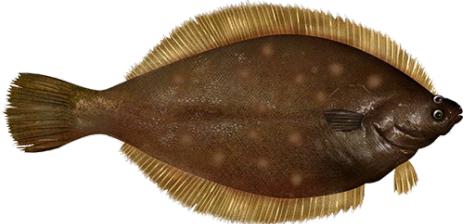


# ToR 4-6: GB yellowtail

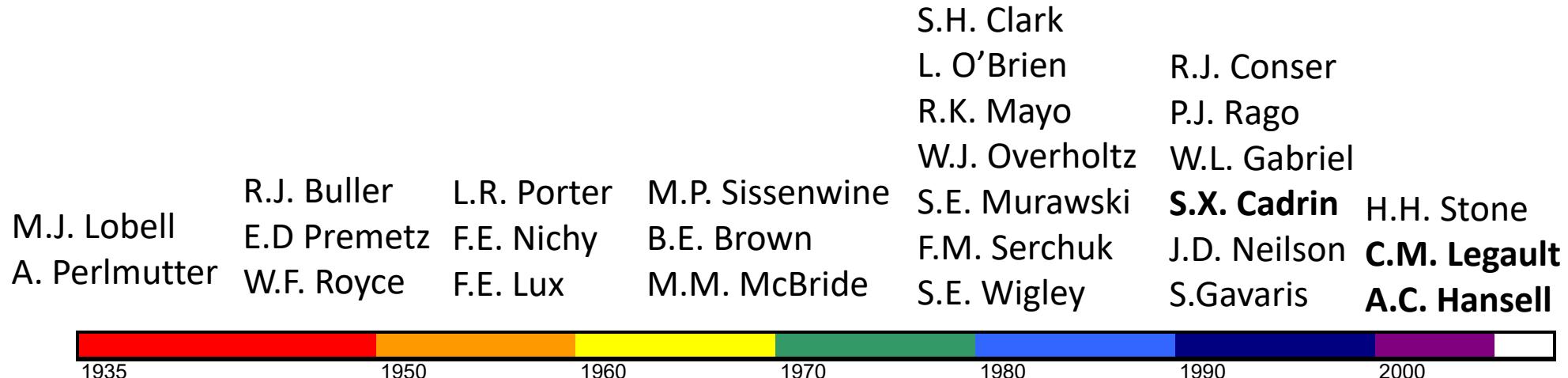
Alexander Hansell

Yellowtail Flounder Research Track Peer Review

11/20/24



# Assessment Who's Who



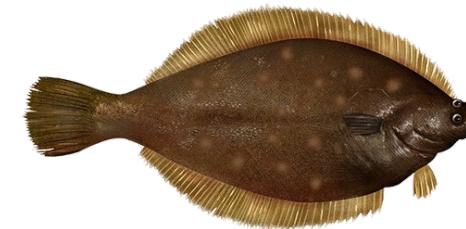
Royce



Lux

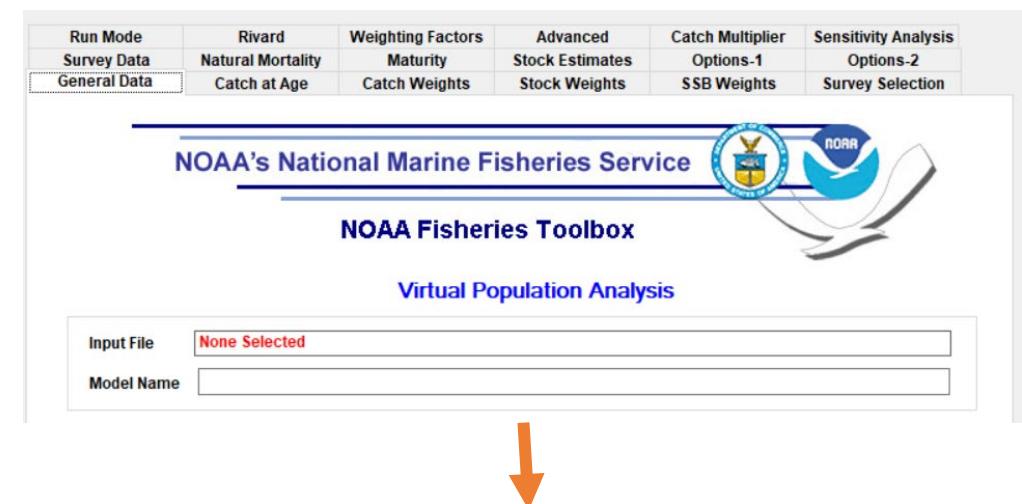
## Yellowtail Flounder Research Track Working Group

Research Track: 2024 Improving Assessments for Yellowtail Flounder



# GB yellowtail history

- Historically assessed as part of TRAC
- Virtual population analysis 2005 benchmark
  - Poor retrospective patterns
- The 2014 empirical benchmark
  - The Limiter
- 2024 research track
  - WHAM



The **W**HAM  
Wood's Hole Assessment Model

# ToR 4: Assessment model

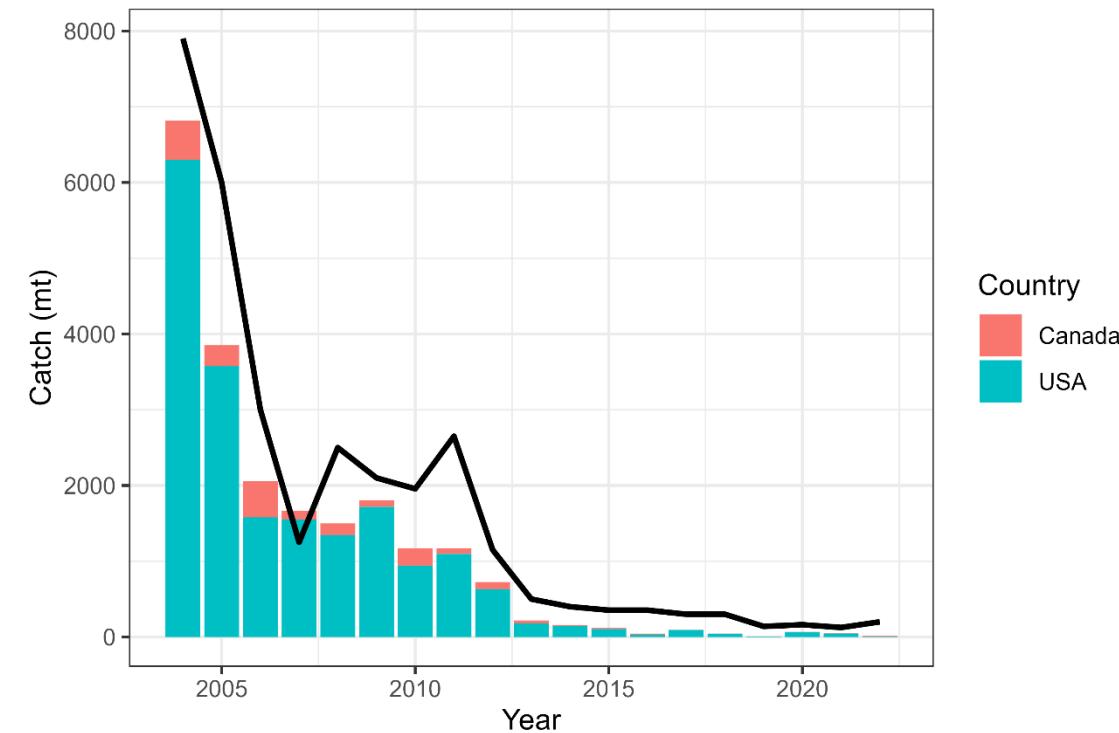
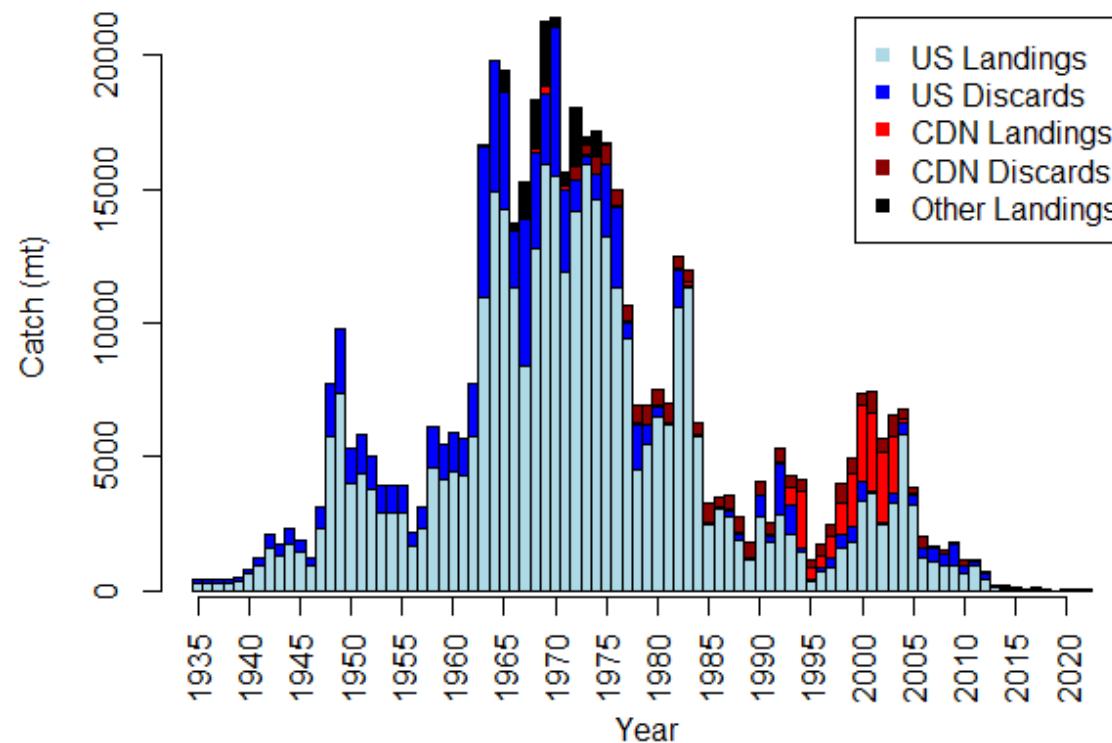
# Catch

Units kg!

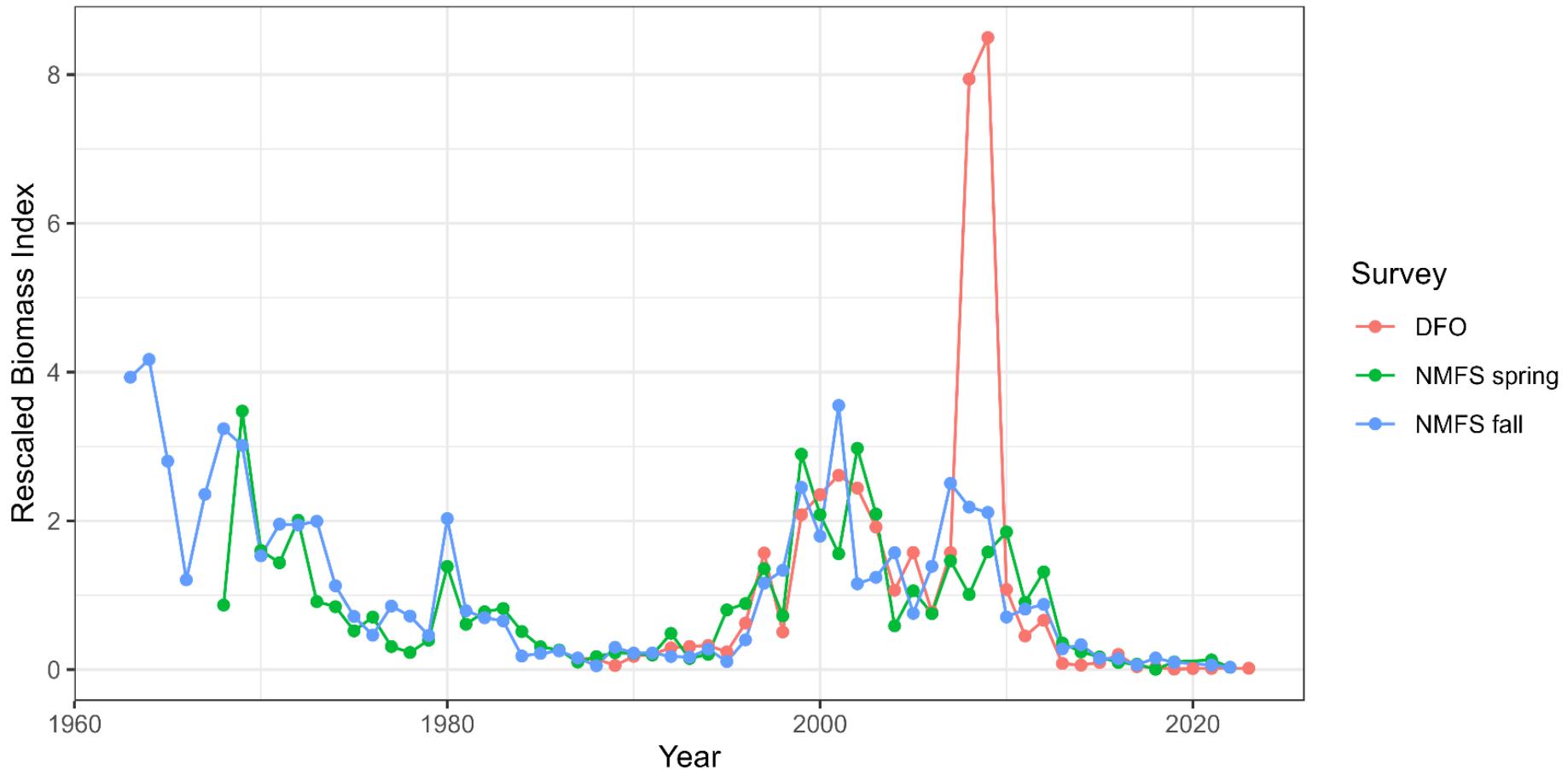
Year	US Land	US Dis	CA Land	CA Dis	Total
2022	331	10,184	987	3,400	14,902

Percentage

Year	US Land	US Dis	CA Land	CA Dis	Total
2022	2	68	7	23	100

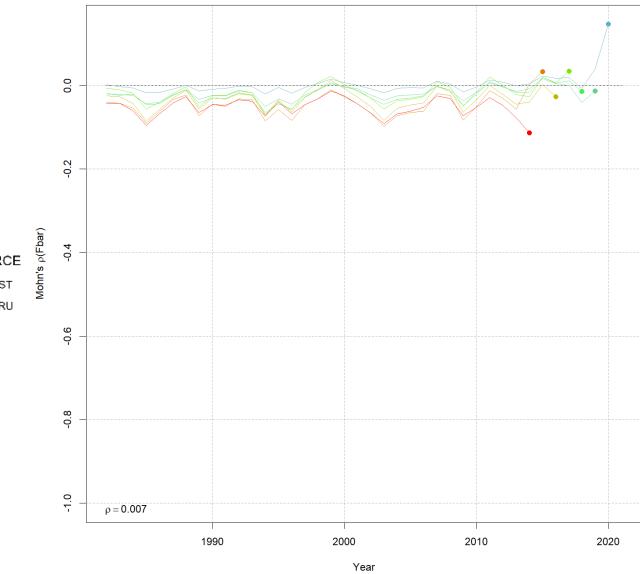
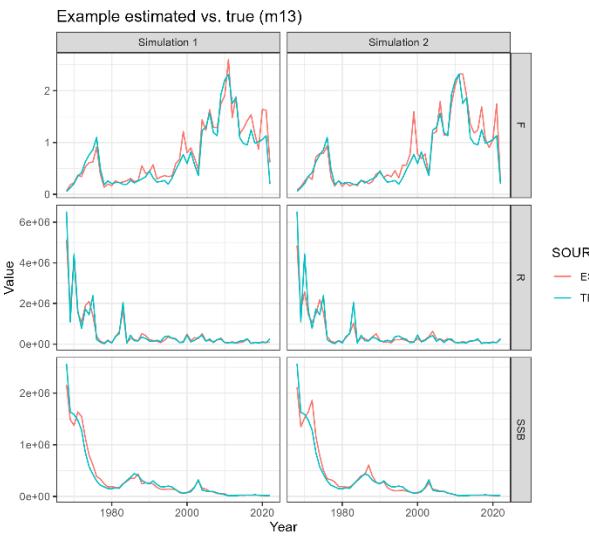
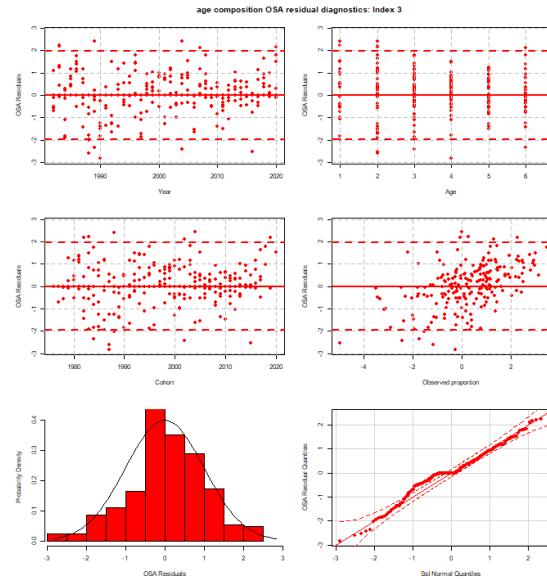


# Surveys

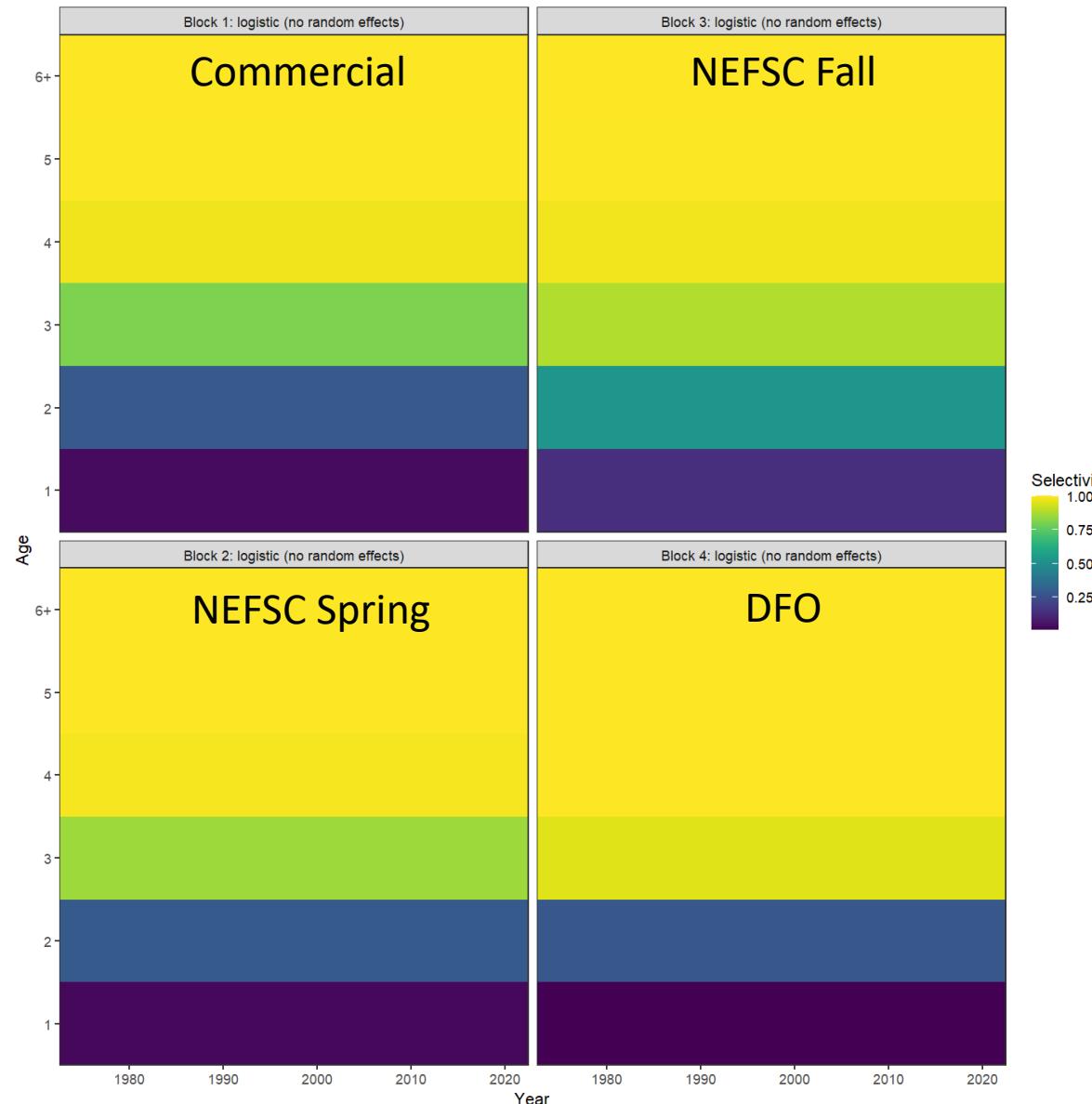
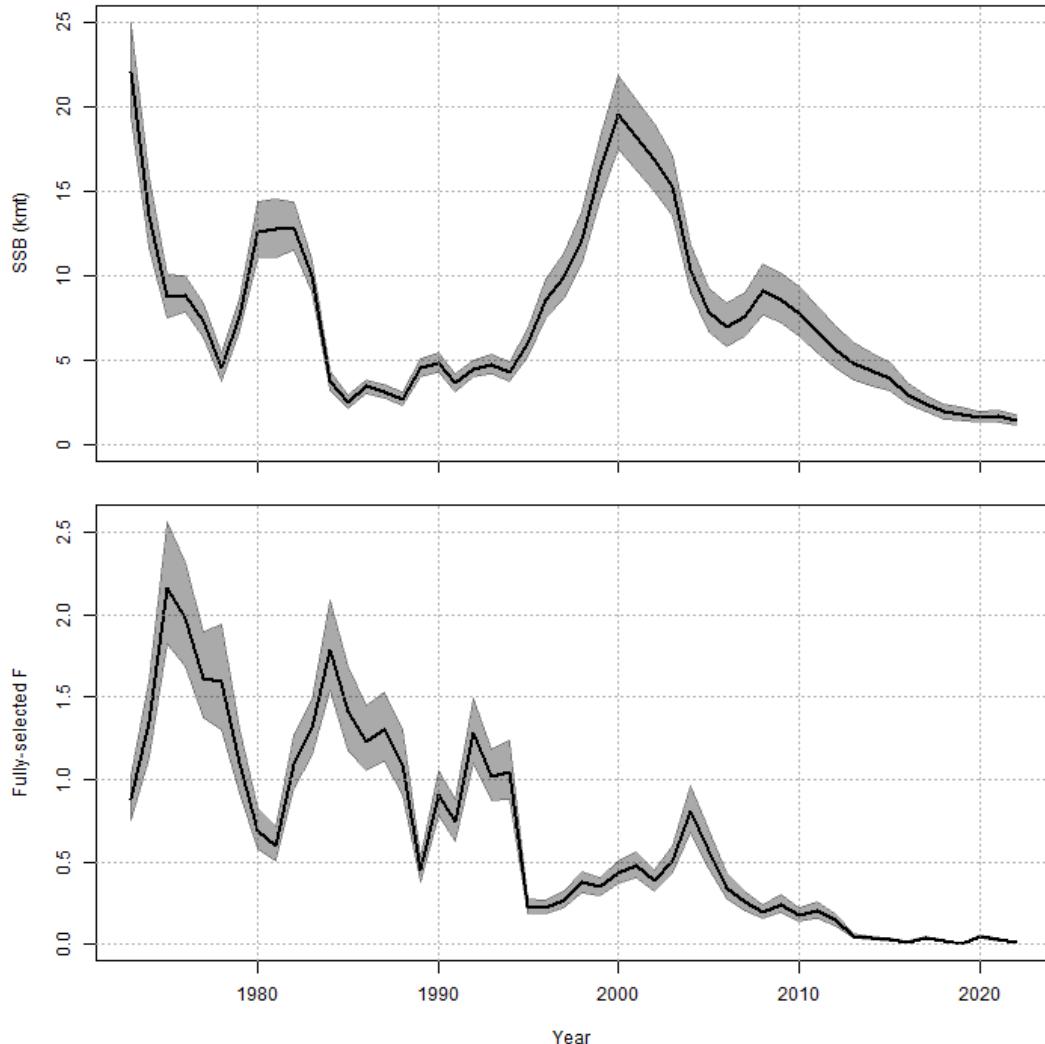


# Diagnostics

- Convergence
- Residuals
- Retrospective patterns
- AIC
- Model performance

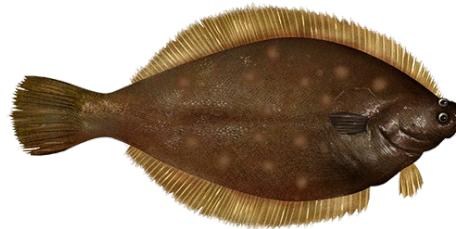
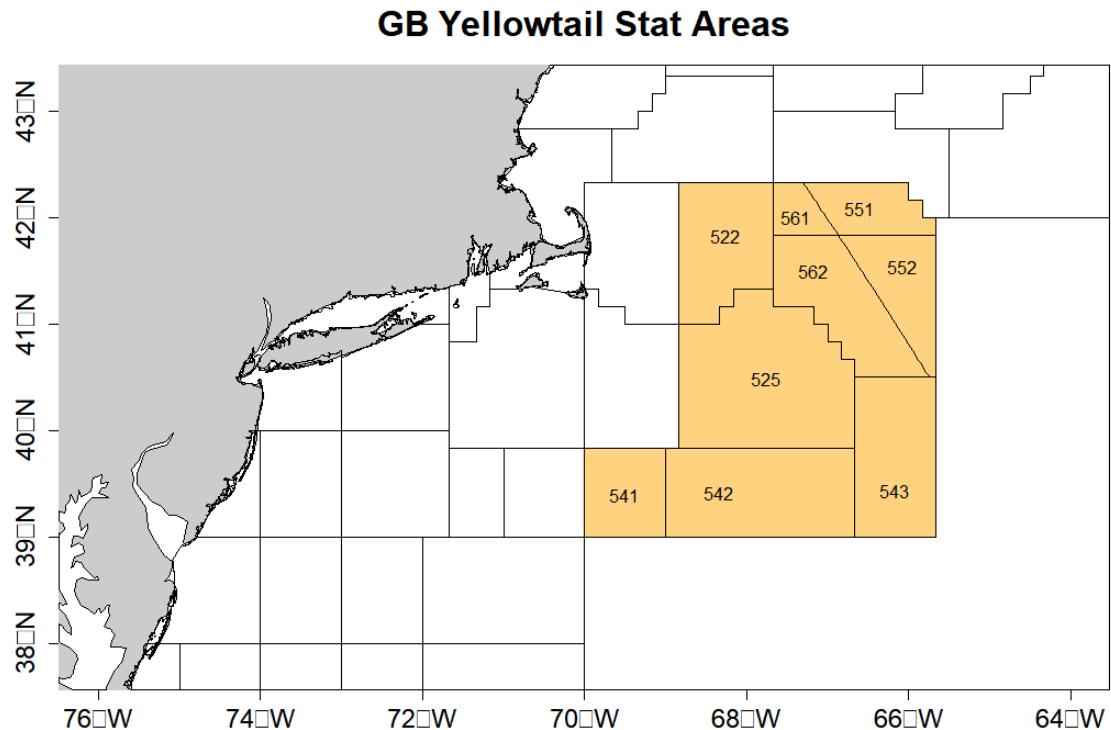


# The base case



# The plan

- Age comps
- Recruitment
- Time varying selectivity
- Time varying survival
- Environmental covariates
- Natural mortality
- Surveys



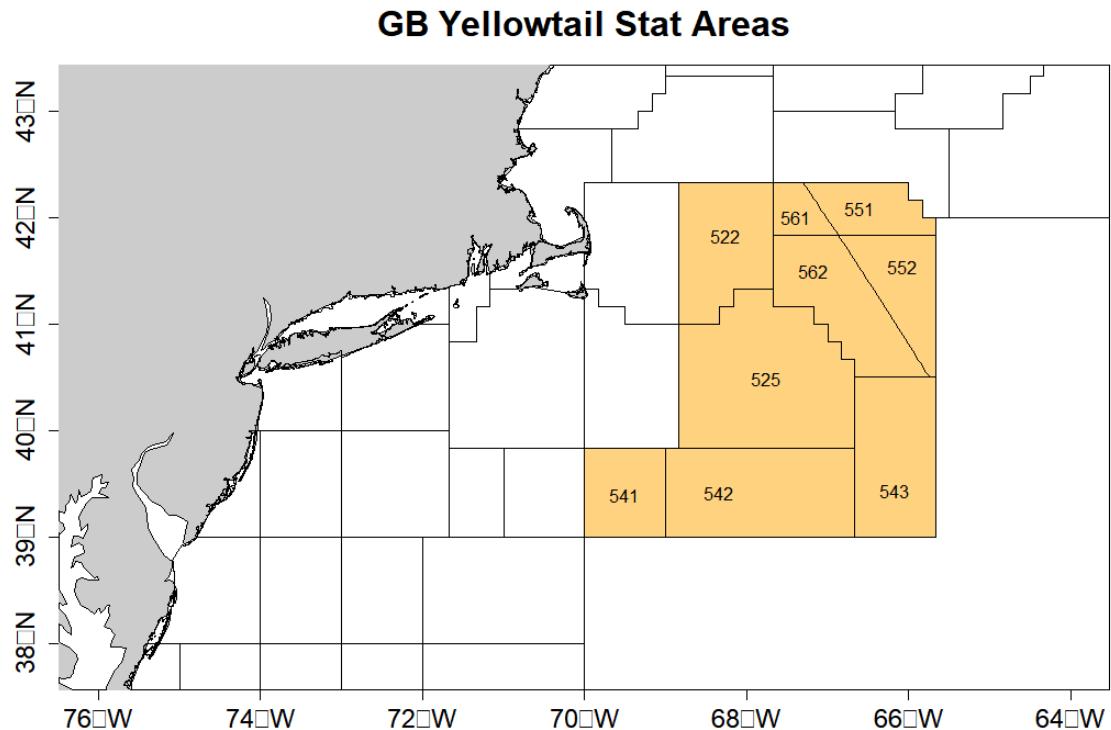
The **WHAM**  
cods  
ole  
essment  
odel

# Age comps

Model	age_comp	NLL	dAIC	AIC	rho_R	rho_SSB	rho_Fbar
m1	multinomial	7489.378	17406.4	15216.8	1.0124	0.8392	-0.4141
m2	dir-mult	3785.416	10006.4	7816.8	2.0078	0.2031	-0.182
m3	dirichlet-miss0	-858.819	718	-1471.6	2.2583	0.1956	-0.179
m4	dirichlet-pool0	-850.234	735.1	-1454.5	2.2456	0.1992	-0.1844
m5	logistic-normal-miss0	-746.359	942.9	-1246.7	3.7946	0.158	-0.1313
m6	logistic-normal-ar1-miss0	-1221.78	0	-2189.6	3.2691	0.1102	-0.173
m7	logistic-normal-pool0	-745.244	945.1	-1244.5	3.5926	0.1494	-0.1283

# The plan

- Age comps → logistic-normal-pool0
- Recruitment
- Time varying selectivity
- Time varying survival
- Ecov on recruitment
- Time varying M
- Surveys
- Proposed model

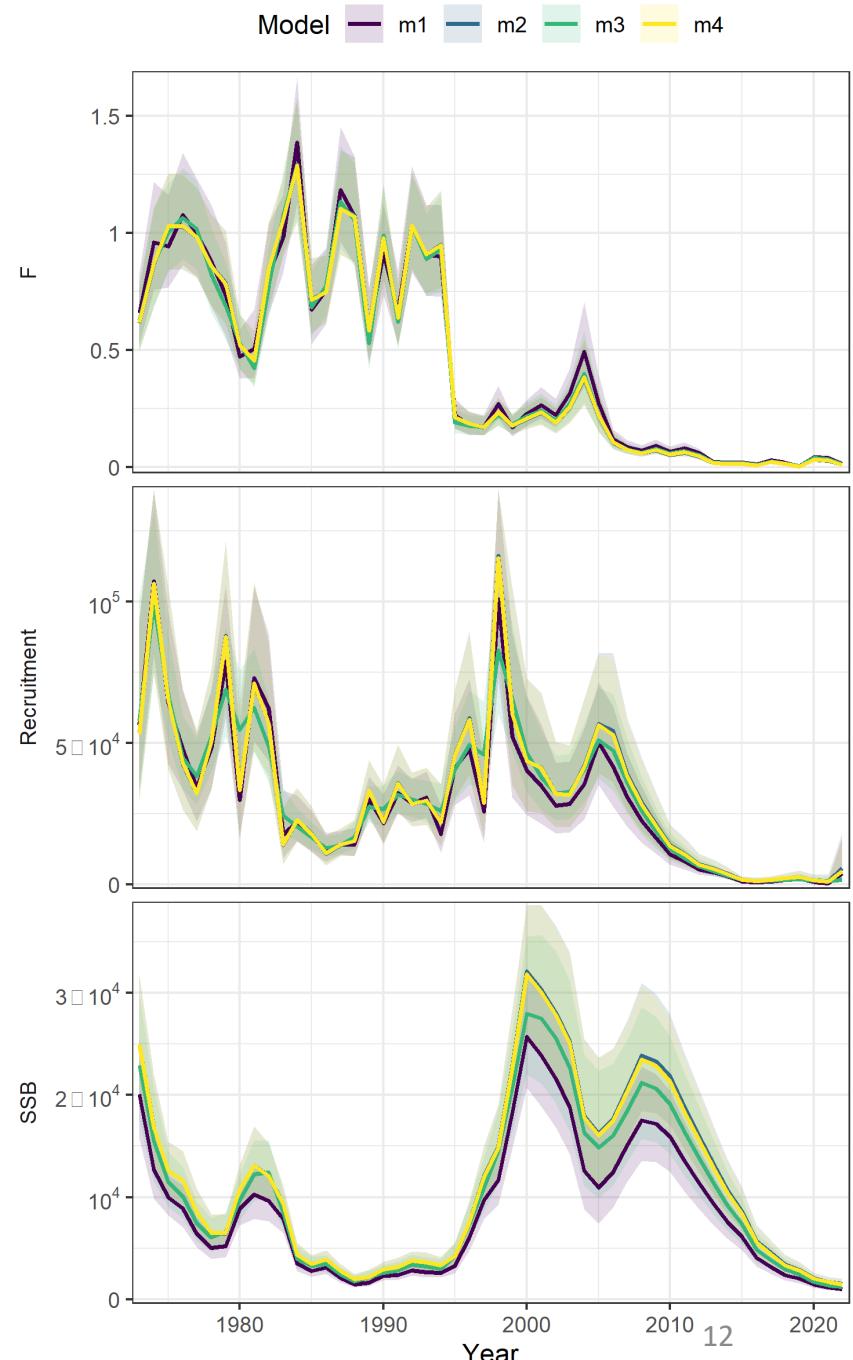


The **WHAM**  
cods sole assessment model

# Recruitment

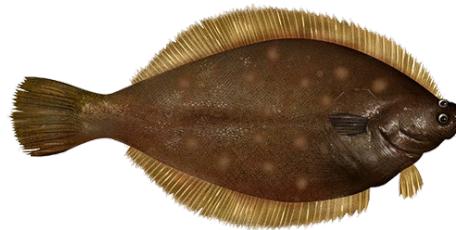
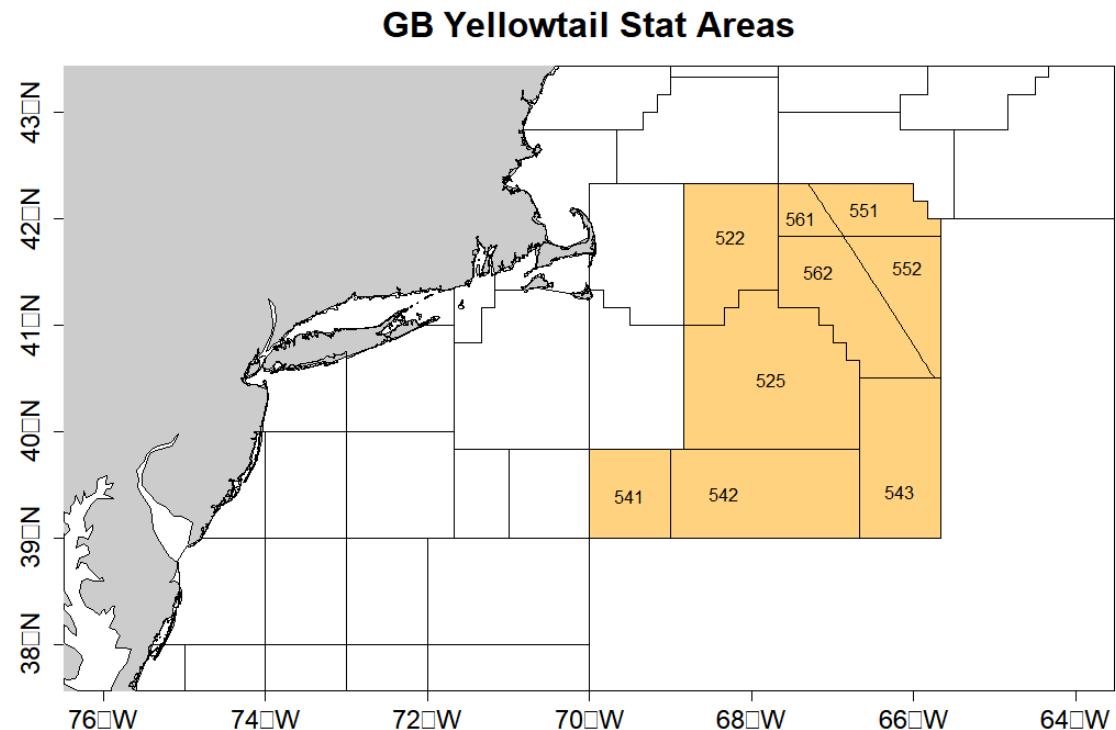
Model	Type	dAIC	AIC	Rho R	Rho SSB	Rho Fbar
m1	Fixed effects	0	-1206	3.5926	0.1494	-0.1283
m3	Ar1_y	85.5	-1120.5	1.6481	0.3487	-0.2398
m4	Beverton-holt	175.6	-1030.4	6.7204	0.3627	-0.2613
m2	iid	179.2	-1026.8	6.569	0.3166	-0.2397

AIC cannot be compared between fixed and random effects on recruitment



# The plan

- Age comps → logistic-normal-pool0
- Recruitment → TBD
- Time varying selectivity
- Time varying survival
- Ecov on recruitment
- Time varying M
- Surveys



The **WHAM**  
cods sole assessment model

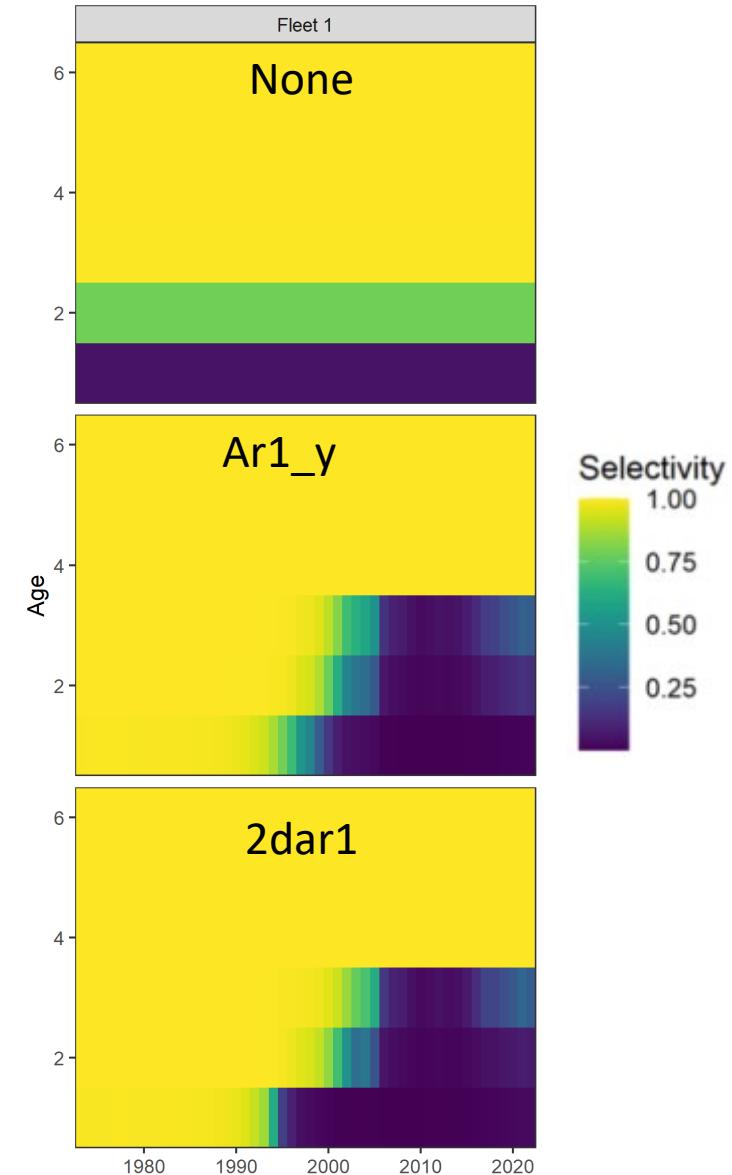
# Selectivity

---

Model	RE	dAIC	AIC	Rho R	Rho SSB	Rho Fbar
m3	2dar1	0	-1496	2.7126	0.5645	-0.3032
m2	Ar1_y	2.4	-1493.6	3.4697	0.6533	-0.314
m5	block_1994	64.9	-1431.1	6.3254	1.5862	-0.4448
m4	block_2010	225	-1271	4.0561	0.6666	-0.1304
m1	None	375.5	-1120.5	3.5926	0.1494	-0.1283
m6	iid	-	-	-	-	-

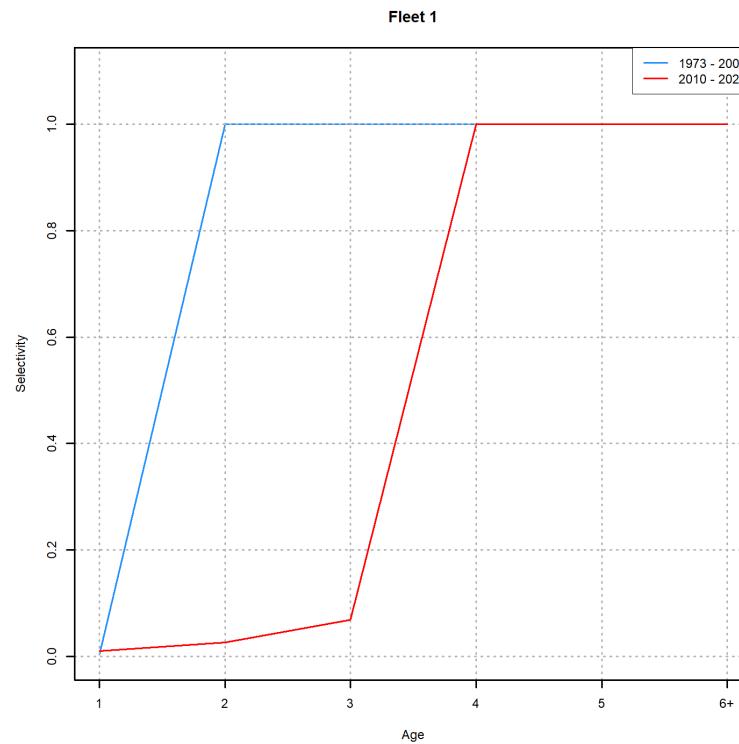
---

Explored age based selectivity to allow the model to freely estimate older and younger ages. Age 4 was fixed at 1.

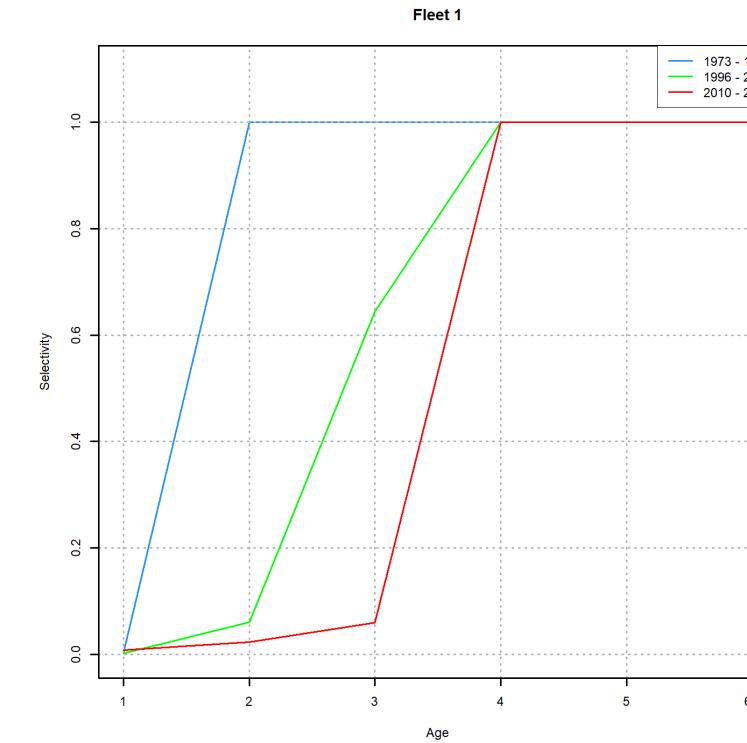


# Blocking

**Block: 2009**

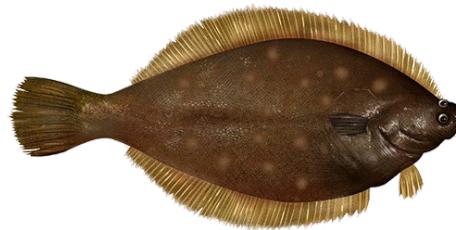
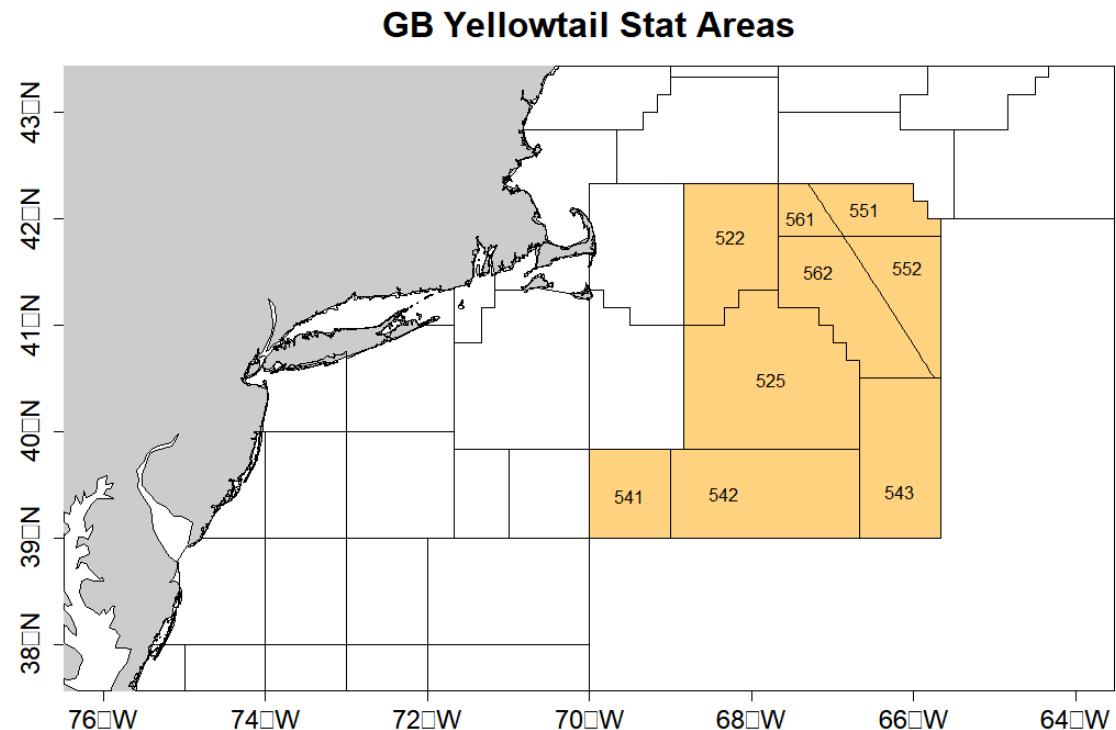


**Blocks: 1994, 2009**



# The plan

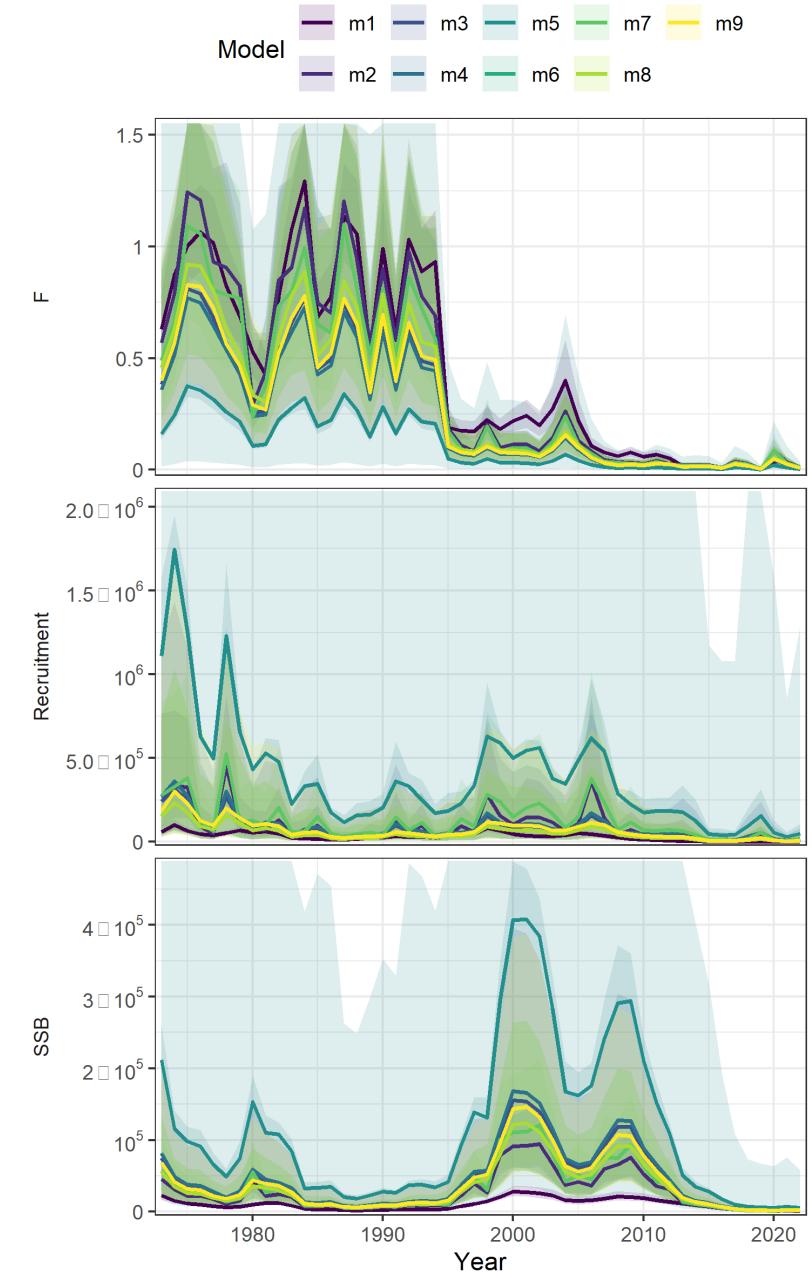
- Age comps → logistic-normal-pool0
- Recruitment → TBD
- Time varying selectivity → TBD
- Time varying survival
- Ecov on recruitment
- Time varying M
- Surveys



The **WHAM**  
cods sole assessment model

# Time varying survival

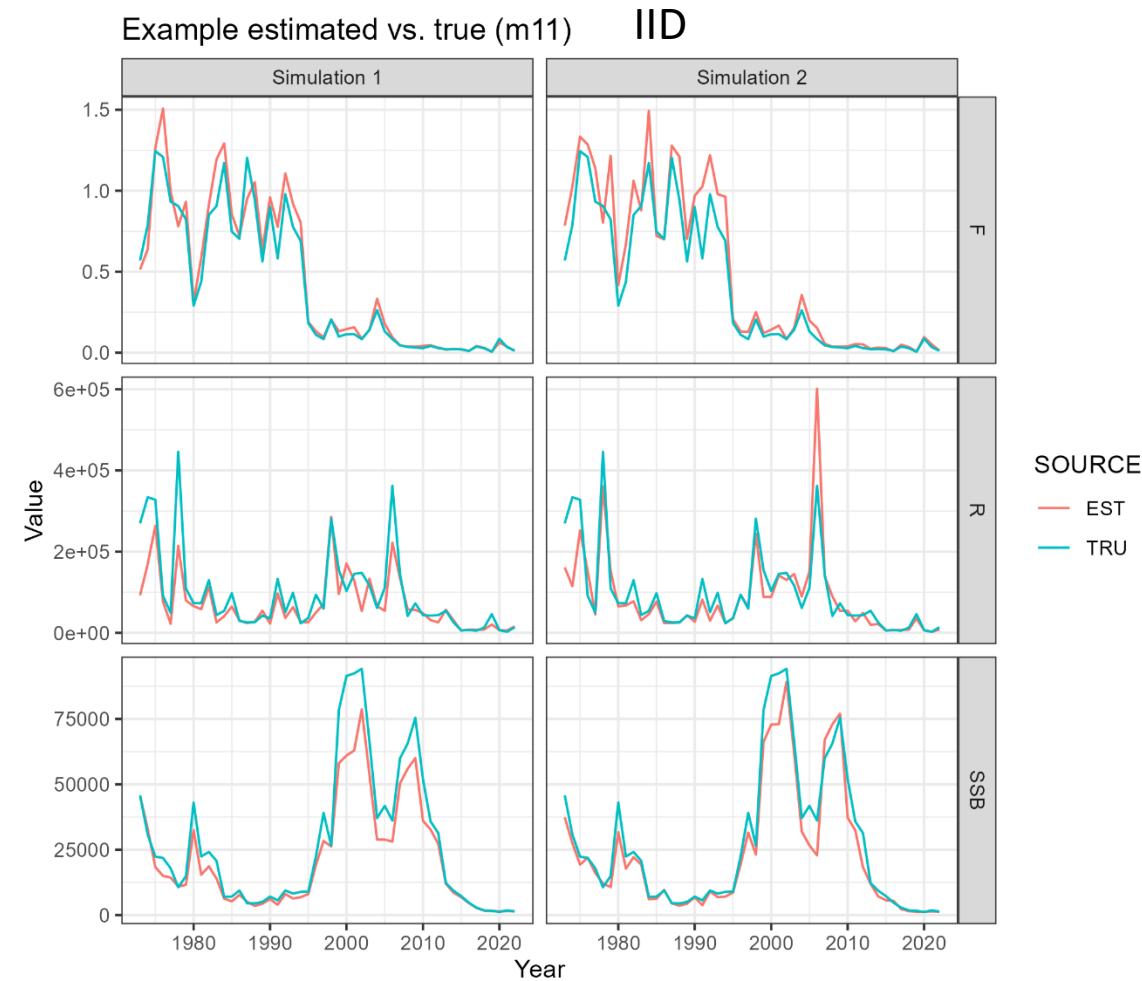
Model	RE		RE		dAIC	AIC	Rho R	Rho SSB	Rho Fbar
	Age-1	Age 2+							
m9	2dar1		0	-2117	0.209	-0.0987	0.1054		
m6	Ar1_y	Ar1_y	1.3	-2115.7	0.1975	-0.1106	0.1101		
m8	Ar1_y		1.3	-2115.7	0.1975	-0.1106	0.1101		
m5	Ar1_y	2dar1	19.2	-2097.8	0.4492	-0.0956	0.1254		
m3	Ar1_y	IID	46	-2071	0.346	-0.115	0.1151		
m4	AR1_y	Ar1_a	47.6	-2069.4	0.4121	-0.0977	0.0998		
m7	Ar1_a		97.2	-2019.8	0.9292	-0.0061	0.0024		
m2	IID		138.3	-1978.7	1.1715	0.0054	-0.0235		
m1	none	none	996.5	-1120.5	1.6481	0.3487	-0.2398		



# Time varying survival

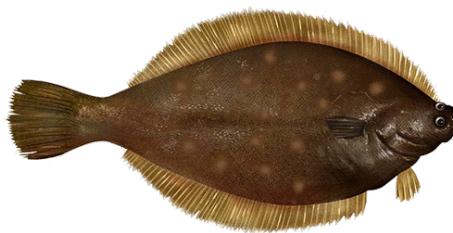
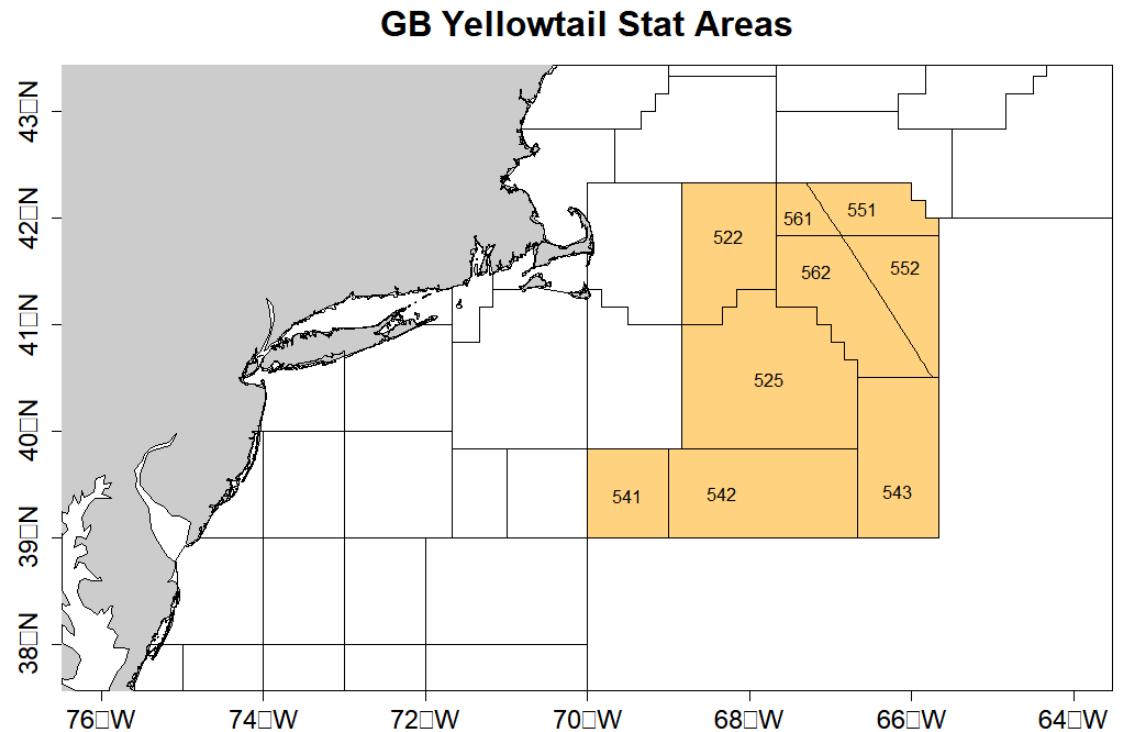
RE Age-1	RE Age 2+	F	R	SSB	Mean bias
IID		17.3	-9.36	-14.56	13.7
Ar1_y	Ar1_y	27.96	-0.06	-15.39	14.5
Ar1_y	IID	28.24	-0.1	-15.53	14.6
Ar1_y	Ar1_a	34.56	-13.55	-18.42	22.2
Ar1_a		30.57	-16.32	-21.42	22.8
2dar1		35.91	-11.98	-21.55	23.1
AR1_y	Ar1_a	40.07	-19.87	-22.46	27.5
Ar1_y	2dar1	106.01	-37.17	-37.36	60.2

100 simulations for each model run



# The plan

- Age comps → logistic-normal-pool0
- Recruitment → TBD
- Time varying selectivity → TBD
- Time varying survival → 2dar1, Ar1\_y, IID
- Ecov on recruitment
- Time varying M
- Surveys
- Final three



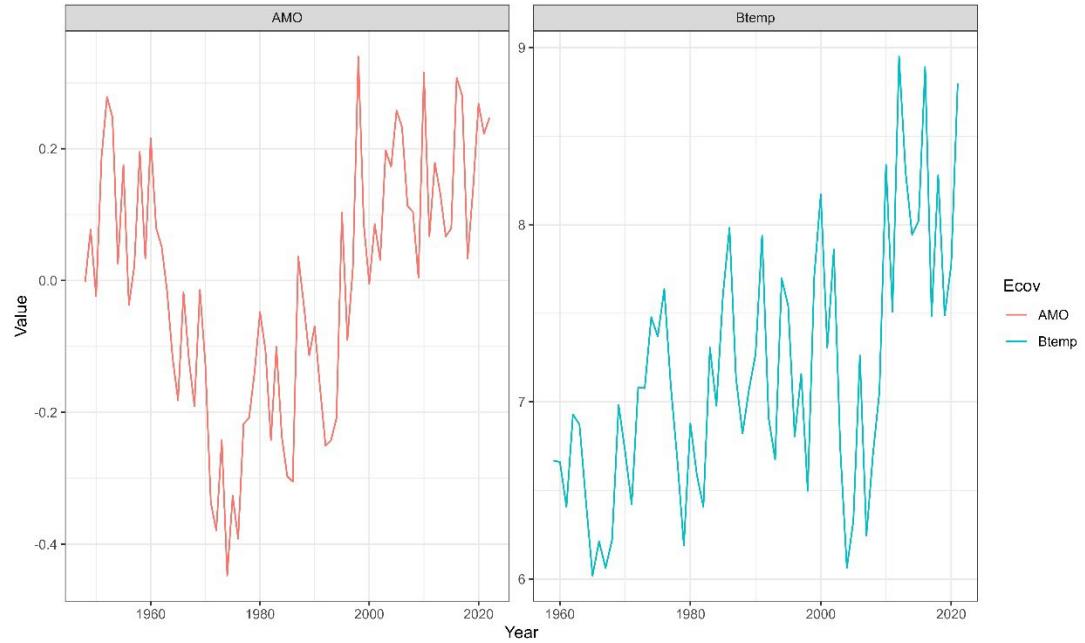
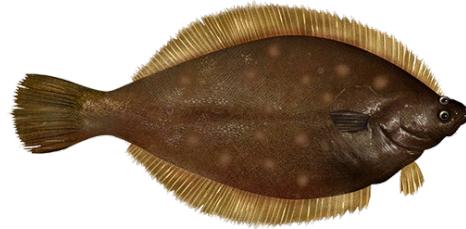
The **WHAM**  
stocks  
age  
assessment  
model

# ToR 1: Recommendations for GB

- Recruitment deviations informed by lagged bottom temperature or AMO
  - Hypothesis: declines in recruitment are due to increases in water temperature
- Annual deviations in M informed by temperature or AMO
  - Hypothesis: declines in SSB are due to increased natural mortality
- Annual changes to survey catchability informed by depth or temperature
  - Hypothesis: availability to the surveys has changed because fish have moved deeper

# Ecov on recruitment

- ToR 1 recommendations to explore the effect of:
  - AMO
  - Bottom temp
- Explore these for top models with RE on NAA:
  - 2dar1
  - Ar1y (coupled and decoupled)
  - IID



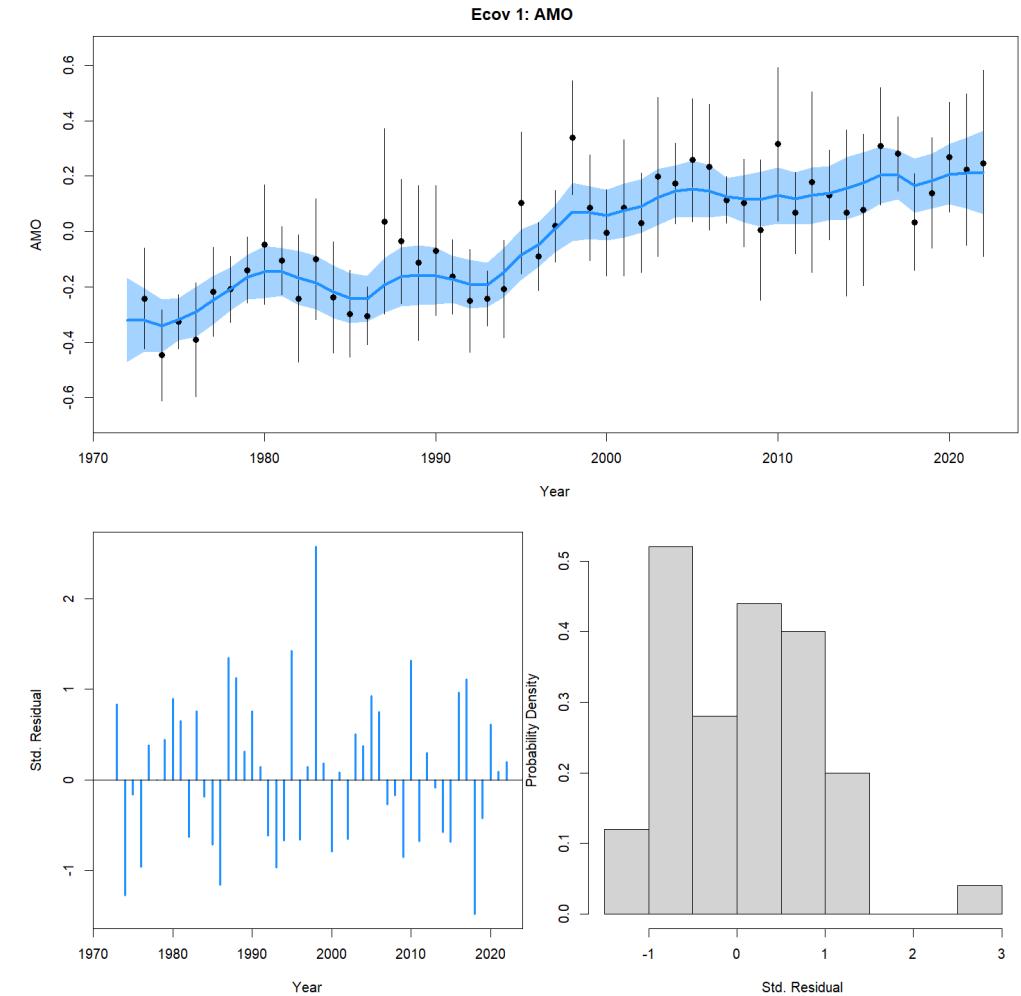
**Controlling:** Density independent mortality

**Limiting:** Ecov determines the amount of suitable habitat

# IID process error on NAA & AMO

Rec	Ecov process	Ecov how	conv	daic	rho R	rho SSB	rho Fbar
Random	rw	none	TRUE	38.7	1.1715	0.0054	-0.0235
Random	rw	Controlling	TRUE	31.3	1.0686	0.0036	-0.0193
Random	ar1	Controlling	TRUE	36.3	1.1547	0.0065	-0.0227
Bev-Holt	rw	none	TRUE	11.6	0.813	0.0188	-0.0303
Bev-Holt	rw	Controlling	TRUE	0.7	0.3504	-0.0162	0.0097
Bev-Holt	rw	Limiting	TRUE	0	0.0829	-0.0385	0.0227
Bev-Holt	ar1	Controlling	TRUE	5.5	0.4362	-0.014	0.0084
Bev-Holt	ar1	Limiting	TRUE	5	0.7276	-0.0028	-0.0057

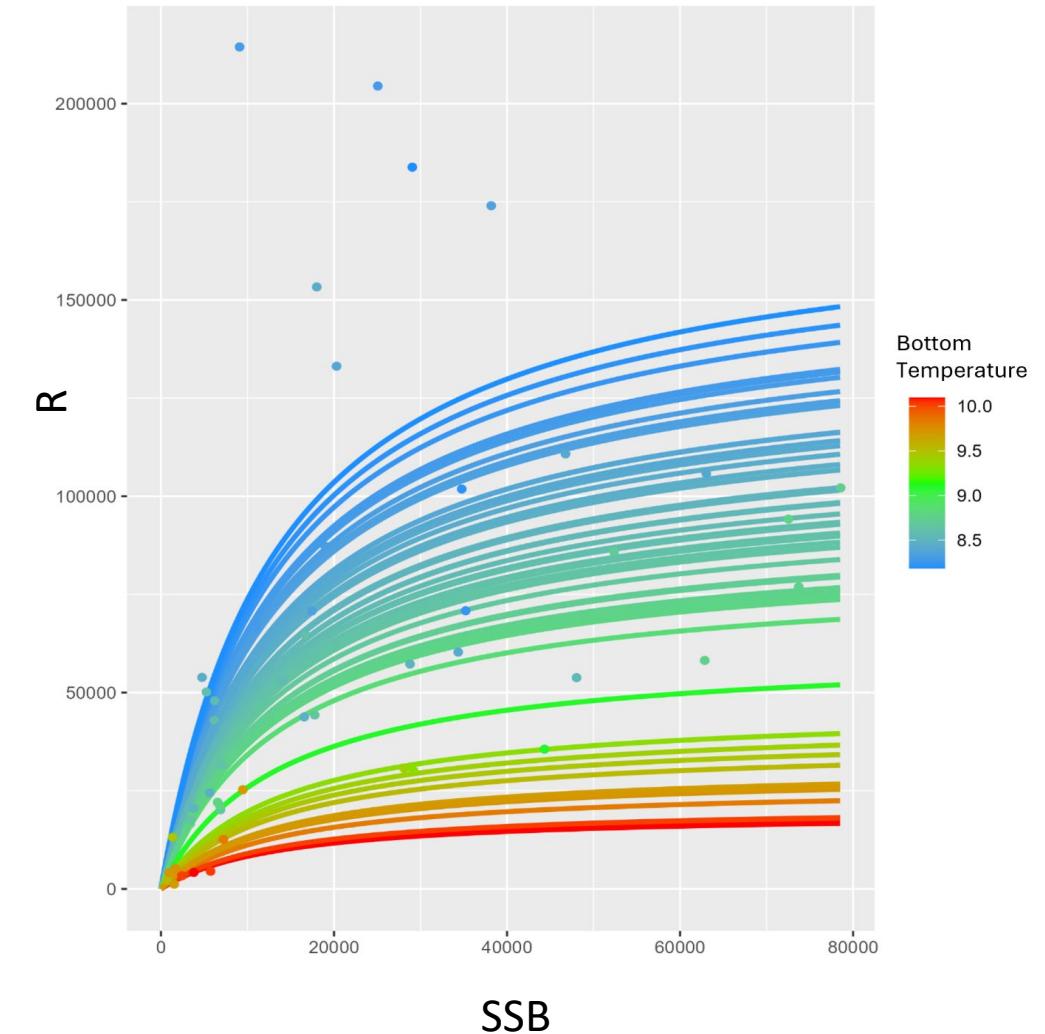
32 different model runs



# IID process error on NAA & bottom temp

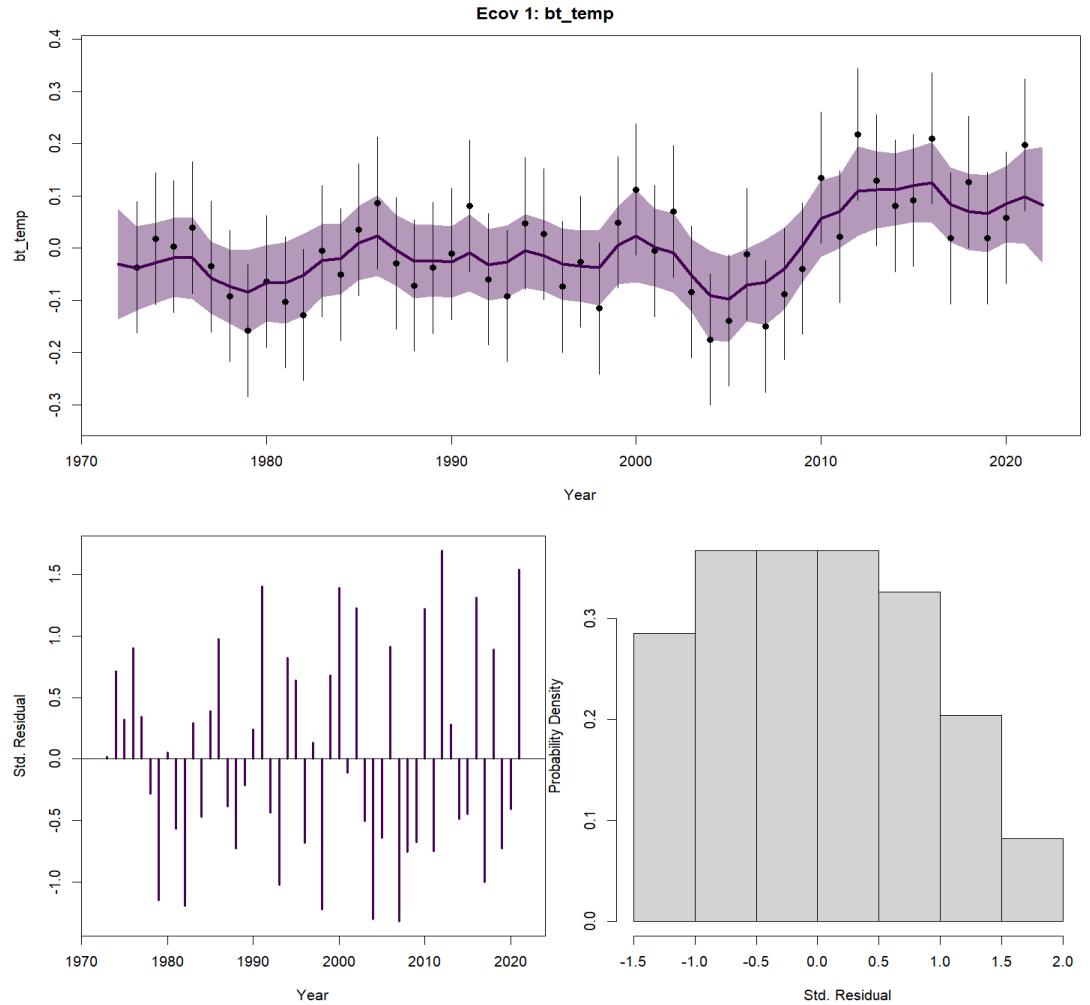
Rec	Ecov process	Ecov how	conv	dAIC	Rho R	Rho SSB	Rho Fbar
Random	rw	none	TRUE	46.6	1.4796	0.0616	-0.0772
Random	rw	controlling	TRUE	8.1	0.7004	0.0414	-0.0531
Random	ar1	controlling	TRUE	12	0.827	0.0452	-0.0576
Bev-Holt	rw	none	TRUE	20.1	1.09851	0.0779	-0.088
Bev-Holt	rw	controlling	TRUE	0.2	0.4168	0.0237	-0.033
Bev-Holt	rw	limiting	TRUE	0	0.7653	0.0361	-0.0383
Bev-Holt	ar1	controlling	TRUE	2.4	0.5025	0.0296	-0.0394
Bev-Holt	ar1	limiting	TRUE	5.2	0.9536	0.0387	-0.0411

32 different model runs



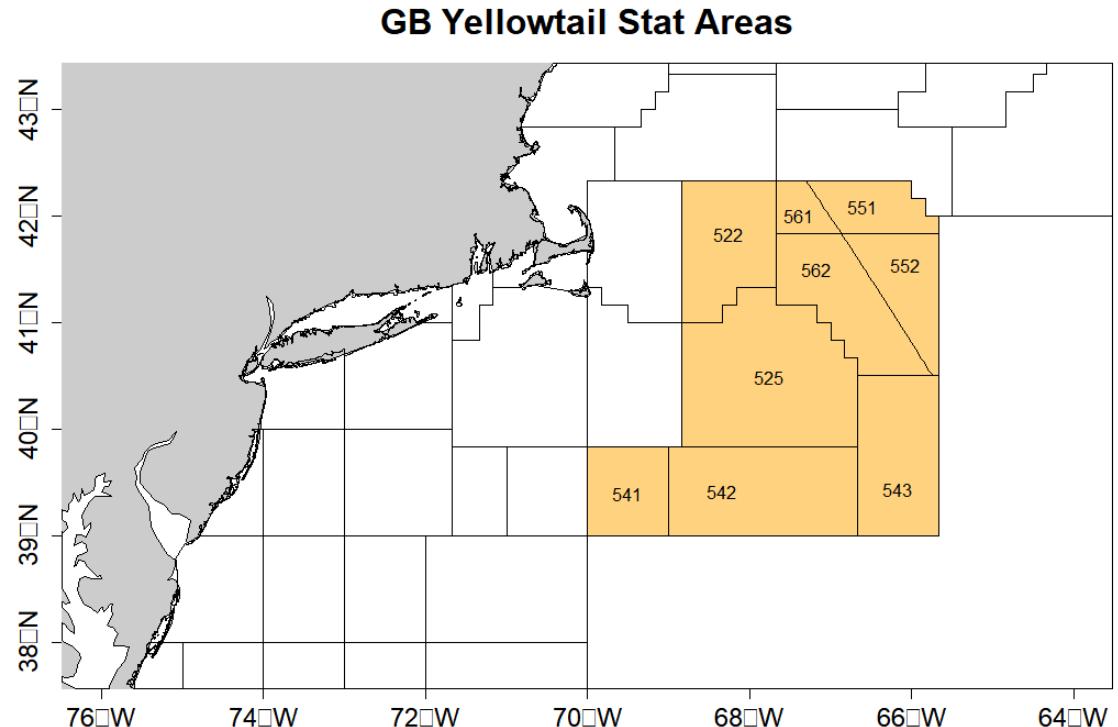
# Ecov on recruitment summary

- Environmental covariates were robust to different process errors
- Model selection:
  - Supported including covariates
  - Supported Beverton-Holt stock recruit relationship
- Models had good fits to the environmental covariates
- Environmental covariates improved retrospective patterns in recruitment
- Takeaways:
  - **Bottom temperature** was selected
  - IID on NAA



# The plan

- Age comps → logistic-normal-pool0
- Recruitment → TBD
- Time varying selectivity → TBD
- Time varying survival → 2dar1, Ar1\_y, IID
- Ecov on recruitment → Bottom temp
- Time varying M
- Surveys
- Proposed model

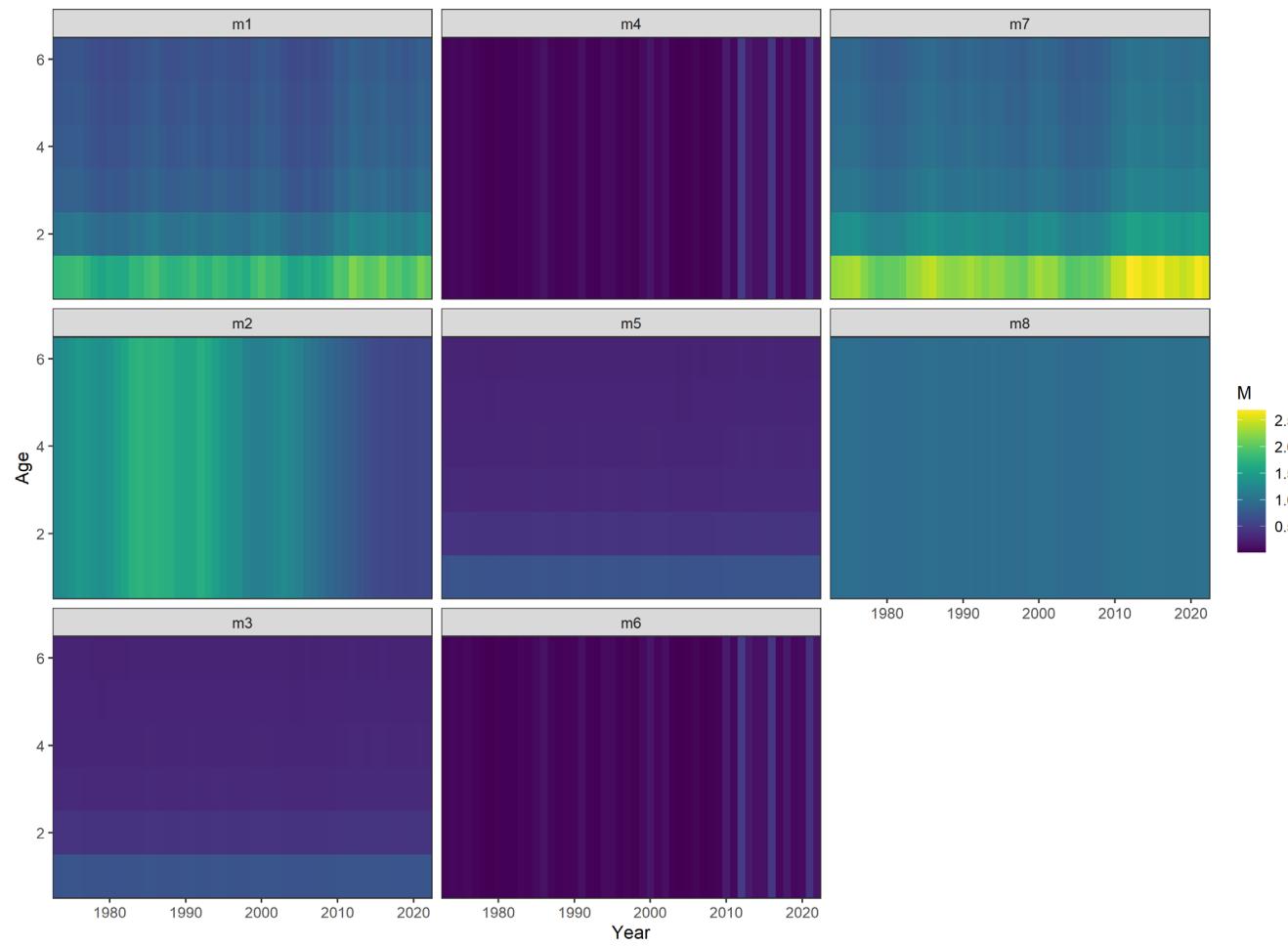
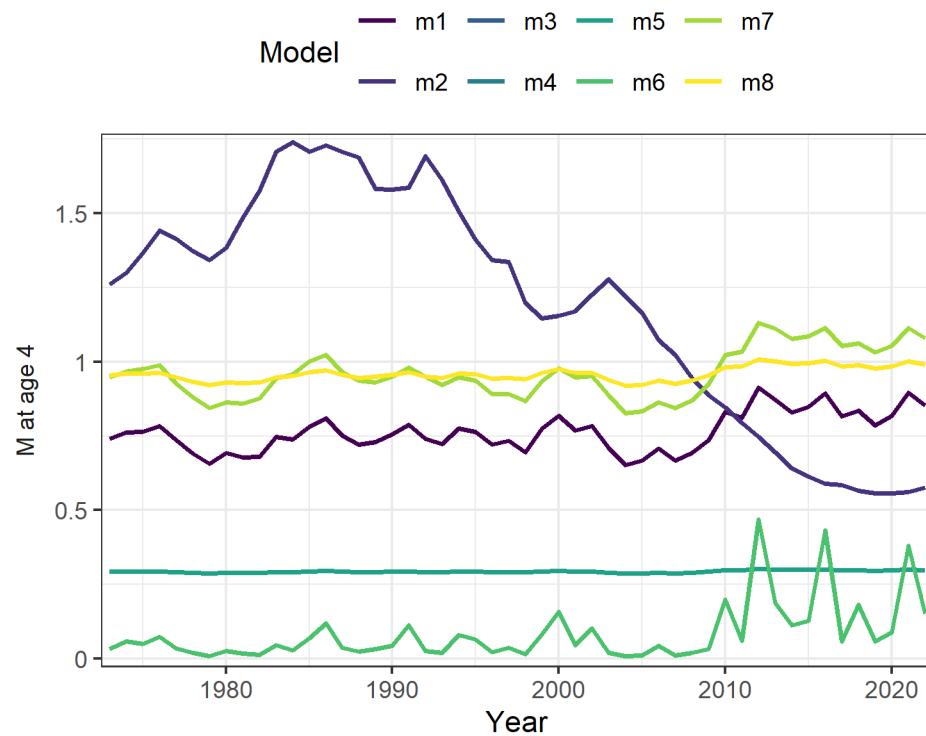


The **WHAM**  
stocks  
age  
assessment  
model

# Natural mortality

- 1: Estimate age based
- 2 & 3: Estimate linear relationship with ecov
- 4 & 5: Estimate but non-linear relationship with ecov
- 6: Age specific (Cadrin, 2024)
- 7: Weight at age (Lorenzen 1996; Miller and Hyun 2018)
- 8: Constant (0.4; Cadrin, 2024)
- 9: Constant but time varying (ar1\_y)
- 10: Age specific but time varying (2dar1)
- 11 & 12: Constant but linear relationship with ecov
- 13: Constant but non-linear relationship with ecov
- 14: Estimate M (2dar1)

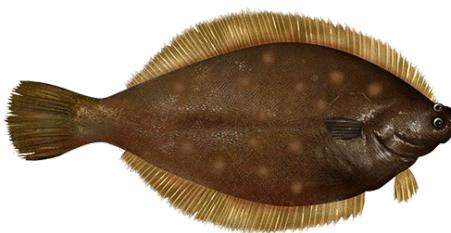
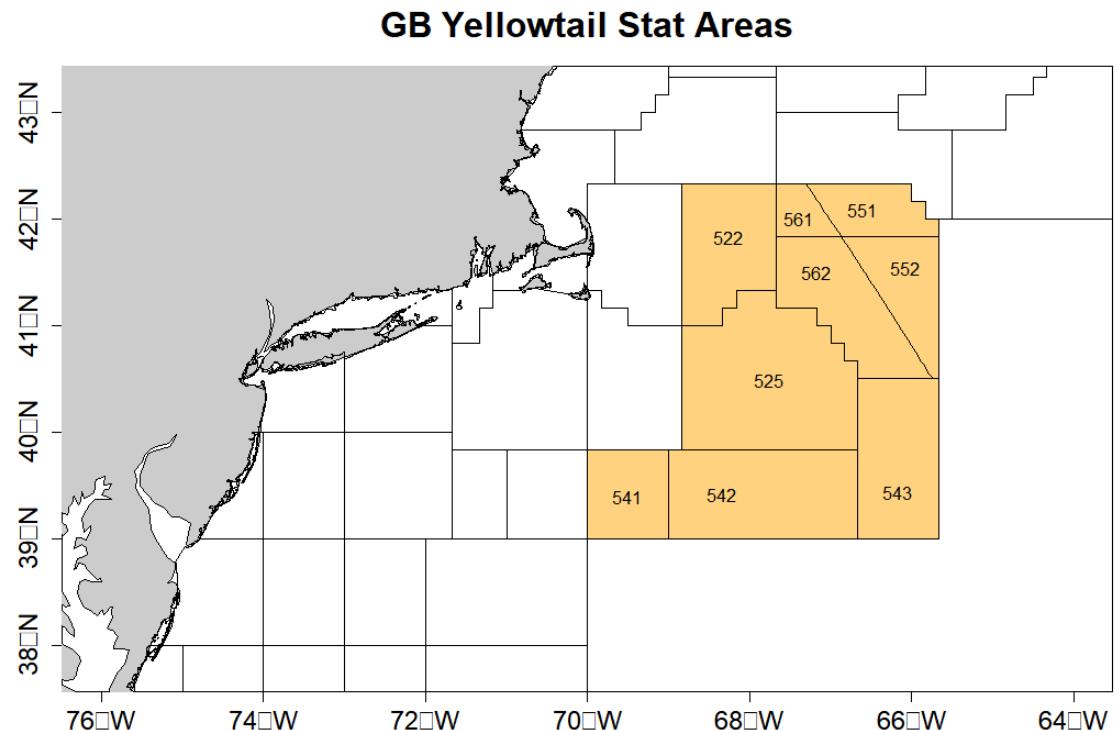
# Bottom temp



M1 = 2dar1 age, M2 = 2dar1 constant, M3 = ar1\_y age, M4 = ar1\_y constant, M5 = ar1\_y D age, M6 = ar1\_y D constant, M7 = IID age, M8 = IID constant,

# The plan

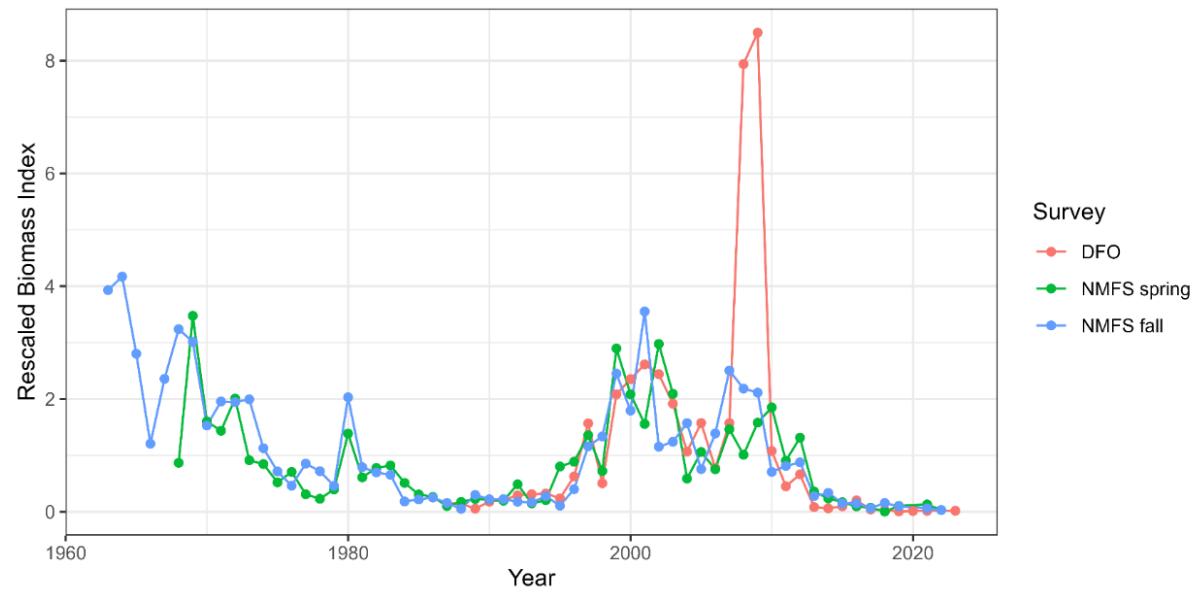
- Age comps → logistic-normal-pool0
- Recruitment → TBD
- Time varying selectivity → TBD
- Time varying survival → 2dar1, Ar1\_y, IID
- Ecov on recruitment → Bottom temp
- Time varying M → Constant (0.4)
- Surveys
- Proposed model



The **WHAM**  
stocks  
age  
assessment  
model

# Time varying catchability

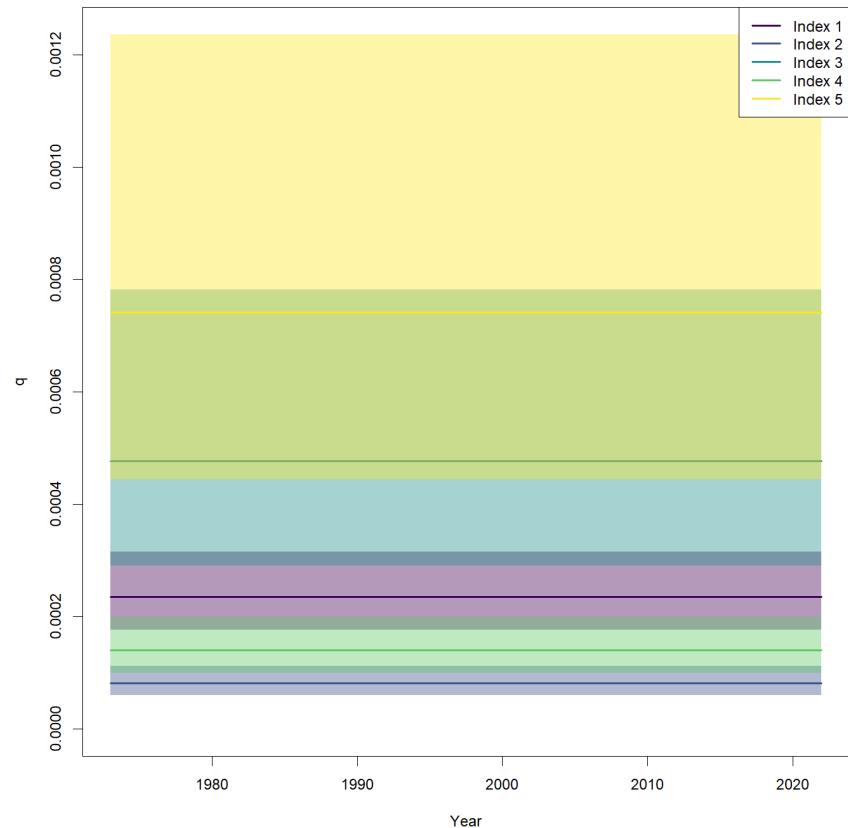
- Used to account for changes in availability to the survey
- Hypothesis: Spatial shifts have occurred and fish are no longer as available to the survey (e.g., shifted deeper).



# Albatross & Bigelow split

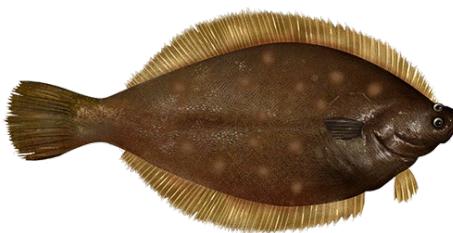
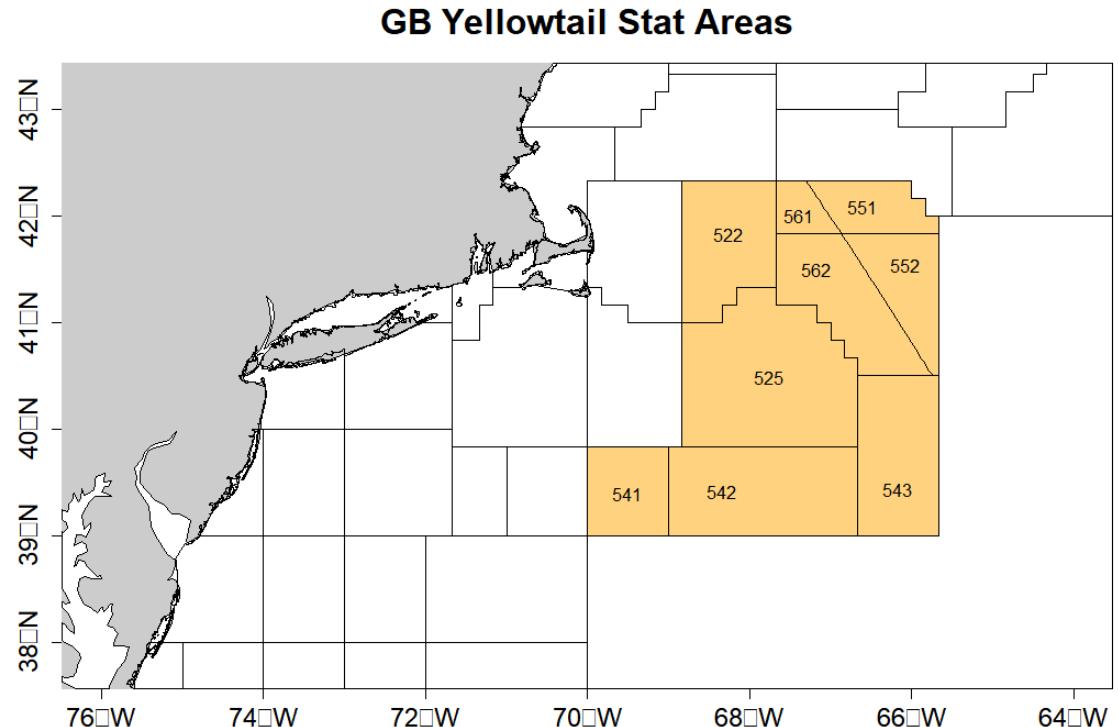
- Struggled with convergence
  - Remove RE on NAA
  - Change age-comps
- Did not improve diagnostics
- Random effects on q:
  - Did not demonstrate a clear breakpoint

Index 1 = DFO  
 Index 2 = Alb Spring  
 Index 3 = Big Spring  
 Index 4 = Alb Fall  
 Index 5 = Big Fall



# The plan

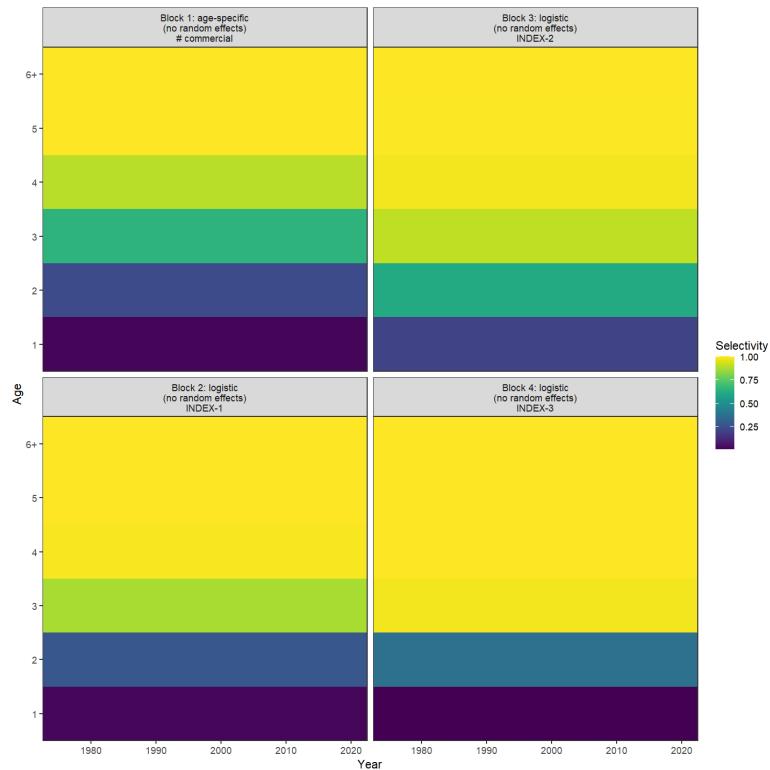
- Age comps → logistic-normal-pool0
- Recruitment → TBD
- Time varying selectivity → TBD
- Time varying survival → 2dar1, Ar1\_y, IID
- Ecov on recruitment → Bottom temp
- Time varying M → Constant (0.4)
- Surveys → Calibrated
- Proposed model



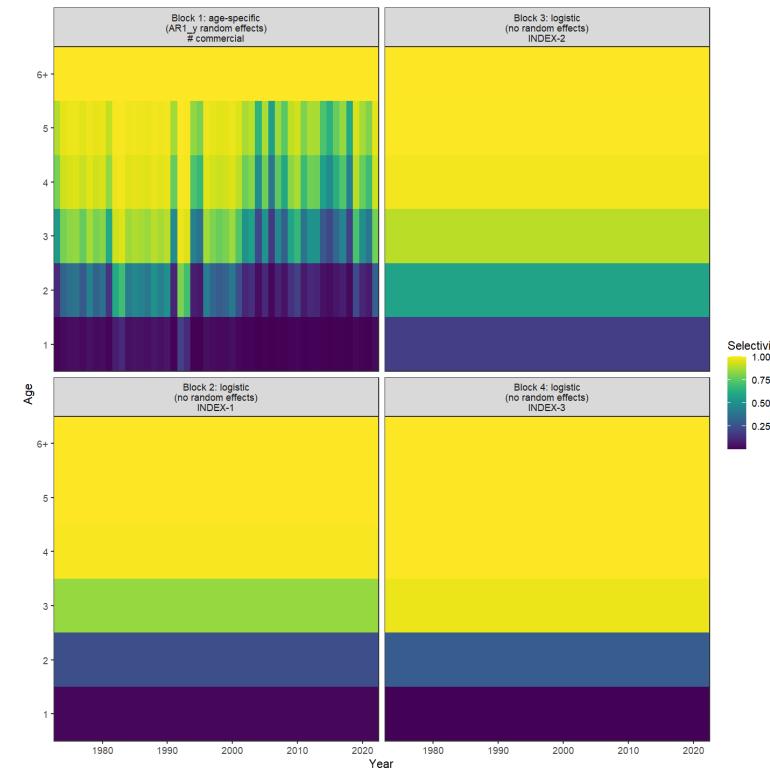
The **WHAM**  
stocks  
cole  
assessme  
odel

# Revisit commercial selectivity

**Constant**

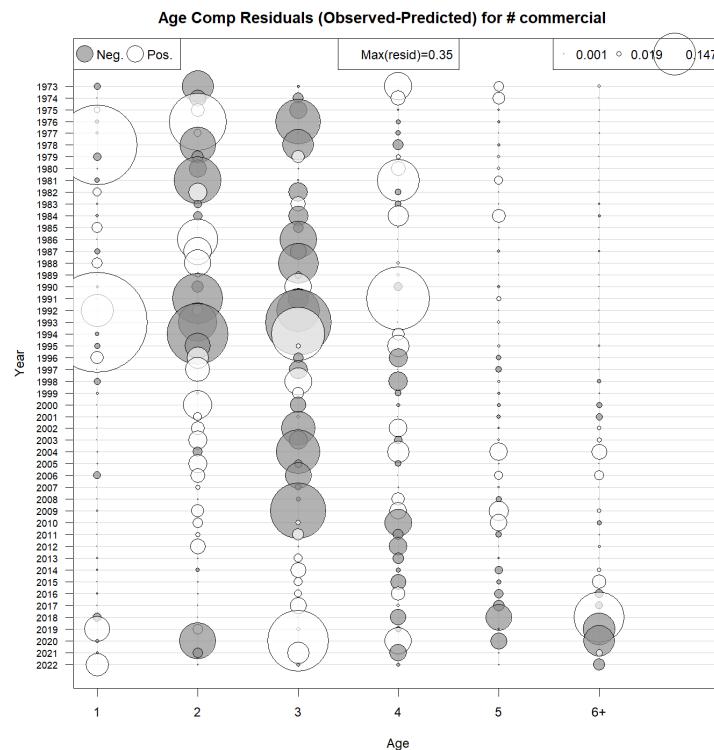


**Ar1\_y**

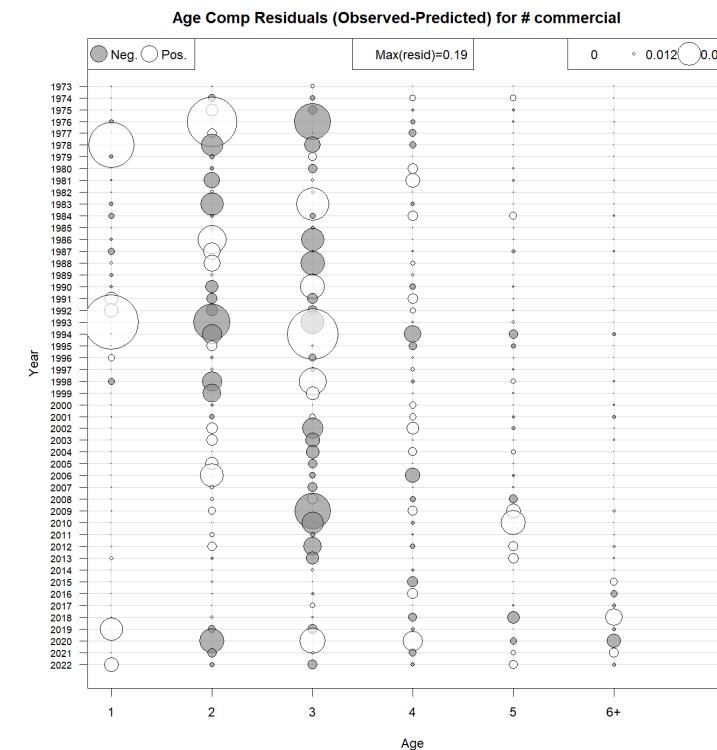


# Revisit commercial selectivity

Constant

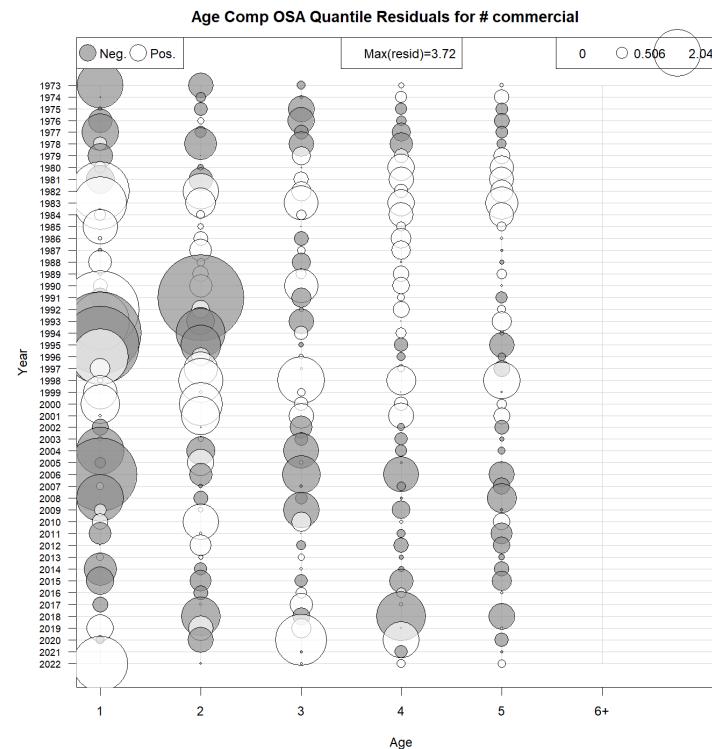


AR1\_y

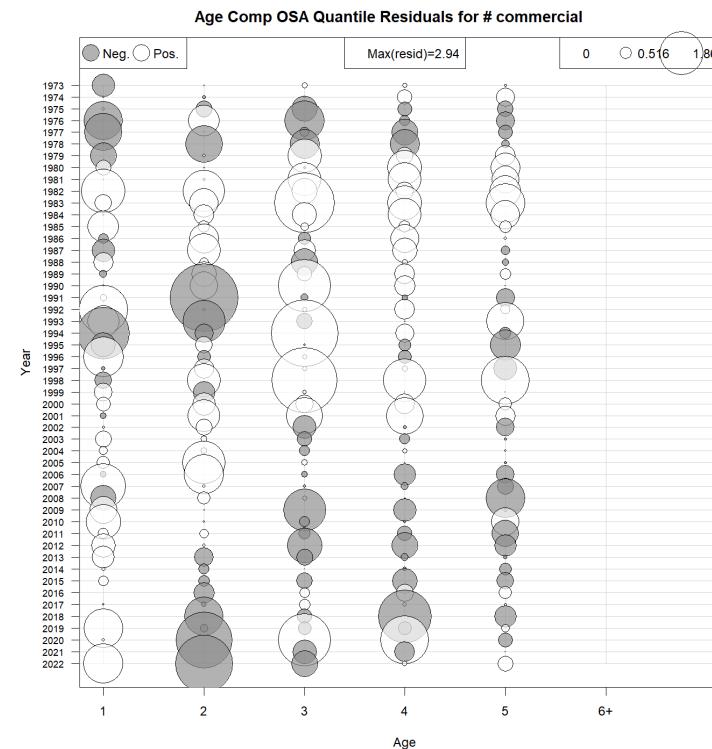


# Revisit commercial selectivity

Constant

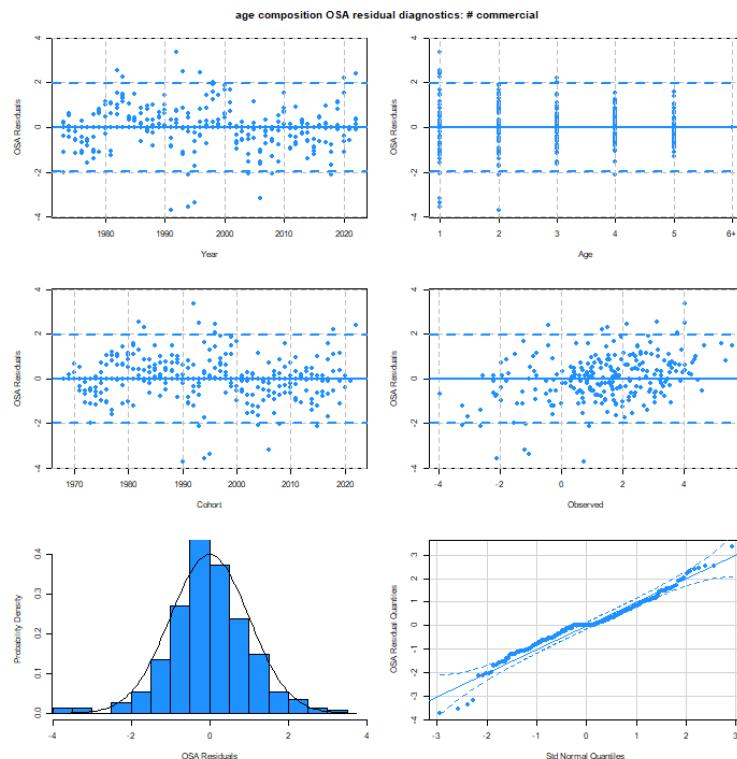


AR1\_y

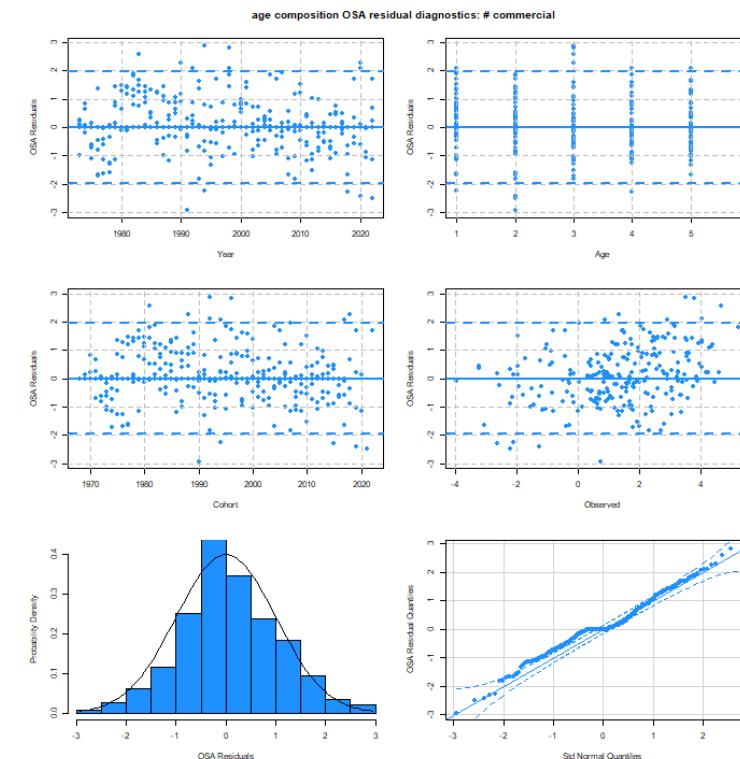


# Revisit commercial selectivity

Constant



AR1\_y



# Proposed model

## Data

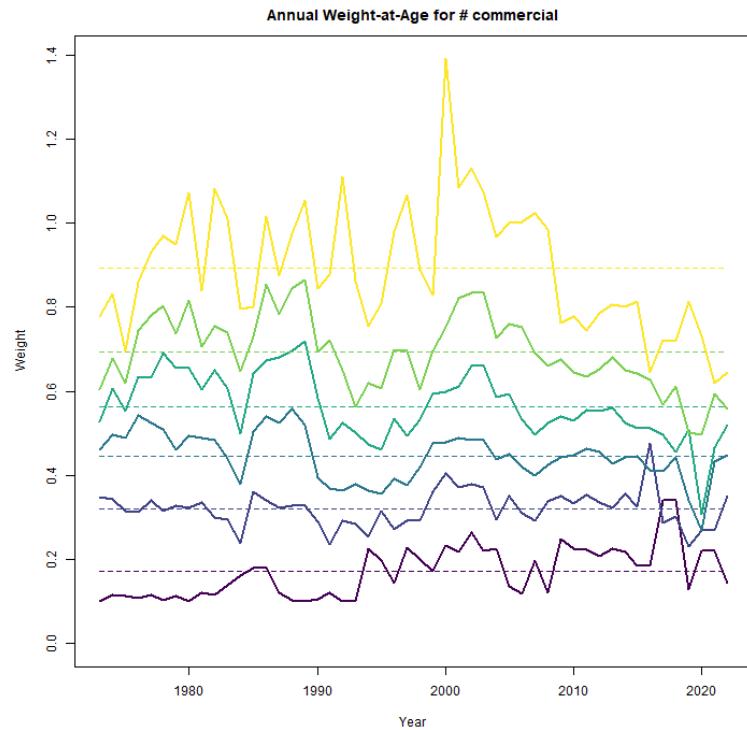
- Combined commercial fleet
- Surveys
  - NEFSC spring
  - NEFSC fall
  - DFO
- WAA is time varying
- Maturity is constant

## WHAM

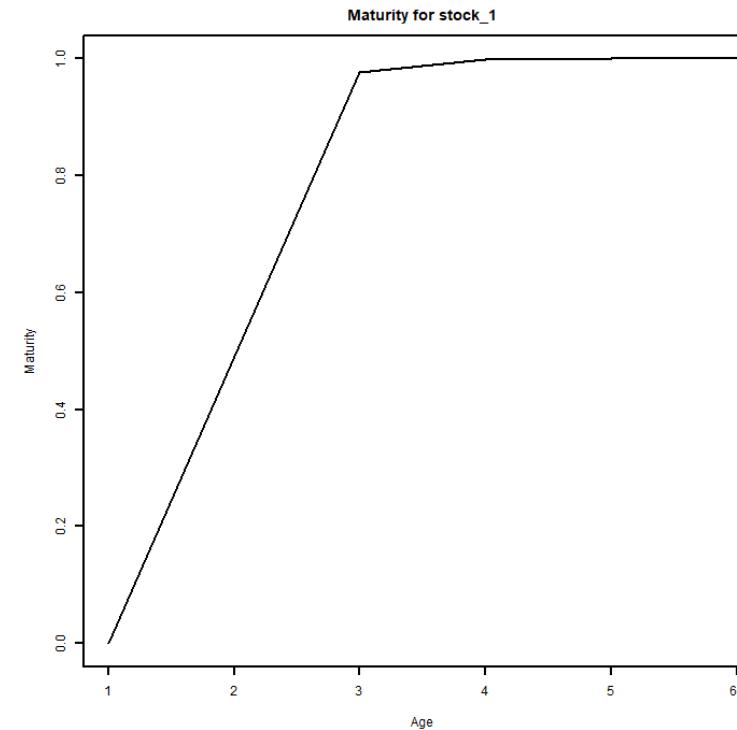
- Age comps:
  - Logistic-normal-pool0
- Commercial selectivity:
  - ar1\_y
- RE NAA:
  - IID
- Ecov:
  - Bottom temp on SR (ar1)

# Inputs

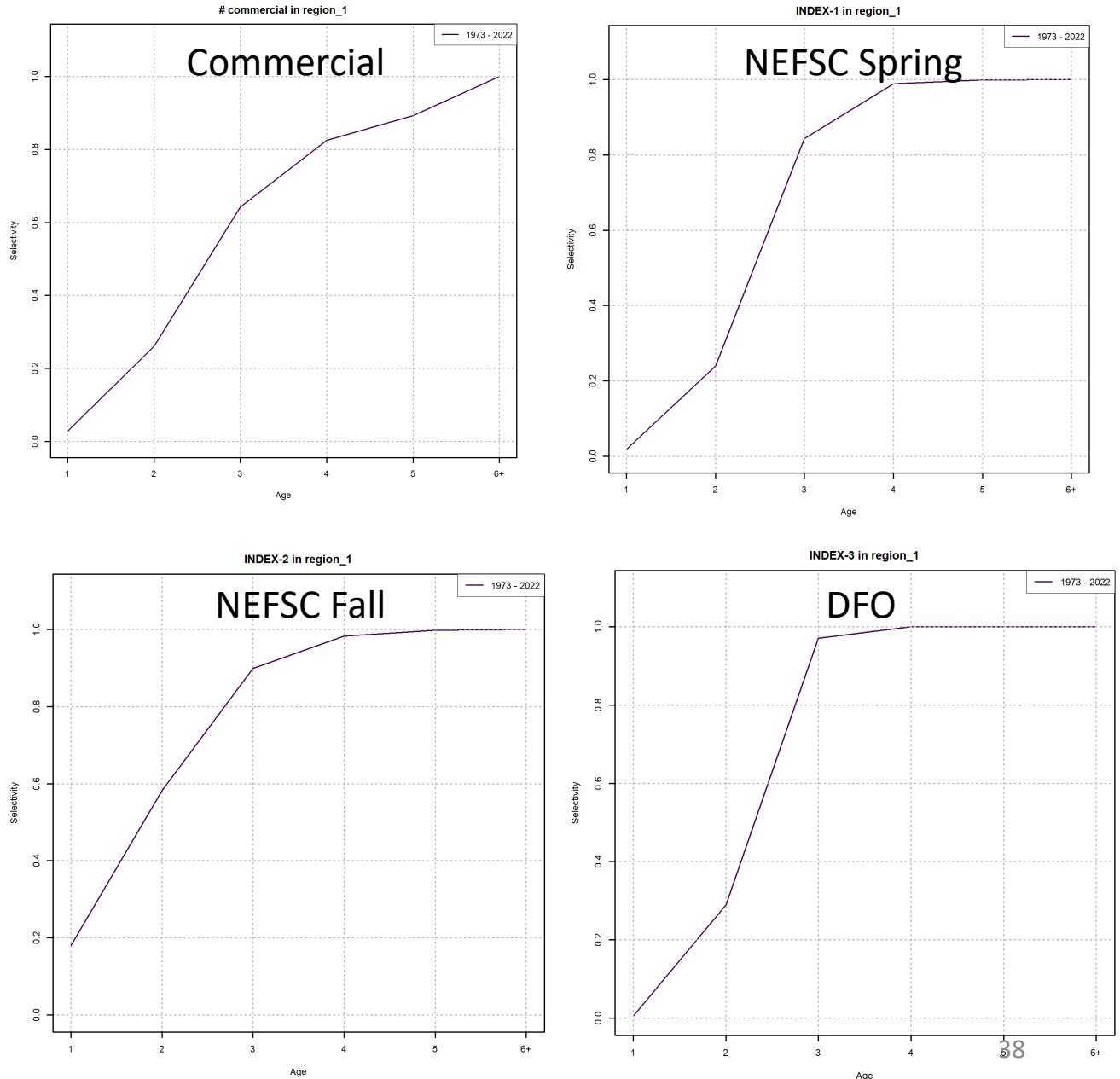
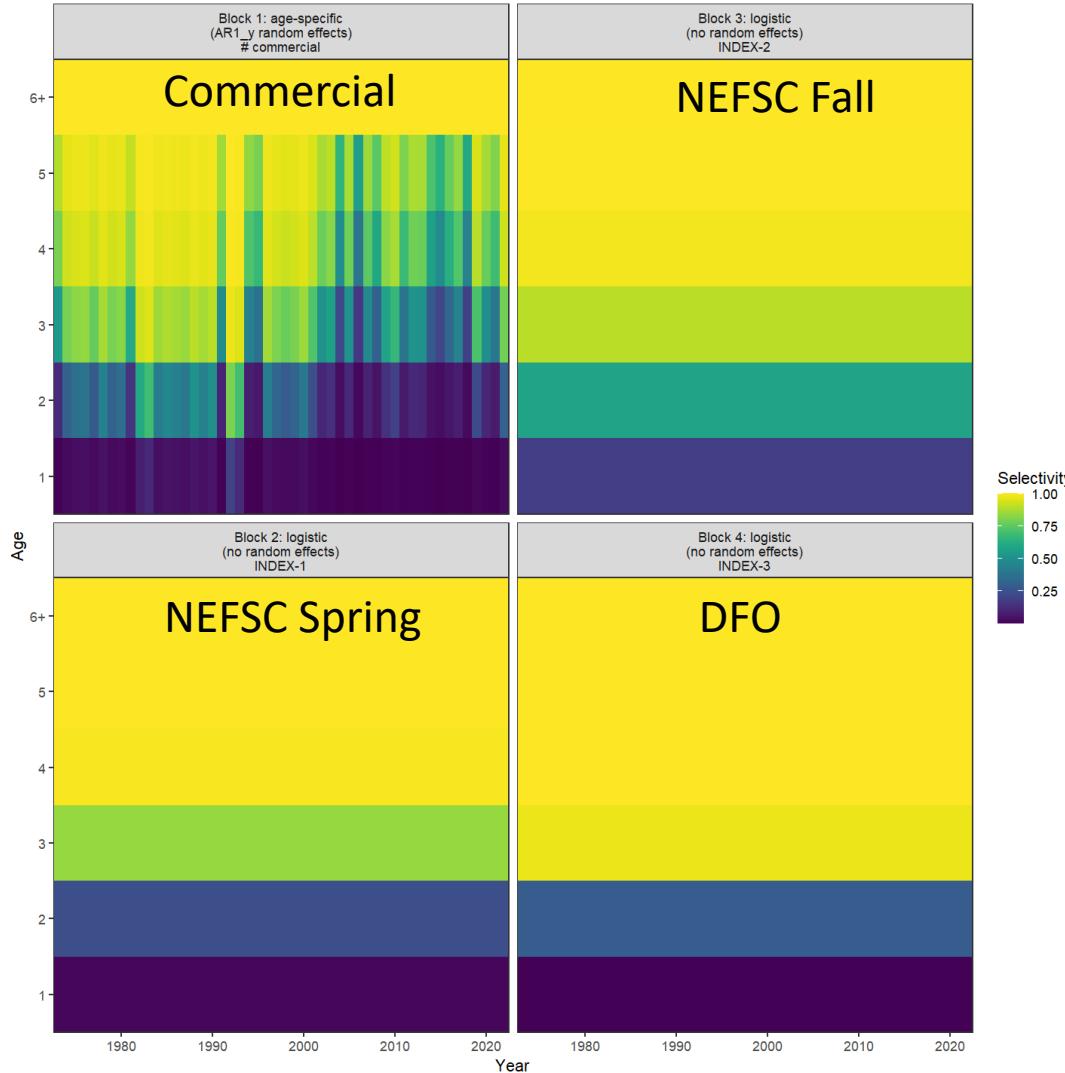
## Weights at age



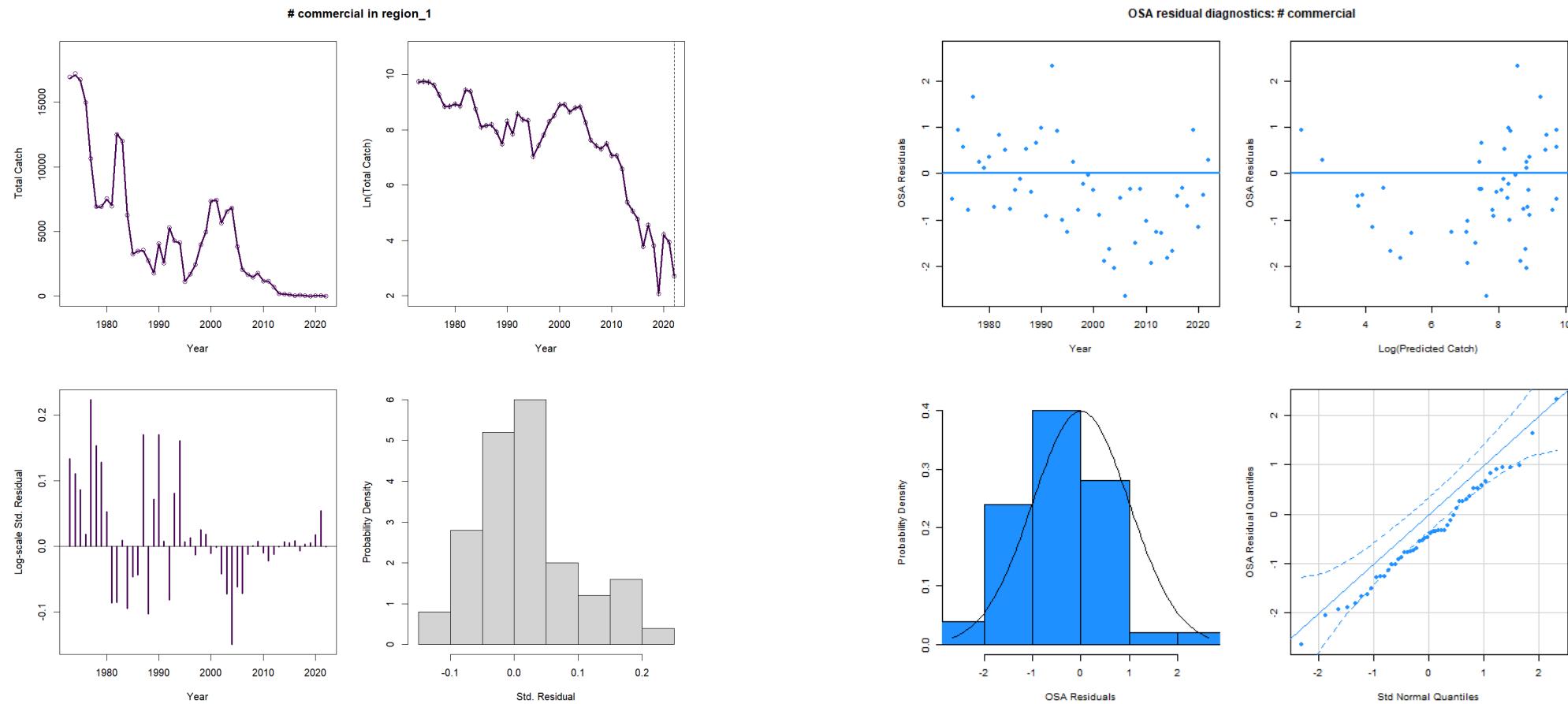
## Maturity



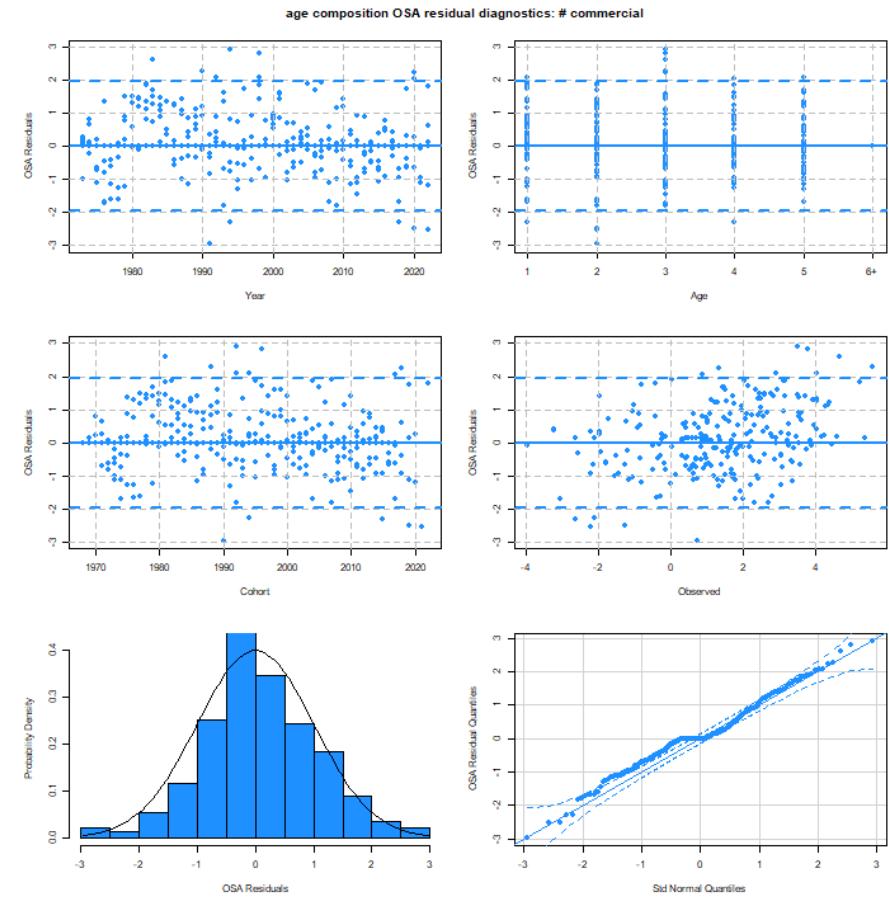
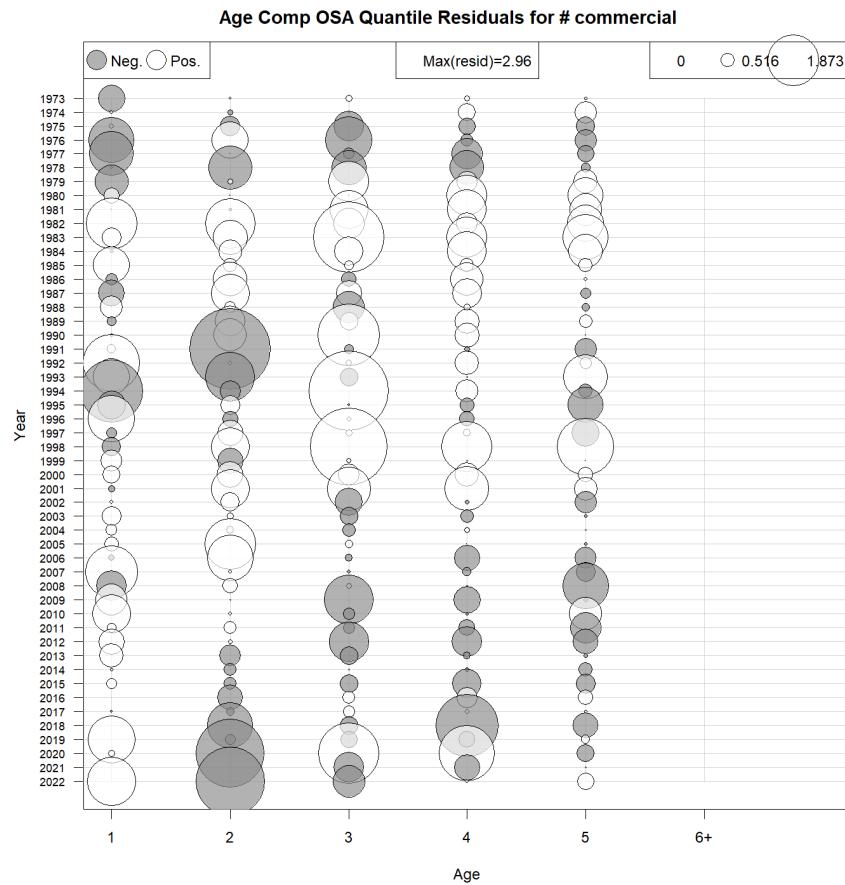
# Selectivity



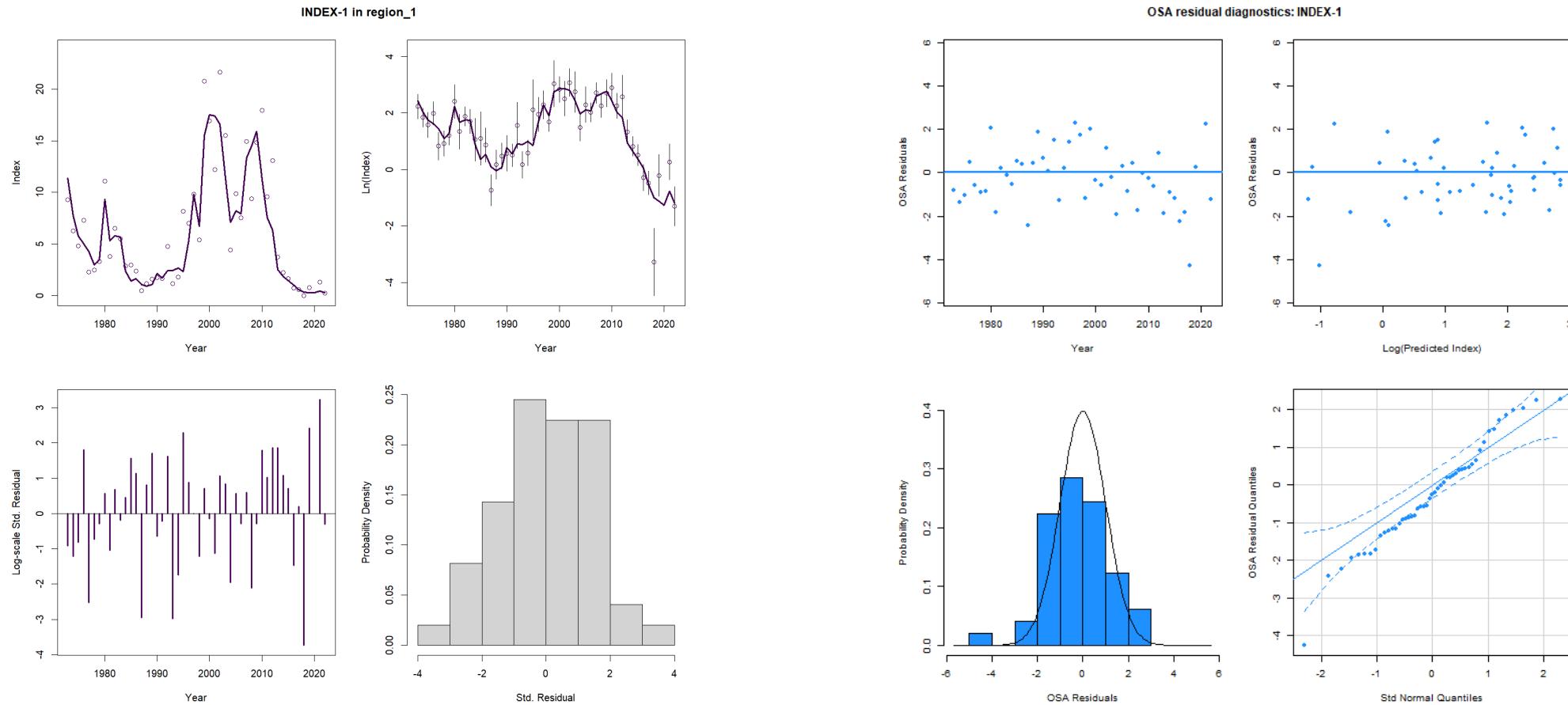
# Fit to commercial catch



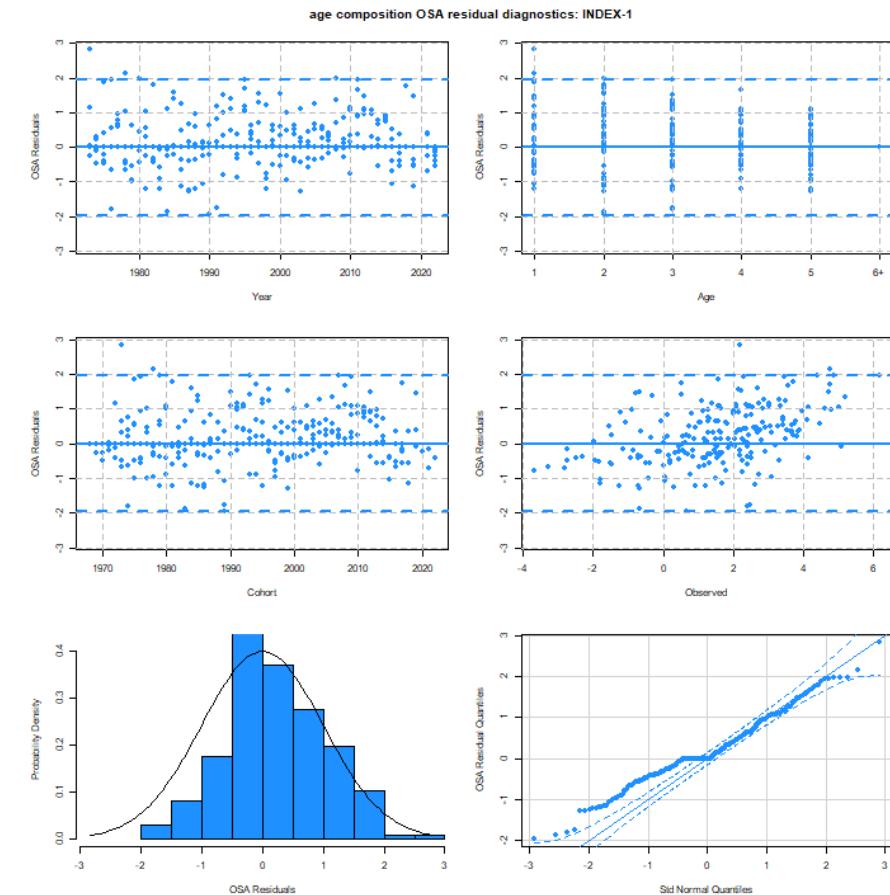
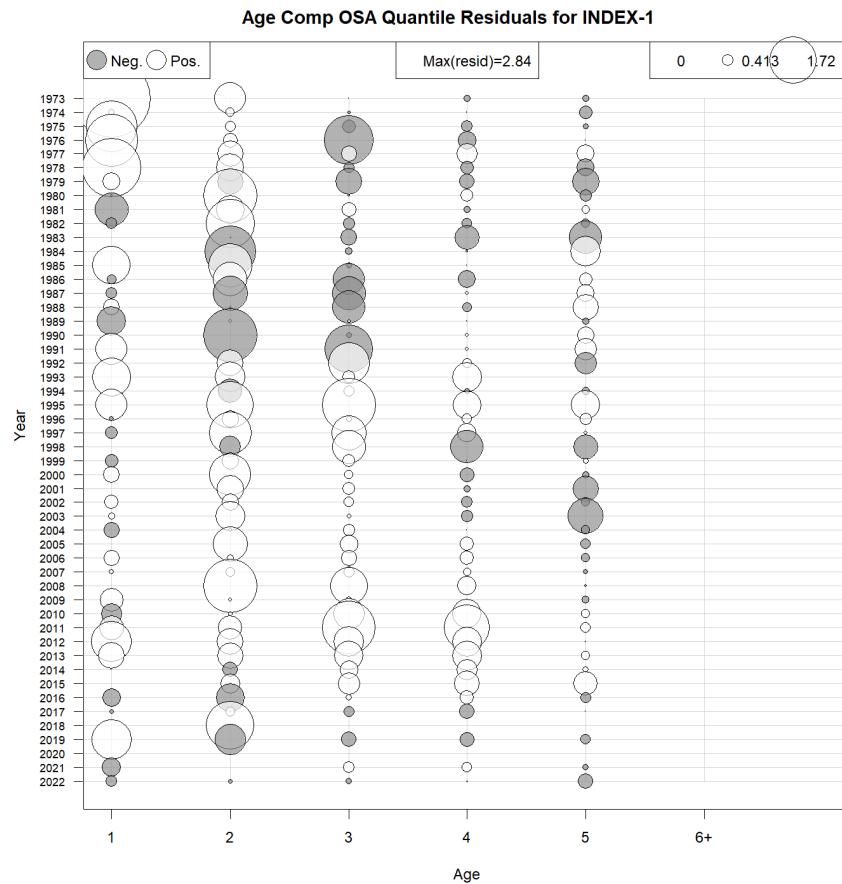
# Commercial OSA age comps



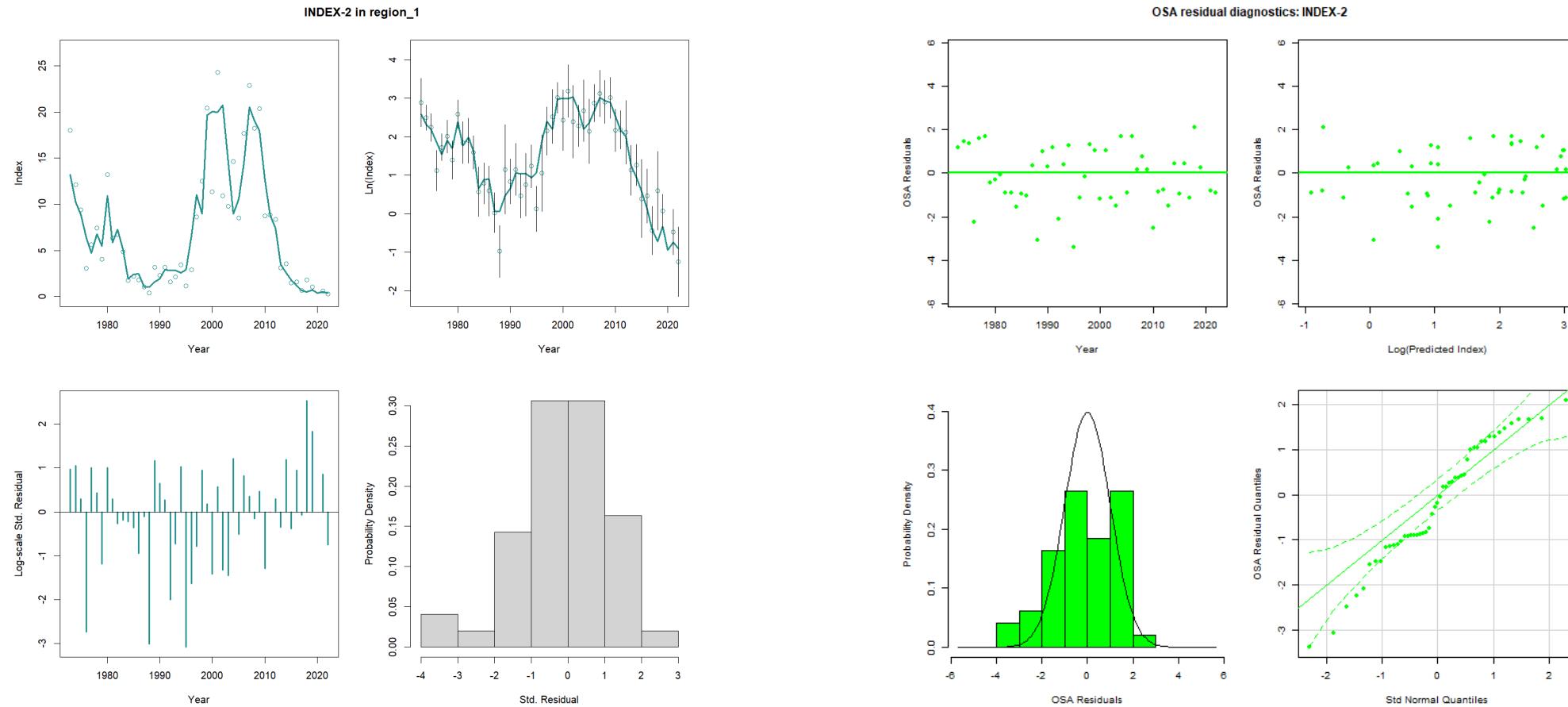
# Fit to the NEFSC spring survey



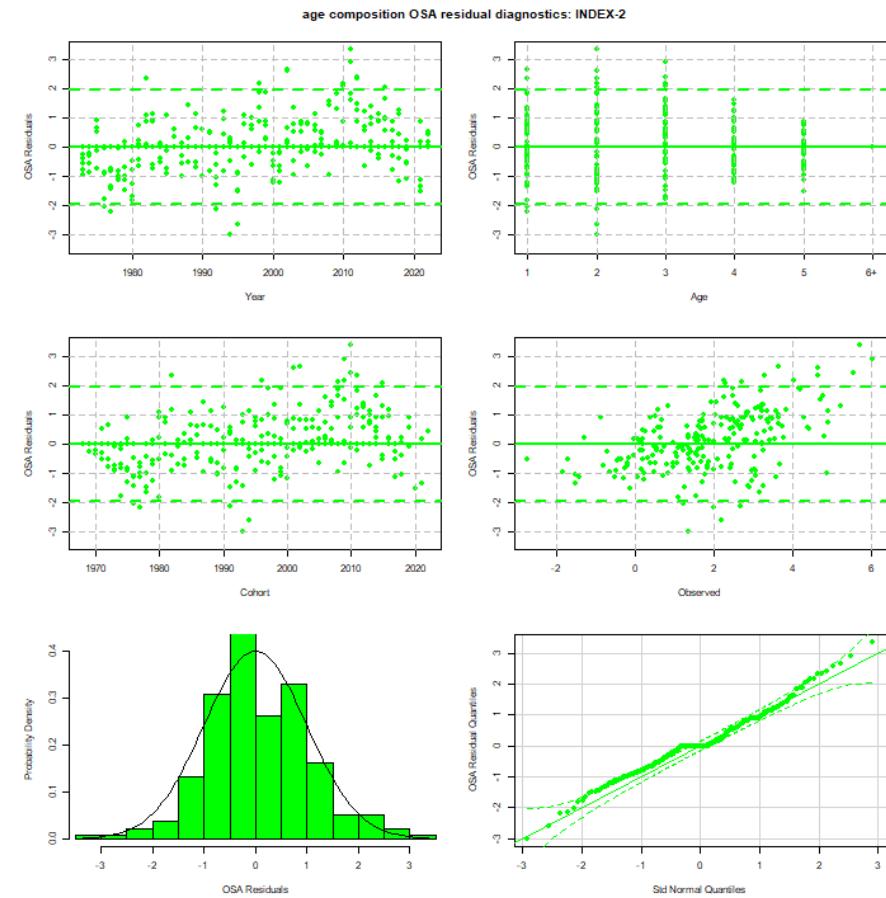
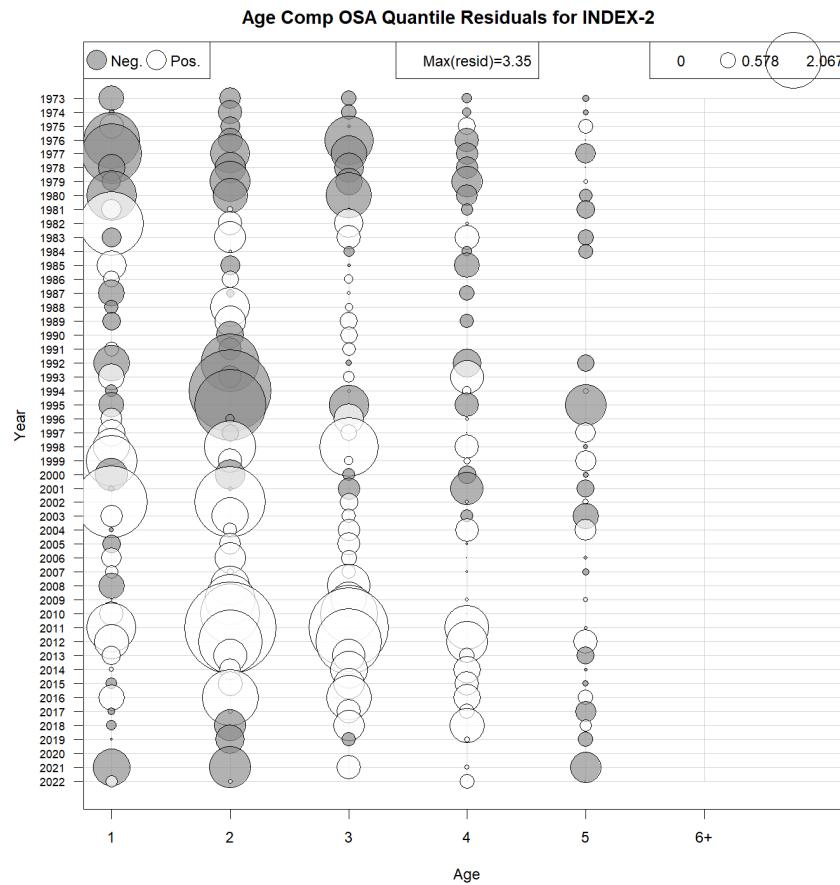
# NEFSC spring OSA age comps



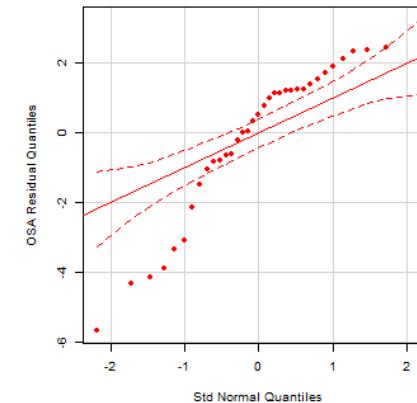
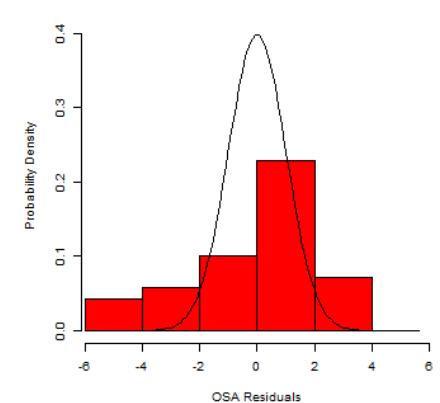
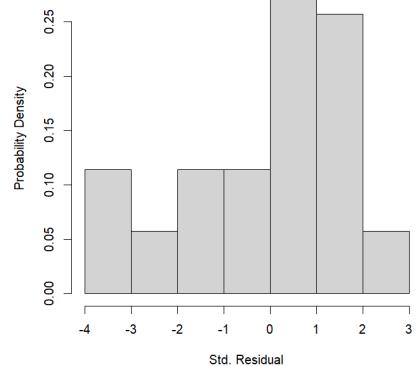
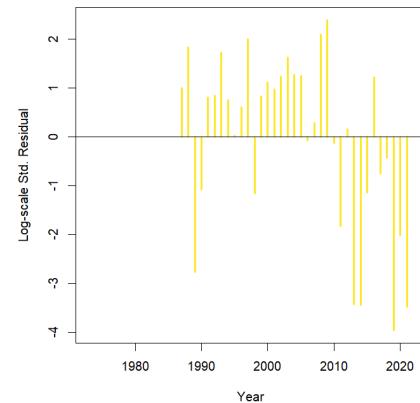
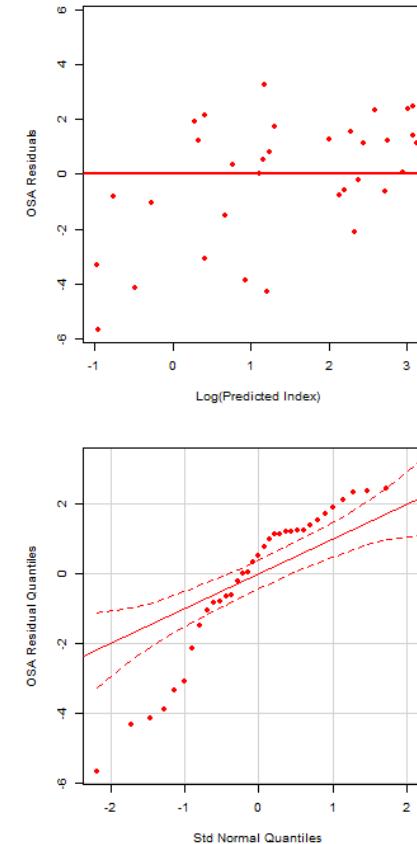
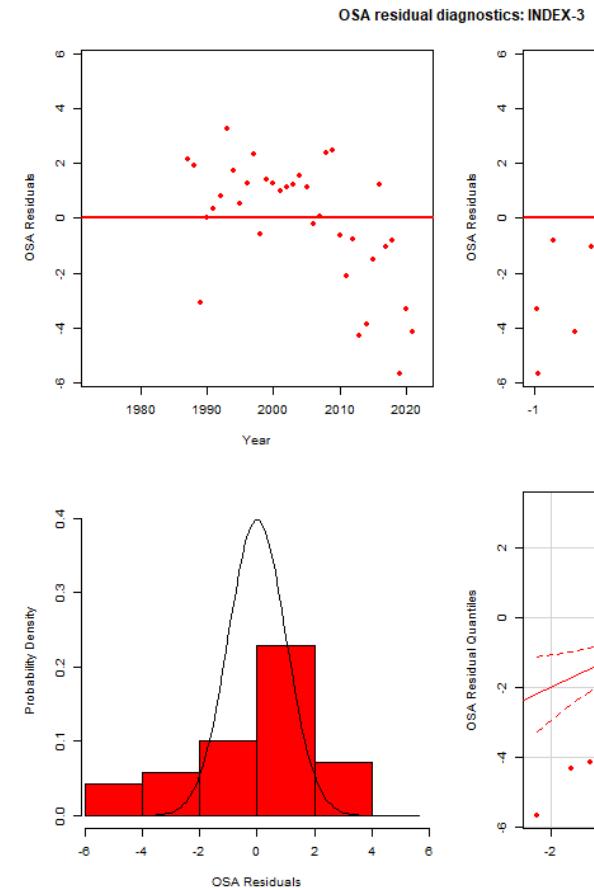
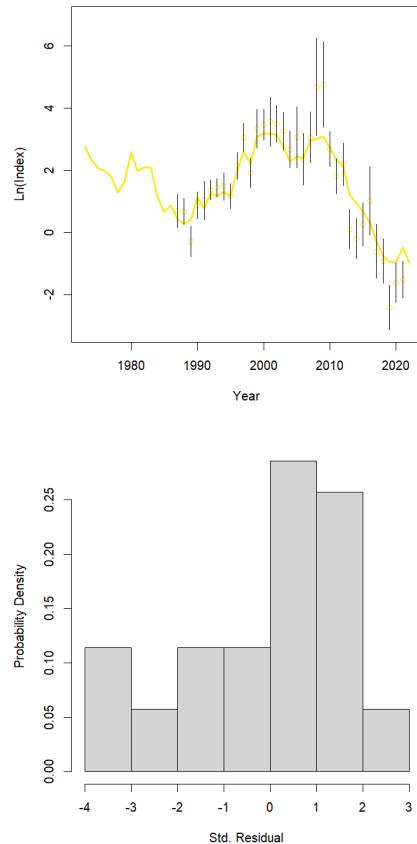
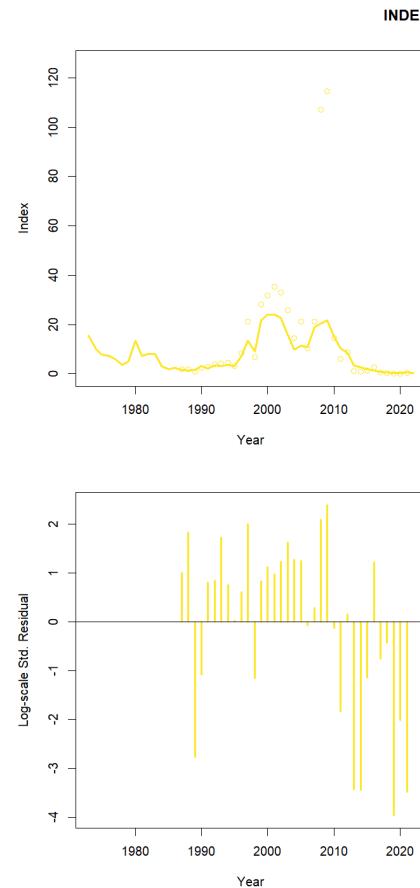
# Fit to the NEFSC fall survey



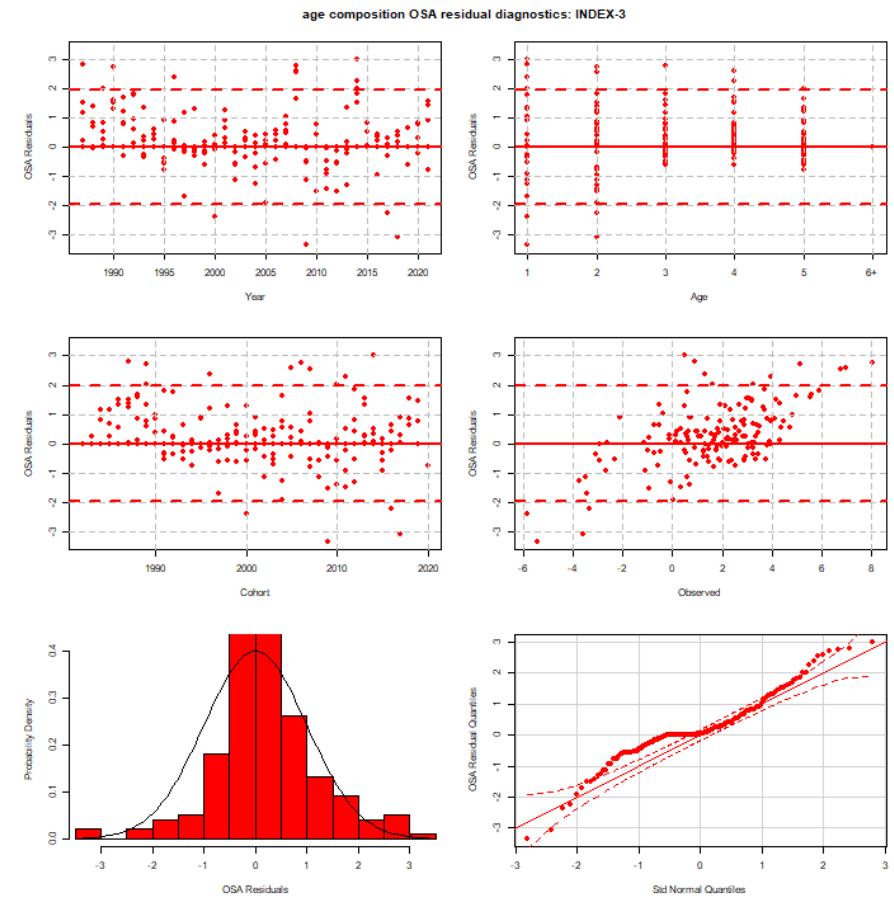
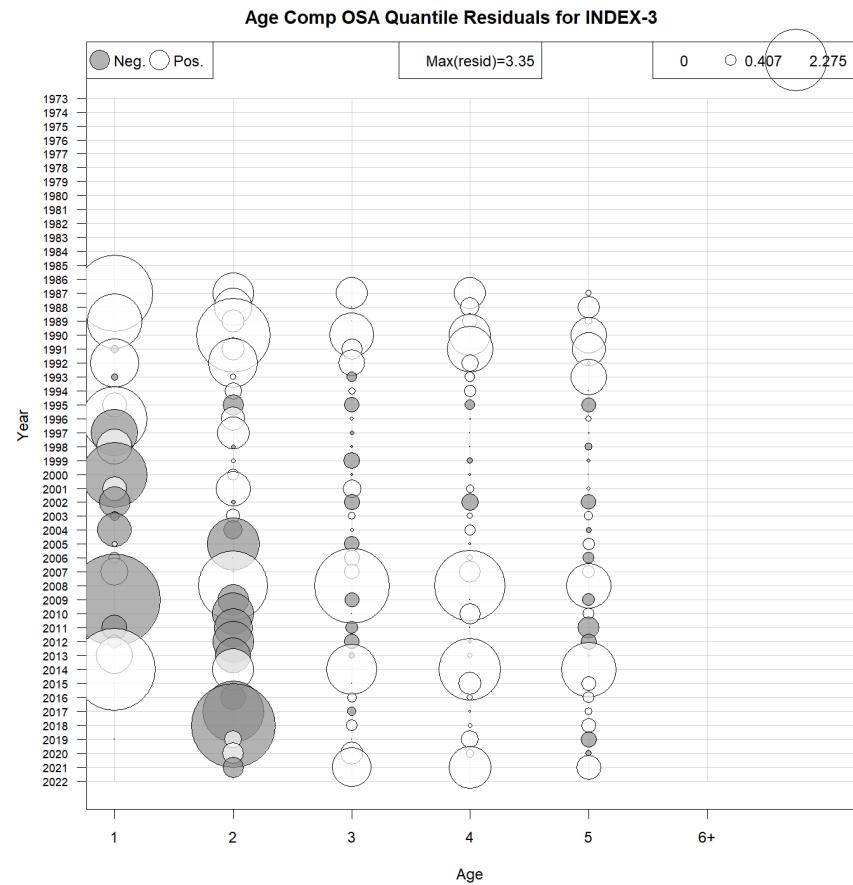
# NEFSC spring OSA fall comps



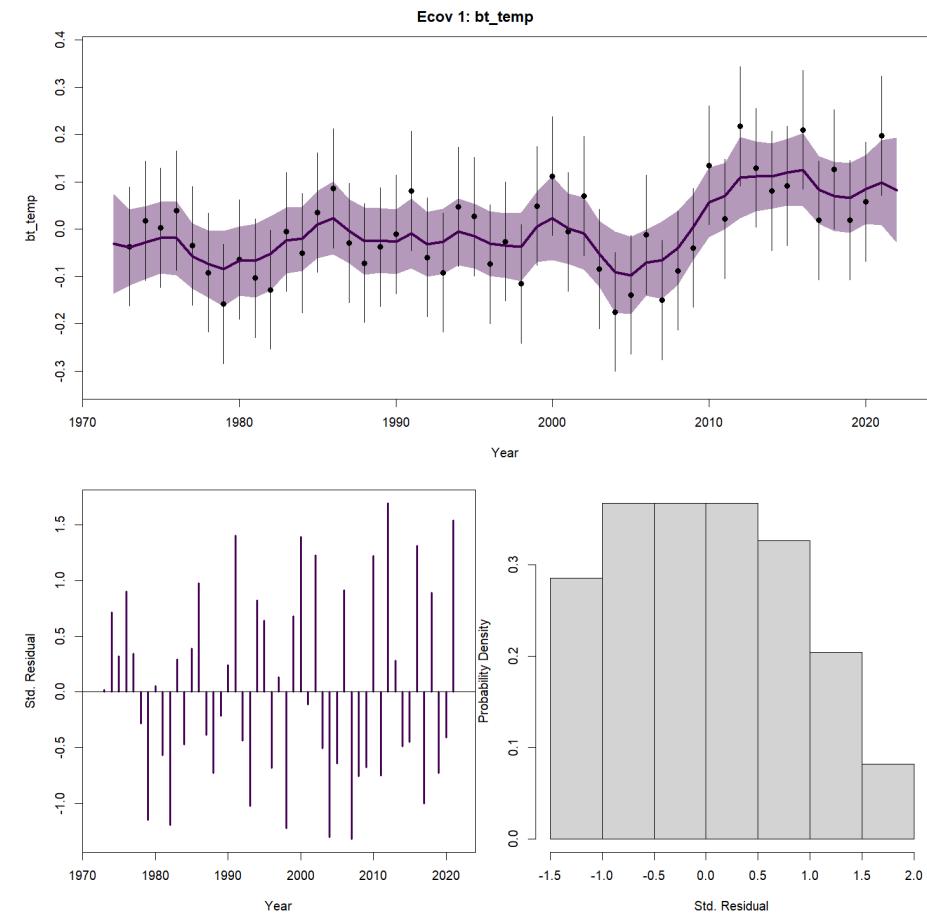
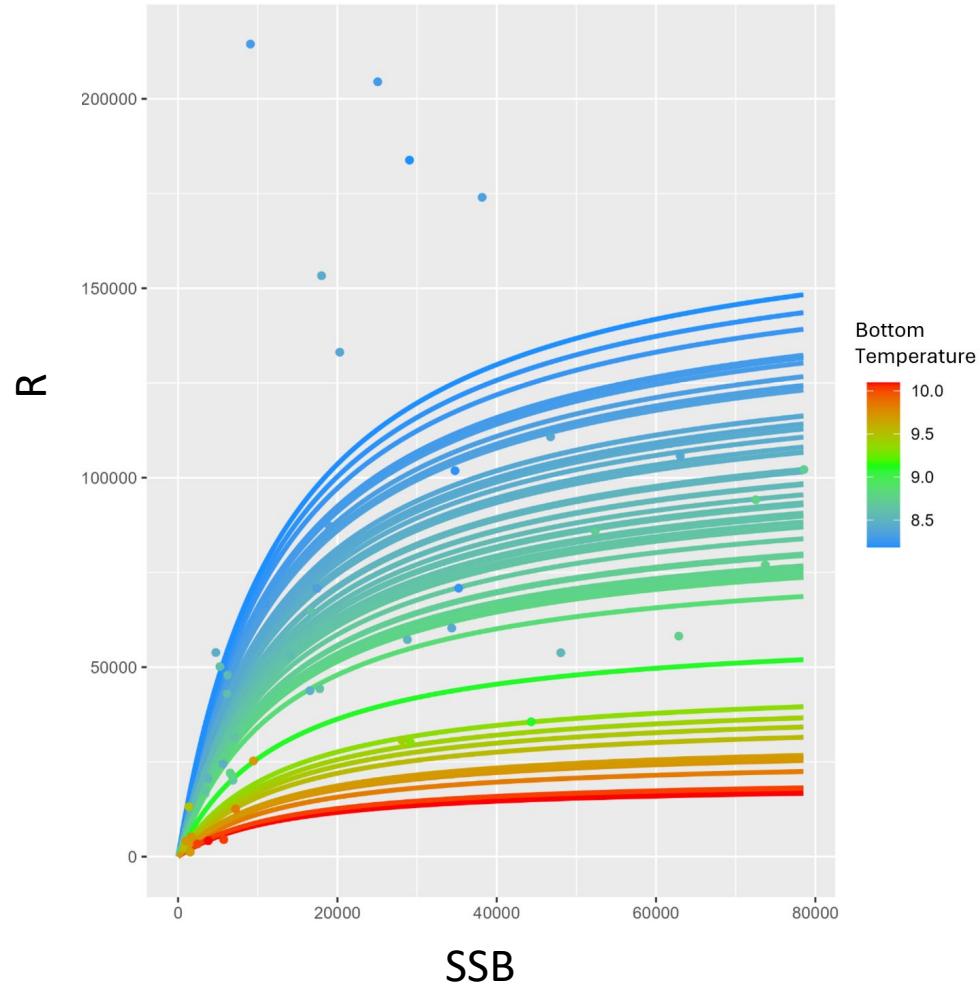
# Fit to the DFO survey



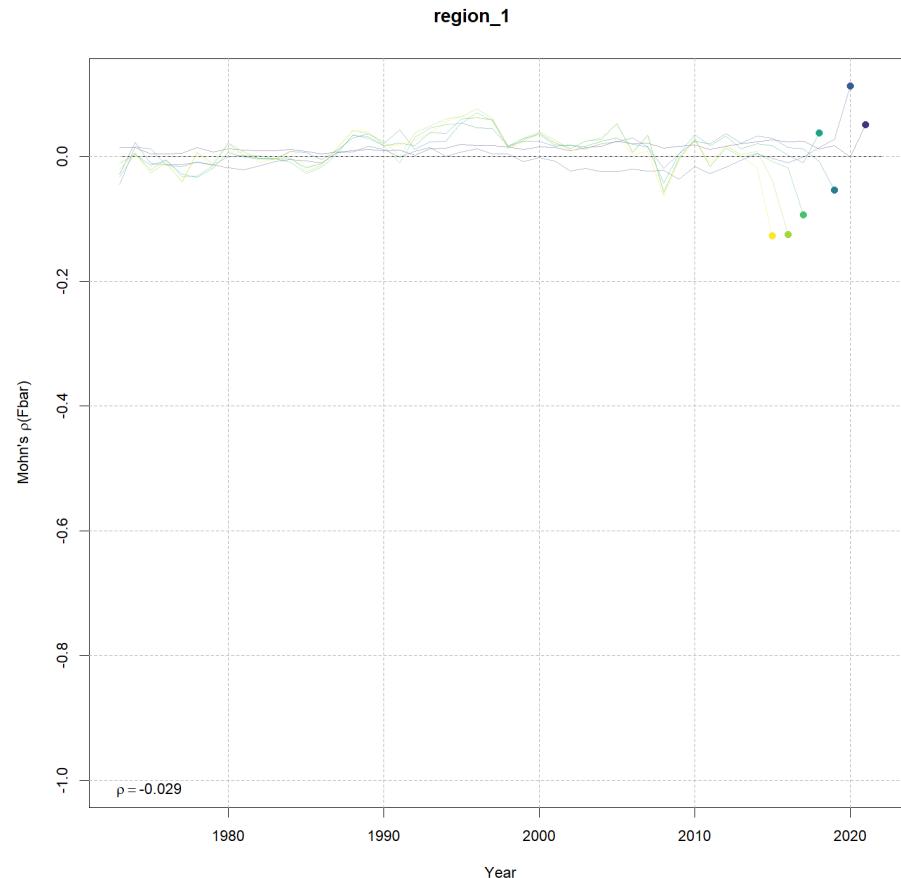
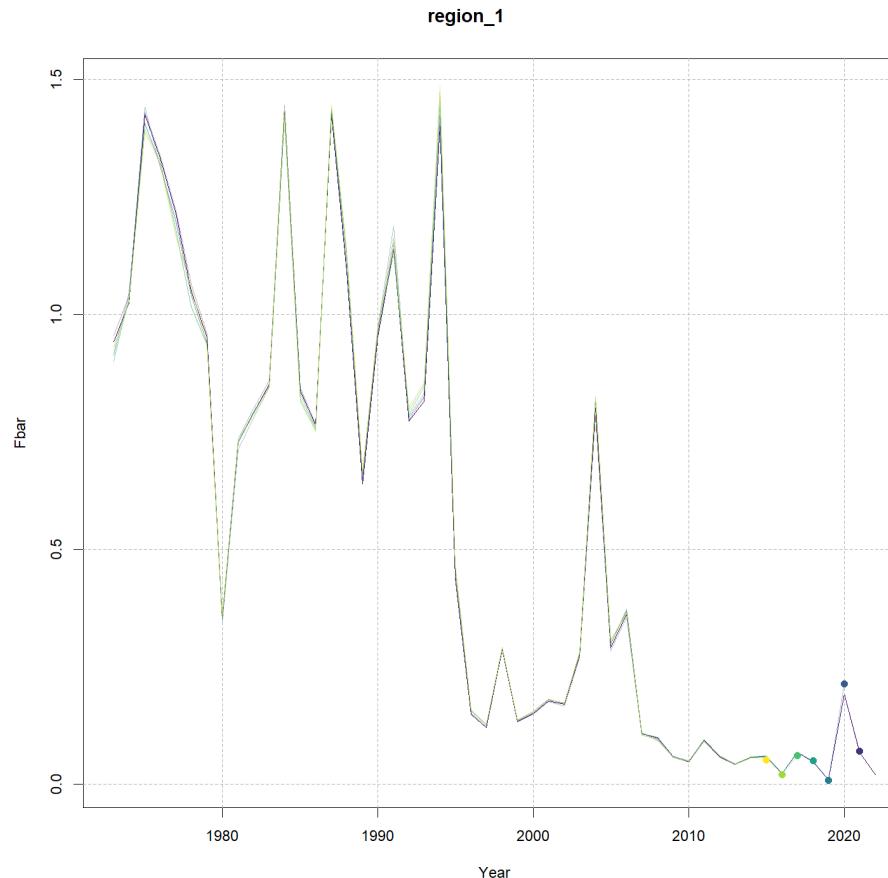
# DFO spring OSA age comps



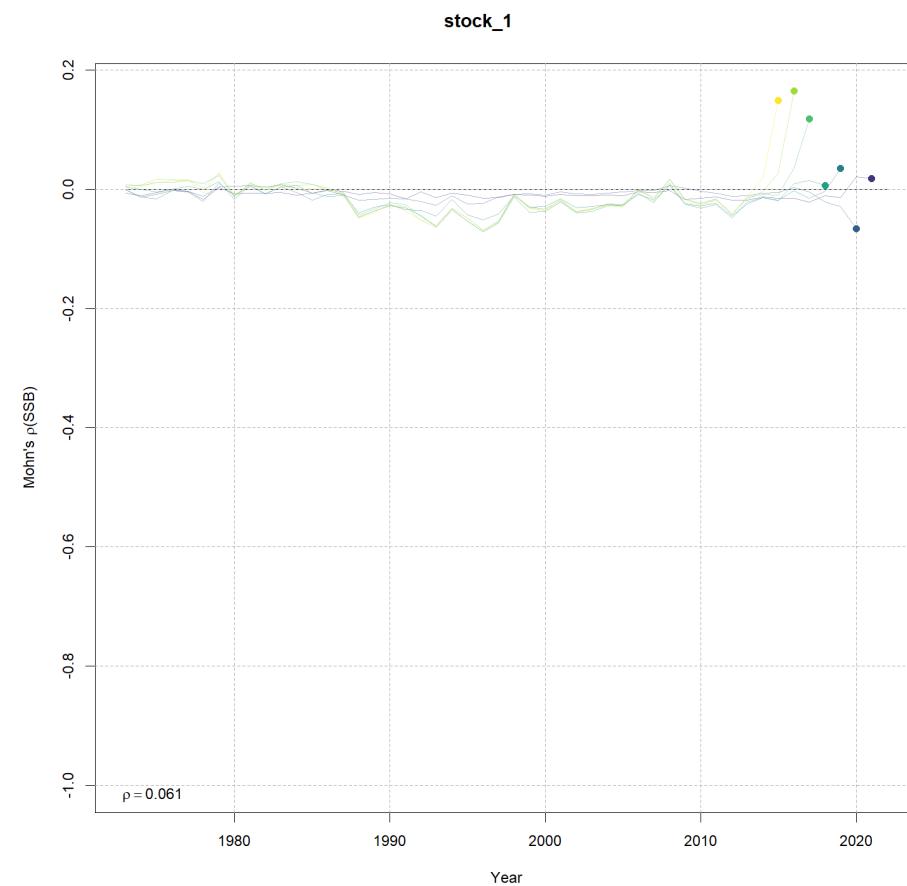
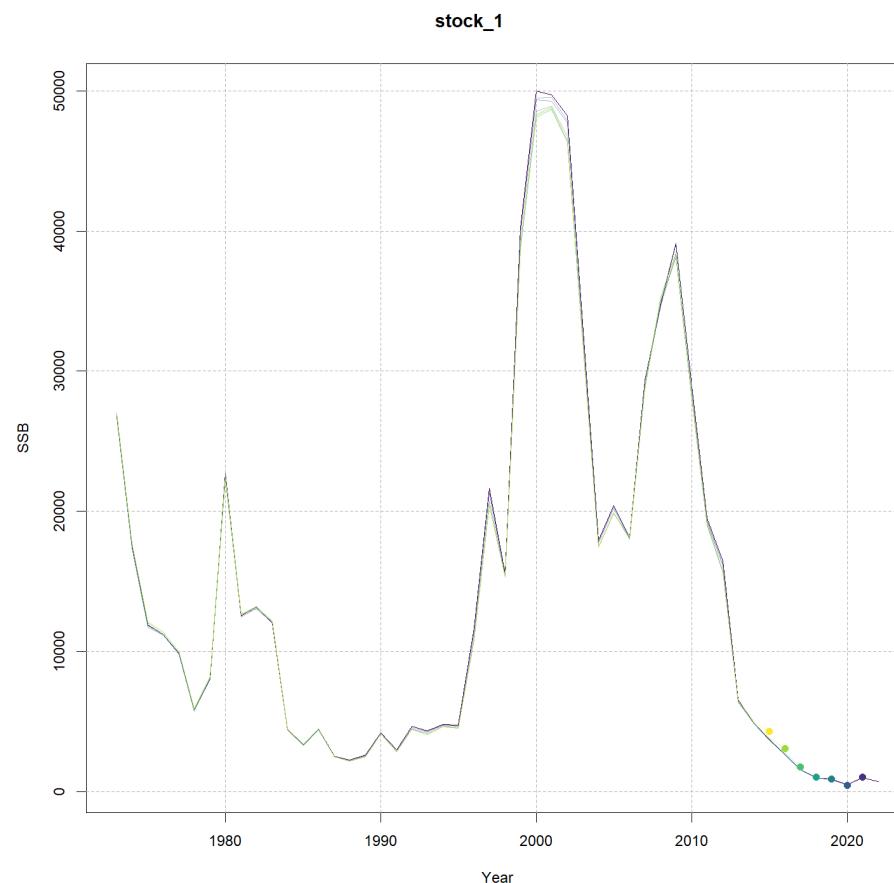
# Fit to bottom temperature



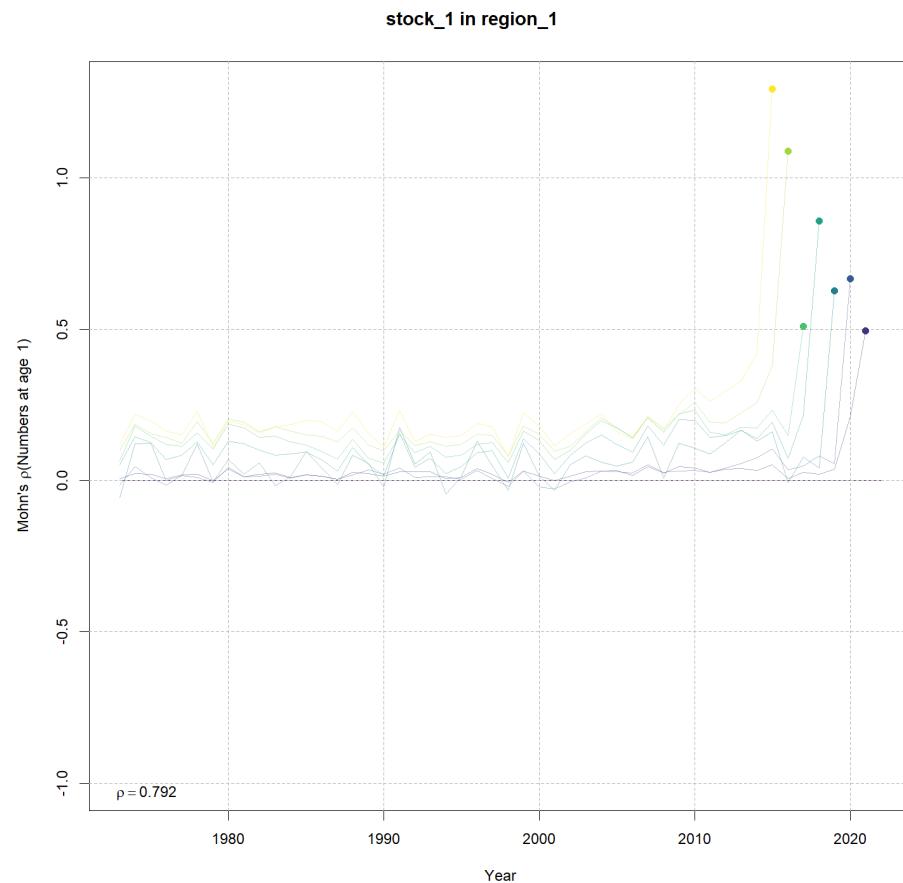
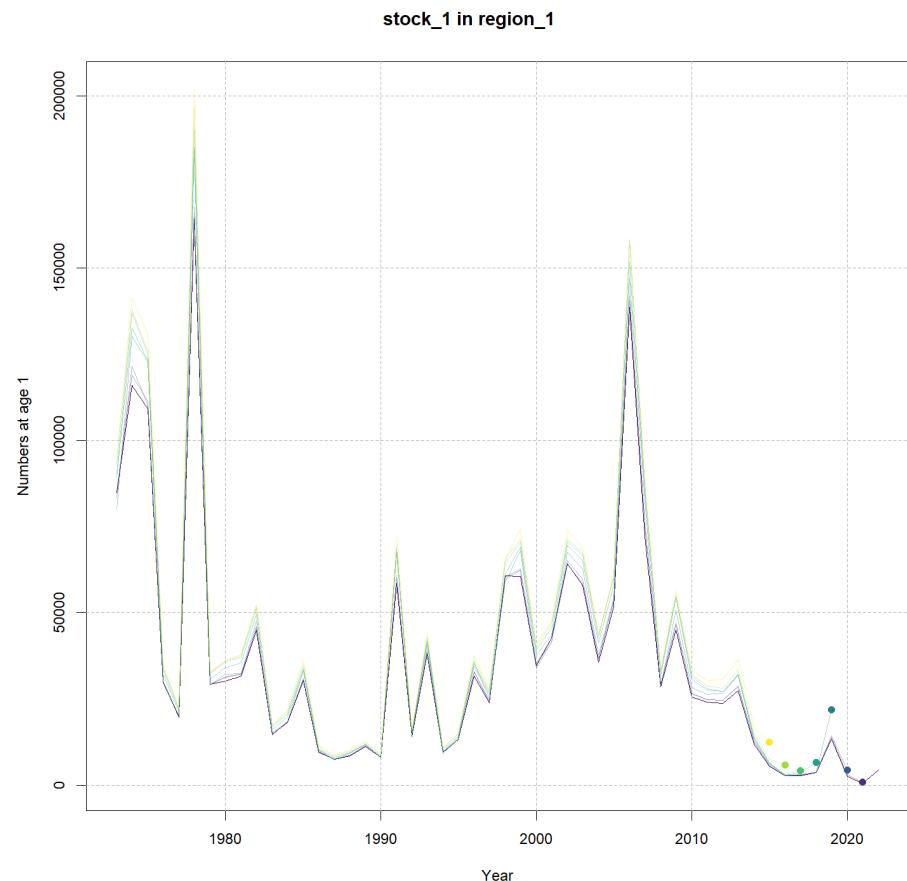
# Retrospective pattern F



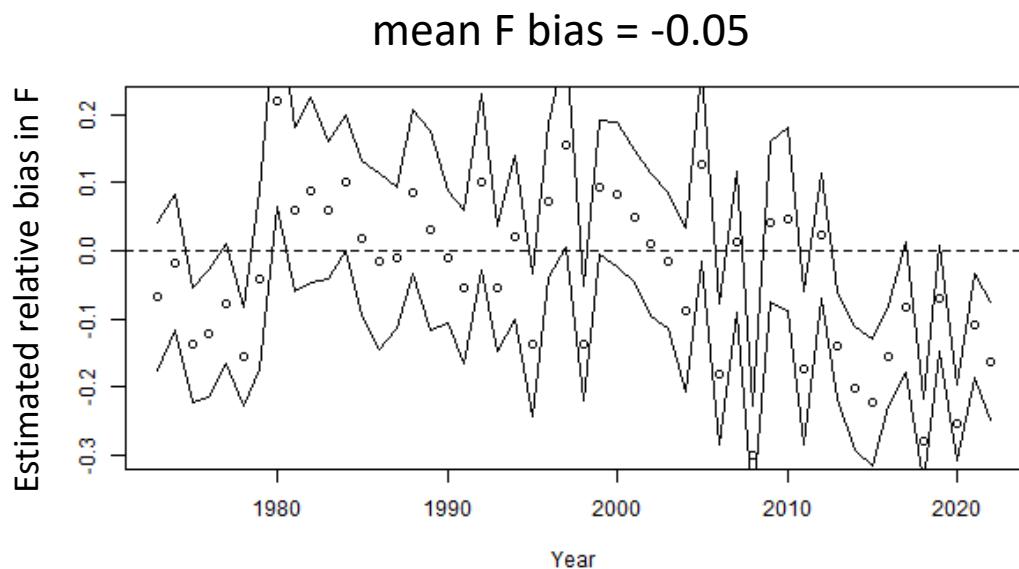
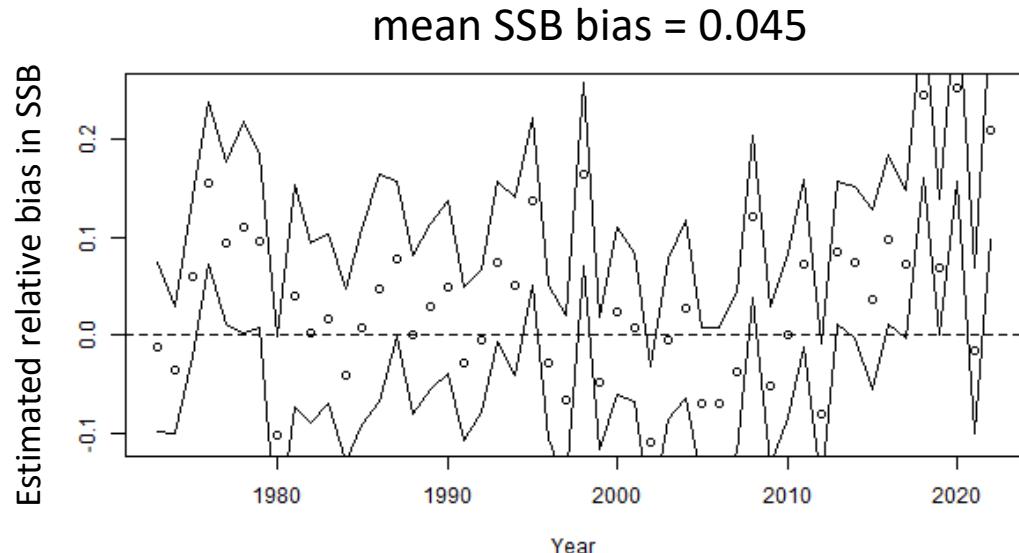
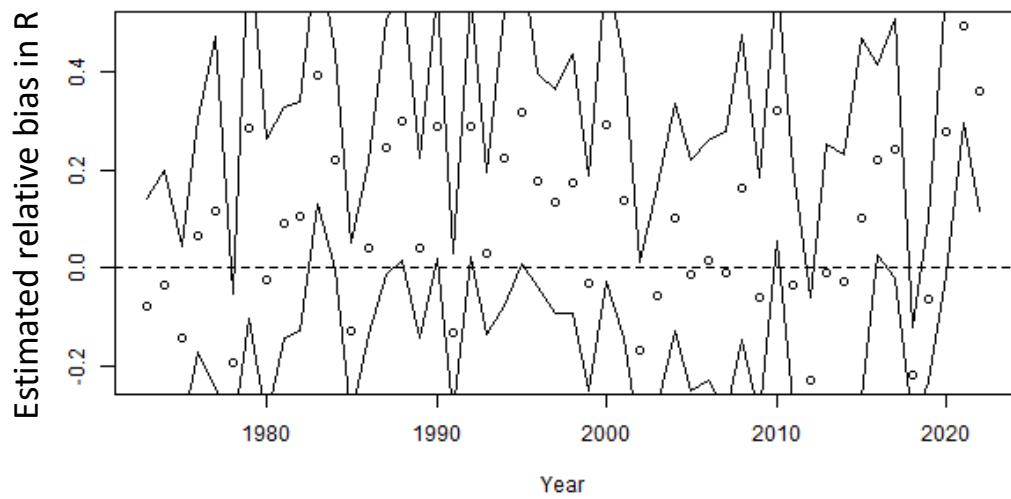
# Retrospective pattern SSB



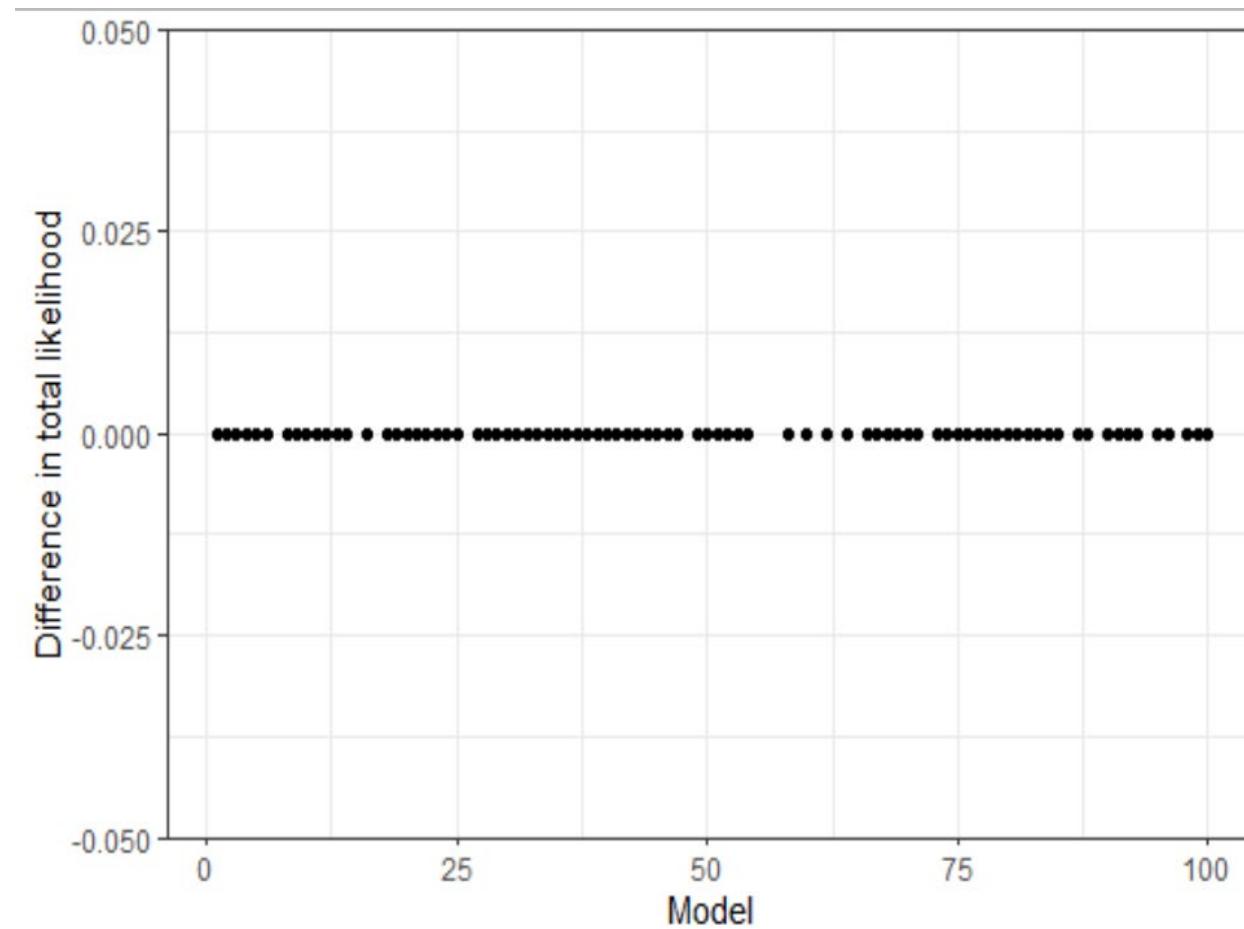
# Retrospective pattern R



# Self test

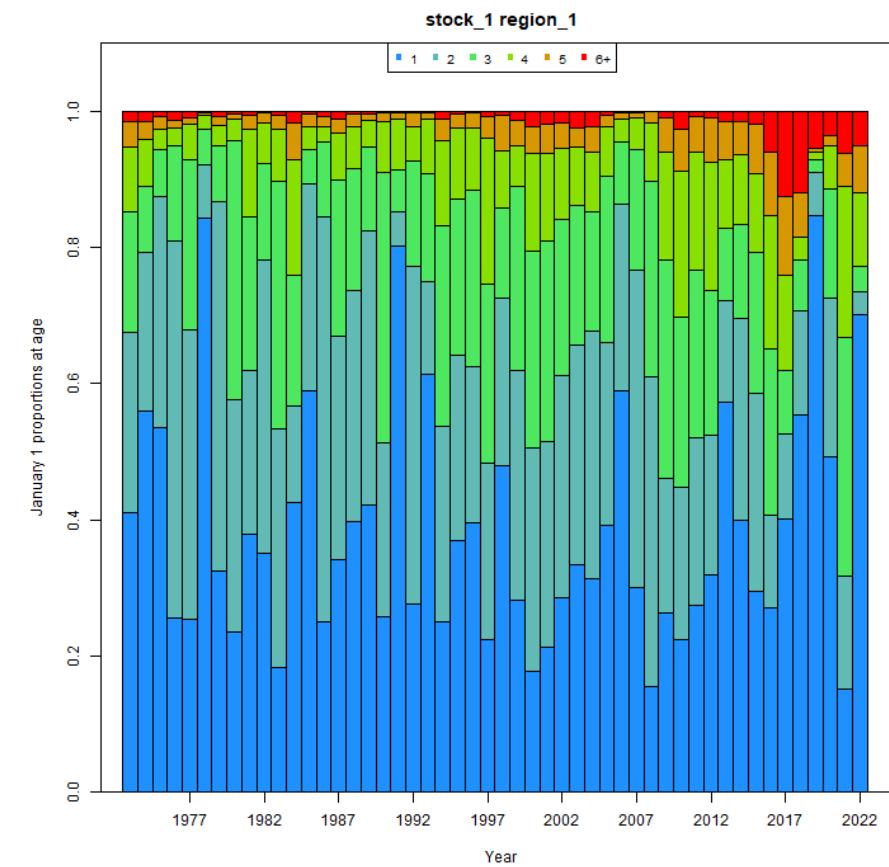
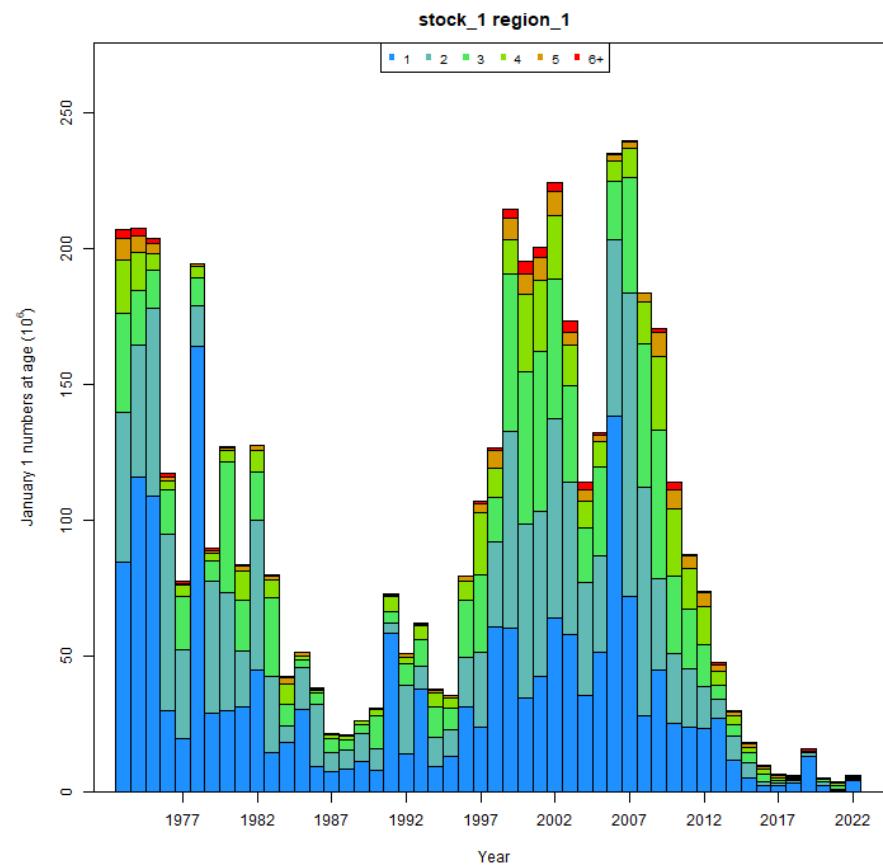


# Jitter

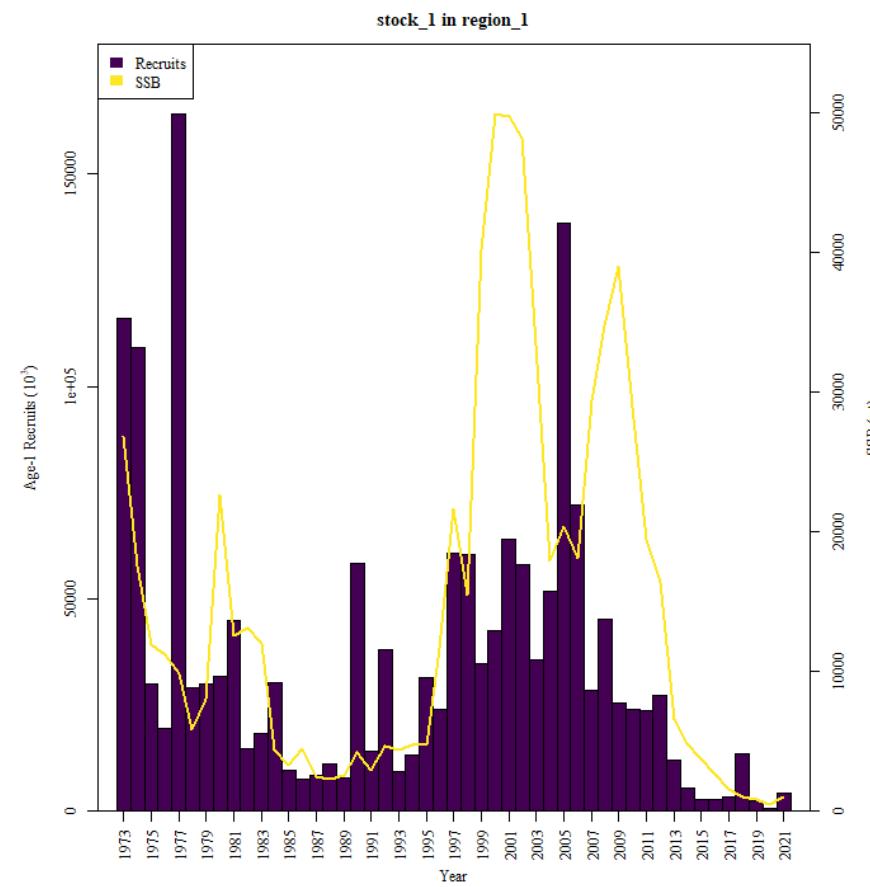
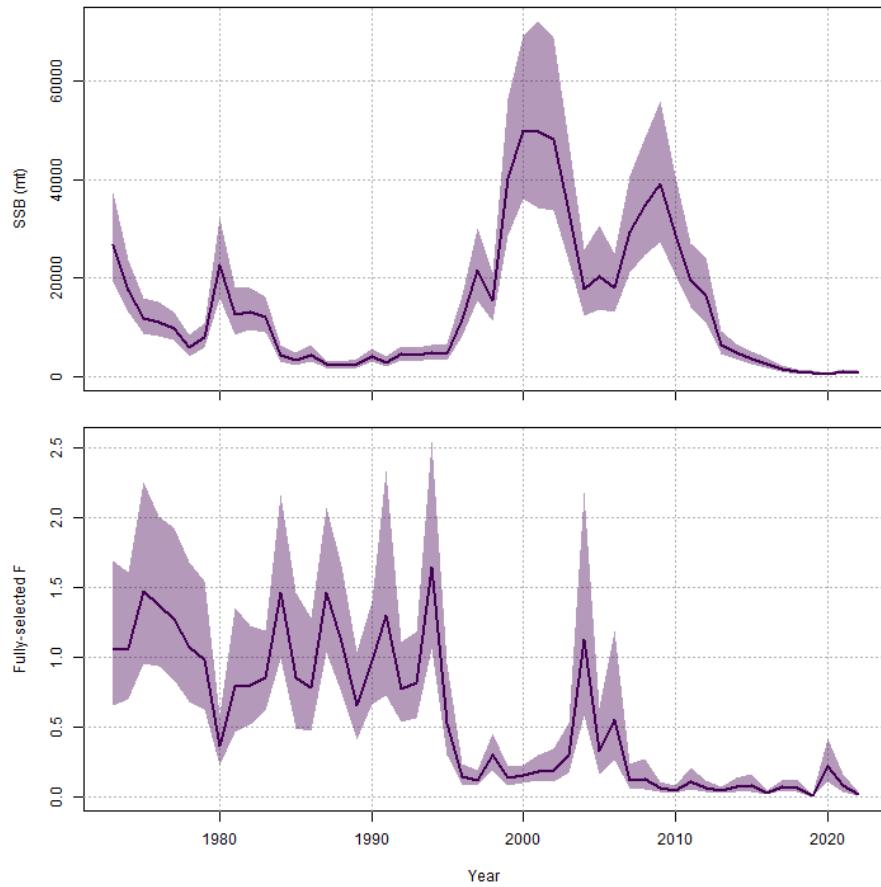


92 % convergence rate

# Numbers at age



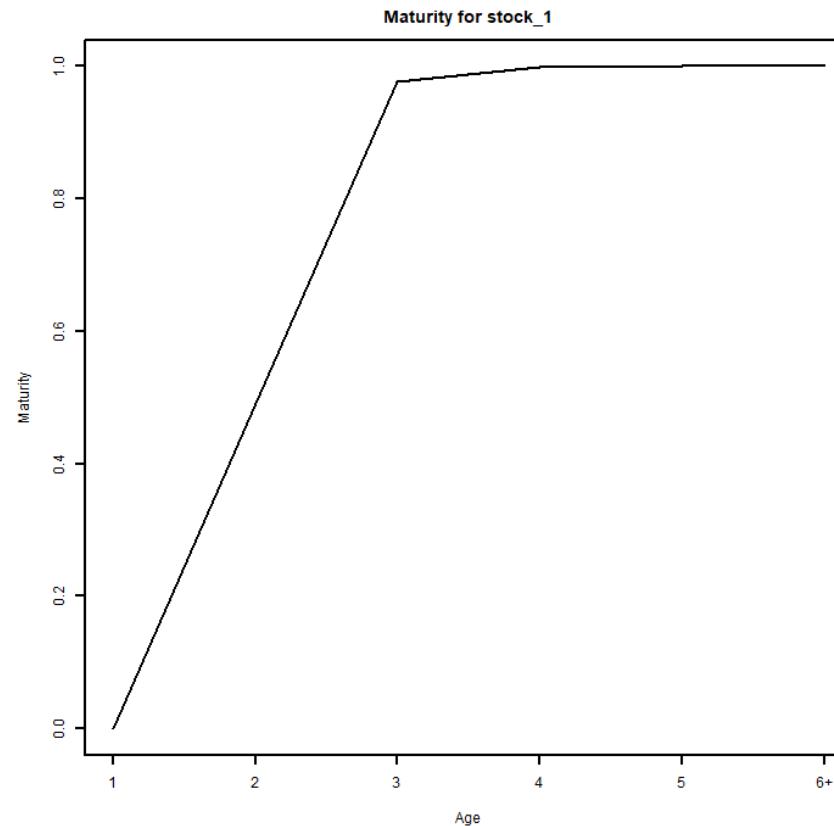
# SSB, F and R trends



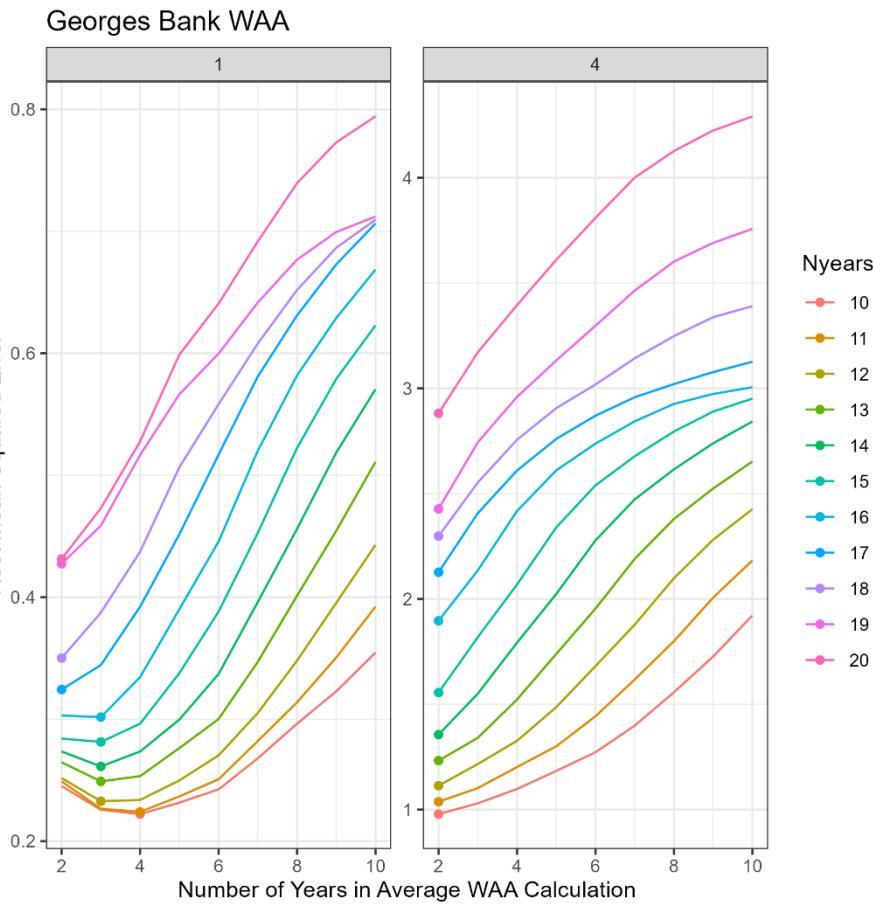
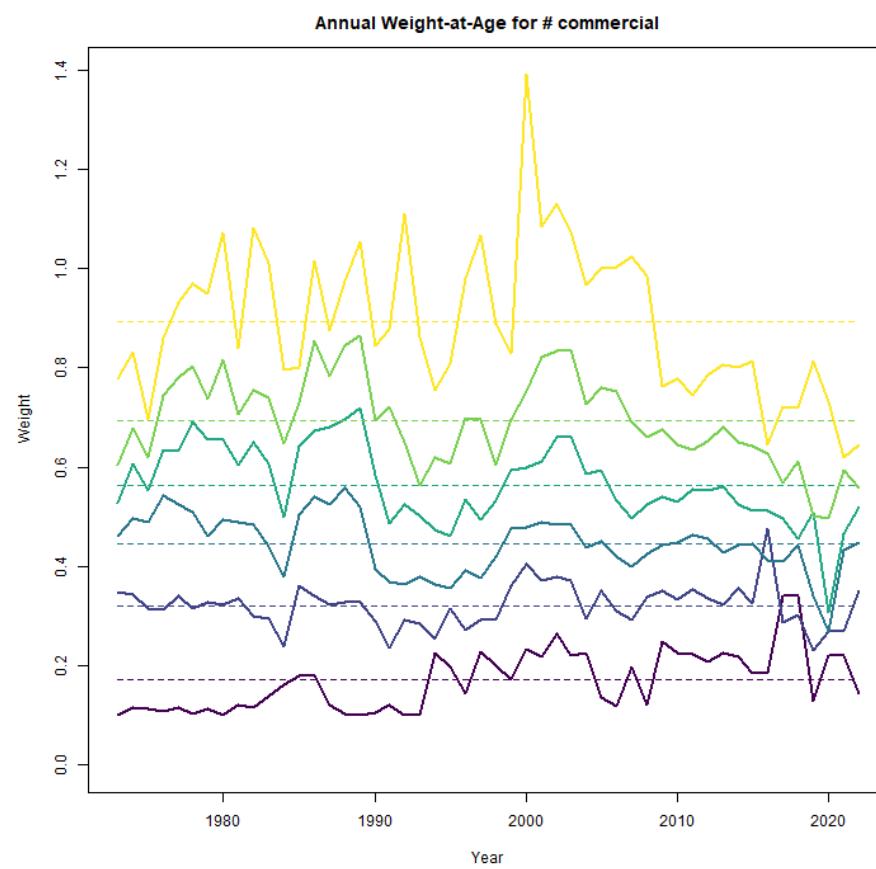
# ToR 5: Biological Reference Points

# BRP inputs

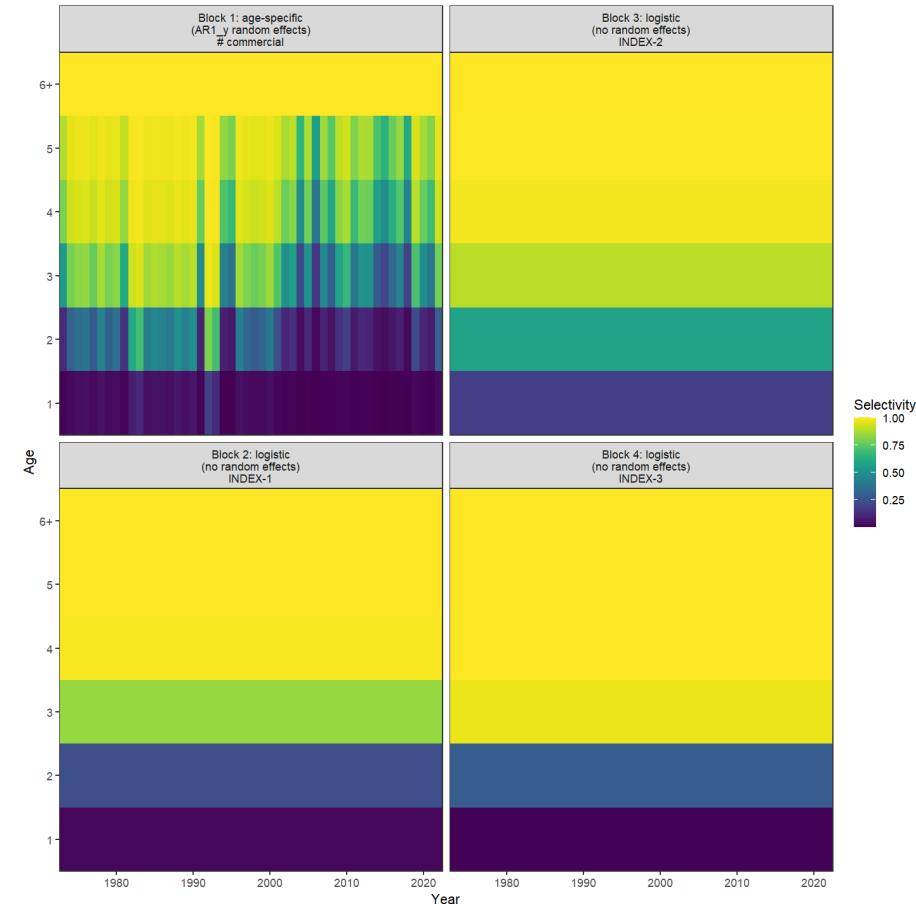
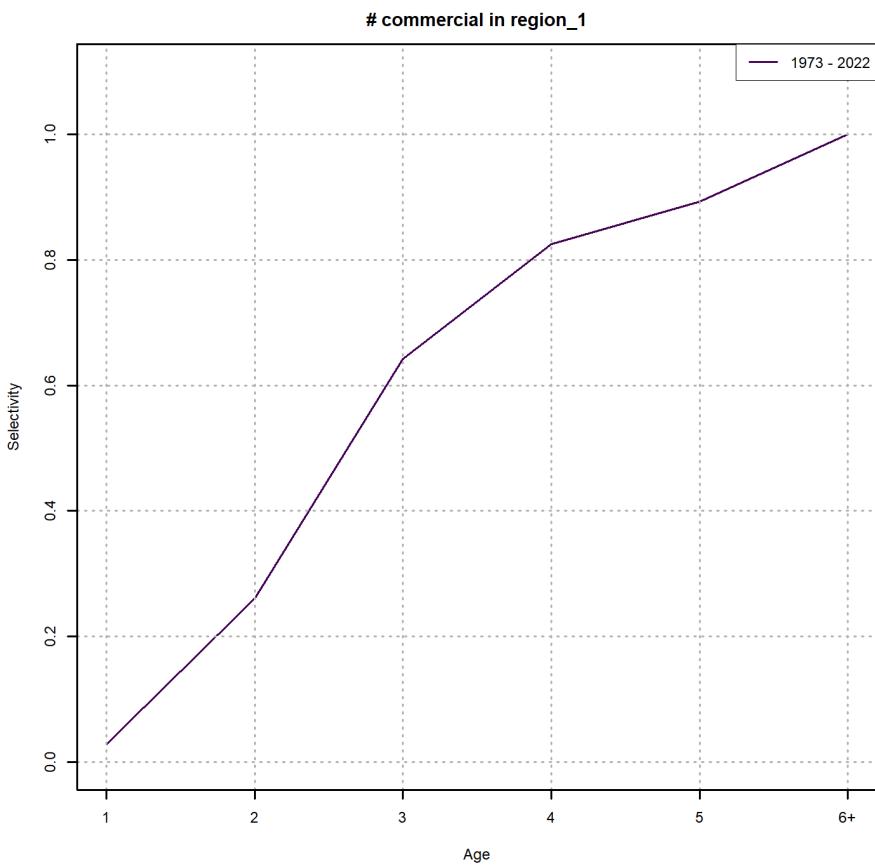
- Proxy or MSY?
- Natural mortality → 0.4
- Maturity → constant
- Selectivity → ar1\_y
- Weights at age → ?
- Recruitment → SR and ecov ?



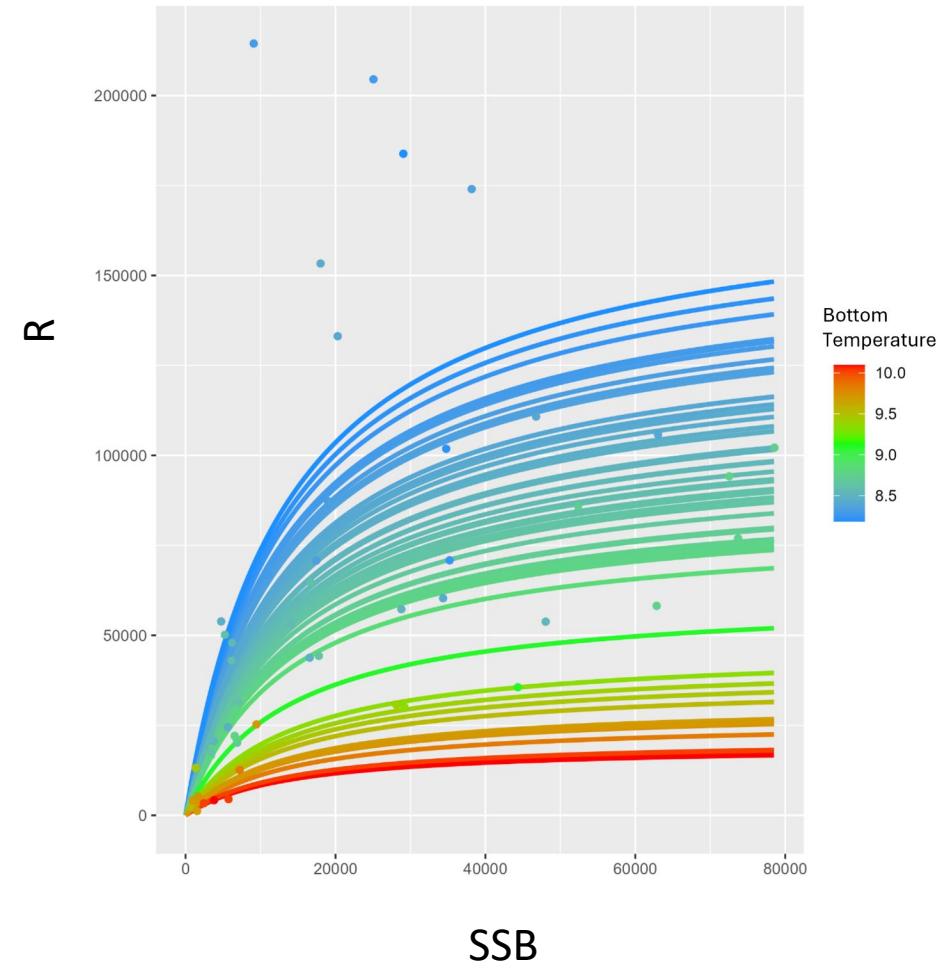
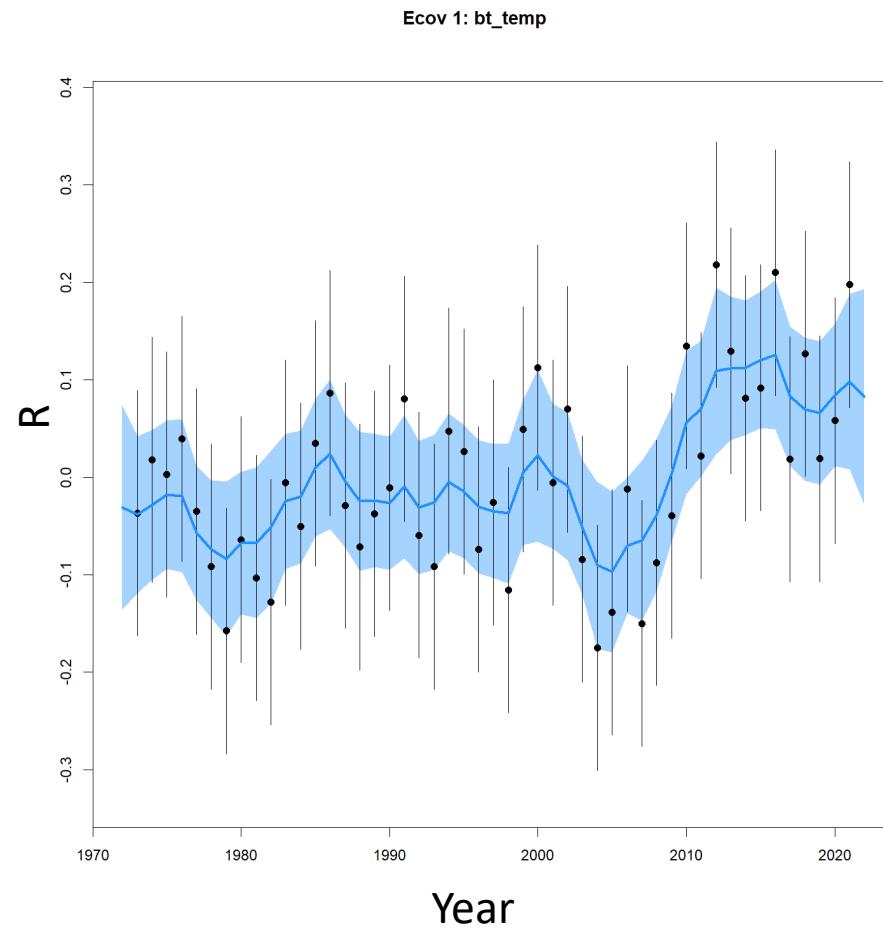
# Weights at age



# Selectivity

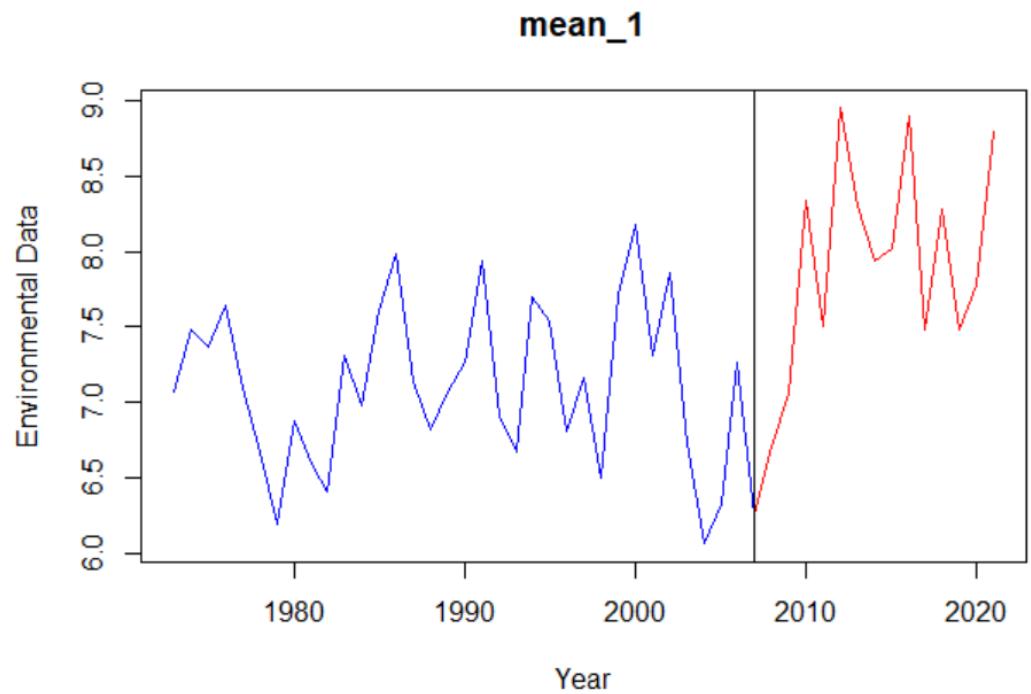


# Recruitment and bottom temperature



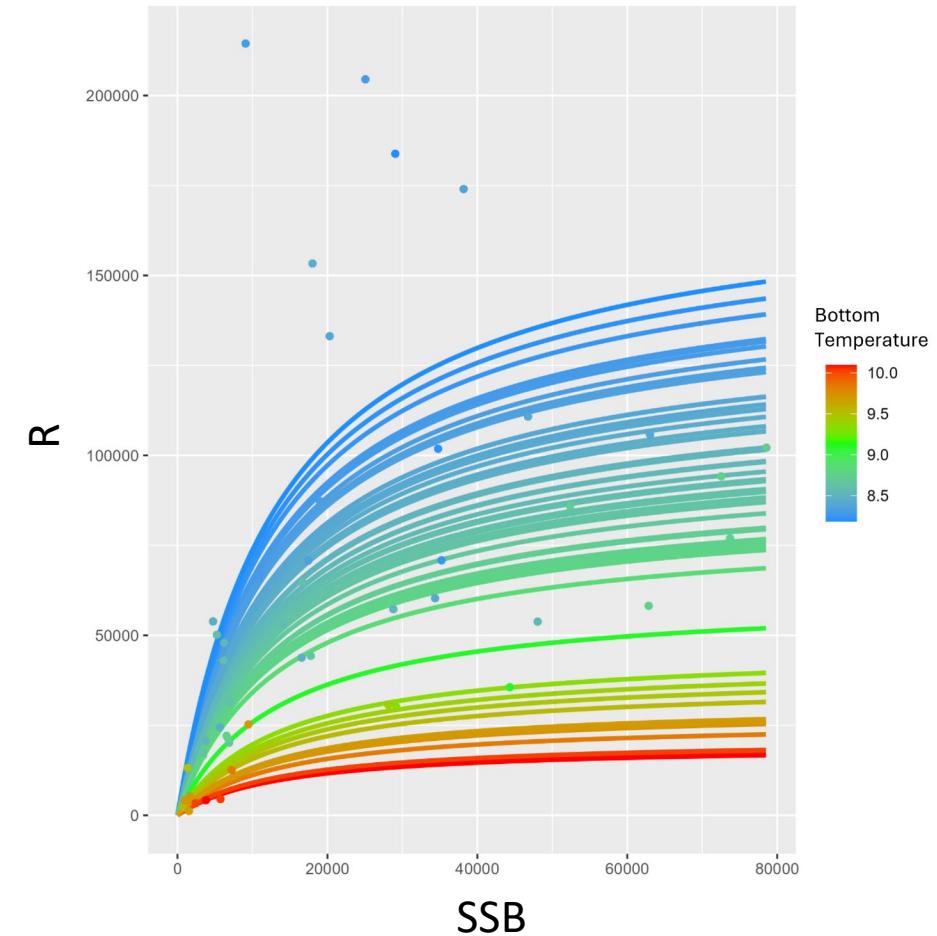
# What are recent conditions?

- Moving average
- Change point showed a break in 2009
- Supported by other studies

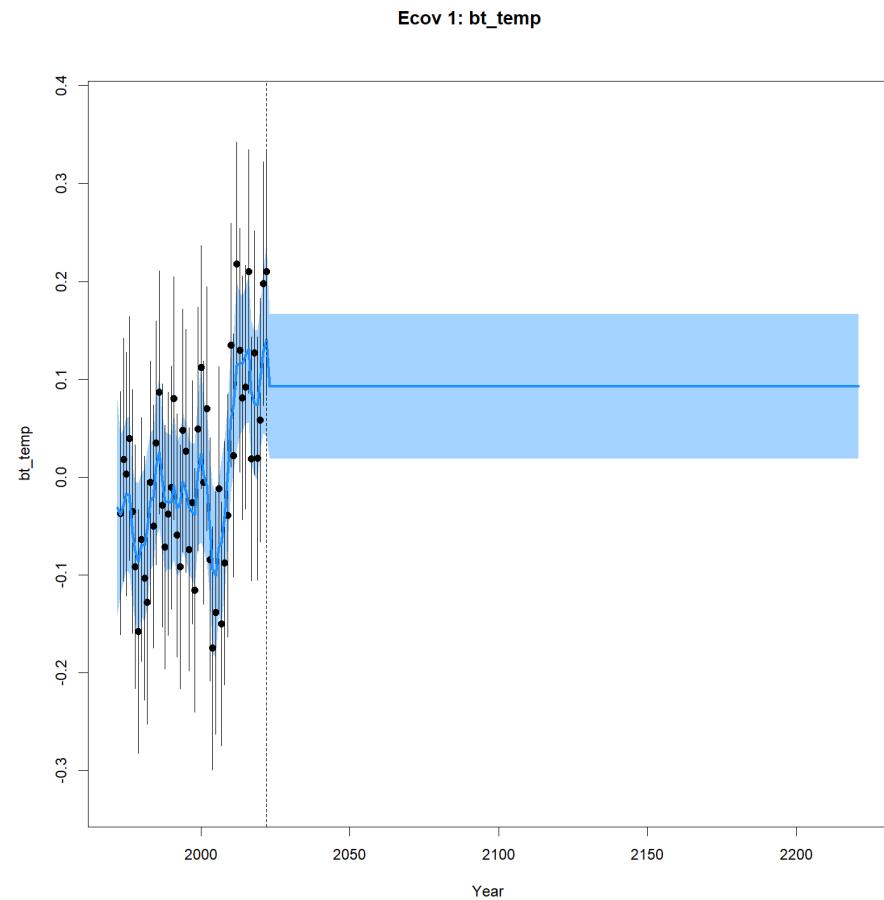


# Recruitment and bottom temperature

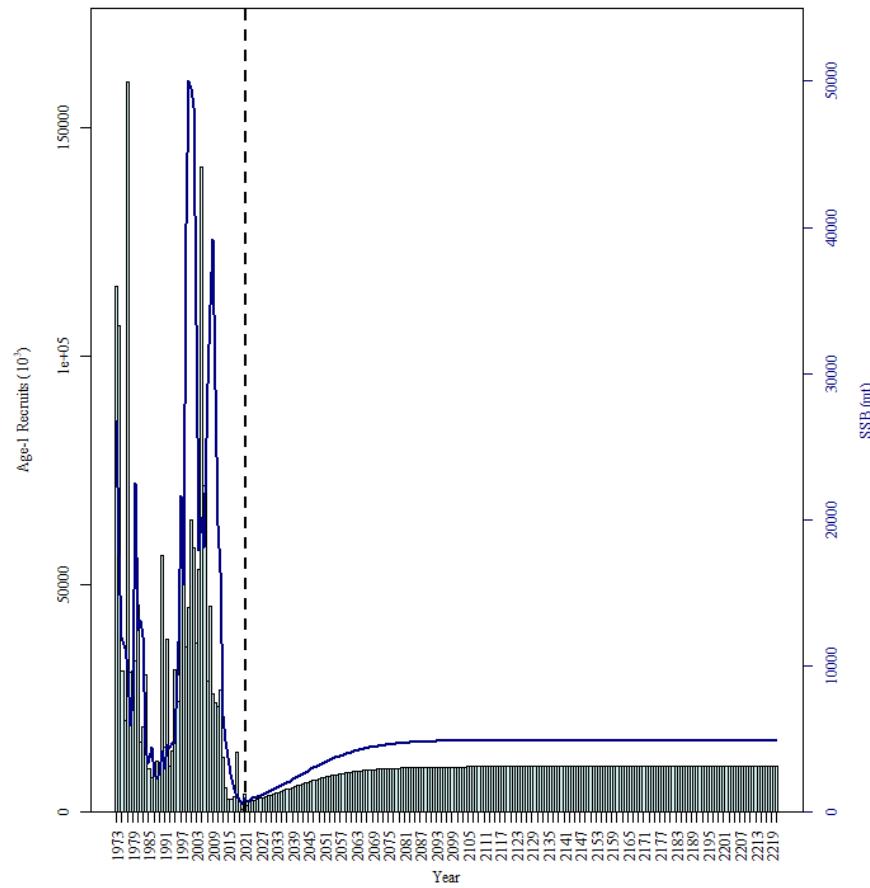
- $F_{\text{msy}} = 0.15$  (0.12-0.19)
- Recruitment is informed by bottom temperature and fishing at  $F_{\text{msy}}$  might not lead to  $\text{SSB}_{\text{msy}}$



# Long term projections



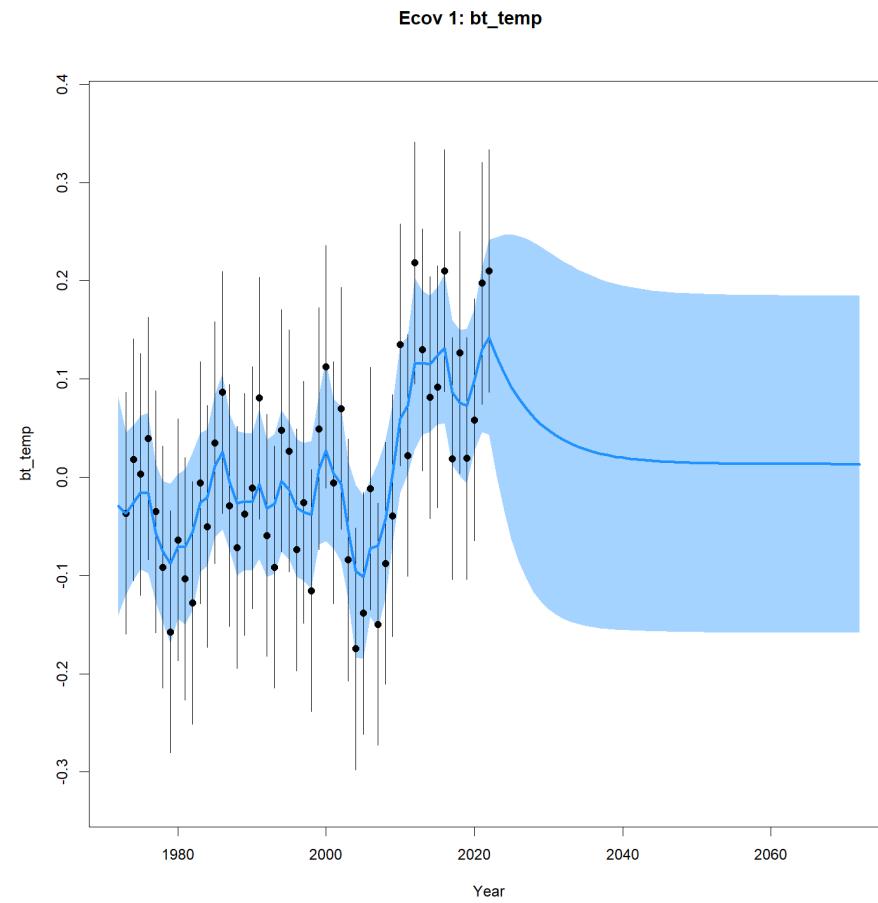
BRP	Values
MSY	554 (54 – 5,661)
Fmsy	0.15 (0.12 – 0.19)
SSBmsy	4,942 (485 – 50,358)



# ToR 6: Projections

# Projection inputs summary

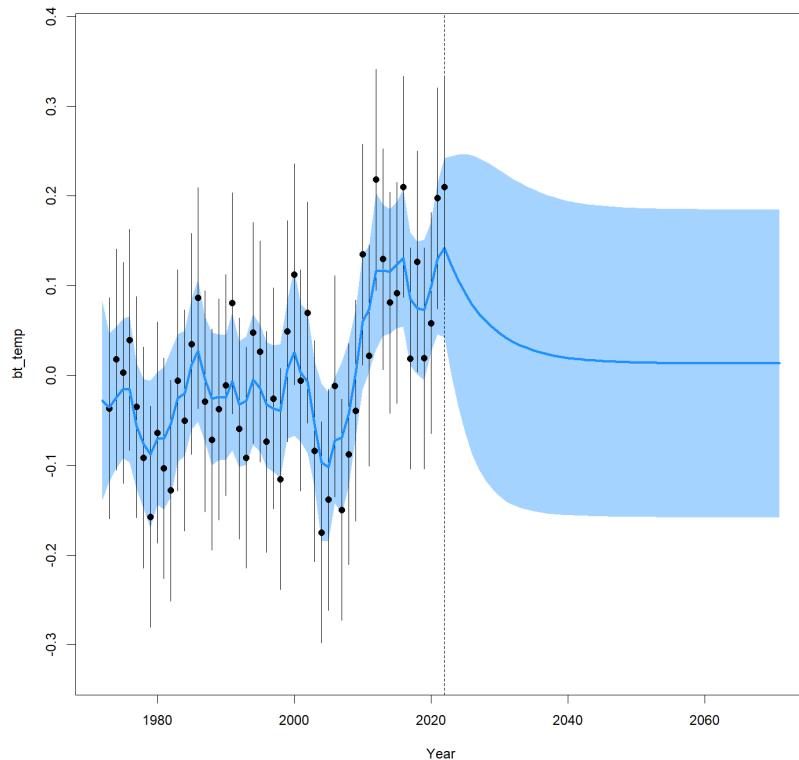
- MSY
- Natural mortality → 0.4
- Maturity → constant
- Selectivity → ar1\_y
- Weights at age → 2 year average
- Recruitment →?



# Ecov options

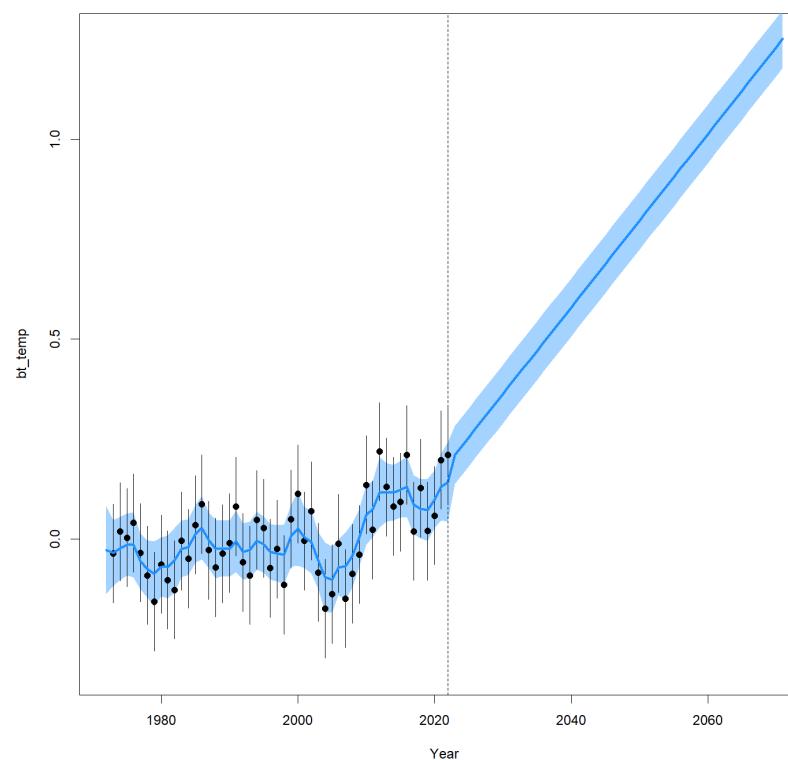
Ar1

Ecov 1: bt\_temp



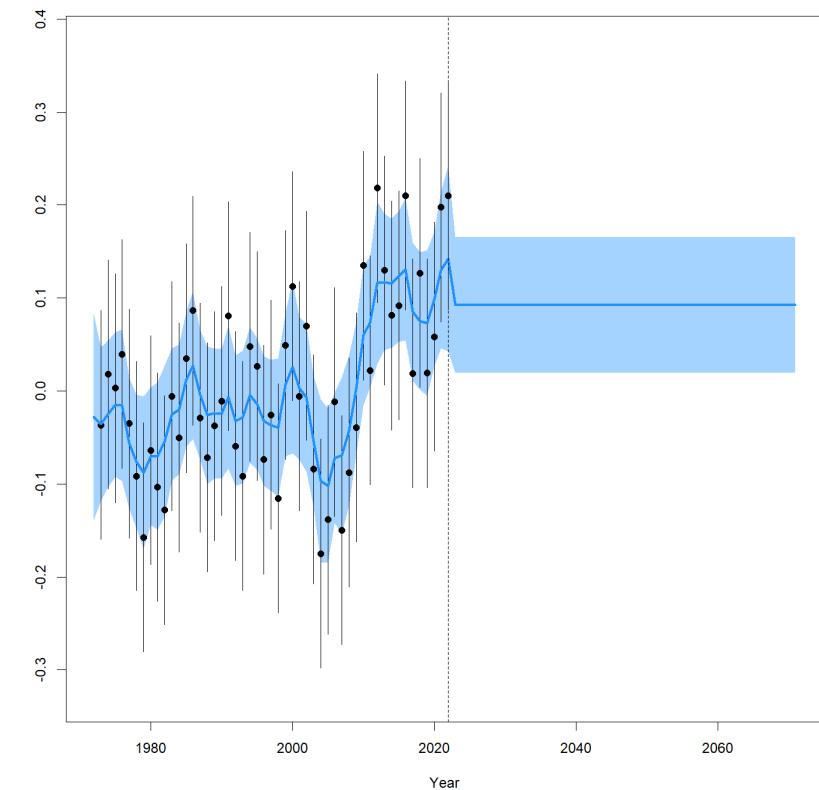
Linear (slope of 2009 – 2022)

Ecov 1: bt\_temp

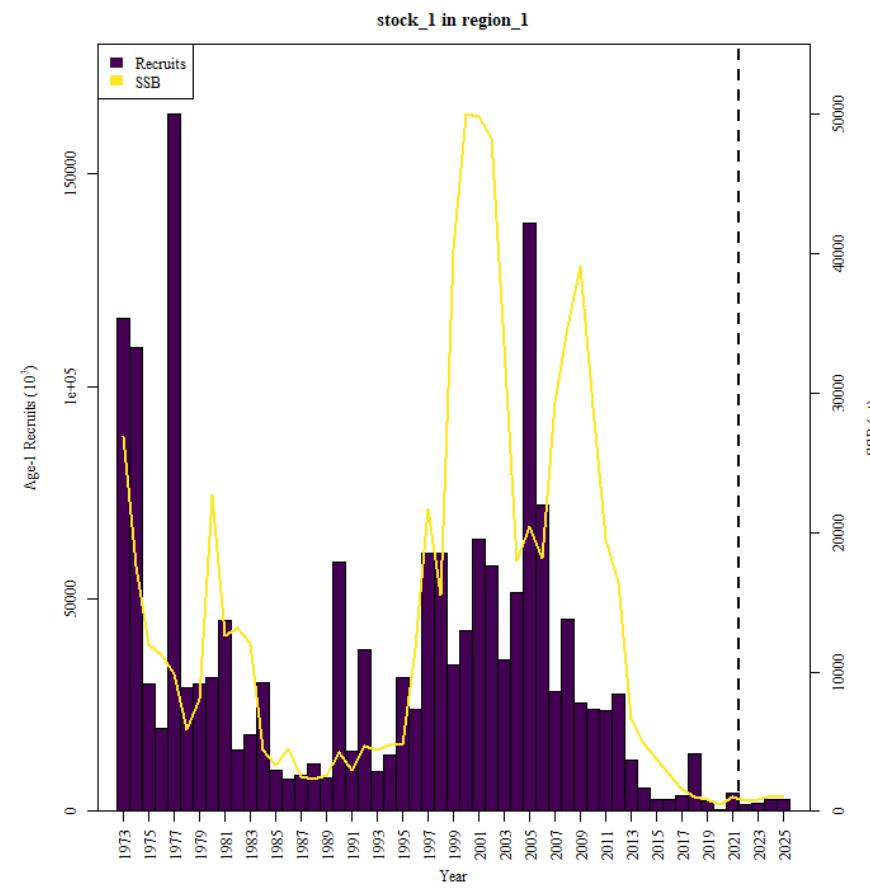
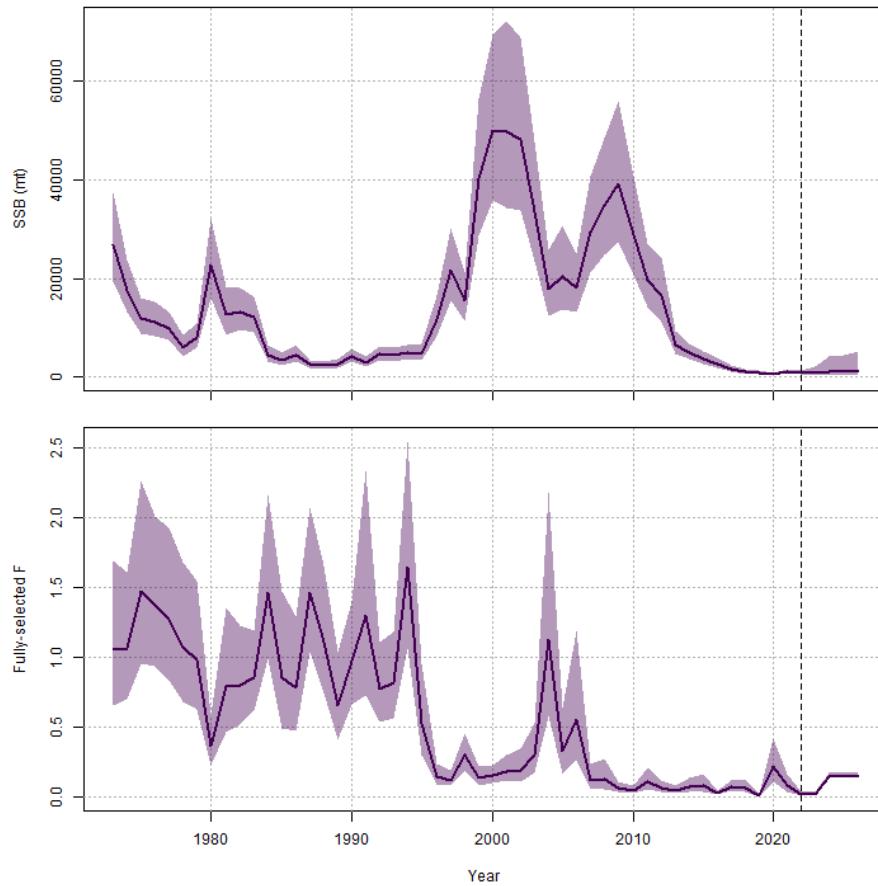


Mean (2009 – 2022)

Ecov 1: bt\_temp



# Example projections



# Summary

- Started with an empirical approach
- ToR 4:
  - WHAM
  - Lognormal-pool0 age comps
  - AR1\_Y on fleet selectivity
  - IID RE on NAA
  - Bottom temperature influences deviations from a Beverton-Holt stock recruit relationship
- ToR 5:
  - $F_{msy} = 0.15$
  - $SSB_{msy} = 4,942 \text{ mt}$
  - $MSY = 554 \text{ mt}$
- ToR 6:
  - 2 year average WAA
  - Ar1\_y fleet selectivity
  - Constant maturity and natural mortality
  - Bottom temperature mean 2009-2022