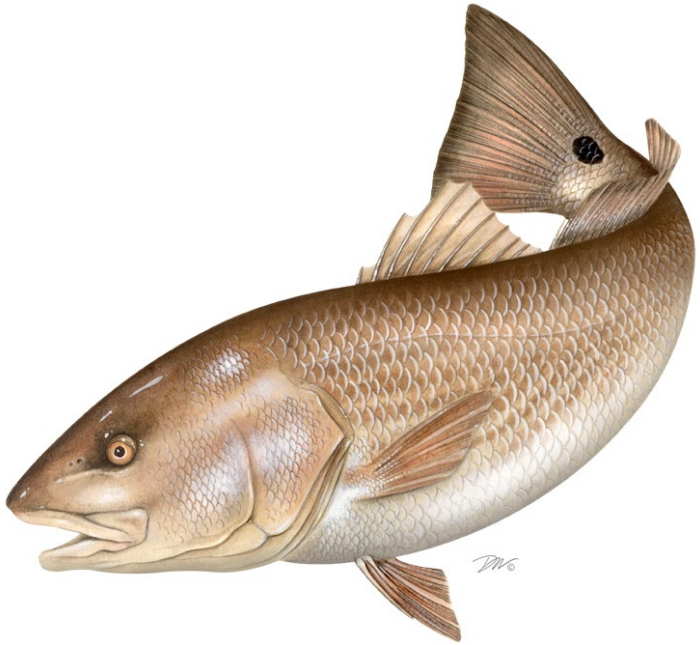
Red Drum Simulation Assessment Report

Presentation to ASMFC Sciaenids Board

ASMFC Spring Meeting

May 2, 2022



Species Guide: REDFISH

MyrtleBeachFishing.org (Redfish)

Bullbuster.net (Bull Redfish in SC and GA)

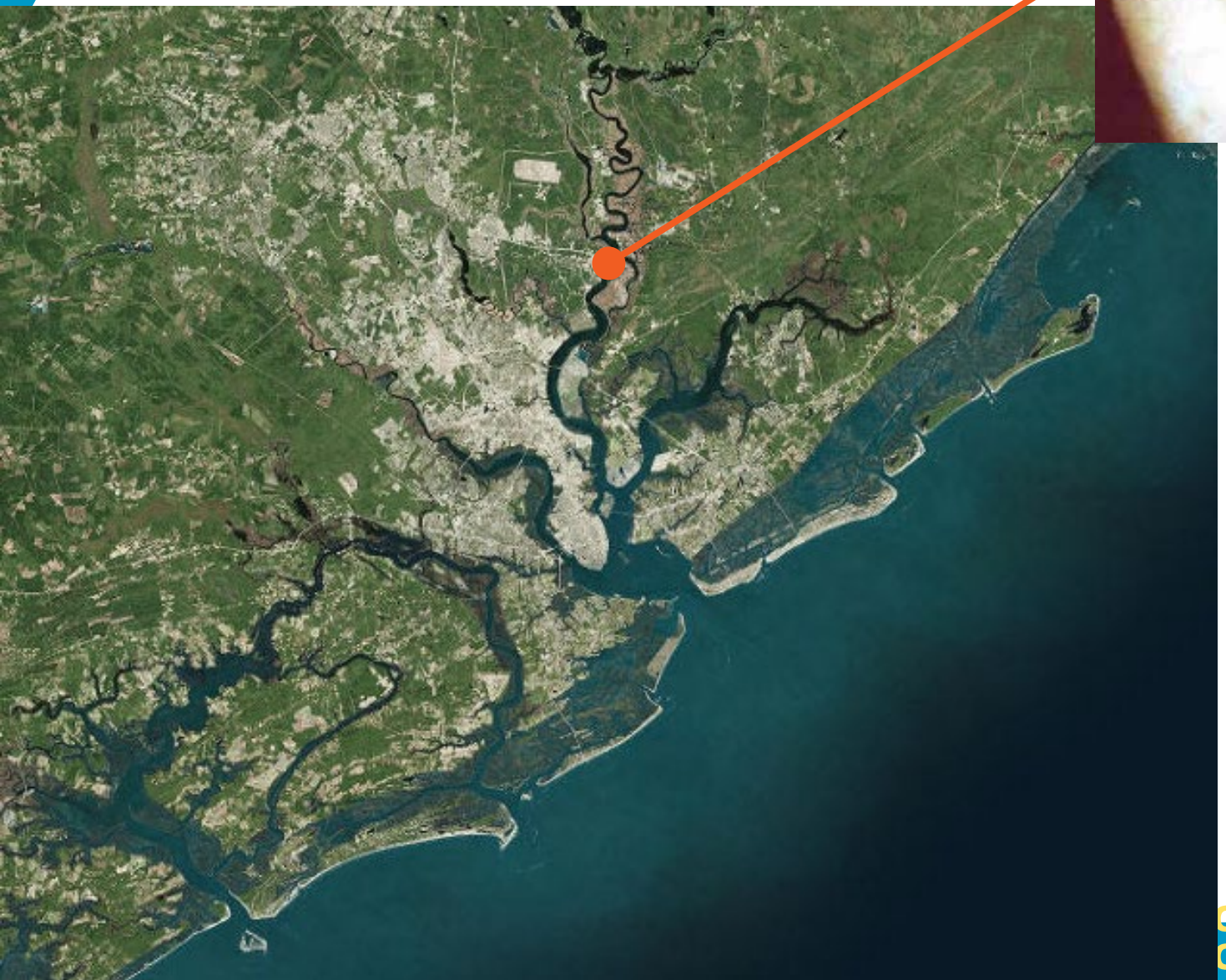
www.wrdw.com (Catch limit on redfish in South Carolina changes July 1)

Livingwaterguide.com (South Carolina's Prize Inshore Game Fish)

Red Drum Life Cycle

oors
oors

Red Drum Life Cycle



Juveniles (0-10 months old)

- Small creeks
- Upper estuaries
- Seagrass beds (FL & NC)

oors
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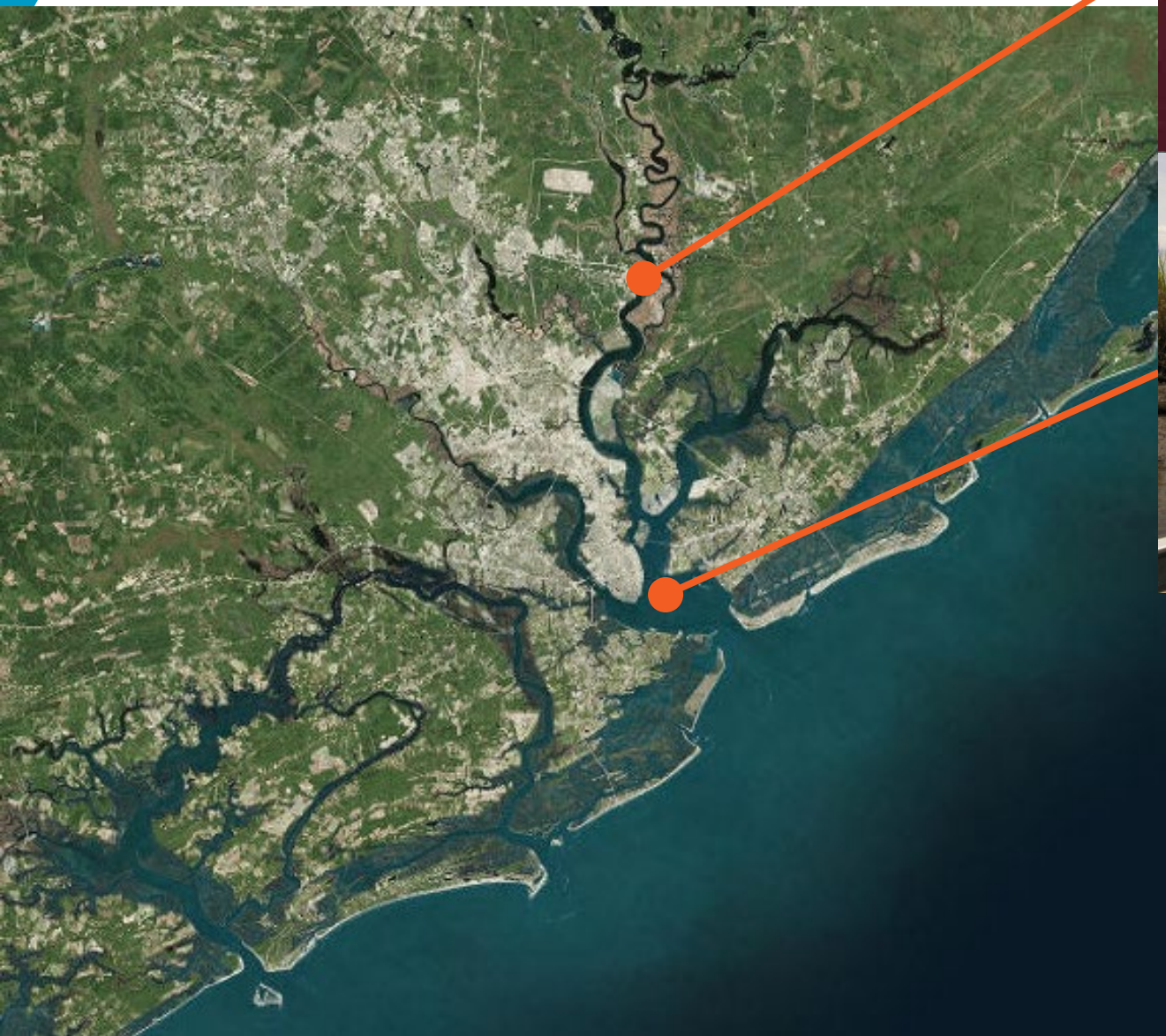

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Sub-adults (10 months to 3-5 years of Age)

- Shallow salt marsh edge and oyster reef habitats
- Lower estuaries

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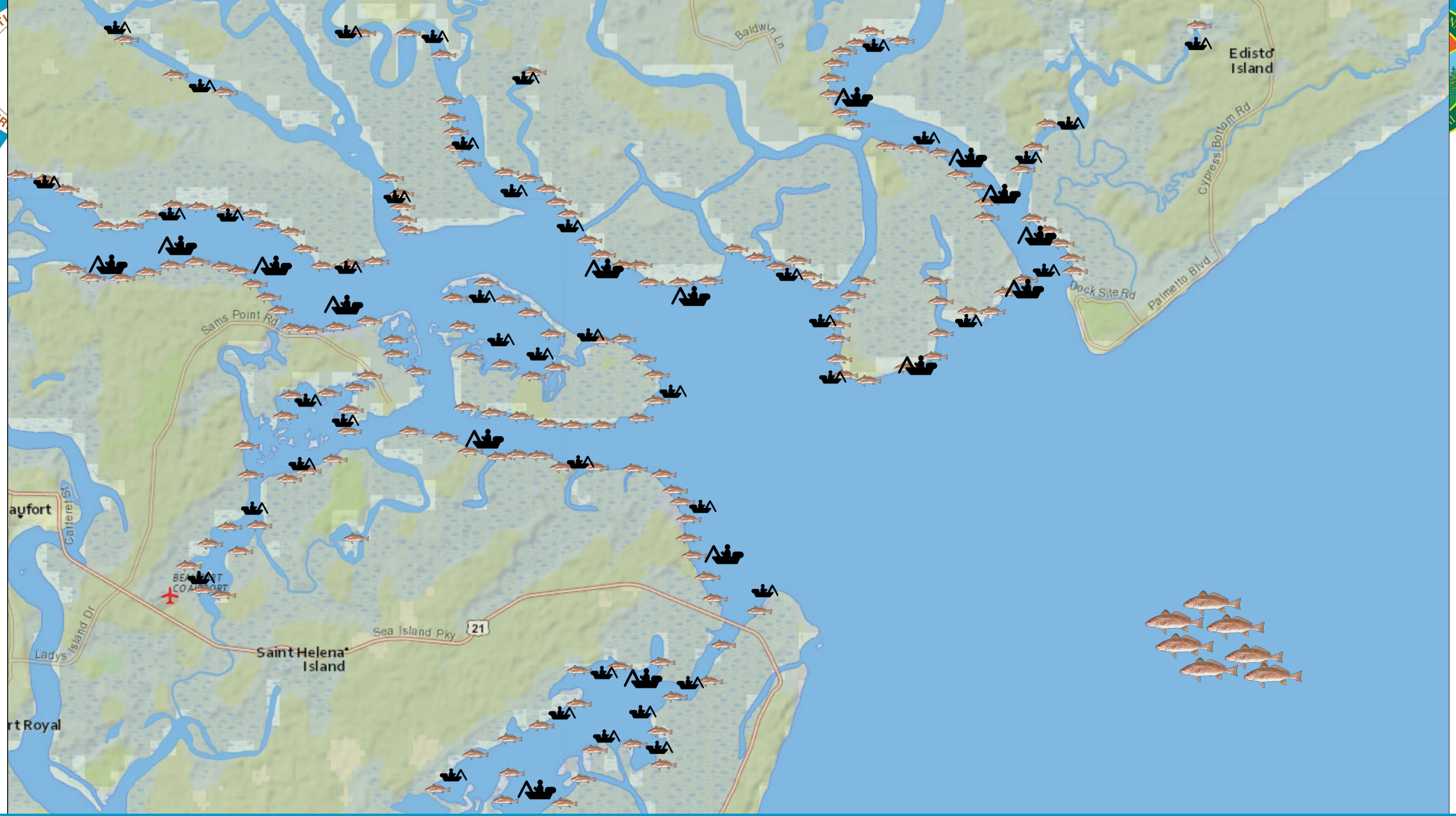
Sub-adults (10 months to 3-5 years of Age)

- Shallow salt marsh edge and oyster reef habitats
- Lower estuaries

Adults (up to 50+ years old)

- Deeper coastal waters
- Form aggregations @ mouths of estuaries


Baldwin Ln
Edisto Island
Cypress Bottom Rd
Dock Site Rd
Palmetto Blvd
Sams Point Rd
Carteret St
BEAUFORT CO AIRPORT
Sea Island Pky
21
Ladys Island Dr
Saint Helena Island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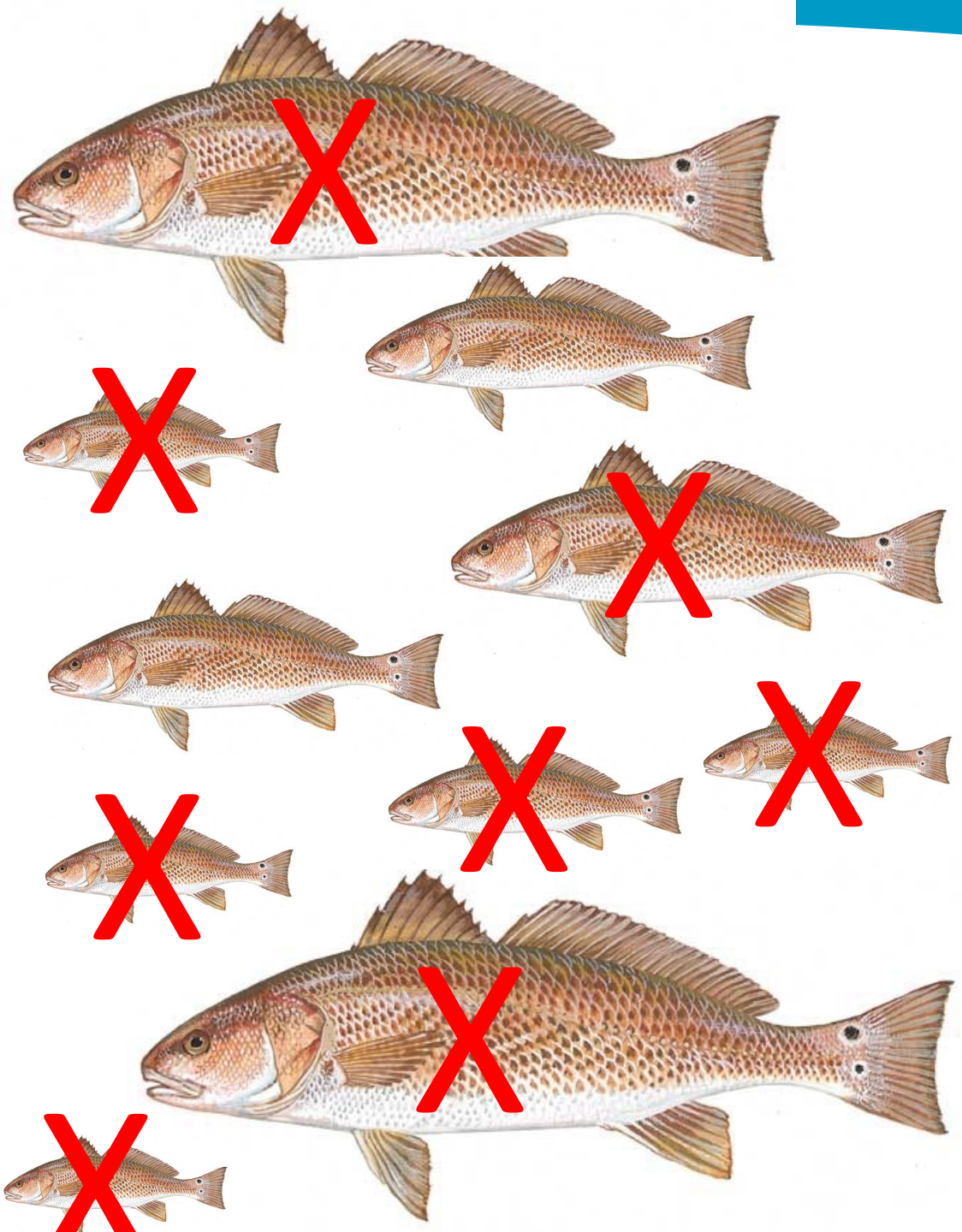
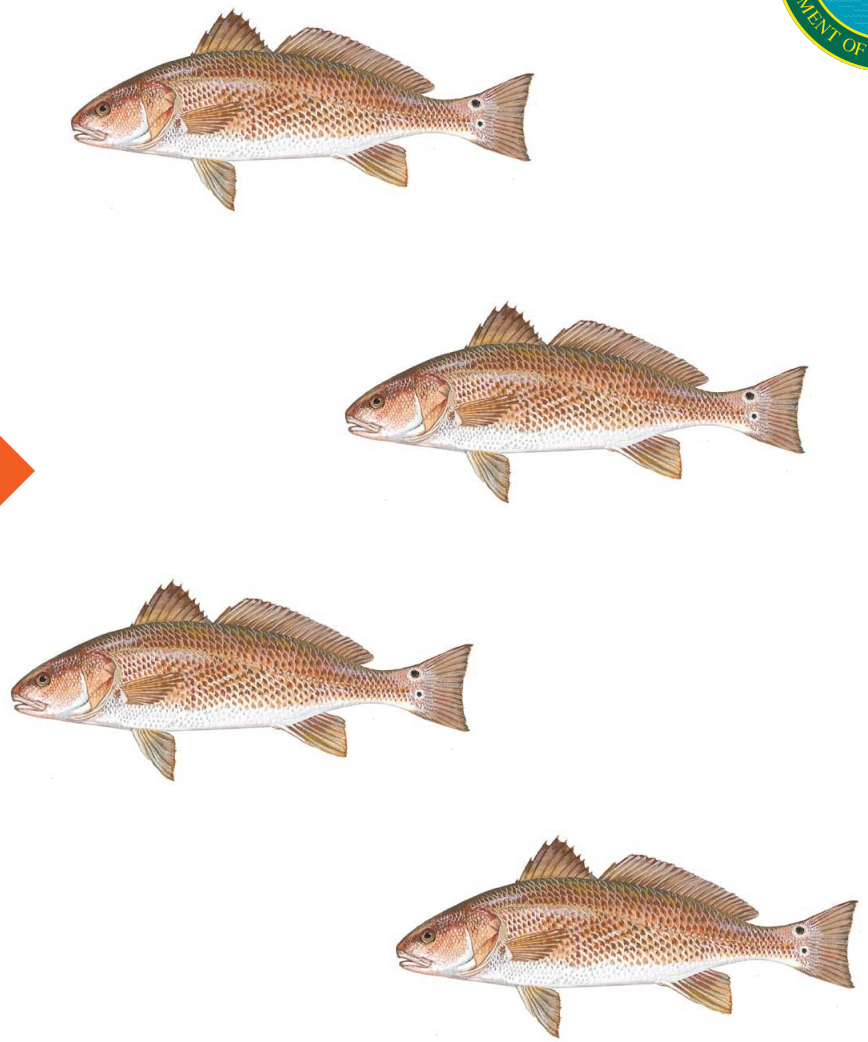
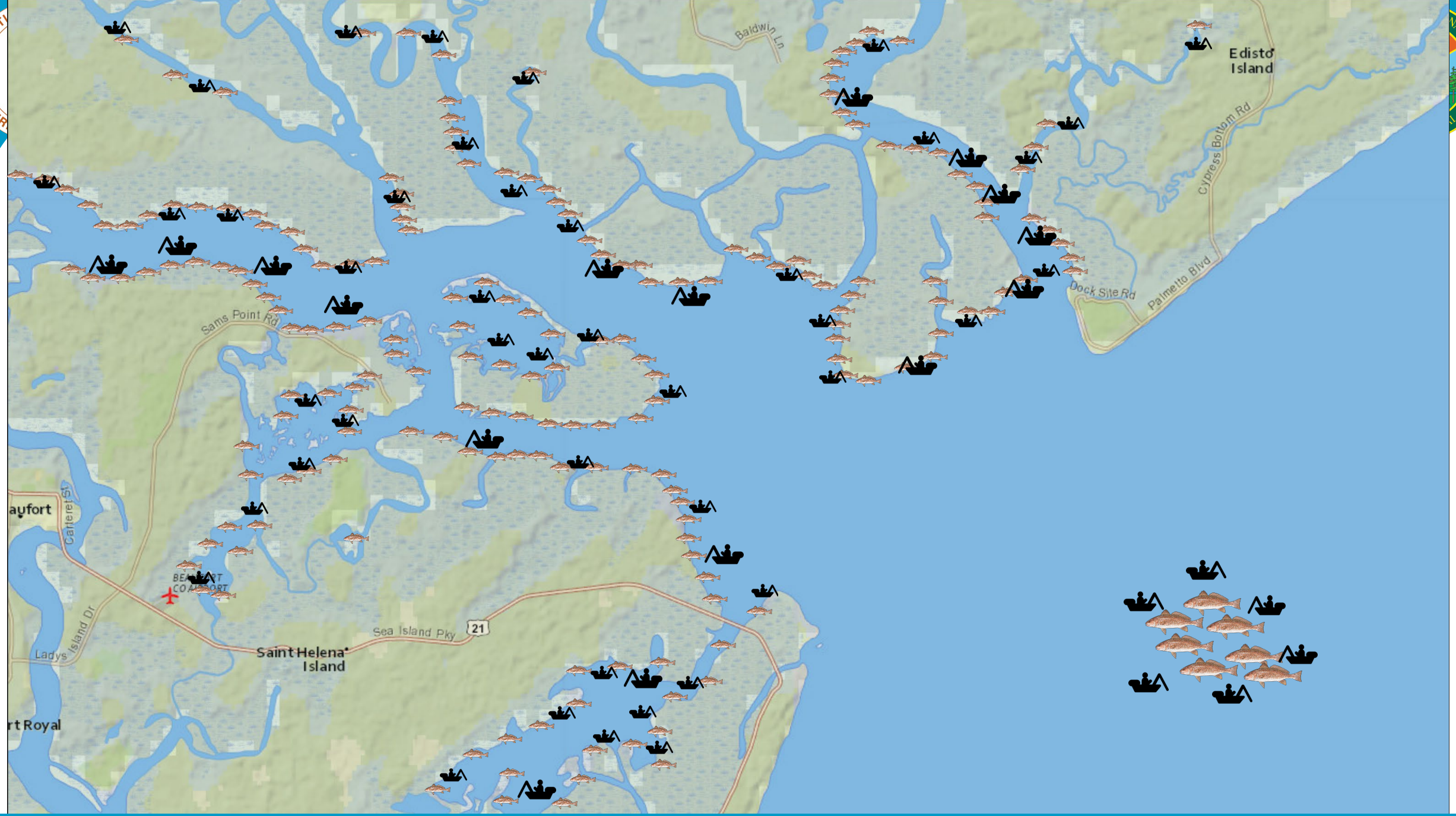


Time

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2. Reduced vulnerability impacts fishery-dependent and fishery-independent data collection, creating data limitations
   - Addressed via influential assumption in past assessments
   - Rise in catch-and-release fishing = increasing impact of these data limitations
     - Limited information on age/length composition of recreational discards which are increasingly representing a larger portion of annual removals

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     - Limited information on age/length composition of recreational discards which are increasingly representing a larger portion of annual removals
3. Management quantities (e.g., SPR) are sensitive to data limitations and assumptions
4. No estimates of the reproductive capacity of the stocks

Red Drum Simulation Assessment

Develop a road map for future red drum stock assessments to determine a path to overcome limitations of previous assessments

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Use a simulation framework

- Simulate red drum stocks, with known population dynamics, subjected to various exploitation patterns – called **Operating Models**
- "Sample" simulated stocks to mimic data streams available to assess the real stocks
- "Assess" simulated stocks using sampled data streams to evaluate the reliability of candidate frameworks – called **Estimation Models**

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Goal – identify preferred framework(s) for providing management advice during subsequent assessments of the real stocks

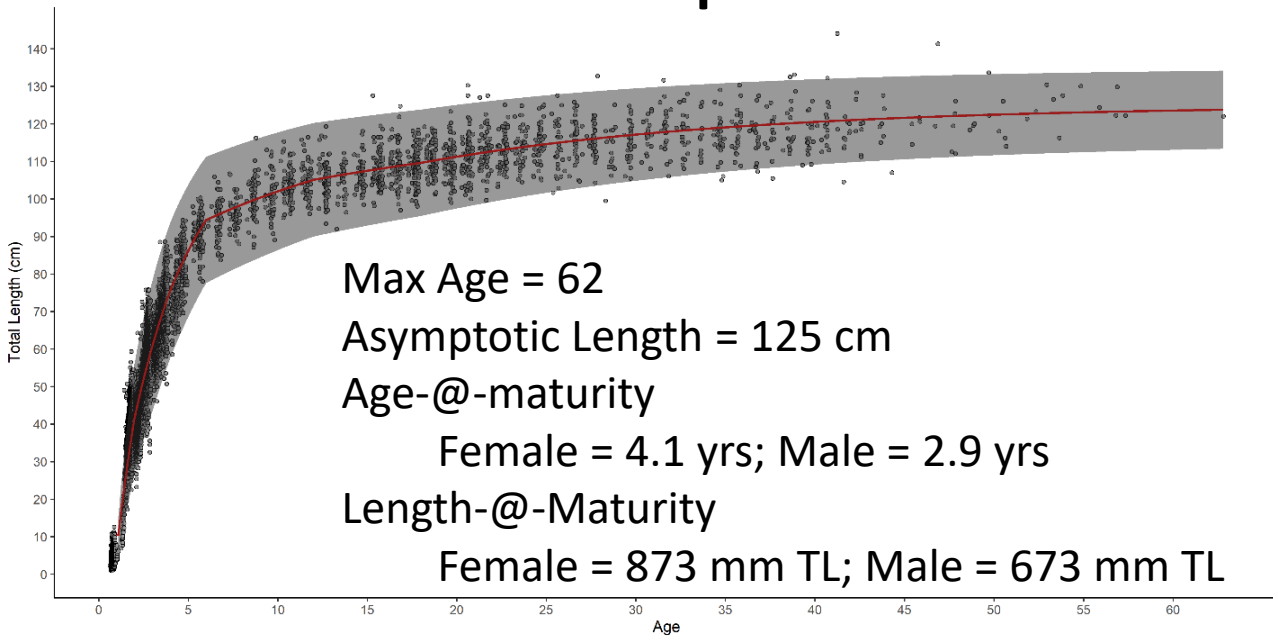
Operating Models (OMs)

General Framework

Separate OMs for each stock (northern stock and southern stock)

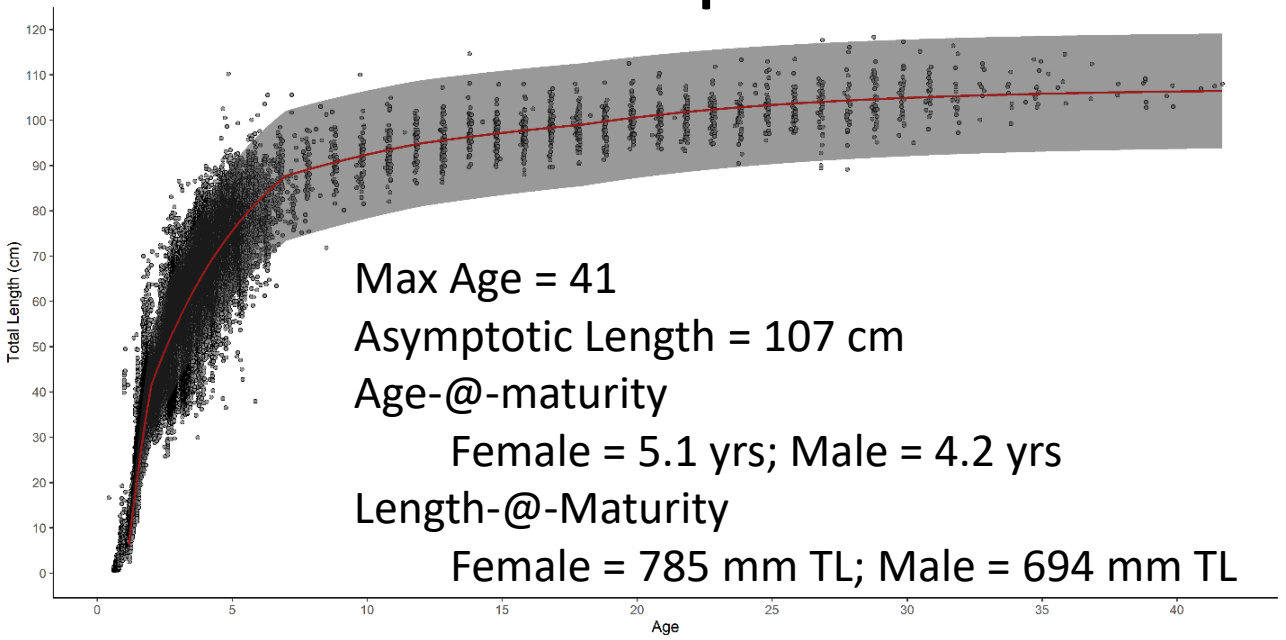
Stocks vary in terms of life history (growth, maximum age, age-@-maturity, natural mortality, etc.) and fisheries (N = commercial + recreational; S = recreational only)

Northern Population



Max Age = 62
Asymptotic Length = 125 cm
Age-@-maturity
Female = 4.1 yrs; Male = 2.9 yrs
Length-@-Maturity
Female = 873 mm TL; Male = 673 mm TL

Southern Population



Max Age = 41
Asymptotic Length = 107 cm
Age-@-maturity
Female = 5.1 yrs; Male = 4.2 yrs
Length-@-Maturity
Female = 785 mm TL; Male = 694 mm TL

General Framework

Separate OMs for each stock (northern stock and southern stock)

Parameterized with information from supporting analyses, published literature, and past stock assessments

- Stock specific where possible
- All parameters fixed (i.e., known) with a specified F time series

General Framework

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Provides “true” population parameters for the simulated stocks

- Fishing mortality, spawning stock biomass, recruitment, etc.

General Framework

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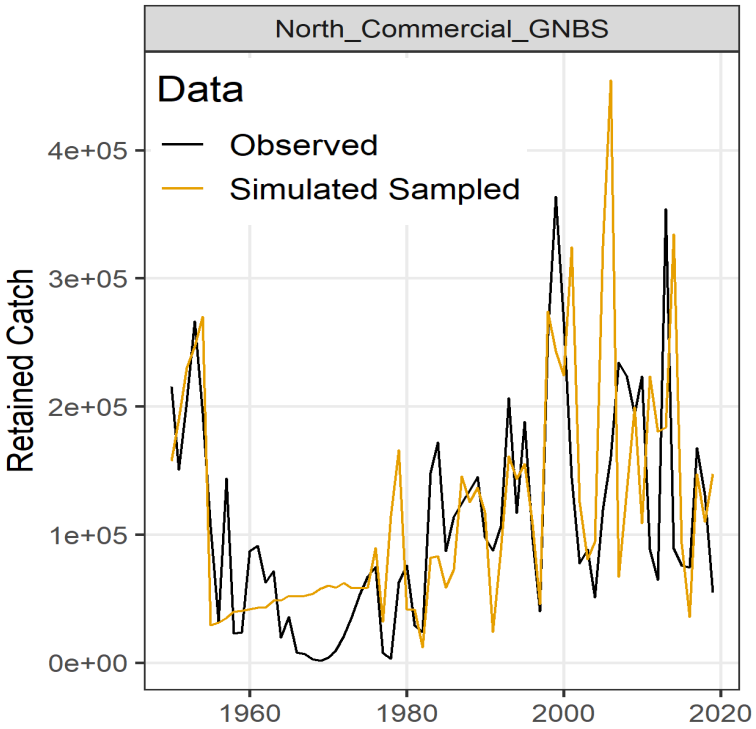
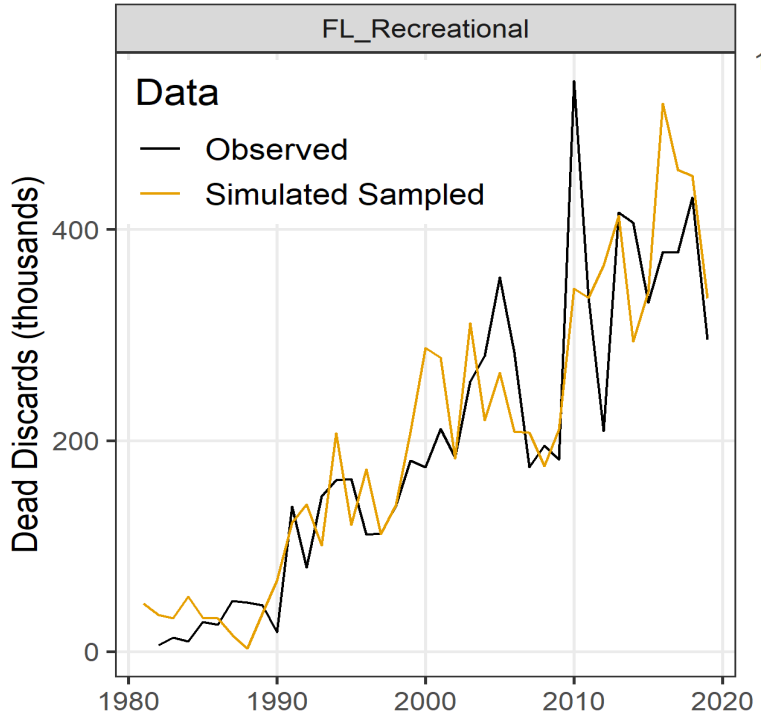
Parameterized with information from supporting analyses, published literature, and past stock assessments

Provides “true” population parameters for the simulated stocks

Tuned with monitoring program data

- Match **trends** and **magnitudes** of changes observed in real data





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Sample each OM 100 times to create iterations for analysis in estimation models

- Introduced process error through unique recruitment deviations for each iteration of the OM
- Provides data (e.g., catch, indices of abundance, composition data) sampled from simulated stocks with sampling error

Estimation Models

Fit to data sampled from simulated stocks with OM to estimate population parameters

Estimation Models (EMs)

Traffic Light Analysis (TLA)

Statistical Catch-at-Age Model (SCA)

Stock Synthesis Model (SS)

Traffic Light Analysis (TLA)

Model-free stock indicator framework

Traffic Light Analysis (TLA)

Model-free stock indicator framework

Indicators

- Recruitment condition – assessed using YOY/Age-1 indices of abundance
- Spawning stock biomass status – assessed using longline survey indices of adult red drum abundance
- Fishing mortality status – assessed using harvest of slot-sized fish divided by slot-sized fish index of abundance (e.g., relative exploitation)

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Only provides categorical estimates of status/condition, no quantitative estimates

Statistical Catch-at-Age Model

Custom age-structured model used in past assessments

Modeling framework used primarily to estimate sub-adult population dynamics

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Fits to fishery catch data, fishery age composition data, and indices of abundance

- Some unique tag-based fishing mortality and selectivity estimates from Bacheler et al. 2008 for the northern stock

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No estimate of recruitment condition

Stock Synthesis Model

Modeling framework to estimate full stock population dynamics

- Recruitment, sub-adult, and adult abundance

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Fits to fishery catch data, fishery-dependent and fishery-independent indices of abundance, and both length and age composition data for indices and fisheries

These models track all age classes in the stocks, estimates spawning stock biomass, and link adults to productivity through an estimated stock-recruit relationship

Operating Model Scenarios

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Developmental Scenarios

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Core Population Dynamics Scenarios

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Additional Structural Scenarios

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Data Prioritization Scenarios

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Core Population Dynamics Scenarios

Additional Structural Scenarios

Data Prioritization Scenarios

Core Population Dynamics Scenarios

Six scenarios with alternate population dynamics prioritized for EM performance evaluations

Include status quo monitoring (i.e. unchanged data set structure) according to current monitoring programs available for real world red drum stocks

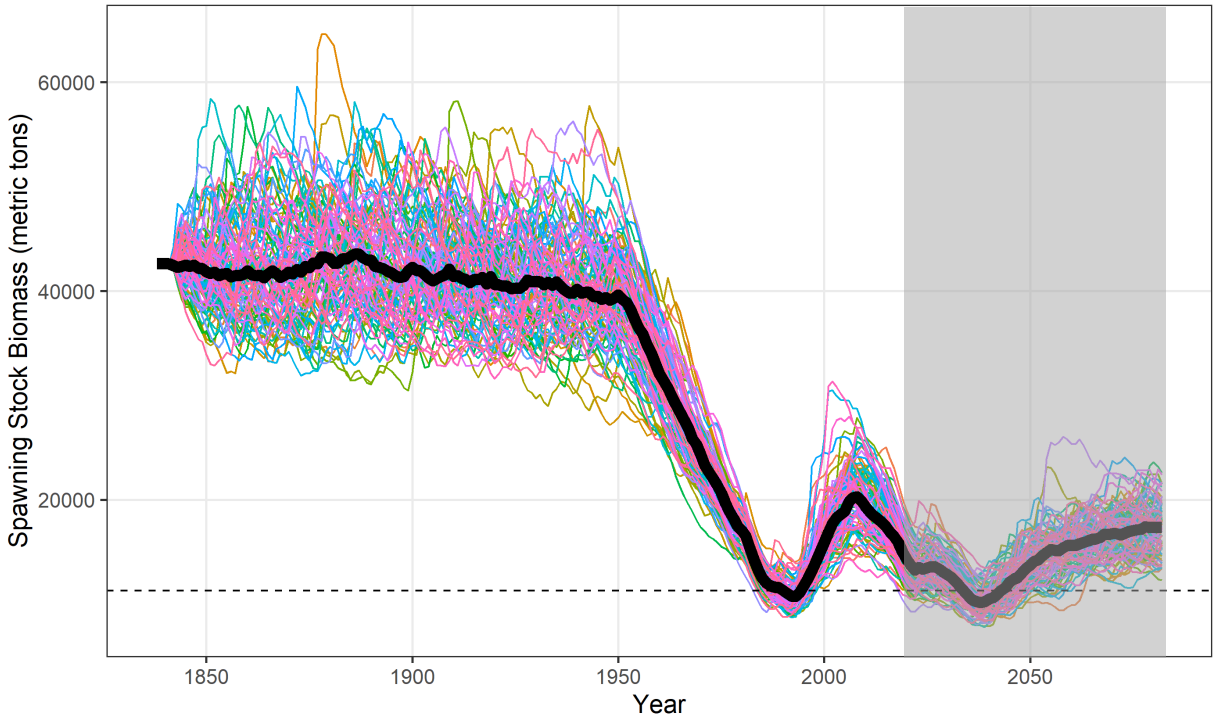
Core Population Dynamics Scenarios

Base: ↑ F early in the projection period followed by a ↓ to target levels

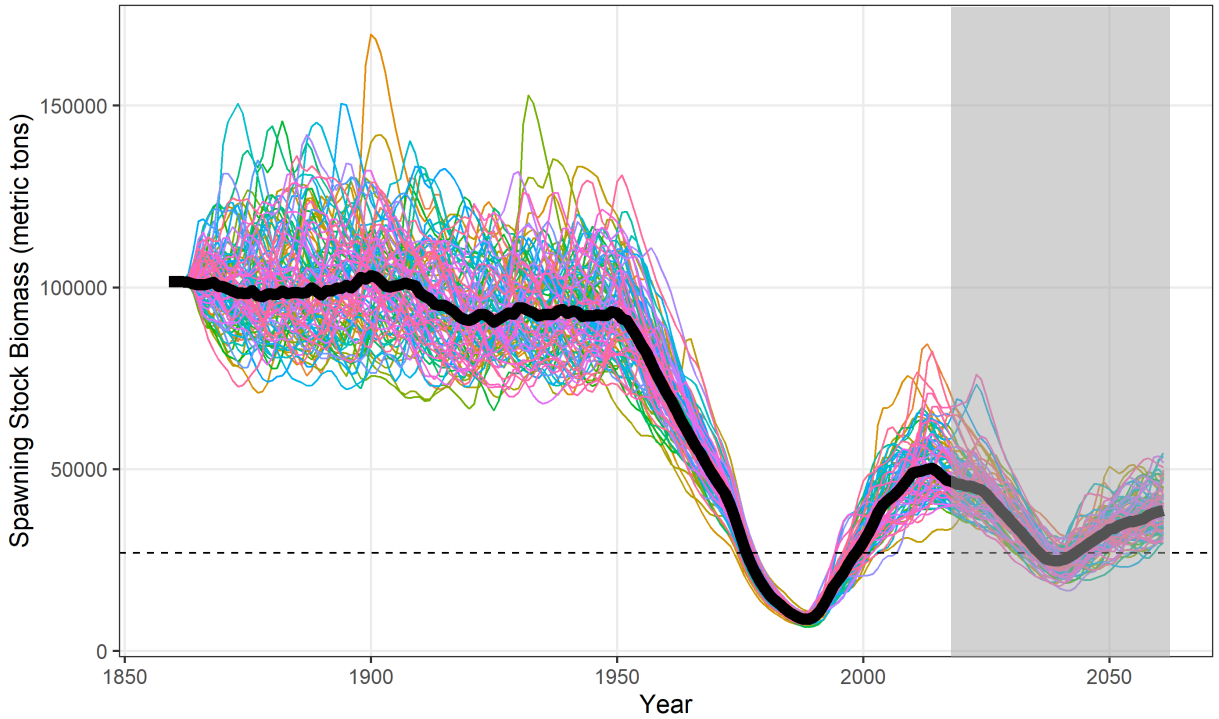
Proxy for a recovering stock & long-term management at targets

Base Scenario

Northern Stock Spawning Stock Biomass



Southern Stock Spawning Stock Biomass



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High F: Base minus the ↓ in F; F stabilizes at high levels

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Miss M: Base, but with ↓ M-at-age

Evaluate a primary uncertainty in stock assessment models

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↓ in stock productivity due to environmental changes

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2023 Term Yr: Base, but with data for assessment models only through 2023

Evaluate short term EM performance

Performance Metrics

Performance Metrics

Convergence Rate

$$\% \text{ Convergence} = \frac{\text{Converged EM Runs}}{100} * 100$$

Measure of EM stability and ease of computation

Only applicable to the SCA and SS models

Convergence Rate

Scenario	Southern		Northern	
	SCA	SS	SCA	SS
Base	77%	100%	94%	100%
High F	80%	100%	95%	100%
Inc Sel	87%	100%	86%	100%
Miss M	67%	99%	92%	90%
Depr R	73%	98%	91%	64%
2023 Term Yr	92%	99%	91%	100%

Population Parameters of Primary Interest

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Recruitment

1. Recruitment condition
    - Not available for SCA model

Performance Metrics

Recruitment

1. Recruitment condition

Biomass Status

2. SSB status

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Fishing Mortality Status

3. 3-yr average SPR ratios
4. 3-yr average SPR status
5. 3-yr average F ratios
6. 3-yr average F status

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Escapement

7. Age-4 escapement
8. Age-6 escapement

Performance Metrics

Convergence Rate

Relative Error

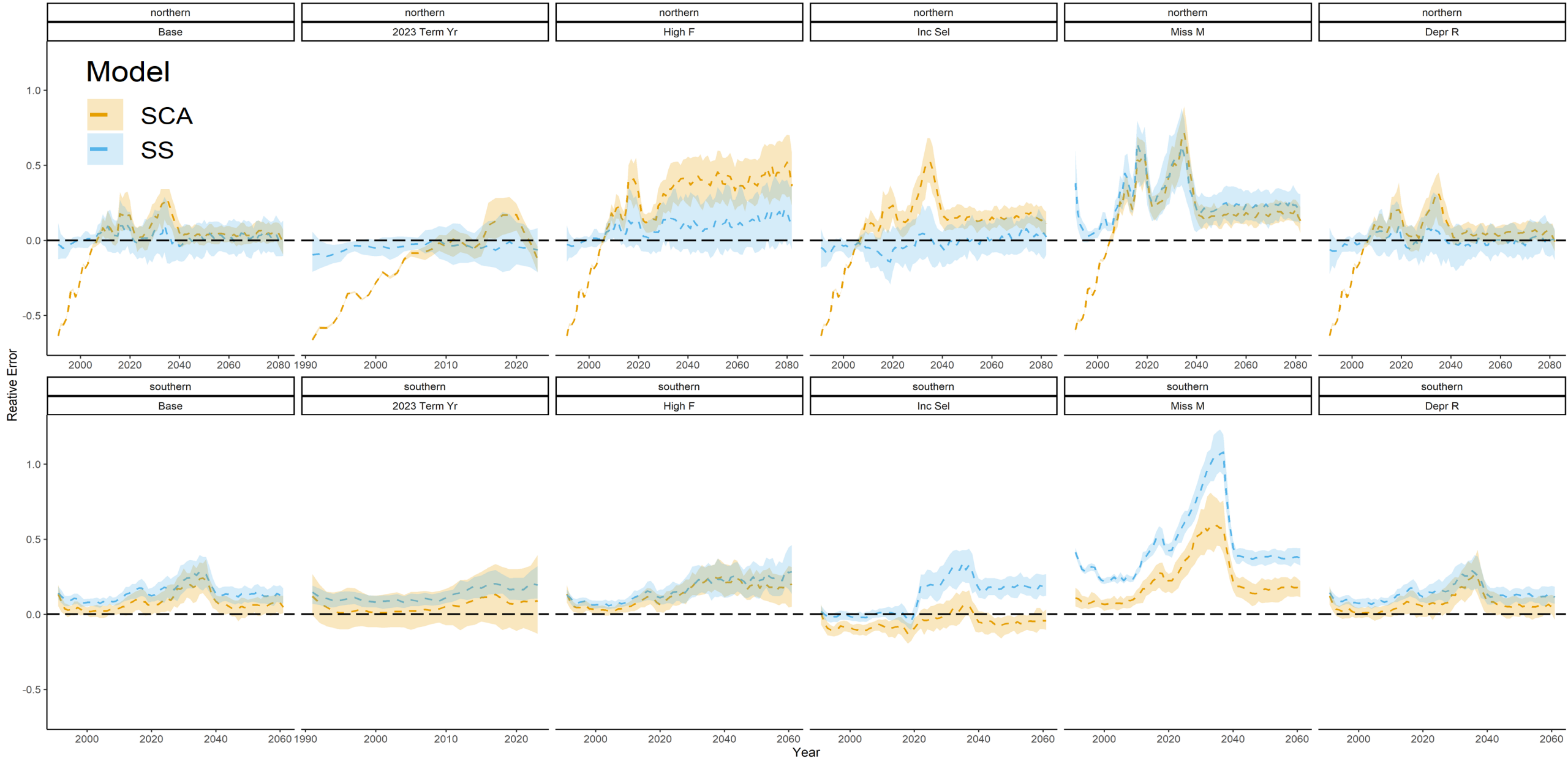
$$\text{Relative Error (RE)} = \frac{\text{Estimated Value} - \text{True Value}}{\text{True Value}}$$

- Positive RE = overestimated by EM
- Negative RE = underestimated by EM

Only applicable to the SCA and SS models

- Distribution across iterations presented through time

3-Yr Spawning Potential Per Recruit



Life's Better Outdoors

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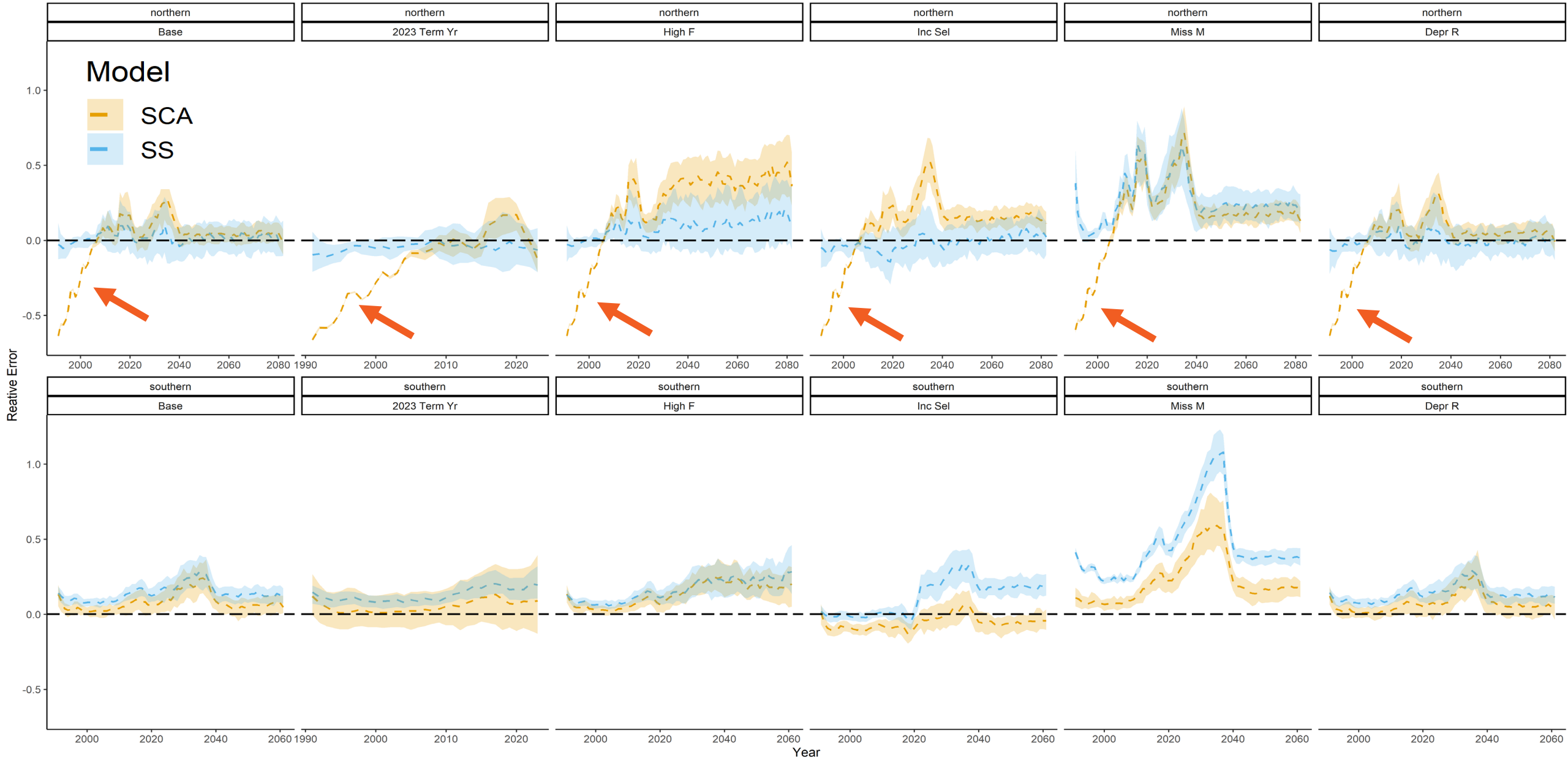

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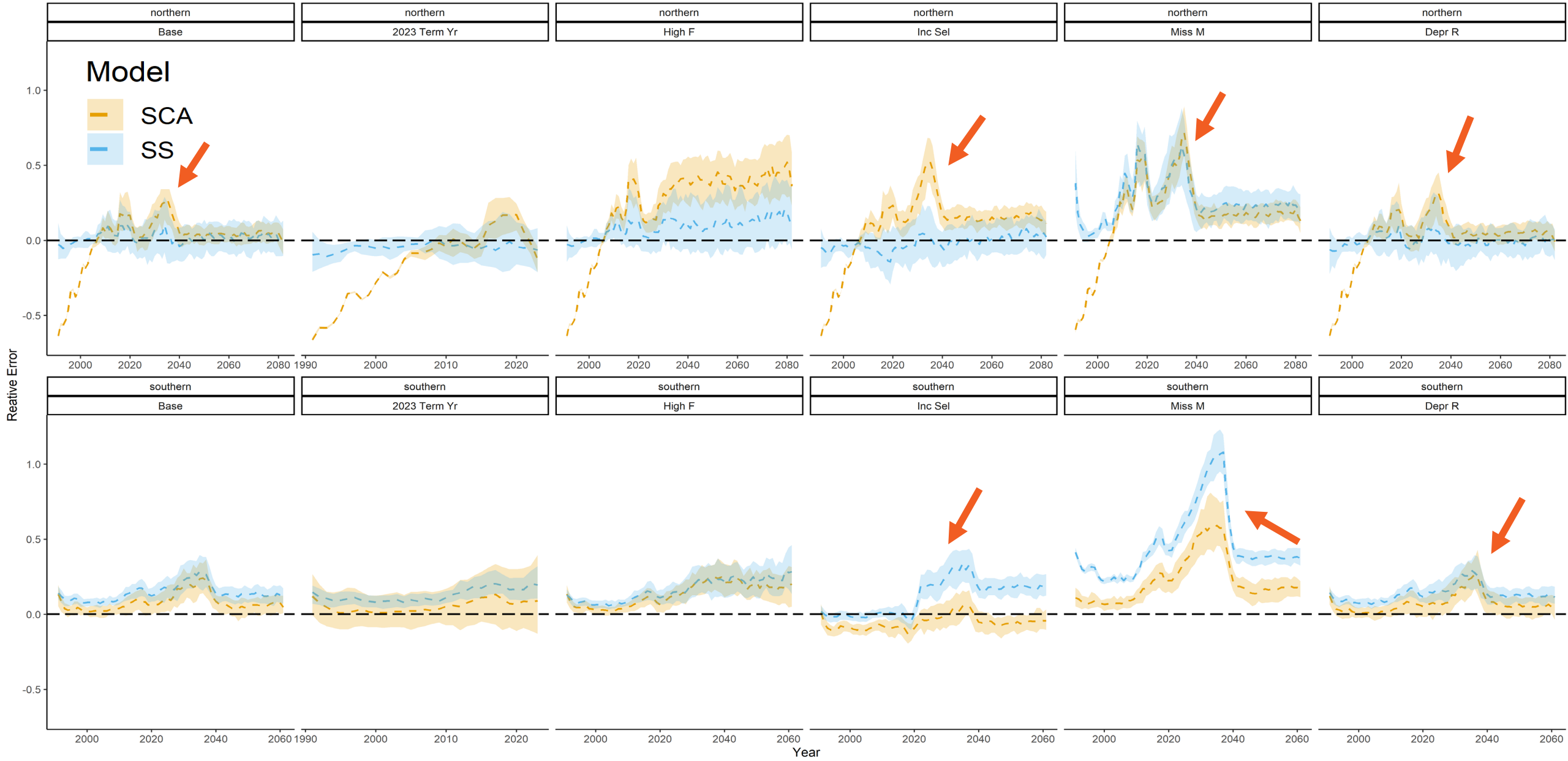

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Convergence Rate

Relative Error

Error Rates (categorical estimates)

$$\text{Error Rate} = \frac{\text{Frequency of Error Type}}{\text{Number of Estimates}}$$

Could be calculated for all EMs

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Type I Error = incorrect estimate when true status/condition is favorable

EM says stock is experiencing overfishing, when true population is **not** experiencing overfishing – EM **more conservative** in status estimation

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EM says stock is experiencing overfishing, when true population is **not** experiencing overfishing – EM more conservative in status estimation

Type II Error = incorrect estimate when true status/condition is unfavorable

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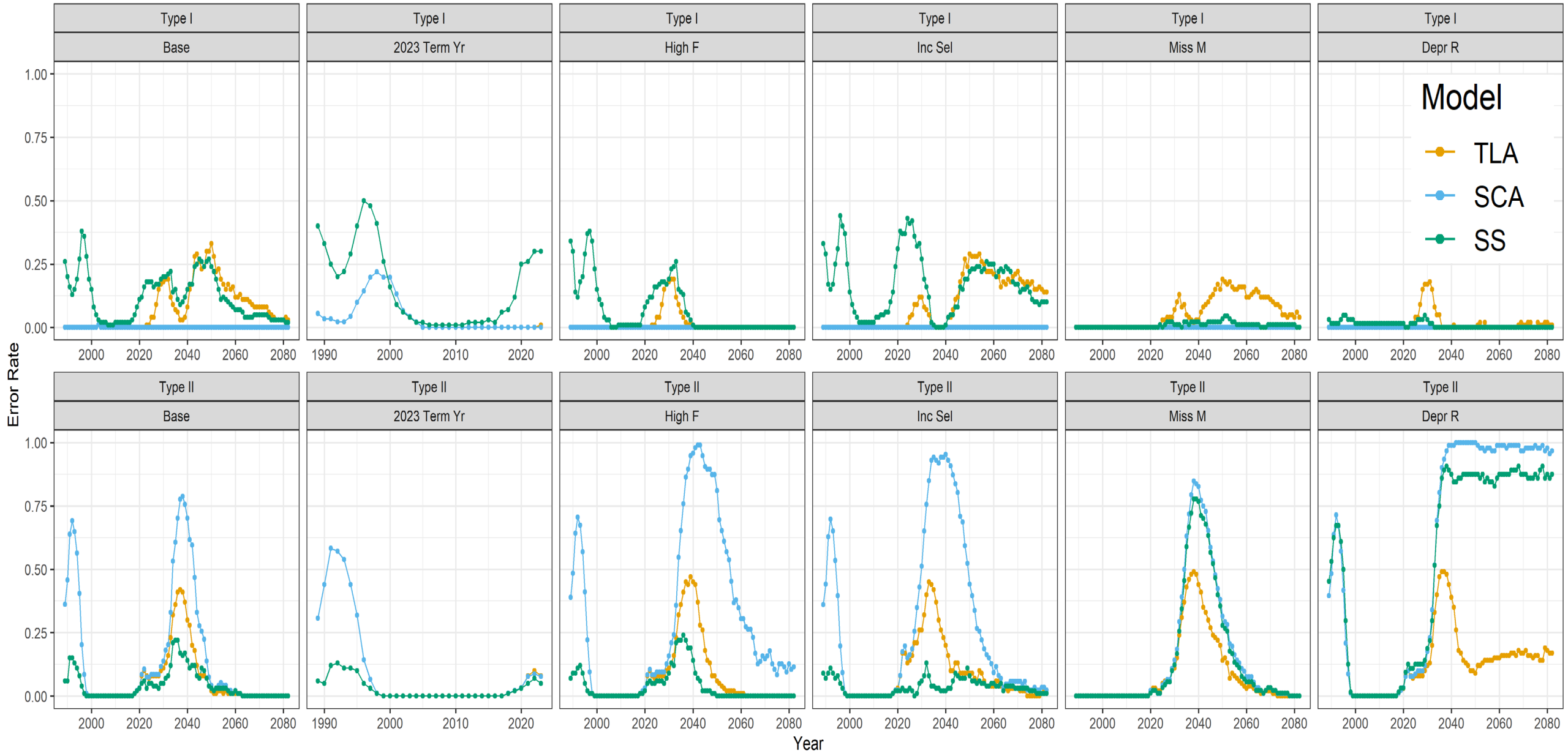
Spawning Stock Biomass – Northern Population



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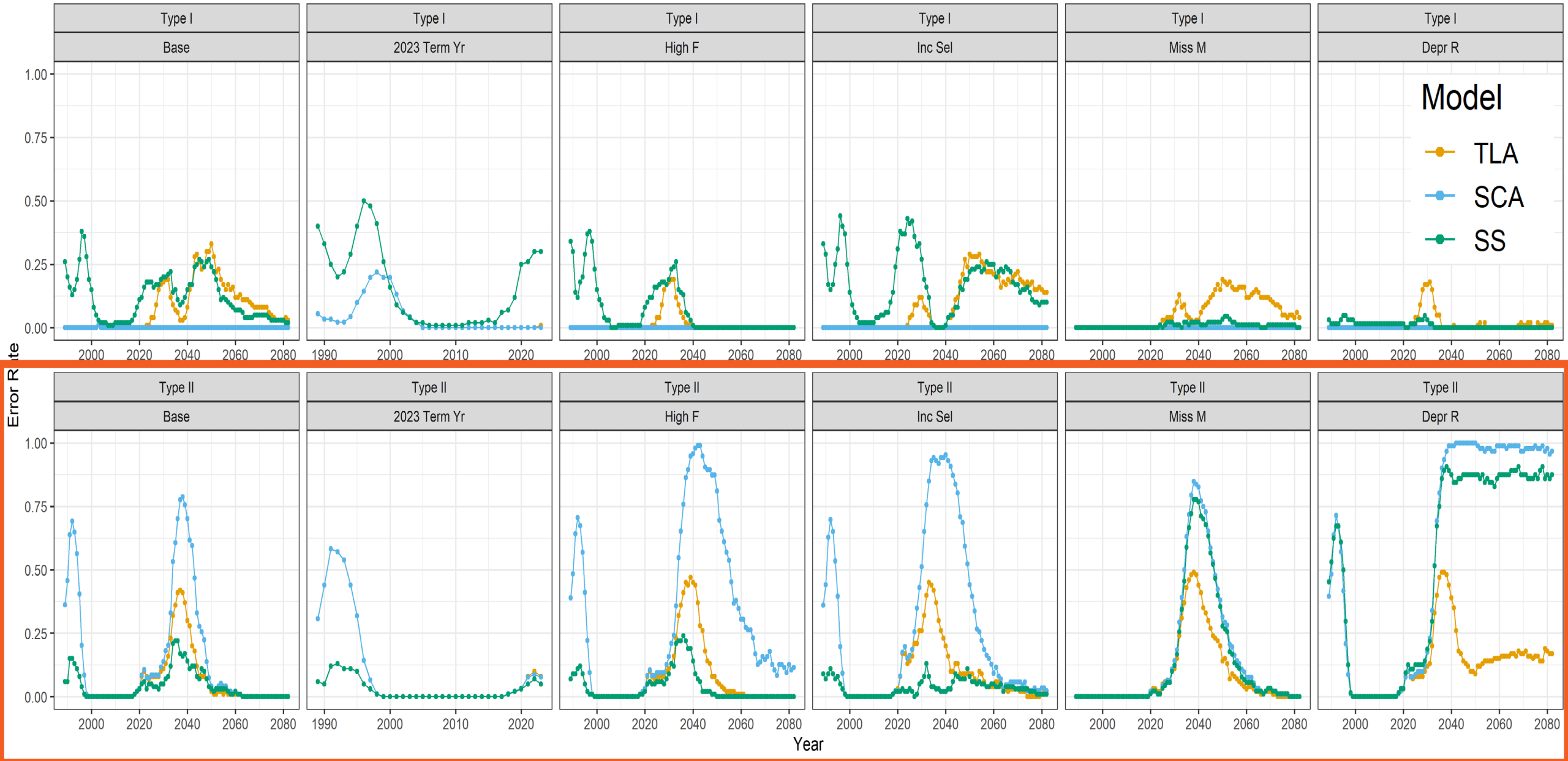

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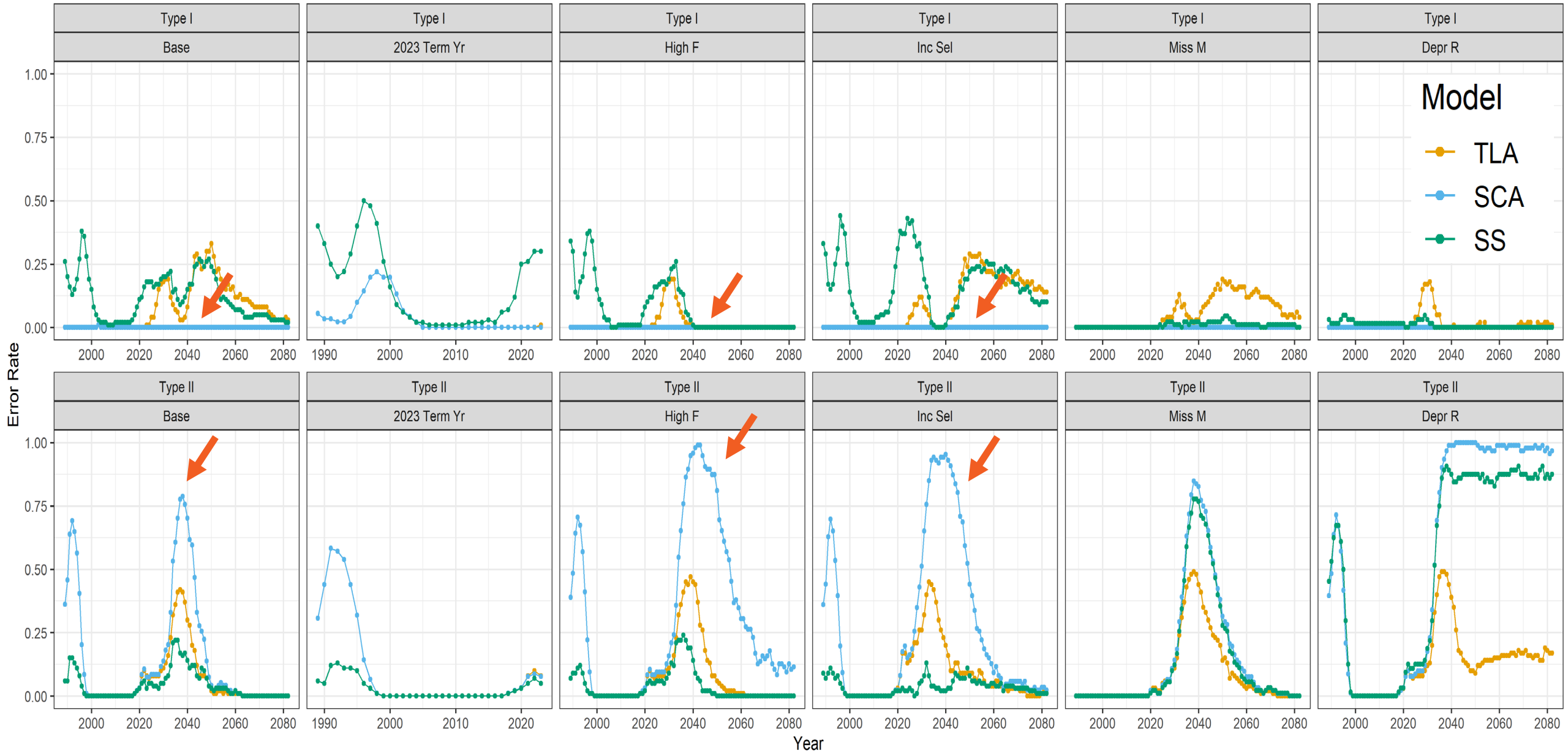

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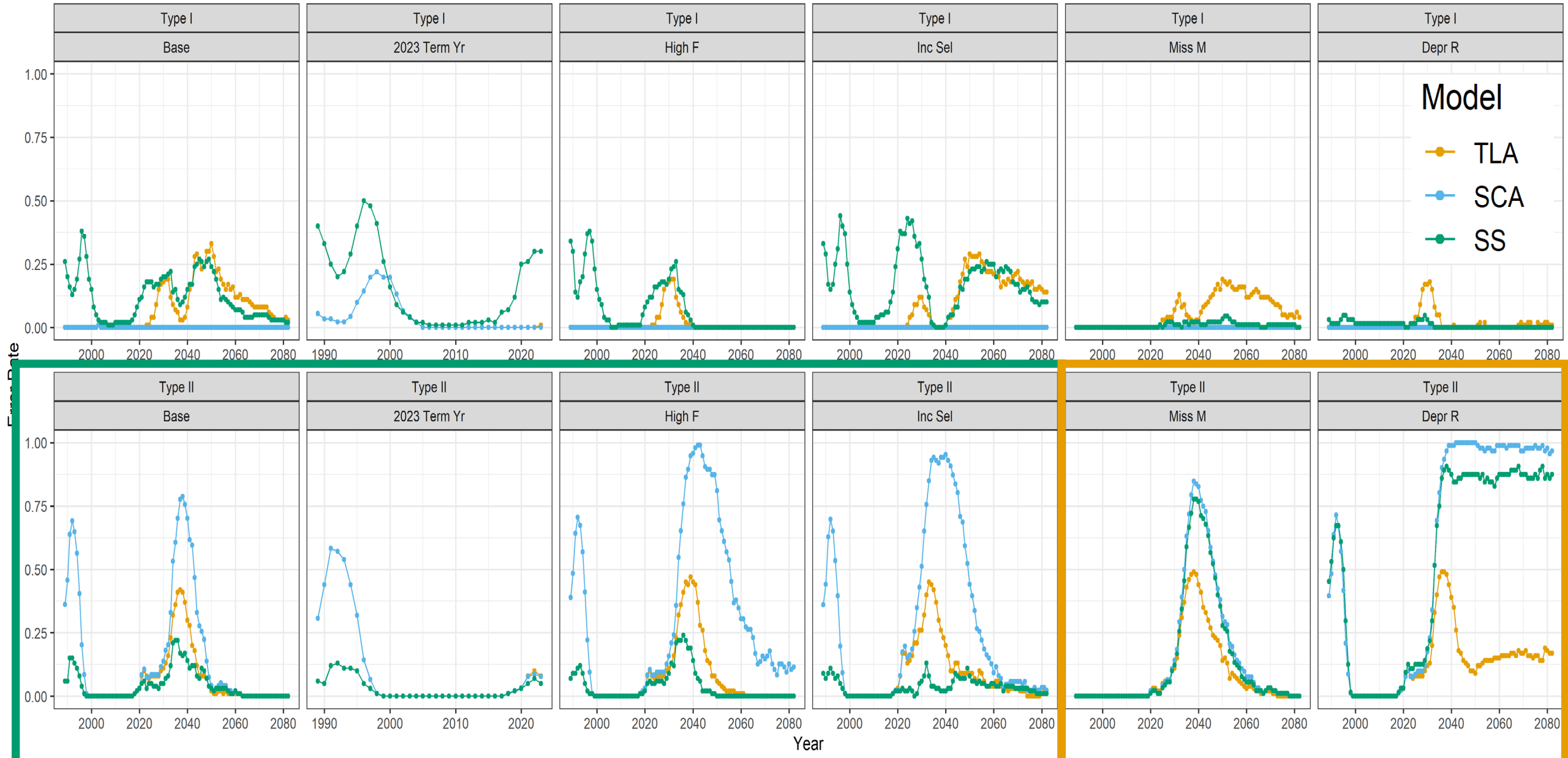

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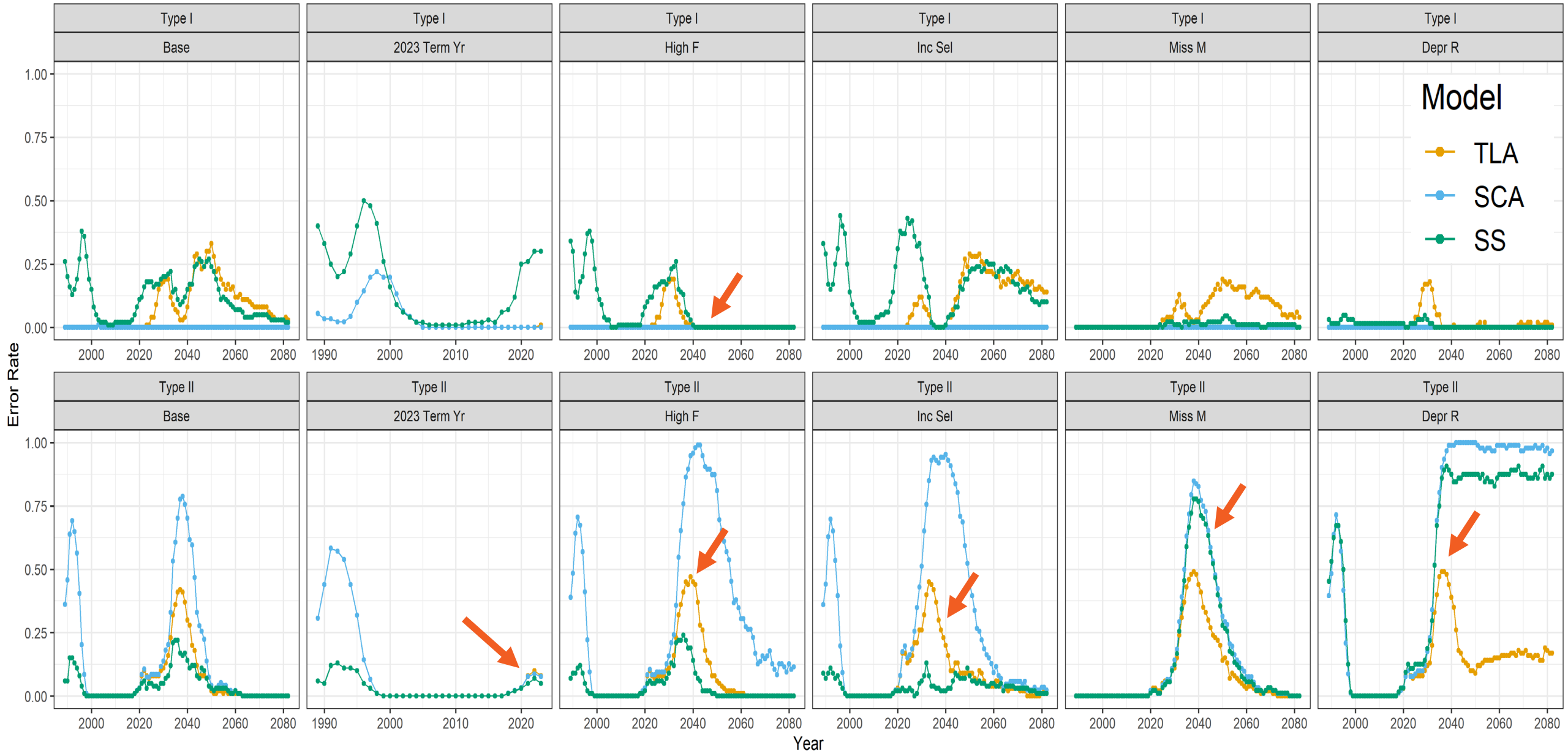

Life's Better Outdoors

Performance Evaluation Tables

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Summarized relative error and error rates of the 8 prioritized population parameters to guide final recommendations

- Focused on period in the near future (i.e., ramp period (2020-2034))

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Type II error rates prioritized as this presents more risk to the stock

Avg. Scenario-Specific Absolute Median Relative Error or Type II Error Rate

Parameter	Type	Southern			Northern			Both		
		TLA	SCA	SS	TLA	SCA	SS	TLA	SCA	SS
Recruitment Condition	Categorical	***0.10***	NA	0.26	***0.12***	NA	0.33	***0.11***	NA	0.29
SSB Status	Categorical	0.04	***0.04***	0.04	0.13	0.18	***0.09***	0.09	0.11	***0.06***
3 Yr F/F_{30}	Numeric	NA	***0.14***	0.18	NA	0.16	***0.14***	NA	***0.14***	0.16
3 Yr F Status	Categorical	***0.12***	0.13	0.19	0.41	0.18	***0.10***	0.26	0.15	***0.15***
3 Yr SPR/SPR_{30}	Numeric	NA	***0.18***	0.26	NA	0.19	***0.18***	NA	***0.18***	0.23
3 Yr SPR Status	Categorical	NA	***0.12***	0.20	NA	0.17	***0.12***	NA	***0.15***	0.16
Age-4 Escapement	Numeric	NA	***0.13***	0.14	NA	***0.13***	0.14	NA	***0.13***	0.14
Age-6 Escapement	Numeric	NA	0.23	***0.22***	NA	***0.14***	0.16	NA	***0.17***	0.19

Avg. Scenario-Specific Standard Deviation

Parameter	Southern		Northern		Both	
	SCA	SS	SCA	SS	SCA	SS
3 Yr F/F_{30}	0.14	***0.08***	***0.15***	0.17	***0.15***	0.16
3 Yr SPR/SPR_{30}	0.18	***0.15***	***0.19***	0.23	***0.20***	0.22
Age-4 Escapement	0.14	***0.14***	***0.19***	0.22	0.19	***0.19***
Age-6 Escapement	0.21	***0.20***	***0.22***	0.25	***0.24***	0.26

Modeling Recommendations

Assessment Methodology

Used the performance of our estimation models (TLA, SCA, and SS) for each stock

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Focused on core population dynamics scenarios

- Used the totality of the scenarios explored to inform overall conclusions

Goal – major conclusions based on the totality of the results from the EMs

- Due to performance of the considered EMs between stocks, we developed stock specific recommendations

Assessment Methodology – Northern Stock

Recommend **pursuing** both the **SS and TLA assessment** approaches

Do Not recommend pursuing the **SCA** or continuation of SCA model development

Assessment Methodology – Northern Stock

Recommend **pursuing** both the **SS and TLA assessment** approaches

Do Not recommend pursuing the SCA or continuation of SCA model development

Prioritize development of the SS model

More consistent and accurate performer

Performed well under the **2023 Term Yr** scenario (lack of a decrease in precision)

Flexibility of SS will provide a benefit to the assessment of Red Drum

Incorporation of additional data sets not considered here – e.g., tag-recapture data

Parameter	Type	Northern		
		TLA	SCA	SS
Recruitment Condition	Categorical	***0.12***	NA	0.33
SSB Status	Categorical	0.13	0.18	***0.09***
3 Yr F/F_{30}	Numeric	NA	0.16	***0.14***
3 Yr F Status	Categorical	0.41	0.18	***0.10***
3 Yr SPR/SPR_{30}	Numeric	NA	0.19	***0.18***
3 Yr SPR Status	Categorical	NA	0.17	***0.12***
Age-4 Escapement	Numeric	NA	***0.13***	0.14
Age-6 Escapement	Numeric	NA	***0.14***	0.16

Assessment Methodology – Northern Stock

Recommend **pursuing** both the **SS and TLA assessment** approaches

Do Not recommend pursuing the SCA or continuation of SCA model development

Prioritize development of the SS model

Develop TLA as a supplementary analysis and as potential tool for monitoring the stock between assessments

- Comparable to the SS EM in making SSB status determinations, use caution for using to characterize F status
- Outperforms SS when characterizing recruitment condition

Parameter	Type	Northern		
		TLA	SCA	SS
Recruitment Condition	Categorical	***0.12***	NA	0.33
SSB Status	Categorical	0.13	0.18	***0.09***
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Age-6 Escapement	Numeric	NA	***0.14***	0.16

Assessment Methodology – Southern Stock

SAS recommended **pursuing all (TLA, SCA, & SS) assessment** approaches

- Concerns with individual EMs, though they overall had similar performance
- More consistency in performance among the models than seen for the northern stock

Parameter	Type	Southern		
		TLA	SCA	SS
Recruitment Condition	Categorical	***0.10***	NA	0.26
SSB Status	Categorical	0.04	***0.04***	0.04
3 Yr F/F_{30}	Numeric	NA	***0.14***	0.18
3 Yr F Status	Categorical	***0.12***	0.13	0.19
3 Yr SPR/SPR_{30}	Numeric	NA	***0.18***	0.26
3 Yr SPR Status	Categorical	NA	***0.12***	0.20
Age-4 Escapement	Numeric	NA	***0.13***	0.14
Age-6 Escapement	Numeric	NA	0.23	***0.22***

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All models appropriate for F status and SSB status estimates

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		TLA	SCA	SS
Recruitment Condition	Categorical	***0.10***	NA	0.26
SSB Status	Categorical	0.04	***0.04***	0.04
3 Yr F/F_{30}	Numeric	NA	***0.14***	0.18
3 Yr F Status	Categorical	***0.12***	0.13	0.19
3 Yr SPR/SPR_{30}	Numeric	NA	***0.18***	0.26
3 Yr SPR Status	Categorical	NA	***0.12***	0.20
Age-4 Escapement	Numeric	NA	***0.13***	0.14
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Review panel recommended discontinuing development of the **SCA assessment** model

- More information during review panels report

Parameter	Type	Southern		
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Assessment Methodology – General Recommendations

Potential alternative management approach for Red Drum could be developed based on trends and levels relative to reference time period

- Models generally provided accurate trends in F, SSB, and recruitment, even if absolute values were biased
- Work needed to define an appropriate time period to use as a reference

Future Simulation Analyses

Explore the cause for trends in bias of models during periods of big changes in stock dynamics

- Associated with large changes in F, leading to changes in performance for estimating stock status
- During these real world shifts it is most crucial to obtain accurate and precise estimates of stock status

SPR Ratio

Prioritized Recommendations on Future Monitoring to Improve Assessment

Conduct additional simulations to better understand models' insensitivity to longline survey data

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Prioritized Recommendations on Future Monitoring to Improve Assessment

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Developing custom growth models a lower priority than other tasks such as exploration of tagging data during the benchmark assessment

Continue to prioritize collection of recreational discard size composition data

- Inclusion of (high quality) discard composition data generally improved precision of parameter estimates

Prioritized Recommendations on Future Monitoring to Improve Assessment

Conduct additional simulations to better understand models' insensitivity to longline survey data

Developing custom growth models a lower priority than other tasks such as exploration of tagging data during the benchmark assessment

Continue to prioritize collection of recreational discard size composition data

- Inclusion of (high quality) discard composition data generally improved precision of parameter estimates

Anticipation that inclusion of tag-recapture data, in SS model, would improve parameter estimates

- Limitation of current OM was the inability to generate tag-recapture data sets

Conclusions

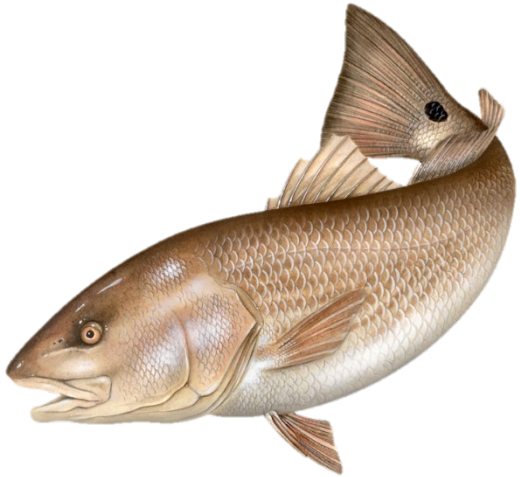
Provide guidance to help prioritize workloads during the upcoming benchmark assessment

Provides information on uncertainty not available in traditional stock assessment

Ultimately, preferred model(s) will depend on diagnostics during the benchmark assessment

Questions?

Red Drum Simulation Assessment Peer Review Report



Sciaenids Management Board

May 2, 2022

Stock Assessment Peer Review Process

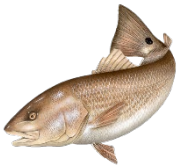
- Red Drum Technical Committee and Stock Assessment Subcommittee developed new Simulation Assessment

- Review Workshop March 28-30, Raleigh, NC

- Scientific review focused on data inputs, models, results, sensitivities, and overall quality of Simulation Assessment

Products

- ASMFC Simulation Assessment and Peer Review Report
- www.asmfc.org/species/red-drum



Peer Review Process

Scientific Peer Review Panel

- Chair + 3 additional Technical Reviewers, with expertise in
  - Red Drum Ecology and Population Dynamics
  - Simulation and Stock Assessment Modeling
  - Stock Synthesis modeling program

Dr. Amy Schueller (Chair), NMFS Southeast Fisheries Science Center

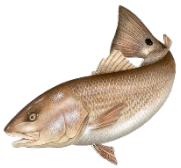
Dr. Mike Allen, University of Florida, Nature Coast Biological Station

Dr. Jie Cao, North Carolina State University, CMAST

Dr. Dan Hennen, NMFS Northeast Fisheries Science Center

Review Panel Overall Findings

- The operating model (OM) appropriately simulated red drum population dynamics and generated data sets useful to assess red drum
  - RP requested generation of 'perfect data' to use in EMs
- The Stock Synthesis (SS) estimation model (EM) should be used to assess the northern and southern stocks, while the SCA model should not be used
  - SS fit to 'perfect data' from the OM for the north
  - More work is needed for the southern model (address later)
- Traffic Light Approach should be used as an accessory model between assessments



Review Findings

✓ **ToR 1:** Data used in models and data uncertainty

Panel Conclusions

- Excellent job analyzing large and complex data sets
- Some room for improvement in growth estimation, index selection, tagging data analysis, and discard mortality

Recommendation 1: Consider alternative growth curve formulations such as bias correction, modeling pre-maturation separately, or modeling size increment data

Recommendation 2: Consider combining indices of abundance using Conn method, VAST, hierarchical modeling, or dynamic factor analysis

Review Findings

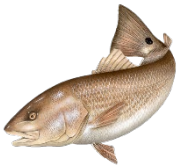
✓ **ToR 1:** Data used in models and data uncertainty

Panel Conclusions

Recommendation 3: Encourage new analyses of the tagging data to obtain estimates of harvest rate information (F)

- ***Estimates of F obtained independently from the assessment could improve model fit, and could influence the effects of selectivity curves on fit to perfect data***
- ***Worth additional analysis of existing tagging data, as well as new data using high-reward tagging programs***

Recommendation 4: Improved collection of discard information, specifically of discard numbers and sizes of individuals



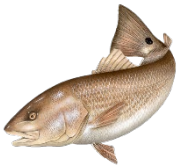
Review Findings

✓ **ToR 2:** Simulation model parametrization

Panel Conclusions

- Thorough job parameterizing the simulation model including difficult parameters such as natural mortality and recruitment compensation
- Some uncertainty in selectivity as regulations changed across time and space

Recommendation 1: Sensitivity analyses to explore how changes in the selectivity curves influence model predictions when given perfect data

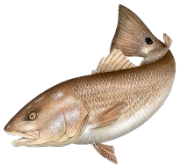


Review Findings

✓ **ToR 3:** Simulation Model

Panel Conclusions

- Stock Synthesis simulation package (Sssim) is an appropriate method or tool for simulating red drum populations and generating data sets for use in the estimation models
- Uncertainty in the operating model represented the observed uncertainty

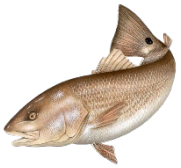


Review Findings

✓ **ToR 4:** Uncertainty in simulated populations

Panel Conclusions

- Uncertainty was handled appropriately and was well described
- Several different scenarios were run to assess key uncertainties including increased fishing pressure, changes in the selectivity at age, natural mortality, and time varying recruitment



Review Findings

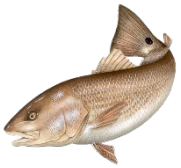
✓ **ToR 5:** Candidate assessment methods

Panel Conclusions

- SCA model has limited configurations compared to SS (e.g. R)
- Application of assessment methods was appropriate

Recommendation 1: Further examination of the estimation of the stock-recruitment curve. If data are insufficient to inform the estimation of steepness (h), then fix h = 0.99

Recommendation 2: Consider alternative start years for the model such as 1950 or 1991 to assess impact on robustness of model outcomes



Review Findings

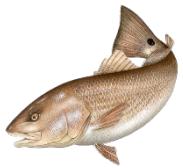
✓ **ToR 6:** Reference Points

Panel Conclusions

- Reference points selected were appropriate
- Escapement is vital as a reference point, given the juvenile-based fishery

Recommendation 1: Monitor both an annual and a 3-year moving average of SPR status

Recommendation 2: SSB status could be turned into a trend-based reference point; however, more work needs to be done to identify an appropriate reference period and to assess the bias in the southern EM using 'perfect data' from the OM



Review Findings

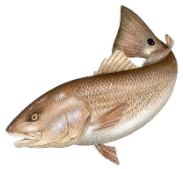
✓ **ToR 7:** Performance Metrics

Panel Conclusions

- Choice of performance metrics was appropriate and represent standard reference points
- 100 simulations were completed for each model to produce relative error and Type I and II error rates, which may be adequate to assess relative performance but needs further exploration

Recommendation 1: Increase the number of iterations to 200 and compare to 100 iterations

Recommendation 2: Perform several runs of 100 iterations and assess variability in relative error and error rates



Review Findings

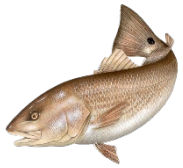
✓ **ToR 8:** Preferred assessment method

Panel Conclusions

- SCA model seems to be intrinsically biased even when using 'perfect data' from the OM
- SS model appears to be unbiased for the northern region
- SS model for the southern region needs further work to provide an unbiased fit to the 'perfect data' from the OM

Recommendation 1: Do not use the SCA model further

Recommendation 2: Use the SS model to assess the northern and southern stocks, but further work is needed to finalize the model for the southern stock (e.g., growth curve analyses, selectivity)



Review Findings

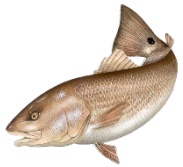
✓ **ToR 8:** Preferred assessment method

Panel Conclusions

- Concerned regarding unexpected outcomes
  - North – inclusion of live discard composition data improved characterization of discards but resulted in increased bias
  - South – use of the true growth model resulted in increased bias
- TLA can be used as an interim accessory tool

Recommendation 3: Determine why counterintuitive results are occurring

Recommendation 4: Repeat the grid search for TLA using only pre-2023 years to determine the reference points



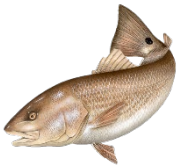
Review Findings

✓ **ToR 9:** Future monitoring

Panel Conclusions

- Difficult to assess given the counterintuitive results regarding the longline survey and composition information for discards
- Apparent lack of data in the 70-90 cm range

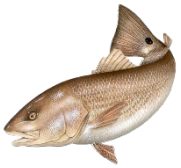
Recommendation 1: Collect data on individuals in the 70-90 cm range to provide information on age, trends in abundance, selectivity across gears, and inform more robust growth analyses



Conclusions and Next Steps

- First, next step - SAS needs to work on fitting the SS southern model to the 'perfect data' from the OM to show that the EM can reproduce the truth

- Then, committee can move forward considering the other recommendations provided by the RP
  - Counterintuitive results in the north and south
  - Additional sensitivity runs
  - Additional data analyses (e.g., growth, tagging, etc)




Questions?

Figure 1. A plot of the relative error in sub-adult abundance for the northern and southern SCA models demonstrating that fixing parameters can lead to reduced bias in the early part of the time period for the north. This likely indicates something amiss with the initialization.

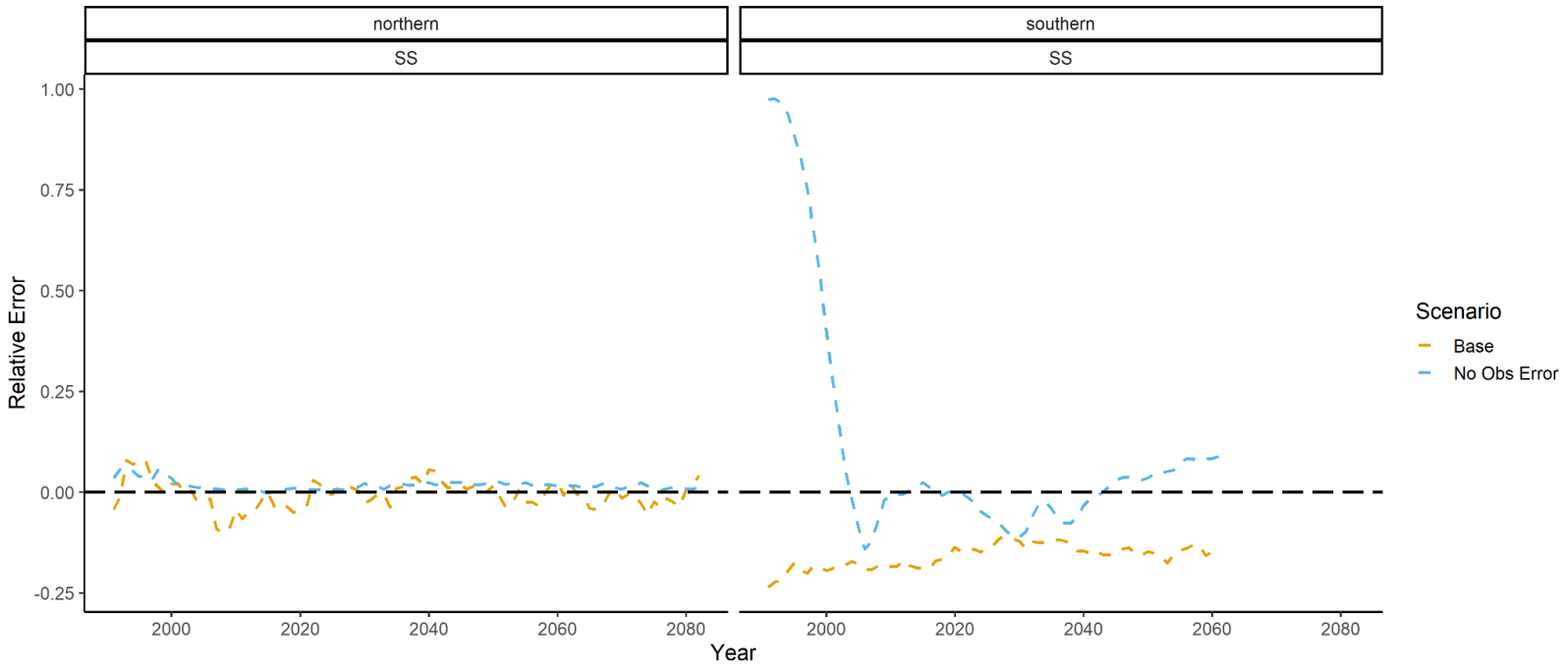


Figure 2. A plot of the relative error in the three year F ratios for the northern and southern SS models demonstrating that the northern model was able to produce unbiased results when using the perfect data from the operating model.

Red Drum Stock Assessment Road Map

1. Simulation Assessment

- Evaluate performance of assessment approaches using simulation analyses
- Recommend preferred assessment approaches for red drum assessment
- Completion in 2022 (External ASMFC Peer Review)

2. Traditional Benchmark Stock Assessment

- Apply recommended assessment approaches (SS and TLA) to red drum data sets
- Provide assessment results for management advice
- TORs and timeline provided summer 2022
- Completion in 2024 (SEDAR Peer Review)