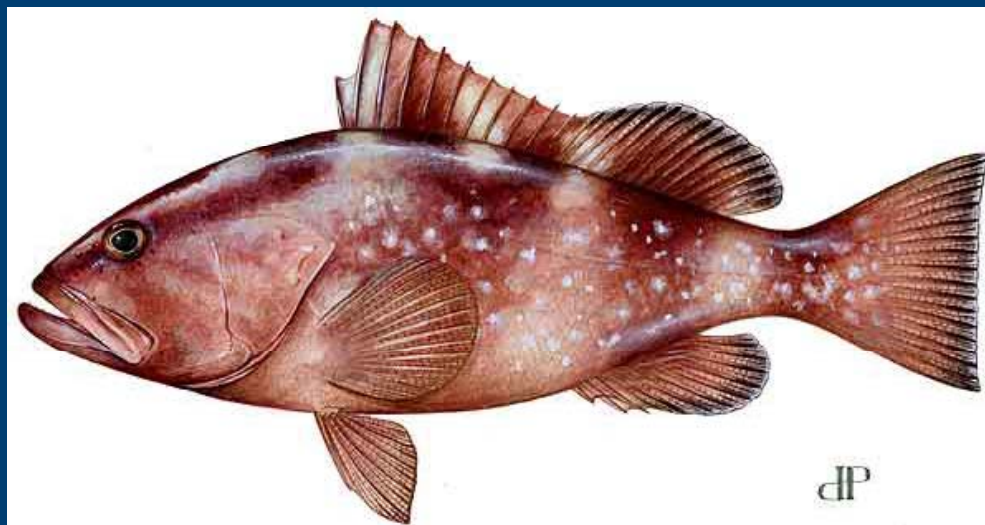
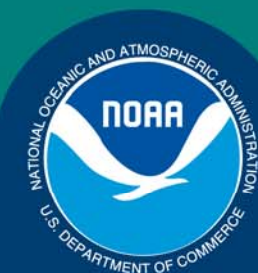


Science, Service, Stewardship



Red grouper (*Epinephelus morio*) Atlantic stock

SEDAR 19 SSC Review
20 April 2010

Kyle Shertzer, NOAA
Beaufort, NC

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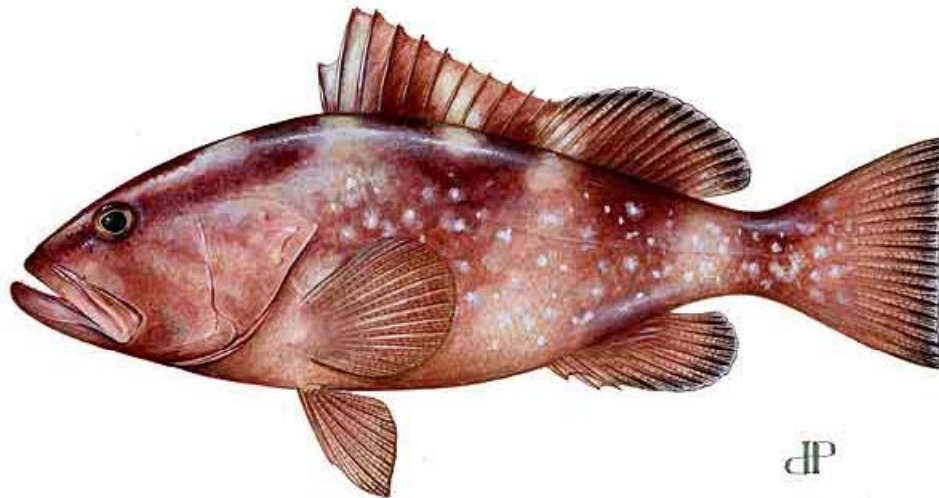
Outline

- Assessment data
 - Stock definition and life history
 - Landings and discards
 - Length and age compositions
 - Indices of abundance
- Assessment models
 - Catch curve analysis
 - Beaufort statistical catch-age model
 - Stock Synthesis 3
 - Surplus production model
- Projections



DATA—Red grouper

Stock definition and life history



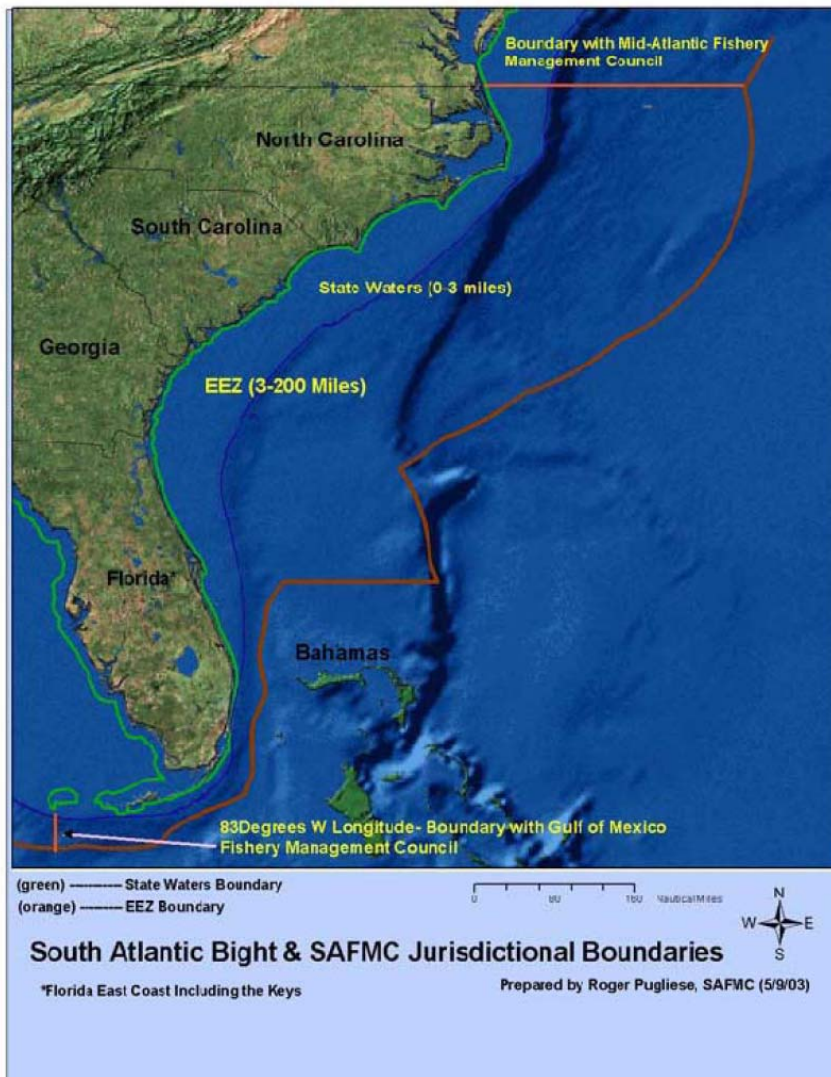


Geographic distribution of red grouper





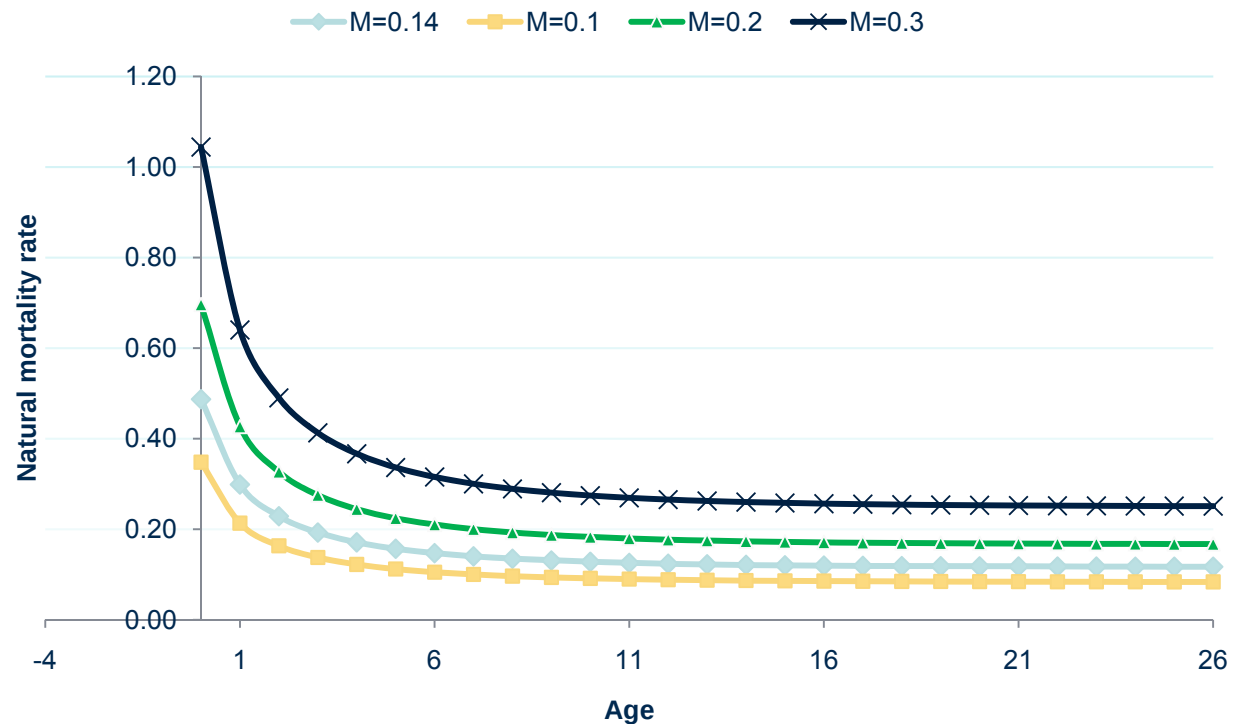
Southeastern U.S., with fishery management council boundaries





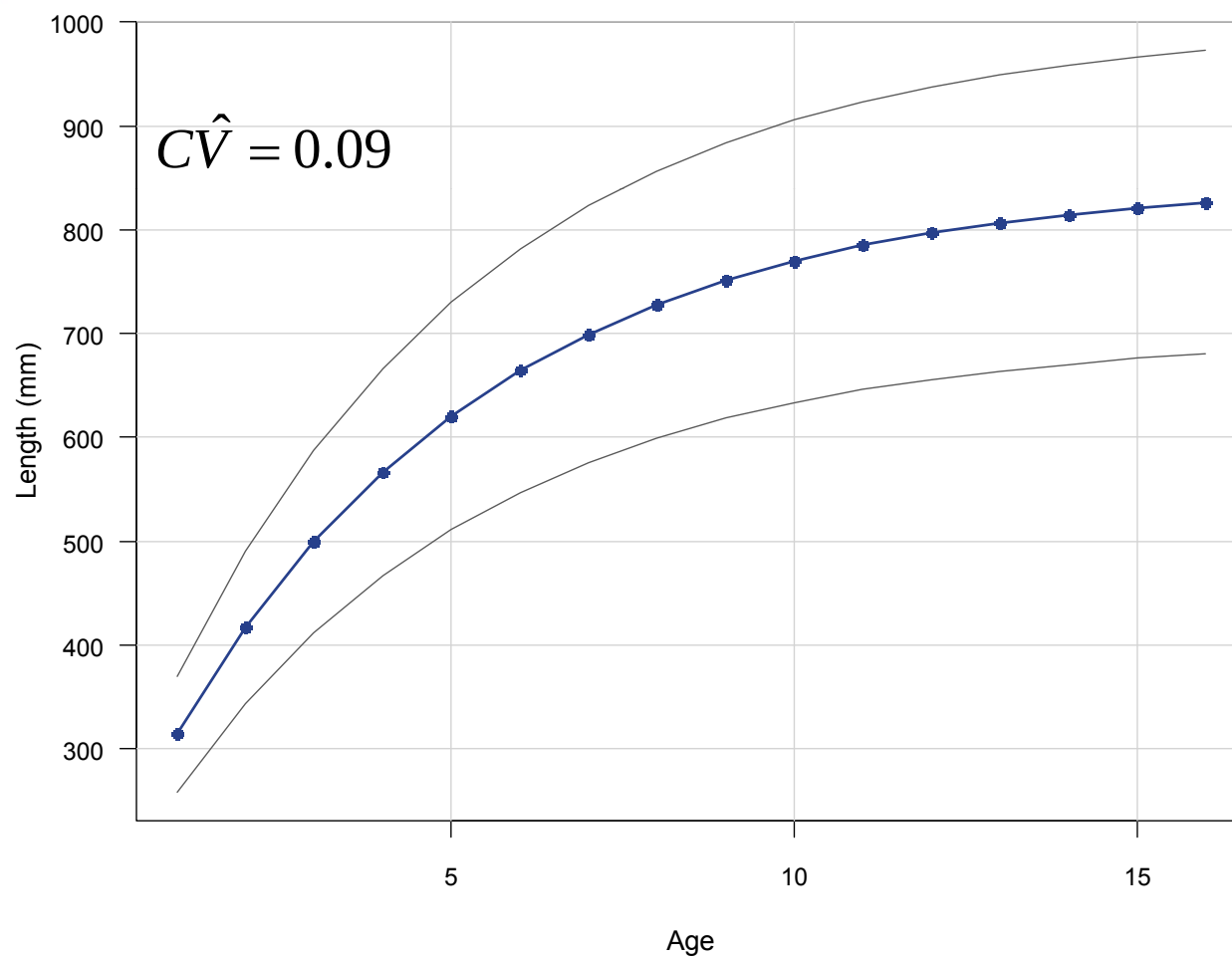
Lorenzen, age-based natural mortality rate

- Maximum observed age of 26
- Hoenig estimate is $M=0.14$





Growth (current size limit 20 inches, 508 mm)



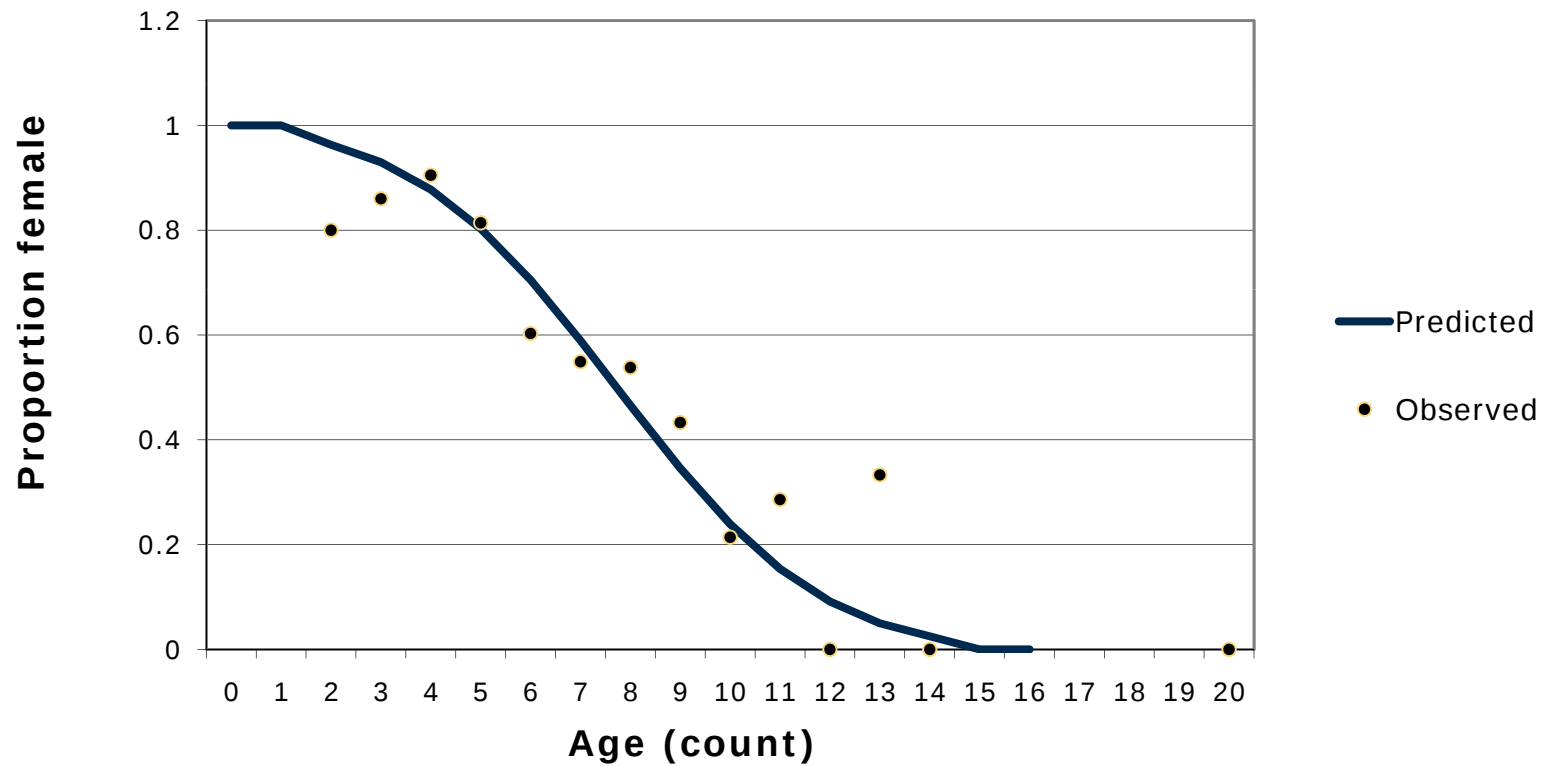


Red grouper reproduction

- Protogynous hermaphrodite (logistic model for proportion male at age)
- Logistic model for female maturity; all males assumed mature
- Spawning season February–June, peak in April (assessment assumes spawning occurs at mid-April)
- Spawning biomass
 - Total mature biomass of both sexes
 - Sensitivity runs using female or male mature biomass

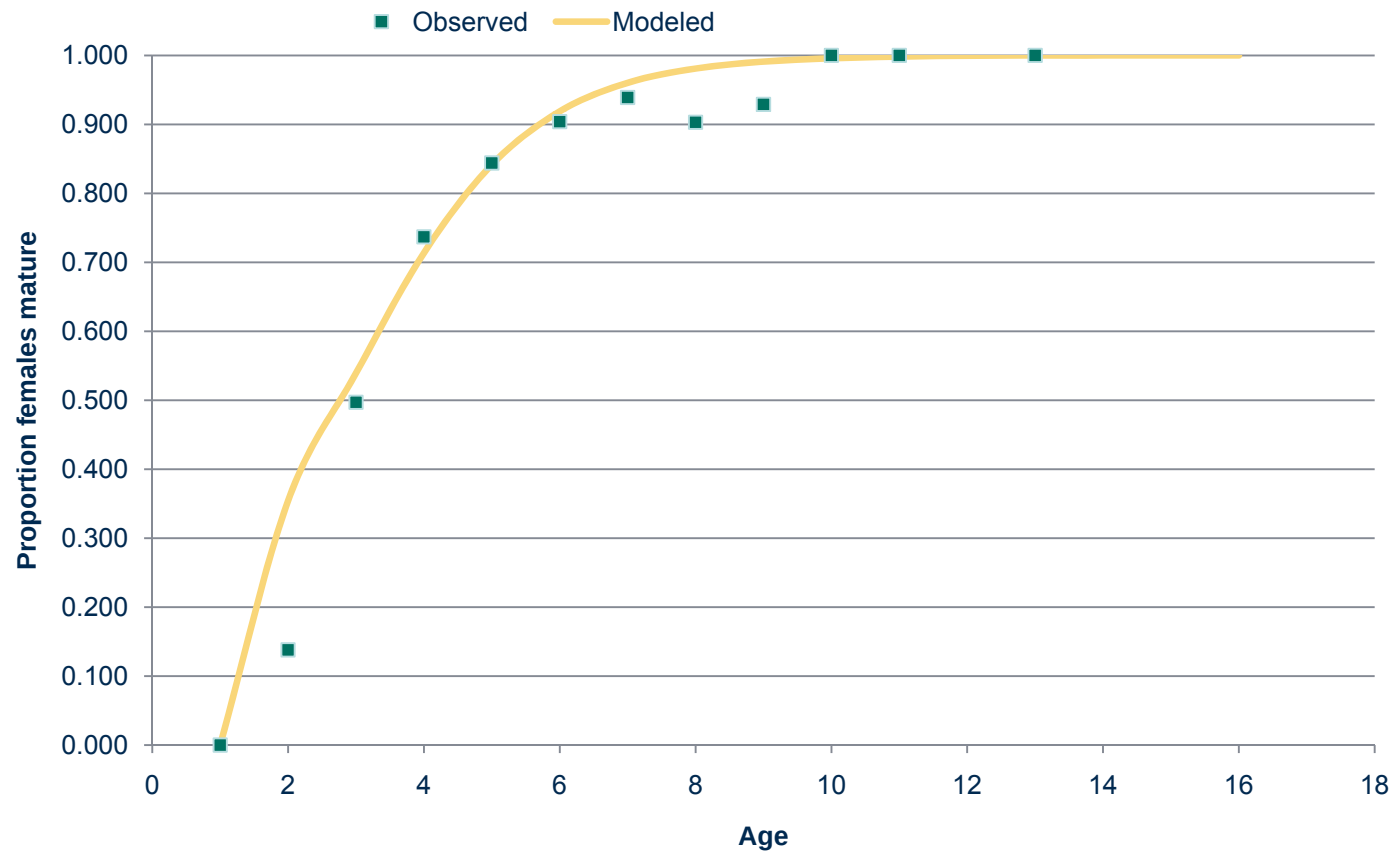


Sex ratio





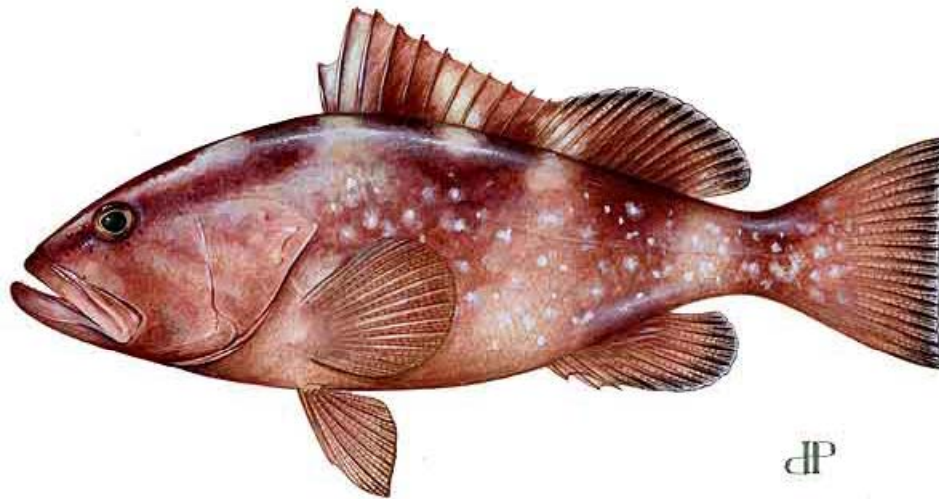
Female maturity (assumed 0 for age 1, logistic model for age 2+)



Age	N
0	0
1	1
2	29
3	185
4	841
5	575
6	136
7	66
8	31
9	14
10	3
11	2
12	0
13	1



DATA—Red grouper Landings and discards



JP



Summary of red grouper regulations

	Commercial	Recreational	
Year	Size Limit	Size Limit	Possession Limit
FEDERAL +NC, SC, GA			
1983 (August)	12" TL	12" TL	
1992 (January)	20" TL	20" TL	5 grouper/person/d
FLORIDA			
1985 (July)	18" TL	18" TL	
1990 (February)	20" TL	20" TL	

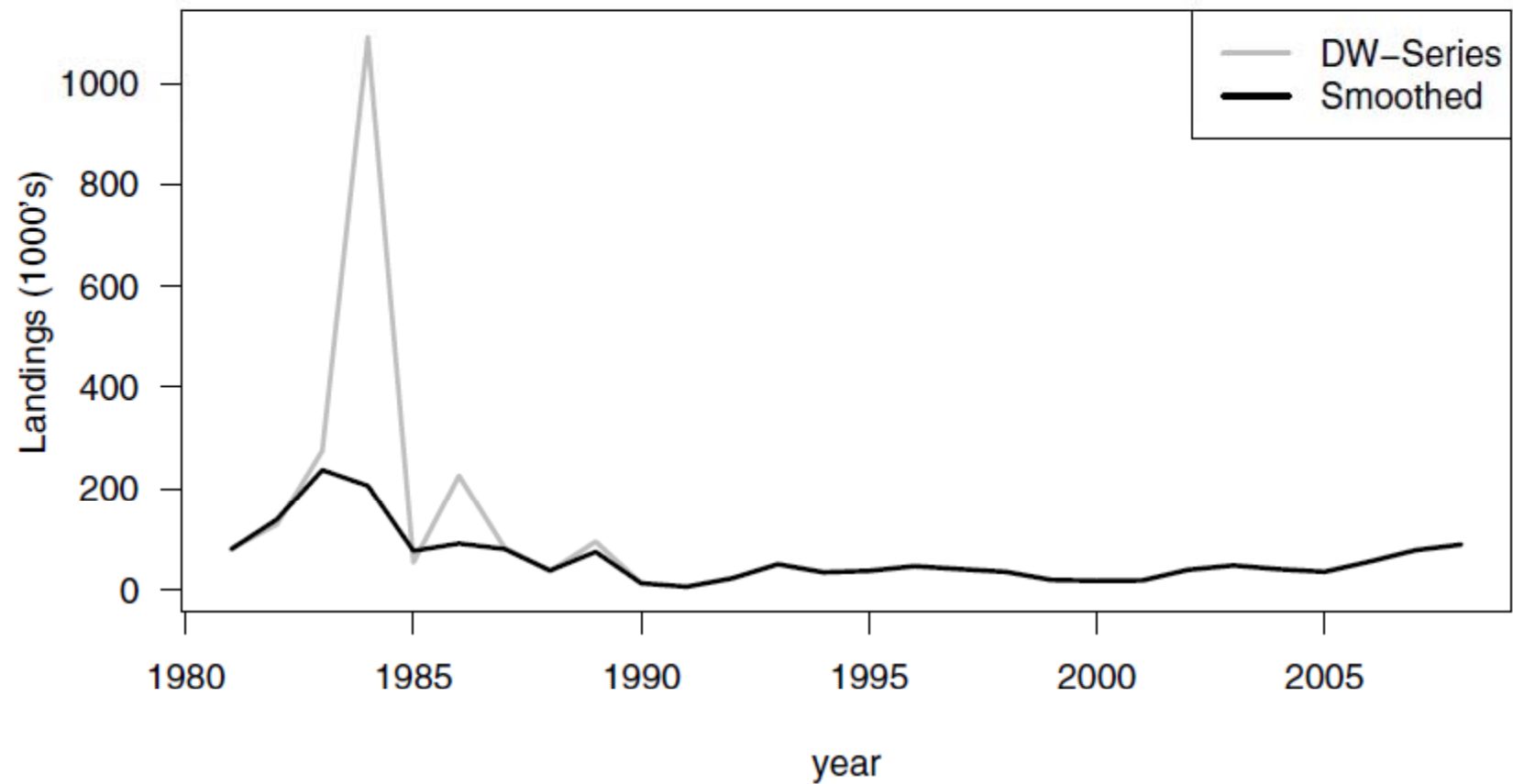


Recreational landings

- Recreational landings in units 1000 fish
- Sampling of general recreational 1981–2008 (MRFSS)
 - MRFSS landings smoothed for input to assessment model
- Sampling of headboats 1972–2008
- Assessment period 1976–2008
 - In years without data, assessment applied average F by fleet

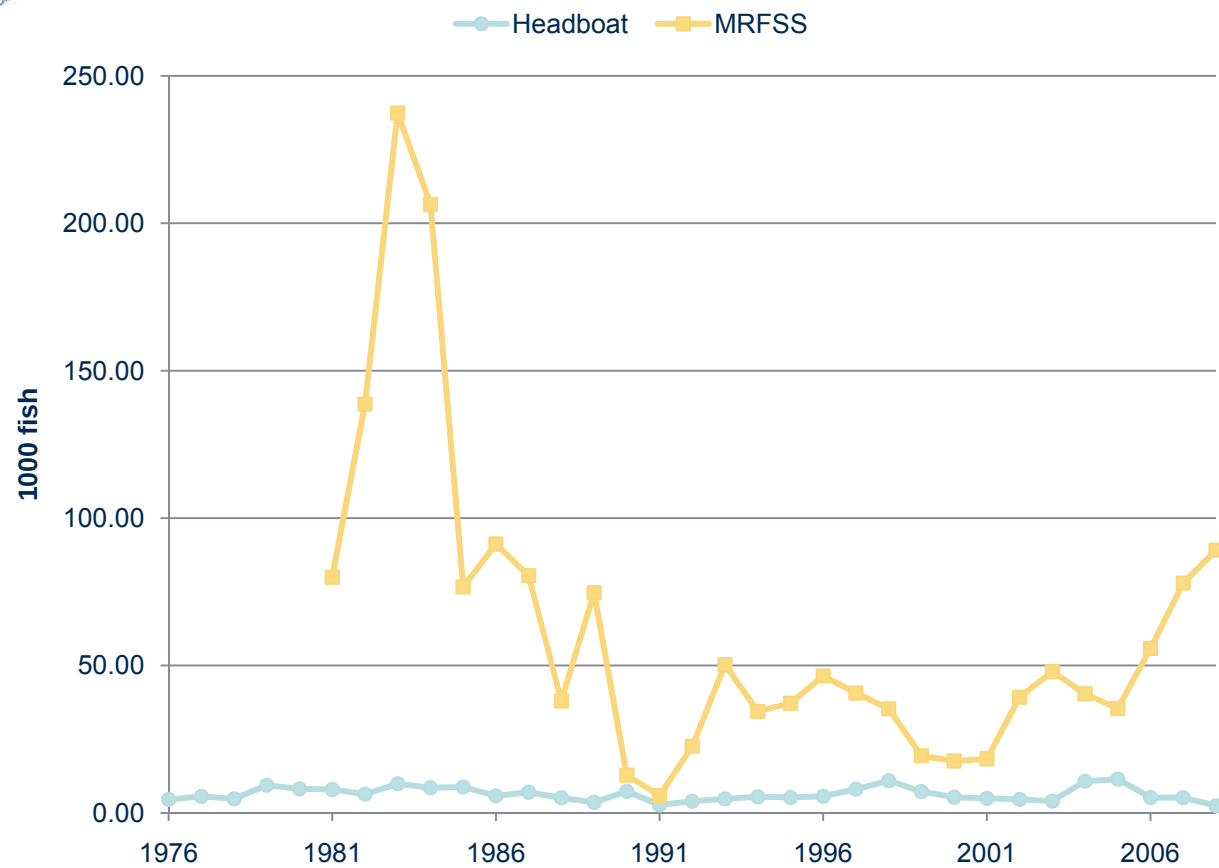


MRFSS landings





Recreational landings



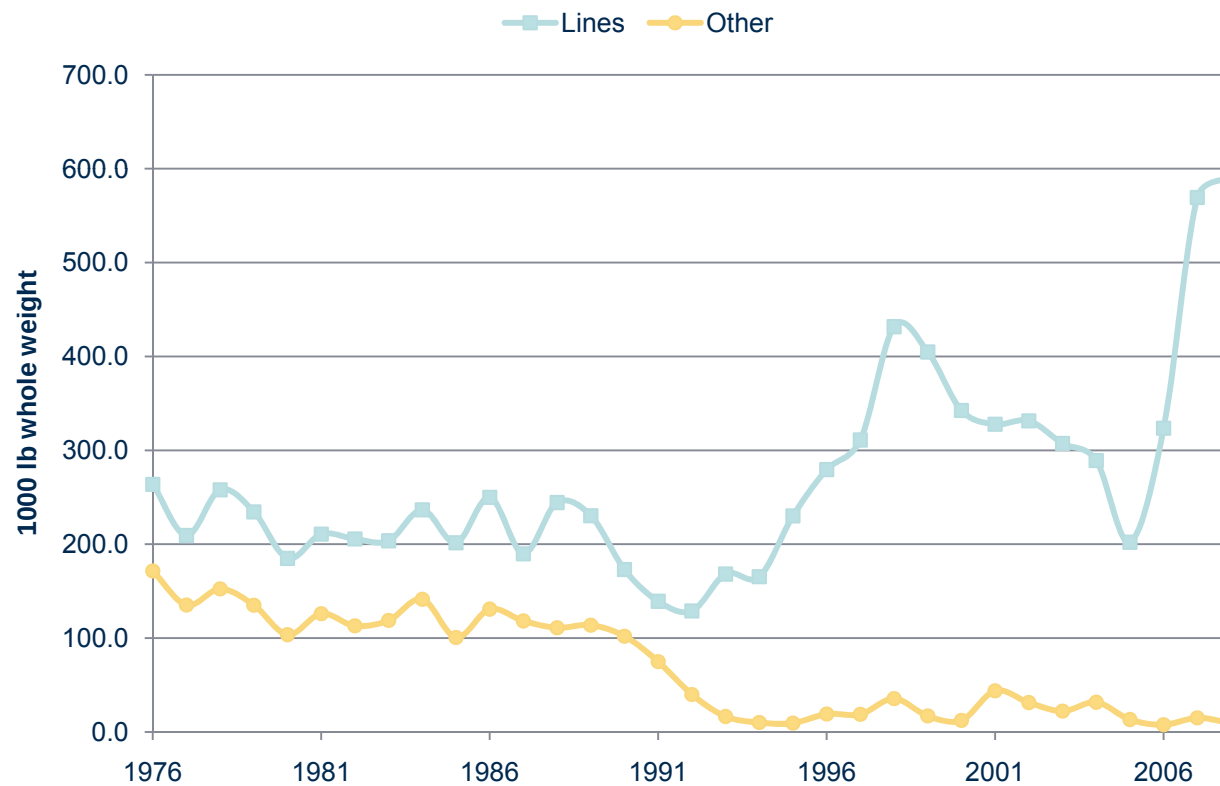


Commercial landings

- Commercial landings in units 1000 lb whole weight
- Pooled commercial handline and longline landings into “commercial lines”
- Pooled commercial diving, trap, and miscellaneous gears into “commercial other”
- Why pool?
 - Not much information to estimate separate selectivity for longline gear
 - Evidence that handline and longline caught similar sized fish
 - Trap, diving, and miscellaneous likely have dome shaped selectivity

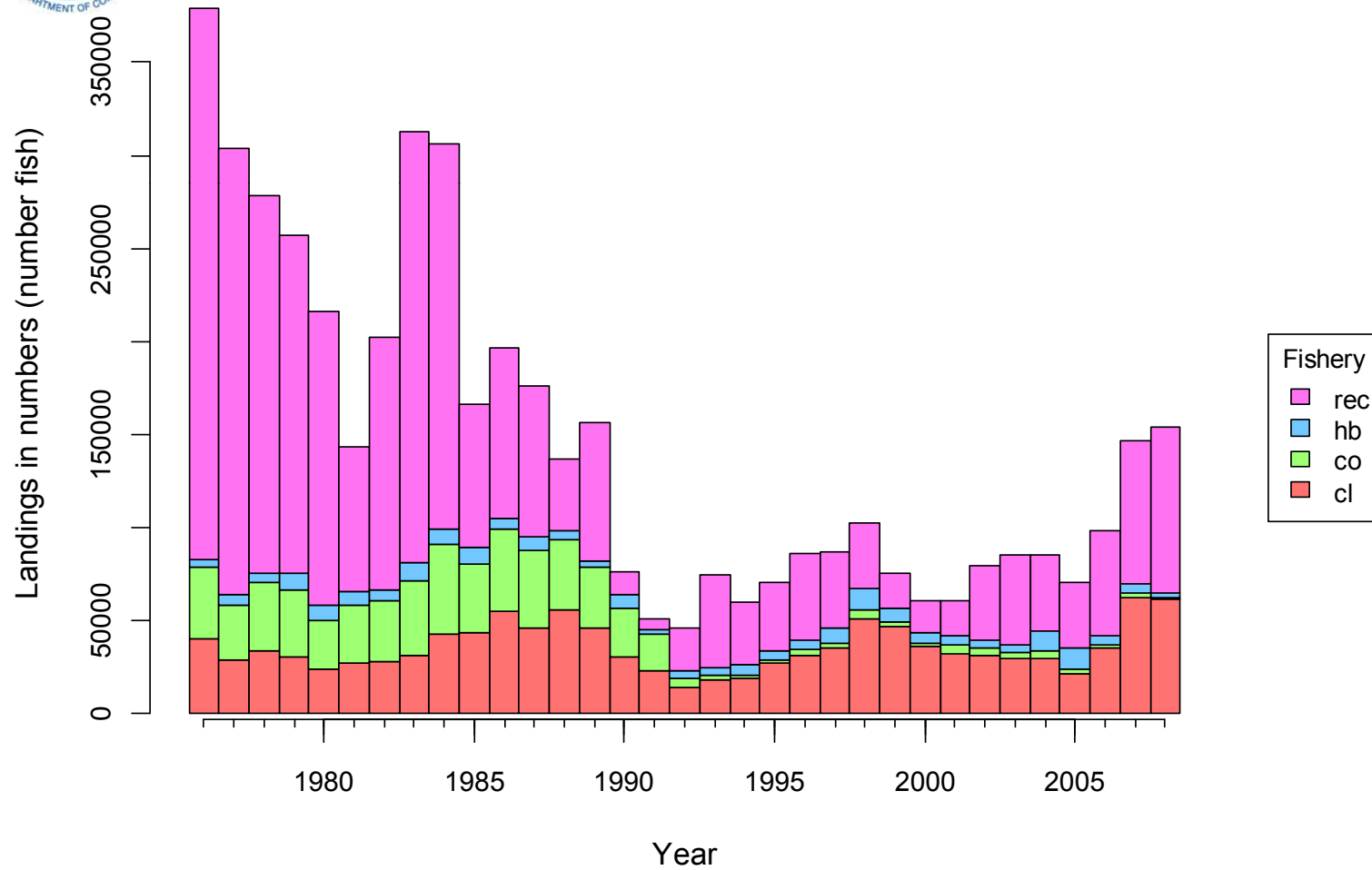


Commercial landings





Total landings by fleet (fishery)



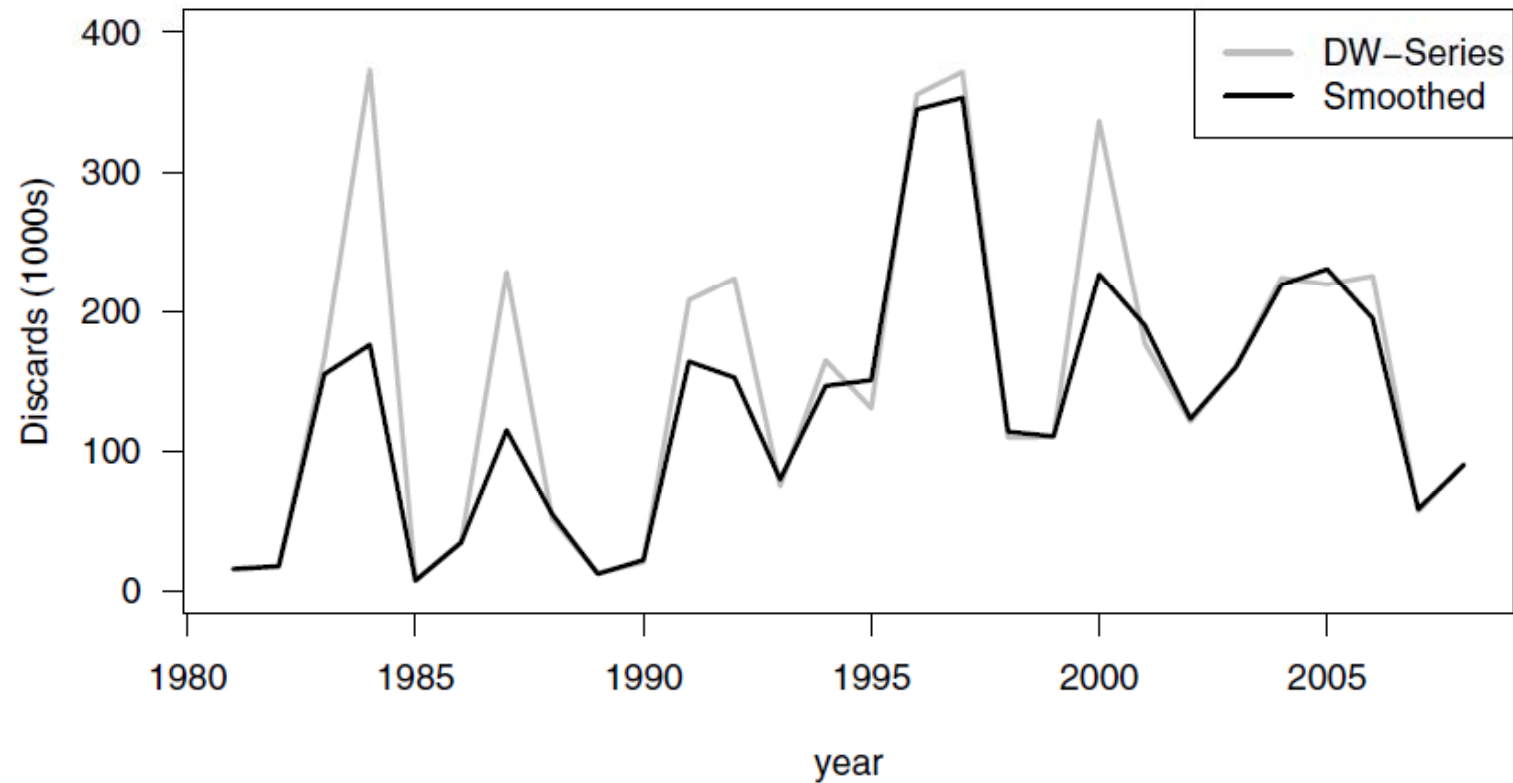


Discards (units 1000 fish)

- Recreational
 - MRFSS discard estimates available for 1981–2008 (smoothed)
 - Headboat discard estimates available for 2005–2007, extended back to 1984 with start of size limit
- Commercial lines
 - Handlines - logbook estimates for 1992–2008, extended back to 1984 with start of size limit
- Assessment period 1976–2008
 - In years without data, assessment applied average F by fleet



MRFSS discards



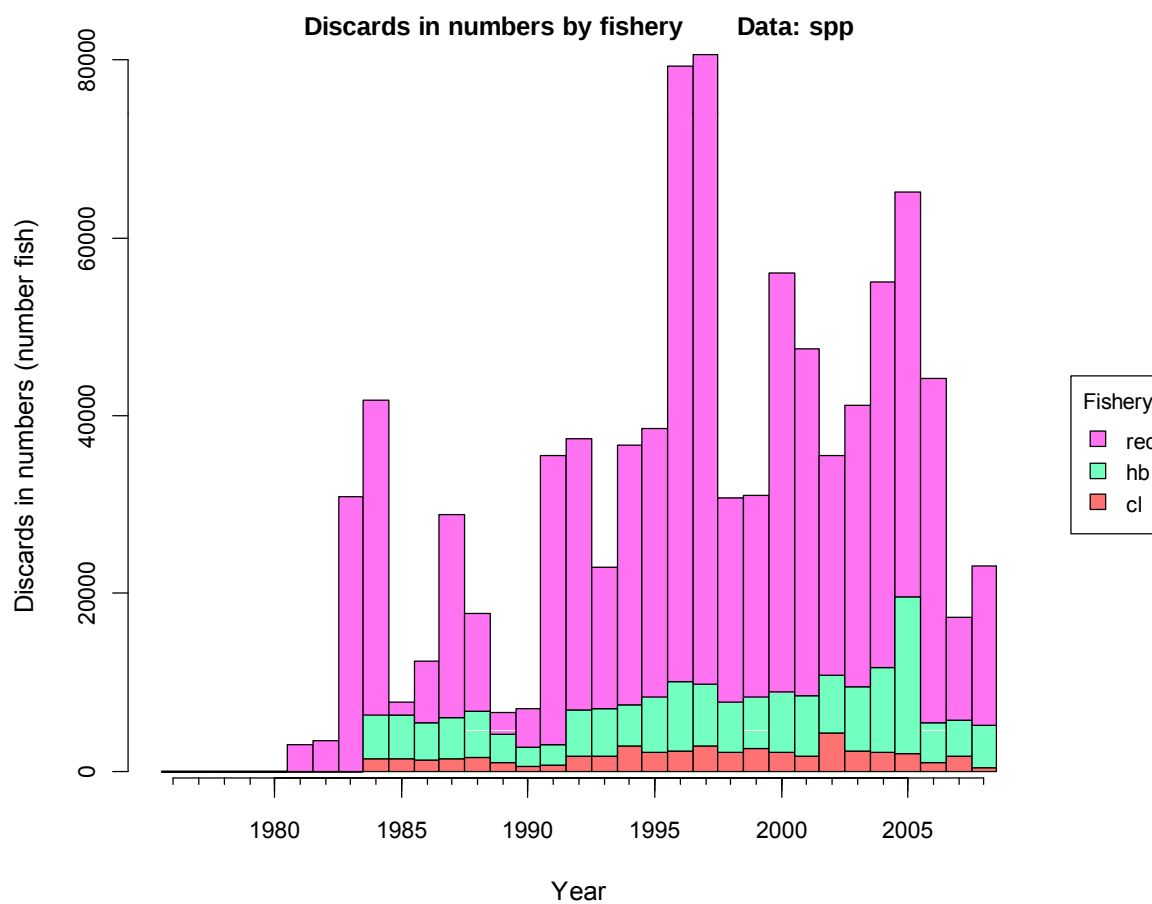


Release mortality rates

- Empirical estimates are few and variable
- Point estimate of 0.2 for all sectors, as suggested by the DW
- Range applied to base model (0.1, 0.3)
- Sensitivity runs: 0.1, 0.3, 0.7

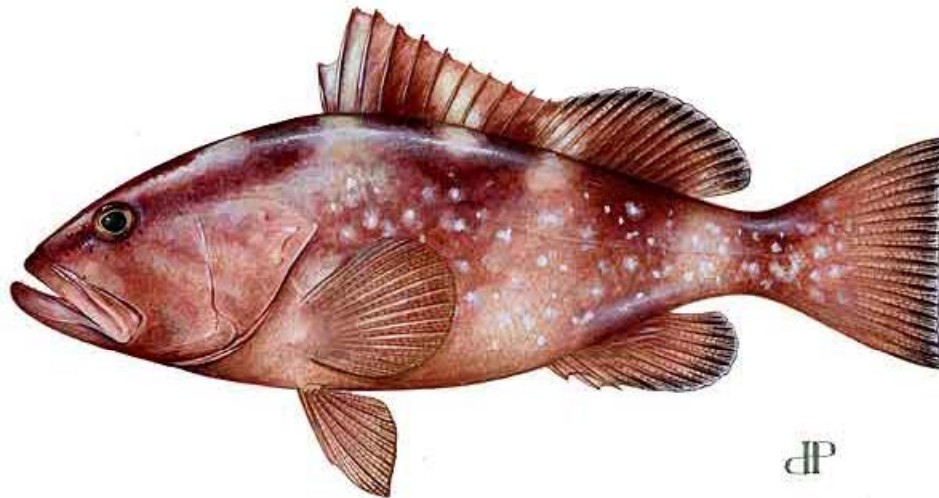


Discard mortalities modeled by fleet





DATA—Red grouper Indices of abundance



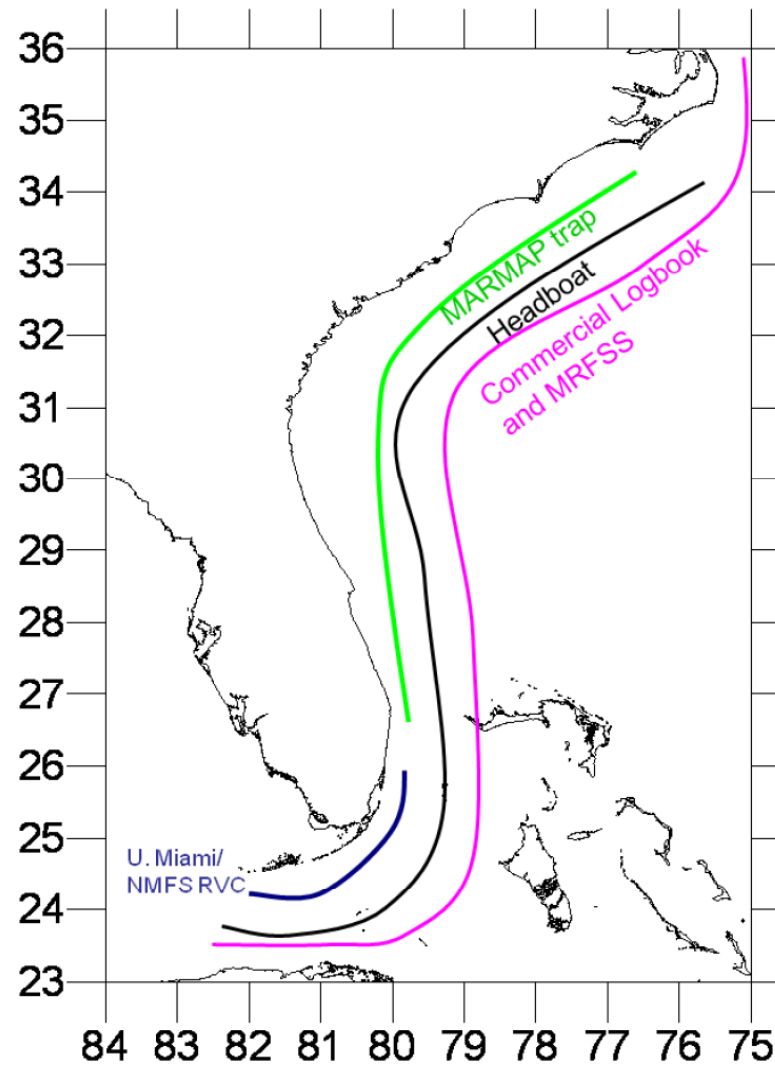


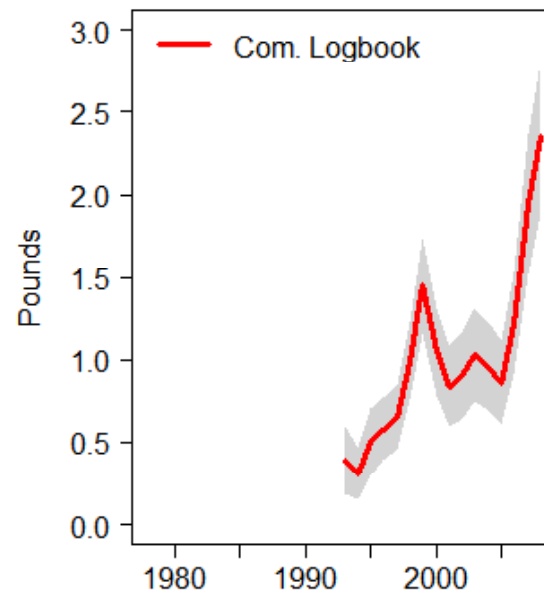
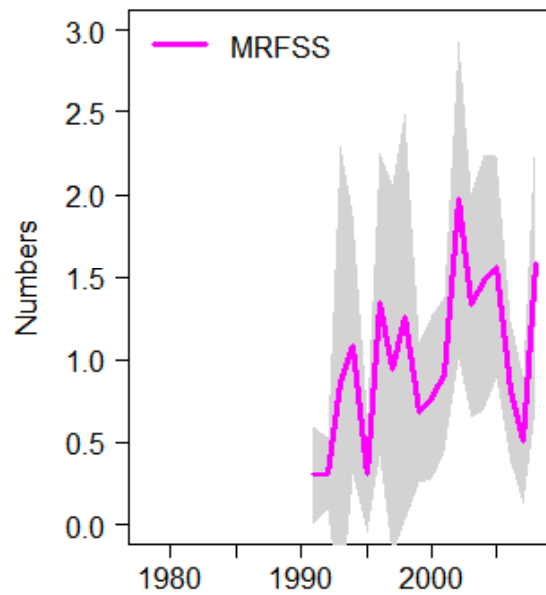
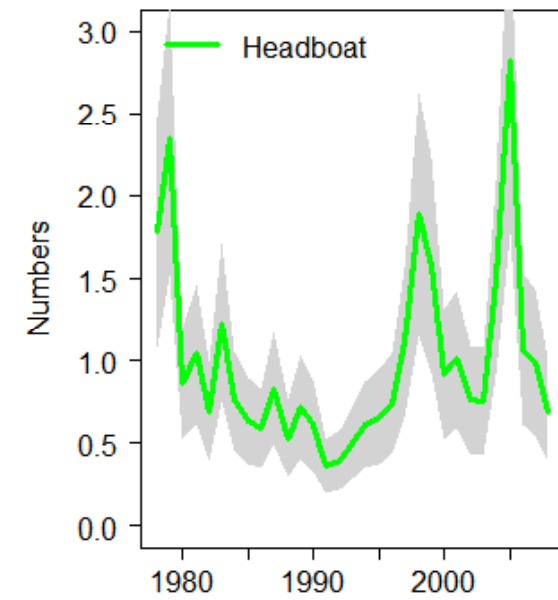
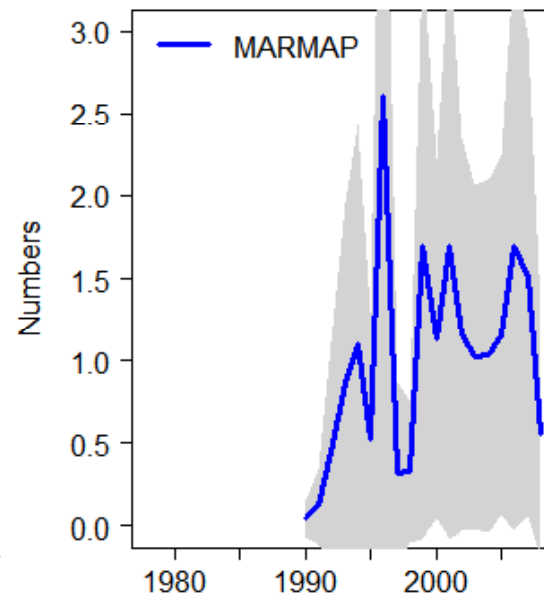
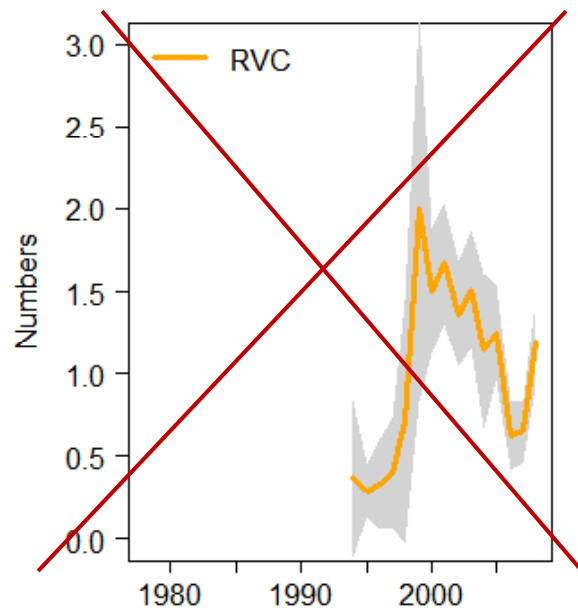
Indices included in assessment

- Fishery independent
 - ~~FL keys visual survey (U. Miami)~~
 - MARMAP chevron traps
- Fishery dependent
 - Commercial logbook
 - Headboat
 - MRFSS



Spatial coverage of indices



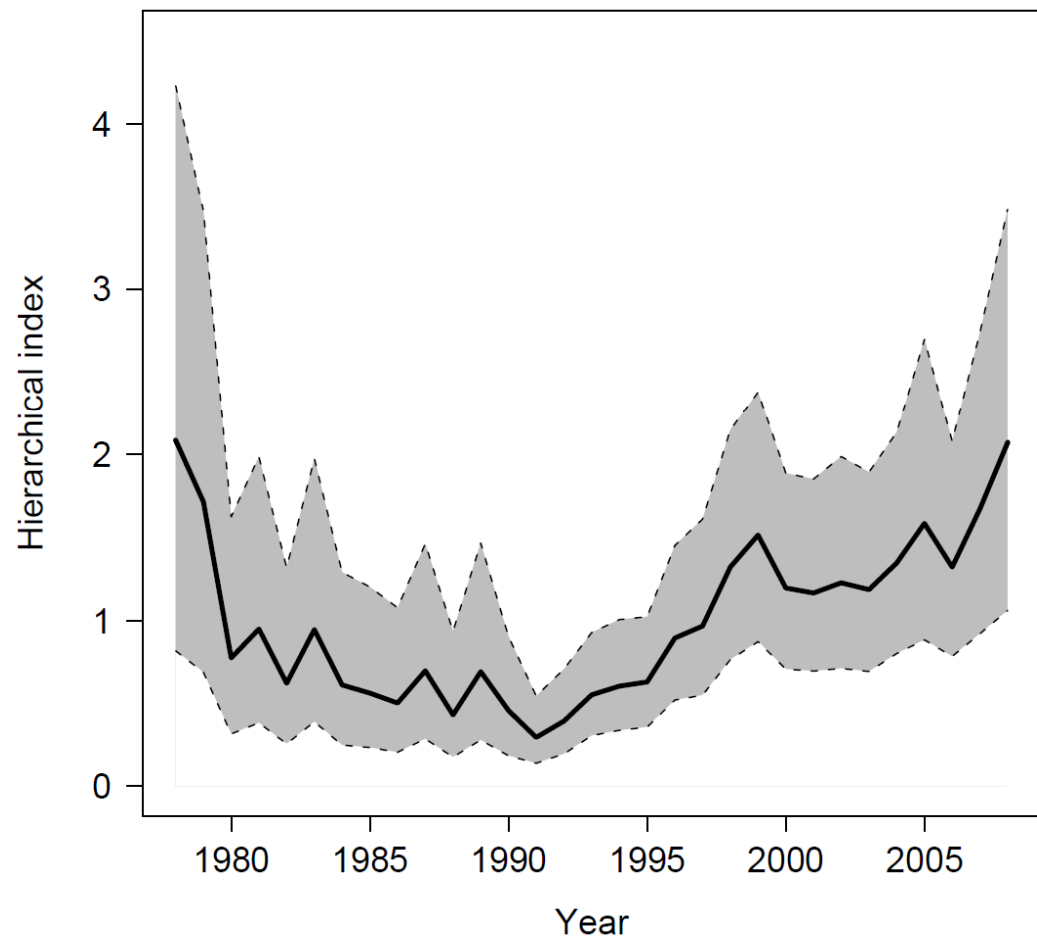


Indices of Abundance



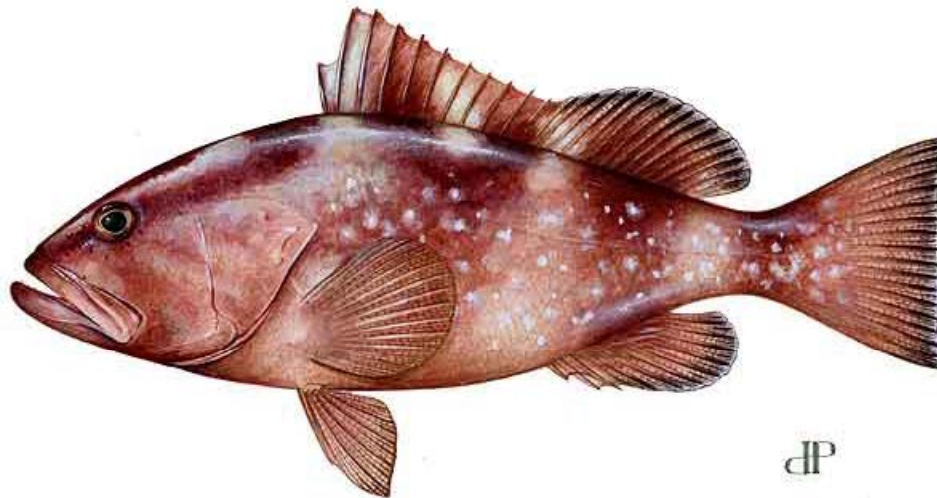
Combined Index w/ 95% credible intervals

- Methods from Conn. 2010. CJFAS 67:108-120.
- Used in select production model runs only





DATA—Red grouper Length and age comps



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**Fishery
independent
and
recreational:
length comp
sample sizes**

Year	MARMAP		RVC Data	MRFSS		Headboat		Headboat Discards	
	N (fish)	N (trips)	N_DiveEvents	N (total)	N (trips)*	N (fish)	N (trips)	N (fish)	N (trips)
1973						10	9		
1974						14	9		
1975						26	18		
1976						65	40		
1977						120	73		
1978						98	56		
1979						158	89		
1980						194	115		
1981				23	17	237	148		
1982				31	16	277	162		
1983				31	19	382	224		
1984				30	22	573	284		
1985				17	14	577	247		
1986				27	14	384	203		
1987				31	21	287	173		
1988				22	14	210	139		
1989				34	11	241	153		
1990	2	2		8	6	155	104		
1991	3	3		7	7	65	54		
1992	16	6		26	23	83	59		
1993	20	8		41	27	111	80		
1994	30	10	126	41	27	144	104		
1995	9	6	291	50	31	186	112		
1996	10	9	151	41	32	263	157		
1997	40	23	408	40	29	404	186		
1998	78	28	461	58	44	466	272		
1999	48	21	440	64	38	310	192		
2000	38	25	527	34	24	203	132		
2001	38	20	742	71	48	160	119		
2002	37	21	628	104	60	189	142		
2003	37	19	448	88	53	120	94		
2004	40	22	246	82	36	152	97		
2005	29	25	498	61	37	154	107	280	93
2006	44	18	608	95	40	137	93	154	59
2007	43	21	619	181	43	126	85	126	36
2008	24	12	735	179	55	64	49	63	22

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Commerical: length comp sample sizes

Year	Lines		Pots and Traps	
	N (fish)	N (trips)	N (fish)	N (trips)
1984	91	19		
1985	131	31		
1986	1017	33	1243	13
1987	1510	46	756	6
1988	1975	67	33	1
1989	774	62	357	8
1990	603	73	70	6
1991	627	77	30	5
1992	194	42	21	2
1993	429	71		
1994	576	76	15	1
1995	1064	94		
1996	364	79		
1997	400	64		
1998	688	105		
1999	1636	176		
2000	1595	214		
2001	850	149		
2002	596	116		
2003	809	135		
2004	1239	181		
2005	1390	259		
2006	2180	314		
2007	3755	432	26	4
2008	3866	408		

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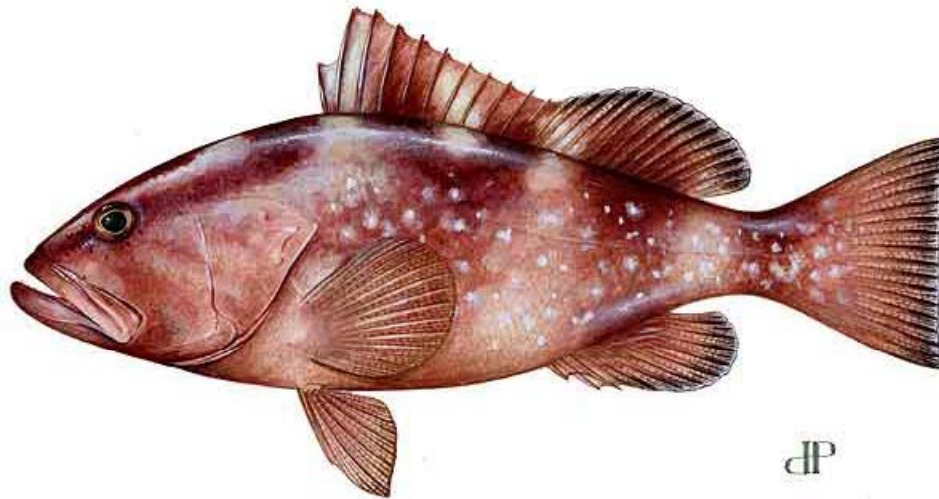


Age comp sample sizes

Year	MARMAP		Recreational		Headboat		Handline	
	N (fish)	N (trips)	N (fish)	N (trips)	N (fish)	N (trips)	N (fish)	N (trips)
1977					7	6		
1978					12	7		
1979					40	30		
1980					153	76		
1981					180	113		
1982					74	51		
1983					38	35		
1984					44	41		
1985					24	20		
1986					18	13		
1987					17	8		
1988					22	14	5	1
1989					5	4		
1990					11	10		
1991	3	3			16	13		
1992	15	6			4	3		
1993	19	8			4	4		
1994	29	10			9	7		
1995	7	6						
1996	9	9			8	7		
1997	36	23			2	2	21	9
1998	72	28			3	3	42	17
1999	47	21					27	13
2000	33	25					22	11
2001	37	20	14	6			52	21
2002	36	21	46	20	3	3	24	17
2003	36	19	30	13	9	8	36	15
2004	39	22	17	7	34	30	268	65
2005	28	25	38	16	82	68	535	147
2006	44	18	19	8	59	52	853	219
2007	43	21	8	3	47	42	1327	387
2008	16	12	3	1	36	25	2104	395



ASSESSMENT—Red grouper Catch curve analysis

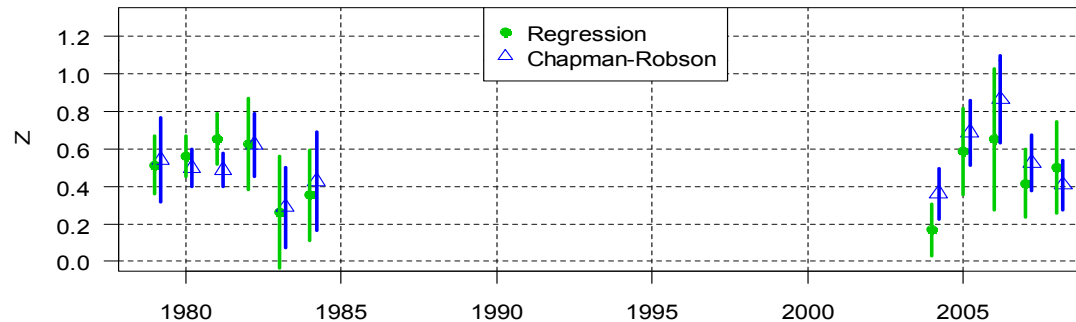


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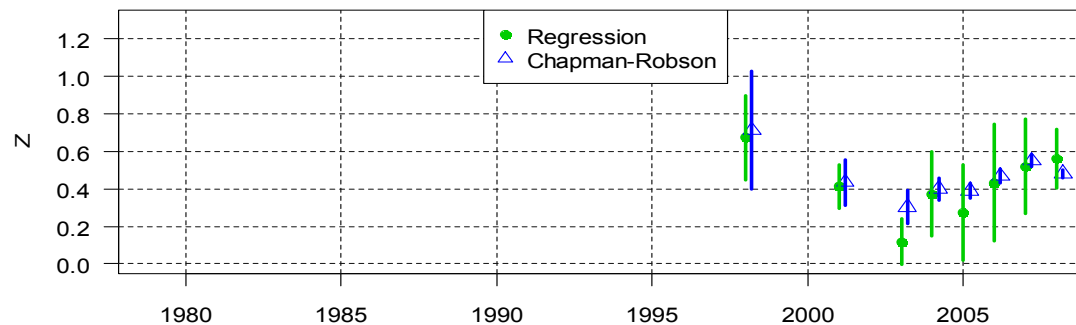
Catch Curve Analysis

- Regression and Chapman-Robson estimators
- Point estimates of total mortality Z are generally in the range of (0.3,0.6), but wide confidence intervals

Z from headboat age comps

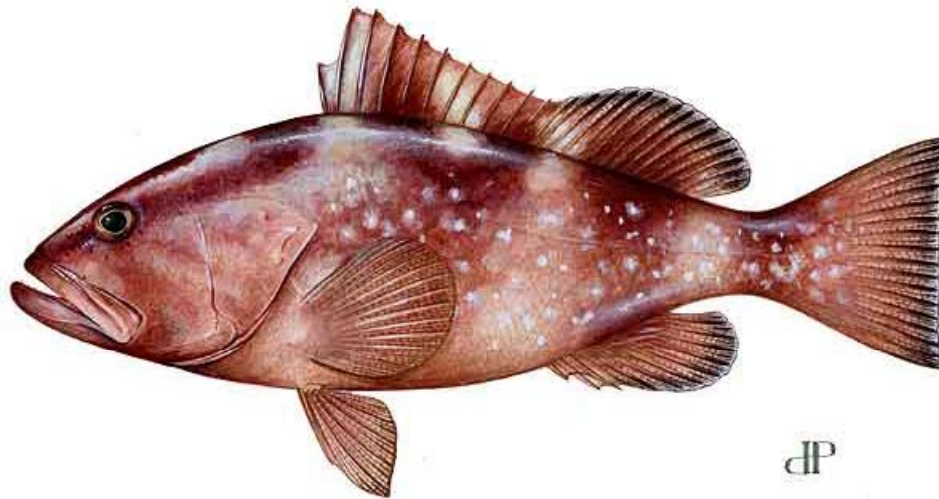


Z from commercial age comps





ASSESSMENT—Red grouper Beaufort assessment model (BAM)





BAM: overview

- Same basic formulation used in previous SEDAR assessments of Atlantic snapper-grouper species.
- Forward-projecting
- AD Model Builder software for optimization (parameters added in phases)
- Tested on simulated data
- Statistical catch-age model: Likelihood includes multinomial (composition data) and lognormal (landings and index data) components, plus priors and penalty terms.



BAM: overview

- Modeled ages 1–16+
- Assessment period: 1976–2008.
- Initial abundance at age estimated, penalized for deviating from stable age structure given early F
- Age-varying natural mortality (M), based on Lorenzen (1996)
- Age-length conversion matrix
 - Probability matrix that assumes normal distribution of length at age with estimated CV
 - Truncated normal if size limit applies
- Baranov catch equation
- Options for catchability applied to fishery dependent indices



BAM: recruitment

- Beverton-Holt spawner-recruit model
- Spawners based on total mature biomass (males + females)
- Annual recruitment events loosely conditioned on S-R curve with lognormal error
- MSY-benchmarks from bias-corrected S-R model



BAM: steepness (h)

- Steepness is a key parameter of the spawner-recruit function defining productivity of the stock, particularly at low stock sizes
- Applied a normal prior, with mean=0.72 and sd=0.17 (SEDAR19-DW-06).
- Model runs indicate steepness ≈ 0.92



BAM: selectivities

- MARMAP trap modeled with the double-logistic fcn (dome-shaped)
- Commercial lines, recreational, headboat
 - Landings selectivities modeled with the logistic fcn (flat-topped)
 - Discard selectivities
 - Age-1 Estimated (free parameter)
 - Age-2 Fixed at 1.0 (full selection)
 - Age-3+ Fixed at age-specific probability of being below cutoff size
- Commercial other (pots, traps, diving, misc.)
 - Modeled as dome-shaped
 - Little comp data for estimation
 - Mirrors chevron trap selectivity, but with ascending inflection point fixed at age at size limit
- Selectivity used to estimate benchmarks is an F-weighted average across landings and discard selectivities from last three assessment years (2006–2008)
- Selectivities for fishery dependent indices were the same as those applied to the fisheries. MRFSS index selectivity included landings and discards.



BAM: catchability options

- Catchability for fishery independent indices
 - Constant q
- Catchability for fishery dependent indices
 - **Constant q**
 - Linearly increasing q until 2003, constant thereafter
 - Density dependent q
 - Random walk
- AW applied random walk to fishery dependent indices, and examined q as a function of either time or biomass. No patterns emerged, and so AW recommended constant q as the most parsimonious choice.



Accommodating missing data

- Assessment yrs are 1976–2008. Landings and discards data not available for all years for all fleets.
 - MRFSS L and D: 1981–2008
 - HB D: 2005–2007 (DW filled in blanks with ratios)
 - Comm lines D: 1992–2008
- Model predicts missing L and D using average F's (these years are not included in the objective fcn)
 - MRFSS L extended back to 1976 using average 1981–1983 F
 - HB D extended to fill 1984–2008, with average 2005–2007 F
 - Comm lines D extended to fill 1984–2008, with average 1992–2008 F



BAM: Likelihood weighting

- No external weights applied
- Lognormal components controlled by CV
 - Landings, discards assumed to have $CV=0.05$ to achieve close fit
 - Indices applied the CV estimated by the DW
- Age/length composition fits influenced by effective sample size, here assumed to equal the number of trips sampled (rather than number of fish)



Base run and uncertainty

- Base run configuration:
 - Age-based M scaled to Hoenig $M=0.14$
 - Discard mortality rate of 0.2
- Uncertainty in results estimated using:
 - Sensitivity and retrospective analyses
 - Mixed Monte Carlo and bootstrap approach (MCB)



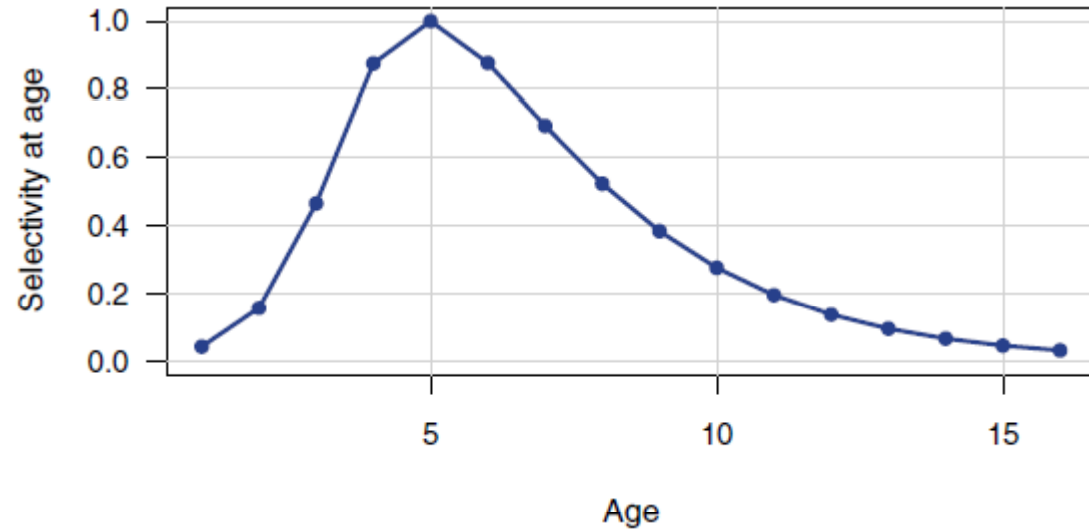
Fits to data (figures in report)

- Landings, discards fit closely (by design)
- Indices and age/length comps fit reasonably well
- Any concerns?



BAM selectivities (base run)

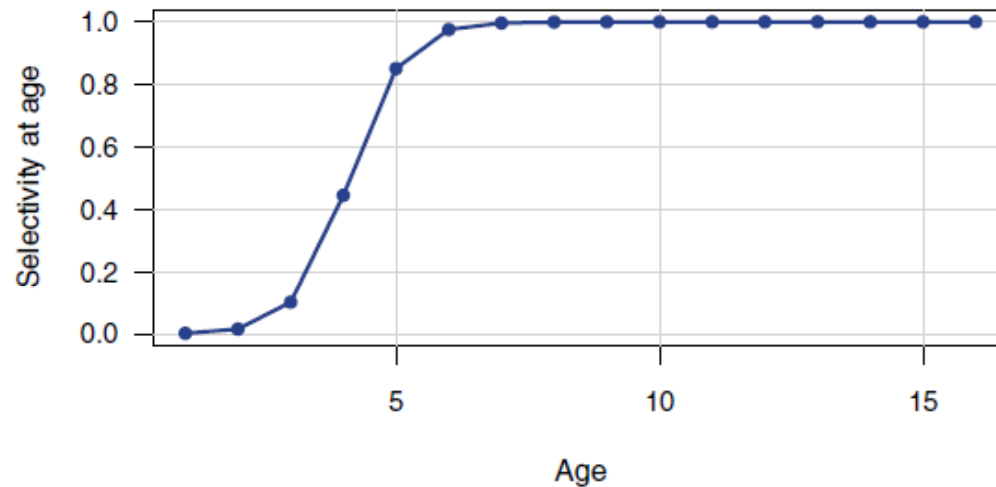
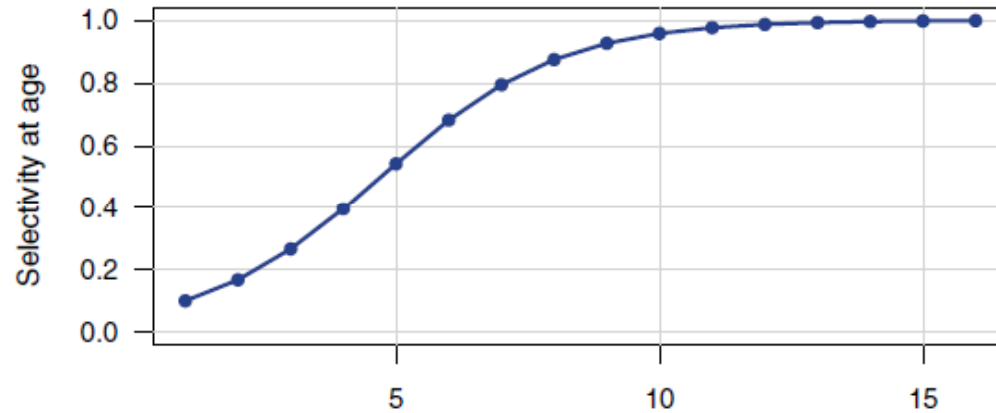
Figure 6.26. Selectivities of the MARMAP chevron traps (fishery independent survey).





BAM selectivities (base run)

Figure 6.27. Selectivities of commercial lines. Top panel: 1976–1991. Bottom panel: 1992–2008.





BAM selectivities (base run)

Figure 6.28. Selectivities of commercial other gears. Top panel: 1976–1991. Bottom panel: 1992–2008.

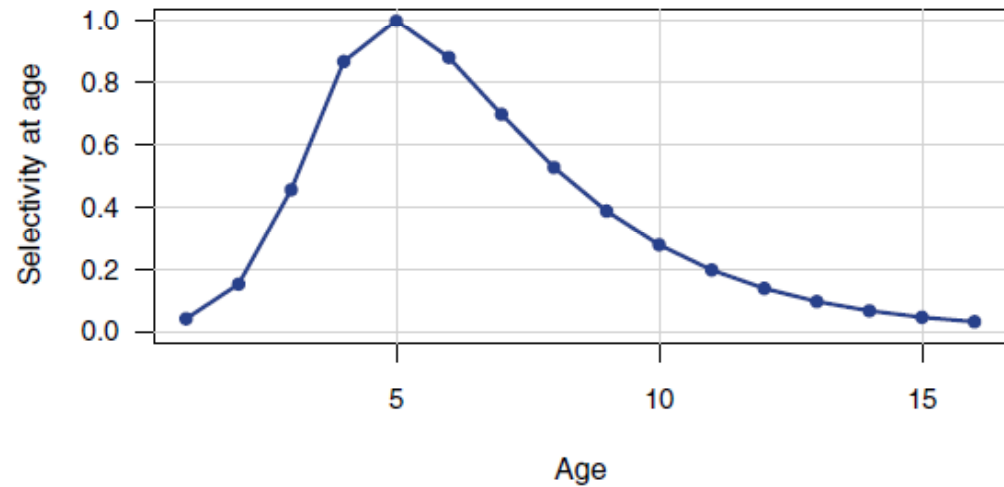
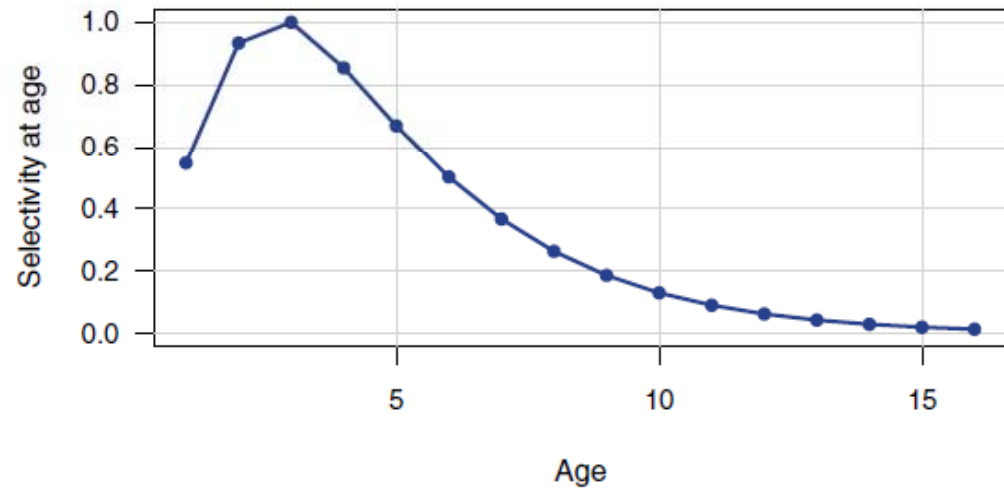
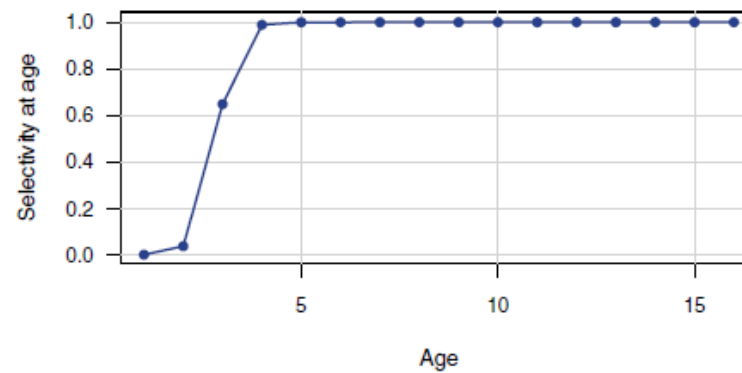
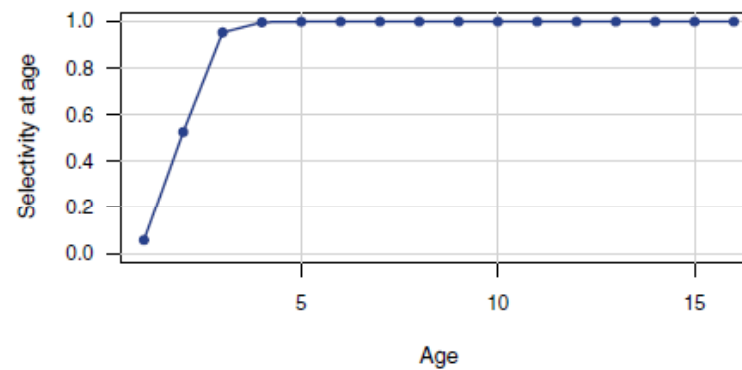
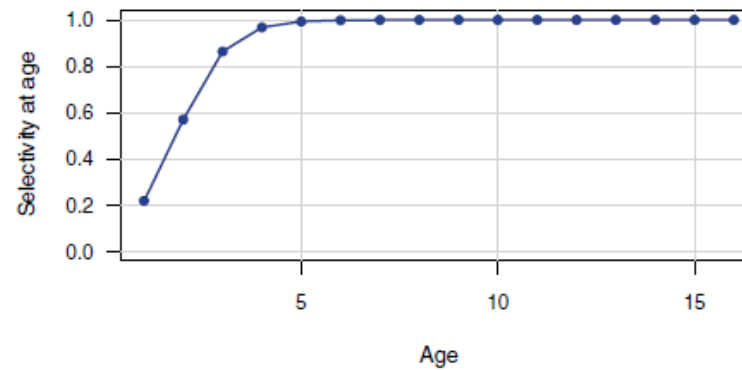




Figure 6.29. Selectivities of the headboat fleet. Top panel: 1976–1983. Middle panel: 1984–1991. Bottom panel: 1992–2008.

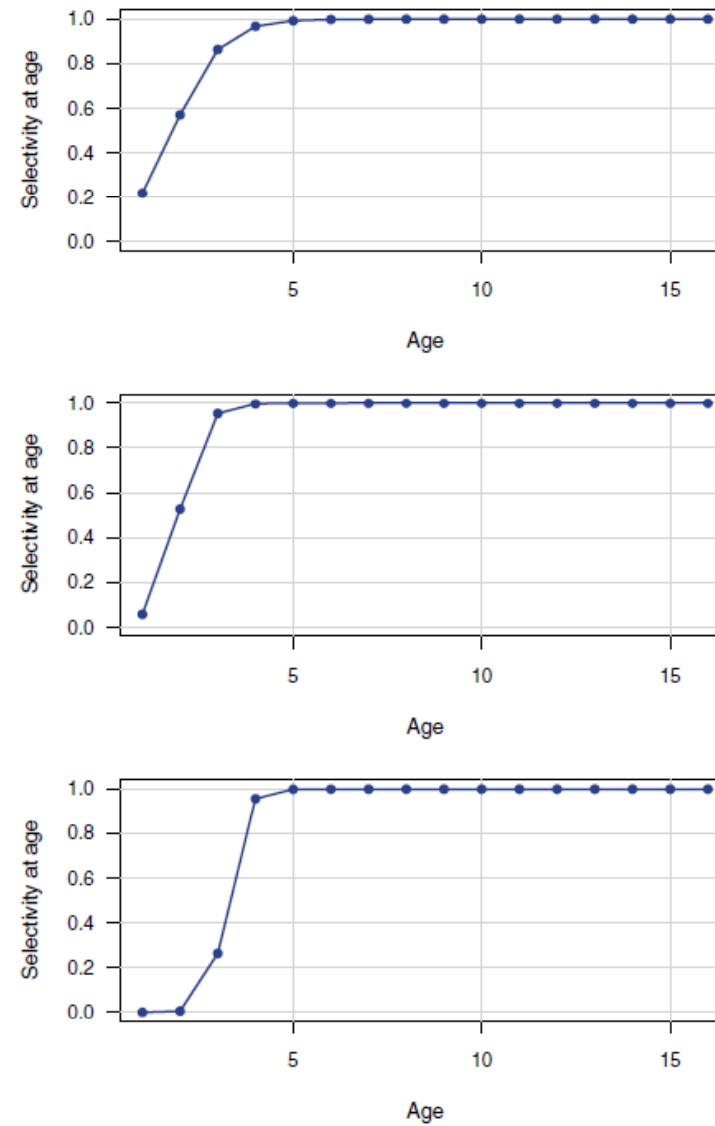


**BAM
selectivities
(base run)**



BAM selectivities (base run)

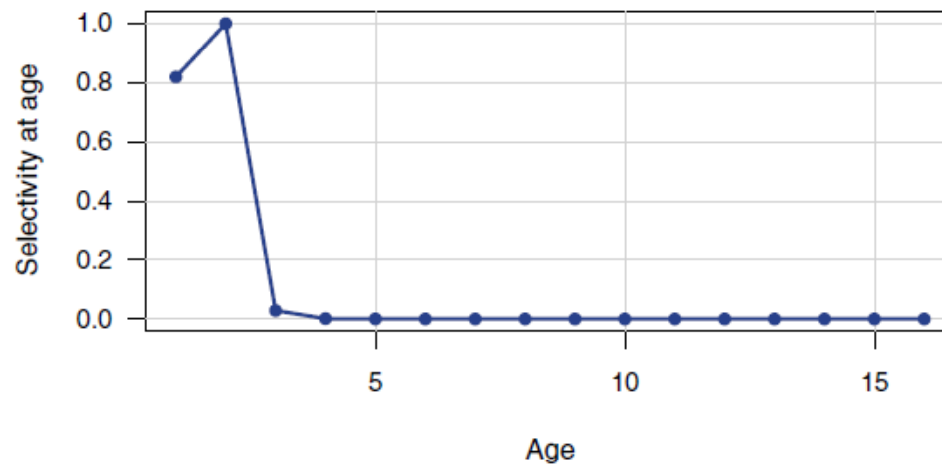
Figure 6.30. Selectivities of the general recreational fleet. Top panel: 1976-1983. Middle panel: 1984-1991. Bottom panel: 1992-2008.





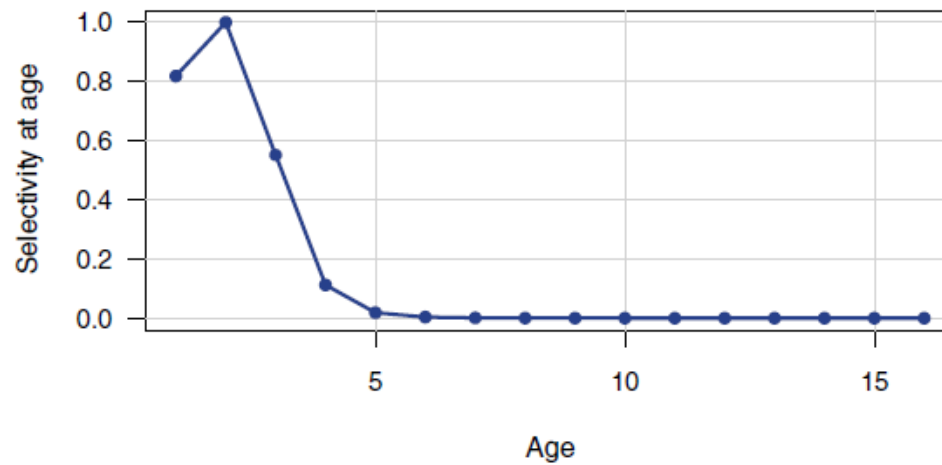
Discard selectivities:
comm lines, recreational, headboat

Pre-1992



BAM selectivities (base run)

1992-2008

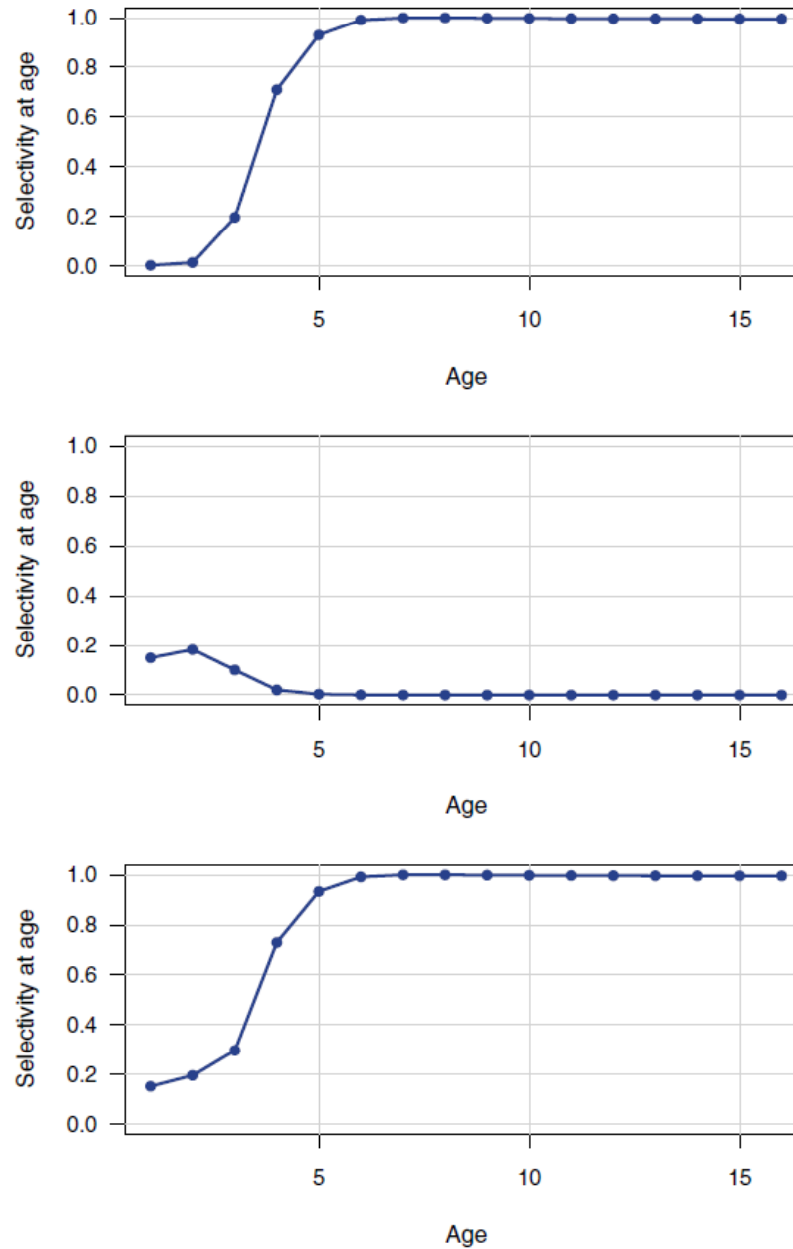


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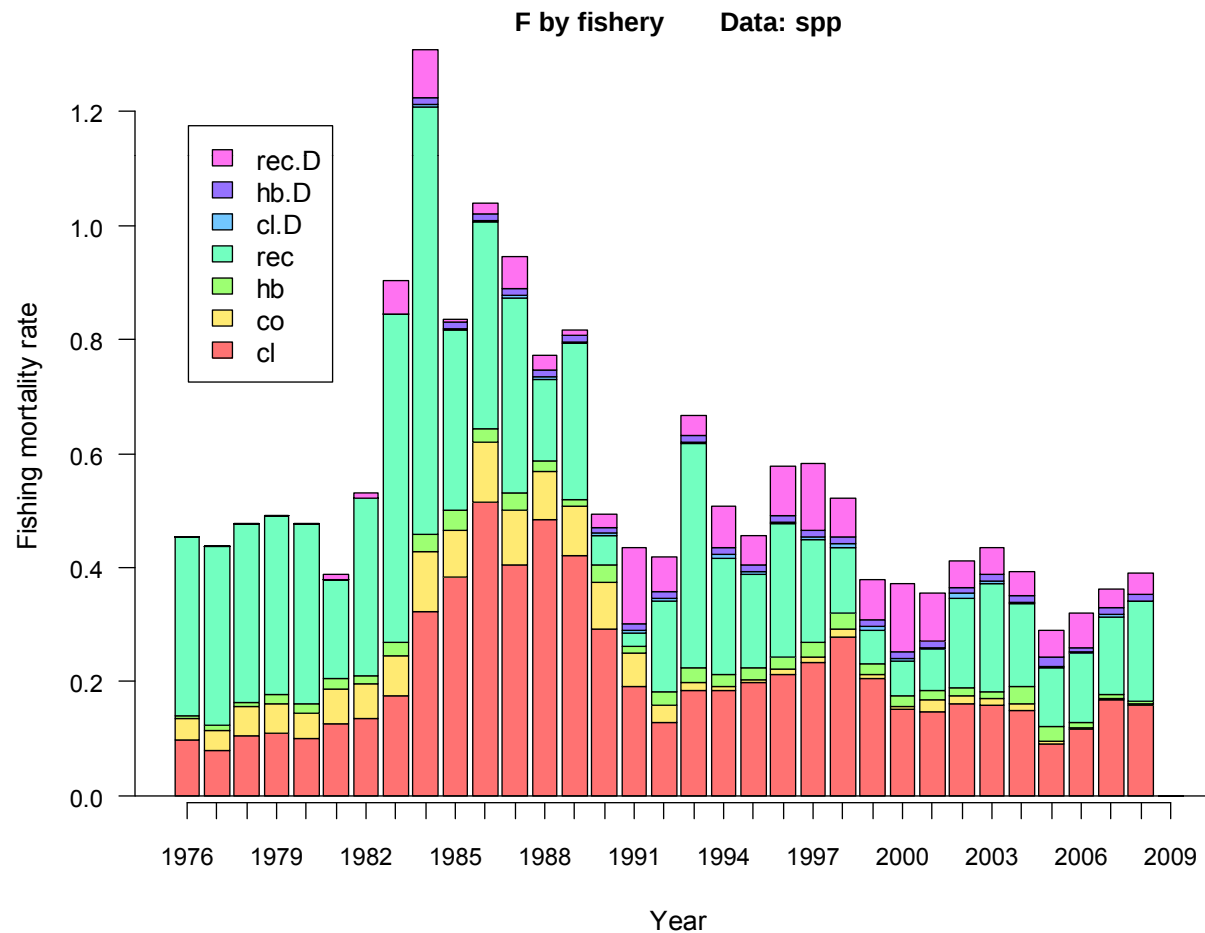
BAM selectivities (base run)

Figure 6.32. Average selectivities from the terminal assessment year (2008, 20-inch limit), weighted by geometric mean F_s from the last three assessment years, and used in computation of benchmarks and base-run projections. Top panel: average selectivity applied to landings. Middle panel: average selectivity applied to discard mortalities. Bottom panel: total average selectivity.



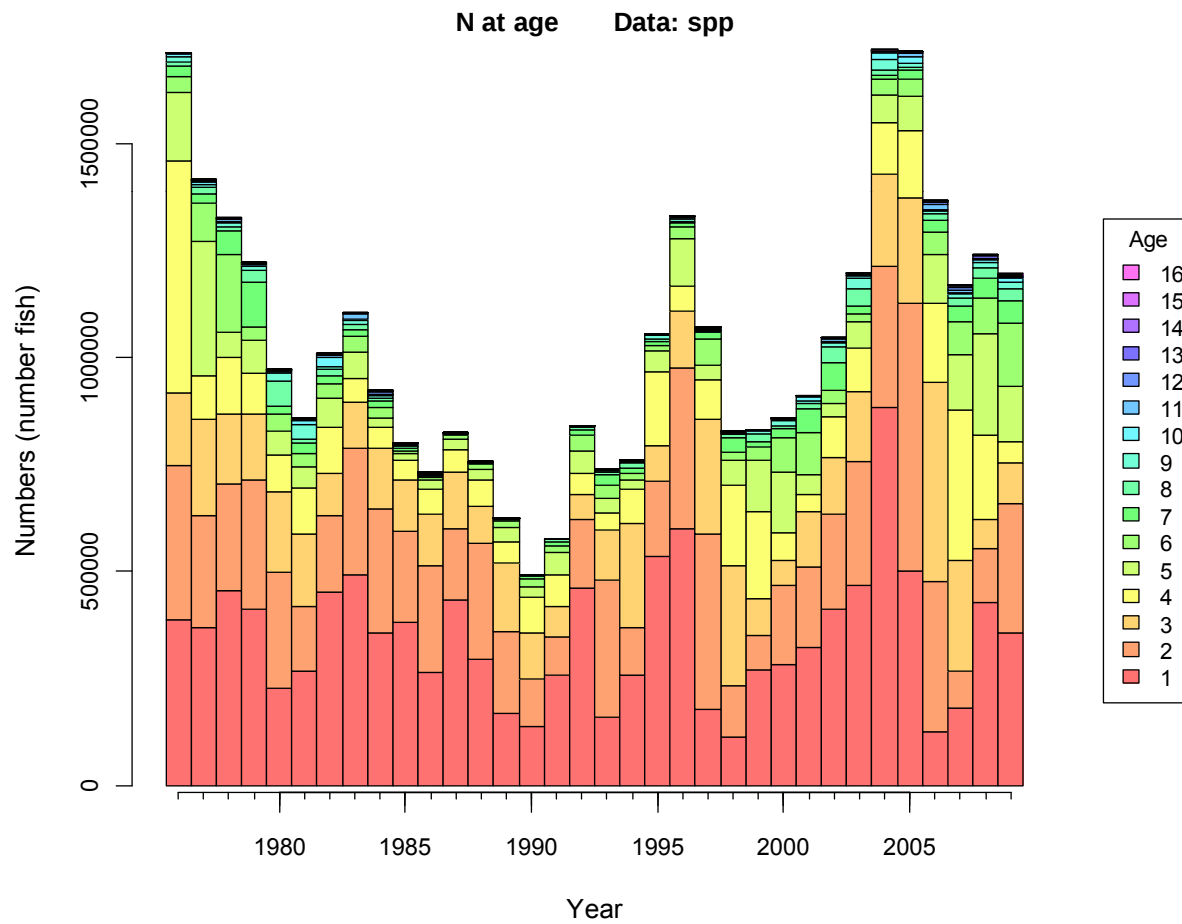


BAM results (base run)



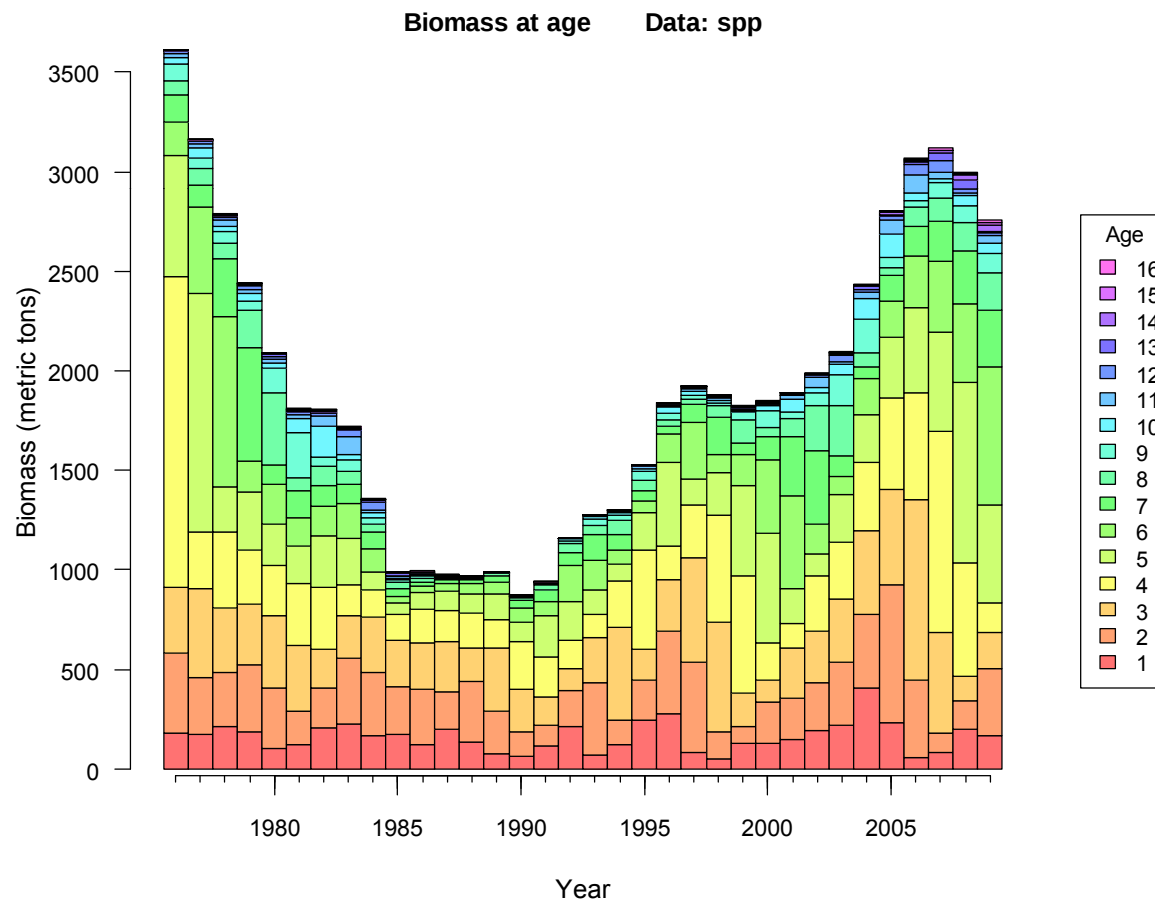


BAM results (base run)





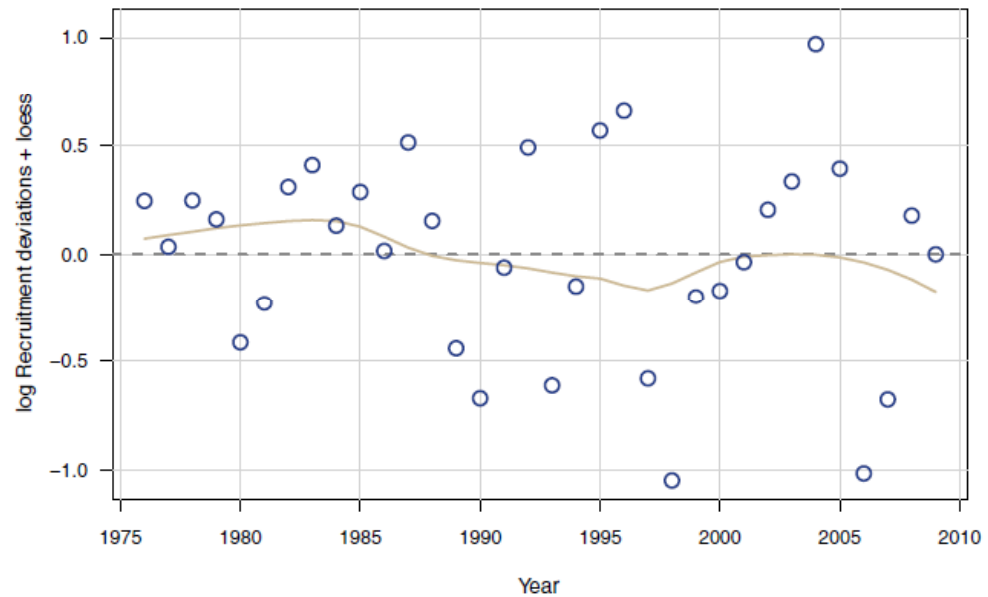
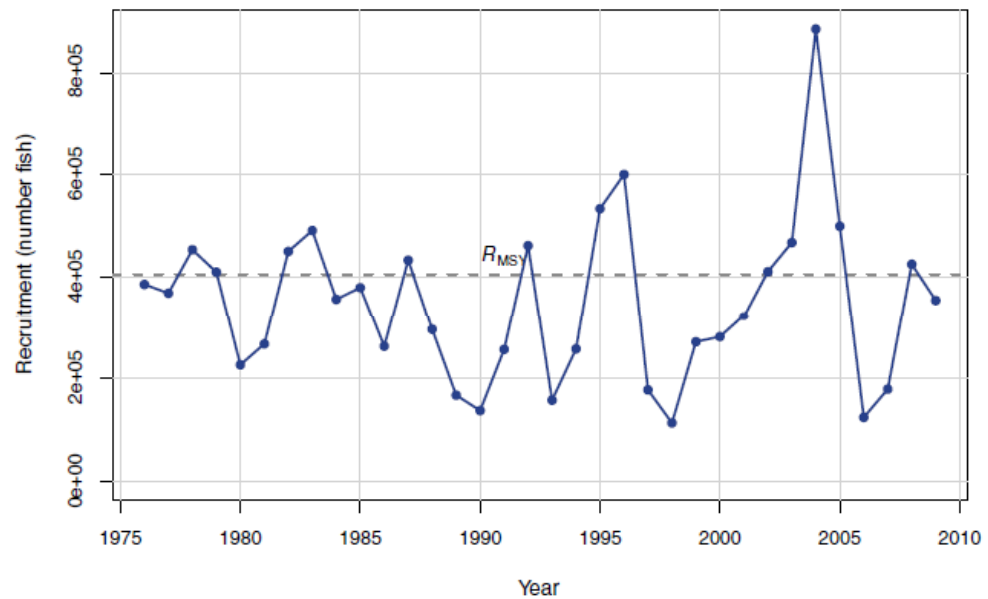
BAM results (base run)

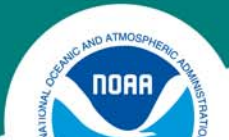


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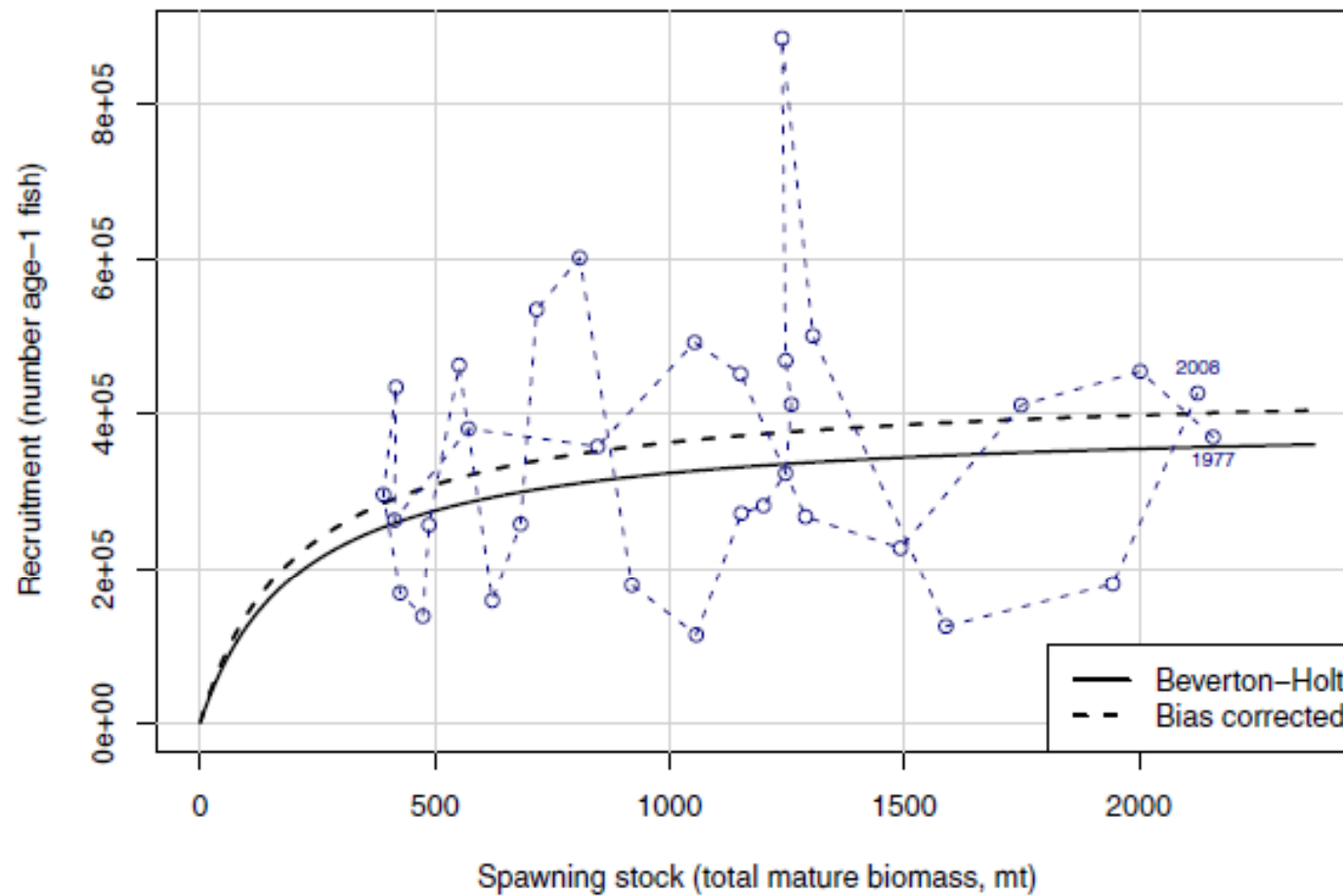


BAM results (base run)



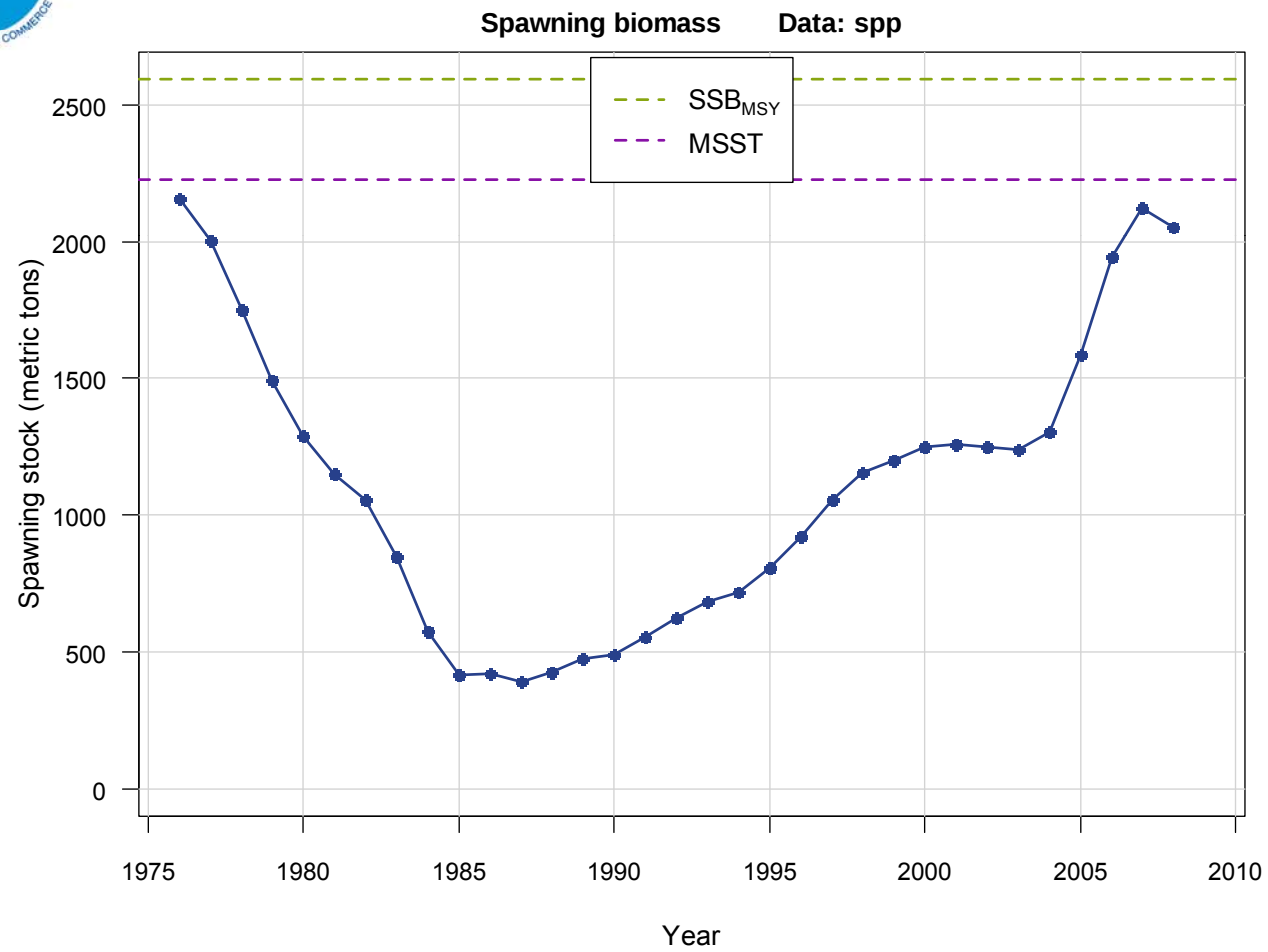


BAM results (base run)



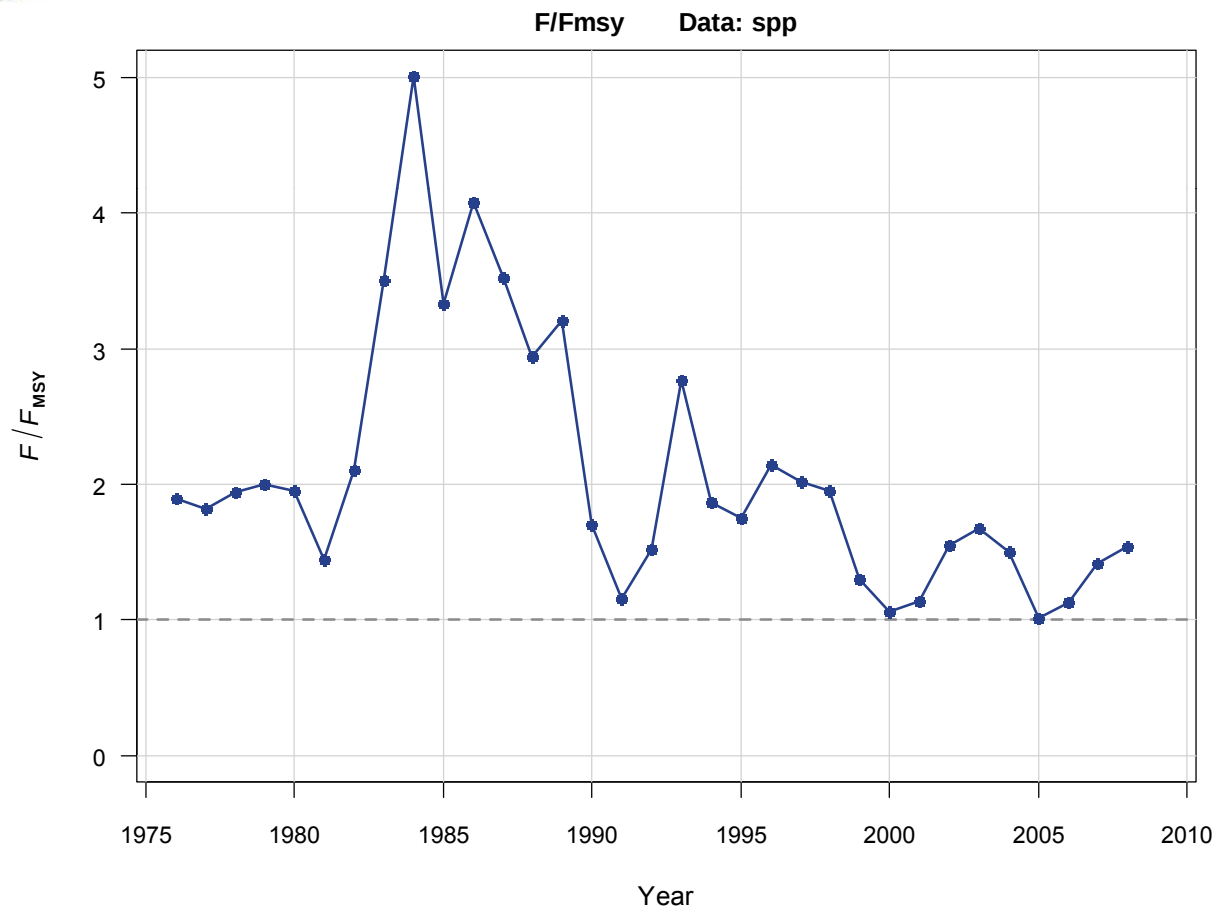


BAM results (base run)



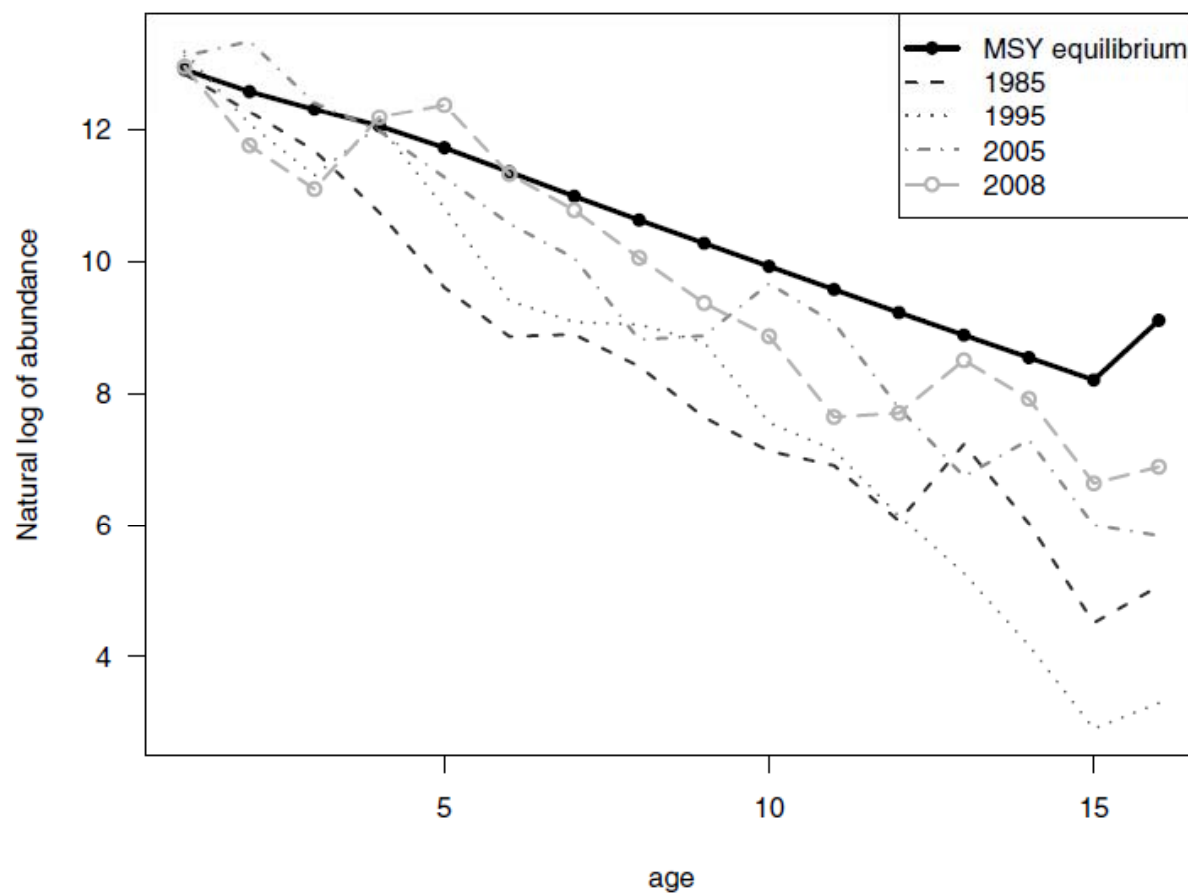


BAM results (base run)





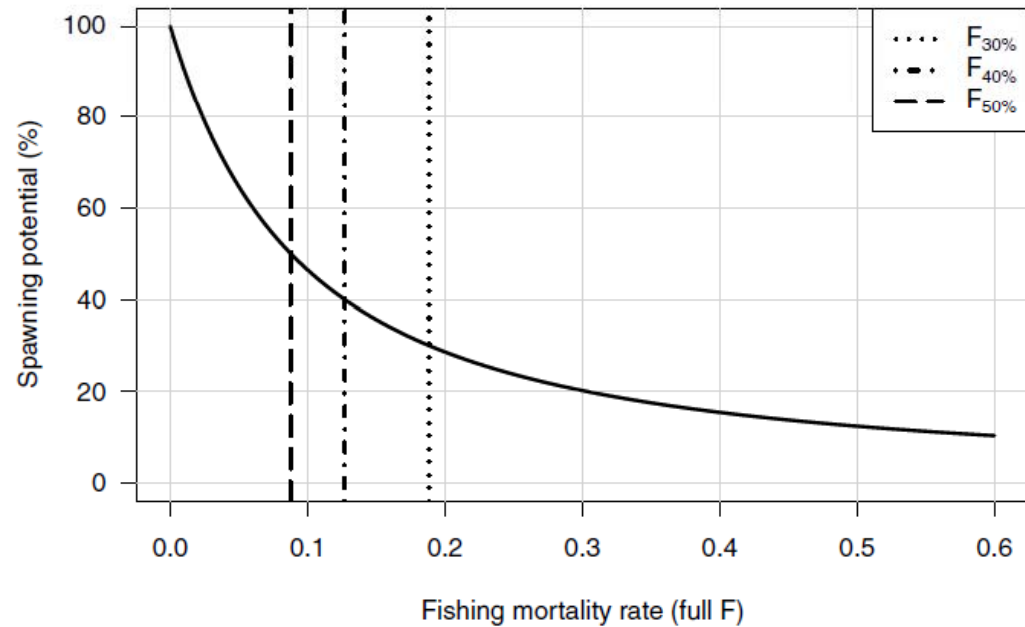
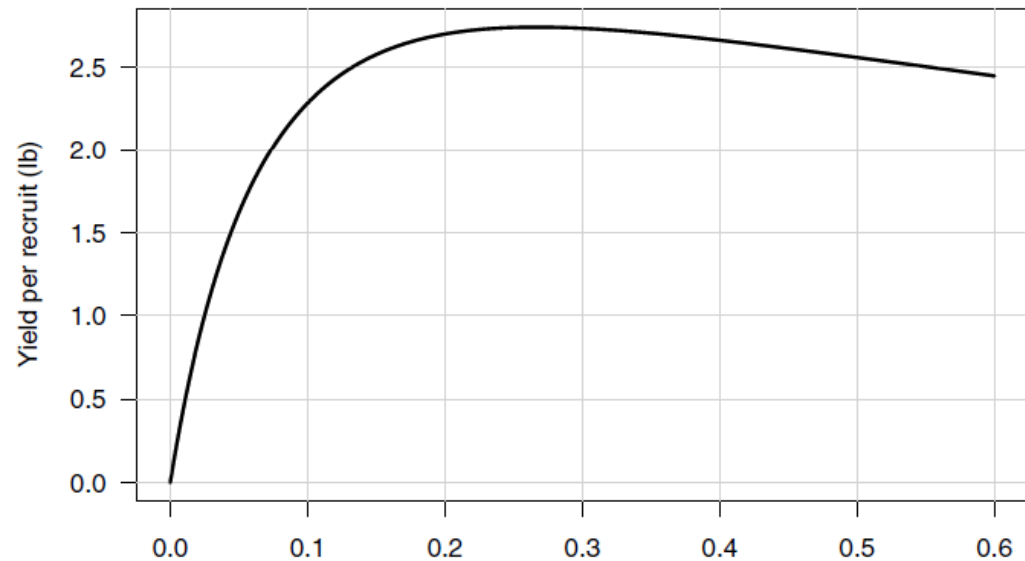
Age structure relative to that expected at MSY



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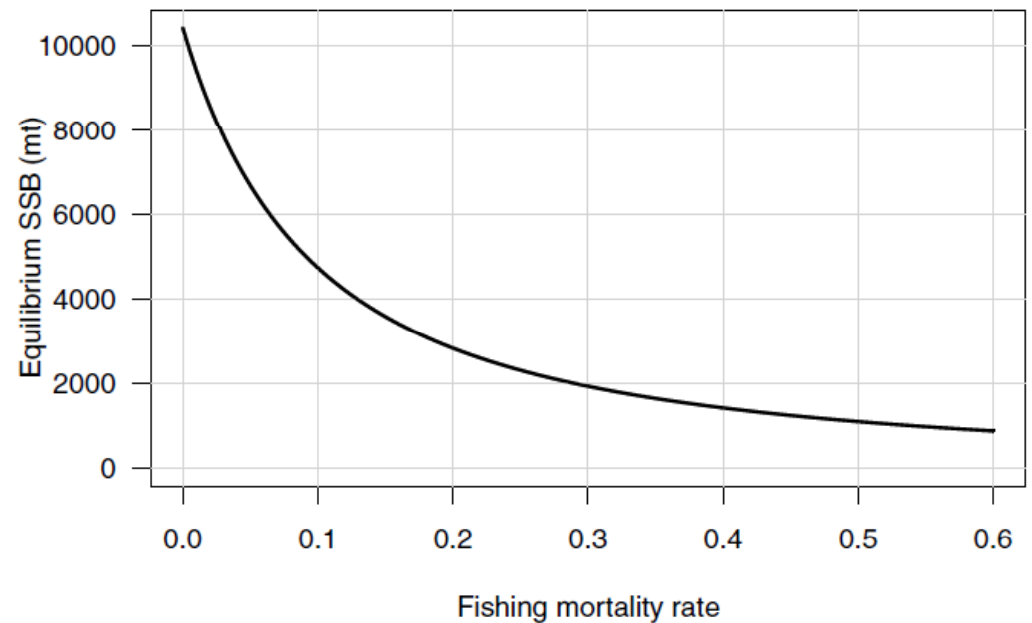
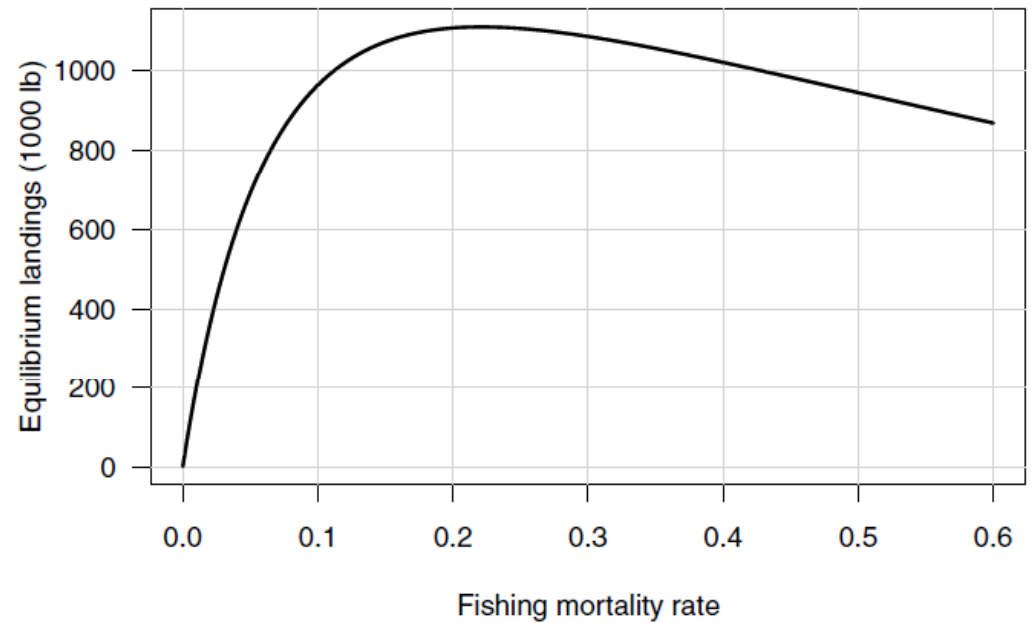
BAM results (base run – per recruit analysis)



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BAM results (base run- equilibrium analysis)





BAM results: management quantities

Quantity	Units	Estimate	SE
F_{MSY}	y^{-1}	0.221	0.030
$85\%F_{MSY}$	y^{-1}	0.188	0.026
$75\%F_{MSY}$	y^{-1}	0.166	0.023
$65\%F_{MSY}$	y^{-1}	0.144	0.020
$F_{30\%}$	y^{-1}	0.189	0.029
$F_{40\%}$	y^{-1}	0.127	0.019
$F_{50\%}$	y^{-1}	0.088	0.012
B_{MSY}	mt	3680	569
SSB_{MSY}	mt	2592	519
MSST	mt	2229	487
MSY	1000 lb	1110	102
D_{MSY}	1000 fish	27	8
R_{MSY}	1000 age-1 fish	407	58
Y at $85\%F_{MSY}$	1000 lb	1103	101
Y at $75\%F_{MSY}$	1000 lb	1089	99
Y at $65\%F_{MSY}$	1000 lb	1064	96
F_{2008}/F_{MSY}	—	1.35	0.26
$SSB_{2008}/MSST$	—	0.92	0.25

NOTE:

Stock status from terminal year

Fishery status from last three years



BAM sensitivity analyses

AW sensitivity runs

Run	Description	F_{MSY}	SSB_{MSY} (mt)	MSY(1000 lb)	F_{2008}/F_{MSY}	$SSB_{2008}/MSST$	steep	R0(1000)
Base	—	0.212	2545	1117	1.46	0.79	0.91	399
S1	Low M	0.171	3501	1270	2.03	0.49	0.95	306
S2	High M	0.274	1825	987	0.92	1.47	0.85	589
S3	Extreme M	0.421	1413	1004	0.41	3.29	0.76	1175
S4	Low D mort	0.248	2085	1069	1.22	0.99	0.92	357
S5	High D mort	0.19	3019	1187	1.67	0.66	0.90	447
S6	SSB female	0.222	1356	1075	1.39	0.94	0.80	376
S7	SSB male	0.222	1027	1121	1.40	0.72	0.97	390
S8	Retro 2004	0.188	2521	1001	1.49	0.72	0.92	375
S9	Retro 2006	0.168	2806	979	1.69	0.58	0.91	394
S10	Retro 2005	0.15	3443	1063	1.36	0.65	0.89	461

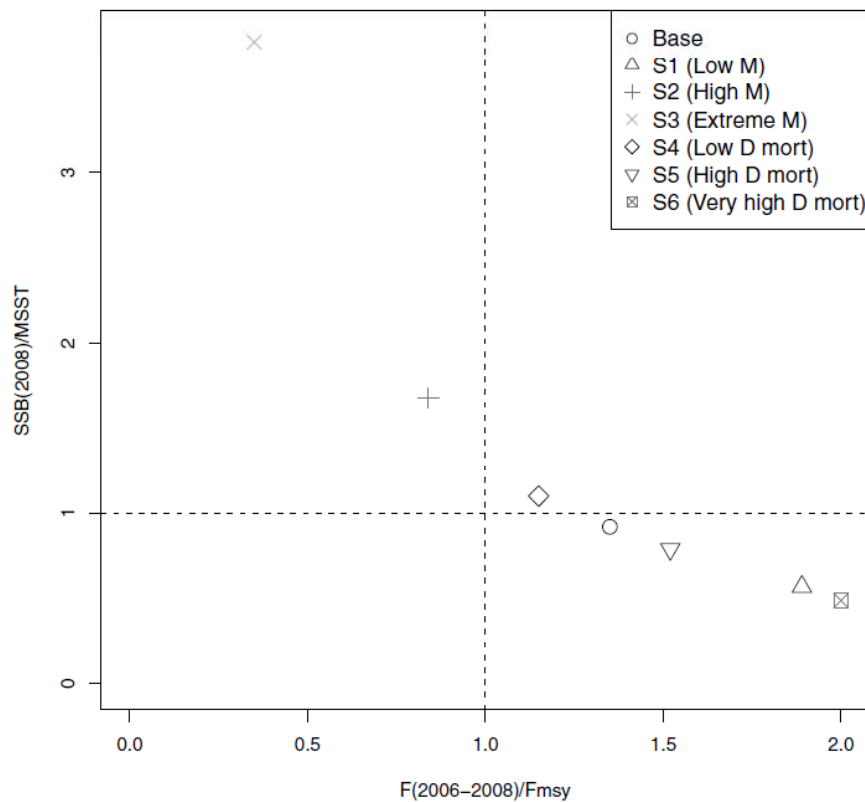
RW sensitivity runs

Run	Description	F_{MSY}	SSB_{MSY} (mt)	MSY(1000 lb)	F_{2008}/F_{MSY}	$SSB_{2008}/MSST$	steep	R0(1000)
Base	—	0.221	2592	1110	1.35	0.92	0.92	384
S1	Low M	0.177	3543	1267	1.89	0.57	0.95	294
S2	High M	0.292	1855	972	0.84	1.68	0.86	564
S3	Extreme M	0.464	1449	985	0.35	3.77	0.78	1139
S4	Low D mort	0.261	2153	1072	1.15	1.1	0.93	347
S5	High D mort	0.196	3026	1161	1.52	0.79	0.91	424
S6	Very high D mort	0.147	4919	1437	2	0.49	0.88	605

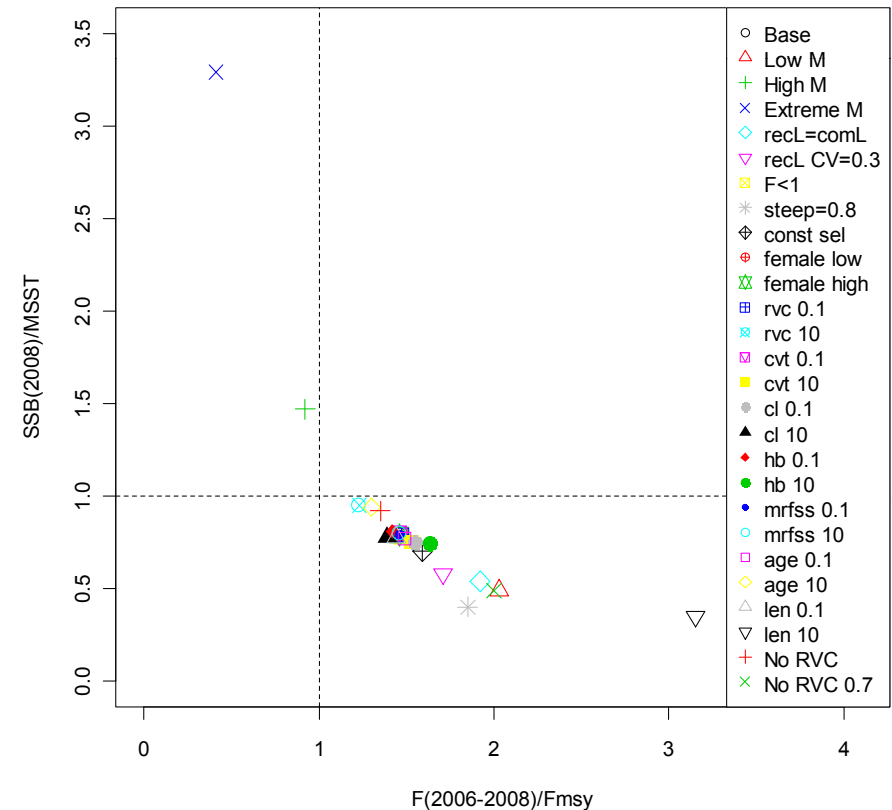


BAM sensitivity analyses Status indicators

RW sensitivity runs



Additional RW runs



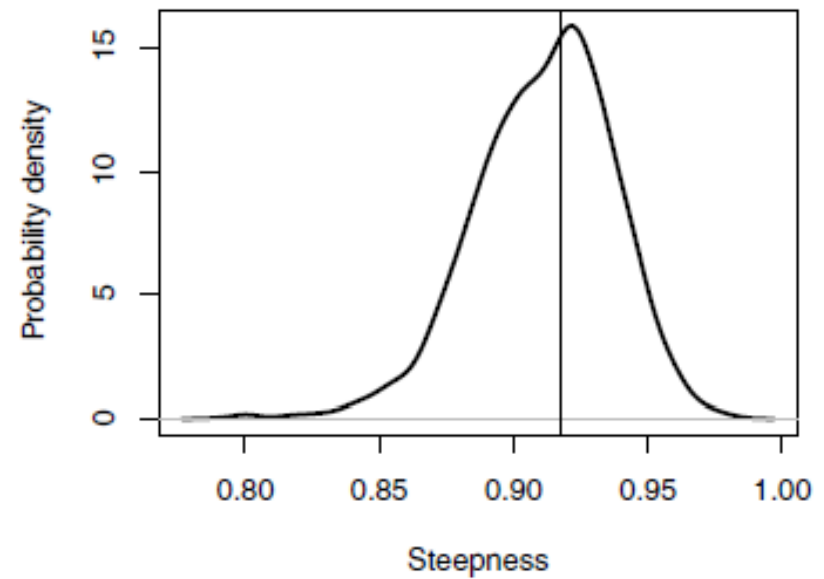
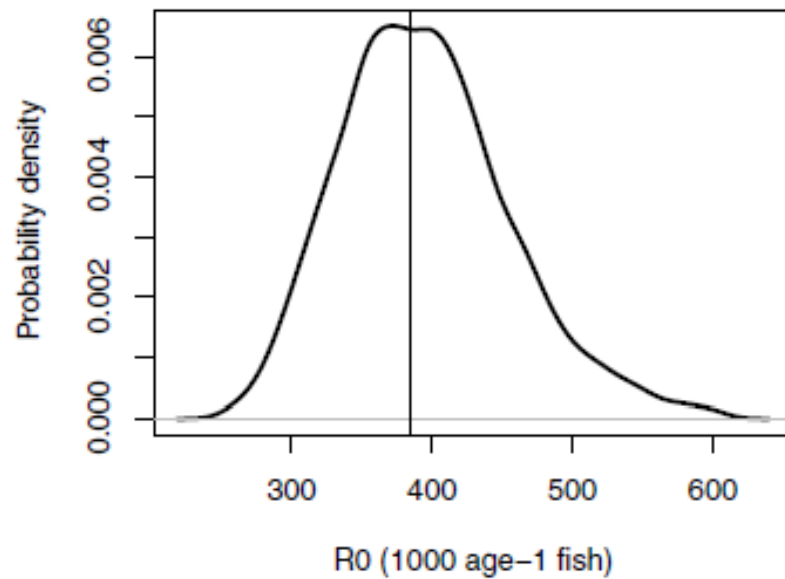


Monte Carlo/Bootstrap (MCB) approach

- Bootstrap of data
 - Landings, discards, and indices: lognormal distribution with CV in arithmetic space assumed to be 0.05 (landings and discards) or as estimated (indices)
 - Age, length comps: multinomial distribution with annual cell probabilities and sample sizes from original data
- Monte Carlo of key parameter inputs
 - Natural mortality (to scale Lorenzen M): Truncated normal distribution [0.1,0.2] with mean $M=0.14$ and standard deviation such that the lower bound (0.1) is the 95% confidence limit
 - Discard mortality: Uniform distribution [0.1,0.3]
- N=2500 MCB trials attempted, N=2467 used to characterize uncertainty (remaining 1.3% discarded because did not converge)

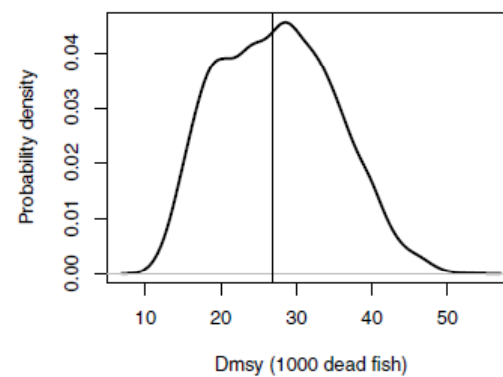
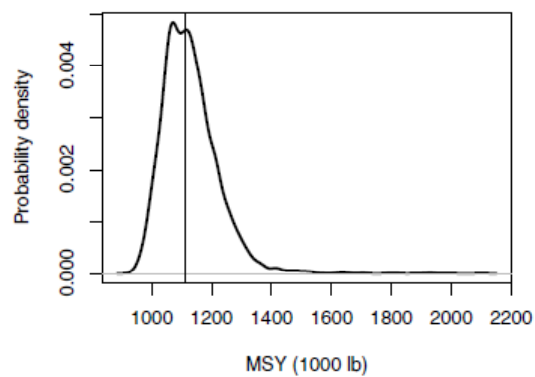
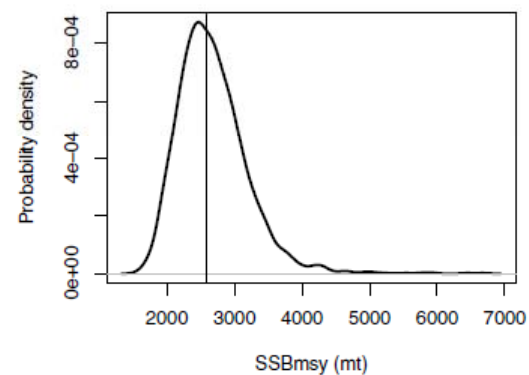
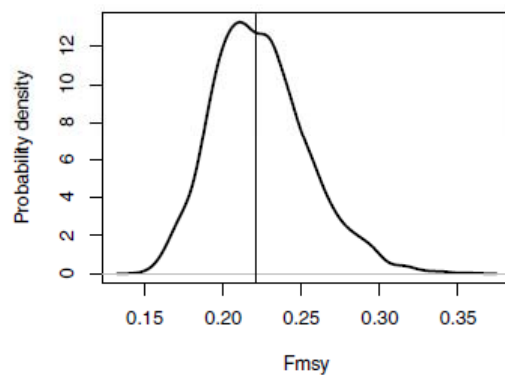


BAM MCB Beverton-Holt estimates (base run, MCB runs)





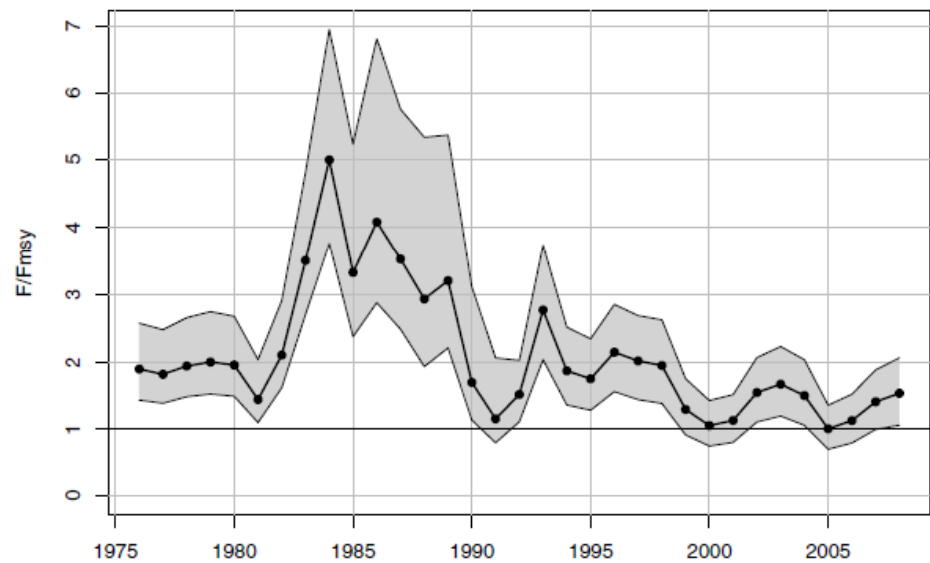
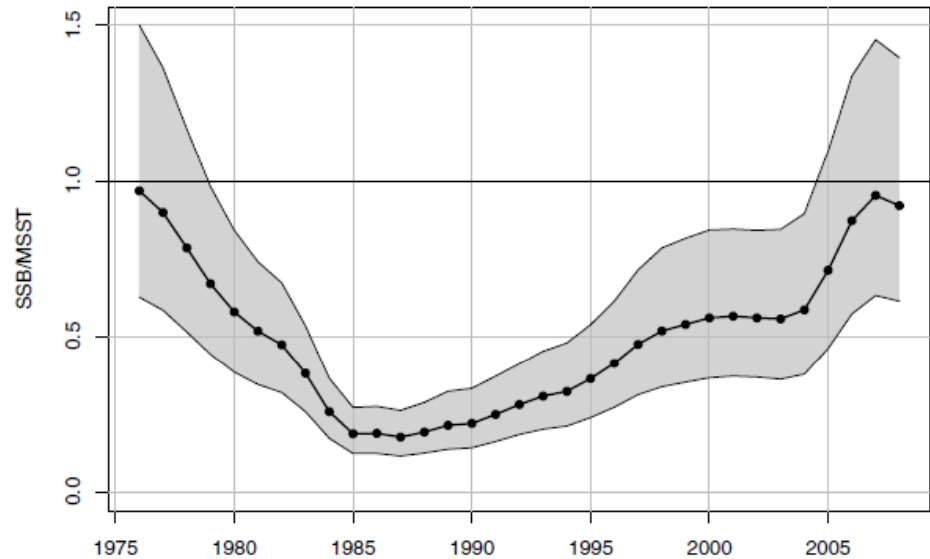
BAM MCB management quantities (base run, MCB runs)



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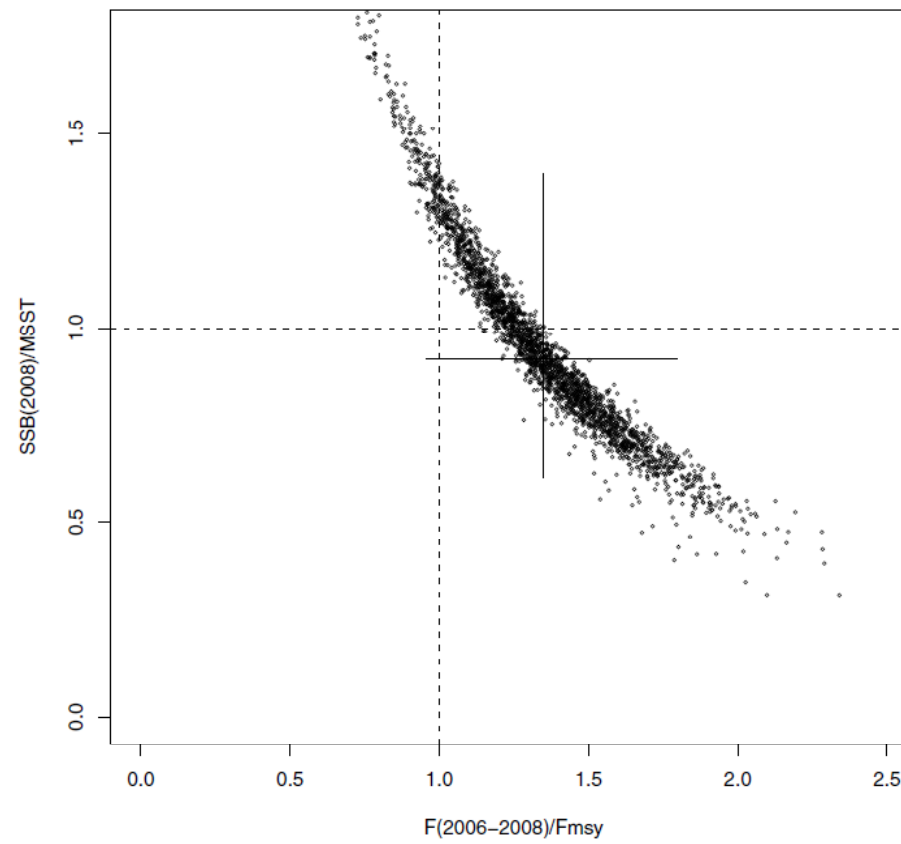


**BAM MCB results:
Gray indicates
5th and 95th percentiles
from MCB runs**



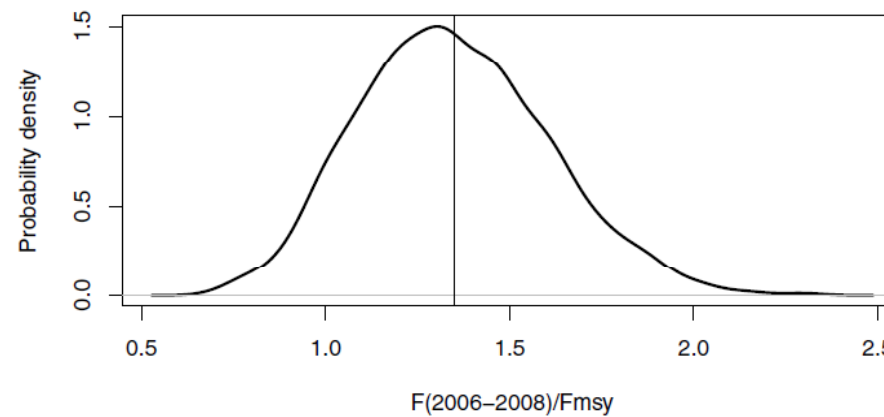
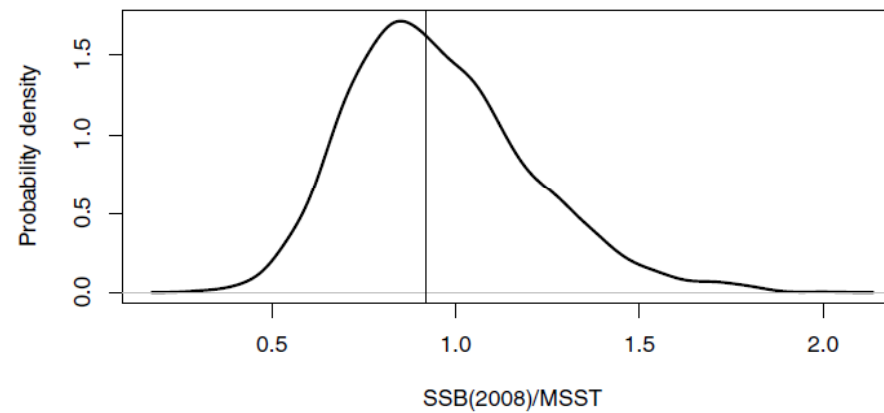


BAM MCB analyses Status indicators



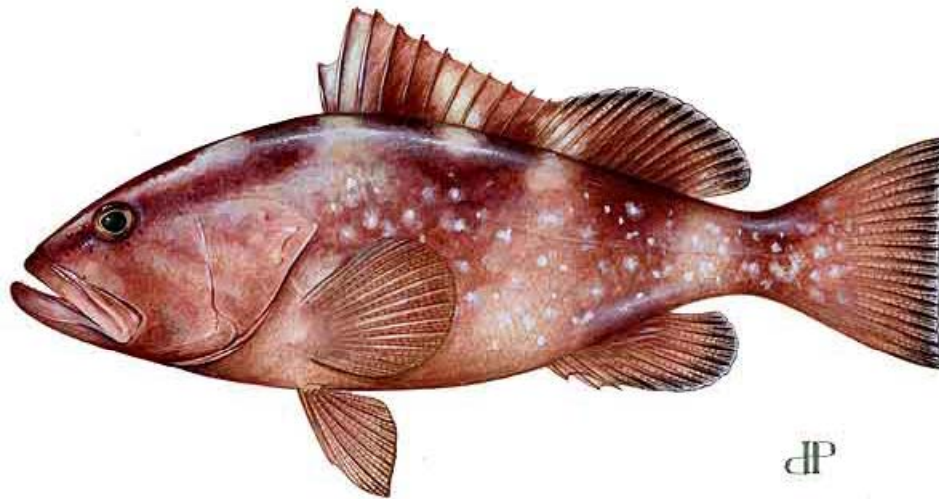


BAM MCB analyses Status indicators





ASSESSMENT—Red grouper Stock Synthesis 3





Stock synthesis (SS)

- Canned software from NMFS toolbox, programmed in ADMB by Rick Methot
 - Rick recently added the “sex-switcher” option
 - Rick helped configure red grouper input files
- Statistical catch-age model
- SS is very similar in structure to the BAM, with some differences ...



How does SS model differ from BAM?

- Recruits at age 0, rather than age 1
- SSB computed at beginning of year, rather than time of peak spawning
- Selectivities are length-based, rather than age-based (although modeled population is still age-based)
- Catch divided into landings and discards with a retention function
- Dome-shaped selectivities modeled with the double normal function, rather than double logistic
- Probability of sex transition modeled with the cumulative normal function, rather than proportion male at age with the logistic function.
- SS was not re-run without the RVC index



How do SS data inputs differ from those of BAM?

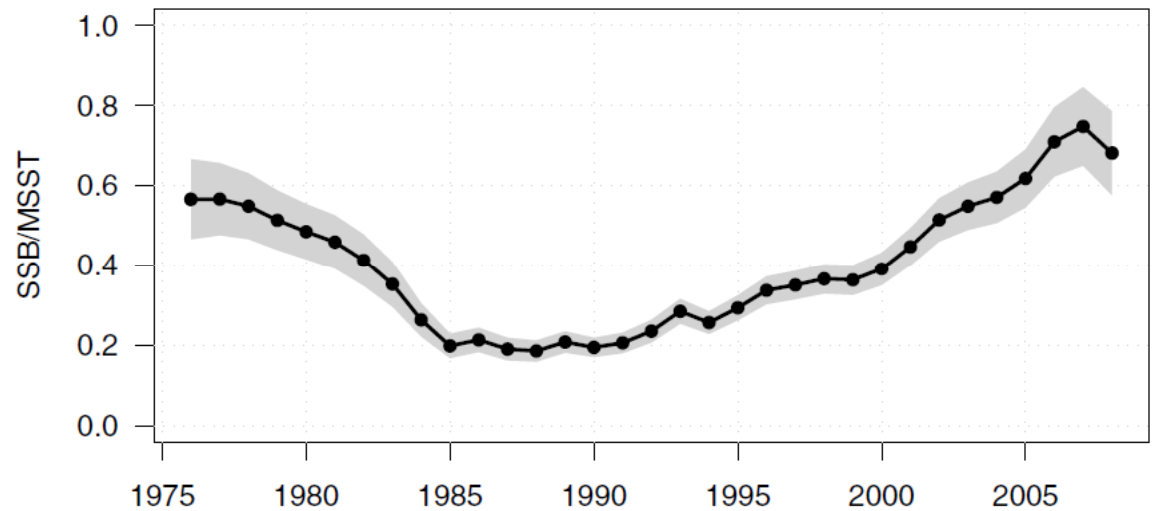
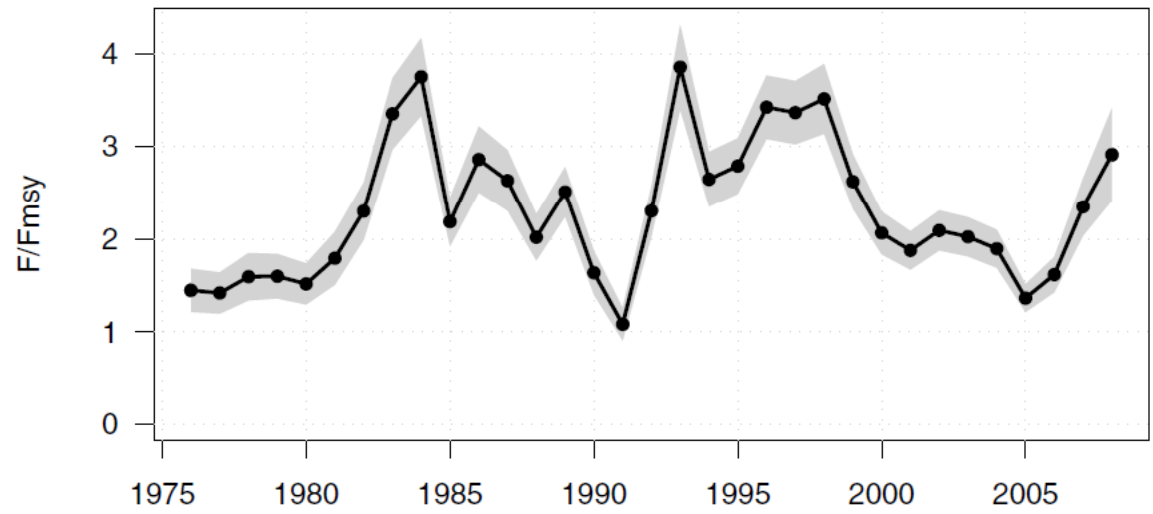
- Pre-data initialization period 1960-1975 assumes constant landings by fleet (geometric means of 1976-1978)
- Discards need to be supplied in same units as landings (commercial discards converted to weight assuming average weight of age-2 fish)
- Missing landings data are supplied as input, rather than predicted with average F
 - Early recreational landings (1976-1980) assumed same as first year of MRFSS (1981)

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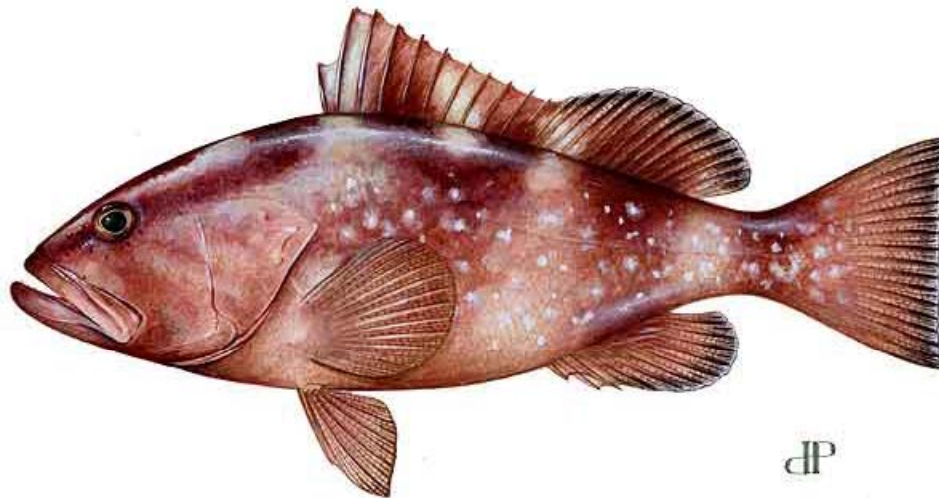
SS results:
Gray represents
95% confidence
bands using
asymptotic
variance estimates

Terminal status:
F ratio 2.22
SSB ratio 0.68





ASSESSMENT—Red grouper Surplus production model



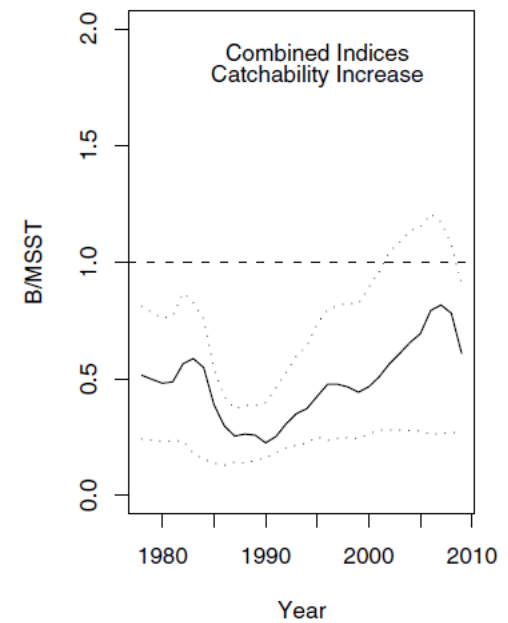
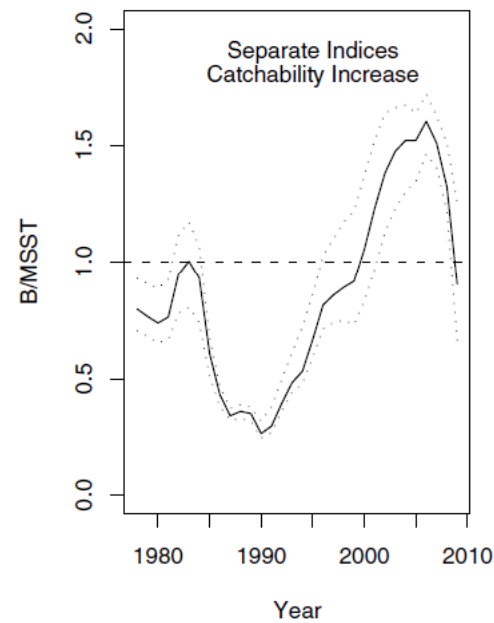
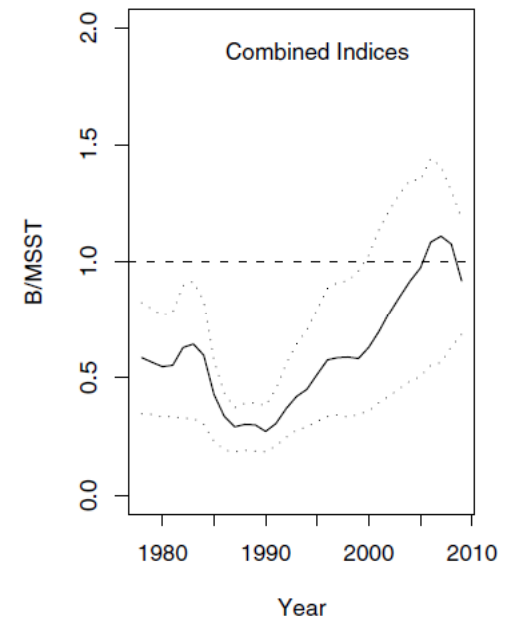
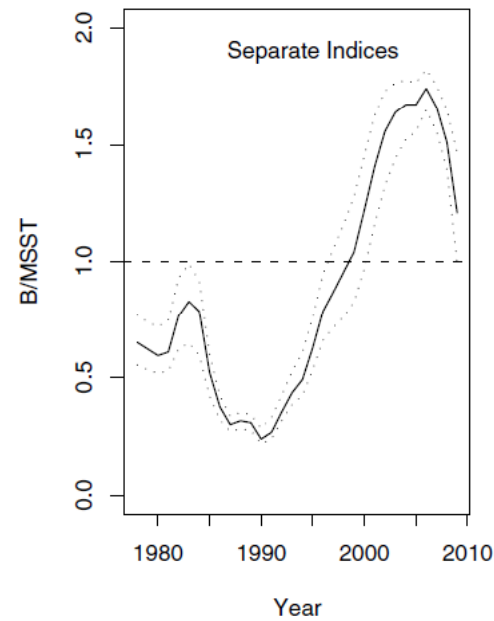


Production model

- No age structure
- Non-equilibrium logistic formulation
- Conditioned on yield
- Combined index of abundance (hierarchical analysis)
- ASPIC software of Prager (1994)
- Uncertainty from bootstrap
- Model runs:
 - Combinations of separate or combined indices, constant or increasing q
 - No RVC survey
 - Headboat index only



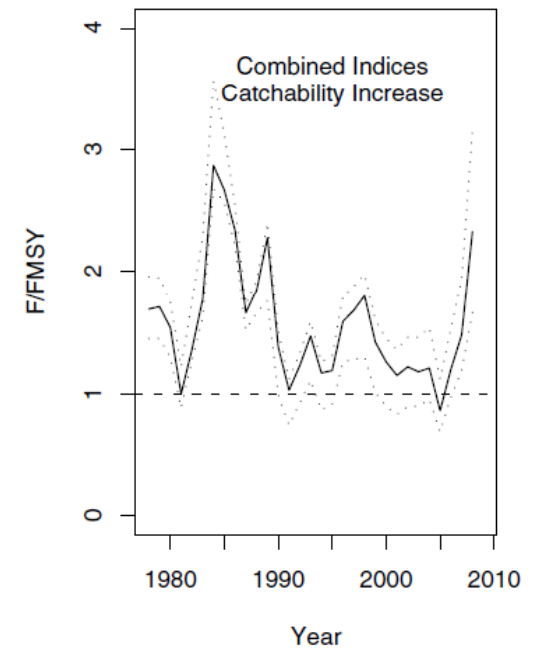
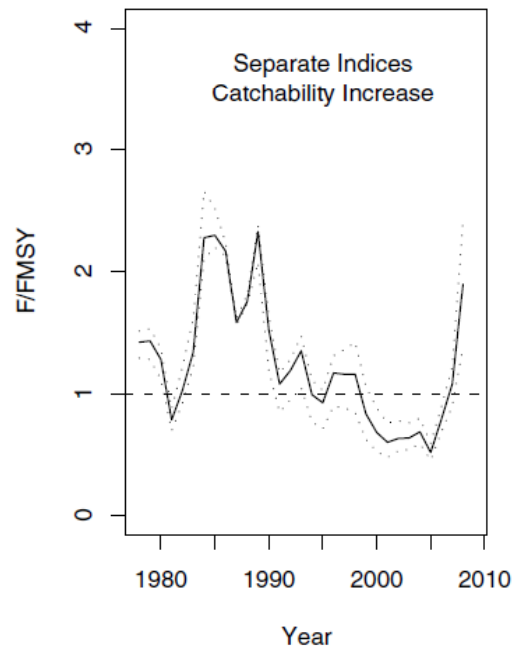
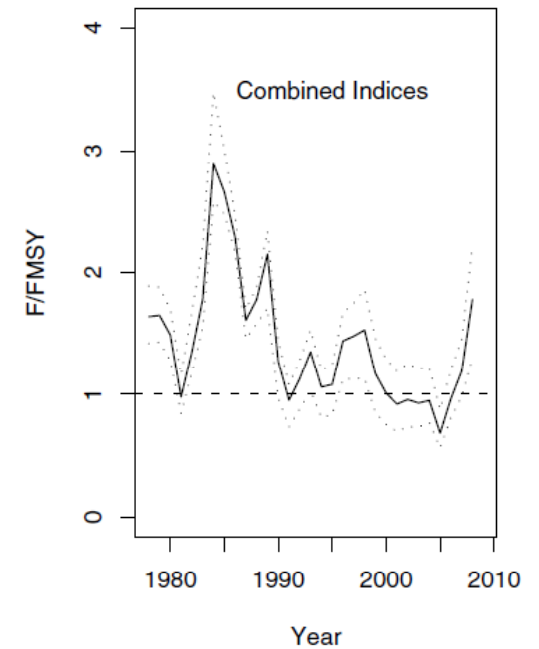
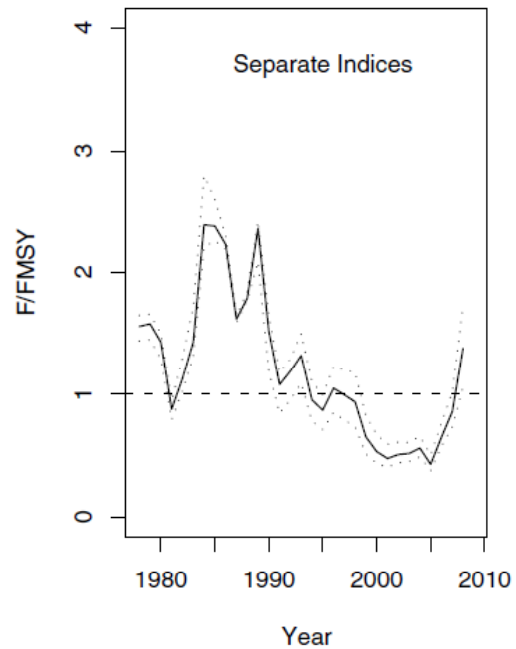
Production model results



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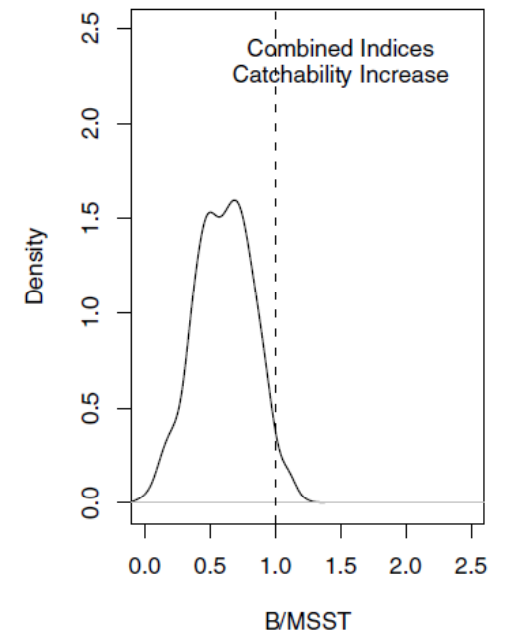
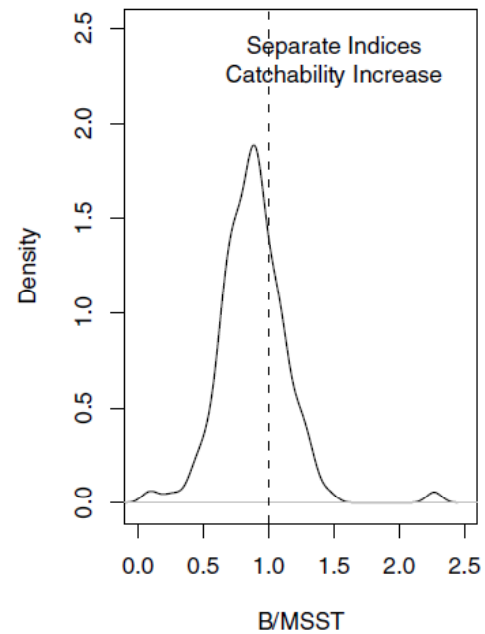
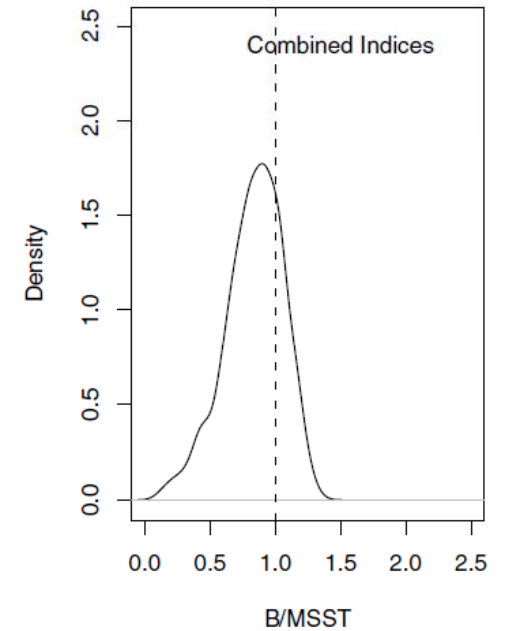
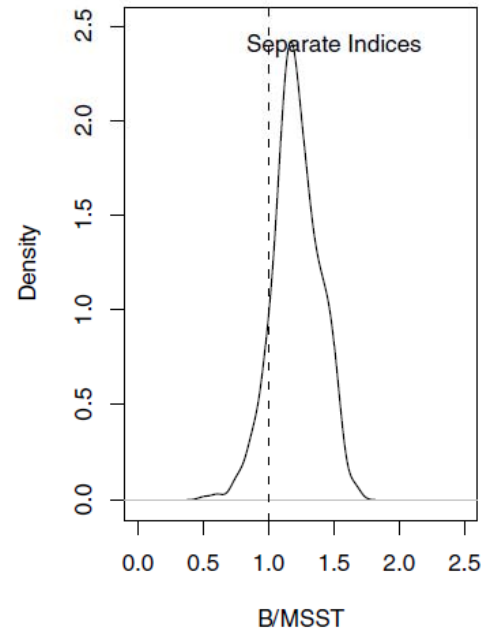
Production model results



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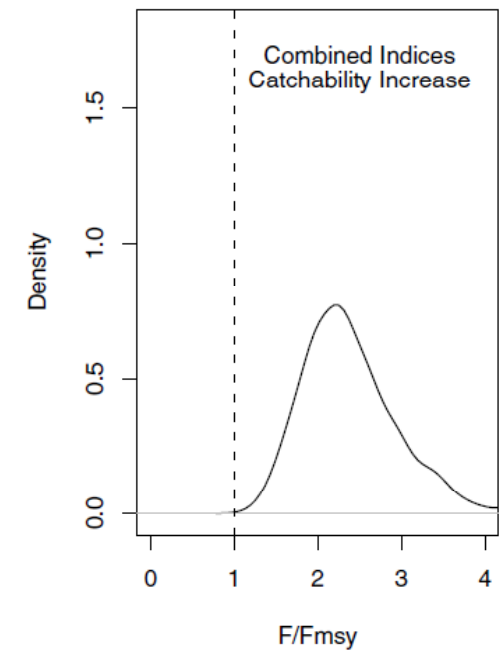
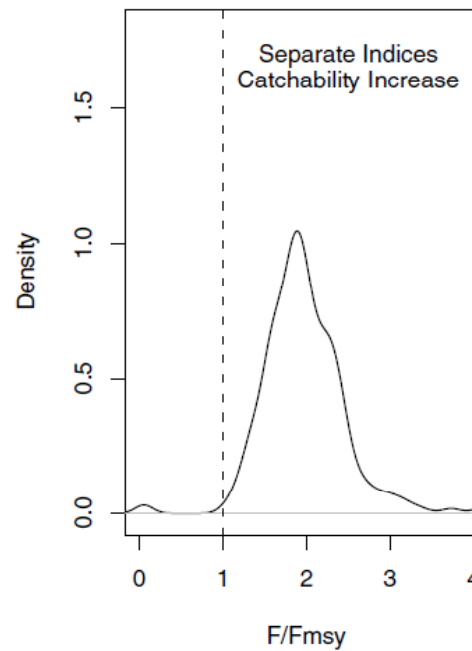
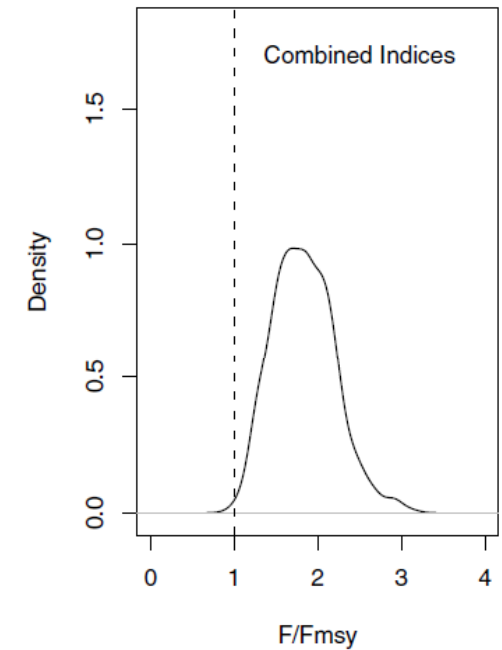
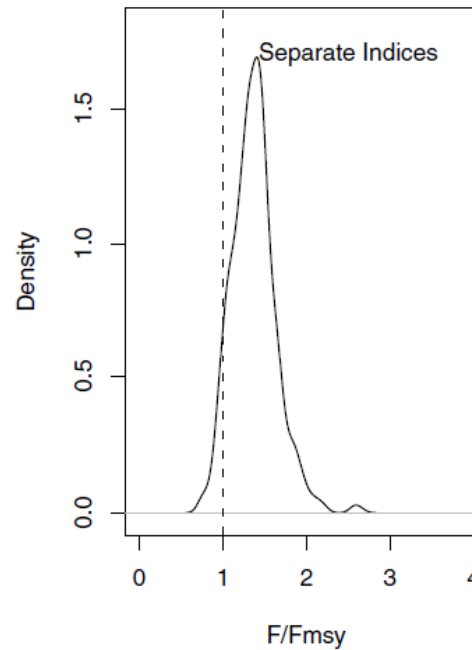
Production model results: B status



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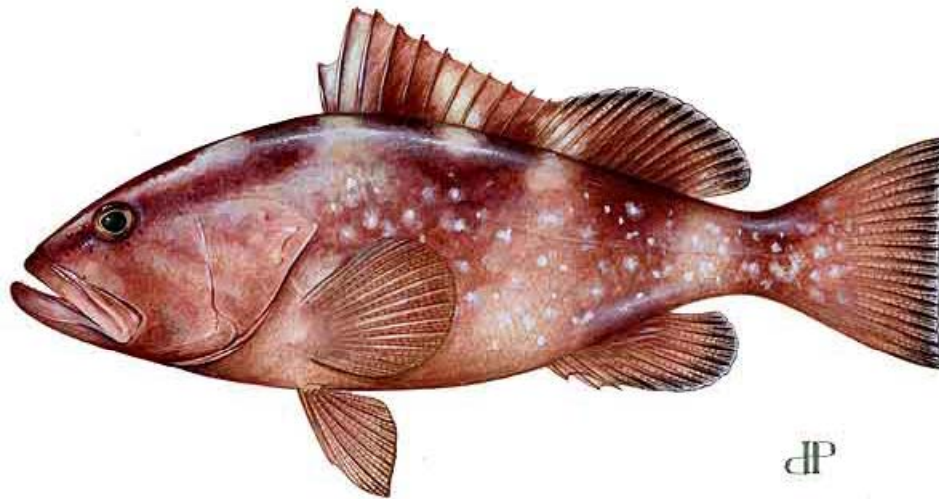


Production model results: F status





Projections—Red grouper





Age-based projection model

- 12-year projections (2009-2020)
- Same structure as assessment model
- Full F apportioned among fisheries according to recent estimates (geometric means of last 3 yrs)
- Initial (2009) N at age based on 2008 estimates discounted by Z . Initial recruits from S-R model.
- Current F applied in 2009-2010. New management assumed to start in 2011.
 - Several scenarios considered reduction in 2010 F
- Expected values from deterministic projections with bias-corrected S-R.
 - Consistency between projections and benchmarks



Uncertainty in projections

- N=40,000 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 included stochastic recruitment (lognormal residuals)
- “Rebuilding” defined by $SSB \geq SSB_{msy}$ in at least 50% of projected time series. Here SSB_{msy} is the point estimate from the base model.



Projection scenarios

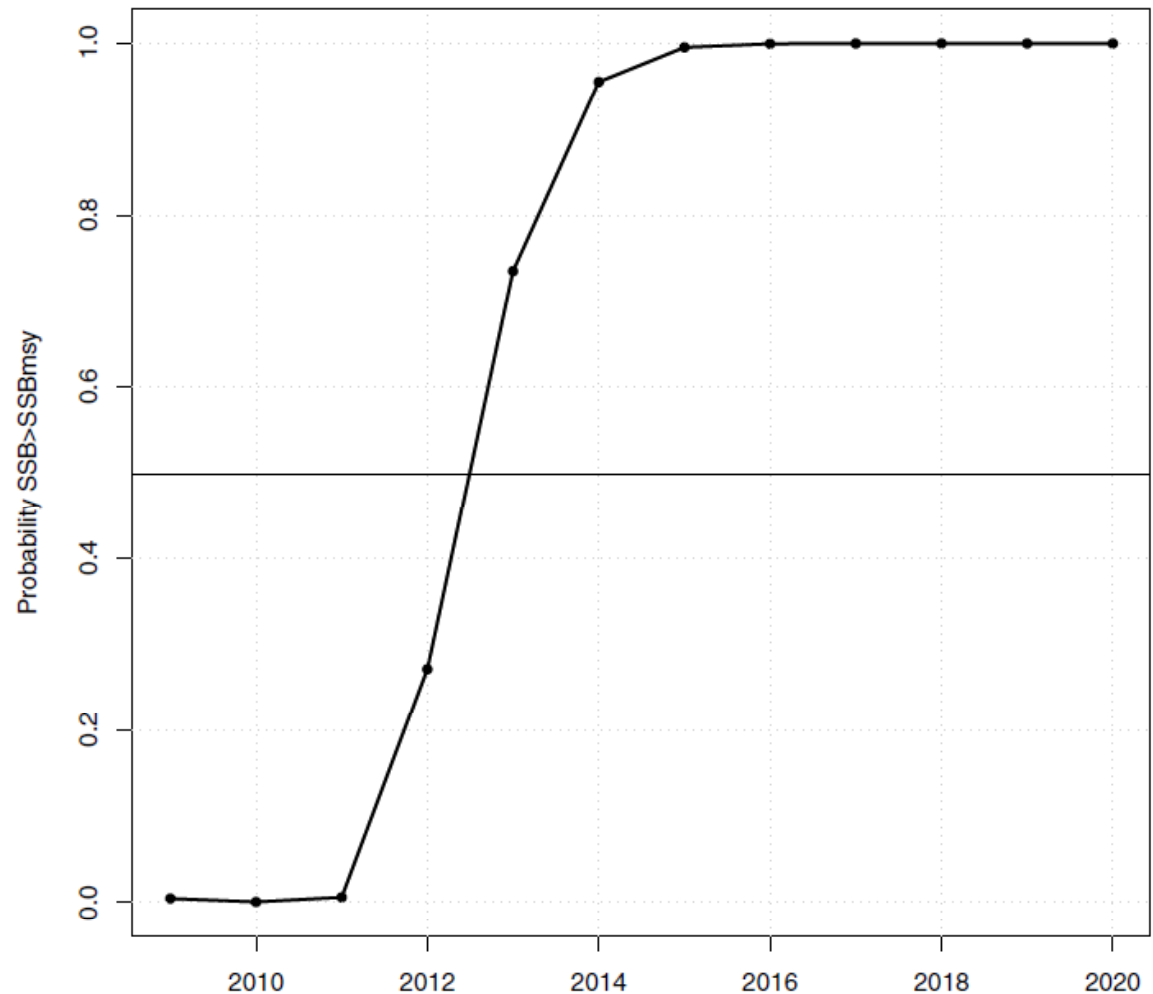
- Constant F projections
 - Scenario 1: $F = 0$
 - Scenario 2: $F = F_{\text{current}}$
 - Scenario 3: $F = F_{\text{current}}$ in 2009 and $F = 75\%F_{\text{current}}$ thereafter
 - Scenario 4: $F = F_{\text{current}}$ in 2009 and $F = 50\%F_{\text{current}}$ thereafter
 - Scenario 5: $F = F_{\text{current}}$ in 2009 and $F = 25\%F_{\text{current}}$ thereafter
 - Scenario 6: $F = 65\%F_{\text{MSY}}$
 - Scenario 7: $F = 75\%F_{\text{MSY}}$
 - Scenario 8: $F = 85\%F_{\text{MSY}}$
 - Scenario 9: $F = F_{\text{MSY}}$
 - Scenario 10: $F = F_{\text{rebuild}}$
 - Scenario 11: $F = F_{\text{rebuild}}$, with $F = F_{\text{current}}$ in 2009 and $F = 75\%F_{\text{current}}$ in 2010
 - Scenario 12: $F = F_{\text{rebuild}}$, with $F = F_{\text{current}}$ in 2009 and $F = 50\%F_{\text{current}}$ in 2010
 - Scenario 13: $F = F_{\text{rebuild}}$, with $F = F_{\text{current}}$ in 2009 and $F = 25\%F_{\text{current}}$ in 2010

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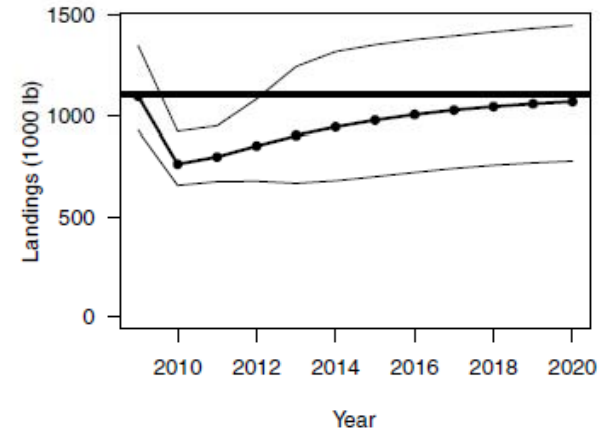
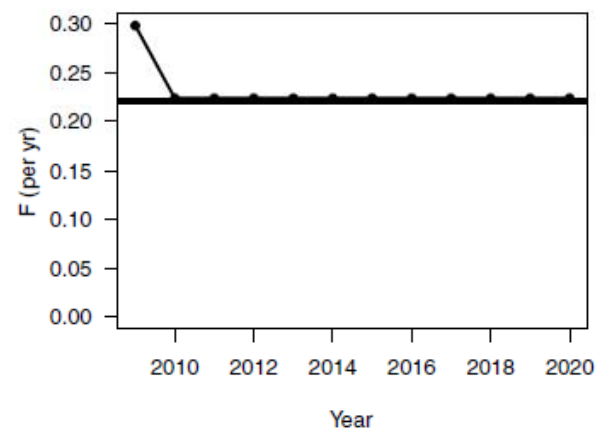
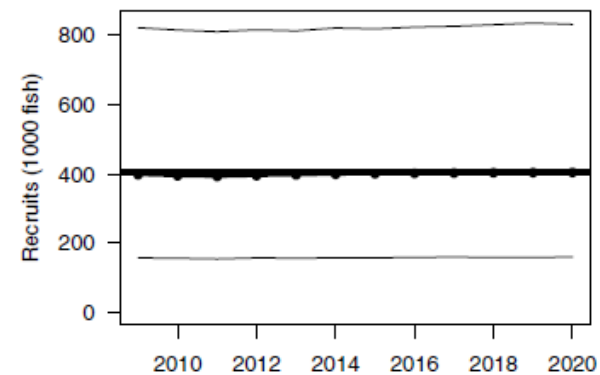
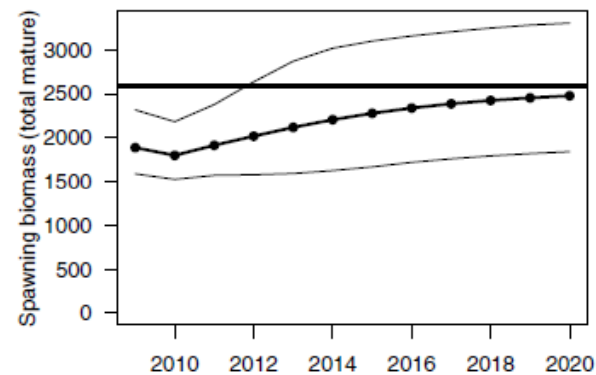
Projection: $F=0$

This defines the
rebuilding time frame.
 $T_{min}=3$ y (2011-2013),
 $T_{max}=10$ y (2011-2020)



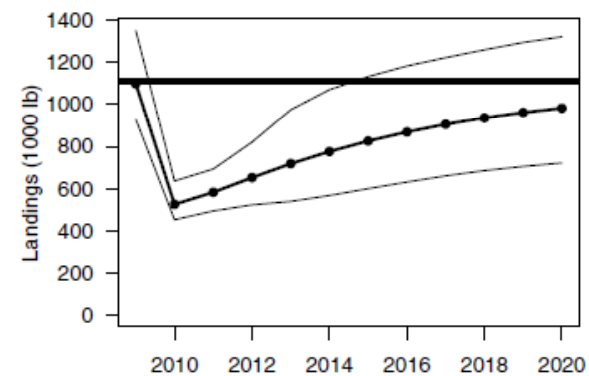
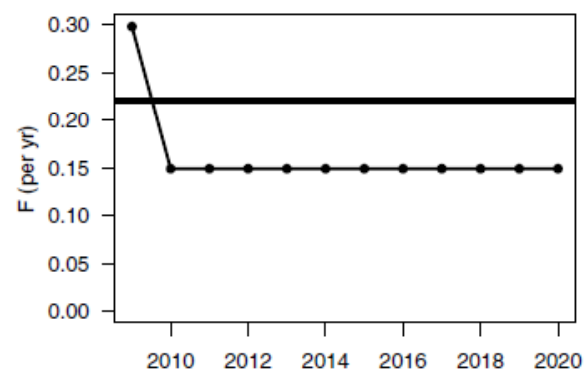
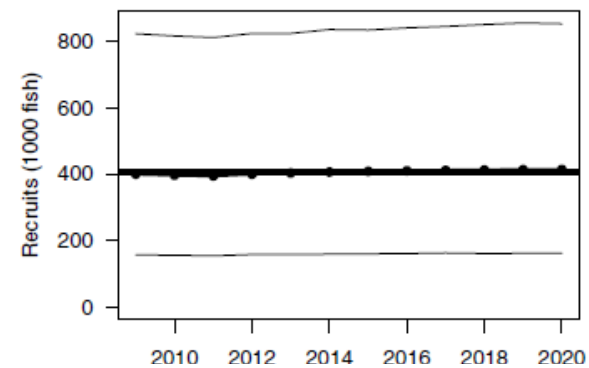
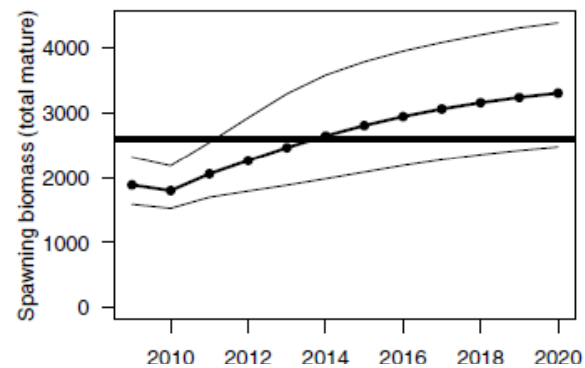


Example projection: $F=75\%F_{\text{current}}$





Example projection: $F=50\%F_{\text{current}}$





Questions?

