Blueline Tilefish: South of Cape Hatteras
SEDAR 50

NOAA FISHERIES

Southeast Fisheries Science Center

October 20, 2017

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  Review Workshop Reference (ASPM RW Ref)
- Summary

Introduction

Timeline

1. 2016 June 28-30 Workshop. Stock ID Workgroup concludes that available data "not support the existence of separate biological populations at either the MAFMC/SAFMC or SAFMC/GMFMC jurisdictional boundaries" (SEDAR50-DW12[1]).
2. 2016 August 29-31 Blueline Tilefish Age Workshop II. "The consensus of the participants of the workshop is that Blueline Tilefish could not be precisely aged at this time" (SEDAR50-DW18)
3. 2016 October 28 Webinar. Joint SSC Sub-Panel effectively accepted the results of the Stock ID Work Group (SEDAR50-DW16)
4. 2016 November 14 Conference call. Members of the Council, Science Center, and Regional Office leadership recommended "using the boundary between the Gulf of Mexico and South Atlantic Council as the Southwestern boundary for the SEDAR 50 stock assessment of Blueline Tilefish" (SEDAR50-DW17)

[1] Blue san serif text hyperlinks to document

Introduction

Timeline

1. 2017 January 23-27. SEDAR 50 Data Workshop (DW Report)
   - Preceded by 3 webinars and calls with DW Panel
   - Followed by 1 webinar with DW Panel
   - Followed by 1 webinar with DW and AW Panels
2. 2017 May 23-26. SEDAR 50 Assessment Workshop (AW Report)
   - Preceded by 1 webinar with DW and AW Panels
   - Preceded by 2 webinars with AW Panel
   - Followed by 3 webinars with AW Panel
3. 2017 Aug 29-31. SEDAR 50 Review Workshop (RW Report)

Introduction

Assessment Challenges

- Potential for movement of eggs and larvae between Gulf of Mexico and Atlantic
- Age data not usable
  - No age composition data
  - No direct estimates of maximum age to inform natural mortality
  - No direct estimates of Von Bertalanffy growth parameters
- Maturity data contains only four immature fish
- No fishery independent index of abundance
- Abundance indices end in 2005-2007 while terminal year of assessment is 2015

Introduction

Assessment Workshop Models

Two main model types developed by the Analytical team and Assessment Panel:

Age-aggreggated production model (ASPIC)

- i.e. biomass dynamic model, surplus production model
- Models undifferentiated biomass
- No age-structured dynamics
- Simple input: time series of removals and abundance indices

Age-structured production model (ASPM)

- Modified version of Beaufort Assessment Model not fitting recruitment deviations
- Models age-structured population
- Age-structured dynamics
- Extensive input: time series of removals and abundance indices, length compositions, growth, length-weight, natural mortality, maturity, and fecundity
- Unfortunately, growth, natural mortality, and steepness from meta-analysis, and estimate of maturity based on only four immature fish

Introduction

Assessment Workshop Models

- Assessment Workshop panel recommended using ASPIC as the primary model and considering ASPM as supporting analysis
- Though the AW Panel acknowledged the simplistic nature of the ASPIC model, it was preferred over the ASPM due to the large uncertainty in most of the life history information in the ASPM
- ASPIC AW Base model was the average of two models, each with one index of abundance (commercial handline or longline), since indices were judged to be equally plausible
- Averaging models was preferred over including both indices in one model which weights indices based on annual CVs

Introduction

Review Workshop Models

- Quoting the Review Panel Report, Executive Summary:
  "the RW preferred the ASPM over the ASPIC because it has more appropriate population dynamics and it allowed the consequences of uncertainties in the life history parameters to be explored through alternative sensitivity analysis, and hence considered the ASPM the superior base model." (RW Report)
- The Review Workshop Panel also modified the ASPM AW Base model in the following ways:
  1. Use constant index CVs of 0.2
  2. Estimate growth parameters within the model
  3. Use assumed age at 100% maturity of age-6 instead of observed but poorly estimated value of age-2
- The RW Panel also preferred a single ASPIC model including both the commercial handline and longline indices using a constant CV of 0.2

Introduction

Lists of Workshop Panelists

Data Workshop

Joey Ballenger, SCDNR
Alan Bianchi, NCDMF
Ken Brennan, SEFSC-Beaufort
Steve Brown*, FL FWCC
Wally Bubley, SCDNR
Julie Califf*, GADNR
Rob Cheshire, SEFSC-Beaufort
Joe Cimino, VMRC
Wiley Coppersmith, Fisherman
Kevin Craig, SEFSC-Beaufort
Julie DeFilippi-Simpson, ACCSP
Amy Dukes, SCDNR
Skip Feller*, Fisherman
Eric Fitzpatrick, SEFSC-Beaufort
Kelly Fitzpatrick*, SEFSC-Beaufort
David Gloeckner, SEFSC-Miami
Jeff Gutman*, Fisherman
Pat Harris*, ECU
Eric Hiltz, SCDNR
Rusty Hudson, Fisherman
Cynthia Jones*, ODU/MAFMC SSC
Nikolai Klibansky, SEFSC-Beaufort
Kathy Knowlton*, GADNR
Kevin Kolmos, SCDNR
Anne Lange, SAFMC SSC
Lee Lavery, Fisherman
Vivian Matter, SEFSC-Miami
Kevin McCarthy, SEFSC-Miami
Paul Nitschke, NEFSC
Refik Ohrun*, SEFSC-Miami
Andy Ostrowski, SEFSC-Beaufort
Andy Piland, Fisherman
Jennifer Potts, SEFSC-Beaufort
Marcel Reichert, SCDNR/SAFMC SSC
Beverly Sauls*, FL FWCC
Michael Schmidtke, ASMFC
Steve Shelley, Fisherman
Tracey Smart, SCDNR
Tom Sminkey, NMFS S&T
Chris Wilson*, NCDMF
Beth Wrege, SEFSC-Miami
Erik Williams, SEFSC-Beaufort

*Panelist was unable to attend workshop

Introduction

Lists of Workshop Panelists

Assessment Workshop

Nikolai Klibansky - Lead Analyst Atlantic Blueline Tilefish, SEFSC Beaufort
Robert Ahrens, UFL / South Atlantic SSC
Joseph Ballenger, SCDNR
Rob Cheshire, SEFSC Beaufort
Kevin Craig, SEFSC Beaufort
Eric Fitzpatrick, SEFSC Beaufort
Anne Lange, South Atlantic SSC
Paul Nitschke, NEFSC
Michael Schmidtke, ASMFC
Alexei Sharov, MD DNR / South Atlantic SSC*
Kyle Shertzer, SEFSC Beaufort
Erik Williams, SEFSC Beaufort

*Panelist was unable to attend workshop

Introduction

Lists of Workshop Panelists

Review Workshop

Review Panel
Scott Crosson Review Panel Chair, SAFMC SSC
Churchill Grimes Reviewer, SAFMC SSC
Yan Jiao Reviewer, MAFMC SSC
Patrick Cordue CIE Reviewer, CIE
Jamie Gibson CIE Reviewer, CIE
Paul Medley CIE Reviewer, CIE

Analytical Representatives
Nikolai Klibansky Lead analyst SEFSC Beaufort
Kevin Craig Assessment Team SEFSC Beaufort
Paul Nitschke* Assessment team NEFSC
Kyle Shertzer Assessment Team SEFSC Beaufort
Erik Williams Assessment Team SEFSC Beaufort

*Panelist was unable to attend workshop

Blueline Tilefish: South of Cape Hatteras Age-aggregated Production Model (ASPIC) Assessment Workshop Base Model (AW Base)

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Southeast Fisheries Science Center

October 17, 2017

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Methods

Model description

- Models run with ASPIC Suite Version 7
- Age-aggregated annual biomass, no age-structure
- Assumes recruitment + growth - nat. mortality = 'surplus' production
- Graham-Schaefer logistic formulation (continuous time): $\frac{d\mathrm{B}_t}{dt} = r\mathrm{B}_t - \frac{r}{K}\mathrm{B}_t^2 - F_t\mathrm{B}_t$
- Assumes surplus production symmetric about $B_{\mathrm{MSY}} = 0.5K$ (shape parameter=0.5)
- Conditioned on yield
- Fit to CPUE indices of abundance (ASPIC, Prager 1994)
- Model estimates B_1/K, F_{MSY}, MSY, and q_i parameters

Methods

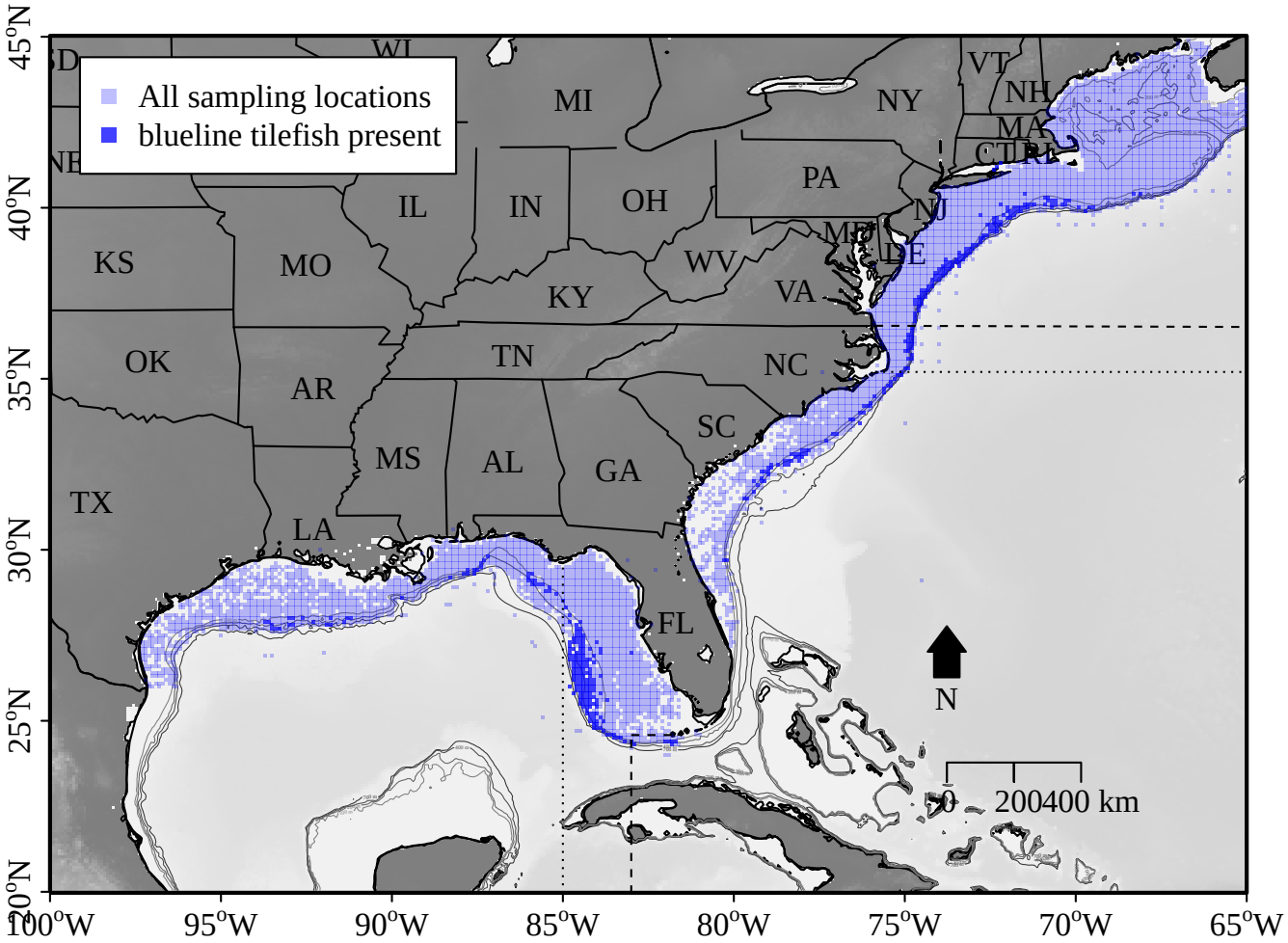
Model description

- Inputs
  - Single series of removals
  - Abundance indices and annual CVs
  - Item values of B_1/K, F_{MSY}, MSY, and q_i parameters
  - Range limits or prior distributions on parameters
  - Settings (e.g. fitting method, rules, tolerance)
- Outputs
  - Single estimated biomass series
  - Estimates of B_1/K, F_{MSY}, MSY, and q_i parameters
  - Estimated CPUE series (scaling B by q_i)
  - Status series (F/F_{MSY}, B/B_{MSY})

Methods

Data

Data series restricted to area between GMFMC/SAFMC boundary at Key West north in the Atlantic to Cape Hatteras

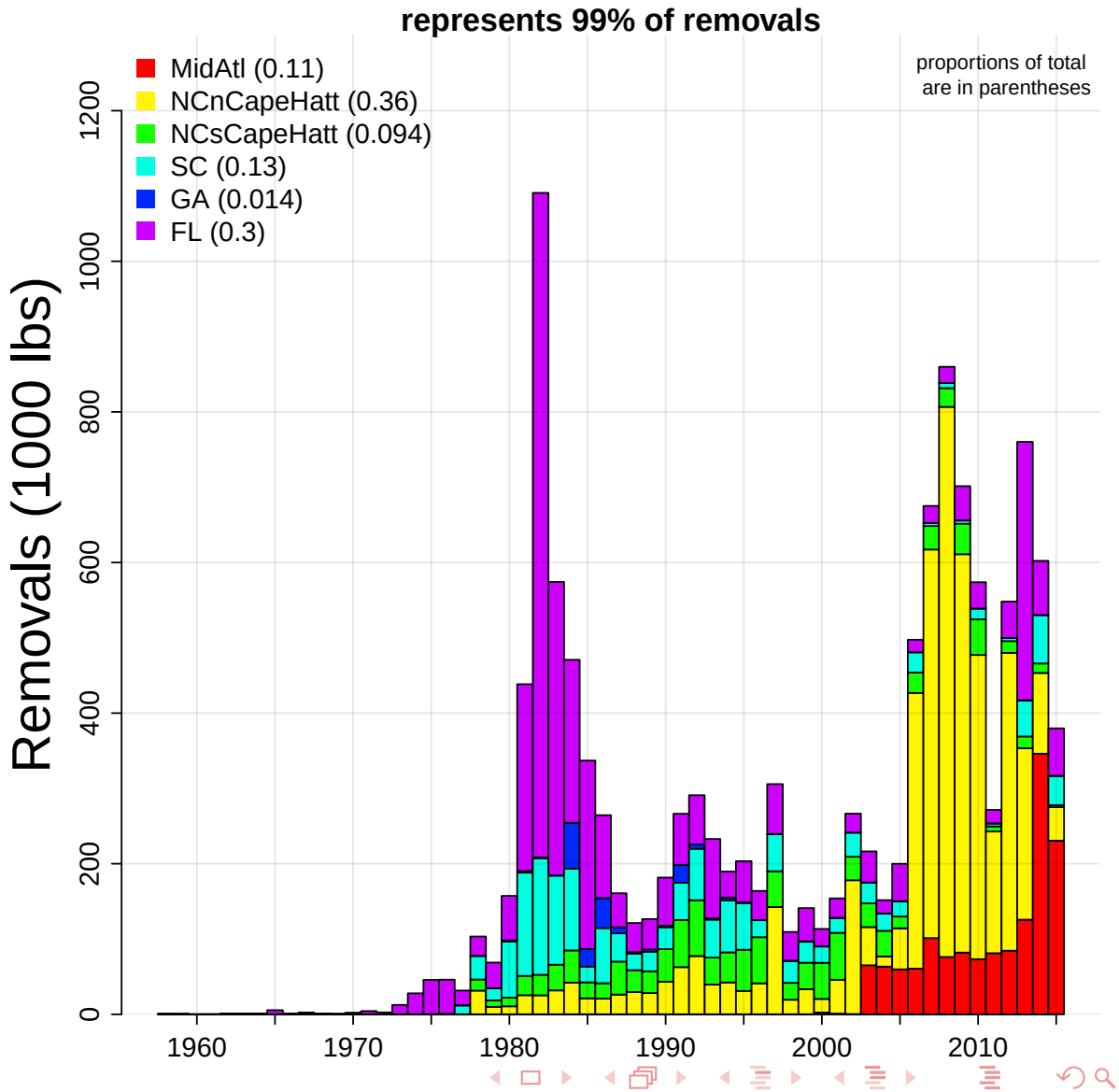


Methods

Data

All Atlantic removals by aggregated area

- Landings included in models south of Cape Hatteras included:
  - NCsCapeHatt
  - SC
  - GA
  - FL (east)

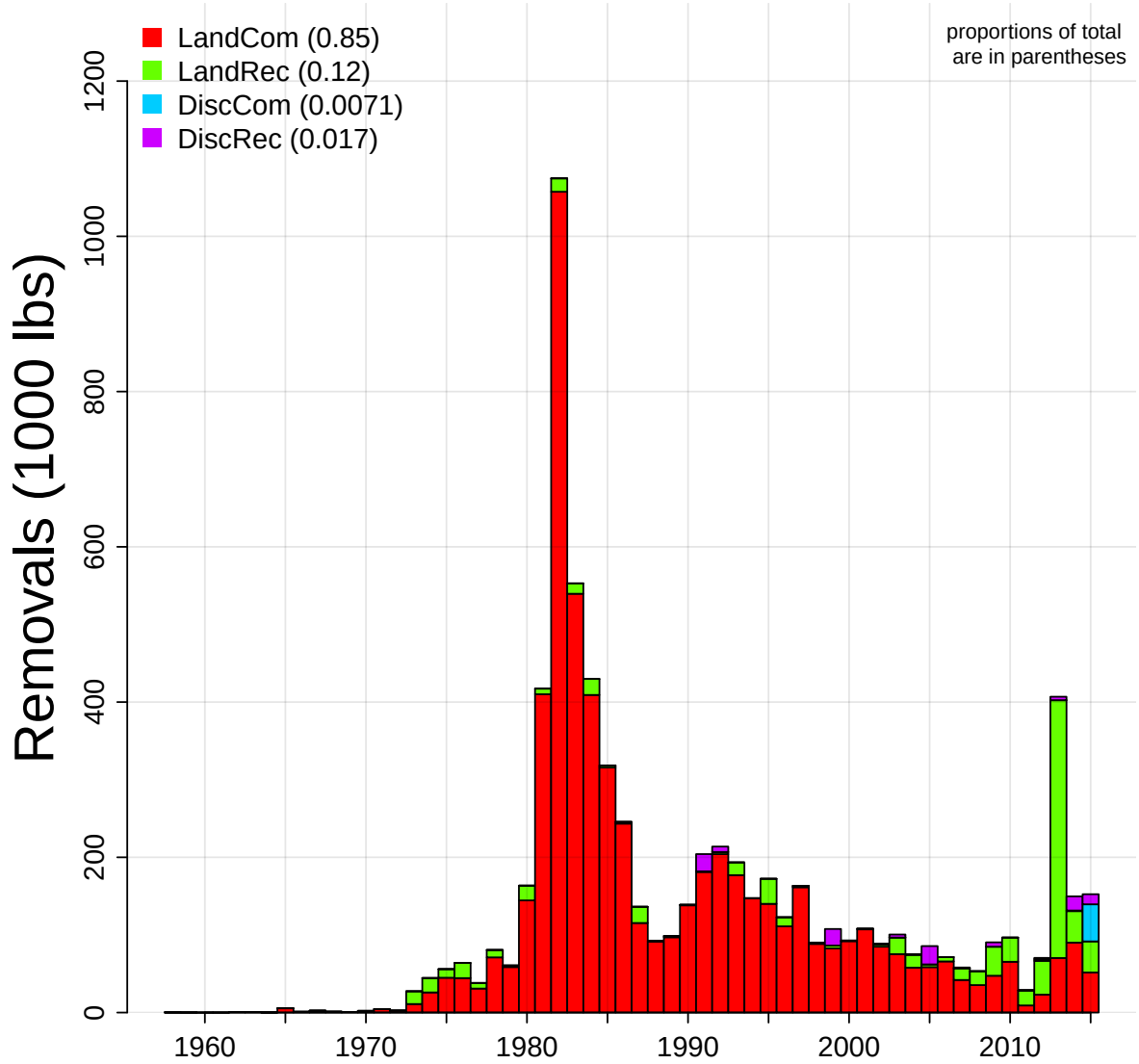


Methods

Data

Removals south of Cape Hatteras, by fleet

- Commercial landings
- Recreational landings
- Commercial dead discards
- Recreational dead discards

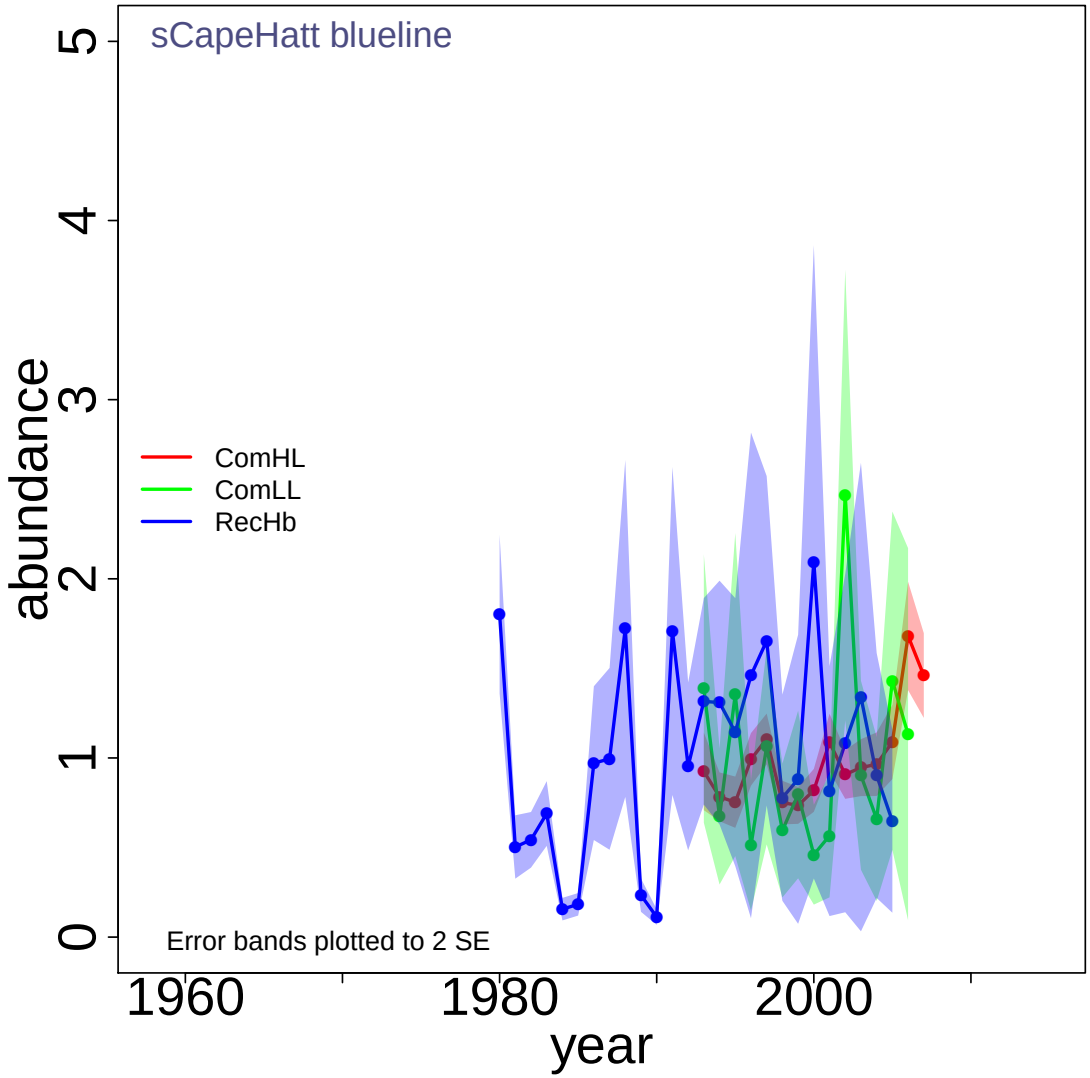


Methods

Data

Indices of abundance

- Commercial handline (ComHL)
- Commercial longline (ComLL)
- Recreational headboat (RecHb)



Methods

AW Base Model Specifications

- Ran models with all combinations of indices
- Ran models with combined (i.e. averaging; Conn, 2010) versions of indices
- Headboat index excluded from base models
  - Fishery only covers margins of Blueline Tilefish distribution
  - Concern that wide swings in CPUE may be more representative of fleet behavior rather than true abundance
  - Negatively correlated with commercial indices
- Handline and longline indices considered equal quality
- Assessment Panel chose to average the results of the handline and longline models
- Combining indices or running both in one model weights indices based on CVs, placing undue weight on the handline index

Methods

AW Base Model Specifications

- Models run from 1958-2015
- Removals 1958-2015
  - Commercial handline (1993-2007)
  - Commercial longline (1993-2008)
  - Recreational headboat (1993-2006)
- Status determination
  - F status: $F_{2013-2015}/F_{\text{MSY}}$
  - Overfishing if $F_{2013-2015}/F_{\text{MSY}} > 1$
  - Minimum Stock Size Threshold $=$ MSST $= 0.75B_{\text{MSY}}$
  - B status: B_{2015}/MSST
  - Overfished if $B_{2015}/\text{MSST} < 1$

Methods

Sensitivity

- Runs with other combinations of indices were considered as sensitivity runs
- Additional sensitivity runs were configured to match ASPIC models from SEDAR 32, and/or included removals north of Cape Hatteras

Methods

Uncertainty

- ASPIC Bootstrap procedures were run to estimate uncertainty in the models
  1. ASPIC fits to observed data and saves predicted population data and residuals
  2. Normalized inflated residuals are randomly drawn with replacement and incorporated into predicted values to generate a trial resampled dataset
  3. Resampled data are fit, results saved, and the next trial begins
- Results of bootstrapping were combined (i.e. merged) to characterize the uncertainty in the average of the handline and longline models

Methods

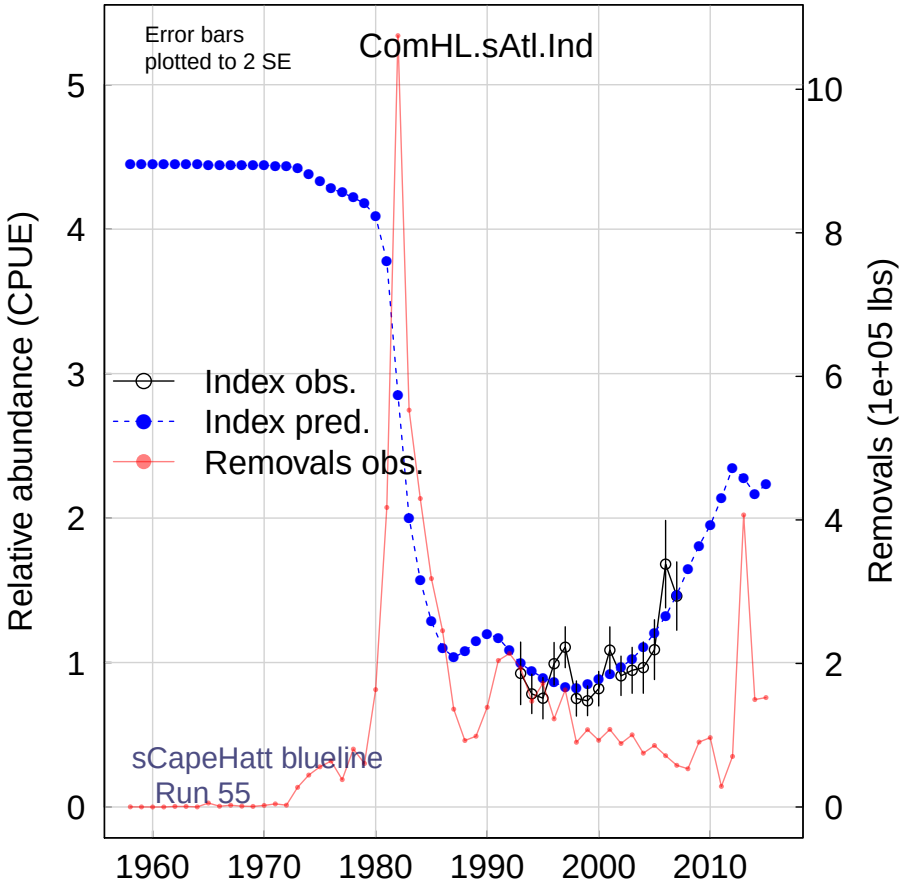
Projections

- Five year projections at:
  - $F = F_{\text{MSY}}$
  - $F = F_{\text{current}}$
  - $F = F_{\text{target}} = 0.75F_{\text{MSY}}$
- $F_{2016} = F_{\text{current}}$
- Projections were made from the combined bootstrap results from the handline and longline models
- Uncertainty in projections based on bootstrap runs

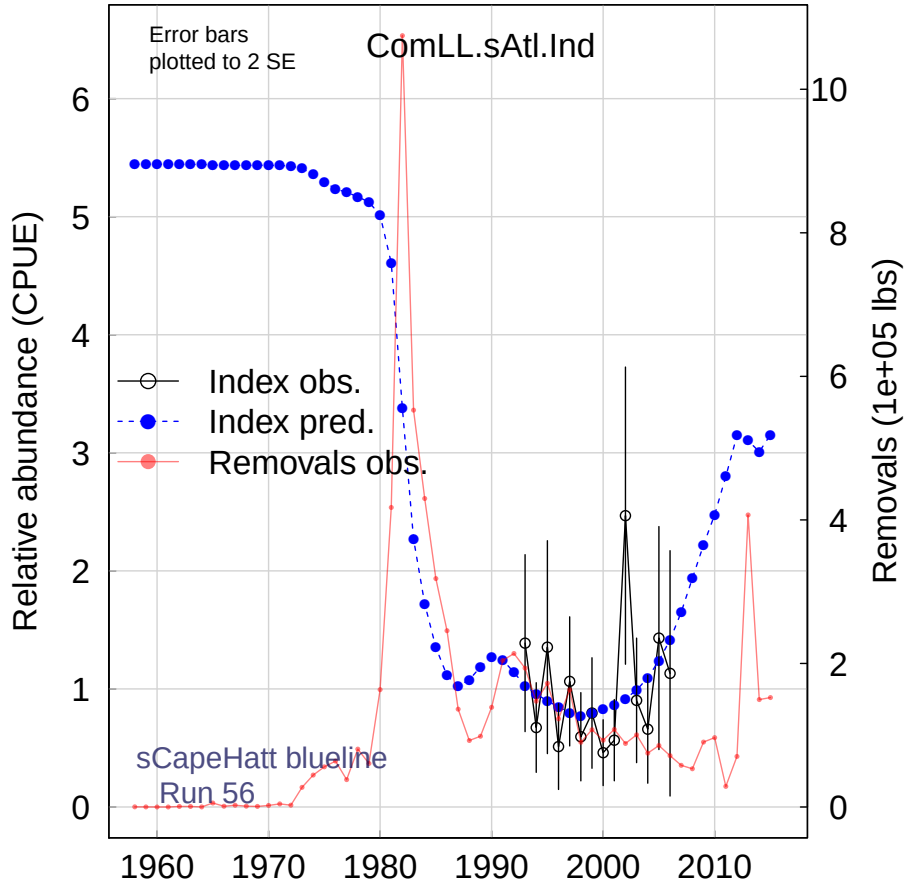
Results

AW Base Model Results and Uncertainty

Fit to handline model (Run 55)



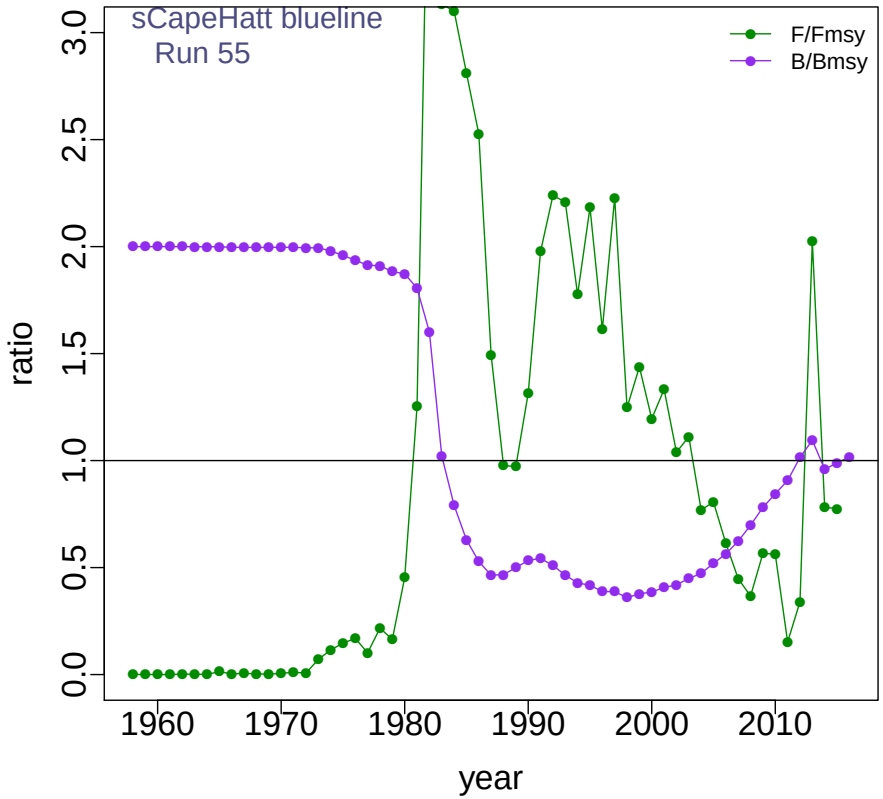
Fit to longline model (Run 56)



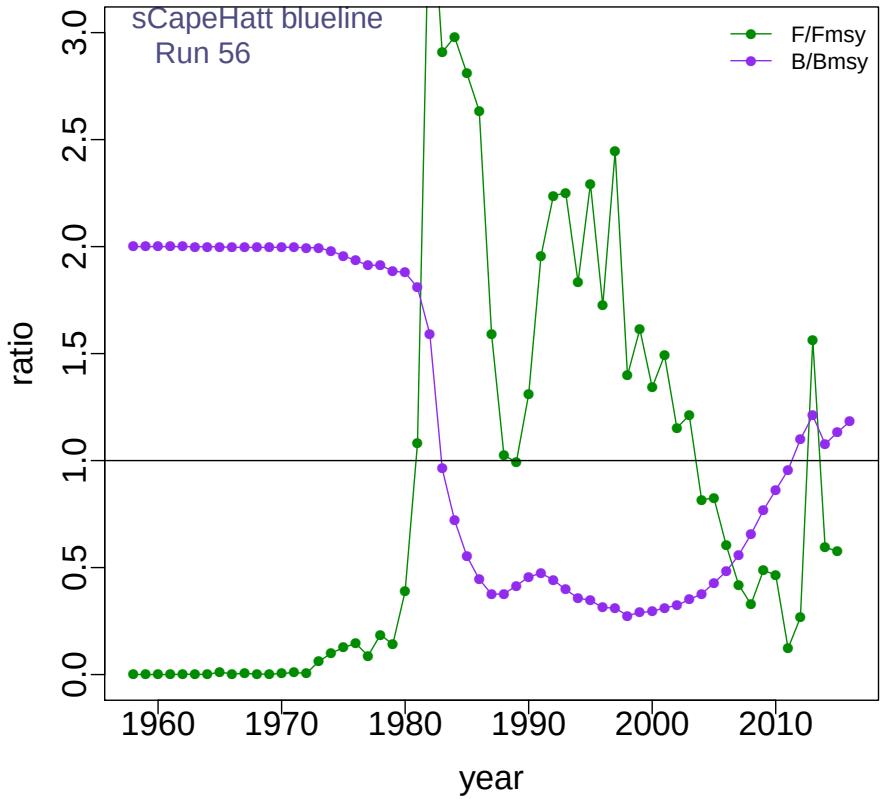
Results

AW Base Model Results and Uncertainty

Status trends for handline model (Run 55)



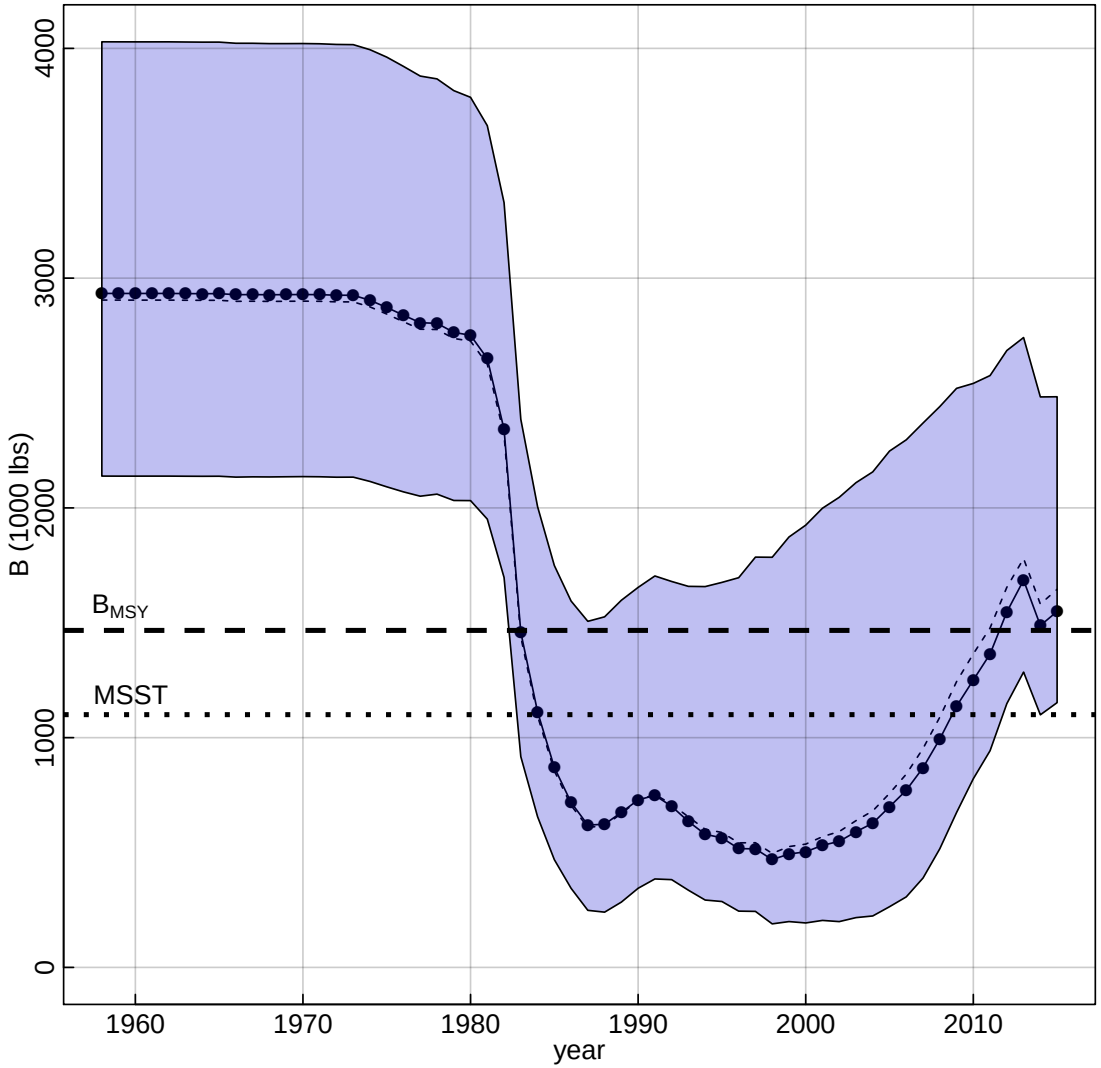
Status trends for longline model (Run 56)



Results

AW Base Model Results and Uncertainty

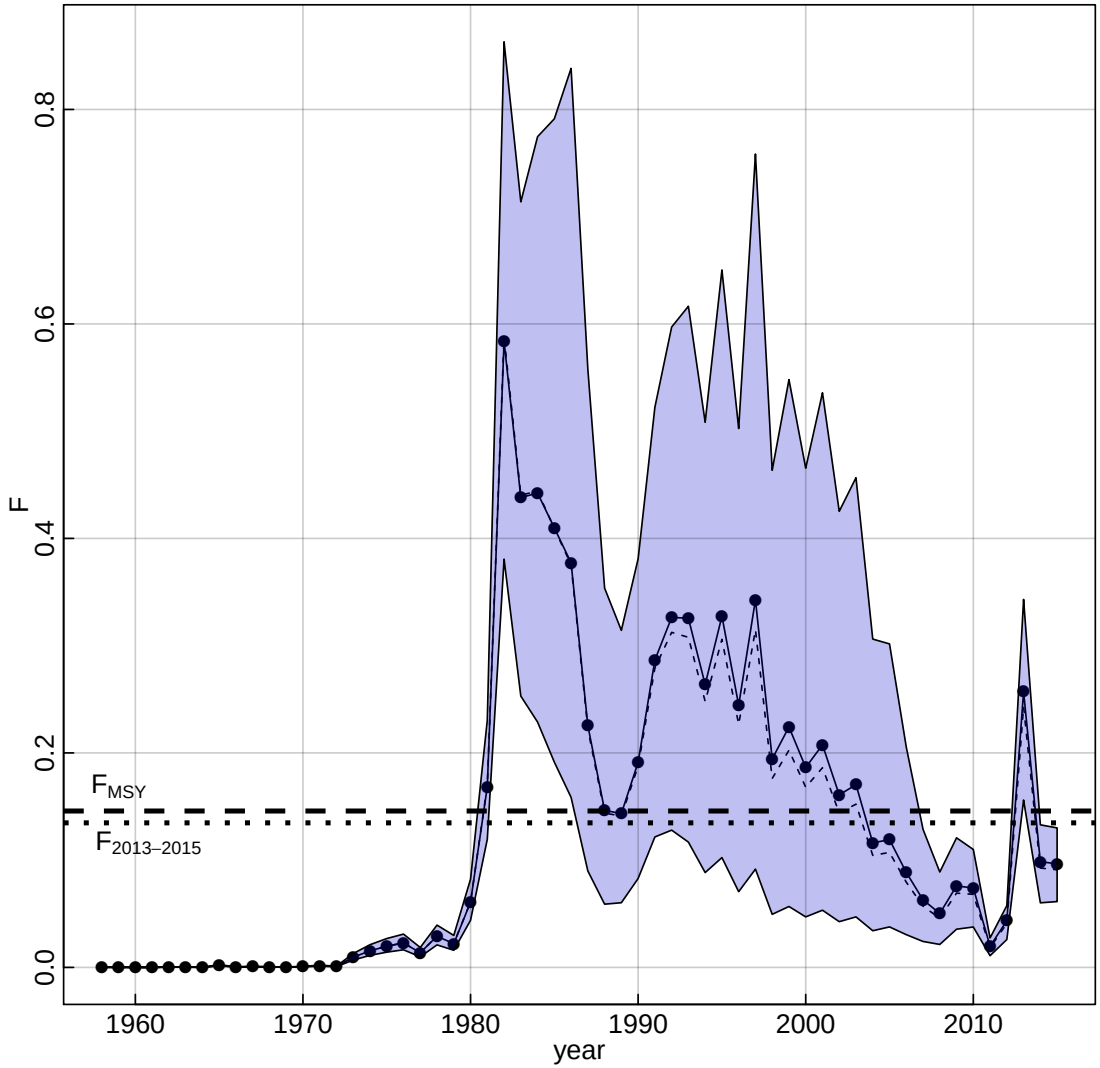
Estimated biomass series (B) combining Runs 55 and 56 from ASPIC



Results

AW Base Model Results and Uncertainty

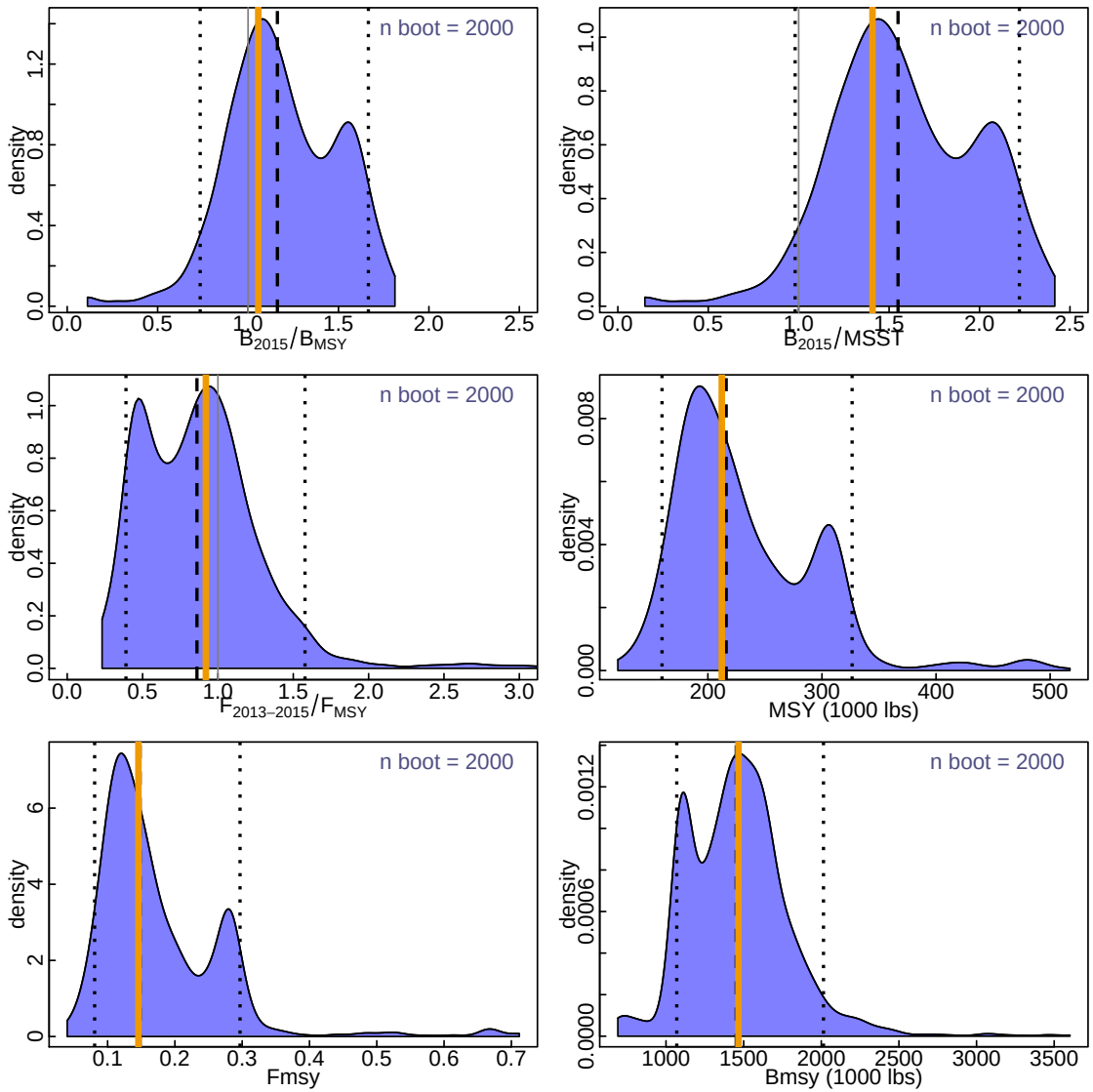
Estimated fishing mortality series (F) combining Runs 55 and 56 from ASPIC



Results

AW Base Model Results and Uncertainty

ASPIC bootstrap parameter distributions combining Runs 55 and 56

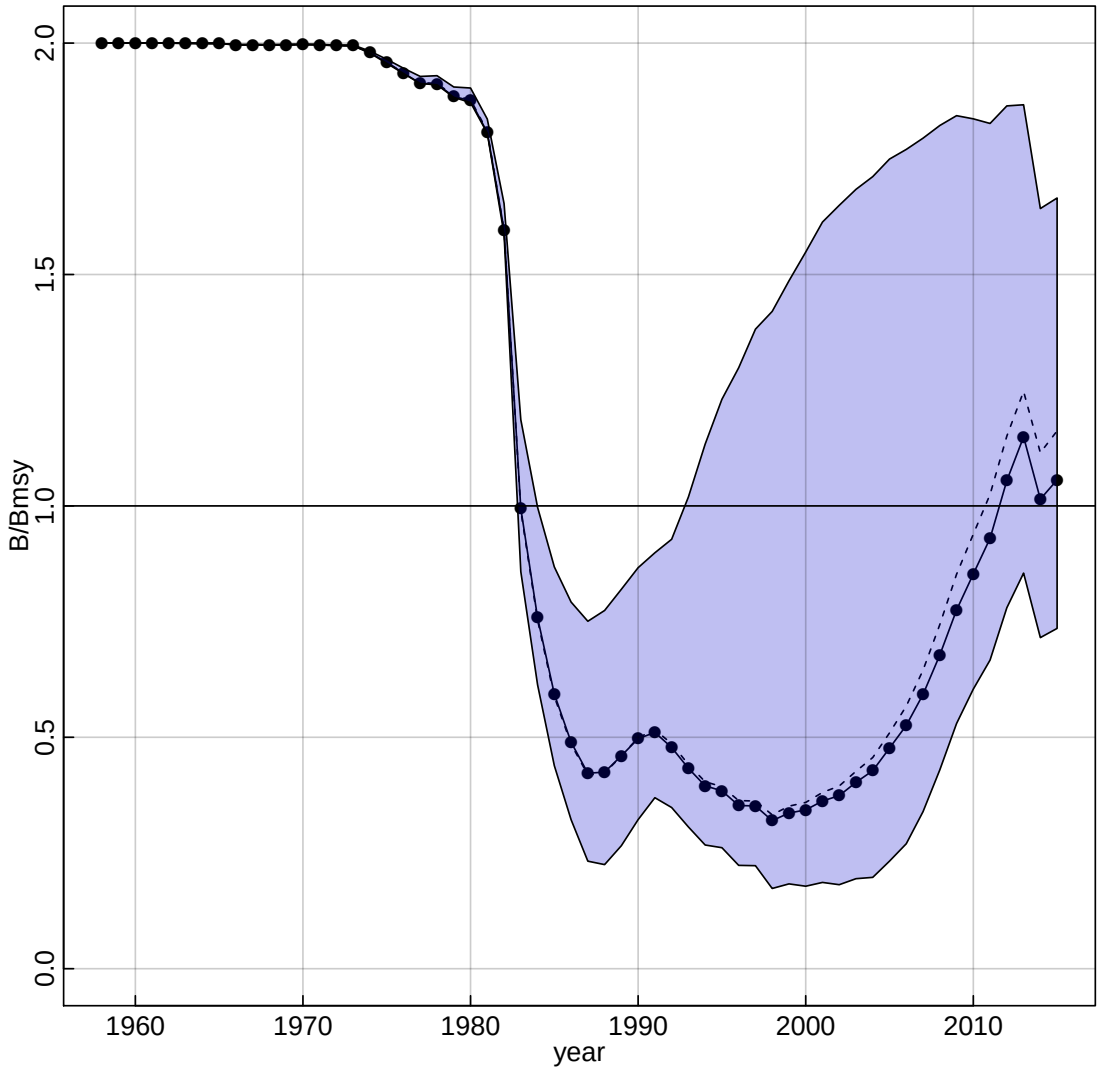


Results

AW Base Model Results and Uncertainty

Estimated biomass series (B) relative to B_{MSY} combining Runs 55 and 56 from ASPIC

- Solid line indicates average B series relative to average B_{MSY}.
- Dashed line represents the median B/B_{MSY}
- Blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials

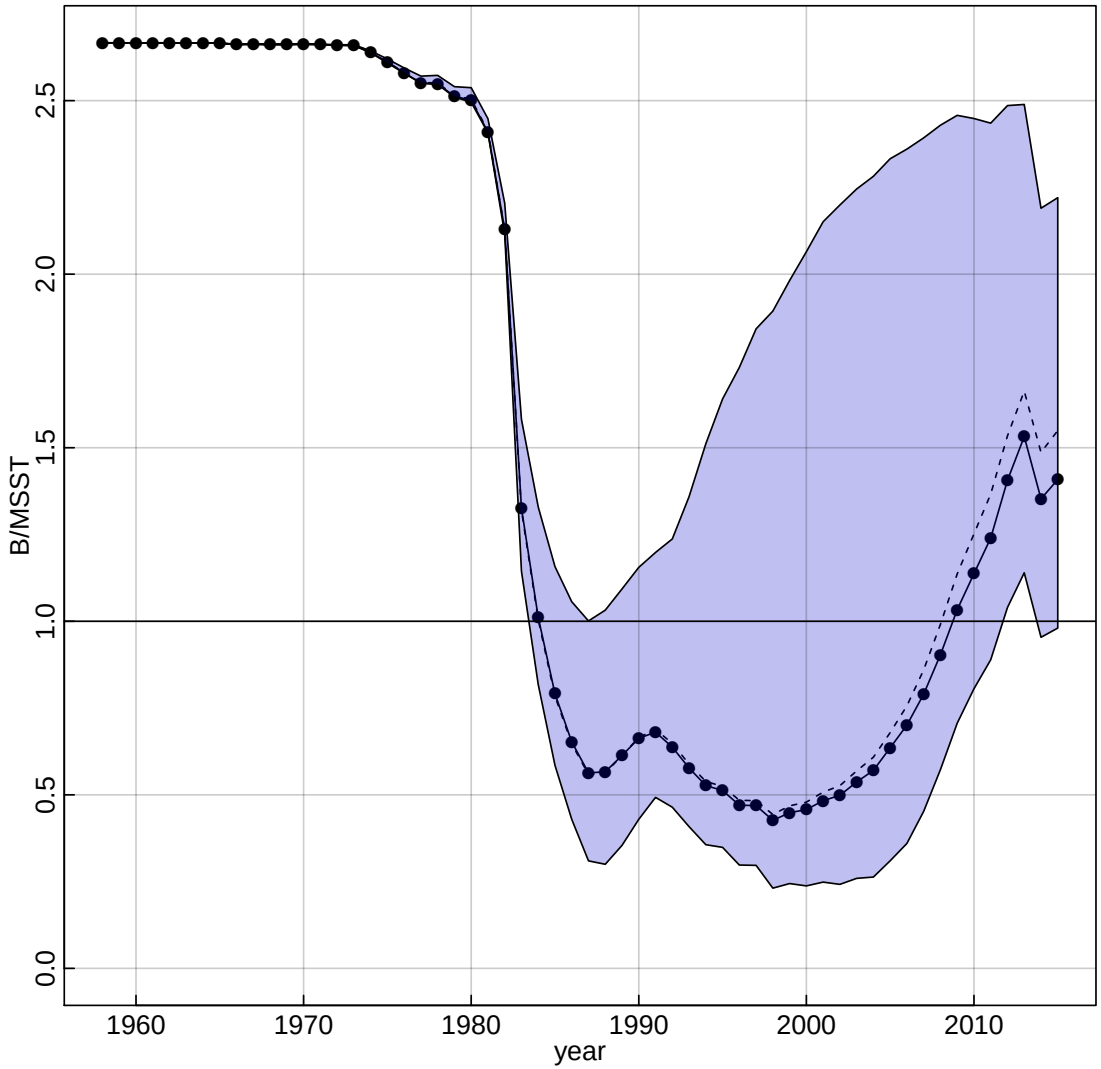


Results

AW Base Model Results and Uncertainty

Estimated biomass series (B) relative to MSST combining Runs 55 and 56 from ASPIC

- Solid line indicates average B series relative to average MSST.
- Dashed line represents the median B/MSST
- Blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials

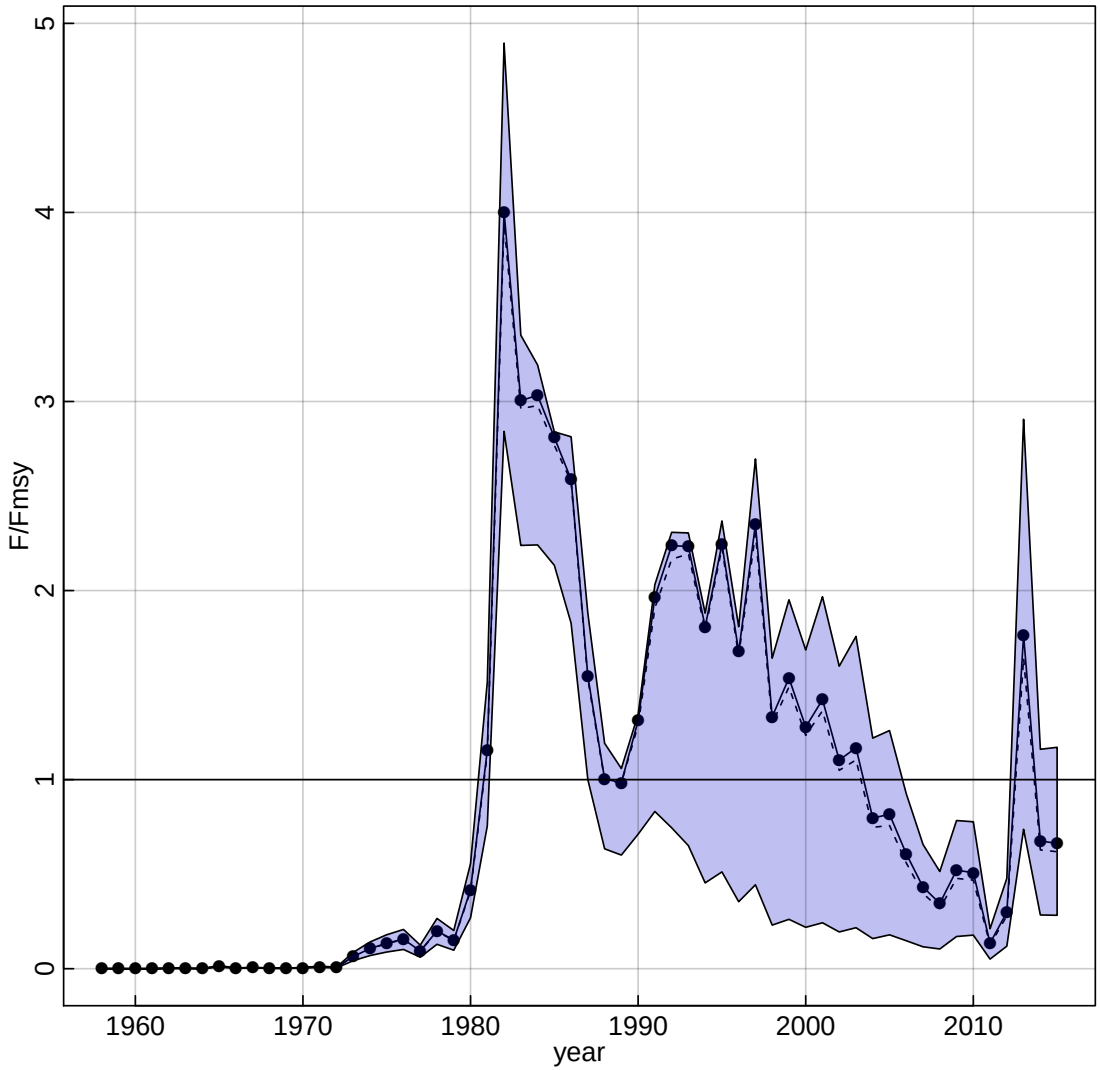


Results

AW Base Model Results and Uncertainty

Estimated F series relative to F_{MSY} combining Runs 55 and 56 from ASPIC

- Solid line indicates average F series relative to average F_{MSY}.
- Dashed line represents the median F/F_{MSY}
- Blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials

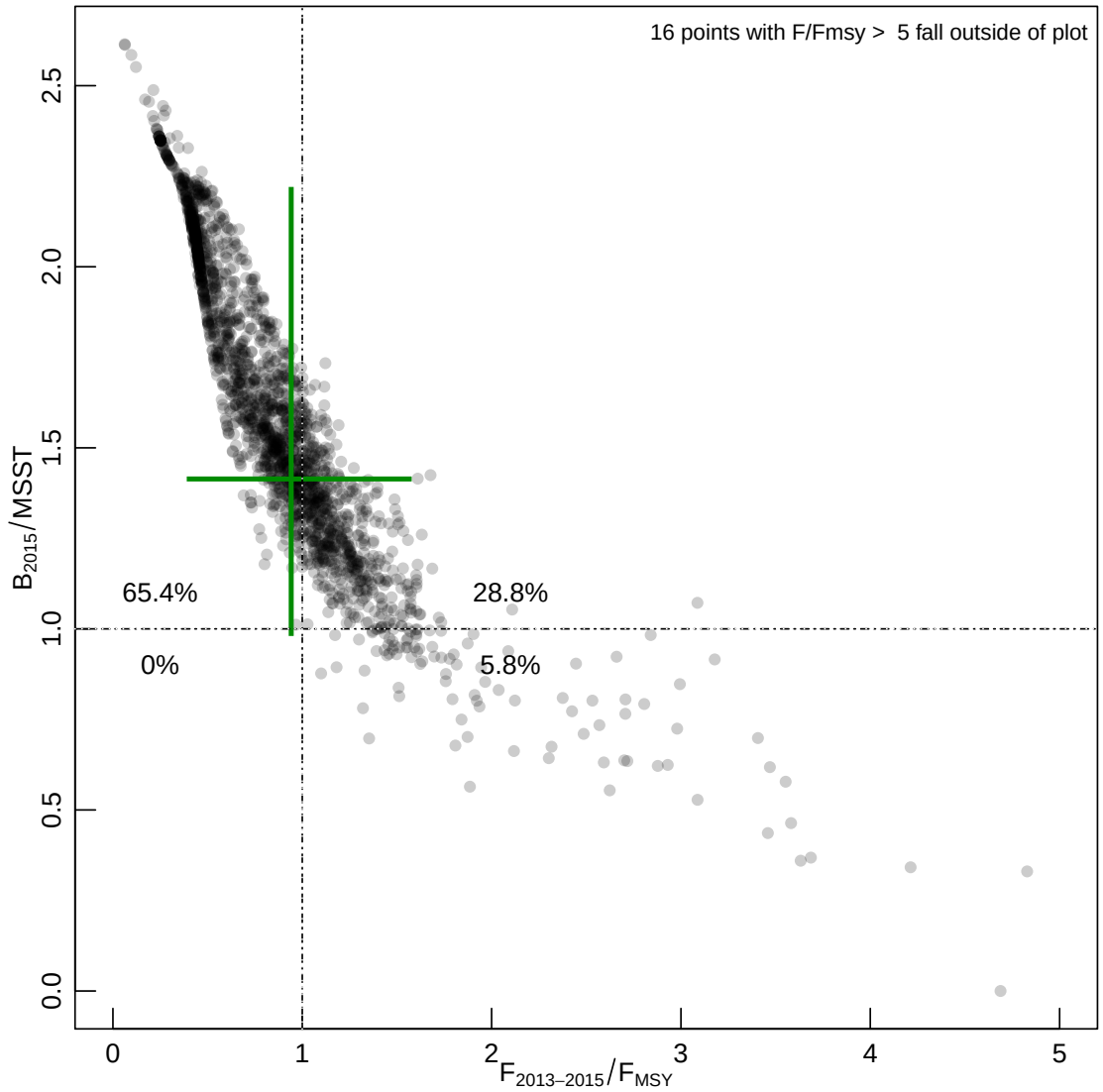


Results

AW Base Model Results and Uncertainty

Bootstrap status phase plots combining Runs 55 and 56 from ASPIC

- Bootstrapping was conducted for each model separately, results were combined
- The intersection of crosshairs indicates average estimate from the base runs
- Lengths of crosshairs defined by 5^{th} and 95^{th} percentiles
- Percent of runs falling into each quadrant indicated



Results

AW Base Model Results and Uncertainty

Base run estimates

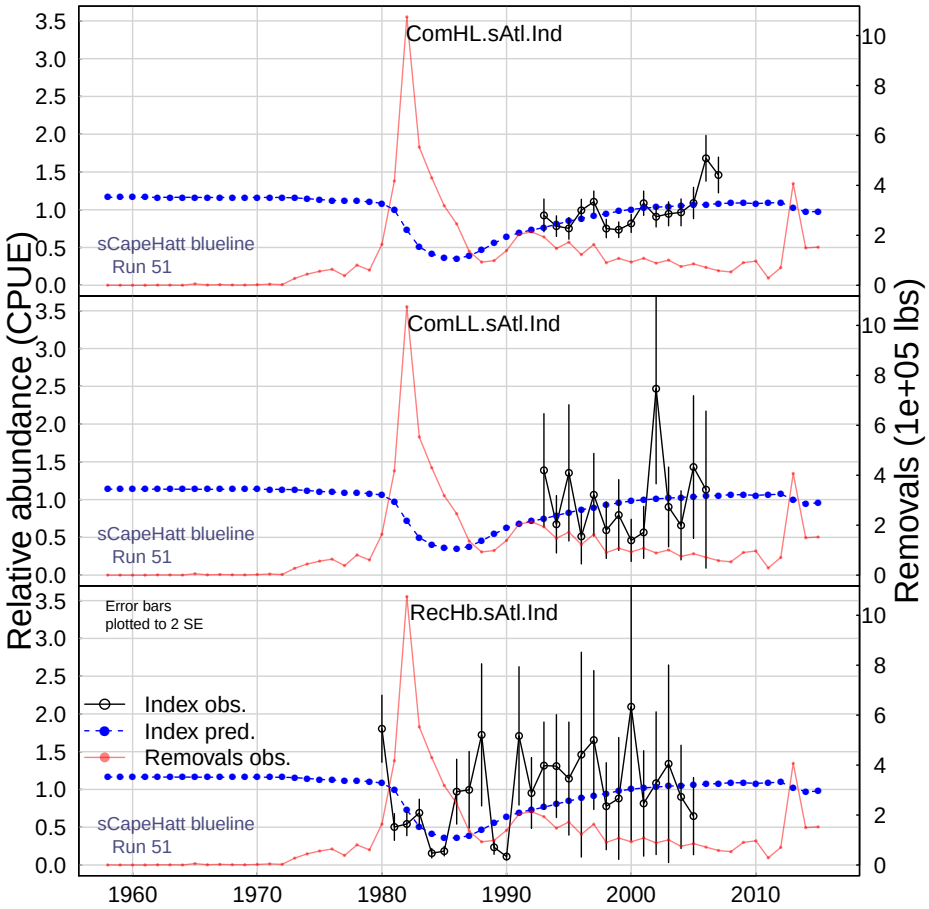
Table: Estimated status indicators, benchmarks, and related quantities from ASPIC, averaged between the handline and longline models for the Atlantic south of Cape Hatteras. Also presented are median values and measures of precision (standard errors, SE) from the bootstrap analysis. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; and biomass estimates are in units of 1000 pounds, as indicated.

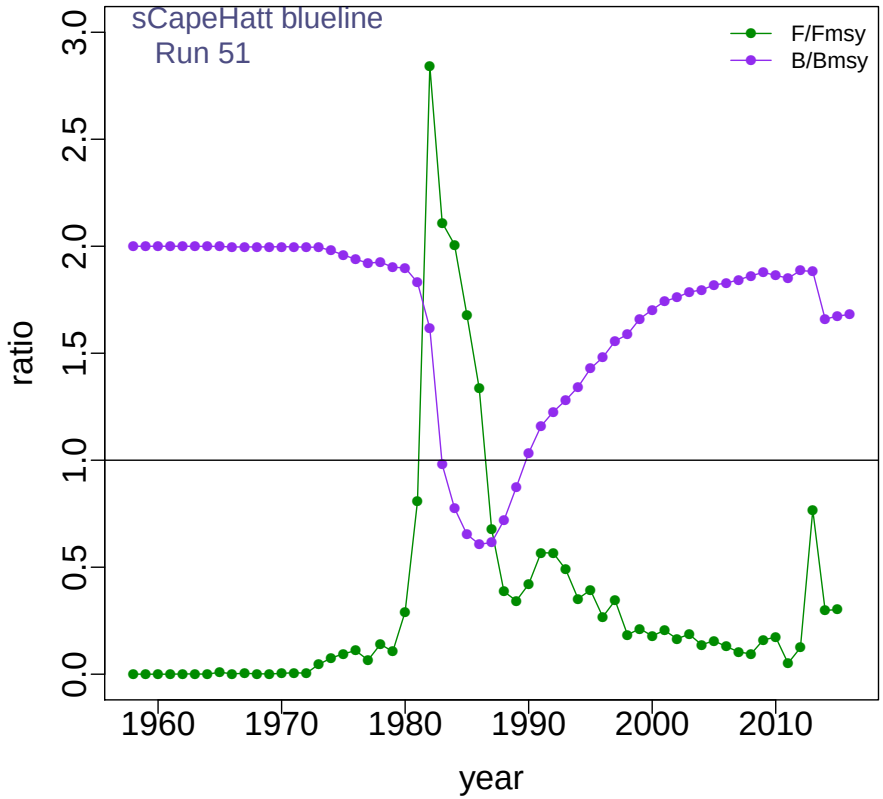
Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.146	0.148	0.106
$85\%F_{\text{MSY}}$	y^{-1}	0.124	0.126	0.090
$75\%F_{\text{MSY}}$	y^{-1}	0.109	0.111	0.080
$65\%F_{\text{MSY}}$	y^{-1}	0.095	0.096	0.069
B_{MSY}	1000 lb	1467	1452	1225
MSST	1000 lb	1100	1089	918
MSY	1000 lb	212	216	85
$F_{2013-2015}/F_{\text{MSY}}$	—	0.92	0.86	0.96
B_{2015}/MSST	—	1.41	1.55	0.41
B_{2015}/B_{MSY}	—	1.06	1.16	0.31

Results

Sensitivity

Include handline, longline, and headboat indices (Run 51)

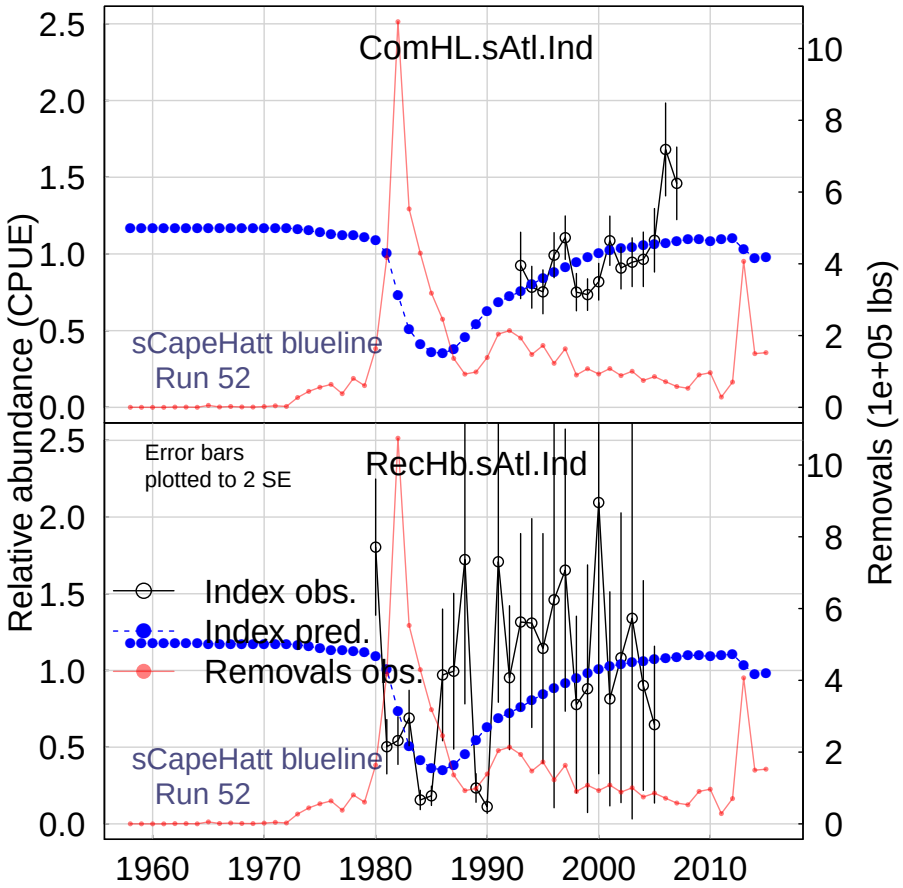


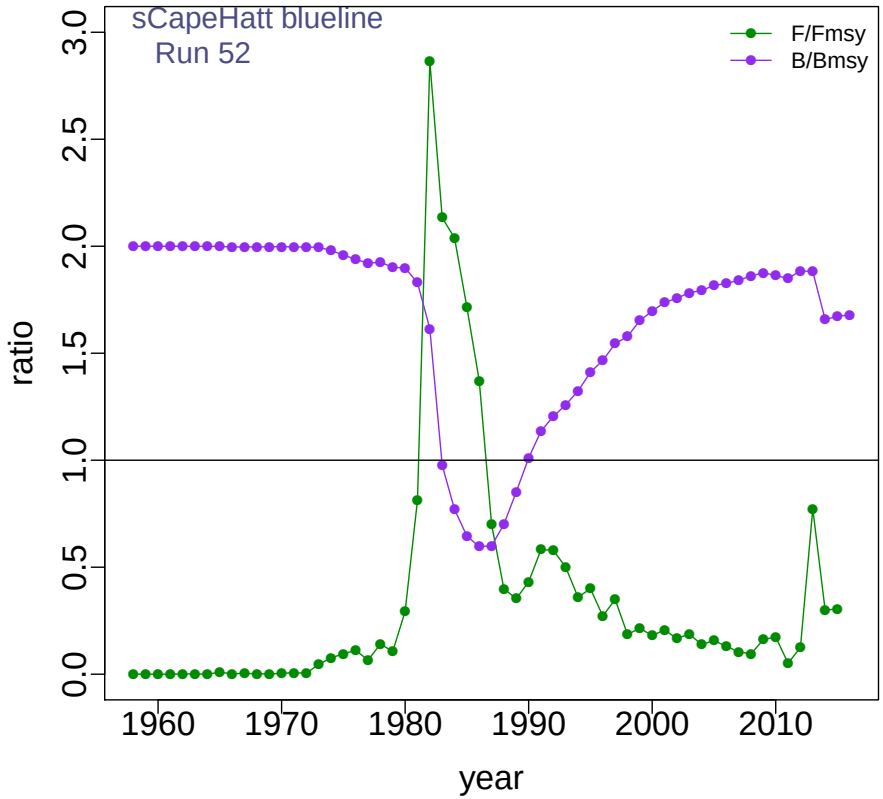


Results

Sensitivity

Include handline and headboat indices (Run 52)

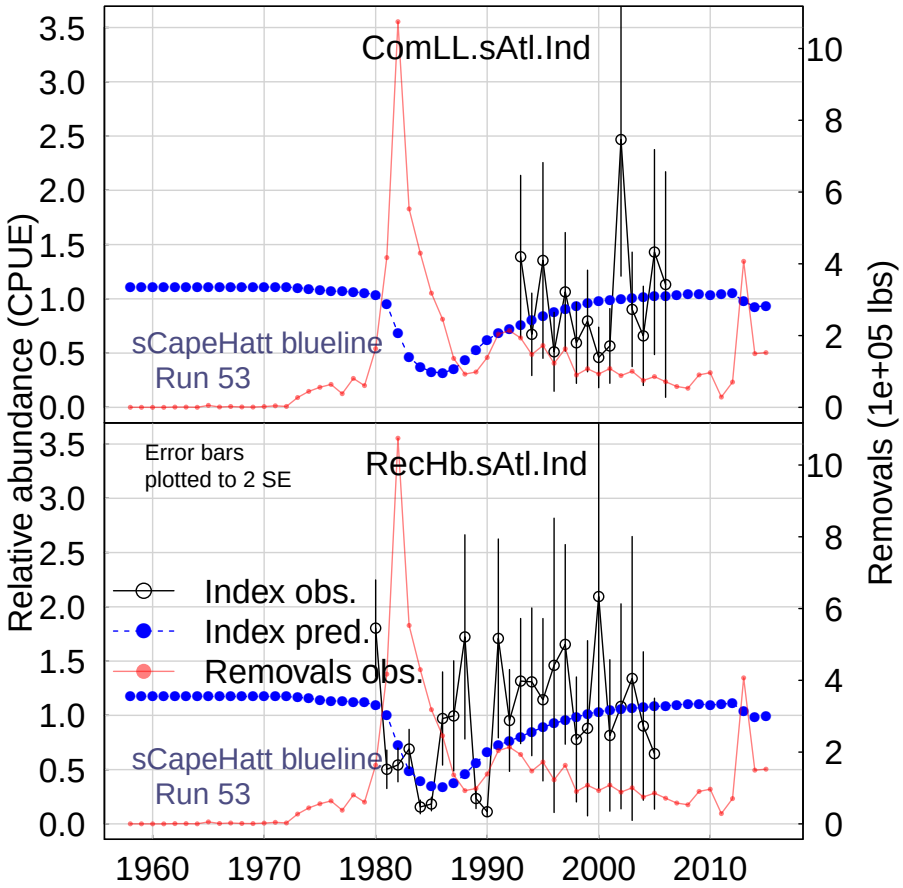


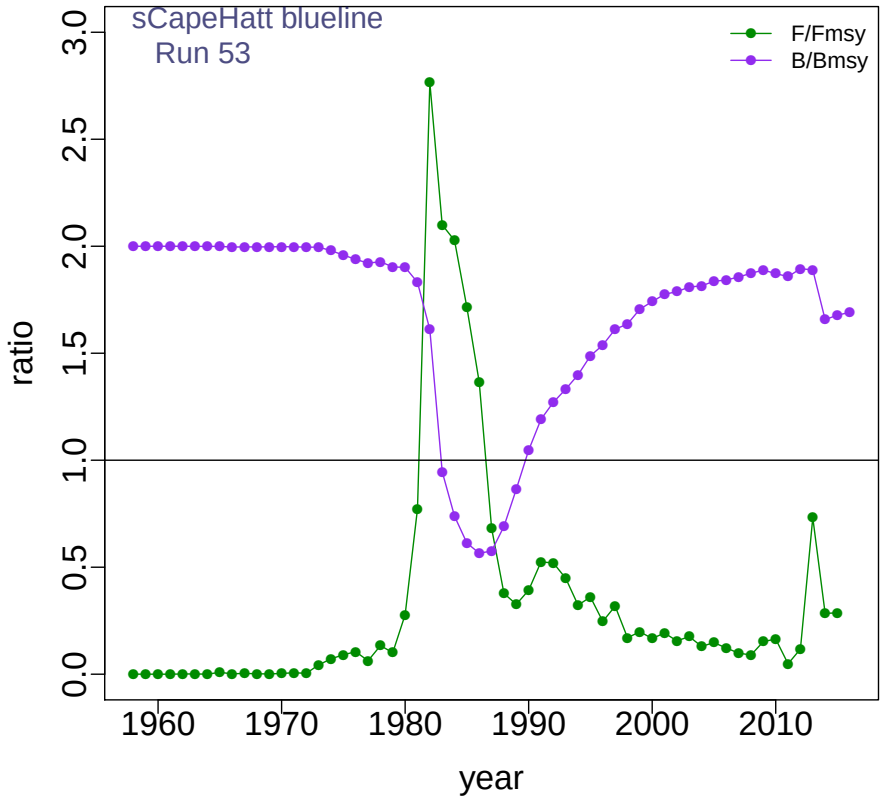


Results

Sensitivity

Include longline and headboat indices (Run 53)

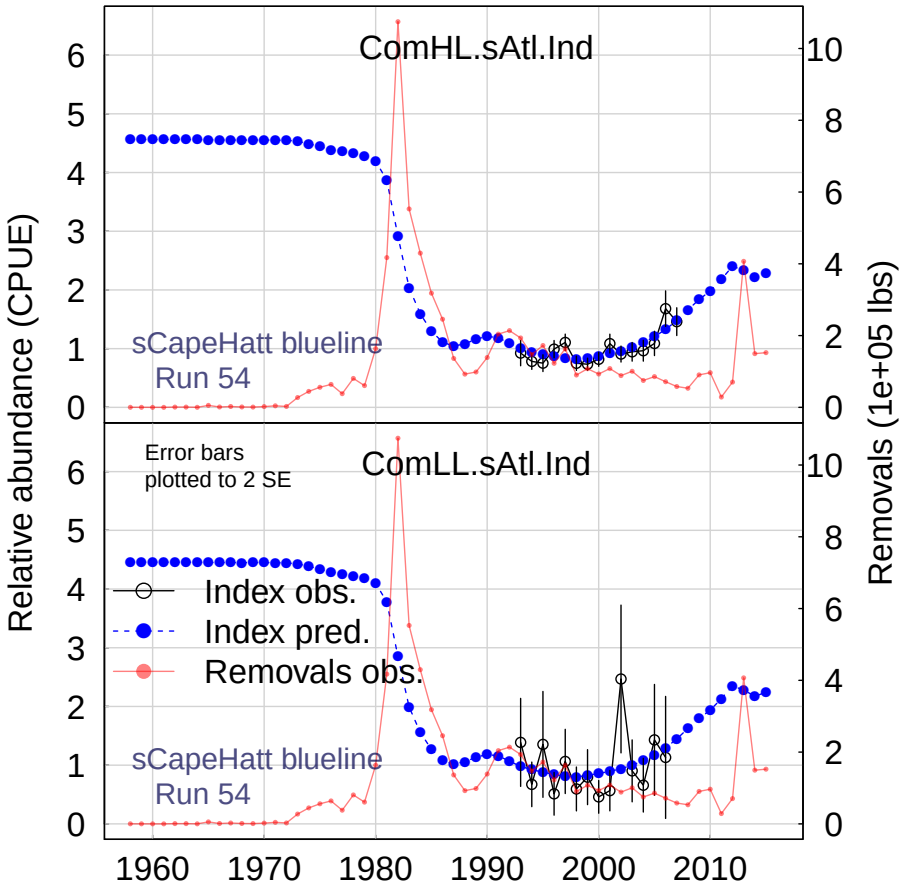


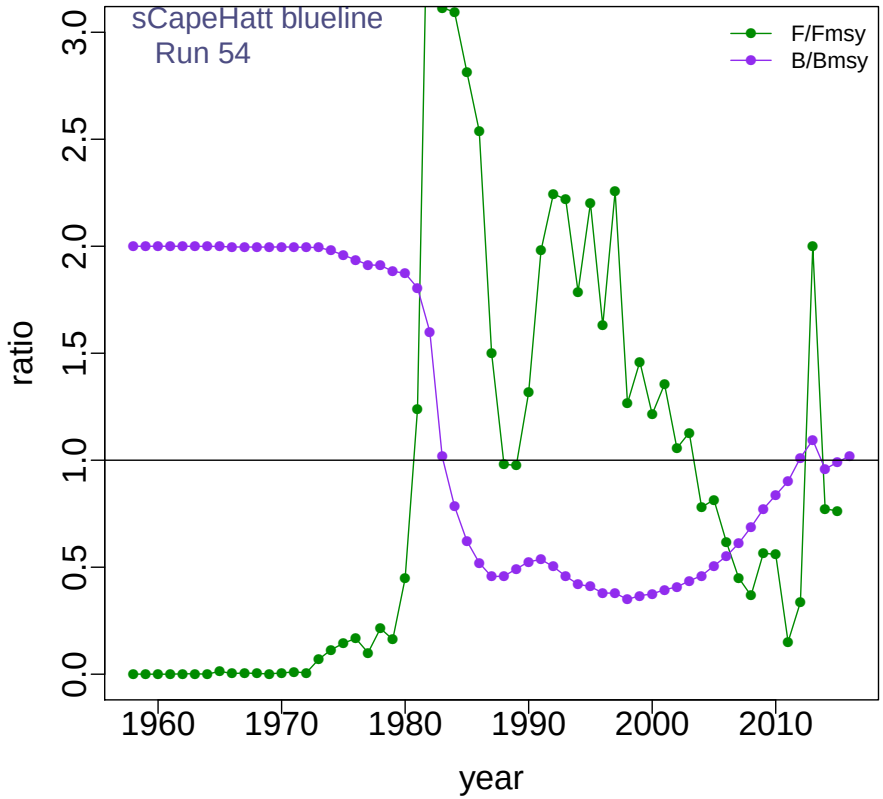


Results

Sensitivity

Include handline and longline indices (Run 54)

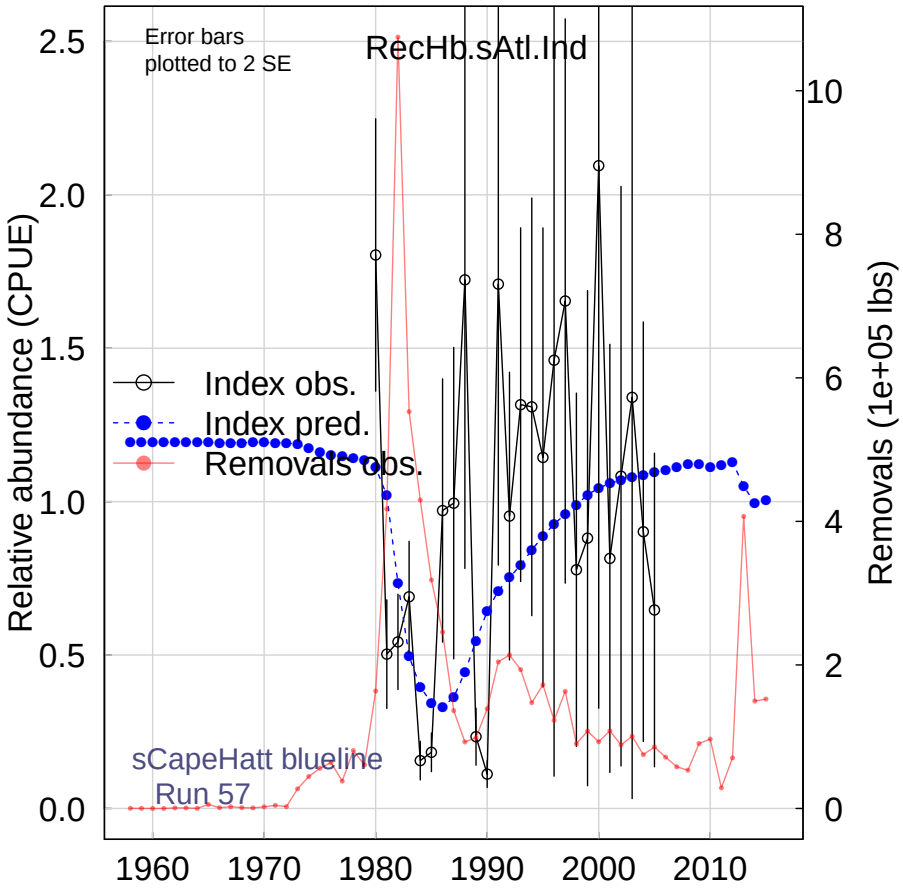


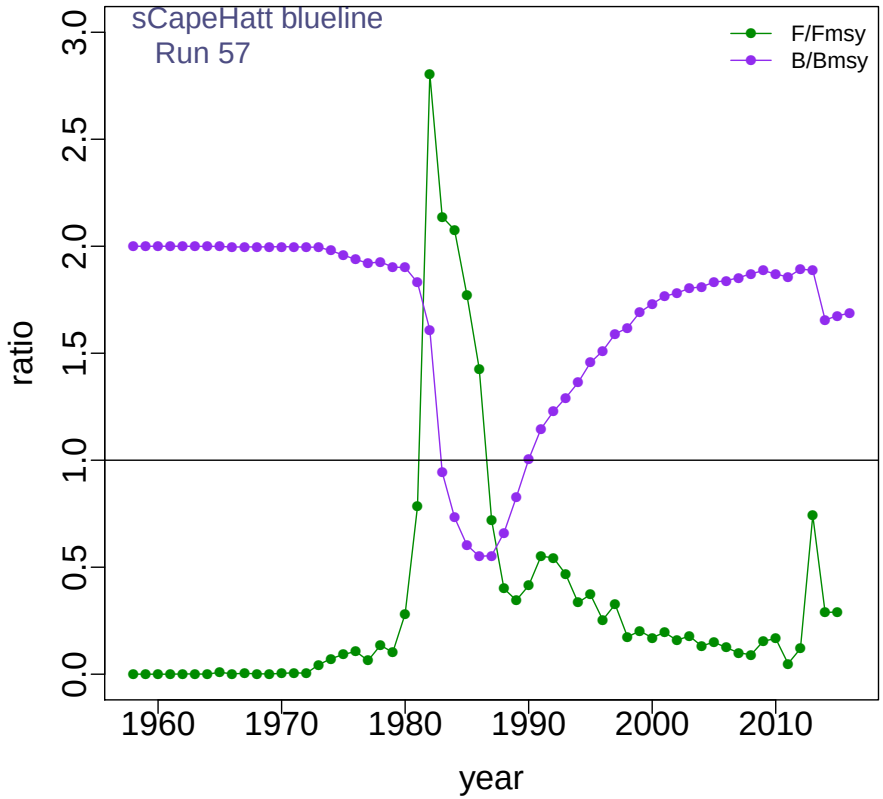


Results

Sensitivity

Include headboat index (Run 57)



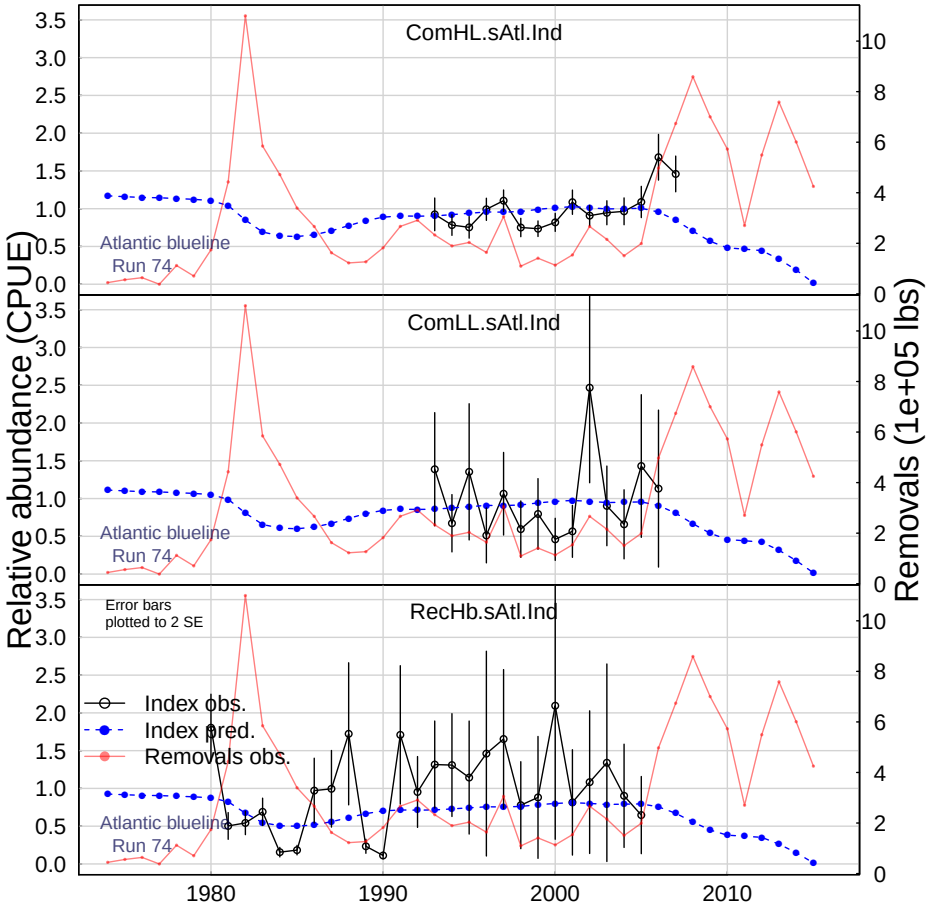


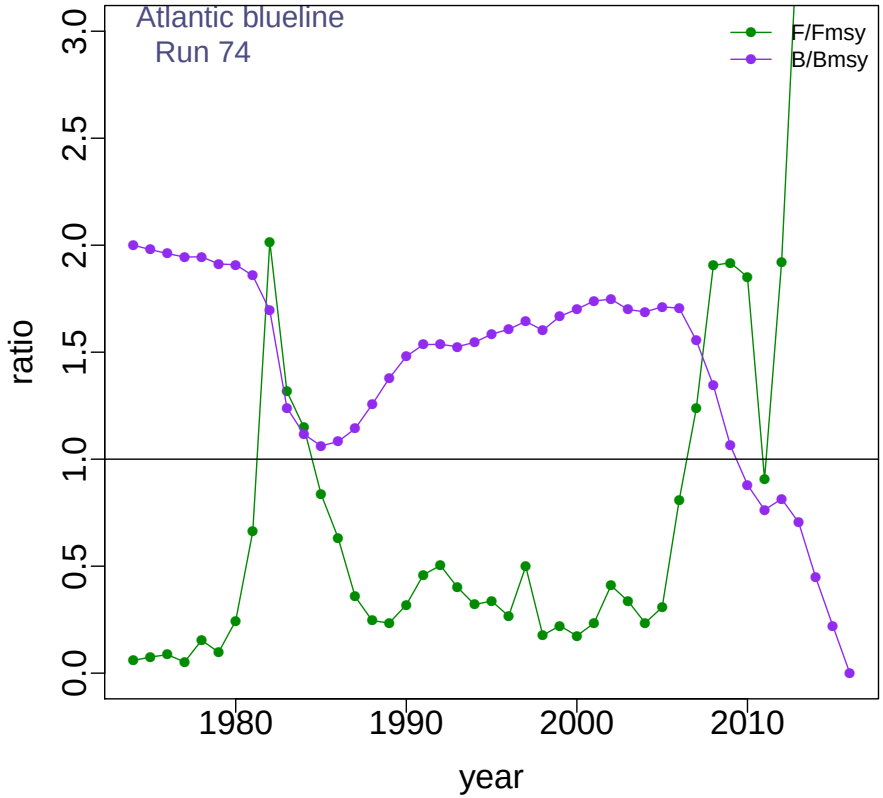
Results

Sensitivity

Continuity with SEDAR 32 (Run 74)

- Include handline, longline, and headboat indices
- Include all Atlantic removals
- Start model in 1974



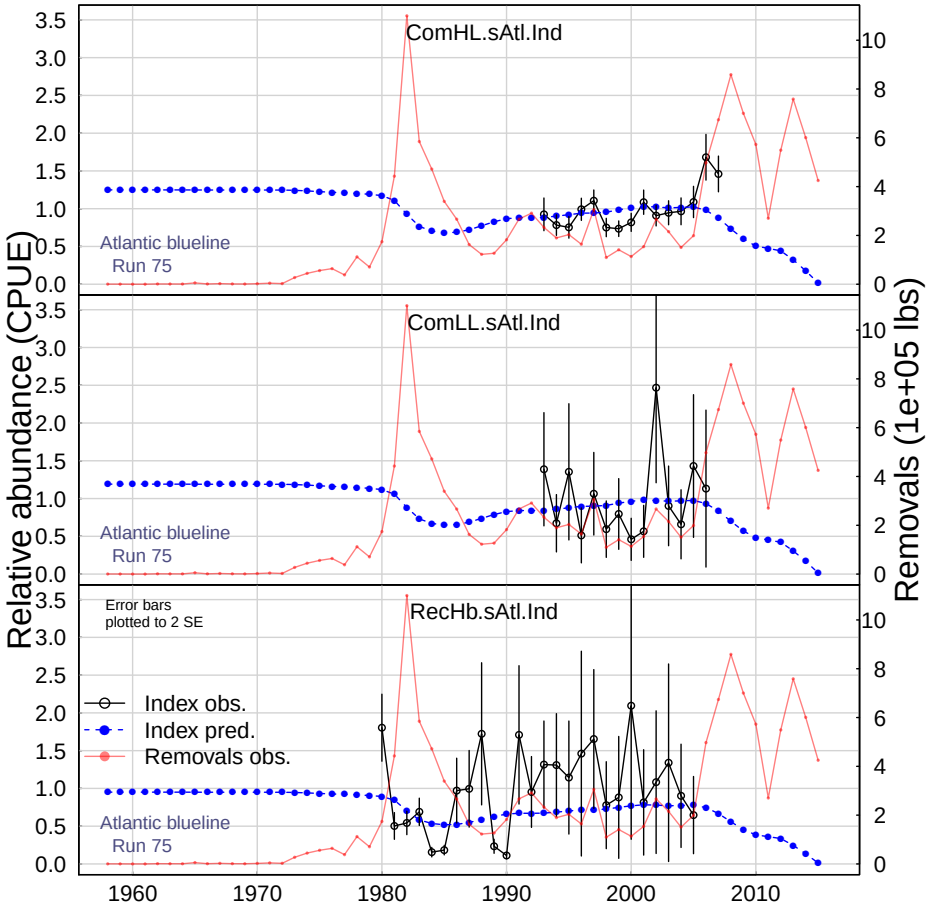


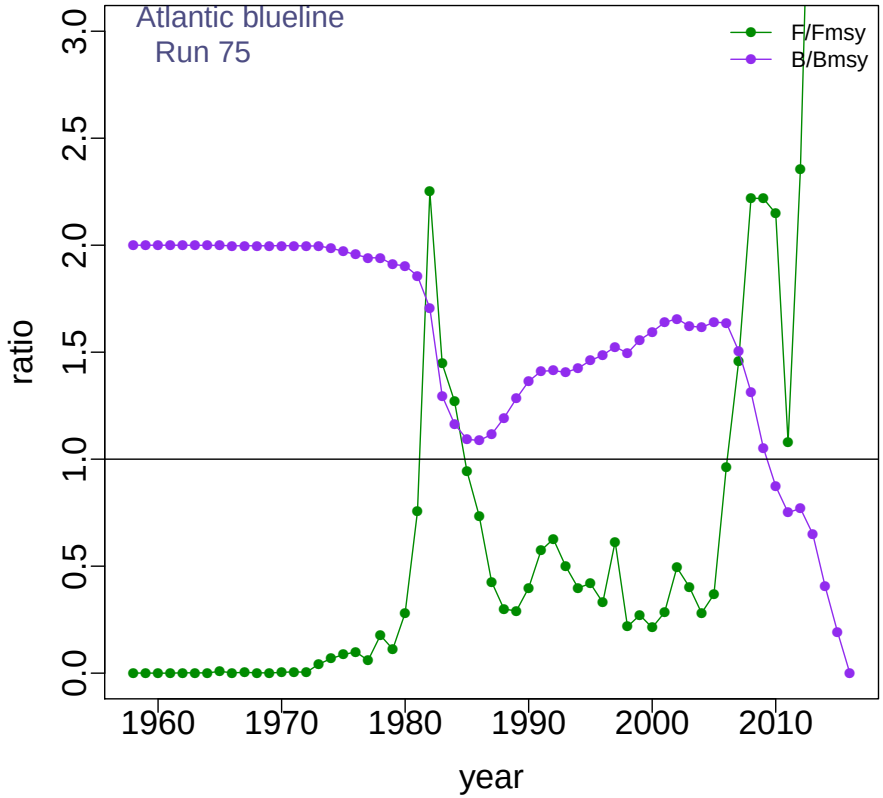
Results

Sensitivity

Continuity with SEDAR 32 (Run 75)

- Include handline, longline, and headboat indices
- Include all Atlantic removals
- Start model in 1958





Results

Sensitivity

Summary of sensitivity runs

Table: Parameter estimates from selected So. Atl. ASPIC surplus production model runs. B_{MSY} and MSY are in units of 1000 pounds. Likelihood components (Lik) are presented for each index and as a total (Lik_{total}). The numerator in F/F_{MSY} is the geometric mean F from the last three years of the assessment (2013-2015) and the numerator in B/B_{MSY} and B/MSST is biomass in the terminal year of the assessment (2015). Abbreviations in Run Name are as follows: HL = handline index, LL = longline index, Hb = headboat index, Atl. = all Atlantic removals are included, 1974 or 1958 indicates the model start year. Estimates from the AW Base run (AW.Base; mean of runs 55 and 56) are also shown for comparison.

Run	RunName	F/F_{MSY}	B/B_{MSY}	B/MSST	B_{MSY}	MSST	MSY	F_{MSY}	Lik_{total}	Lik_{HL}	Lik_{LL}	Lik_{Hb}
51	HLLLHb	0.41	1.67	2.23	1263	947	301	0.238	167.2	23.2	15.7	128.2
52	HLHb	0.41	1.67	2.23	1260	945	299	0.238	151.4	23.2		128.2
53	LLHb	0.39	1.68	2.24	1186	889	316	0.266	143.5		15.7	127.8
54	HLLL	1.06	0.99	1.32	1538	1153	199	0.129	16.9	4.1	12.8	
55	HL	1.07	0.99	1.32	1554	1165	196	0.126	4.1	4.1		
56	LL	0.81	1.13	1.51	1380	1035	228	0.165	12.7		12.7	
57	Hb	0.40	1.68	2.23	1190	892	312	0.262	127.8			127.8
74	Atl.HLLLHb.1974	8.71	0.22	0.30	1769	1327	378	0.214	205.2	46.0	15.1	144.1
75	Atl.HLLLHb.1958	11.27	0.19	0.26	2076	1557	330	0.159	202.3	40.9	15.0	146.5
55, 56	AW.Base	0.92	1.06	1.41	1467	1100	212	0.146				

Results

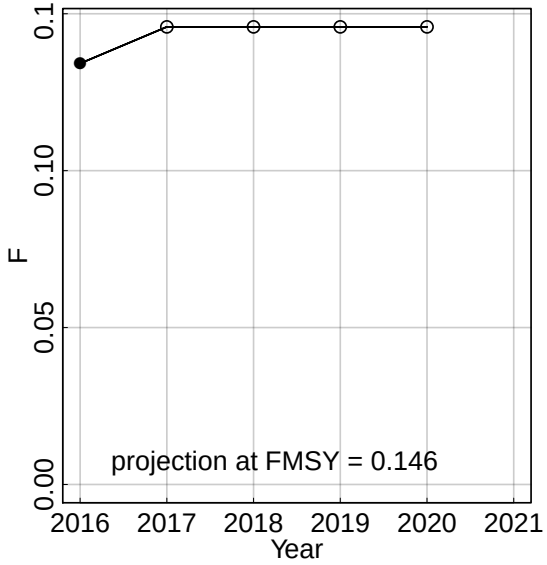
Projections

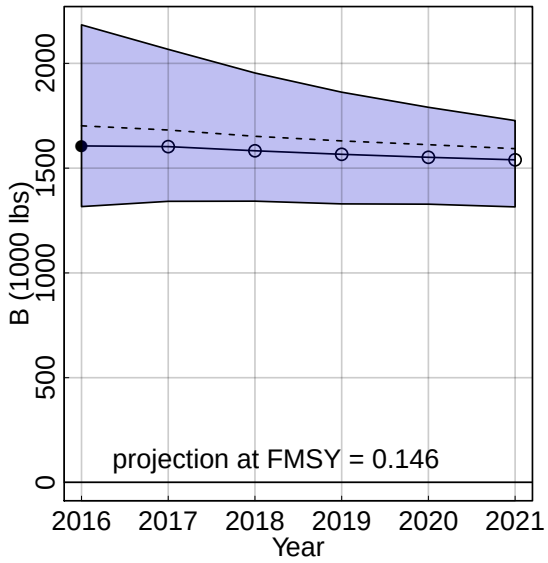
- Projections at:
  - $F = F_{\text{MSY}}$
  - $F = F_{\text{current}}$
  - $F = F_{\text{target}} = 0.75F_{\text{MSY}}$
- $F_{2016} = F_{\text{current}}$
- Solid circles (2016) represent values projected by the assessment model
- Open circles (2017-2021) represent values produced by the projection code
- Solid lines are deterministic estimates
- Dashed lines are medians of the bootstrap projections, respectively
- Blue error bands indicate 10^{th} and 90^{th} percentiles of the combined bootstrap trials

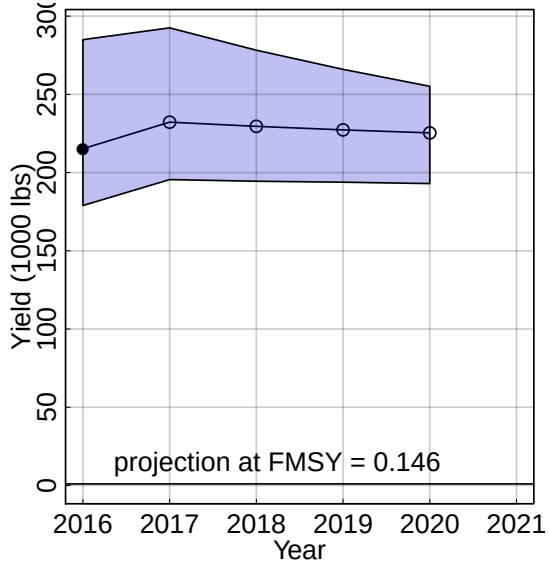
Results

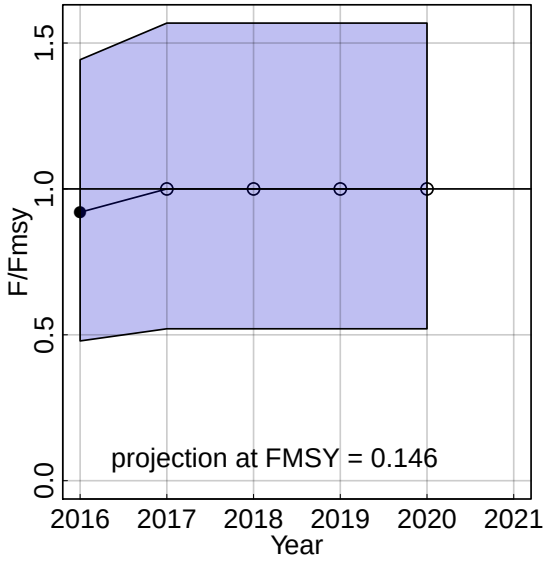
Projections

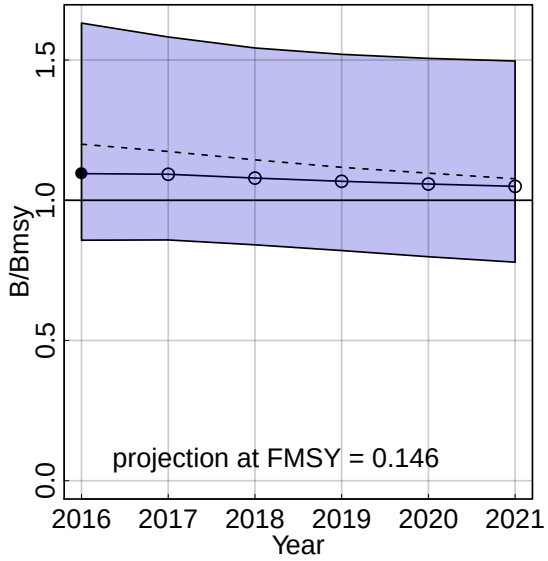
Projections at: $F = F_{\text{MSY}}$

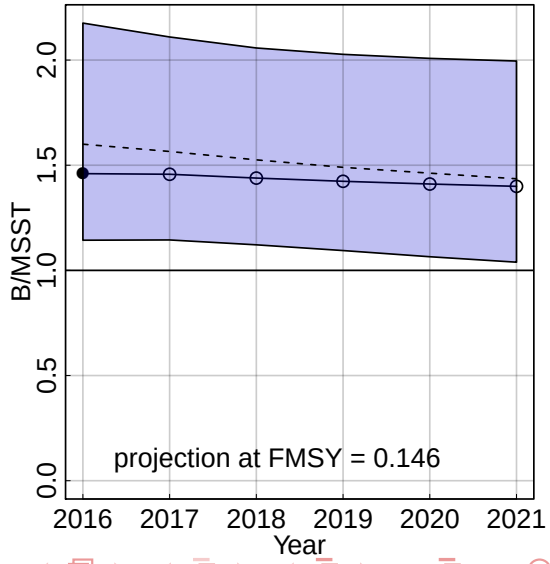












Results

Projections

Projections at: $F = F_{\text{MSY}}$

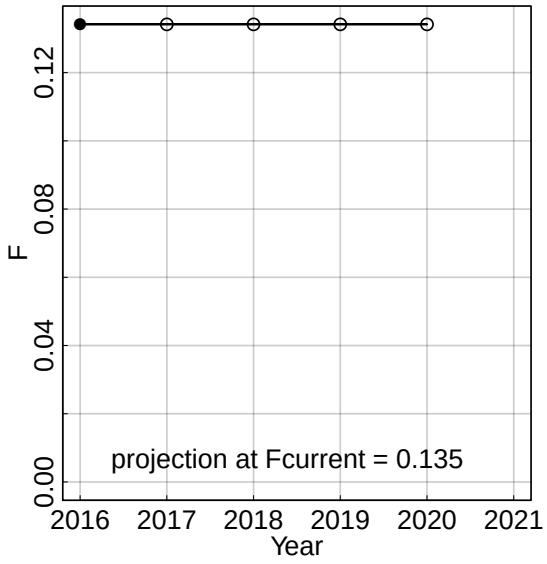
Table: Projection results with fishing mortality fixed at $F = F_{\text{MSY}}$ starting in 2017 . For 2016 , $F = F_{\text{current}}$. F = fishing mortality rate (per year), $P(B > B_{\text{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \text{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B_{median} = median biomass (1000 lbs) estimate among projections, B = deterministic biomass (1000 lbs) estimate, Y = deterministic yield (1000 lbs) estimate, Sum Y = cumulative sum of deterministic yield (1000 lbs). Yield includes landings and dead discards.

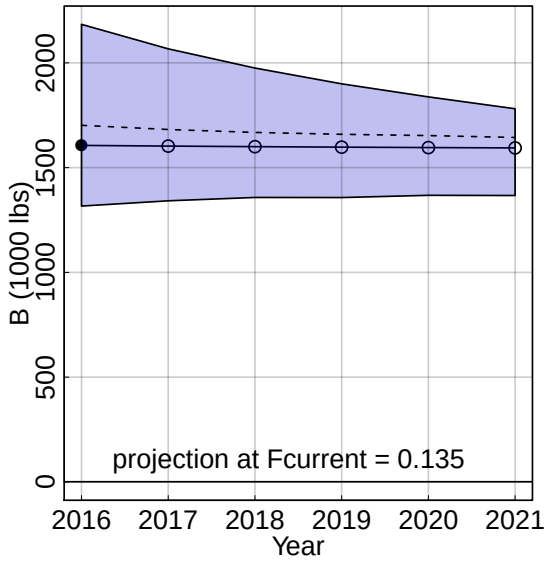
Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.134	0.77	0.95	1702	1606	215	215
2017	0.146	0.76	0.95	1682	1603	232	447
2018	0.146	0.72	0.95	1652	1583	230	677
2019	0.146	0.69	0.94	1630	1566	227	904
2020	0.146	0.65	0.93	1612	1552	225	1130
2021		0.61	0.92	1593	1540		

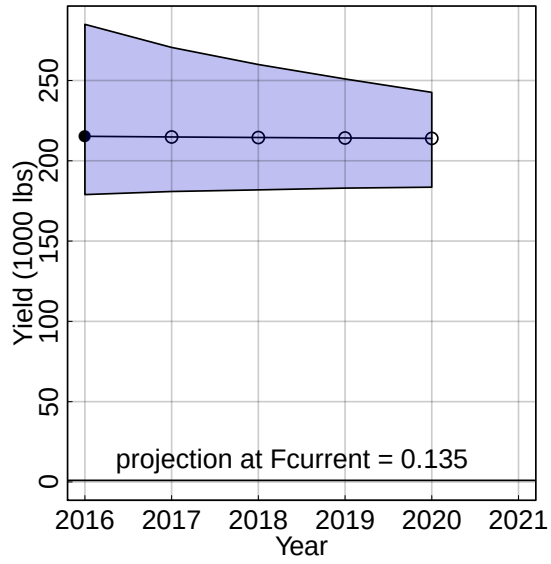
Results

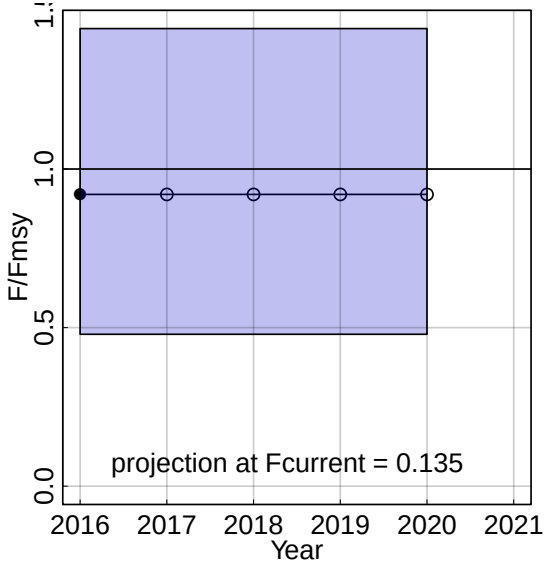
Projections

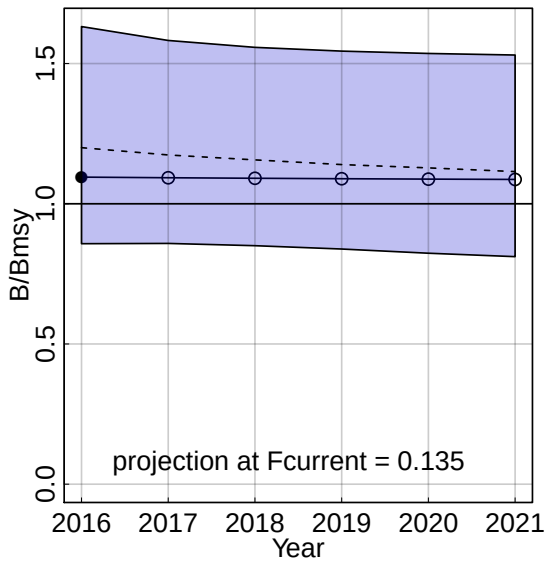
Projections at: $F = F_{\text{current}}$

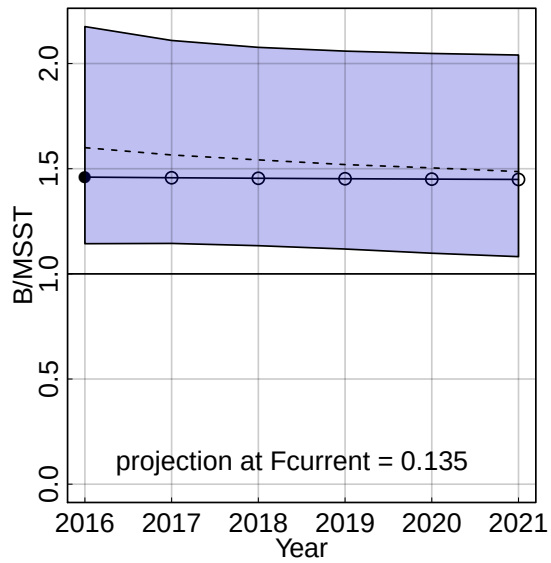












Results

Projections

Projections at: $F = F_{\text{current}}$

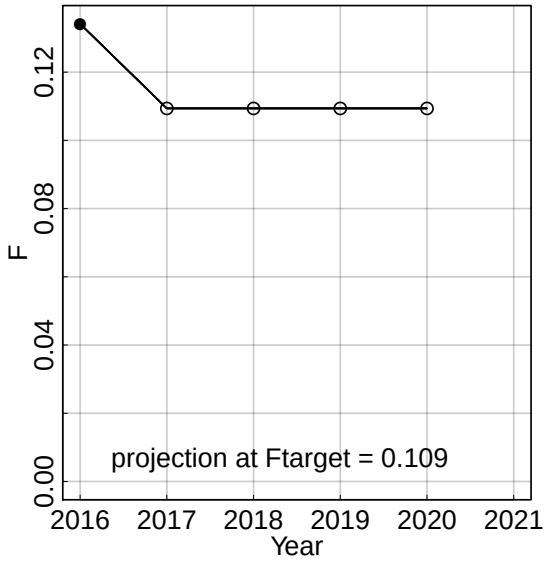
Table: Projection results with fishing mortality fixed at $F = F_{\text{current}}$ starting in 2017 . For 2016 , $F = F_{\text{current}}$. F = fishing mortality rate (per year), $P(B > B_{\text{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \text{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B_{median} = median biomass (1000 lbs) estimate among projections, B = deterministic biomass (1000 lbs) estimate, Y = deterministic yield (1000 lbs) estimate, Sum Y = cumulative sum of deterministic yield (1000 lbs). Yield includes landings and dead discards.

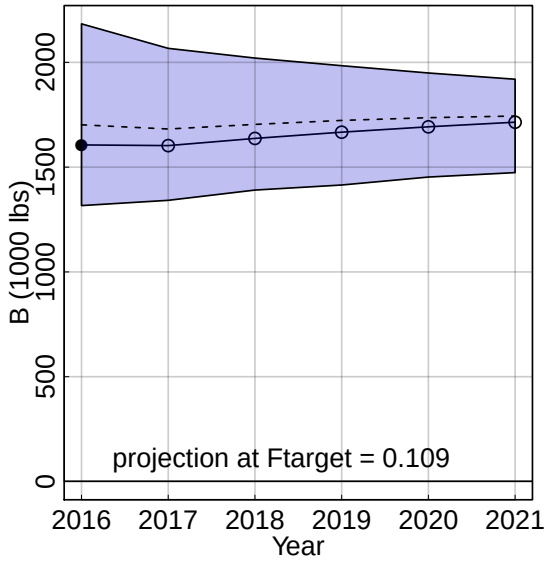
Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.134	0.77	0.95	1702	1606	215	215
2017	0.134	0.76	0.95	1682	1603	215	430
2018	0.134	0.74	0.95	1668	1600	214	645
2019	0.134	0.72	0.94	1659	1598	214	859
2020	0.134	0.70	0.94	1653	1596	214	1073
2021		0.67	0.93	1644	1594		

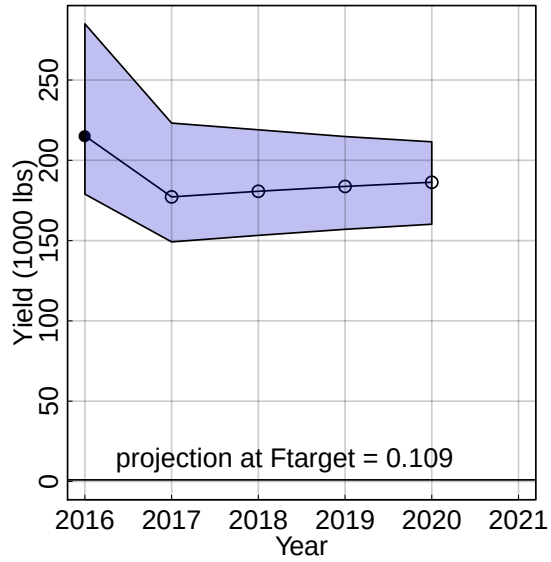
Results

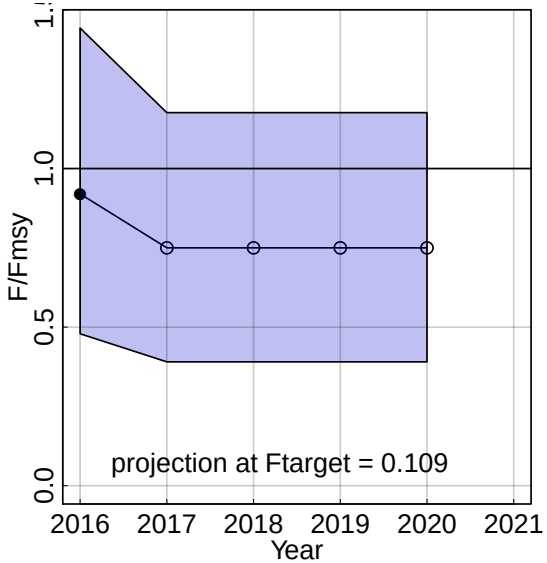
Projections

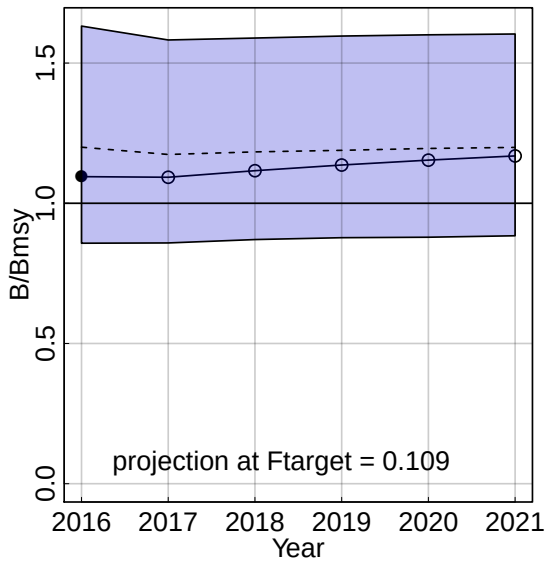
Projections at: $F = F_{\text{target}} = 0.75F_{\text{MSY}}$

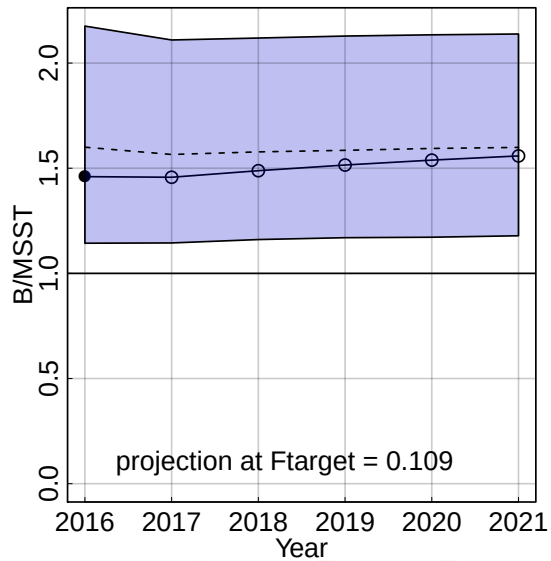












Results

Projections

Projections at: $F = F_{\text{target}} = 0.75F_{\text{MSY}}$

Table: Projection results with fishing mortality fixed at $F = F_{\text{target}}$ starting in 2017 . For 2016 , $F = F_{\text{current}}$. F = fishing mortality rate (per year), $P(B > B_{\text{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \text{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B_{median} = median biomass (1000 lbs) estimate among projections, B = deterministic biomass (1000 lbs) estimate, Y = deterministic yield (1000 lbs) estimate, Sum Y = cumulative sum of deterministic yield (1000 lbs). Yield includes landings and dead discards.

Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.134	0.77	0.95	1702	1606	215	215
2017	0.109	0.76	0.95	1682	1603	177	392
2018	0.109	0.77	0.96	1704	1637	181	573
2019	0.109	0.79	0.96	1723	1667	184	757
2020	0.109	0.79	0.96	1736	1693	186	943
2021		0.80	0.96	1744	1714		

Conclusions

- Blueline Tilefish south of Cape Hatteras are not overfished (B_{2015}/MSST=1.41) and overfishing is not occurring ($F_{2013-2015}/F_{\text{MSY}}$=0.92)
- Bootstrap analysis suggests that stock status (B) is fairly certain, as only 5.8% of runs found the stock to be overfished
- Bootstrap analysis suggests that fishery status (F) is much less certain, as 28.8% of runs found the stock to be undergoing overfishing

Blueline Tilefish: South of Cape Hatteras Age-structured Production Model (ASPM) Assessment Workshop Base Model (AW Base)

NOAA FISHERIES

Southeast Fisheries Science Center

October 19, 2017

Table of contents

Methods

AW Base Run Configuration

- Model coded in Automatic Differentiation Model Builder (ADMB)
- Modified from code for the most recent version of the catch-at-age model used in most SEDAR assessments in the US South Atlantic, the Beaufort Assessment Model (BAM)

Methods

AW Base Run Configuration

- Major differences from a catch-at-age model include:
  - No age composition data
  - Do not fit recruitment deviations
  - Do not fit initial numbers-at-age deviations

Methods

AW Base Run Configuration

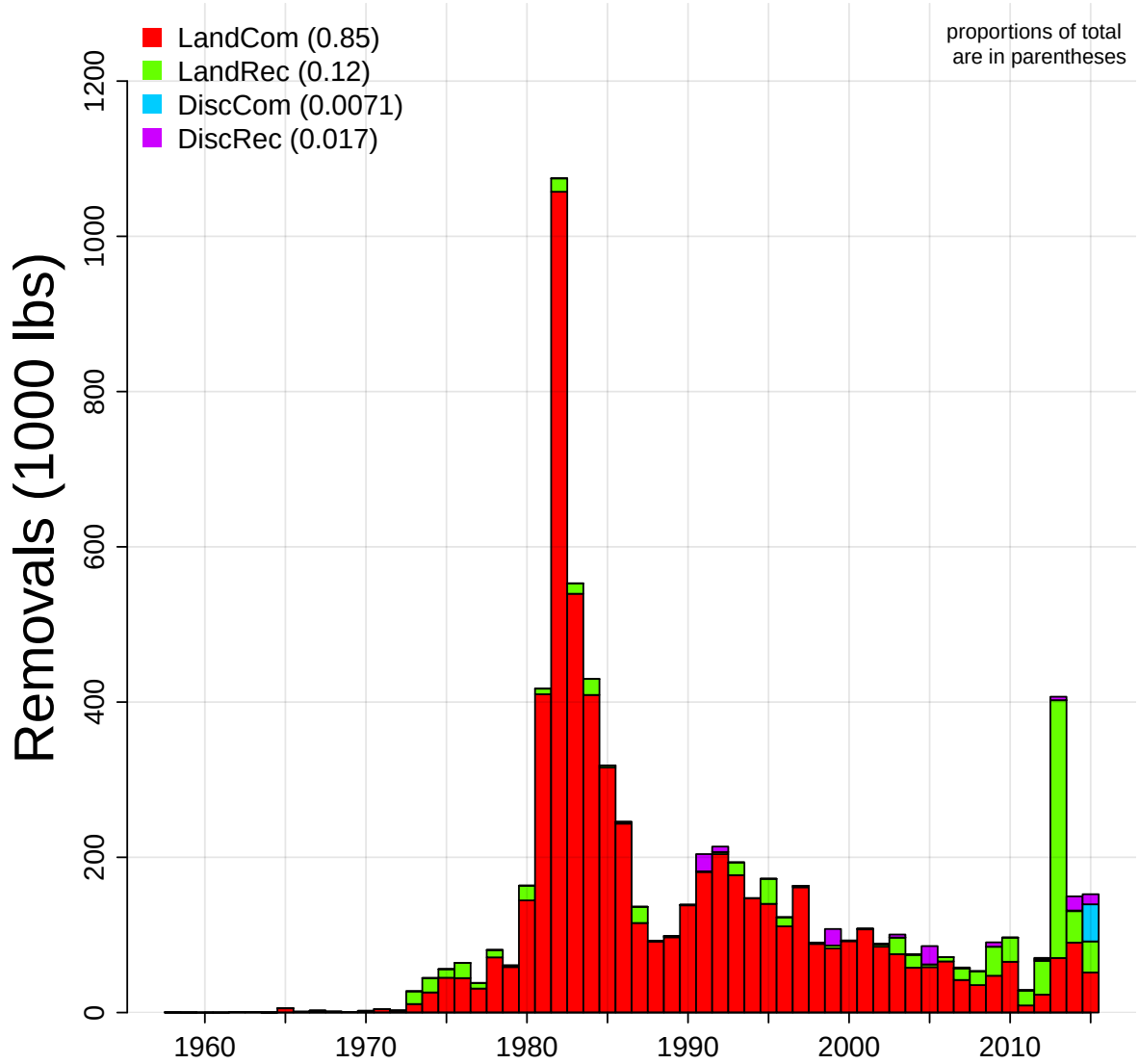
- Major similarities with a catch-at-age model include:
  - Population is modeled as age-structured
    - ★ Growth model
    - ★ Age-dependent natural mortality
    - ★ Age-dependent reproductive potential
  - Beverton-Holt stock-recruit function
  - Removals are separated by fleet
  - Estimate fleet specific fishing mortality
  - Fit to multiple indices of abundance
  - Fit to multiple sets of length compositions
  - Fit selectivity functions

Methods

Data

Removals by fleet

- Same removals as in the ASPIC model for south of Cape Hatteras

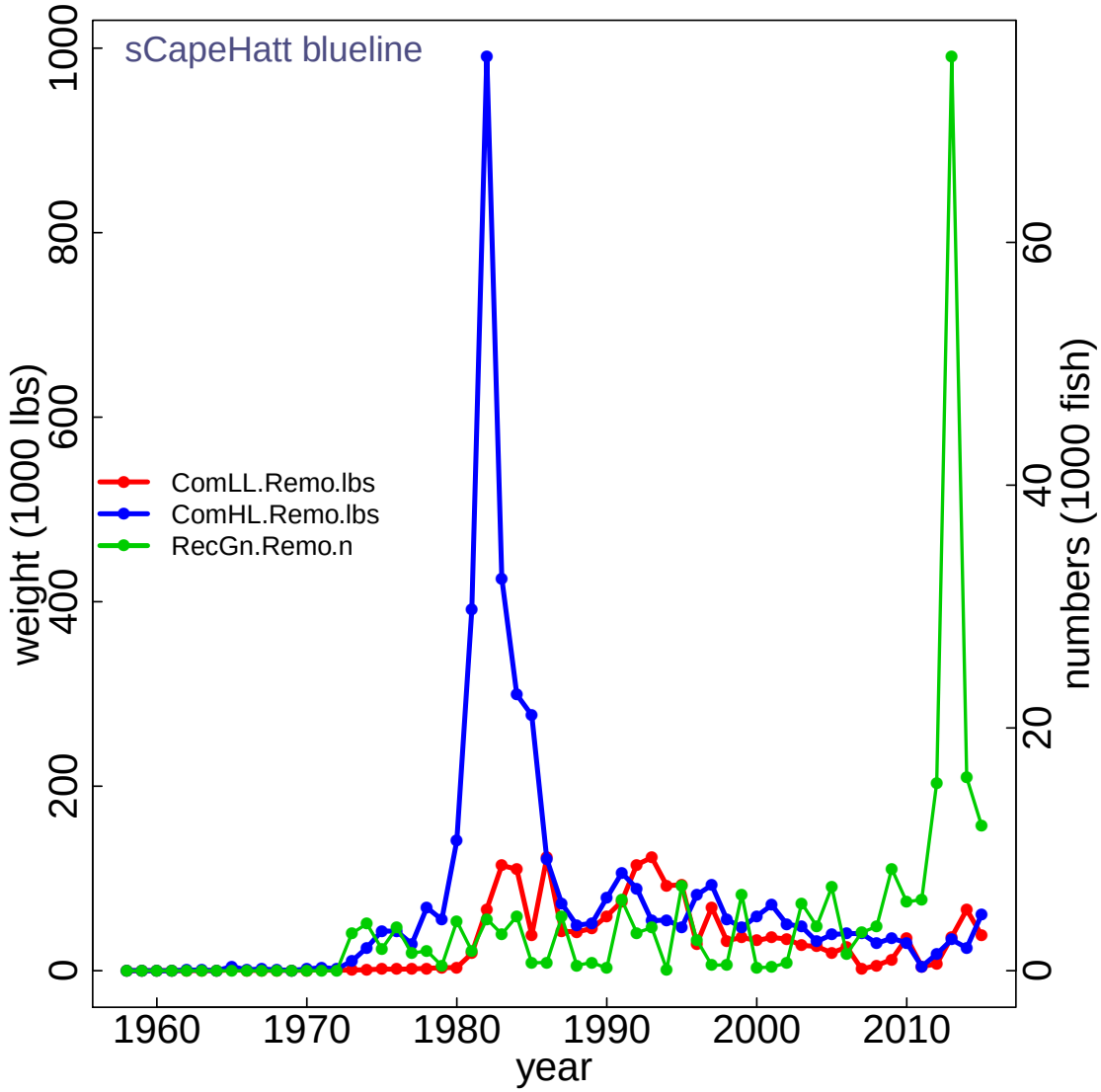


Methods

Data

Removals by fleet

- For the ASPM, removals were modeled as three separate fleets (combining landings and dead discards):
  1. Commercial handline (lbs)
  2. Commercial longline (lbs)
  3. General recreational (n)

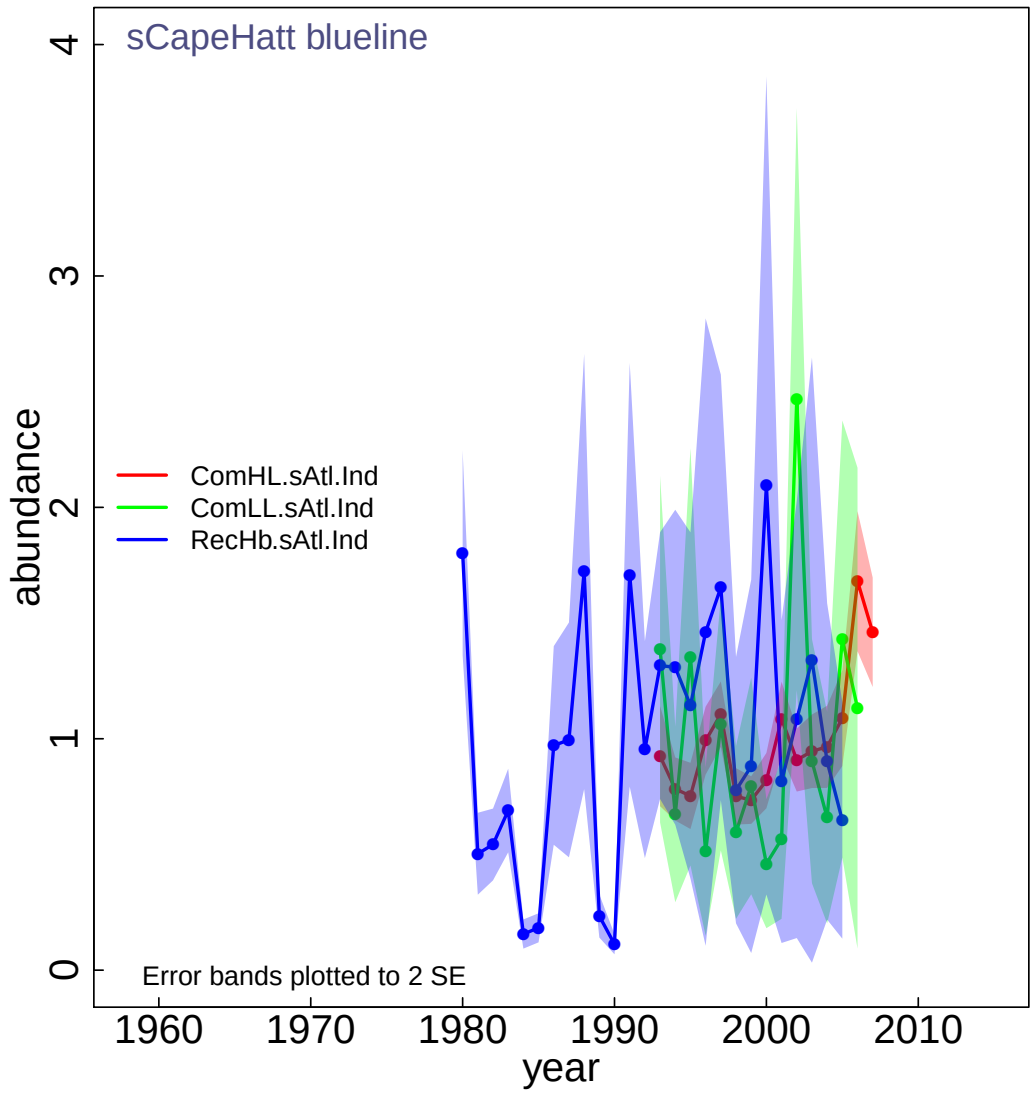


Methods

Data

Indices of abundance

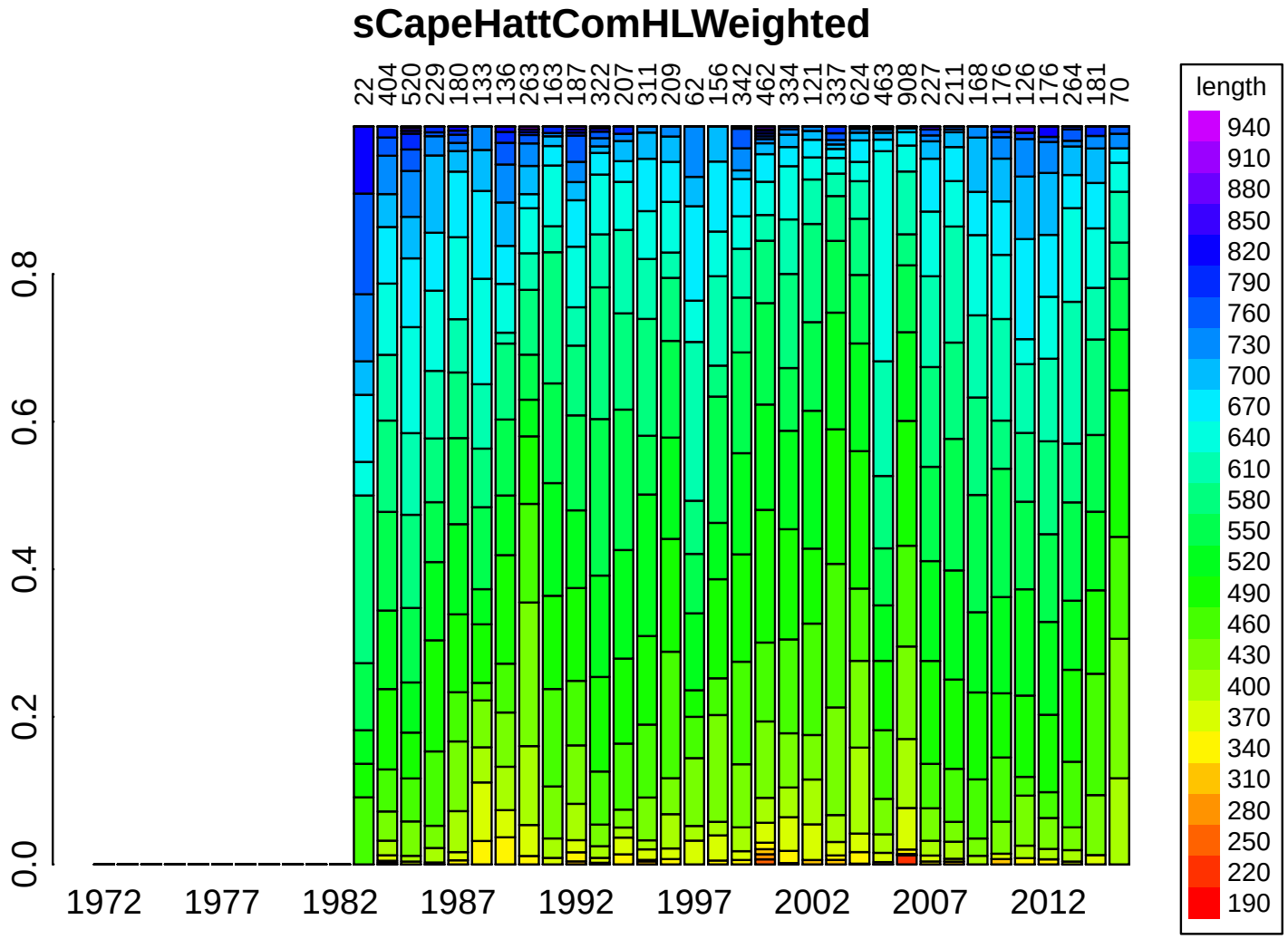
- The same indices as in the ASPIC model for south of Cape Hatteras



Methods

Data

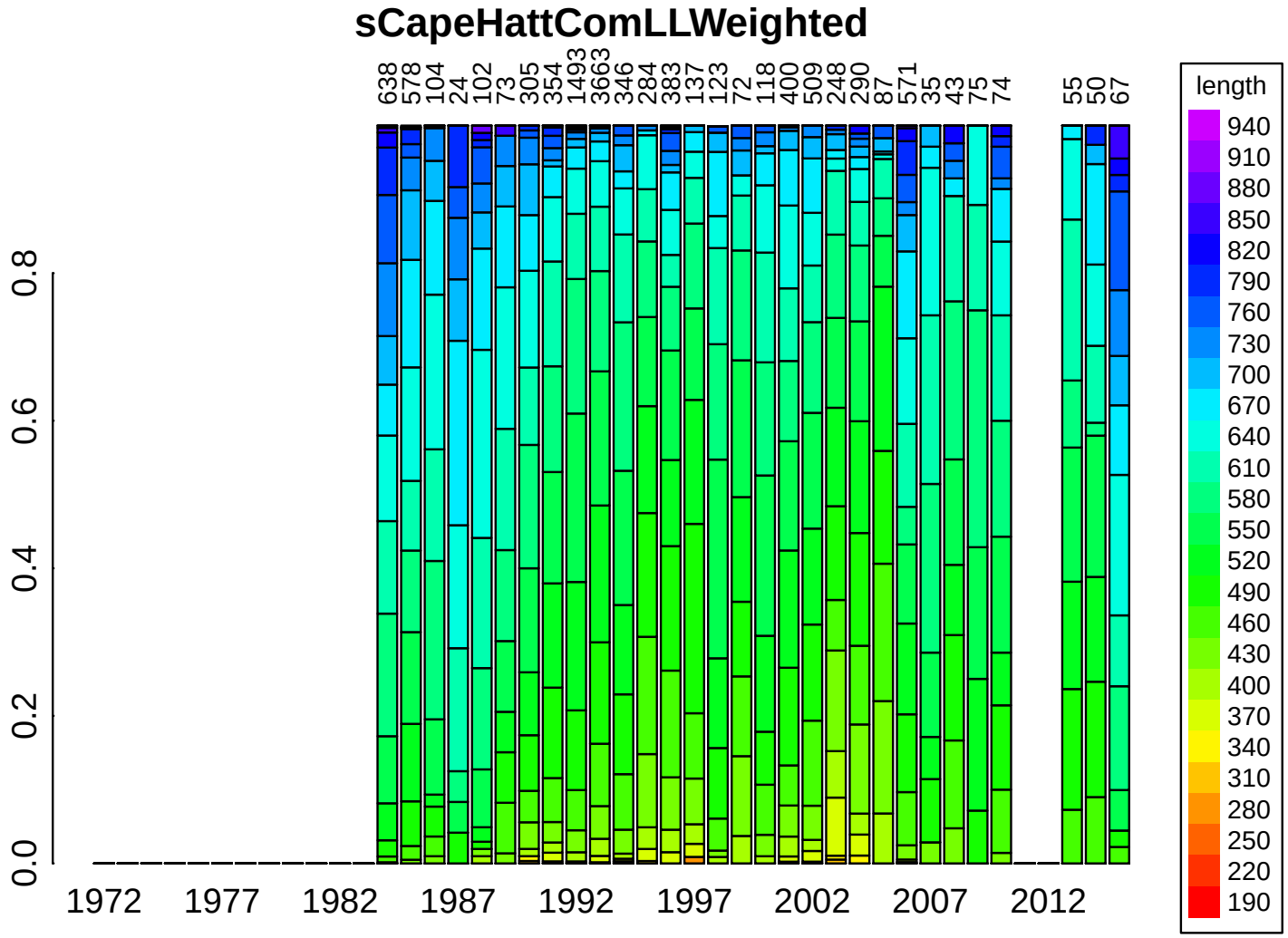
Commercial handline lengths



Methods

Data

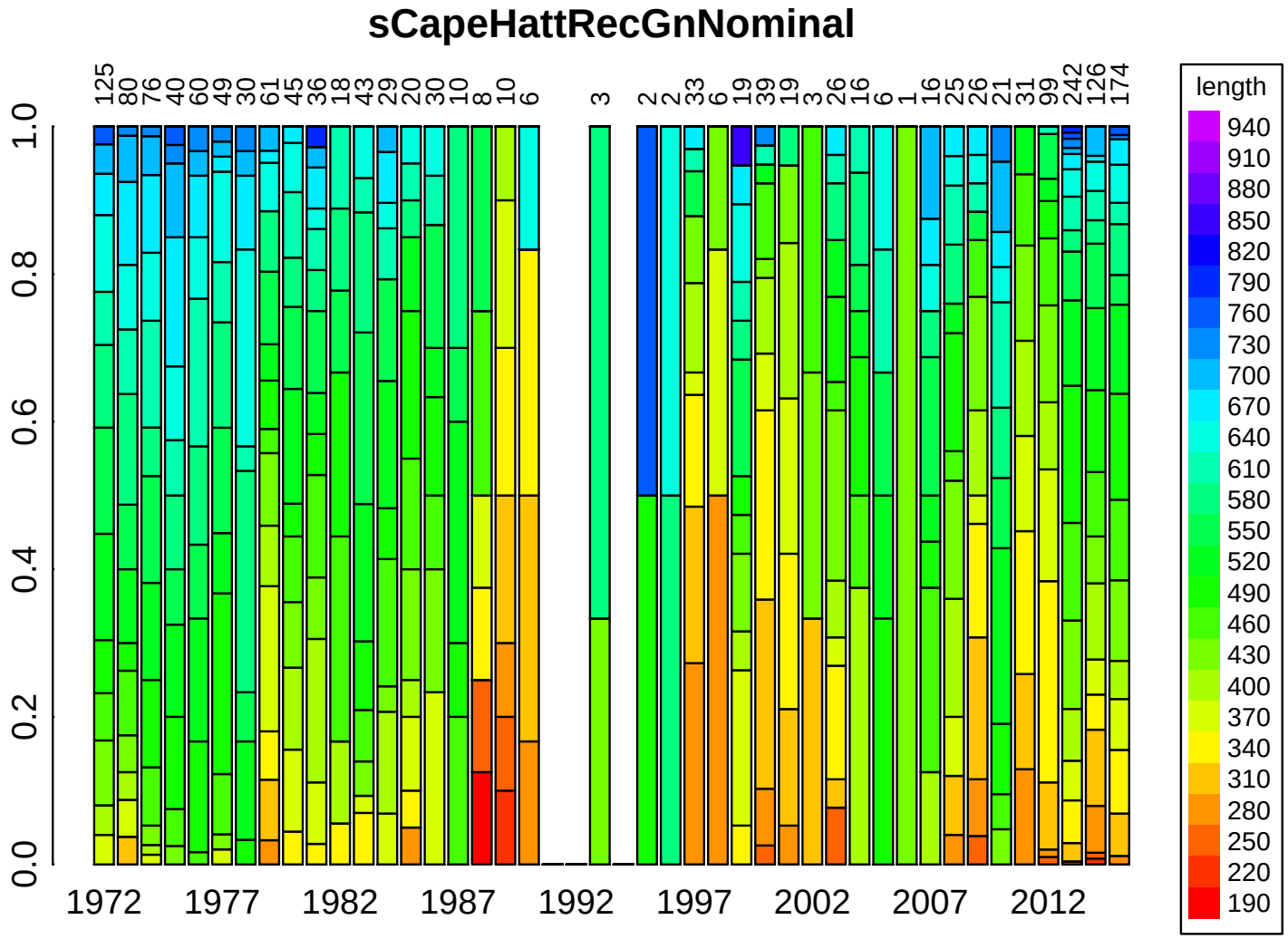
Commercial longline lengths



Methods

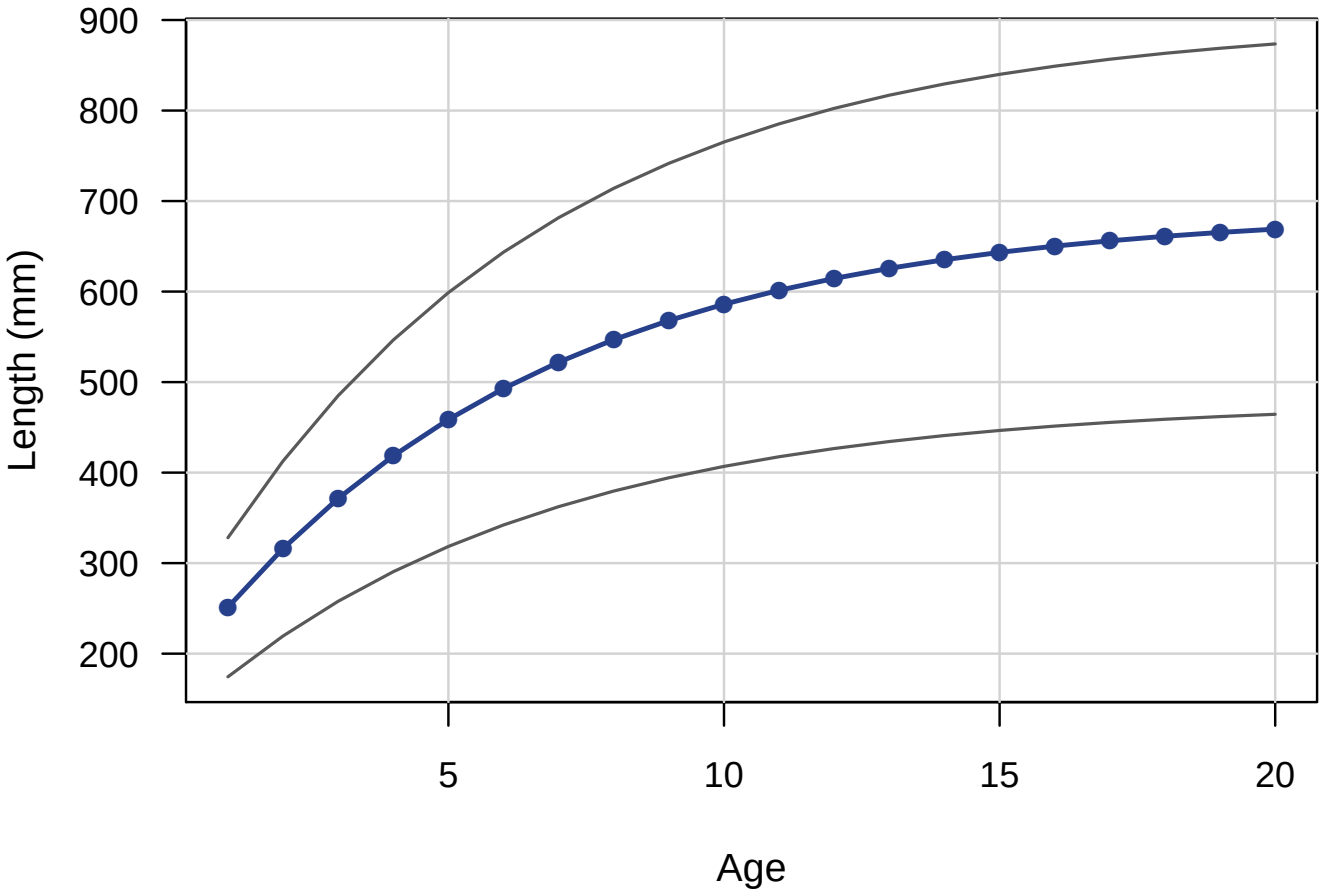
Data

General recreational lengths



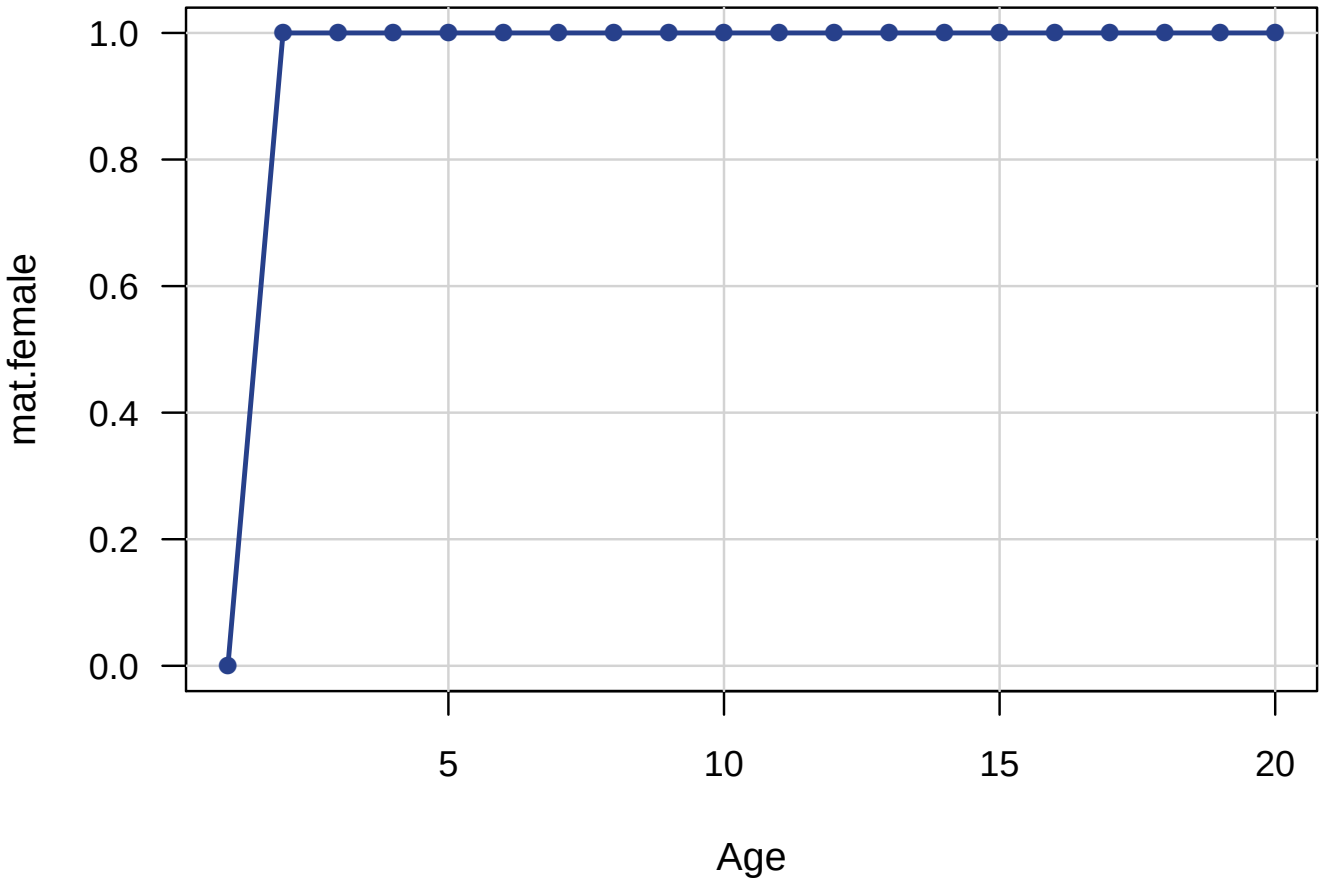
Life History

- A Von Bertalanffy growth model was supplied to the ASPM AW Base run using parameter estimates from a meta-analysis of similar species
- $K = 0.16$
- $L_\infty = 690$ mm
- $t_0 = -1.33$ yr



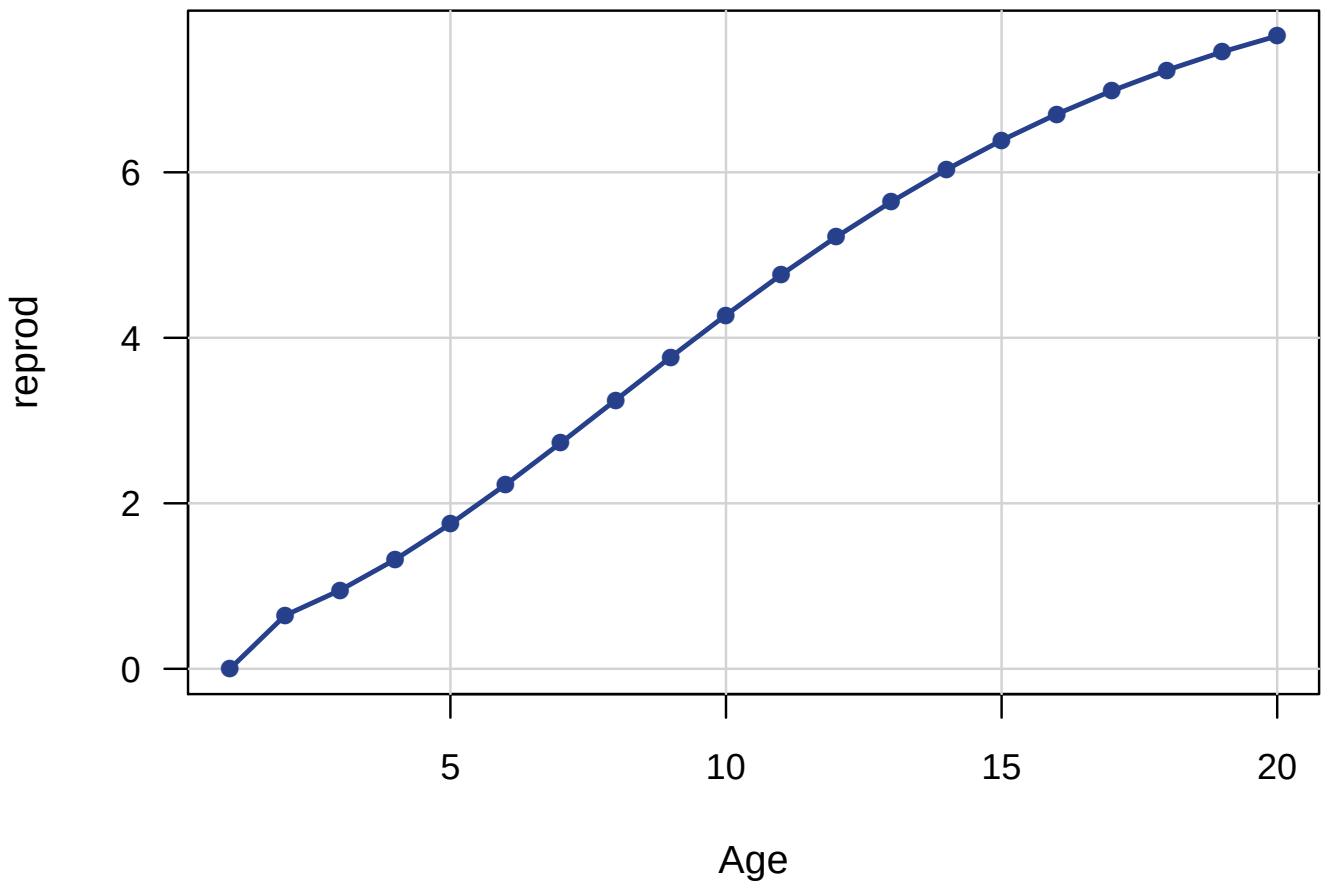
Life History

Female maturity by age



Life history

Reproductive output at age (million eggs)



Methods

Data

Life history traits at age

Table: Life history traits at age used in the age-structured production model for the Atlantic south of Cape Hatteras, and certain data limited methods in all regions. Length (FL, mm), weight (kg), proportion female (PFemale), proportion of females mature (PMature), Fecundity (millions of eggs), reproductive output, (Reprod=fecundity*PFemale*PMature), and natural mortality (M) at age.

ages	Age	Length	Weight	PFemale	PMature	Fecundity	Reprod	M
1	1	251	0.20	0.5	0.0		0.00	0.71
2	2	316	0.40	0.5	1.0	1.29	0.64	0.50
3	3	371	0.64	0.5	1.0	1.90	0.95	0.40
4	4	419	0.91	0.5	1.0	2.64	1.32	0.33
5	5	459	1.19	0.5	1.0	3.50	1.75	0.29
6	6	493	1.47	0.5	1.0	4.45	2.22	0.26
7	7	522	1.74	0.5	1.0	5.46	2.73	0.24
8	8	547	1.99	0.5	1.0	6.50	3.25	0.22
9	9	568	2.23	0.5	1.0	7.54	3.77	0.21
10	10	586	2.44	0.5	1.0	8.55	4.28	0.20
11	11	601	2.64	0.5	1.0	9.52	4.76	0.19
12	12	615	2.81	0.5	1.0	10.44	5.22	0.19
13	13	626	2.96	0.5	1.0	11.29	5.64	0.18
14	14	635	3.10	0.5	1.0	12.07	6.03	0.18
15	15	643	3.21	0.5	1.0	12.77	6.39	0.17
16	16	650	3.32	0.5	1.0	13.41	6.70	0.17
17	17	656	3.41	0.5	1.0	13.97	6.99	0.17
18	18	661	3.48	0.5	1.0	14.47	7.24	0.17
19	19	665	3.55	0.5	1.0	14.91	7.46	0.16
20	20	669	3.61	0.5	1.0	15.30	7.65	0.16

Methods

Sensitivity

Sensitivity of AW Base model to age at maturity

- ASPM S01: 100% female maturity at age-6.
- ASPM S02: 100% female maturity at age-12.

Methods

Sensitivity

Sensitivity of AW Base model to natural mortality

- ASPM S03: Constant $M = 0.1$ ($t_{\max} = 40$; use Hoenig (1983) equation).
- ASPM S04: Constant $M = 0.25$ ($t_{\max} = 26$; use Then et al. (2014) equation).

Methods

Sensitivity

Sensitivity of AW Base model to age at maturity and natural mortality

- ASPM S05: Constant $M = 0.1$, 100% female maturity at age-6.

Methods

Sensitivity

Sensitivity of AW Base model to Golden Tilefish life history parameters

- ASPM S06: Golden Tilefish growth model, M, and female maturity vector.
- ASPM S07: Golden Tilefish growth model only

Methods

Sensitivity

Sensitivity of AW Base model to SEDAR 32 Blueline Tilefish settings

- ASPM S08: SEDAR 32 Blueline Tilefish growth model, M, and female maturity vector.
- ASPM S09: SEDAR 32 Blueline Tilefish growth model, M, and female maturity vector. Include length composition data and removals both north and south of Cape Hatteras.
- ASPM S10: SEDAR 32 Blueline Tilefish growth model, M, and female maturity vector. Include length composition data and removals both north and south of Cape Hatteras. Fit recruitment deviations.

Methods

Sensitivity

Sensitivity of AW Base model to including length composition data and removals north of Cape Hatteras.

- ASPM S11: Include length composition data and removals north (and south) of Cape Hatteras.

Methods

Sensitivity

Sensitivity of RW Ref model to indices

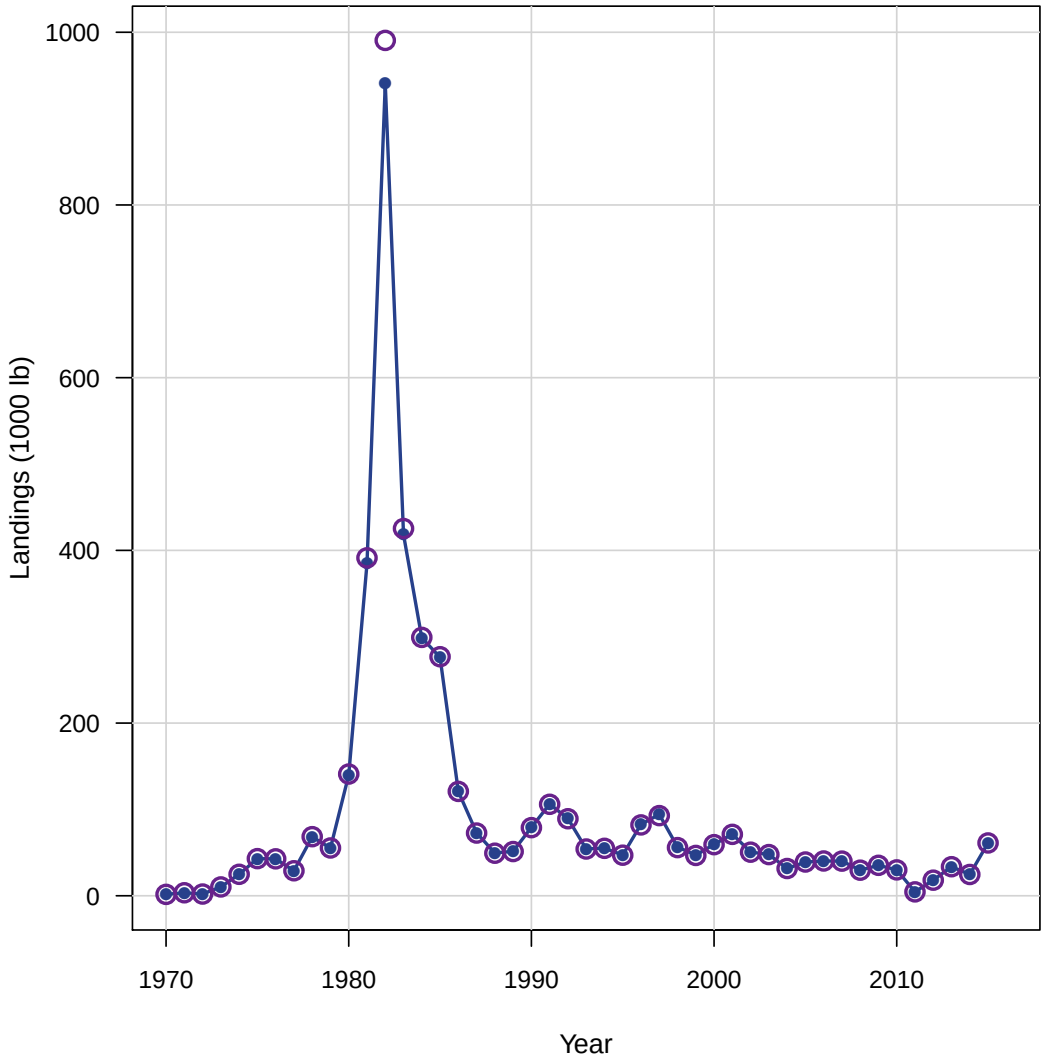
- ASPM S12: Include only handline and longline indices
- ASPM S13: Include only handline index
- ASPM S14: Include only longline index
- ASPM S15: Include only headboat index

Results

AW Base Run

Fit to removals

Commercial handline

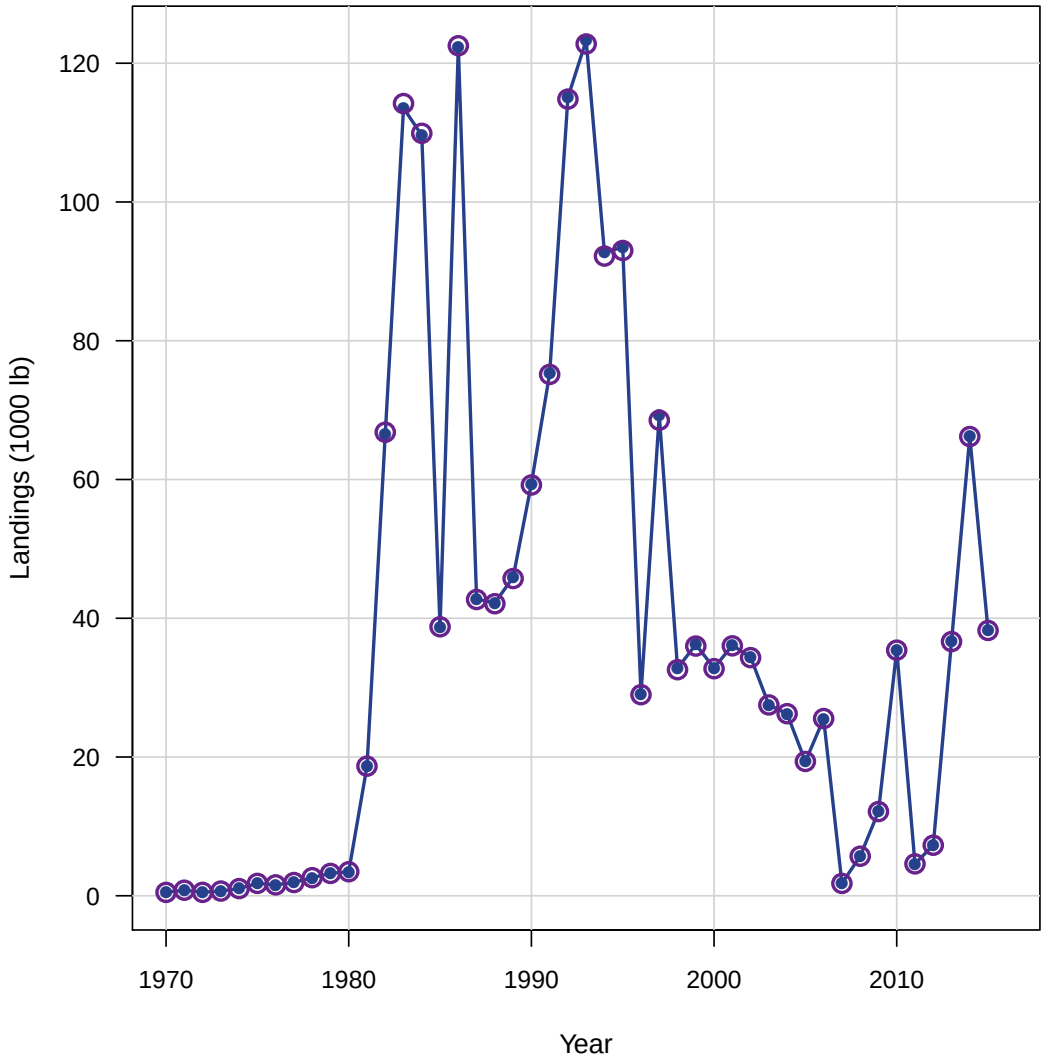


Results

AW Base Run

Fit to removals

Commercial longline

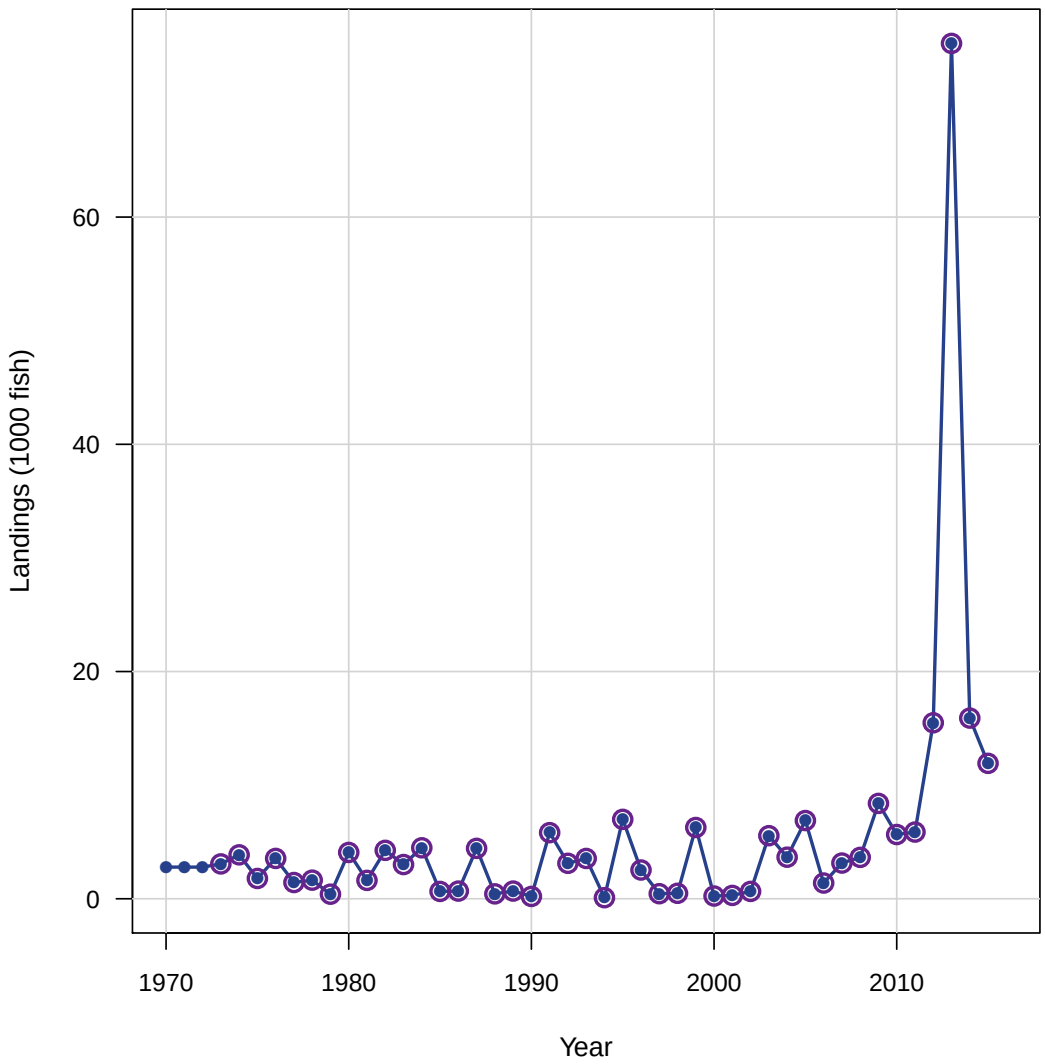


Results

AW Base Run

Fit to removals

General recreational

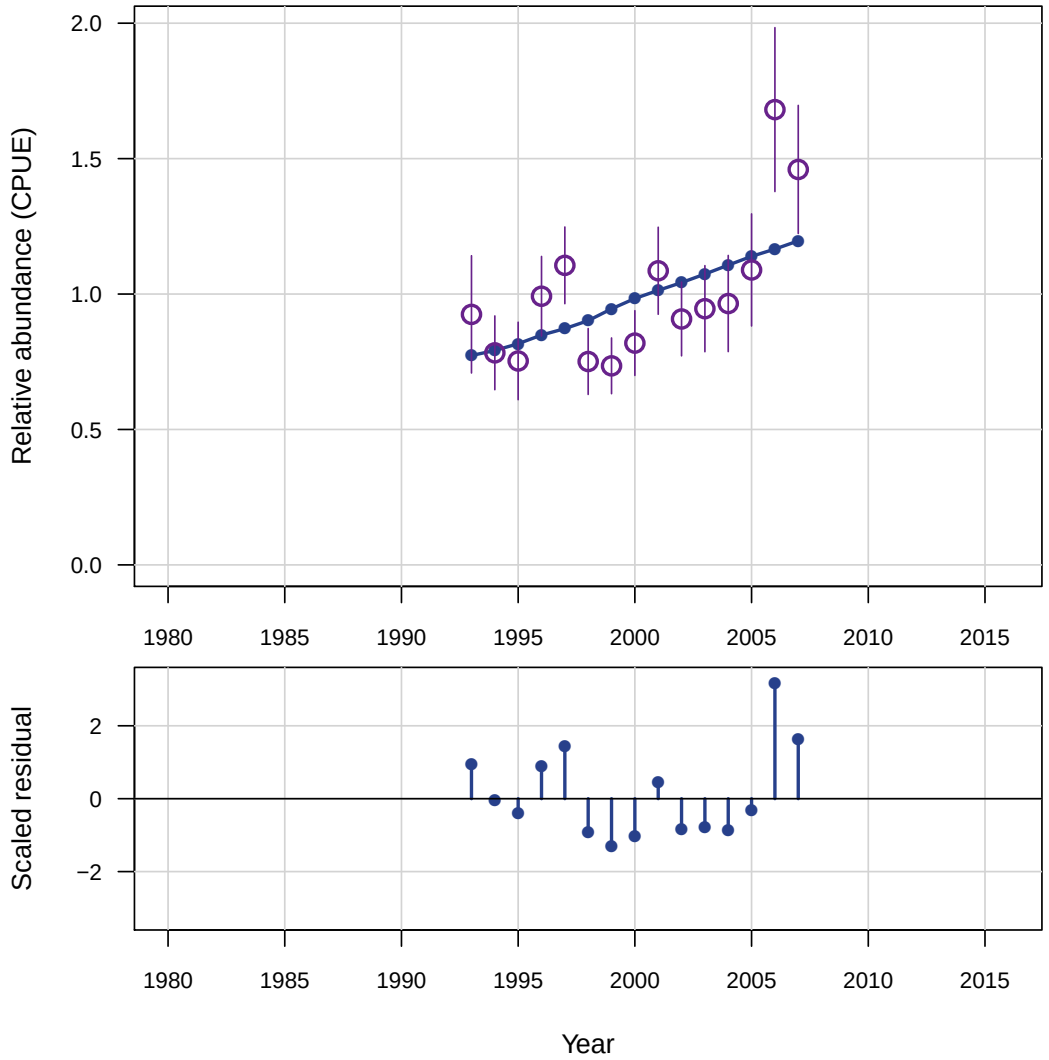


Results

AW Base Run

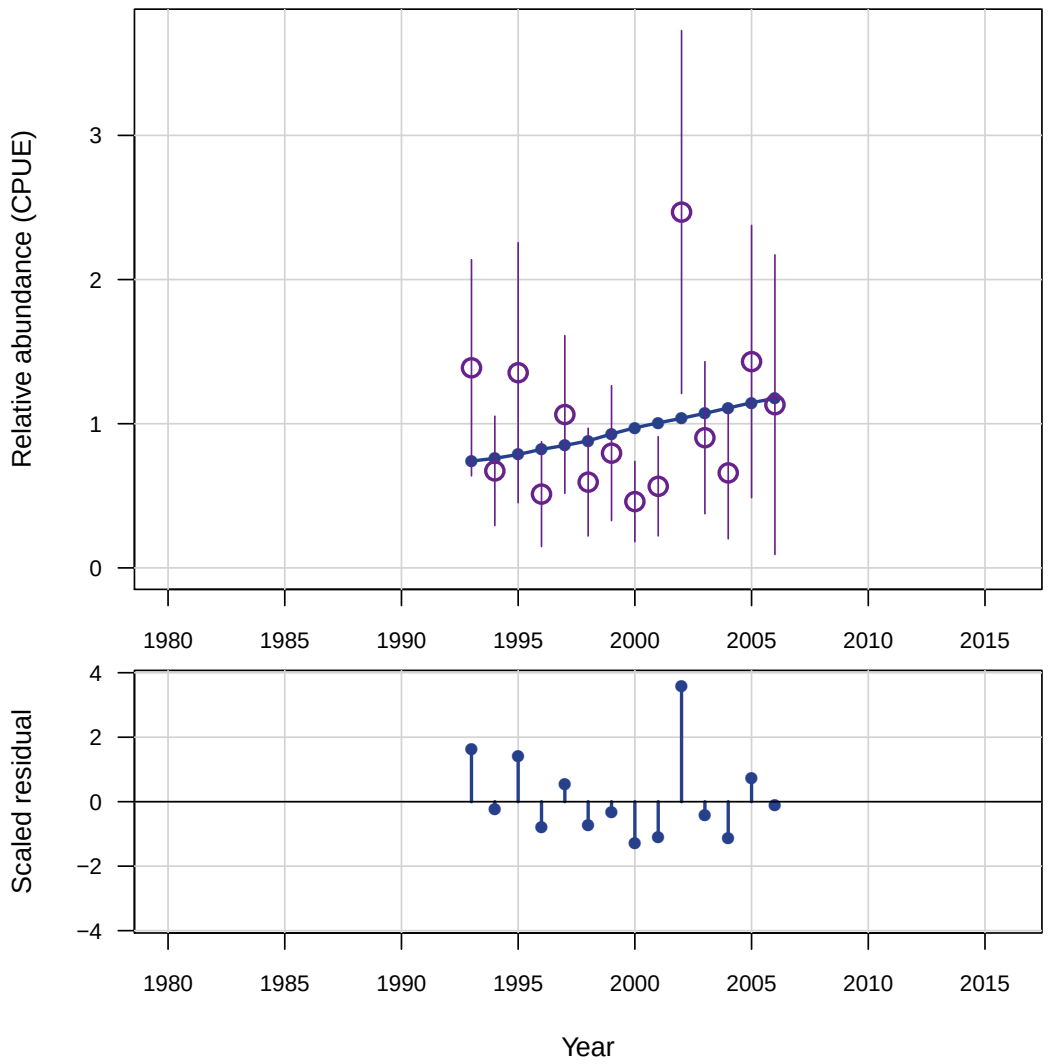
Fit to indices

Commercial handline



Fit to indices

Commercial longline

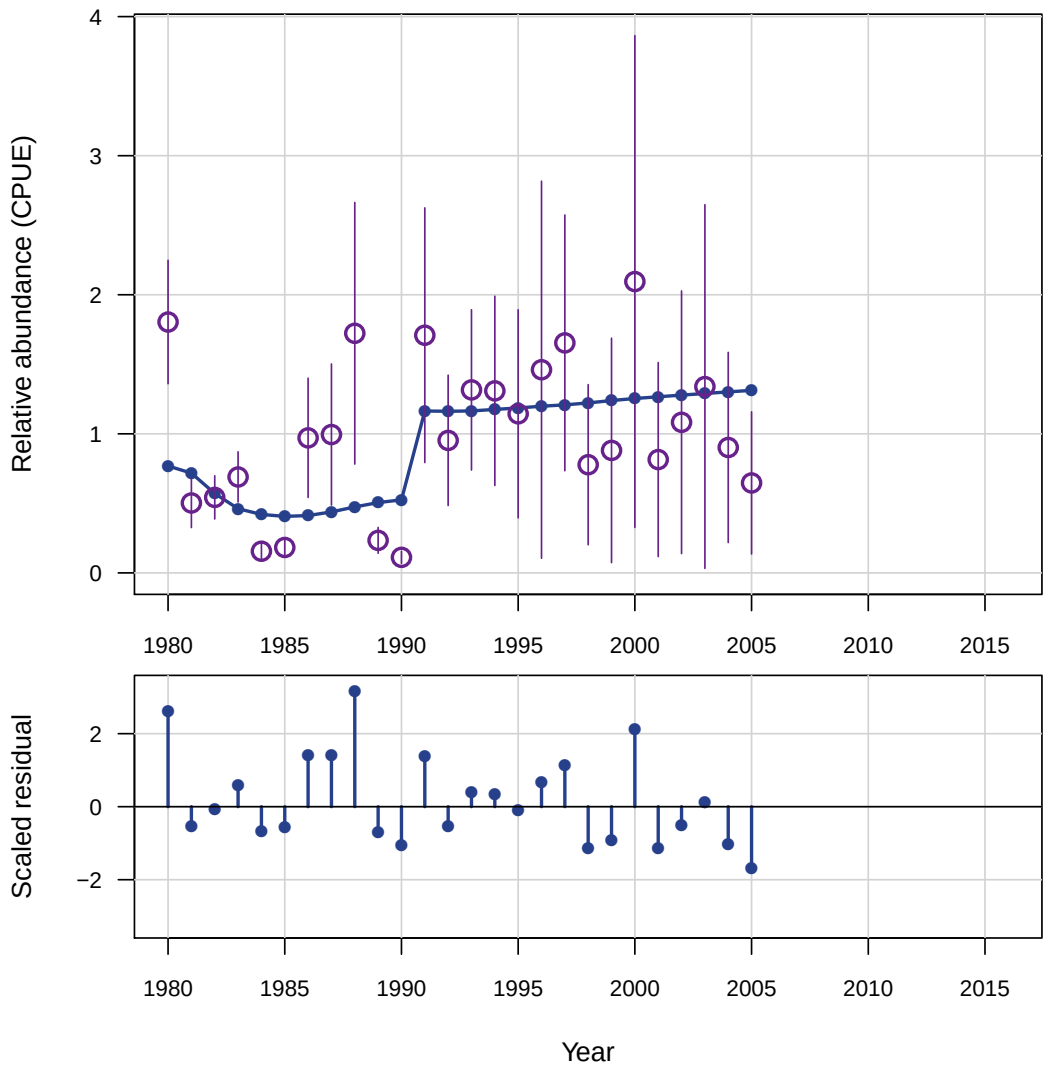


Results

AW Base Run

Fit to indices

Headboat (recreational)

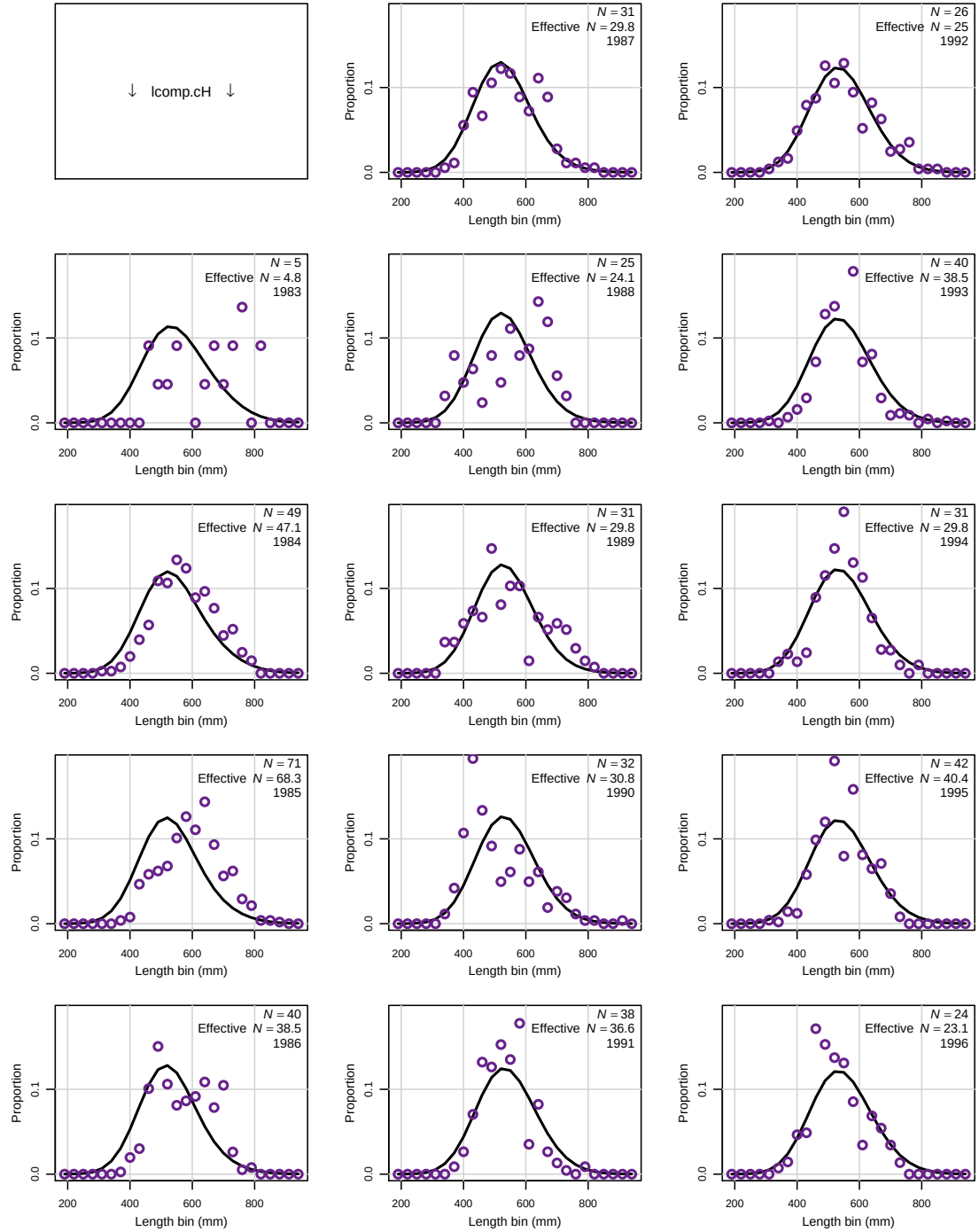


Results

AW Base Run

Fit to lengths
Page 1:

Commercial handline 1983-1996

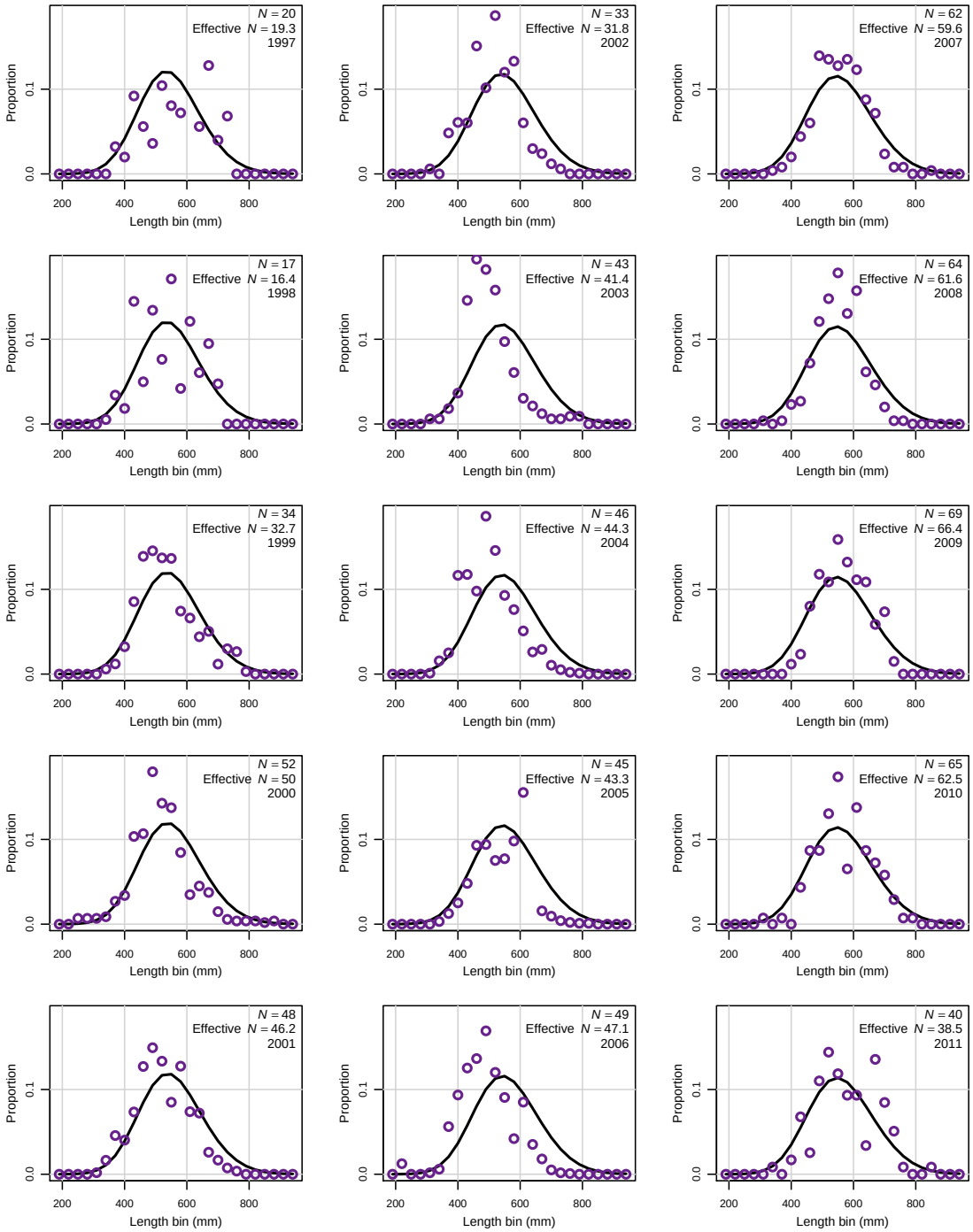


Results

AW Base Run

Fit to lengths
Page 2:

Commercial handline 1997-2011



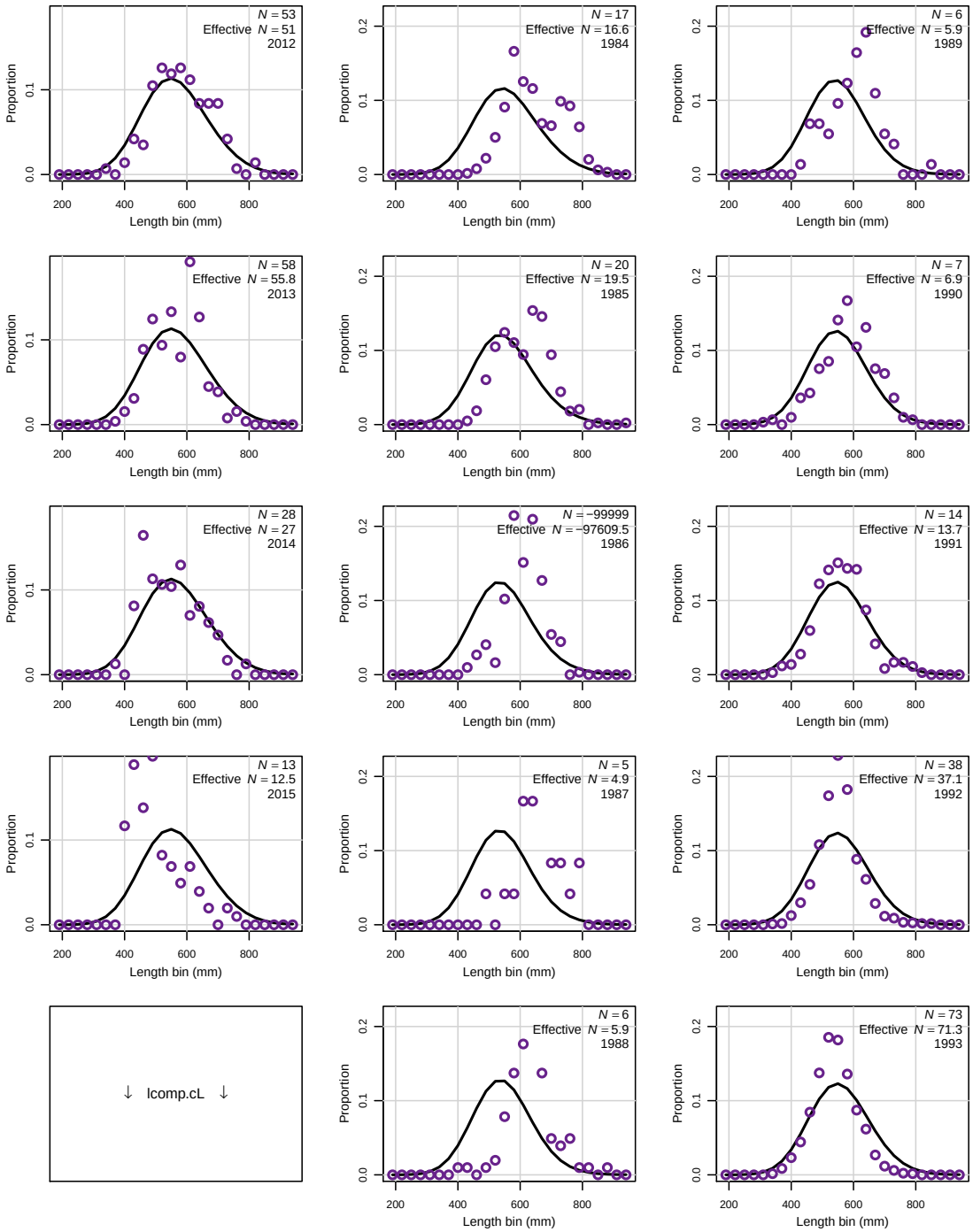
Results

AW Base Run

Fit to lengths
Page 3:

Commercial handline 2012-2015

Commercial longline 1984-1993



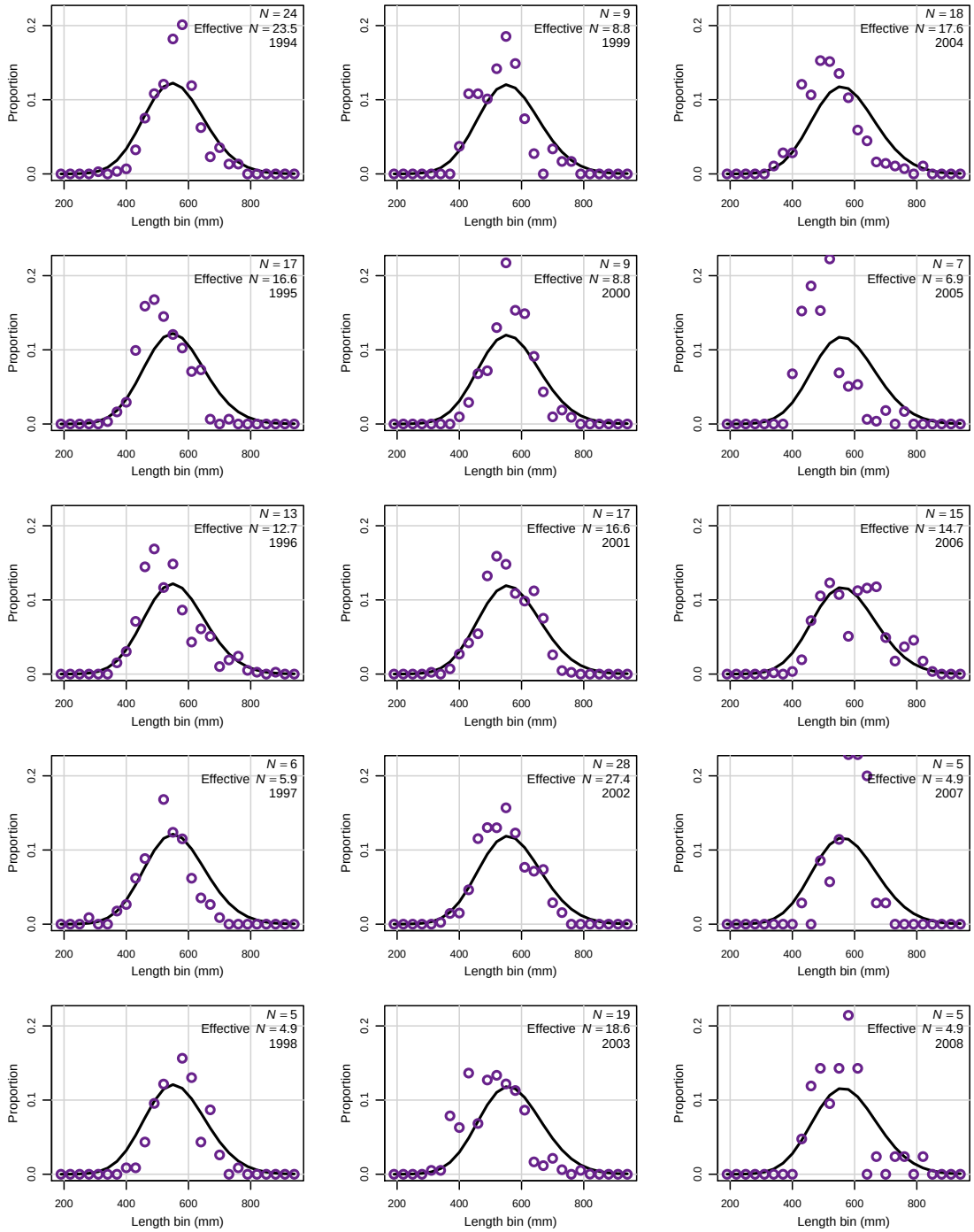
Results

AW Base Run

Fit to lengths

Page 4:

Commercial longline 1994-2008



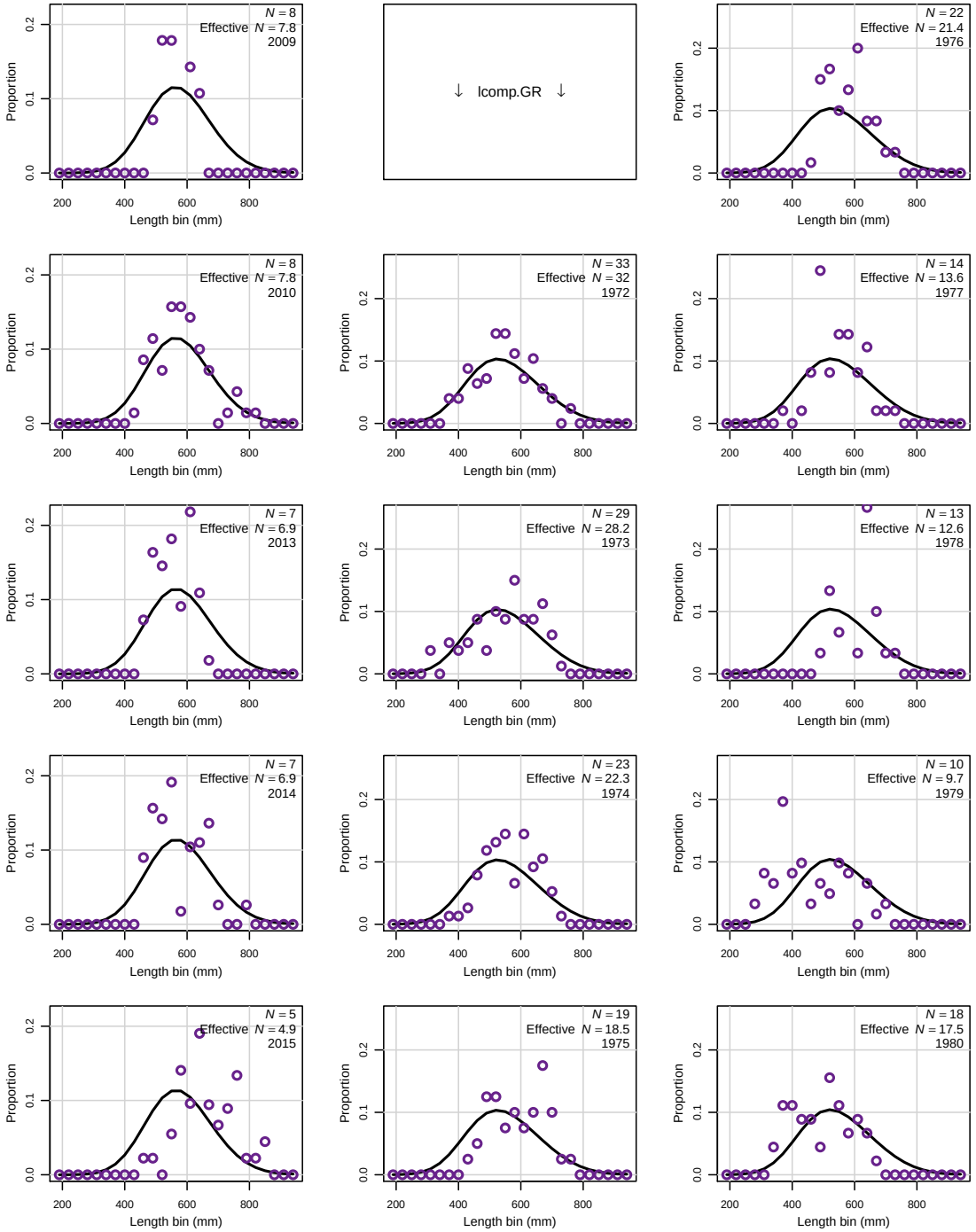
Results

AW Base Run

Fit to lengths
Page 5:

Commercial longline 2009-2015

General recreational 1972-1980

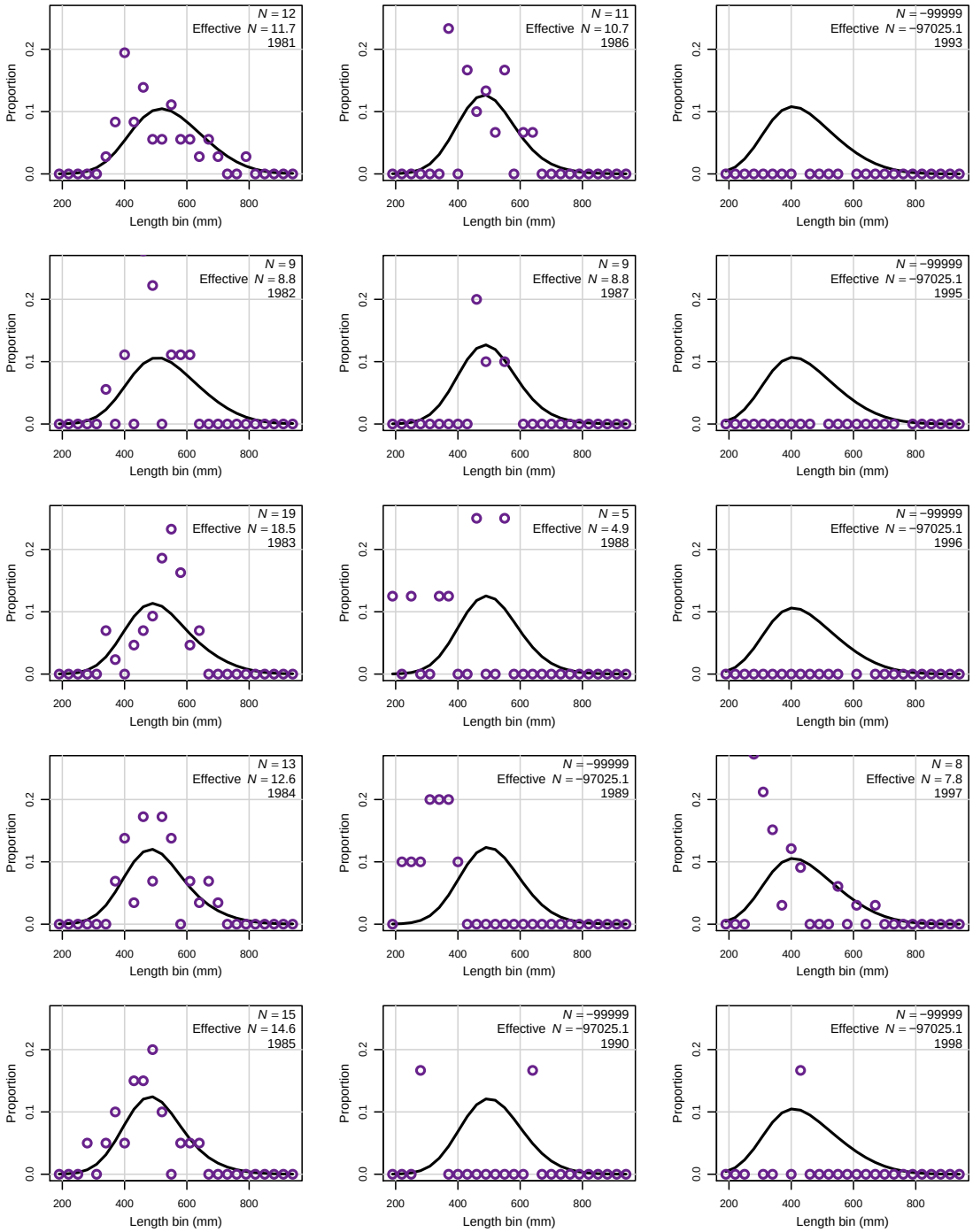


Results

AW Base Run

Fit to lengths
Page 6:

General recreational 1981-1998



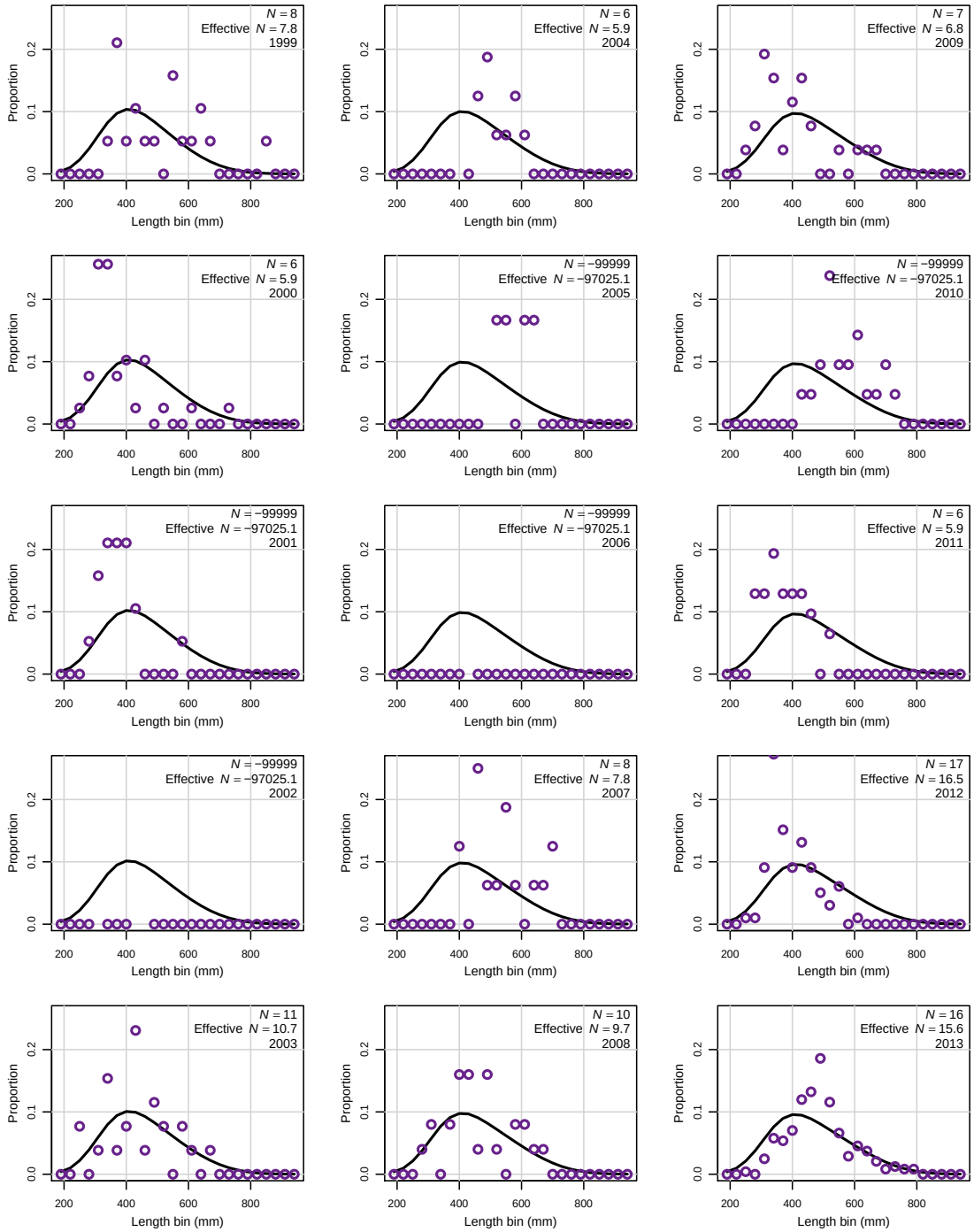
Results

AW Base Run

Fit to lengths

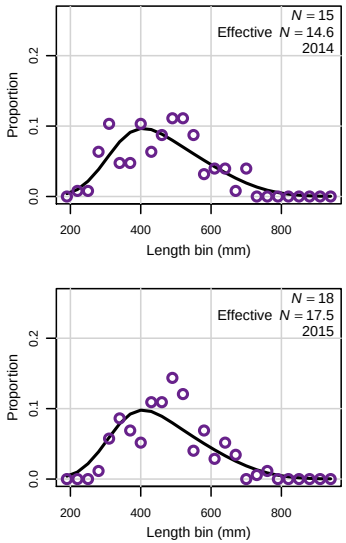
Page 7:

General recreational 1999-2013



Results

AW Base Run



Fit to lengths

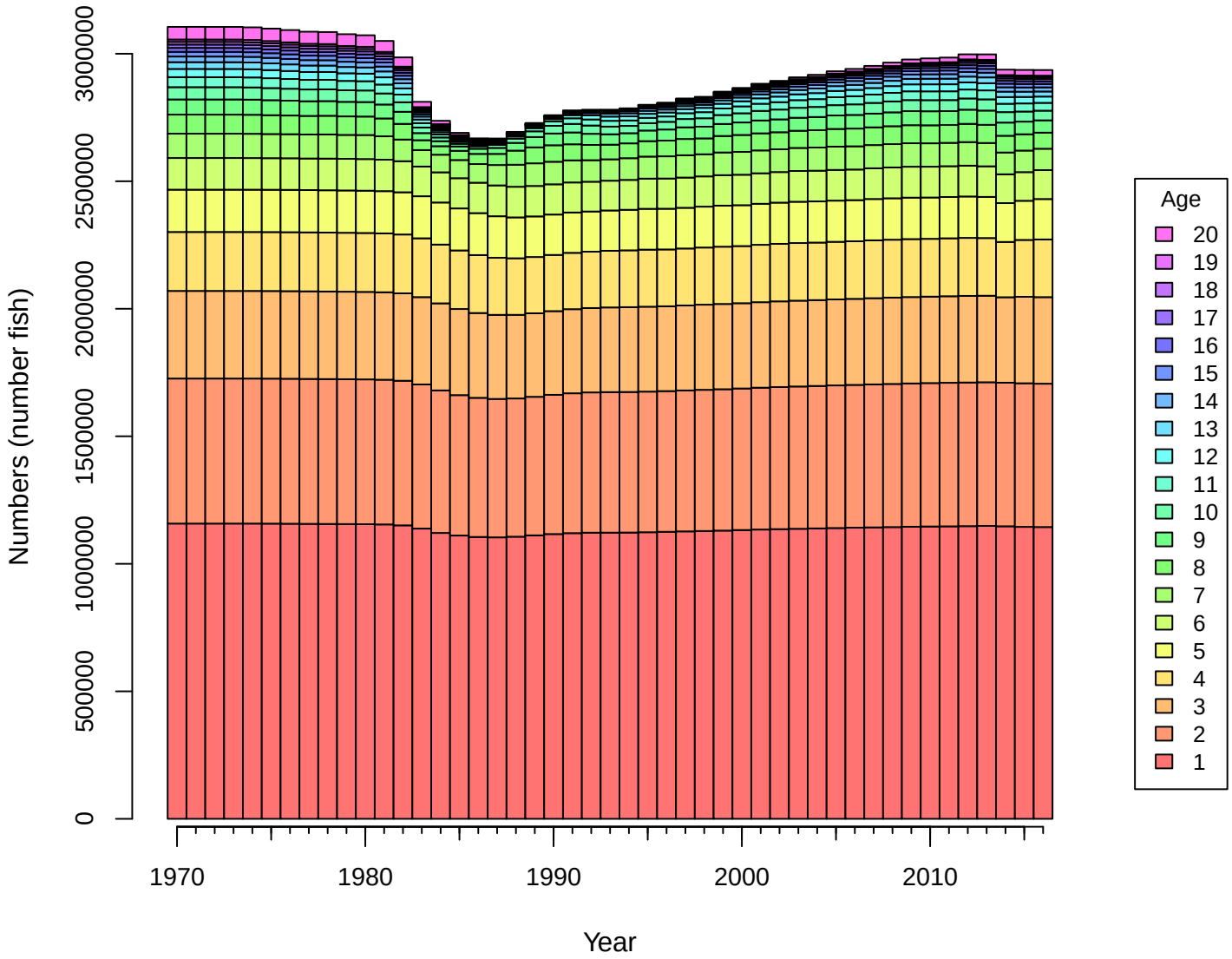
Page 8:

General recreational 2014-2015

Results

AW Base Run

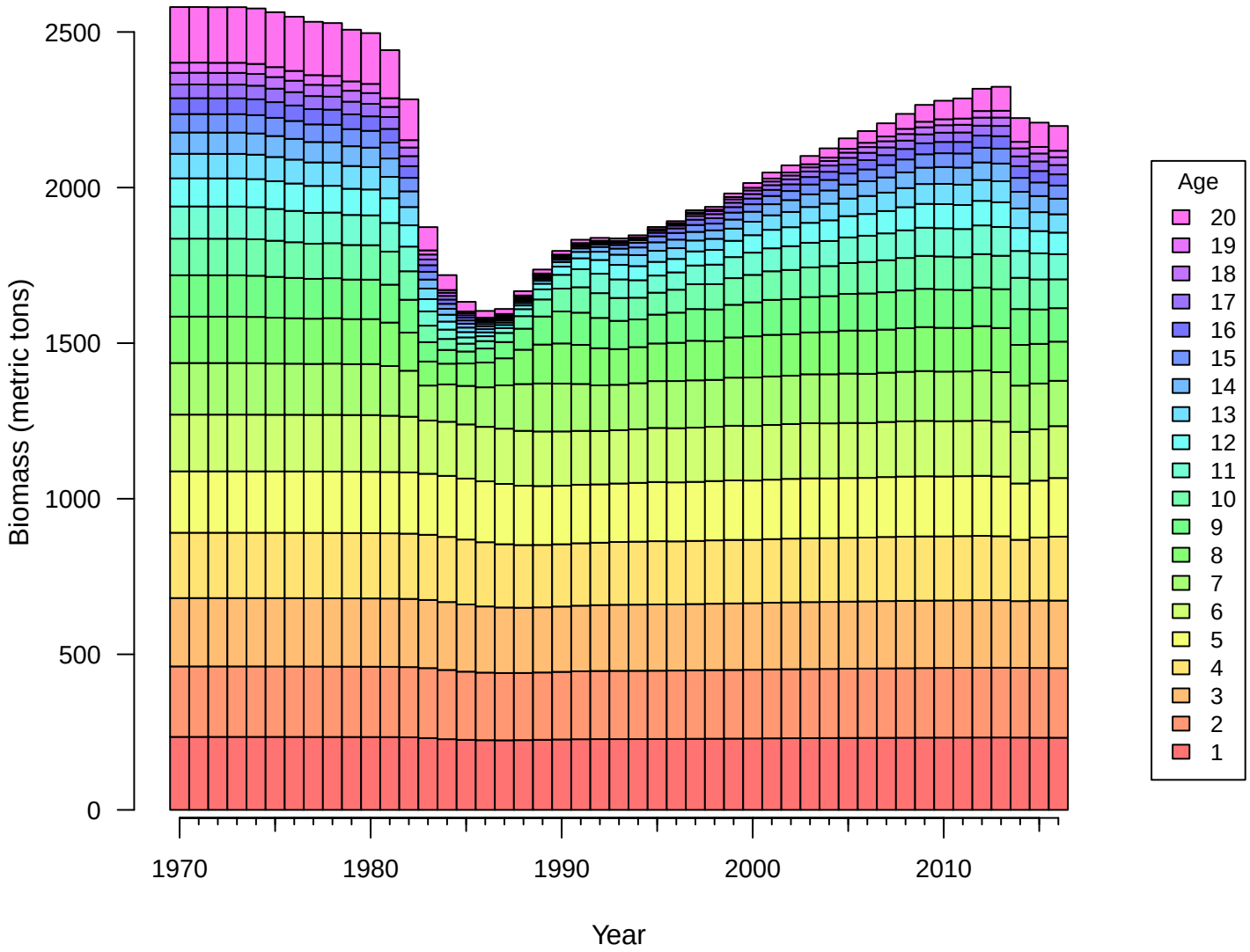
Estimated abundance at age at start of year



Results

AW Base Run

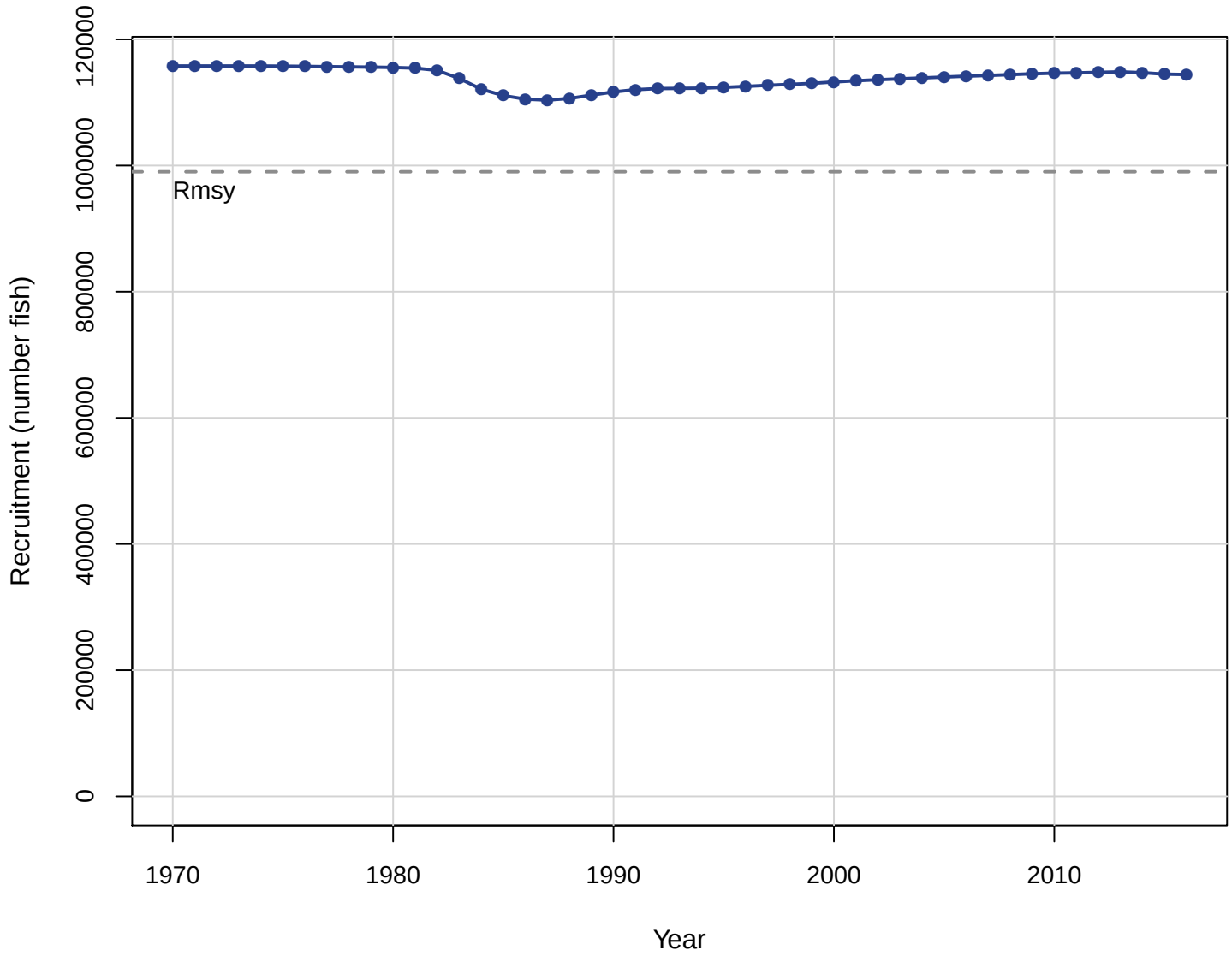
Estimated biomass at age at start of year



Results

AW Base Run

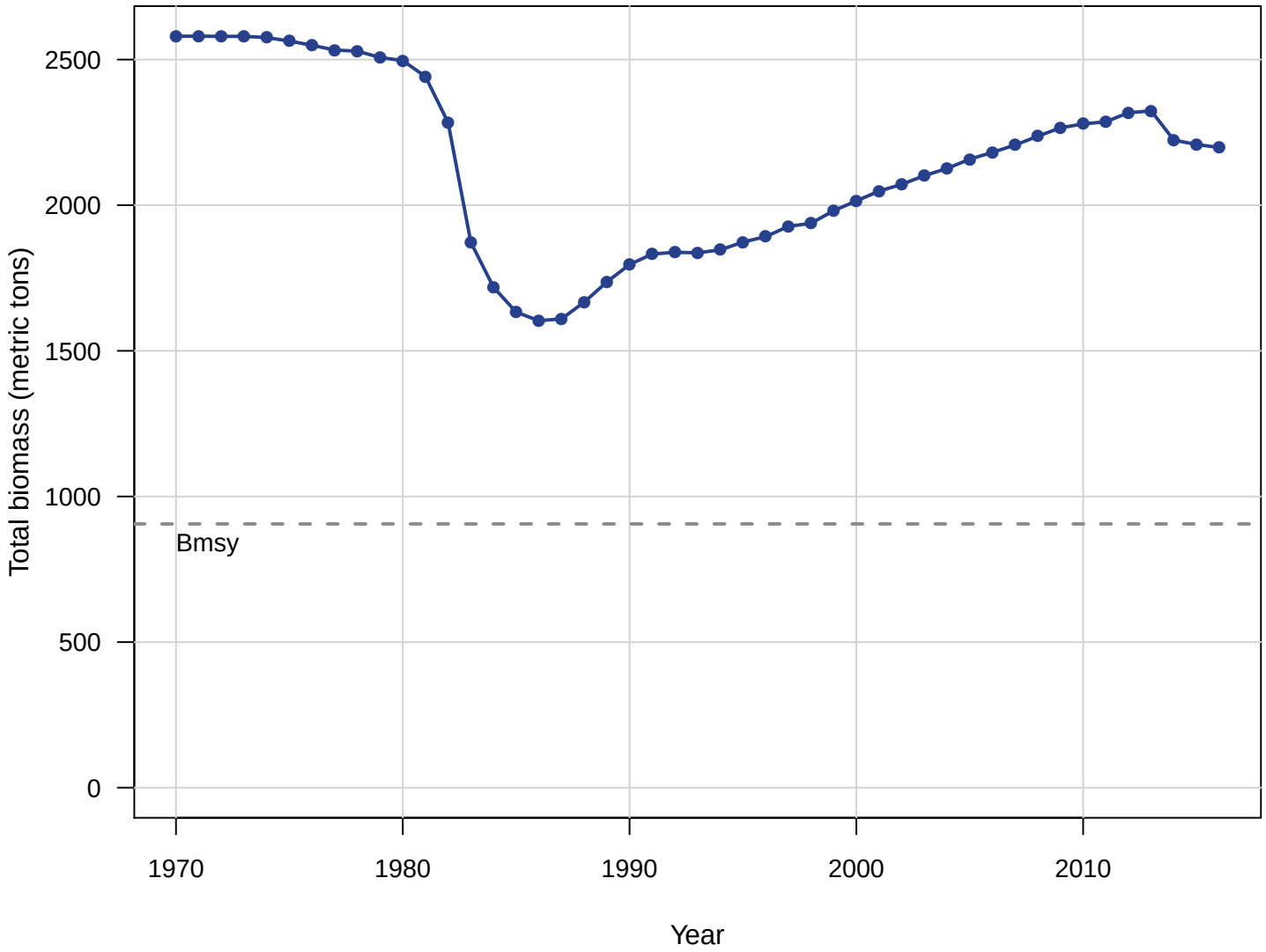
Estimated recruitment of age-1 fish



Results

AW Base Run

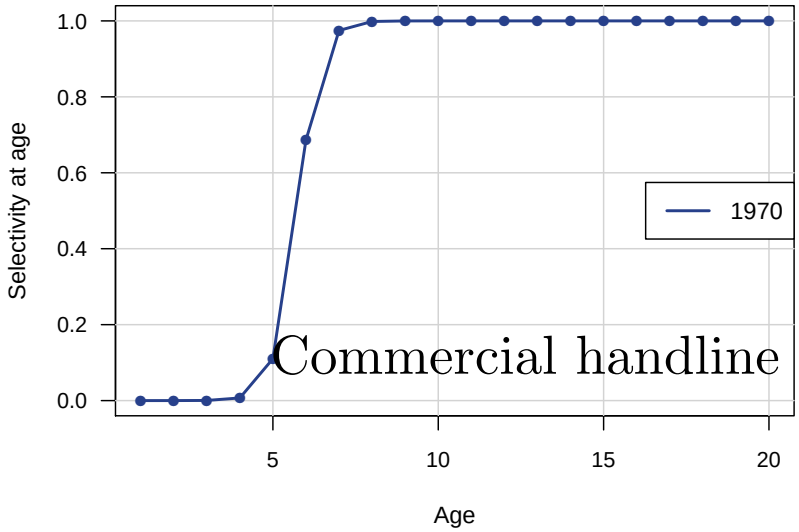
Estimated total biomass

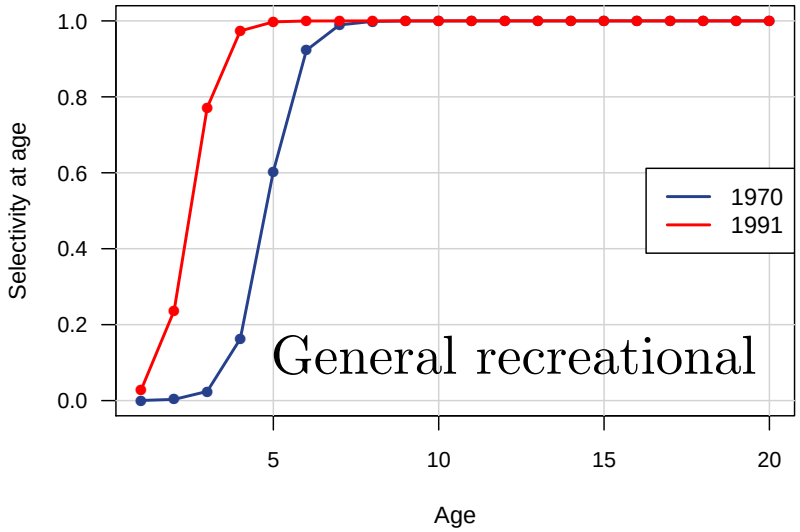


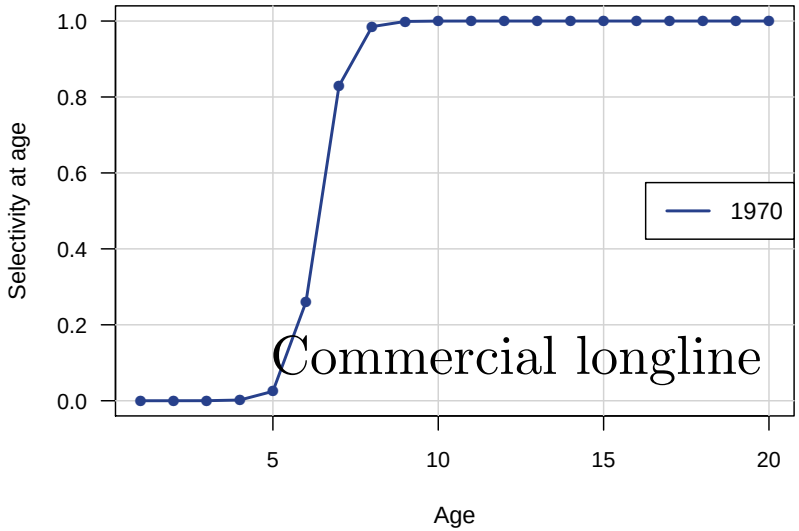
Results

AW Base Run

Estimated selectivity at age

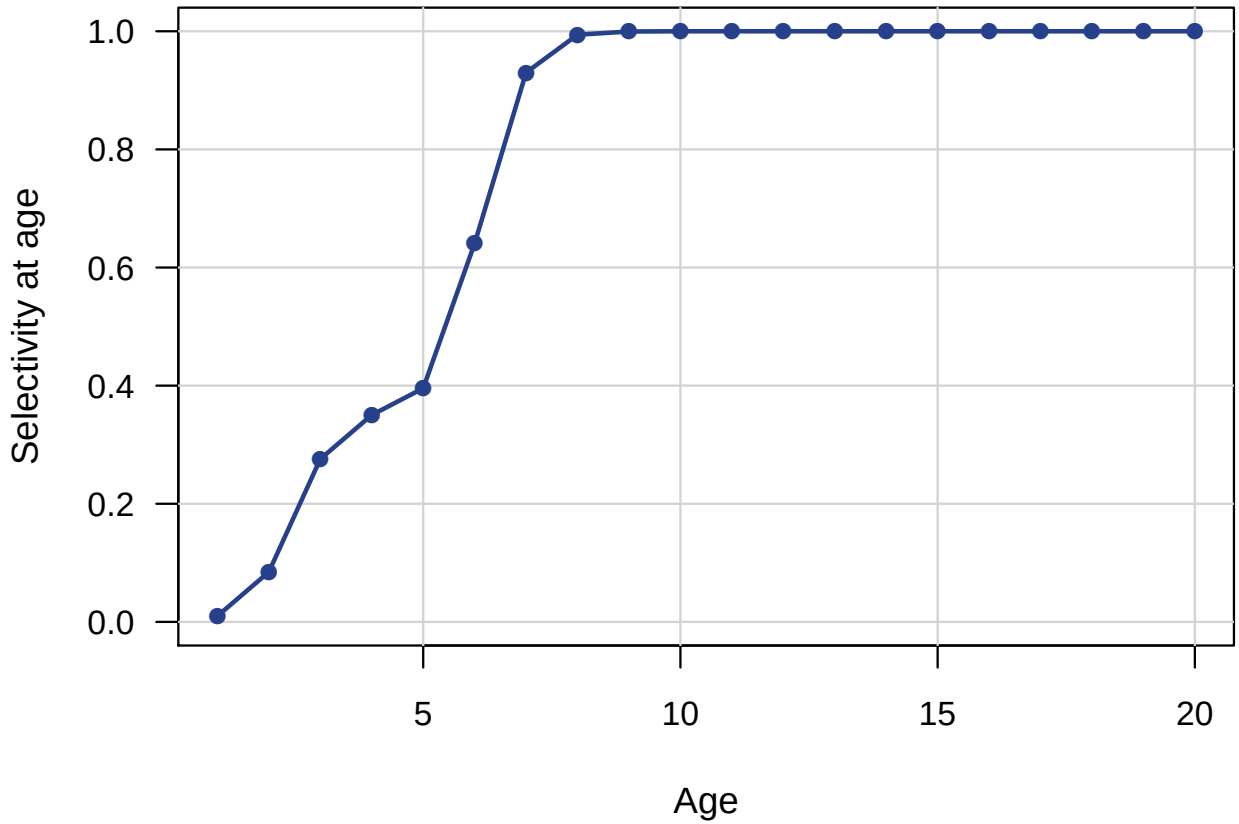






Estimated average selectivity at age for terminal year (2015)

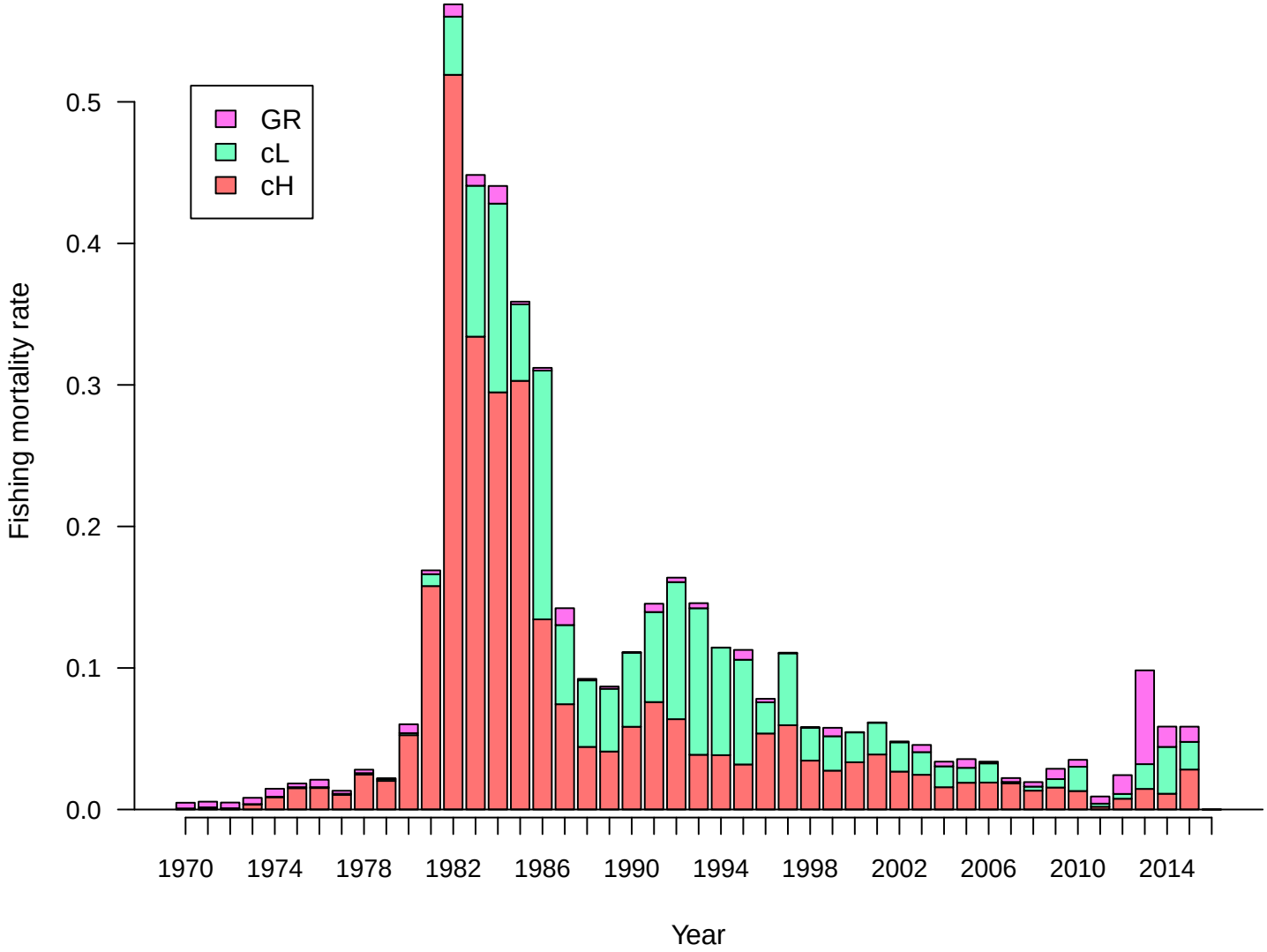
- Weighted by geometric mean F from the last three years (2013-2015)



Results

AW Base Run

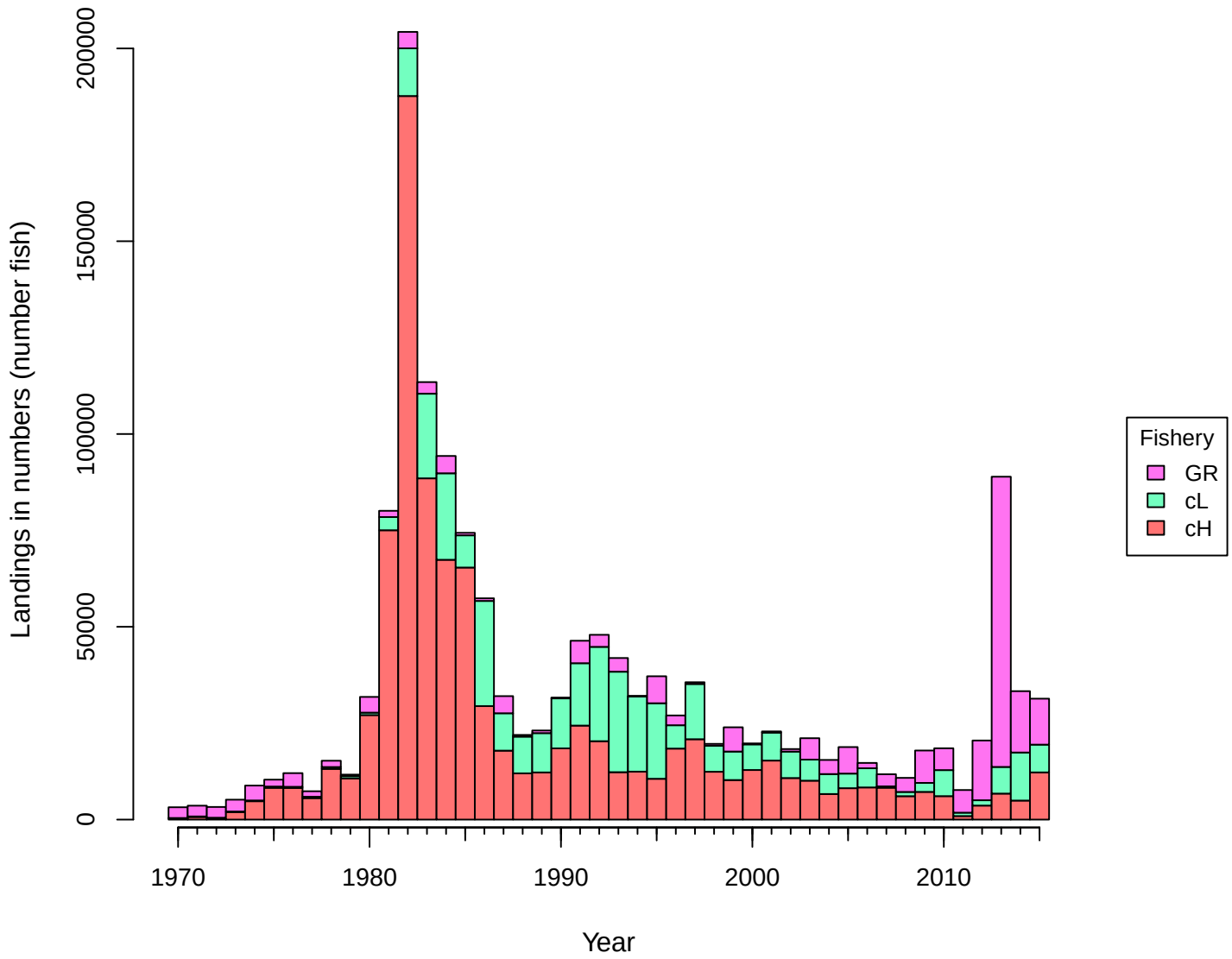
Estimated fully selected fishing mortality rates by fleet



Results

AW Base Run

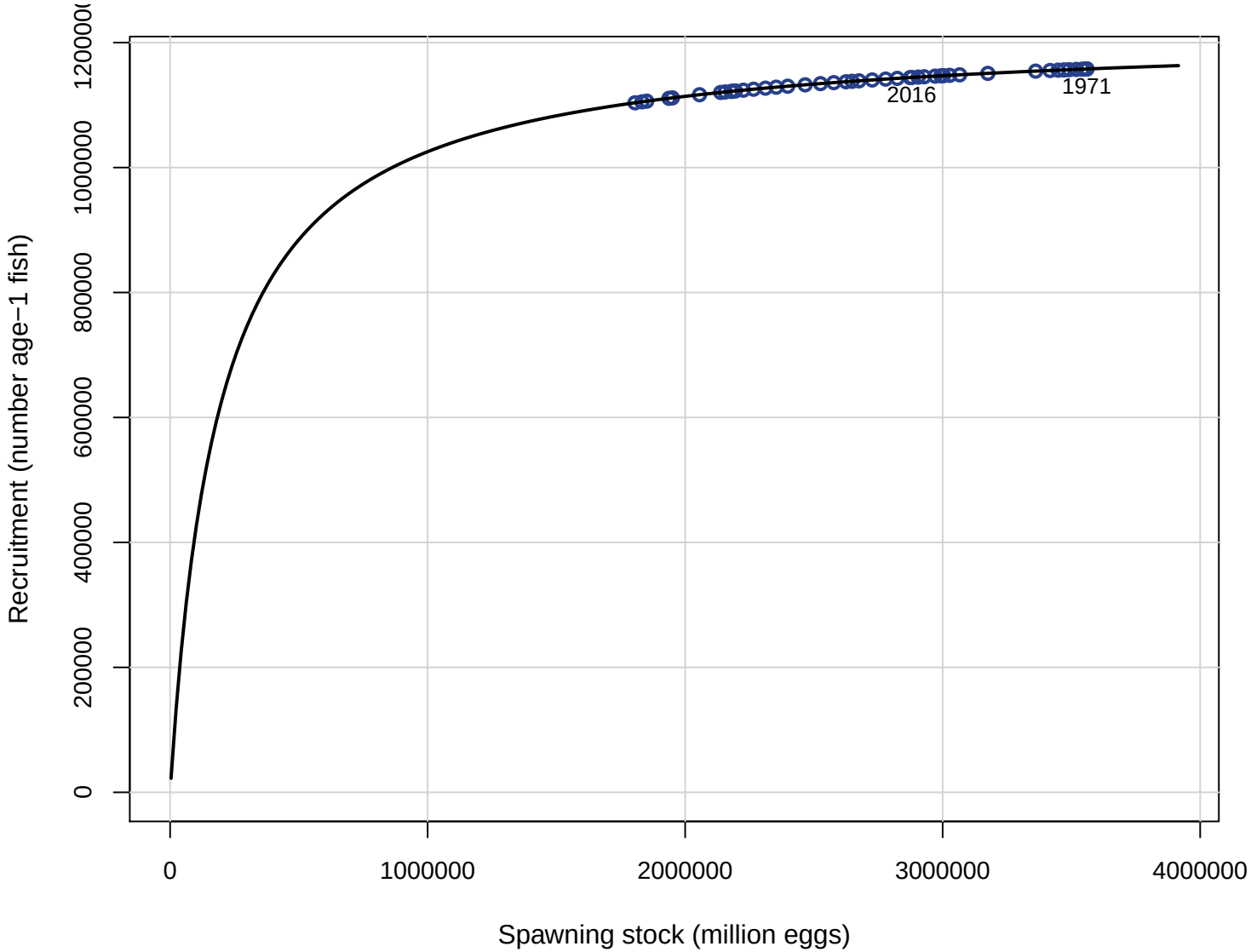
Estimated removals in numbers by fleet



Results

AW Base Run

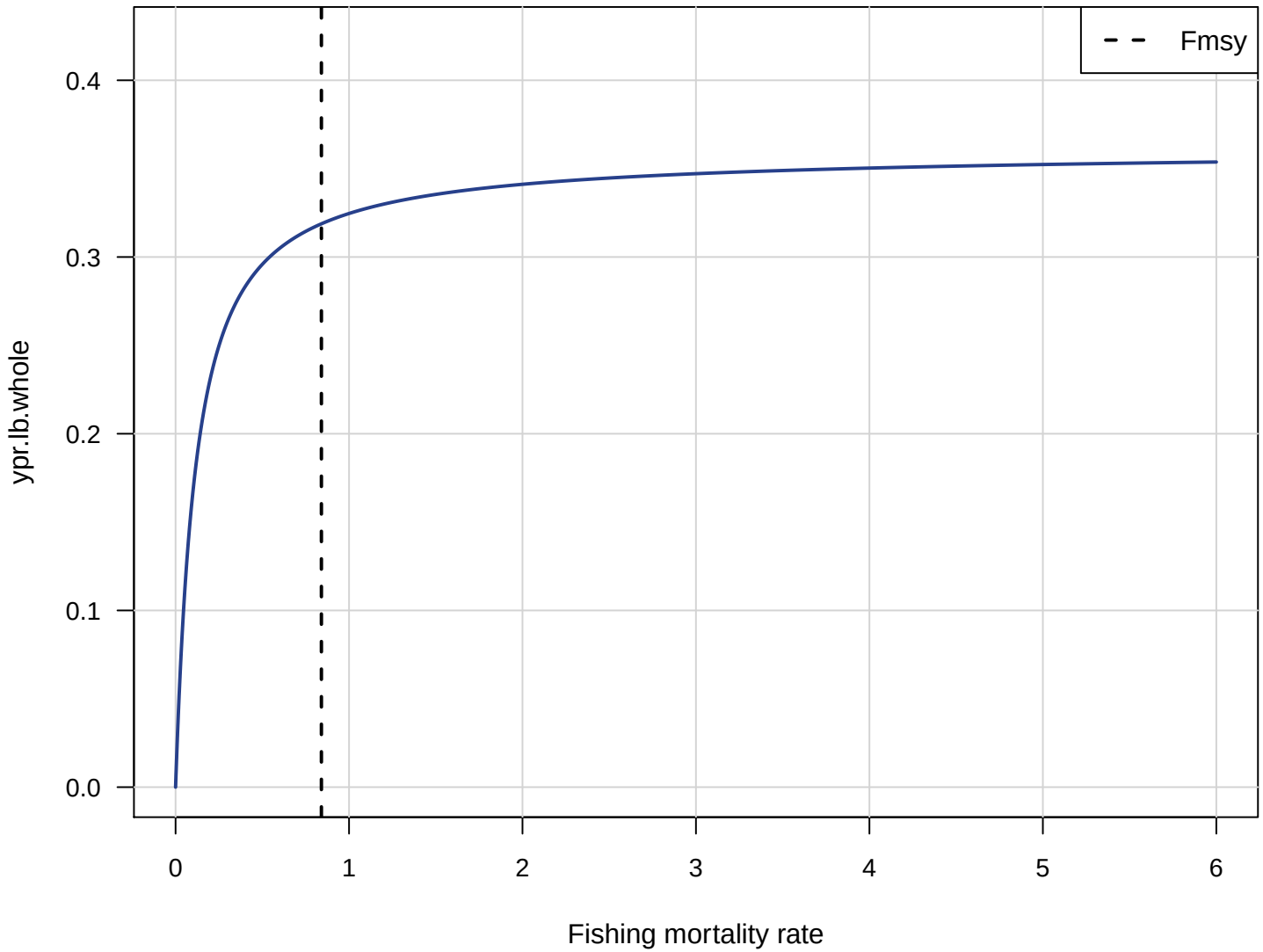
Beverton–Holt spawner-recruit curve



Results

AW Base Run

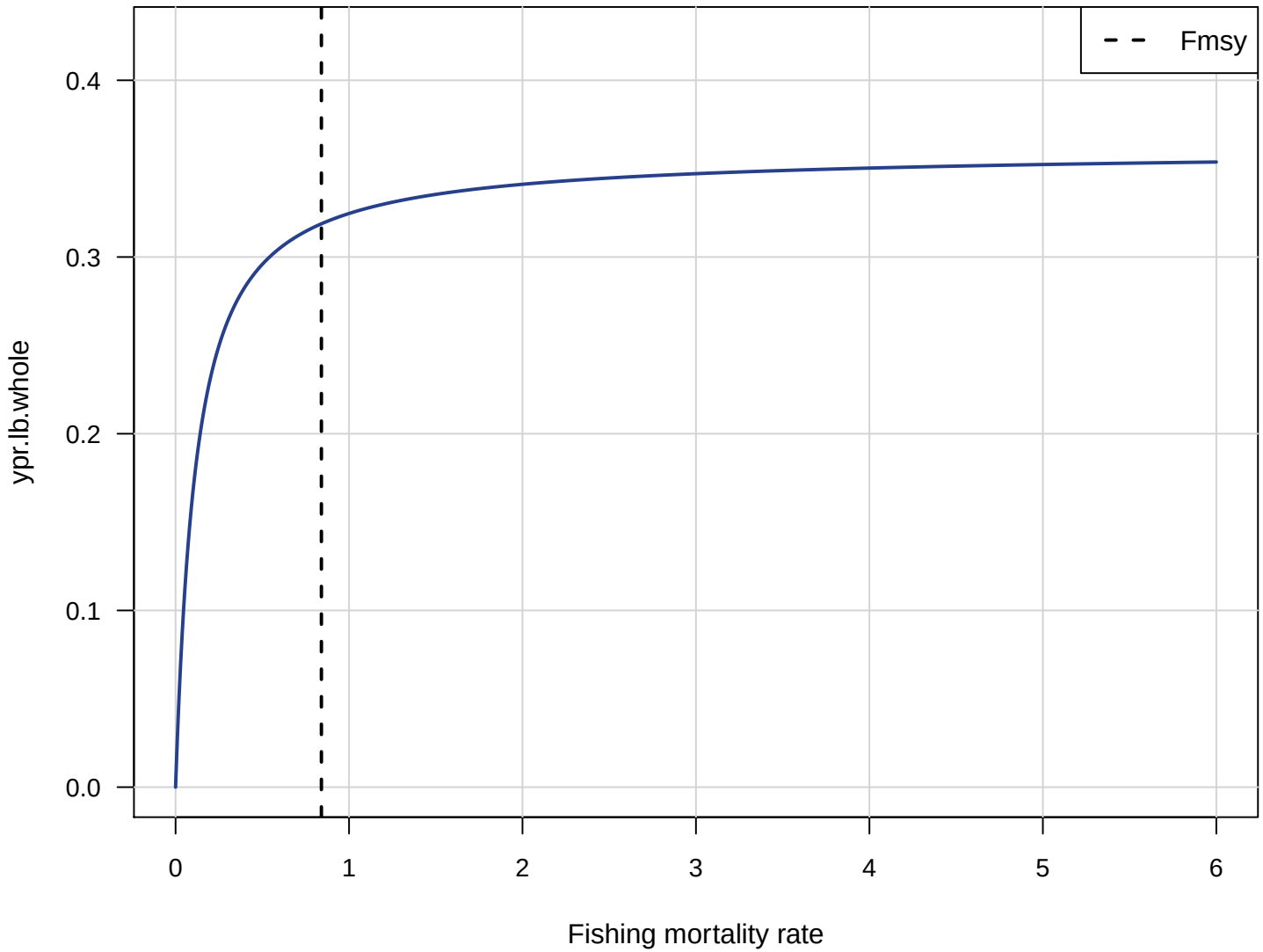
Yield per recruit at F



Results

AW Base Run

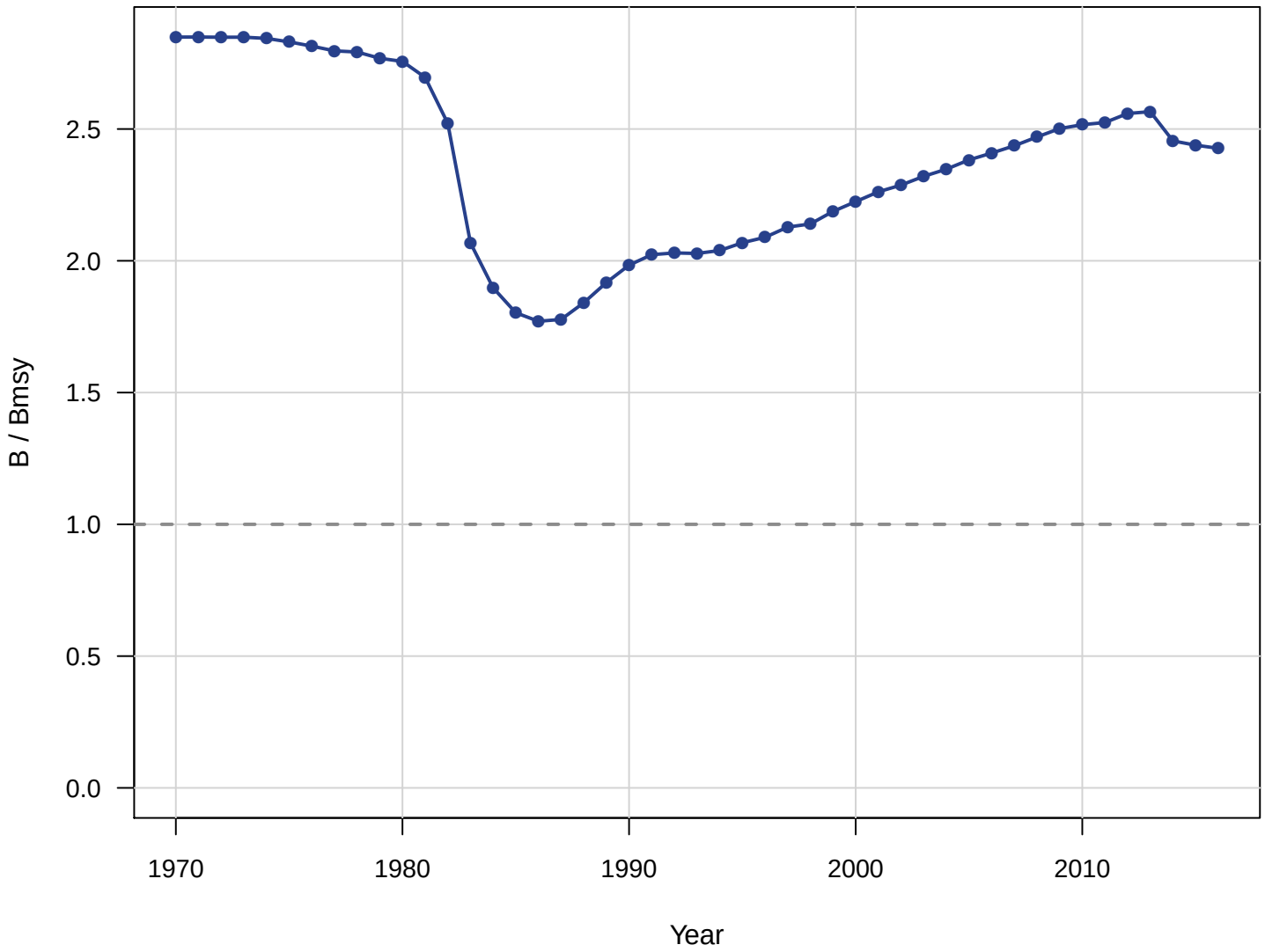
Yield per recruit at F



Results

AW Base Run

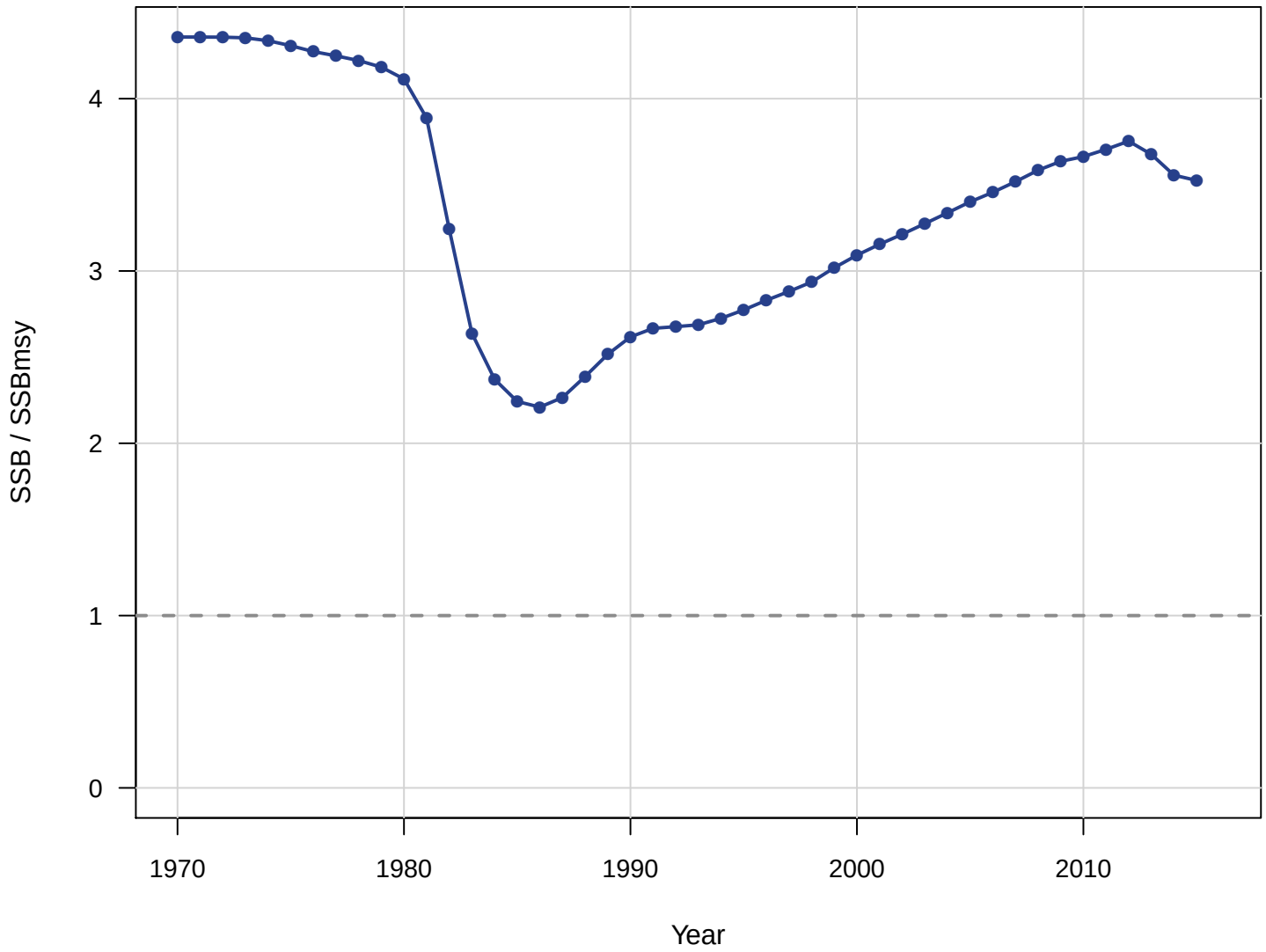
Total biomass relative to biomass at F_{MSY} (B_{MSY})



Results

AW Base Run

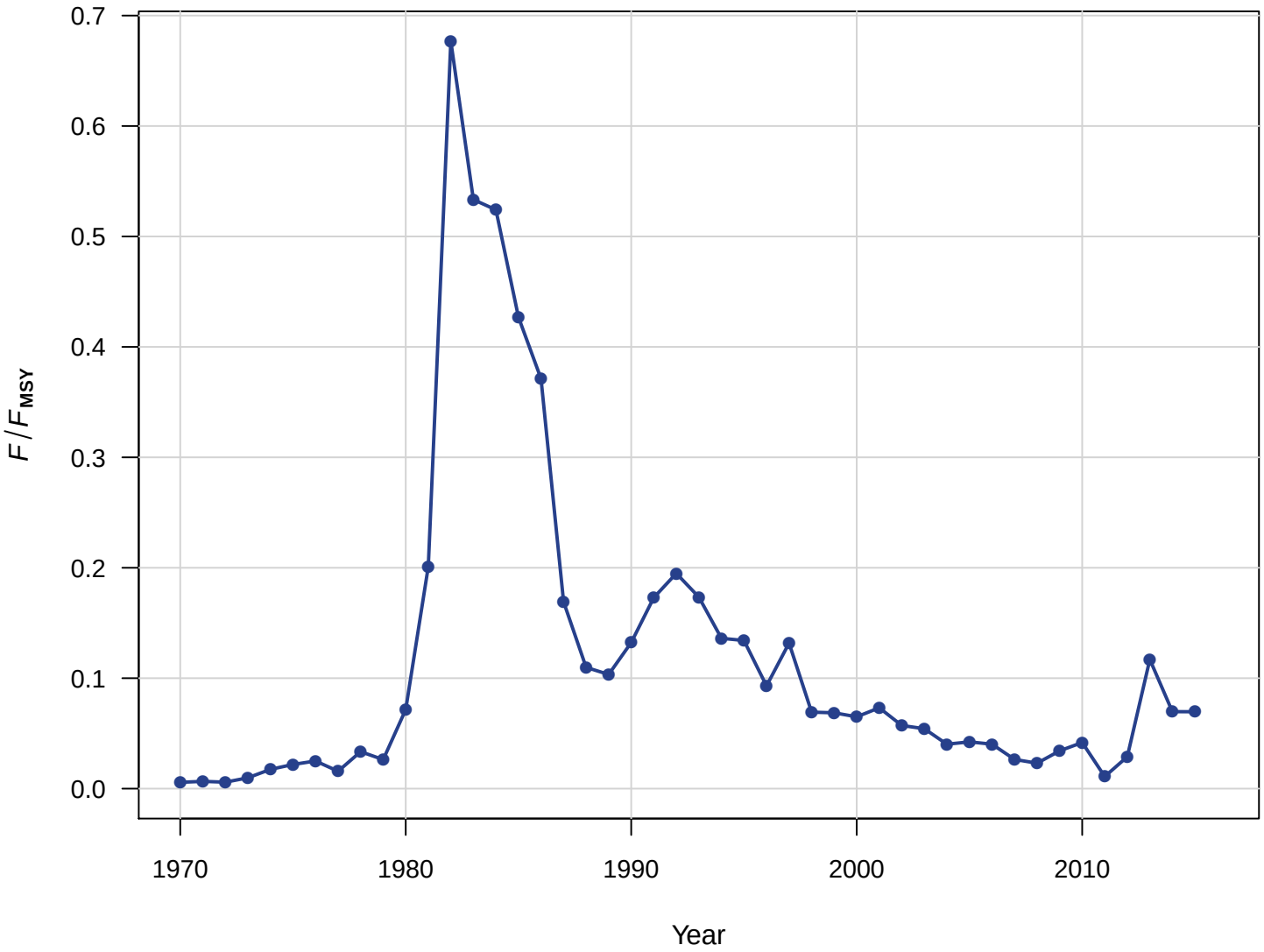
Spawning biomass relative to SSB_{MSY}



Results

AW Base Run

F relative to F_{MSY}



Results

AW Base Run

Benchmarks relative to F_{MSY}

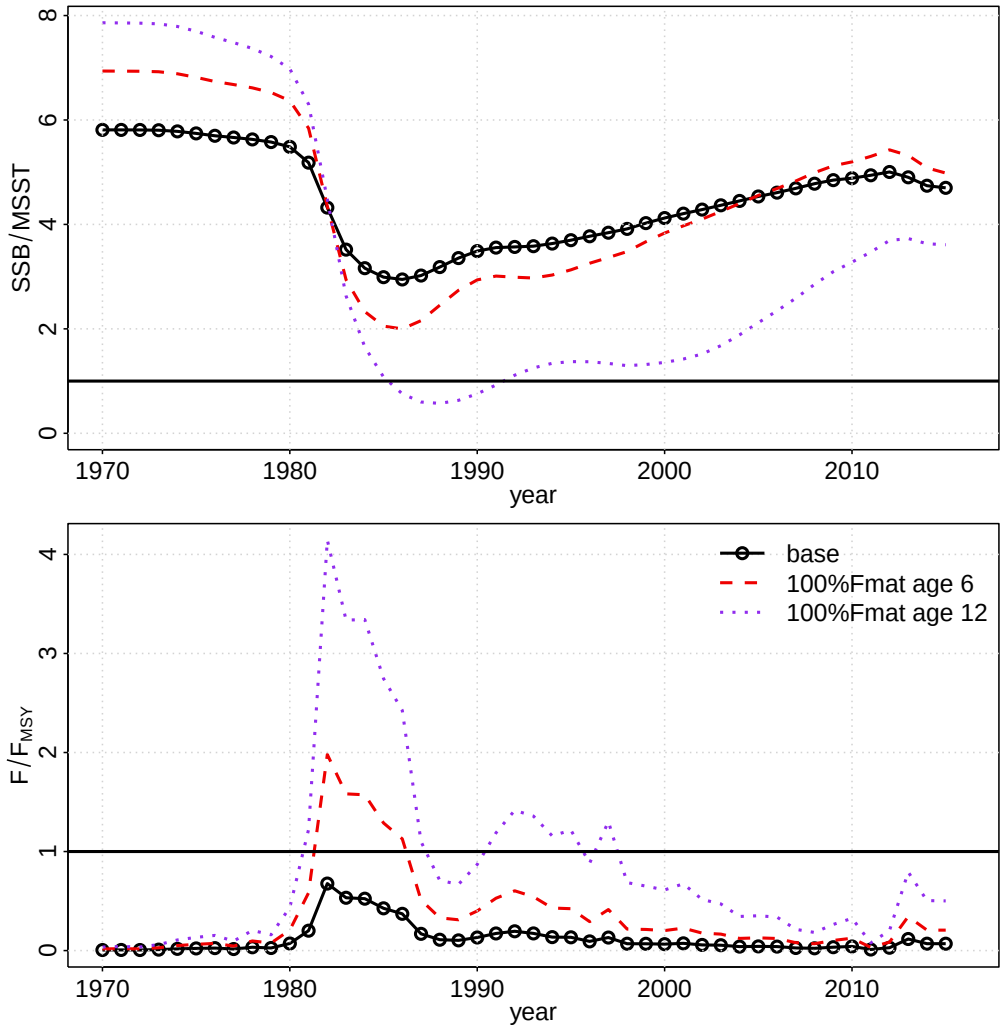
Table: Estimated status indicators, benchmarks, and related quantities from the ASPM south of Cape Hatteras, conditional on estimated current selectivities averaged across fleets. Monte Carlo/Bootstrap analysis was not conducted for this model, so median values and measures of precision (standard errors, SE) are unavailable. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; and biomass estimates are in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured as population fecundity (number of eggs)

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.841	—	—
$85\%F_{\text{MSY}}$	y^{-1}	0.715	—	—
$75\%F_{\text{MSY}}$	y^{-1}	0.630	—	—
$65\%F_{\text{MSY}}$	y^{-1}	0.546	—	—
$F_{30\%}$	y^{-1}	0.628	—	—
$F_{40\%}$	y^{-1}	0.337	—	—
B_{MSY}	1000 lb whole	1997	—	—
SSB_{MSY}	million eggs	816899	—	—
MSST	million eggs	612674	—	—
MSY	1000 lb whole	316	—	—
R_{MSY}	number fish	990100	—	—
$L_{85\%\text{MSY}}$	1000 lb whole	315	—	—
$L_{75\%\text{MSY}}$	1000 lb whole	313	—	—
$L_{65\%\text{MSY}}$	1000 lb whole	310	—	—
$F_{2013-2015}/F_{\text{MSY}}$	—	0.08	—	—
$\text{SSB}_{2015}/\text{MSST}$	—	4.70	—	—
$\text{SSB}_{2015}/\text{SSB}_{\text{MSY}}$	—	3.53	—	—

Results

Sensitivity analysis

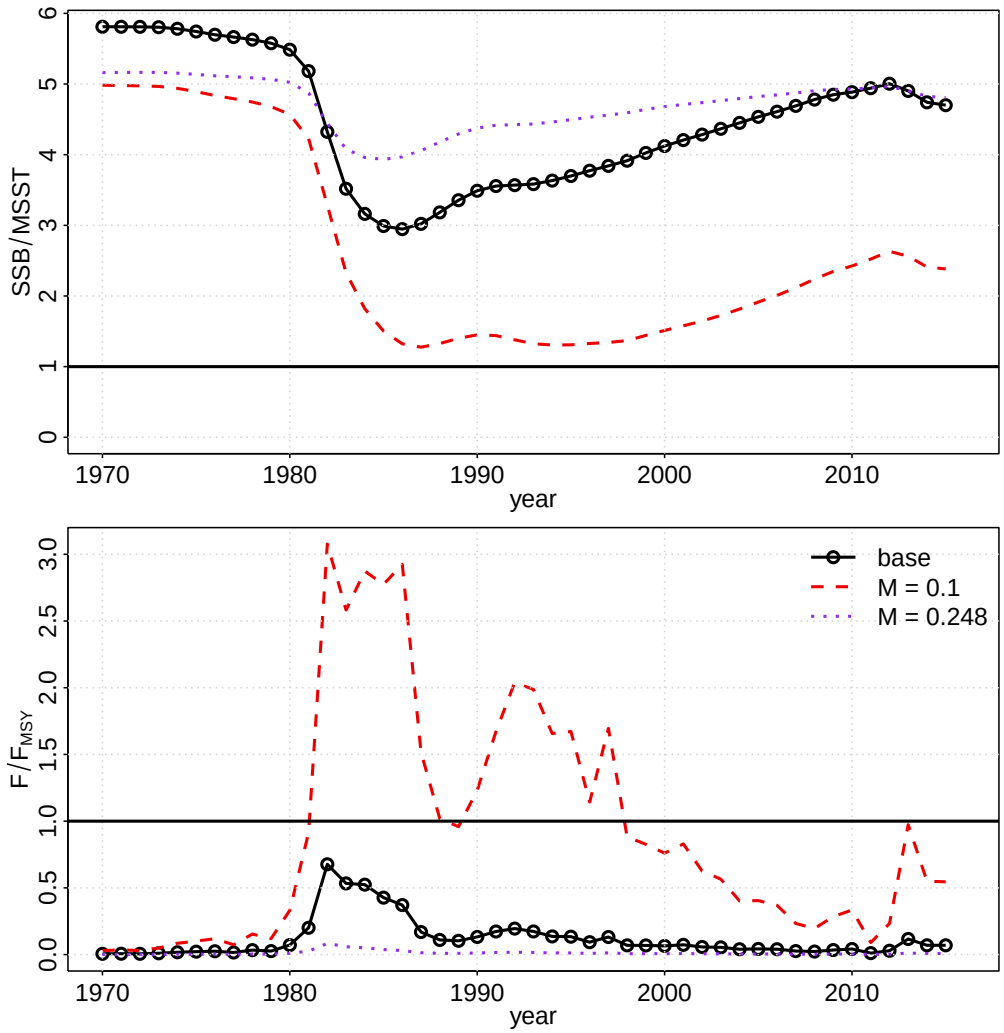
Sensitivity to age at maturity: ASPM Runs S1-S2



Results

Sensitivity analysis

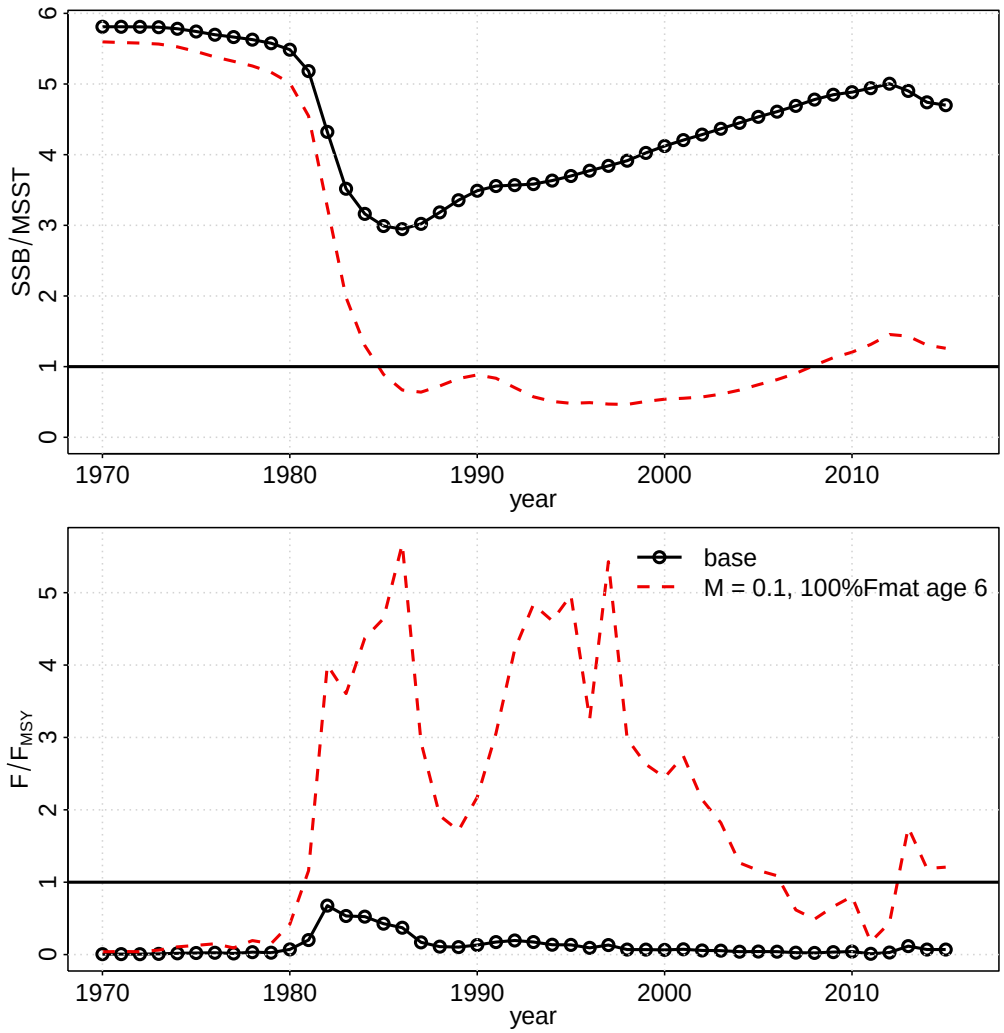
Sensitivity to natural mortality: ASPM Runs S3-S4



Results

Sensitivity analysis

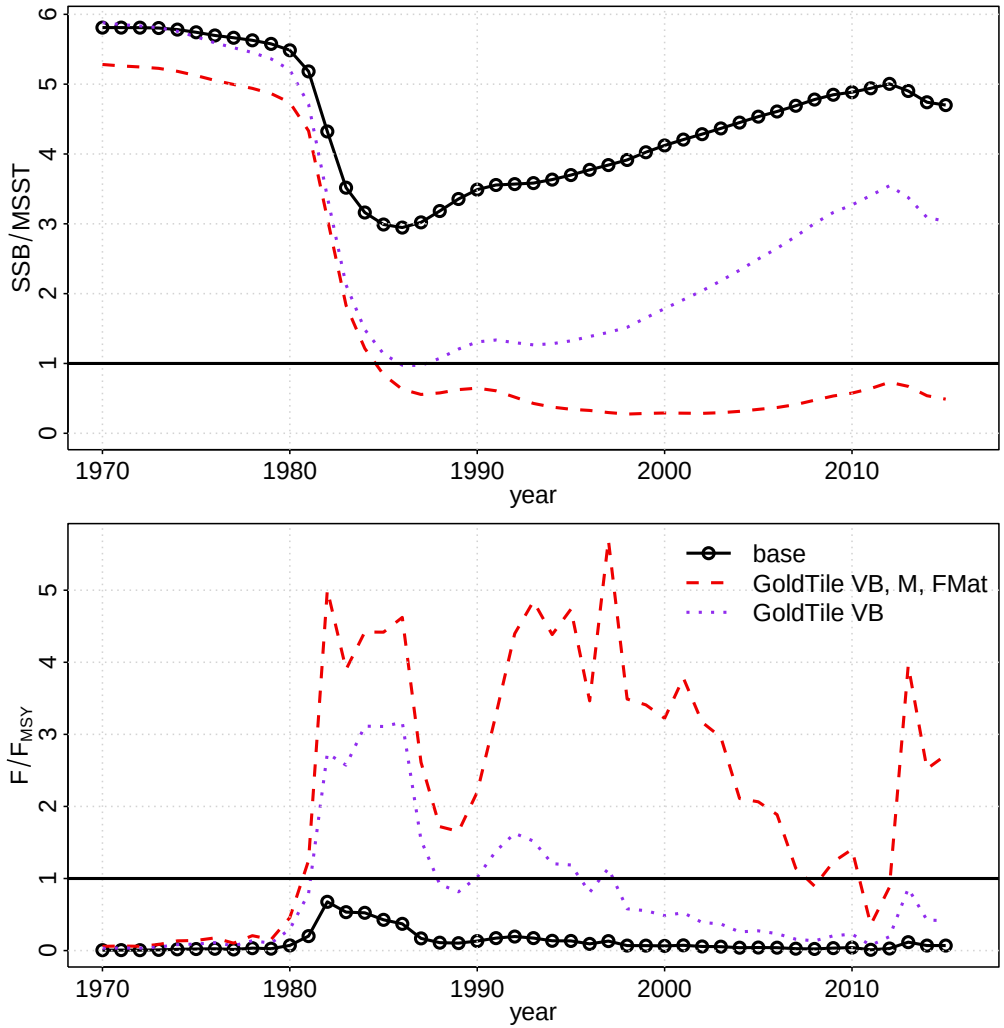
Sensitivity to age at maturity and natural mortality: ASPM Run S5



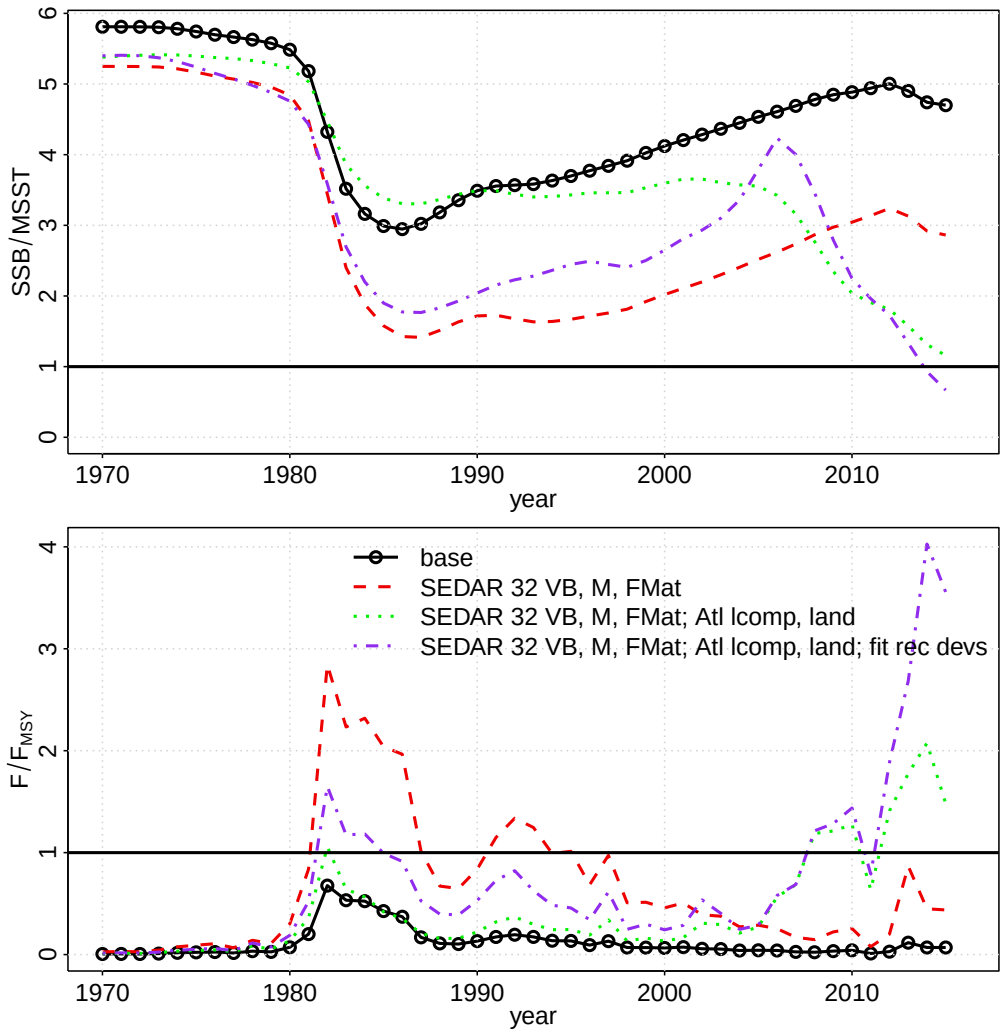
Results

Sensitivity analysis

Sensitivity to Golden Tilefish life history parameters: ASPM Runs S6-S7



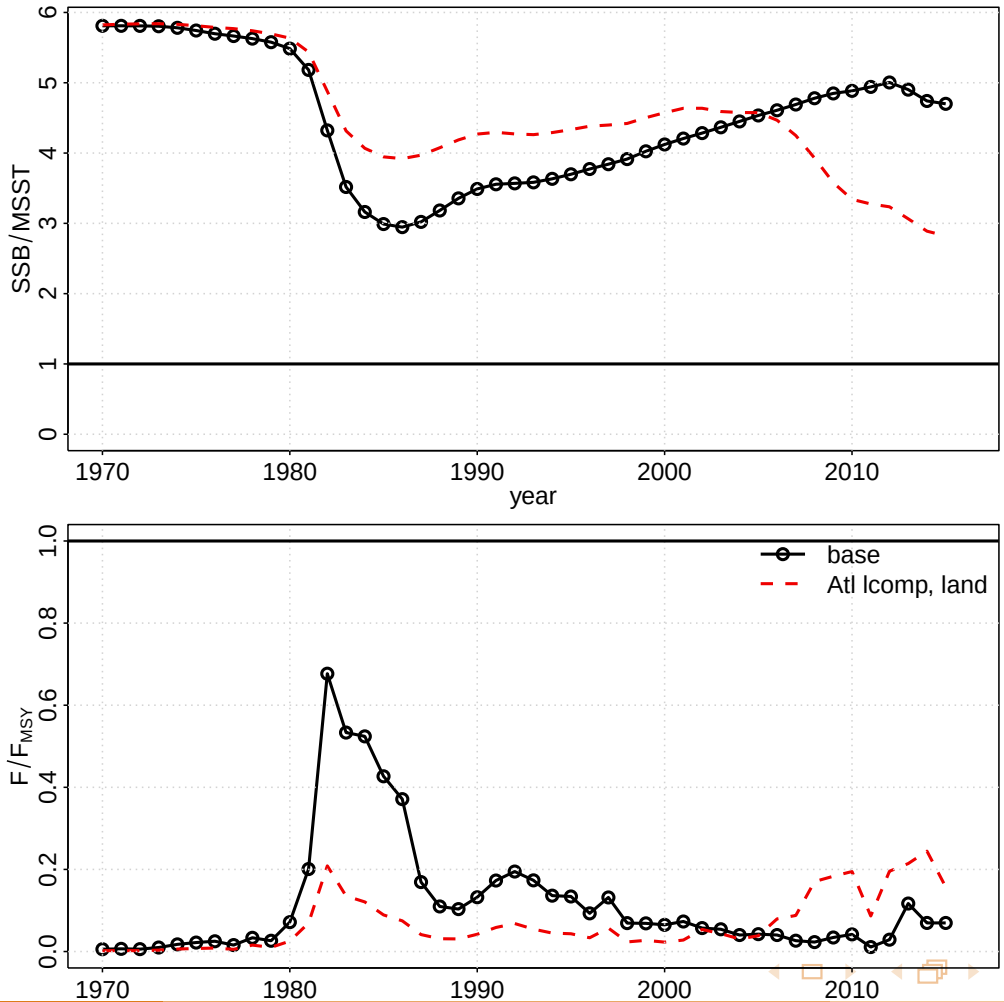
Sensitivity to SEDAR 32 Blueline Tilefish settings: ASPM Runs S8-S10



Results

Sensitivity analysis

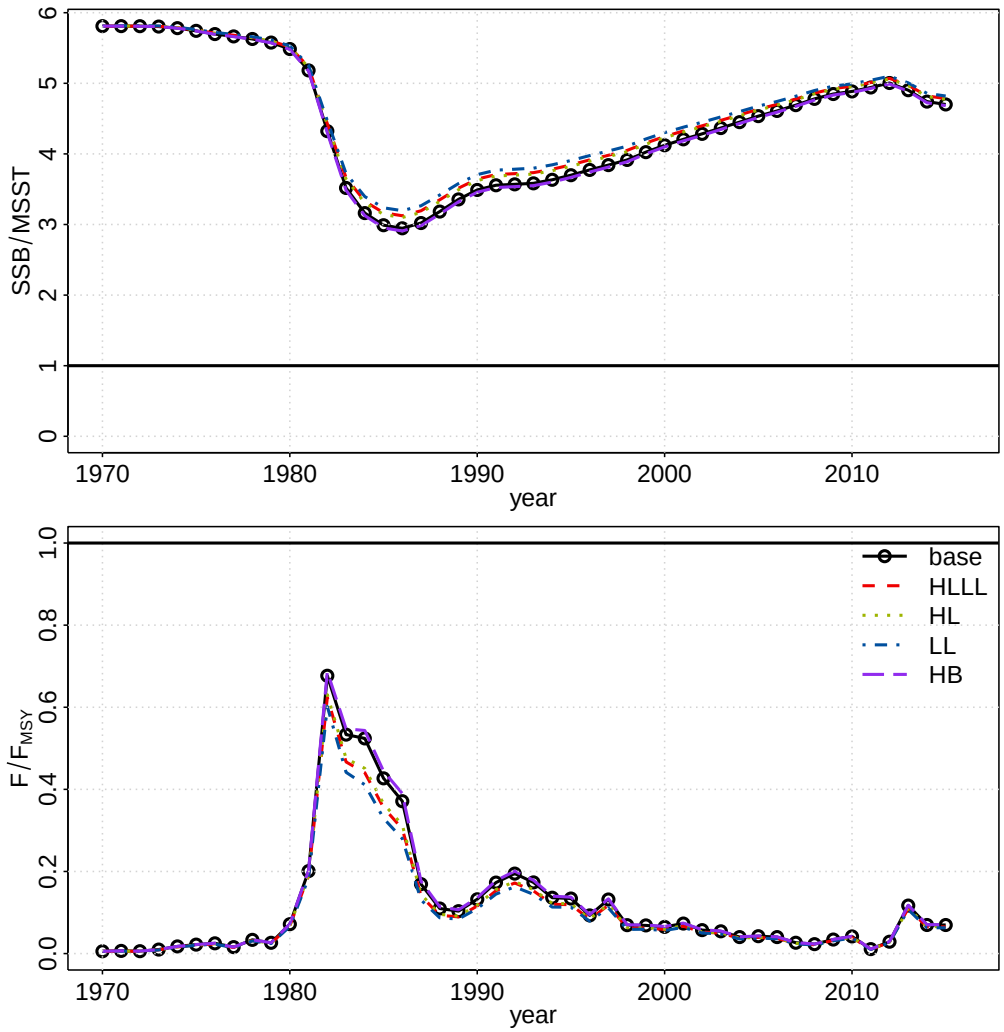
Sensitivity to including length composition data and removals north of Cape Hatteras:
ASPM Run S11



Results

Sensitivity analysis

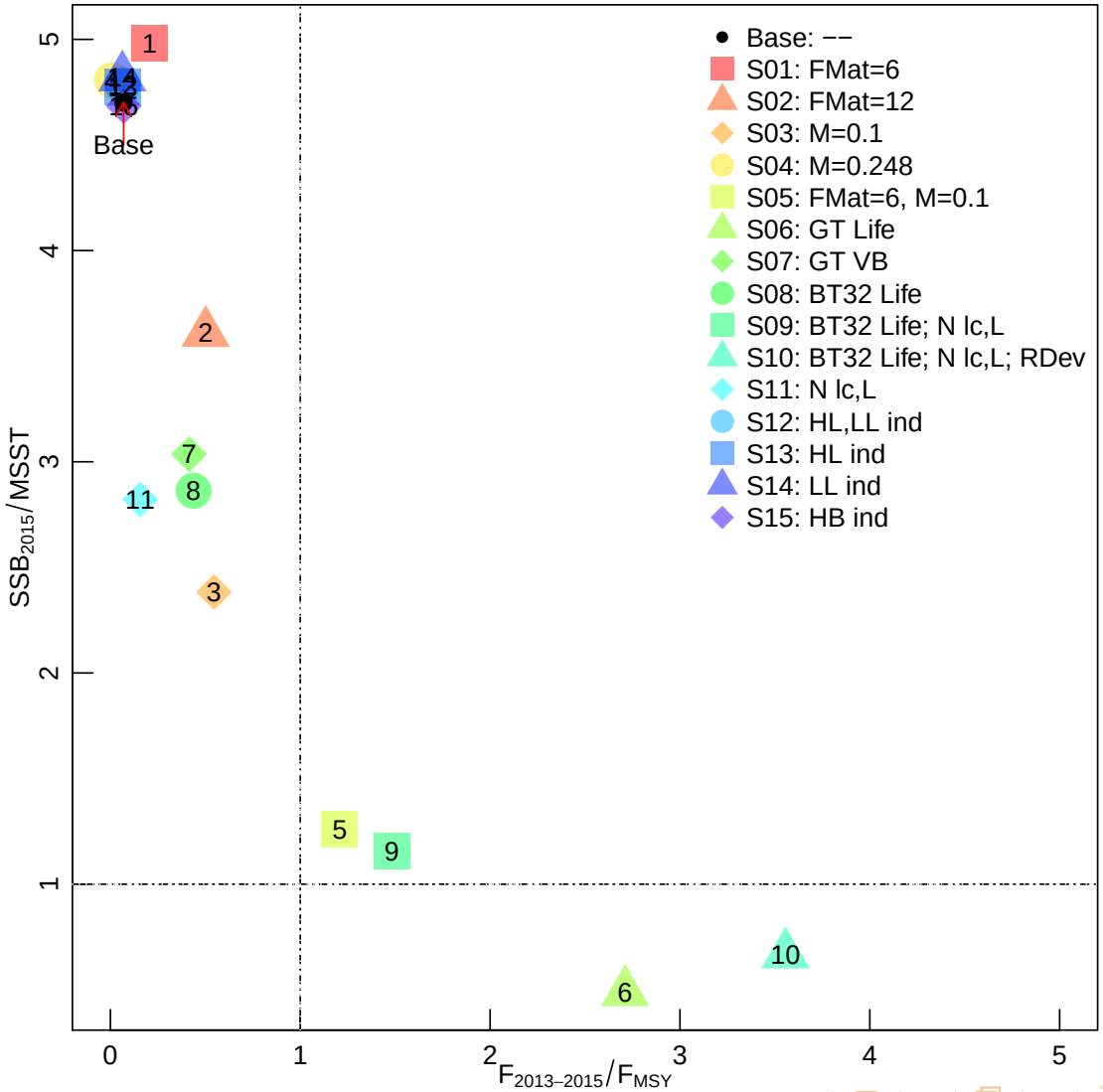
Sensitivity to indices:
ASPM Runs S12-S15



Results

Sensitivity analysis

Sensitivity status phase plots



Results

Sensitivity analysis

Table: Estimated status indicators, benchmarks, and related quantities for sensitivity runs for the ASPM south of Cape Hatteras. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; and biomass estimates are in units of 1000 pounds, Beverton-Holt R_0 is in units of 1000 fish. Spawning stock biomass (SSB) is measured as population fecundity (millions of eggs). F/F_{MSY} is based on the geometric mean F for the last three years of the assessment. $\text{SSB}/\text{SSB}_{\text{MSY}}$ and SSB/MSST are based on the terminal year of the assessment. steep = Beverton Holt steepness. Lik_{total} = total likelihood for the model. See text for full description of sensitivity runs.

Run	Description	F_{MSY}	SSB_{MSY}	B_{MSY}	MSY	F/F_{MSY}	$\text{SSB}/\text{SSB}_{\text{MSY}}$	SSB/MSST	steep	R_0	Lik_{total}
Base	–	0.841	816899	1997	316	0.07	3.53	4.70	0.84	1159	5708
S01	FMat=6	0.296	466217	2600	246	0.21	3.74	4.98	0.84	1142	5705
S02	FMat=12	0.143	199398	3090	179	0.50	2.71	3.61	0.84	1142	5694
S03	M=0.1	0.182	810436	1331	139	0.55	1.79	2.38	0.84	228	5699
S04	M=0.248	6.000	1494072	5896	980	0.01	3.61	4.81	0.84	6319	5719
S05	FMat=6, M=0.1	0.157	592599	1417	125	1.21	0.94	1.26	0.84	217	5680
S06	GT Life	0.130	1056703	1398	134	2.71	0.37	0.49	0.84	163	5935
S07	GT VB	0.256	688452	1272	169	0.41	2.28	3.04	0.84	469	5931
S08	BT32 Life	0.185	683401	1297	158	0.44	2.15	2.86	0.84	141	5673
S09	BT32 Life; N lc,L	0.208	1315956	2540	324	1.48	0.87	1.16	0.84	278	6992
S10	BT32 Life; N lc,L; RDev	0.224	968895	1881	244	3.56	0.50	0.67	0.84	206	6799
S11	N lc,L	1.511	1330051	3286	525	0.16	2.12	2.82	0.84	1890	7016
S12	HL,LL ind	0.822	869822	2126	336	0.06	3.59	4.78	0.84	1235	5581
S13	HL ind	0.826	861466	2105	333	0.07	3.58	4.77	0.84	1223	5562
S14	LL ind	0.817	894096	2185	346	0.06	3.62	4.82	0.84	1270	5542
S15	HB ind	0.849	807506	1974	312	0.07	3.51	4.68	0.84	1146	5650

Blueline Tilefish: South of Cape Hatteras Age-aggregated Production Model (ASPIC) Review Workshop Reference Model (RW Ref)

NOAA FISHERIES

Southeast Fisheries Science Center

October 17, 2017

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Methods

RW Reference Run Model Configuration

- The ASPIC Assessment Workshop Base Model (AW Base) was an average of two models:
  - Commercial handline model (Run 55)
  - Commercial handline model (Run 56)
- Used annual CVs submitted by data providers based on bootstrapping index residuals and refitting

Methods

RW Reference Run Model Configuration

- Based on recommendations by the Review Workshop Panel, a Review Workshop Reference (RW Ref) model was developed which included the commercial handline and commercial longline indices in the same model (as in Run 54)
- The RW Ref model uses annual CVs fixed at 0.2, based on RW Panel recommendations
- All other aspects of this model (e.g. removals series, fitting procedure) are the same as in the AW Base model

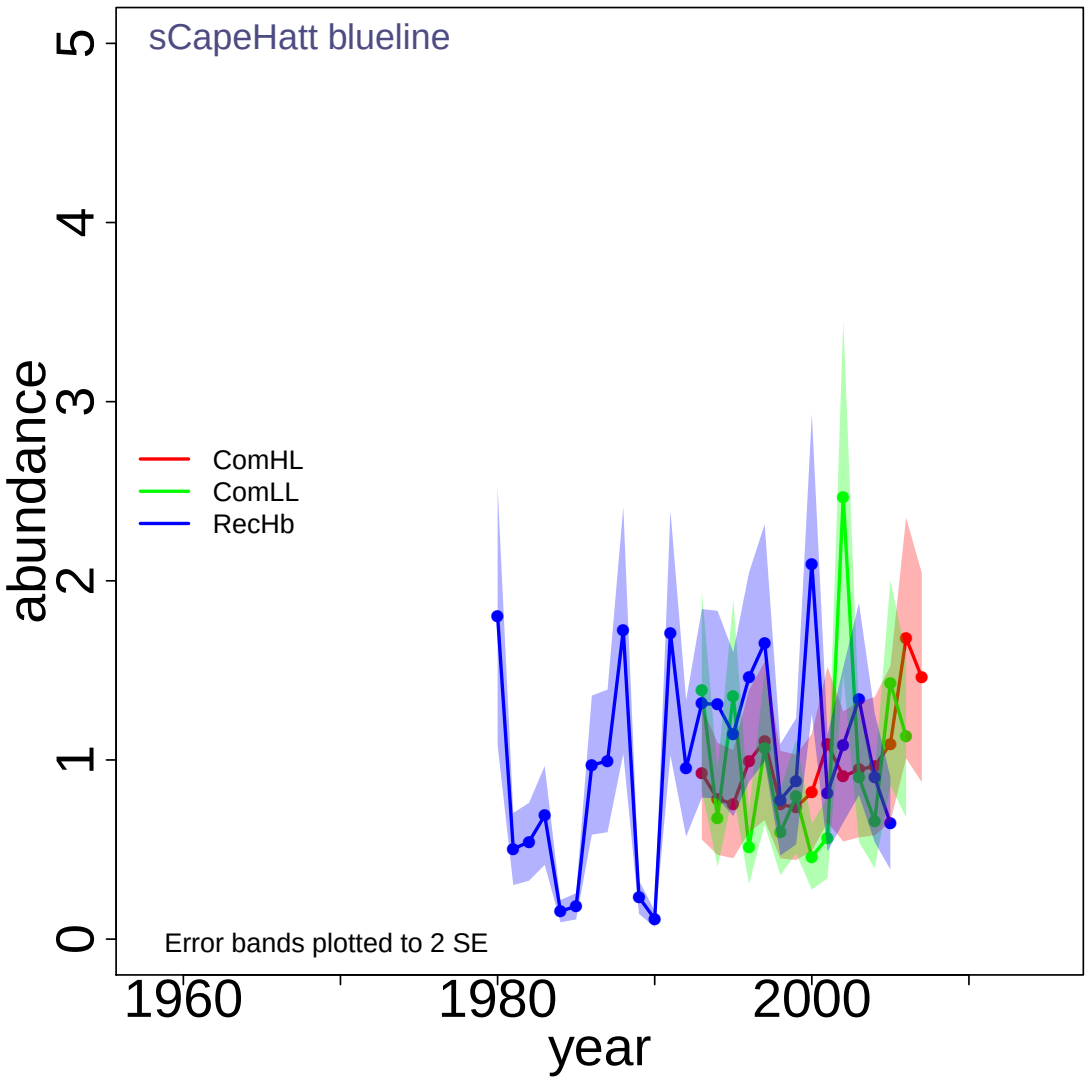
Methods

Data

Indices of abundance with constant CV=0.2

- Commercial handline (ComHL)
- Commercial longline (ComLL)
- Recreational headboat (RecHb)

Note that error bars are plotted as 2 standard errors and therefore vary with the annual mean index values



Methods

Uncertainty

- ASPIC Bootstrap procedures were run to estimate uncertainty in the models
  1. ASPIC fits to observed data and saves predicted population data and residuals
  2. Normalized inflated residuals are randomly drawn with replacement and incorporated into predicted values to generate a trial resampled dataset
  3. Resampled data are fit, results saved, and the next trial begins

Methods

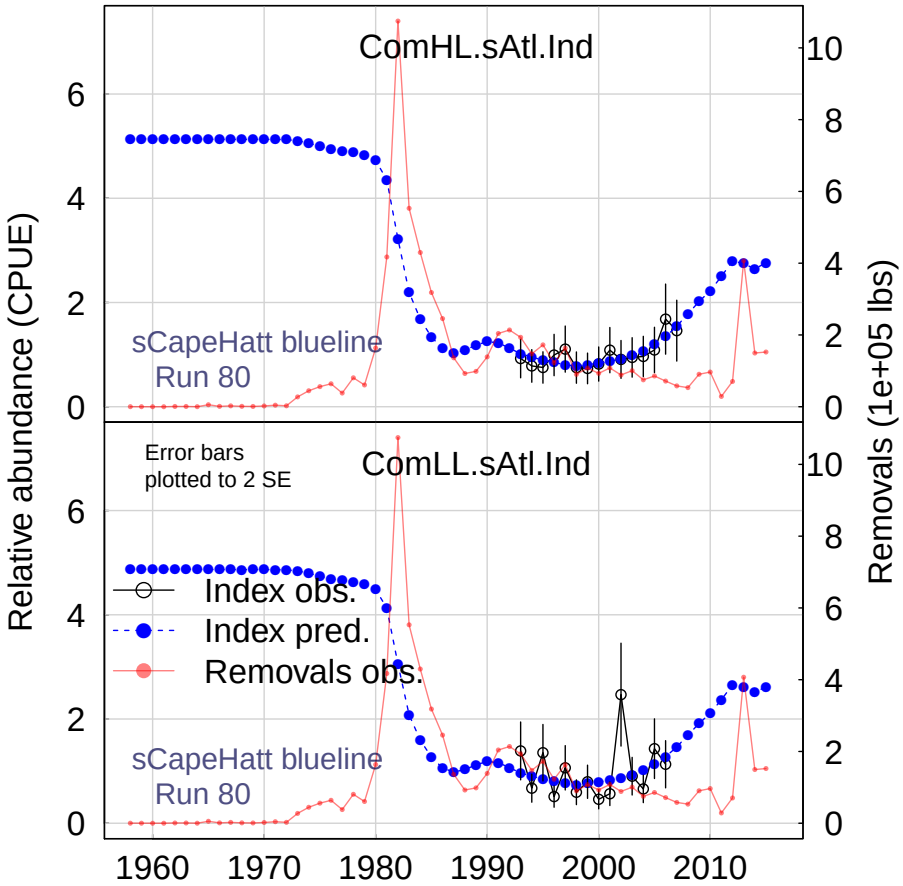
Projections

- Five year projections at:
  - $F = F_{\text{MSY}}$
  - $F = F_{\text{current}}$
  - $F = F_{\text{target}} = 0.75F_{\text{MSY}}$
- $F_{2016} = F_{\text{current}}$
- Projections were made from the bootstrap results from the RW Ref model
- Uncertainty in projections based on bootstrap runs

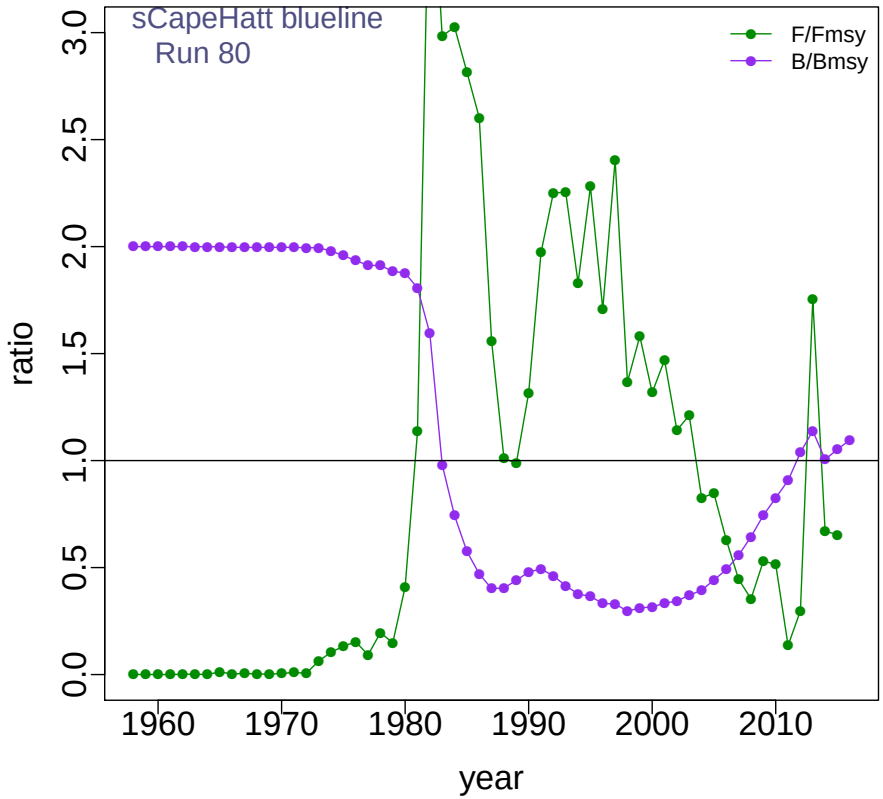
Results

RW Ref Model Results and Uncertainty

Fit to indices of RW Ref model (Run 80)



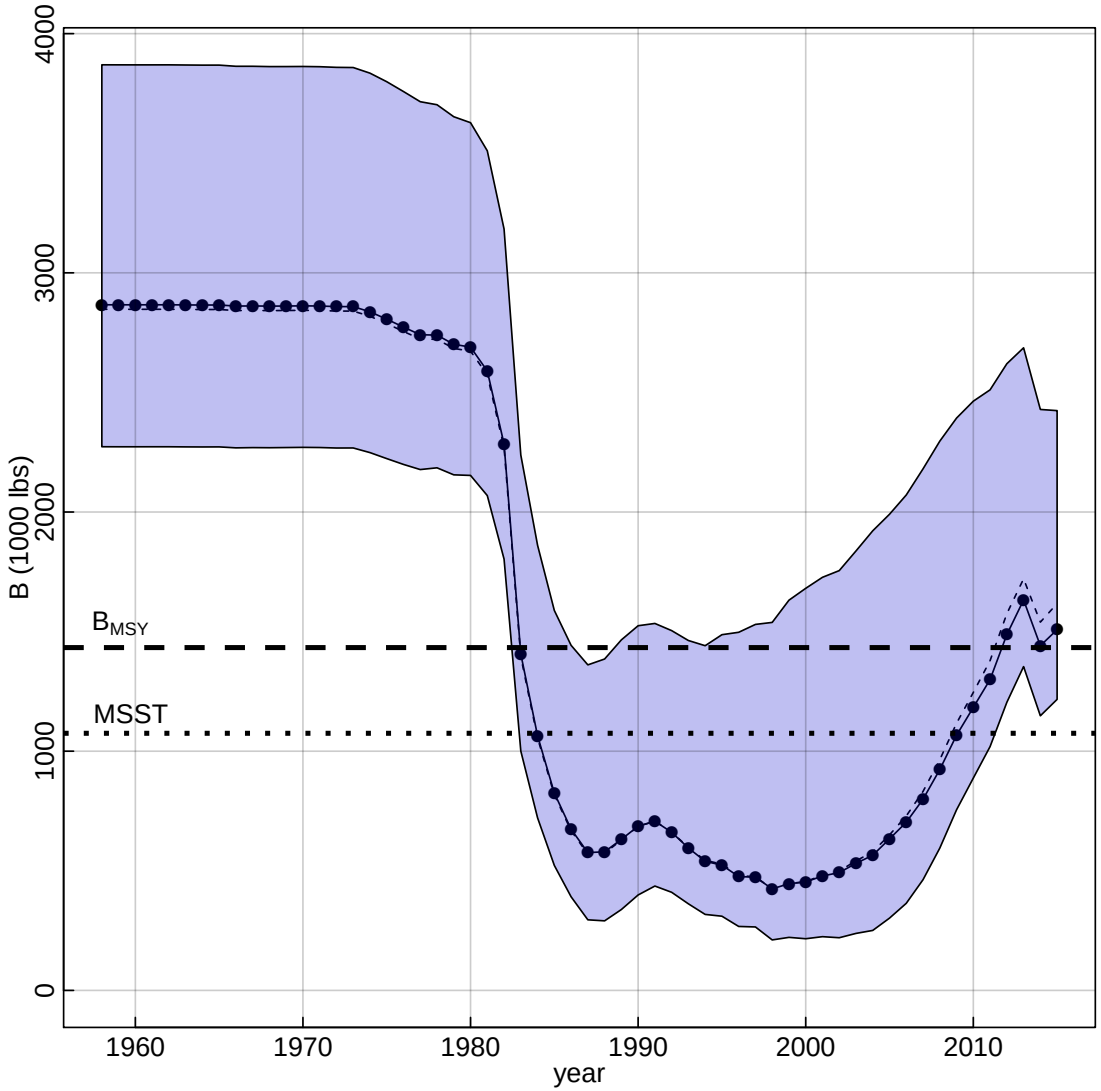
Status trends for RW Ref model (Run 80)



Results

RW Ref Model Results and Uncertainty

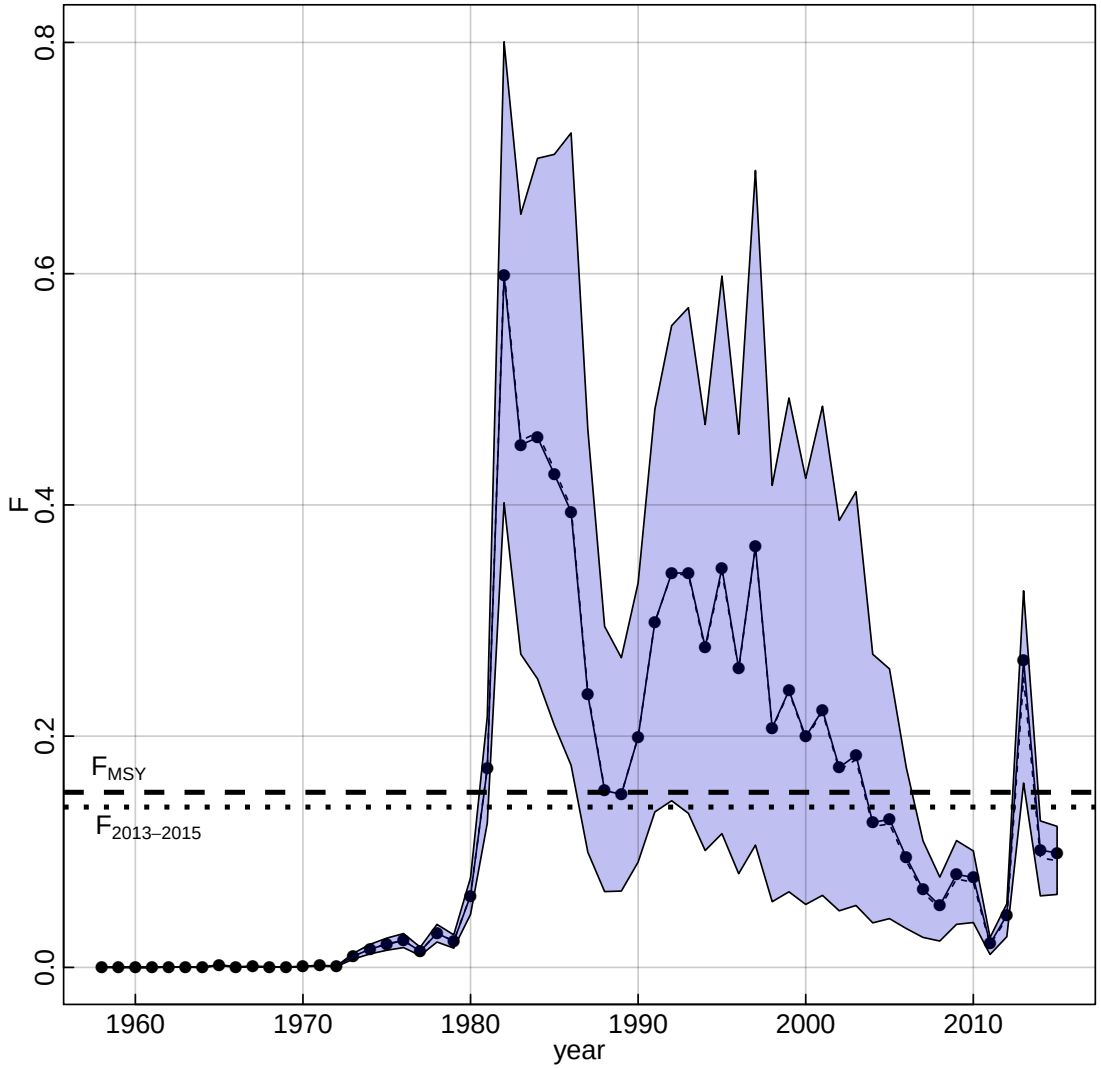
Estimated biomass series (B) for the ASPIC RW Ref model (Run 80)



Results

RW Ref Model Results and Uncertainty

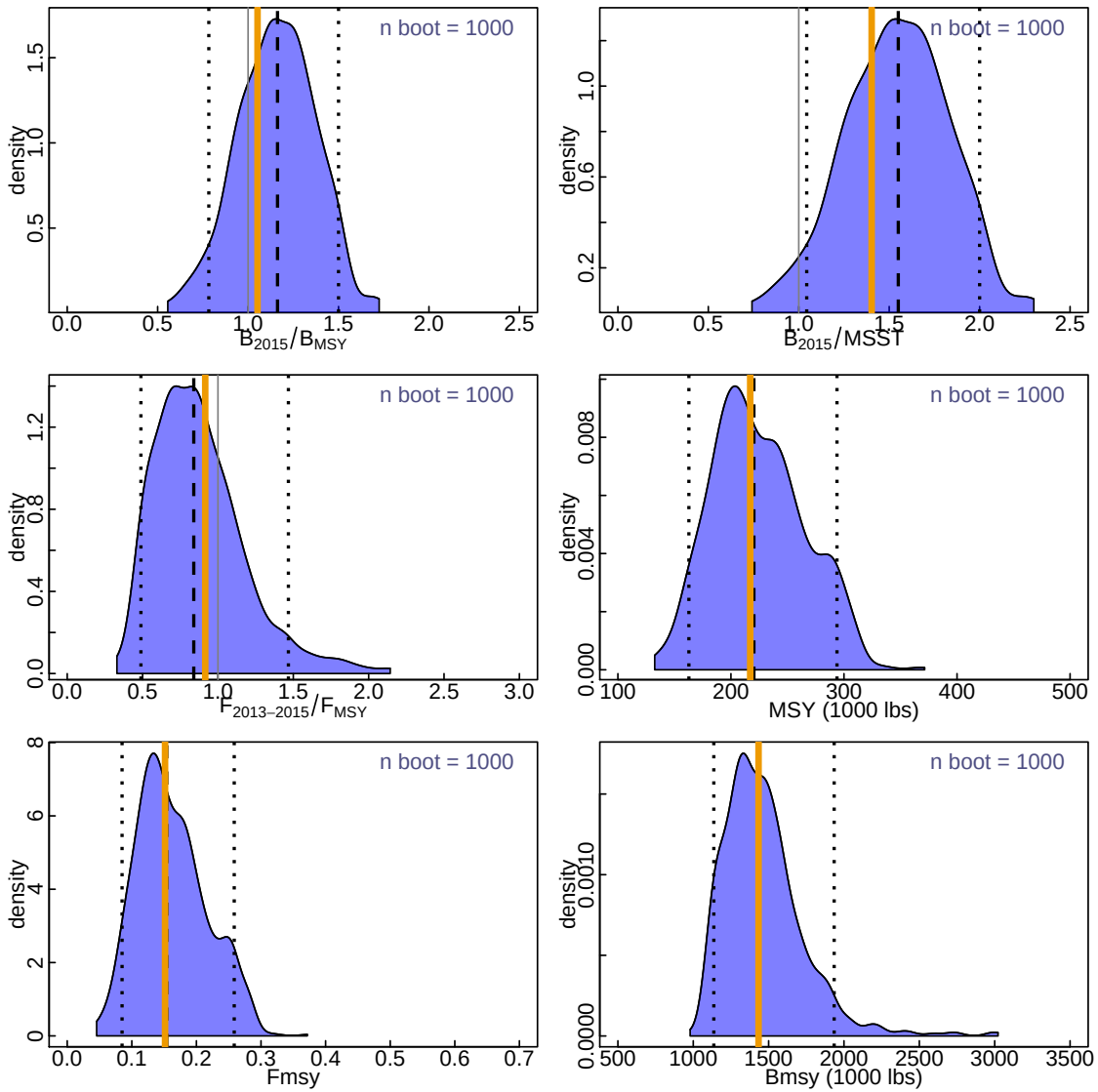
Estimated fishing mortality series (F) for the ASPIC RW Ref model (Run 80)



Results

RW Ref Model Results and Uncertainty

ASPIC bootstrap parameter distributions for the ASPIC RW Ref model (Run 80)

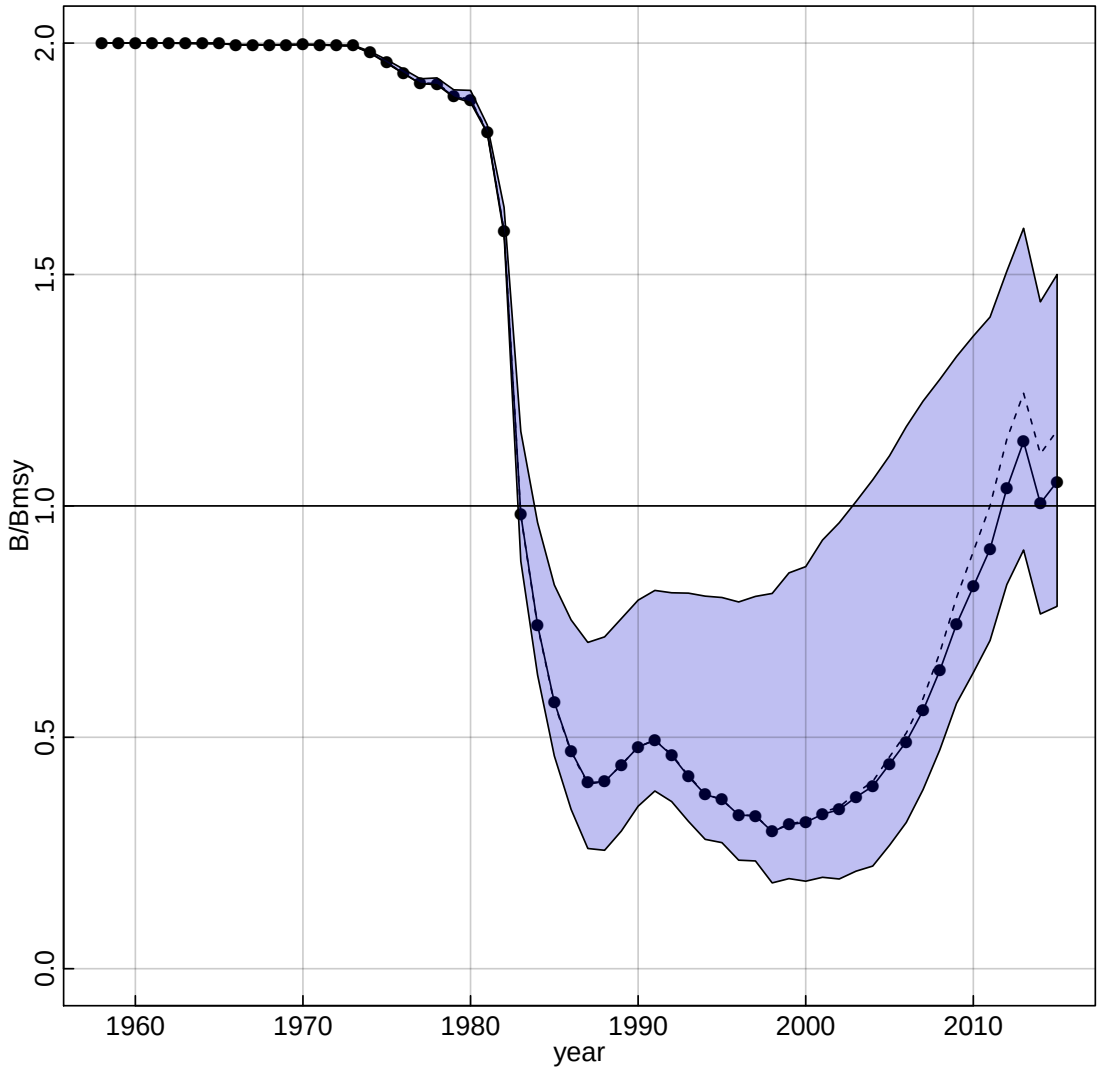


Results

RW Ref Model Results and Uncertainty

Estimated biomass series (B) relative to B_{MSY} for the ASPIC RW Ref model (Run 80)

- Solid line indicates average B series relative to average B_{MSY}.
- Dashed line represents the median B/B_{MSY}
- Blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials

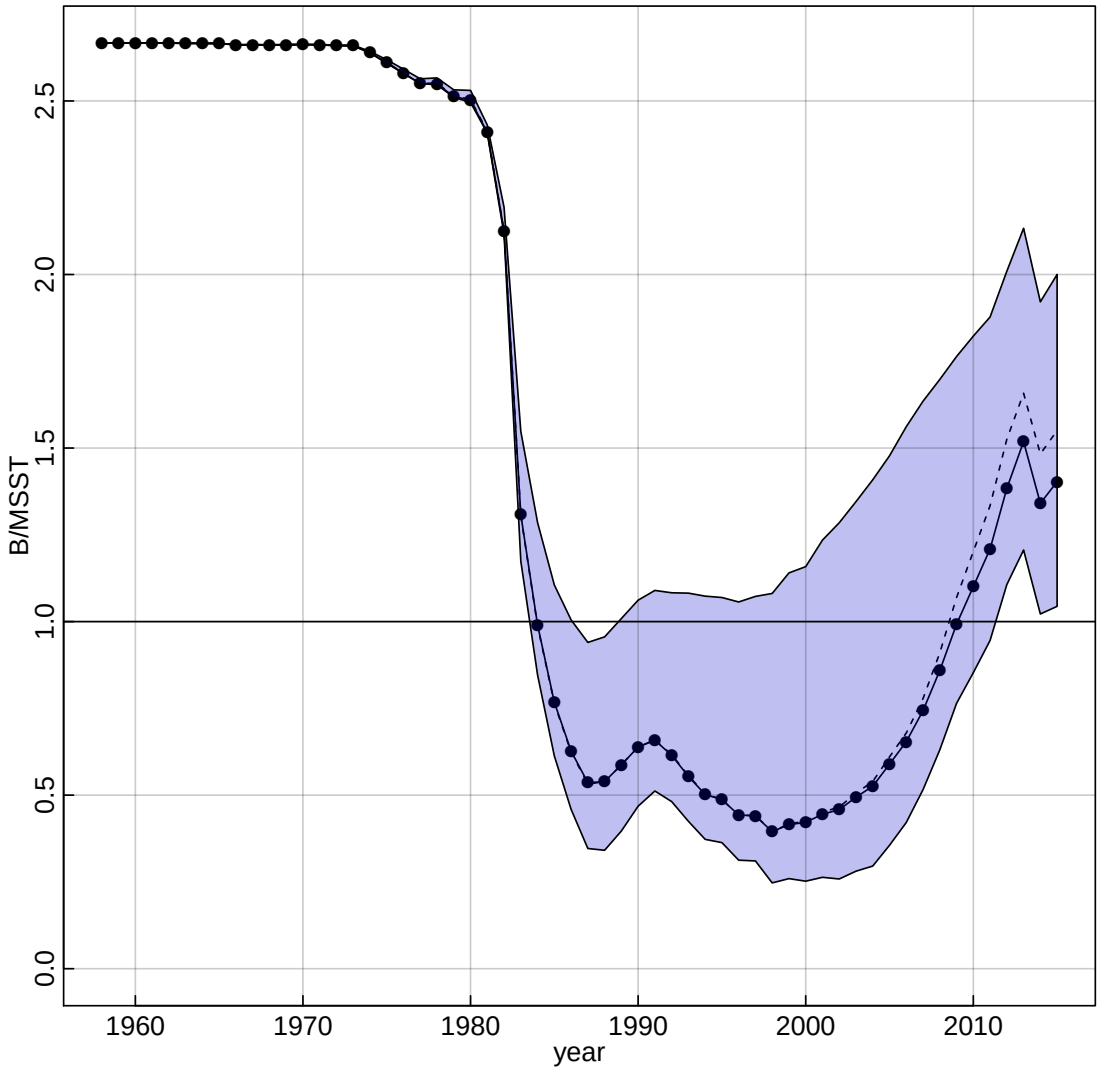


Results

RW Ref Model Results and Uncertainty

Estimated biomass series (B) relative to MSST for the ASPIC RW Ref model (Run 80)

- Solid line indicates average B series relative to average MSST.
- Dashed line represents the median B/MSST
- Blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials

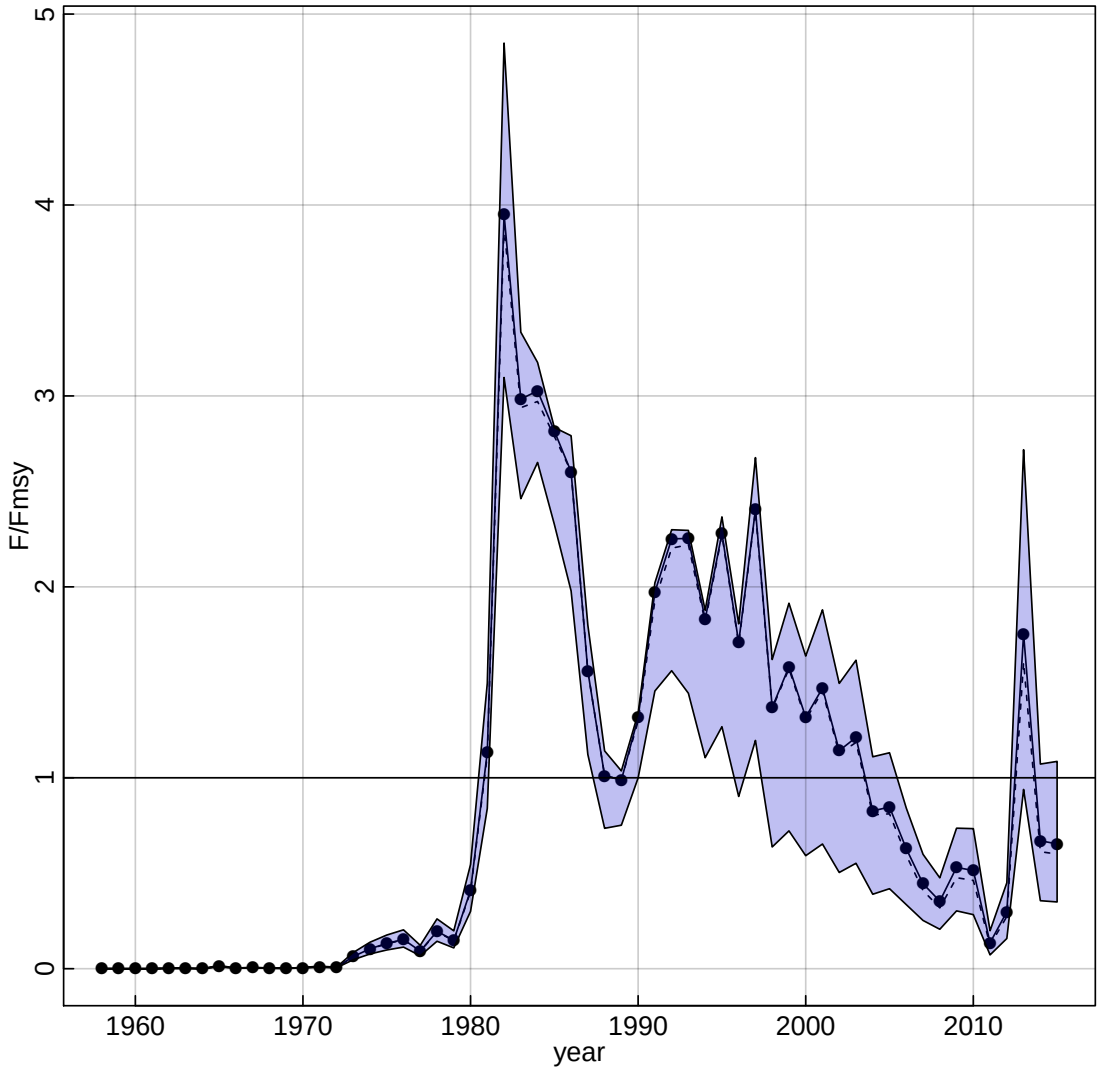


Results

RW Ref Model Results and Uncertainty

Estimated F series relative to F_{MSY} for the ASPIC RW Ref model (Run 80)

- Solid line indicates average F series relative to average F_{MSY}.
- Dashed line represents the median F/F_{MSY}
- Blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials

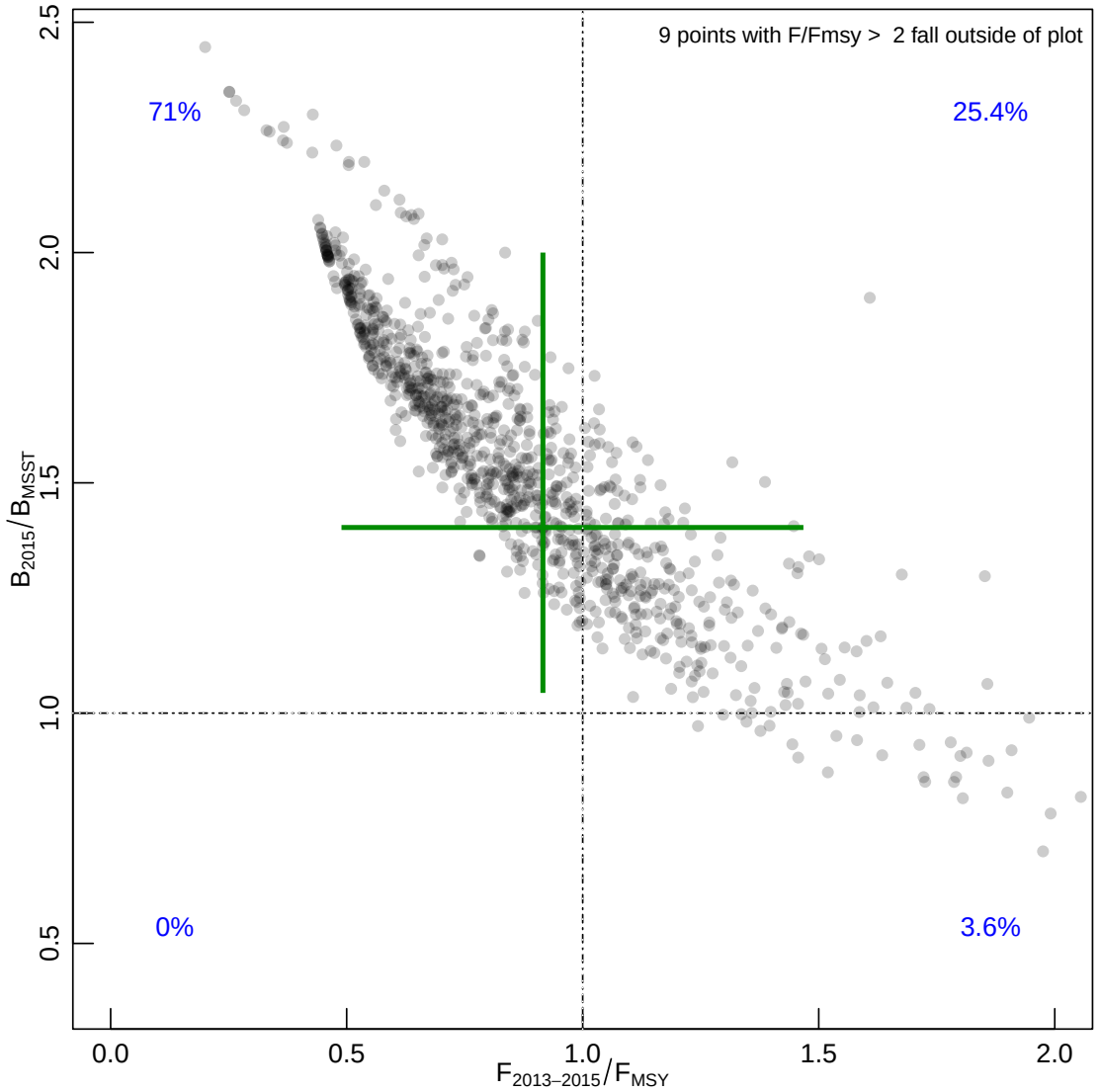


Results

RW Ref Model Results and Uncertainty

Bootstrap status phase plots for the ASPIC RW Ref model (Run 80)

- The intersection of crosshairs indicates the estimates from the RW Ref
- Lengths of crosshairs defined by 5^{th} and 95^{th} percentiles
- Percent of runs falling into each quadrant indicated



Results

RW Ref Model Results and Uncertainty

Base run estimates

Table: Estimated status indicators, benchmarks, and related quantities for So. Atl. ASPIC Review Workshop reference run (RW Ref.). Also presented are median values and measures of precision (standard errors, SE) from the bootstrap analysis. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; and biomass estimates are in units of 1000 pounds, as indicated.

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.151	0.154	0.062
$85\%F_{\text{MSY}}$	y^{-1}	0.129	0.131	0.052
$75\%F_{\text{MSY}}$	y^{-1}	0.114	0.116	0.046
$65\%F_{\text{MSY}}$	y^{-1}	0.098	0.100	0.040
B_{MSY}	1000 lb	1433	1424	394
MSST	1000 lb	1075	1068	296
MSY	1000 lb	217	220	45
$F_{2013-2015}/F_{\text{MSY}}$	—	0.92	0.84	0.35
B_{2015}/MSST	—	1.40	1.55	0.29
B_{2015}/B_{MSY}	—	1.05	1.16	0.22

Results

Summary of ASPIC runs including AW Base, AW sensitivity runs, and RW Ref

Table: Parameter estimates from selected So. Atl. ASPIC surplus production model runs. B_{MSY} and MSY are in units of 1000 pounds. Likelihood components (Lik) are presented for each index and as a total (Lik_{total}). The numerator in F/F_{MSY} is the geometric mean F from the last three years of the assessment (2013-2015) and the numerator in B/B_{MSY} and B/MSST is biomass in the terminal year of the assessment (2015). Abbreviations in Run Name are as follows: HL = handline index, LL = longline index, Hb = headboat index, Atl. = all Atlantic removals are included, 1974 or 1958 indicates the model start year. The Review Workshop Reference run (RW Ref.) is HLLL.CV0.2. Estimates from the AW Base run (AW.Base; mean of runs 55 and 56) are also shown for comparison.

Run	RunName	F/F_{MSY}	B/B_{MSY}	B/MSST	B_{MSY}	MSST	MSY	F_{MSY}	Lik_{total}	Lik_{HL}	Lik_{LL}	Lik_{Hb}
51	HLLLHb	0.41	1.67	2.23	1263	947	301	0.238	167.2	23.2	15.7	128.2
52	HLHb	0.41	1.67	2.23	1260	945	299	0.238	151.4	23.2		128.2
53	LLHb	0.39	1.68	2.24	1186	889	316	0.266	143.5		15.7	127.8
54	HLLL	1.06	0.99	1.32	1538	1153	199	0.129	16.9	4.1	12.8	
55	HL	1.07	0.99	1.32	1554	1165	196	0.126	4.1	4.1		
56	LL	0.81	1.13	1.51	1380	1035	228	0.165	12.7		12.7	
57	Hb	0.40	1.68	2.23	1190	892	312	0.262	127.8			127.8
74	Atl.HLLLHb.1974	8.71	0.22	0.30	1769	1327	378	0.214	205.2	46.0	15.1	144.1
75	Atl.HLLLHb.1958	11.27	0.19	0.26	2076	1557	330	0.159	202.3	40.9	15.0	146.5
80	HLLL.CV0.2	0.92	1.05	1.40	1433	1075	217	0.151	17.0	−6.2	23.2	
55, 56	AW.Base	0.92	1.06	1.41	1467	1100	212	0.146				

Results

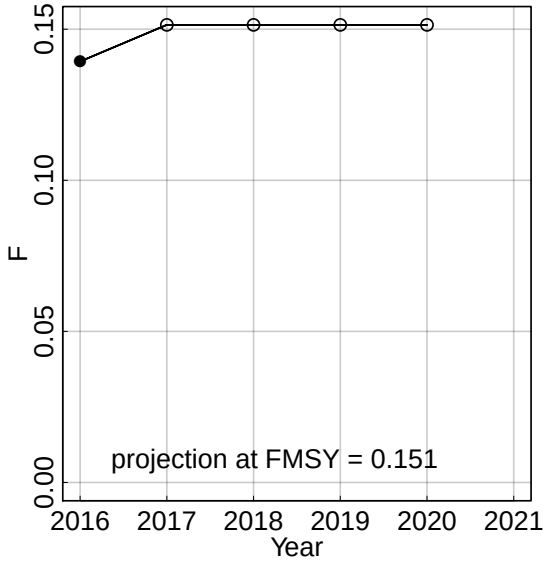
Projections

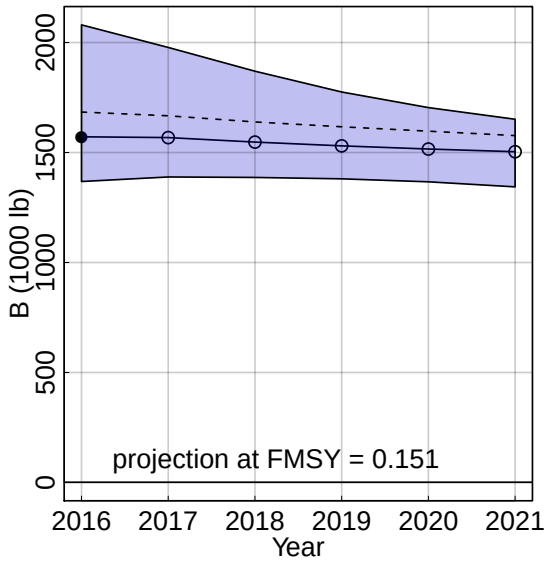
- Projections at:
  - $F = F_{\text{MSY}}$
  - $F = F_{\text{current}}$
  - $F = F_{\text{target}} = 0.75F_{\text{MSY}}$
- $F_{2016} = F_{\text{current}}$
- Solid circles (2016) represent values projected by the assessment model
- Open circles (2017-2021) represent values produced by the projection code
- Solid lines are deterministic estimates
- Dashed lines are medians of the bootstrap projections, respectively
- Blue error bands indicate 10^{th} and 90^{th} percentiles of the combined bootstrap trials

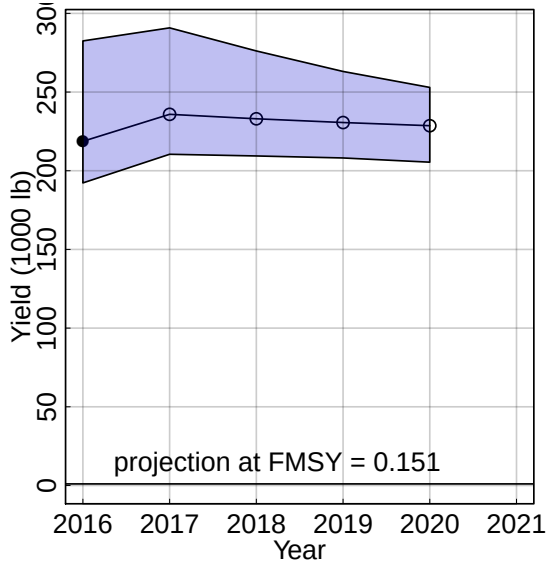
Results

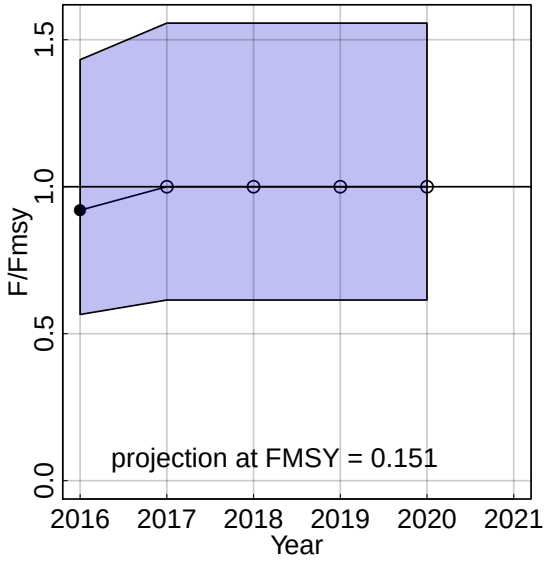
Projections

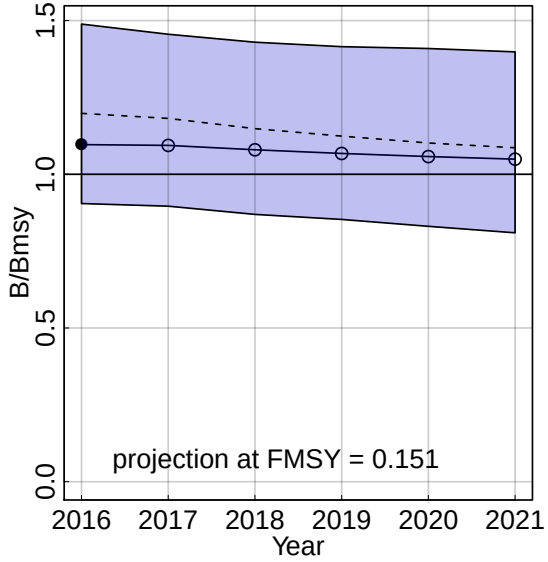
Projections at: $F = F_{\mathrm{MSY}}$

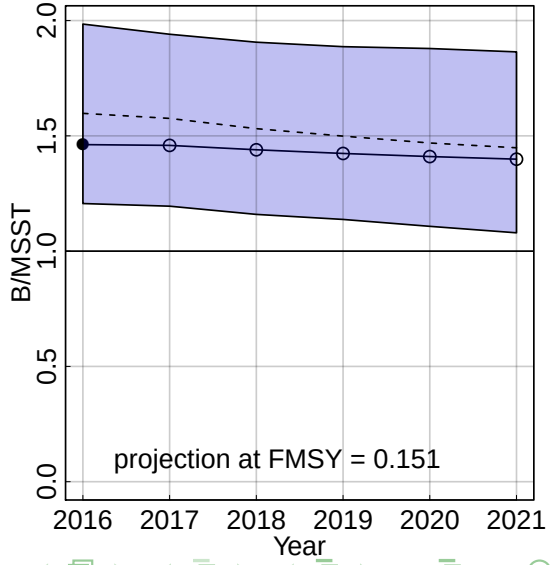












Results

Projections

Projections at: $F = F_{\text{MSY}}$

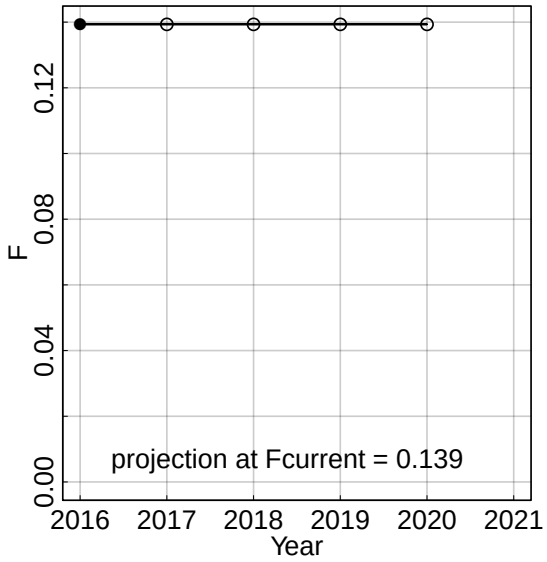
Table: Projection results with fishing mortality fixed at $F = F_{\text{MSY}}$ starting in 2017 for the So. Atl. ASPIC RW Ref. run. For 2016 , $F = F_{\text{current}}$. F = fishing mortality rate (per year), $P(B > B_{\text{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \text{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B_{median} = median biomass (1000 lb) estimate among projections, B = deterministic biomass (1000 lb) estimate, Y = deterministic yield (1000 lb) estimate, Sum Y = cumulative sum of deterministic yield (1000 lb). Yield includes landings and dead discards.

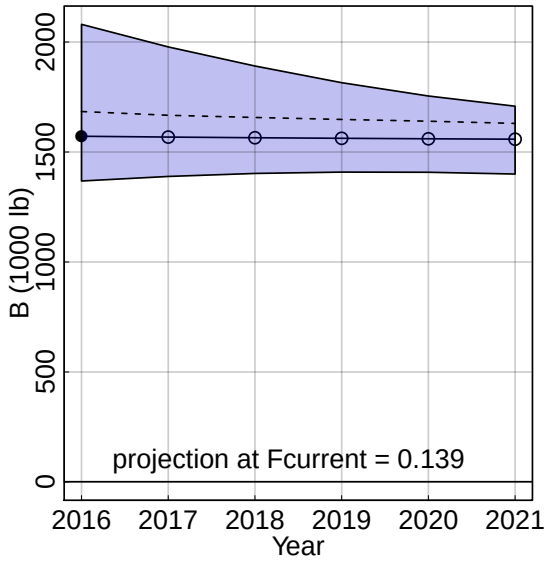
Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.139	0.80	0.97	1684	1572	219	219
2017	0.151	0.79	0.96	1667	1568	236	455
2018	0.151	0.76	0.96	1639	1547	233	688
2019	0.151	0.72	0.95	1617	1530	231	918
2020	0.151	0.69	0.94	1597	1516	229	1147
2021		0.65	0.93	1577	1504		

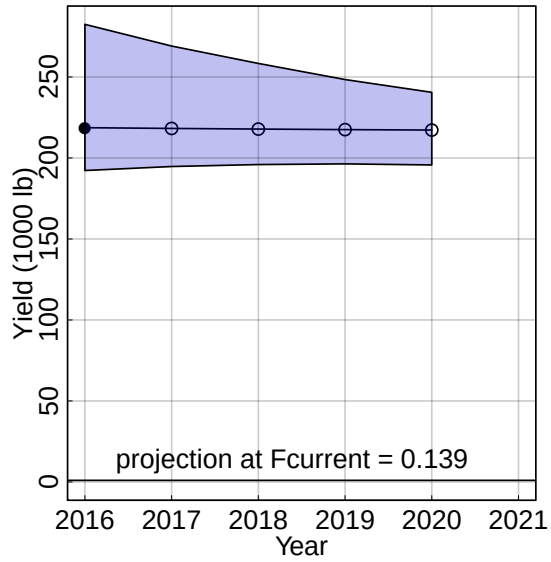
Results

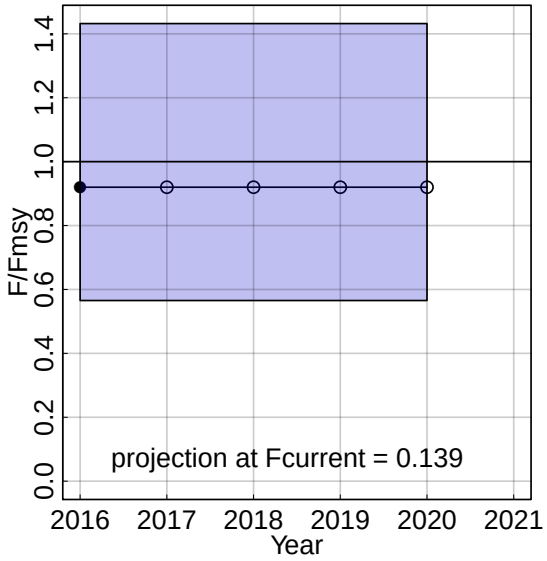
Projections

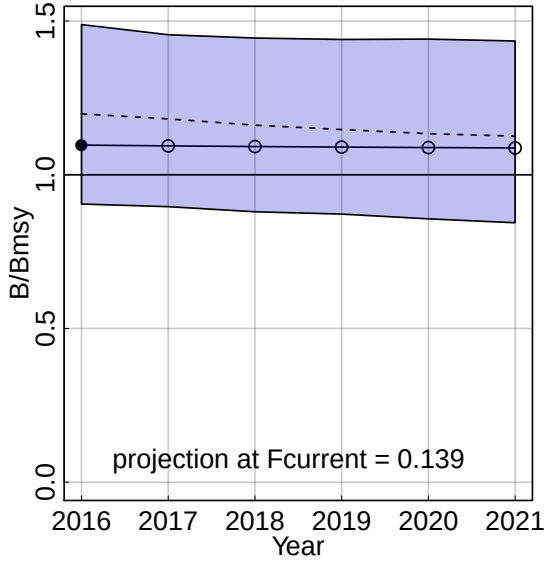
Projections at: $F = F_{\text{current}}$

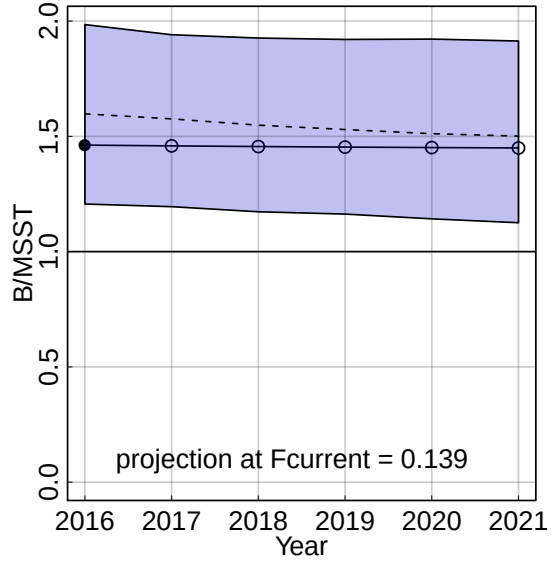












Results

Projections

Projections at: $F = F_{\text{current}}$

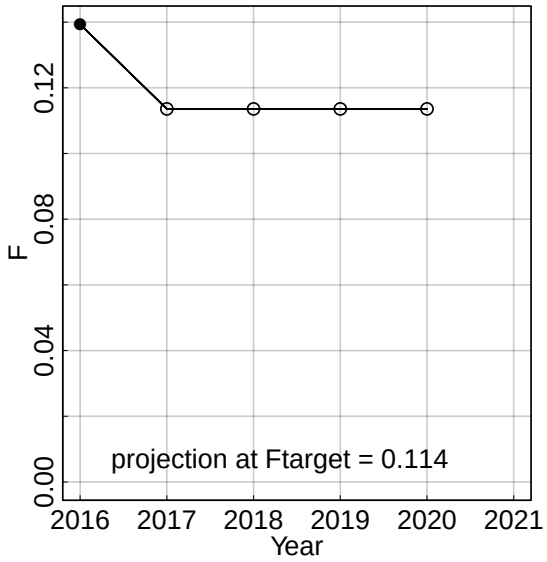
Table: Projection results with fishing mortality fixed at $F = F_{\text{current}}$ starting in 2017 for the So. Atl. ASPIC RW Ref. run. For 2016 , $F = F_{\text{current}}$. F = fishing mortality rate (per year), $P(B > B_{\text{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \text{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B_{median} = median biomass (1000 lb) estimate among projections, B = deterministic biomass (1000 lb) estimate, Y = deterministic yield (1000 lb) estimate, Sum Y = cumulative sum of deterministic yield (1000 lb). Yield includes landings and dead discards.

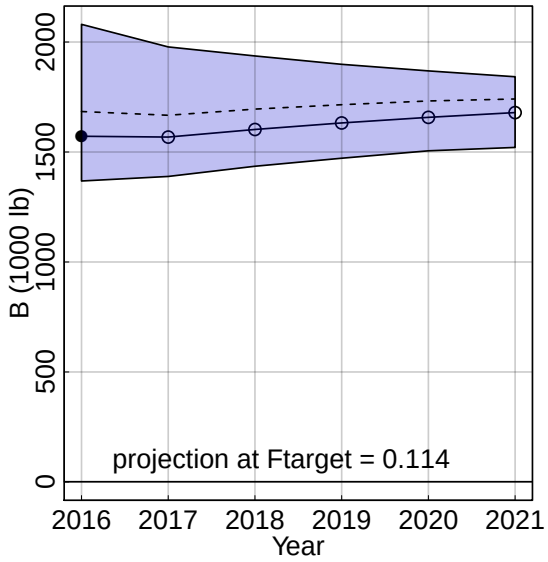
Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.139	0.80	0.97	1684	1572	219	219
2017	0.139	0.79	0.96	1667	1568	218	437
2018	0.139	0.78	0.96	1657	1565	218	655
2019	0.139	0.75	0.96	1648	1562	218	872
2020	0.139	0.72	0.95	1640	1560	217	1090
2021		0.70	0.94	1630	1558		

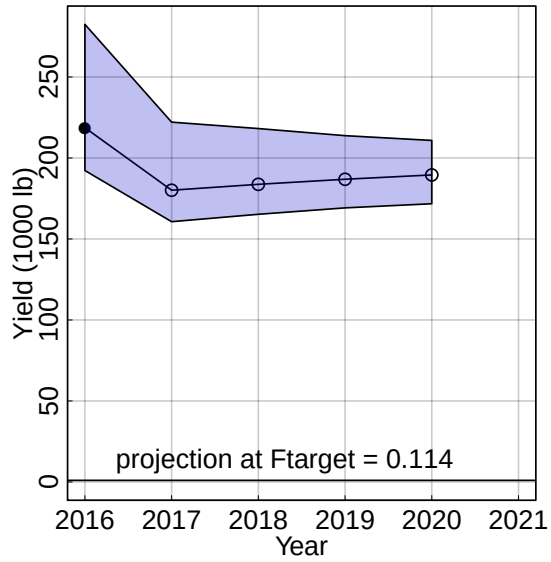
Results

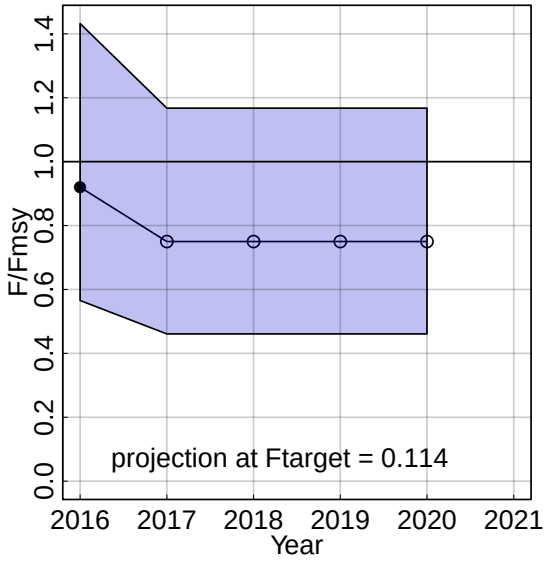
Projections

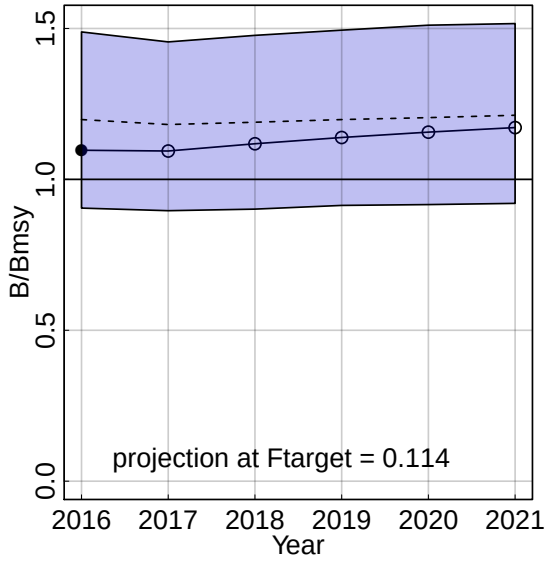
Projections at:

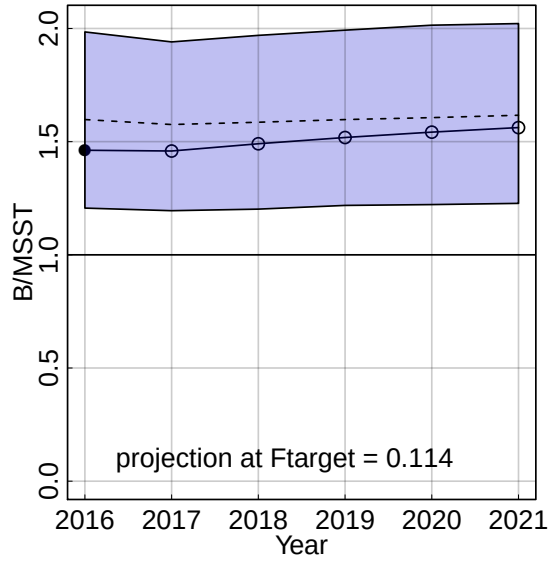












Results

Projections

Projections at: $F = F_{\text{target}} = 0.75F_{\text{MSY}}$

Table: Projection results with fishing mortality fixed at $F = F_{\text{target}}$ starting in 2017 for the So. Atl. ASPIC RW Ref. run. For 2016 , $F = F_{\text{current}}$. F = fishing mortality rate (per year), $P(B > B_{\text{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \text{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B_{median} = median biomass (1000 lb) estimate among projections, B = deterministic biomass (1000 lb) estimate, Y = deterministic yield (1000 lb) estimate, Sum Y = cumulative sum of deterministic yield (1000 lb). Yield includes landings and dead discards.

Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.139	0.80	0.97	1684	1572	219	219
2017	0.114	0.79	0.96	1667	1568	180	399
2018	0.114	0.80	0.97	1695	1602	184	583
2019	0.114	0.82	0.97	1715	1632	187	769
2020	0.114	0.82	0.97	1732	1658	190	959
2021		0.82	0.97	1741	1679		

Conclusions

- Results and conclusions are very similar as from the AW Base model
- Blueline Tilefish south of Cape Hatteras are not overfished ($B_{2015}/\text{MSST} = 1.4$) and overfishing is not occurring ($F_{2013-2015}/F_{\text{MSY}} = 0.92$)
- Bootstrap analysis suggests that stock status (B) is fairly certain, as only 3.6% of runs found the stock to be overfished
- Bootstrap analysis suggests that fishery status (F) is much less certain, as 29.0% of runs found the stock to be undergoing overfishing

Blueline Tilefish: South of Cape Hatteras Age-structured Production Model (ASPM) Review Workshop Reference Model (RW Ref)

NOAA FISHERIES

Southeast Fisheries Science Center

October 18, 2017

Table of contents

Methods

RW Reference Run Configuration

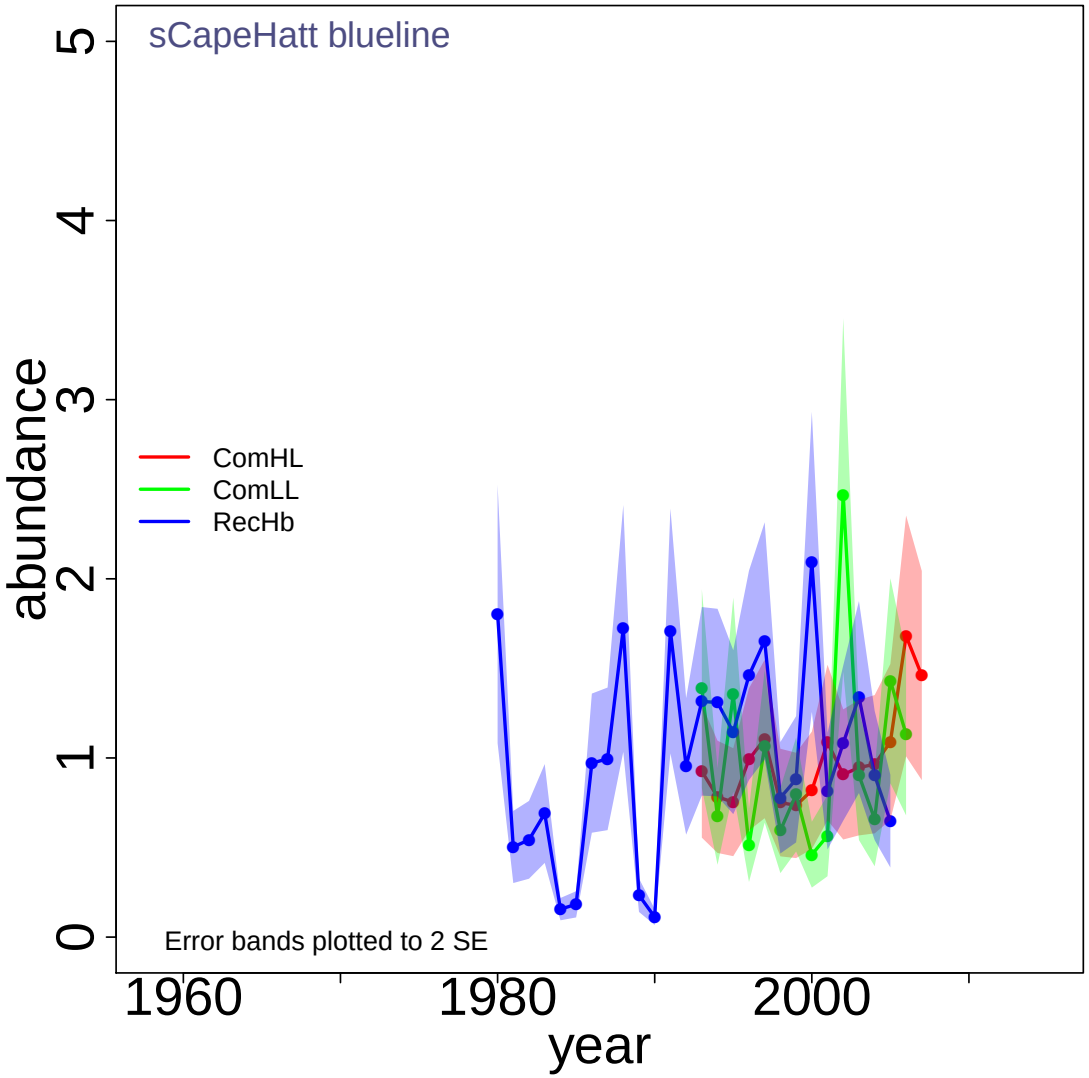
- The reference model developed at the SEDAR 50 Review Workshop (RW Ref) was a modified from the Assessmnent Workshop Base model in the following ways:
  1. Annual CVs for indices of abundance were all fixed at 0.2
  2. Age at 100% female maturity was fixed at age 6 (compared with age 2 in the AW Base)
  3. Von Bertalanffy growth parameters were estimated in the model

Methods

Data

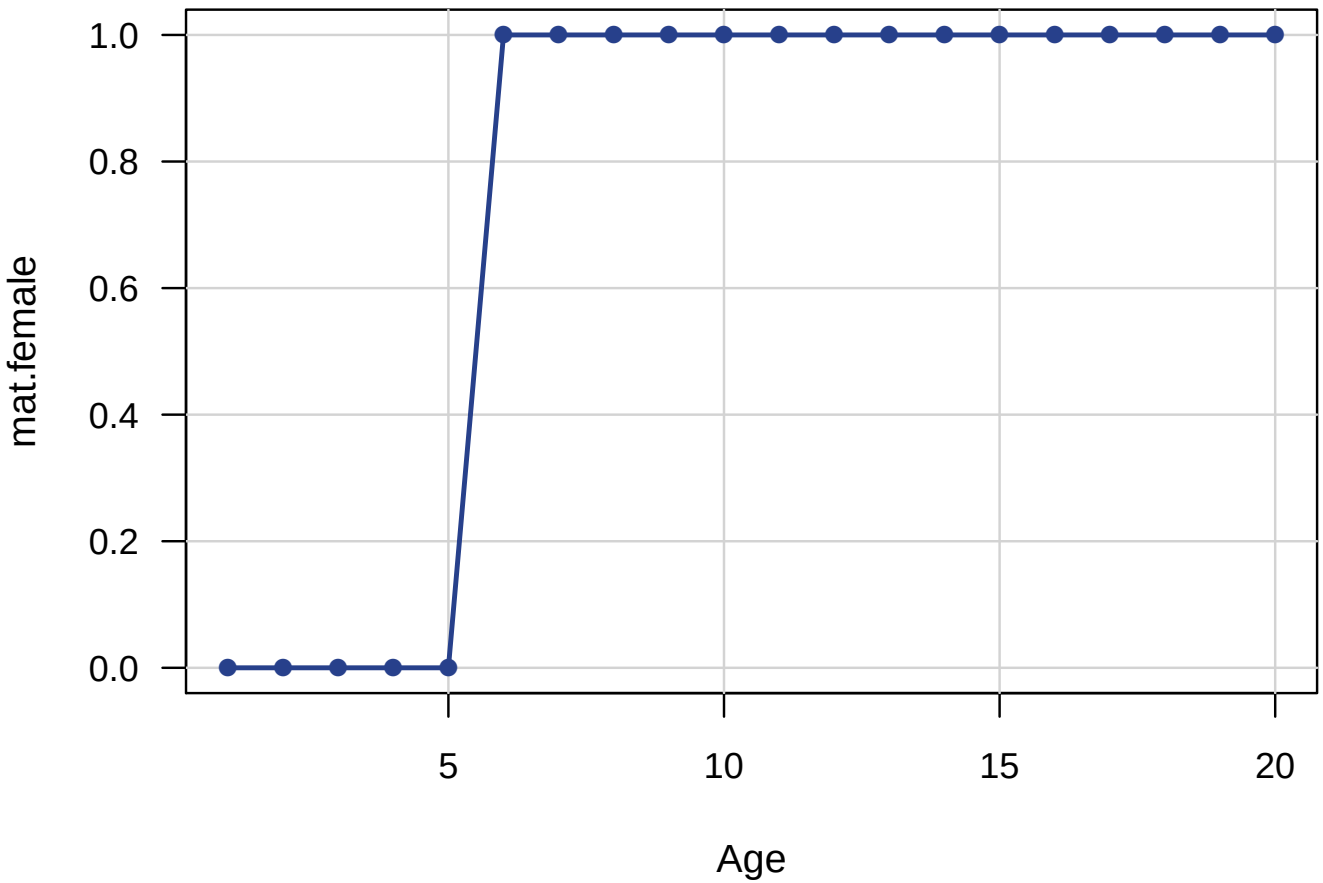
Indices of abundance

- The same indices as in the ASPIC model for south of Cape Hatteras



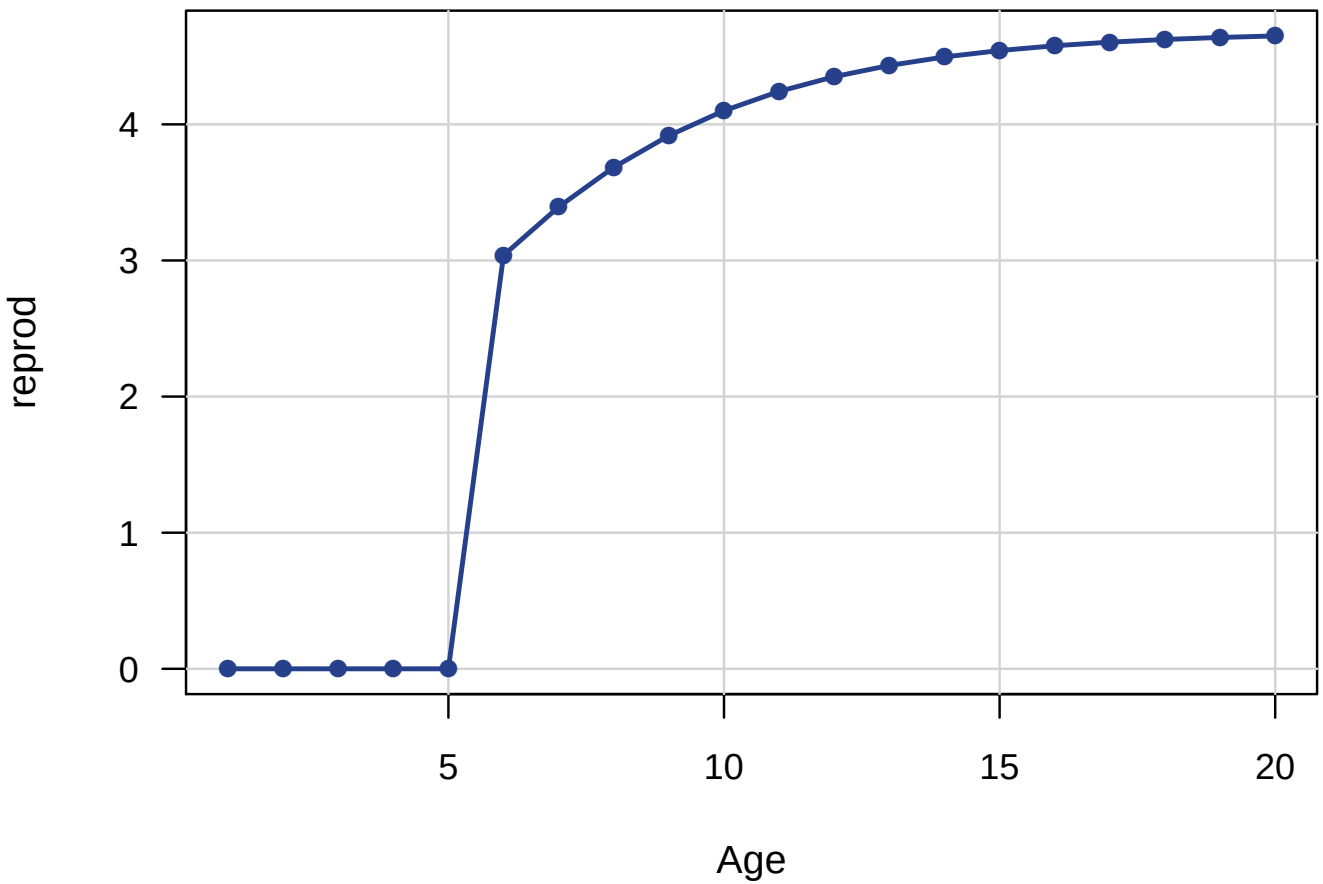
Life history

Female maturity by age



Life history

Reproductive output at age (million eggs)



Methods

Sensitivity

Sensitivity of AW Base model to individual modifications made to create RW Ref model

- ASPM S00: Assessment Workshop Base Model.
- ASPM S01: Assessment Workshop Base Model with fit to growth model parameters.
- ASPM S02: Assessment Workshop Base Model with 100% female maturity at age-6.
- ASPM S03: Assessment Workshop Base Model with CV of abundance indices fixed at 0.2.

Methods

Sensitivity

Sensitivity of RW Ref model to age at maturity

- ASPM S04: 100% female maturity at age-4.
- ASPM S05: 100% female maturity at age-9.

Methods

Sensitivity

Sensitivity of RW Ref model to natural mortality

- ASPM S06: Constant $M = 0.1$ ($t_{\max} = 40$; use Hoenig (1983) equation).
- ASPM S07: Constant $M = 0.25$ ($t_{\max} = 26$; use Then et al. (2014) equation).

Methods

Sensitivity

Sensitivity of RW Ref model to estimating recruitment deviations

- ASPM S08: Estimate recruitment deviations (1972-2015) with a weight of 10.
- ASPM S09: Estimate recruitment deviations (1972-2015) with a weight of 1.

Methods

Sensitivity

Sensitivity of RW Ref model to large 1980-1985 peak in commercial handline removals

- ASPM S10: Multiply commercial handline removals from 1980-1985 by 0.1 (i.e. reduce by 90%).
- ASPM S11: Multiply commercial handline removals from 1980-1985 by 0.5 (i.e. reduce by 50%).

Methods

Sensitivity

Sensitivity of RW Ref model to indices

- ASPM S12: Reduce weights of all indices to 0.1.
- ASPM S13: Remove last 3 yr from indices.

Methods

Sensitivity

Sensitivity of RW Ref model to Beverton-Holt steepness parameter

- ASPM S14: Fix steepness at 0.25
- ASPM S15: Fix steepness at 0.35
- ASPM S16: Fix steepness at 0.45
- ASPM S17: Fix steepness at 0.55
- ASPM S18: Fix steepness at 0.65
- ASPM S19: Fix steepness at 0.75
- ASPM S20: Estimate steepness with uniform prior

Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

Removals: Commercial

- For commercial landings, bounds were provided in the Data Workshop Report by year and region

Table 3.4 Uncertainty in commercial landings by data state/region. Upper and lower bounds prior to dividing (red) line. Upper bound only post diving line.

Year	Mid-Atlantic/NE	NC	SC	GA	FL - Atlantic	FL - GOM	GOM
1958-1961	NA	0.25	NA	NA	0.25	0.25	NA
1962-1977	NA	0.2	0.2	0.2	0.2	0.2	NA
1978-1985	NA	0.1	0.1	0.1	0.2	0.1	0.25
1986-1989	NA	0.1	0.1	0.1	0.05	0.05	0.25
1990-1993	NA	0.1	0.1	0.1	0.05	0.05	0.15
1994	NA	0.05	0.1	0.1	0.05	0.05	0.15
1995-1996	NA	0.05	0.1	0.1	0.05	0.05	0.15
1997-2001	0.25	0.05	0.1	0.1	0.05	0.05	0.1
2002-2003	0.25	0.05	0.05	0.1	0.05	0.05	0.1
2004	0.25	0.05	0.05	0.05	0.05	0.05	0.1
2005-2009	0.1	0.05	0.05	0.05	0.05	0.05	0.1
2010-present	0.1	0.05	0.05	0.05	0.05	0.05	0.05

Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

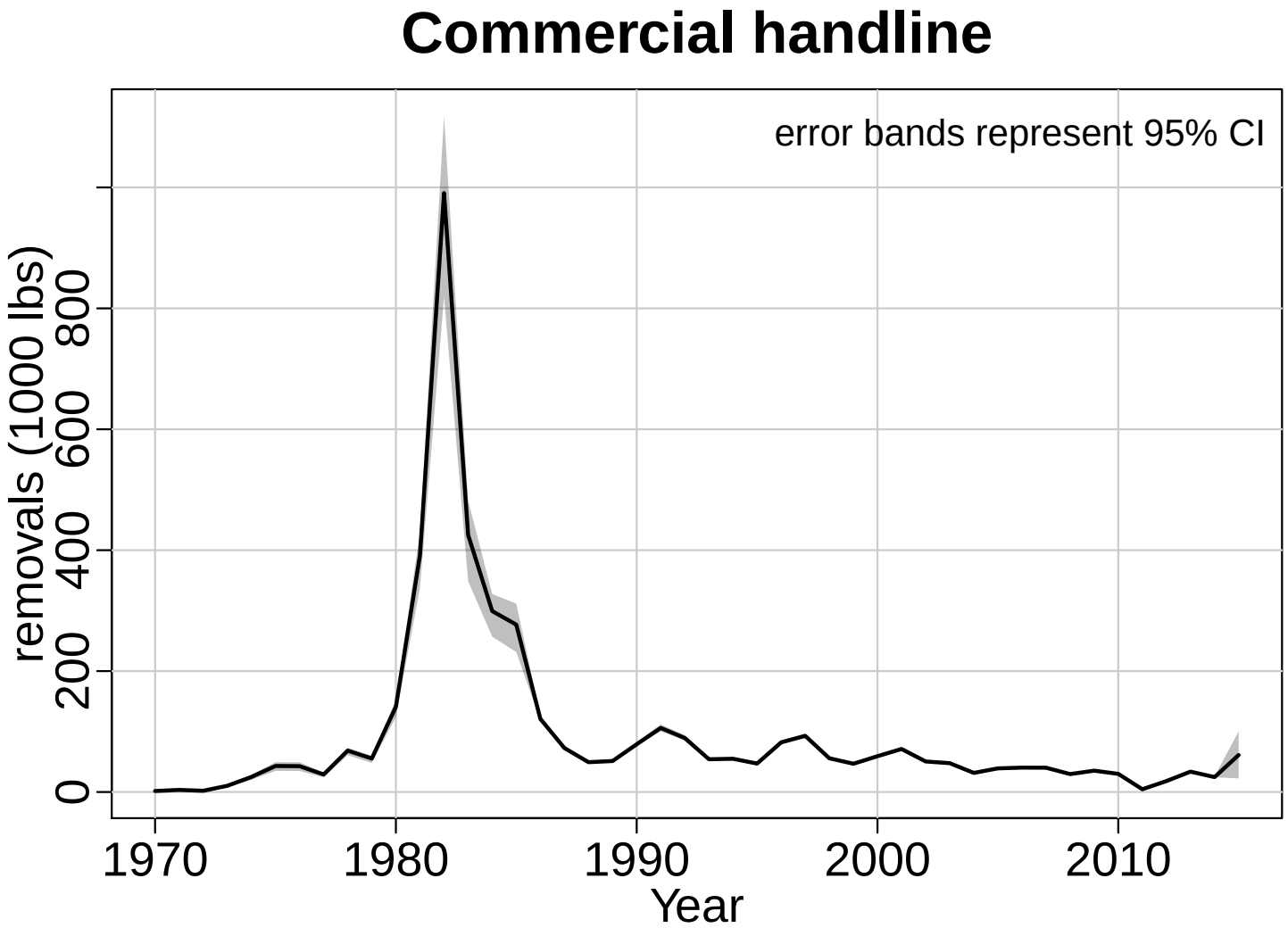
Removals: Commercial

- For commercial landings, bounds were provided by year and region
  - Commercial landings were sampled by year and region from a uniform distribution between the bounds provided in Table 3.4 of the SEDAR 50 DW Report
- Commercial discards were sampled from a lognormal distribution by year and region with a CV of 0.5 (from SEDAR50 DW)
- Commercial discard mortality was sampled from a uniform distribution within the range suggested at the data workshop for commercial hook and line (0.9 to 1.0)
- Commercial landings were then aggregated by fleet as in the RW Ref model

Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

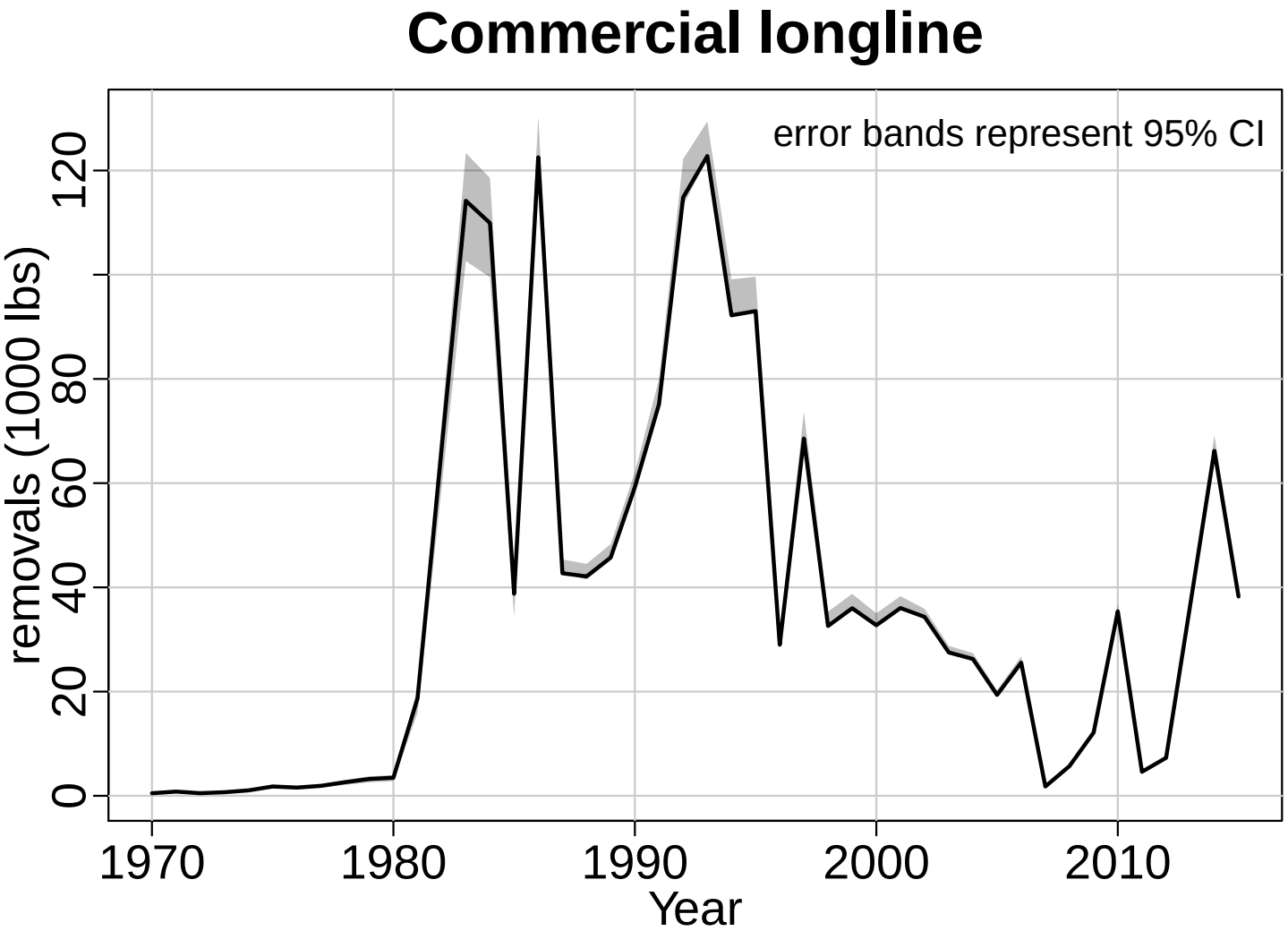
Removals: Commercial



Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

Removals: Commercial



Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

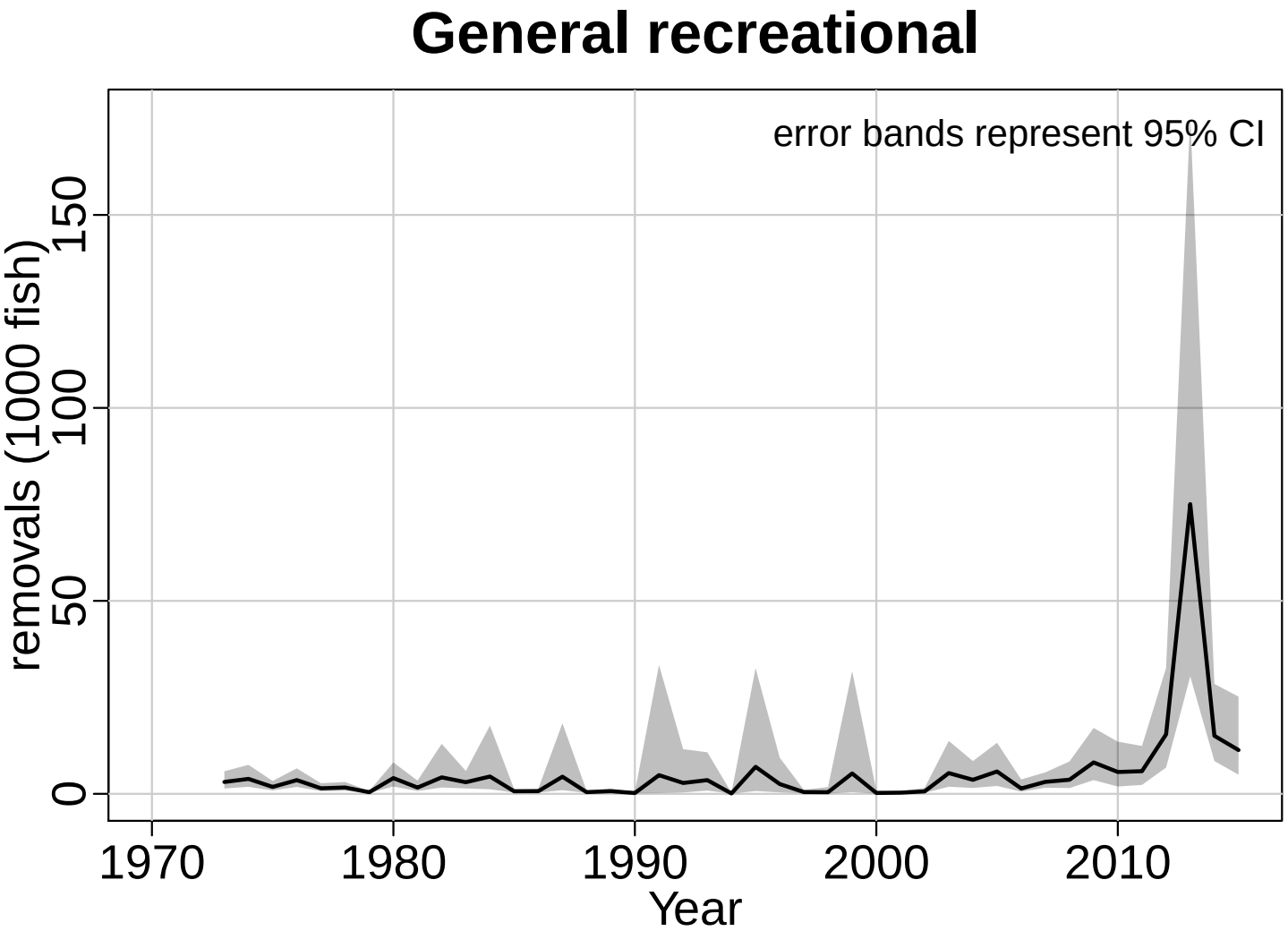
Removals: Recreational

- For recreational landings and discards, CVs were provided by year and region for MRIP only
  - MRIP landings and discards were sampled from lognormal distributions by year and region using the CVs provided
  - Headboat landings and discards were sampled from lognormal distributions by year and region using median MRIP CVs for the corresponding region
- recreational discard mortality was sampled from a uniform distribution within the range suggested at the data workshop (0.64 to 1)
- commercial discard mortality was sampled from a uniform distribution within the range suggested at the data workshop for commercial hook and line (0.9 to 1.0)
- recreational landings were then aggregated as in the base model

Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

Removals: Recreational



Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

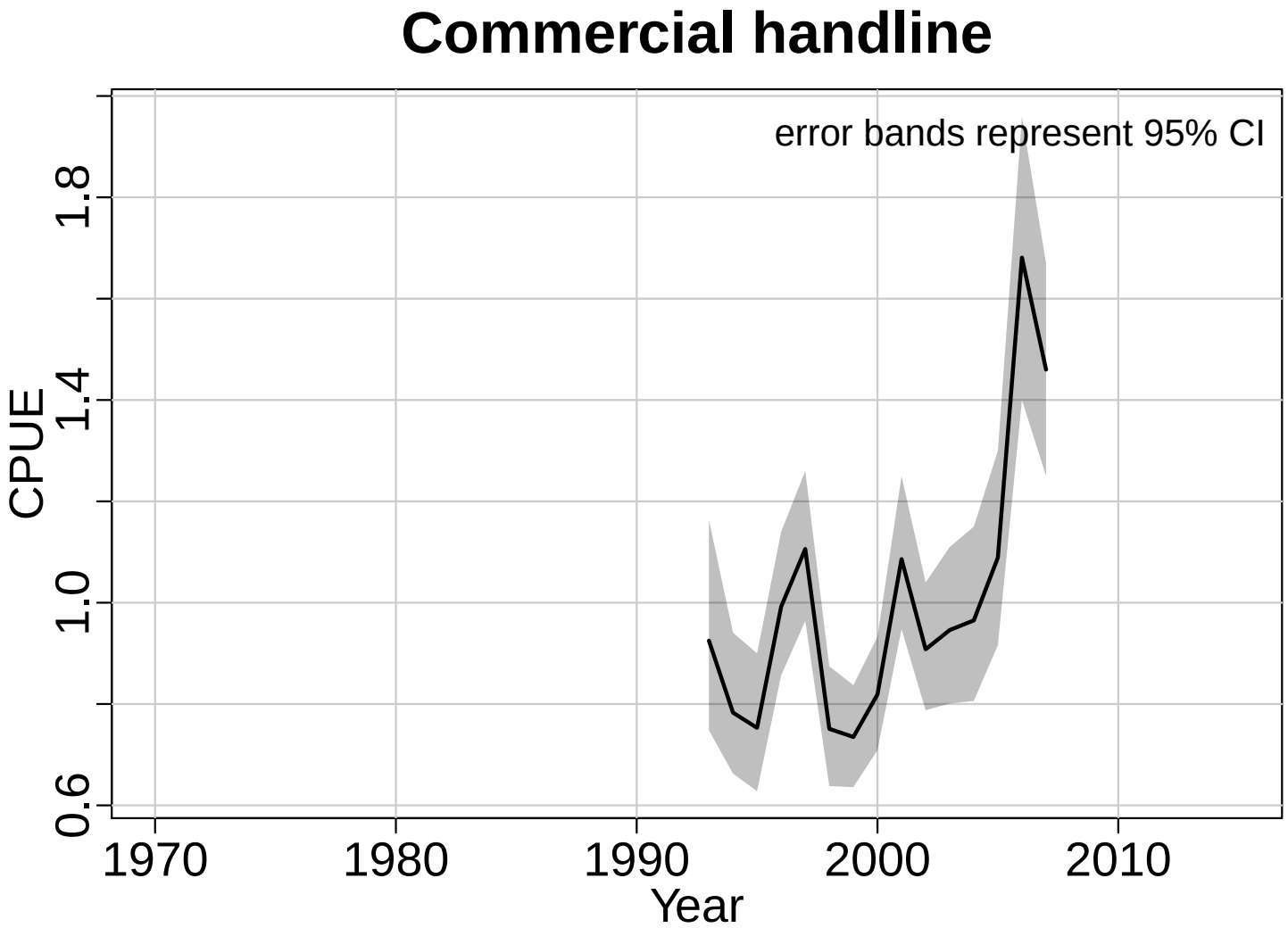
Indices

- Each index was sampled from lognormal distributions by year using the CVs provided at the DW, and restandardized to a mean of 1
- Note that CV=0.2 were used when estimating the indices in each MCB run, as in the RW Ref model

Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

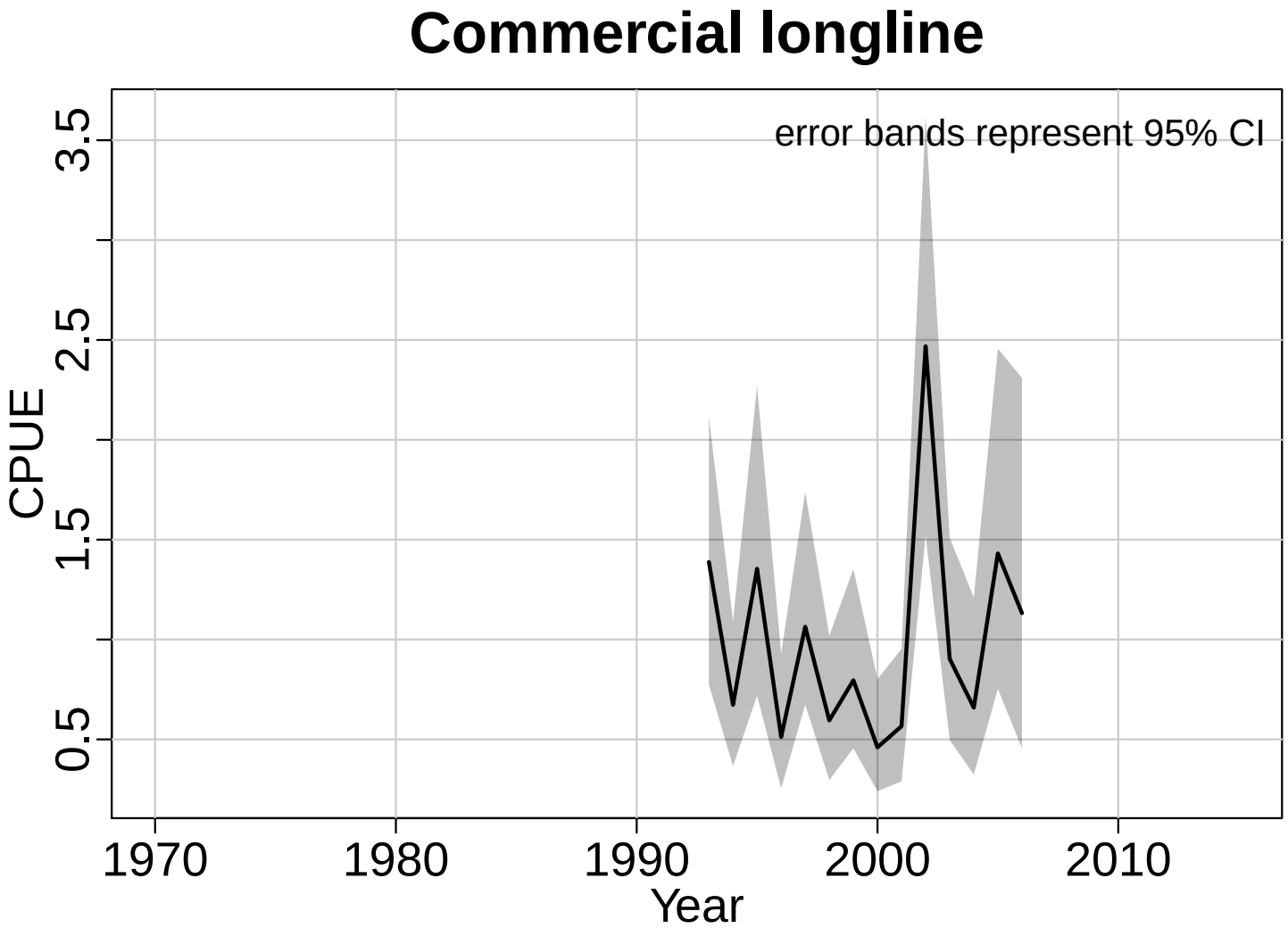
Indices of abundance



Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

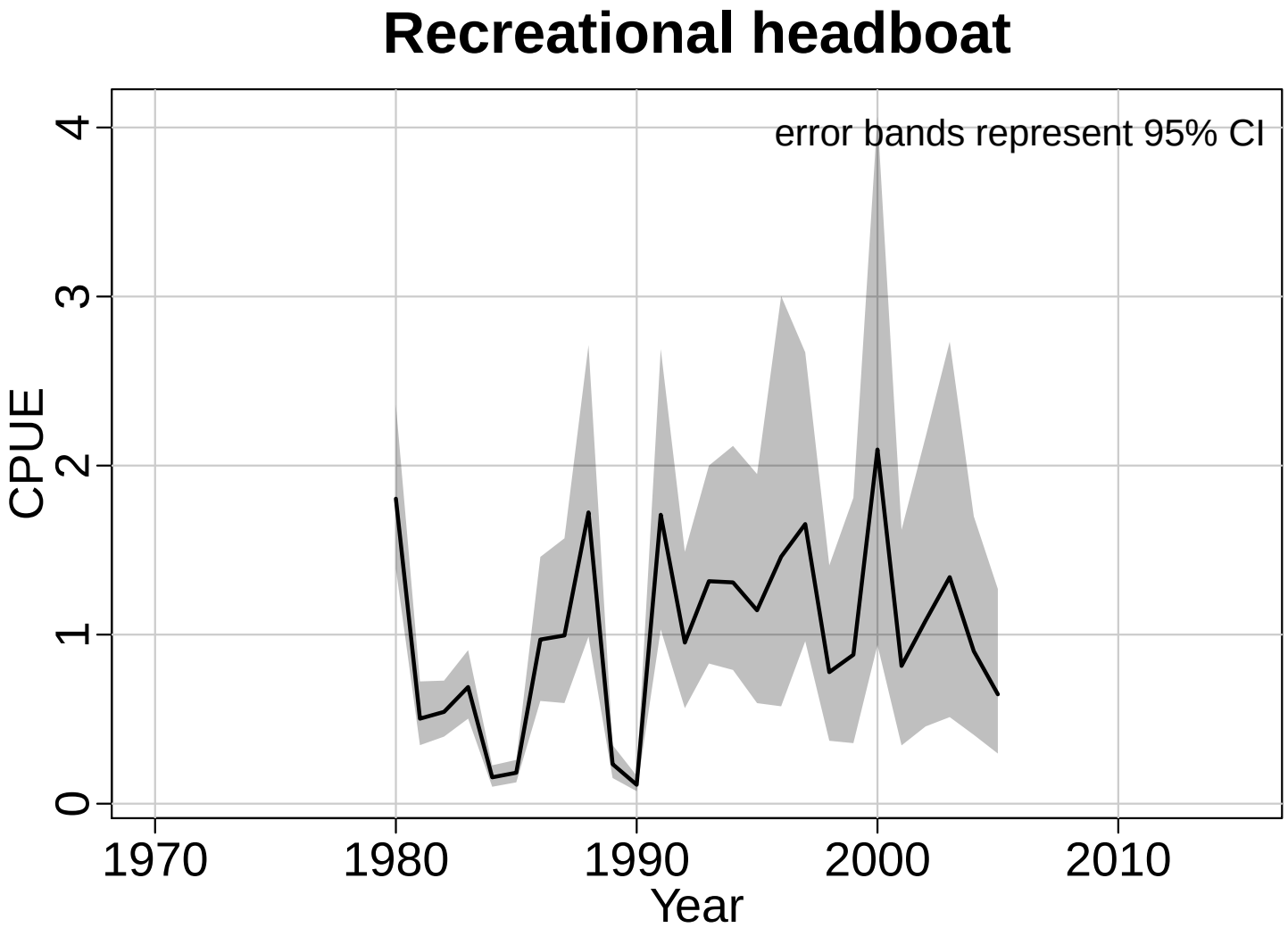
Indices



Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

Indices

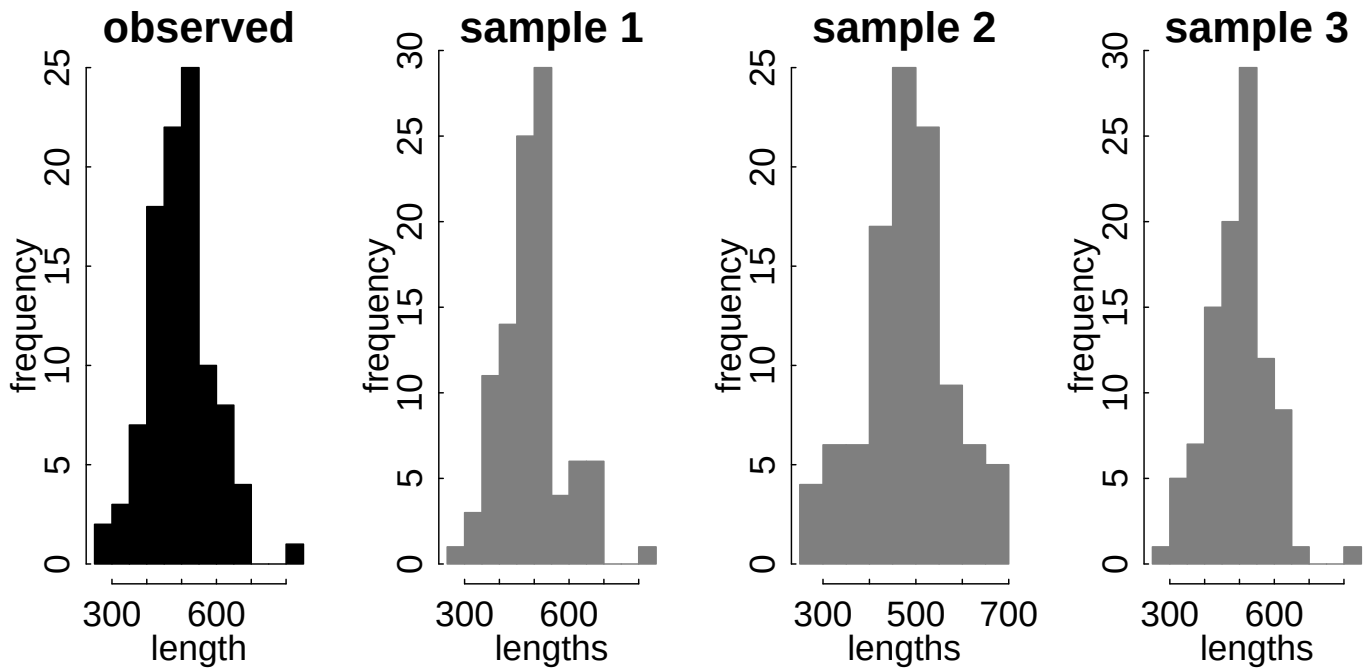


Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

Length composition

- For each fleet, the actual length composition data was bootstrapped by sampling the same number of lengths as was observed in a given year, with replacement
- Histograms below illustrate this concept with three simulated samples

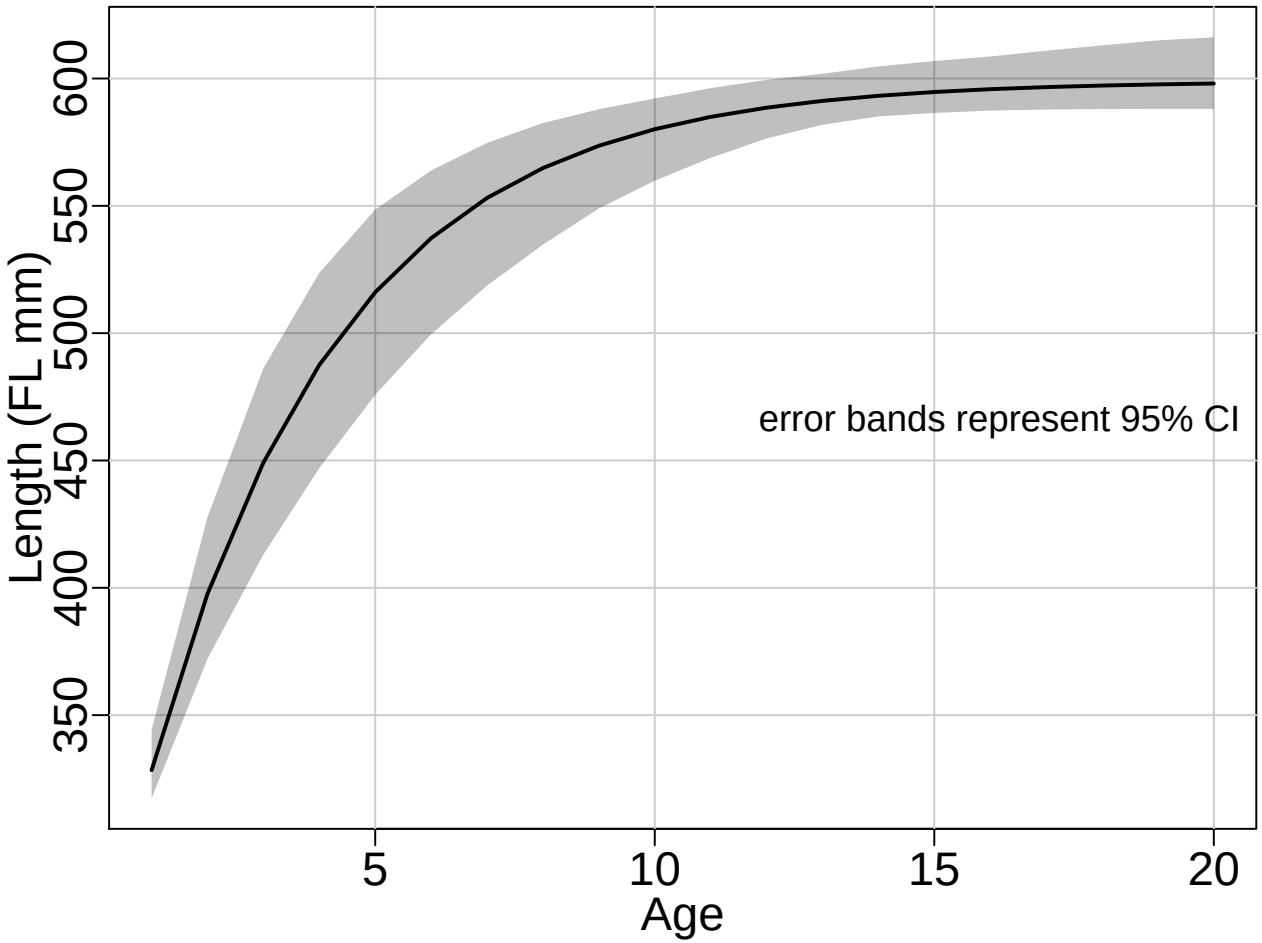


Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

Life history

- Growth - In the RW Ref model, growth parameters were estimated

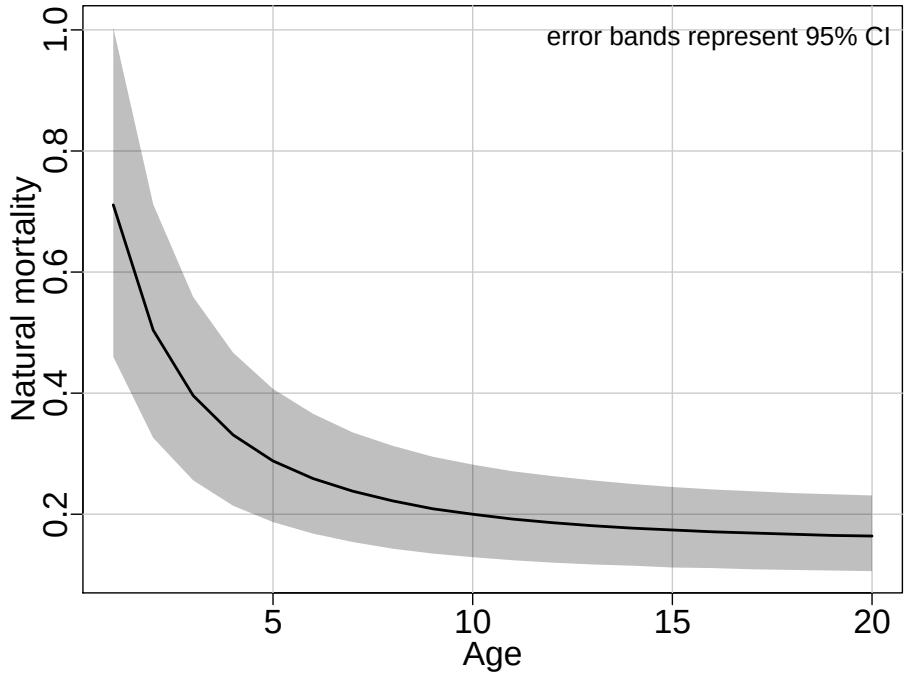


Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

Life history

- Natural mortality
  - Values were drawn from a truncated normal distribution (range [0.1, 0.25]) with mean equal to the point estimate (M = 0.17) and standard deviation set to provide a lower 95% confidence limit at 0.1
  - Each value of M was used to scale the age-specific Charnov M, as in the AW Ref model



Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

Life history

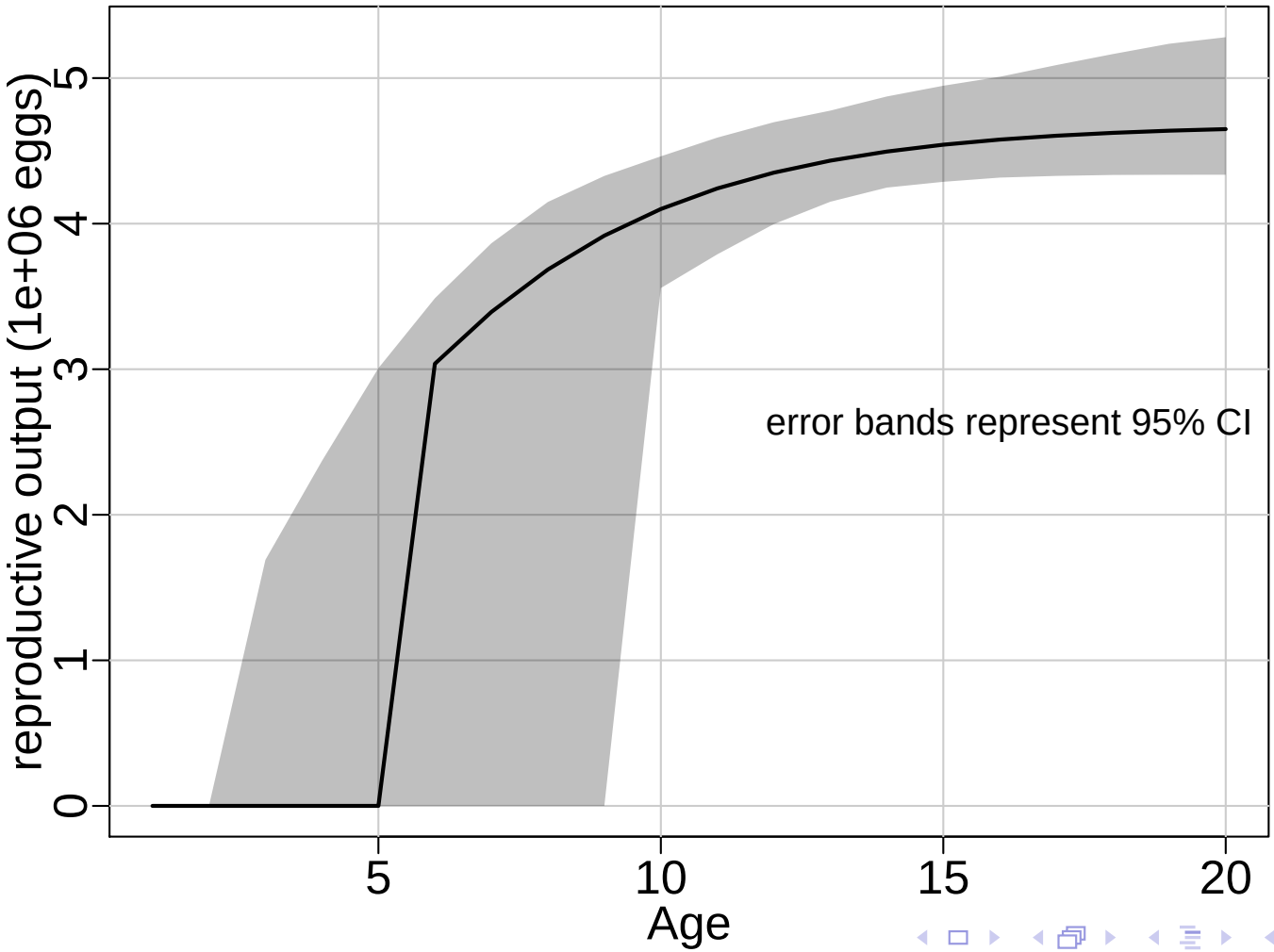
- Reproductive output (reprod)
  - In the ASPM, reproductive output-at-age is the product of several vectors-at-age:
    $reprod = P(female) * P(mature) * batchFecundity * batchNumber$
  - P(female) was fixed at 0.5 (i.e. 1:1 sex ratio)
  - Age at 100% maturity was sampled from a uniform distribution (range [2, 10])
  - Batch fecundity-length data were bootstrapped (paired observations sampled with replacement) and regression model parameters estimated for each MCB run
  - Batch number was fixed at the DW recommended base run value of 94 batches per mature female per year

Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

Life history

- Reproductive output (reprod)

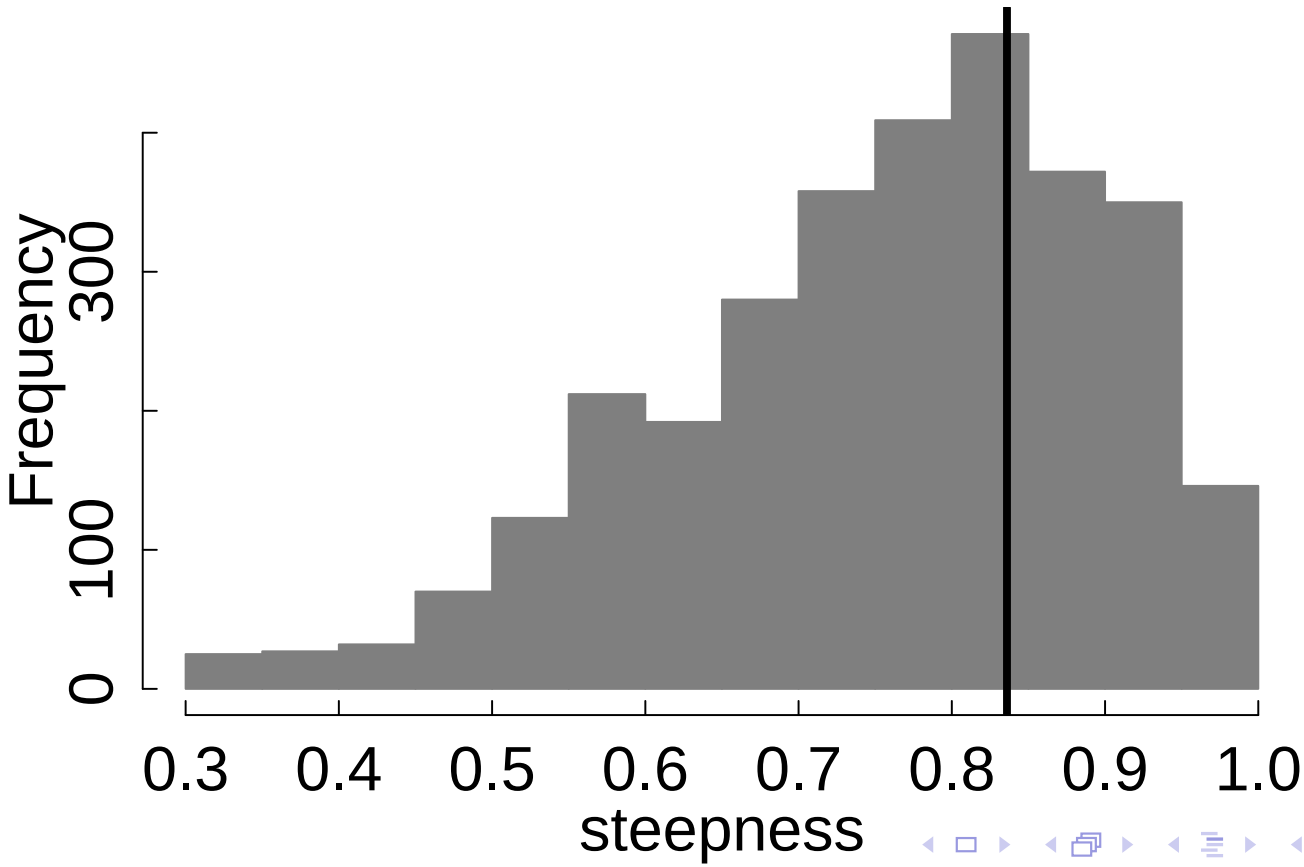


Methods

Uncertainty Analysis (Monte Carlo Bootstrap; MCB)

Life history

- Steepness - In each MCB run, a value of steepness was drawn from a beta distribution of steepness values from a meta-analysis by Shertzer and Conn (2012), and then fixed at that value.



Methods

Projections

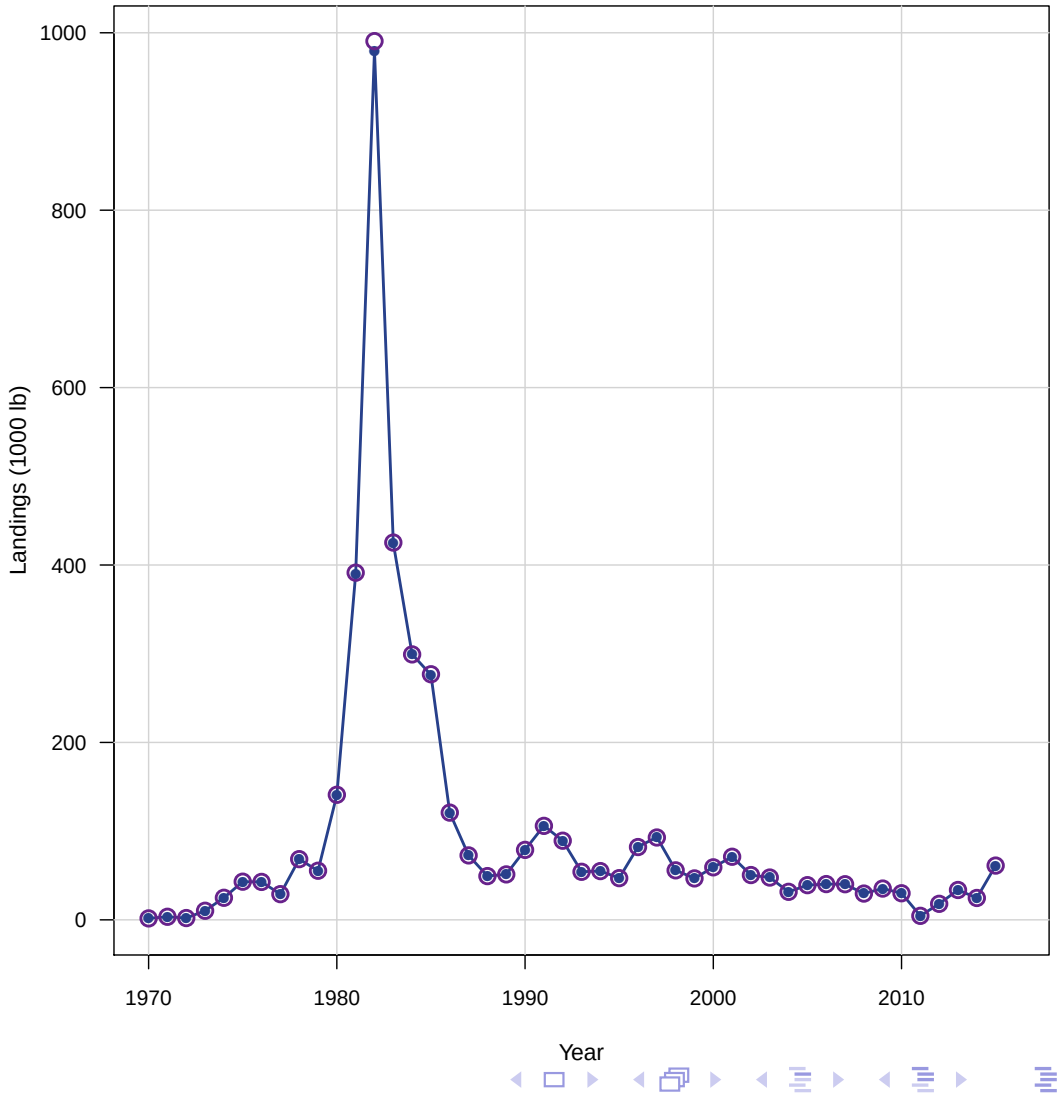
- Projections were made from the MCB results from the RW Ref model
- One deterministic projection was made for each MCB run
- Since recruitment deviations were set to zero in the RW Ref model, stochasticity in recruitment deviations was not incorporated into the projections
- Uncertainty in projections therefore depends solely on uncertainty in MCB trials
- $F_{2016} = F_{\text{current}}$
- Five year projections with $F_{2017-2021}$ set equal to:
  - F_{MSY}
  - F_{current}
  - $F_{\text{target}} = 0.75F_{\text{MSY}}$
  - $F_{30\%}$
  - $F_{40\%}$

Results

RW Reference Run

Fit to removals

Commercial handline

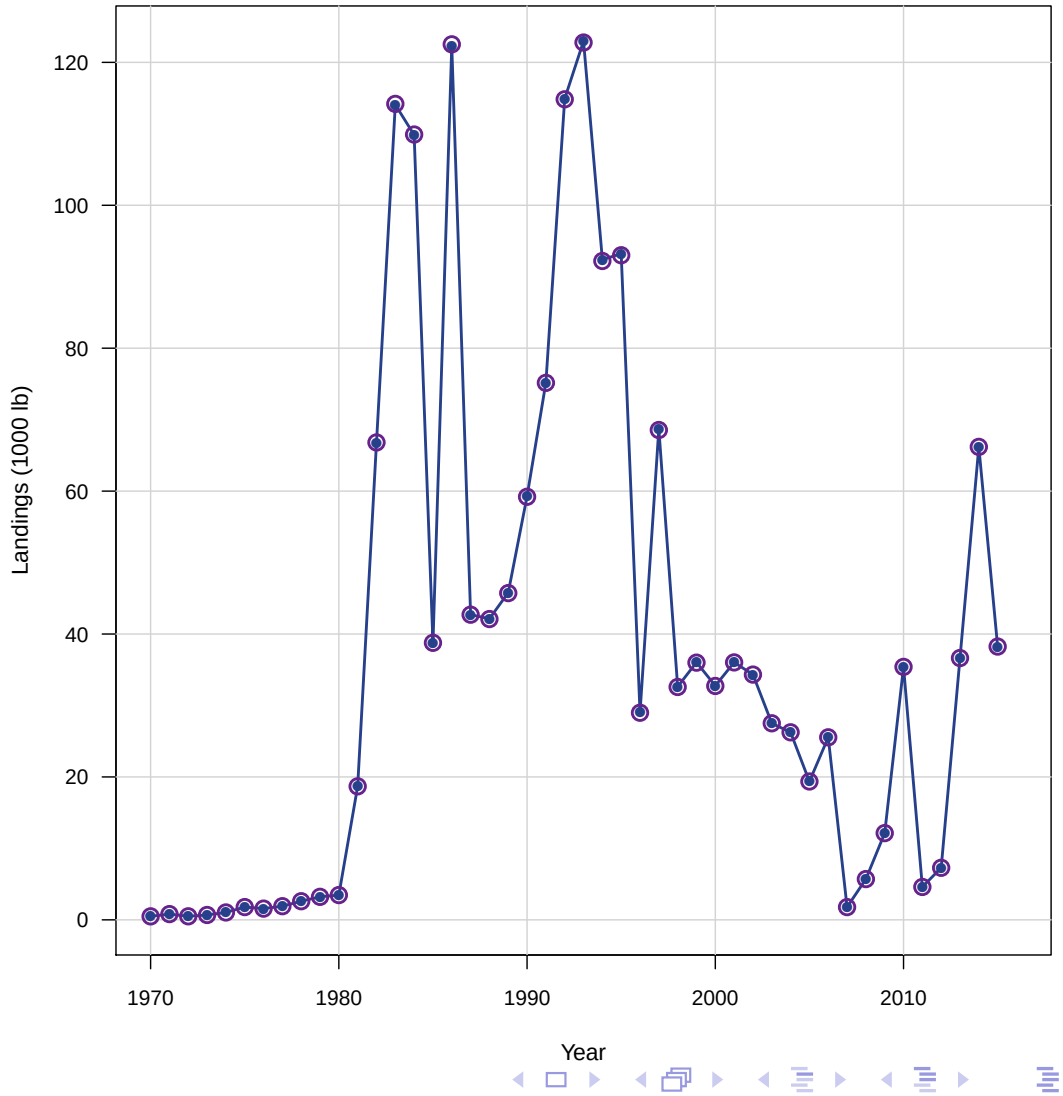


Results

RW Reference Run

Fit to removals

Commercial longline

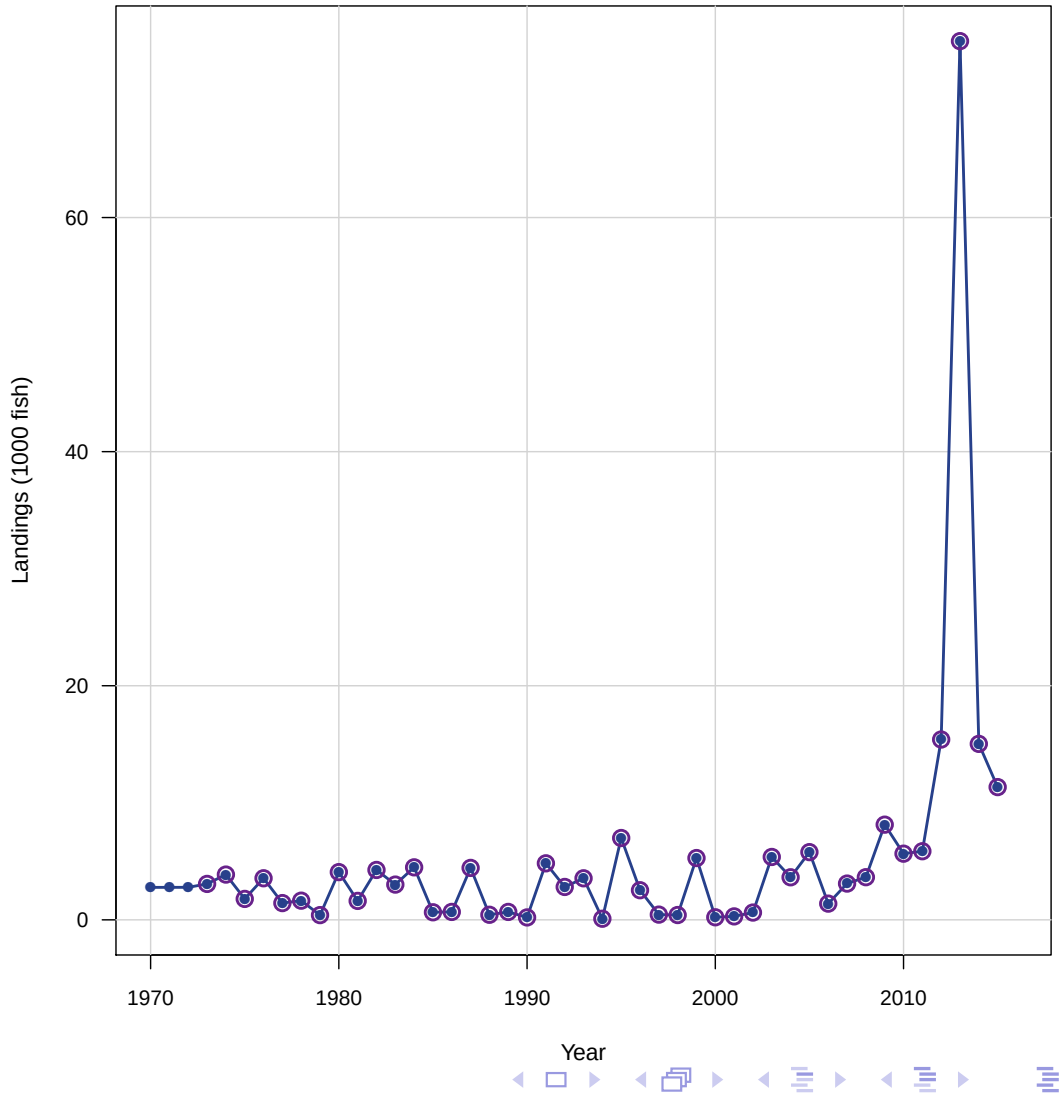


Results

RW Reference Run

Fit to removals

General recreational

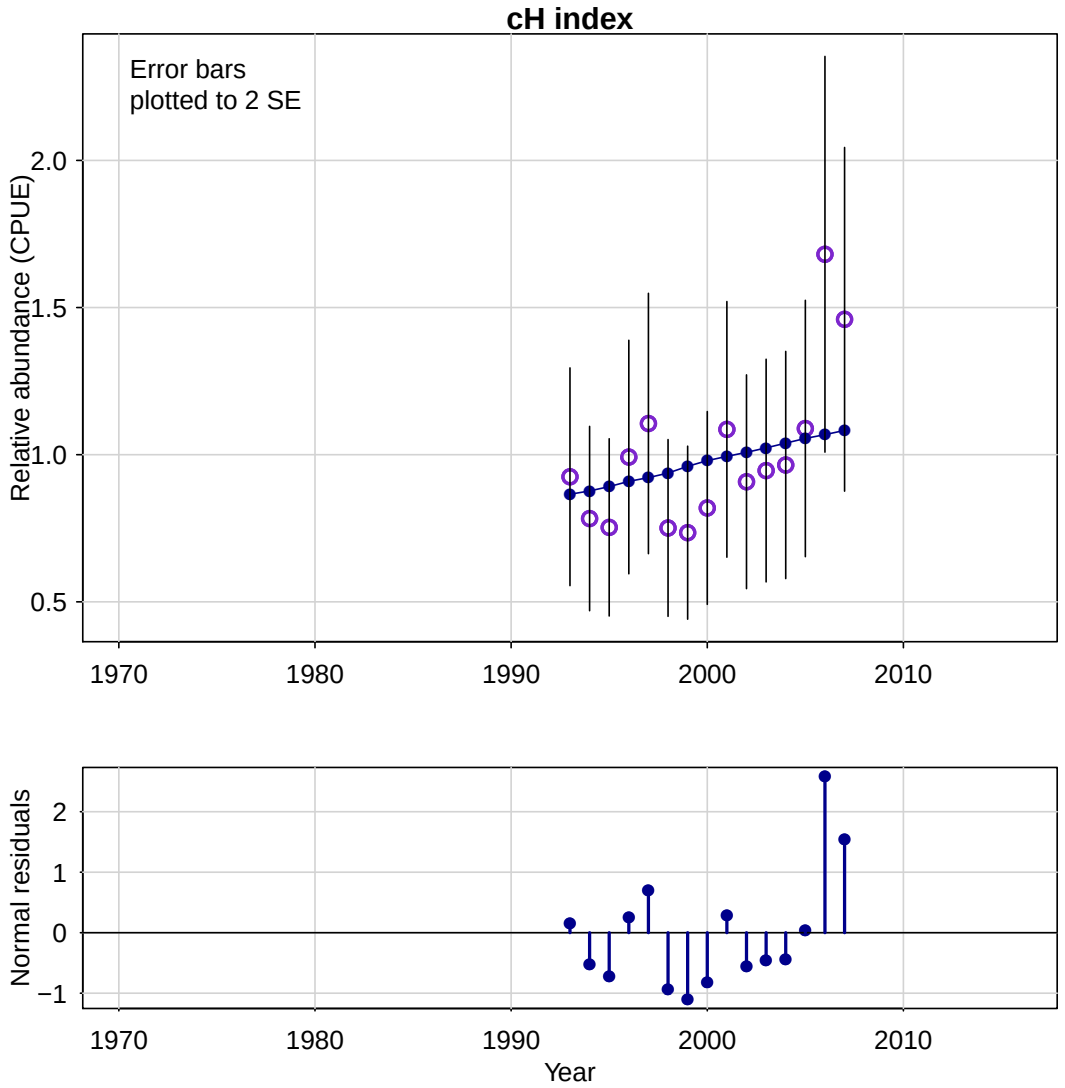


Results

RW Reference Run

Fit to indices

Commercial handline

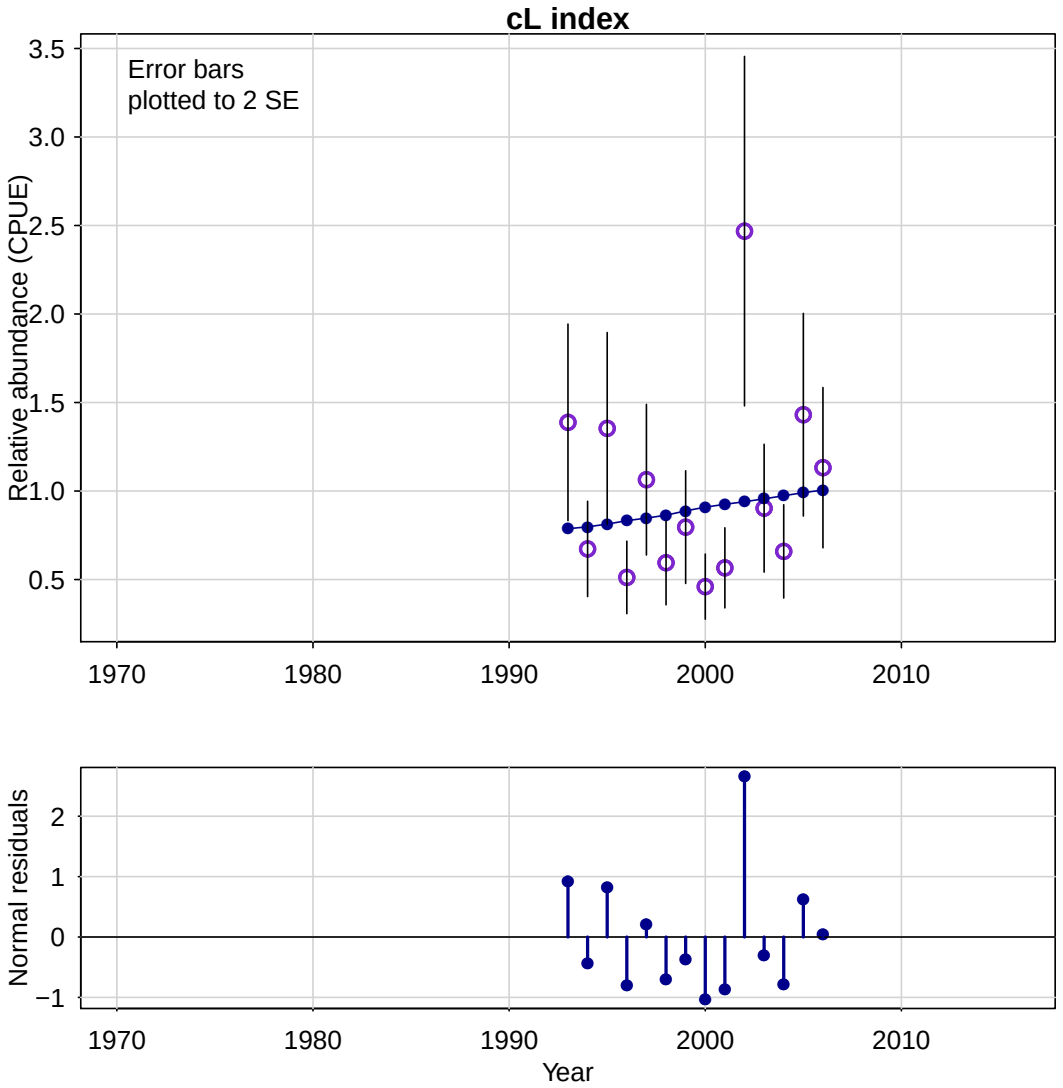


Results

RW Reference Run

Fit to indices

Commercial longline

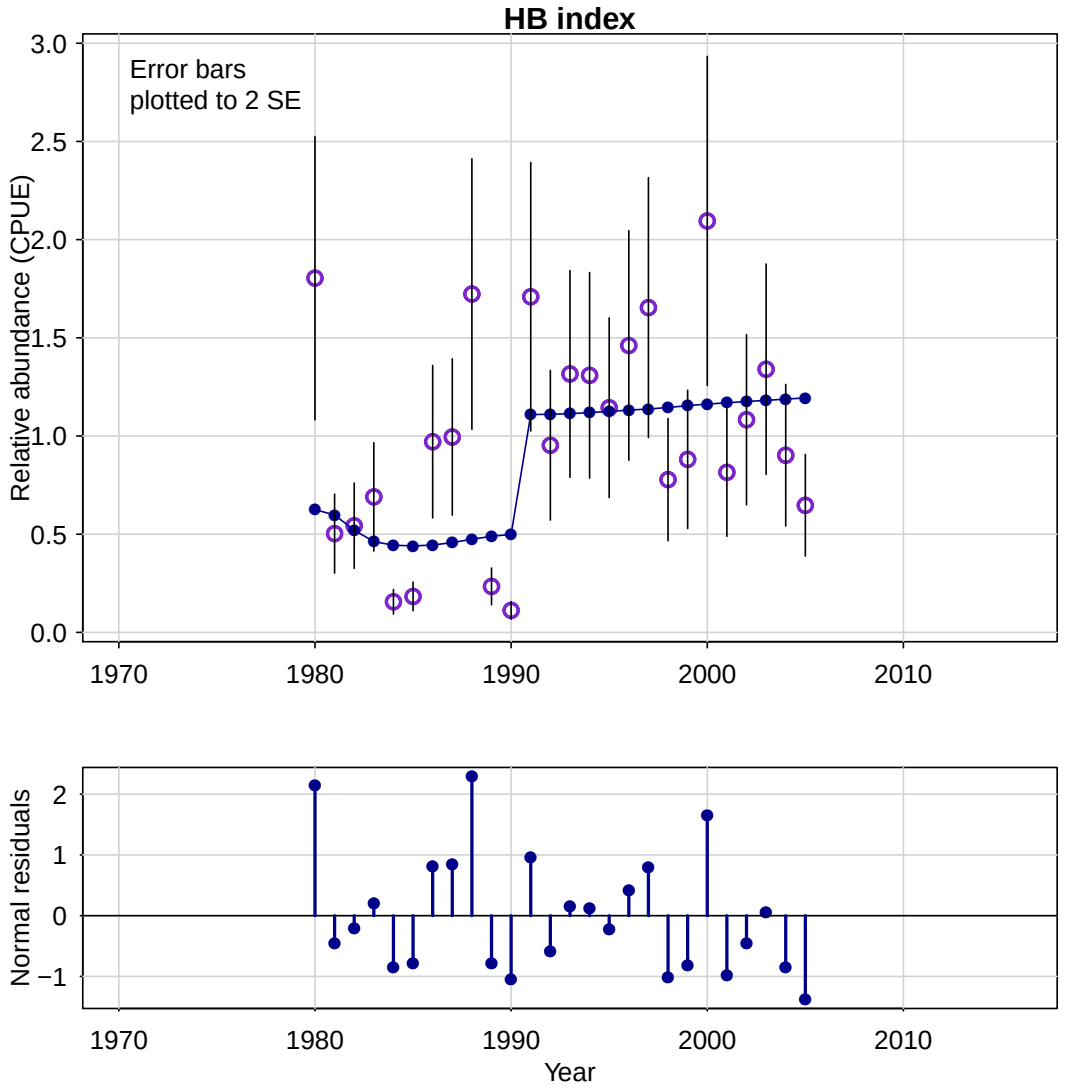


Results

RW Reference Run

Fit to indices

Headboat (recreational)



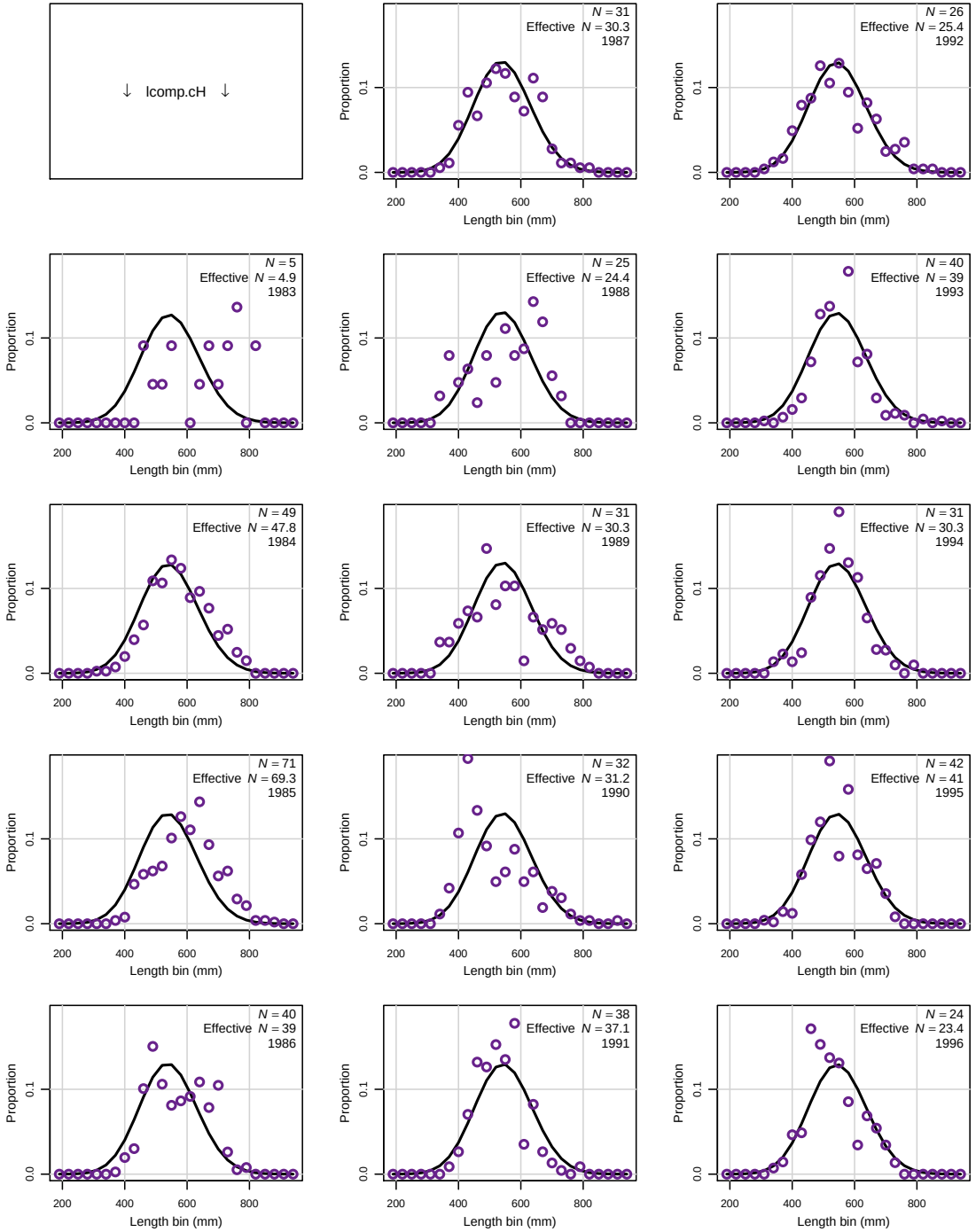
Results

RW Reference Run

Fit to lengths

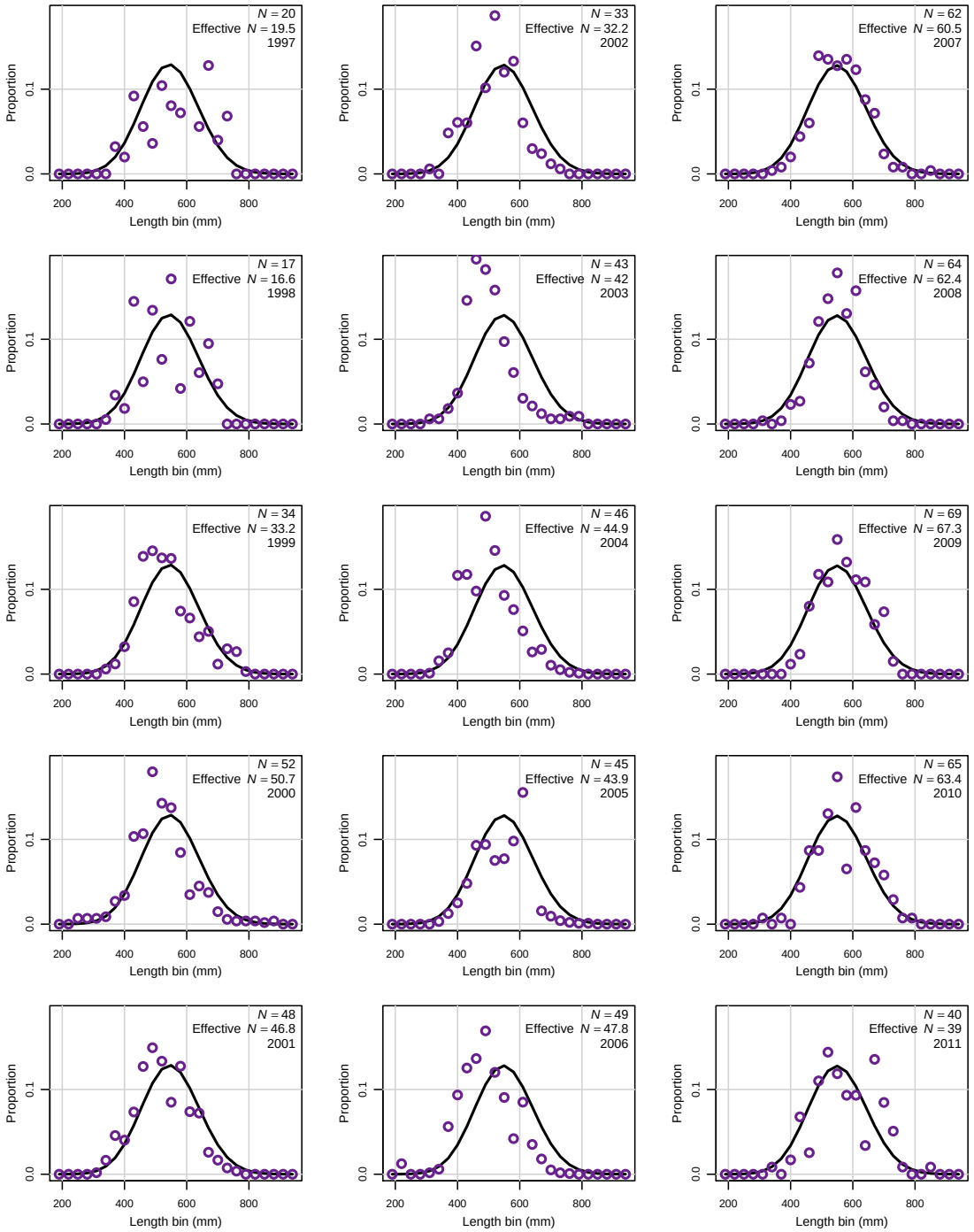
Page 1:

Commercial handline 1983-1996



Results

RW Reference Run



Fit to lengths
Page 2:

Commercial handline 1997-2011

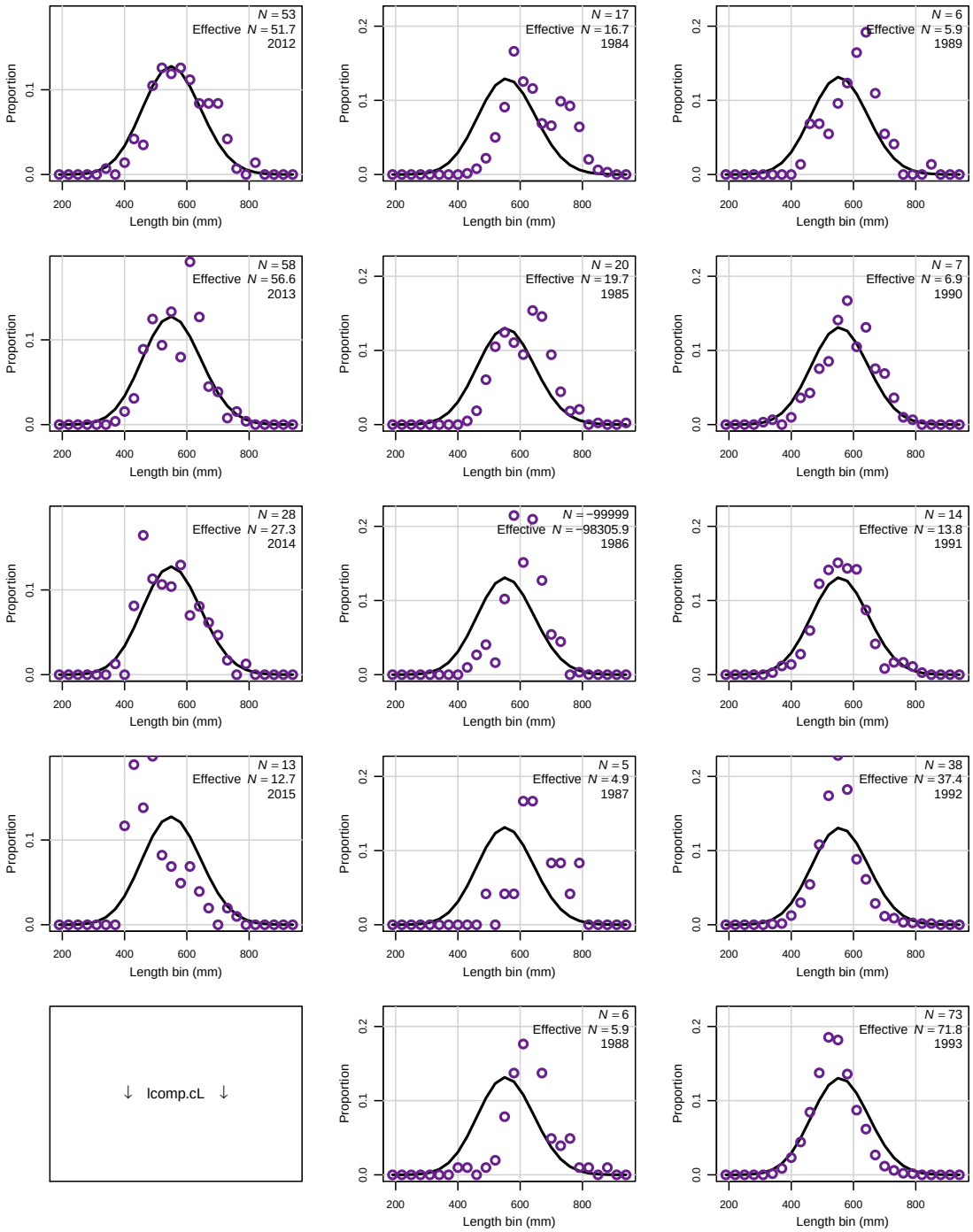
Results

RW Reference Run

Fit to lengths
Page 3:

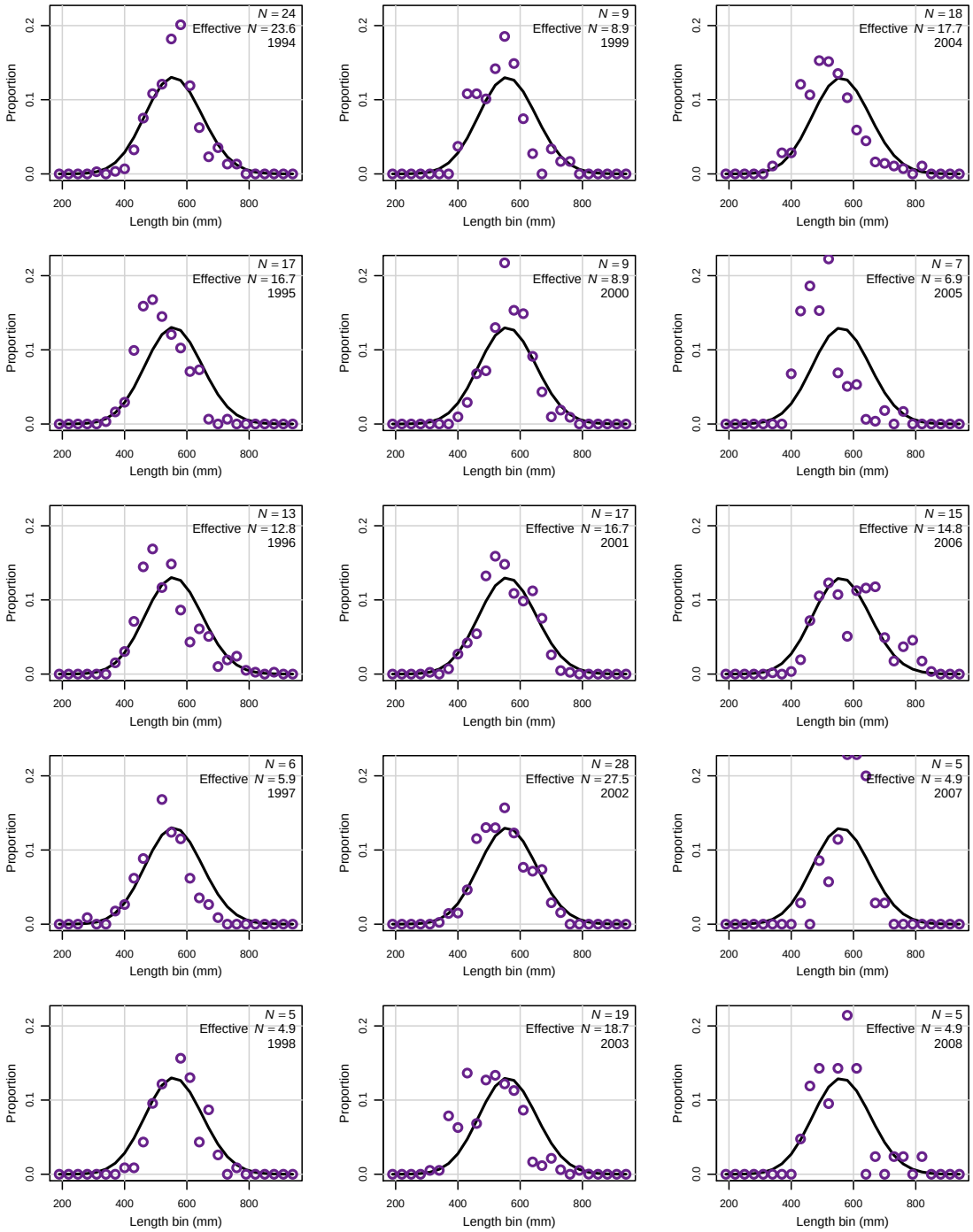
Commercial handline 2012-2015

Commercial longline 1984-1993



Results

RW Reference Run



Fit to lengths
Page 4:

Commercial longline 1994-2008

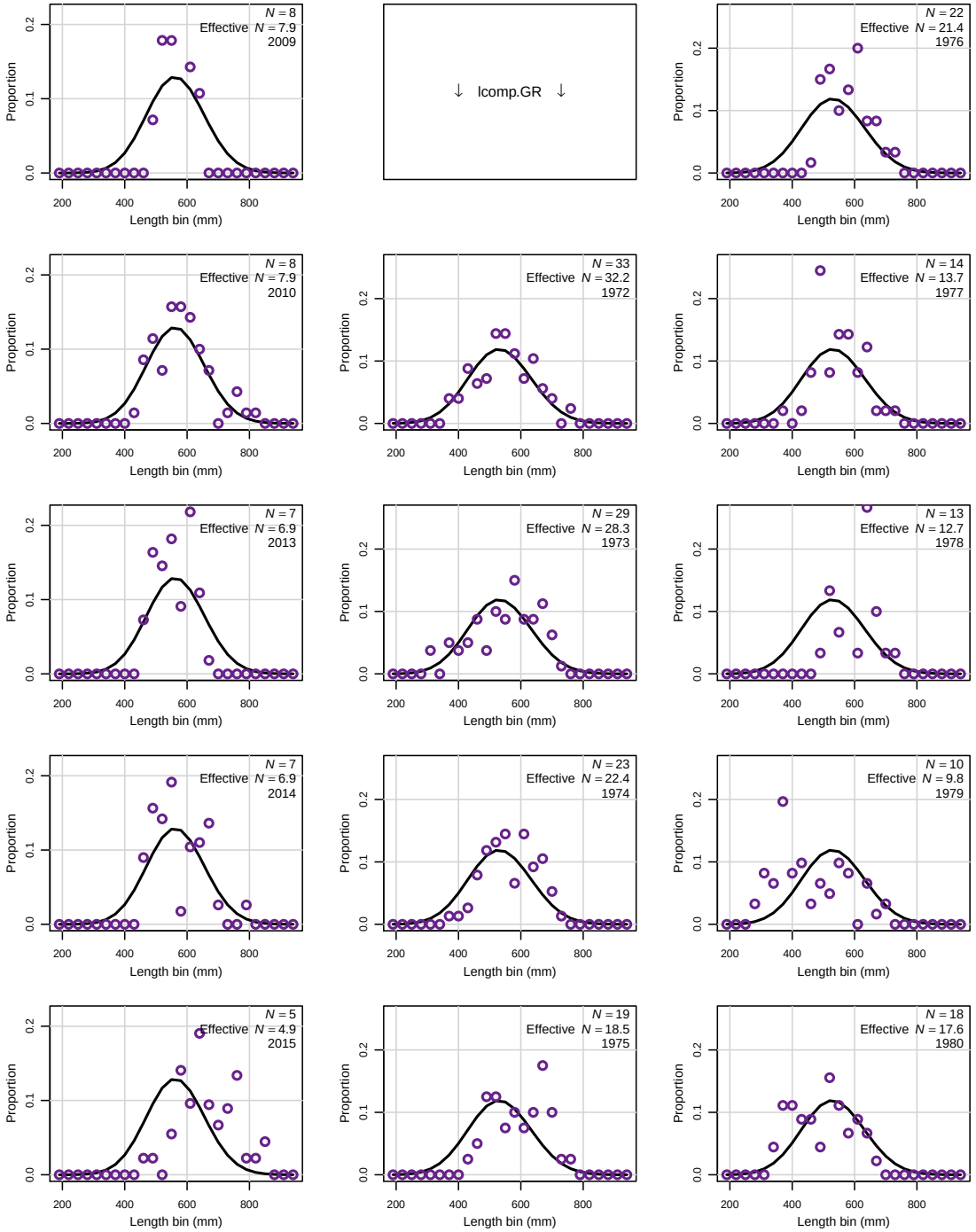
Results

RW Reference Run

Fit to lengths
Page 5:

Commercial longline 2009-2015

General recreational 1972-1980

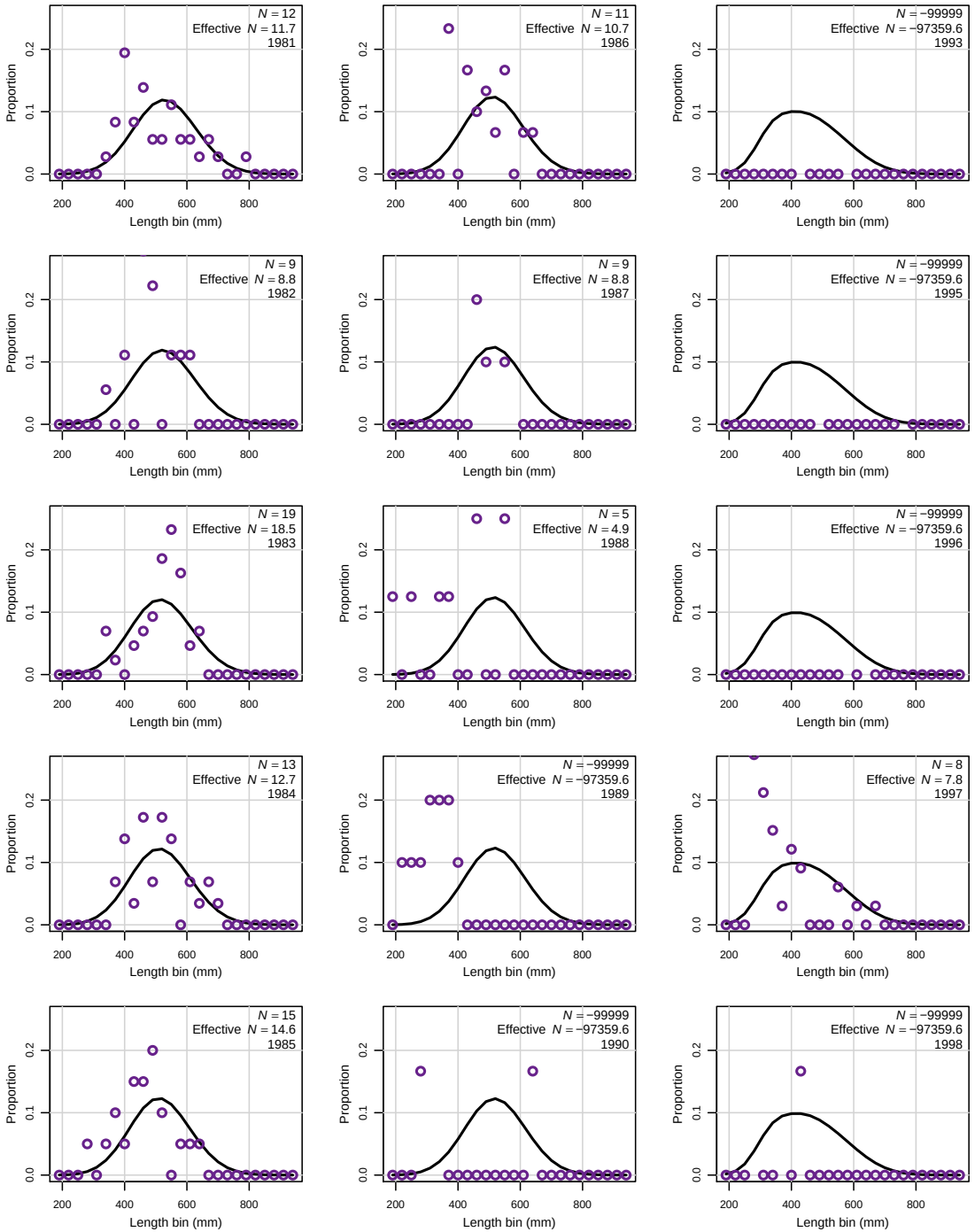


Results

RW Reference Run

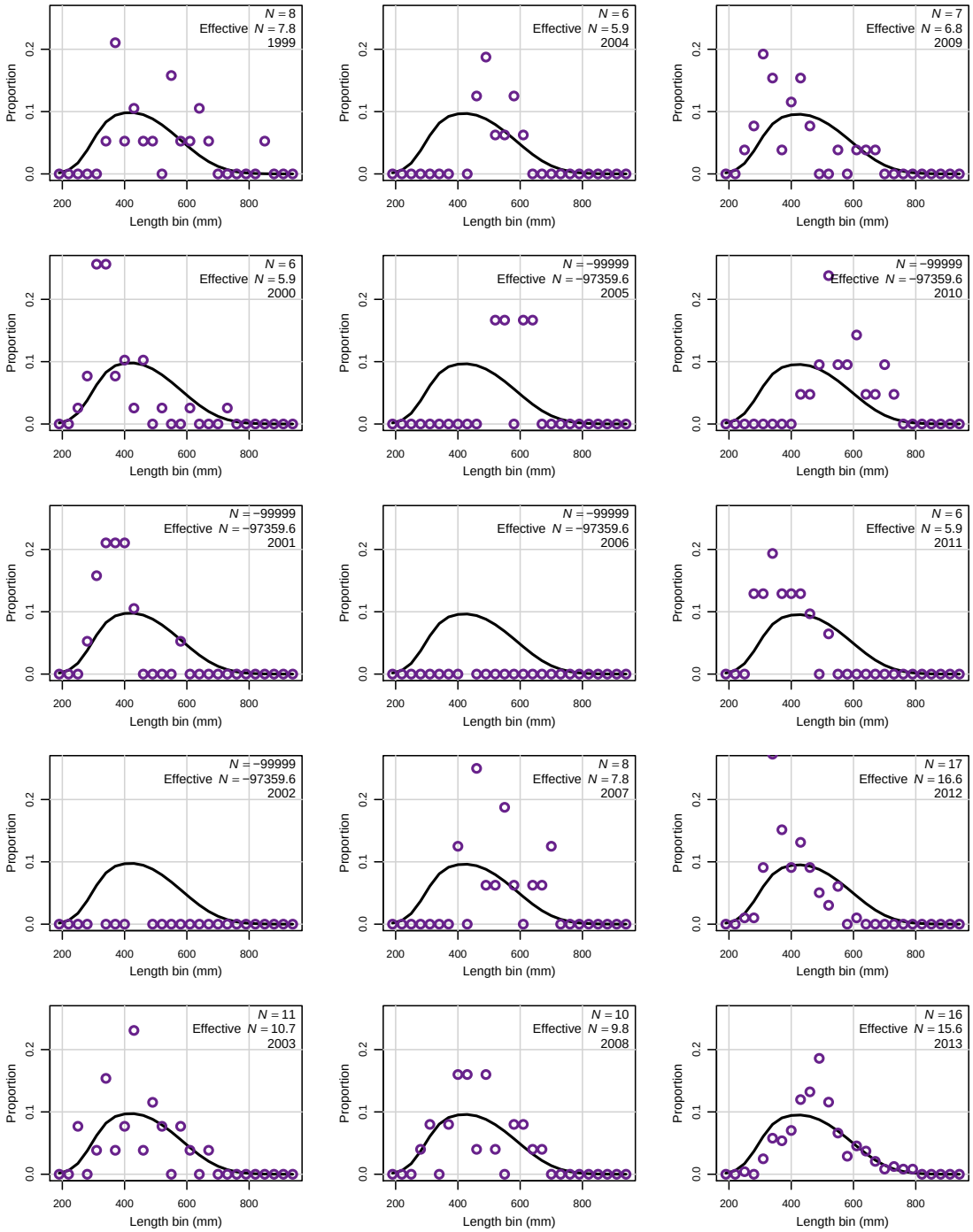
Fit to lengths
Page 6:

General recreational 1981-1998



Results

RW Reference Run



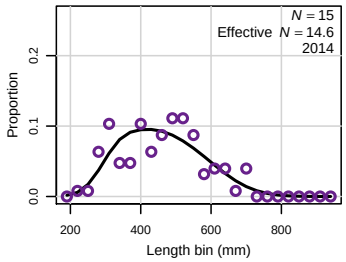
Fit to lengths

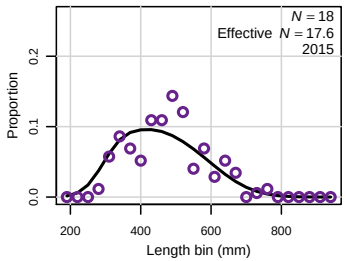
Page 7:

General recreational 1999-2013

Results

RW Reference Run





Fit to lengths

Page 8:

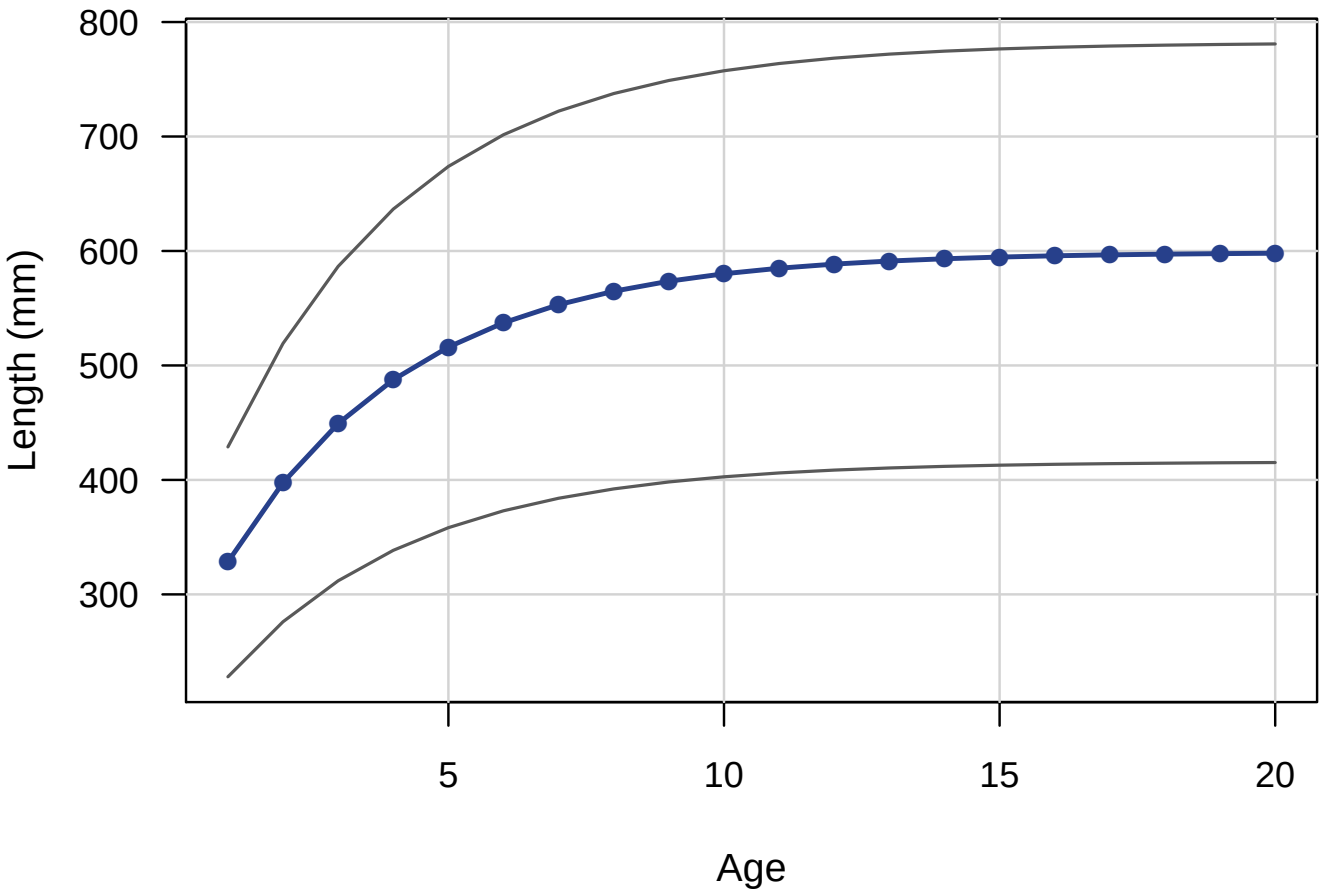
General recreational 2014-2015

Results

RW Reference Run

Life history

Growth
$K = 0.3$,
$L_\infty = 599$,
$t_0 = -1.19$



Results

RW Reference Run

Life history traits at age

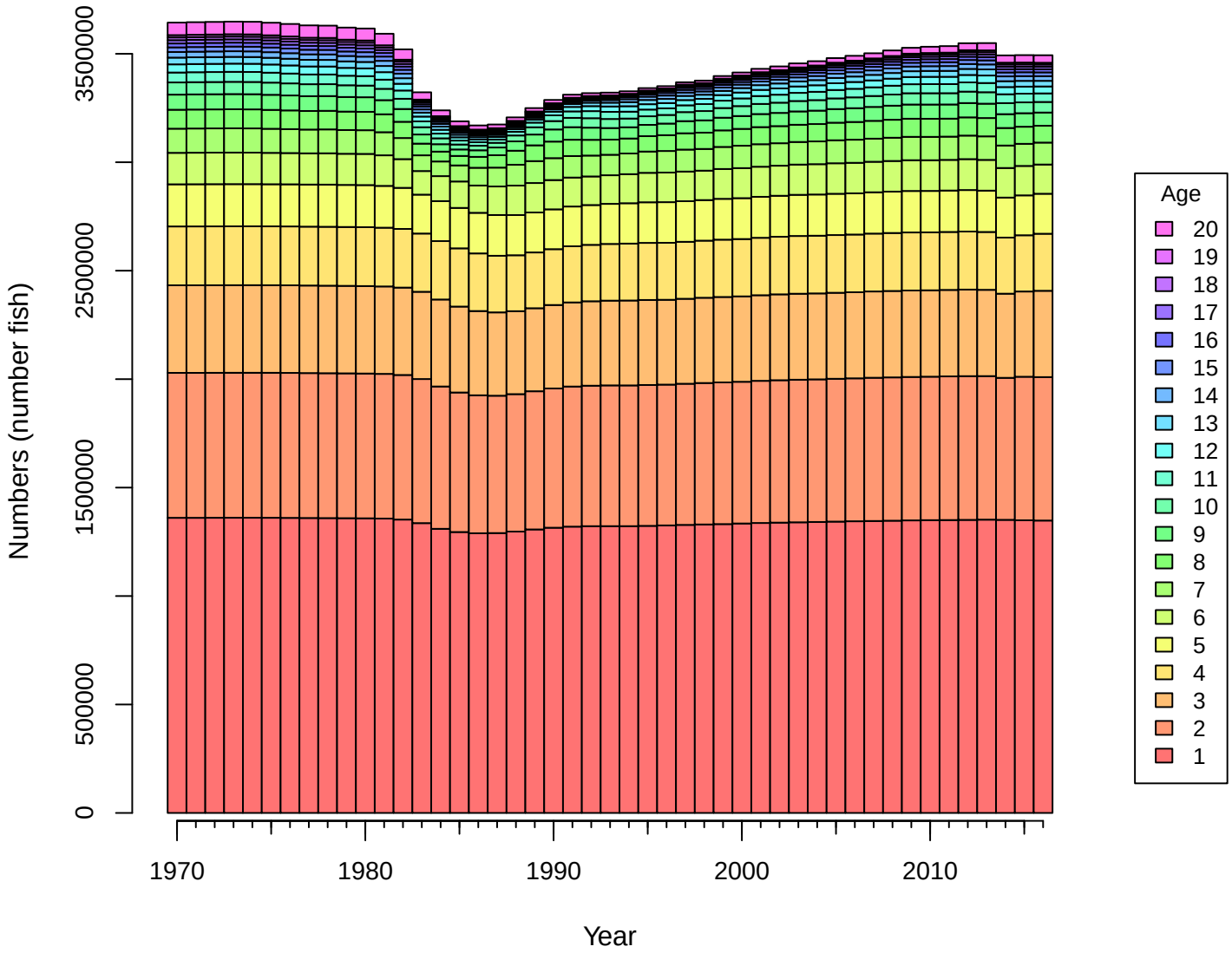
Table: Life history traits at age used in the ASPM Review Workshop Reference model for the Atlantic south of Cape Hatteras. Length (FL, mm), weight (kg), proportion female (PFemale), proportion of females mature (PMature), Fecundity (millions of eggs), reproductive output, (Reprod=fecundity*PFemale*PMature), and natural mortality (M) at age.

Age	Length	Weight	PFemale	PMature	Fecundity	Reprod	M
1	328	0.45	0.5	0.0	0.00	0.00	0.71
2	398	0.78	0.5	0.0	0.00	0.00	0.50
3	449	1.12	0.5	0.0	0.00	0.00	0.40
4	488	1.42	0.5	0.0	0.00	0.00	0.33
5	516	1.68	0.5	0.0	0.00	0.00	0.29
6	537	1.89	0.5	1.0	6.08	3.04	0.26
7	553	2.06	0.5	1.0	6.79	3.39	0.24
8	565	2.19	0.5	1.0	7.37	3.68	0.22
9	574	2.29	0.5	1.0	7.84	3.92	0.21
10	580	2.37	0.5	1.0	8.20	4.10	0.20
11	585	2.43	0.5	1.0	8.48	4.24	0.19
12	589	2.47	0.5	1.0	8.70	4.35	0.19
13	591	2.51	0.5	1.0	8.87	4.43	0.18
14	593	2.53	0.5	1.0	8.99	4.50	0.18
15	595	2.55	0.5	1.0	9.08	4.54	0.17
16	596	2.57	0.5	1.0	9.16	4.58	0.17
17	597	2.58	0.5	1.0	9.21	4.60	0.17
18	597	2.58	0.5	1.0	9.25	4.62	0.17
19	598	2.59	0.5	1.0	9.28	4.64	0.16
20	598	2.59	0.5	1.0	9.30	4.65	0.16

Results

RW Reference Run

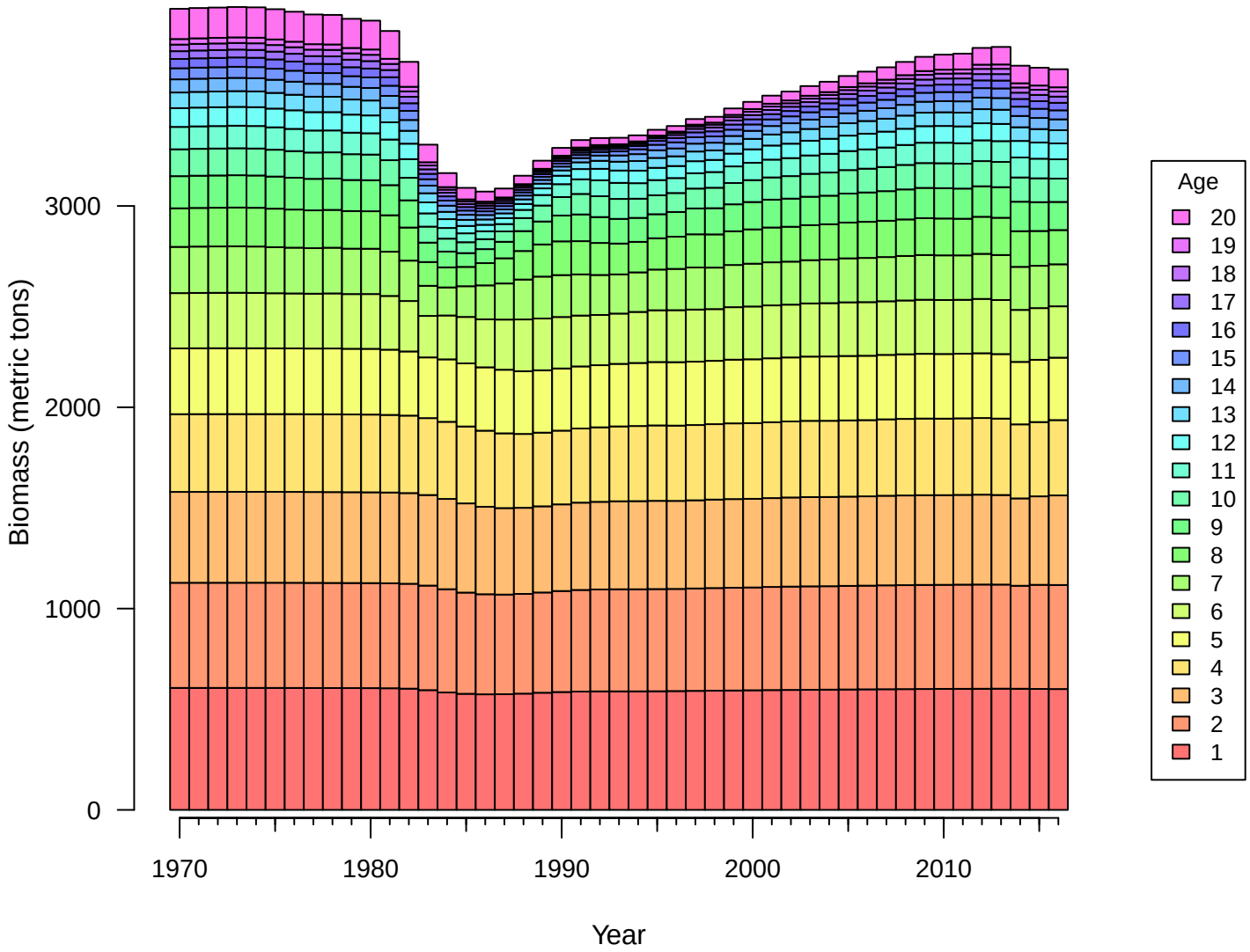
Estimated abundance at age at start of year



Results

RW Reference Run

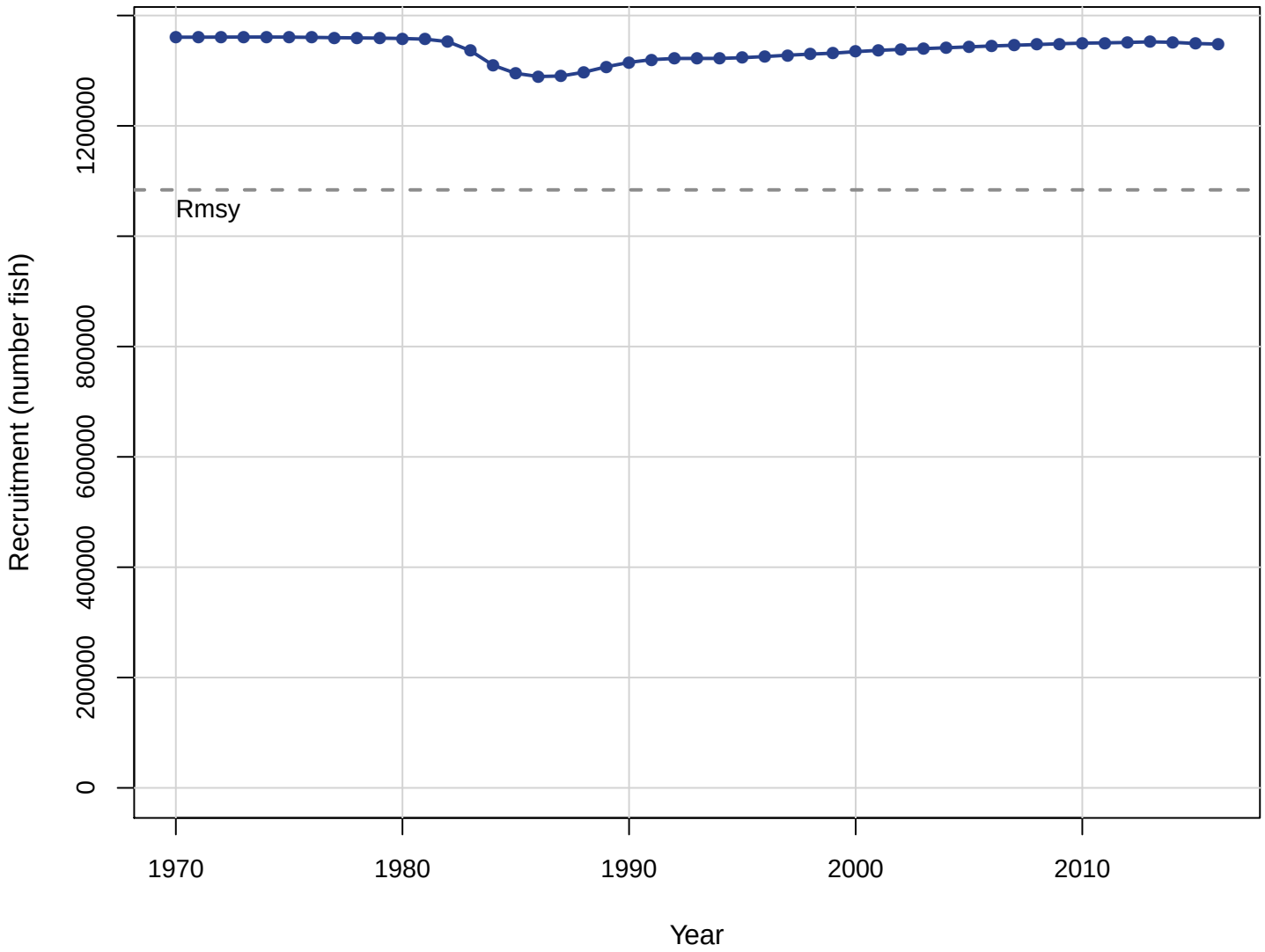
Estimated biomass at age at start of year



Results

RW Reference Run

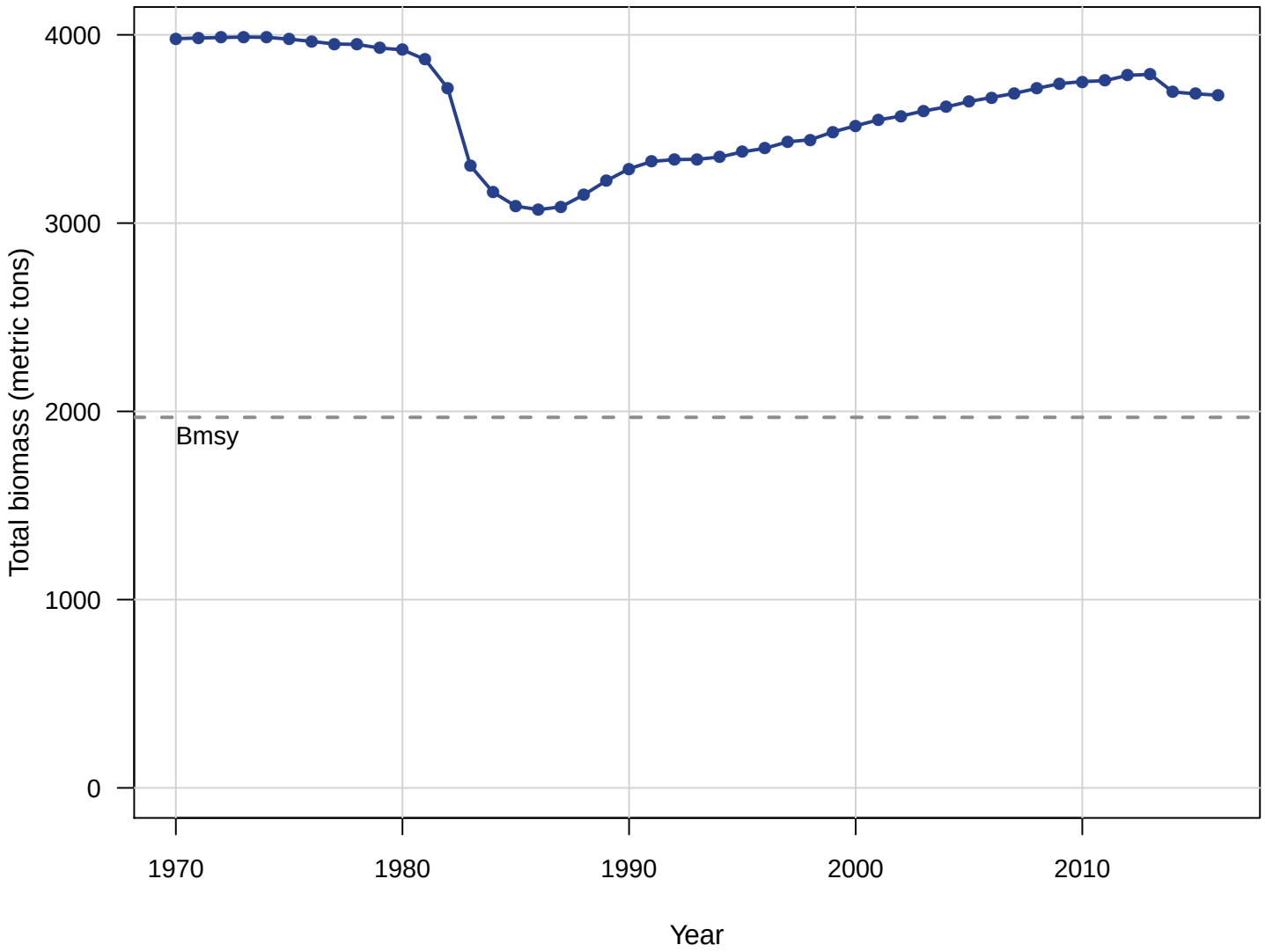
Estimated recruitment of age-1 fish



Results

RW Reference Run

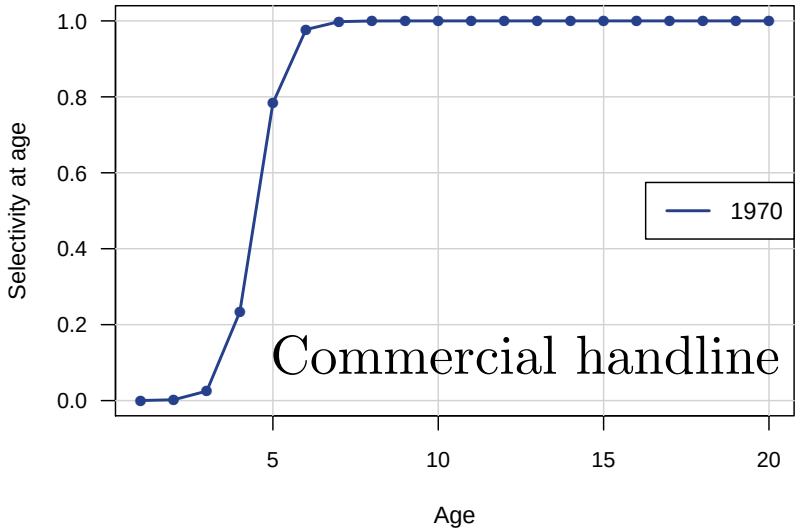
Estimated total biomass

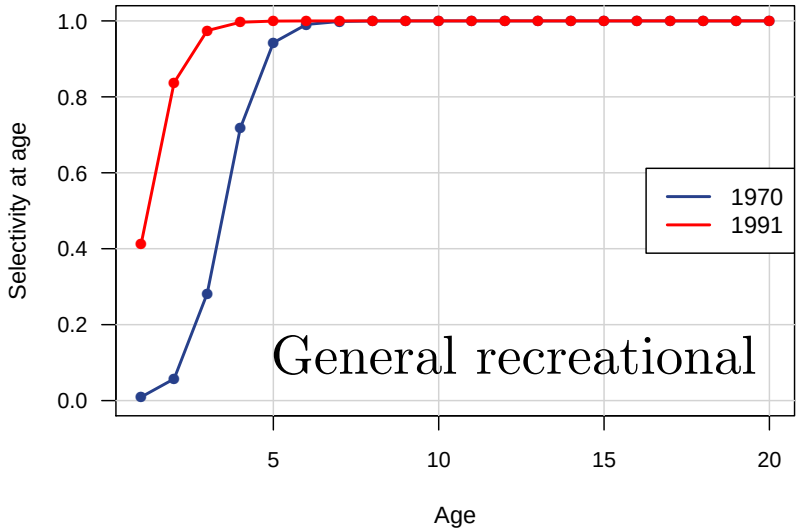


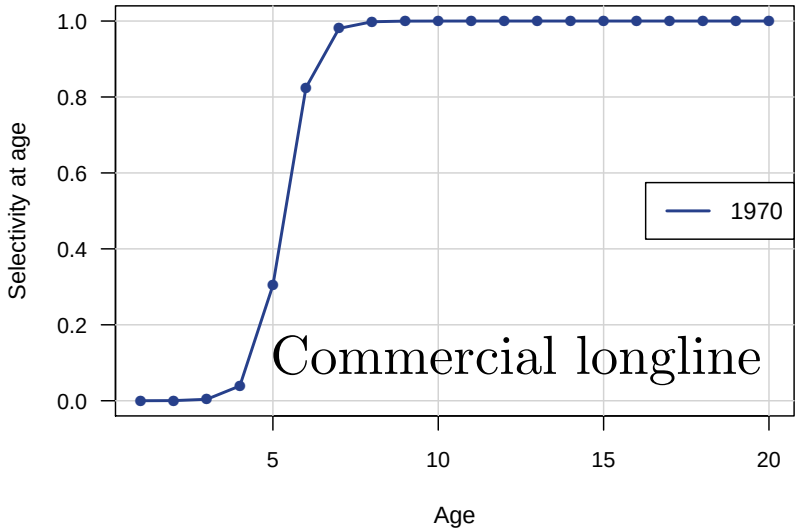
Results

RW Reference Run

Estimated selectivity at age





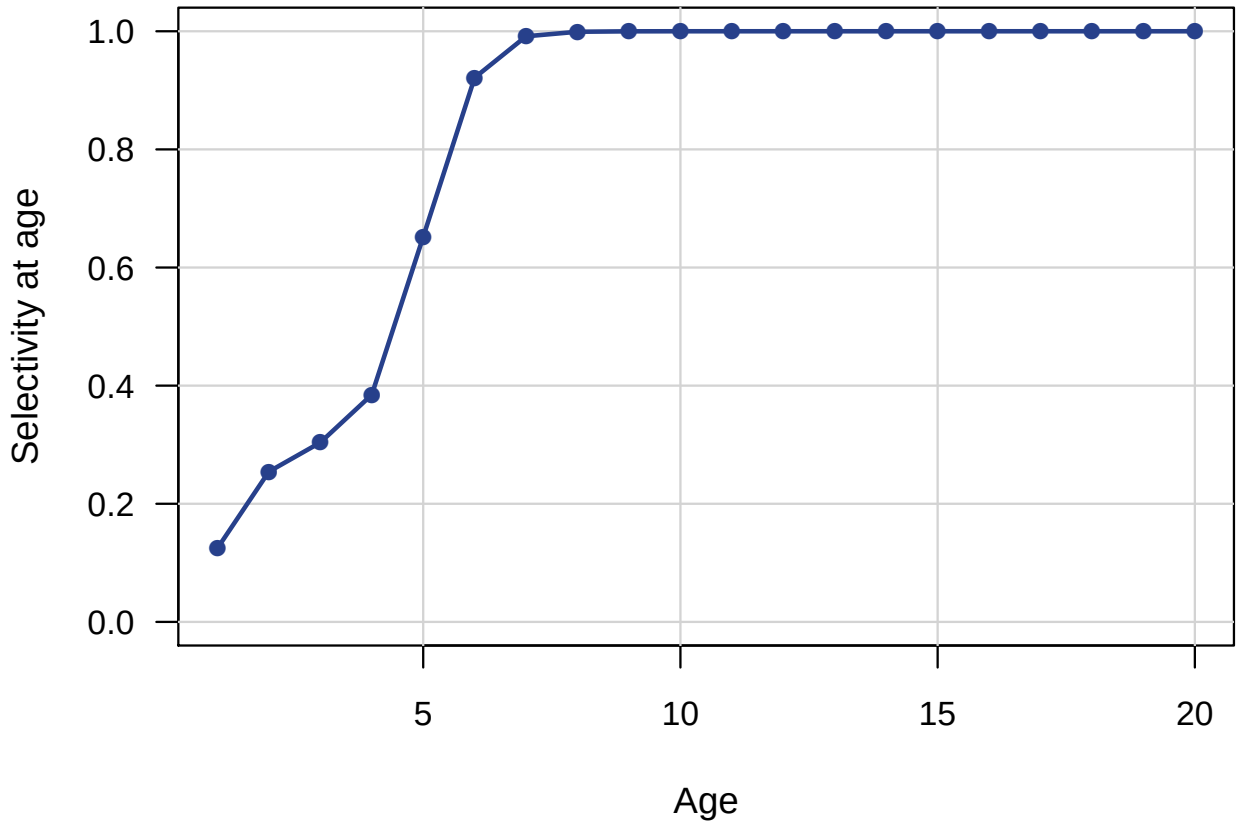


Results

RW Reference Run

Estimated average selectivity at age for terminal year (2015)

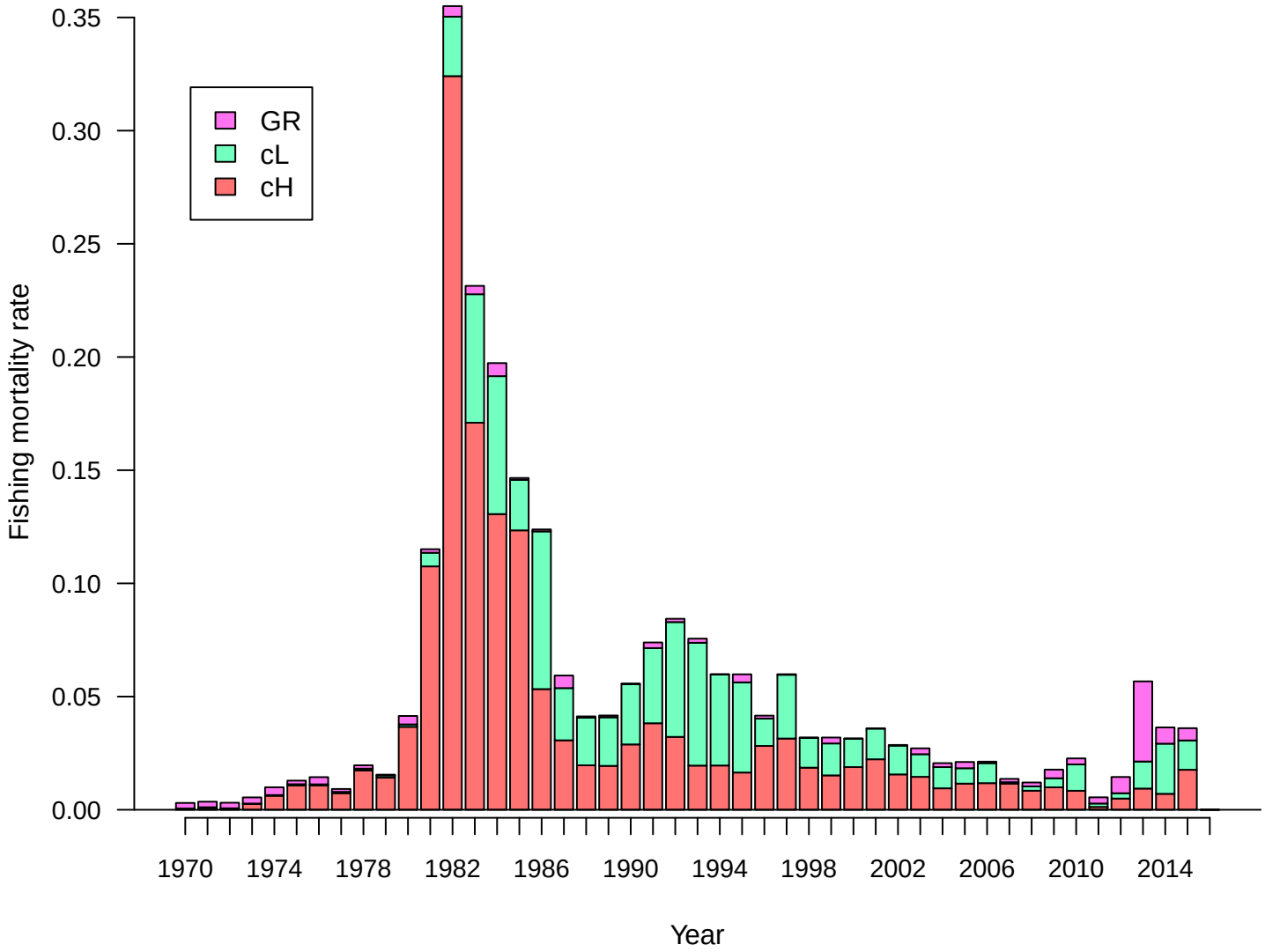
- Weighted by geometric mean F from the last three years (2013-2015)



Results

RW Reference Run

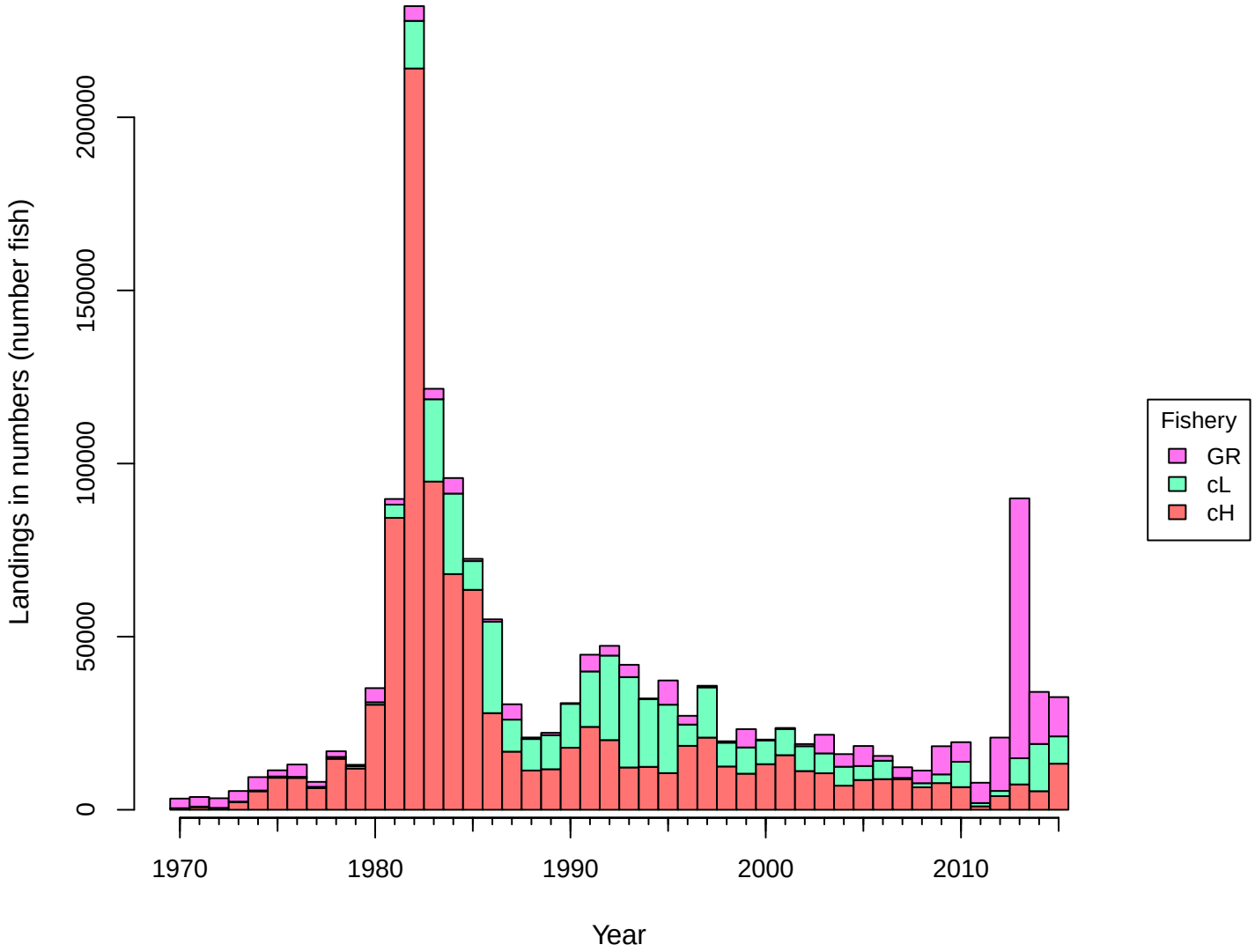
Estimated fully selected fishing mortality rates by fleet



Results

RW Reference Run

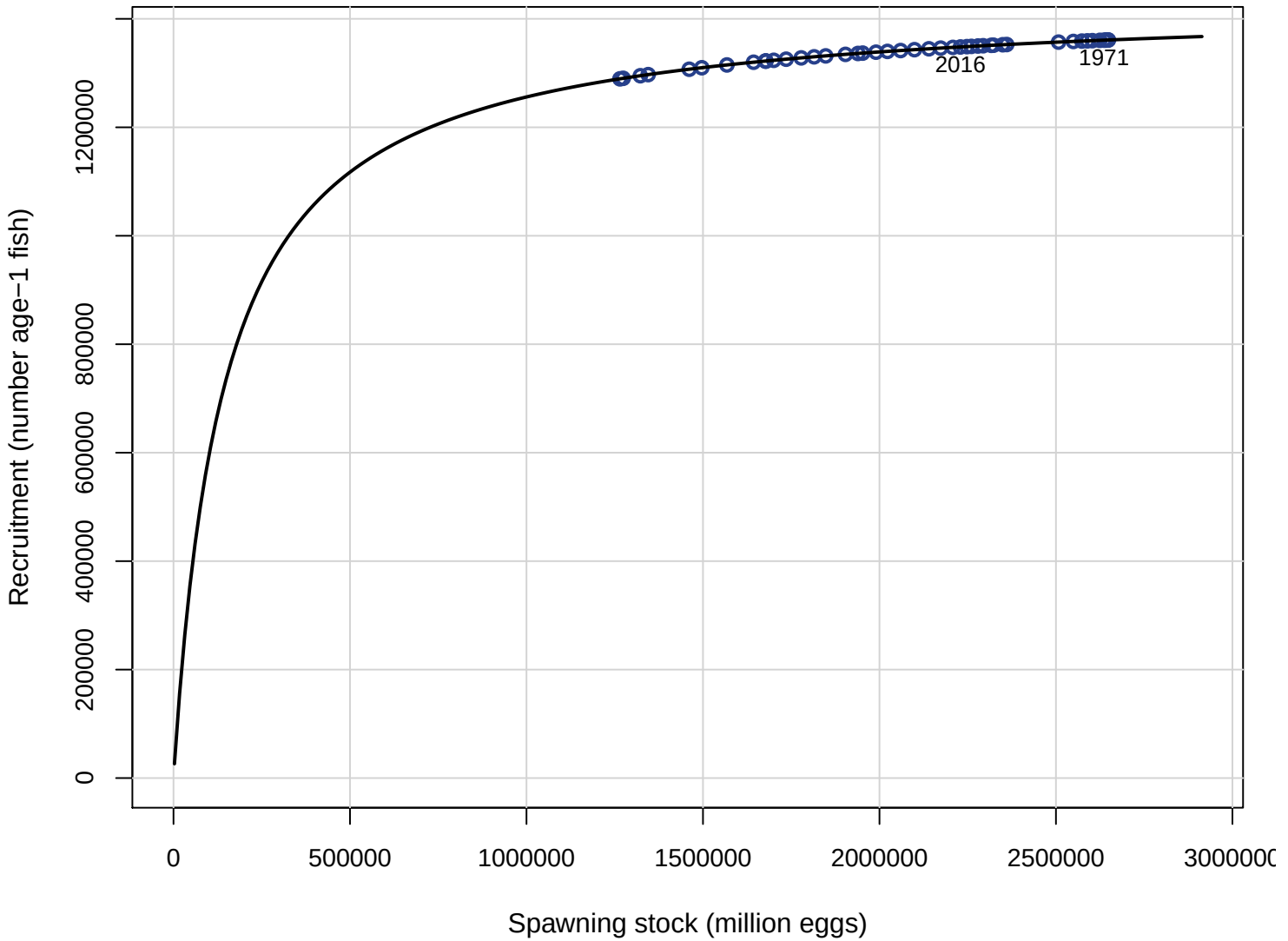
Estimated removals in numbers by fleet



Results

RW Reference Run

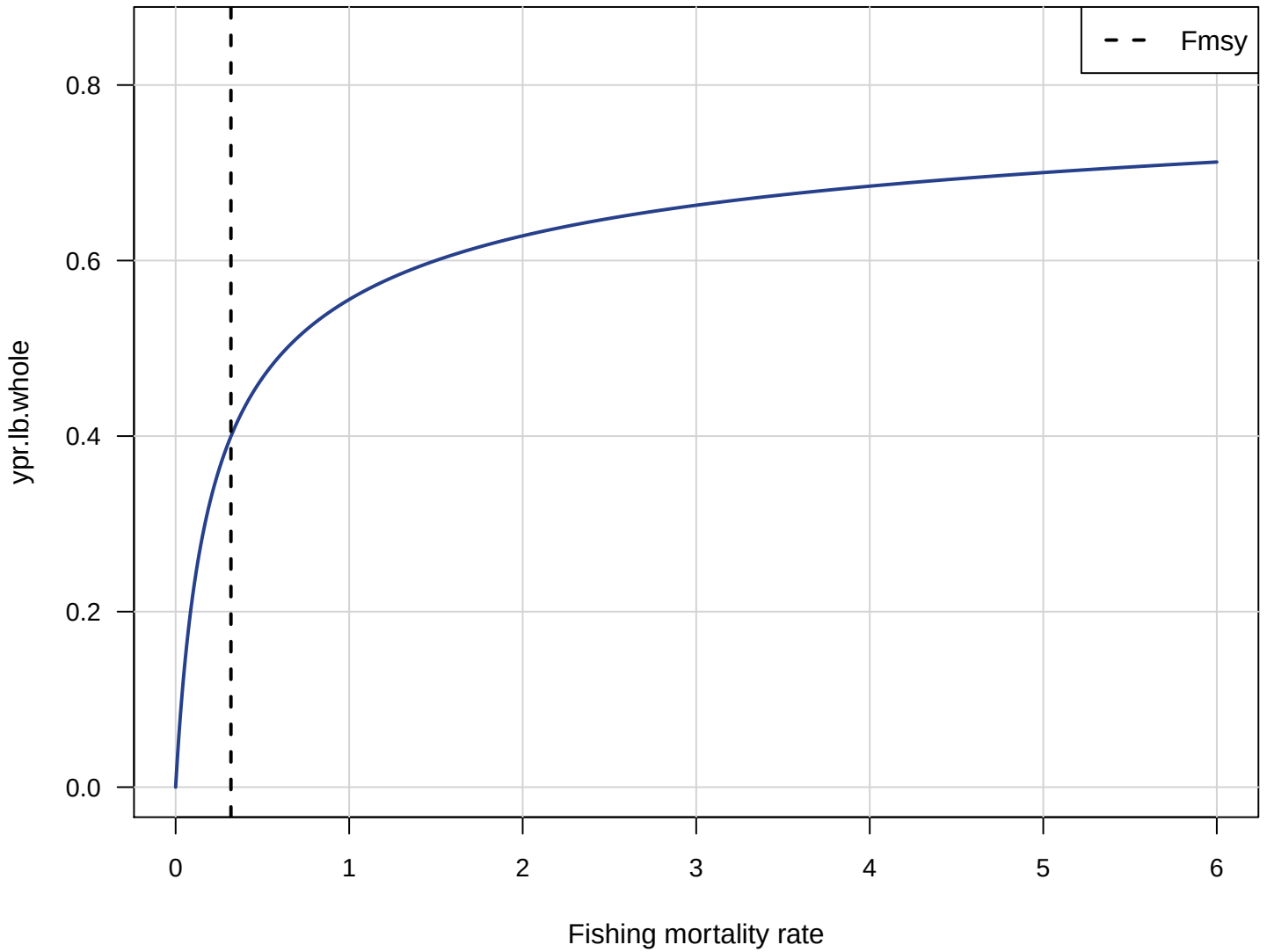
Beverton–Holt spawner-recruit curve



Results

RW Reference Run

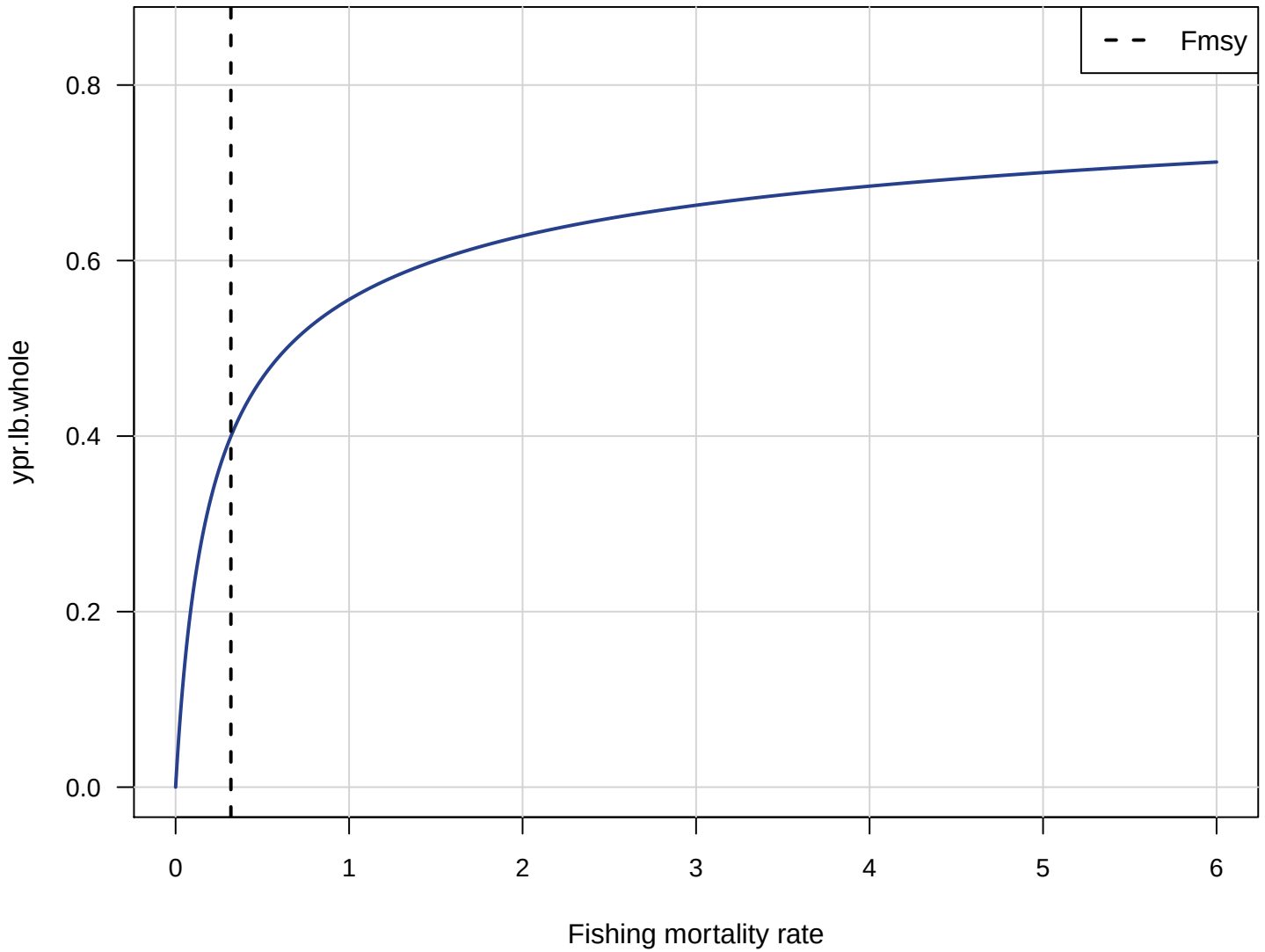
Yield per recruit at F



Results

RW Reference Run

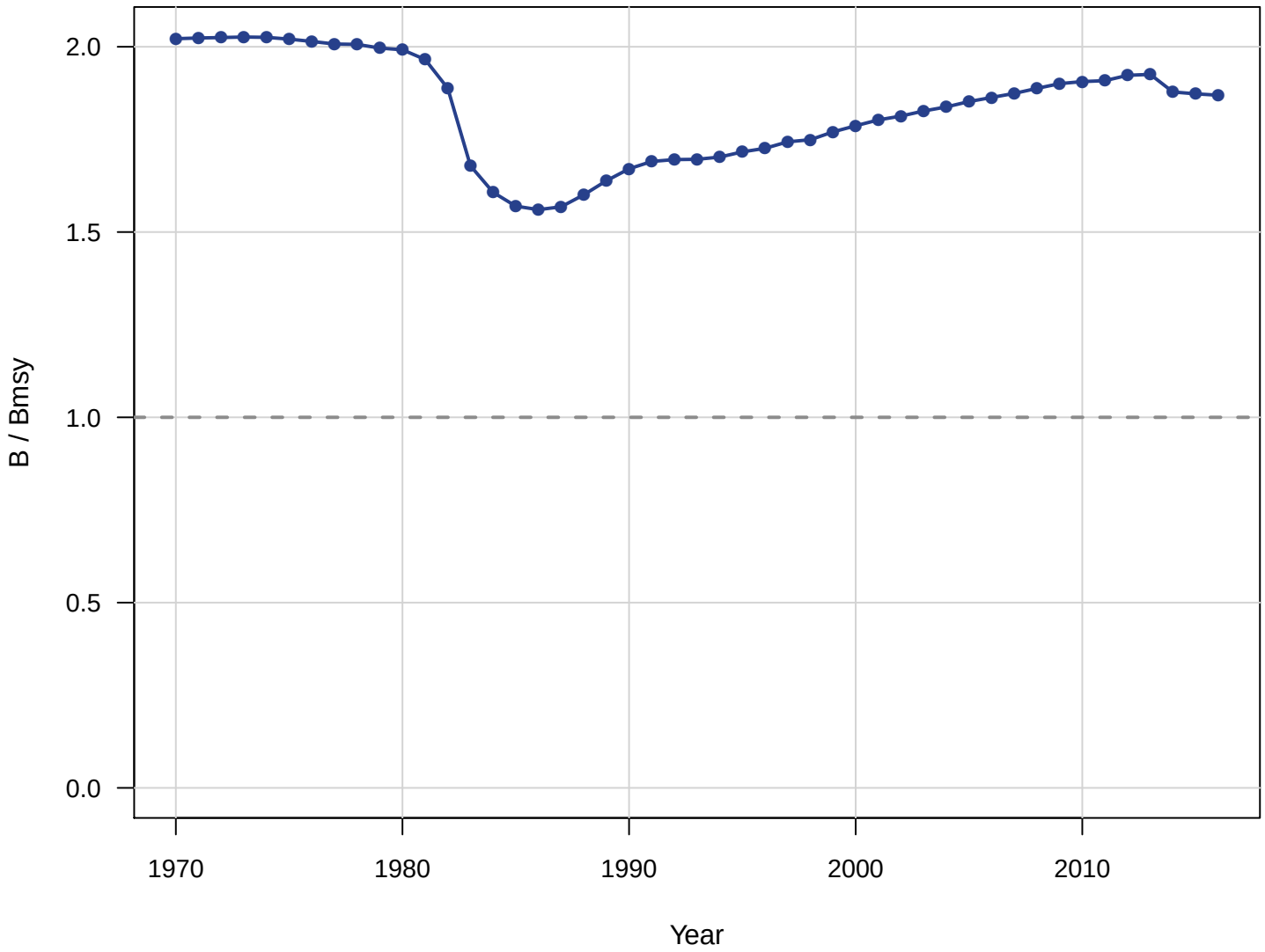
Yield per recruit at F



Results

RW Reference Run

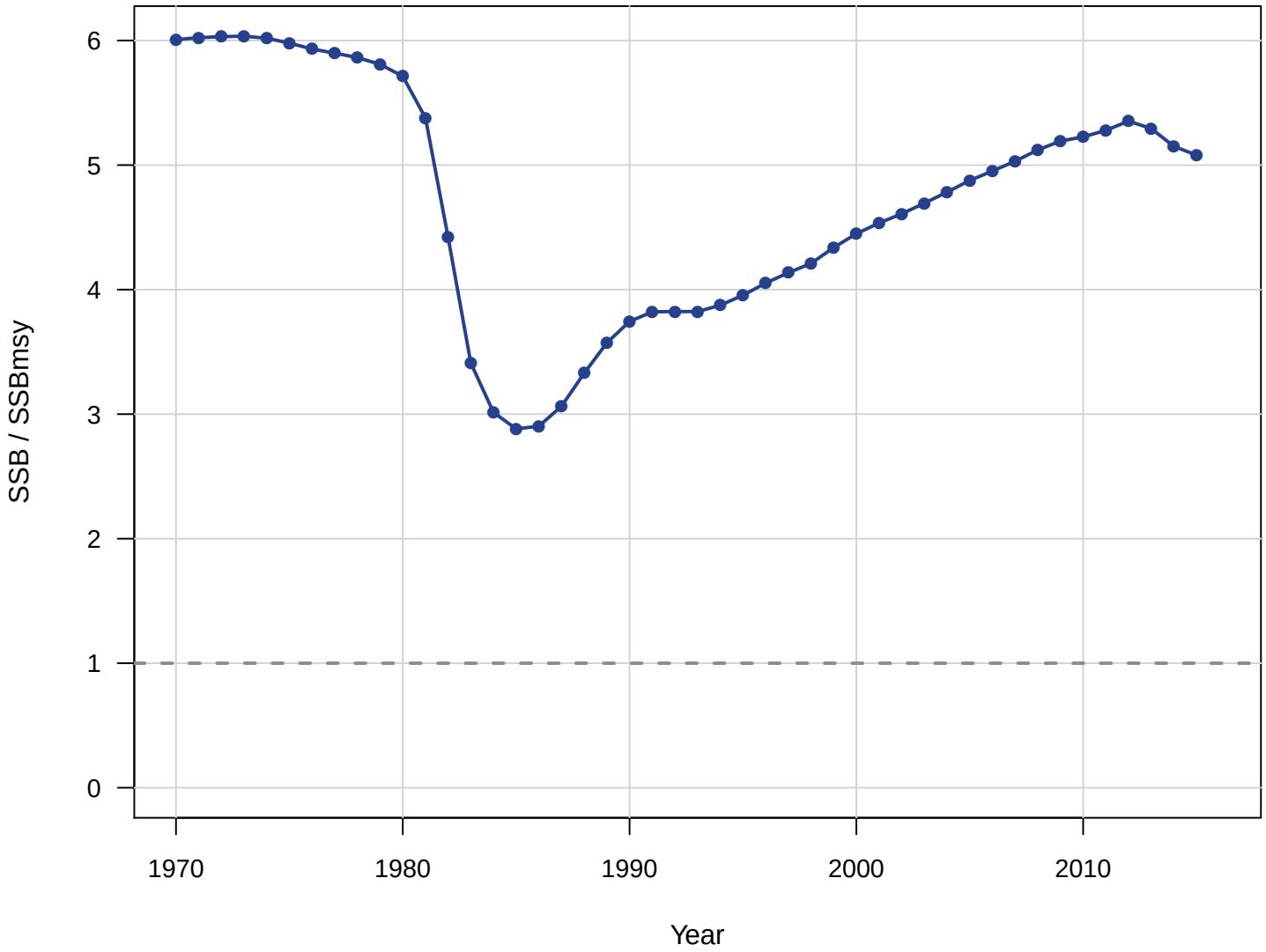
Total biomass relative to biomass at F_{MSY} (B_{MSY})



Results

RW Reference Run

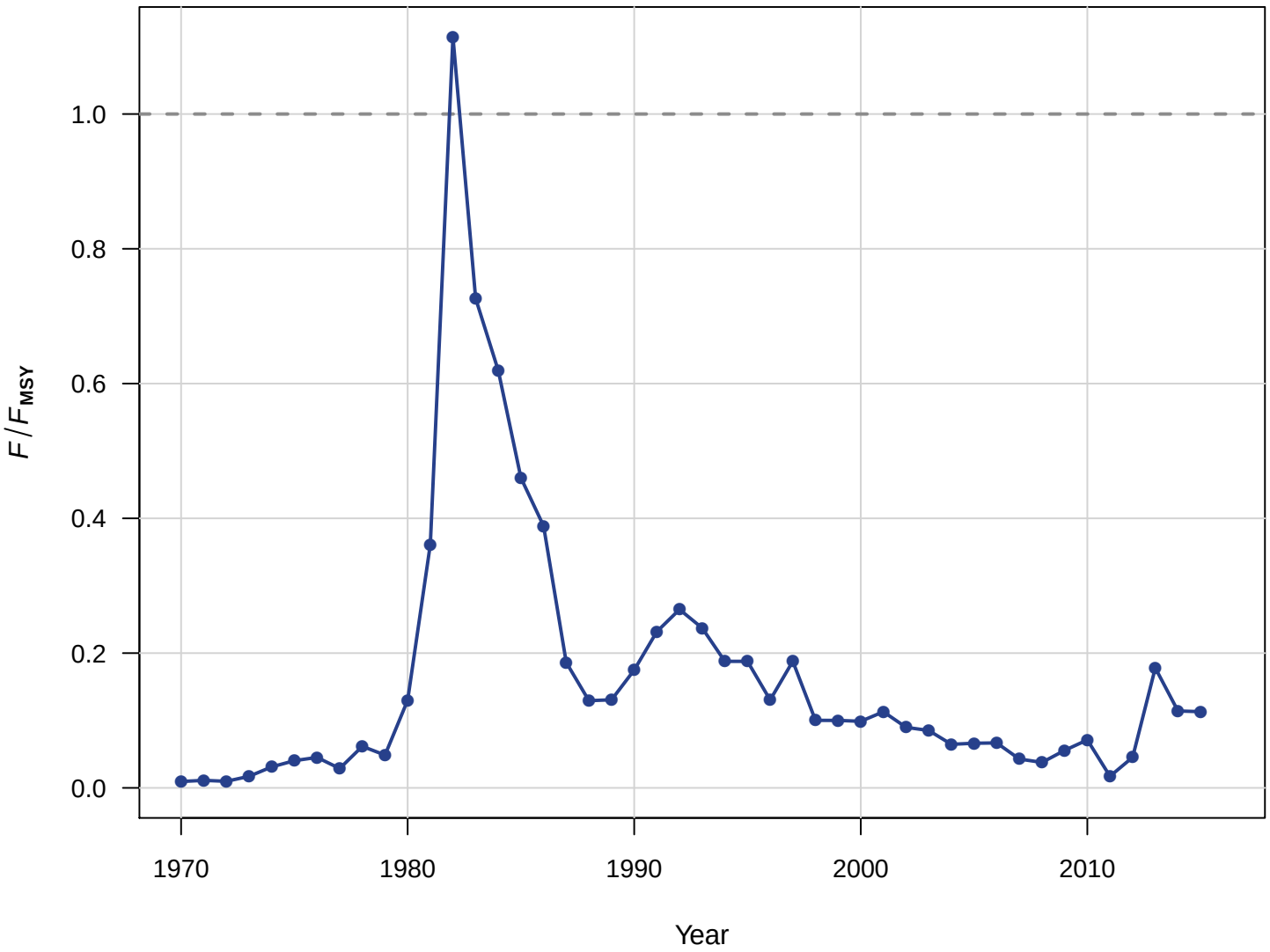
Spawning biomass relative to SSB_{MSY}



Results

RW Reference Run

F relative to F_{MSY}



Results

RW Reference Run

Benchmarks relative to F_{MSY}

Table: Estimated F_{MSY}-based status indicators, benchmarks, and related quantities for the ASPM Review Workshop Reference model, conditional on estimated current selectivities averaged across fleets. Medians and standard errors of values from Monte Carlo/Bootstrap (MCB) analysis are also provided. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; and biomass estimates are in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured as population fecundity (million eggs)

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.319	0.234	0.290
$85\%F_{\text{MSY}}$	y^{-1}	0.271	0.199	0.246
$75\%F_{\text{MSY}}$	y^{-1}	0.239	0.176	0.217
$65\%F_{\text{MSY}}$	y^{-1}	0.207	0.152	0.188
$F_{30\%}$	y^{-1}	0.218	0.193	0.136
$F_{40\%}$	y^{-1}	0.154	0.137	0.082
B_{MSY}	1000 lb whole	4339	1846	1023
SSB_{MSY}	million eggs	438871	454964	281925
MSST	million eggs	329153	341223	211444
MSY	1000 lb whole	433	332	274
R_{MSY}	number fish	1084009	934907	897626
$L_{85\%\text{MSY}}$	1000 lb whole	428	328	271
$L_{75\%\text{MSY}}$	1000 lb whole	418	320	265
$L_{65\%\text{MSY}}$	1000 lb whole	402	309	257
$F_{2013-2015}/F_{\text{MSY}}$	—	0.13	0.19	0.40
$\text{SSB}_{2015}/\text{MSST}$	—	6.77	5.24	4.38
$\text{SSB}_{2015}/\text{SSB}_{\text{MSY}}$	—	5.08	3.93	3.28

Results

RW Reference Run

Benchmarks relative to $F_{30\%}$

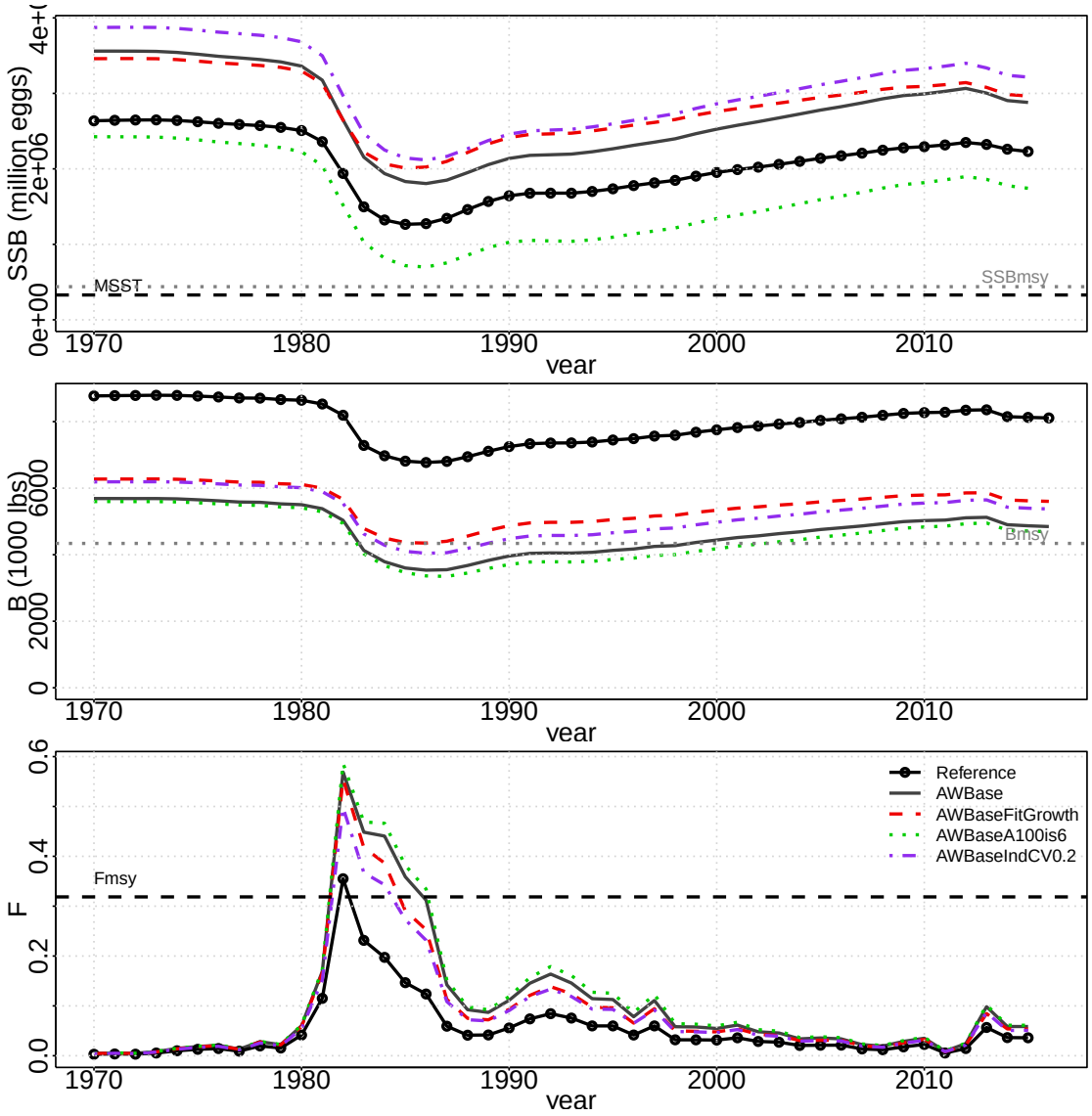
Table: Estimated $F_{30\%}$-based status indicators, benchmarks, and related quantities for the ASPM Review Workshop Reference model, conditional on estimated current selectivities averaged across fleets. Medians and standard errors of values from Monte Carlo/Bootstrap (MCB) analysis are also provided. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; and biomass estimates are in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured as population fecundity (million eggs)

Quantity	Units	Estimate	Median	SE
$F_{30\%}$	y^{-1}	0.218	0.193	0.136
$85\%F_{30\%}$	y^{-1}	0.185	0.164	0.116
$75\%F_{30\%}$	y^{-1}	0.163	0.145	0.102
$65\%F_{30\%}$	y^{-1}	0.142	0.126	0.089
$F_{30\%}$	y^{-1}	0.218	0.193	0.136
$F_{40\%}$	y^{-1}	0.154	0.137	0.082
$B_{\mathrm{F30\%}}$	1000 lb whole	5878	2338	1492
$\mathrm{SSB}_{\mathrm{F30\%}}$	million eggs	807254	698273	350966
MSST	million eggs	605440	341223	211444
$L_{\mathrm{F30\%}}$	1000 lb whole	454	373	257
$R_{\mathrm{F30\%}}$	number fish	1334975	1127699	1149310
$L_{\mathrm{85\%F30\%}}$	1000 lb whole	387	303	219
$L_{\mathrm{75\%F30\%}}$	1000 lb whole	368	292	207
$L_{\mathrm{65\%F30\%}}$	1000 lb whole	346	278	194
$F_{2013-2015}/F_{30\%}$	—	0.19	0.19	0.40
$\mathrm{SSB}_{2015}/\mathrm{MSST}$	—	3.68	5.24	4.38
$\mathrm{SSB}_{2015}/\mathrm{SSB}_{\mathrm{F30\%}}$	—	2.76	3.93	3.28

Results

Sensitivity analysis

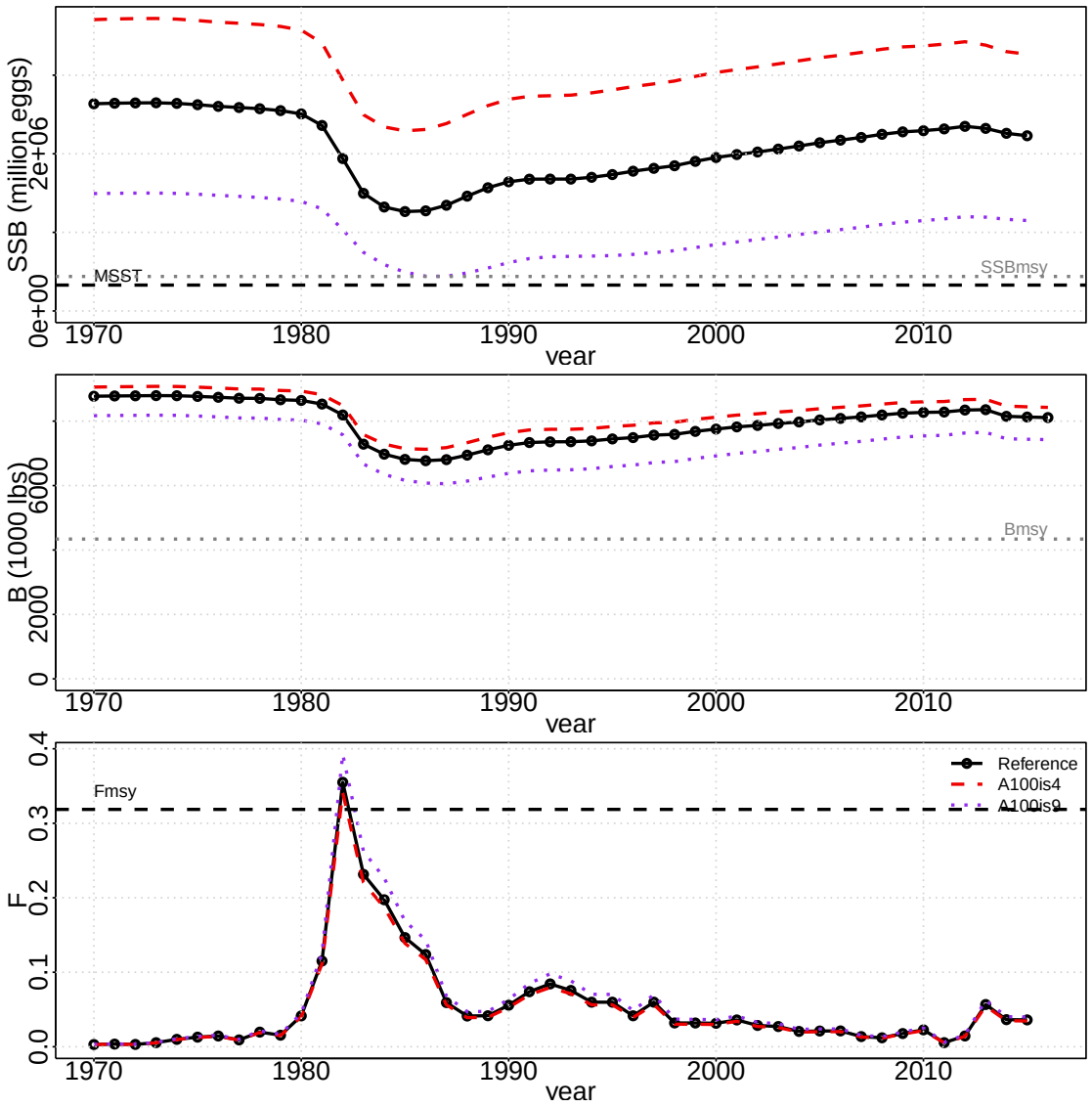
Sensitivity to changes made to the Assessment Workshop Base model resulting in the Review Workshop Reference model:
ASPM Runs S00-S03



Results

Sensitivity analysis

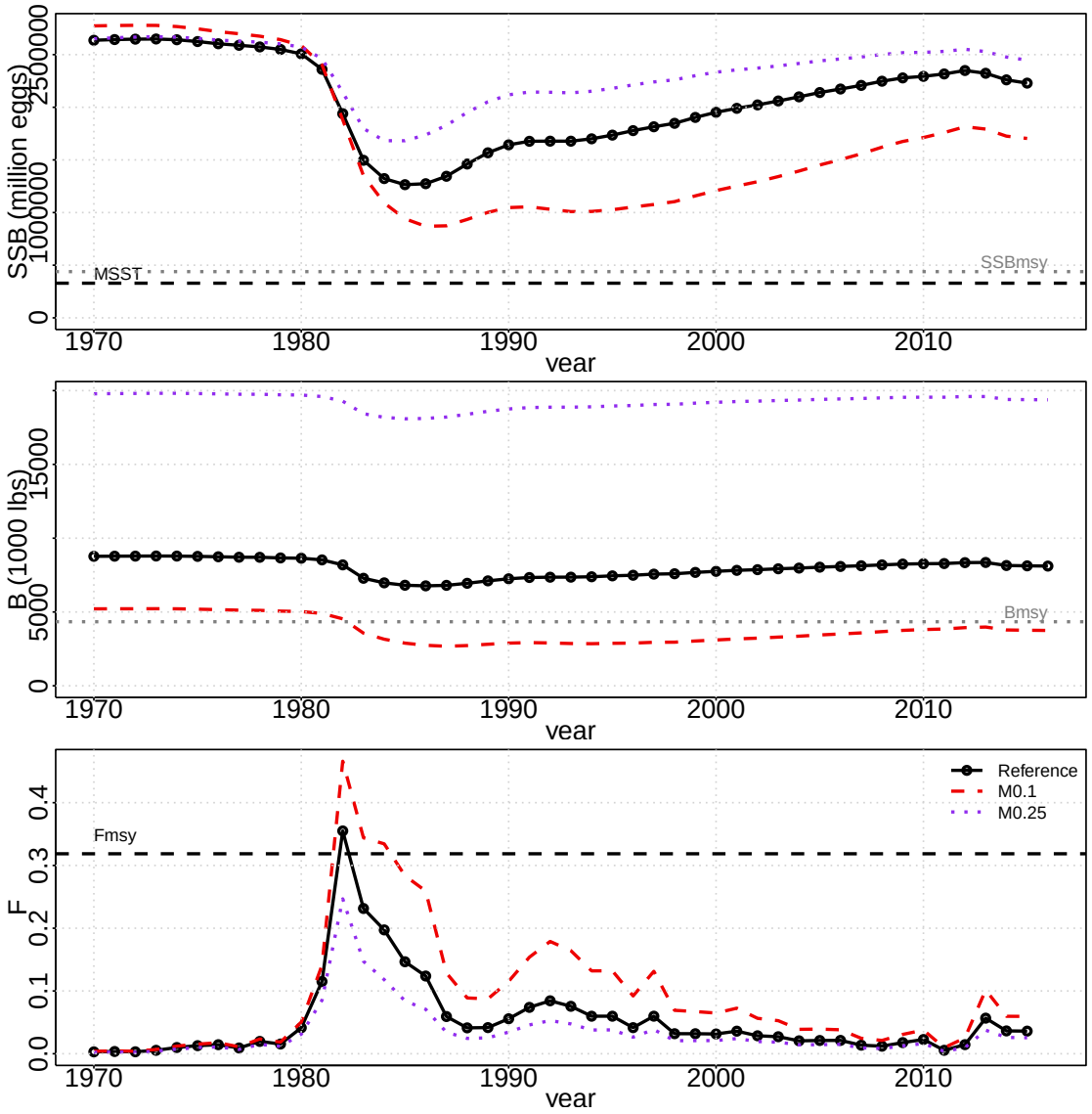
Sensitivity of the ASPM RW Ref model to age at maturity:
ASPM Runs S04-S05



Results

Sensitivity analysis

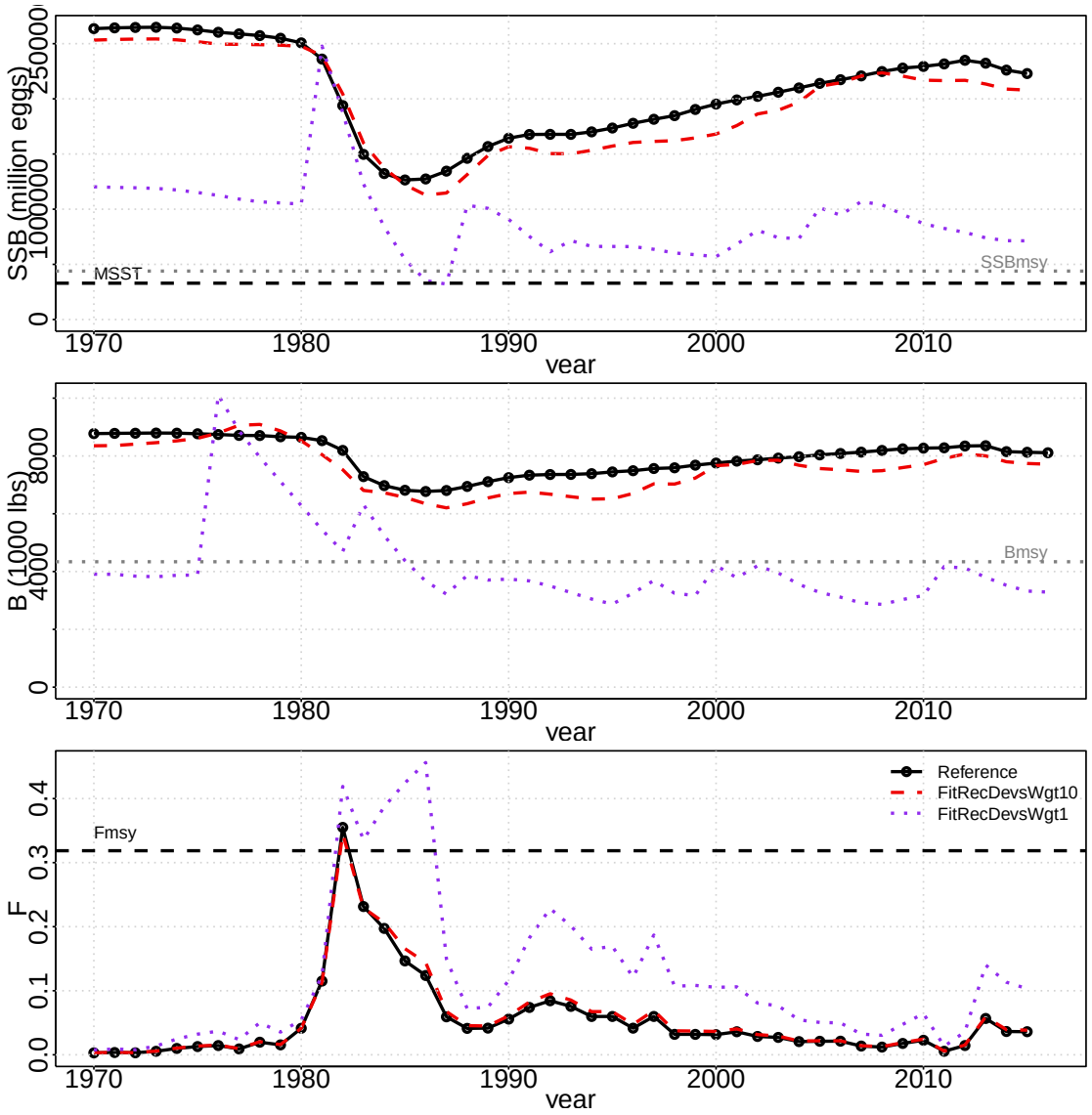
Sensitivity of the ASPM RW Ref model to natural mortality: ASPM Runs S06-S07



Results

Sensitivity analysis

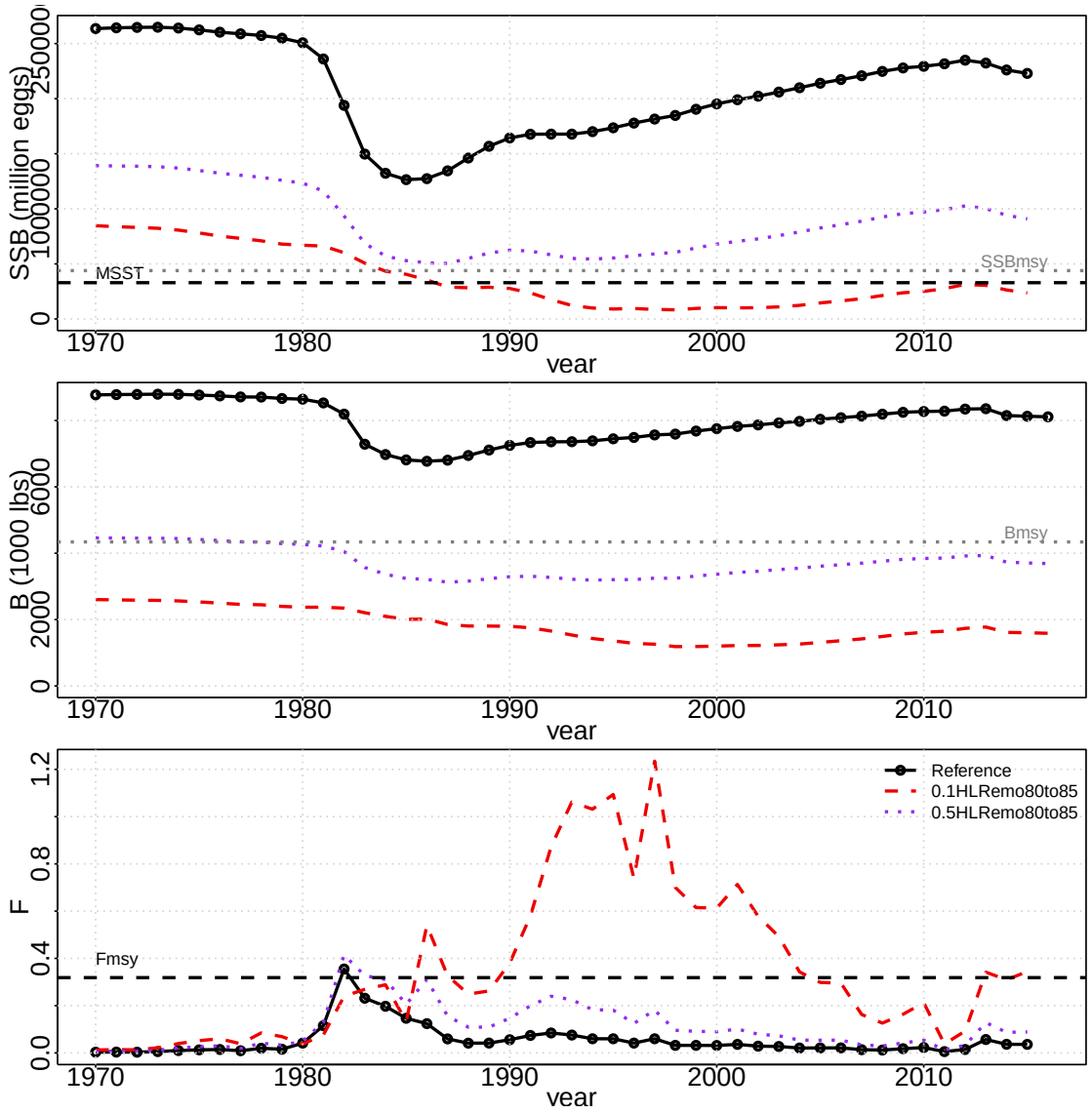
Sensitivity of the ASPM RW Ref model to fitting recruitment deviations: ASPM Runs S08-S09



Results

Sensitivity analysis

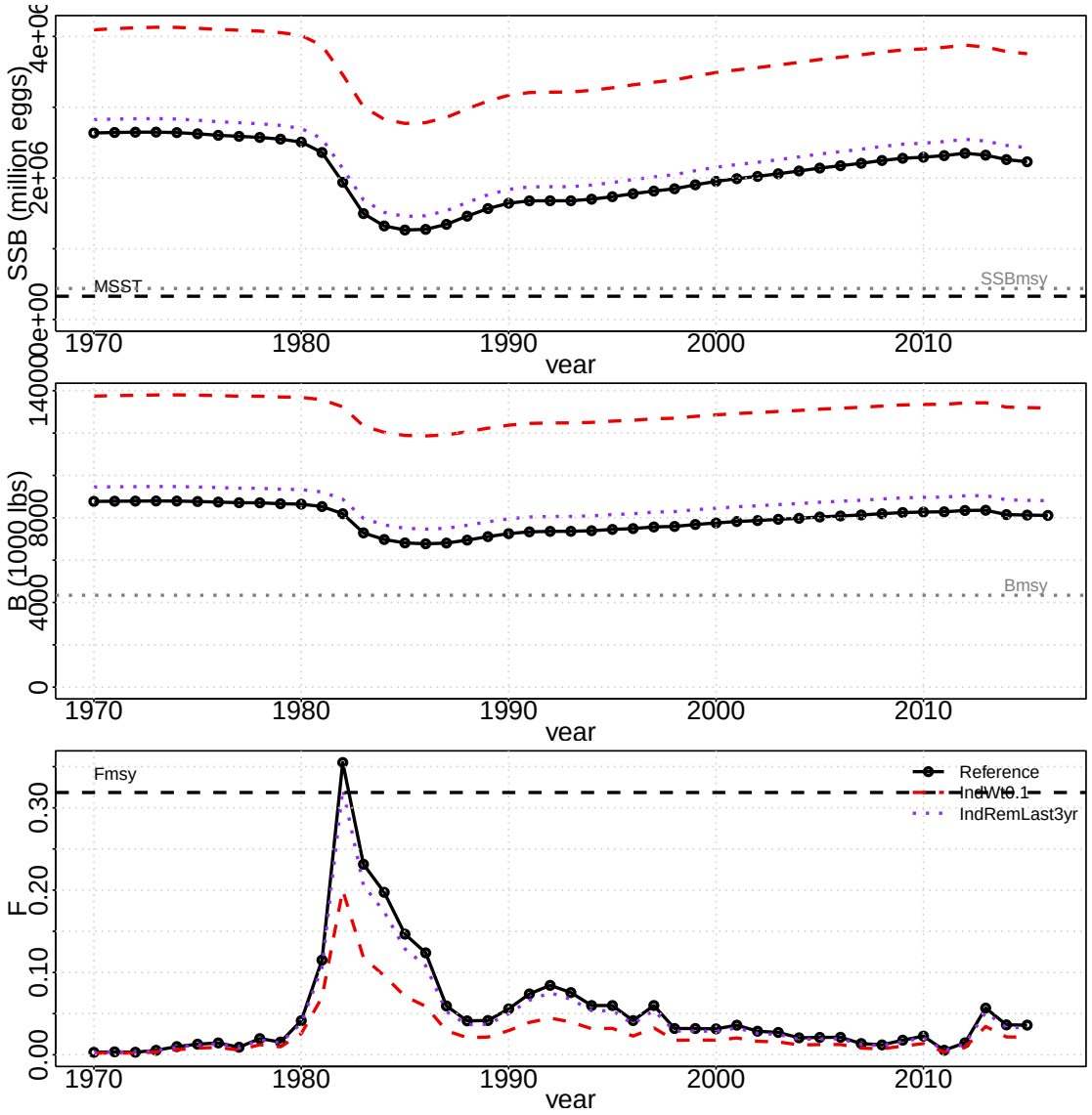
Sensitivity of the ASPM RW Ref model to 1980-1985 handline removals:
ASPM Runs S10-S11



Results

Sensitivity analysis

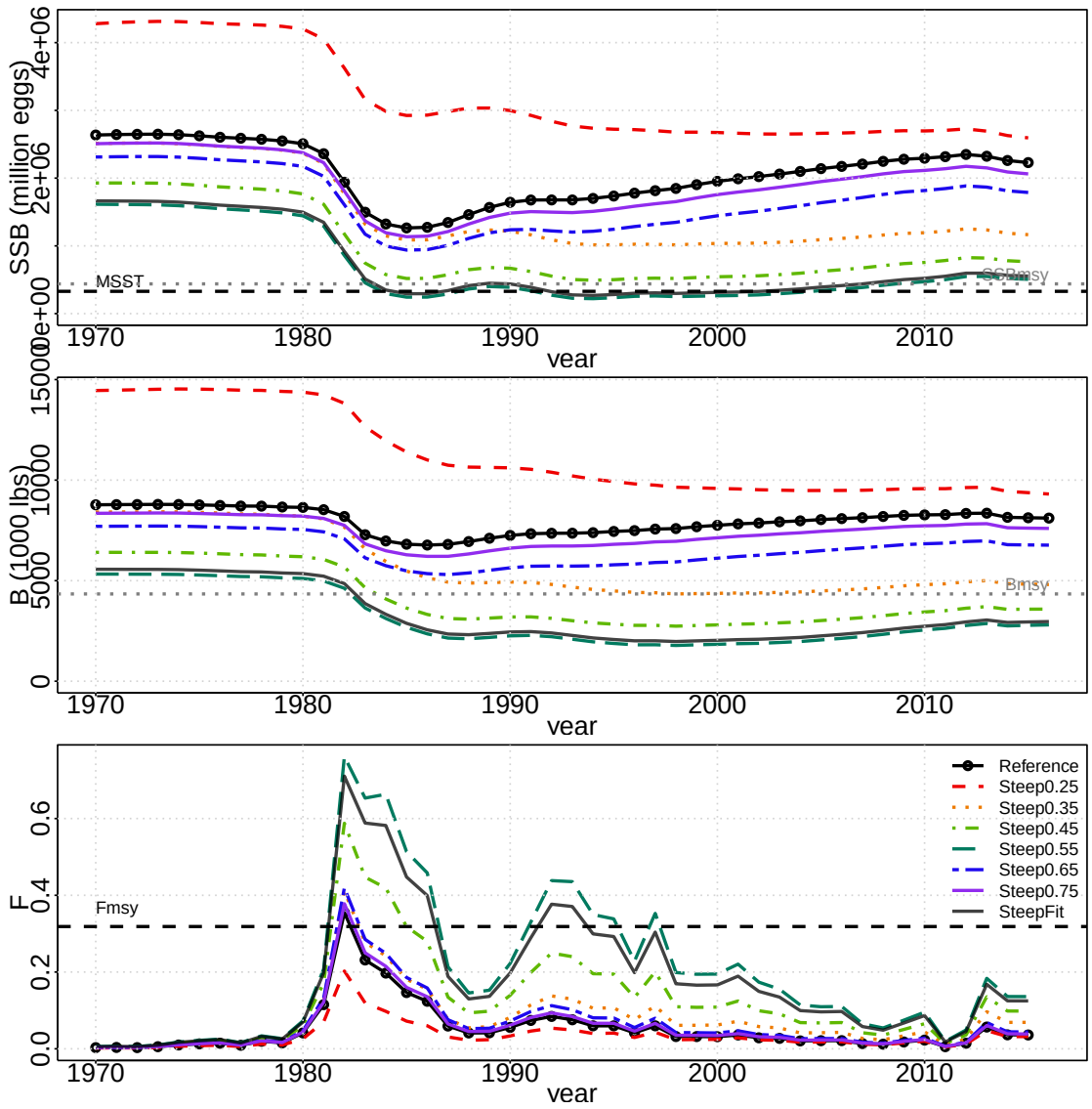
Sensitivity of the ASPM RW Ref model to indices of abundance:
ASPM Runs S12-S13



Results

Sensitivity analysis

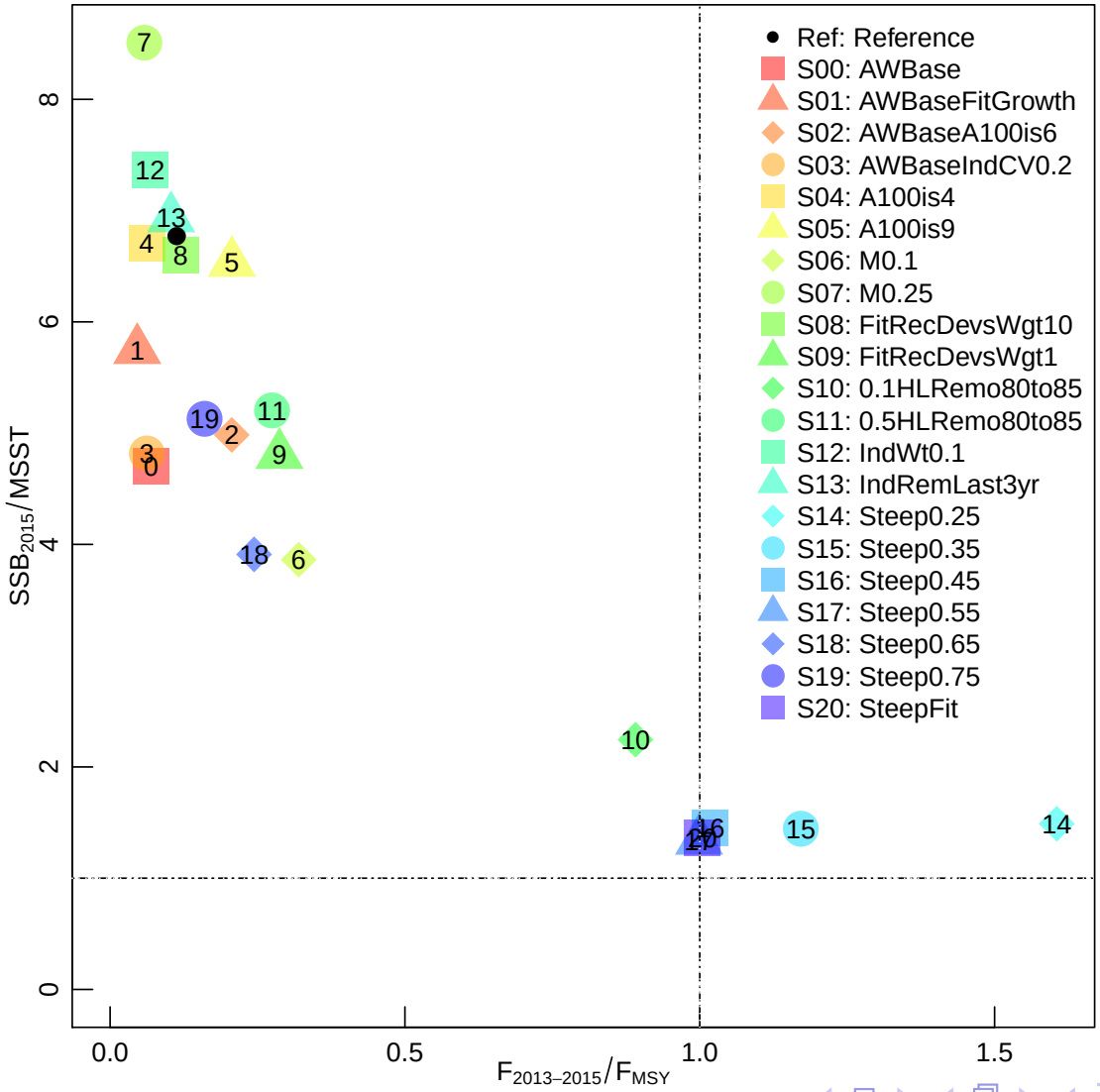
Sensitivity of the ASPM RW Ref model to steepness:
ASPM Runs S14-S20



Results

Sensitivity analysis

Sensitivity status phase plots for the ASPM RW Ref model



Results

Sensitivity analysis

Table: Estimated status indicators, benchmarks, and related quantities for sensitivity runs for the ASPM Reference Run, south of Cape Hatteras. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; and biomass estimates are in units of 1000 pounds, Beverton-Holt R_0 is in units of 1000 fish. Spawning stock biomass (SSB) and minimum stock size threshold (MSST) are measured as population fecundity (millions of eggs). F/F_{MSY} is based on the geometric mean F for the last three years of the assessment. SSB/SSB_{MSY} and SSB/MSST are based on the terminal year of the assessment. steep = Beverton Holt steepness. Lik_{total} = total likelihood for the model. See text for full description of sensitivity runs.

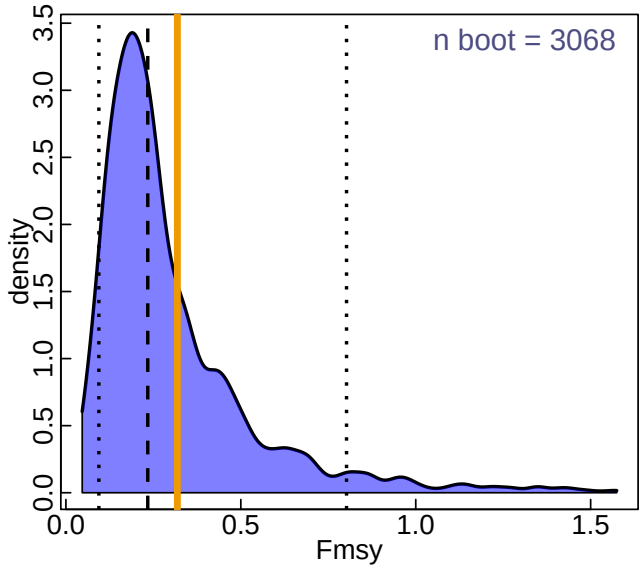
Run	Description	F_{MSY}	MSST	B_{MSY}	MSY	F/F_{MSY}	SSB/SSB_{MSY}	SSB/MSST	steep	R_0	Lik_{total}
Ref	Reference	0.319	329153	4339	433	0.11	5.08	6.77	0.84	1363	5660
S00	AWBase	0.841	612674	1997	316	0.07	3.53	4.70	0.84	1159	5708
S01	AWBaseFitGrowth	1.162	516000	2193	461	0.05	4.31	5.75	0.84	967	5676
S02	AWBaseA100is6	0.296	349663	2600	246	0.21	3.74	4.98	0.84	1142	5705
S03	AWBaseIndCV0.2	0.815	667576	2174	343	0.06	3.61	4.82	0.84	1262	5701
S04	A100is4	0.558	487082	3886	545	0.06	5.03	6.71	0.84	1411	5661
S05	A100is9	0.193	176225	4500	318	0.21	4.90	6.53	0.84	1264	5659
S06	M0.1	0.186	441170	2026	184	0.32	2.90	3.86	0.84	325	5655
S07	M0.25	0.438	287644	12056	922	0.06	6.38	8.51	0.84	5779	5665
S08	FitRecDevsWgt10	0.322	315212	4134	405	0.12	4.95	6.60	0.84	1304	5446
S09	FitRecDevsWgt1	0.359	148432	1950	182	0.29	3.60	4.80	0.84	614	5589
S10	0.1HLRemo80to85	0.386	105156	1308	118	0.89	1.68	2.24	0.84	380	5628
S11	0.5HLRemo80to85	0.323	174656	2213	214	0.27	3.90	5.20	0.84	686	5652
S12	IndWt0.1	0.315	510161	6794	680	0.07	5.52	7.36	0.84	2155	5485
S13	IndRemLast3yr	0.318	350518	4667	467	0.10	5.20	6.93	0.84	1466	5645
S14	Steep0.25	0.020	1741600	8356	80	1.61	1.12	1.49	0.25	2598	5665
S15	Steep0.35	0.059	806833	4479	115	1.17	1.08	1.44	0.35	1352	5658
S16	Steep0.45	0.097	528570	3364	134	1.02	1.09	1.45	0.45	976	5654
S17	Steep0.55	0.136	379162	2781	148	1.00	1.00	1.34	0.55	775	5653
S18	Steep0.65	0.179	457302	3951	268	0.24	2.93	3.91	0.65	1183	5658
S19	Steep0.75	0.241	402097	4216	351	0.16	3.85	5.13	0.75	1293	5660
S20	SteepFit	0.124	407256	2911	144	1.00	1.02	1.36	0.52	808	5653

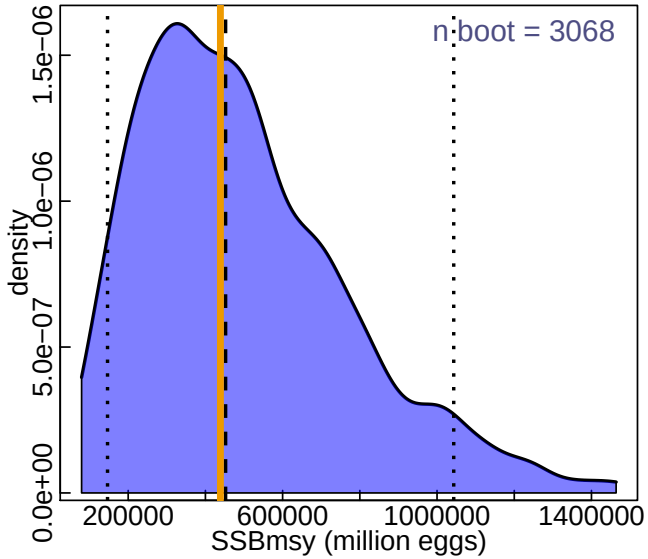
Results

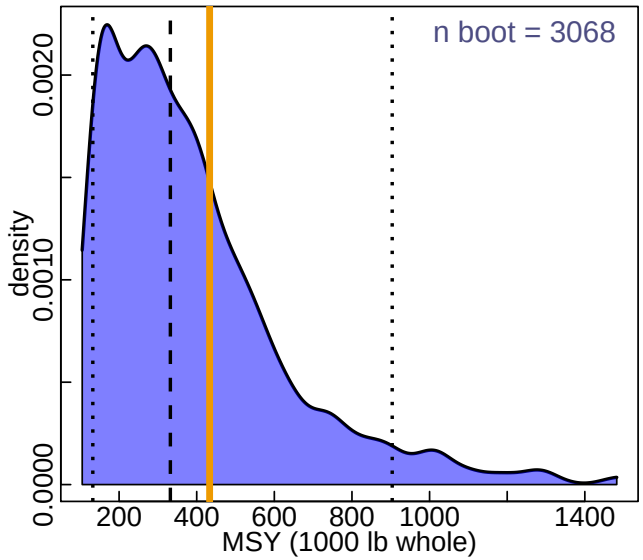
Uncertainty Analysis

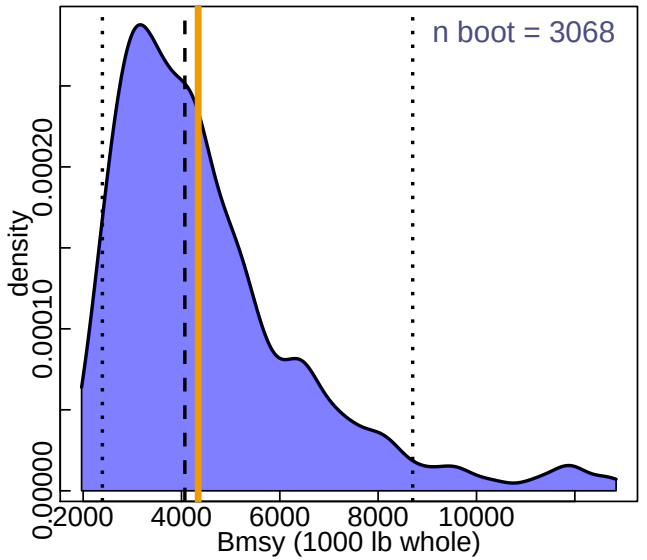
Probability densities of MSY-related benchmarks from MCB analysis

- Thick solid orange lines represent estimates from the RW Reference model.
- Dashed lines represent the median of the MCB trials
- Dotted lines represent 5^{th} and 95^{th} percentiles







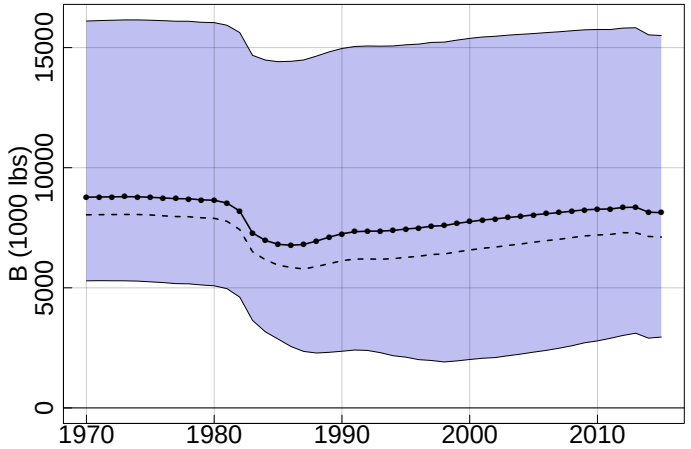


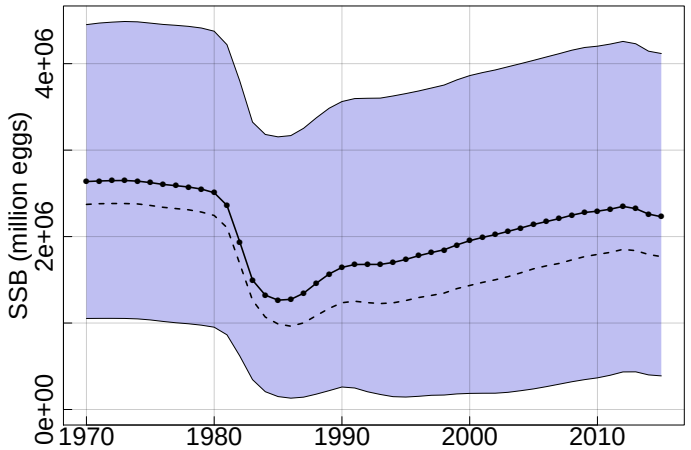
Results

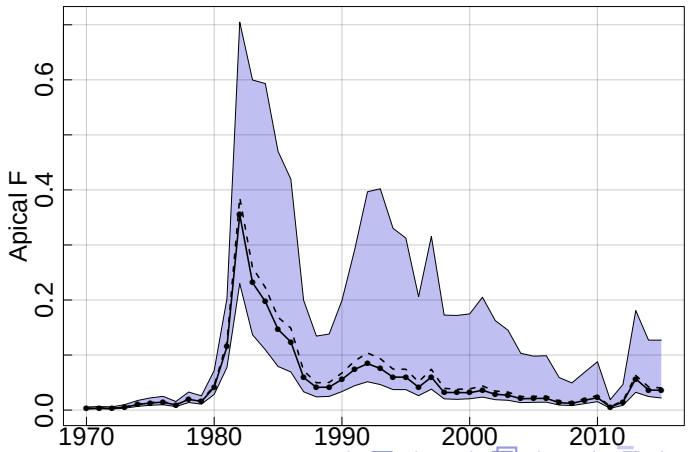
Uncertainty Analysis

Estimated time series of B, SSB, and F for the ASPM RW Ref

- Solid lines indicate RW Ref estimates
- Dashed lines represent the median of the MCB trials
- Error bands indicate 5^{th} and 95^{th} percentiles of the MCB trials





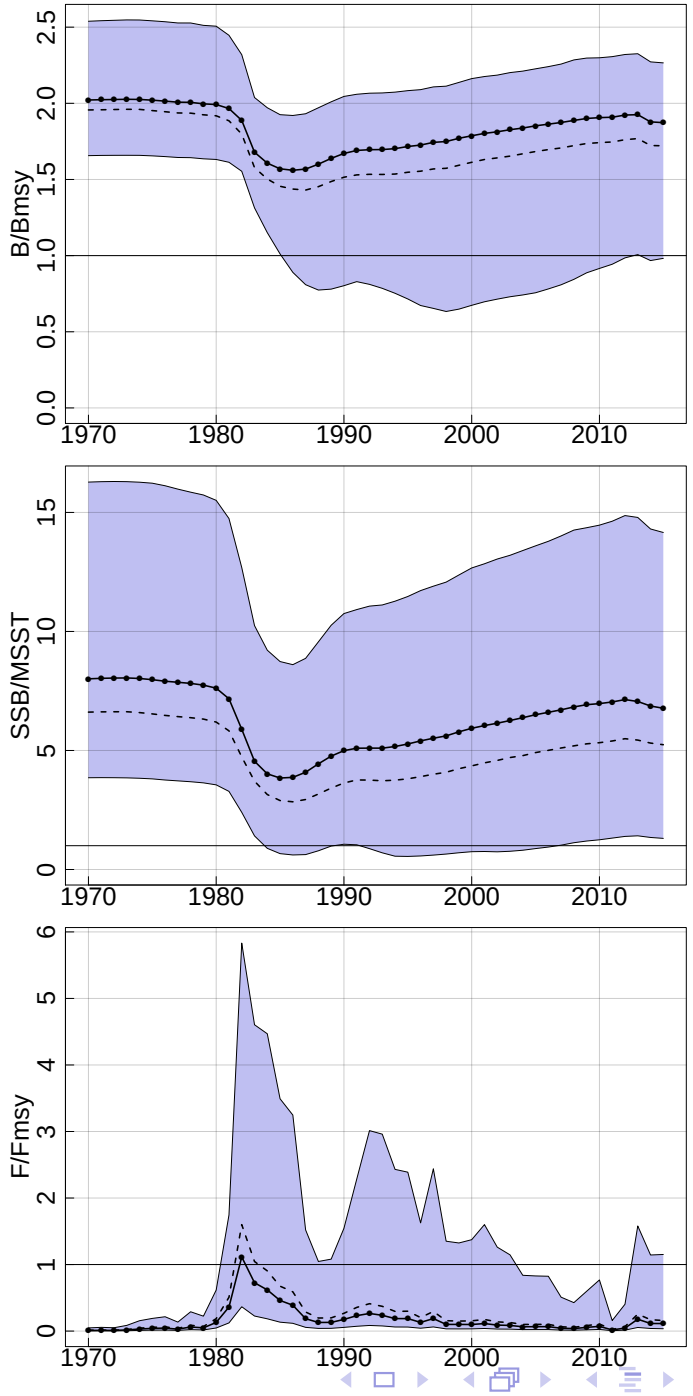


Results

Uncertainty Analysis

Estimated time series of B, SSB, and F relative to benchmarks, for the ASPM RW Ref

- Solid lines indicate RW Ref estimates
- Dashed lines represent the median of the MCB trials
- Error bands indicate 5^{th} and 95^{th} percentiles of the MCB trials

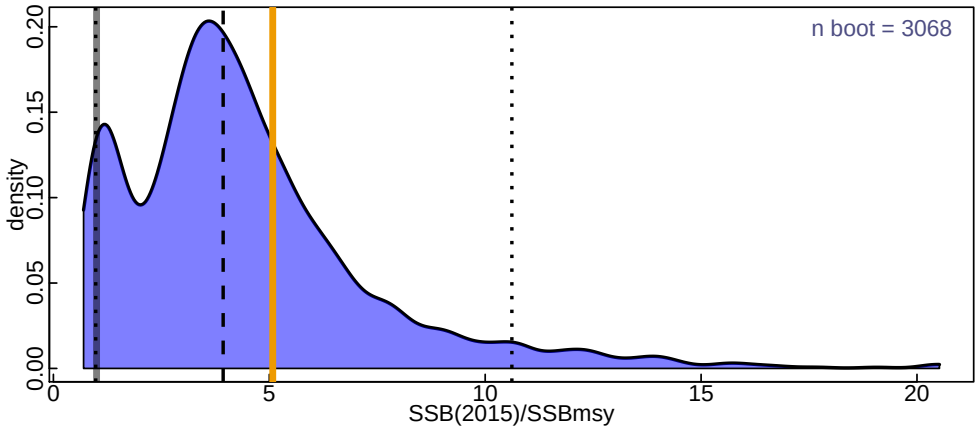


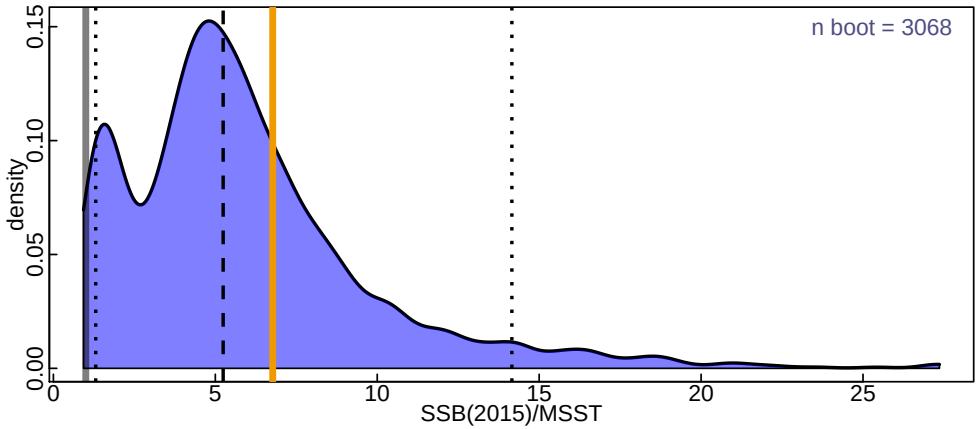
Results

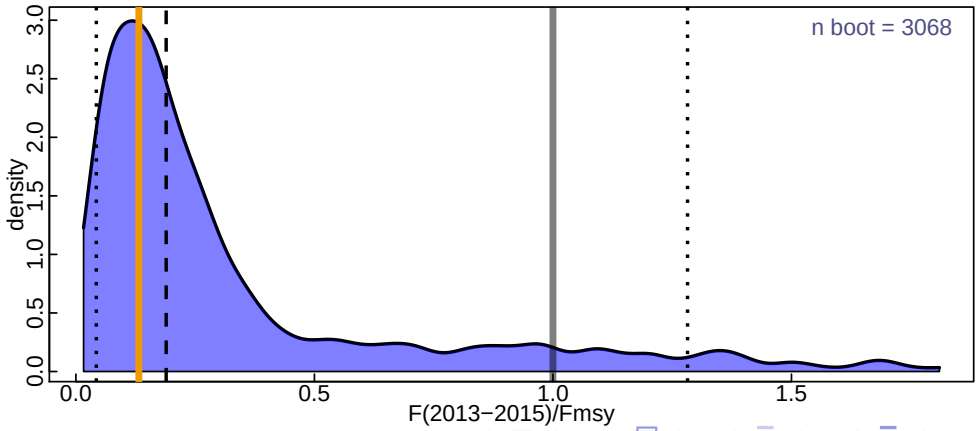
Uncertainty Analysis

Probability densities of terminal status estimates from MCB analysis of the ASPM

- Thick solid orange lines represent estimates from the RW Reference model
- Dashed line represents the median of the MCB trials
- Dotted lines represent 5^{th} and 95^{th} percentiles of the MCB trials





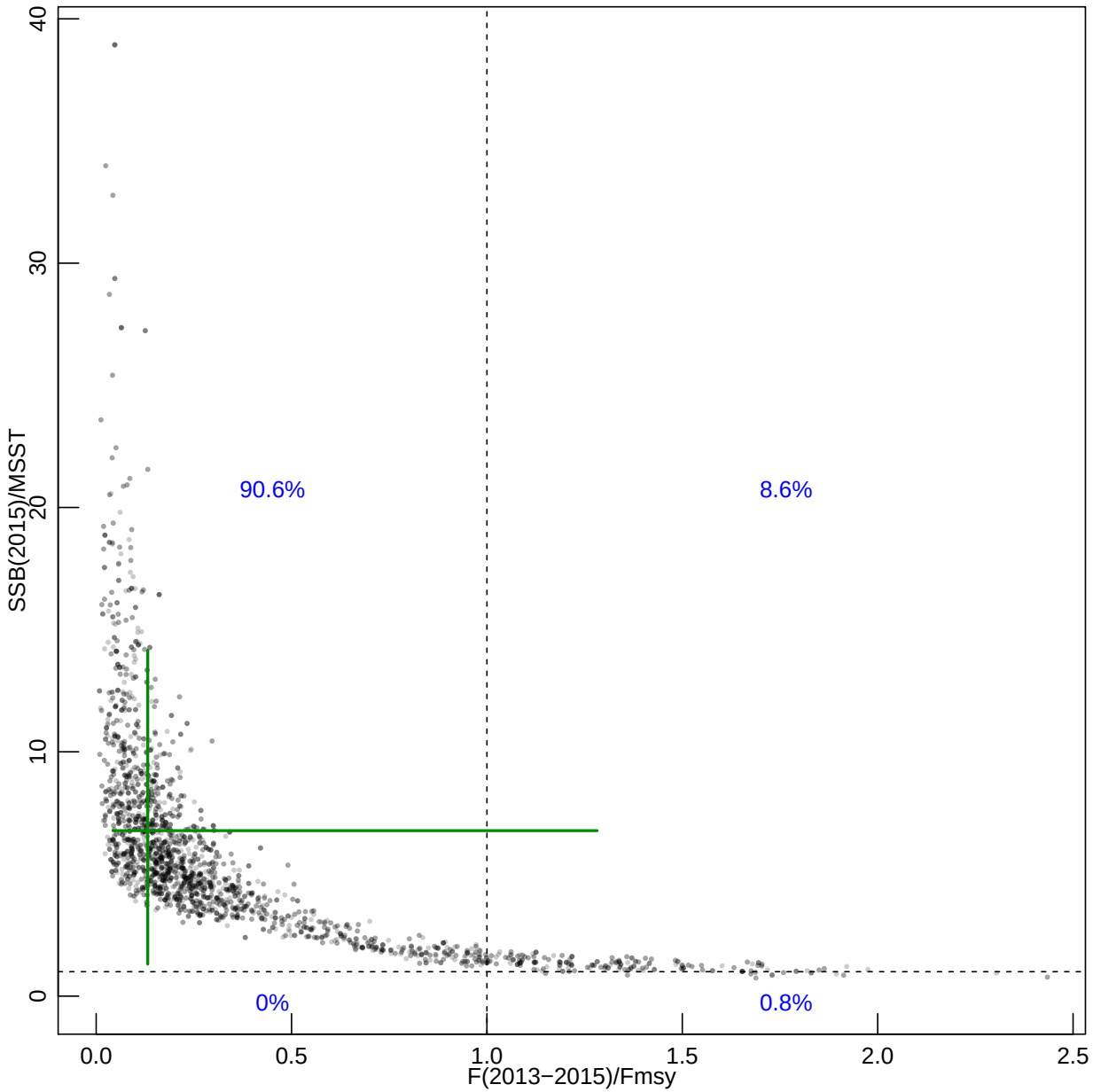


Results

Uncertainty Analysis

Phase plot of terminal status estimates from MCB analysis

- The intersection of crosshairs indicates estimate from the RW Ref
- Lengths of crosshairs defined by 5^{th} and 95^{th} percentiles
- Percent of runs falling in each quadrant indicated

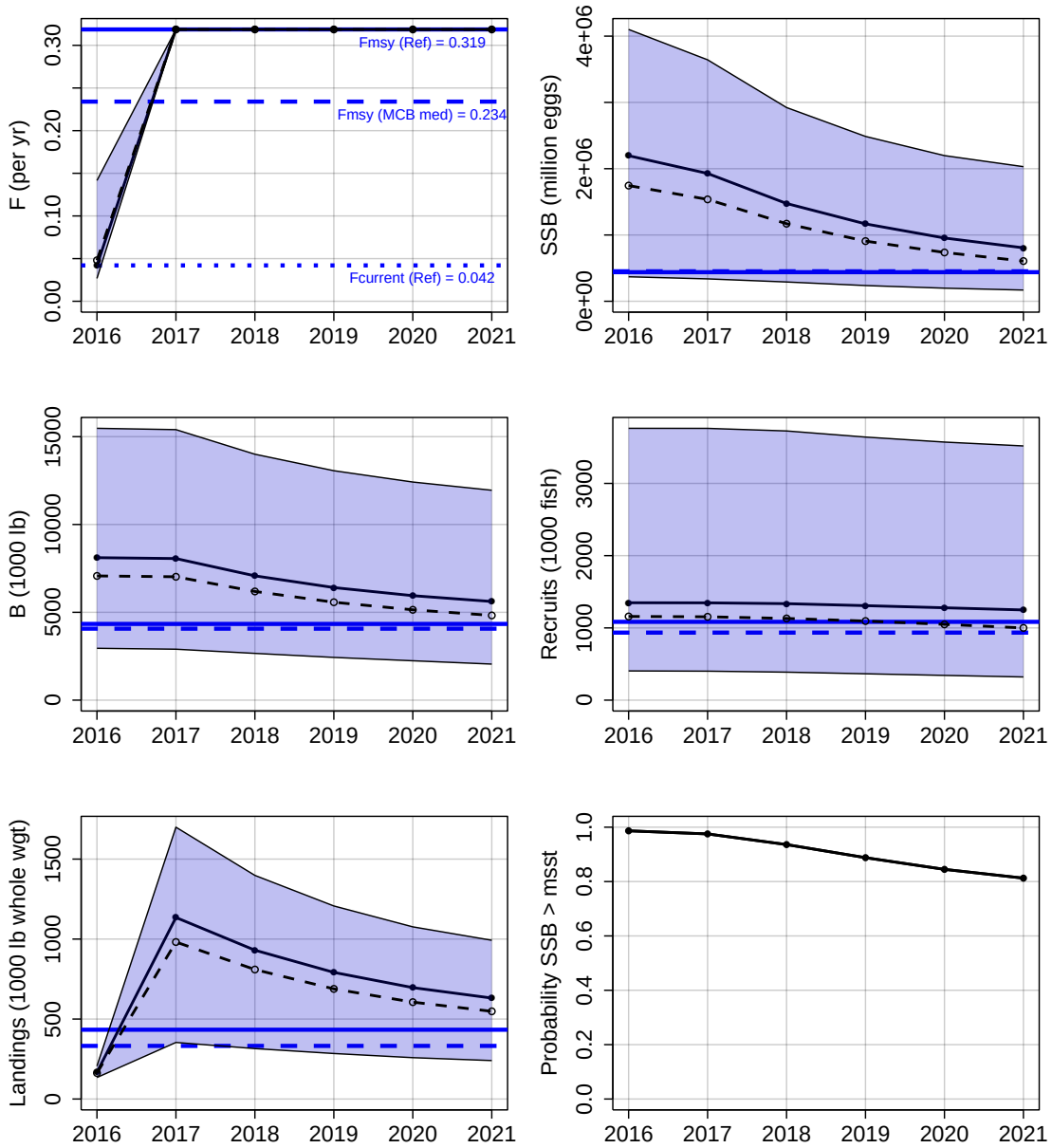


Results

Projections

Projections at F_{MSY} from the ASPM RW Ref

- Solid and dashed black lines are the deterministic estimates and medians of the MCB projections, respectively
- Error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials



Results

Projections

Projections at: $F = F_{\text{MSY}}$

Table: Projection results for the ASPM south of Cape Hatteras with fishing mortality rate fixed at $F = F_{\text{MSY}}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), SSB = spawning stock (million eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 *lb*).The proportion of 3068 stochastic projection replicates with SSB $\geq$ MSST is also indicated. The subscript *med* indicates median values from the stochastic projections.

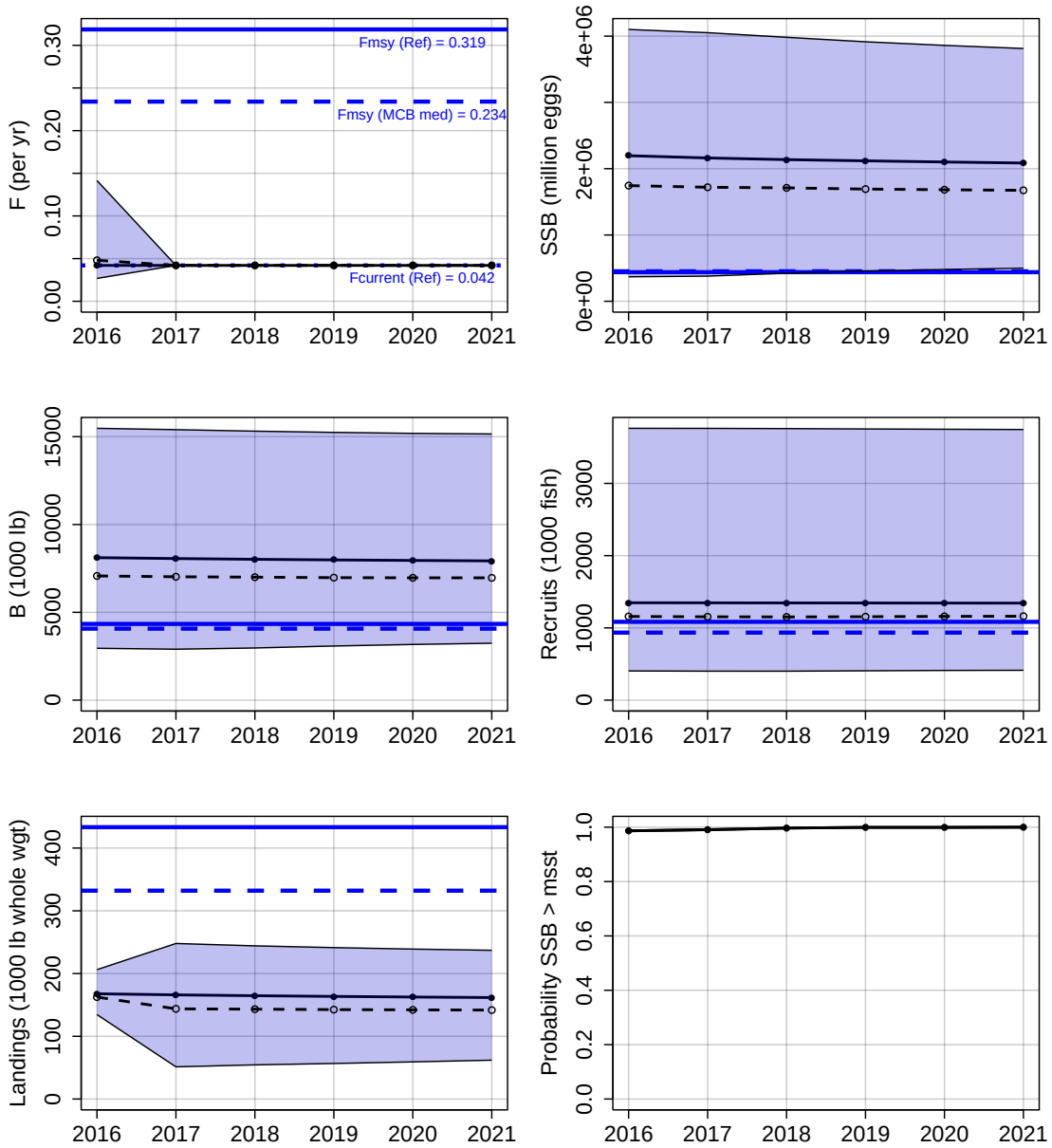
Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	P(SSB $\geq$ MSST)
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	0.987
2017	1347	1154	0.319	0.319	1928056	1537127	318	269	1135	982	0.975
2018	1336	1131	0.319	0.319	1475294	1170095	273	232	931	810	0.936
2019	1308	1095	0.319	0.319	1167340	907481	243	206	792	689	0.888
2020	1279	1049	0.319	0.319	954548	736359	223	188	697	606	0.845
2021	1249	1000	0.319	0.319	806244	606675	208	174	631	548	0.813

Results

Projections

Projections at F_{current} from the ASPM RW Ref

- Solid and dashed black lines are the deterministic estimates and medians of the MCB projections, respectively
- Error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials



Results

Projections

Projections at: $F = F_{\text{current}}$

Table: Projection results for the ASPM south of Cape Hatteras with fishing mortality rate fixed at $F = F_{\text{current}}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), SSB = spawning stock (million eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 *lb*).The proportion of 3068 stochastic projection replicates with SSB $\geq$ MSST is also indicated. The subscript *med* indicates median values from the stochastic projections.

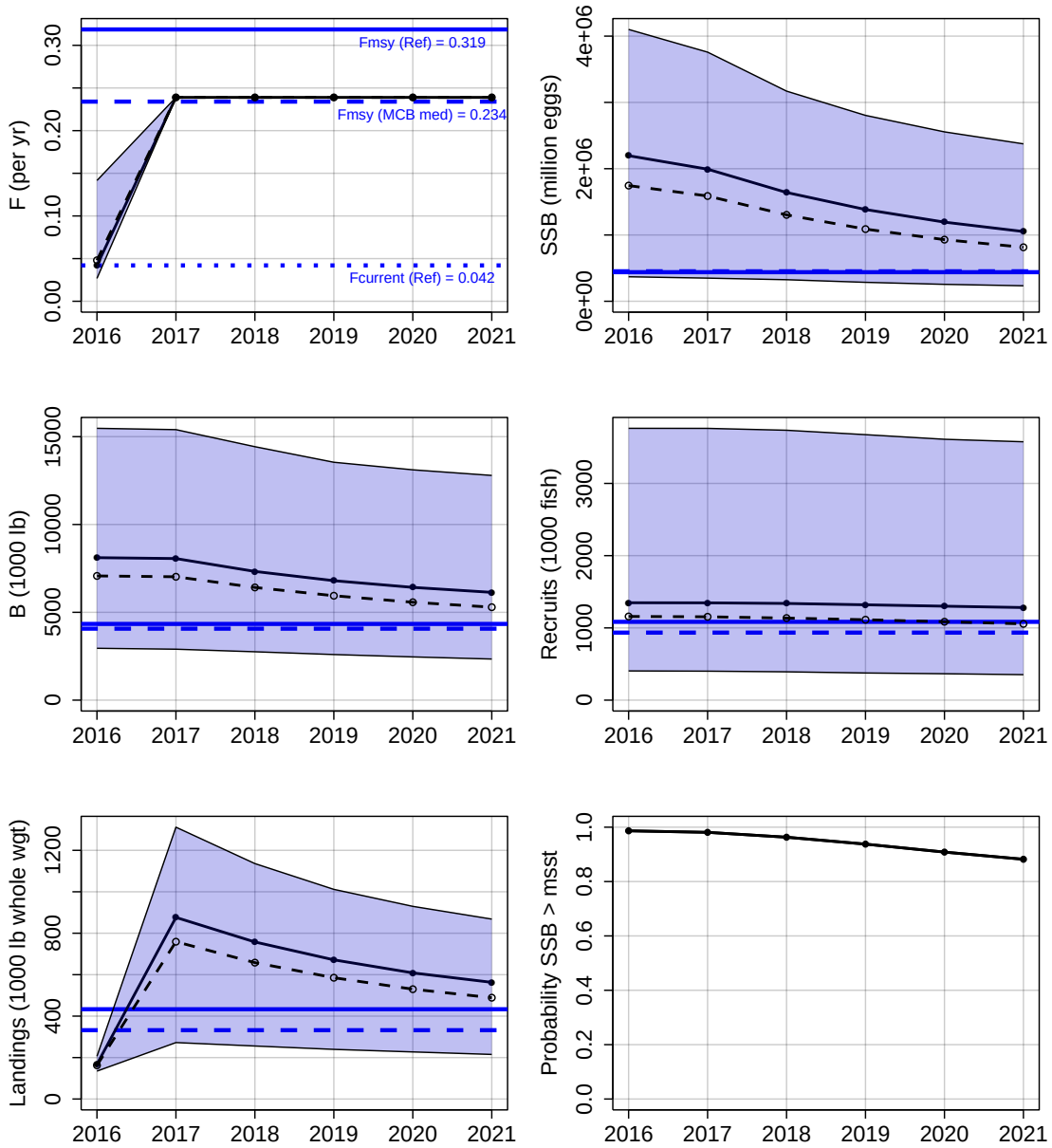
Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	P(SSB $\geq$ MSST)
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	0.987
2017	1347	1154	0.042	0.042	2161901	1720181	46	39	166	144	0.991
2018	1346	1152	0.042	0.042	2136905	1710806	45	39	165	143	0.997
2019	1345	1155	0.042	0.042	2118573	1692481	45	38	164	143	0.999
2020	1344	1159	0.042	0.042	2101179	1682592	45	38	163	142	0.999
2021	1343	1162	0.042	0.042	2085621	1673572	45	38	162	142	1.000

Results

Projections

Projections at F_{target} from the ASPM RW Ref

- Solid and dashed black lines are the deterministic estimates and medians of the MCB projections, respectively
- Error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials



Results

Projections

Projections at: $F = F_{\text{target}}$

Table: Projection results for the ASPM south of Cape Hatteras with fishing mortality rate fixed at $F = F_{\text{target}}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), SSB = spawning stock (million eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 *lb*).The proportion of 3068 stochastic projection replicates with SSB $\geq$ MSST is also indicated. The subscript *med* indicates median values from the stochastic projections.

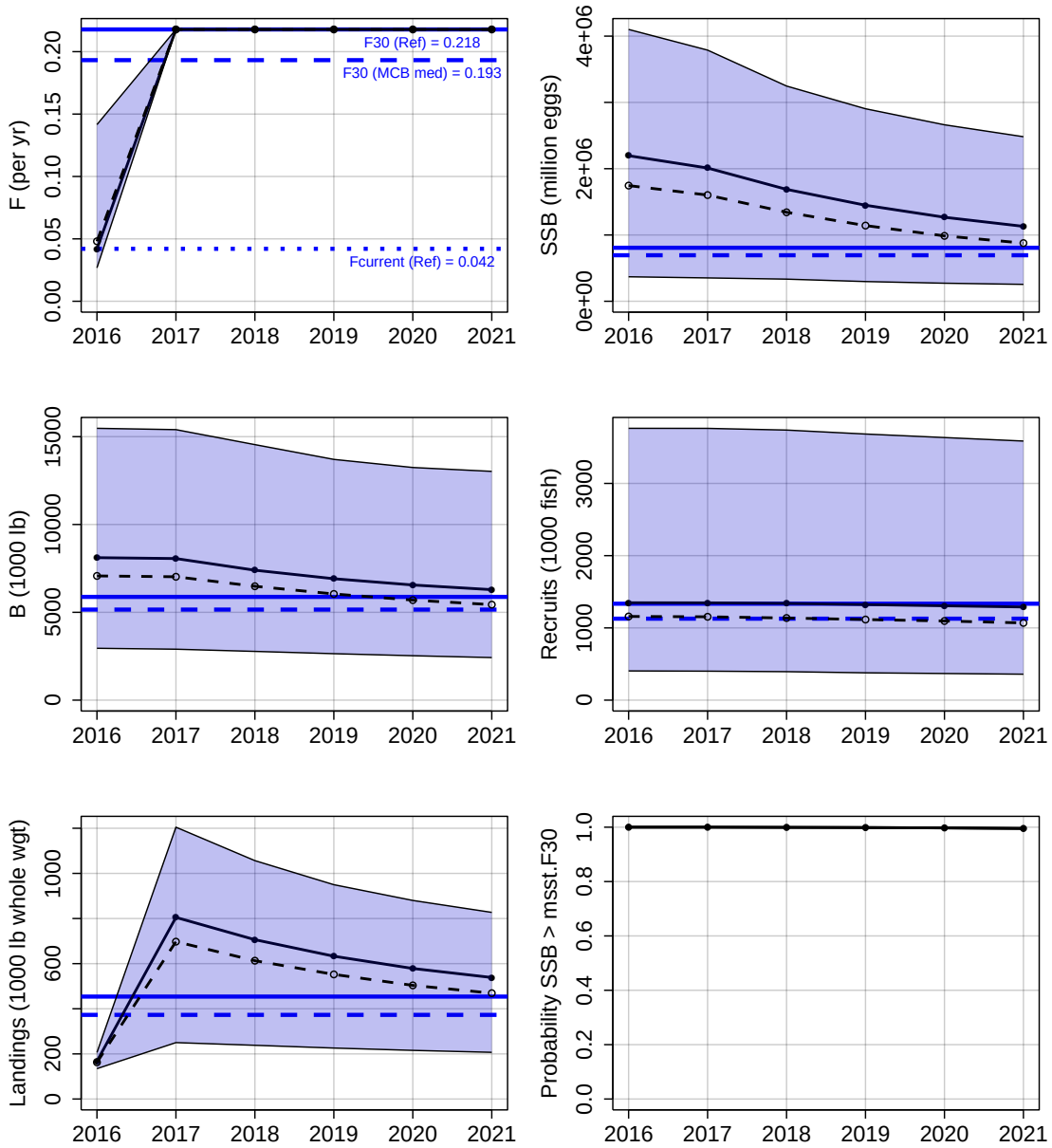
Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	P(SSB $\geq$ MSST)
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	0.987
2017	1347	1154	0.239	0.239	1992681	1588173	244	207	876	759	0.981
2018	1339	1136	0.239	0.239	1641164	1303360	218	186	758	658	0.963
2019	1320	1113	0.239	0.239	1384330	1088796	200	170	672	585	0.938
2020	1301	1085	0.239	0.239	1193797	929781	187	158	609	530	0.908
2021	1282	1056	0.239	0.239	1052151	814673	177	149	563	489	0.882

Results

Projections

Projections at $F_{30\%}$ from the ASPM RW Ref

- Solid and dashed black lines are the deterministic estimates and medians of the MCB projections, respectively
- Error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials



Results

Projections

Projections at: $F = F_{30\%}$

Table: Projection results for the ASPM south of Cape Hatteras with fishing mortality rate fixed at $F = F_{30\%}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), SSB = spawning stock (million eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 *lb*).The proportion of 3068 stochastic projection replicates with SSB $\geq$ $\text{MSST}_{\text{F30\%}}$ is also indicated. The subscript *med* indicates median values from the stochastic projections.

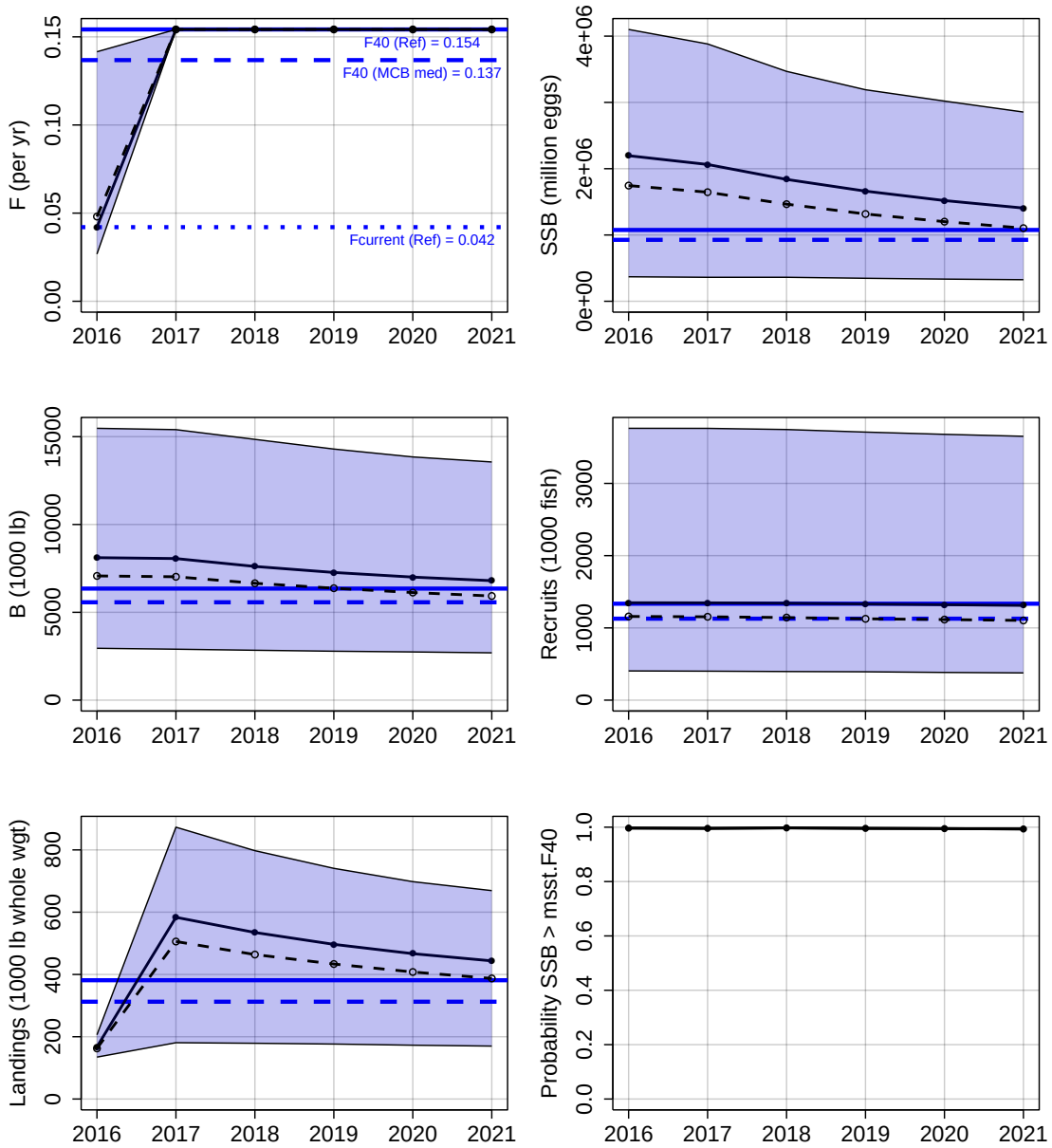
Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	P(SSB $\geq$ $\text{MSST}_{\text{F30\%}}$)
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	1.000
2017	1347	1154	0.218	0.218	2010203	1602341	224	190	805	697	1.000
2018	1339	1137	0.218	0.218	1688297	1342502	202	172	706	613	0.999
2019	1323	1116	0.218	0.218	1448677	1141989	187	159	633	552	0.999
2020	1306	1096	0.218	0.218	1267478	986531	175	149	579	504	0.997
2021	1290	1069	0.218	0.218	1130395	877573	167	141	539	469	0.995

Results

Projections

Projections at $F_{40\%}$ from the ASPM RW Ref

- Solid and dashed black lines are the deterministic estimates and medians of the MCB projections, respectively
- Error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials



Results

Projections

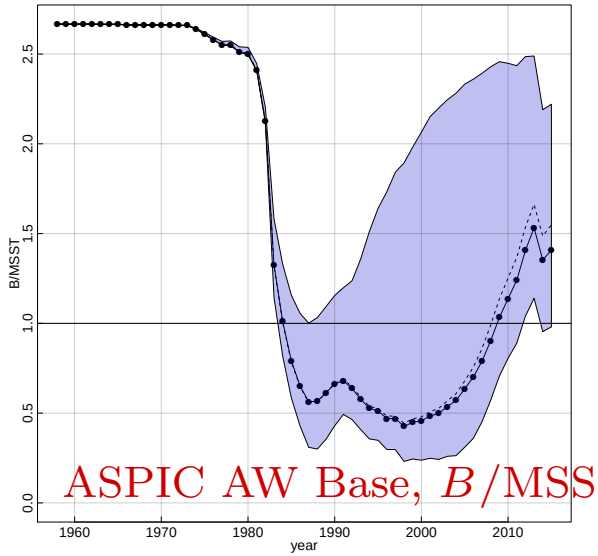
Projections at: $F = F_{40\%}$

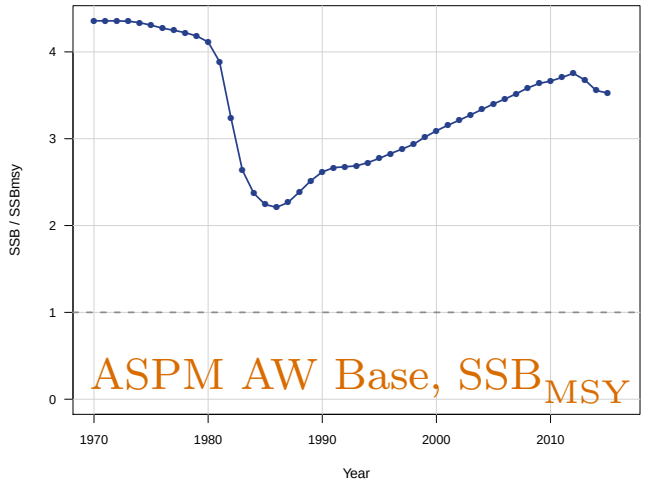
Table: Projection results for the ASPM south of Cape Hatteras with fishing mortality rate fixed at $F = F_{40\%}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), SSB = spawning stock (million eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 *lb*).The proportion of 3068 stochastic projection replicates with SSB $\geq$ $\text{MSST}_{\text{F40\%}}$ is also indicated. The subscript *med* indicates median values from the stochastic projections.

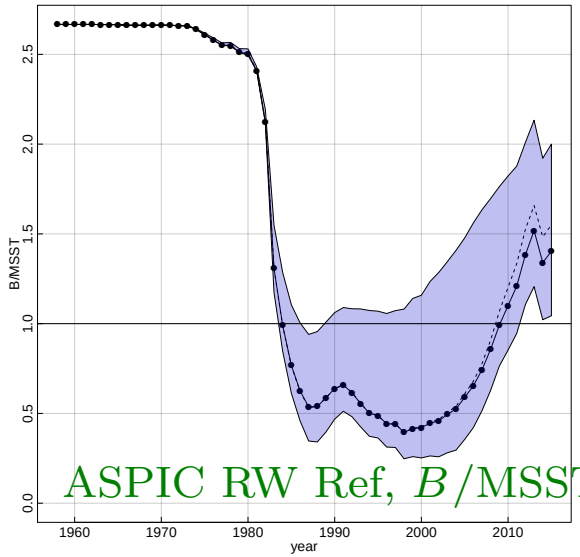
Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	P(SSB $\geq$ $\text{MSST}_{\text{F40\%}}$)
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	0.997
2017	1347	1154	0.154	0.154	2063827	1645585	162	137	584	506	0.996
2018	1342	1143	0.154	0.154	1838443	1465053	151	128	535	464	0.997
2019	1331	1126	0.154	0.154	1661428	1316731	143	122	497	434	0.996
2020	1321	1116	0.154	0.154	1519467	1201382	137	117	467	408	0.995
2021	1312	1103	0.154	0.154	1406161	1103169	132	112	444	387	0.993

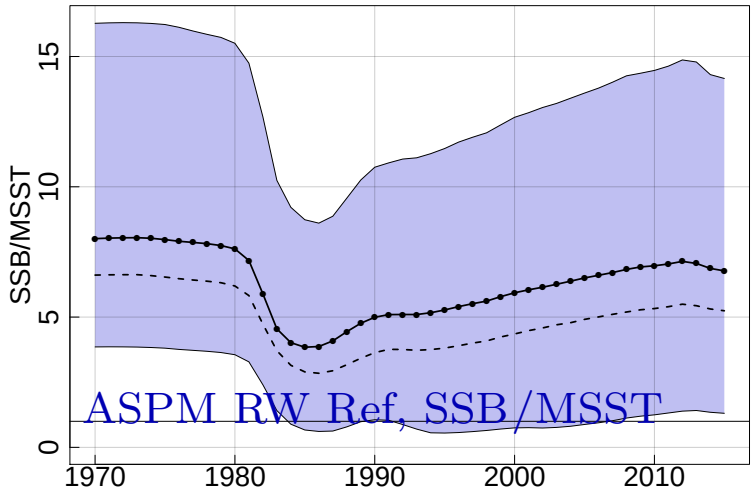
Summary

B status



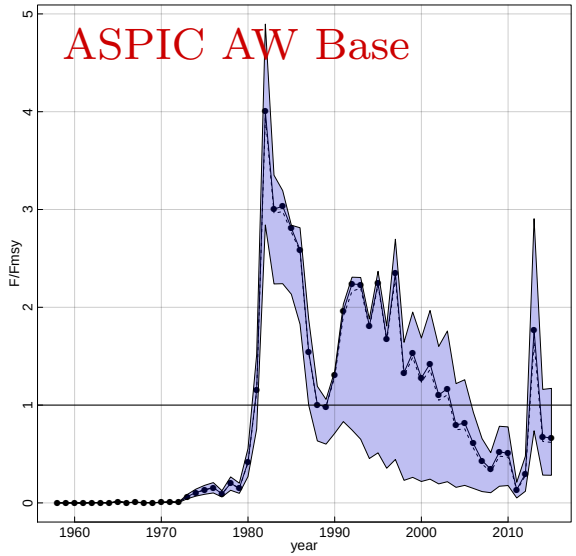


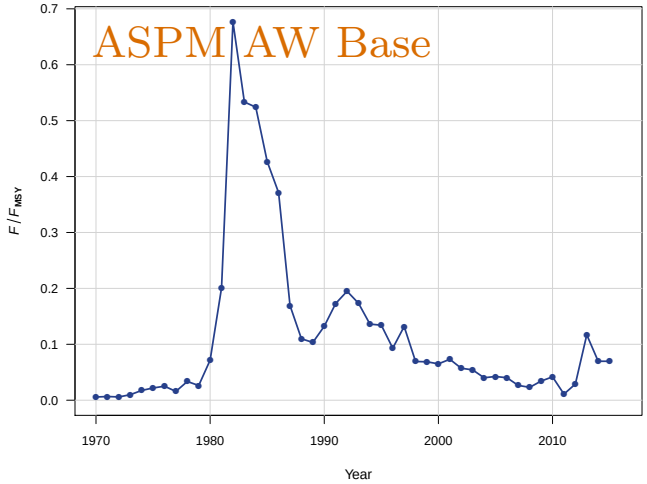


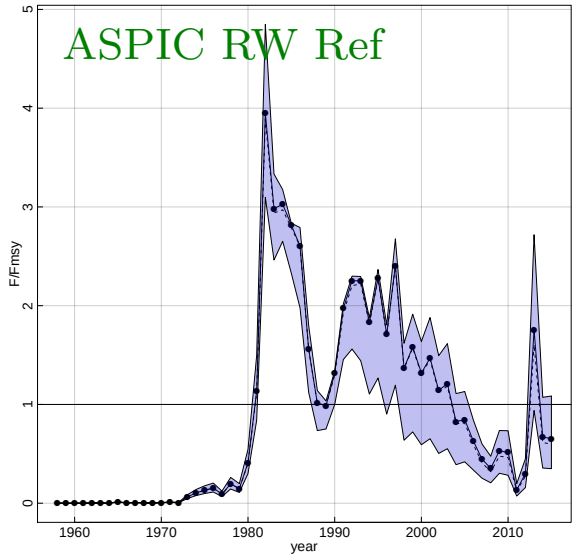


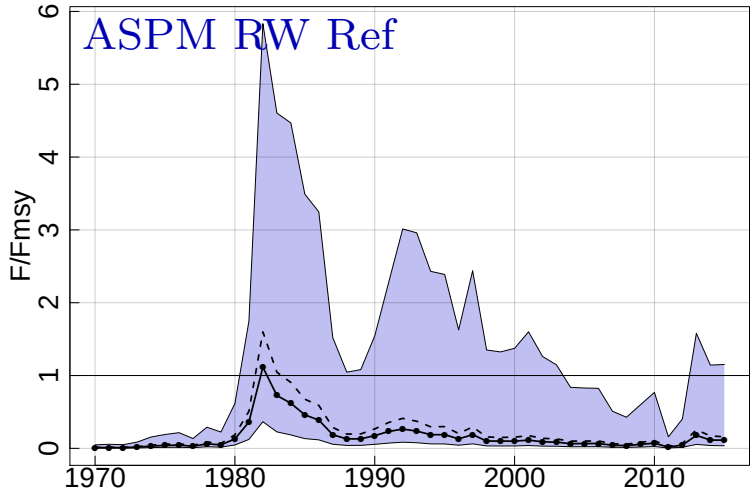
Summary

F status









Summary

Benchmarks

Table: ASPIC AW Base

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.146	0.148	0.106
$85\%F_{MSY}$	y^{-1}	0.124	0.126	0.090
$75\%F_{MSY}$	y^{-1}	0.109	0.111	0.080
$65\%F_{MSY}$	y^{-1}	0.095	0.096	0.069
B_{MSY}	1000 lb	1467	1452	1225
MSST	1000 lb	1100	1089	918
MSY	1000 lb	212	216	85
$F_{2013-2015}/F_{MSY}$	—	0.92	0.86	0.96
B_{2015}/MSST	—	1.41	1.55	0.41
B_{2015}/B_{MSY}	—	1.06	1.16	0.31

Table: ASPIC RW Ref

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.151	0.154	0.062
$85\%F_{MSY}$	y^{-1}	0.129	0.131	0.052
$75\%F_{MSY}$	y^{-1}	0.114	0.116	0.046
$65\%F_{MSY}$	y^{-1}	0.098	0.100	0.040
B_{MSY}	1000 lb	1433	1424	394
MSST	1000 lb	1075	1068	296
MSY	1000 lb	217	220	45
$F_{2013-2015}/F_{MSY}$	—	0.92	0.84	0.35
B_{2015}/MSST	—	1.40	1.55	0.29
B_{2015}/B_{MSY}	—	1.05	1.16	0.22

Table: ASPM AW Base

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.841	—	—
$85\%F_{MSY}$	y^{-1}	0.715	—	—
$75\%F_{MSY}$	y^{-1}	0.630	—	—
$65\%F_{MSY}$	y^{-1}	0.546	—	—
$F_{30\%}$	y^{-1}	0.628	—	—
$F_{40\%}$	y^{-1}	0.337	—	—
B_{MSY}	1000 lb whole	1997	—	—
SSB_{MSY}	million eggs	816899	—	—
MSST	million eggs	612674	—	—
MSY	1000 lb whole	316	—	—
R_{MSY}	number fish	990100	—	—
$L_{85\%MSY}$	1000 lb whole	315	—	—
$L_{75\%MSY}$	1000 lb whole	313	—	—
$L_{65\%MSY}$	1000 lb whole	310	—	—
$F_{2013-2015}/F_{MSY}$	—	0.08	—	—
SSB_{2015}/MSST	—	4.70	—	—
SSB_{2015}/SSB_{MSY}	—	3.53	—	—

Table: ASPM RW Ref

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.319	0.234	0.290
$85\%F_{MSY}$	y^{-1}	0.271	0.199	0.246
$75\%F_{MSY}$	y^{-1}	0.239	0.176	0.217
$65\%F_{MSY}$	y^{-1}	0.207	0.152	0.188
$F_{30\%}$	y^{-1}	0.218	0.193	0.136
$F_{40\%}$	y^{-1}	0.154	0.137	0.082
B_{MSY}	1000 lb whole	4339	1846	1023
SSB_{MSY}	million eggs	438871	454964	281925
MSST	million eggs	329153	341223	211444
MSY	1000 lb whole	433	332	274
R_{MSY}	number fish	1084009	934907	897626
$L_{85\%MSY}$	1000 lb whole	428	328	271
$L_{75\%MSY}$	1000 lb whole	418	320	265
$L_{65\%MSY}$	1000 lb whole	402	309	257
$F_{2013-2015}/F_{MSY}$	—	0.13	0.19	0.40
SSB_{2015}/MSST	—	6.77	5.24	4.38
SSB_{2015}/SSB_{MSY}	—	5.08	3.93	3.28

Summary

Projections at: $F = F_{\text{current}}$

Table: ASPIC AW Base

Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.134	0.77	0.95	1702	1606	215	215
2017	0.134	0.76	0.95	1682	1603	215	430
2018	0.134	0.74	0.95	1668	1600	214	645
2019	0.134	0.72	0.94	1659	1598	214	859
2020	0.134	0.70	0.94	1653	1596	214	1073
2021		0.67	0.93	1644	1594		

Table: ASPIC RW Ref

Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.139	0.80	0.97	1684	1572	219	219
2017	0.139	0.79	0.96	1667	1568	218	437
2018	0.139	0.78	0.96	1657	1565	218	655
2019	0.139	0.75	0.96	1648	1562	218	872
2020	0.139	0.72	0.95	1640	1560	217	1090
2021		0.70	0.94	1630	1558		

Table: ASPM RW Ref

Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	P(SSB $\geq$ MSST)
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	0.987
2017	1347	1154	0.042	0.042	2161901	1720181	46	39	166	144	0.991
2018	1346	1152	0.042	0.042	2136905	1710806	45	39	165	143	0.997
2019	1345	1155	0.042	0.042	2118573	1692481	45	38	164	143	0.999
2020	1344	1159	0.042	0.042	2101179	1682592	45	38	163	142	0.999
2021	1343	1162	0.042	0.042	2085621	1673572	45	38	162	142	1.000

Summary

Projections at: $F = F_{\mathrm{MSY}}$

Table: ASPIC AW Base

Year	F(per yr)	$P(B > B_{\mathrm{MSY}})$	$P(B >$ MSST)	B_{median}	B	Y	Sum Y
2016	0.134	0.77	0.95	1702	1606	215	215
2017	0.146	0.76	0.95	1682	1603	232	447
2018	0.146	0.72	0.95	1652	1583	230	677
2019	0.146	0.69	0.94	1630	1566	227	904
2020	0.146	0.65	0.93	1612	1552	225	1130
2021		0.61	0.92	1593	1540		

Table: ASPIC RW Ref

Year	F(per yr)	$P(B > B_{\mathrm{MSY}})$	$P(B >$ MSST)	B_{median}	B	Y	Sum Y
2016	0.139	0.80	0.97	1684	1572	219	219
2017	0.151	0.79	0.96	1667	1568	236	455
2018	0.151	0.76	0.96	1639	1547	233	688
2019	0.151	0.72	0.95	1617	1530	231	918
2020	0.151	0.69	0.94	1597	1516	229	1147
2021		0.65	0.93	1577	1504		

Table: ASPM RW Ref

Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	P(SSB $\geq$ MSST)
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	0.987
2017	1347	1154	0.319	0.319	1928056	1537127	318	269	1135	982	0.975
2018	1336	1131	0.319	0.319	1475294	1170095	273	232	931	810	0.936
2019	1308	1095	0.319	0.319	1167340	907481	243	206	792	689	0.888
2020	1279	1049	0.319	0.319	954548	736359	223	188	697	606	0.845
2021	1249	1000	0.319	0.319	806244	606675	208	174	631	548	0.813

Summary

Projections at: $F = F_{\text{target}}$

Table: ASPIC AW Base

Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.134	0.77	0.95	1702	1606	215	215
2017	0.109	0.76	0.95	1682	1603	177	392
2018	0.109	0.77	0.96	1704	1637	181	573
2019	0.109	0.79	0.96	1723	1667	184	757
2020	0.109	0.79	0.96	1736	1693	186	943
2021		0.80	0.96	1744	1714		

Table: ASPIC RW Ref

Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.139	0.80	0.97	1684	1572	219	219
2017	0.114	0.79	0.96	1667	1568	180	399
2018	0.114	0.80	0.97	1695	1602	184	583
2019	0.114	0.82	0.97	1715	1632	187	769
2020	0.114	0.82	0.97	1732	1658	190	959
2021		0.82	0.97	1741	1679		

Table: ASPM RW Ref

Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	P(SSB $\geq$ MSST)
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	0.987
2017	1347	1154	0.239	0.239	1992681	1588173	244	207	876	759	0.981
2018	1339	1136	0.239	0.239	1641164	1303360	218	186	758	658	0.963
2019	1320	1113	0.239	0.239	1384330	1088796	200	170	672	585	0.938
2020	1301	1085	0.239	0.239	1193797	929781	187	158	609	530	0.908
2021	1282	1056	0.239	0.239	1052151	814673	177	149	563	489	0.882