SEDAR 82 US South Atlantic Gray Triggerfish Review Workshop: Data and Base Model

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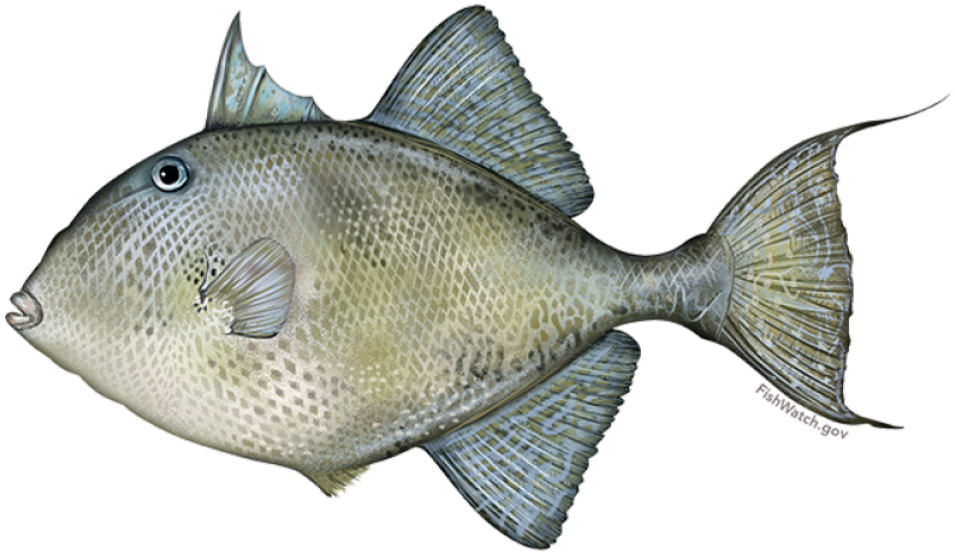

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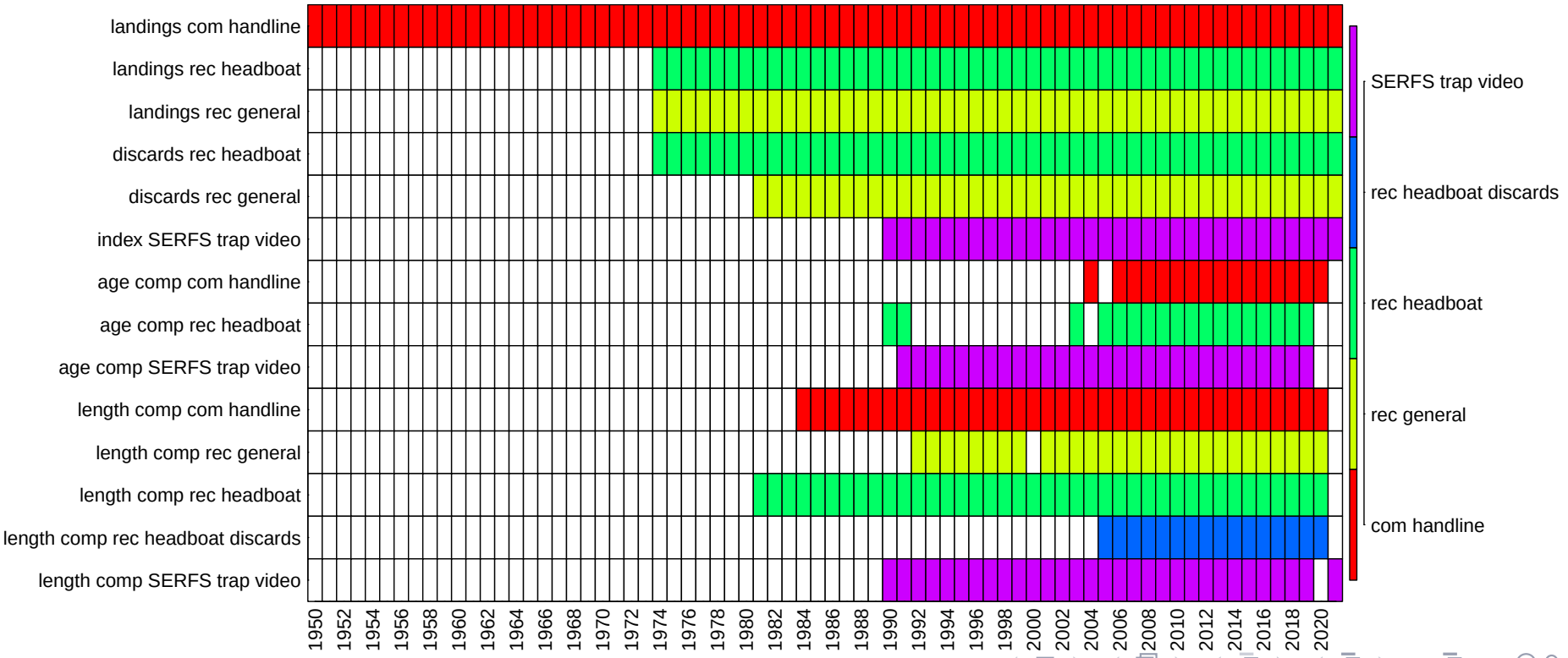
Data

Summary of data

Data available to SEDAR 82

- commercial landings (1950-2021)
- recreational landings (1974-2021)
- length compositions (1981-2021)
- age compositions (1990-2020)
- SERFS trap/video index (1990-2021)

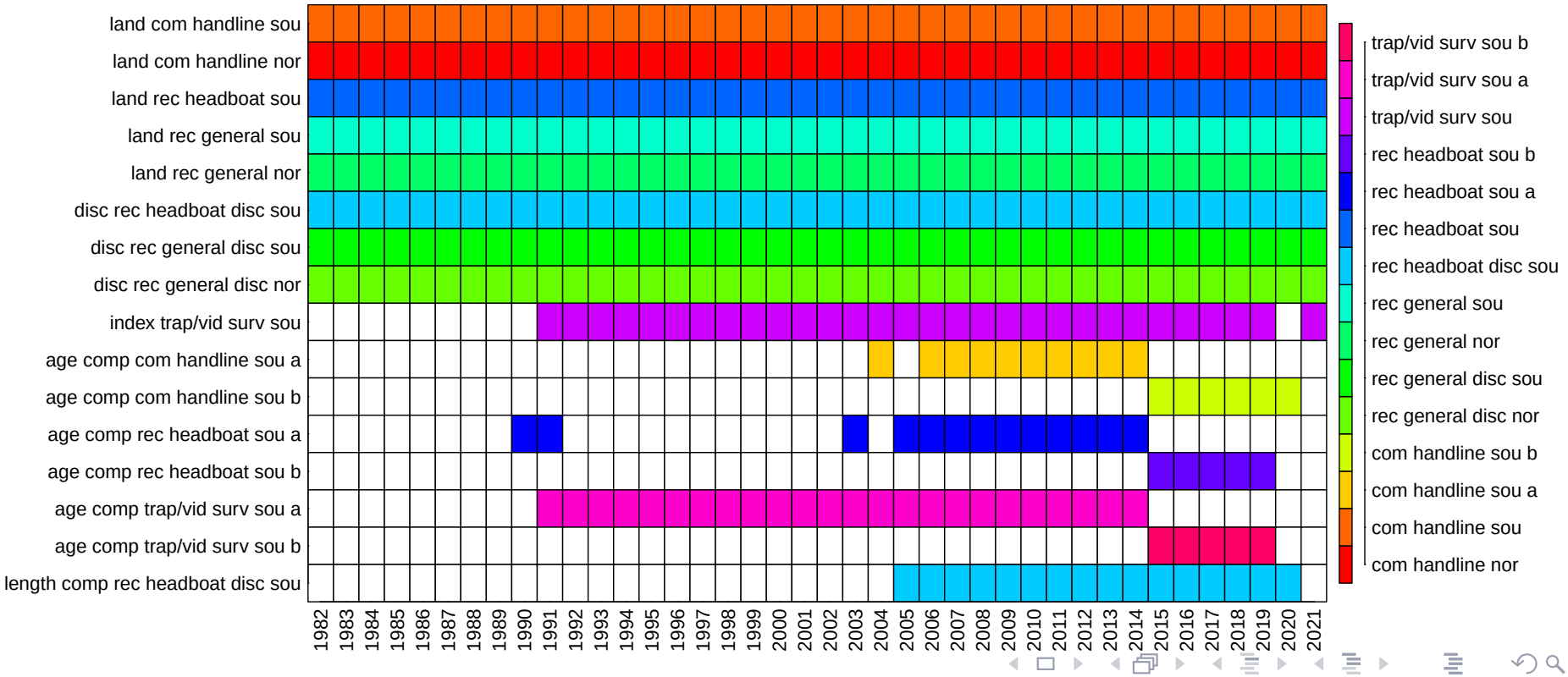


Data

Summary of data

Data in current SEDAR 82 model

- Model starting in 1982
- Removals split by region (north and south of NC/VA line)
- Length comps were dropped for fleets with age comps (cHL, rHB, sTV) and for one fleet (rGN) where a similar fleet (rHB) had age comps
- Age comps split temporally
  - a. start-2014: age 1-5+
  - b. 2015-2021: age 1-8+



Data

Removals

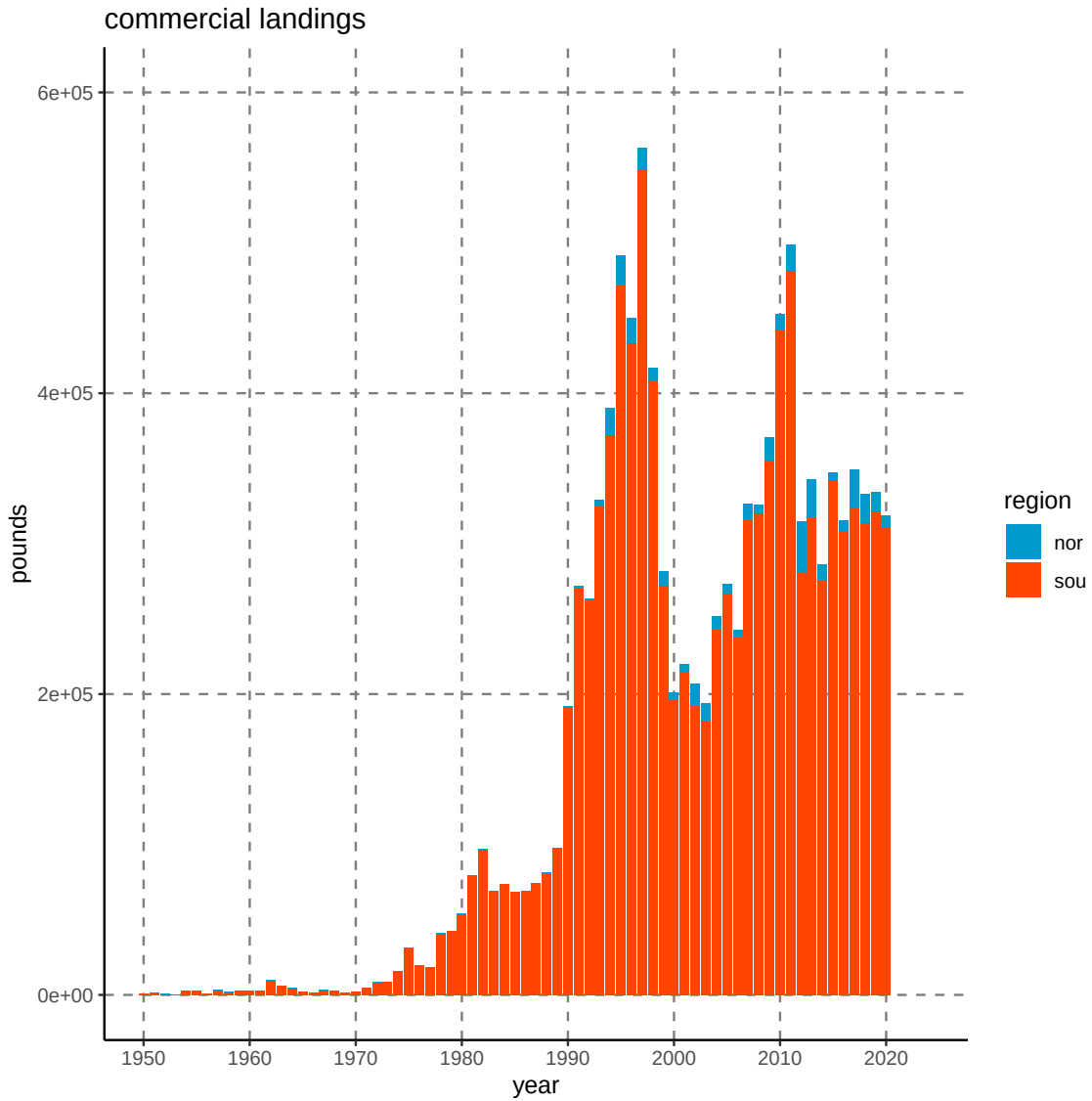
- Fleet structure for removals:
  - Landings
    1. commercial handline north
    2. commercial handline south
    3. recreational general north
    4. recreational general south
    5. recreational headboat south
  - Discards
    1. recreational general north
    2. recreational general south
    3. recreational headboat south

Data

Removals

Commercial landings by region

- commercial handline north (nor)
- commercial handline south (sou)

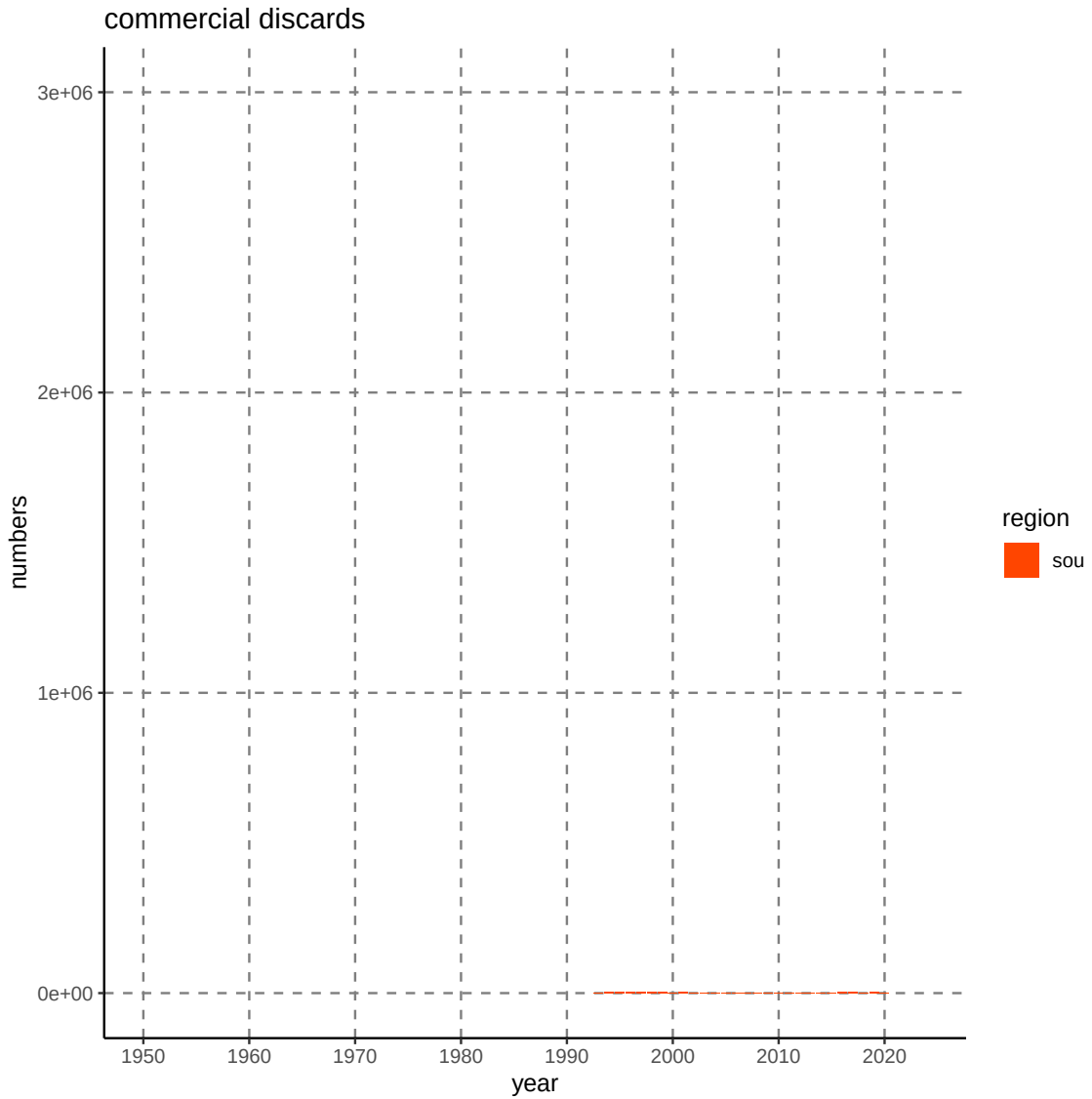


Data

Removals

Commercial discards by type

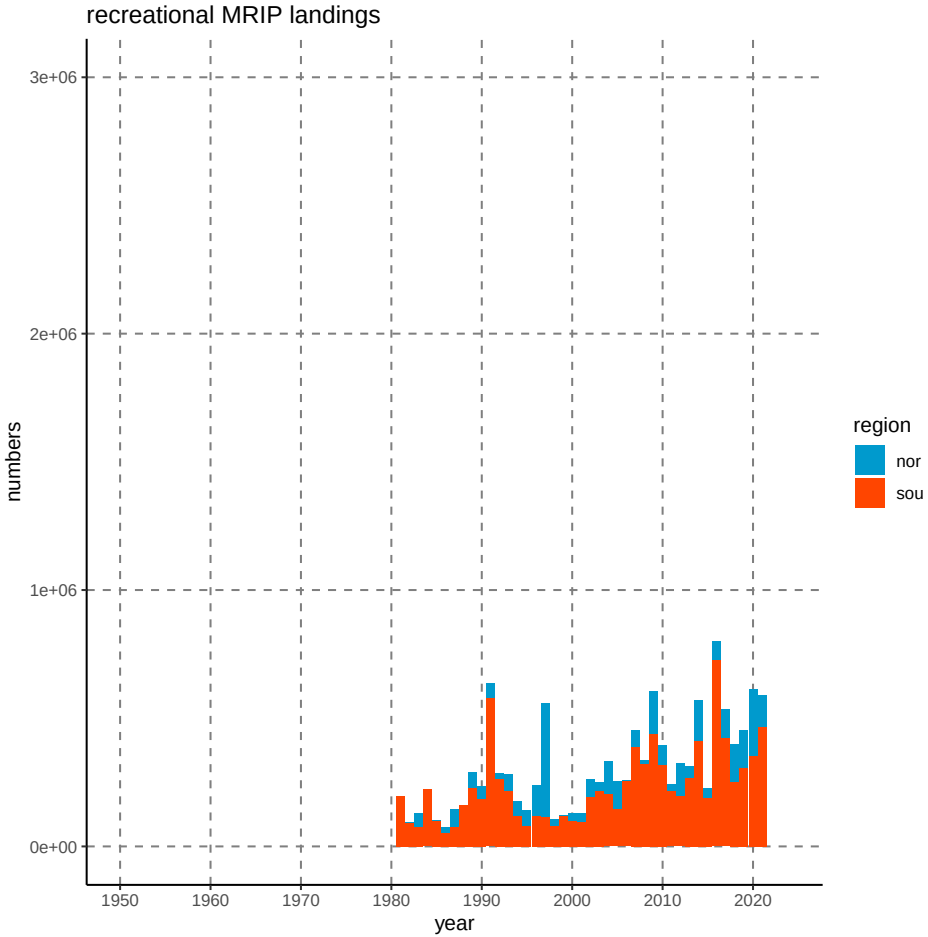
- commercial handline discards for the southern area, in numbers
- discards from the north not available but expected to be negligible, based on low commercial landings in the northern area and the small number of discards in the southern area
- Discards were converted to dead discards by applying a mortality rate, and combined with the commercial landings



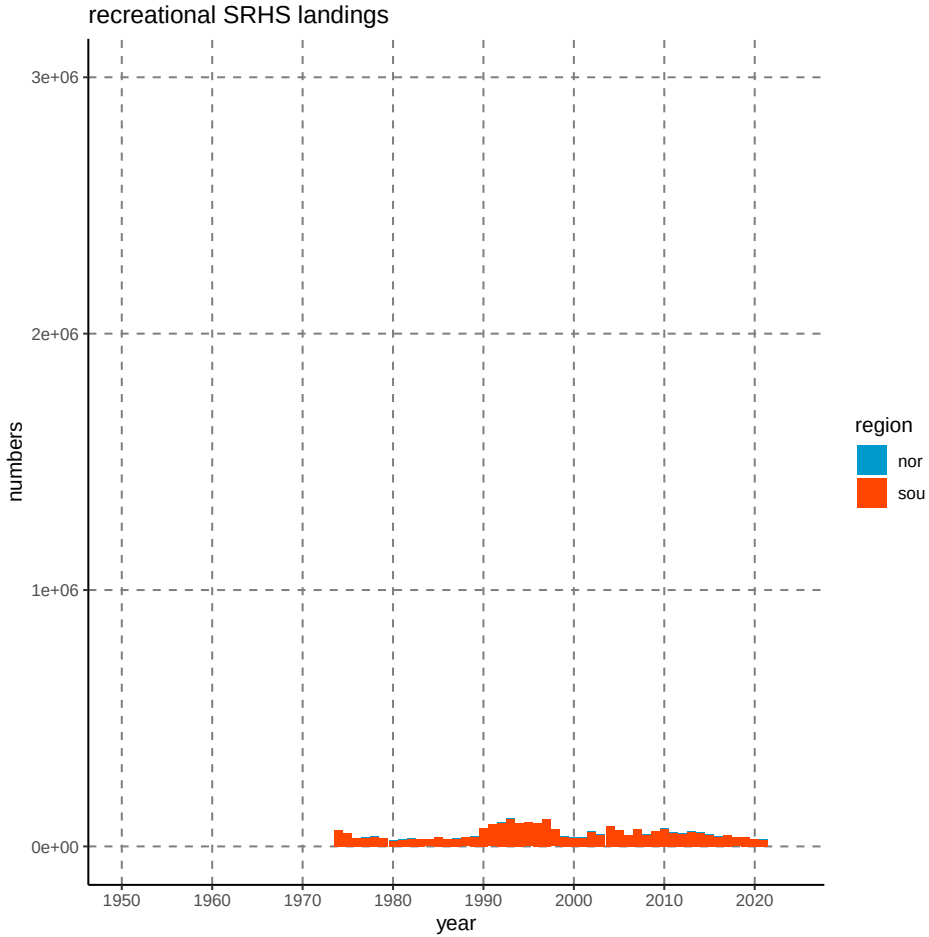
Data

Removals

Recreational general landings



Recreational headboat landings

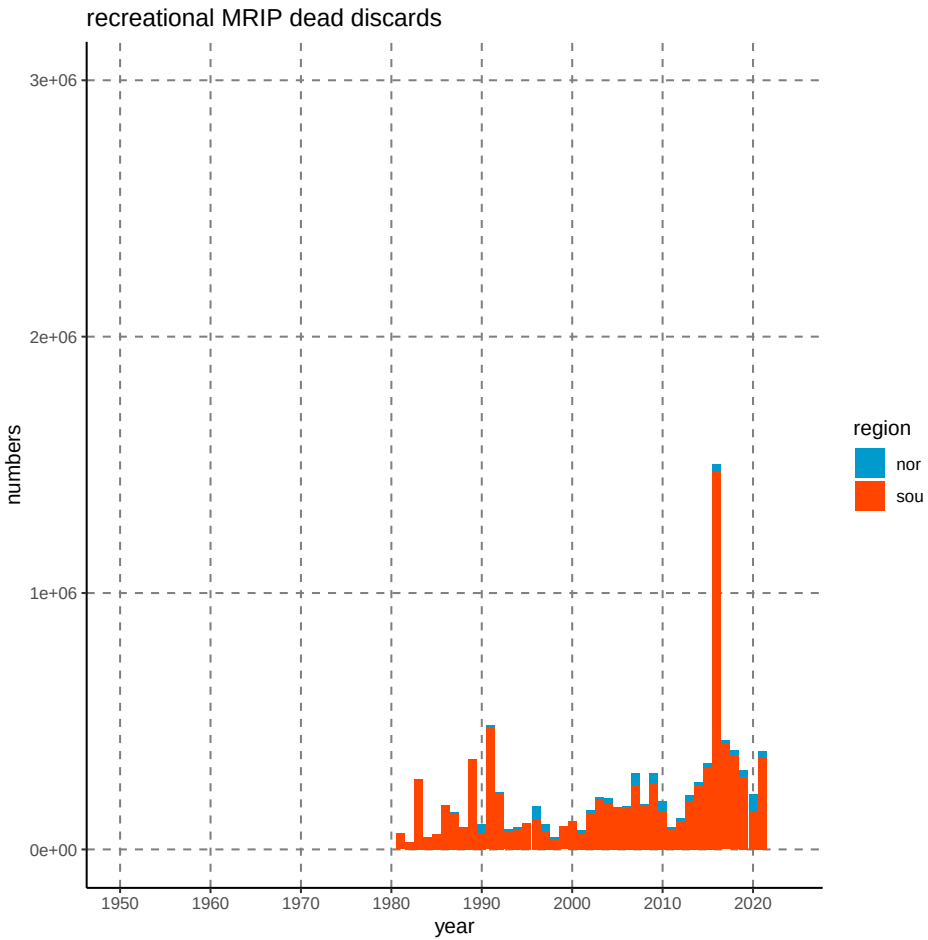


nor = north, sou = south

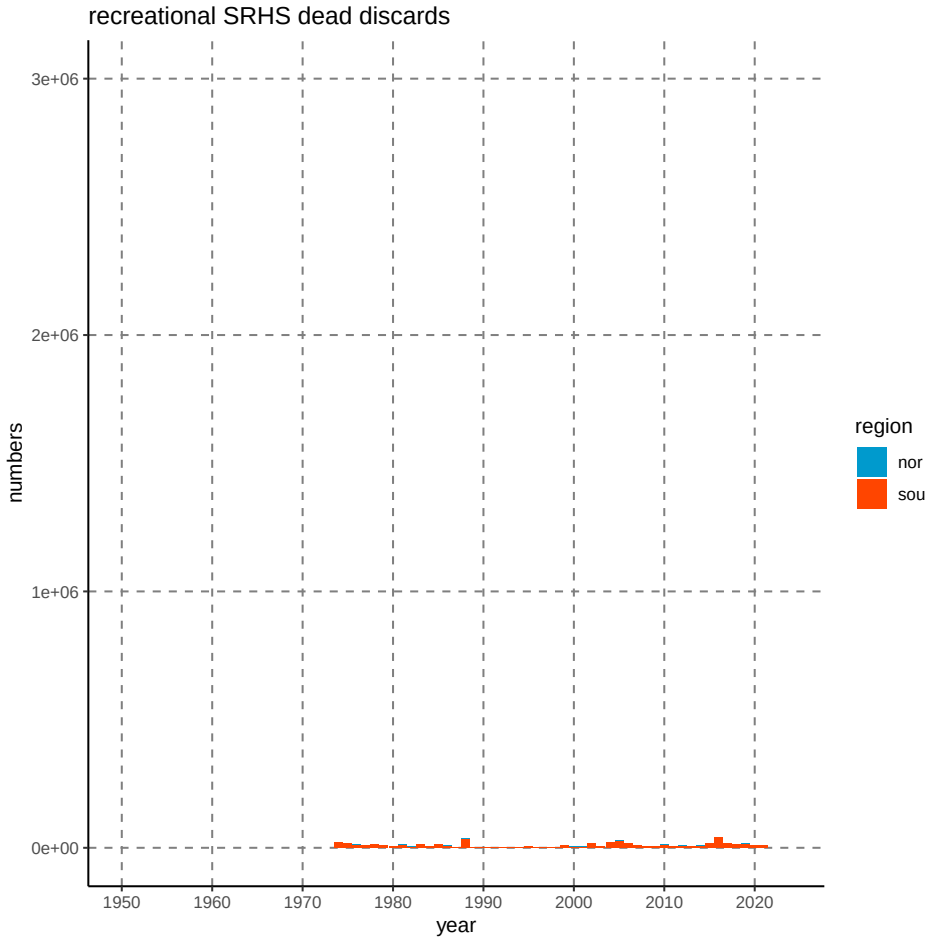
Data

Removals

Recreational general dead discards



Recreational headboat dead discards

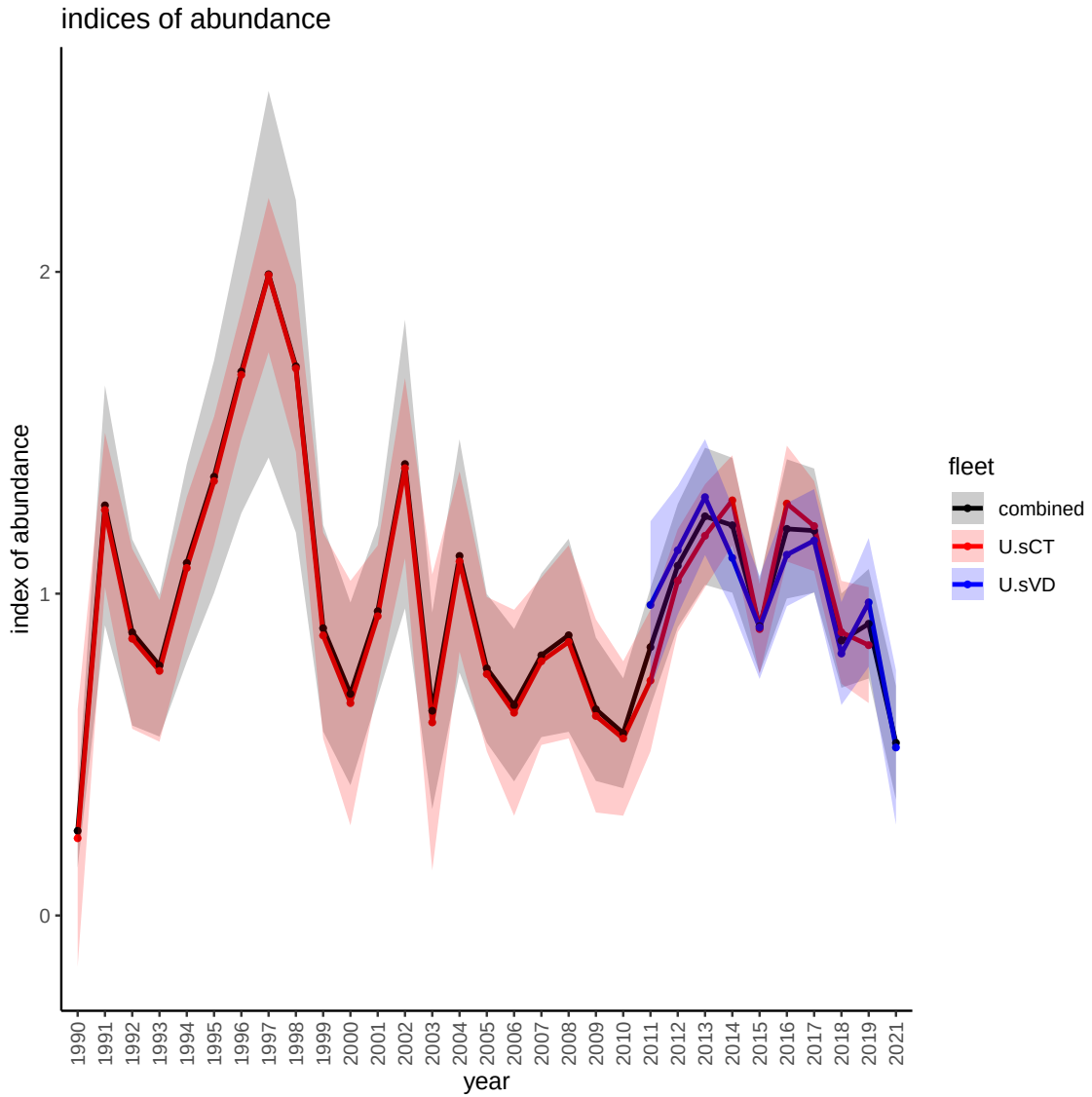


nor = north, sou = south

Data

Indices of abundance

- SERFS trap/video survey
  - The Southeast Reef Fish Survey (SERFS) deploys chevron traps with video cameras mounted on them on known reef habitat
  - Separate trap (U.sCT) and video (U.sVD) indices were developed
  - These paired survey indices were combined with a hierarchical Bayesian approach (Conn 2010)
  - Missing value for 2020 due to COVID



Data

Age and length compositions

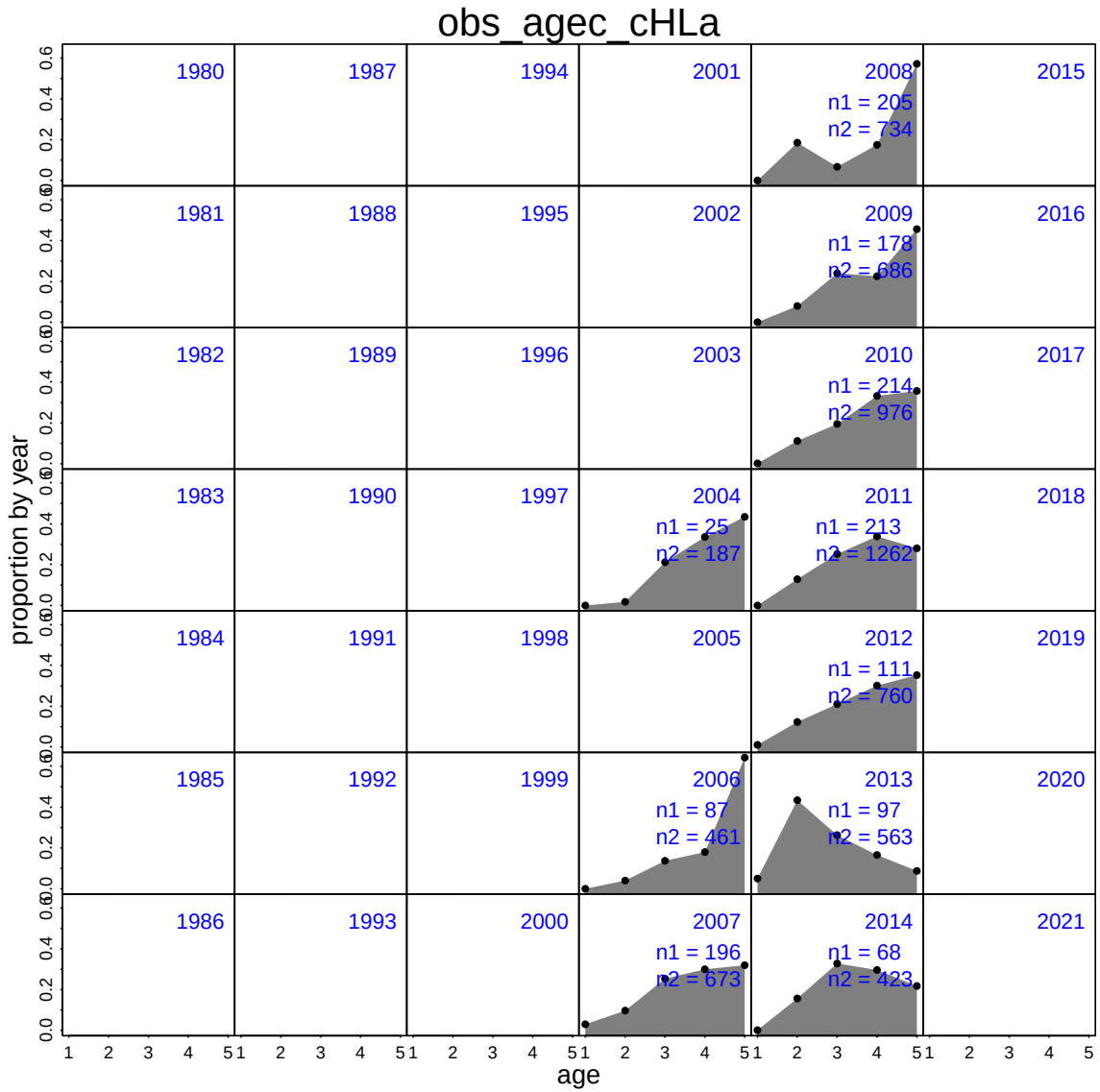
- Data structure for age and length compositions
  - Age compositions
    1. commercial handline south
       a. start-2014: age 1-5+
       b. 2015-end: age 1-8+
    2. recreational headboat south
       a. start-2014: age 1-5+
       b. 2015-end: age 1-8+
    3. SERFS trap/video survey south
       a. start-2014: age 1-5+
       b. 2015-end: age 1-8+
  - Length compositions
    1. recreational headboat south

Data

Age and length compositions

Commercial handline a (start-2014)

- age bins 1-5+

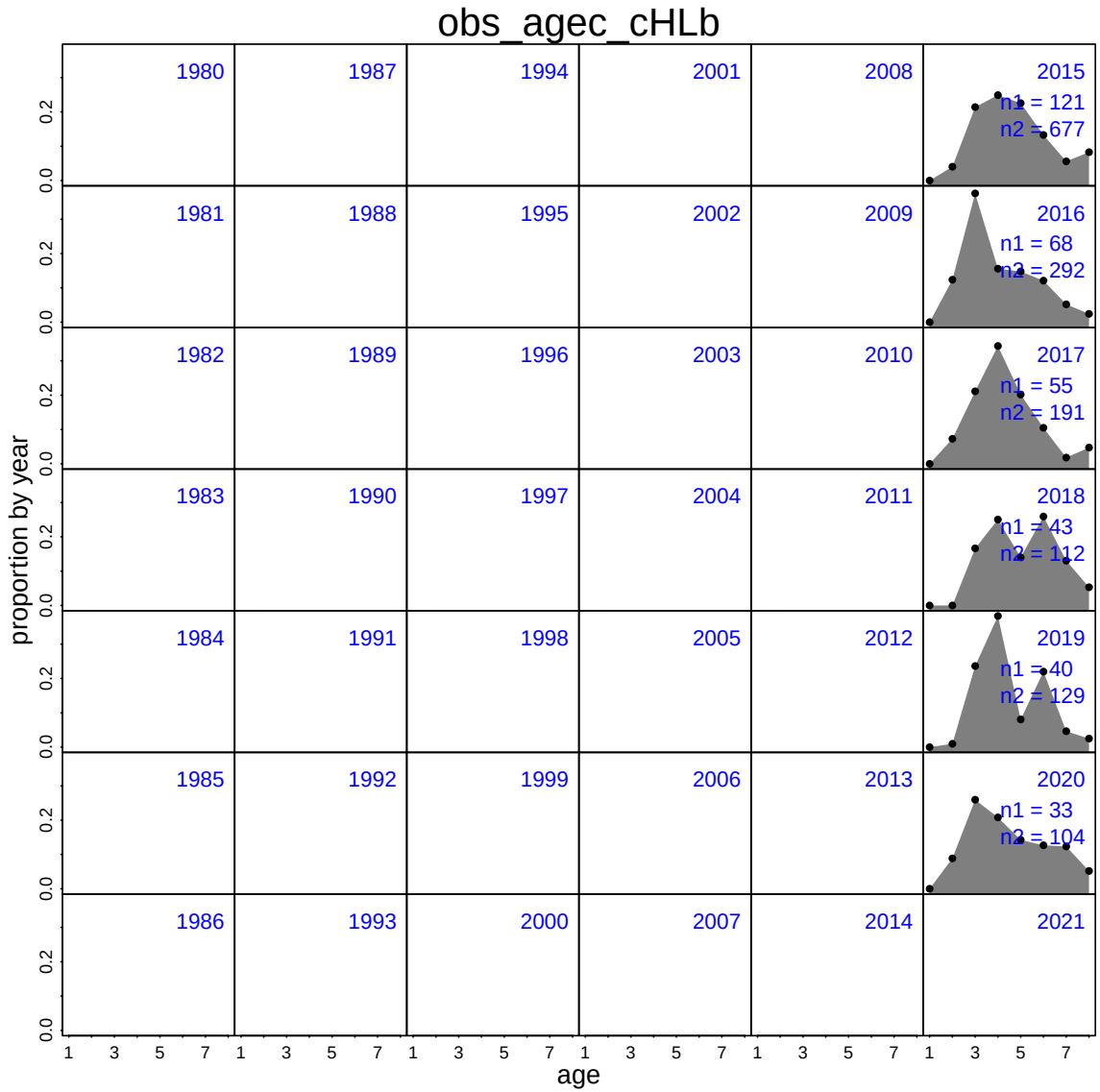


Data

Age and length compositions

Commercial handline b (2015-end)

- age bins 1-8+

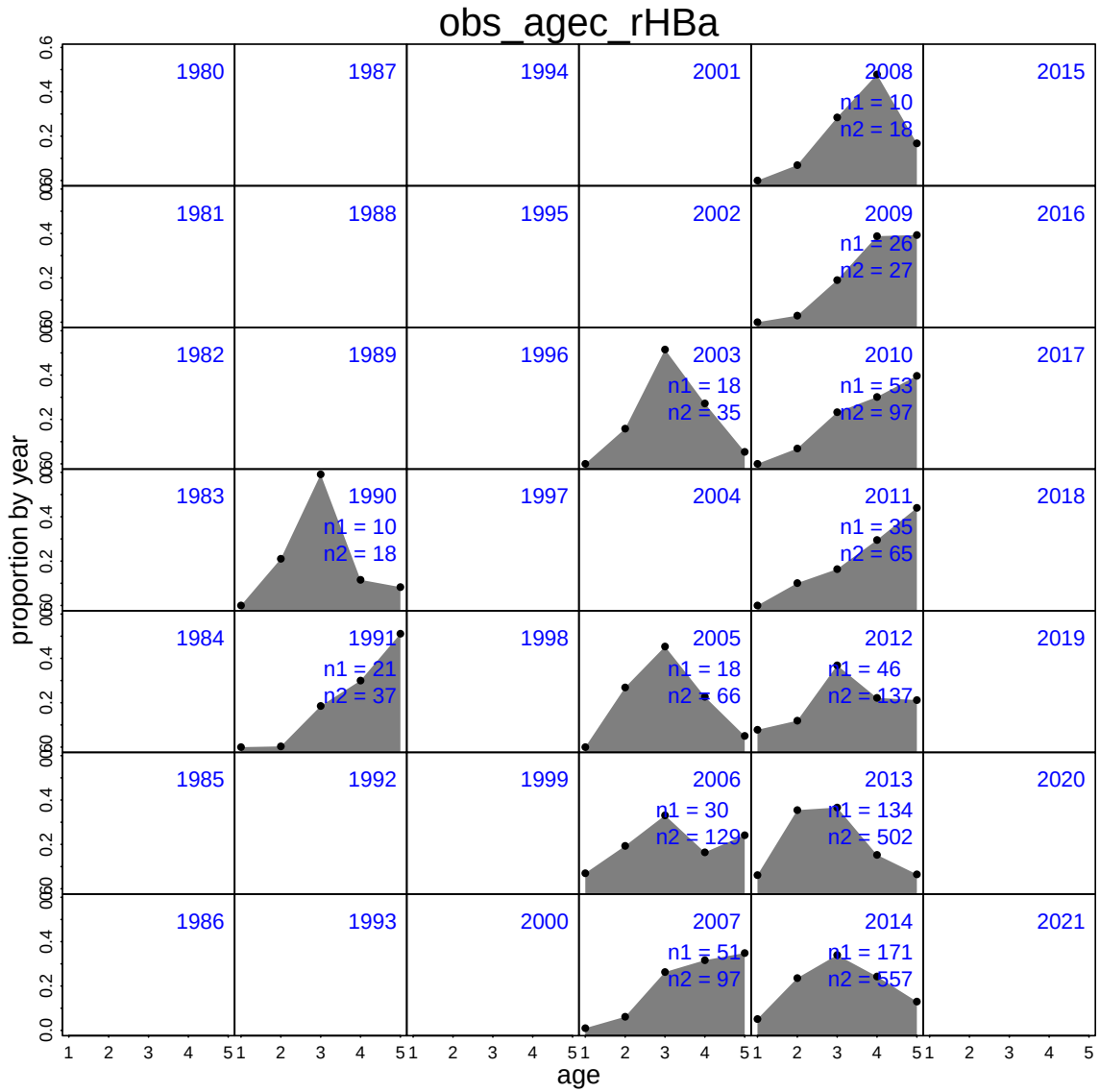


Data

Age and length compositions

Recreational headboat a (start-2014)

- age bins 1-5+

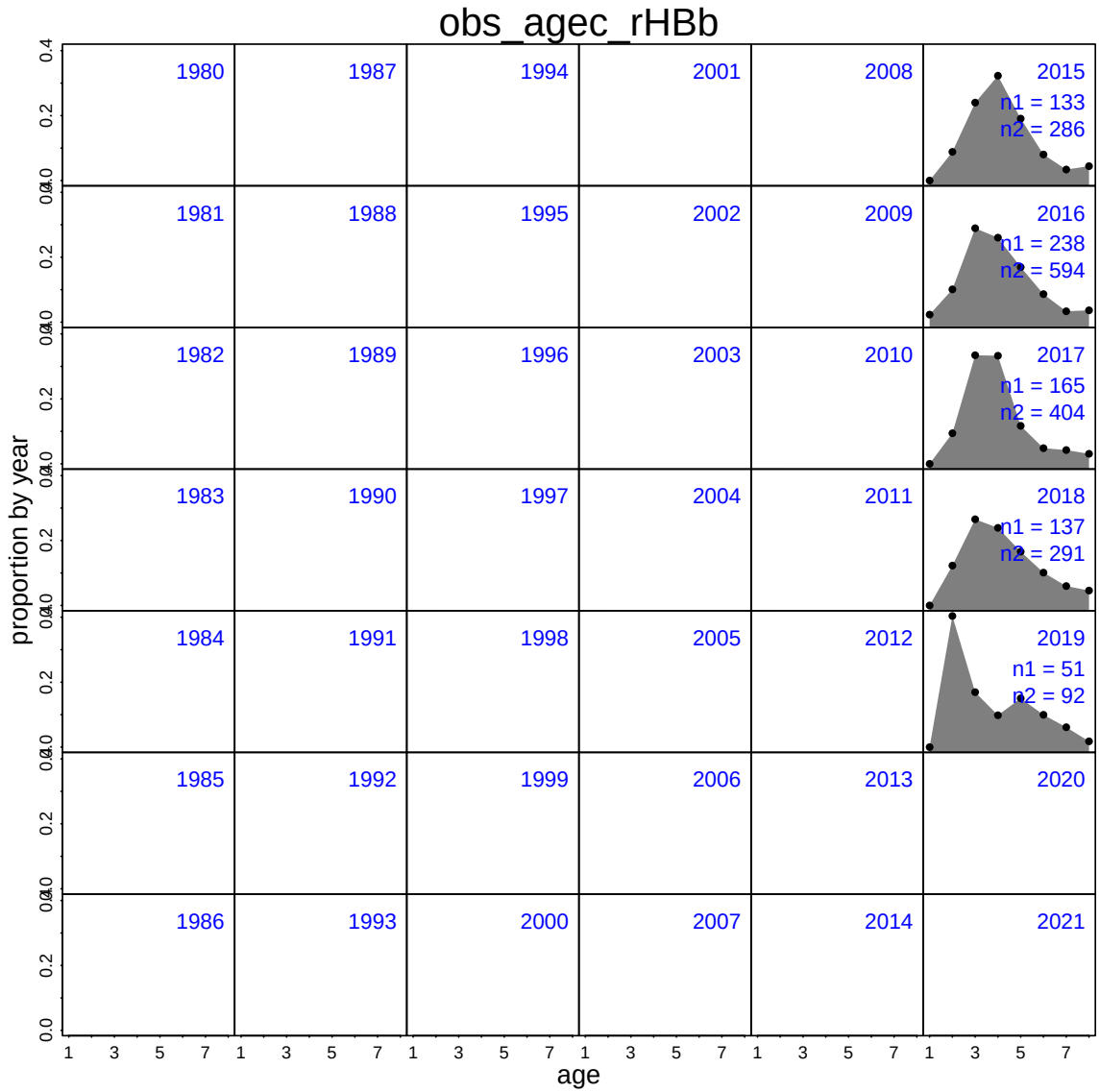


Data

Age and length compositions

Recreational headboat b (2015-end)

- age bins 1-8+

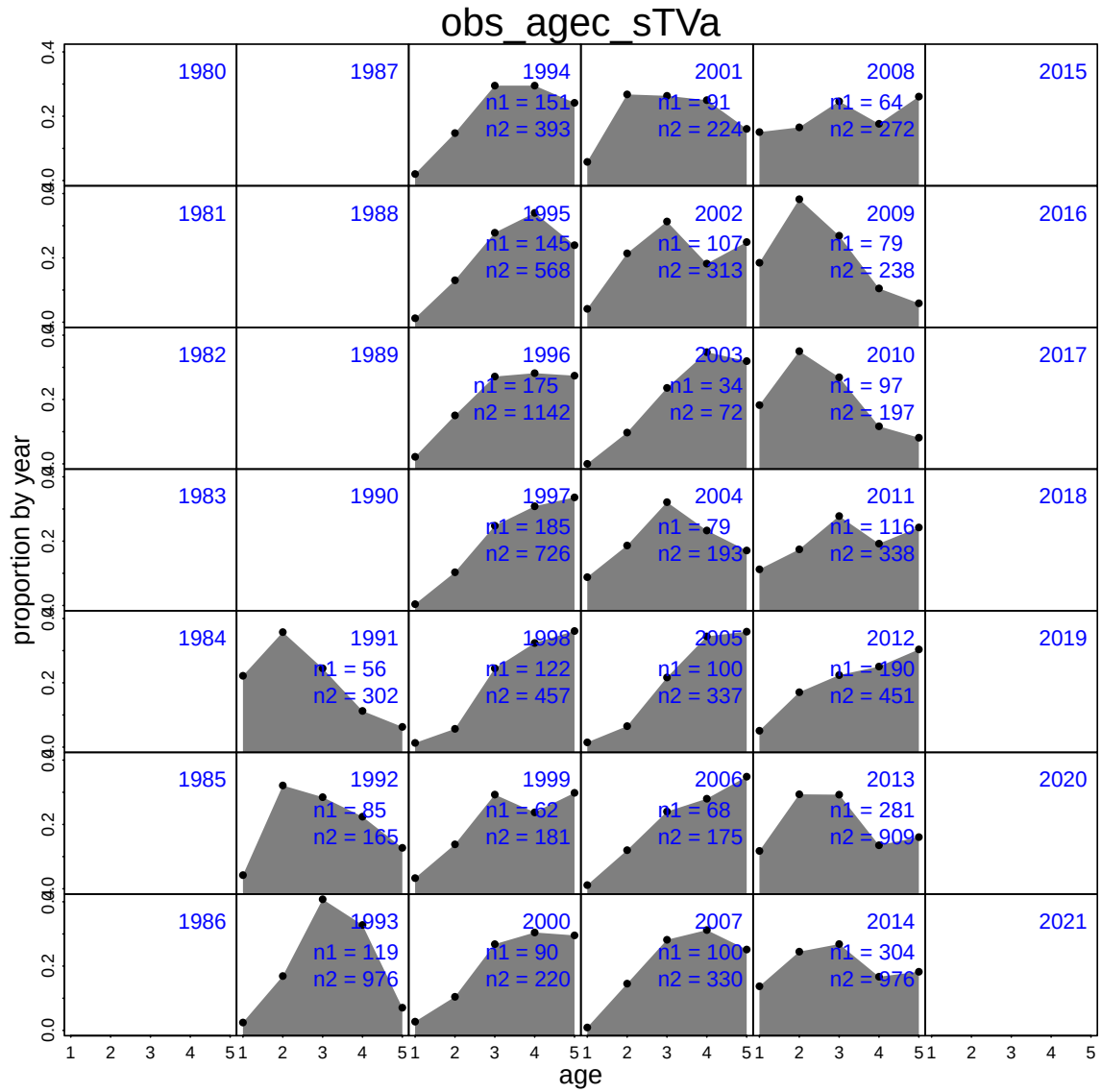


Data

Age and length compositions

SERFS trap/video survey a (start-2014)

- age bins 1-5+

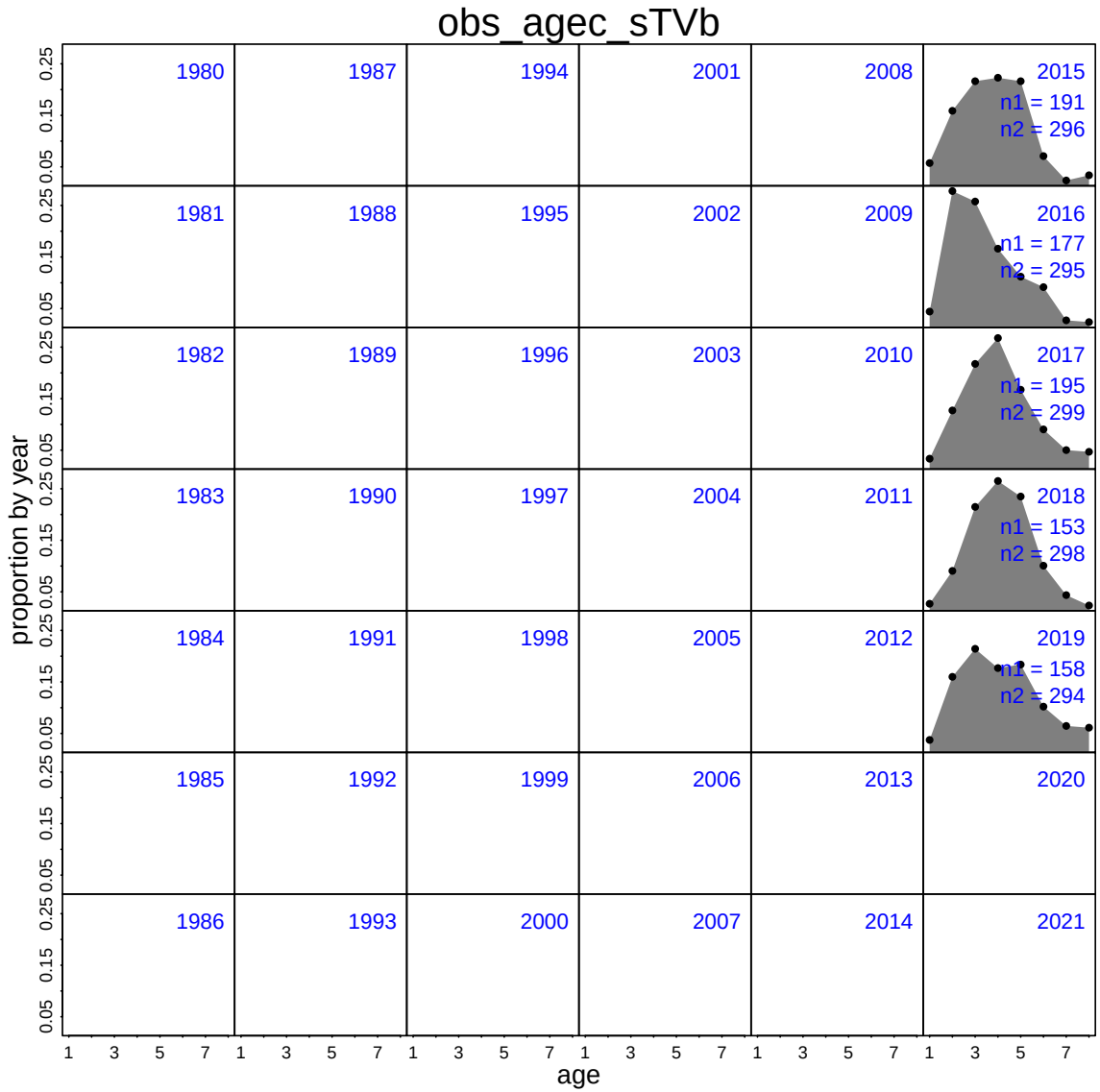


Data

Age and length compositions

SERFS trap/video survey b (2015-end)

- age bins 1-8+

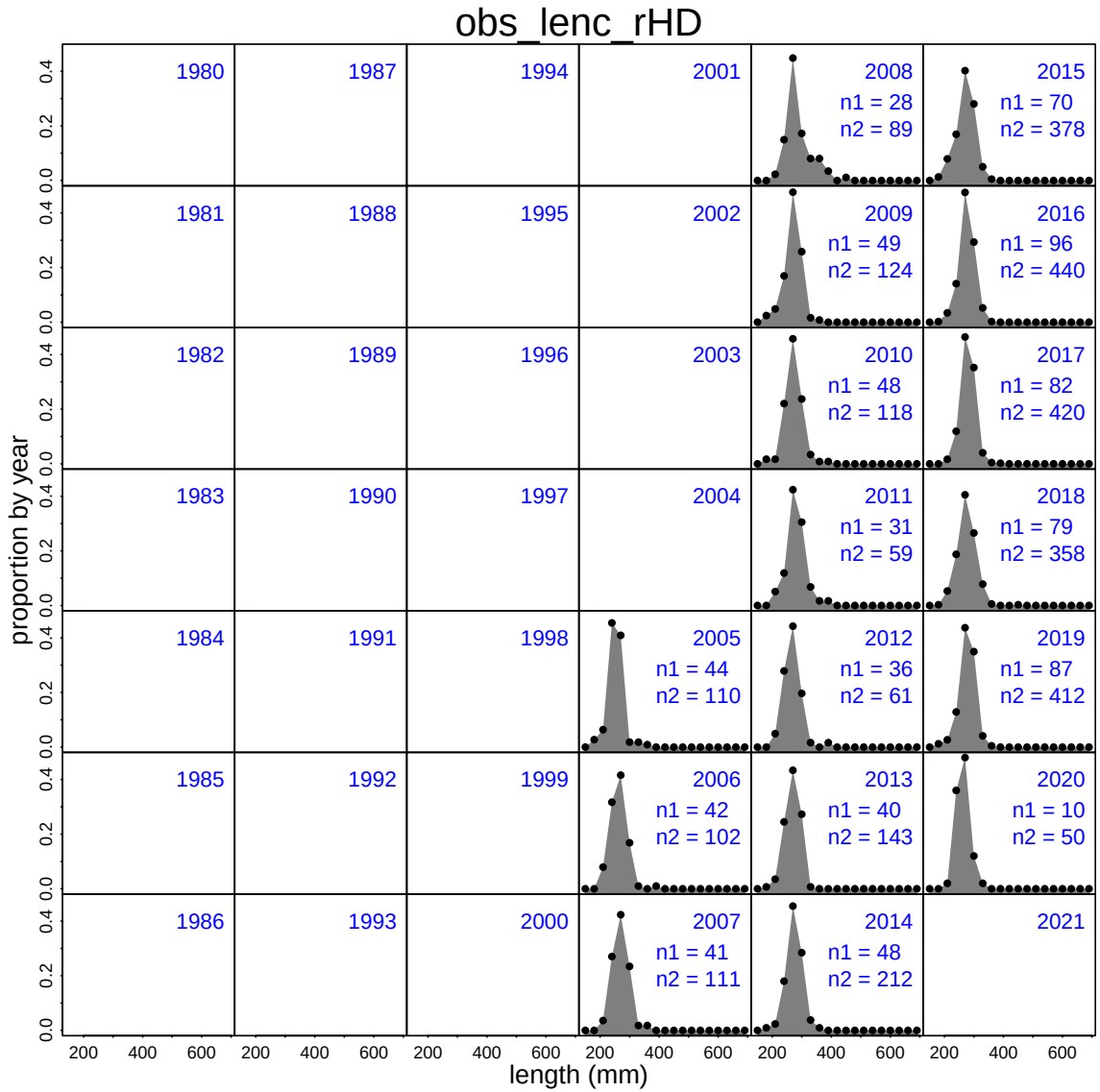


Data

Age and length compositions

Recreational headboat discards

- length bins 150-690 mm
- 30 mm wide bins



Data

Life history

- $W_{\text{fishWhole}} = aL^b$

  $a = 2.8e-08$, $b = 2.97$
  $W_{\text{fishWhole}}$ = whole fish weight (g)
  L = FL (mm)

- batch fecundity: $f_{\text{batch}} = c + dL$

  $c = -1776483$, $d = 8704$
  f_{batch} = batch fecundity
  L = FL (mm)

- Number of batches spawned (n_{batch}) varies with age (Table 1)
- Time of (peak) spawning: June 29th

  $spawn\_time\_frac = 181/365 = 0.5$

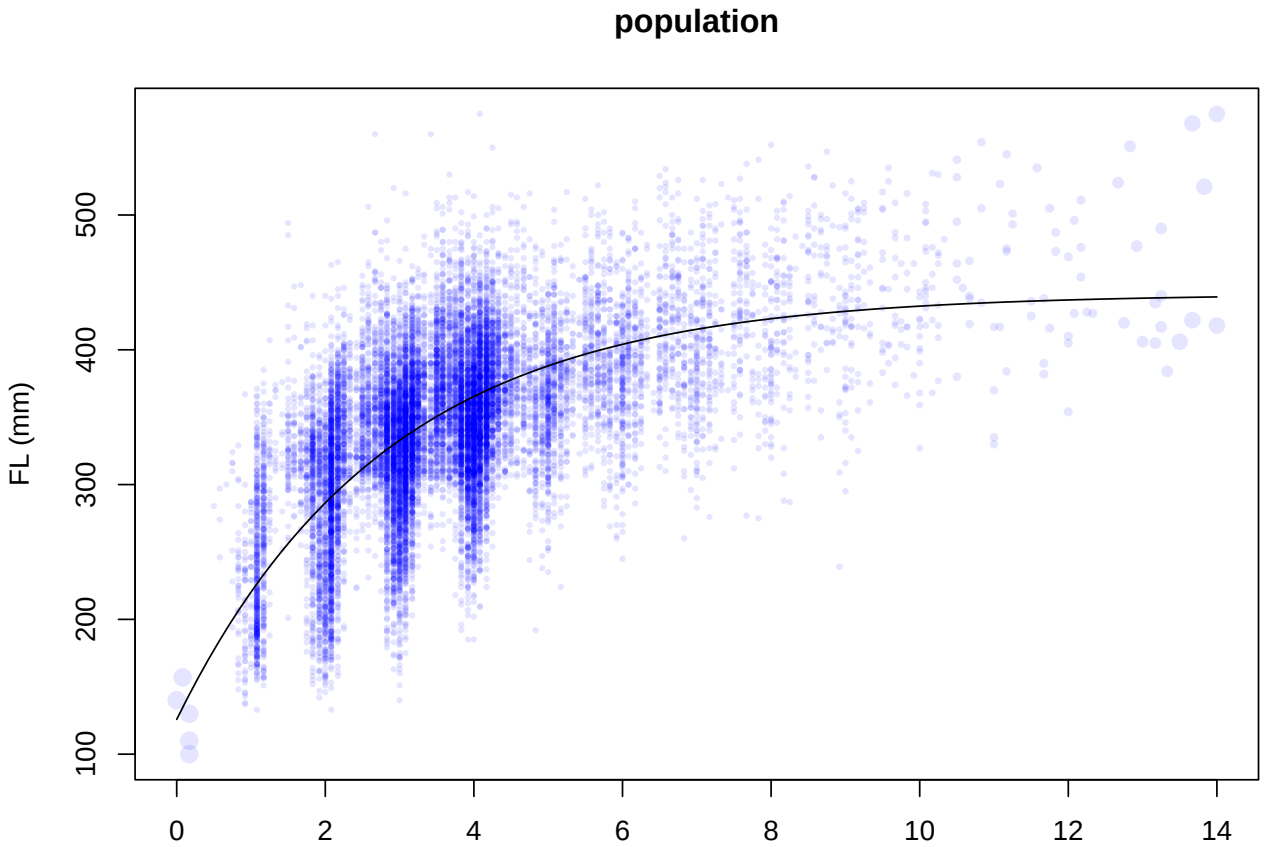
- Natural mortality (M) varies with age (Table 1)

Data

Life history

Von Bertalanffy growth $L_\infty(1 - exp(-k(a - t_0)))$

- population (fixed)
  - $L_\infty = 441$
  - $k = 0.36$
  - $t_0 = -0.94$
  - $CV_{length} = 0.16$
  - Used with recreational headboat discard length comps
  - Used to compute length- and weight-at-age in the population

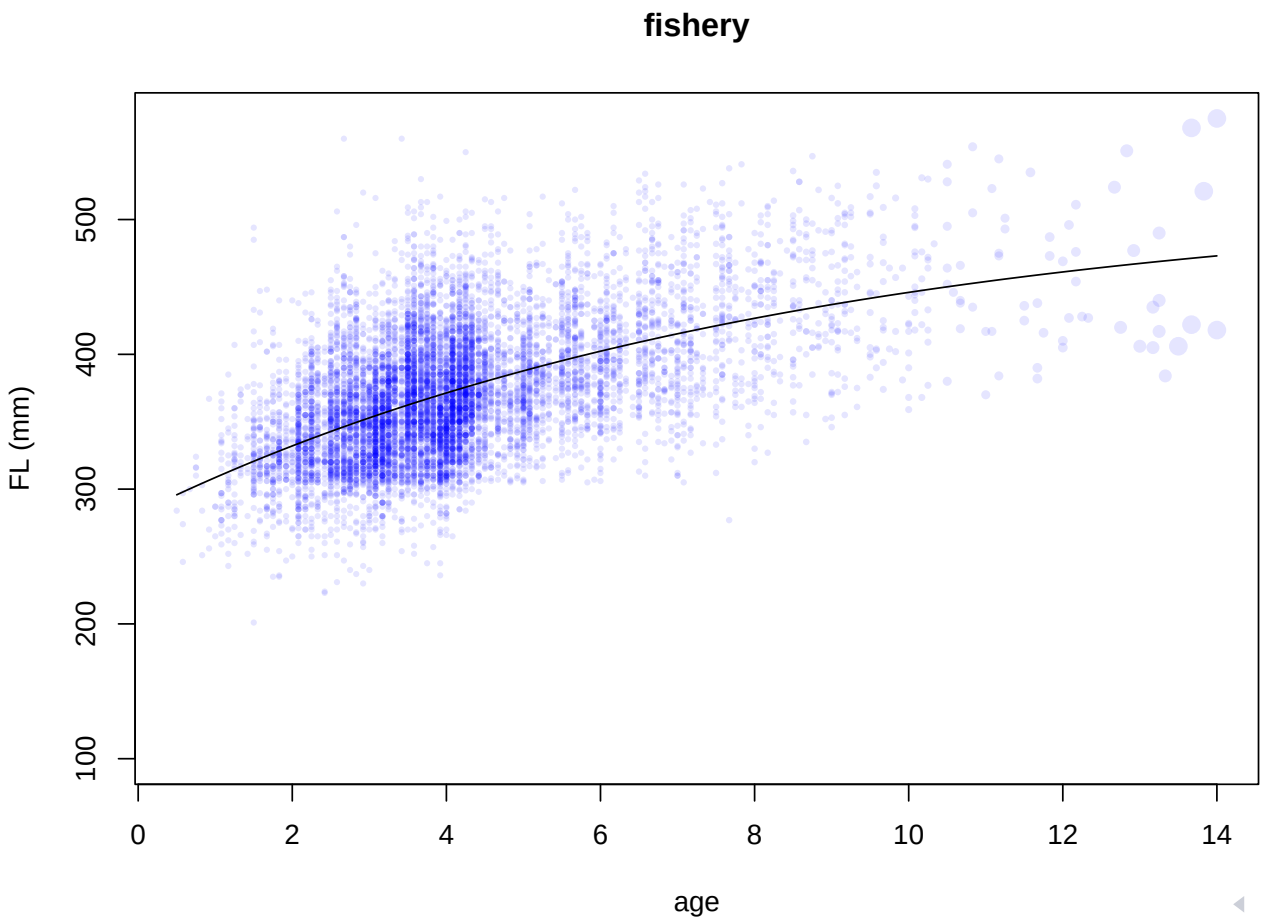


Data

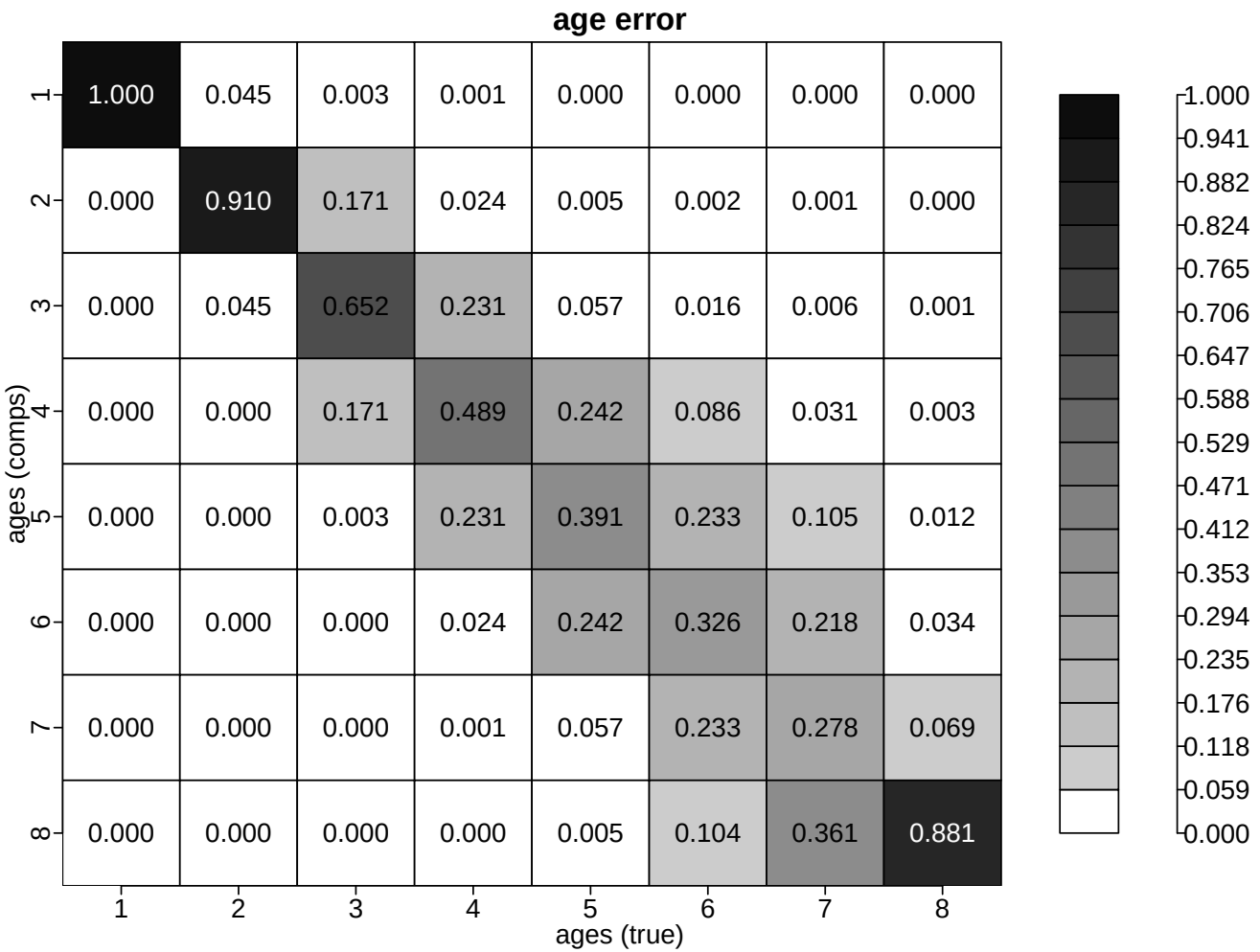
Life history

Von Bertalanffy growth $L_\infty(1 - exp(-k(a - t_0)))$

- fishery (fixed)
  - $L_\infty = 517$
  - $k = 0.12$
  - $t_0 = -6.62$
  - $CV_{length} = 0.11$
  - Used to convert landings between weight and numbers



Age error matrix



Data

Life history

Table 1: Life-history characteristics at age. Variables include size information of fish at midyear: fork length for the population (FL) and landings (FL_L) in millimeters (mm), whole weight (WW) in kilograms (kg) and pounds (lb) for the population. Other variables include proportion female (P_{fem}), proportion of females mature ($P_{fem.mat}$), batch fecundity (f_{batch}) and number of batches (n_{batch}) of individual females. Reproductive value (reprod) is an SSB analog in units of million eggs produced per fish in the population. M= natural mortality.

Age	FL_{pop} (mm)	FL_L (mm)	WW (kg)	WW (lb)	P_{fem}	$P_{fem.mat}$	f_{batch}	n_{batch}	reprod	M
1	256	321	0.39	0.86	0.59	0.75	0.45	0.10	0.02	0.61
2	312	343	0.70	1.55	0.55	0.93	0.94	2.10	1.01	0.51
3	351	362	0.99	2.19	0.56	0.98	1.27	3.30	2.31	0.46
4	378	380	1.24	2.73	0.53	1.00	1.51	4.30	3.44	0.43
5	397	395	1.44	3.17	0.55	1.00	1.68	6.30	5.81	0.41
6	410	409	1.58	3.49	0.55	1.00	1.79	6.30	6.21	0.40
7	419	421	1.69	3.73	0.55	1.00	1.87	6.30	6.50	0.39
8	426	432	1.77	3.91	0.55	1.00	1.93	6.30	6.69	0.39

Data

Discard mortality

$Dmort_{\text{rHDs}} = 0.59$

$Dmort_{\text{rGDn}} = 0.59$

$Dmort_{\text{rGDs}} = 0.59$

A discard mortality rate of 0.59 was also applied to commercial discards prior to combining with commercial landings

Modeling

Base model configuration

- Model coded in Automatic Differentiation Model Builder (ADMB)
- Catch-at-age model used in most SEDAR assessments in the US South Atlantic, the Beaufort Assessment Model (BAM)
- Assessment period: 1982 - 2021

Modeling

Base model configuration

- Age-structured life history
  - $W_{\text{fishWhole}} = aL^b$
  - $FL_{population} = VB_{population}(age)$
  - $FL_{landings} = VB_{landings}(age)$
  - Age-error matrix
  - Age-dependent natural mortality
  - Age-dependent sex ratio
  - Age-dependent female maturity
  - Age-dependent fecundity
- Match landings and discard time series
- Fit indices of abundance time series
- Fit age compositions
- Fit length compositions
- Estimate recruitment deviations
- Estimate initial numbers-at-age deviations
- Estimate fleet specific fishing mortality (average and time series of deviations)
- Estimate selectivity parameters
- Calculate biological reference points and stock status

- F_{init} is being estimated with a light prior, and is used in calculations of initial fishing mortality
  - A sensitivity run with initial mortality computed from the average F for the first three years resulted in very high estimates of initial F
  - Likelihood profiles on F_{init} were also conducted
- Initial age structure in 1982 is fixed at equilibrium since composition data was not available in early years to inform deviation from equilibrium

Modeling

Selectivity

Landings

- Commercial handline
  - Logistic
  - One time block
- Recreational headboat
  - Logistic
  - One time block
- Recreational general
  - Set equal to recreational headboat selectivity

Discards

- Recreational headboat
  - Logistic exponential (4 parameters; only 1 estimated)
  - One time block
- Recreational general
  - Set equal to recreational headboat discard selectivity

Modeling

Selectivity

Survey

- SERFS trap video
  - Logistic
  - One time block

Modeling

Recruitment

Stock-recruit relationship

- No estimable stock-recruit relationship
- Using mean recruitment model
- R_0 (unfished age-1 recruitment) is being estimated
- Steepness (h) is not used
- Rec sigma (σ) is estimated with a normal prior

Recruitment deviations

- Age composition data spans 1990-2020
- Recruitment deviations estimated from 1990-2018

Modeling

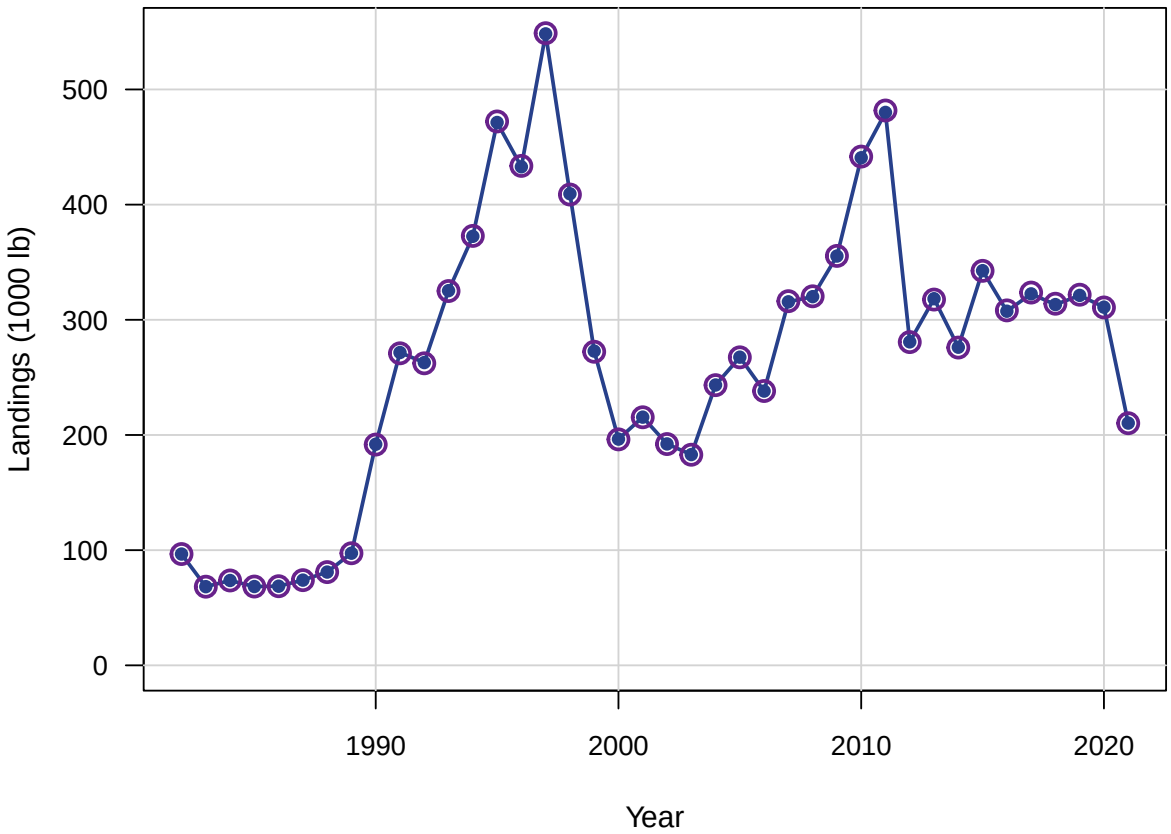
Reference points

- The current model uses SPR_{40} reference points
  - Maximum Fishing Mortality Threshold (MFMT)
    - $MFMT_{40} = F_{40}$
  - Minimum Stock Size Threshold (MSST)
    - $MSST_{40} = (1 - M) * SSB_{40}$
      - M = constant natural mortality
      - SSB = spawning stock biomass = total egg production
  - Fishery status
    - Not overfishing if: $F_{current}/F_{40} < 1$
      - $F_{current} = geomean(F_{2019-2021})$
  - Stock status
    - Not overfished if: $SSB_{current}/MSST_{40} > 1$
      - $SSB_{current} = SSB_{2021}$

Model results

Fit to landings

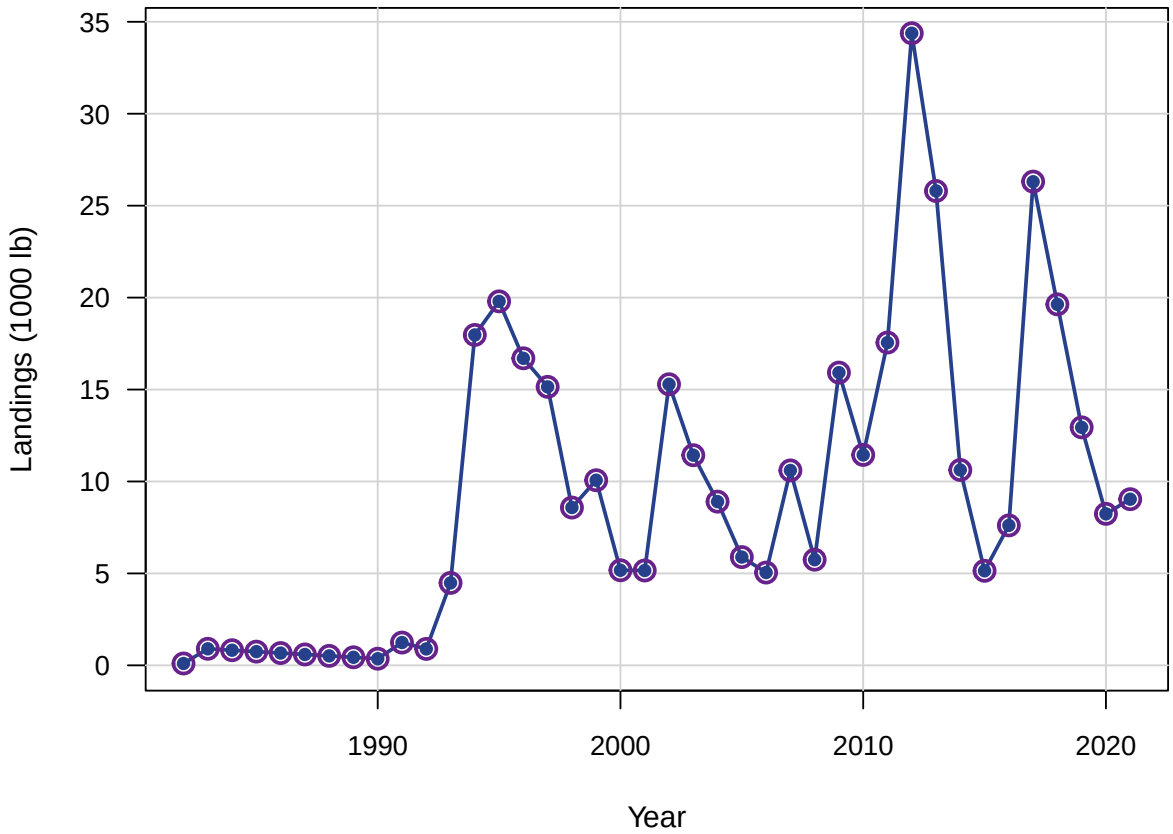
Commercial handline landings (south)



Model results

Fit to landings

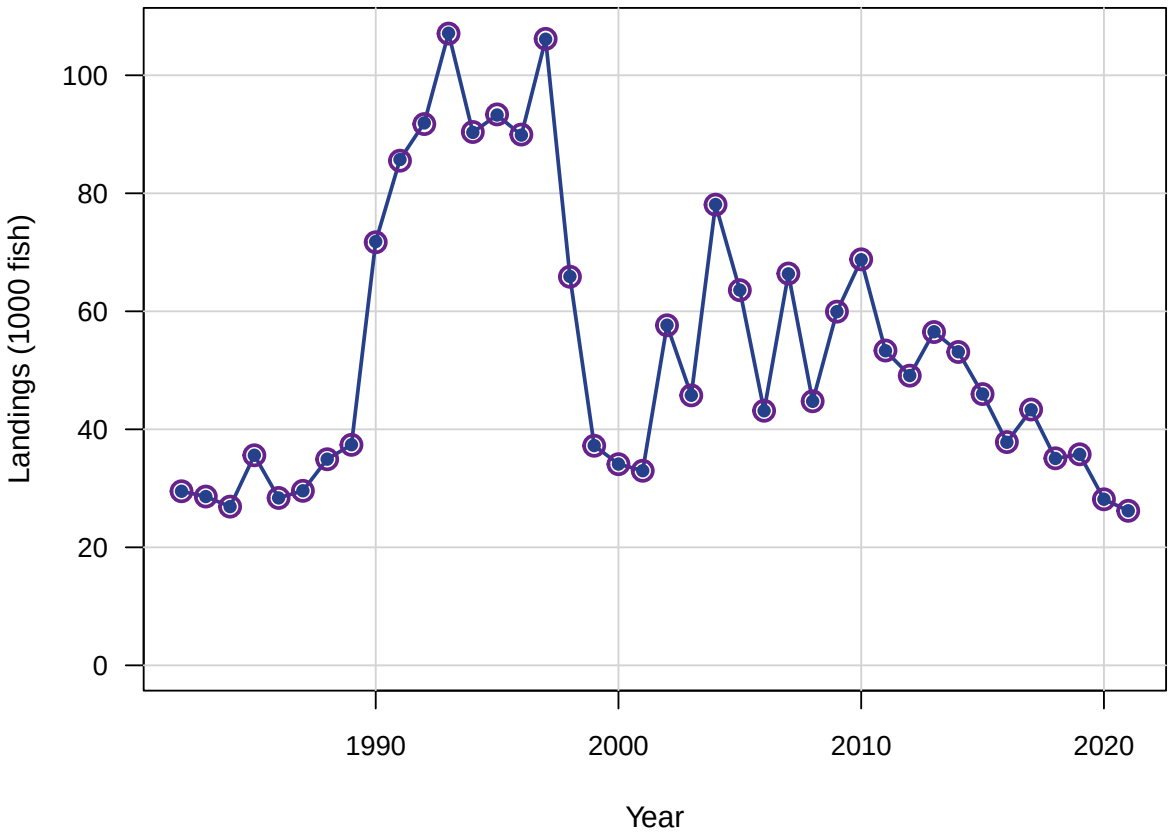
Commercial handline landings (north)



Model results

Fit to landings

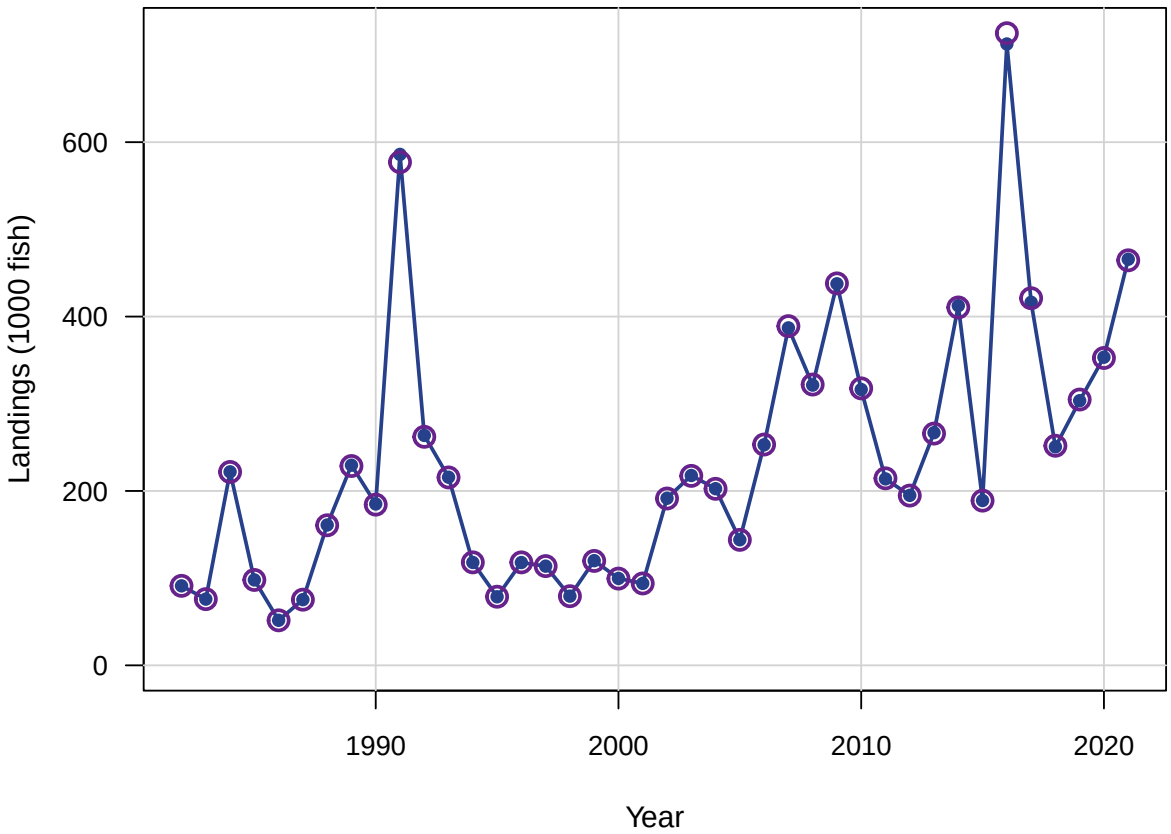
Recreational headboat landings (south)



Model results

Fit to landings

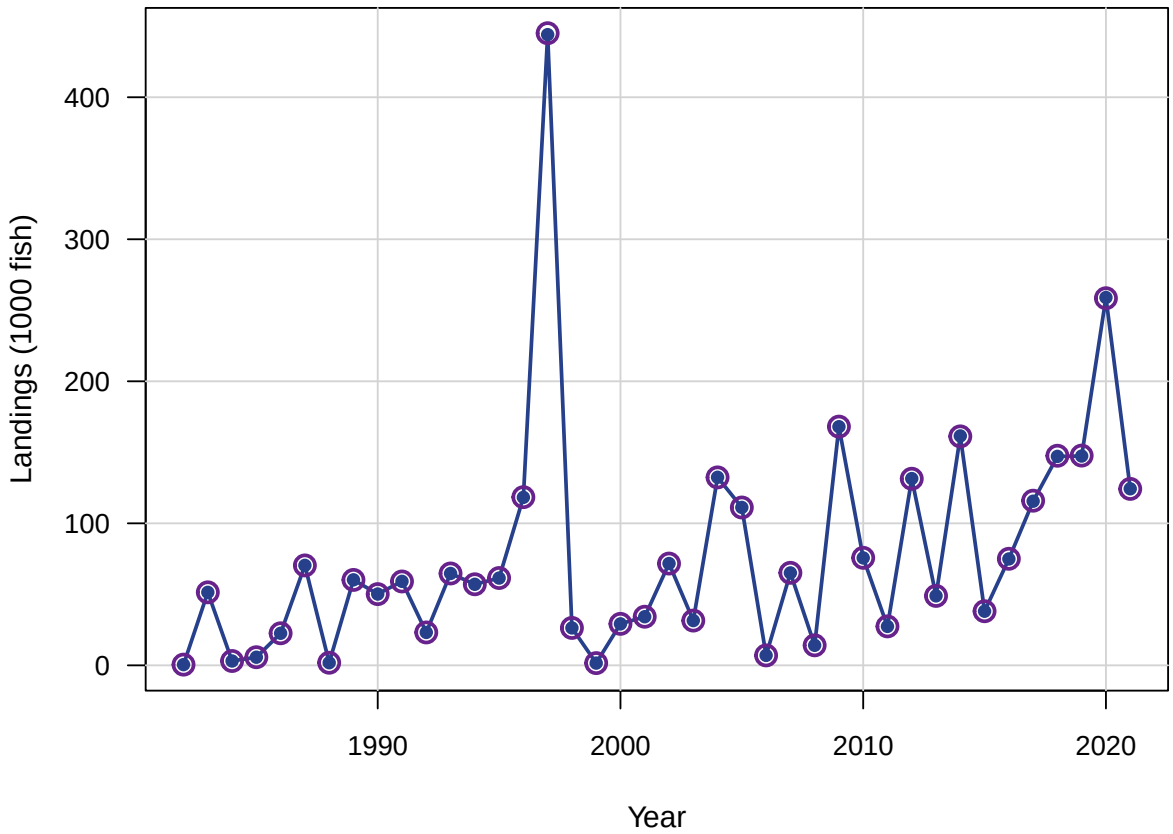
Recreational general landings (south)



Model results

Fit to landings

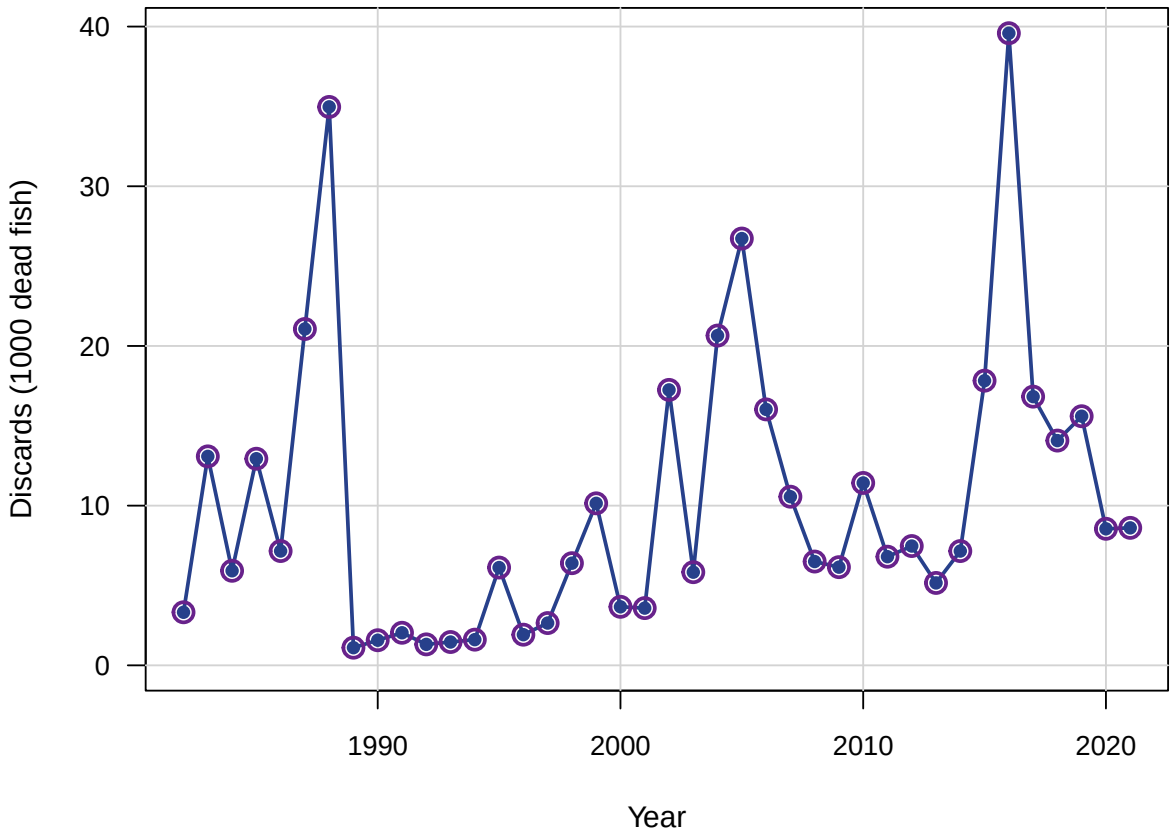
Recreational general landings (north)



Model results

Fit to discards

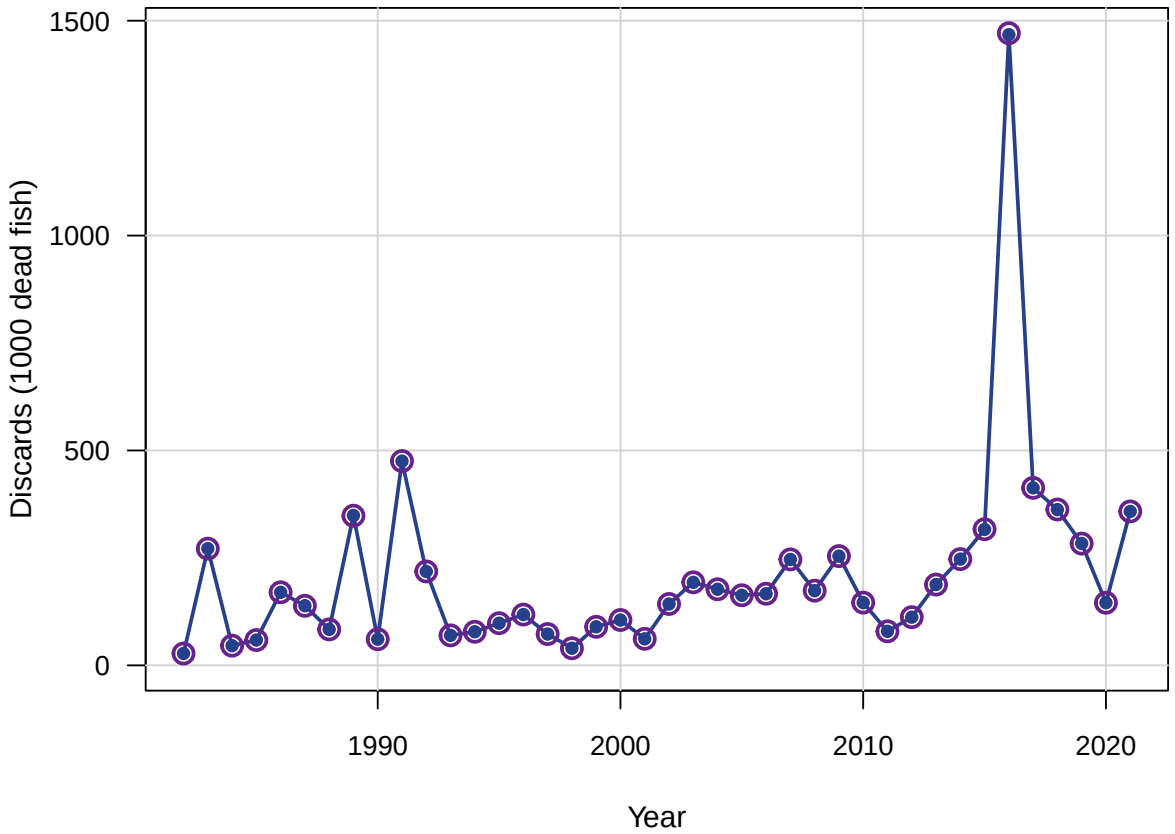
Recreational headboat discards (south)



Model results

Fit to discards

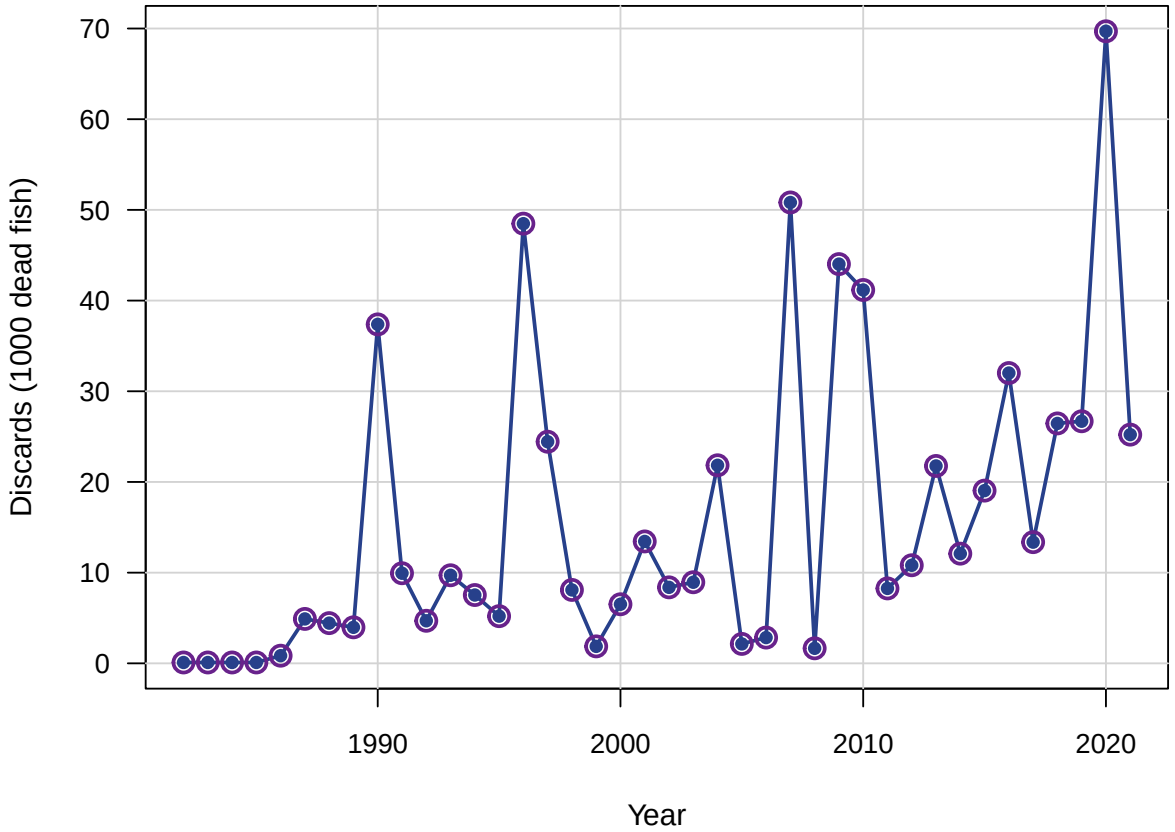
Recreational general discards (south)



Model results

Fit to discards

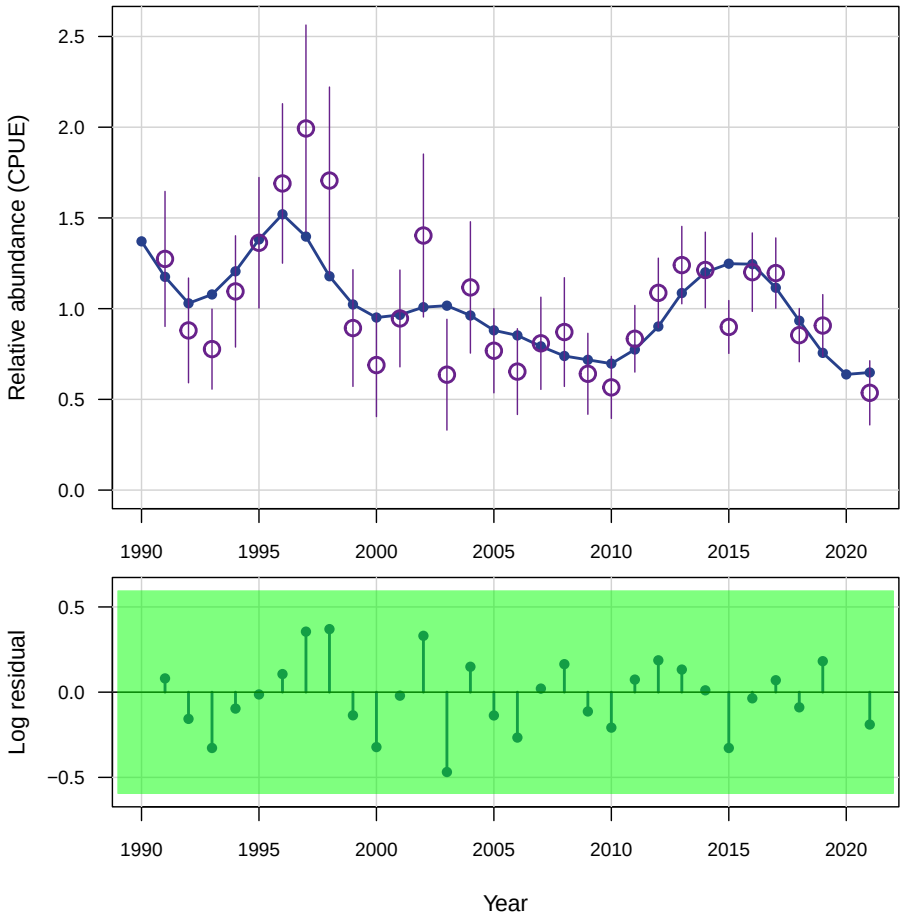
Recreational general discards (north)



Model results

Fit to indices

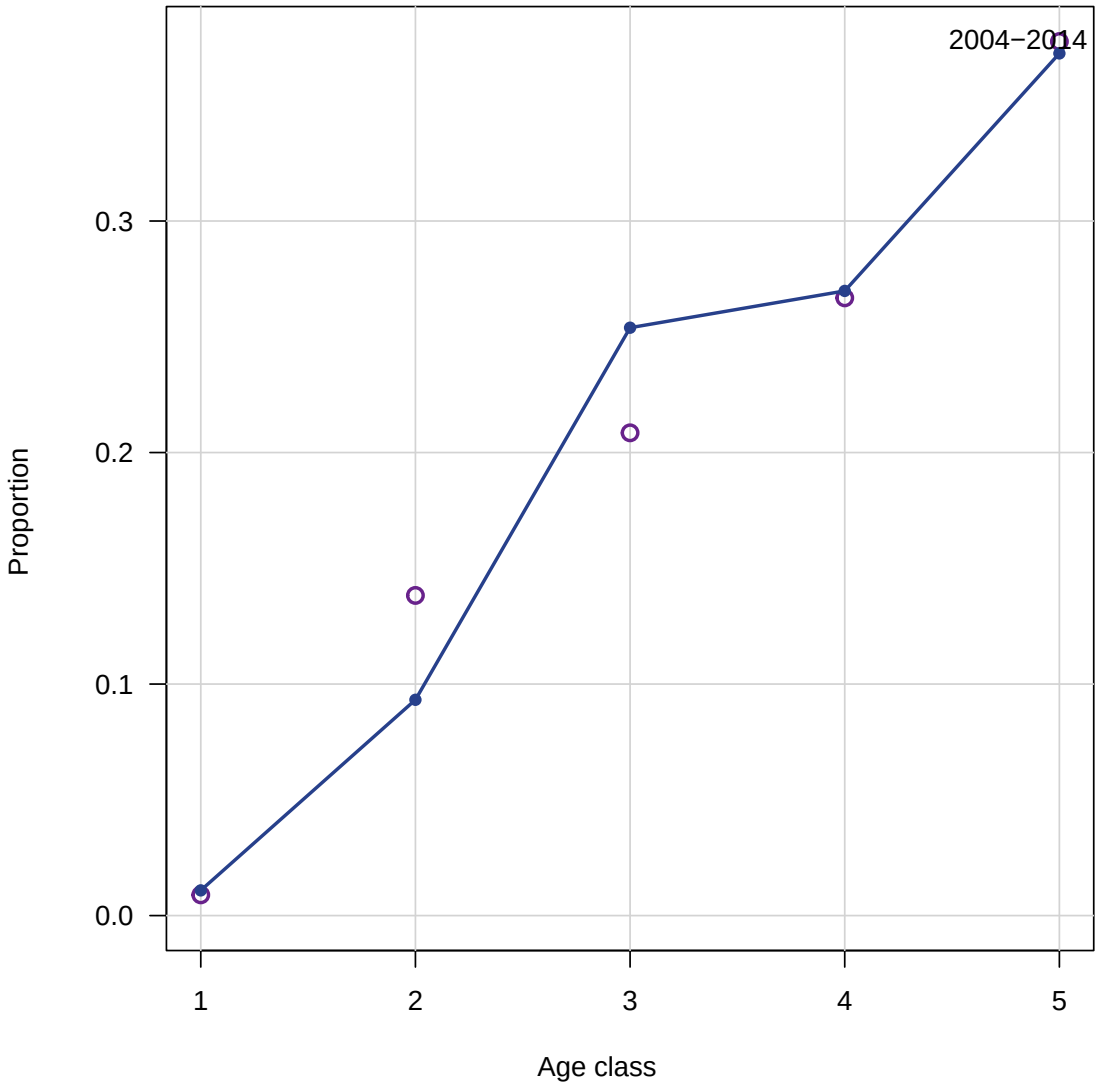
SERFS trap video index



Model results

Fit to age and length compositions

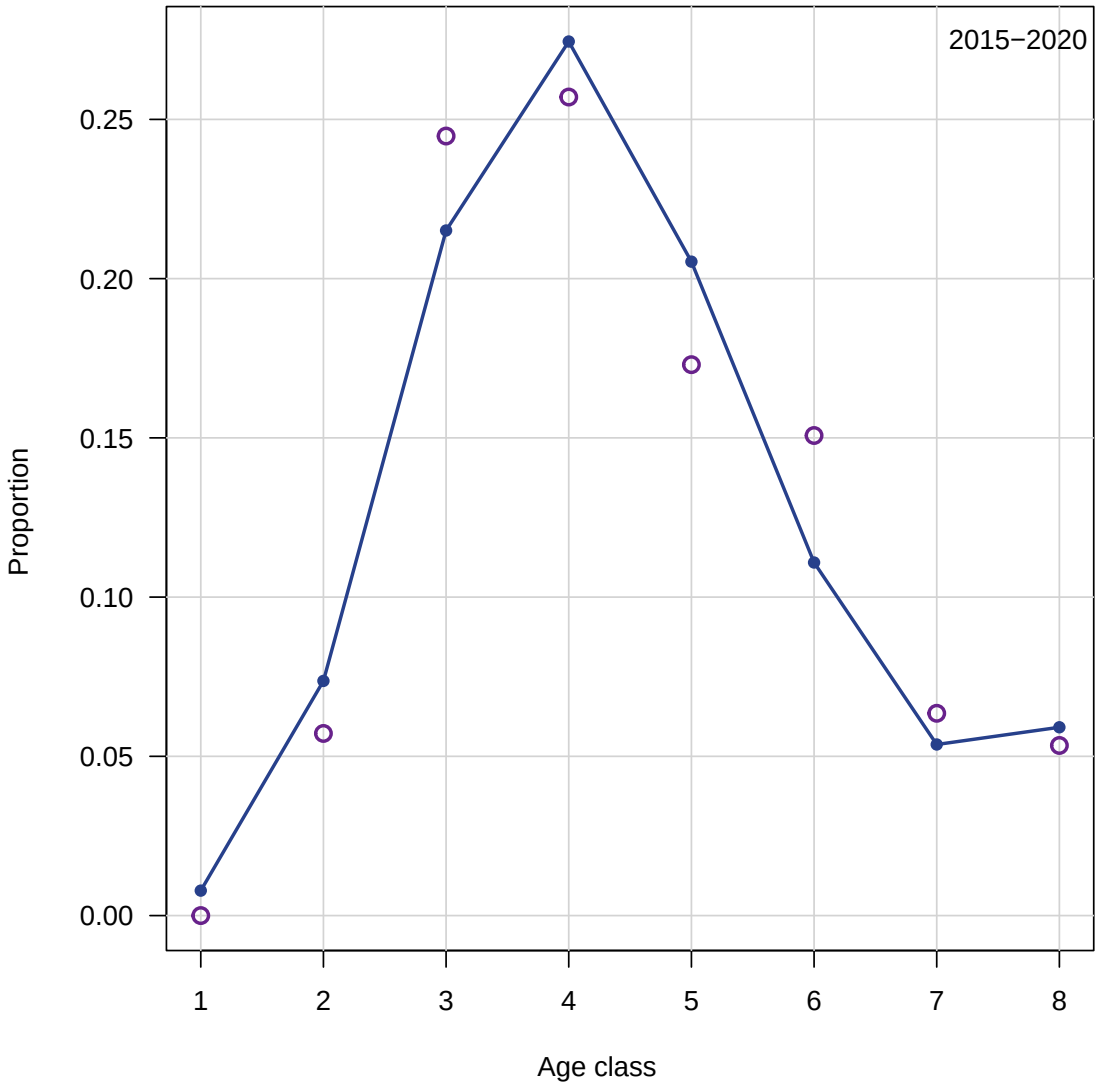
Commercial handline ages: < 2015



Model results

Fit to age and length compositions

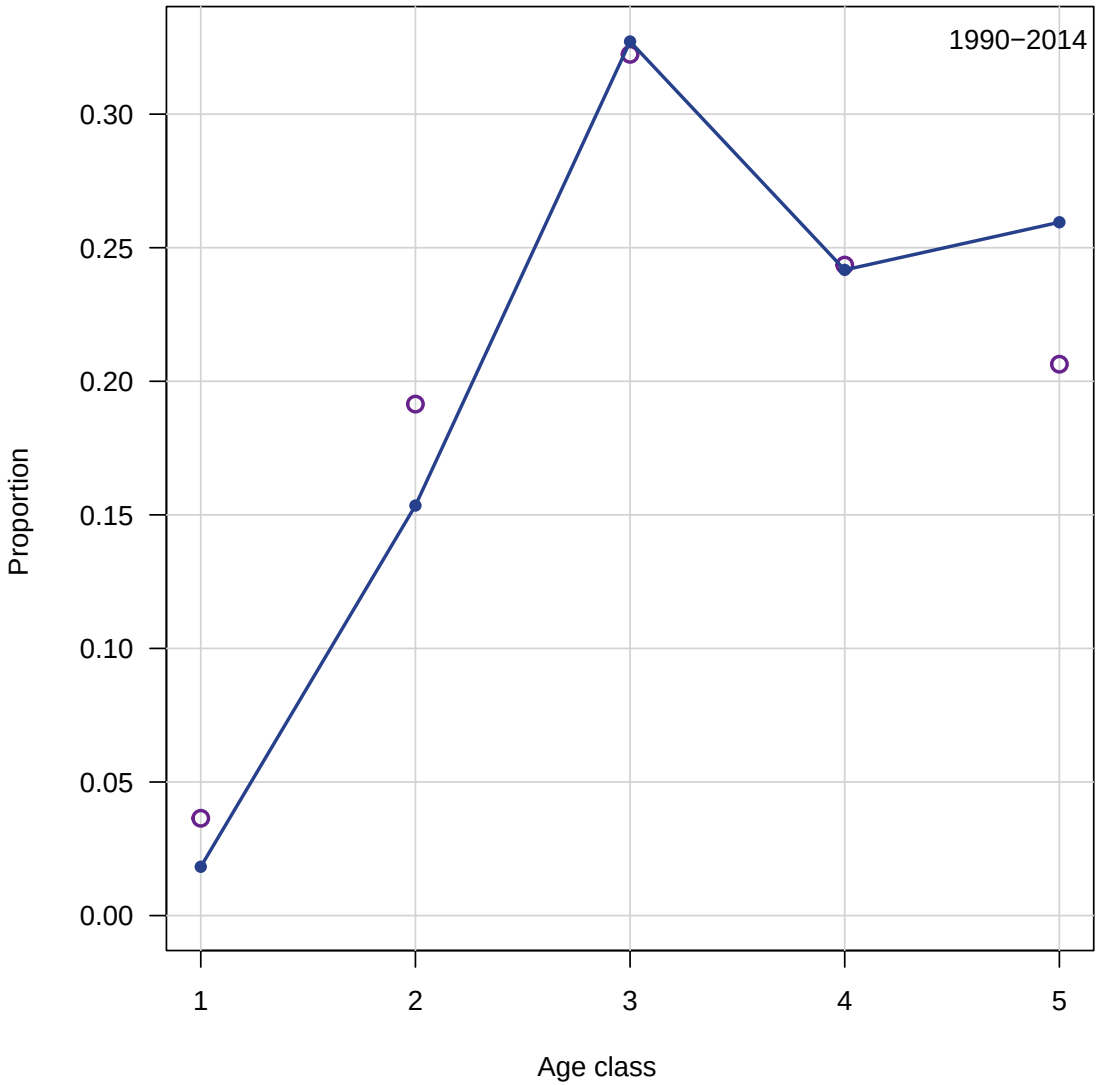
Commercial handline ages: ≥ 2015



Model results

Fit to age and length compositions

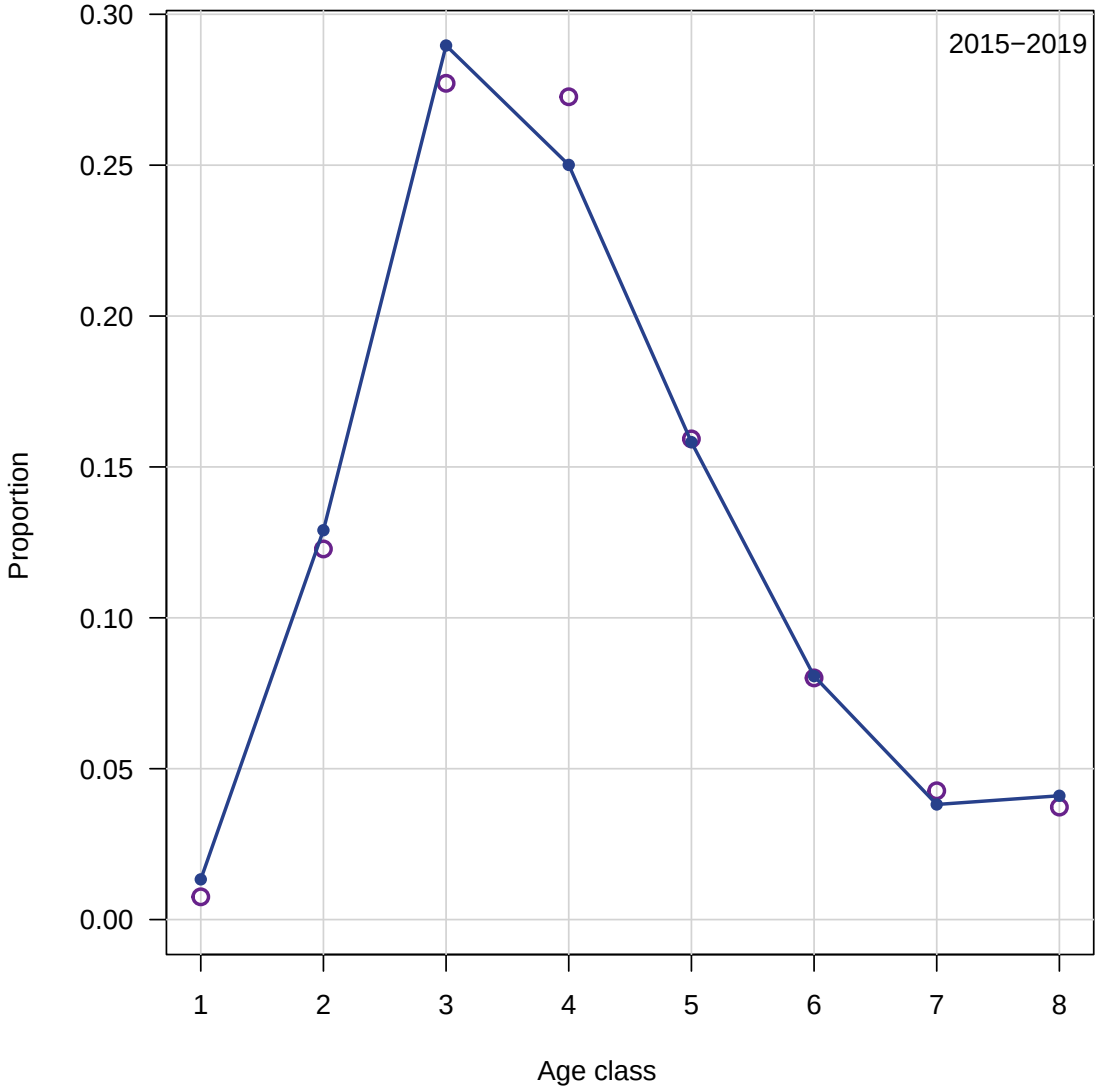
Recreational headboat ages: < 2015



Model results

Fit to age and length compositions

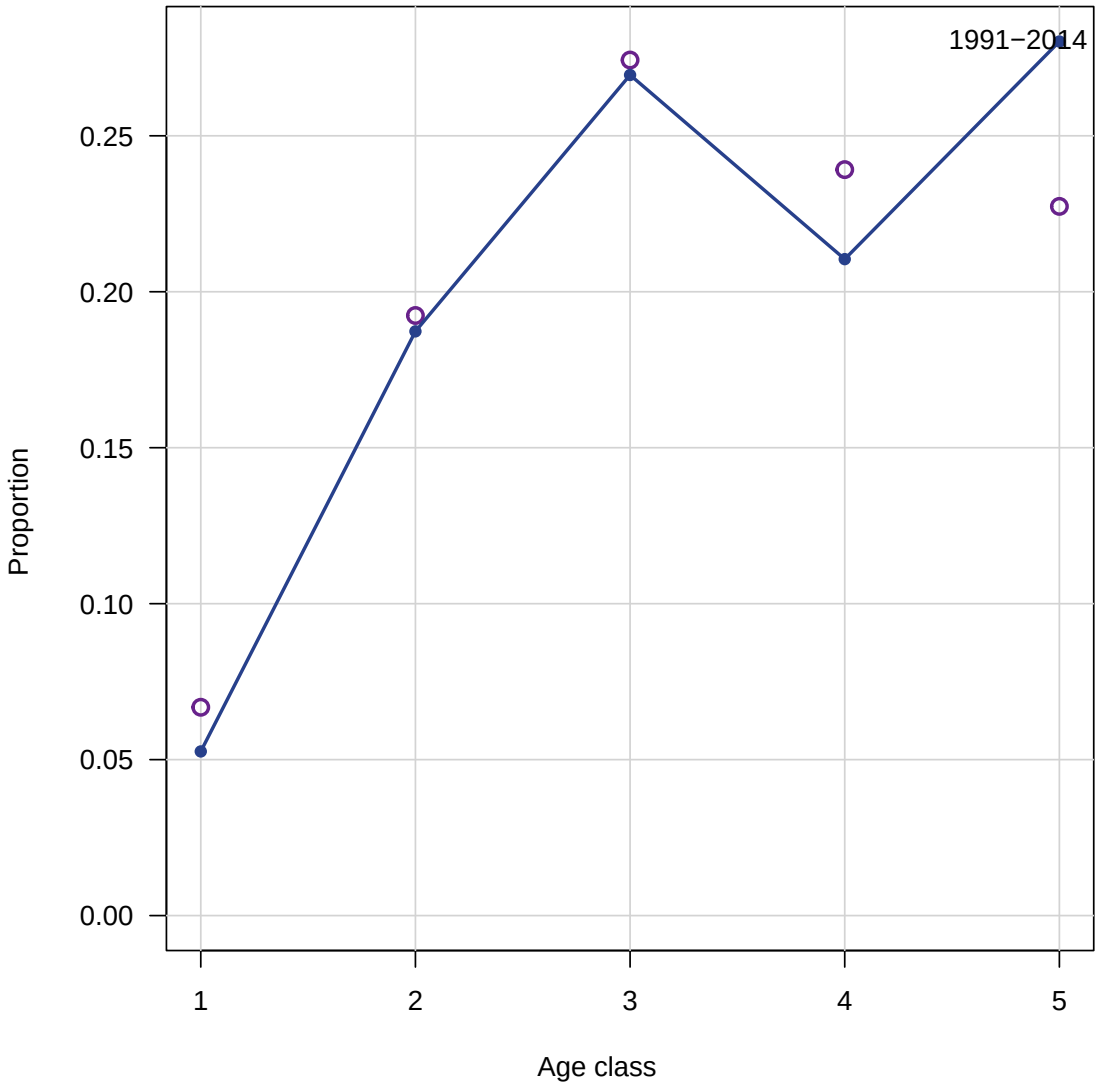
Recreational headboat ages: ≥ 2015



Model results

Fit to age and length compositions

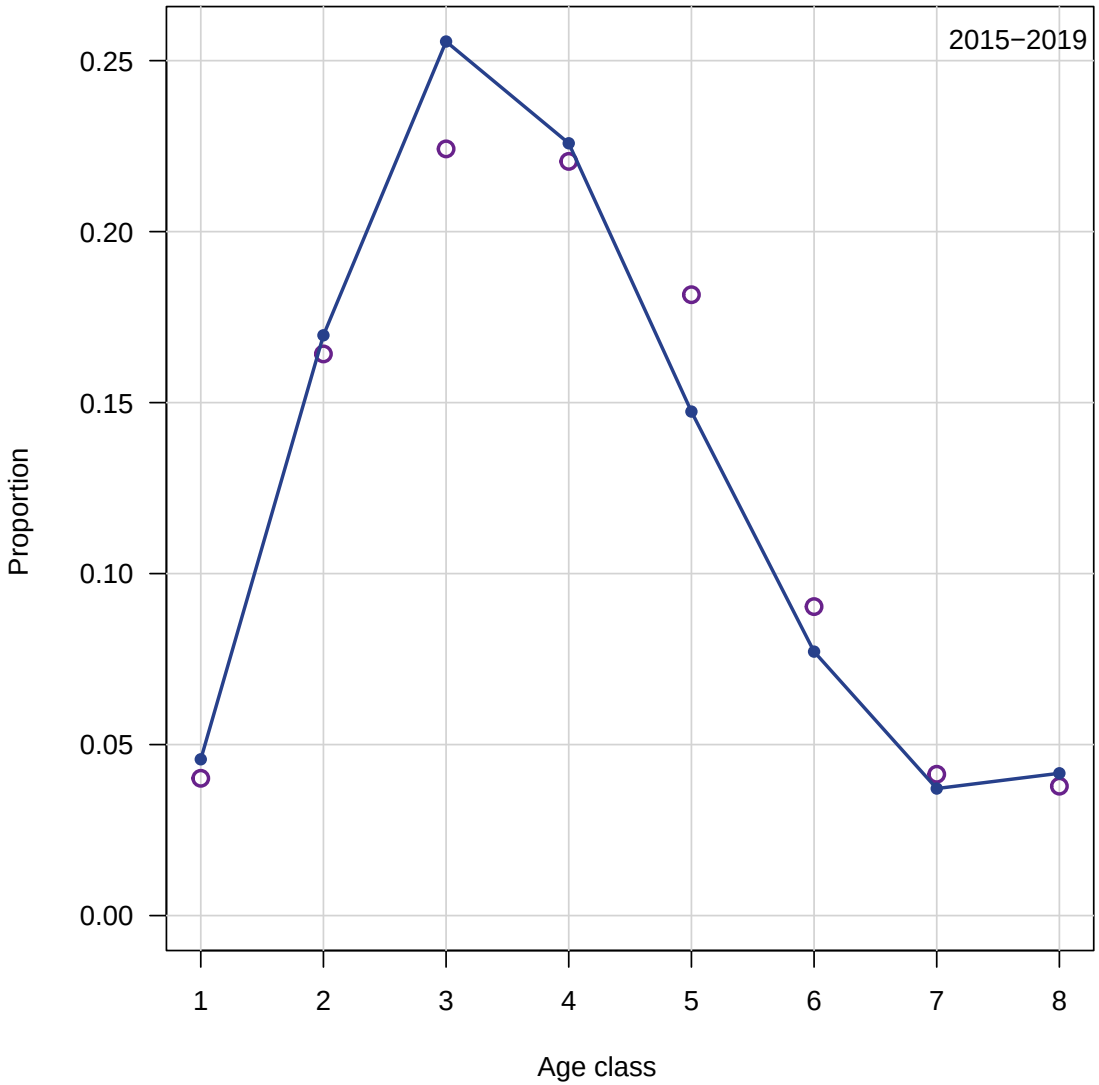
SERFS trap video survey ages: < 2015



Model results

Fit to age and length compositions

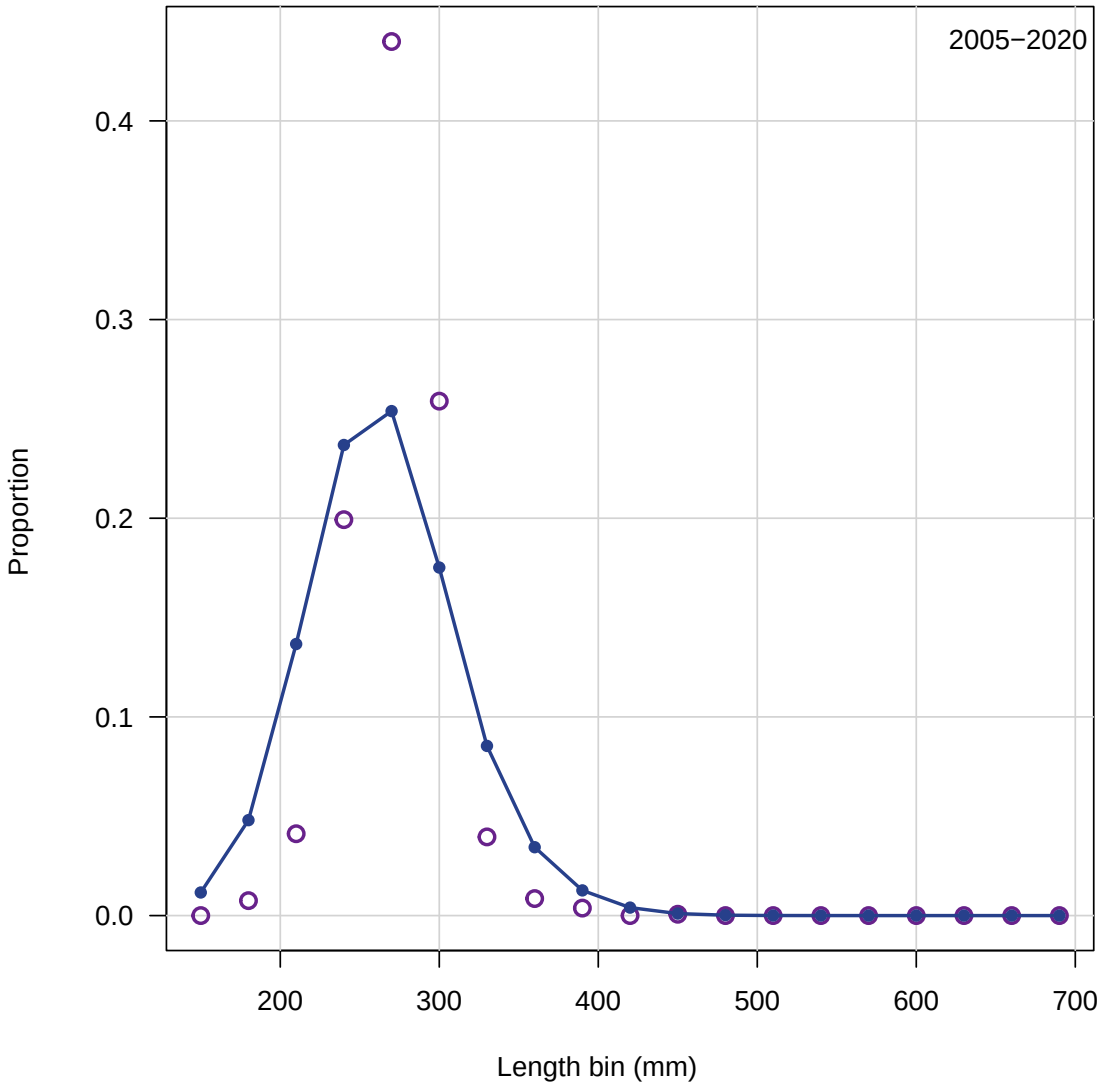
SERFS trap video survey ages: ≥ 2015



Model results

Fit to age and length compositions

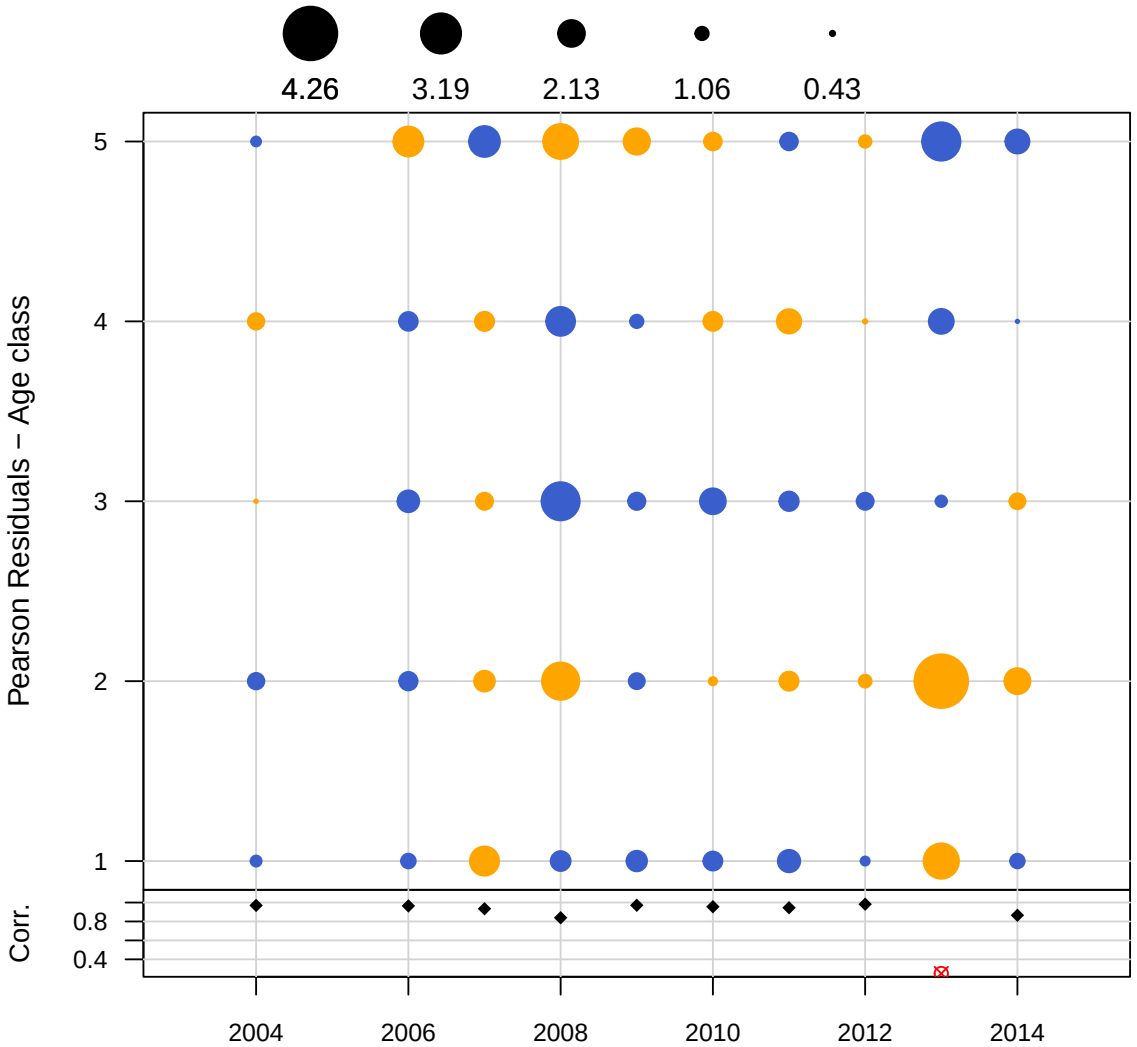
Recreational headboat discard lengths



Model results

Fit to age and length compositions: residuals

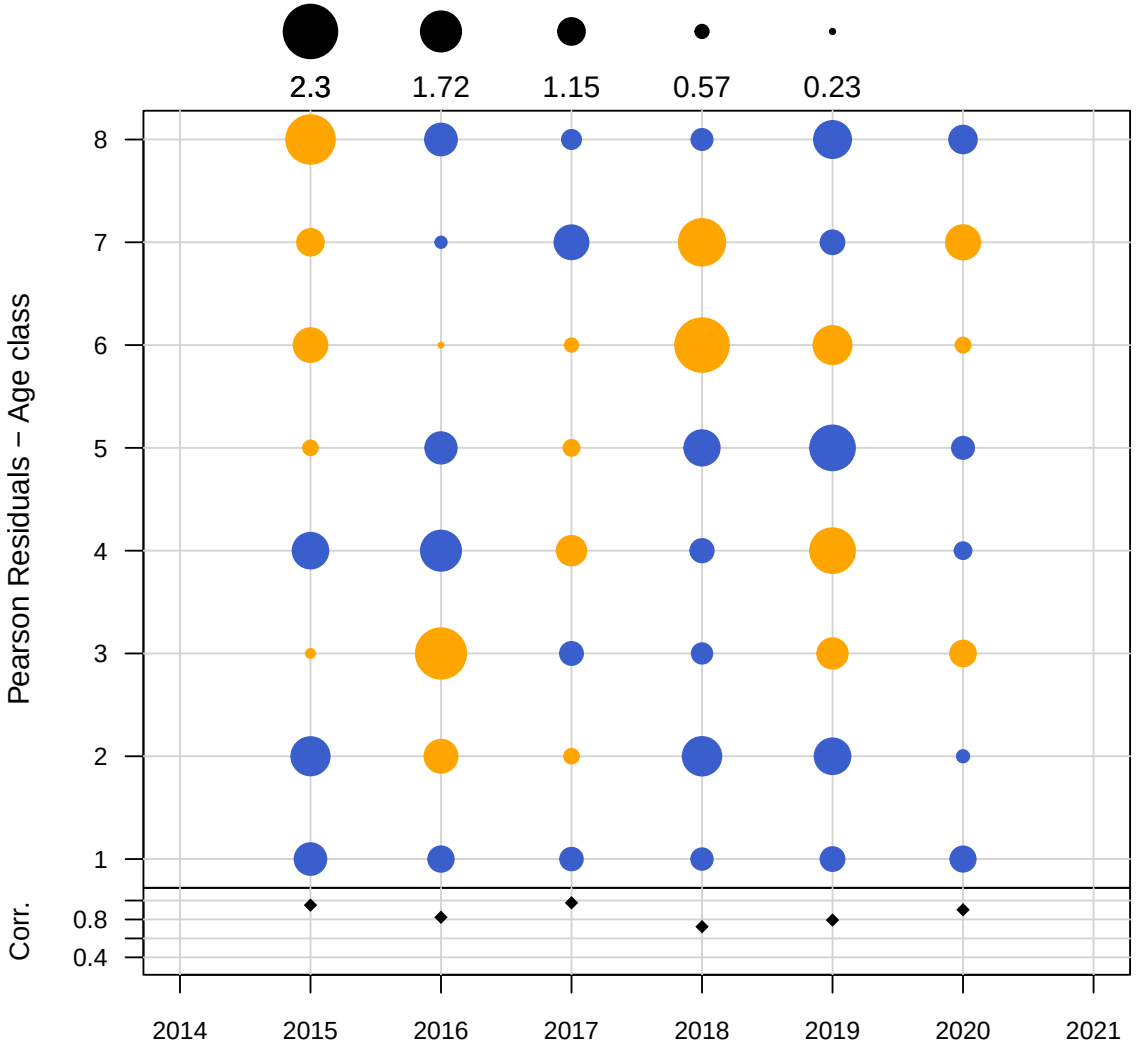
Commercial handline ages: < 2015



Model results

Fit to age and length compositions: residuals

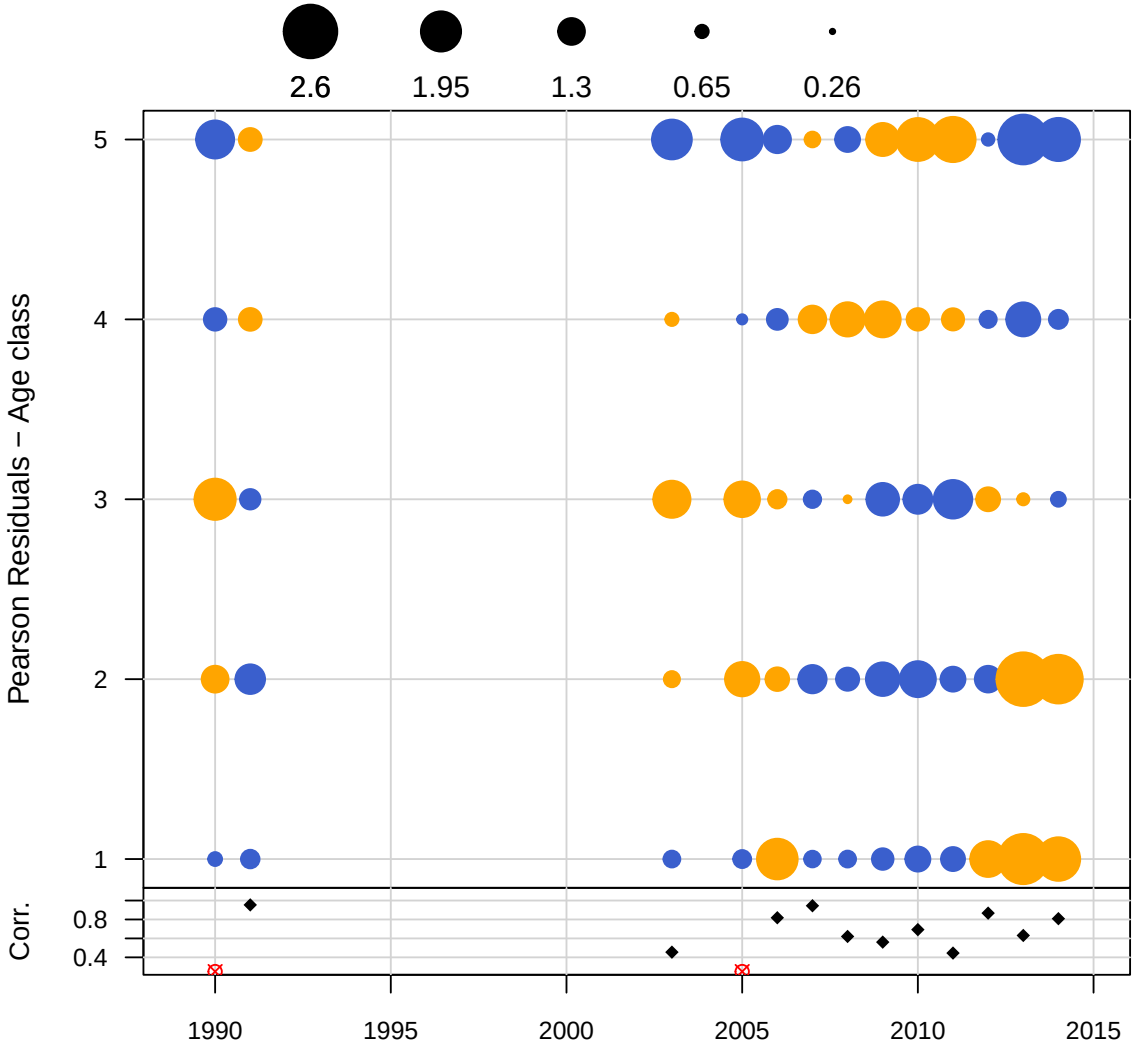
Commercial handline ages: ≥ 2015



Model results

Fit to age and length compositions: residuals

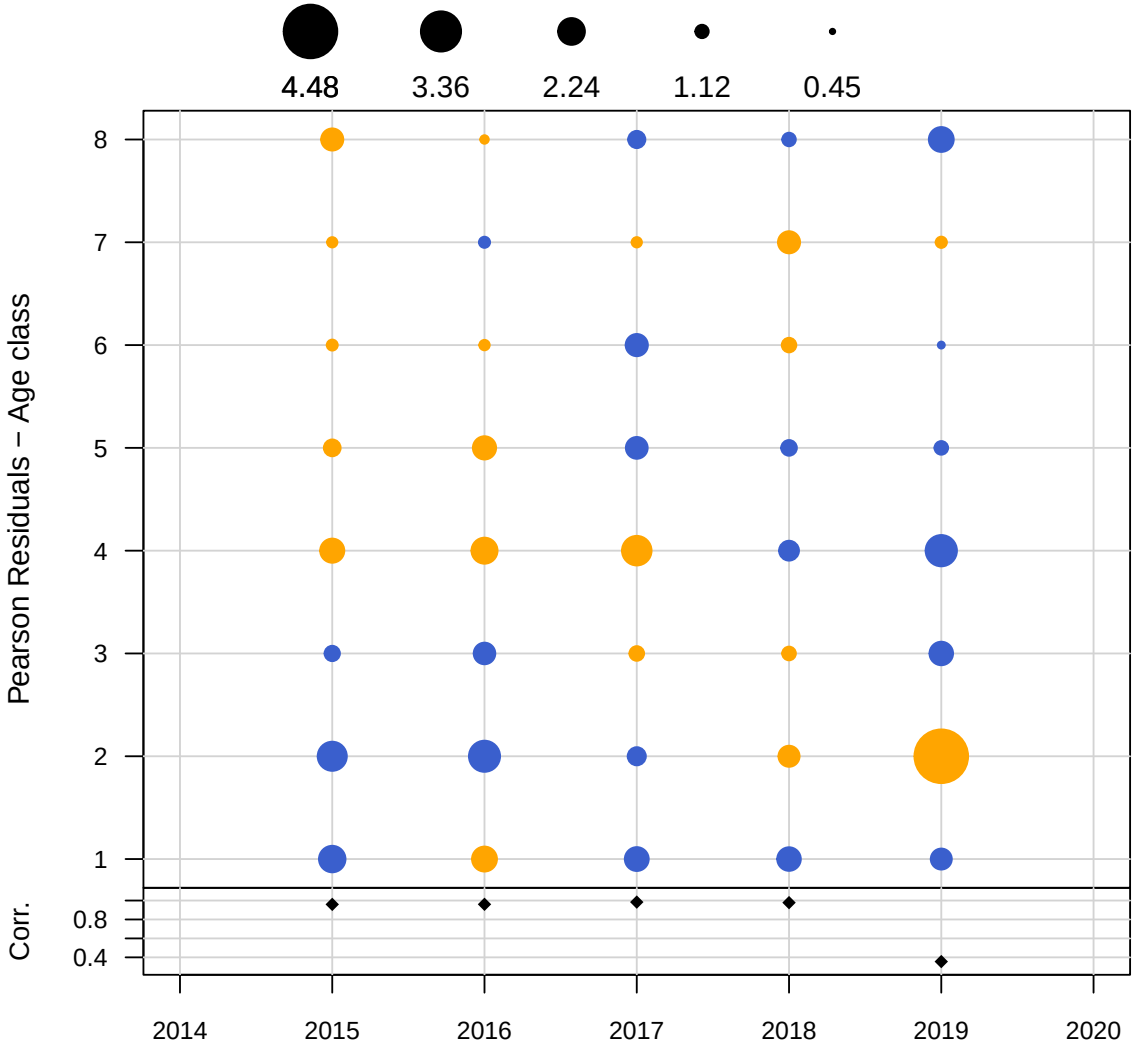
Recreational headboat ages: < 2015



Model results

Fit to age and length compositions: residuals

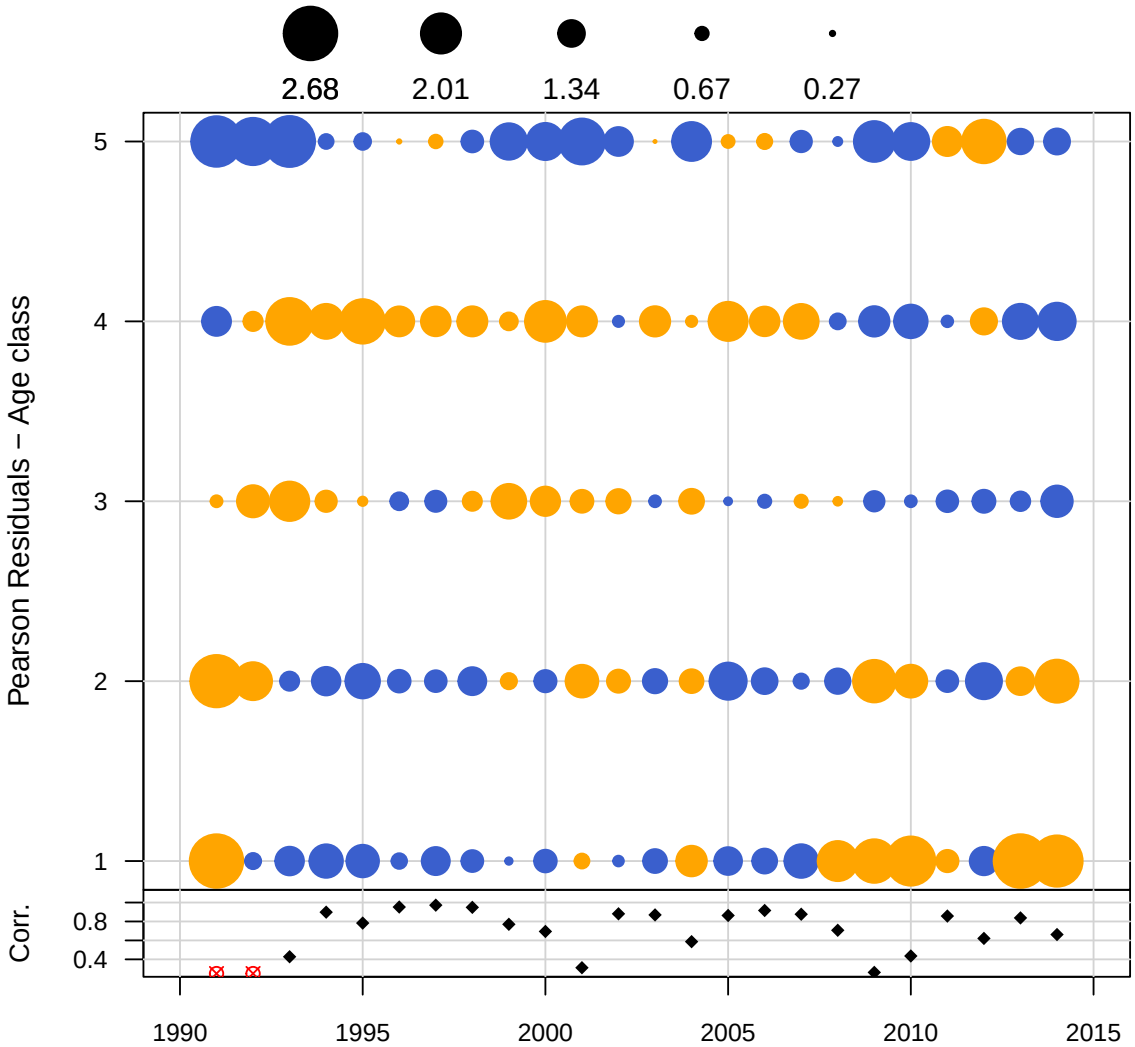
Recreational headboat ages: ≥ 2015



Model results

Fit to age and length compositions: residuals

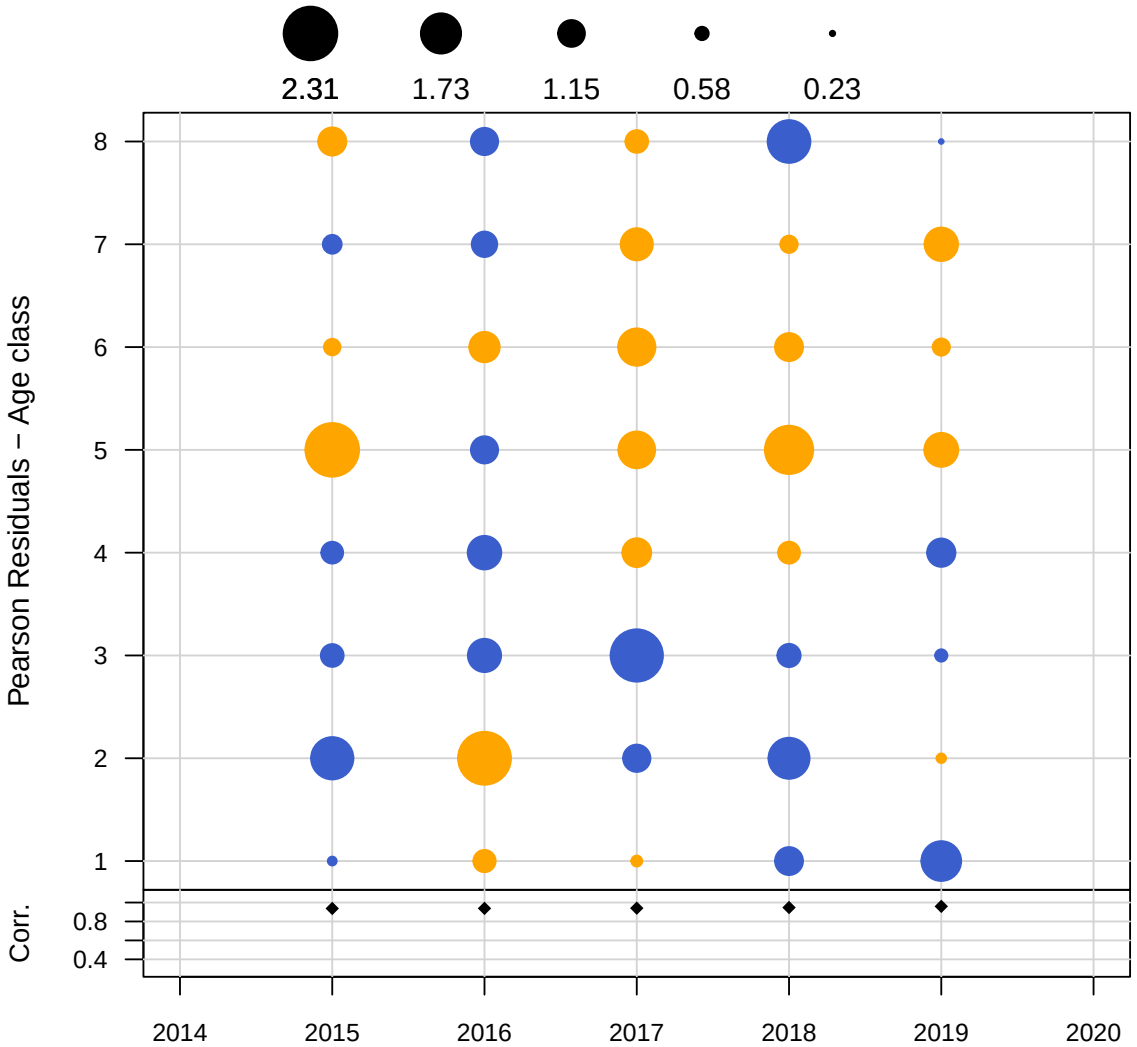
SERFS trap video survey ages: < 2015



Model results

Fit to age and length compositions: residuals

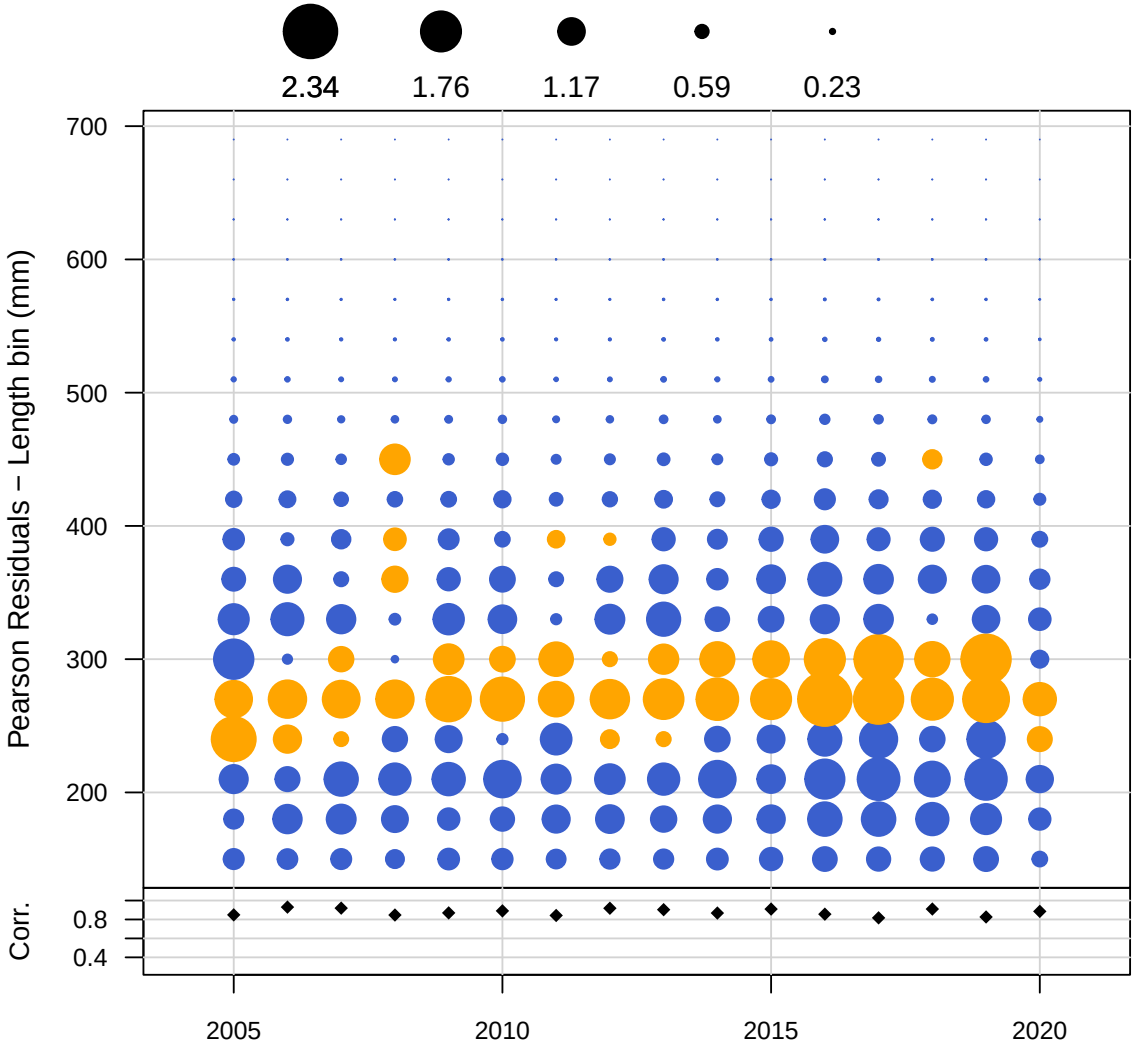
SERFS trap video survey ages: ≥ 2015



Model results

Fit to age and length compositions: residuals

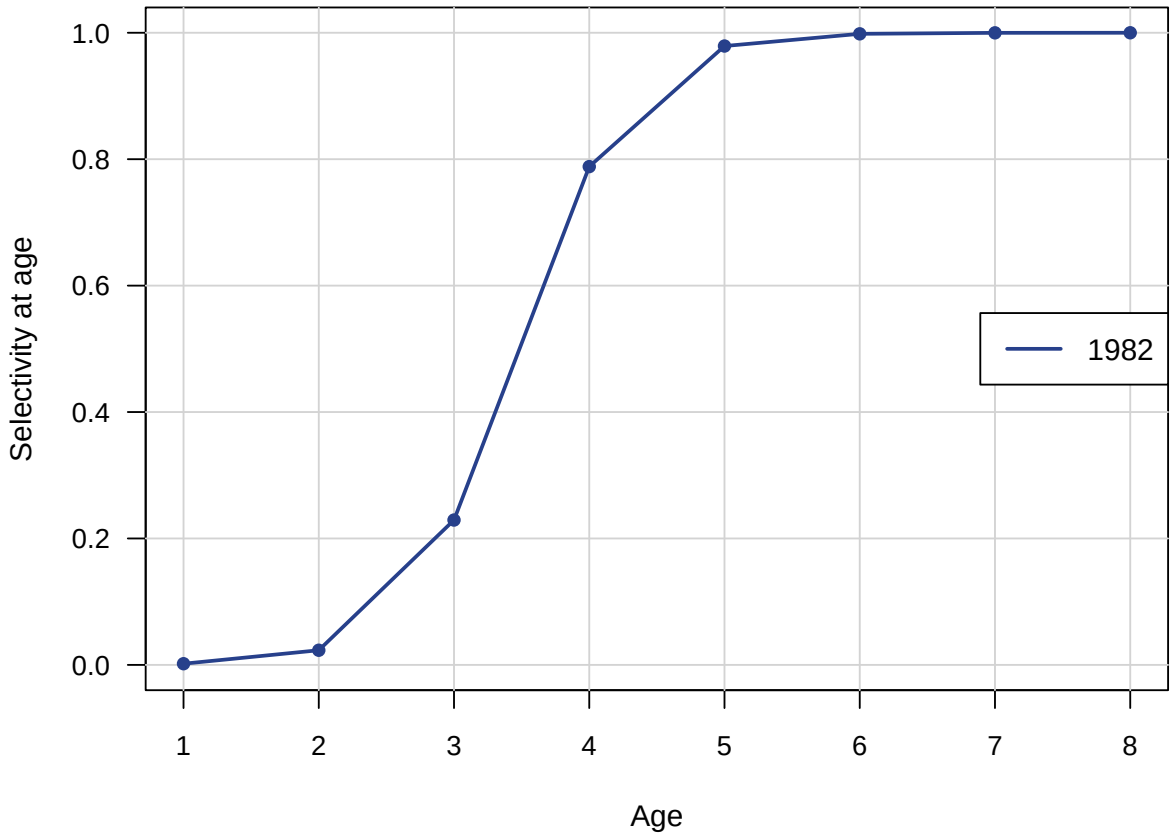
Recreational headboat discard lengths



Model results

Estimated selectivity

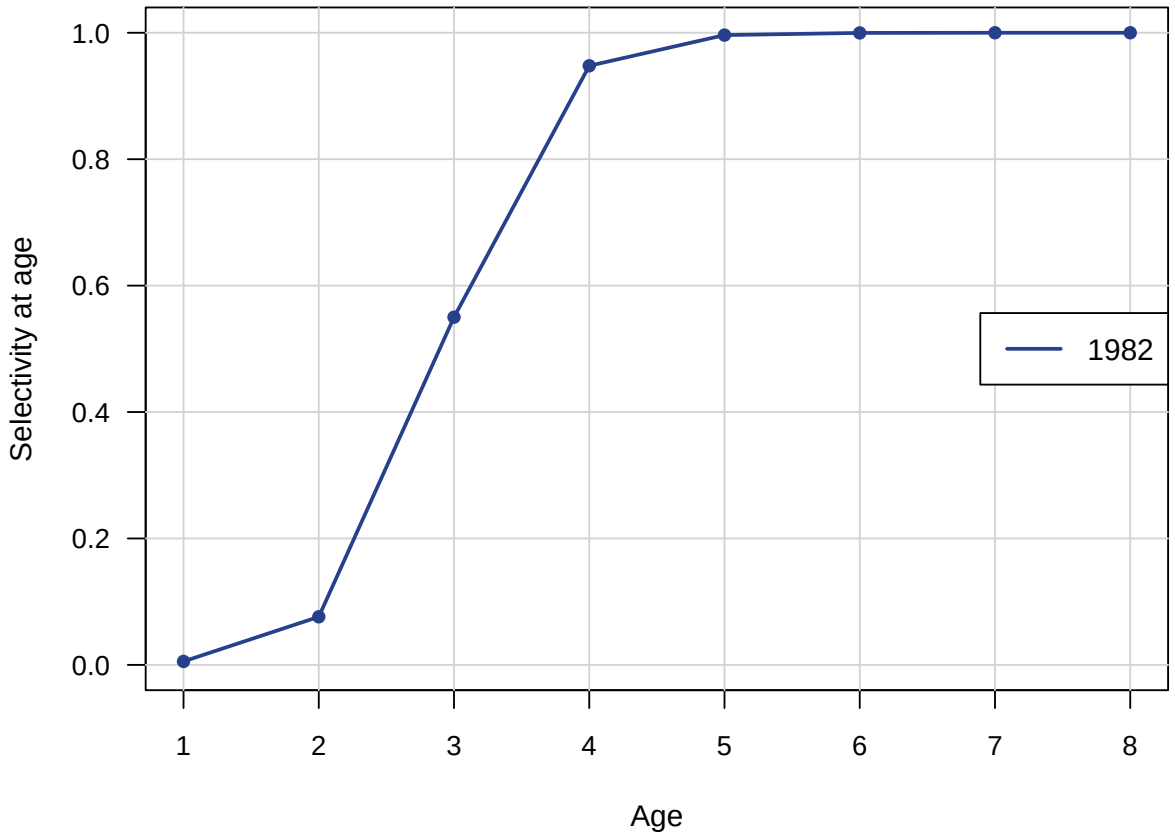
Commercial handline landings



Model results

Estimated selectivity

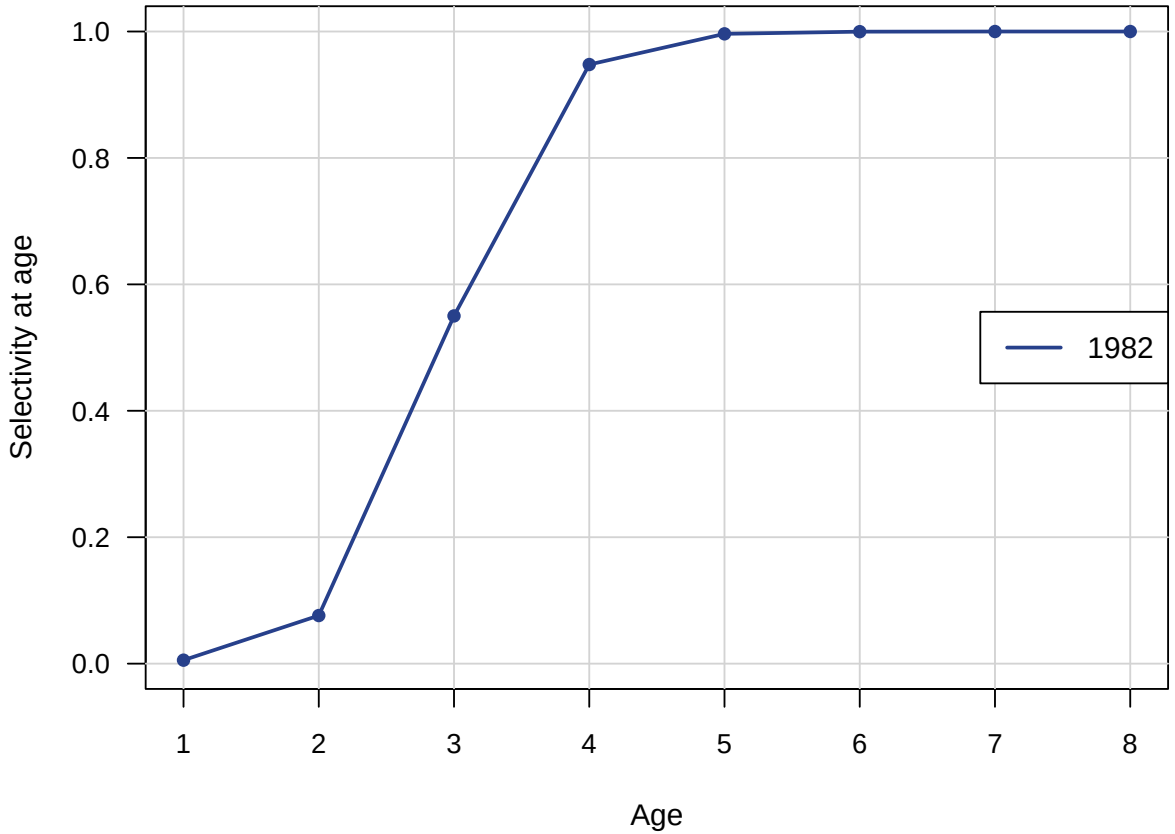
Recreational headboat landings



Model results

Estimated selectivity

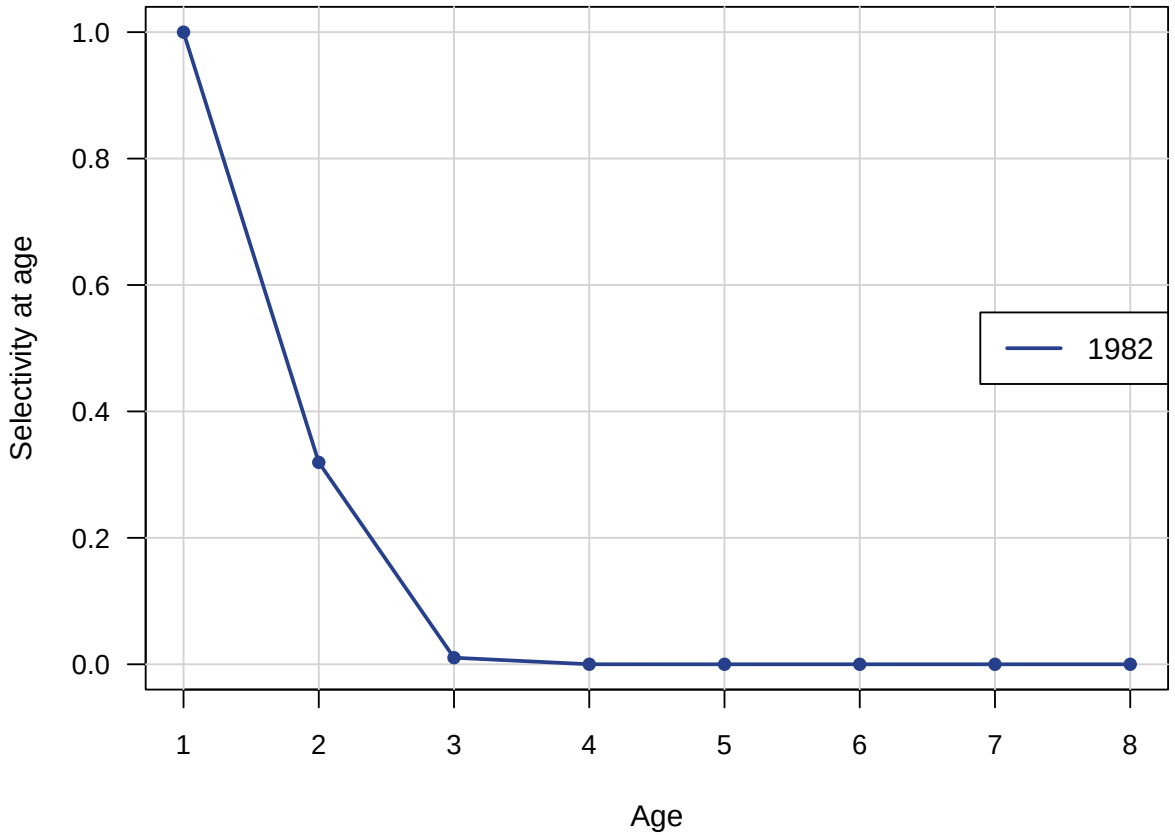
Recreational general landings (equal to headboat selectivity)



Model results

Estimated selectivity

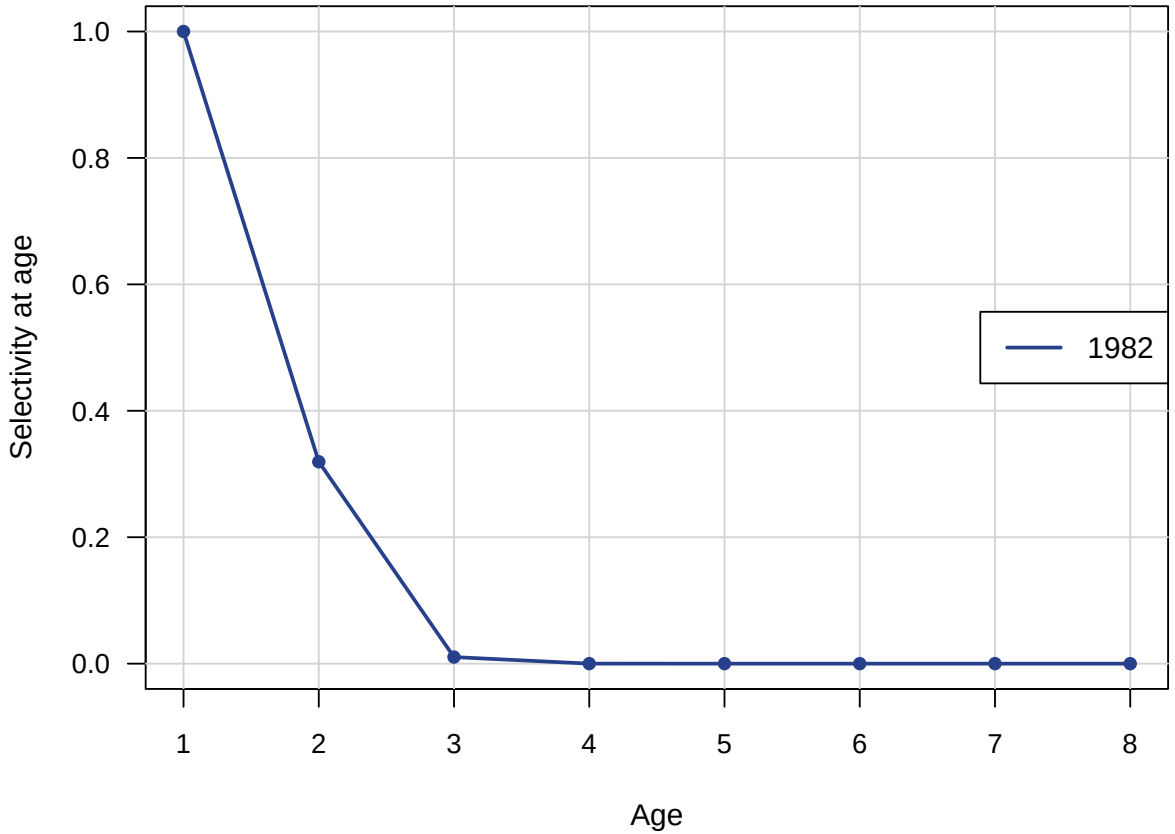
Recreational headboat discards



Model results

Estimated selectivity

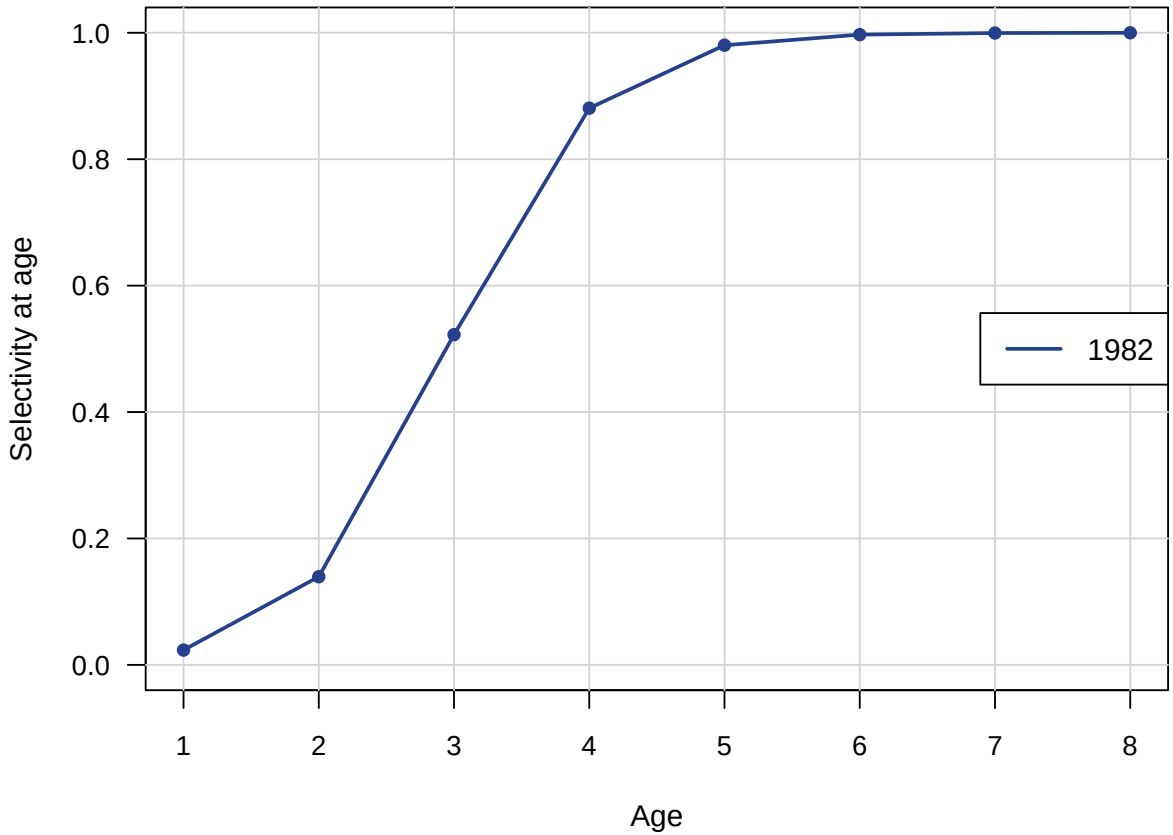
Recreational general discards (equal to headboat discard selectivity)



Model results

Estimated selectivity

SERFS trap video survey



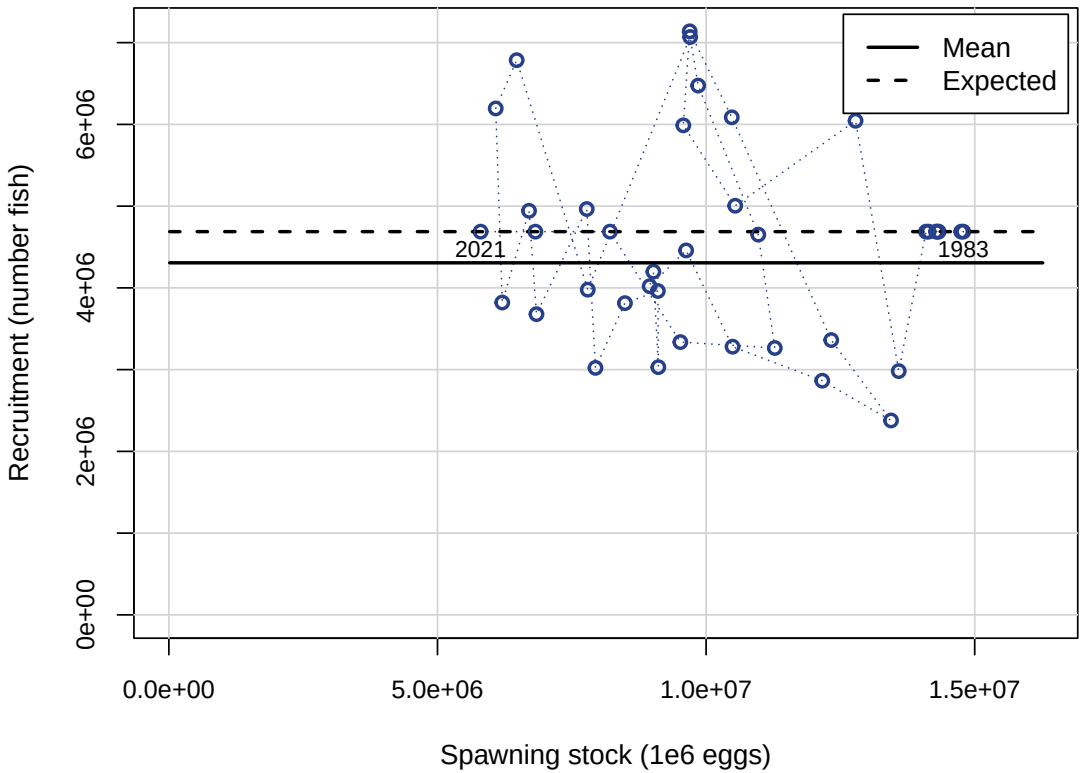
Model results

Spawner-recruit relationship

$h = \text{NA}$

$R_0 = 4,306,649$

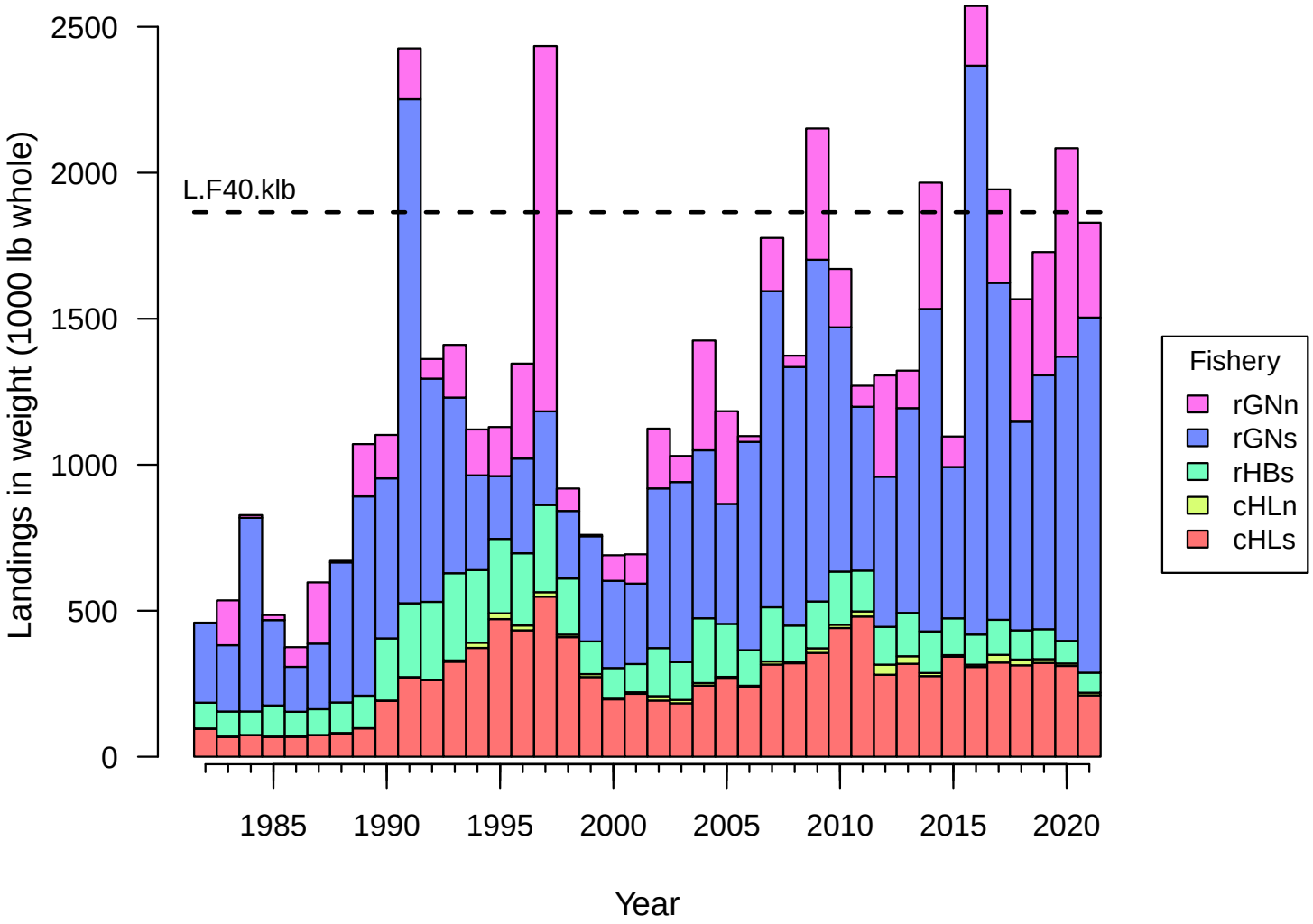
$\sigma_R = 0.41$



Model results

Landings and Discards

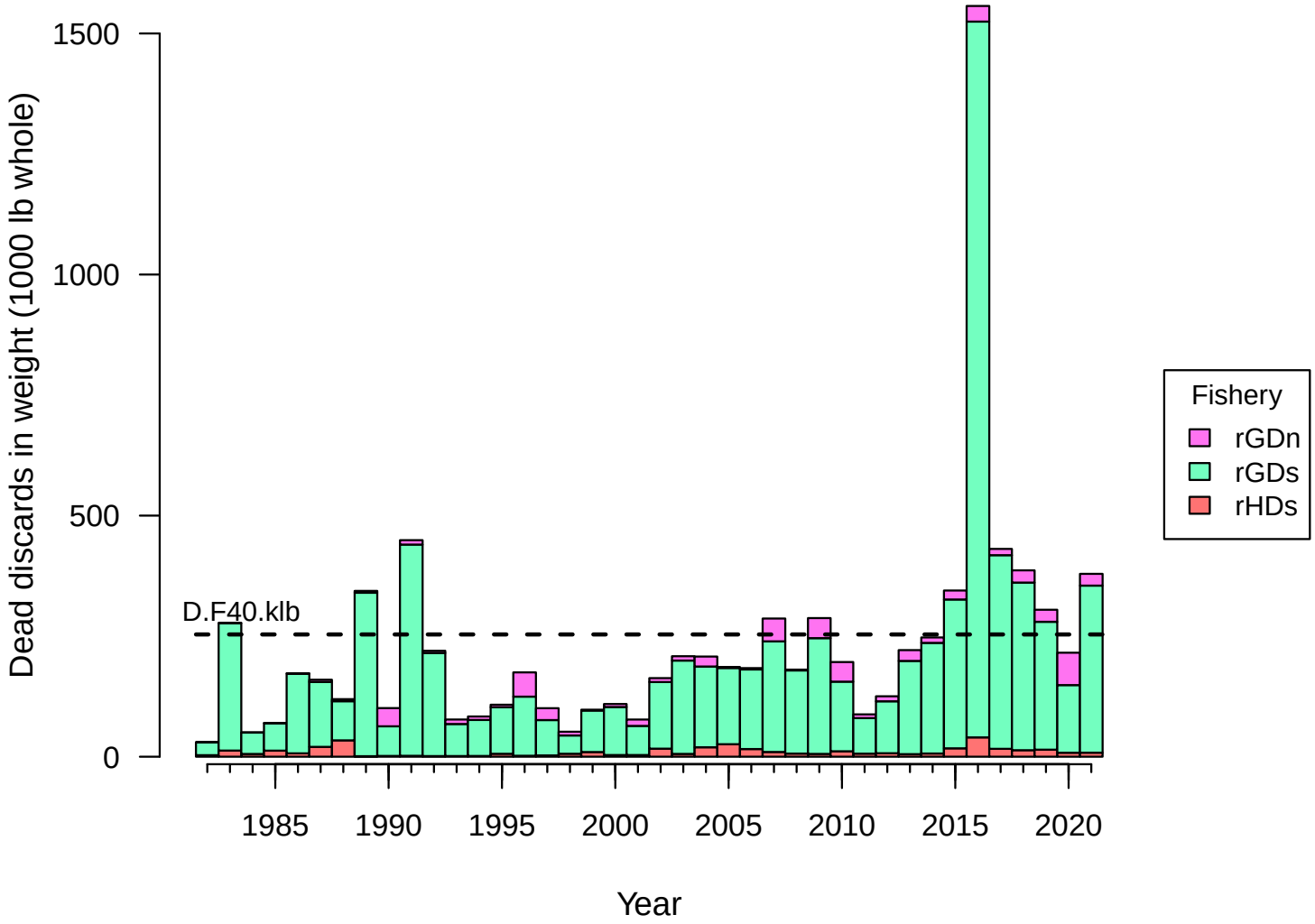
Landings (1000 lb)



Model results

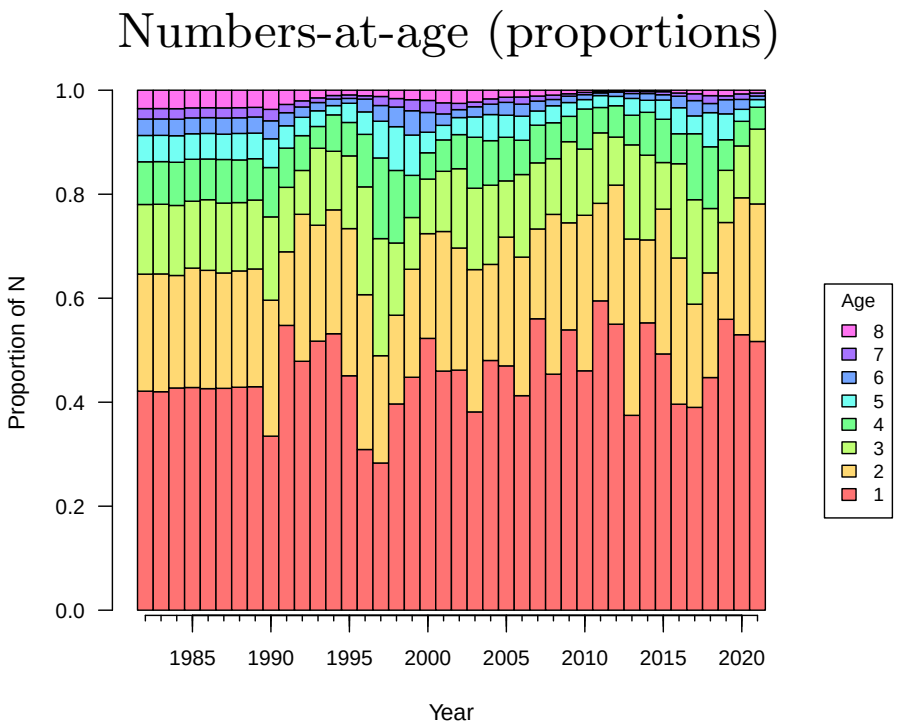
Landings and Discards

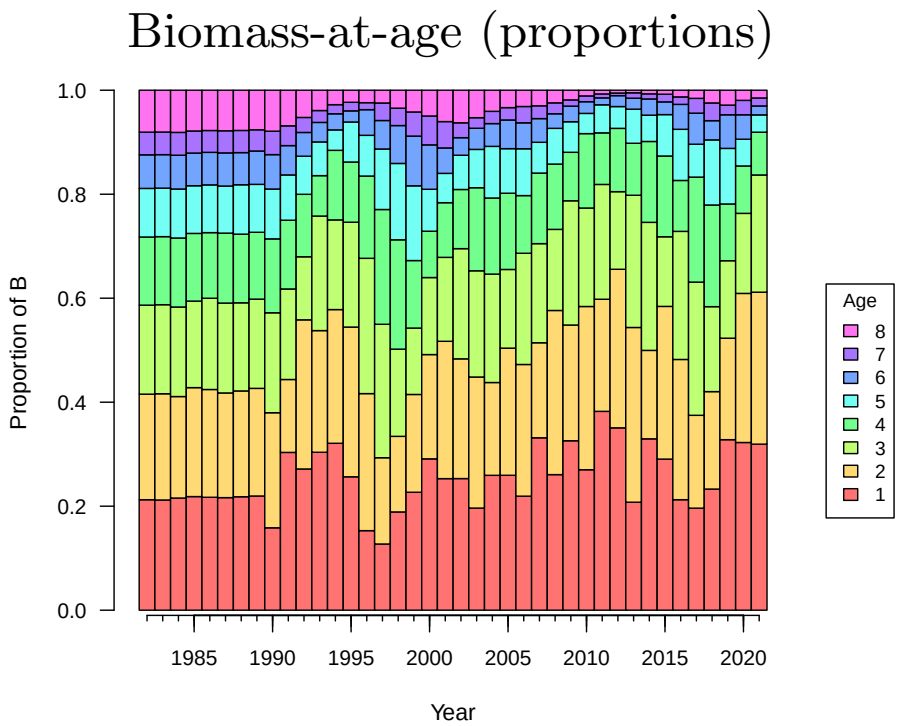
Discards (1000 lb)



Model results

Age structure

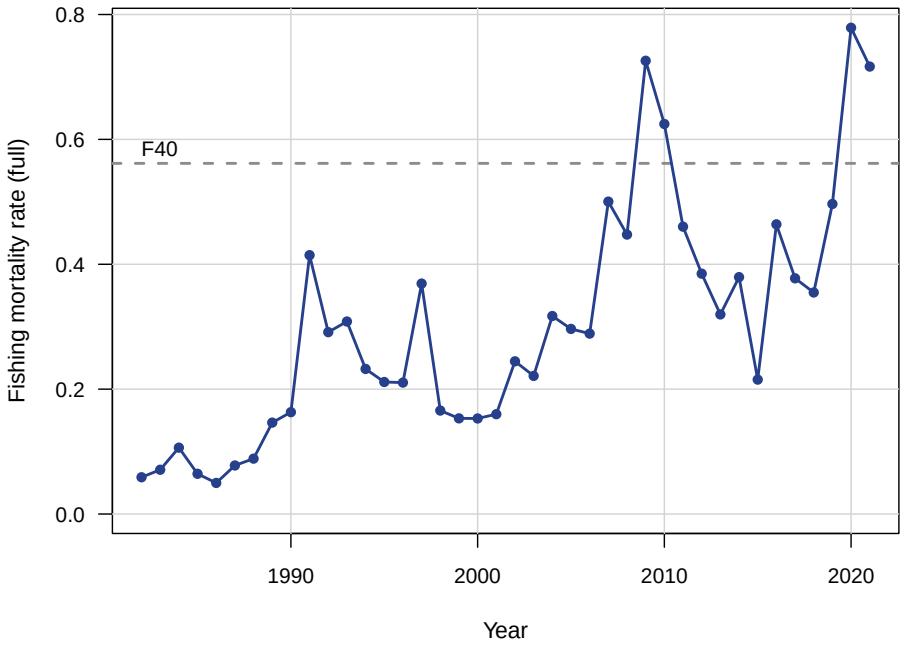




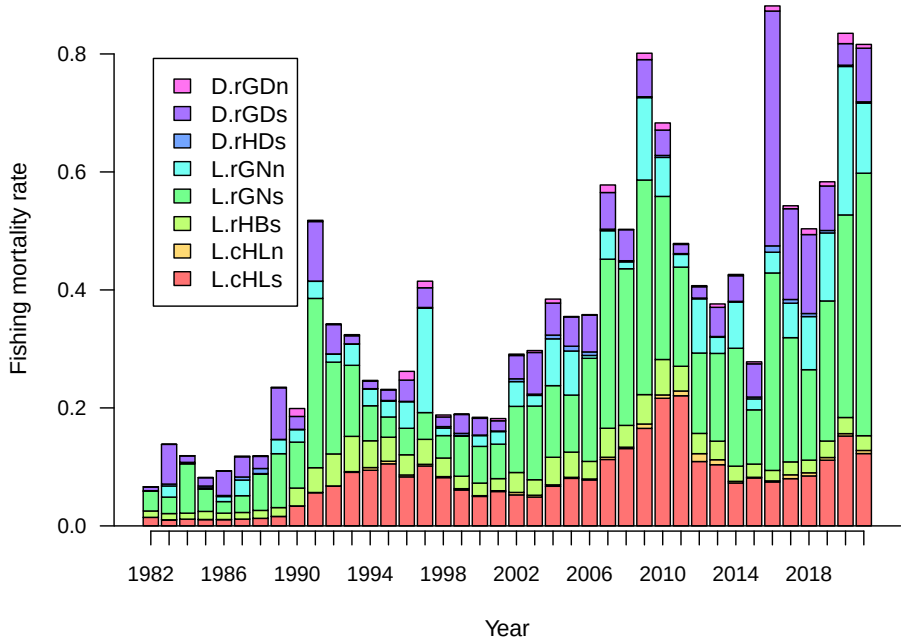
Model results

Benchmark time series

F-full



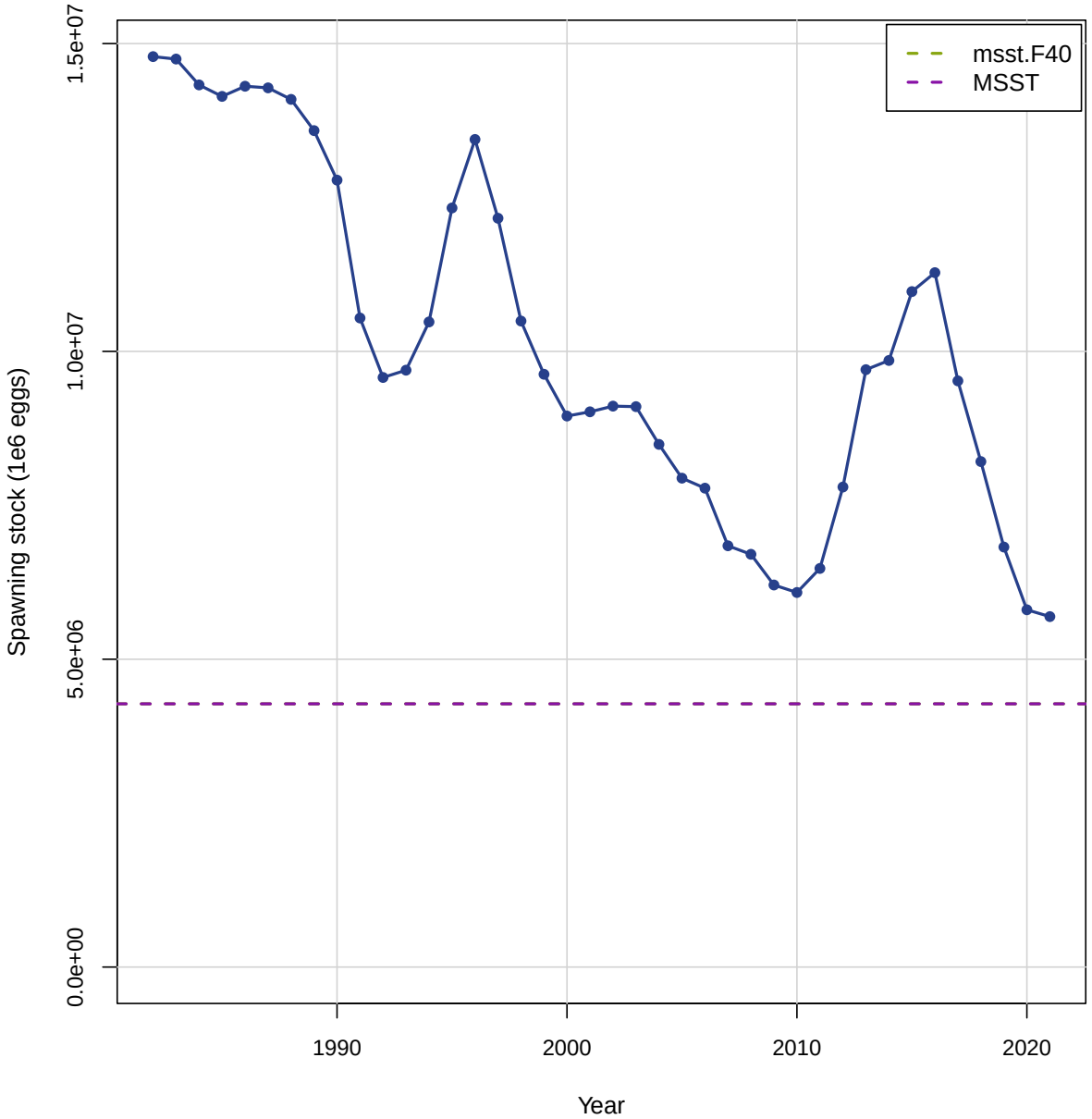
F by fleet



Model results

Benchmark time series

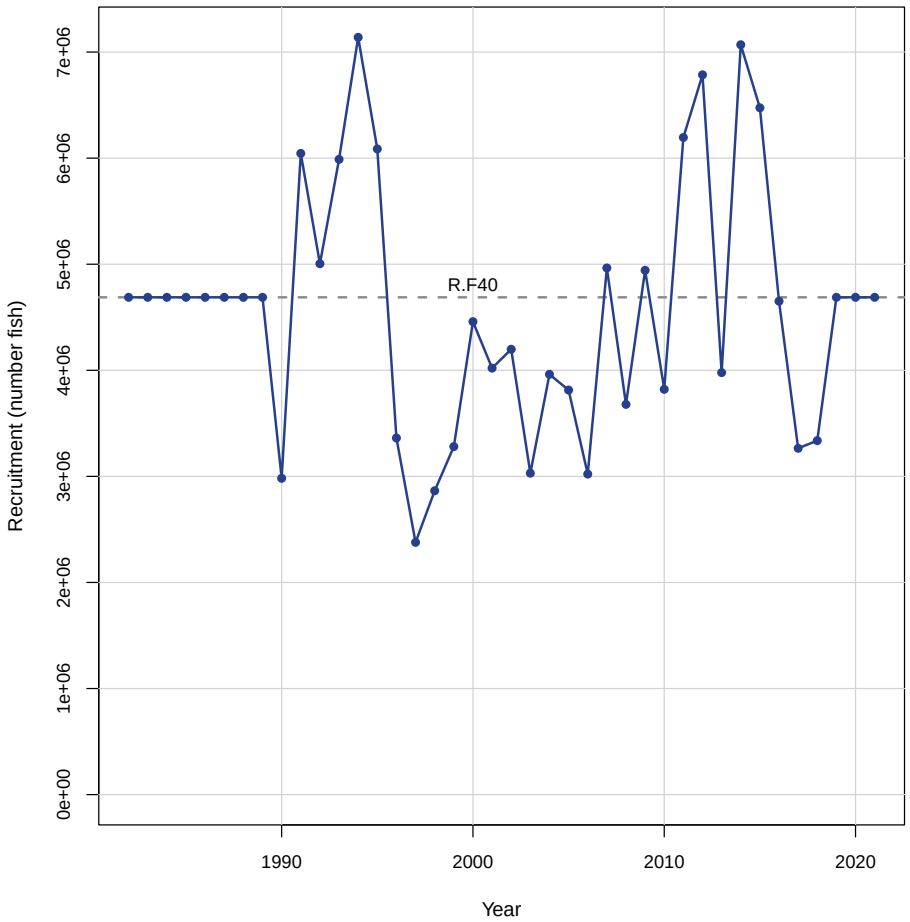
Spawning stock biomass (SSB)



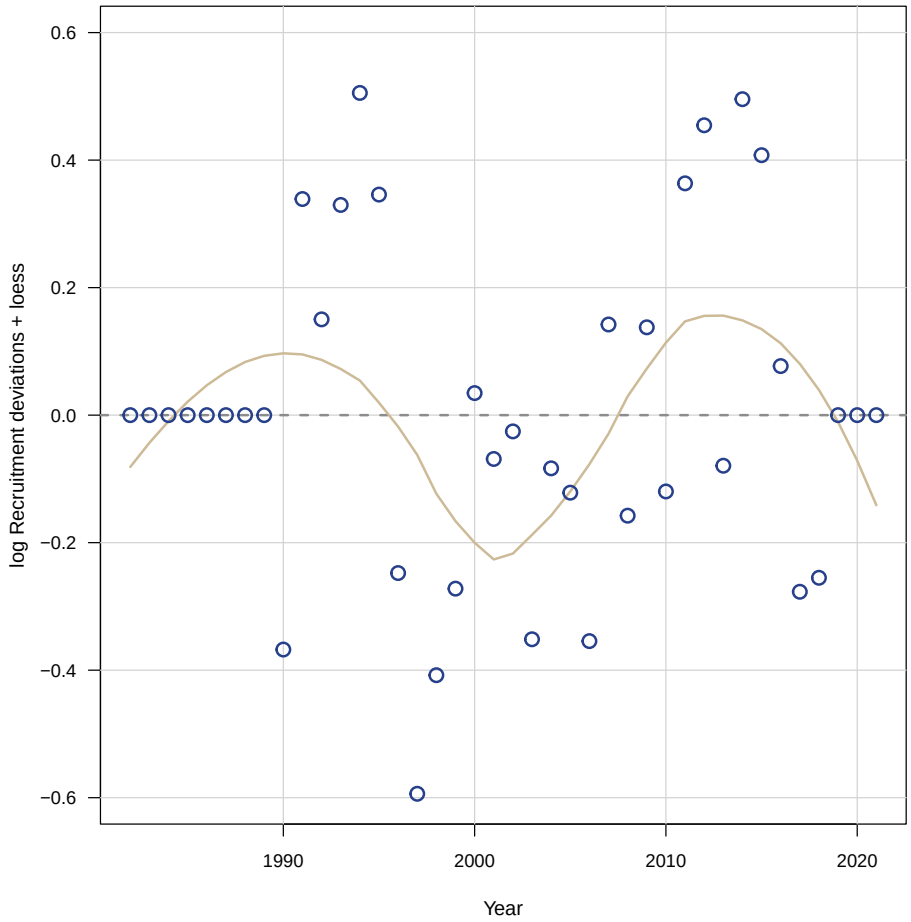
Model results

Benchmark time series

Recruitment



log recruitment deviations



Model results

Benchmarks

Quantity	Units	Estimate	MCBE			
			Median	SE	25%	75%
$F_{40\%}$	y^{-1}	0.56	0.57	0.22	0.42	0.77
$85\%F_{40\%}$	y^{-1}	0.48	0.49	0.18	0.36	0.65
$75\%F_{40\%}$	y^{-1}	0.42	0.43	0.16	0.32	0.58
$65\%F_{40\%}$	y^{-1}	0.37	0.37	0.14	0.27	0.5
$F_{30\%}$	y^{-1}	0.89	0.91	0.39	0.65	1.26
$F_{40\%}$	y^{-1}	0.56	0.57	0.22	0.42	0.77
$F_{50\%}$	y^{-1}	0.37	0.38	0.13	0.28	0.5
$B_{\mathrm{F40\%}}$	metric tons	6266	6389	2043	5305	8322
$\mathrm{SSB}_{\mathrm{F40\%}}$	1e+12 eggs	6.95	7.33	0.68	6.9	7.85
MSST	1e+12 eggs	4.28	4.33	0.79	3.94	4.98
$L_{\mathrm{F40\%}}$	1000 lb whole	1865	1904	556	1586	2412
$D_{\mathrm{F40\%}}$	1000 lb dead fish	254	256	256	256	256
$D_{\mathrm{F40\%}}$	1000 dead fish	262	269	269	269	269
$R_{\mathrm{F40\%}}$	1000 fish	4688	4889	2877	3221	7530
$L_{\mathrm{85\%F40\%}}$	1000 lb whole	1770	1806	530	1500	2294
$L_{\mathrm{75\%F40\%}}$	1000 lb whole	1683	1724	510	1426	2185
$L_{\mathrm{65\%F40\%}}$	1000 lb whole	1578	1625	484	1344	2058
$F_{2019-2021}/F_{40\%}$	—	1.16	1.06	0.76	0.64	1.75
$\mathrm{SSB}_{2021}/\mathrm{MSST}$	—	1.33	1.41	0.69	0.91	2.03
$\mathrm{SSB}_{2021}/\mathrm{SSB}_{\mathrm{F40\%}}$	—	0.82	0.86	0.29	0.62	1.1