



# **SS Model Configuration Background**

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# Time Series



- 1981-2022 fishing years (Sept. 1981-Aug. 2022)
  - Time step changed from calendar year to Sep.-Aug. fishing year
  - Model start year changed from 1989 to 1981
  - 2022 fishing year data incomplete or preliminary, not used for stock status determination
  - Initial conditions are estimated based on:
    1. estimated initial  $F$  levels to reduce the unfished biomass level to that in the model start year
    2. estimated deviations to the equilibrium age structure as informed by early year class data in the start of the model

# Population Structure

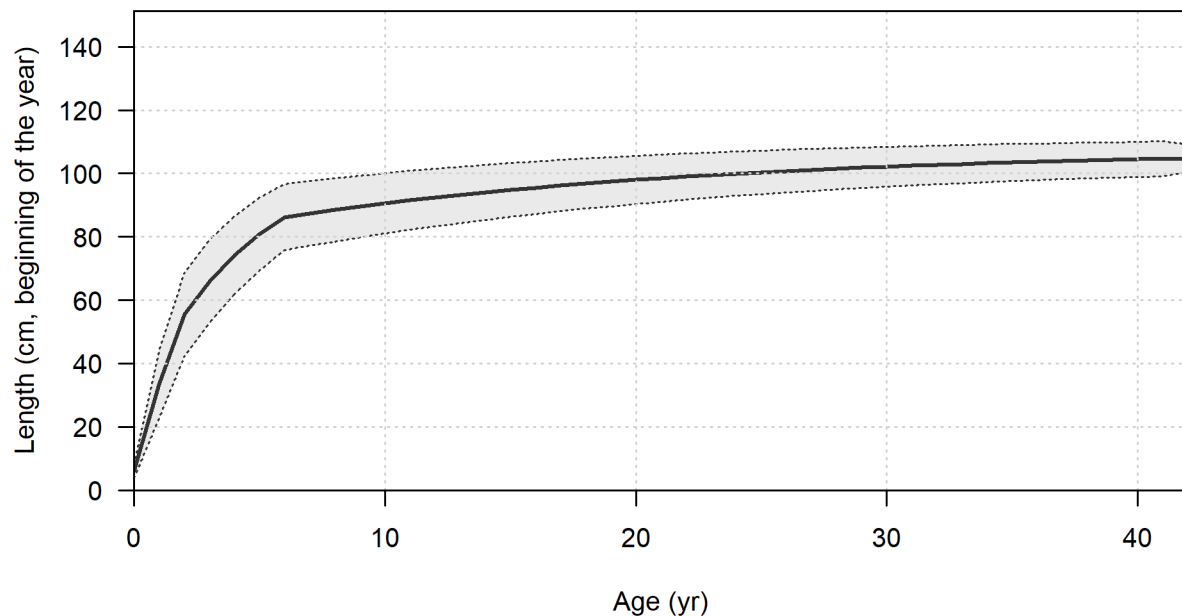


- Total length (cm)
  - 1cm population length bins from 6cm to 137cm
  - 2cm data length bins from 10cm and 12cm, for the northern and southern stocks, respectively out to largest observed length bin
- Age
  - 0 through max observed age (northern=62, southern=41)
  - No ageing error
- No sex-specific dynamics

# Growth



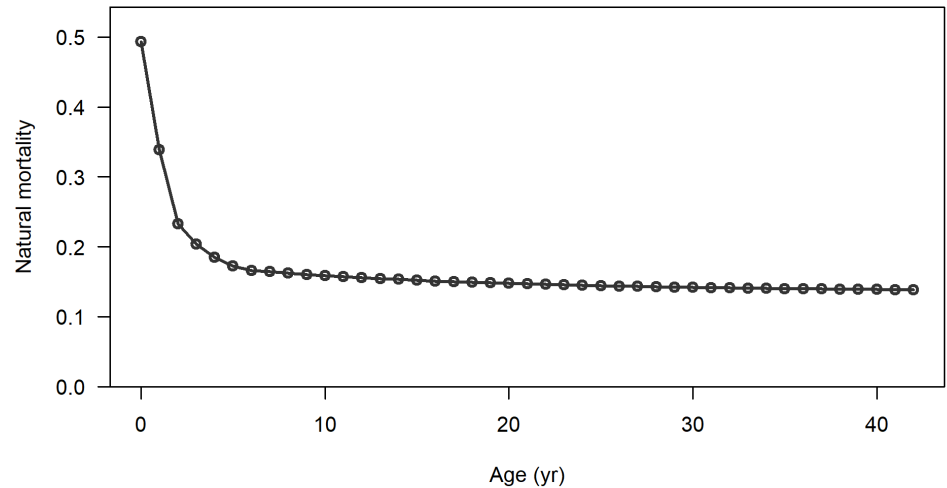
- Age-varying K growth
  - von Bertalanffy growth function with K parameter varying at specified ages
- YOY grow linearly after settling at the smallest population size bin (6cm) to  $A_{min}$ , then follow growth function
- Parameters:
  - Length at  $A_{min}$  ( $L_{min}$ )
  - $L_{inf}$
  - Base K
  - K multipliers (2)
  - CV young age
  - CV old age
- Ages where K allowed to vary specified from external analyses



# Natural Mortality



- Age-specific  $M$  estimated externally with external age-varying  $K$  growth model estimates and the Lorenzen (2022) length-inverse  $M$  model
- Age-2  $M$  fixed based on external estimates and scaled for other ages internally according to model-estimated growth

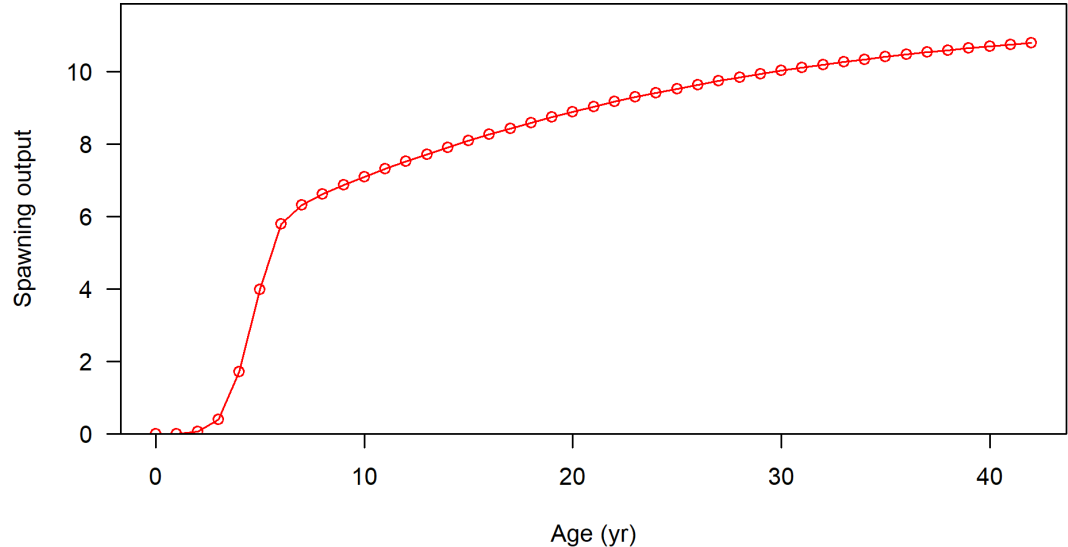


# Maturity



- Spawning occurs September 1
- Fixed logistic age-based parameters
  - Maturity hardwired to start for age-2 fish

- 1:1 sex ratio
- Female SSB used a proxy for fecundity



# Spawner-Recruit



- Standard Beverton-Holt
- Parameters:
  - Unfished recruitment -  $\ln(R_0)$
  - Sigma R - fixed based on tuning guidance from the r4ss package
  - Steepness fixed at 0.99
- Settings controlling bias adjustments to ensure mean unbiased recruitment from the lognormally distributed estimates were tuned according to recommended inputs after initial runs of the models (Methot and Taylor 2011)

# Fishing Fleets



- Fishery catch occurs throughout the year
- Recreational CPUE excluded from models due to signs of hyperstability and availability of FI indices
- Defined based on sectors and fishing gears with different regulations and selectivity patterns



# Fishing Fleet Selectivity

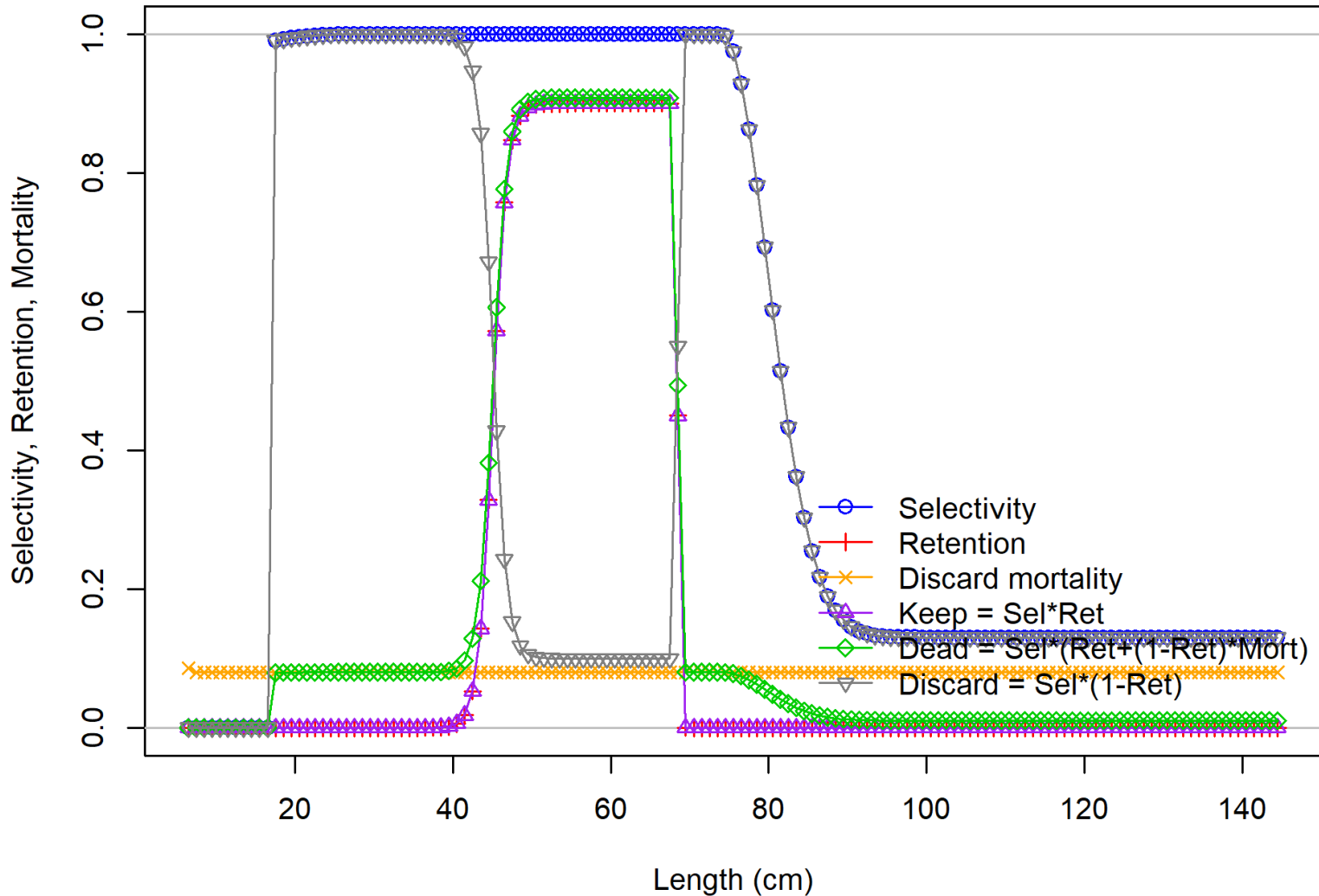


- Six parameter length-based double normal selectivity pattern
  - Size first selected
  - Ascending selectivity rate
  - Peak selectivity
  - Width of the full selectivity dome
  - Descending selectivity rate
  - Constant selectivity of the largest sizes
- Selectivity patterns represent selectivity for total catch
- Catch partitioned into retained catch and discards according to five parameter length-based, dome-shaped retention curve
  - Ascending selectivity inflection and width (2)
  - Peak retention
  - Descending selectivity inflection and width (2)
  - Retention was allowed to change through time in a blocking pattern based on changes in regulations
- Discards partitioned into live discards and dead discards according to a specified discard mortality rate

# Fishing Fleet Selectivity



Ending year selectivity for Recreational



# Fishery-Independent Surveys

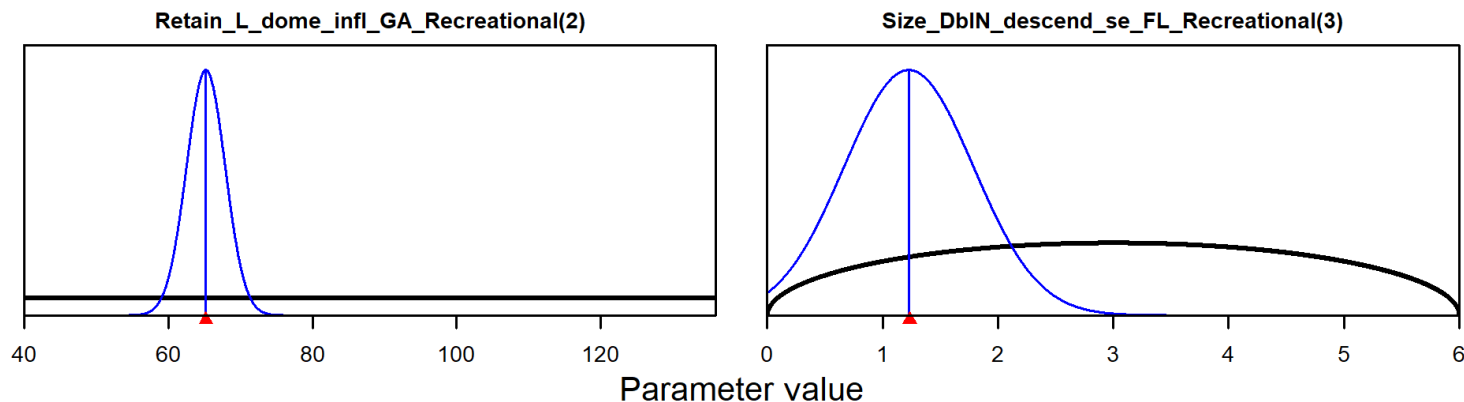


- Each survey includes a catchability coefficient scaling its relative catch rate to the absolute abundance it is tracking
- Surveys sample at specified points within the year
- Selectivity patterns:
  - Recruitment (special type=33) or age-0 for YOY catches
  - Double normal for sub-adult catches
  - Logistic for adult longline catches

# Additional Selectivity Notes



- For fleets and surveys with estimated length-based selectivity, age-based selectivity patterns are derived from length-based selectivity and the internal growth model
- Symmetric beta priors used for poorly-informed or problematic parameters



# Data Sets



- Fishing fleet catches (retained and discarded)
- Survey indices of abundance
- Length and age compositions for the fishery catches and survey indices of abundance
  - Marginal age compositions used to describe distribution of catches/indices across ages within a year as determined according to age-length keys external to the assessment models
  - Conditional age-at-length (CAAL) data used as frequencies of ages observed within length bins

# Population Estimates



- Fishing mortality (by fleet and overall)
- SPR
- Recruitment
- Population abundance
- Biomass (total and spawning stock)

# Reference Points



- Threshold reference points are parameters associated with  $SPR_{30\%}$ , threshold adopted in FMP
  - $F_{30\%}$  (in terms of  $F$  for age-2 fish)
    - Calculated with terminal three-year averages of life history characteristics, selectivity, and fleet-specific relative  $F$
  - $SSB_{30\%}$
- Target reference points are parameters associated with  $SPR_{40\%}$ , target adopted in FMP
  - $F_{40\%}$
  - $SSB_{40\%}$
- $SSB_{XX\%}$  reference points are newly recommended as supported by the simulation assessment

# Convergence



- Positive definite Hessian matrix
- Parameters not estimated at bounds
- Maximum gradient value  $< 0.0001$
- Jitter analysis with starting values adjusted by jitter factor (0.1) across 200 iterations
- Likelihood profile on population scaling parameter  $R_0$



# Goodness of Fit



- Maximum likelihood primary measure of GOF
  - Log-normal error structure for catch and indices
    - SEs derived from PSEs (rec catch), CVs (indices), or assumed (comm catch)
  - Multinomial error structure for composition data
    - Positive observations used for effective sample sizes
- Residual diagnostics

# Uncertainty Characterization



- Asymptotic standard errors from maximum likelihood estimates using delta method
- Sensitivity analysis around key model configuration choices and data inputs
- Retrospective analysis
  - Retrospective peels
  - Historical retrospective

# Model Changes – Both Stocks



Configuration/Data Aspect	Simulation Estimation Model	Benchmark Assessment Model
Start Year	1989	1981
Model Year Definition	Calendar Year	Fishing Year
K Growth Parameter	Constant	Age-varying
Age Composition Data	Marginal	Marginal/ CAAL
M	Input age vector based on age-constant growth rate	Input age-2 based on age-varying growth rate
Steepness Parameter	Estimated	Fixed (0.99)
Sigma R Parameter	Estimated	Fixed
Recreational CPUE	Include	Exclude
Fishing Fleet Selectivity	Time-varying	Constant

# Model Changes – Northern Stock



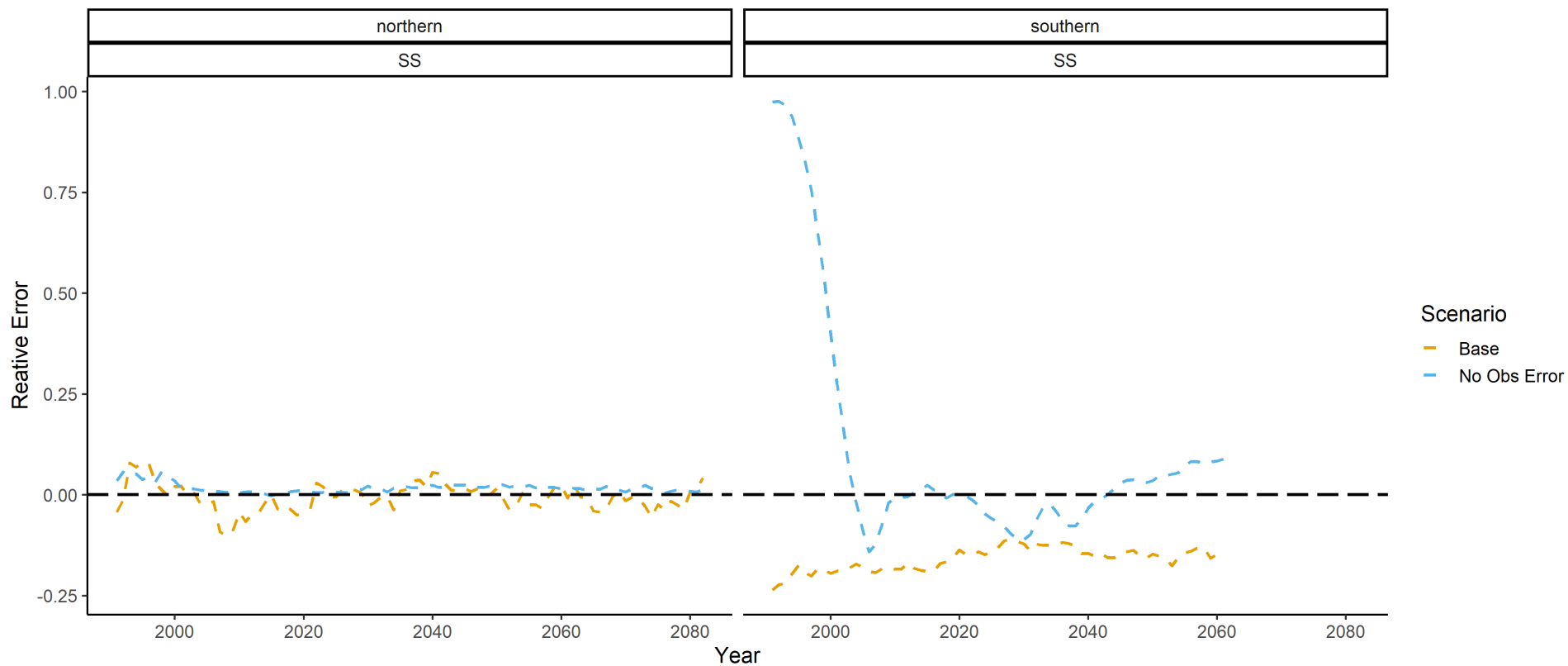
Configuration/Data Aspect	Simulation Estimation Model	Benchmark Assessment Model
Length at Amin	Estimated	Fixed
Longline Selectivity	Length-based	Age-based
$L_{inf}$ Growth Parameter	Normal prior	Sym beta prior
K Growth Parameter	Normal prior	No prior
$\ln(R0)$	No prior	Sym beta prior
Selectivity & Retention Parameters	Sym beta priors on ~30 parameters	No priors used

# Model Changes – Southern Stock

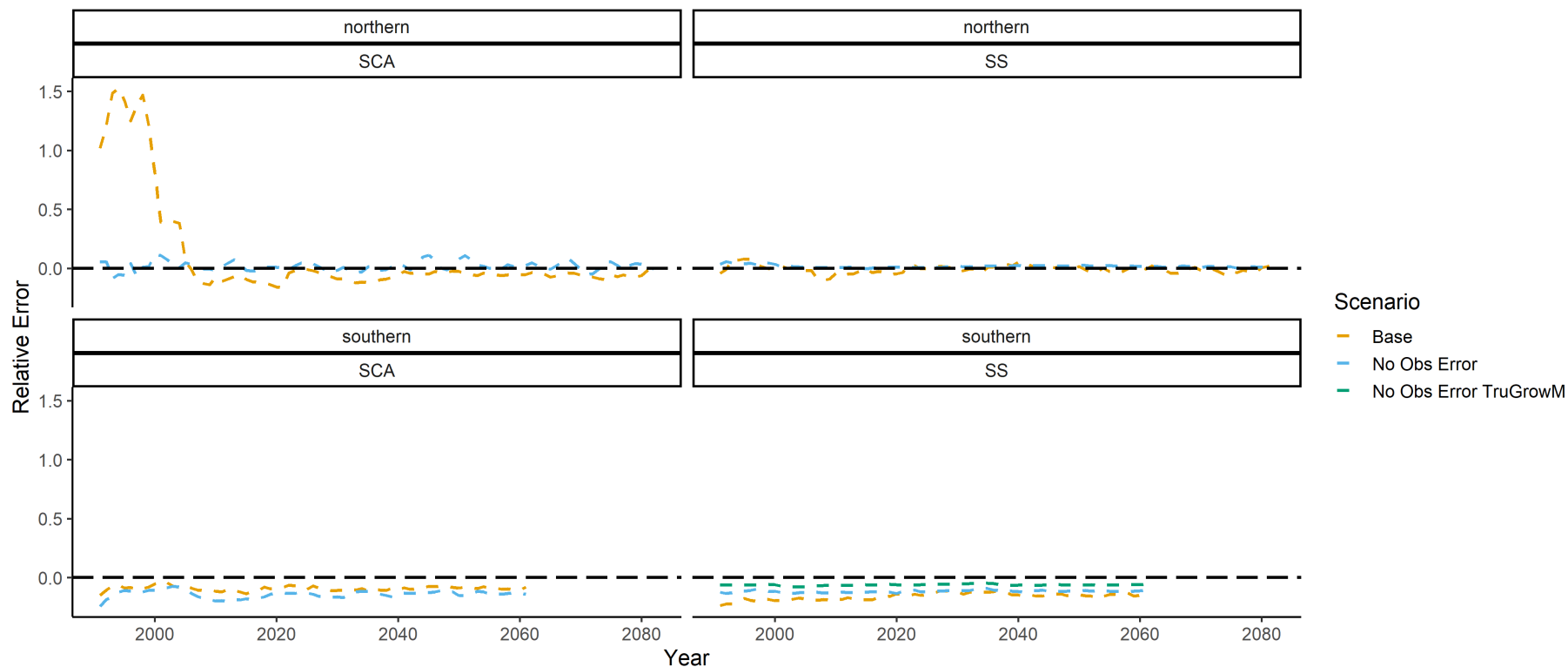


Configuration/Data Aspect	Simulation Estimation Model	Benchmark Assessment Model
F method	Hybrid (method 3)	Fleet-specific (method 4)
SC_Longline_historic data	Include	Exclude
GA_Longline	Include	Exclude
GA_Recreational discard size data	Exclude	Include
Recreational width selectivity parameter	Estimated	Fixed
SC_Recreational end selectivity parameter	Sym beta prior	Normal prior
Selectivity for sub-adult surveys	Length-based	Age-based
Longline selectivity	Estimated	Fixed

# SS No Obs Error – three year F ratios



# Southern Model EM No Obs Error





# Questions?