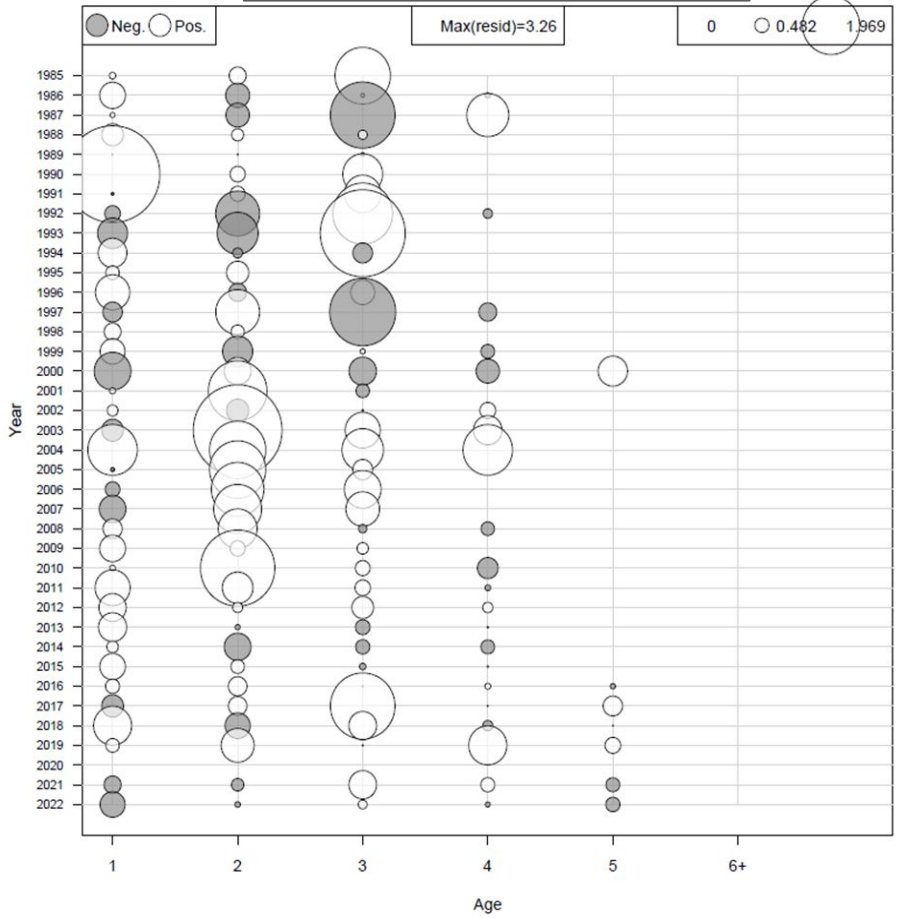
MEDMR Fall


OSA Residuals
Year
Age
Cohort
Observed proportion
Probability Density
OSA Residuals
OSA Residual Quantiles
Std Normal Quantiles

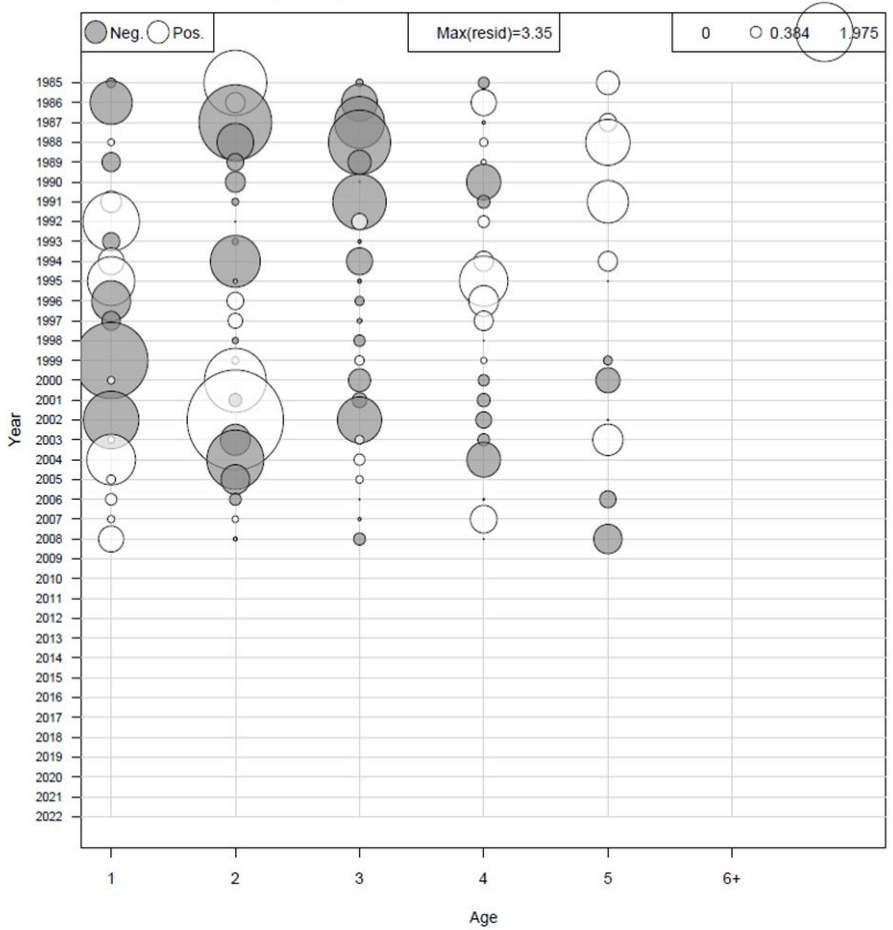
FLEET



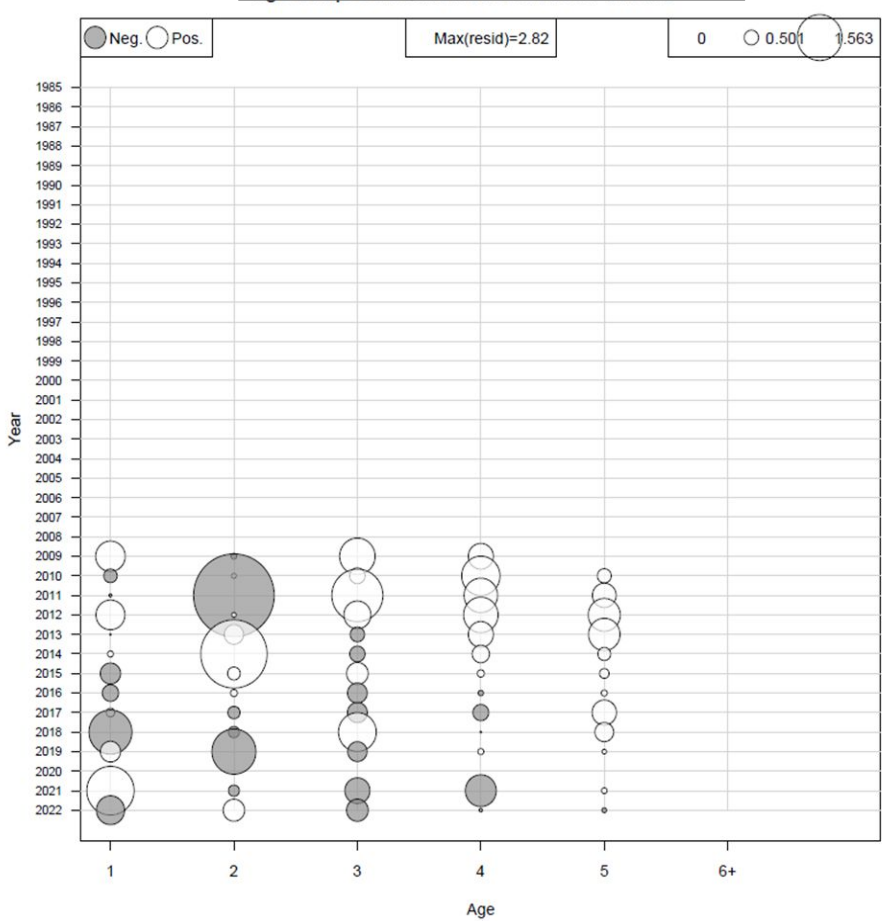
MADMF Fall



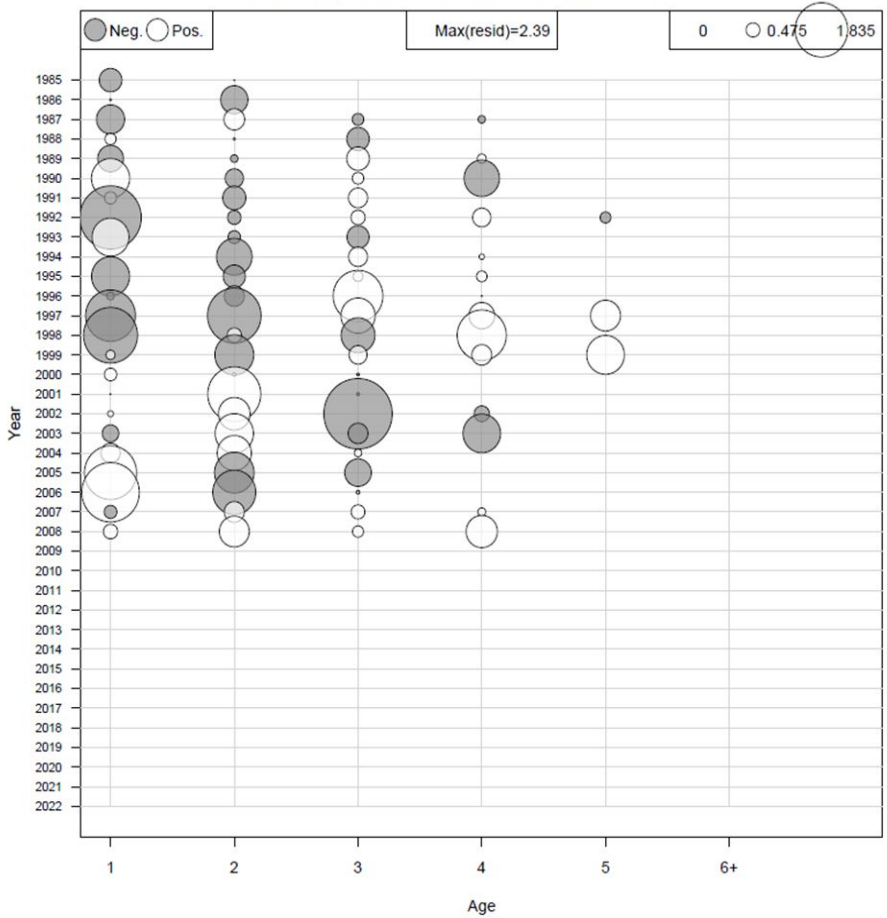
NEFSC Spring Albatross



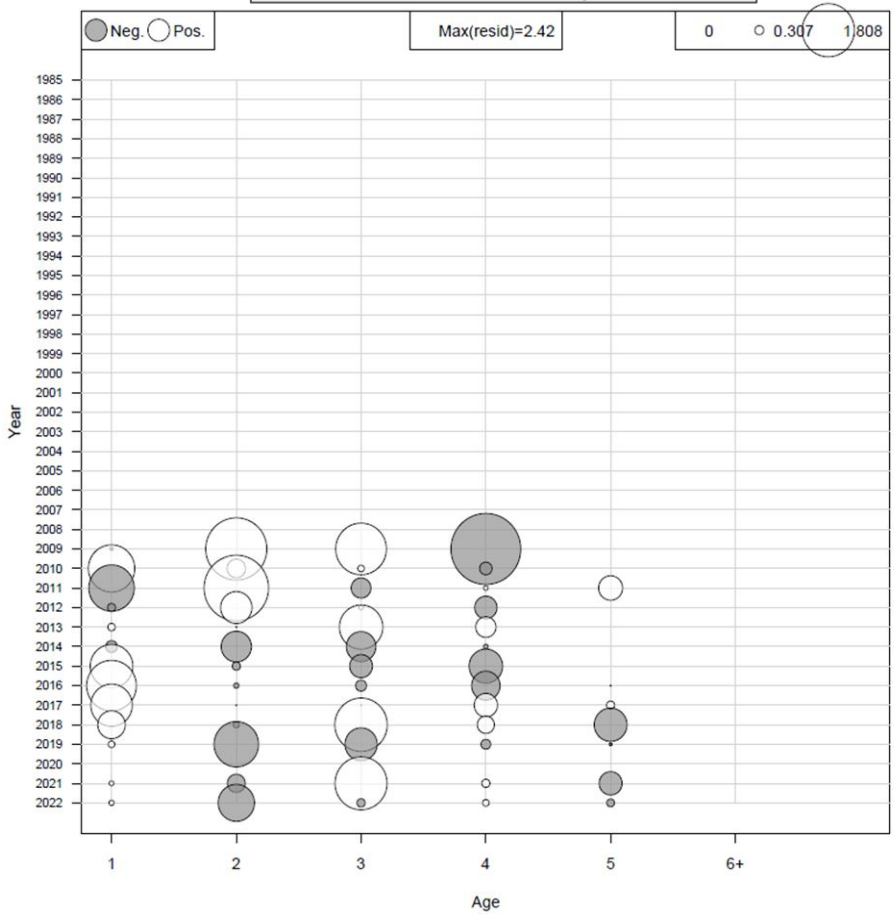
NEFSC Spring Bigelow



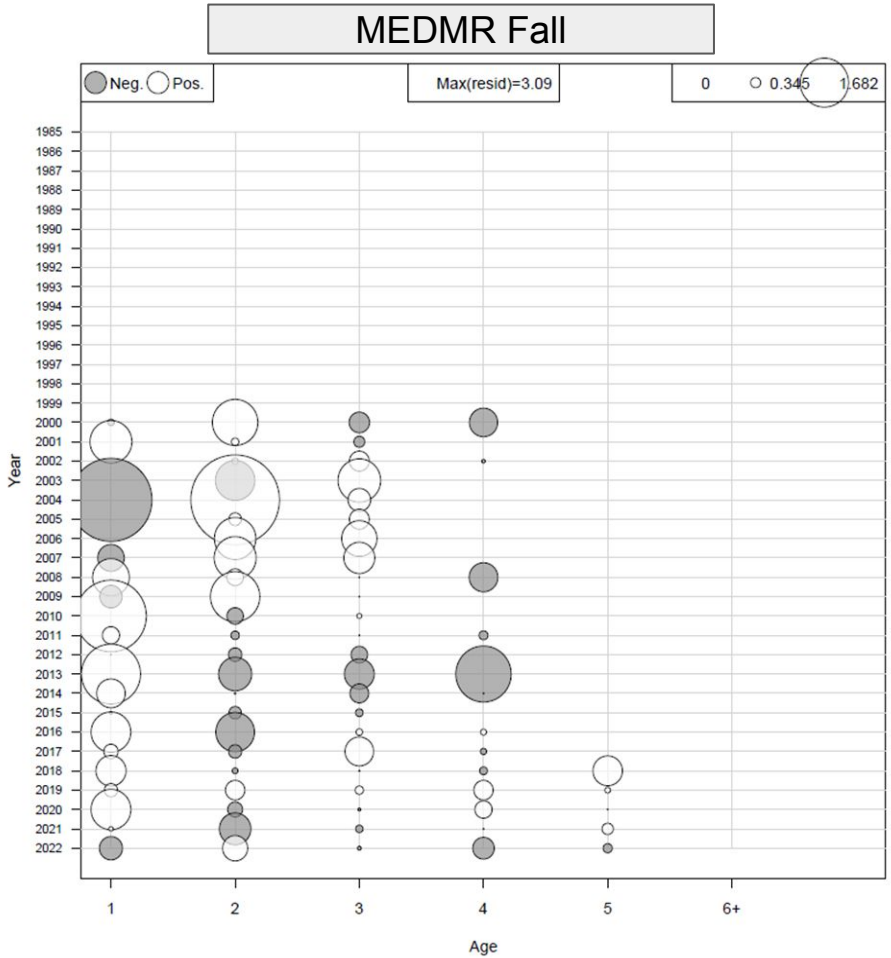
NEFSC Fall Albatross



NEFSC Fall Bigelow



MEDMR Fall


Neg.
Pos.
Max(resid)=3.09
0
0.345
1.682
Year
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
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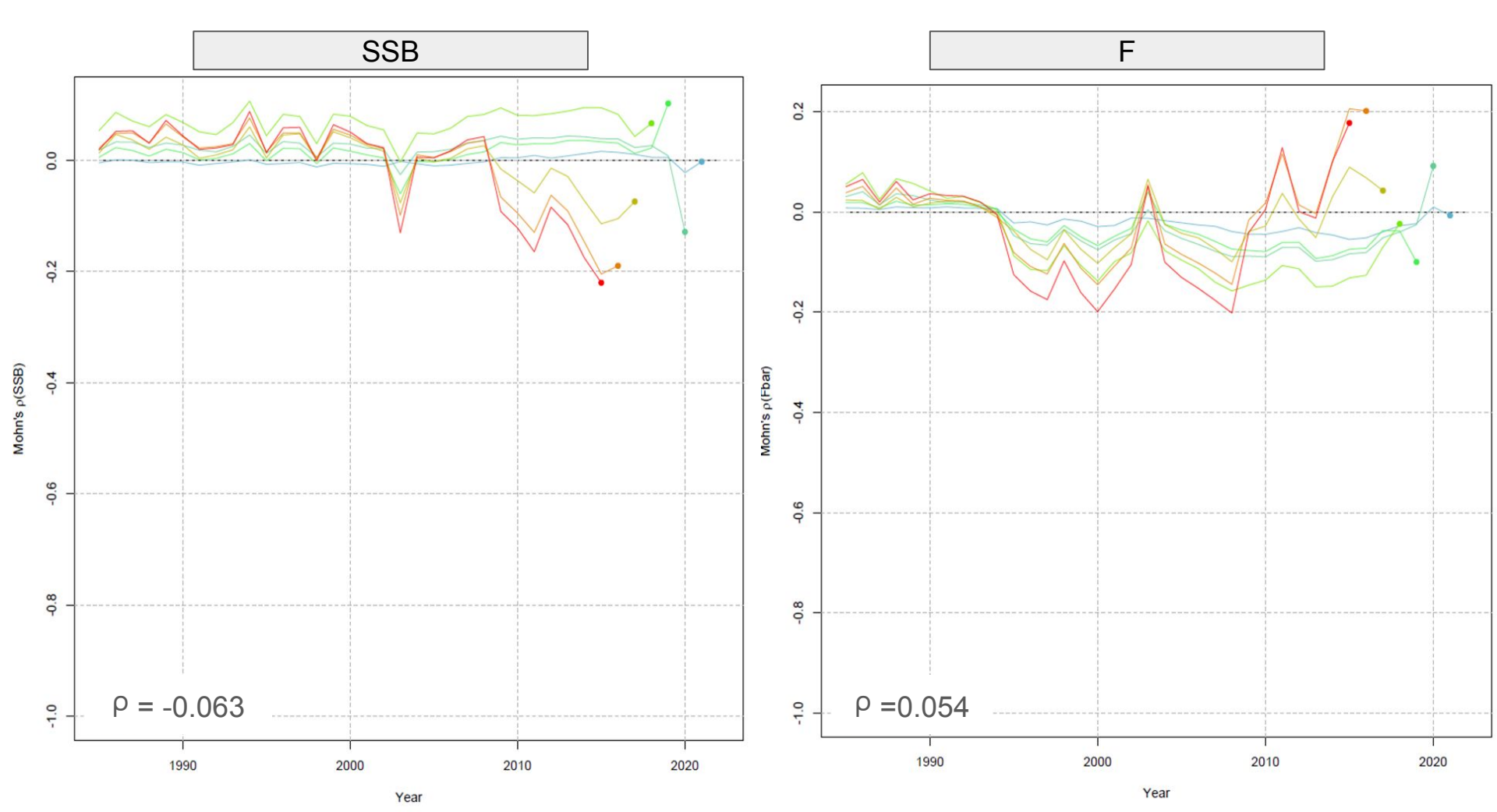
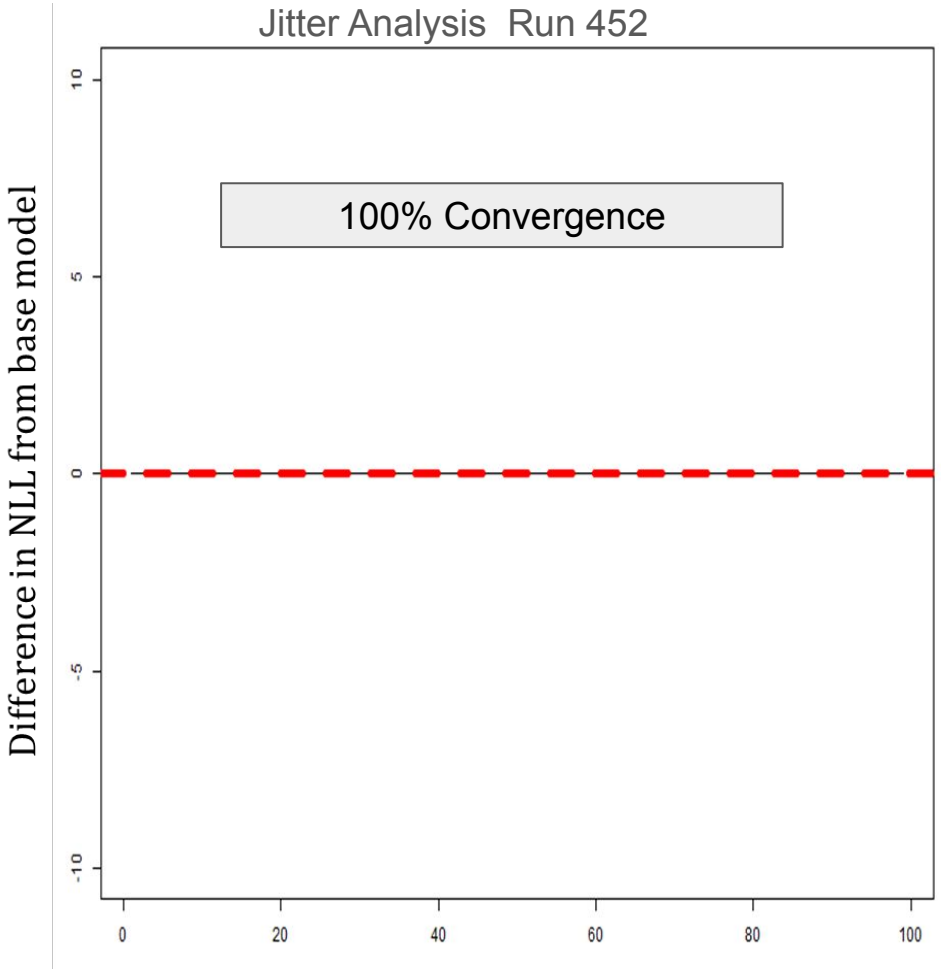
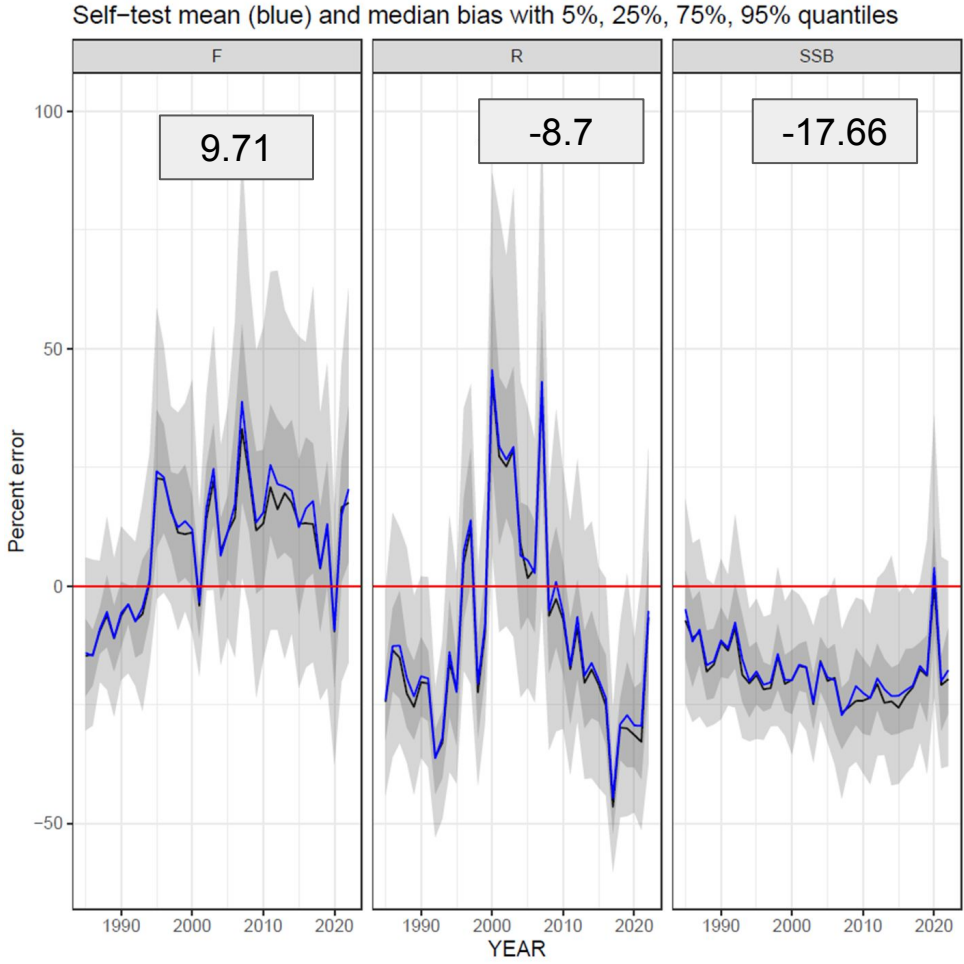
2014
2015
2016
2017
2018
2019
2020
2021
2022
1
2
3
4
5
6+
Age


SSB
F
Mohn's ρ(SSB)
Mohn's ρ(Fbar)
ρ = -0.063
ρ =0.054
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1990
2000
2010
2020
Year

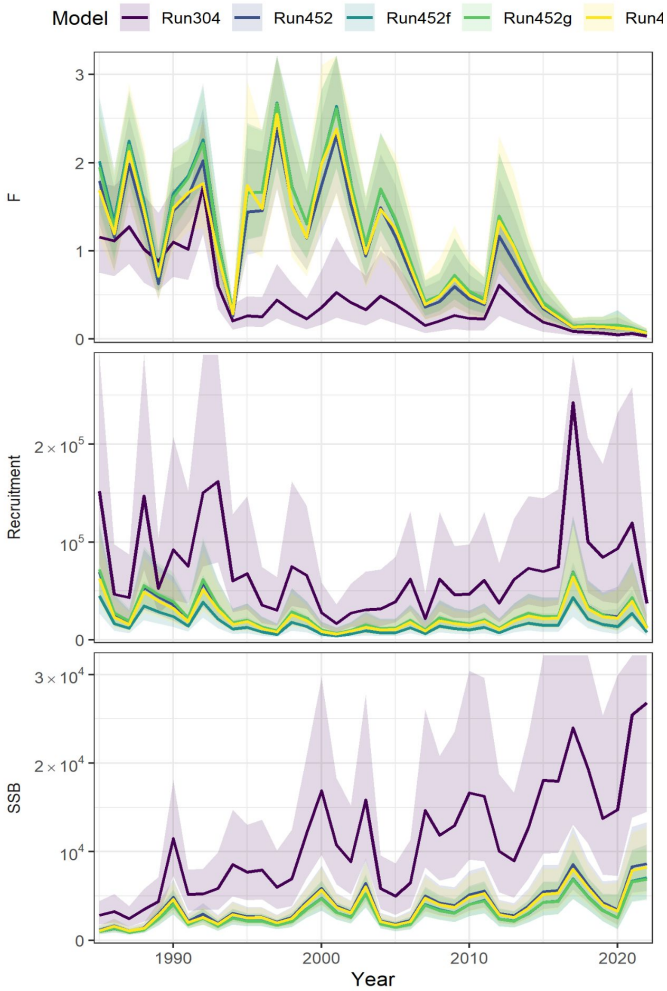

Jitter Analysis Run 452
Difference in NLL from base model
100% Convergence
10
5
0
-5
-10
0
20
40
60
80
100


Self−test mean (blue) and median bias with 5%, 25%, 75%, 95% quantiles
F
R
SSB
9.71
-8.7
-17.66
Percent error
100
50
0
−50
1990
2000
2010
2020
YEAR

Sensitivity Analyses

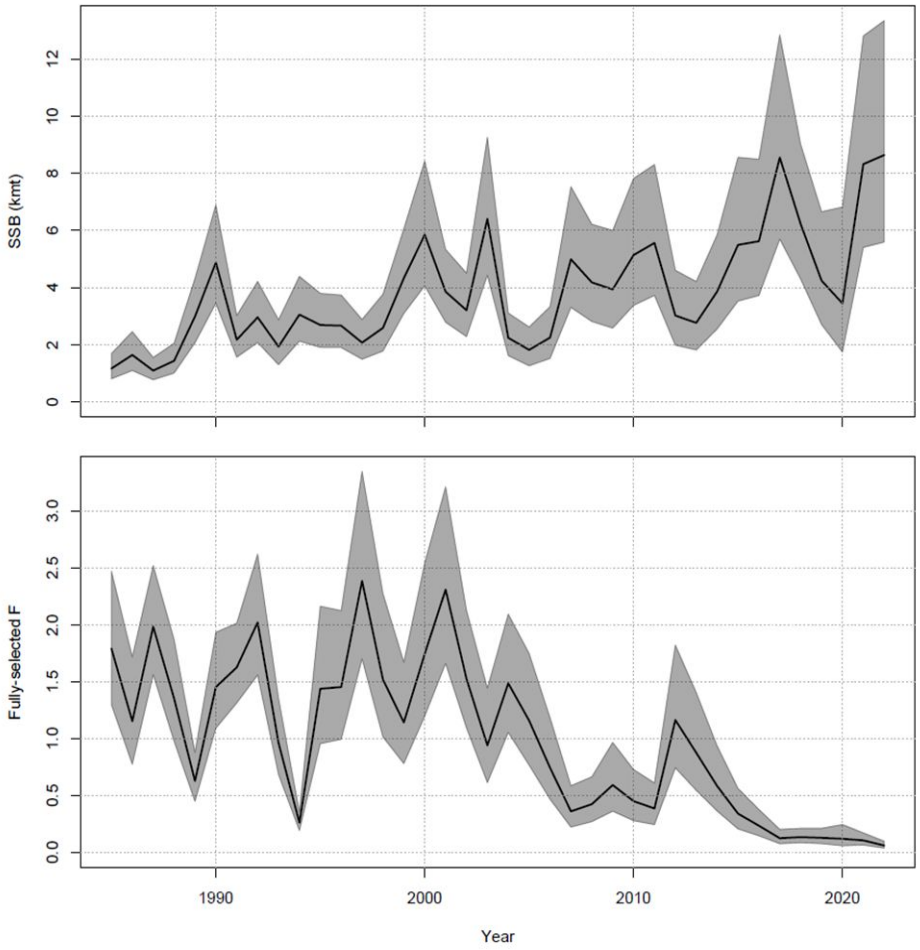
- M452 - Candidate Model
- m452f - M assumption (Constant M = 0.2)
- m452g - M assumption (age specific)
- m452h - Alternative CV on Catch (assume CV = 0.2)
- m304 - Random Effect on Selectivity (2dar1)

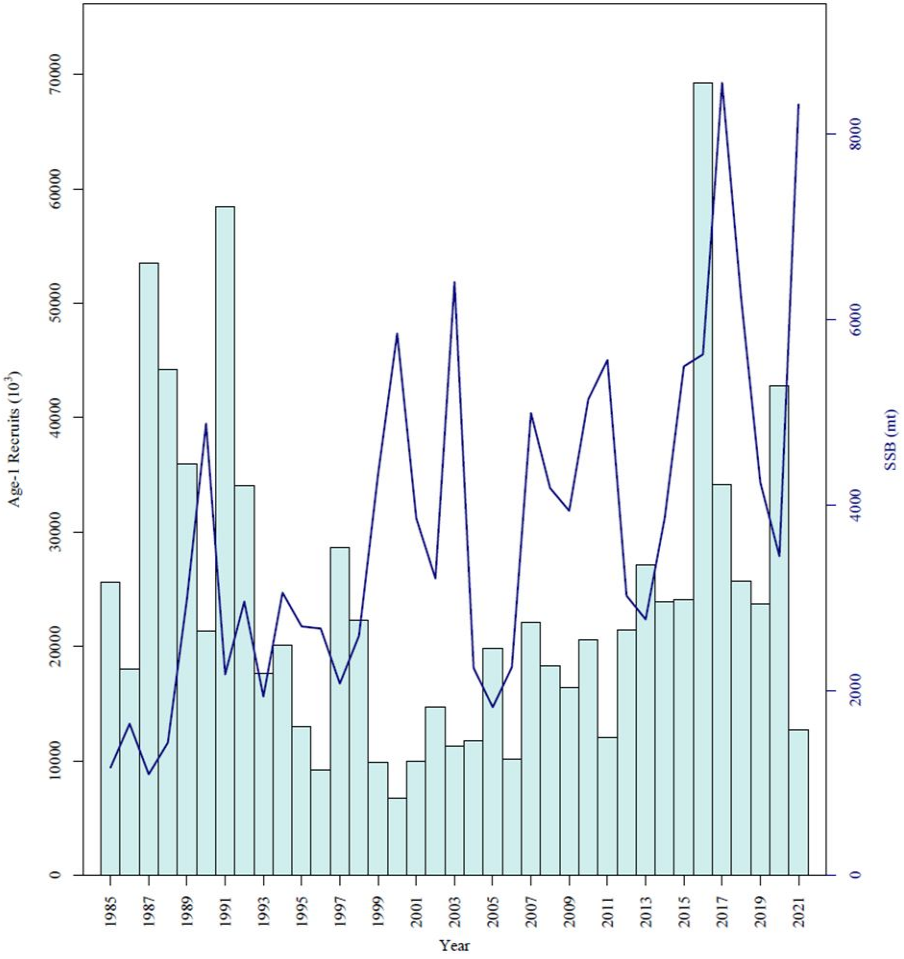
Model	dAIC	AIC	rho_R	rho_SSB	rho_Fbar
Run304	1542.5	-439.7	0.281	-0.0635	0.0727
Run452	0	-1982.2	0.17	-0.0635	0.0544
Run452f	7.9	-1974.3	0.1643	-0.0592	0.05
Run452g	11.6	-1970.6	0.1543	-0.0605	0.0585
Run452h	26.6	-1955.6	0.1684	-0.0624	0.0439

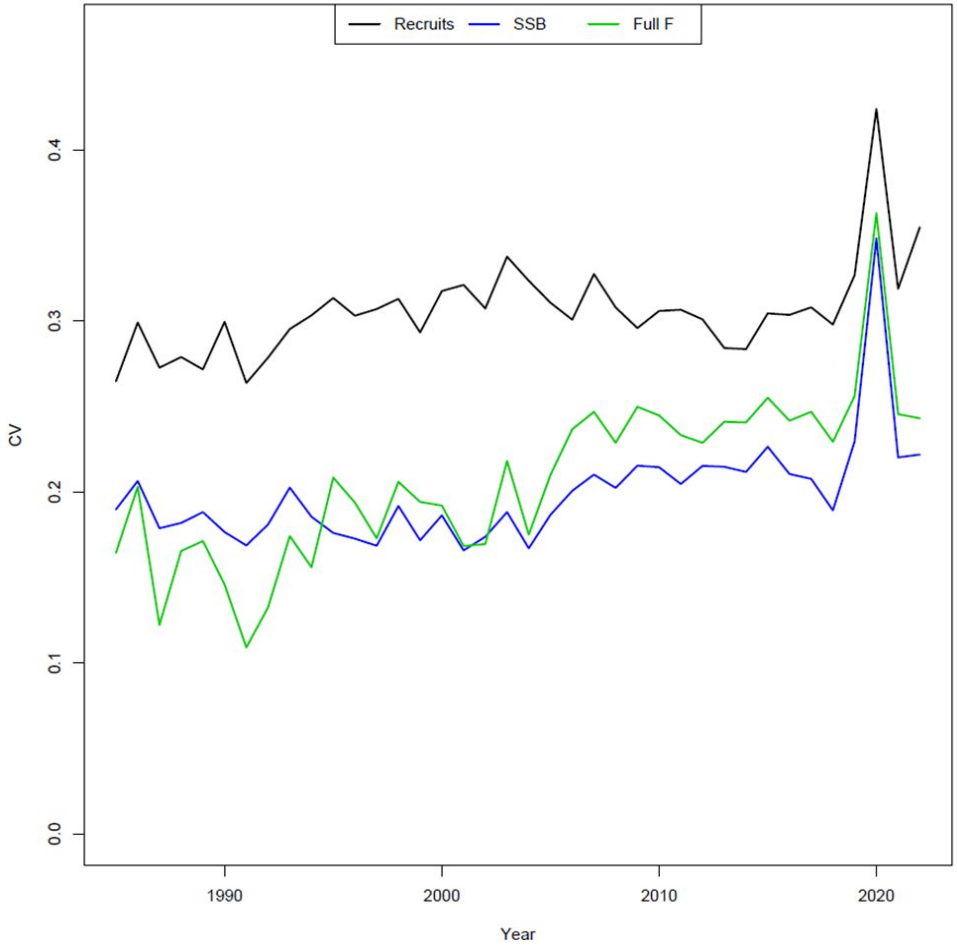


Part Four

Candidate Model Results

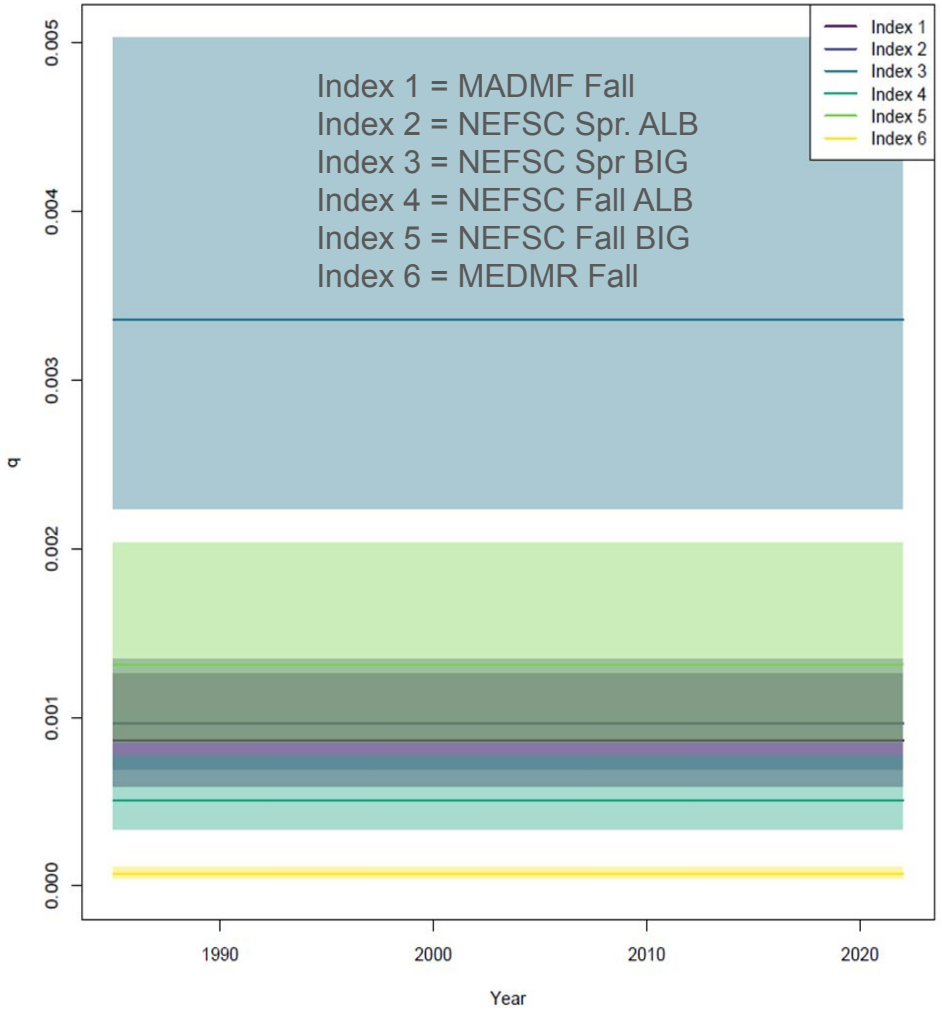

SSB (kmt)
0
2
4
6
8
10
12
Fully-selected F
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1990
2000
2010
2020
Year

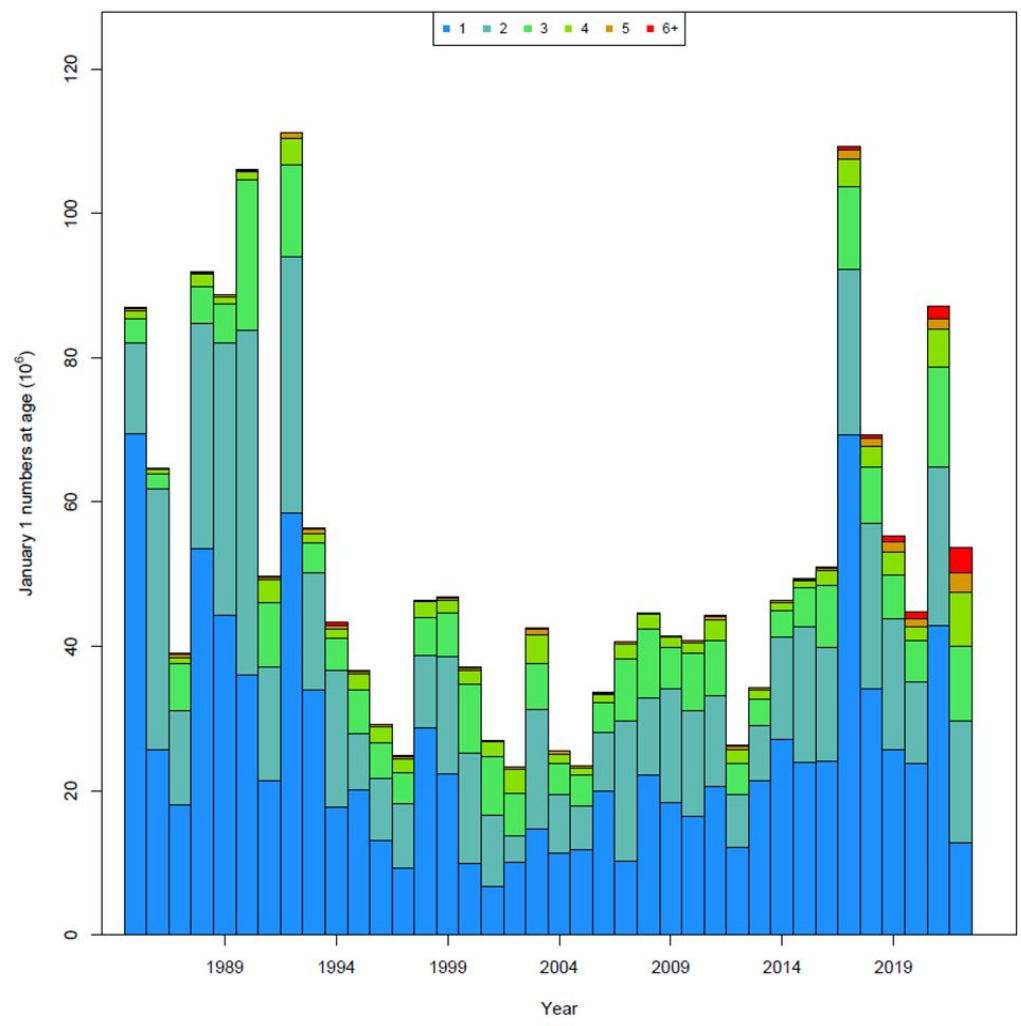

Age-1 Recruits (10^3)
0
10000
20000
30000
40000
50000
60000
70000
SSB (mt)
0
2000
4000
6000
8000
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
Year

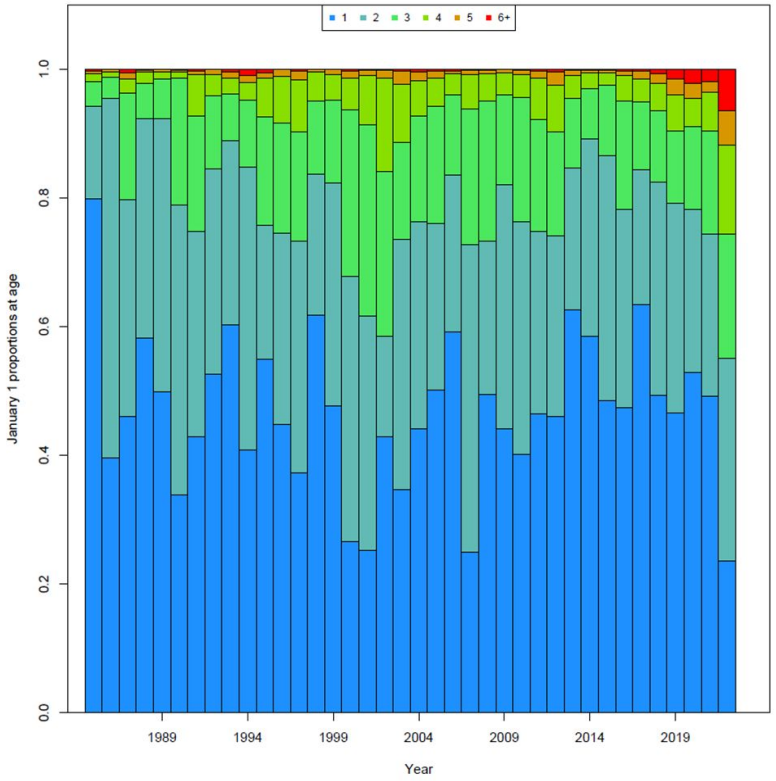


CVs for F, SSB, and R remained relatively steady with the highest values observed in 2020-coinciding with years where most surveys had missing data

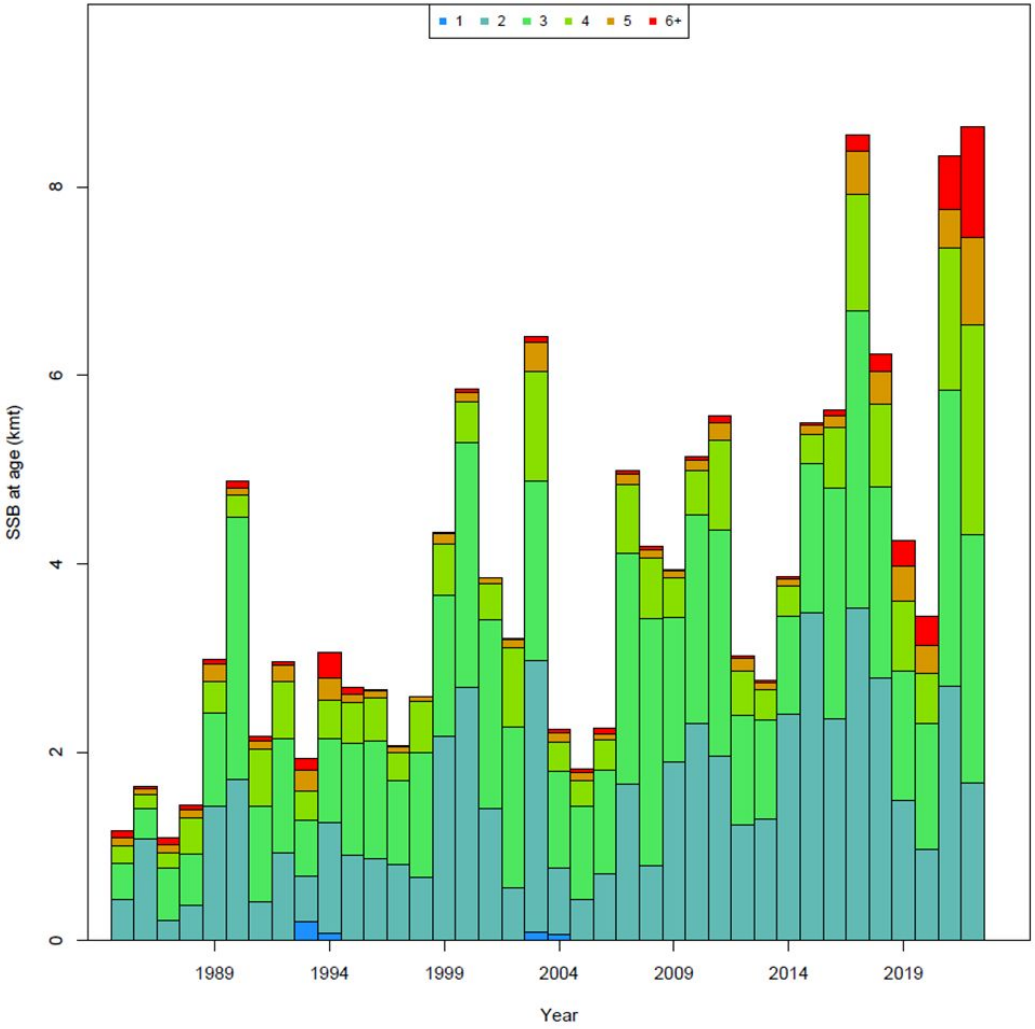

Block 1: logistic (no random effects)
Fleet (Blk1. 85-94)
Block 4: logistic (no random effects)
NEFSC Spr. ALB
Block 7: logistic (no random effects)
NEFSC Fall. BIG
Block 2: logistic (no random effects)
Fleet (Blk2. 95-22)
Block 5: logistic (no random effects)
NEFSC Spr. BIG
Block 8: logistic (no random effects)
MEDMR Fall
Block 3: logistic (no random effects)
MADMF Fall
Block 6: logistic (no random effects)
NEFSC Fall. ALB
Age
Year

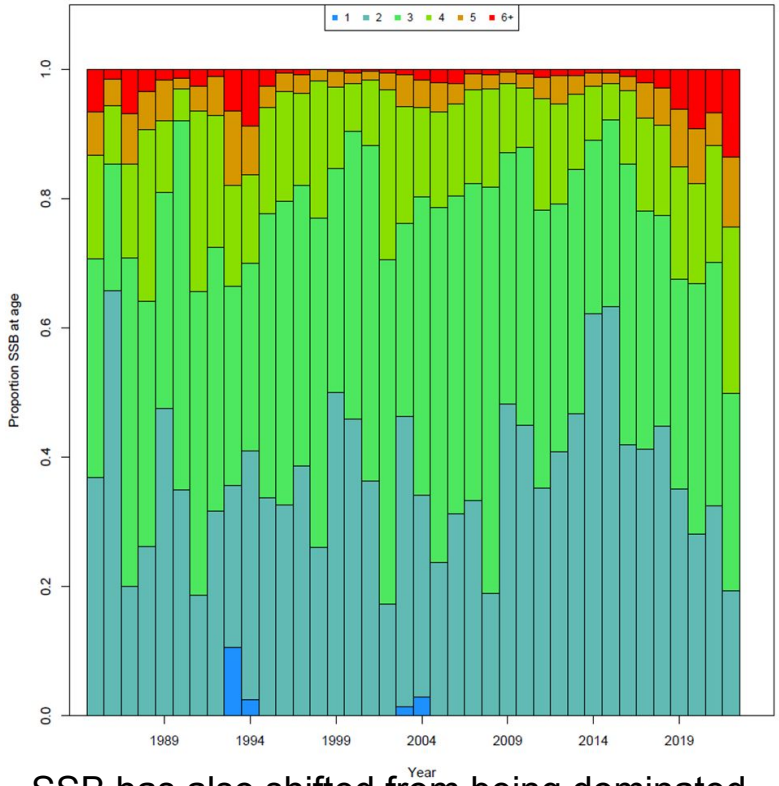

Index 1
Index 2
Index 3
Index 4
Index 5
Index 6
Index 1 = MADMF Fall
Index 2 = NEFSC Spr. ALB
Index 3 = NEFSC Spr BIG
Index 4 = NEFSC Fall ALB
Index 5 = NEFSC Fall BIG
Index 6 = MEDMR Fall
q
Year





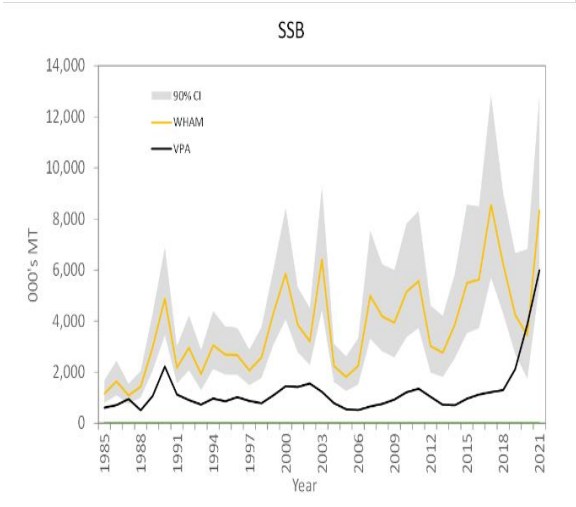
1985-2022, the stock has shifted from being dominated by age-1 individuals to a broader age-structure with a notable increase in age 6+ now representing 13% of the population.

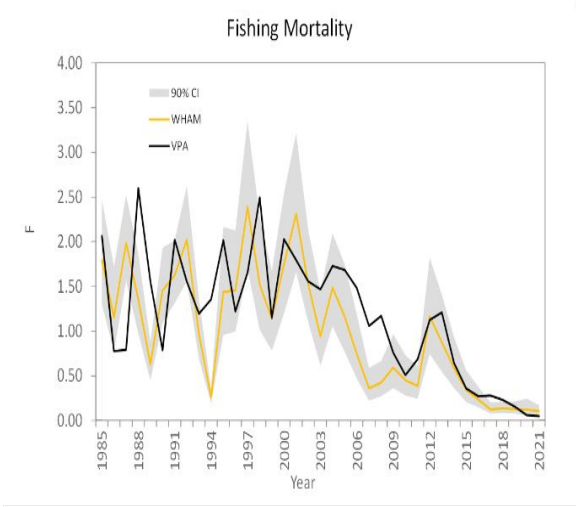


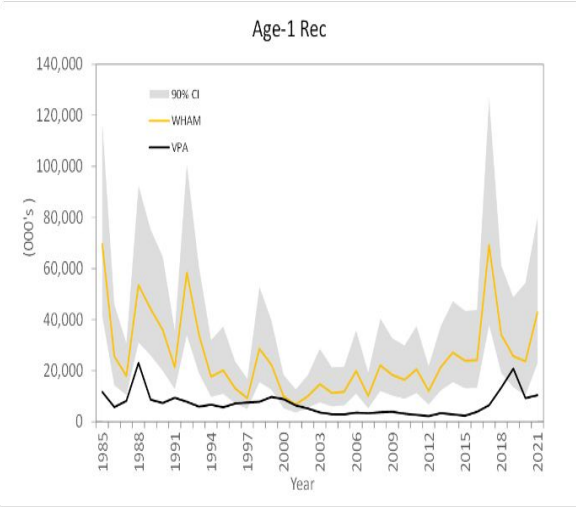


SSB has also shifted from being dominated by age-2 and age-3 fish to a more mature age structure, with age-6+ now representing 14% of the total SSB in 2022.

WHAM vs. VPA


SSB
90% CI
WHAM
VPA
000's MT
Year


Fishing Mortality
90% CI
WHAM
VPA
F
Year


Age-1 Rec
90% CI
WHAM
VPA
(000's)
Year

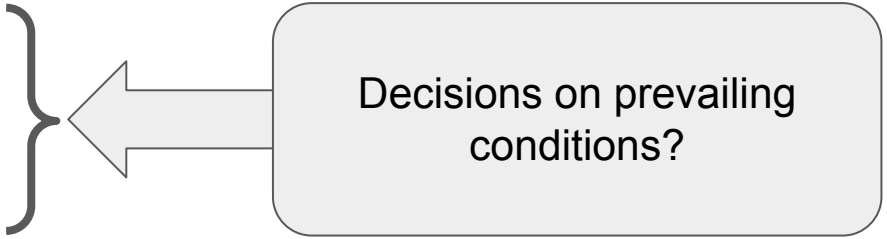
Part Five

Biological Reference Points

Approach and Inputs (CCGOM Specific)

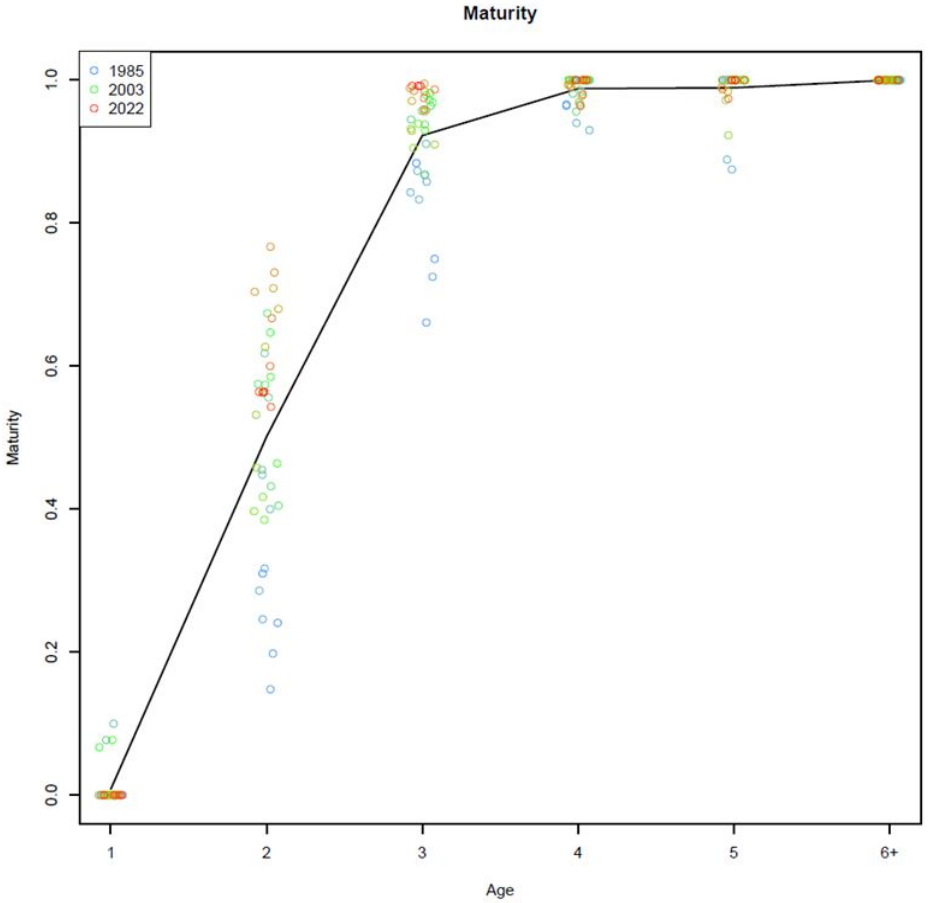
- Spawner per recruit Analyses for F40%

- Maturity (varies)
- Weight-at-age (varies)
- Recruitment for SSB40% - (Varies)



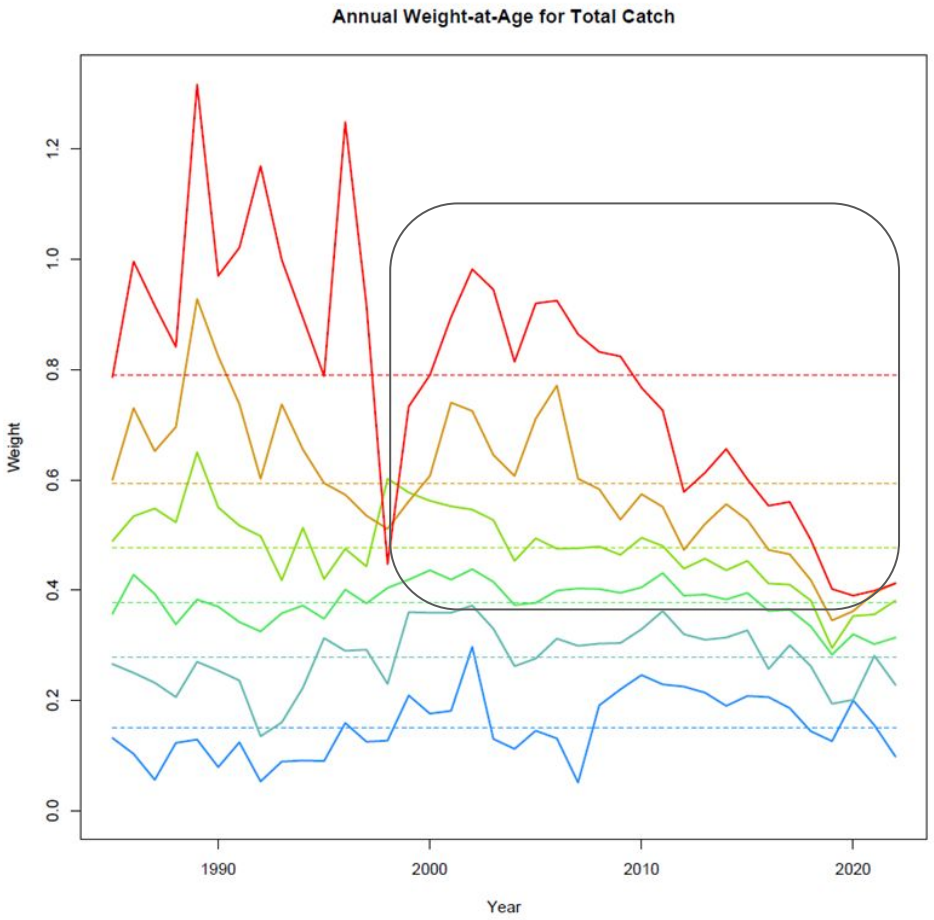
- Natural mortality (constant)
- Fleet Selectivity (Constant)

Maturity



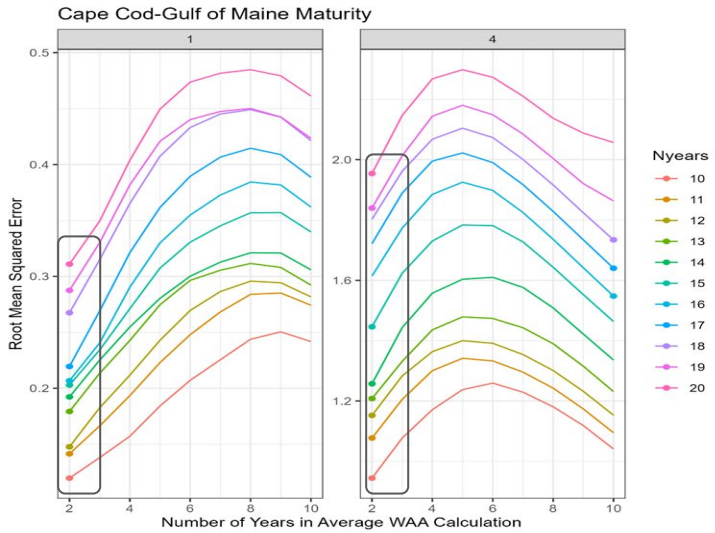
- On average 50% of age-2's are mature and up to 70% in recent years
- Similar increases for age-3
- 100% mature by age-4
- Fish are maturing at younger age in recent years

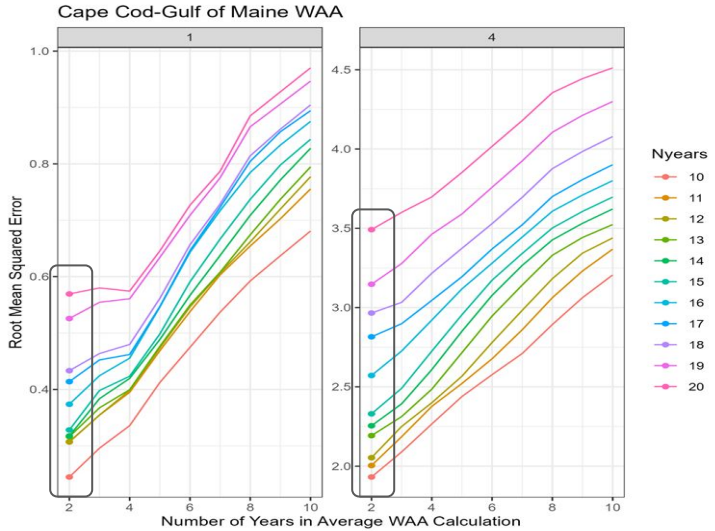
Weight-at-age



- Declining Weights at age (ages 3+) since around the early 2000's
- Stable in recent years, and below time series average.
- Lightweight fish in recent years

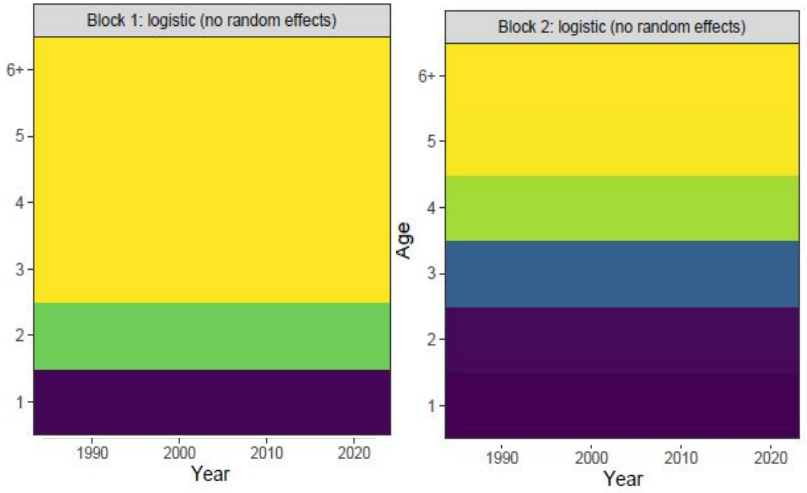
What average to use?
Moving Window Analyses

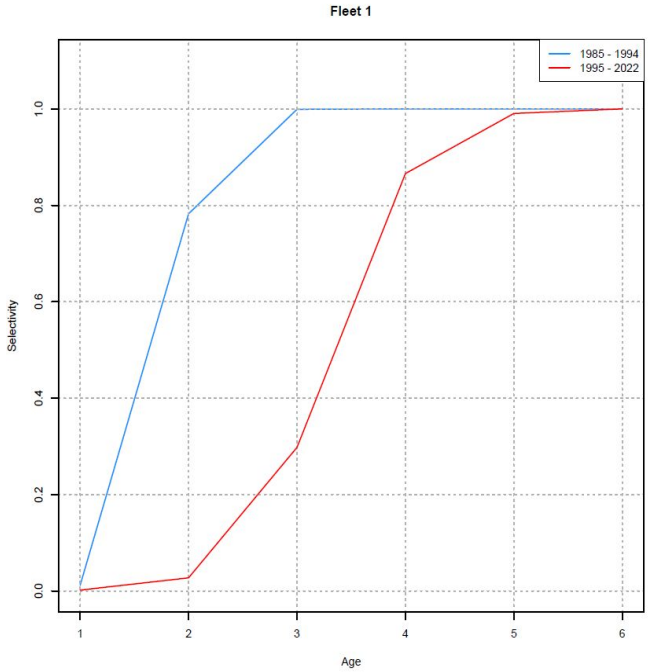




- Optimal average for WAA and Maturity was determined through a moving window analysis.
- 2-year average WAA was the best for predicting near-term WAA values (better than the default of 5 years)

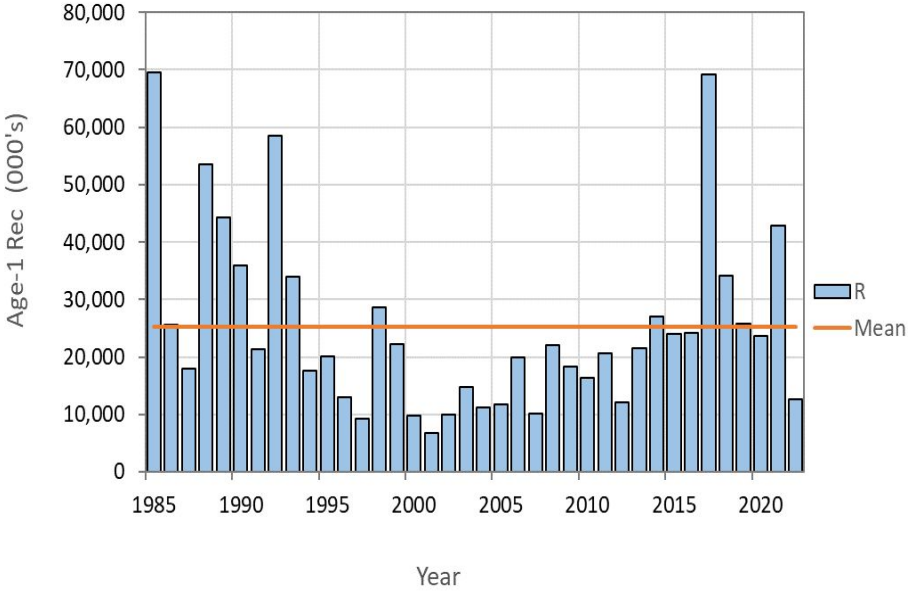
Fleet Selectivity

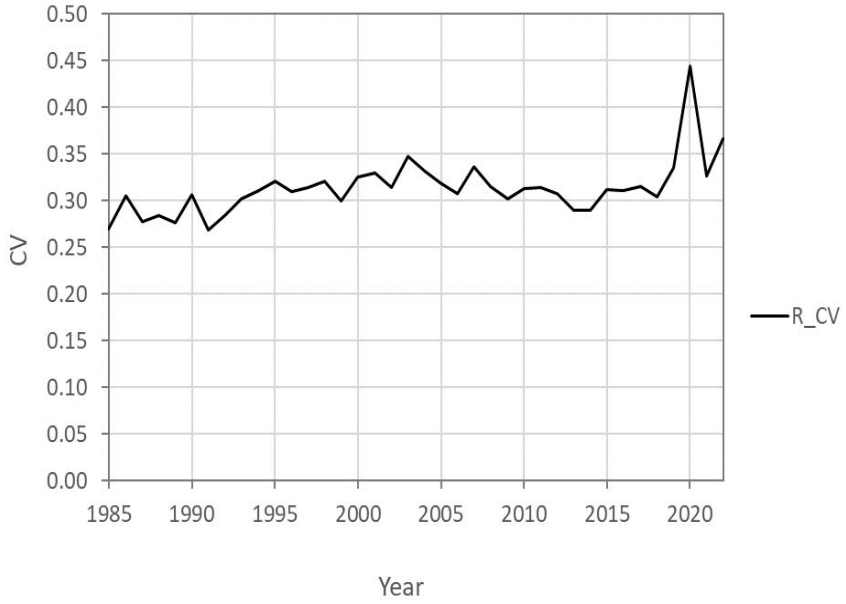




Decline in fleet selectivity for ages 2-4 in recent years (Block 2)

Age-1 Recruitment





Stable Recruitment Patterns: Lack of strong trends in recruitment over time supports the use of the entire time series for consistency.

High Precision in Estimates: The low variability (CV=0.31) in recruitment estimates indicates reliability, making the full time series suitable for reference point estimation.

Final BRP Inputs (CCGOM Specific)

- Maturity (Recent 2 years: 2021-2022)
- Weight-at-age (Recent 2 years: 2021-2022)
- Recruitment for SSB40% - (Time series mean: 1985-2022)
- Natural Mortality (Constant - Time and age invariant: 0.4)
- Fleet Selectivity (Constant - Fleet Block 2)

Estimated BRPs

New BRP's - WHAM (M=0.4)
2 yr average conditions

$F_{40\%}$	$SSB_{40\%}$	MSY Proxy
1.64	4,870 mt (2,463-6,948 mt)	1,998 mt (1,263-3,572 mt)

Sensitivity BRP's - WHAM (M=0.2)
2 yr average conditions

$F_{40\%}$	$SSB_{40\%}$	MSY Proxy
0.44	8,909 mt (6,019-13,187 mt)	2,389 mt (1,611-3,543 mt)

- **Increased F40% Reference Point**: Higher natural mortality and earlier maturity allow fish populations to handle more fishing pressure while maintaining 40% of spawning potential, leading to a higher F40% threshold.

- **Sensitivity Analysis at Lower M**: An SPR analysis with a reduced natural mortality (M=0.2) showed a notably lower F40% (0.47), highlighting the impact of natural mortality assumptions on fishing reference points.

2024 RT BRP's vs 2022 MT BRP's

New BRP's - WHAM (M=0.4)
2 yr average conditions

$F_{40\%}$	$SSB_{40\%}$	MSY Proxy
1.64	4,870 mt (2,463-6,948 mt)	1,998 mt (1,263-3,572 mt)

Sensitivity BRP's - VPA (M=0.2)
5 yr average conditions

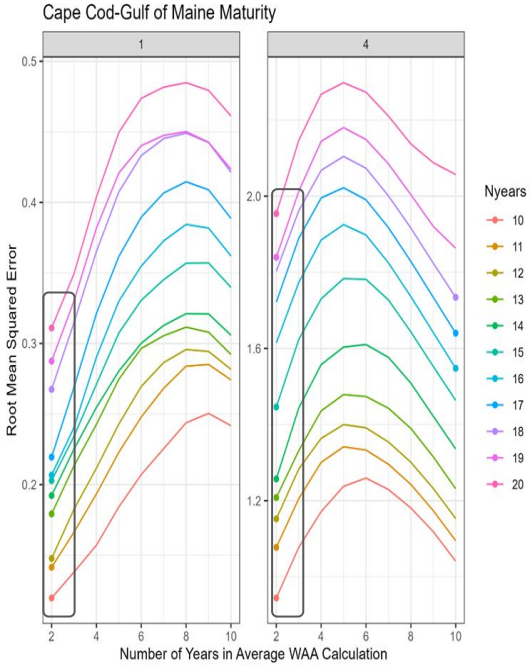
$F_{40\%}$	$SSB_{40\%}$	MSY Proxy
0.32	3,068 mt (2,108-4,751 mt)	1,008 mt (696-1,554 mt)

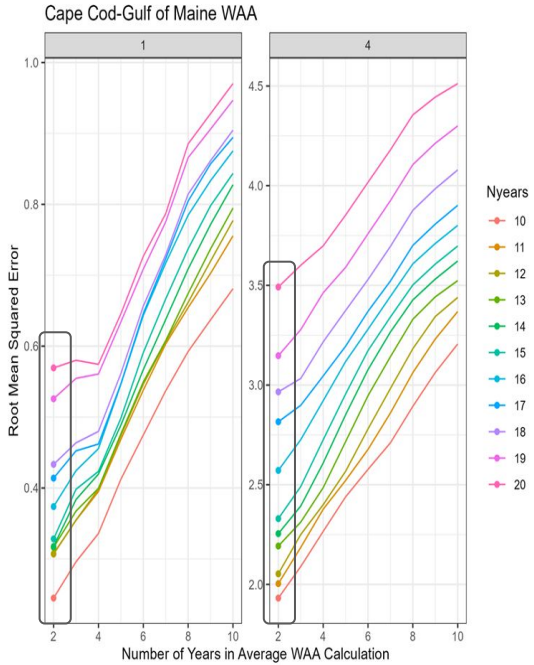
Part Six

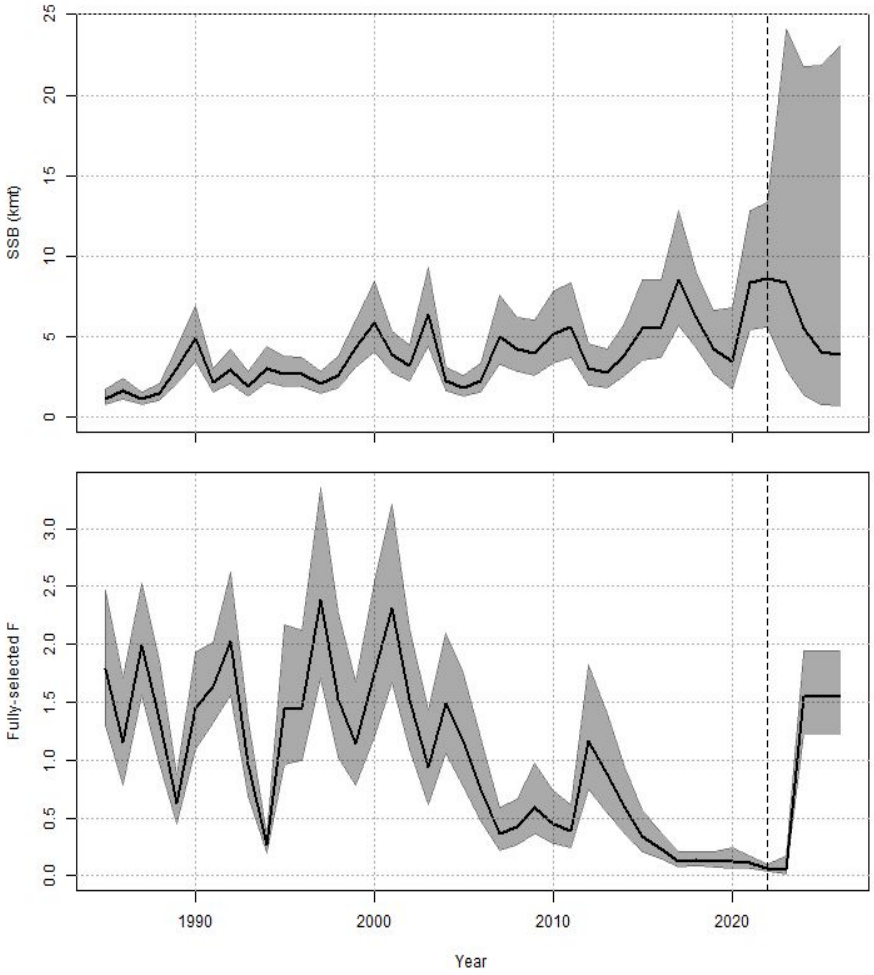
Projections

Projection inputs

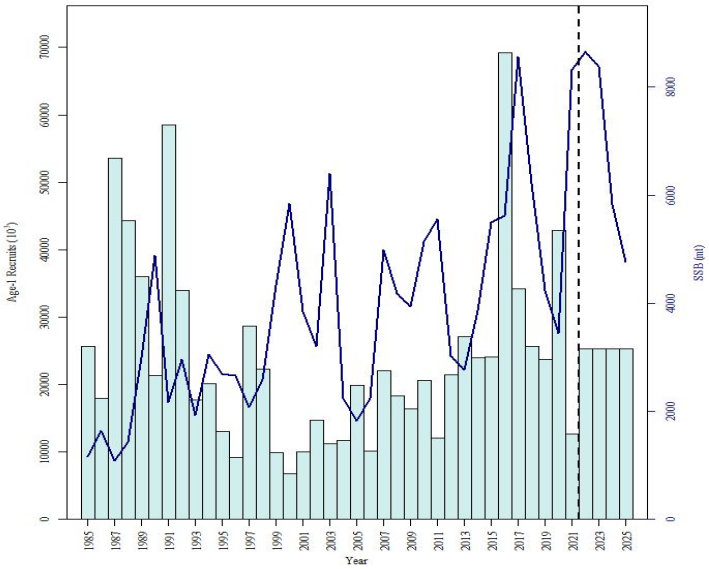
- Natural mortality
  - M=0.4
- Selectivity and Maturity
  - Recent 2 years
- Recruitment = 1985-2022
- 2023 BY catch (303 mt) = 2022 catch 303 mt
- Ecov
  - None







Assuming time series mean of recruitment (with 2022 lowest in recent decade), SSB declines and levels off in 2026. SSB is above the time series average and converges to SSB40% in the long-term.



Summary (Update)

Candidate model

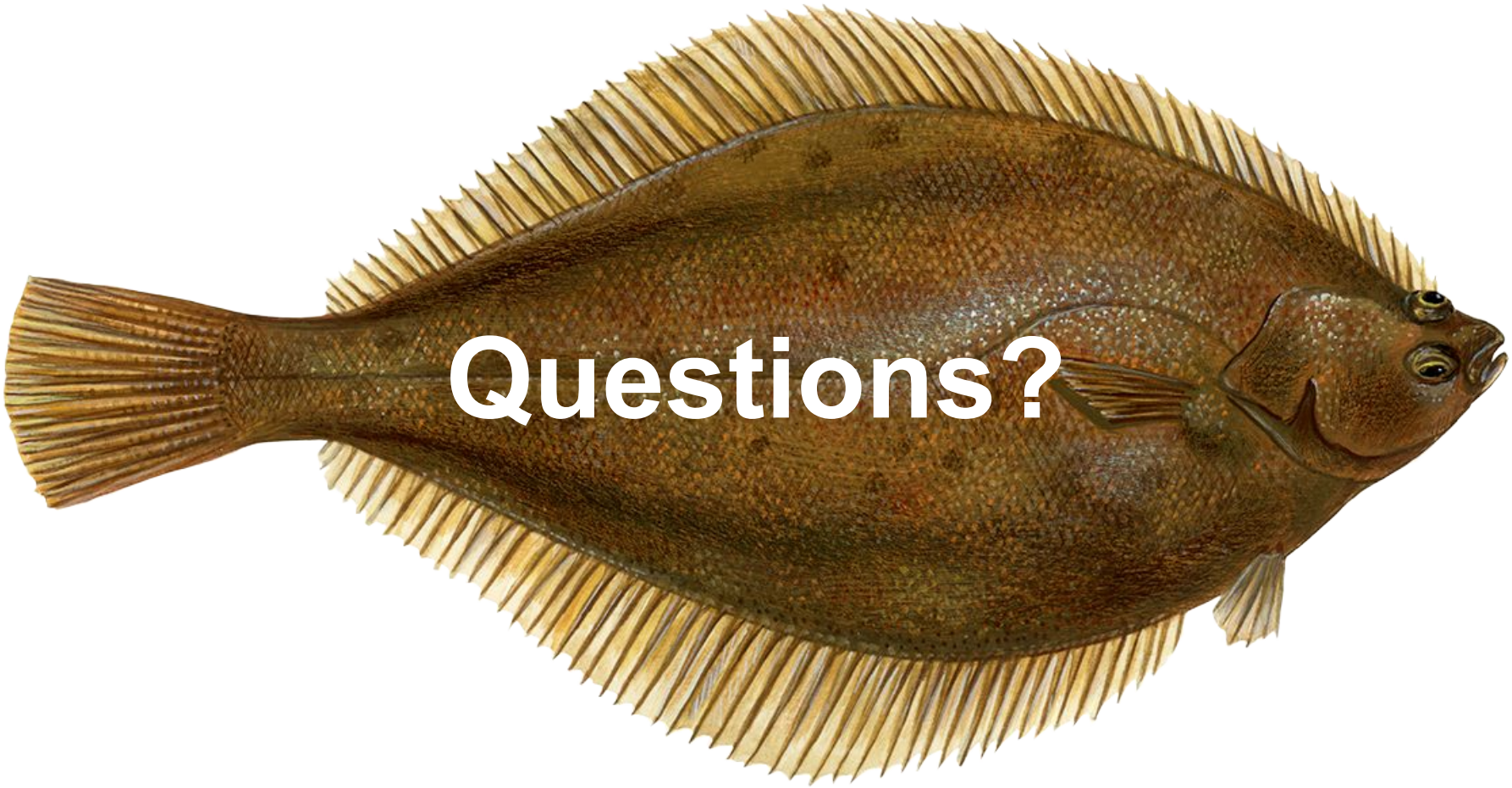
- WHAM
- 6 indices
  - NEFSC Fall/Spring Albatross (1985-2008)
  - NEFSC Fall/Spring Bigelow (2009-2022)
  - MADMF Fall
  - MEDMR Fall
- Single fleet
- Age comp
  - Fleet: Logistic normal-miss0
  - Survey: Logistic normal-ar1-miss0
- Natural Mortality = 0.4
- Time-varying WAA
- RE on NAA (ar1_a)
- RE on fleet selectivity: None
- RE on survey selectivity: None
- Ecov settings: None

BRPs (To be updated in 2025)

- $F_{40\%}$: 1.64
- $SSB_{40\%}$: 4,870 mt
- MSY Proxy: 1,998 mt

BRPs/Projections settings

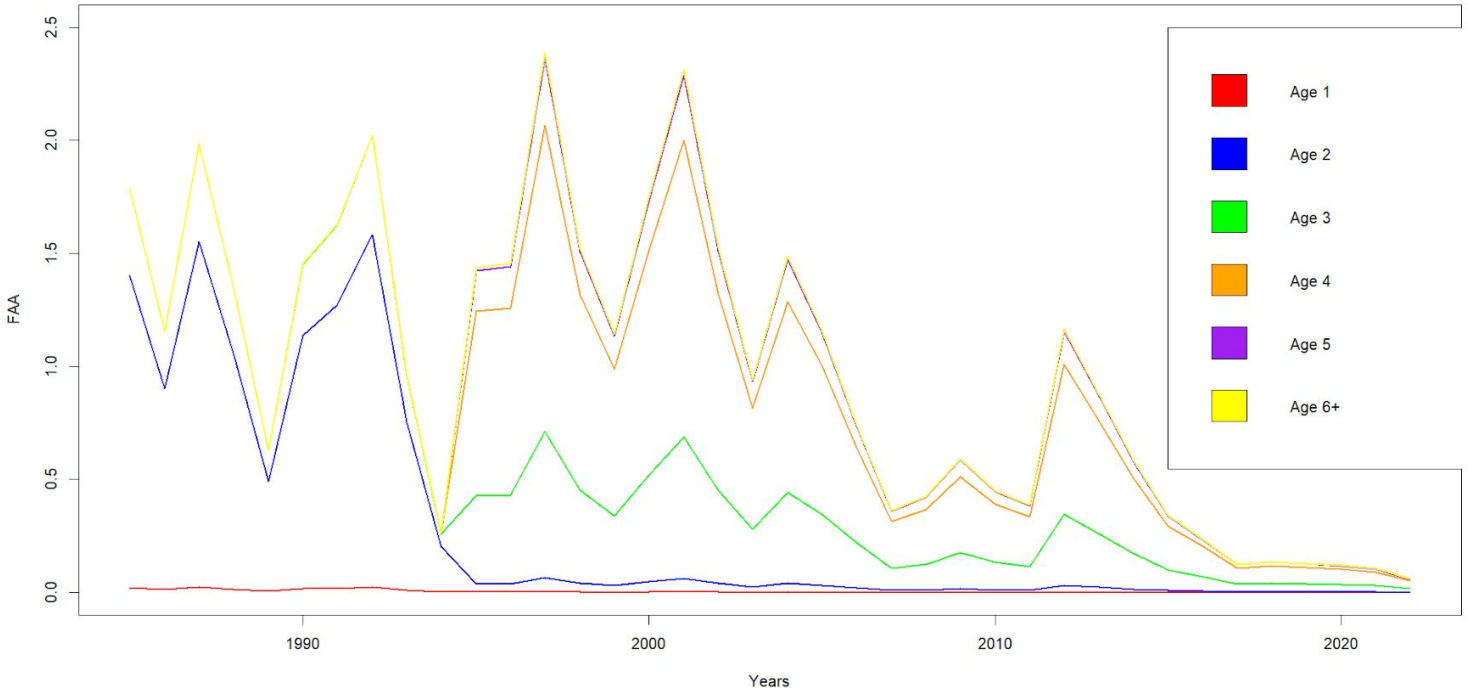
- 2-year average WAA
- 2-year average Maturity
- Fleet Selectivity: Constant
- M = 0.4
- Rec: 1985-2022


Questions?

Age-Specific F40%

% SPR	F(%SPR)	YPR
0.2	2.1309	0.1028
0.25	1.3002	0.098
0.3	0.8738	0.0929
0.35	0.6268	0.0874
0.4	0.4692	0.0816
0.45	0.361	0.0755
0.5	0.2824	0.0692
0.55	0.223	0.0626
0.6	0.1765	0.056
0.65	0.1392	0.0492
0.7	0.1085	0.0424
0.75	0.083	0.0354

F-at_Age


FAA
0.0
0.5
1.0
1.5
2.0
2.5
1990
2000
2010
2020
Years
Age 1
Age 2
Age 3
Age 4
Age 5
Age 6+