



# Blueline Tilefish: South of Cape Hatteras Age-structured Production Model (ASPIC)

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## 1 Methods

- Basic model configuration
- Data

## 2 Results

- Sensitivity analysis



## Basic model 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)



## Basic model 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



## Basic model configuration

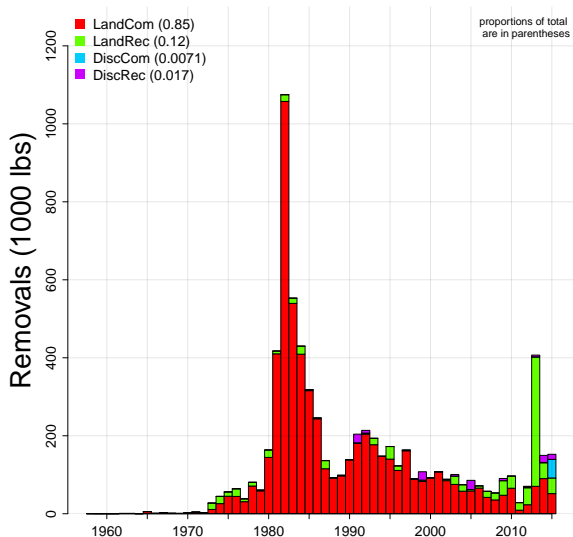
- Major similarities with a catch-at-age model include:
  - ▶ Population is modeled as age-structured
    - ★ Growth model
    - ★ Age-dependent natural mortality
    - ★ Age-dependent reproductive potential
  - ▶ Beverton-Holt stock-recruit function
  - ▶ Removals are separated by fleet
  - ▶ Estimate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

# Methods



## Removals by fleet

- Generally, the same removals as in the ASPIC model for south of Cape Hatteras
- Note this figure is also in the ASPIC presentation for this area

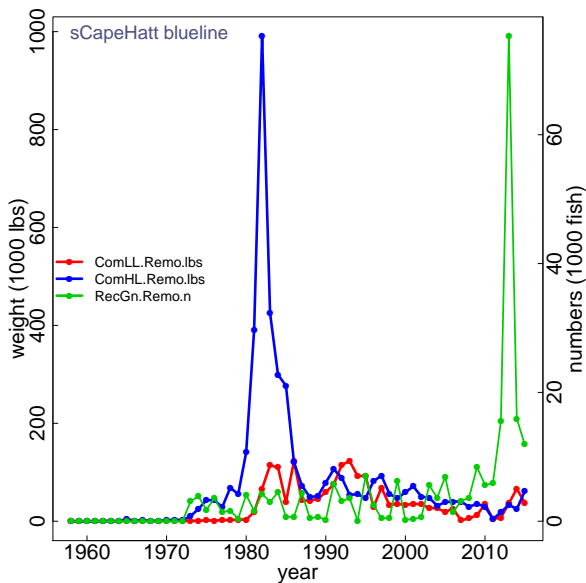


# Methods



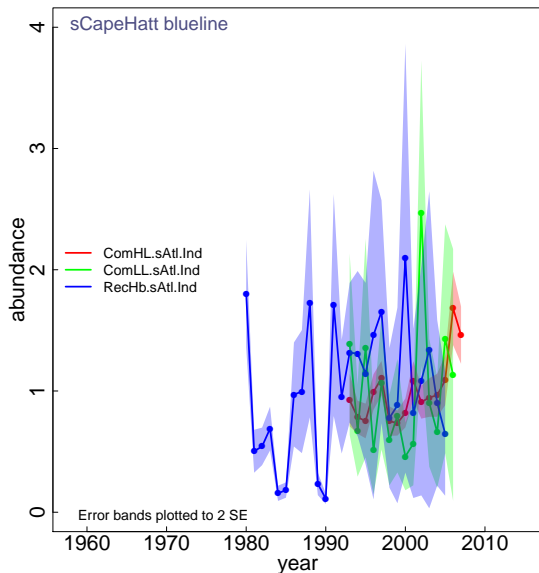
## Removals by fleet

- 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)



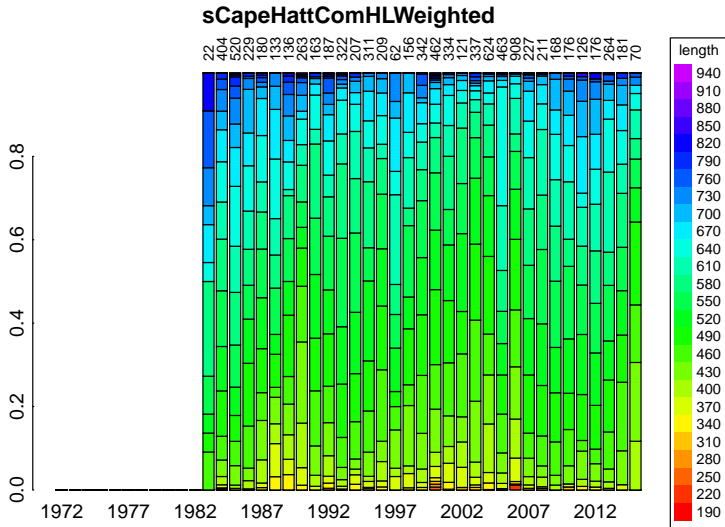
## Indices of abundance

- The same indices as in the ASPIC model for south of Cape Hatteras
- Note this figure is also in the ASPIC presentation for this area

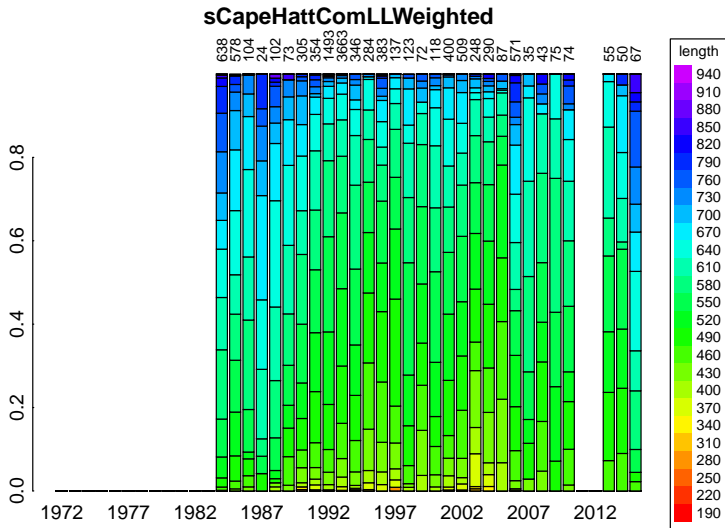




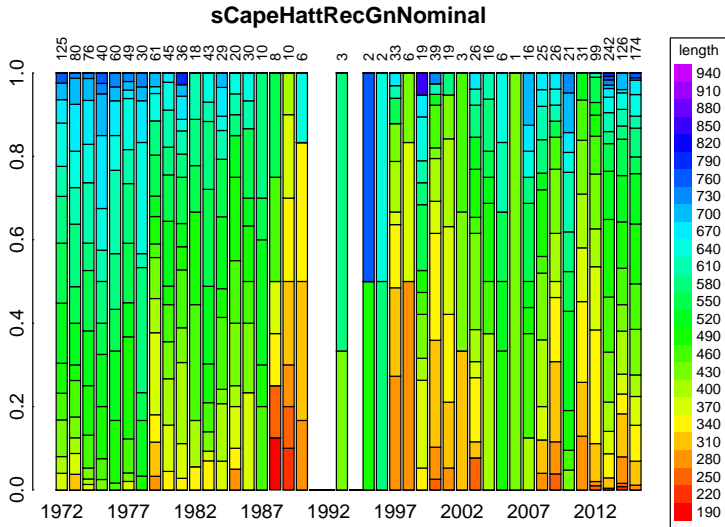
## Commercial handline lengths



## Commercial longline lengths

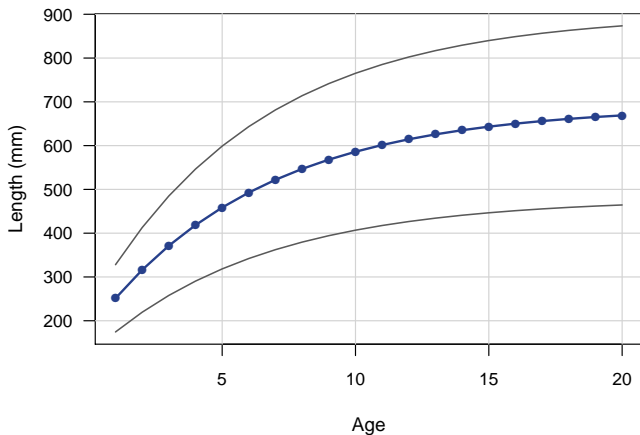


## General recreational lengths



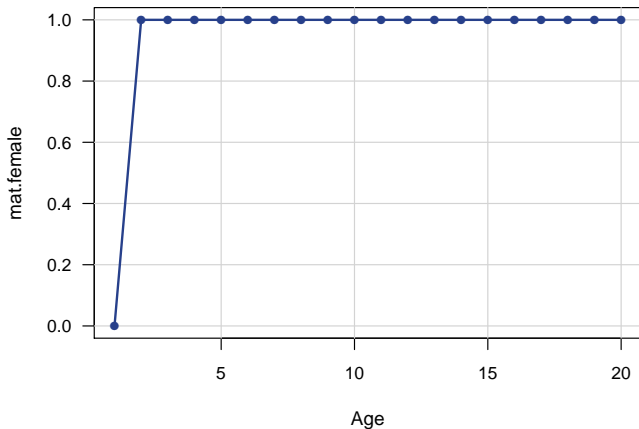
## Life history

Length at age  
(mm)



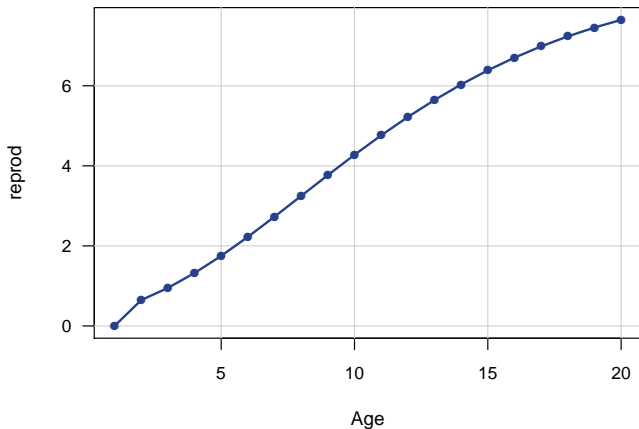
## Life history

Female maturity  
by age



## Life history

Reproductive output at age (million eggs)



## 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.

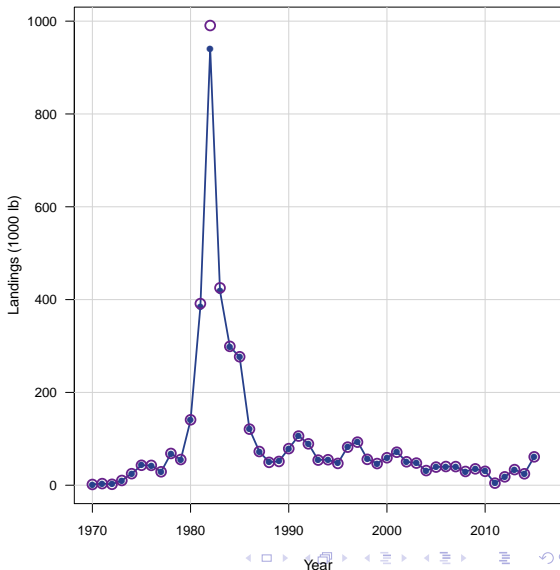
ages	Age	Length	Weight	PFemale	PMature	Fecundity	Reprod	$M$
1	1	251	0.20	0.5	0.0		0.00	0.71
2	2	316	0.40	0.5	1.0	1.29	0.64	0.50
3	3	371	0.64	0.5	1.0	1.90	0.95	0.40
4	4	419	0.91	0.5	1.0	2.64	1.32	0.33
5	5	459	1.19	0.5	1.0	3.50	1.75	0.29
6	6	493	1.47	0.5	1.0	4.45	2.22	0.26
7	7	522	1.74	0.5	1.0	5.46	2.73	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

# Results



## Fit to removals

### Commercial handline



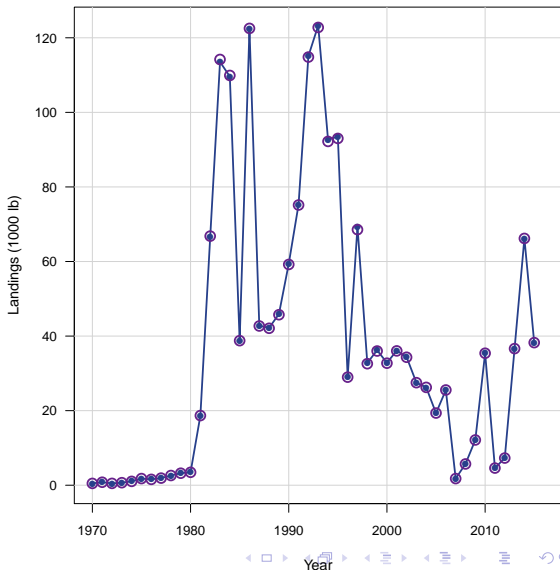


# Results



## Fit to removals

### Commercial longline

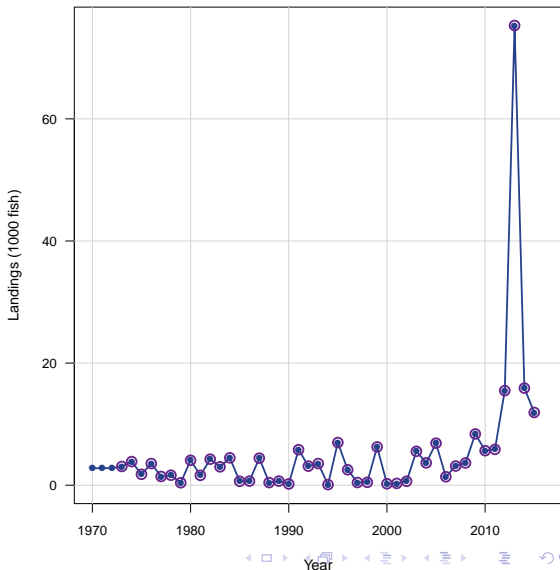


# Results



## Fit to removals

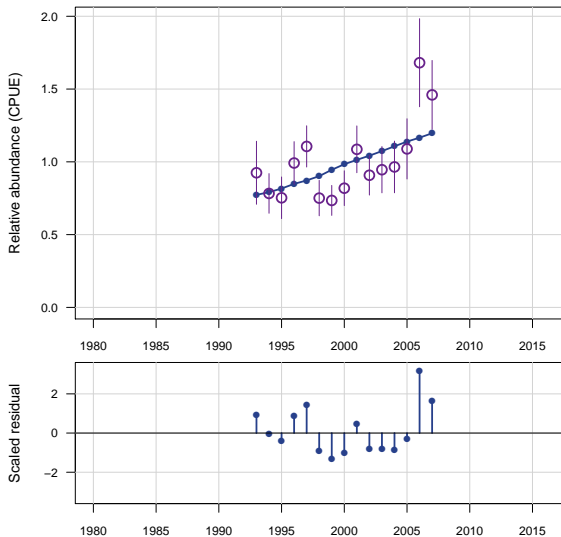
### General recreational



# Results

## Fit to indices

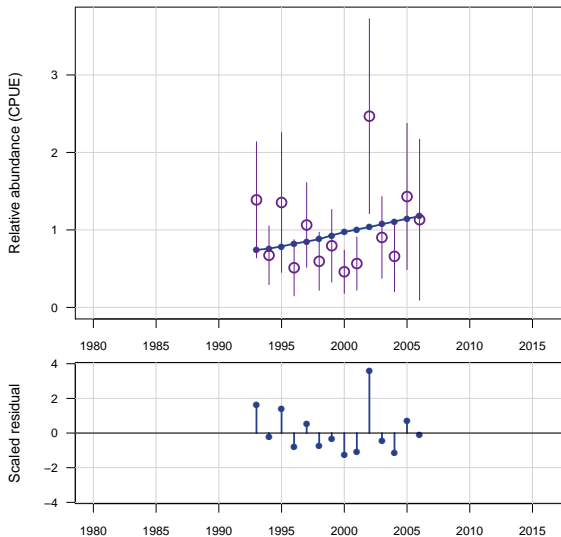
### Commercial handline



# Results

## Fit to indices

### Commercial longline

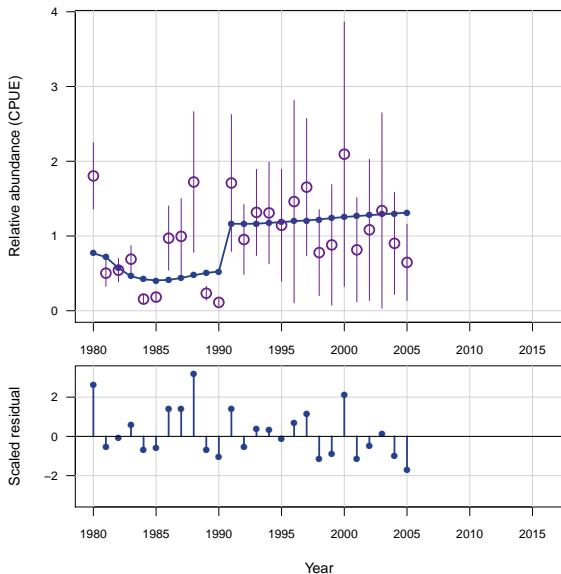


# Results



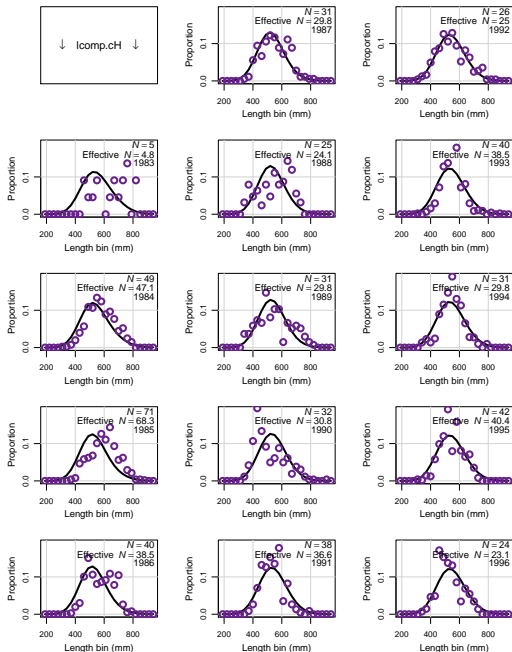
## Fit to indices

Headboat (recreational)

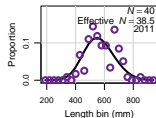
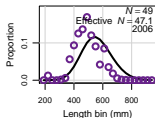
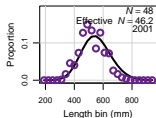
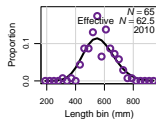
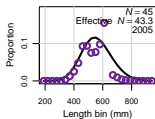
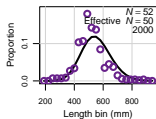
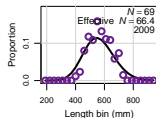
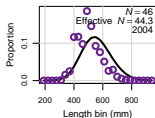
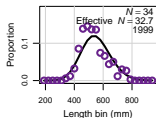
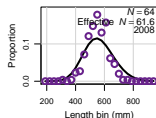
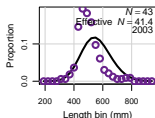
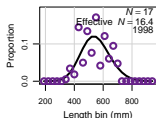
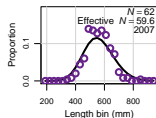
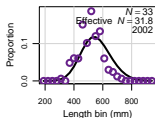
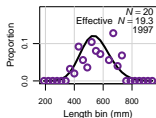


## Fit to lengths Page 1: Commercial handline 1983-1996

↓ lcomp.ch ↓



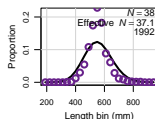
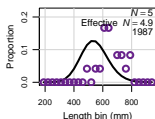
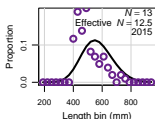
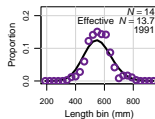
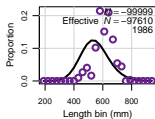
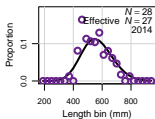
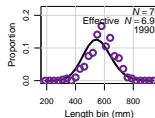
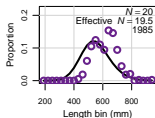
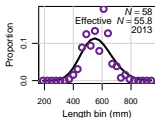
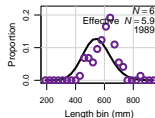
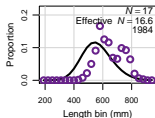
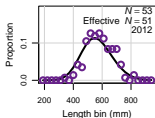
## Fit to lengths Page 2: Commercial handline 1997-2011



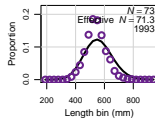
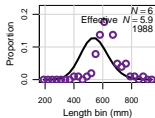
# Results



Fit to  
lengths  
Page 3:  
Commercial  
handline  
2012-2015  
Commercial  
longline  
1984-1993

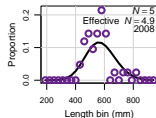
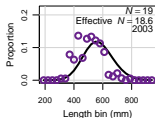
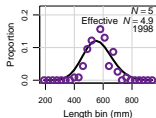
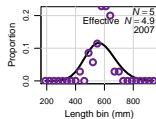
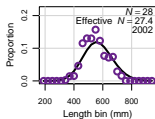
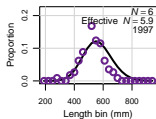
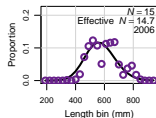
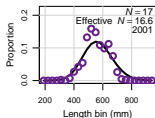
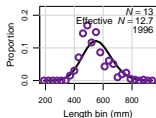
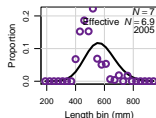
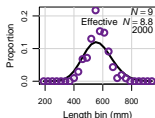
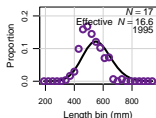
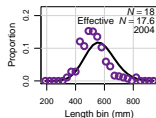
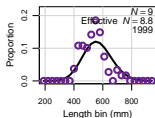
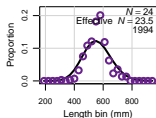


↓ lcomp.cL ↓





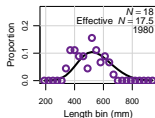
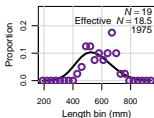
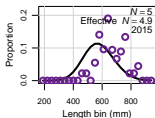
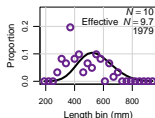
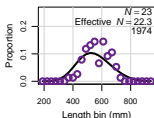
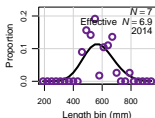
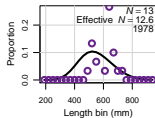
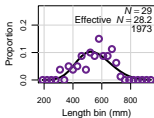
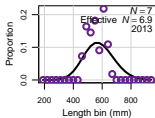
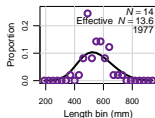
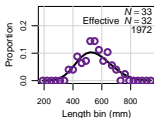
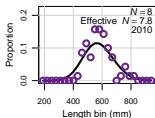
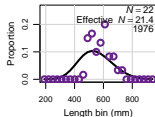
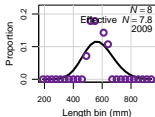
## Fit to lengths Page 4: Commercial longline 1994-2008



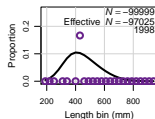
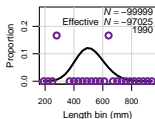
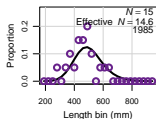
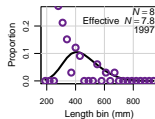
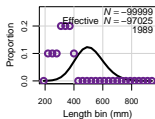
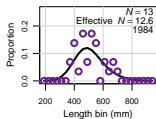
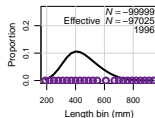
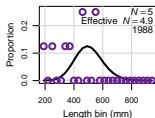
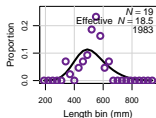
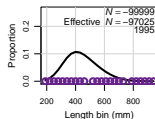
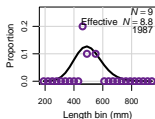
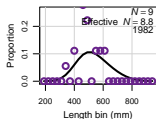
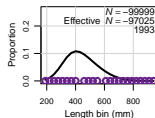
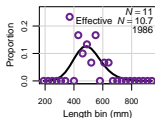
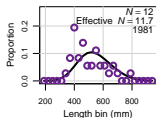
# Results



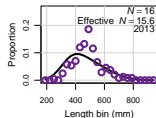
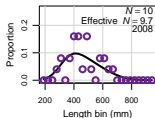
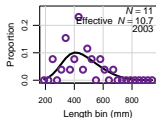
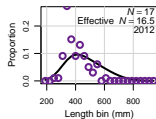
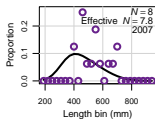
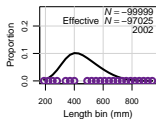
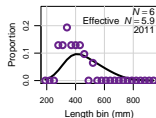
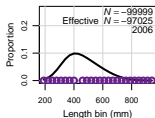
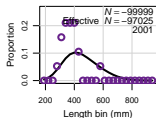
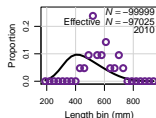
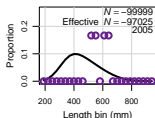
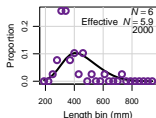
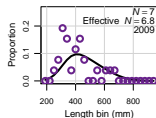
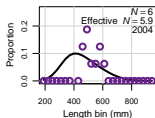
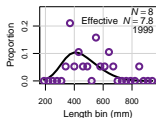
Fit to  
lengths  
Page 5:  
Commercial  
longline  
2009-2015  
General  
recreational  
1972-1980



## Fit to lengths Page 6: General recreational 1981-1998

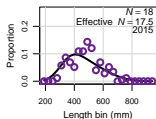
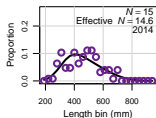


## Fit to lengths Page 7: General recreational 1999-2013





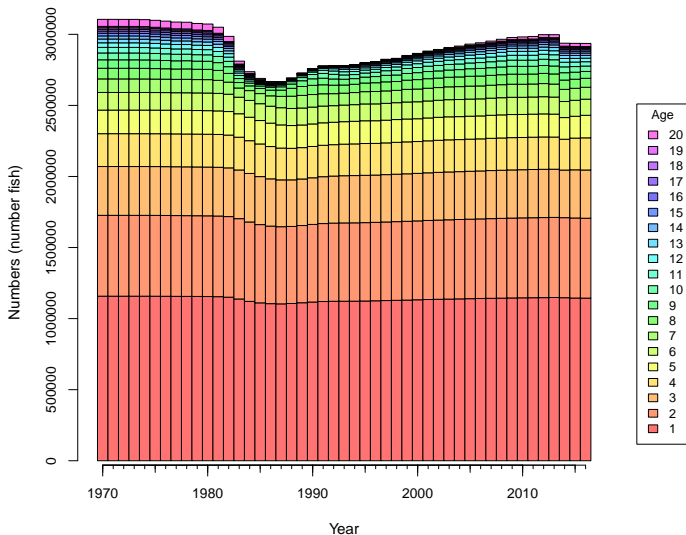
## Fit to lengths Page 8: General recreational 2014-2015



# Results



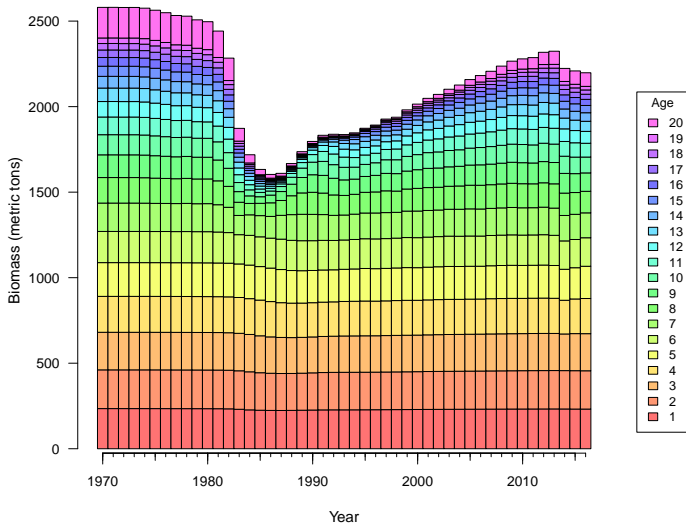
Estimated  
abundance at  
age at start of  
year



# Results



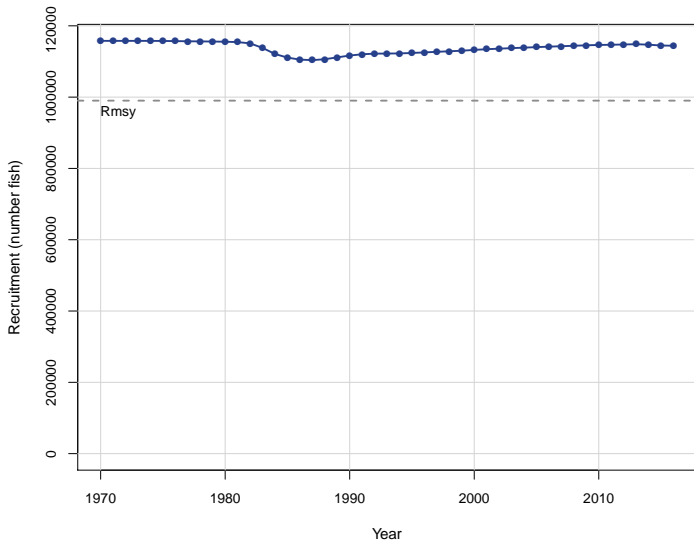
Estimated biomass at age at start of year



# Results



Estimated recruitment of age-1 fish

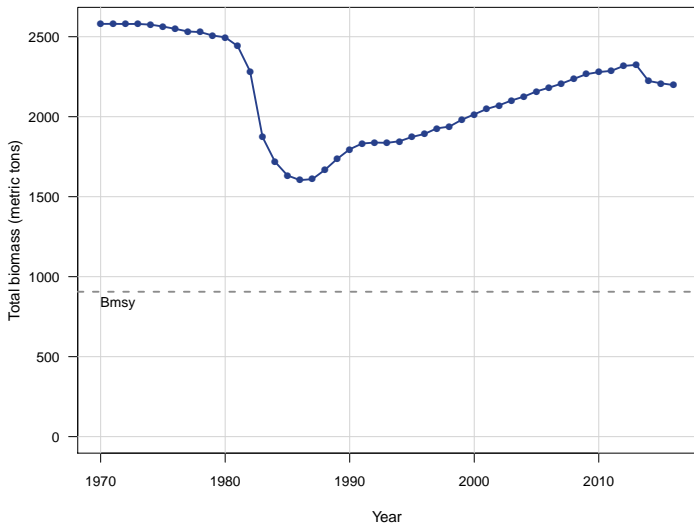




# Results



## Estimated total biomass

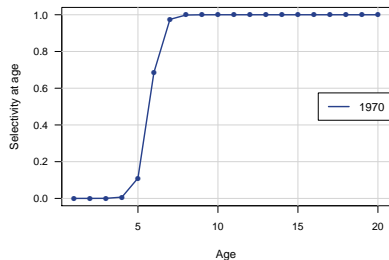


# Results

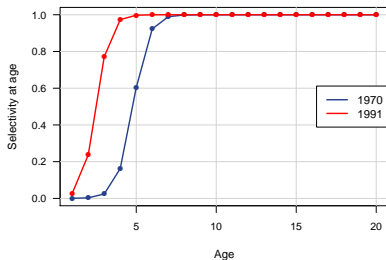


## Estimated selectivity at age

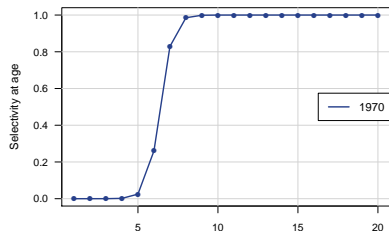
### Commercial handline



### General recreational

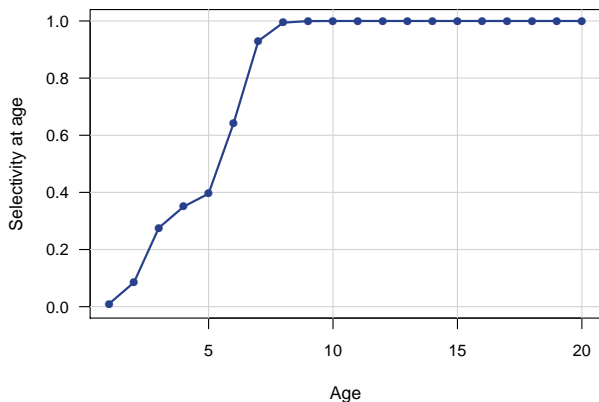


### Commercial longline



Estimated average selectivity at age for terminal year (2015)

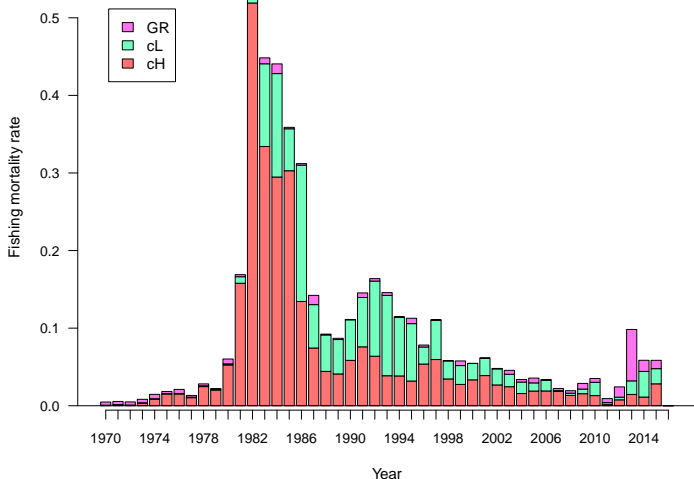
- Weighted by geometric mean  $F$  from the last three years (2013-2015)



# Results



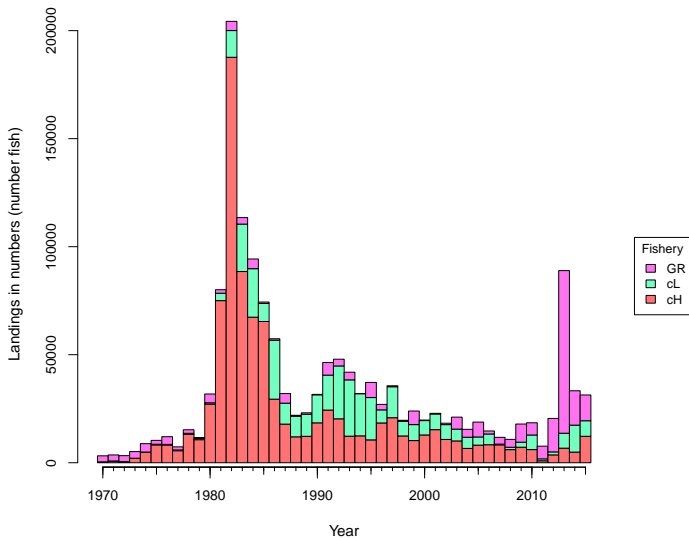
Estimated  
fully selected  
fishing  
mortality  
rates by fleet



# Results



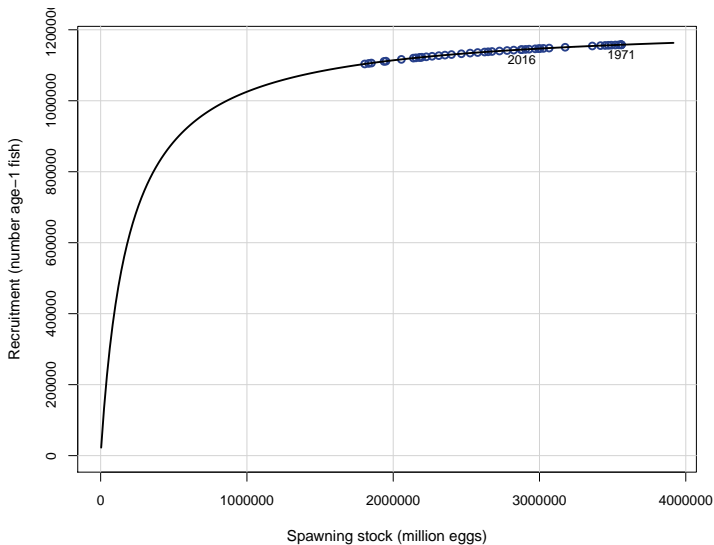
Estimated removals in numbers by fleet



# Results



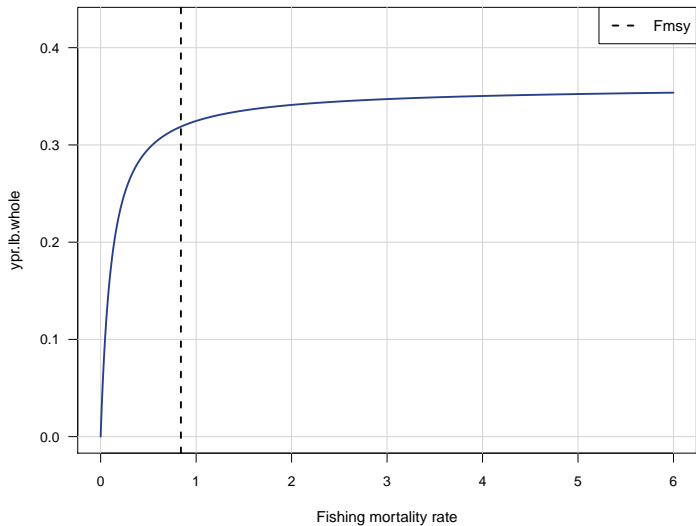
Beverton-Holt  
spawner-recruit  
curve



# Results



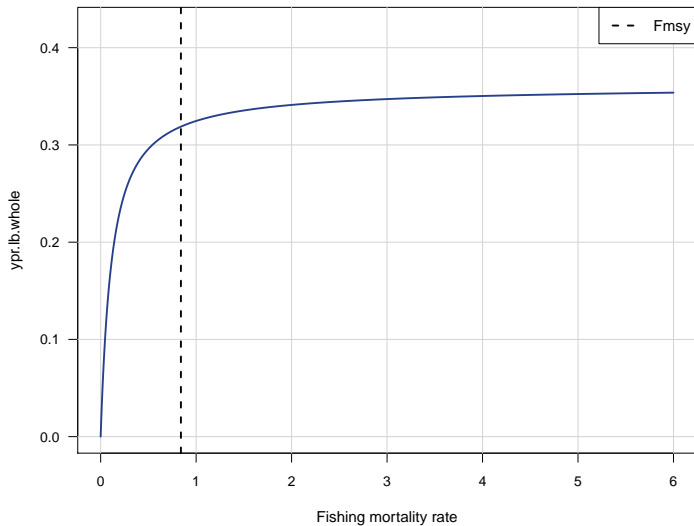
Yield per recruit at  $F$



# Results



Yield per recruit at  $F$

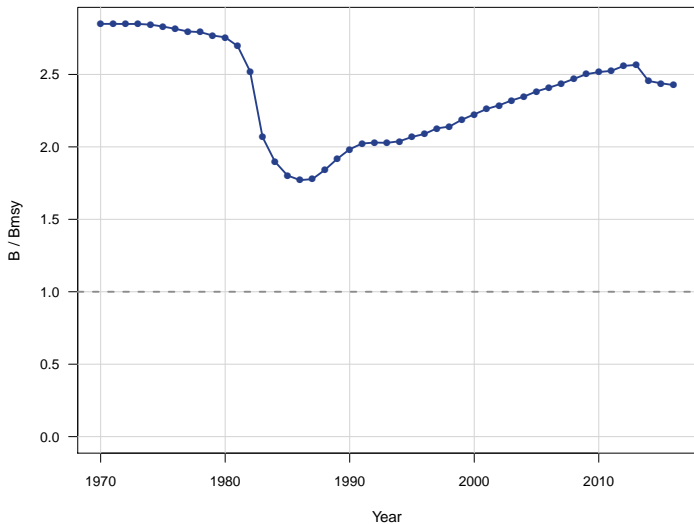




# Results



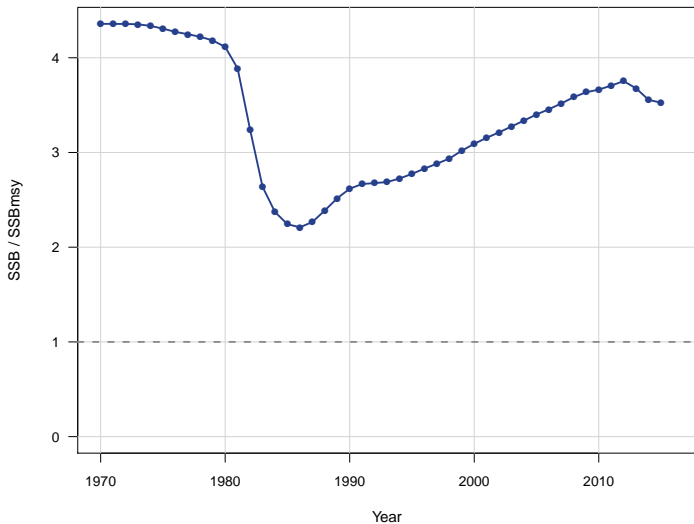
Total biomass  
relative to  
biomass at  
 $F_{MSY}$  ( $B_{MSY}$ )



# Results



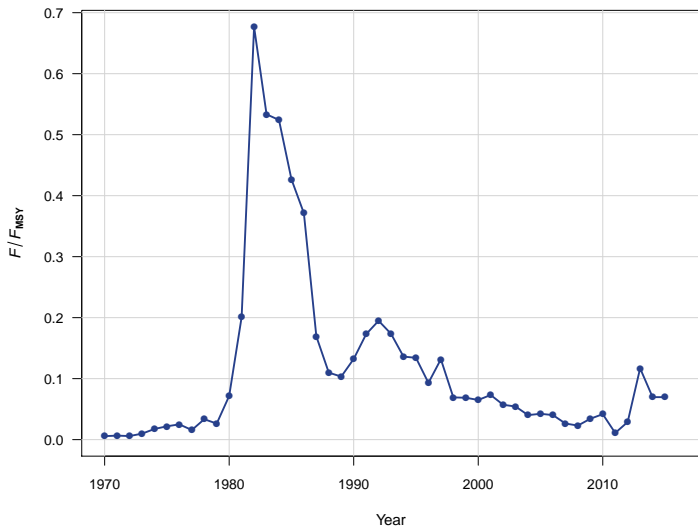
Spawning  
biomass  
relative to  
 $SSB_{MSY}$



# Results



$F$  relative to  
 $F_{MSY}$



# Results



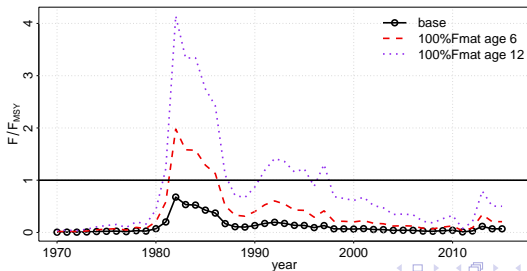
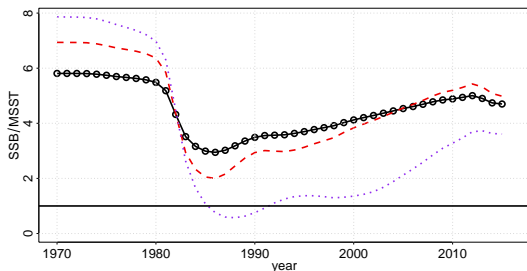
**Table:** Estimated status indicators, benchmarks, and related quantities from the ASPM south of Cape Hatteras, conditional on estimated current selectivities averaged across fleets. Monte Carlo/Bootstrap analysis was not conducted for this model, so median values and measures of precision (standard 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	—	—
$85\%F_{MSY}$	$y^{-1}$	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	—	—

# Results



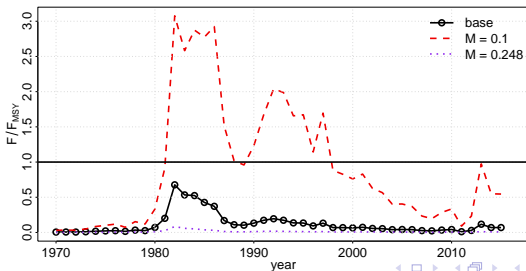
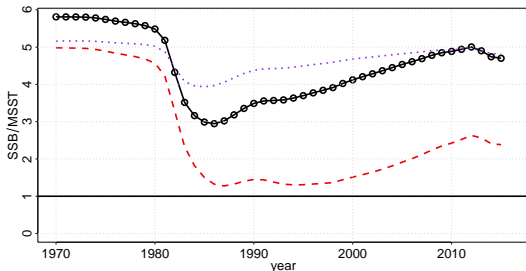
Sensitivity to age at maturity:  
ASPM Runs S1-S2



# Results



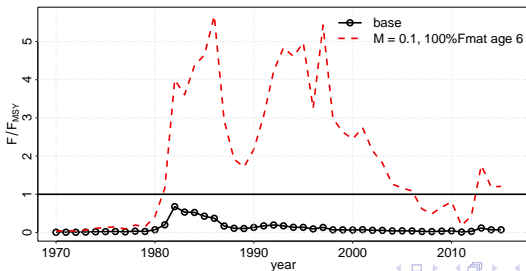
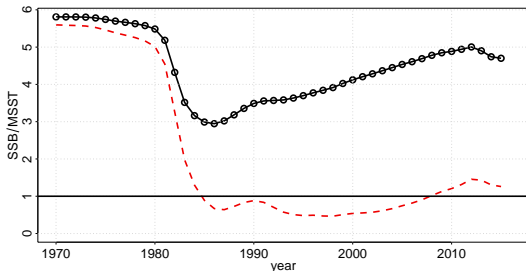
Sensitivity to natural mortality:  
ASPM Runs S3-S4



# Results



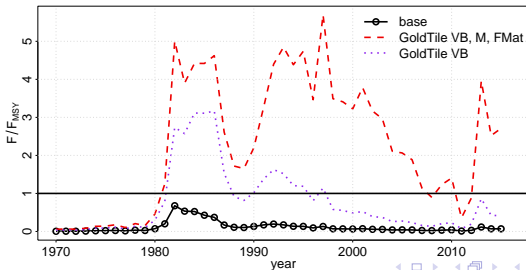
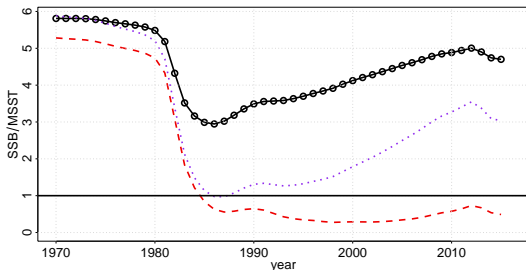
## Sensitivity to age at maturity and natural mortality: ASPM Run S5



# Results



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

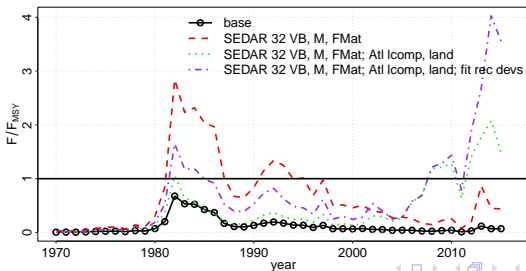
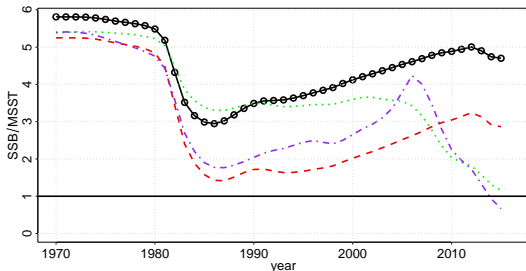




# Results



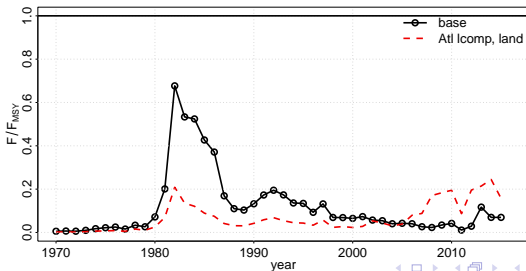
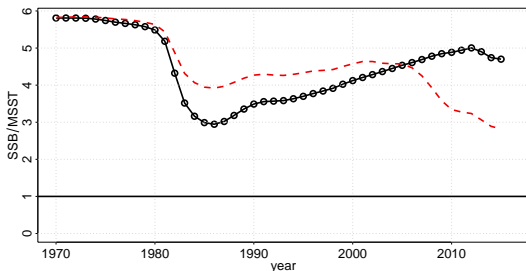
## Sensitivity to SEDAR 32 Blueline Tilefish settings: ASPM Runs S8-S10



# Results



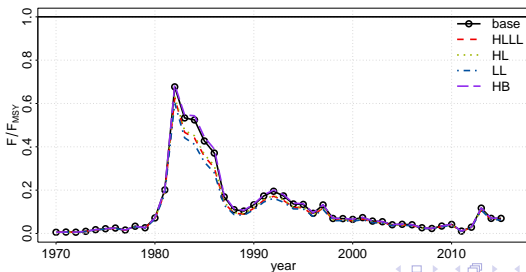
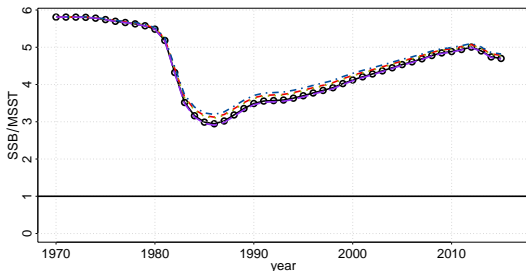
## Sensitivity to including removals north of Cape Hatteras: ASPM Run S11



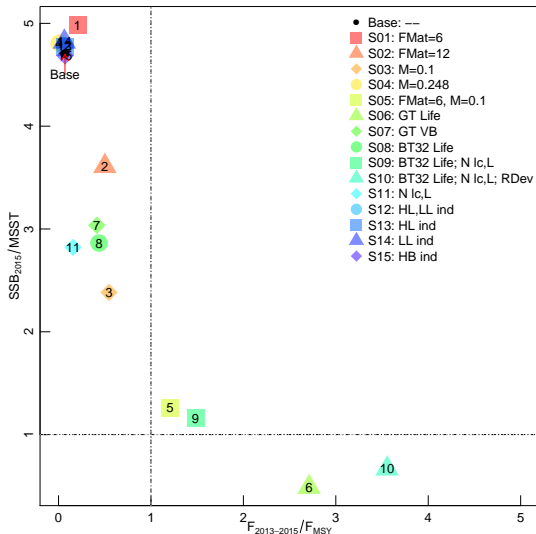
# Results



Sensitivity to indices:  
ASPM Runs S12-S15



## Sensitivity status phase plots



**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.  $SSB/SSB_{MSY}$  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	$F_{MSY}$	$SSB_{MSY}$	$B_{MSY}$	MSY	$F/F_{MSY}$	$SSB/SSB_{MSY}$	$SSB/MSST$	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