

Science, Service, Stewardship



SEDAR 25 Stock Assessment: U.S. South Atlantic black sea bass



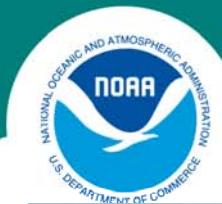
SEDAR 25 Review Workshop
Charleston, SC
October 11-13, 2011

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Outline

- Data
 - Stock definition and life-history characteristics
 - Fishery and survey data
 - Landings and discards
 - Age and length compositions
 - Indices of abundance
- Assessment
 - Statistical catch-age model (BAM)
 - Surplus production model (ASPIC)



Geographic distribution of black sea bass

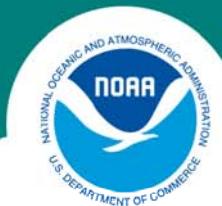


From Fishbase (map not reviewed)

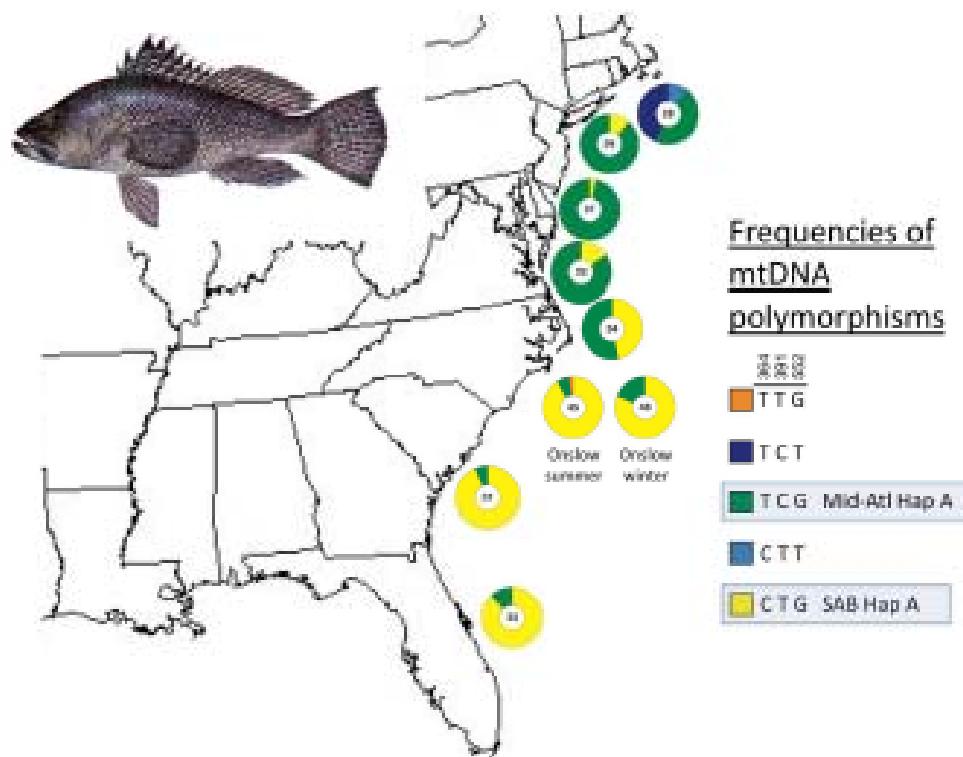


Stock Definition – black sea bass

- Same stock definition as used in previous assessment
 - Northern boundary: Cape Hatteras, NC
 - Southern boundary: FL Keys
- New genetic study since last assessment supports the break near Cape Hatteras

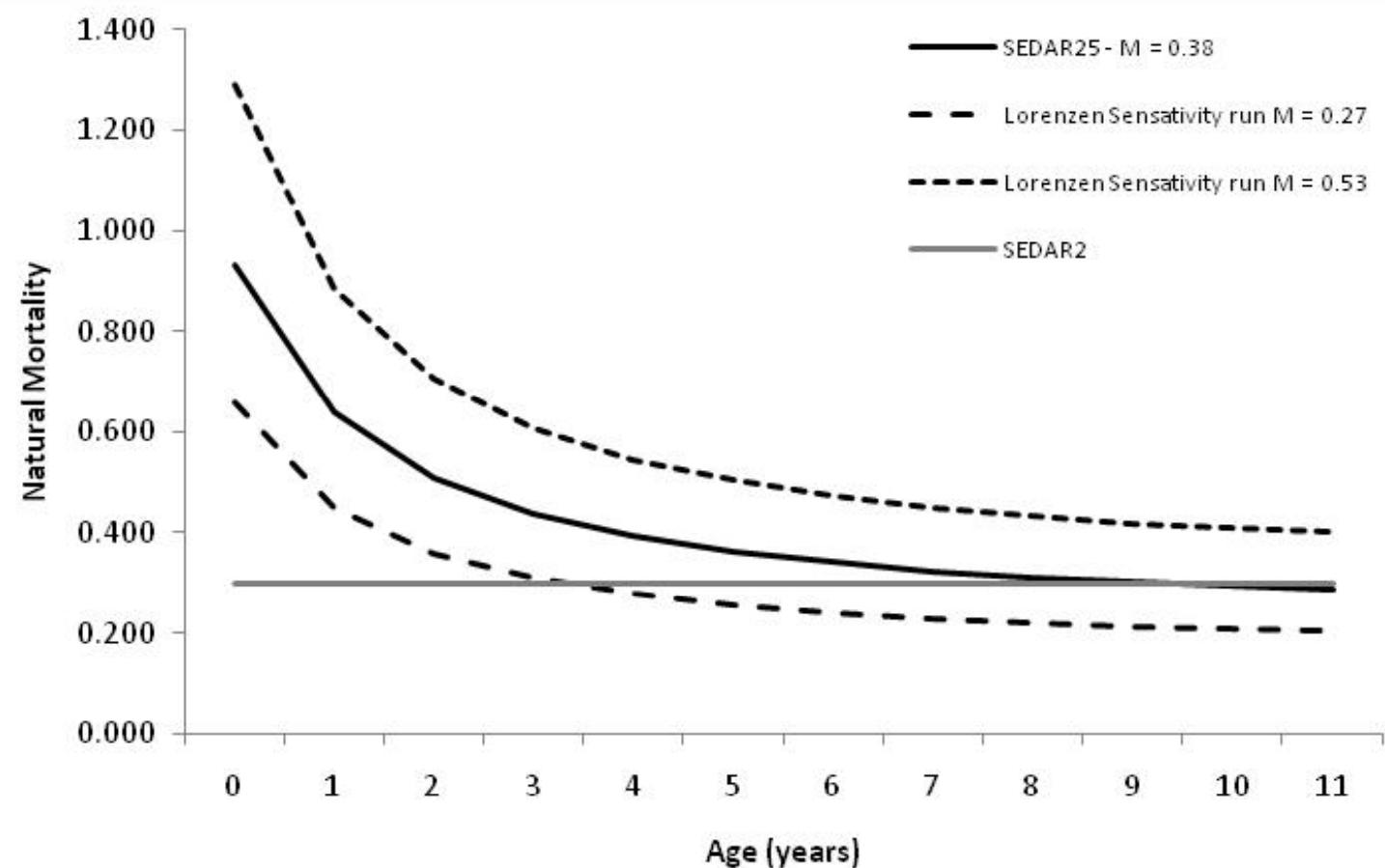


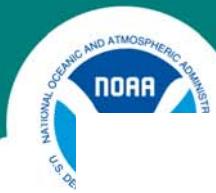
From McCartney and Burton, SEDAR25-RD42





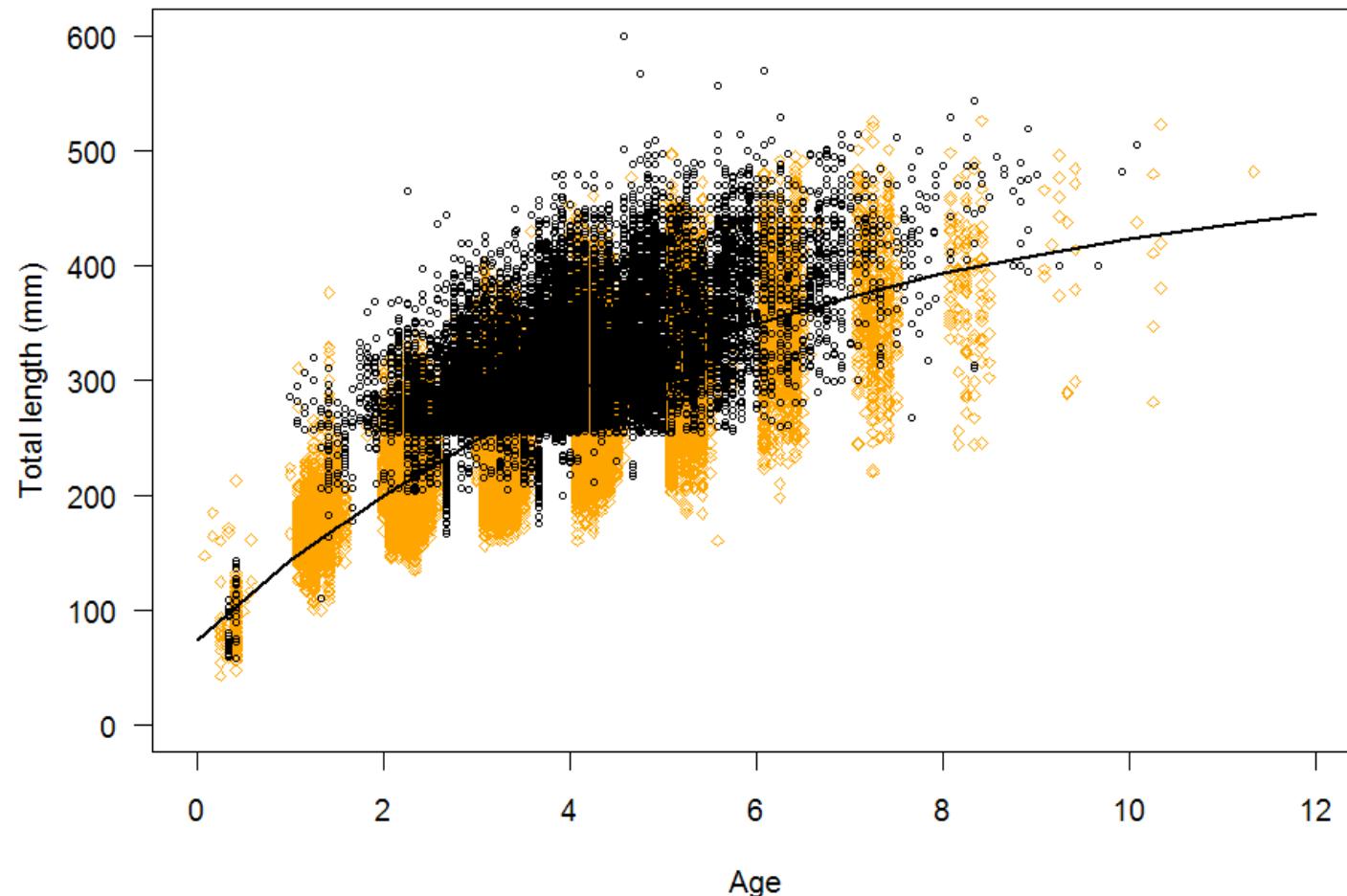
Natural mortality





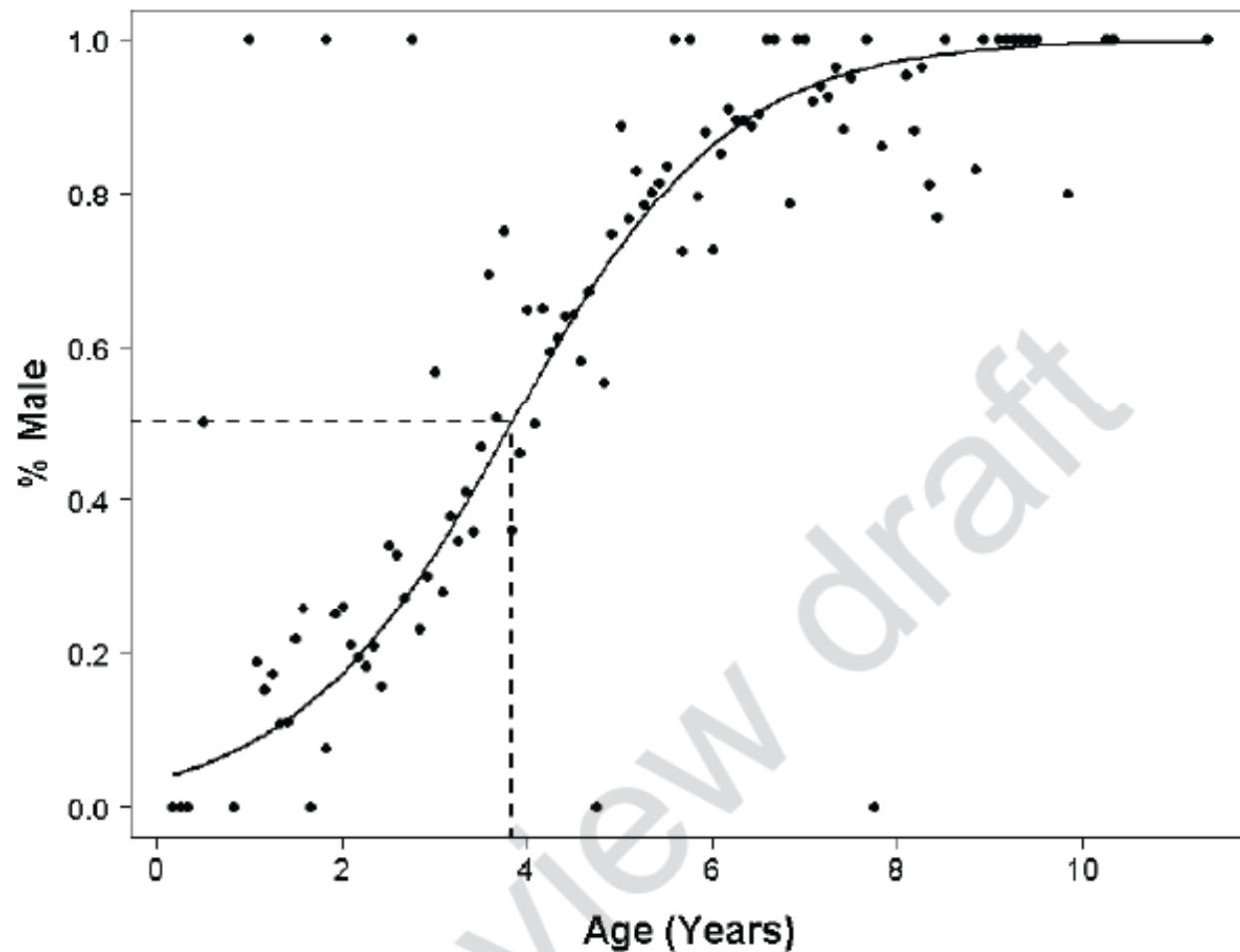
Growth

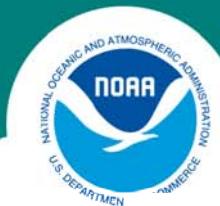
Orange=fishery independent, black=fishery dependent



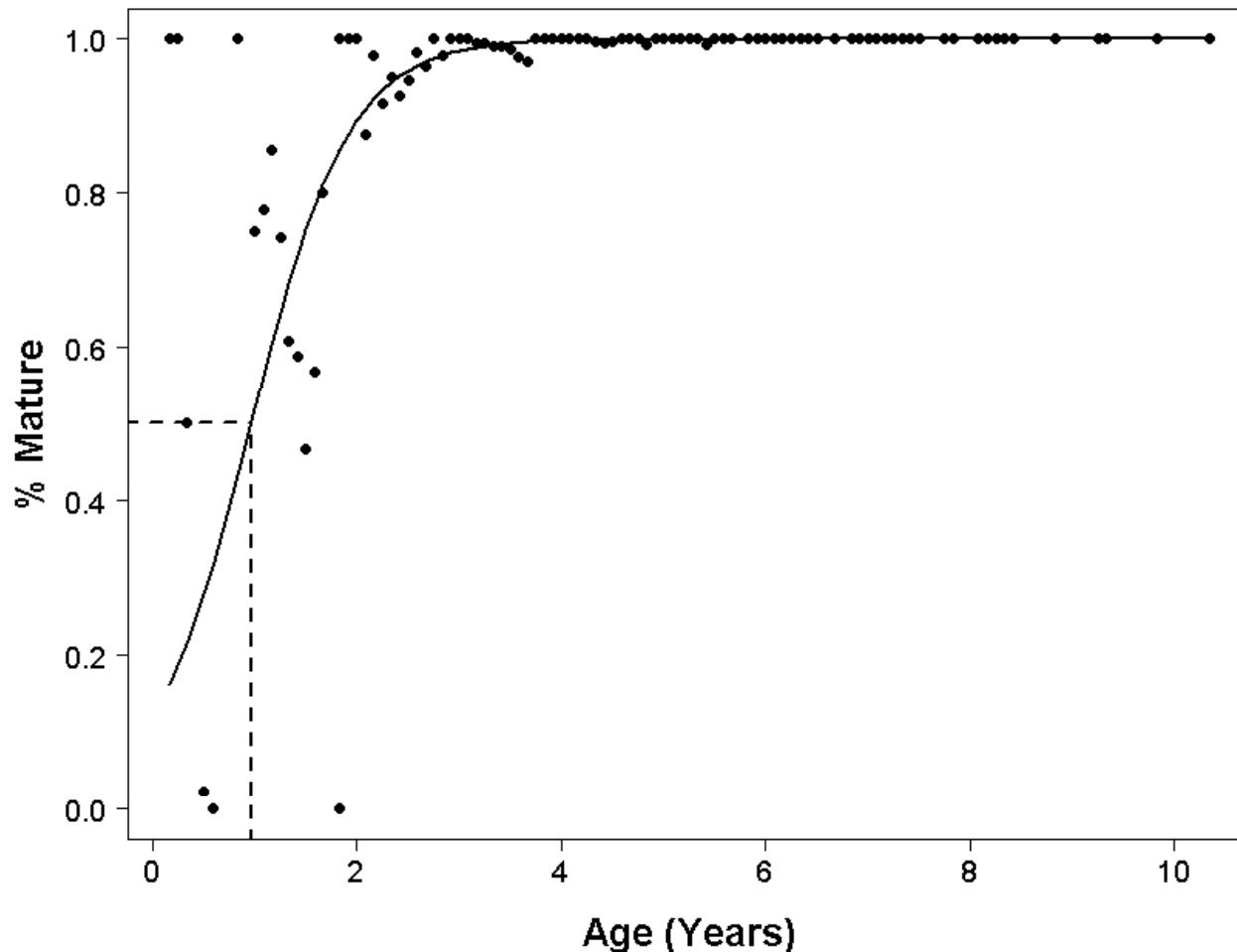


Sex ratio



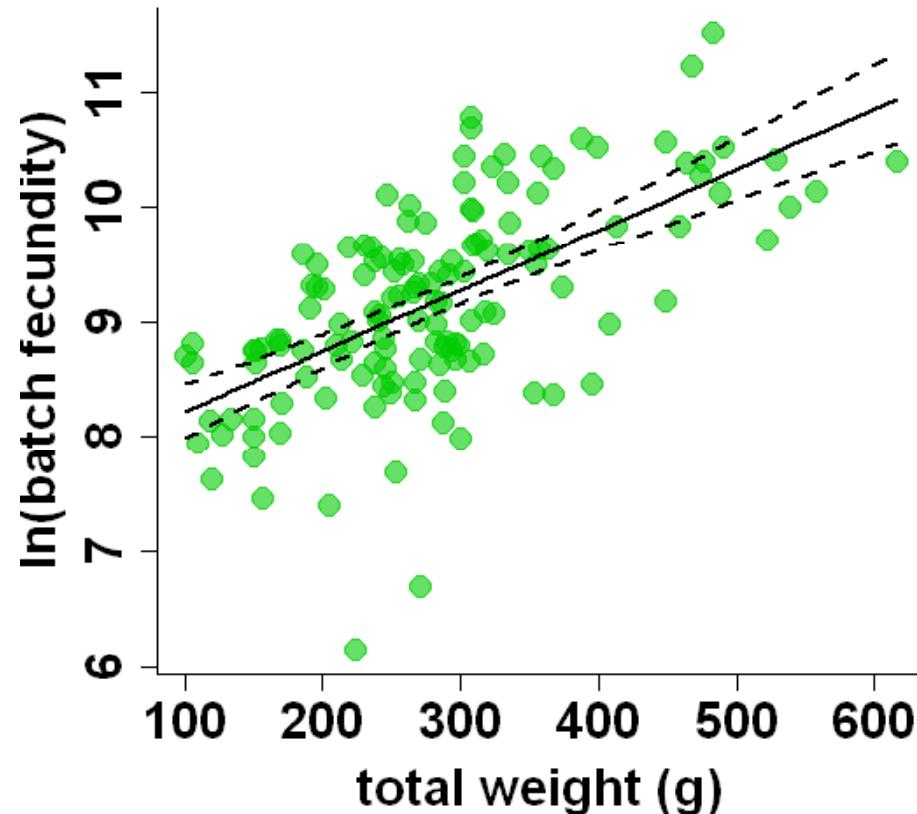


Female maturity





Fecundity





Fleets and surveys

- Commercial fleets
 - Trawl (ct)
 - Pots/traps (cp)
 - Vertical lines (cl)
- Recreational fleets
 - General recreational (mrfss or mrip)
 - Headboat (hb)
- Surveys
 - MARMAP blackfish/snapper traps, 1981-1987 (Mbft)
 - MARMAP chevron traps, 1990-2010 (Mcvt)

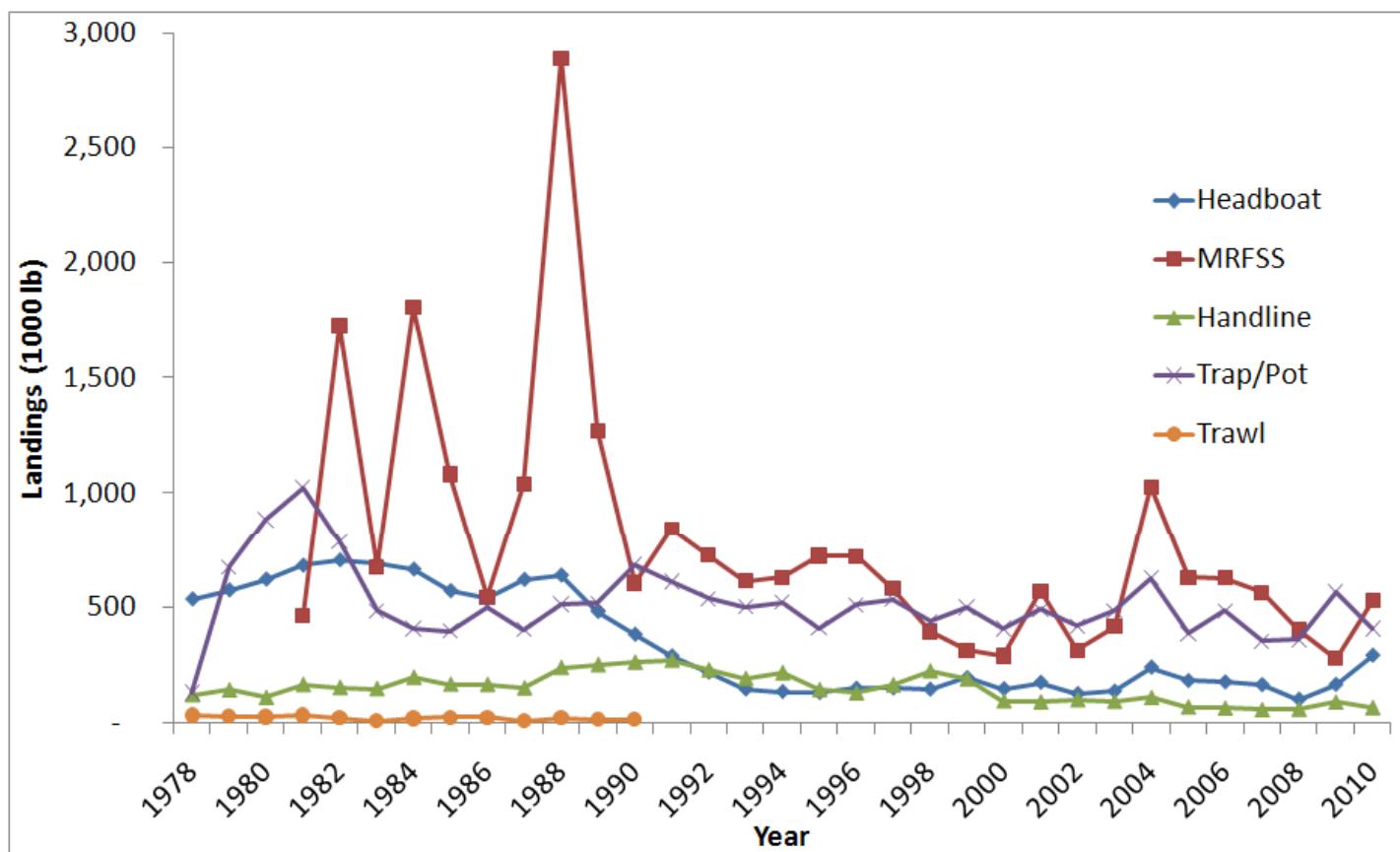


Summary of size limit regulations

Year	Recreational	Commercial
1984	8 inches	8 inches
1999	10 inches	10 inches
2007 (fishing yr)	12 inches	10 inches



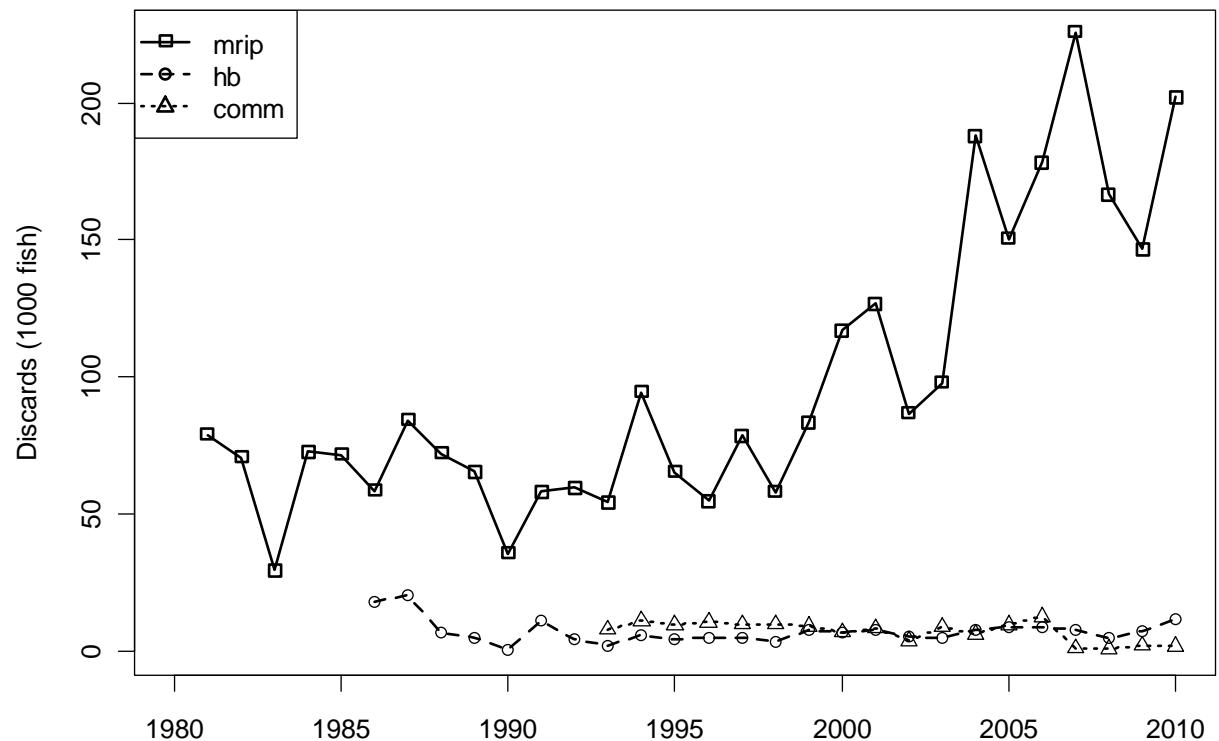
Landings



Discards mortality rate

Gear	Point estimate	Minimum	Maximum
Hook and Line	0.07	0.04	0.15
Trap (1 1/2" panel)	0.05	-	0.15
Trap (2" panel)	0.01	-	0.15

Discard mortalities



Sample sizes – recreational

Year	MRFSS				Headboat				Headboat At-sea discard	
	Length comps*		Age comps		Length comps		Age comps		Length Comps	
	N.fish	N.trip	N.fish	N.trip	N.fish	N.trip	N.fish	N.trip	N.fish	N.trip
1978					2353	330				
1979					1654	201				
1980					2418	276				
1981	194	97			3035	388				
1982	417	222			3686	439				
1983	174	113			5732	625				
1984	285	163			6086	694				
1985	488	222			5842	638				
1986	380	175			6549	682				
1987	668	387			6442	787				
1988	604	339			4253	545	7	3		
1989	605	445			3836	427	5	3		
1990	440	372			5772	481	25	11		
1991	334	220					85	43		
1992	655	492					60	31		
1993	494	345			3948	389	7	5		
1994	349	376			4215	350	5	2		
1995	363	281			3325	283	2	1		
1996	492	281			3212	285	27	12		
1997	306	301	8	1	3678	379	4	2		
1998	452	302	379	57	4364	462	75	9		
1999	706	315			4114	402				
2000	473	250			3419	333	1	1		
2001	775	452	9	4	2982	329				
2002	504	264	84	29	1957	304	23	15		
2003	998	413	77	21			105	31		
2004	1283	597	567	46			234	53		
2005	1039	395	139	36			480	104	2773	151
2006	1042	524	173	17			1,066	247	3913	133
2007	897	368	37	4			671	271	5408	152
2008	616	355	2	1			309	161	5038	153
2009	667	402	19	2			517	218	6388	136
2010	1125	542	29	4			1,029	341	11055	146



Sample sizes – commercial

Year	Pot/Trap				Handline			
	Length comps*		Age comps		Length comps		Age comps	
	N.fish	N.trip	N.fish	N.trip	N.fish	N.trip	N.fish	N.trip
1978								
1979								
1980								
1981								
1982								
1983	258	7			54	6	50	6
1984	757	9			1,528	66	2	66
1985	0	0			1,248	56	2	56
1986	0	0			695	45		
1987	694	5			804	50		
1988	1,080	12			814	52		
1989	265	3			695	30		
1990	770	9			1,140	43		
1991	470	7			812	46		
1992	477	5			404	26		
1993	115	2			398	32		
1994	250	3			570	41	77	41
1995	0	0			235	39		
1996	0	0			239	23		
1997	0	0			149	17	22	17
1998	319	1			184	20	29	20
1999	0	0			802	42		
2000	416	3			410	47		
2001	268	2			937	73		
2002	916	6			1,039	61	81	61
2003	1,238	7			394	53	443	53
2004	1,015	8	127	8	1,527	98	609	98
2005	670	16	423	16	1,339	116	836	116
2006	1,115	26	785	26	1,214	98	809	98
2007	1,958	47	2124	47	860	93	779	93
2008	1,945	79	2098	79	629	90	553	90
2009	2,218	89	2252	89	622	71	693	71
2010	1,883	74	1572	74	631	91	586	91

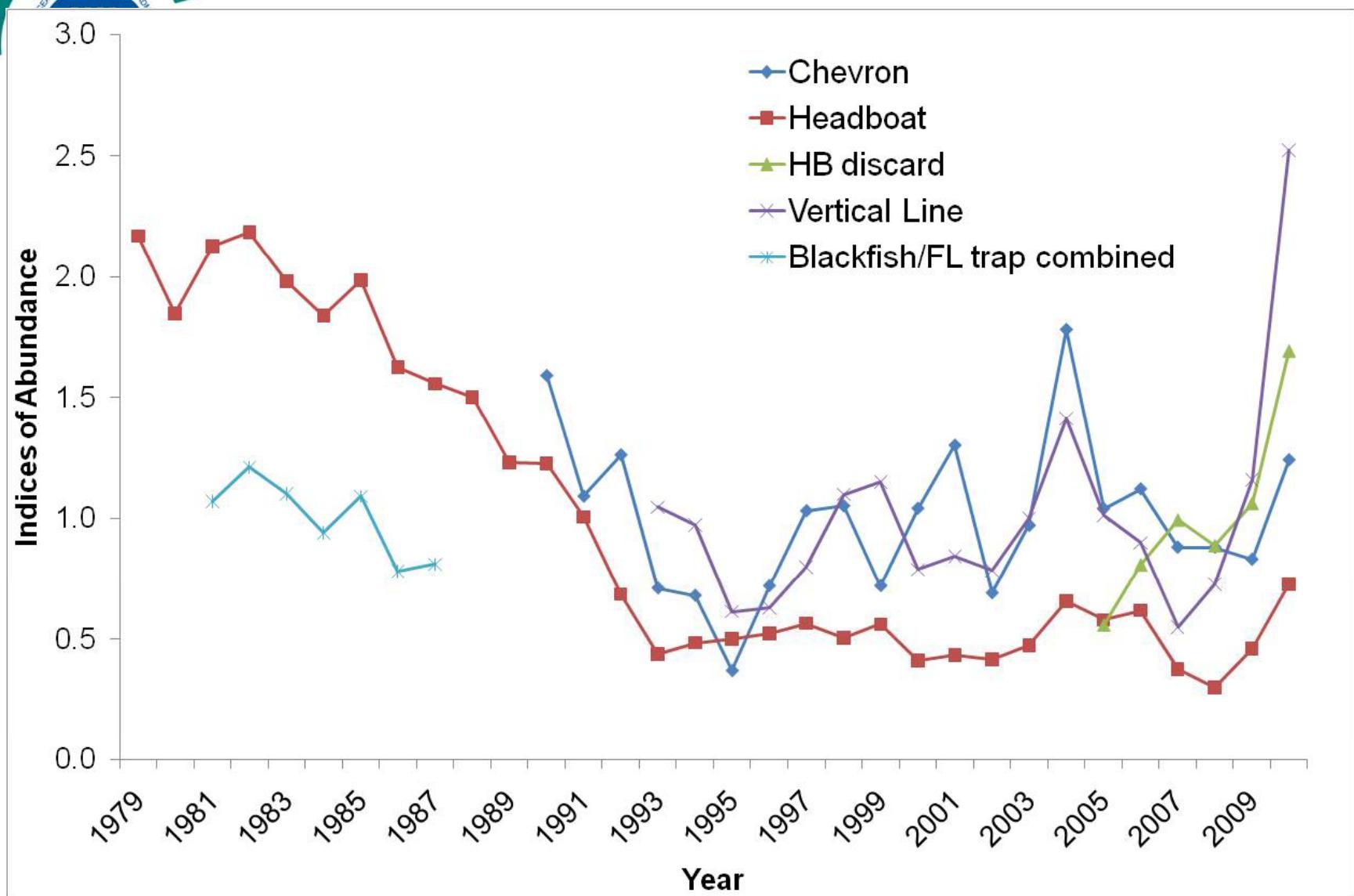
*due to low sample size by year, pooled 1984, 1988, 1990, 1991; weighted by sample size, used to estimate selectivity during 8" limit



Sample sizes - MARMAP

Year	MARMAP Chevron				MARMAP Blackfish/FL Trap combined			
	Length comps		Age comps		Length comps		Age comps	
	N.fish	N.trip	N.fish	N.trip	N.fish	N.trip	N.fish	N.trip
1978								
1979								
1980								
1981					4669	108	973	107
1982					4851	120	906	117
1983					5518	459	5486	453
1984					7946	62	1555	61
1985					5319	25	702	24
1986					3415	26	435	26
1987					2460	16	338	16
1988								
1989								
1990	6771	161	2136	159				
1991	4092	110	4050	107				
1992	4667	132	4585	130				
1993	3260	165	3240	163				
1994	3787	135	3710	135				
1995	3457	110	3423	109				
1996	3771	170	3656	167				
1997	4324	141	4257	139				
1998	4324	130	4225	128				
1999	4779	87	4623	86				
2000	4589	97	4550	97				
2001	4225	81	4001	79				
2002	2798	79	2721	78				
2003	1815	67	1660	64				
2004	5136	91	5041	91				
2005	6021	107	5636	106				
2006	4673	107	4466	105				
2007	3264	100	3174	99				
2008	3160	106	710	102				
2009	3871	127	740	124				
2010	5462	176	1385	176				

Indices





Index correlations

Table 24. Pearson correlation analysis (p-values for two-sided test of H0: correlation=0) for indices included in BAM base model input.

	MARMAP Chevron	Headboat	Headboat At-sea Discard	Commercial logbook vertical line	MARMAP Blackfish/FL trap combined
MARMAP Chevron	1	0.557 (0.0086)	0.418 (0.4089)	0.454 (0.0585)	
Headboat		1	0.397 (0.4353)	0.689 (0.002)	0.956 (0.0008)
Headboat At-sea Discard			1	0.824 (0.043)	
Commercial logbook vertical line				1	
MARMAP Blackfish/FL trap combined					1

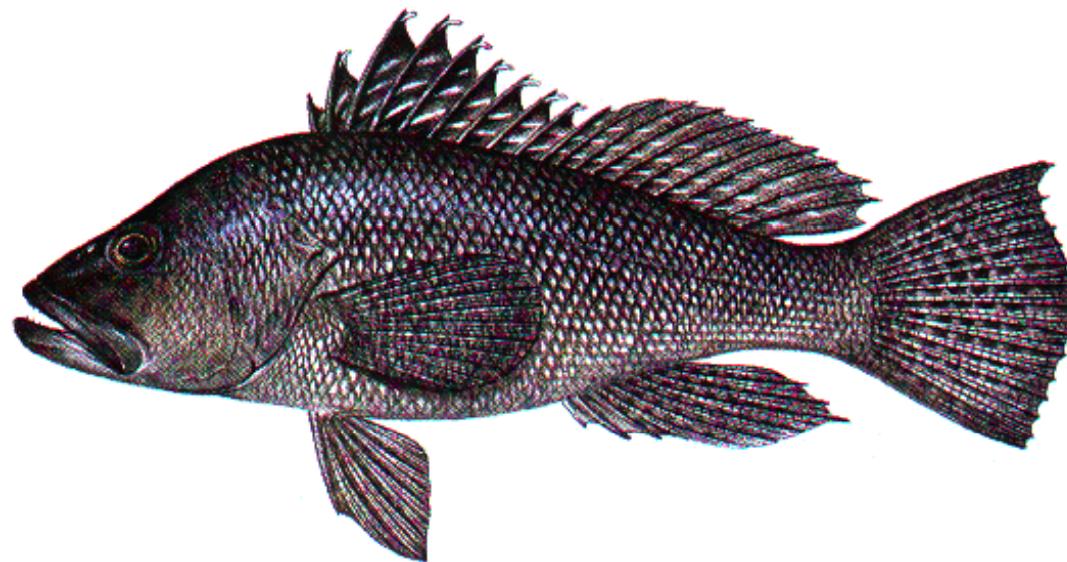
Table 25. Correlation of first differences (p-values for two-sided test of H0: correlation=0) for indices included in BAM base model input.

	MARMAP Chevron	Headboat	Headboat At-sea Discard	Commercial logbook vertical line	MARMAP Blackfish/FL trap combined
MARMAP Chevron	1	0.45 (0.04)	0.72 (0.17)	0.5 (0.036)	
Headboat		1	0.64 (0.24)	0.77 (0.00028)	0.96 (0.002)
Headboat At-sea Discard			1	0.68 (0.197)	
Commercial logbook vertical line				1	
MARMAP Blackfish/FL trap combined					1

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ASSESSMENT—black sea bass Beaufort assessment model (BAM)





BAM Configuration

- Assessment years: 1978–2010
- Modeled ages: 0–11+
- Fleets: commercial trawl, commercial lines, commercial pots, general recreational, headboat
- Discards: general recreational, headboat, commercial (lines and pots combined)
- Abundance Indices: commercial lines (FD), headboat landings (FD), headboat discards (FD), MARMAP blackfish/snapper traps (FI), MARMAP chevron traps (FI)
- Selectivity: logistic functions for landings and surveys, dome-shaped for discards. Constant within blocks of regulations.
- Fishing mortality: annual estimates (free parameters) for each fleet. In yrs with no data on landings or discards, average F applied to predict the unobserved
- Spawner-recruit: Beverton-Holt curve with lognormal recruitment deviations; spawning potential based on population fecundity
- Length-age: conversion matrix based on normally distributed lengths at age



BAM Estimated Parameters

- S-R parameters (3): steepness, R₀, sigma-R
- Annual R devs (33): 1978-2010
- Initialization (12): Abundance at age 1-11+; F_{init.ratio}
- Selectivity (23): 20 slopes and A50s for fleets and surveys; 3 for ages 0-2 of discard selectivity
- Catchability (5): q for each abundance index
- Fishing mortality (223): average F + annual deviations for each fleet (landings and discards)
- Length-at-age (1): CV of length-at-age conversion matrix



BAM Likelihood Components

- Landings and discards: Lognormal with assumed CV=0.05
- Indices: Lognormal with annual CVs provided by data workshop; headboat CVs were inflated
- Age Compositions: Multinomial with annual n = number of sampled trips
- Length Compositions: Multinomial with annual n = number of sampled trips
- Recruitment deviations: Lognormal with estimated sigma-R parameter
- Prior penalties:
 - CV of length-at-age: normal with mean and CV from empirical estimates
 - sigma-R: normal with mean and CV from published meta-analysis
 - steepness: beta with mean and CV from published meta-analysis
 - selectivity parameters: normal with mean and CV = 1.0 set to be loose

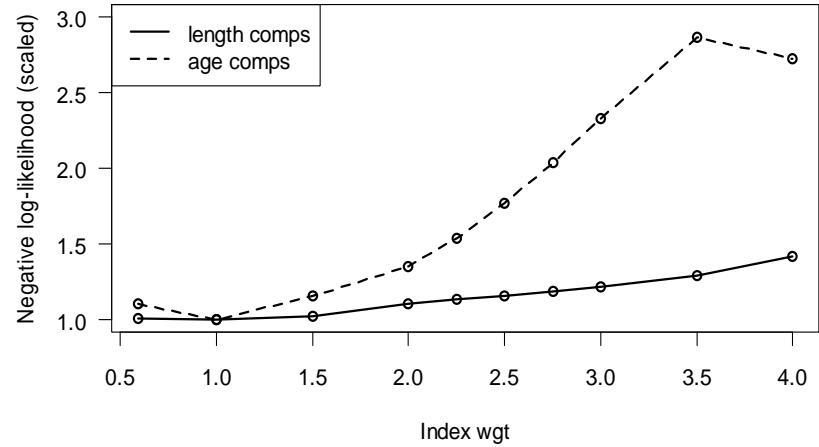
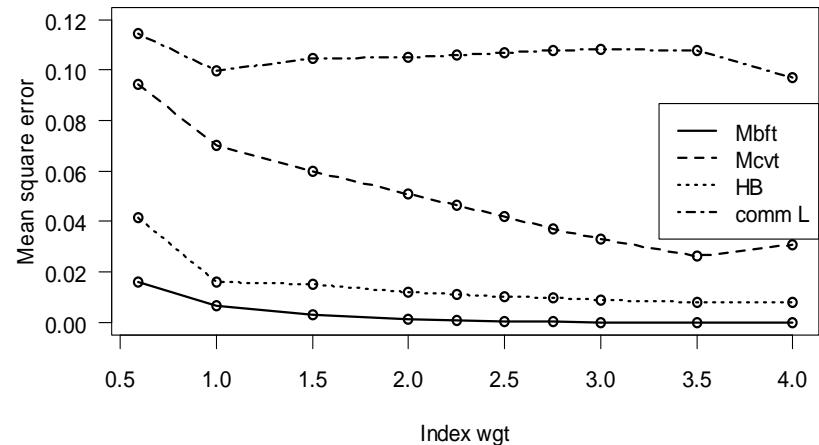


BAM Iterative Re-weighting

Run	Source	SDNR								Weights								Cumulative weights (for next iteration)										
		MARMAP		Headboat		MRIP		Comm. L		MARMAP		Headboat		MRIP		Comm. L		MARMAP		Headboat		MRIP		Comm. L				
		Mbf t	Mcvt	L	D	L	lines	pots	Mbf t	Mcvt	L	D	L	lines	pots	Mbf t	Mcvt	L	D	L	lines	pots	Mbf t	Mcvt	L	lines	pots	
1	CPUE	2.63	3.19	1.93	2.41	-	1.46	-	0.38	0.31	0.52	0.41	-	0.68	-	0.38	0.31	0.52	0.41	-	0.68	-	0.52	0.41	-	0.68	-	
	Length comp	1.95	-	4.32	2.19	5.24	1.67	-	0.26	-	0.05	0.21	0.04	0.36	-	0.26	-	0.05	0.21	0.04	0.36	-	0.05	0.21	0.04	0.36	-	
	Age comp	-	3.38	3.63	-	2.35	1.30	2.60	-	0.09	0.08	-	0.18	0.59	0.15	-	0.09	0.08	-	0.18	0.59	0.15	-	0.08	-	0.18	0.59	0.15
2	CPUE	0.80	1.00	0.86	1.06	-	0.87	-	1.25	1.00	1.16	0.94	-	1.15	-	0.48	0.31	0.60	0.39	-	0.79	-	0.60	0.39	-	0.79	-	
	Length comp	0.95	-	1.12	1.11	1.26	1.06	-	1.11	-	0.80	0.81	0.63	0.89	-	0.29	-	0.04	0.17	0.02	0.32	-	0.04	0.17	0.02	0.32	-	
	Age comp	-	0.73	0.82	-	0.66	0.95	1.05	-	1.88	1.49	-	2.30	1.11	0.91	-	0.16	0.11	-	0.42	0.66	0.13	-	0.11	-	0.42	0.66	0.13
3	CPUE	0.97	0.99	0.90	1.01	-	0.95	-	1.03	1.01	1.11	0.99	-	1.05	-	0.49	0.32	0.67	0.39	-	0.83	-	0.67	0.39	-	0.83	-	
	Length comp	1.06	-	1.04	0.99	0.99	1.07	-	0.89	-	0.92	1.02	1.02	0.87	-	0.26	-	0.04	0.17	0.02	0.28	-	0.04	0.17	0.02	0.28	-	
	Age comp	-	0.89	0.82	-	0.75	0.96	0.96	-	1.26	1.49	-	1.78	1.09	1.09	-	0.21	0.17	-	0.74	0.71	0.15	-	0.17	-	0.74	0.71	0.15
4	CPUE	1.00	1.02	0.96	1.02	-	0.99	-	1.00	0.98	1.04	0.98	-	1.01	-	0.49	0.31	0.70	0.38	-	0.84	-	0.70	0.38	-	0.84	-	
	Length comp	1.09	-	1.08	0.98	1.03	0.99	-	0.84	-	0.86	1.04	0.94	1.02	-	0.22	-	0.03	0.18	0.02	0.28	-	0.03	0.18	0.02	0.28	-	
	Age comp	-	0.99	0.99	-	0.89	0.99	1.01	-	1.02	1.02	-	1.26	1.02	0.98	-	0.21	0.17	-	0.93	0.73	0.14	-	0.17	-	0.93	0.73	0.14
5	CPUE	0.99	0.99	0.97	1.00	-	1.00	-																				
	Length comp	1.06	-	0.99	0.99	1.06	1.05	-																				
	Age comp	-	0.98	0.97	-	0.96	1.00	0.98																				

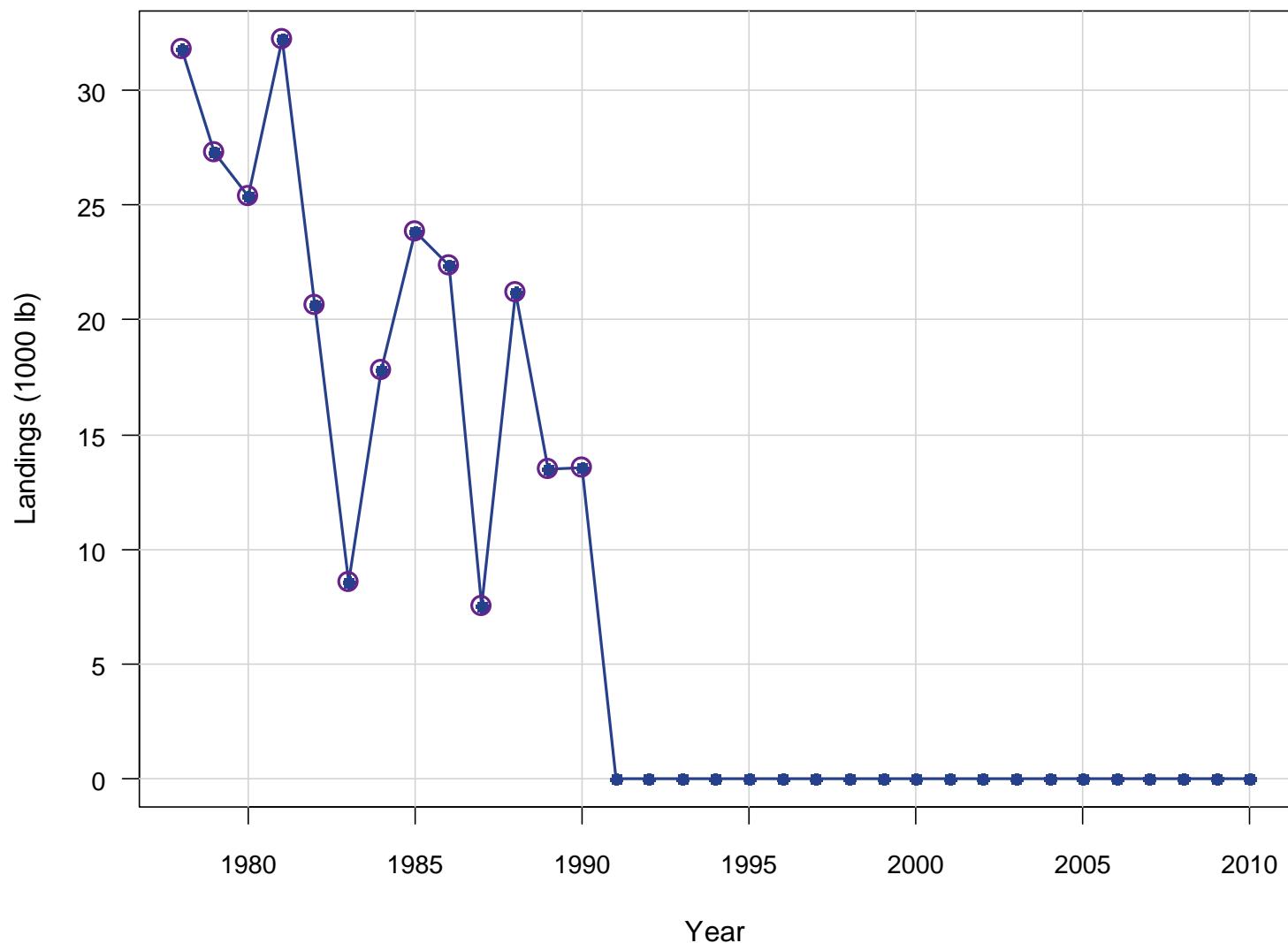
After iterative reweighting

- Problems:
 - sigma-R hit lower bound
 - MARMAP cvt index not fitted well
 - Residual patterns in headboat index
- AW addressed these problems by increasing the likelihood component weights on indices (excluding headboat discard index)
- AW chose a weight of 2.5 for the base run



Fishery: L.ct Data: spp

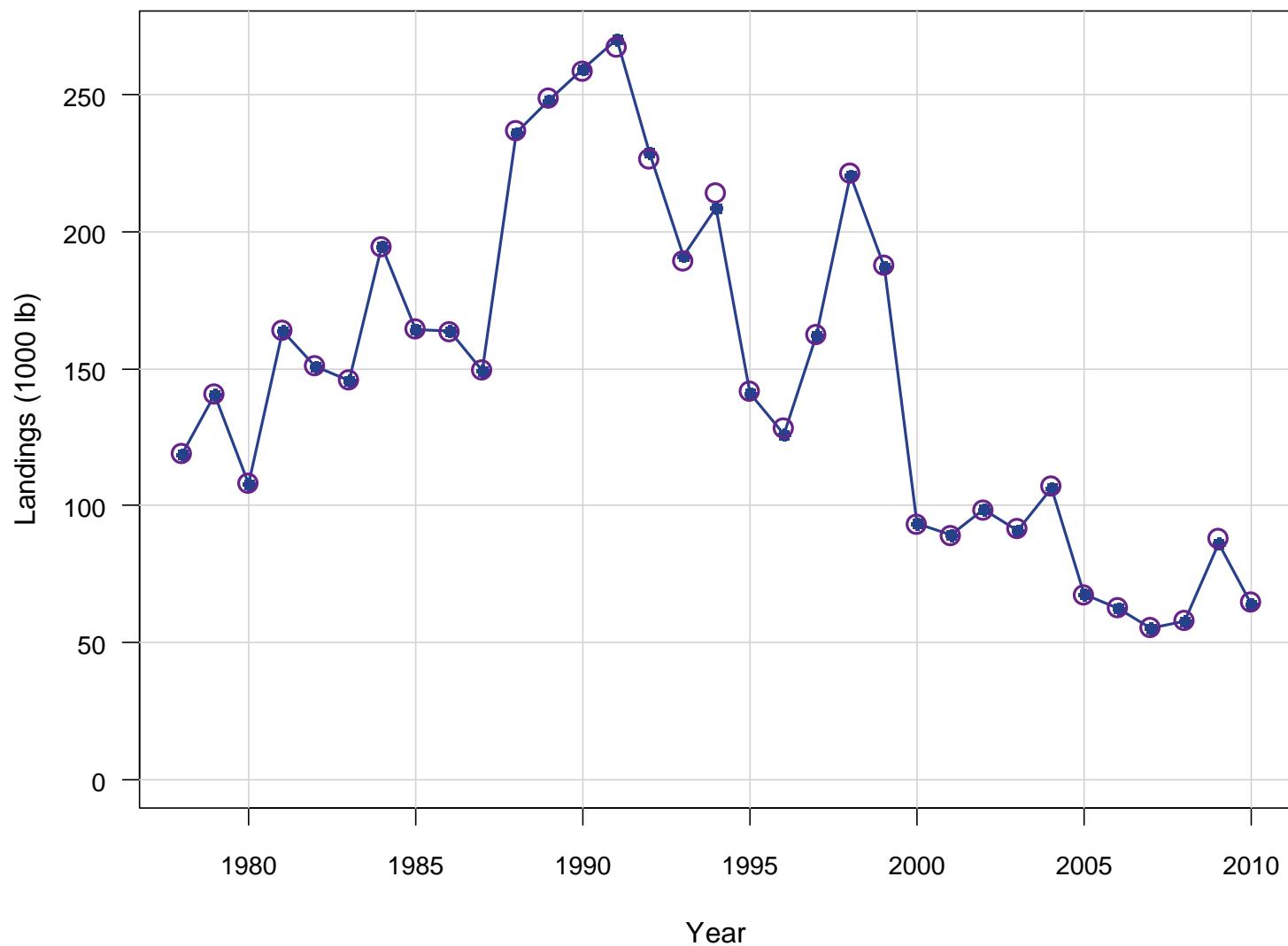
BAM
Base Run Fit



Fishery: L.cl

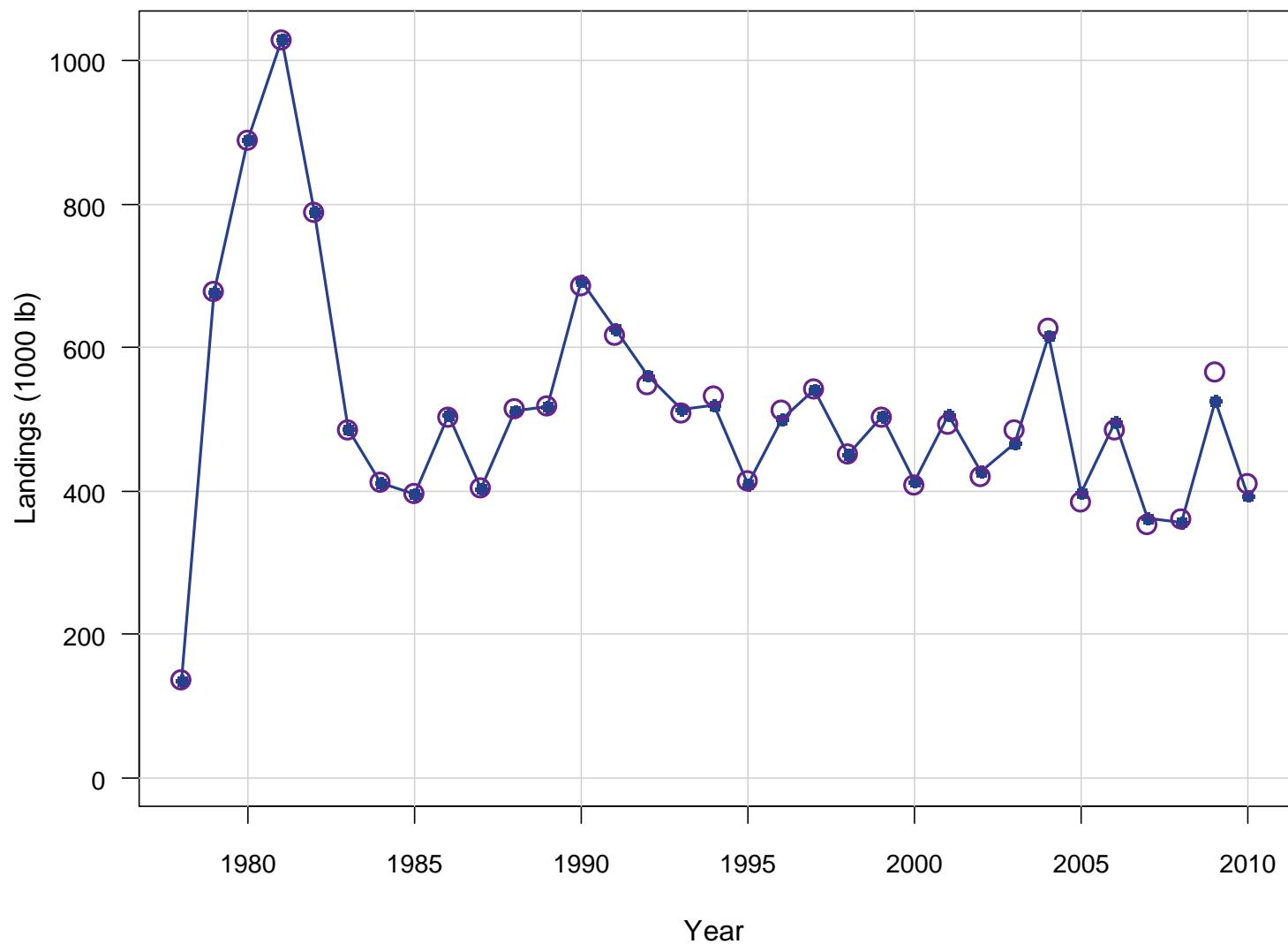
Data: spp

BAM
Base Run Fit



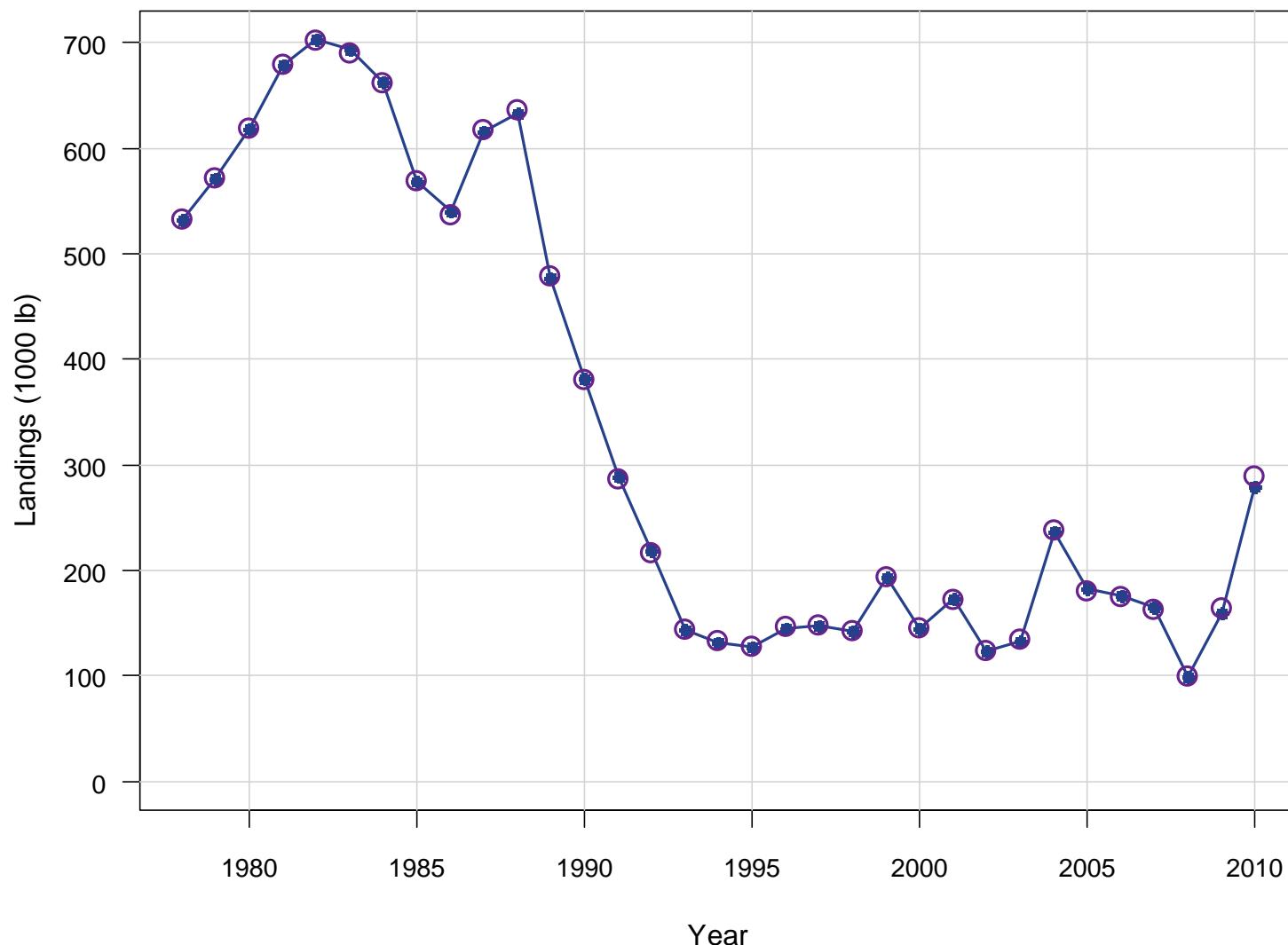
Fishery: L.cp Data: spp

BAM
Base Run Fit



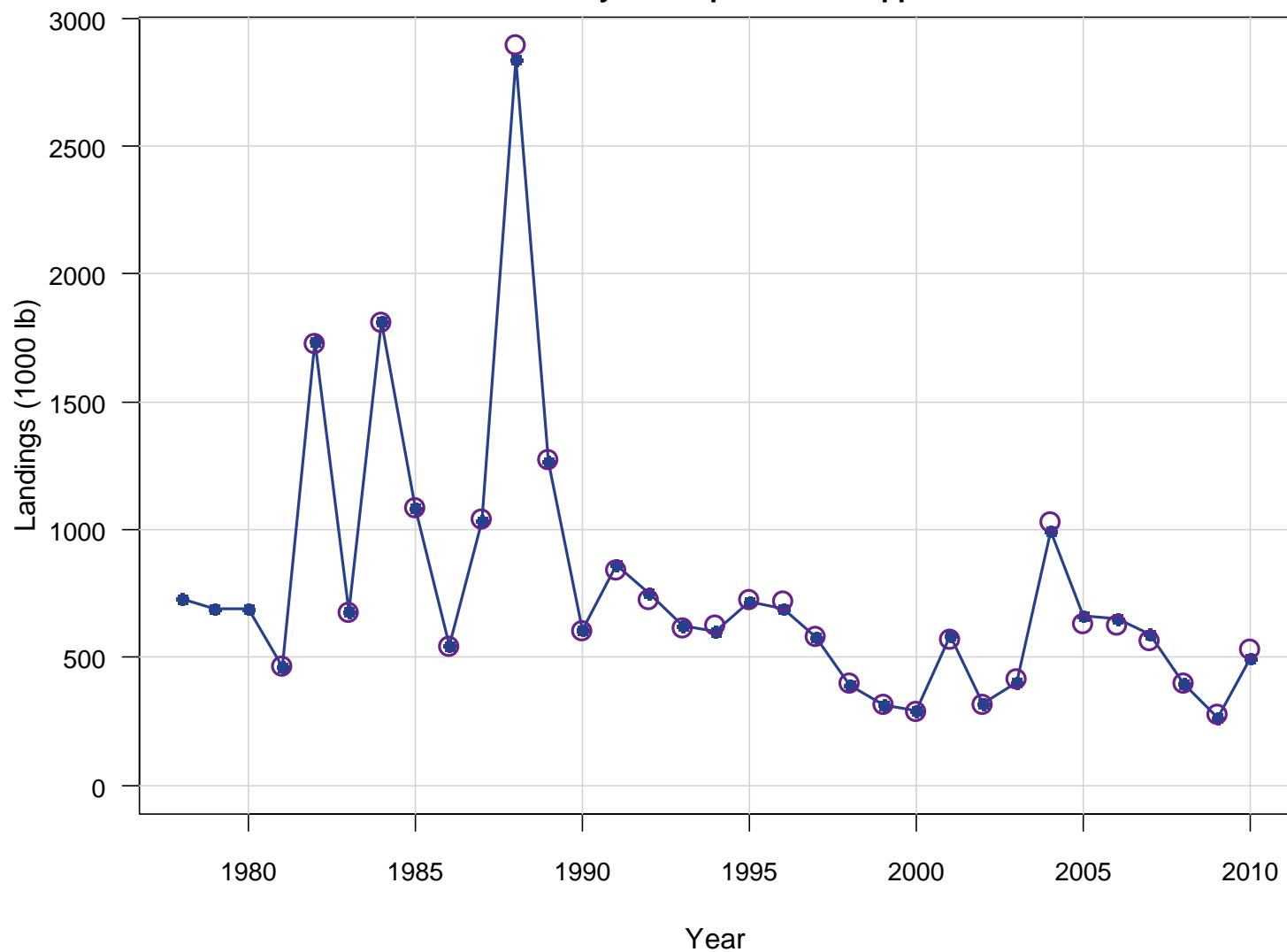
Fishery: L.hb Data: spp

BAM
Base Run Fit



Fishery: L.mrip Data: spp

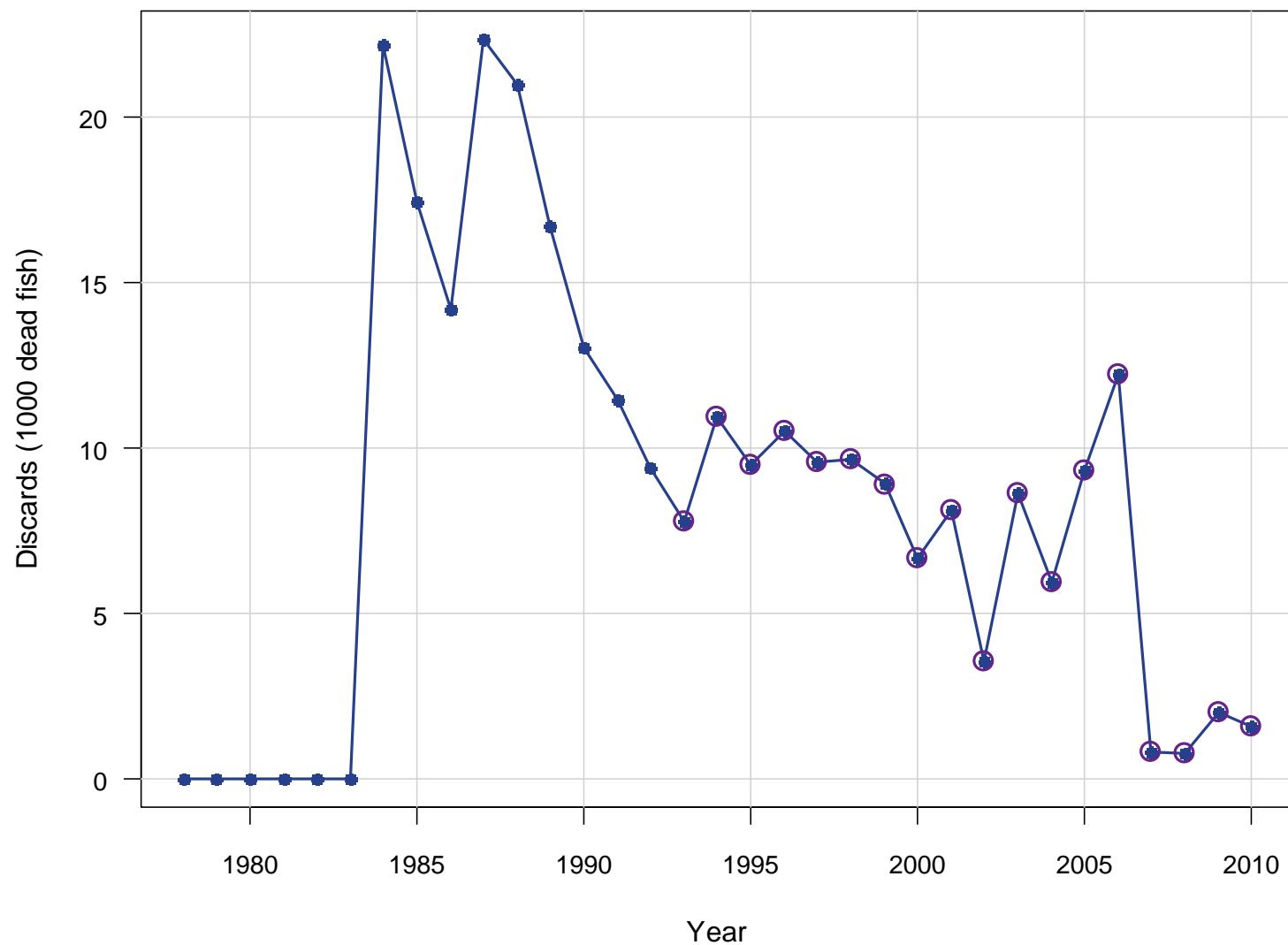
BAM
Base Run Fit



Fishery: D.comm

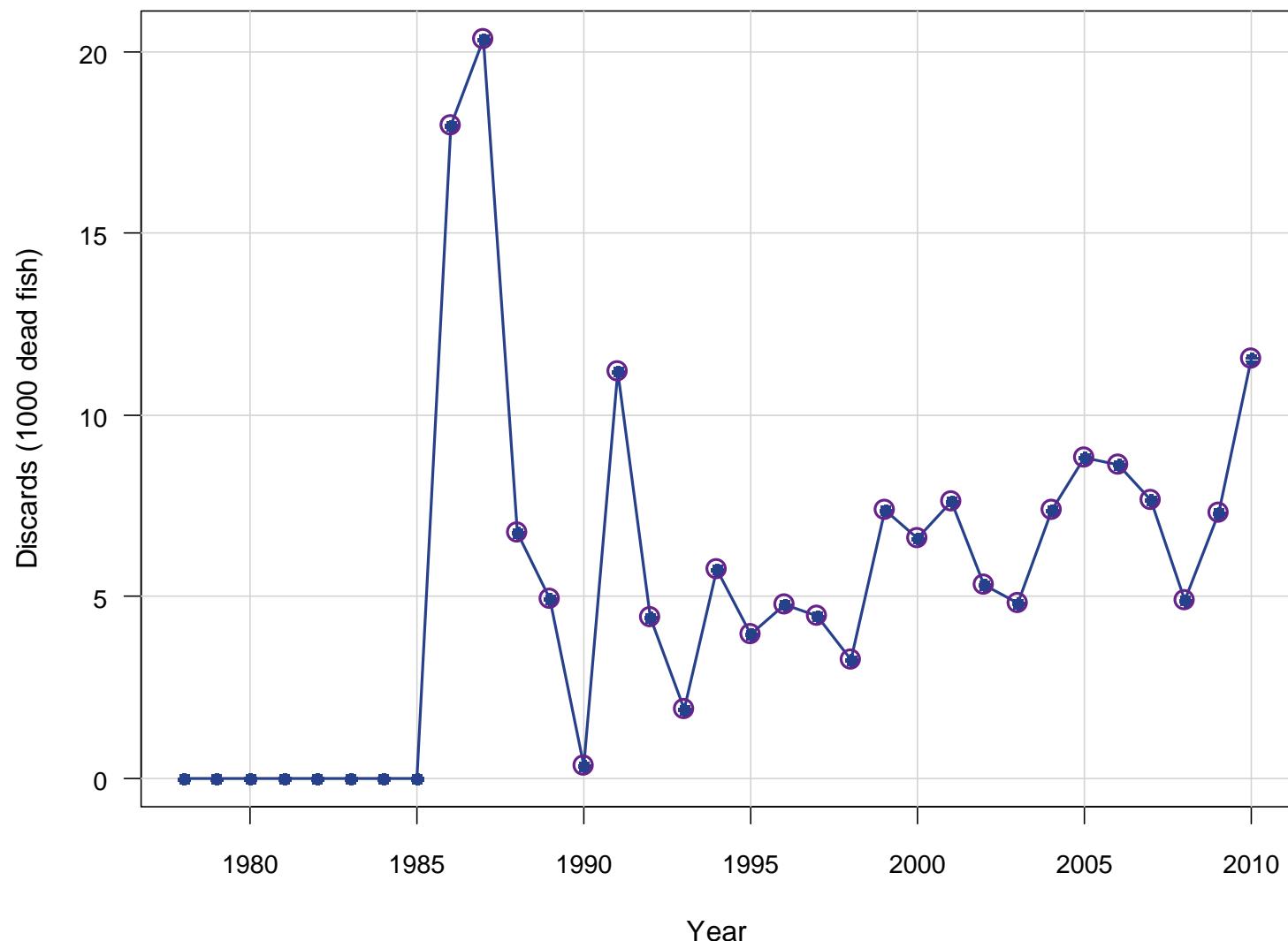
Data: spp

BAM
Base Run Fit



Fishery: D.hb Data: spp

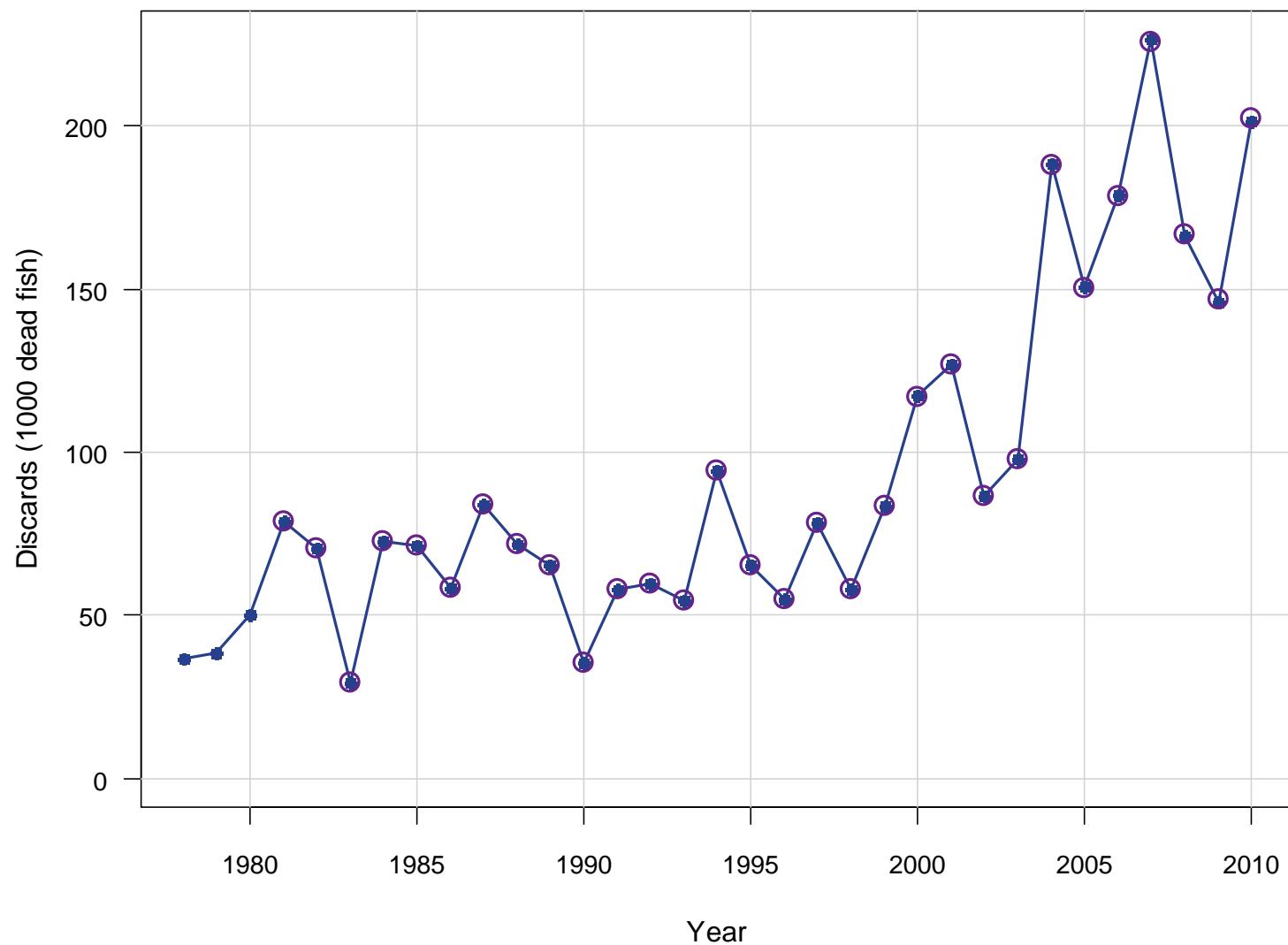
BAM
Base Run Fit



Fishery: D.mrip

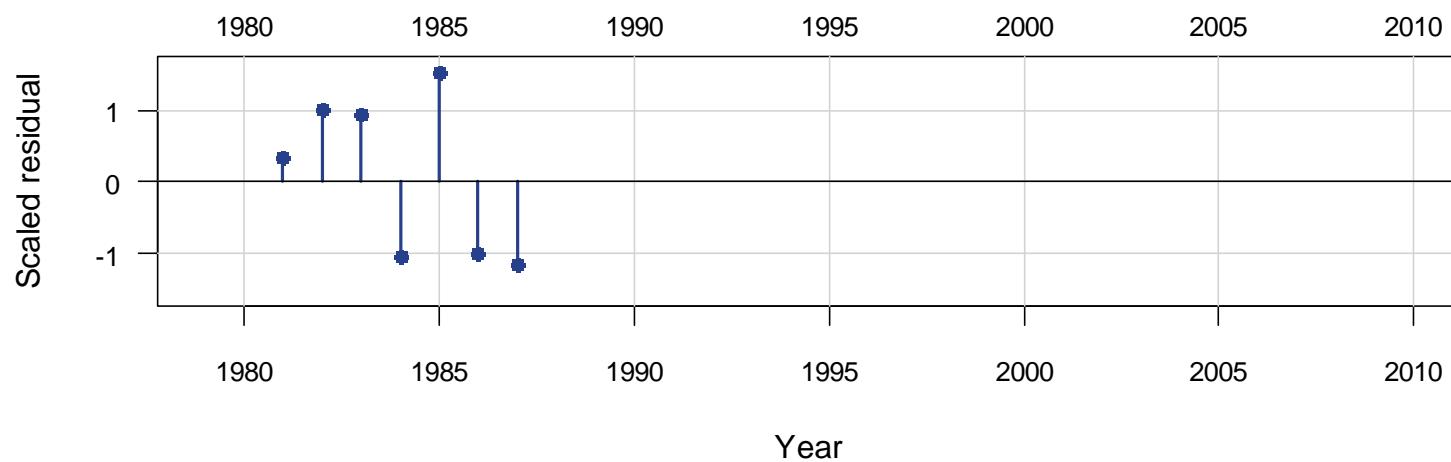
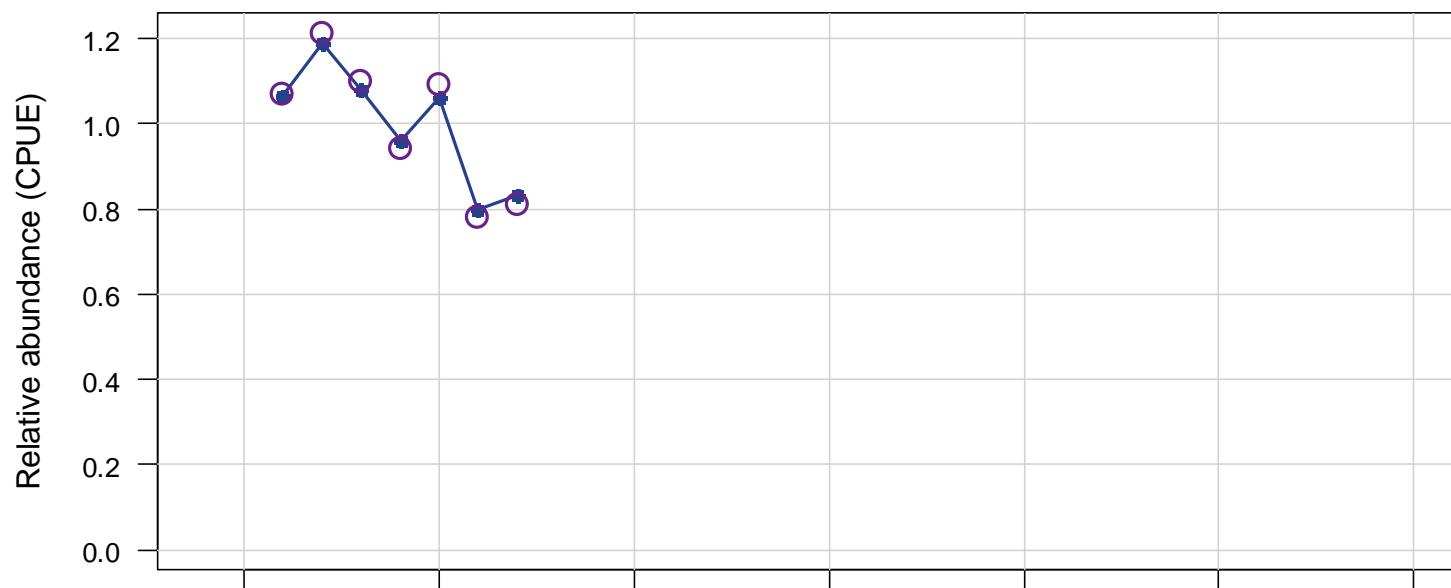
Data: spp

BAM
Base Run Fit



Index: Mbft Data: spp

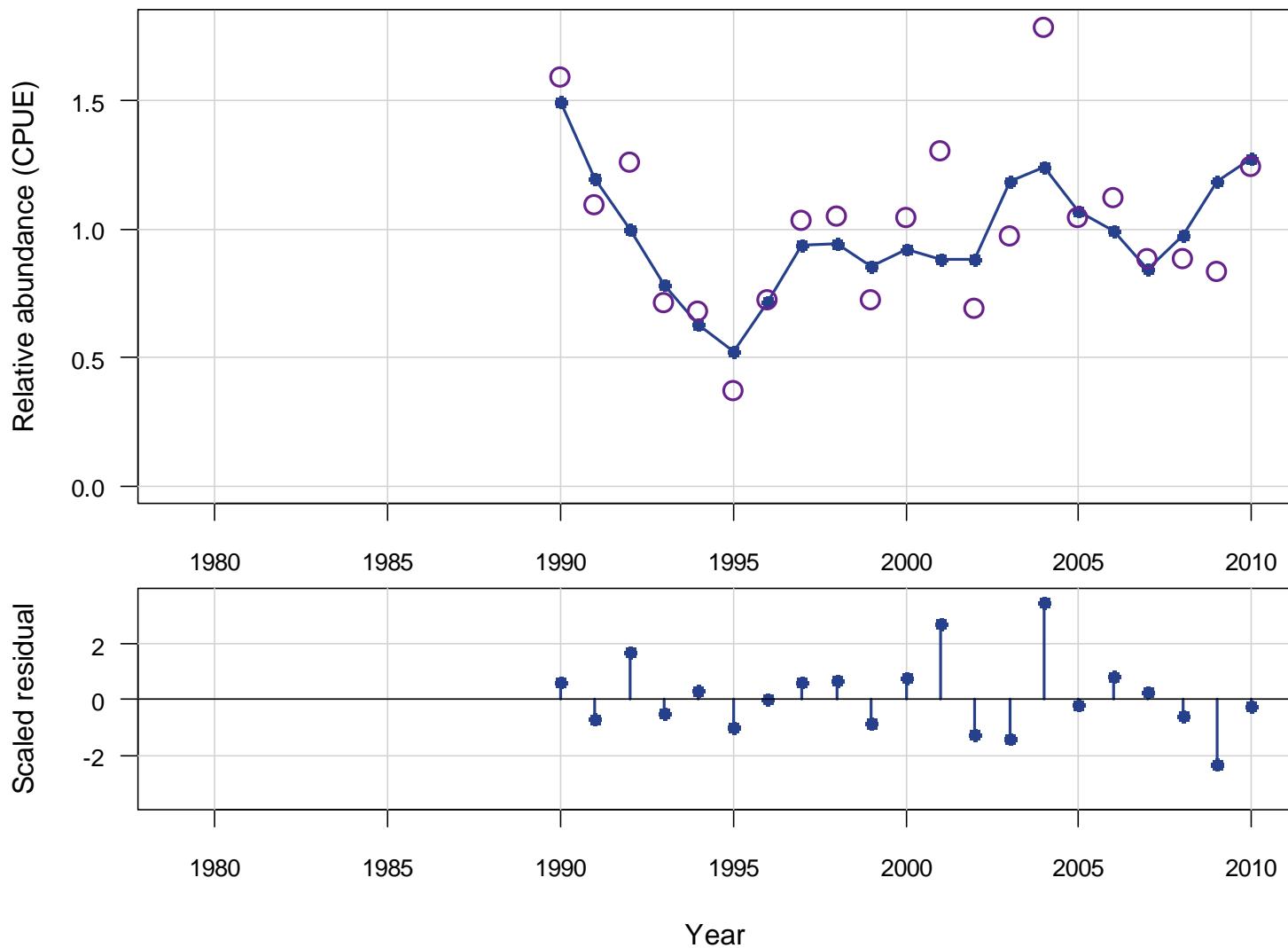
BAM
Base Run Fit



Index: Mcvt

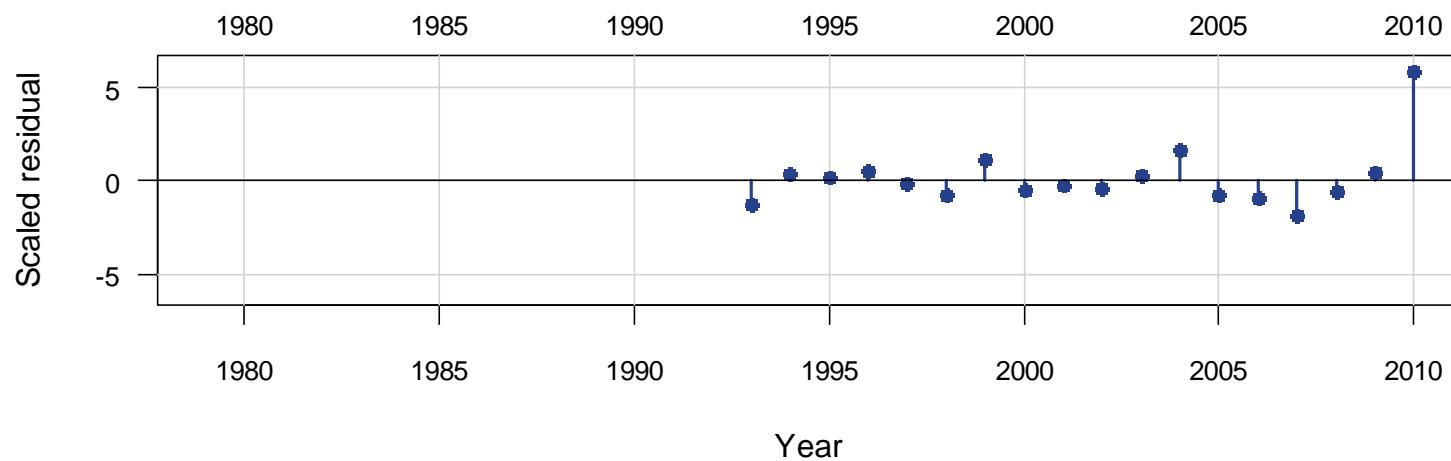
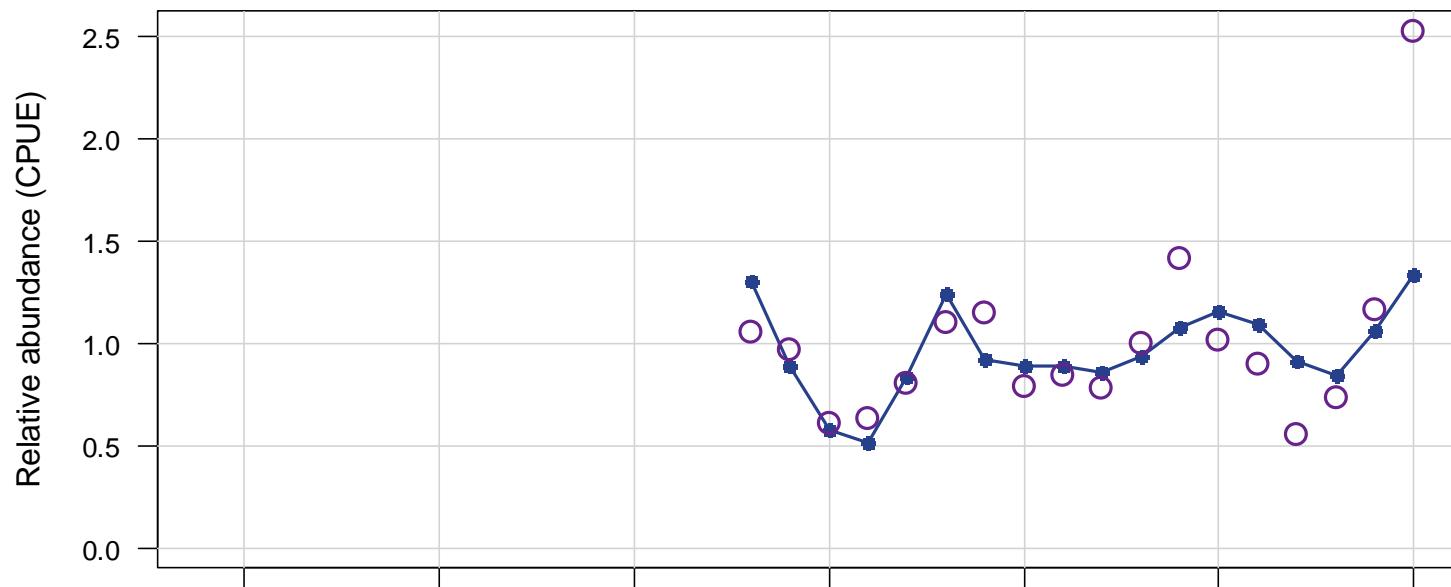
Data: spp

BAM
Base Run Fit



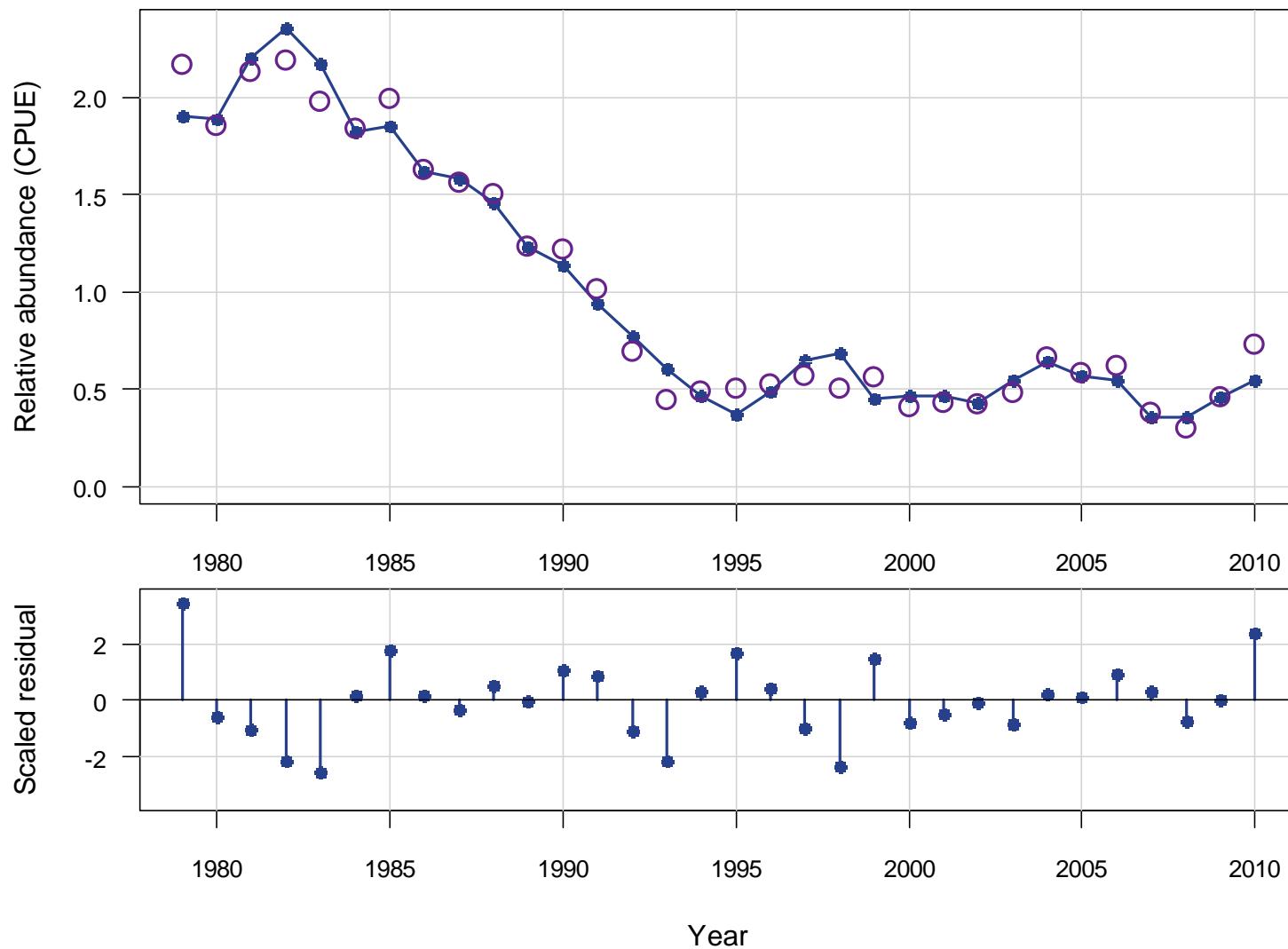
Index: cl Data: spp

BAM
Base Run Fit



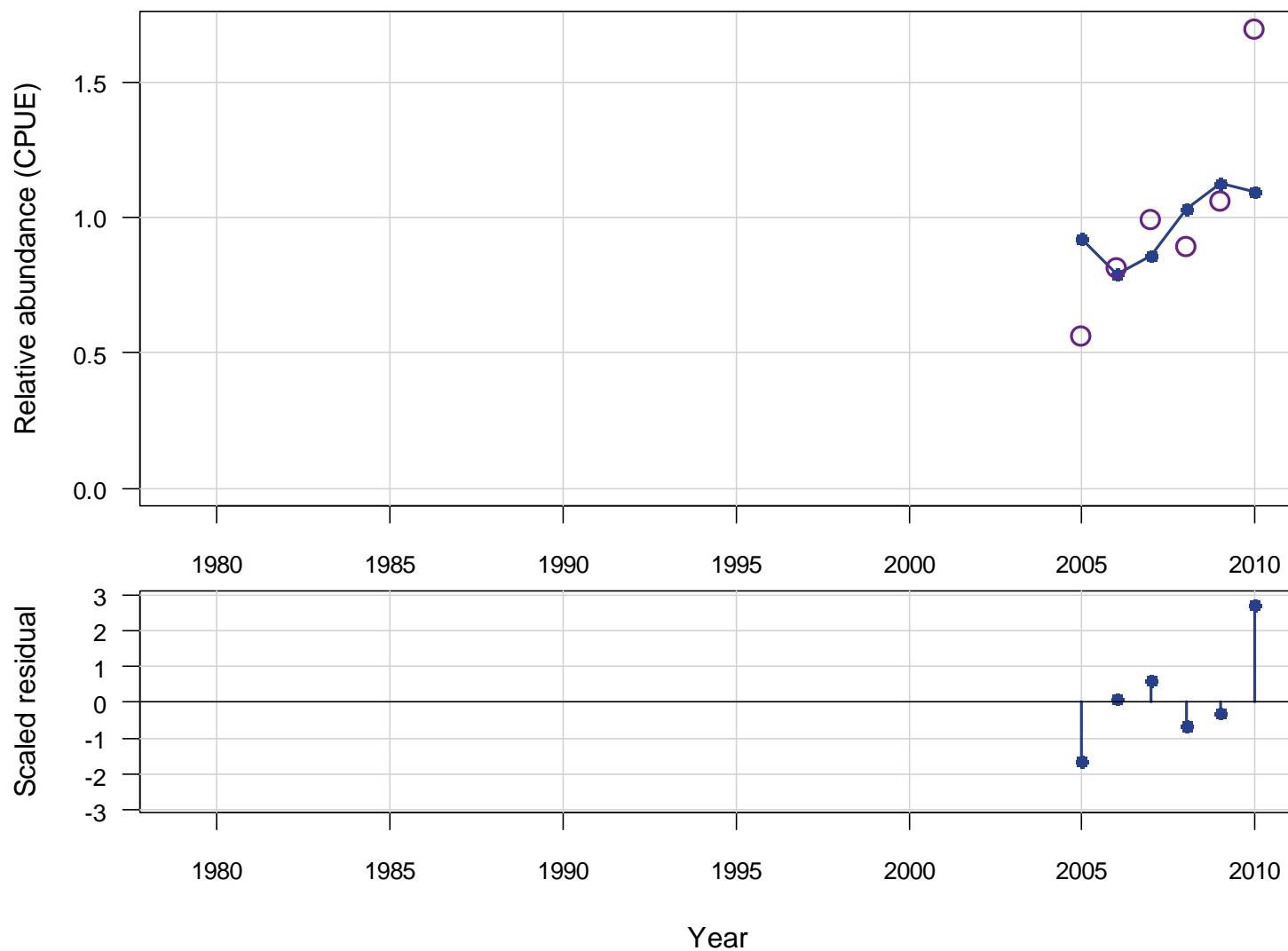
Index: hb Data: spp

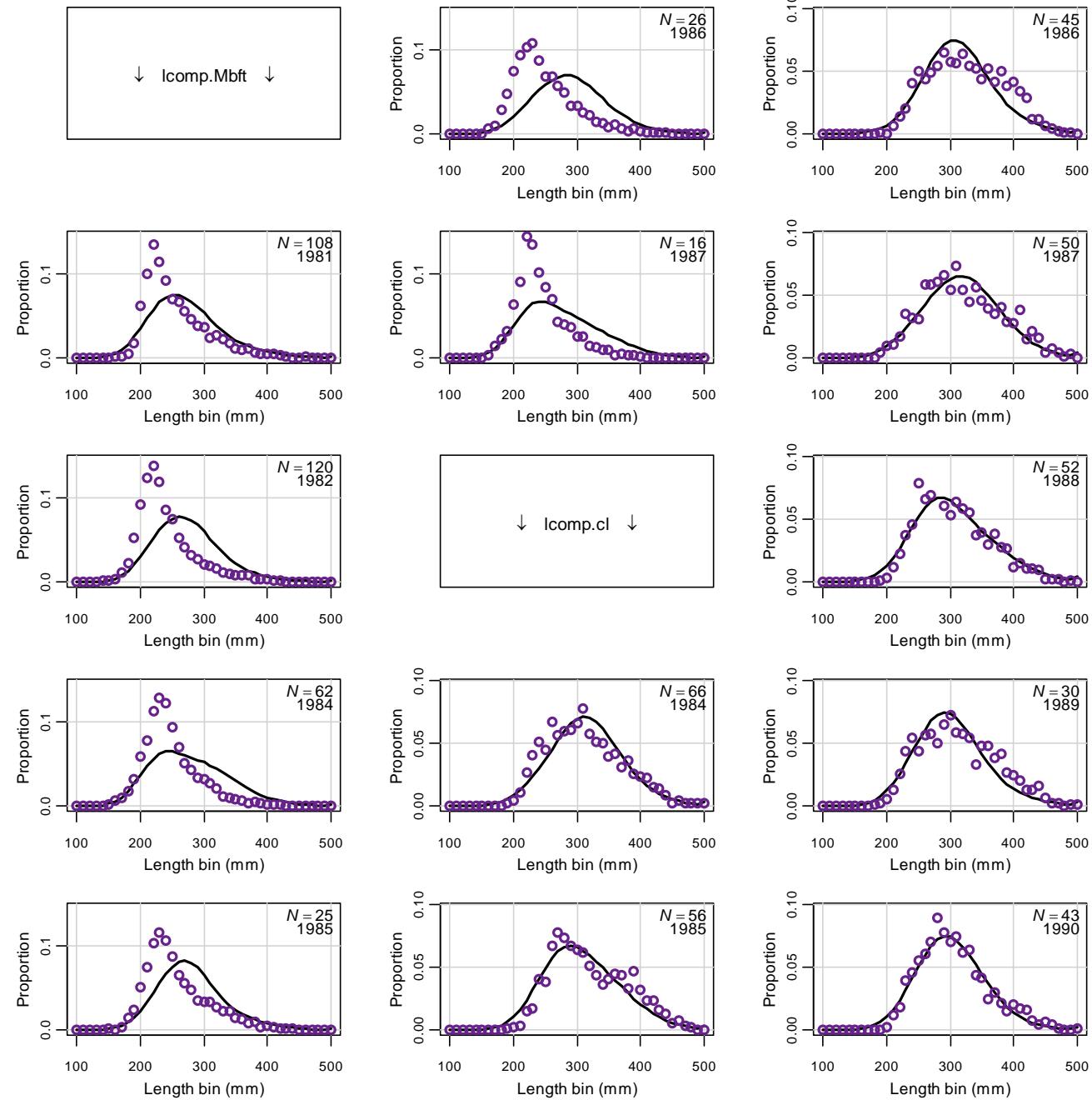
BAM
Base Run Fit



Index: hbd Data: spp

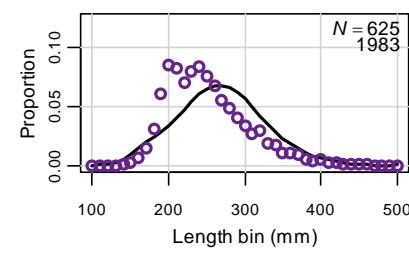
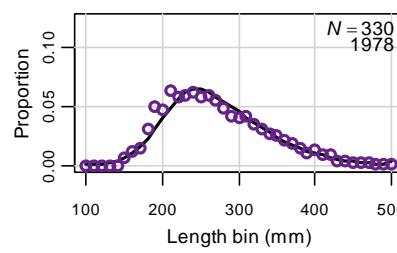
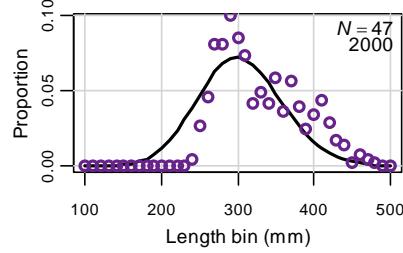
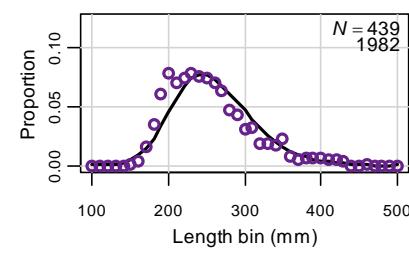
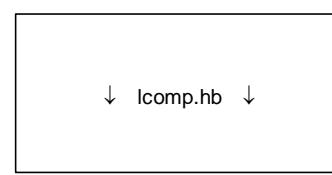
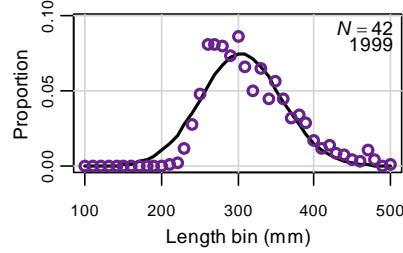
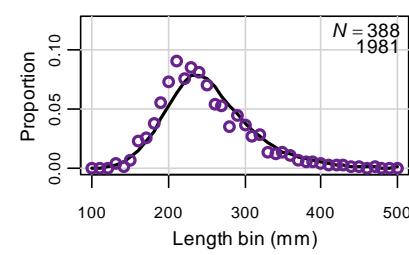
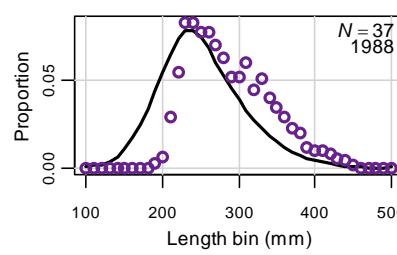
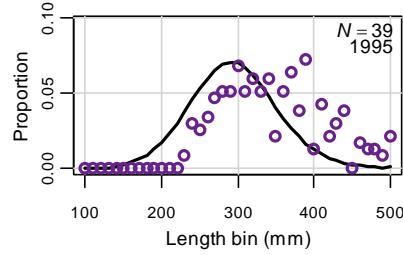
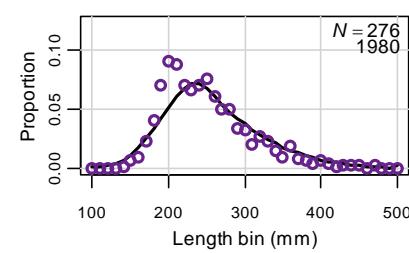
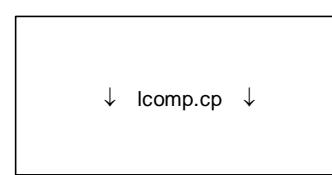
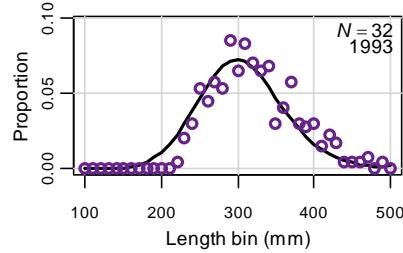
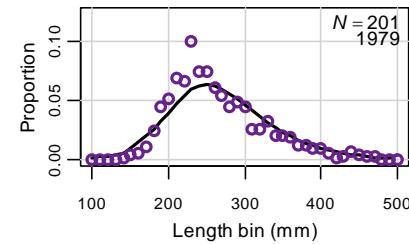
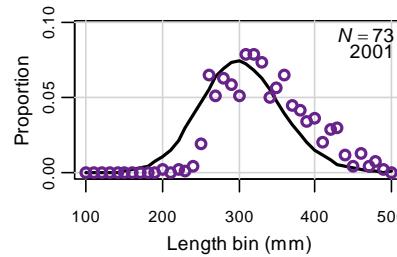
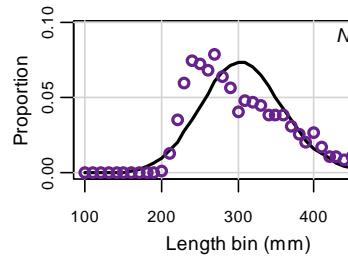
BAM
Base Run Fit



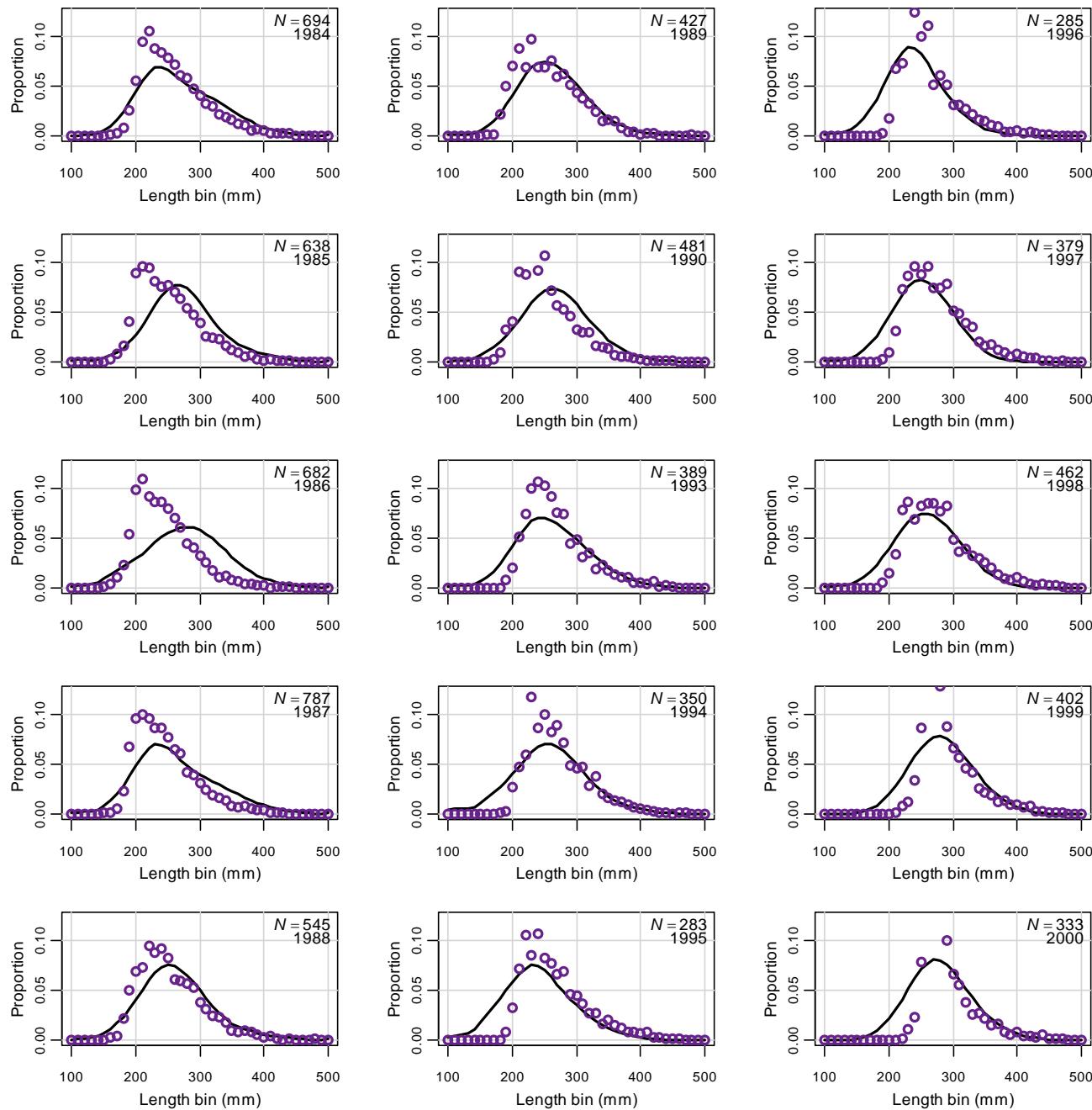


BAM
Base Run Fit

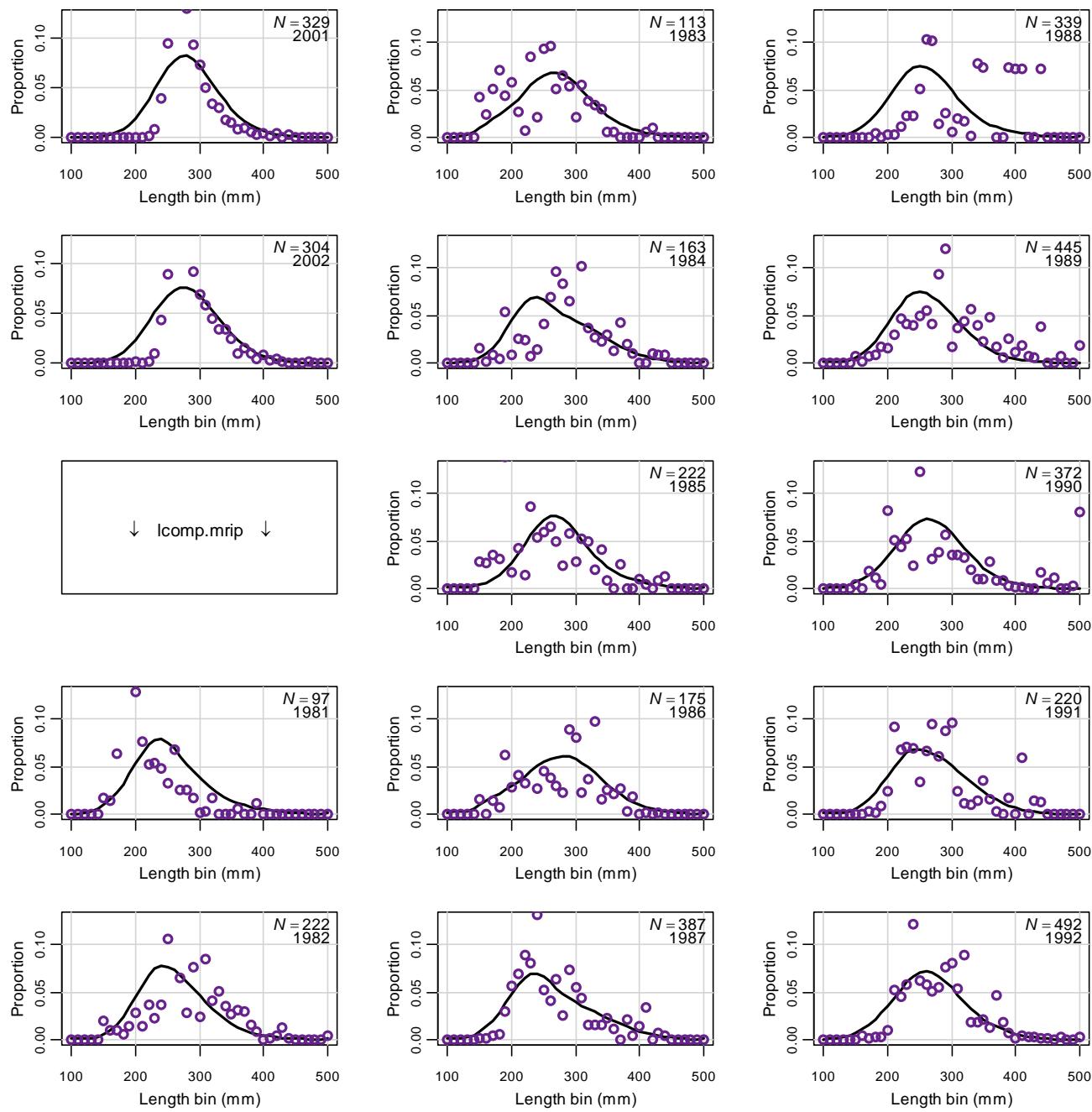
BAM
Base Run Fit



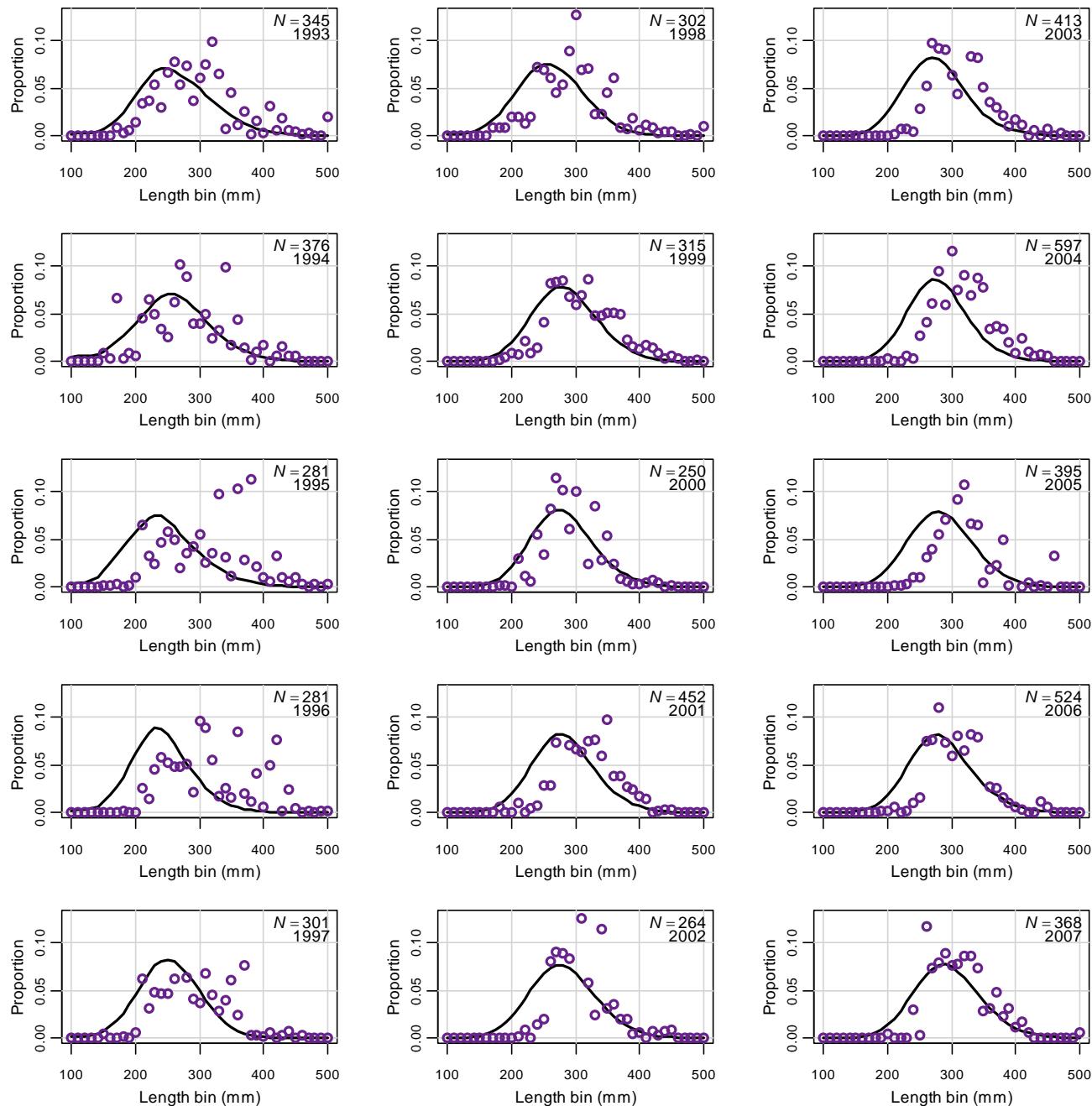
BAM
Base Run Fit



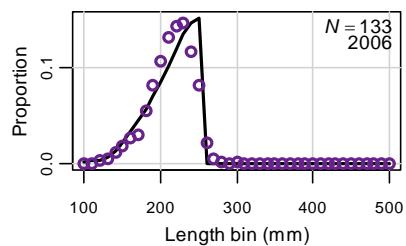
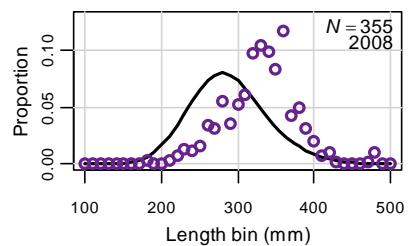
BAM
Base Run Fit



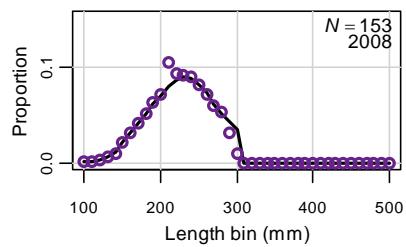
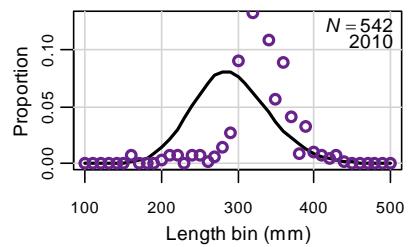
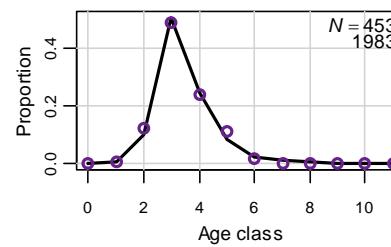
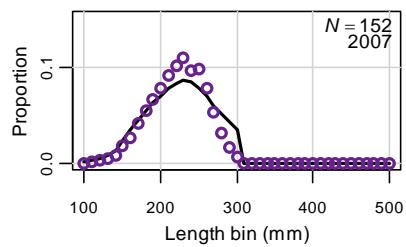
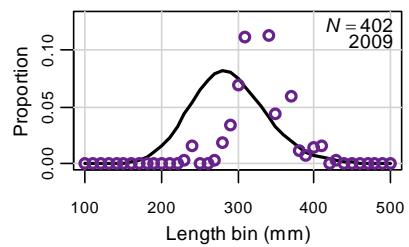
BAM
Base Run Fit



BAM
Base Run Fit

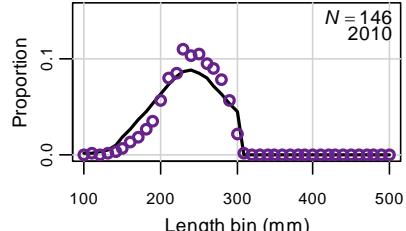
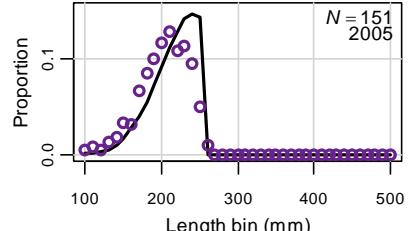
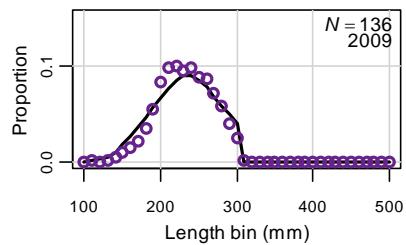
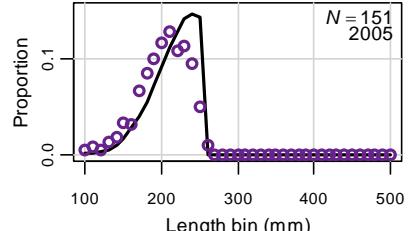


↓ acomp.Mbft ↓

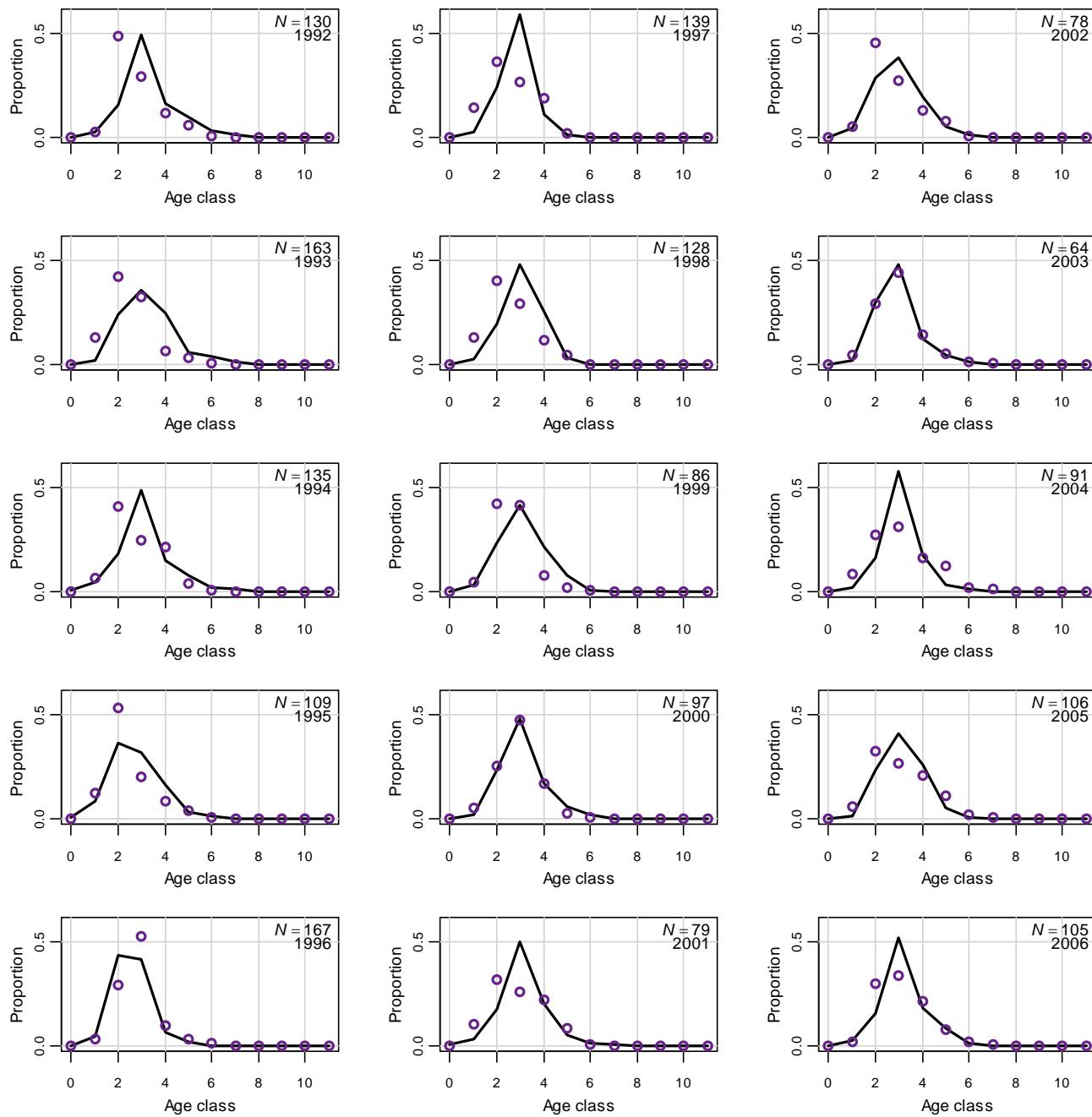


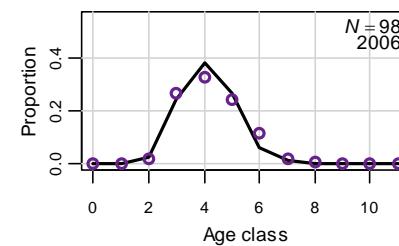
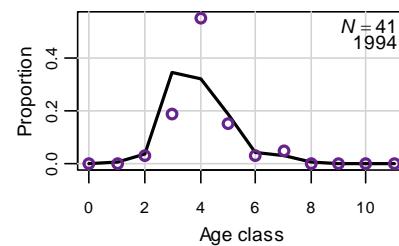
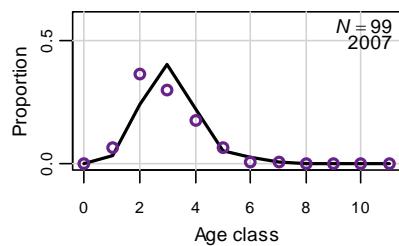
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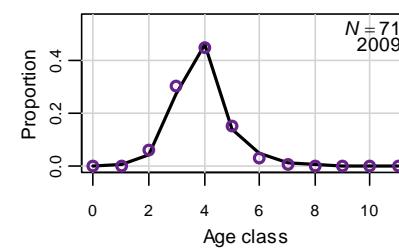
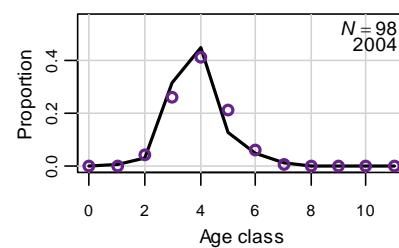
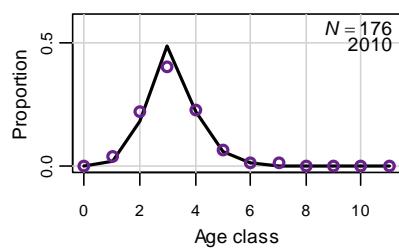
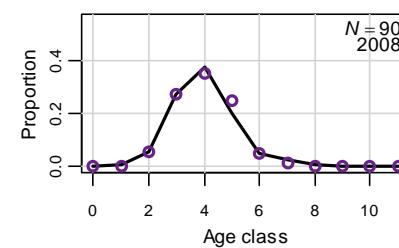
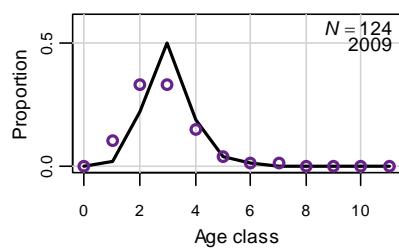
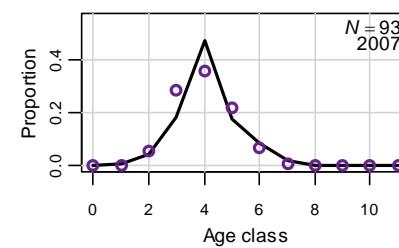
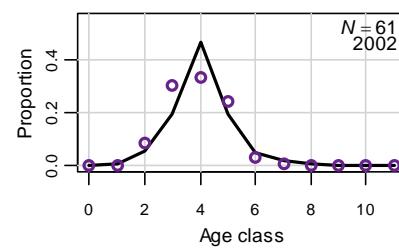
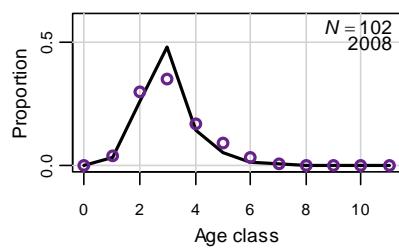
BAM
Base Run Fit



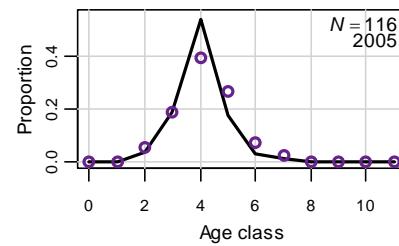


BAM

Base Run Fit

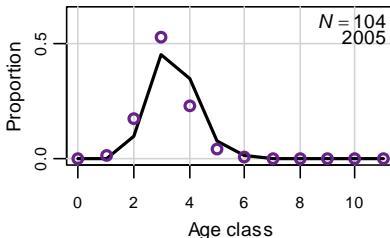


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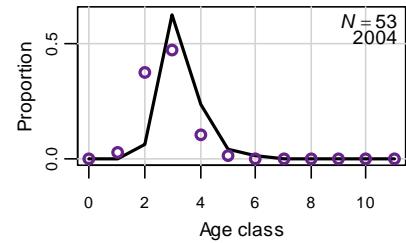
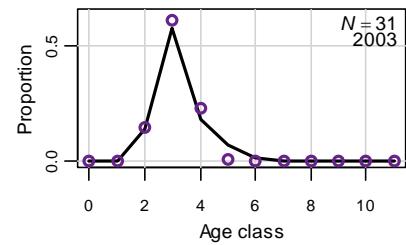
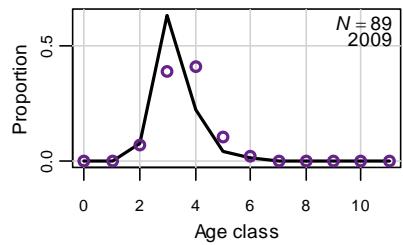
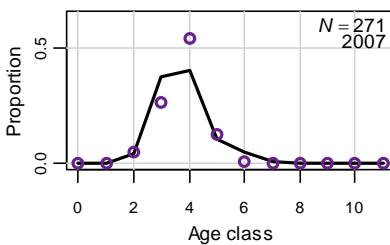
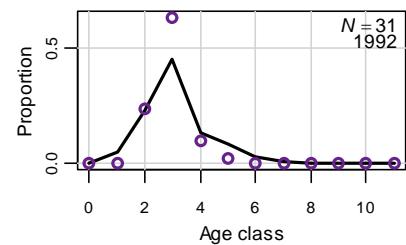
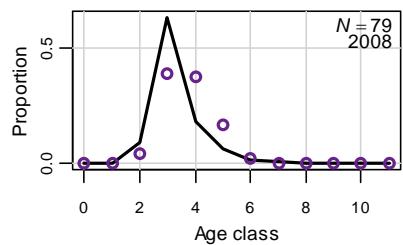
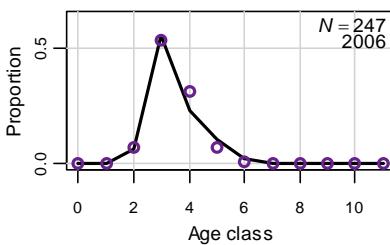
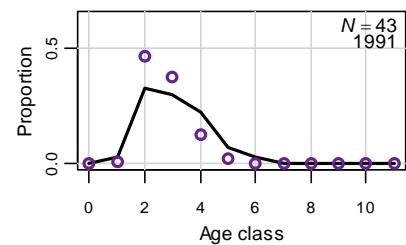
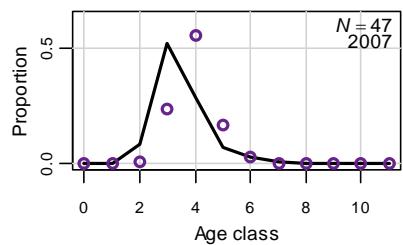
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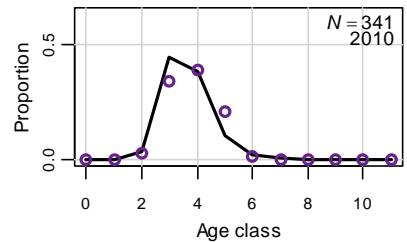
↓ accomp.hb ↓



BAM

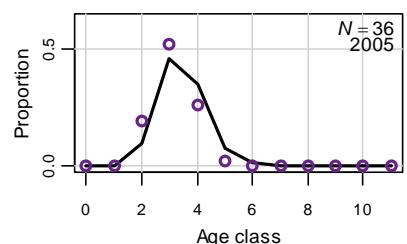
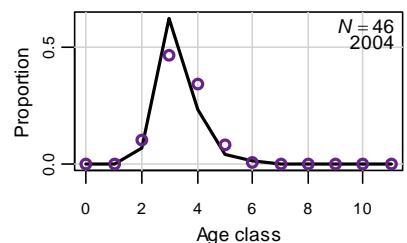
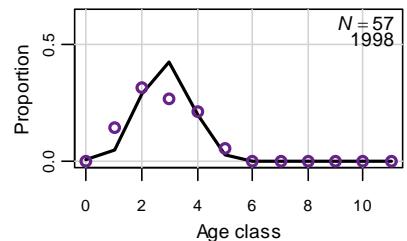
Base Run Fit





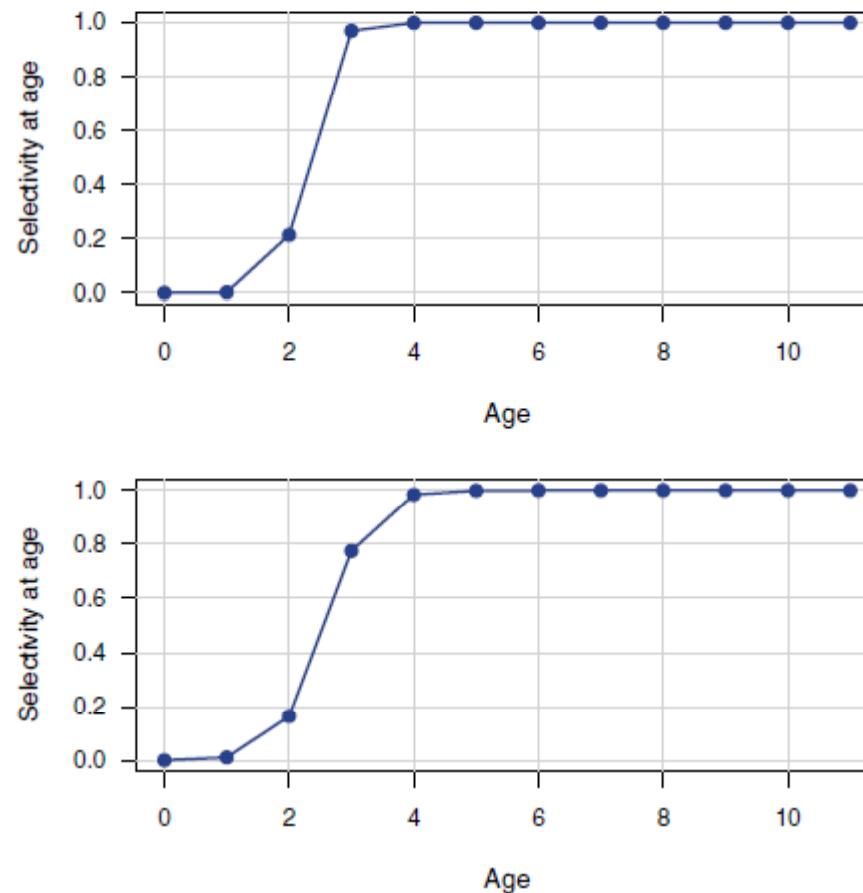
BAM
Base Run Fit

↓ acompmrip ↓



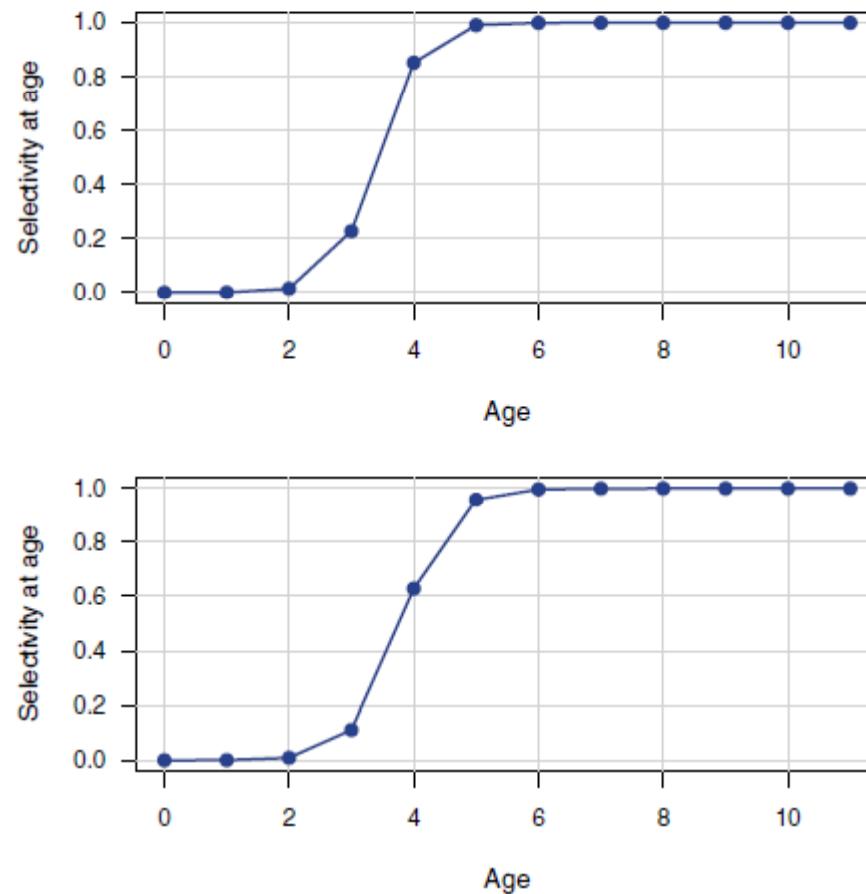
BAM
Base Run Fit

Figure 3.20. Selectivities of MARMAP gears. Top panel: blackfish/snapper traps. Bottom panel: chevron traps.



BAM
Base Run Fit

Figure 3.21. Selectivities of commercial lines. Top panel: 1978-1998. Bottom panel: 1999-2010.



BAM
Base Run Fit

Figure 3.22. Selectivities of commercial pots. Selectivity of commercial trawl (1978–1990) mirrored that of commercial pots. Top panel: 1978–1998. Bottom panel: 1999–2010.

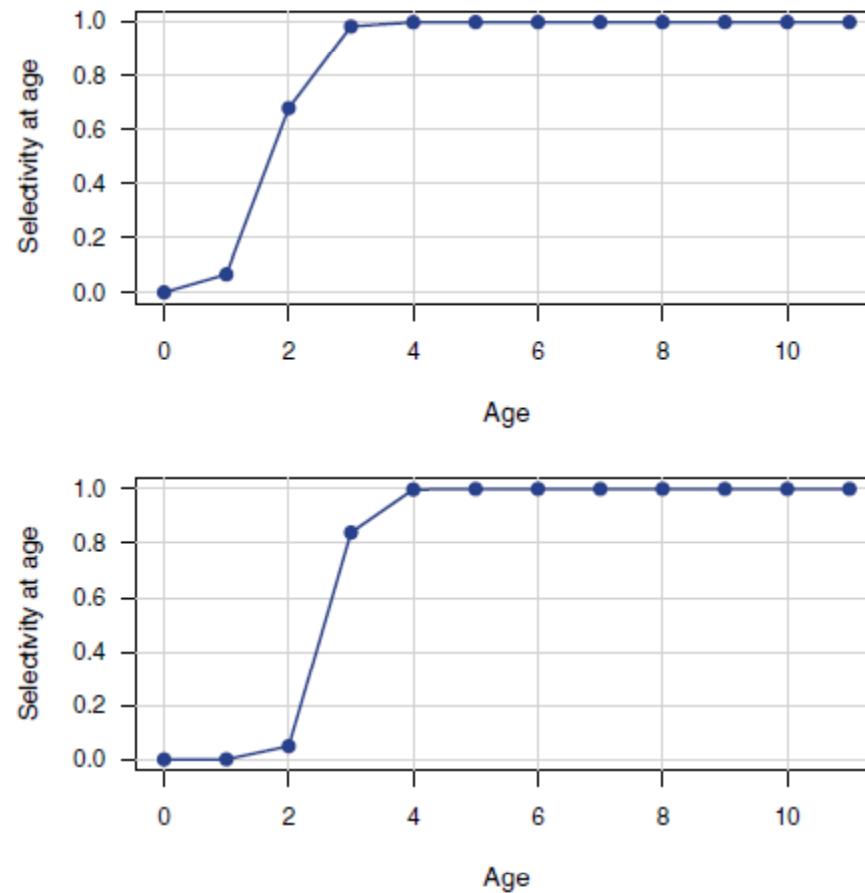


Figure 3.23. Selectivities of the headboat and general recreational fleets. First (top) panel: 1978–1983. Second panel: 1984–1998. Third panel: 1999–2006. Fourth panel: 2007–2010.

BAM
Base Run Fit

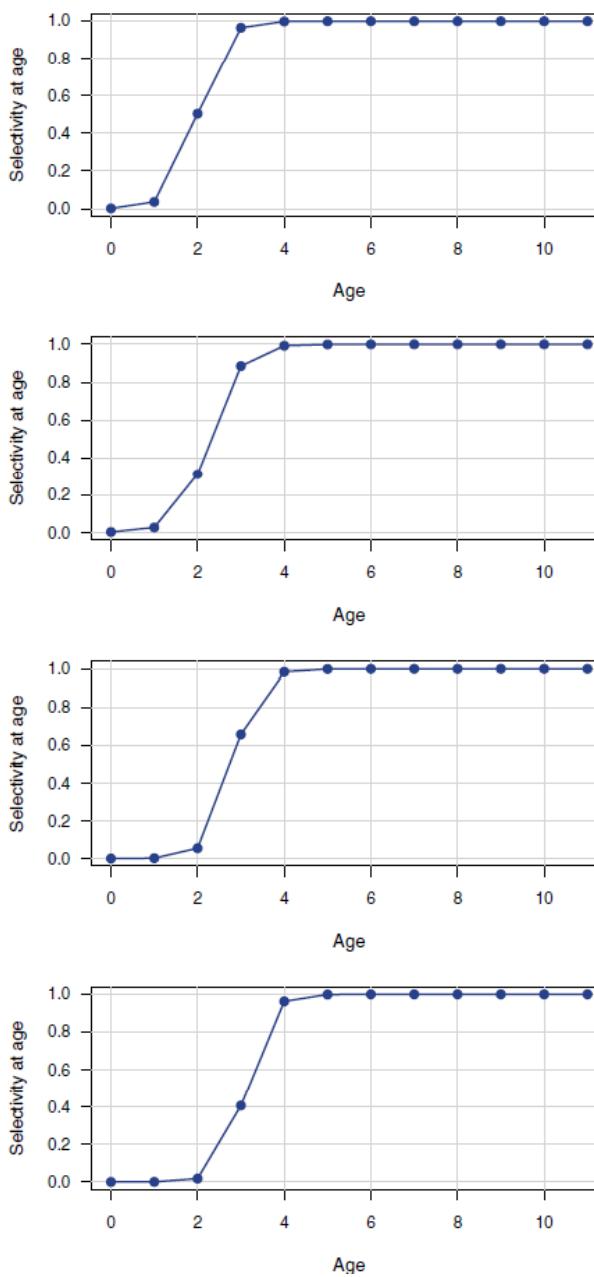


Figure 3.24. Selectivities of commercial discard mortalities. Top panel: 1984-1998. Middle panel: 1999-2008. Bottom panel: 2009-2010.

BAM
Base Run Fit

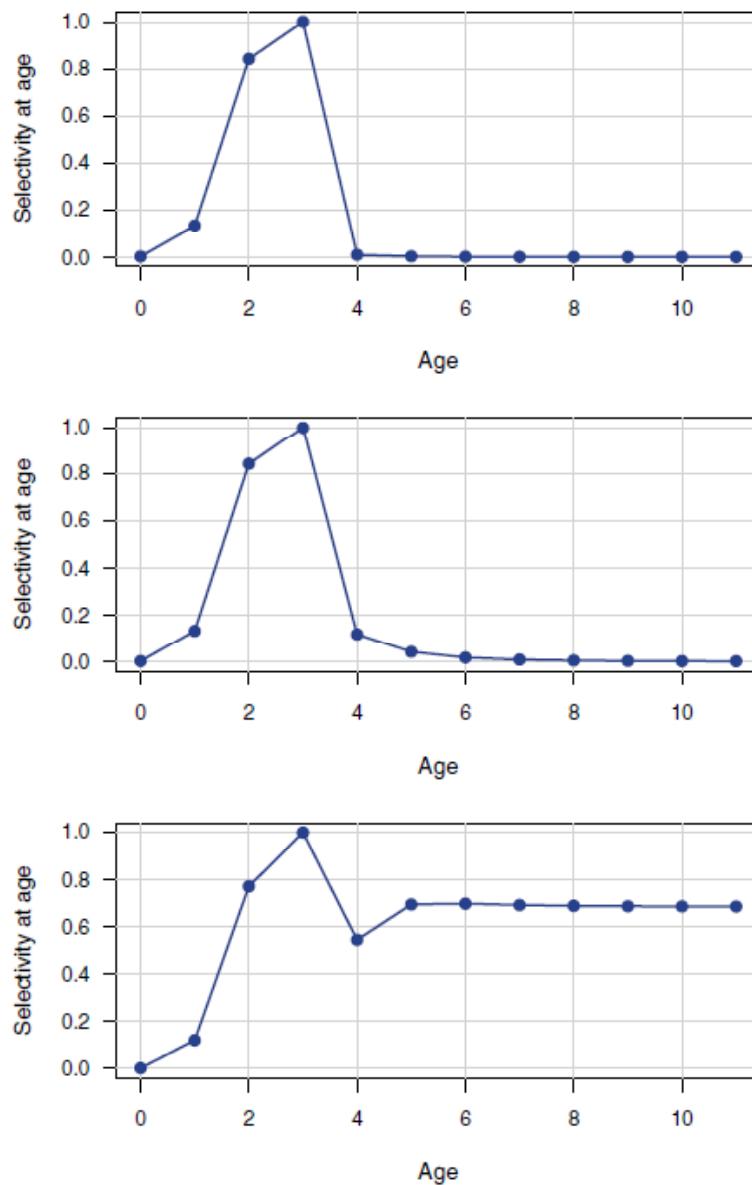


Figure 3.25. Selectivities of headboat and general recreational discard mortalities. Top panel: 1978-1998. Middle panel: 1999-2006. Bottom panel: 2007-2010.

BAM
Base Run Fit

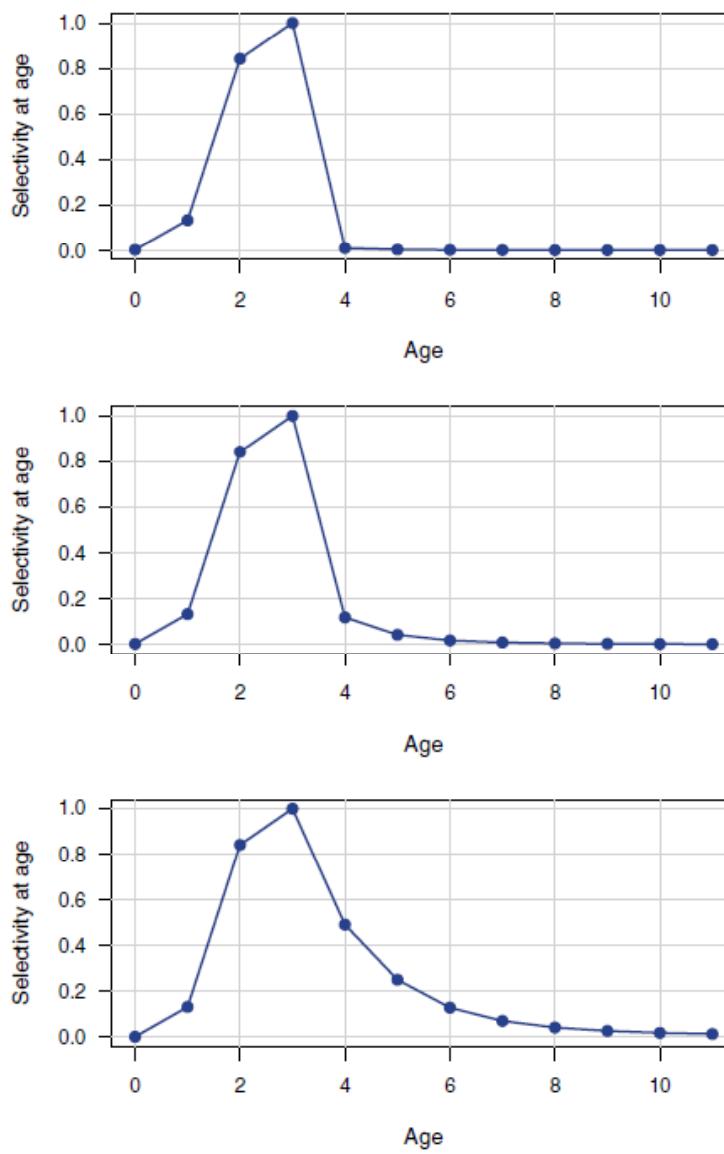
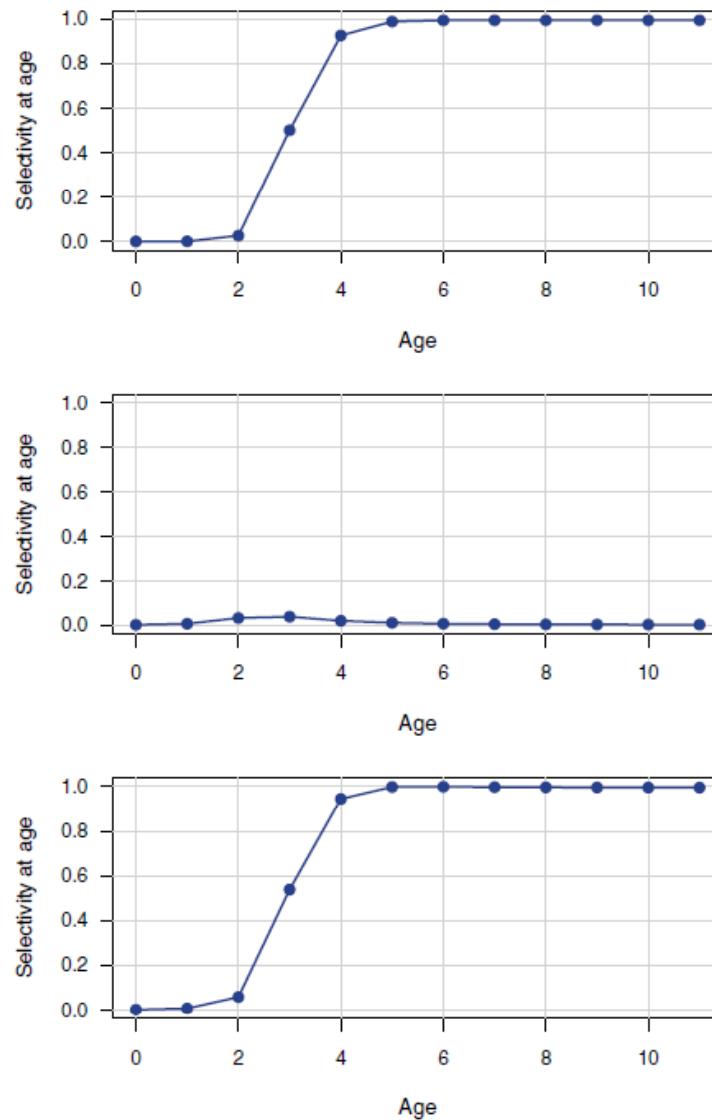


Figure 3.26. Average selectivities from the terminal assessment year (2010), weighted by geometric mean F_s from the last two assessment years, and used in computation of benchmarks and central-tendency projections. Top panel: average selectivity applied to landings. Middle panel: average selectivity applied to discard mortalities. Bottom panel: total average selectivity.

BAM
Base Run Fit



BAM
Base Run Fit

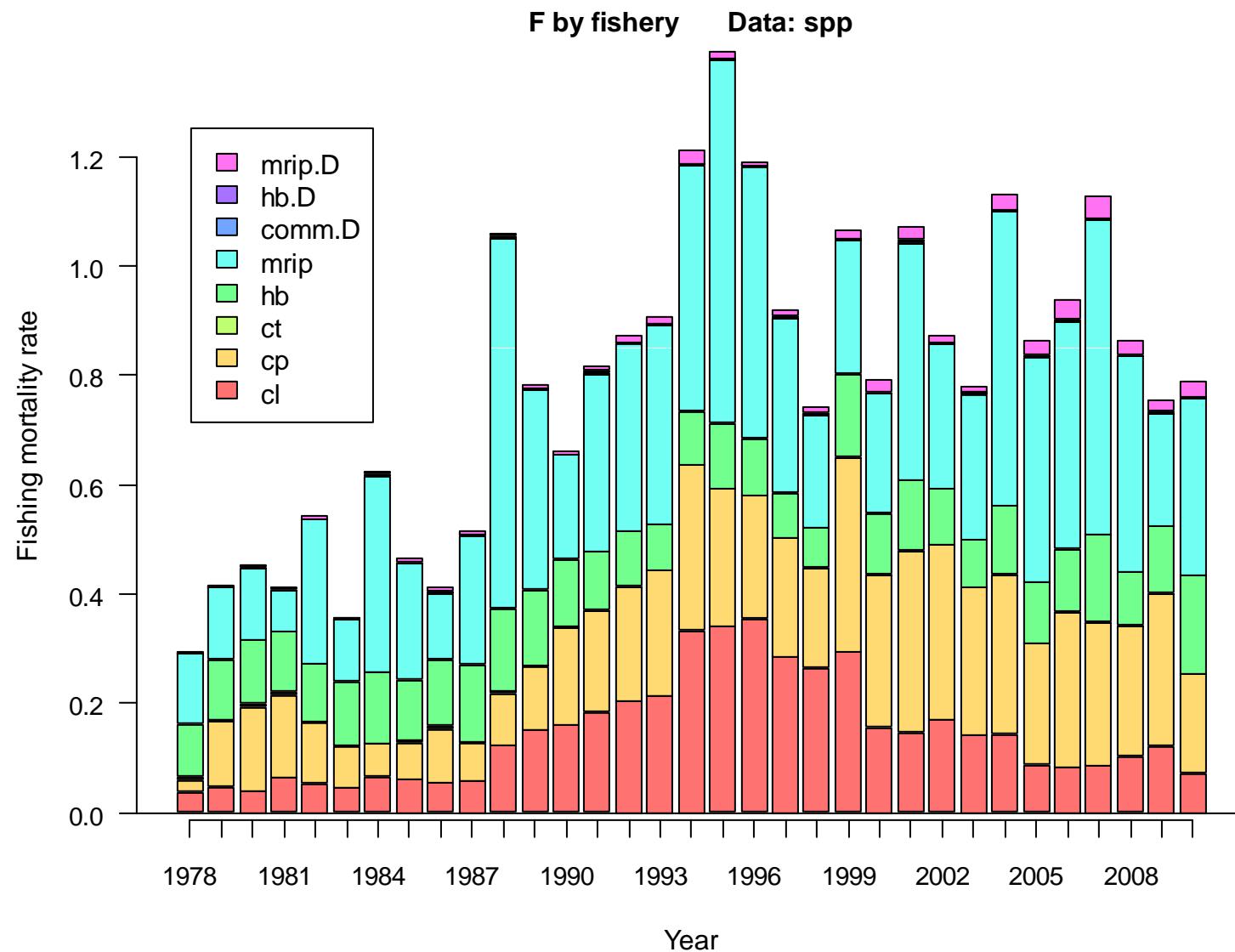
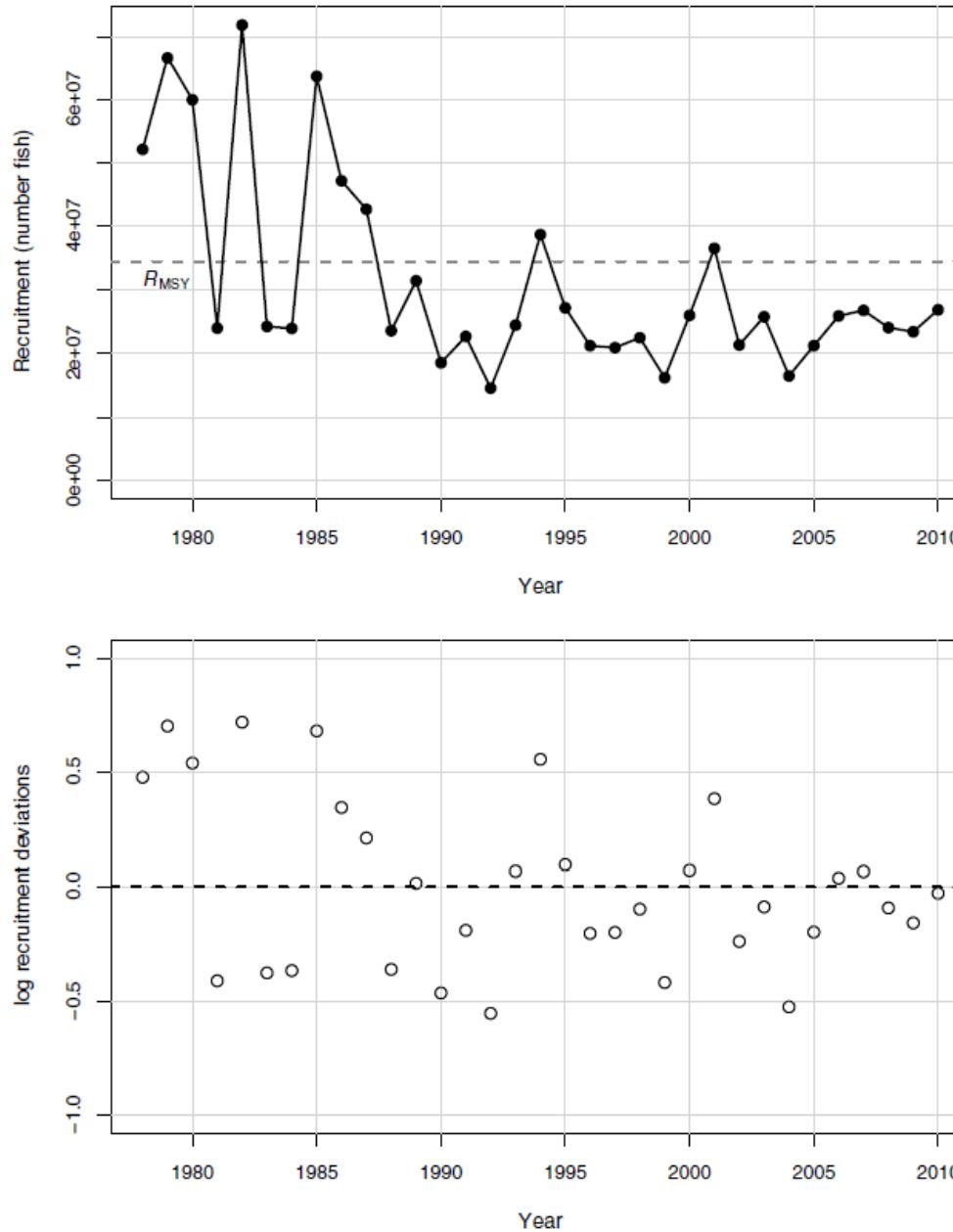
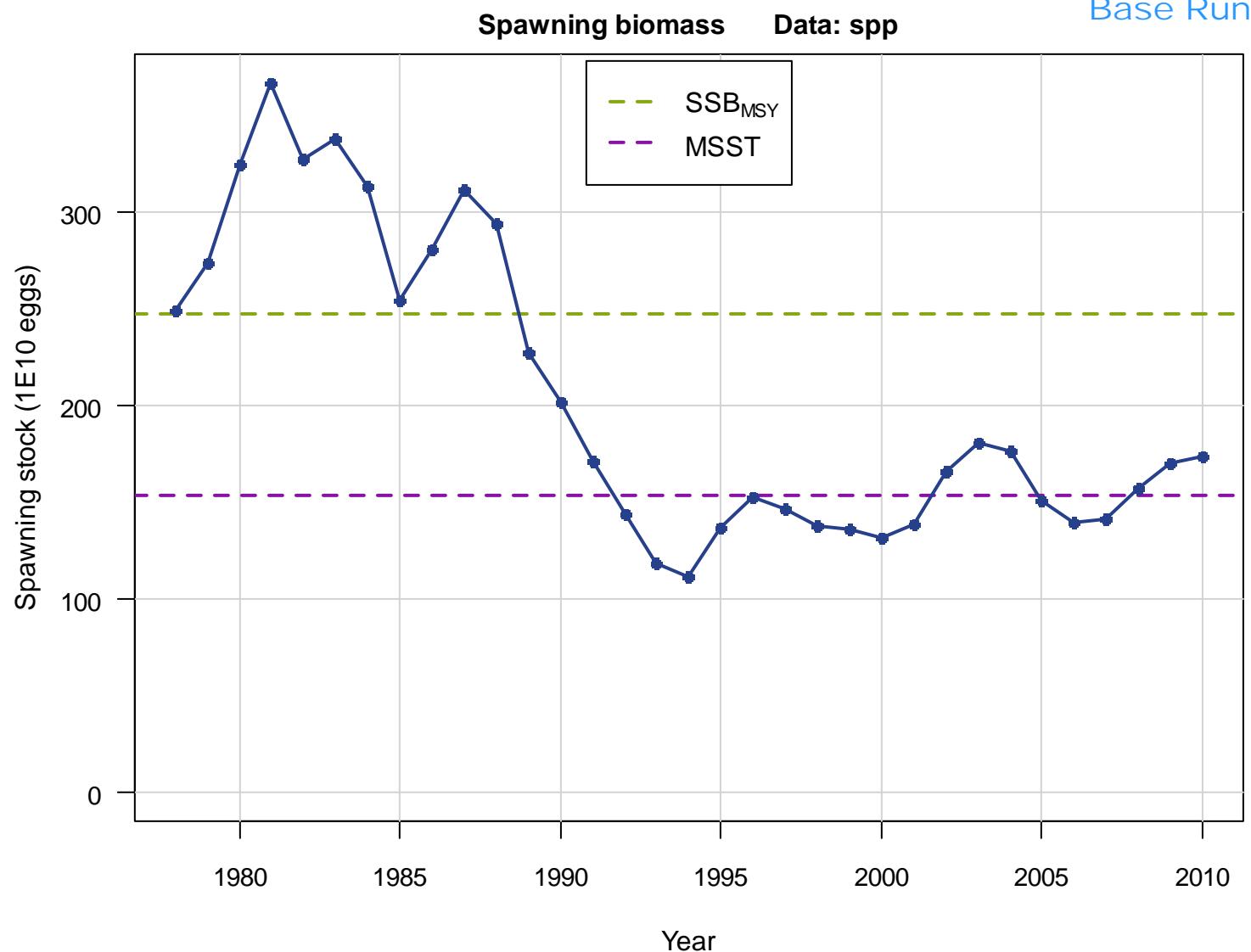


Figure 3.17. Top panel: Estimated recruitment of age-0 fish. Horizontal dashed line indicates R_{MSY} . Bottom panel: log recruitment residuals.

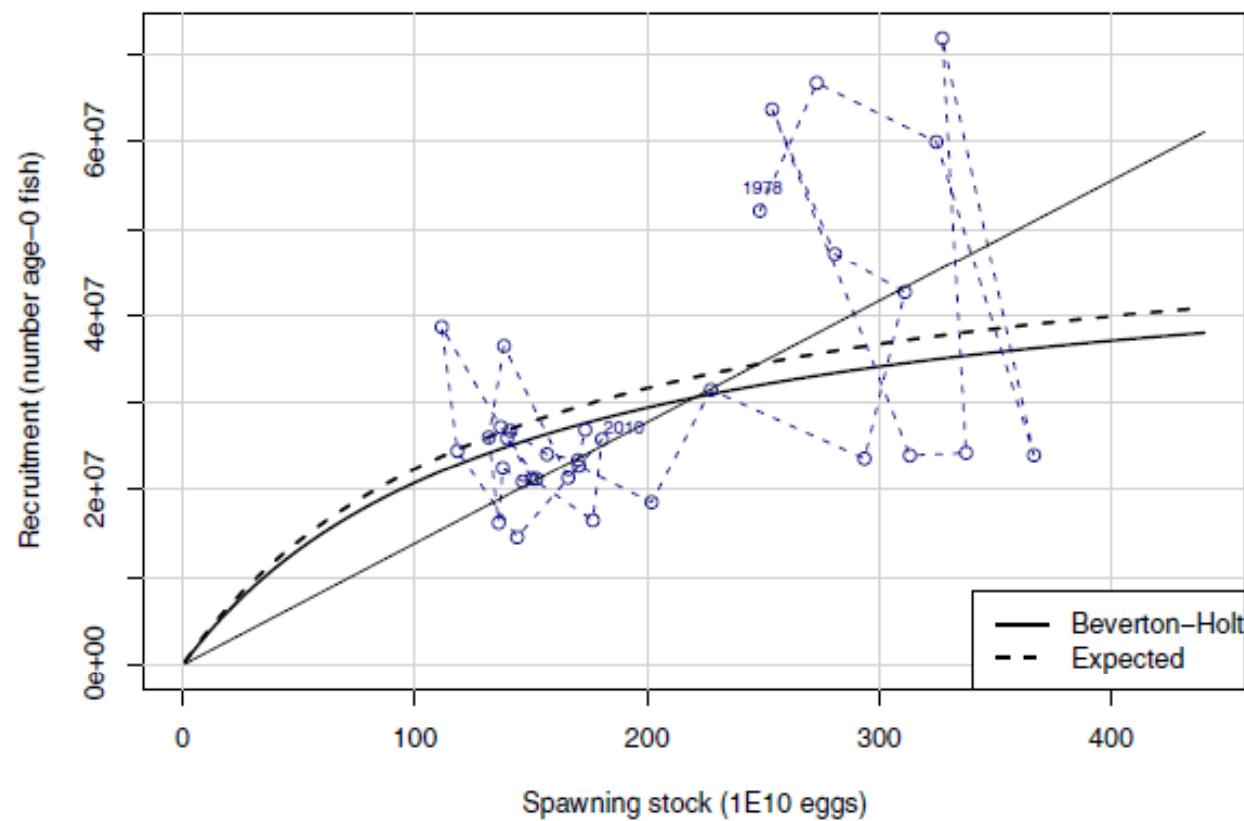


BAM
Base Run Fit

BAM
Base Run Fit



BAM
Base Run Fit



Quantity	Units	Estimate	SE	BAM Base Run Fit
F_{MSY}	y^{-1}	0.698	0.395	
85% F_{MSY}	y^{-1}	0.593	0.336	
75% F_{MSY}	y^{-1}	0.524	0.296	
65% F_{MSY}	y^{-1}	0.454	0.257	
$F_{30\%}$	y^{-1}	NA	NA	
$F_{40\%}$	y^{-1}	NA	NA	
$F_{50\%}$	y^{-1}	2.118	0.635 ¹	
B_{MSY}	mt	5399	672	
SSB _{MSY}	1E10 eggs	248	22	
MSST	1E10 eggs	154	22	
MSY	1000 lb	1767	92	
D_{MSY}	1000 fish	240	106	
R_{MSY}	1000 age-0 fish	34393	11764	
Y at 85% F_{MSY}	1000 lb	1760	91	
Y at 75% F_{MSY}	1000 lb	1746	88	
Y at 65% F_{MSY}	1000 lb	1720	84	
$F_{2009-2010}/F_{\text{MSY}}$	—	1.07	0.38	
SSB ₂₀₁₀ /MSST	—	1.13	0.31	
SSB ₂₀₁₀ /SSB _{MSY}	—	0.70	0.14	



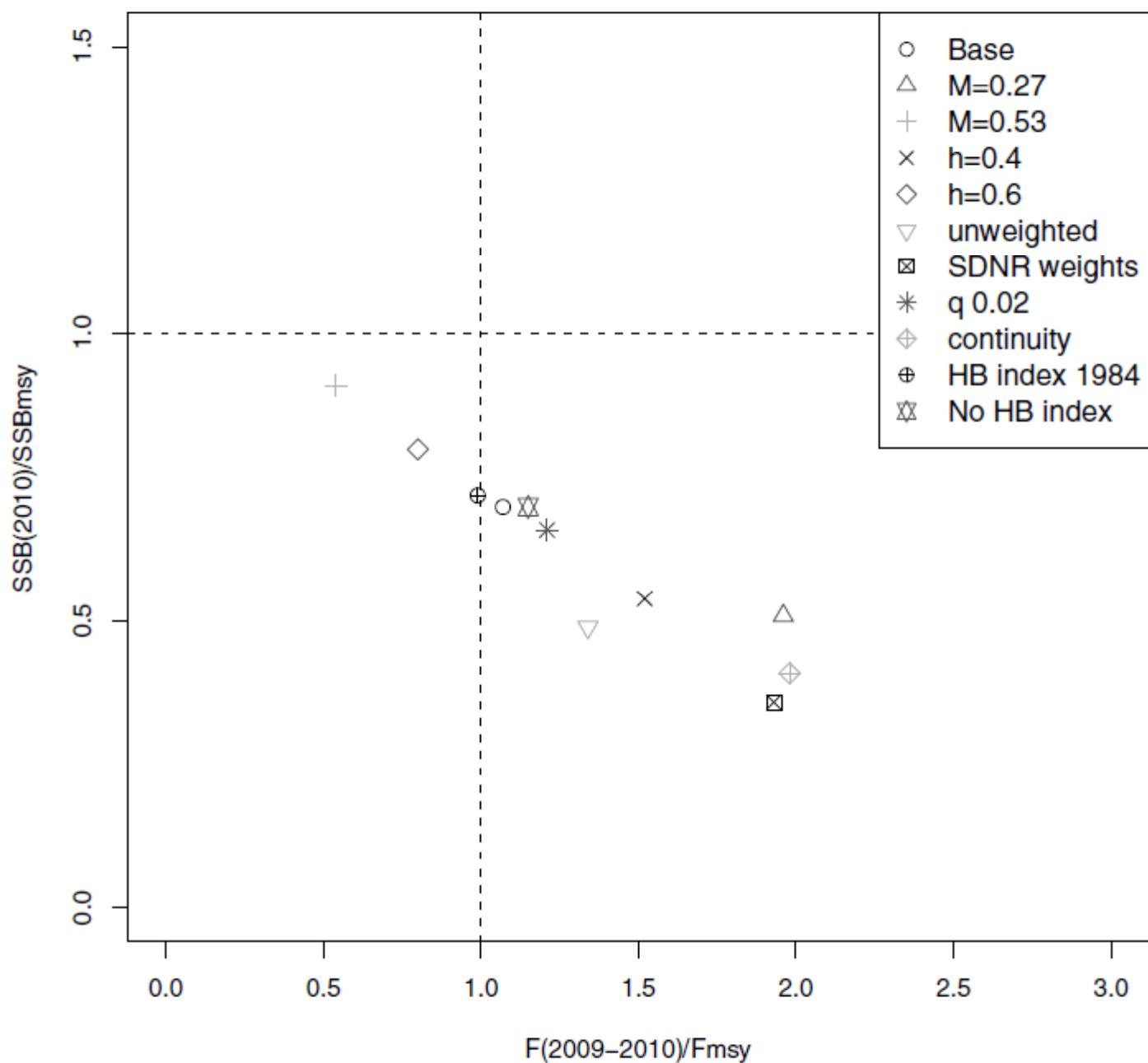
BAM sensitivity analyses

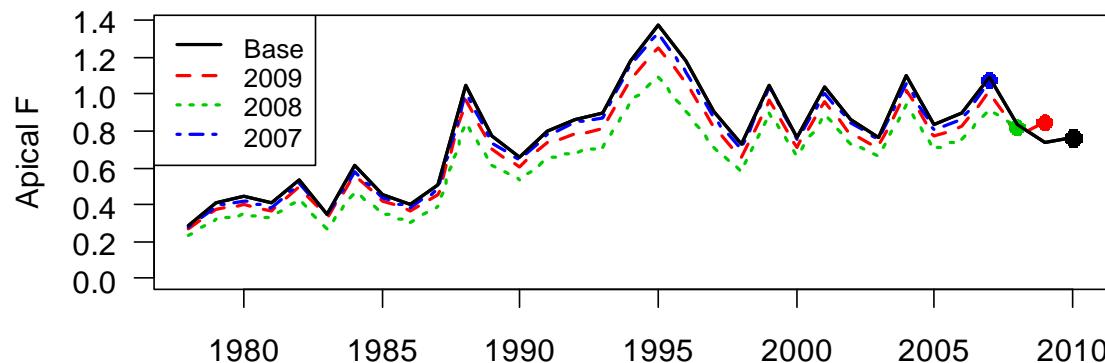
1E10 eggs

Run	Description	F_{MSY}	SSB _{MSY} (mt)	B_{MSY} (mt)	MSY(1000 lb)	$F_{2009-2010}/F_{MSY}$	SSB _{2010/MSST}	SSB _{2010/SSB_{MSY}}	steep	R0(1000)
Base	—	0.698	248	5399	1767	1.07	1.13	0.7	0.49	37330
S1	M=0.27	0.429	270	5671	2038	1.96	0.69	0.51	0.57	18859
S2	M=0.53	1.135	279	7296	1739	0.54	1.81	0.91	0.39	99383
S3	h=0.4	0.492	322	7033	1996	1.52	0.86	0.54	0.4	47462
S4	h=0.6	0.935	216	4744	1706	0.8	1.3	0.8	0.6	33160
S5	Unweighted	0.325	563	12525	2600	1.34	0.8	0.49	0.31	84424
S6	SDNR weights	0.329	601	13337	2842	1.93	0.58	0.36	0.32	95911
S7	q 0.02	0.595	271	5894	1803	1.21	1.07	0.66	0.45	40402
S8	Continuity	0.379	4828 ¹	6231	2113	1.98	0.58	0.41	0.66	13749
S9	HB index 1984	0.762	242	5286	1782	0.99	1.15	0.72	0.52	36444
S10	No HB index	0.787	262	5690	1848	1.15	1.12	0.7	0.49	38355

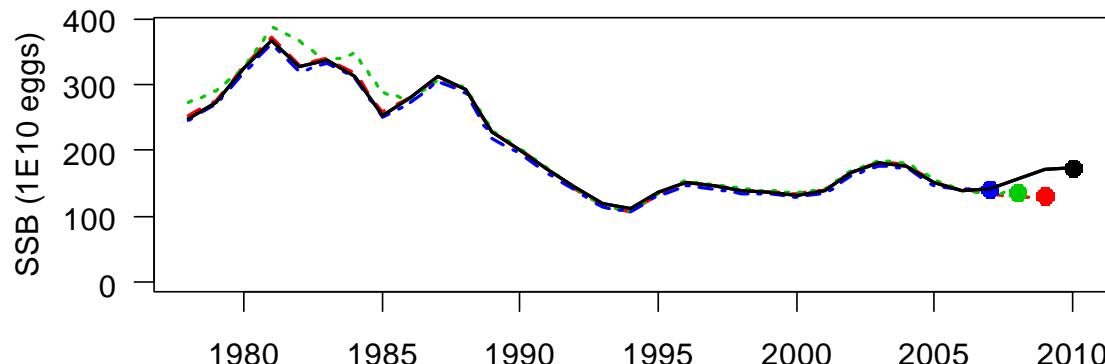
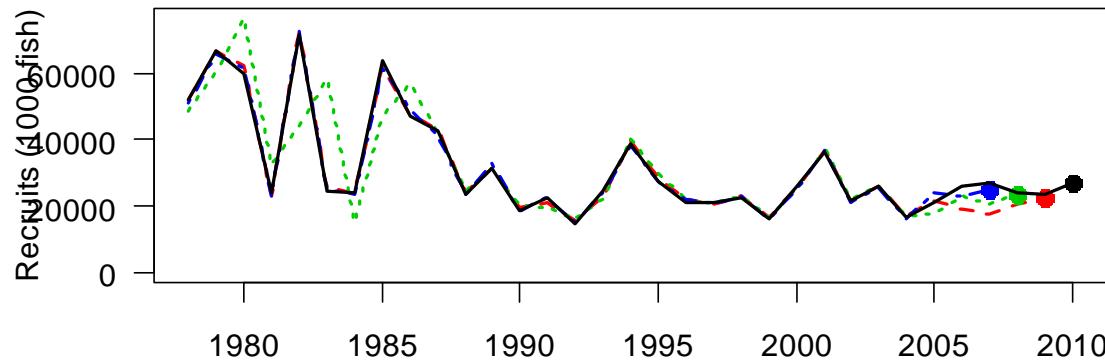
¹ SSB based on biomass of mature males and females

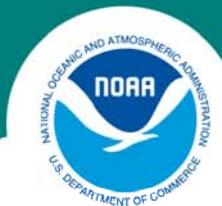
BAM
Sensitivity
analyses





BAM
Retrospective
analyses





Uncertainty Analysis Monte-Carlo Bootstrap

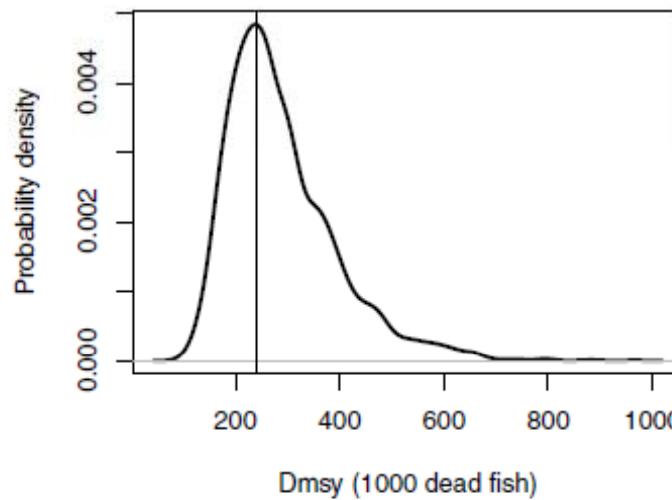
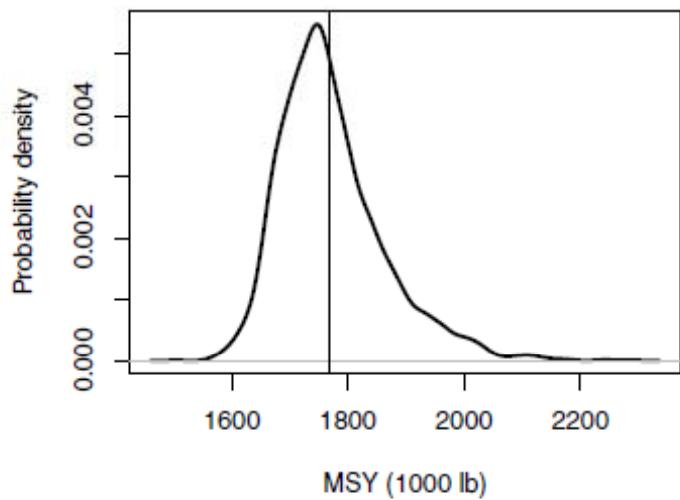
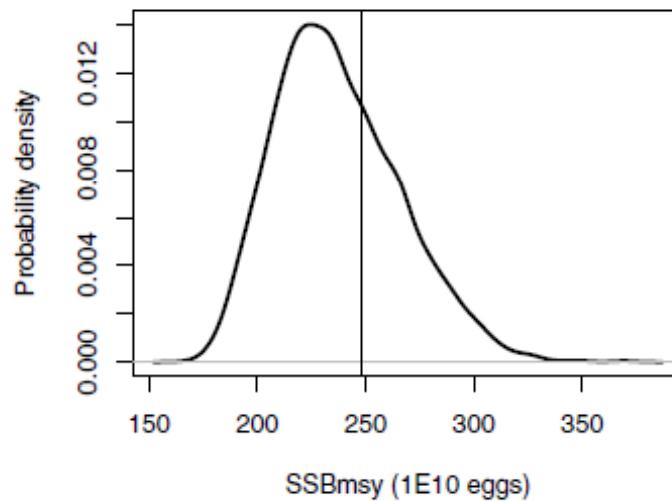
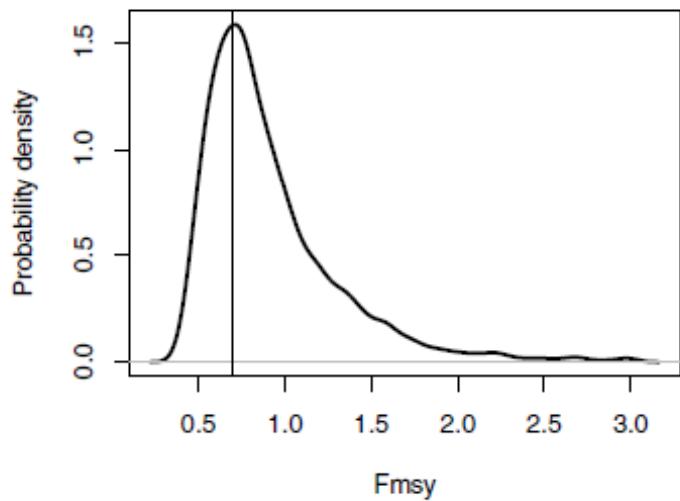
- n=3100 MCB trials attempted; n=3048 retained
- Bootstrap Parts:
 - Lognormal likelihood components (landings, indices): a parametric bootstrap to original data, with CVs as applied in the fitting procedure
 - Multinomial likelihood components (length, age comps): resample Nfish and assign them to bins with probabilities equal to those from original data



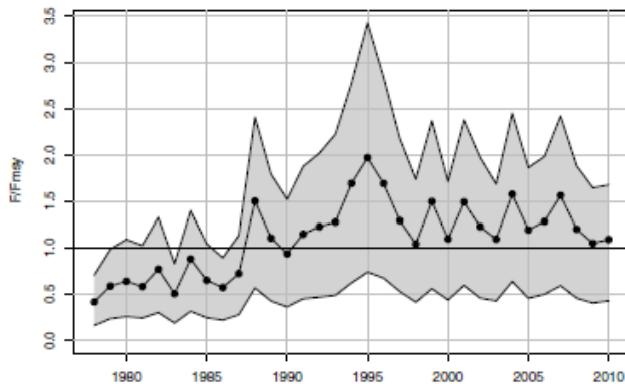
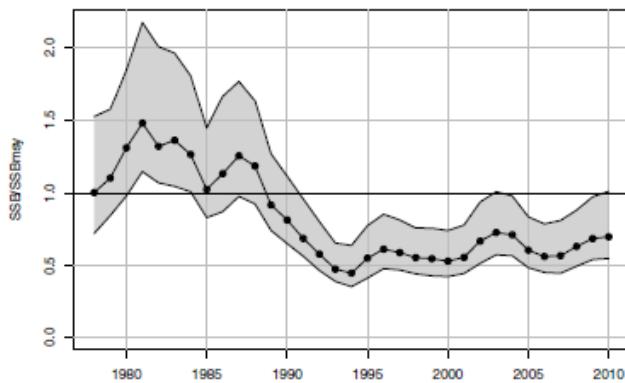
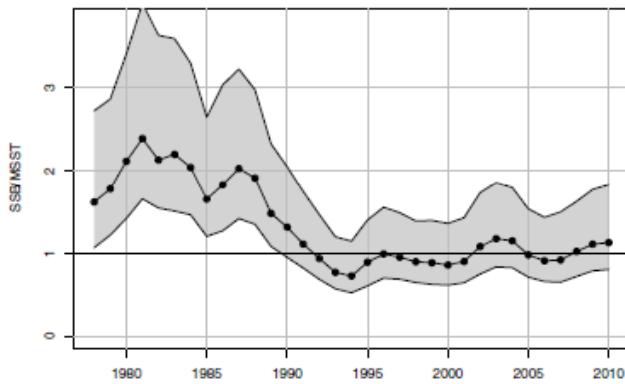
Uncertainty Analysis Monte-Carlo Bootstrap

- Monte Carlo Parts:
 - M: drawn from a truncated normal distribution, with mean equal to base value, and SD computed such that the nearest bound is at the 95% confidence limit
 - Discard mortality: handline rate drawn from a truncated normal distribution, with mean equal to base value, and SD computed such that the nearest bound is at the 95% confidence limit. Trap rates scaled to handline rate.
 - Weights on indices: uniform distribution $\pm 25\%$ of base value (2.5)

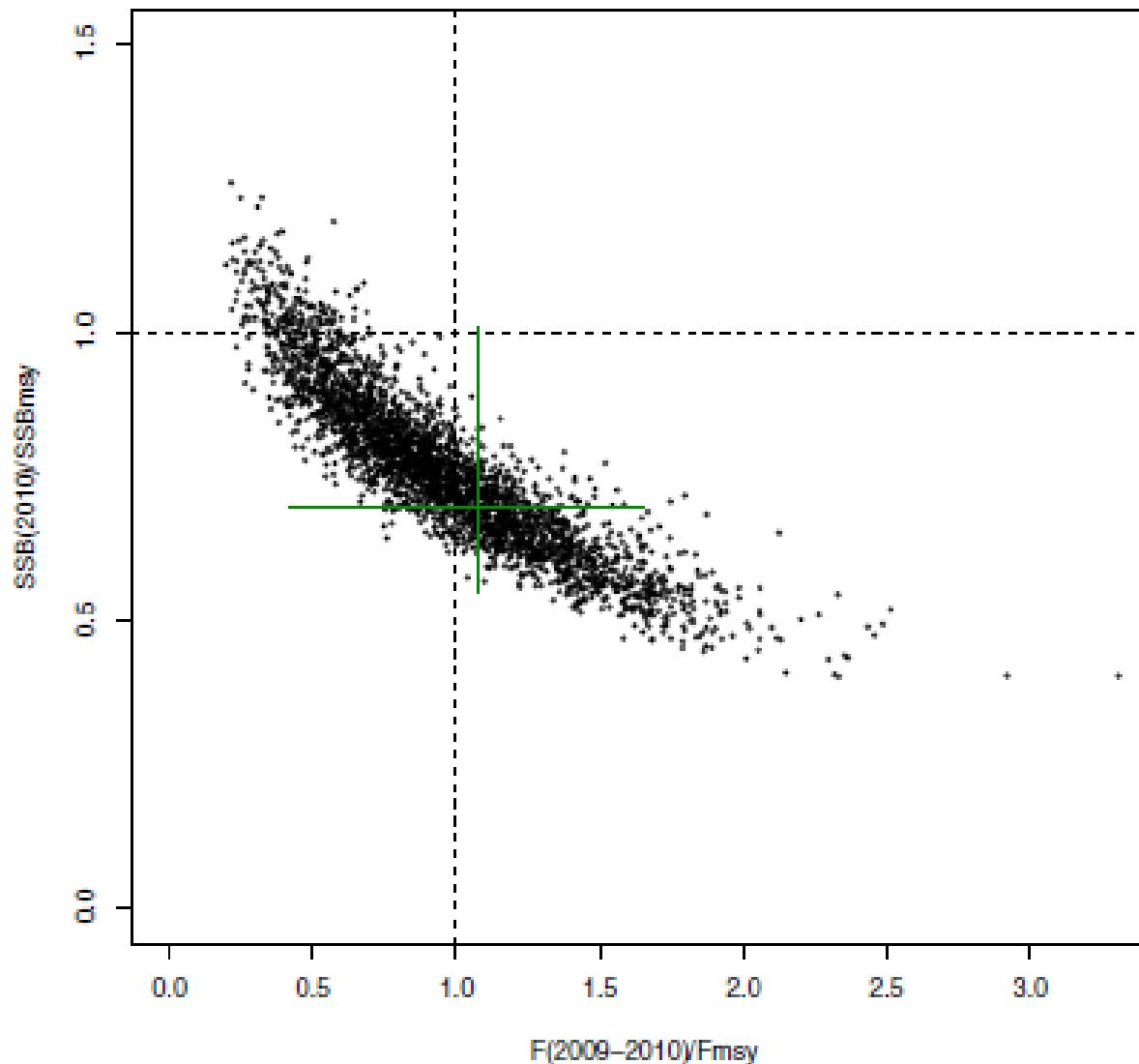
Uncertainty Analysis Monte-Carlo Bootstrap



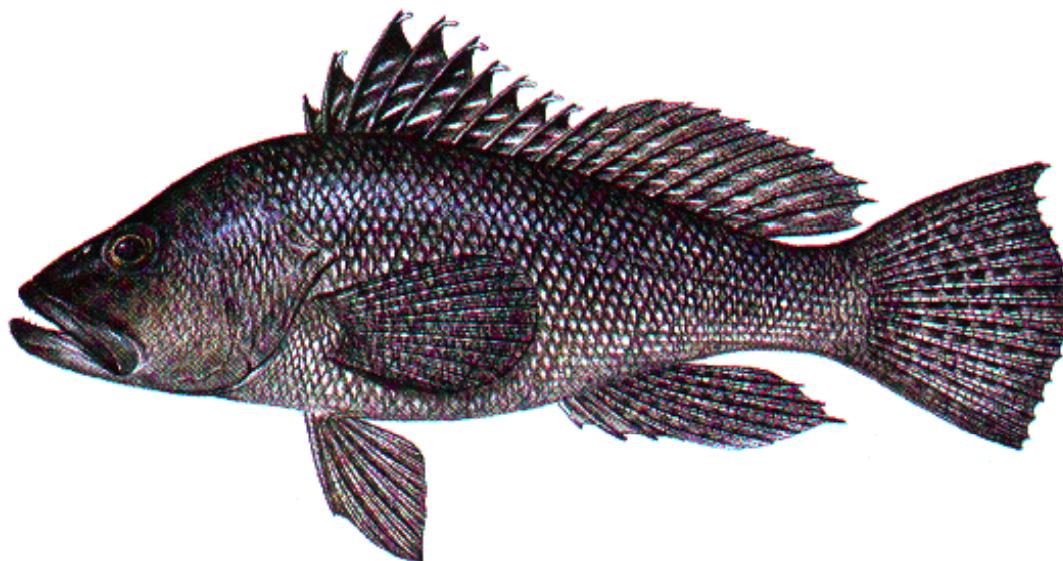
Uncertainty Analysis Monte-Carlo Bootstrap



Uncertainty Analysis Monte-Carlo Bootstrap



PROJECTIONS





Age-based projection model

- Projection years 2011-2016
- Same structure as assessment model
- Initial (2011) N at age based on 2010 estimates discounted by Z. Initial recruits from S-R model.
- Three levels of landings applied in 2011: 100%, 150%, 200% of current quota
- New management assumed to start in 2012
- Expected values from deterministic projections, accounting for bias correction in S-R curve.
 - Consistency between projections and benchmarks



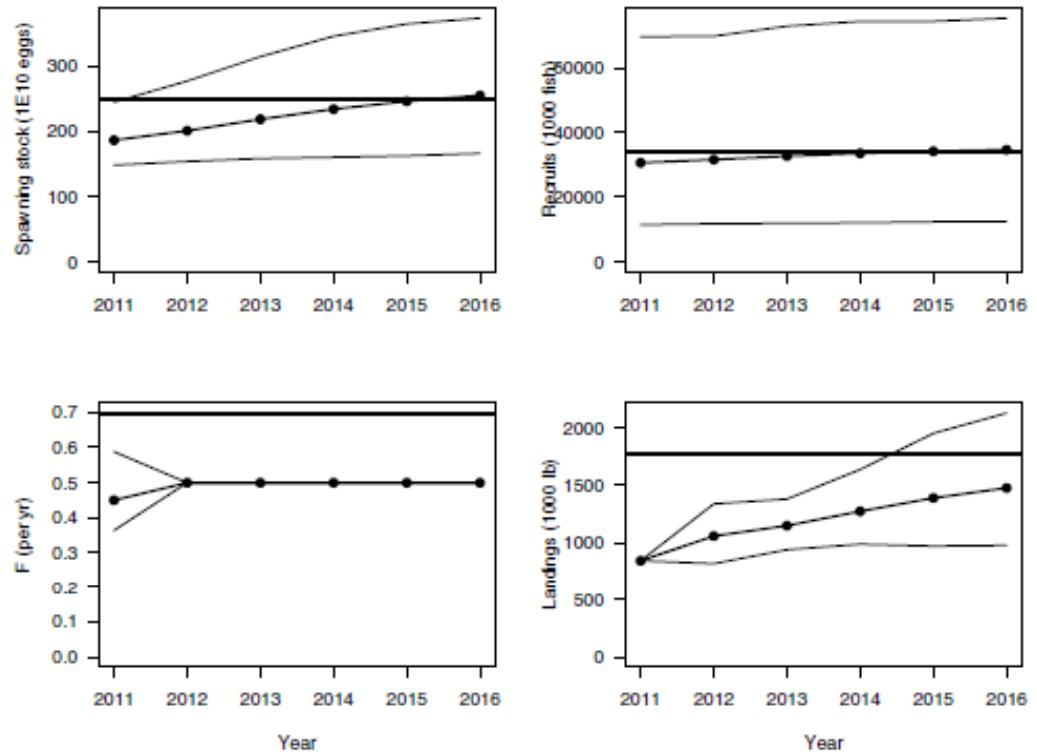
Uncertainty in projections

- $n=20,000$ projected time series
- Each time series carried forward a single Monte Carlo/Bootstrap run, chosen at random
 - thus projections included uncertainty in parameter estimates and initial abundance at age
- Each projection also included stochastic recruitment (lognormal residuals)
- “Rebuilding” defined by $\text{SSB} \geq \text{SSB}_{\text{msy}}$ in at least 50% of projected time series (the Council’s criterion). Here SSB_{msy} is the point estimate from the base model.

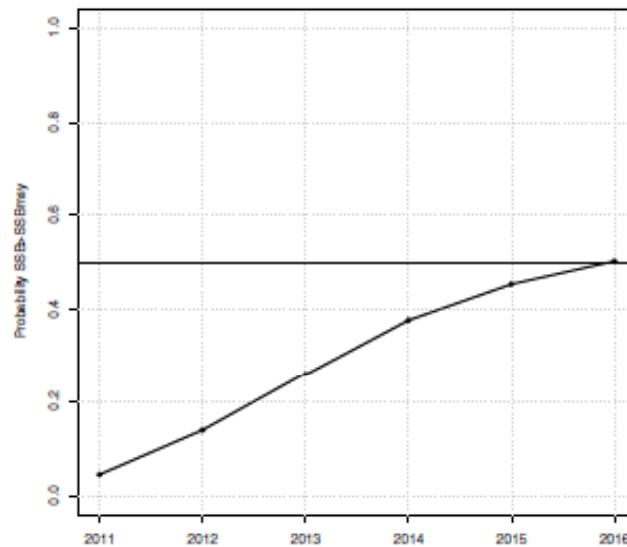


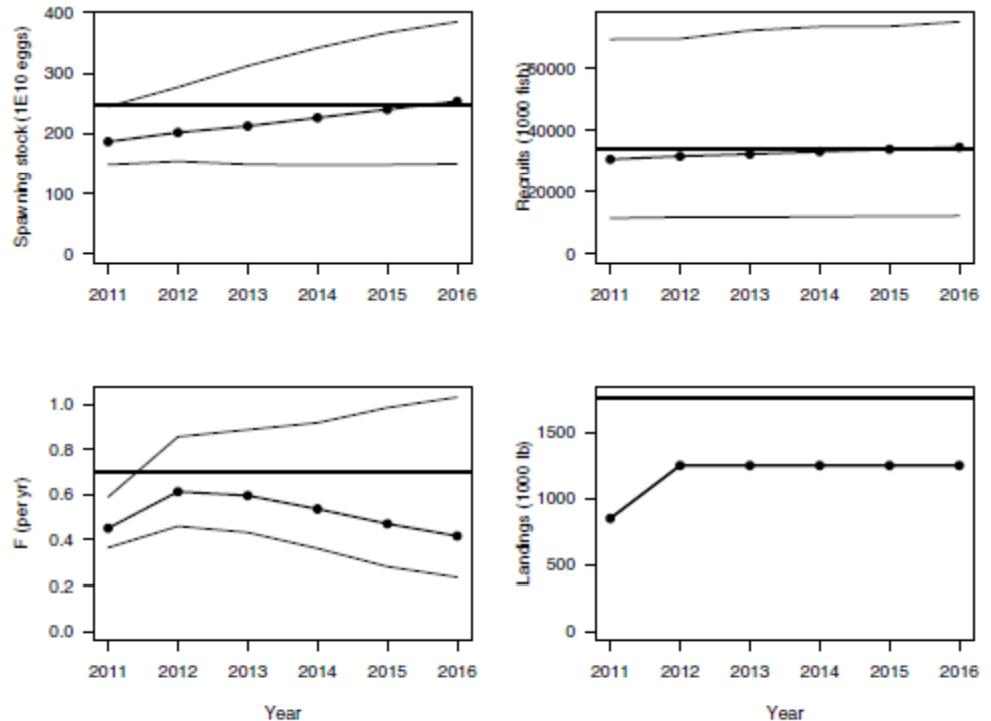
Projection scenarios

- Scenario 1: $F = F_{\text{rebuild}}$, with 2011 landings at 100% of current quota
- Scenario 2: $F = F_{\text{rebuild}}$, with 2011 landings at 150% of current quota
- Scenario 3: $F = F_{\text{rebuild}}$, with 2011 landings at 200% of current quota
- Scenario 4: $L = 847,000 \text{ lb}$, with 2011 landings at 100% of current quota
- Scenario 5: $L = 847,000 \text{ lb}$, with 2011 landings at 150% of current quota
- Scenario 6: $L = 847,000 \text{ lb}$, with 2011 landings at 200% of current quota
- Scenario 7: $L = L_{\text{rebuild}}$, with 2011 landings at 100% of current quota
- Scenario 8: $L = L_{\text{rebuild}}$, with 2011 landings at 150% of current quota
- Scenario 9: $L = L_{\text{rebuild}}$, with 2011 landings at 200% of current quota

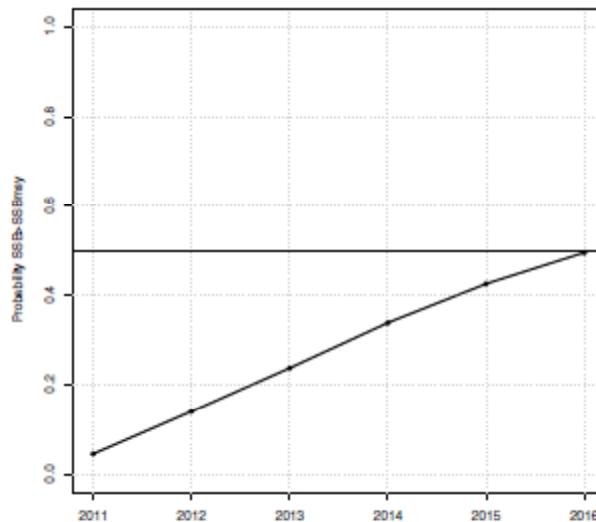


Projection scenario 1:
 F = Frebuild
 2011 landings at 100% quota





Projection scenario 7:
L = Lrebuild
2011 landings at 100% quota



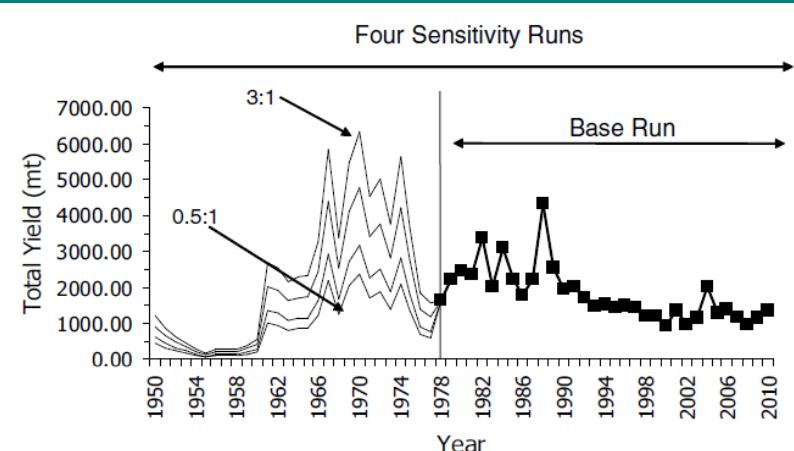


Production model

- No age structure
- Non-equilibrium logistic formulation
- Conditioned on yield
- ASPIC software of Prager (1994)
- Uncertainty from bootstrap



Production model

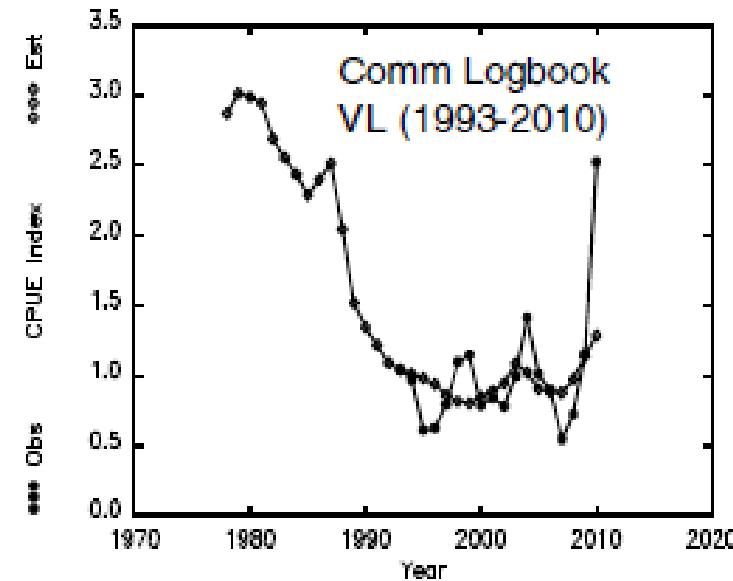
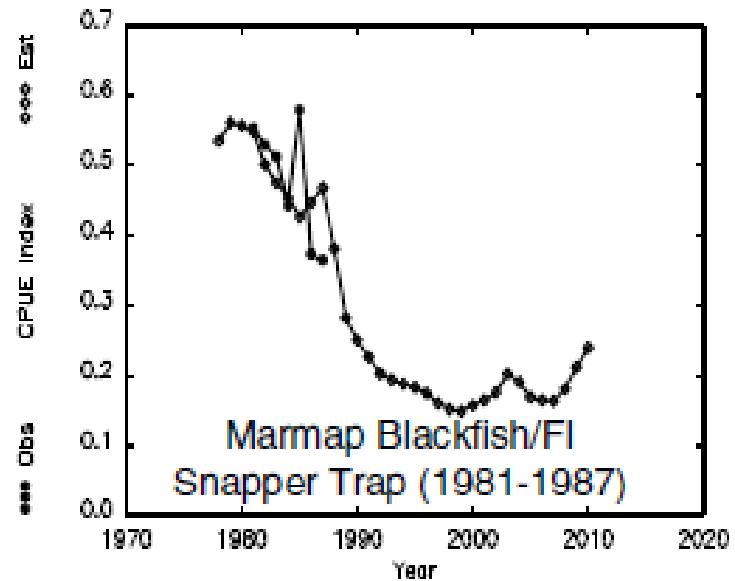
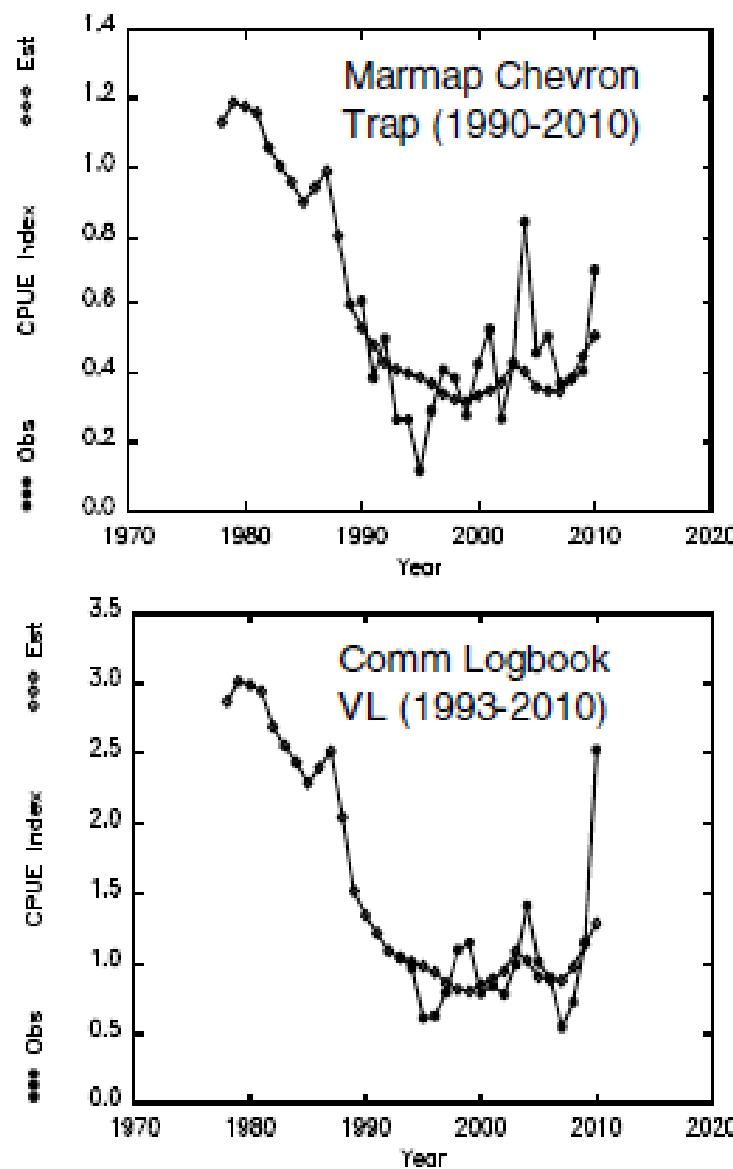
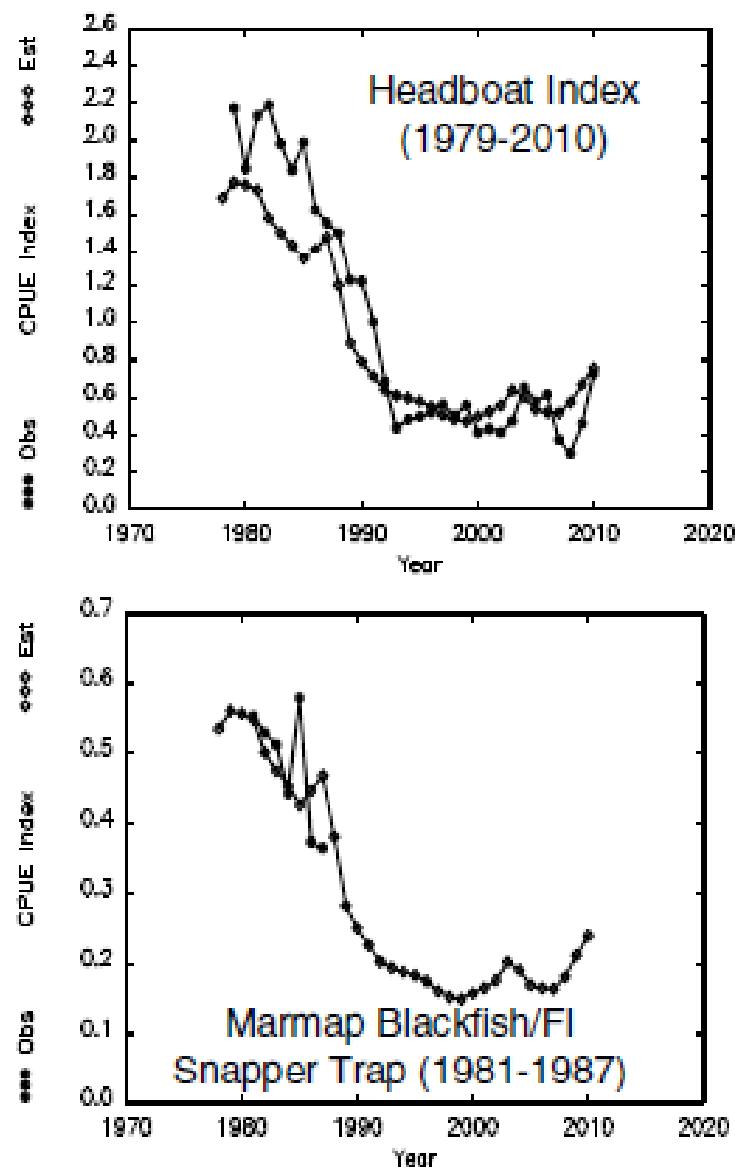


Configurations and results

- Base: 1978–2010
- Sensitivities: 1950–2010, with 1950–1977 recreational landings assumed to track commercial landings at one of four ratios

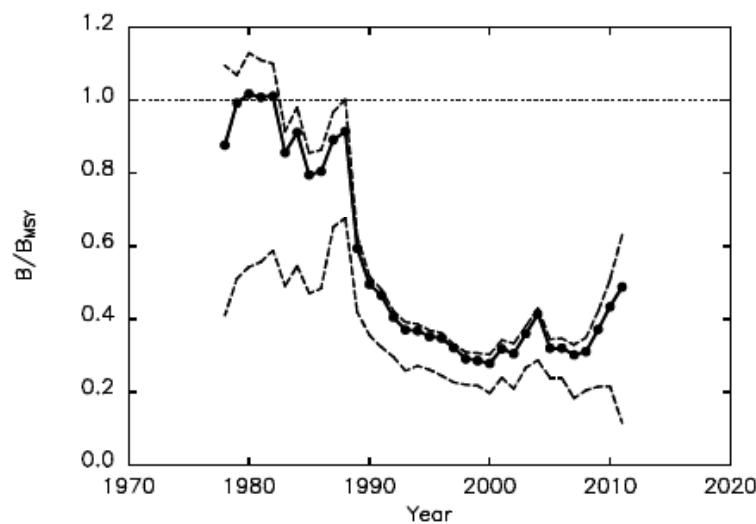
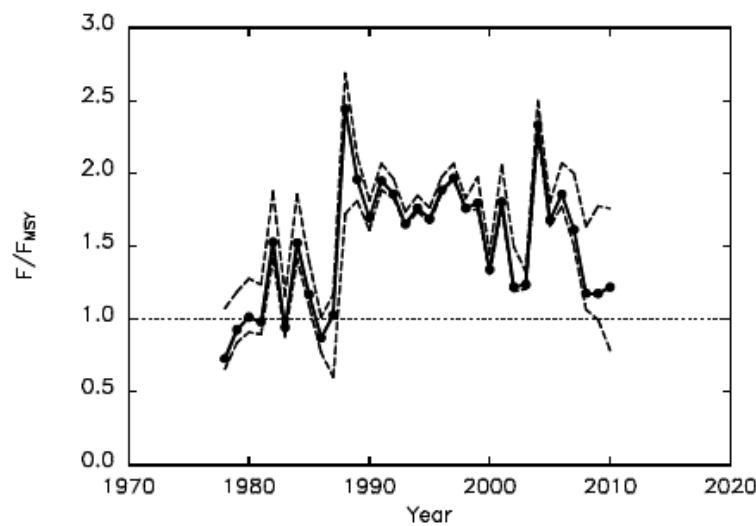
Quantity	Base	Sensitivity 0.5:1	Sensitivity 1:1	Sensitivity 2:1	Sensitivity 3:1
MSY (mt)	2317	2261	2222	2664	3211
K (mt)	13460	10590	12120	20120	31120
B ₁ /K	0.503	0.88	0.63	0.901	0.984
B _{MSY} (mt)	6731	5293	6062	10060	15560
F _{MSY} (per yr)	0.344	0.427	0.367	0.265	0.206
B ₂₀₁₁ /B _{MSY}	0.498	0.564	0.541	0.386	0.289
F ₂₀₁₀ /F _{MSY}	1.22	1.13	1.18	1.36	1.48

ASPIC Fits to data

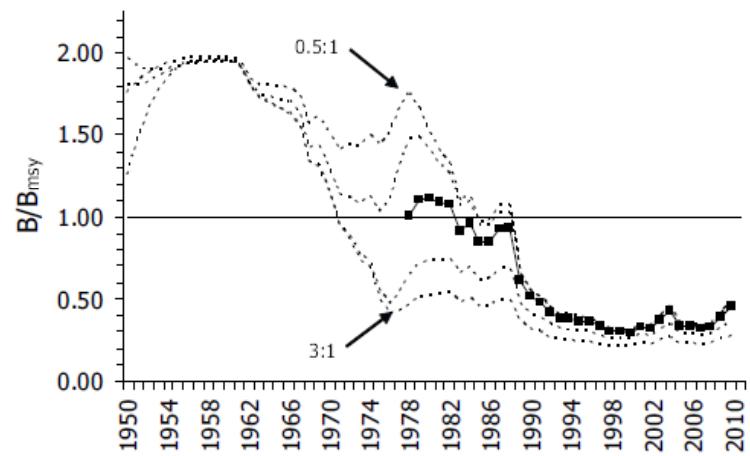
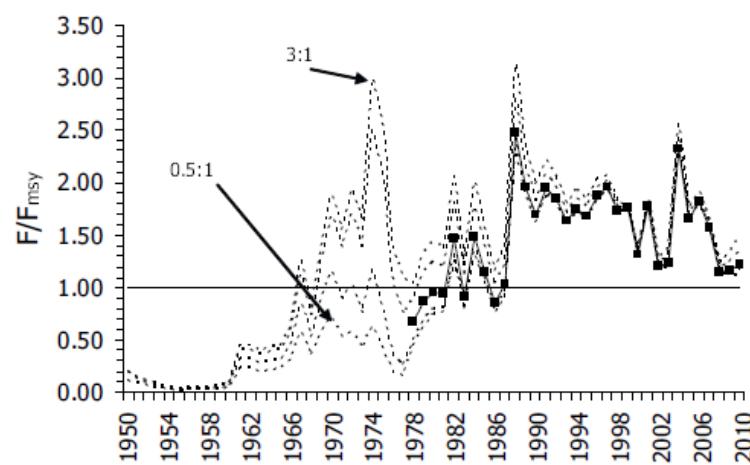


ASPIC: Results and Uncertainty

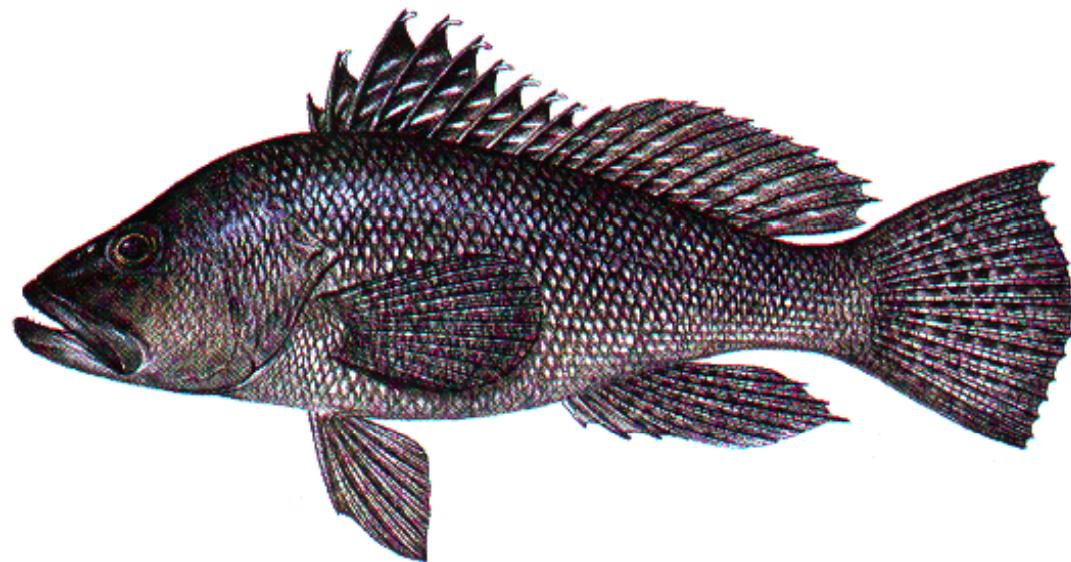
Base run with 80% confidence bands



Base run and sensitivity runs

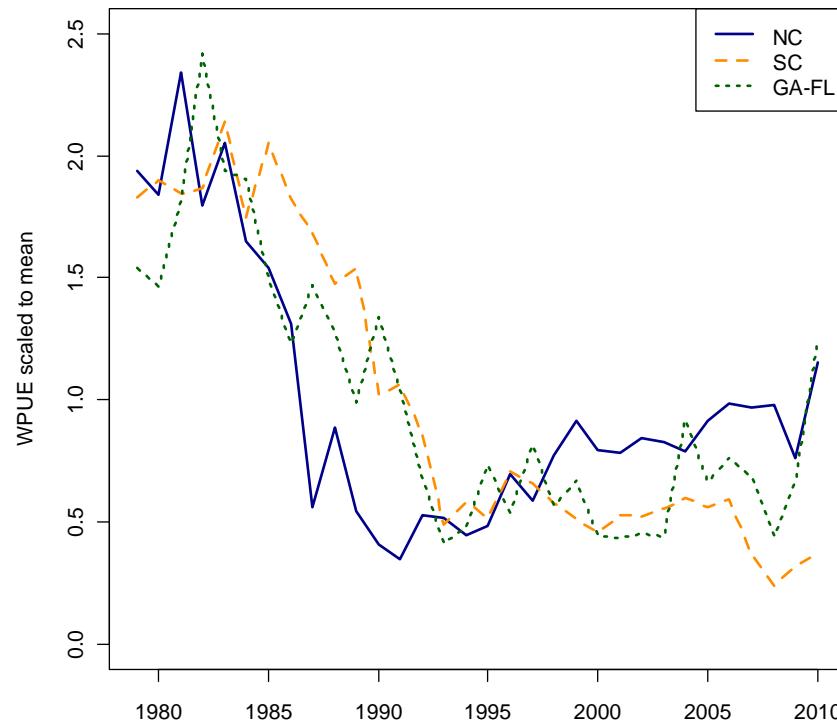


THE END





Headboat indices by area





Size at age by area: commercial traps

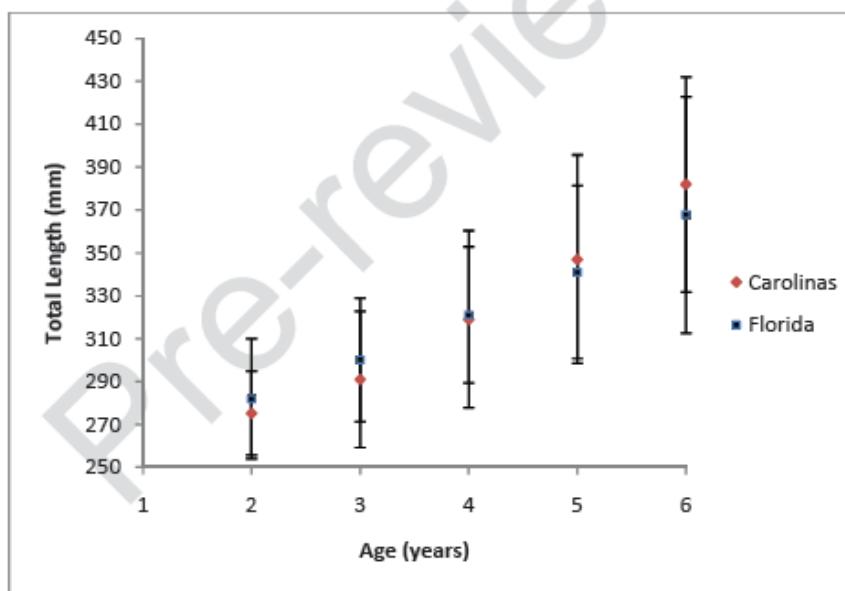


Figure 3a. Mean length-at-age (± 1 SD) of black sea landed in the 2009-2010 commercial trap fishery operating off North Carolina and South Carolina versus Florida.