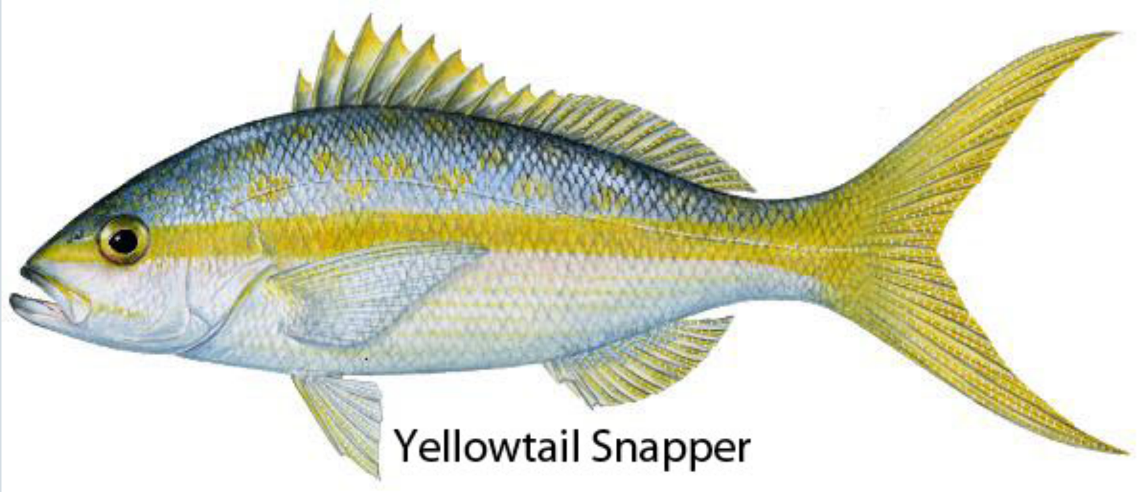


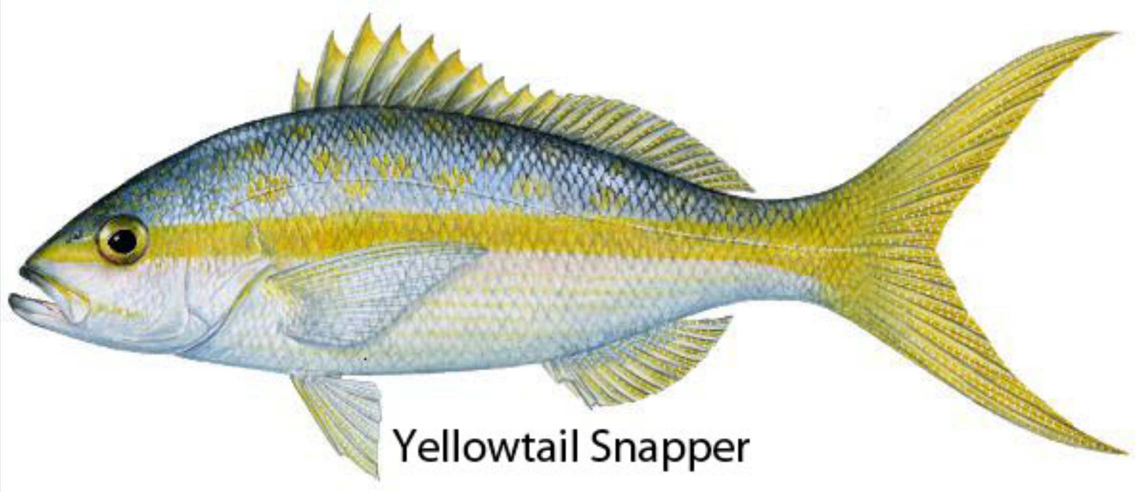
SEDAR 64: Yellowtail Snapper

Assessment Model Methods

Shanae D. Allen and Christopher E. Swanson

FWRI Stock Assessment Group, St. Petersburg, FL

Review Workshop: February 24 – 26, 2020



SEDAR 64: Yellowtail Snapper

Assessment Model Methods

Continuity Model

Continuity Model

'True' continuity model unattainable for SEDAR 64

Most influential reason:

- NMFS redesign and implementation of recreational data collection and estimation procedures (i.e. APAIS and FES calibrated MRIP data)
  - Catch estimates now 2 – 5x higher

Continuity Model

1) Run the SEDAR 27A Final Model in the current version of ASAP to ensure the same results were produced
   - Version 2.0 → version 3.0.16

2) Configure the SEDAR 64 data as close to the methods used for SEDAR 27A as possible (see Table 3.8.1 in the AW Report). For example:
   - 3 weight-at-age matrices
   - 9 selectivity blocks; Flat-topped selectivity types for all fleets
   - Only one RVC index (age 1+), no Headboat index; Constant catchability for Commercial CPUE index
   - Weighting factors (lambdas)
   - Age-Length-Key methods

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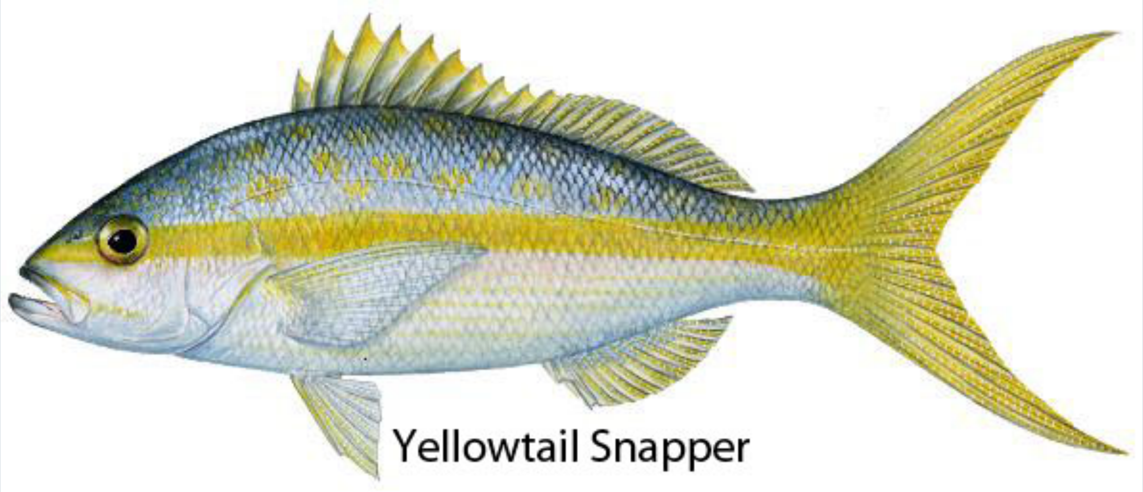

SEDAR 64: Yellowtail Snapper

Assessment Model Methods

Base Model Configuration

Stock Synthesis Model Configuration

Stock Synthesis v. 3.30.14

- Moderate complexity
- Years: 1992 - 2017
- 1 season, 1 area
- Spawning: January
- Settlement: January at Age 0; 2 cm FL
- Combined sex model with female-only SSB (frac_female = 0.5)

Life History

- Estimated growth using external growth model inputs as initial guesses
- 20 ages in the model; Age 12+ group
- Natural mortality: Fixed vector by age
- Maturity: Fixed vector by age
- Fecundity = Spawning biomass at length
- Length-Weight: fixed

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Stock Synthesis Model Configuration

Fleets

- Commercial
  - Landings (mt) and discards (numbers)
- Headboat
  - Landings and discards (numbers)
- MRIP (Charter, Private, Shore Modes)
  - Landings and discards (numbers)

Surveys

- Commercial CPUE
  - retained lbs/hook hour
- RVC
  - Juvenile/subadult
  - Adult
  - number of fish/diver ‘cylinder’
- MRIP CPUE
  - total catch/trip (numbers)

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Stock Synthesis Model Configuration

Length Composition Data

- Commercial
  - Landings and discards
- Headboat
  - Landings
- MRIP
  - Landings
- Headboat/MRIP Discards
  - Same length compositions
- RVC
  - Juvenile
  - Adult

Conditional Age-at-Length Data

- Commercial Landings
- Headboat Landings
- MRIP Landings
- Fishery-independent sources

Stock Synthesis Model Configuration

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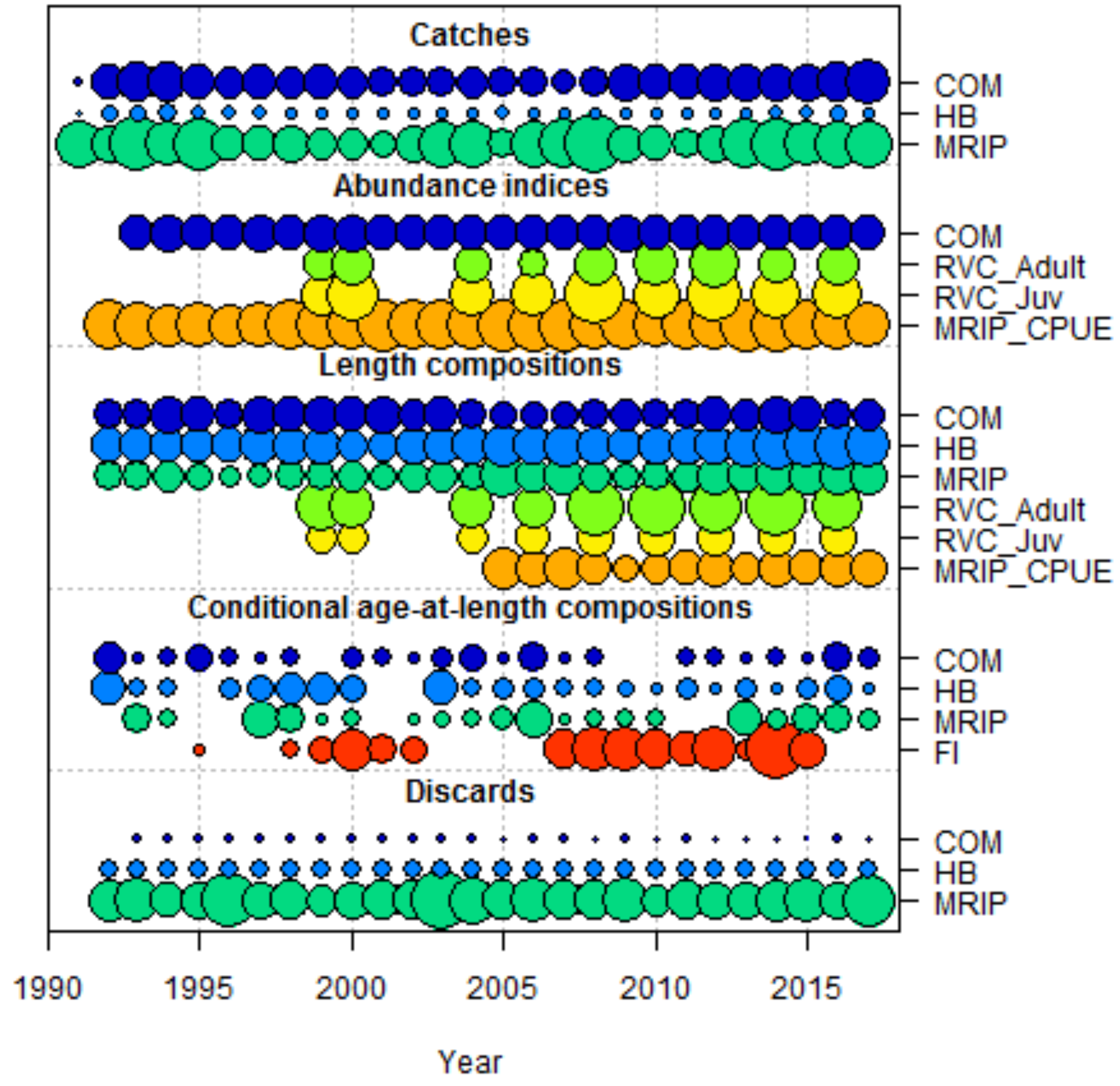
Catches
COM
HB
MRIP
Abundance indices
COM
RVC_Adult
RVC_Juv
MRIP_CPUE
Length compositions
COM
HB
MRIP
RVC_Adult
RVC_Juv
MRIP_CPUE
Conditional age-at-length compositions
COM
HB
MRIP
FI
Discards
COM
HB
MRIP
1990
1995
2000
2005
2010
2015
Year

Stock Synthesis Model Configuration

Fleet Selectivity

- Commercial
  - Selectivity: Simple logistic (flat-topped)
  - Estimated Retention (flat-topped)
  - Discard Mortality = 10%
- Headboat
  - Selectivity: Double normal (dome)
  - Estimated Retention (flat-topped)
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- MRIP
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Index Selectivity

- Commercial CPUE
  - Linked to Commercial fleet
  - Catchability Time Block: 2009 - 2017
- RVC Adult
  - Selectivity: Double normal (dome)
  - Constant catchability
- RVC Juvenile
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- MRIP CPUE
  - Selectivity: Mirrored to MRIP fleet
  - Constant catchability

Stock Synthesis Model Configuration

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Stock Synthesis Model Configuration

Recruitment Dynamics

- Beverton-Holt stock-recruitment relationship
  - Virgin recruitment in log-space (*ln(R0)*), the standard deviation of log of recruitment (*sigmaR*), and *steepness* estimated in model
- Simple recruitment deviations
  - no sum-to-zero constraint
- Early recruitment deviations
  - 1981 – 1990 (period of lower data-richness)
- Main recruitment deviations
  - 1991 – 2017 (period of higher data-richness)
- Bias adjustments (following Methot and Taylor 2011)

Stock Synthesis Model Configuration

Parameters

- 85 out of 117 parameters estimated

Priors

- Symmetric betas on initial Fishing mortality rates for Commercial, Headboat, and MRIP fleets

Lambda

- No emphasis on model fit (=0)
  - Initial equilibrium catch for all three fleets

Reported Fishing Mortality Rates

- Age 4

Stock Synthesis Model Configuration

Model Convergence Criteria

- Total likelihood (sum of individual data source component's likelihoods)
- Invertible Hessian matrix
- Maximum gradient <0.0001

Error Structure

- Assumed log-normal for all landings, indices, and discard data (except commercial discards)

Multinomial Distribution

- Length composition data of landings, discards, and indices
- Conditional age-at-length data of landings and FI sources

Data Weighting

- Length composition and conditional age-at-length data
- Initial sample sizes equal to sqrt (number of trips or number of fish)
- Iterative re-weighting following Francis (2011)

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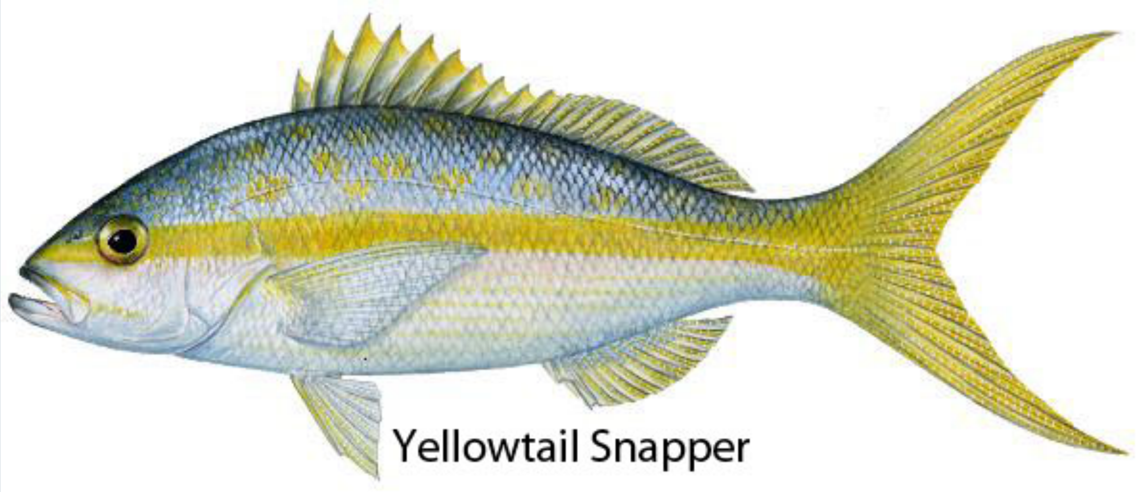

SEDAR 64: Yellowtail Snapper

Assessment Model Methods

Base Model Diagnostics


THIS IS FINE.

Model Diagnostics

Residual Analysis

- Visual inspection for patterns
- Quantitatively evaluated (RMSSE)

Correlation Analysis

- Help identify inadequate model assumptions or erroneous model parameterizations
- Absolute values > 0.7

Profile Likelihoods

- Iteratively run the model while fixing a given parameter across a range of reasonable values
- *steepness, sigmaR, R0, initial_Fs*

Jitter Analysis

- Aids in identifying a global solution vs. a local solution
- Randomly 'jitters' parameter values by a certain percentage
  - 20% as suggested by R. Methot (pers. comm.) with 200 model runs

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Likelihood Profiles

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Jack-knife Analysis

- Removal of each index of abundance (inc. length/age data)
- Determine influence of each index on the model
  - e.g. an index may only be sampling a portion of the stock resulting in conflicting abundance signals or trend of the entire stock

Retrospective Analysis

- Seven-year peel
- Helps evaluate the effect of the final year on model results
- Patterns can indicate model misspecification or temporal dynamics
- Evaluated visually and quantitatively
  - Mohn's Rho
  - Hurtado et al (2015) "Rule of thumb"
    - - 0.15 – 0.20 for longer-lived species

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Model Diagnostics

Parametric Bootstrap

- Resampling method to analyze uncertainty associated with the data
- 500 bootstrapped datasets
  - Error distributions centered on fitted values
- ESS must be integer
  - Multiplied age-at-length ESS by Francis weight, rounded to lowest integer, removed zero bins.

MCMC Analysis

- Generate posterior distributions of model parameters and derived quantities
- Two chains
  - 1) 2,500 iterations saved from 5,000,000 (2,000 burn in)
  - 2) 2,500 iterations saved from 10,000,000 (5,000,000 burn in)
- Two-chain convergence assessed using Gelman and Rubin's (1992) potential reduction scale factor

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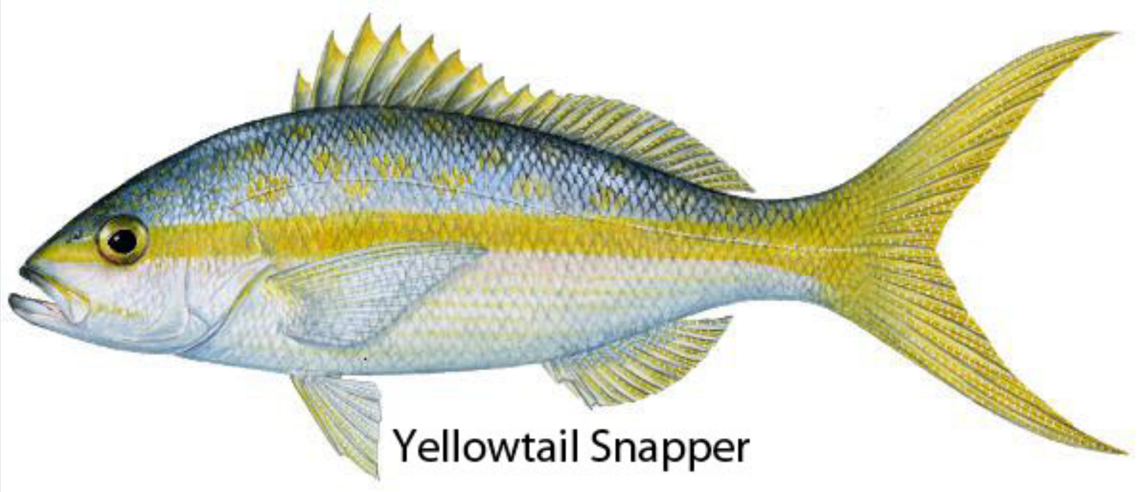


SEDAR 64: Yellowtail Snapper

Assessment Model Methods

Sensitivity Runs

Sensitivity Runs: Getting to the Base Model

Investigated

- Spawning in January; settlement in Apr; linear growth until Oct
  - Mimic recruitment as close as we could given a single season model
- Multiple settlement events: Jan, April, July
- Natural mortality
  - Jensen (1996), Charnov et al. (2013), tmax = 28 yr, tmax = 33 yr
- Initial fishing mortality rates; equilibrium catch
  - No priors; varying levels of equilibrium catch (e.g. 5% - 25% of total catch)
- Changing start year to 1992 from initial base model start year 1981
- Time blocks for retention
- Time-varying q vs. constant q vs. time block q
  - Commercial and MRIP fleets

Sensitivity Runs: Base Model

Start Year in 1981

- Most landings data available in 1981

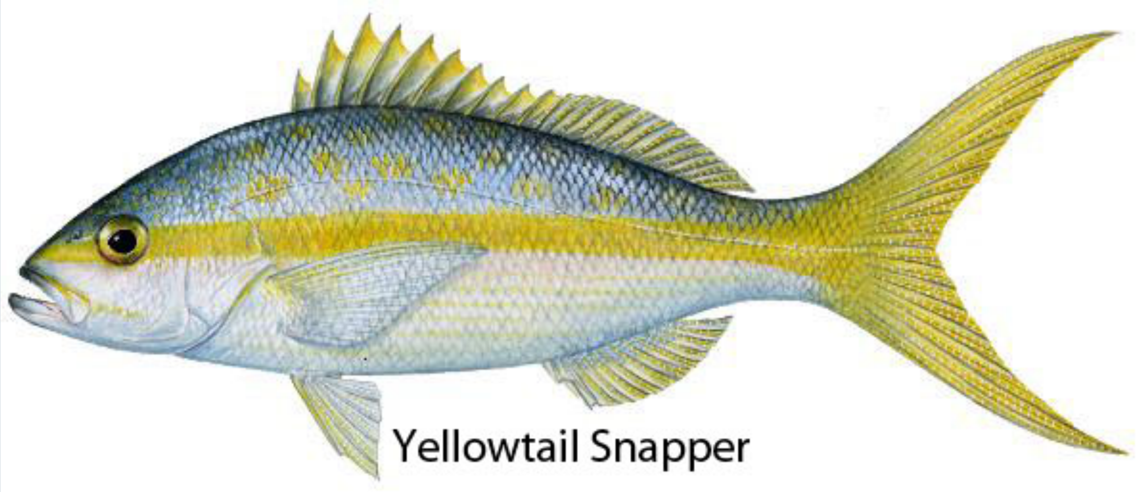
Discard Mortality Rates

- Commercial: 15%
- Recreational (both Headboat and MRIP fleets): 20% and 30%

Bias Adjustments to Rec Devs

- Input values were not updated to reflect recommended bias adjustment values from model output

- Time and resources would not permit this tuning into the final base model with rerun diagnostics, projections, bootstrapping, and MCMC analyses



SEDAR 64: Yellowtail Snapper

Assessment Model Methods

Per-recruit Analysis

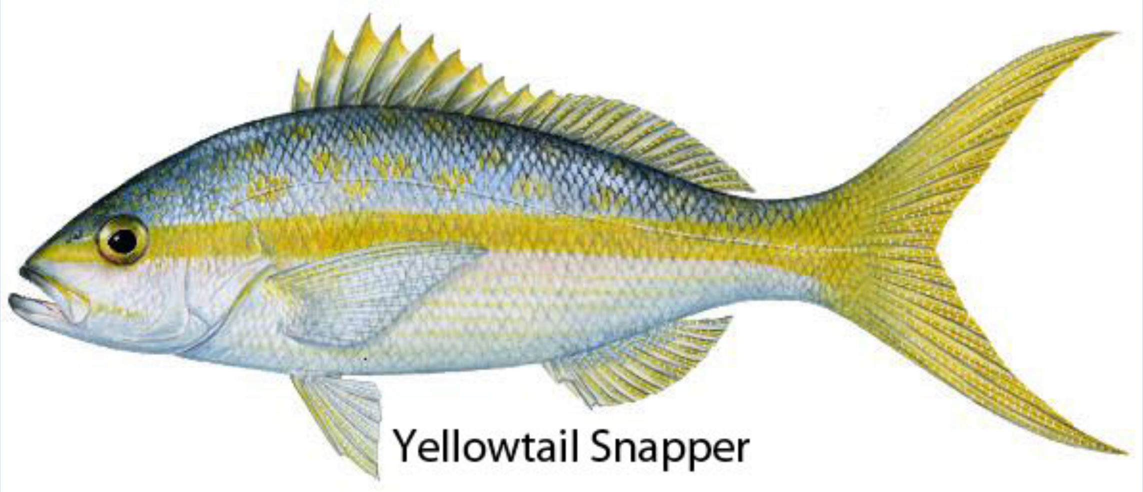
Per-recruit Analysis

Purpose

- Obtain targets of fishing mortality and age at first capture to evaluate various management regulations
- Evaluate stock productivity, identify levels of yield from the fishery, and adjust target based on risk aversion and uncertainty
- Assumes equilibrium fishing mortality rates; constant M, growth, and recruitment

Metrics

- Function of fishing mortality on age-4 fish
- Yield-per-recruit (YPR)
- Spawner-per-recruit (SSB/R)
- Static spawning potential ratio (SPR)
- Yields associated with $F_{30\%SPR}$ and $F_{40\%SPR}$



SEDAR 64: Yellowtail Snapper

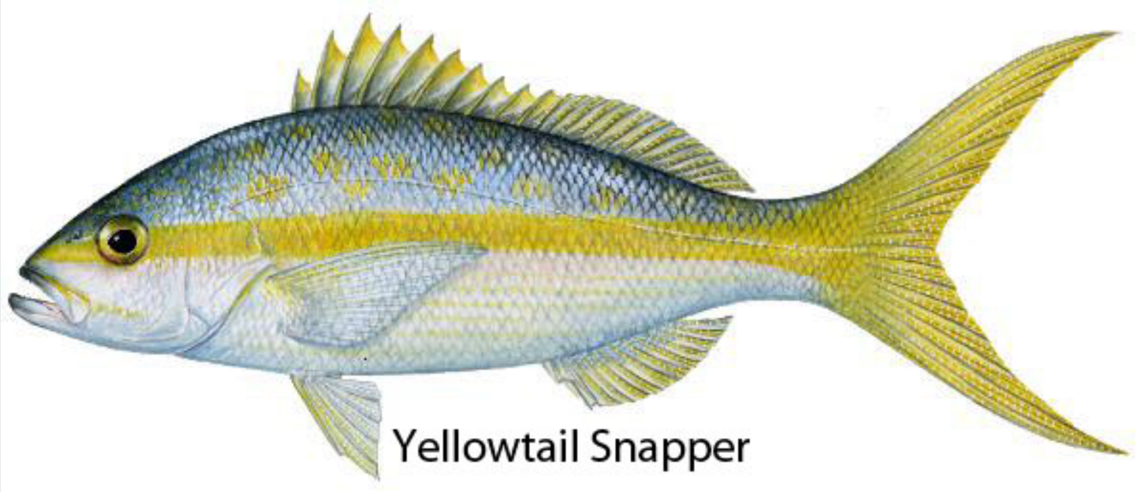
Assessment Model Methods

Catch Curve Analysis

Catch Curve Analysis

Estimate total mortality (Z)

- Useful in understanding the estimated fishing mortality rates
  - Instantaneous M value from the $\text{Hoenig}_{\text{alltaxa}}$ (1983) equation (M=0.16)
- Chapman-Robson estimator (Chapman and Robson 1960; Robson and Chapman 1961)
  - Method 'when age is known for entire sample'
  - Annual survival rate which we convert to total mortality ($Z = -\ln(S)$)
- Used the number of fish-at-age in the Florida age dataset
  - Aggregated across time
- Started at the modal age plus one (peaked at age-3)
  - Ages 4 – 20 (n = 18,316 otoliths)



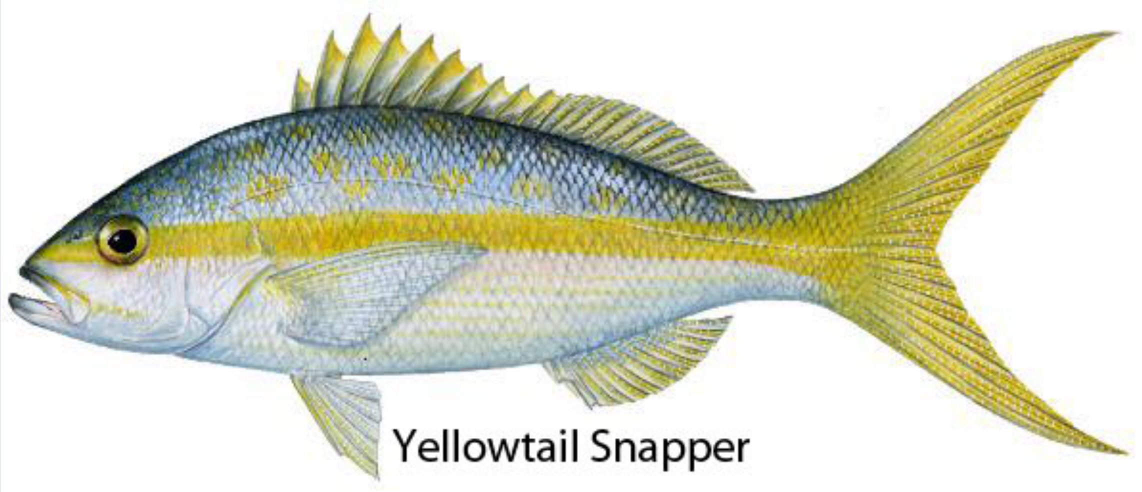
SEDAR 64: Yellowtail Snapper

Assessment Model Methods

Benchmark/Reference Points

South Atlantic and Gulf of Mexico Fishery Management Councils

Criteria	Definition
$SSB_{F30\%SPR}$	Estimated SSB associated with F at 30% SPR
$SSB_{current}$ (recent average of SSB)	The geometric mean of SSB for 2015 – 2017
MSST (Minimum Stock Size Threshold)	$0.75*SSB_{F30\%SPR}$
$F_{30\%SPR}$	The fishing mortality rate associated with 30% SPR
$F_{current}$ (recent average age 4 fishing mortality)	The geometric mean of F for 2015 - 2017
MFMT(Maximum Fishing Mortality Threshold)	$F_{30\% SPR}$
OY (Optimum Yield)	Yield at F_{OY}
F_{OY} (Fishing Mortality Rate at OY)	$F_{40\% SPR}$



SEDAR 64: Yellowtail Snapper

Assessment Model Methods

Projections

Projections

Scenarios

- A) If stock is overfished:

  $F=0$, $F_{Current}$, $F=F_{MSY}$, F at 75% of F_{MSY}

  $F=F_{Rebuild}$ (max exploitation that rebuild in greatest allowed time)
- B) If overfishing is occurring:

  $F=F_{Current}$, $F=F_{MSY}$, F at 75% of F_{MSY}
- C) If stock is neither overfished nor undergoing overfishing:

  $F=F_{Current}$, $F=F_{MSY,}$ F at 75% of F_{MSY}, equilibrium yield
- D) If data limitations preclude classic projections (i.e. A, B, C above), explore alternative models to provide management advice

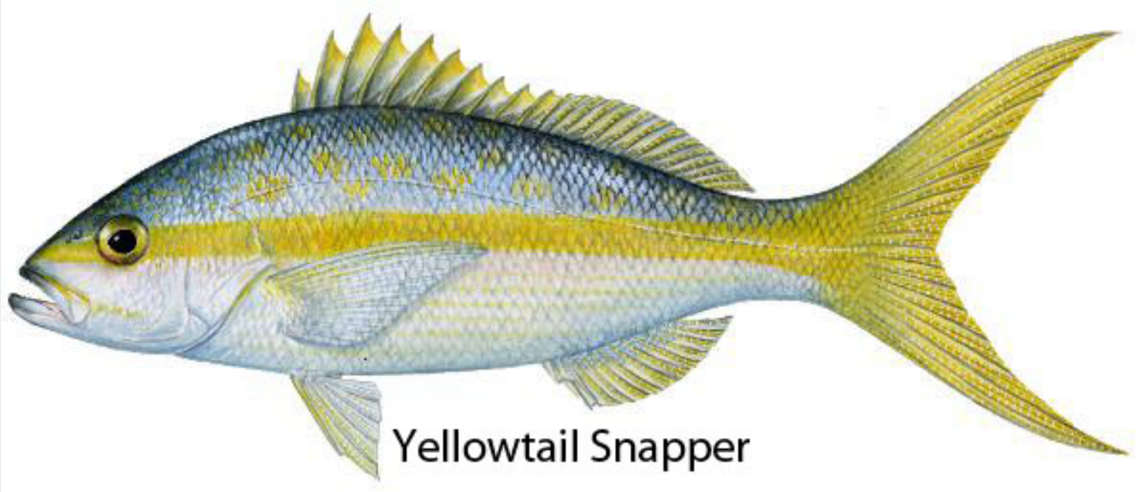
Projections

Five-year horizon

- 2018 – 2022
- Estimates of biomass, abundance, and fishing mortality rates

Values held constant

- Selectivity from terminal year
- Stock-recruitment parameters
- Recruitment for first year of projection equal to terminal 3-year average

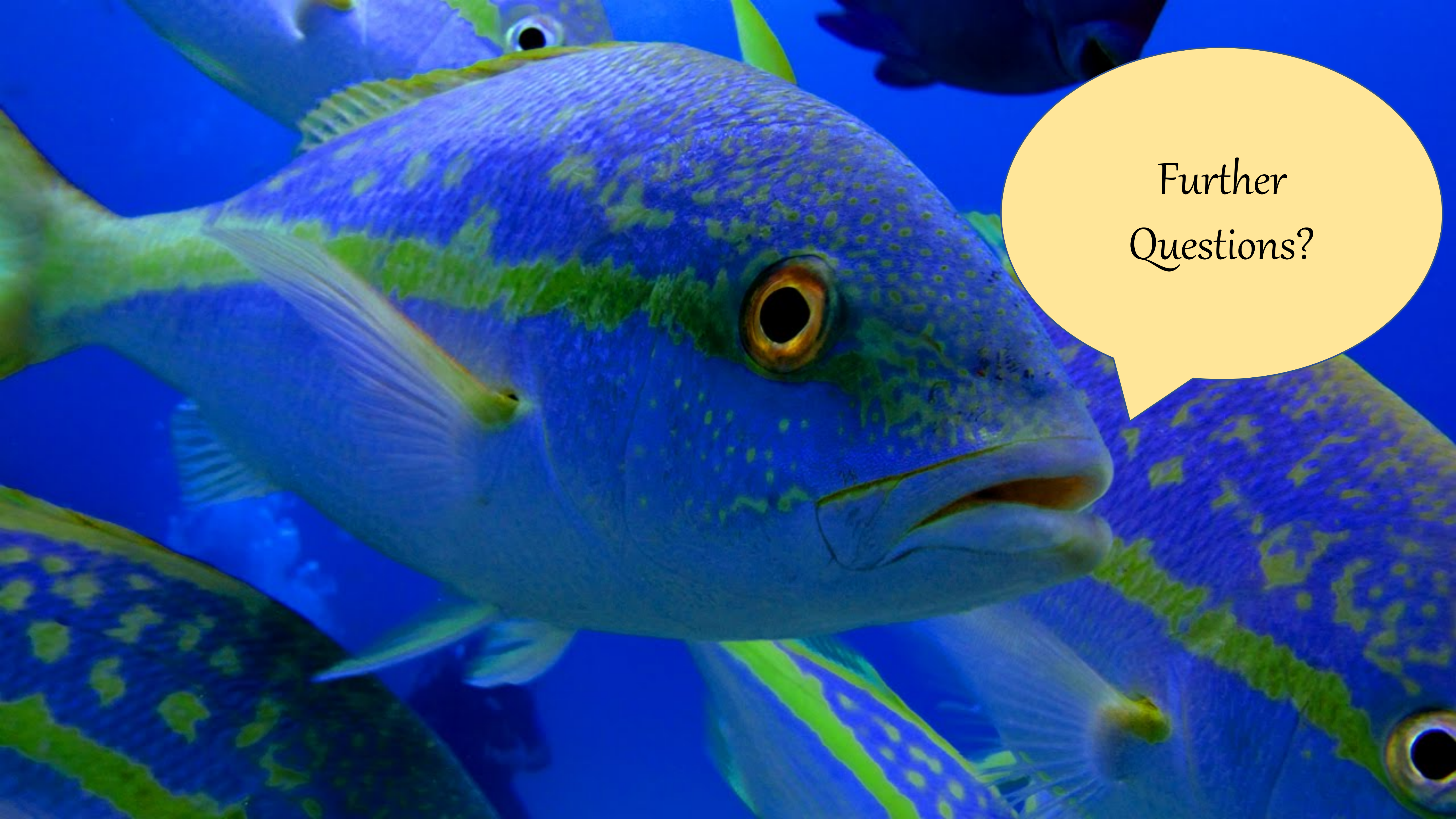


SEDAR 64: Yellowtail Snapper

Assessment Model Methods

Model Bridging Exercise


SEDAR 27A: ASAP2
1981 – 2010
SEDAR 27A: ASAP3
1981 – 2010
SEDAR 27A: ASAP3
1981 – 2017
(Continuity Model)
S64 Data; S27A Config
SEDAR 27A: ASAP3
1981 – 2010
S27A Data; S64 Config.
SEDAR 64: ASAP3
1992 – 2017
SEDAR 64: SS3
1992 – 2017


Further
Questions?

		S27A	S64	
Catchability	RVC age 1+	constant	-	-
	RVC Juv	-	constant	constant
	RVC Adult	-	constant	constant
	Com CPUE	constant	annual devs	block: 2009-2017
	HB CPUE	constant	-	-
	MRIP CPUE	constant	constant	constant
Lambdas	Indices	< 1	1	1
	Deviation from initial steepness	1	1	-
	Deviation from initial N	1	0	-
	Deviation from initial SSB0	1	-	-
	Deviation from initial R1	-	0	-
	Deviation from initial F-Mult	1	0	-
	Deviation from Equilibruim Catch	-	-	0
Calculate Likelihood Constants		yes	no	no
Years		1981-2010	1992-2017	1992-2017
Natural Mortality: Tmax		23 yr	20 yr	20 yr
Release mortality	Commercial	0.115	0.10	0.10
	Recreational MRIP	0.10	0.10	0.10
	Headboat	0.10	0.10	0.10
Average F age		5	4	4

		S27A	S64	
Framework		ASAP 2	ASAP 3	SS3
Natural mortality		Fixed at age	Fixed at age	Fixed at age
Maturity		Fixed at age	Fixed at age	Fixed at age
Growth		-	-	Estimated
Steepness		Estimated	Estimated	Estimated
Sexes		Combined	Combined	Combined
SSB		Female	Female	Female
Fraction of year before spawning		0.5	0.25	0
Number of weight-at-age matrices		3	10	-
# of Selectivity blocks		9	3	3
Fleet Selectivity	Commercial	Flat-topped	Flat-topped	Flat-topped
	Recreational MRIP	Flat-topped	Dome-shaped	Dome-shaped
	Headboat	Flat-topped	Dome-shaped	Dome-shaped
Indices		RVC age 1+ Com CPUE HB CPUE MRIP CPUE	RVC Juv RVC Adult Com CPUE MRIP CPUE	RVC Juv RVC Adult Com CPUE MRIP CPUE
Index selectivity	RVC age 1+	Age-specific	-	-
	RVC Juv	-	RVC age-1	Dome-shaped
	RVC Adult	-	Dome-shaped	Dome-shaped
	Com CPUE	linked	Flat-topped	linked
	HB CPUE	linked	-	-
	MRIP CPUE	linked	linked	mirrored to MRIP selectivity