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SEDAR 21 Dusky Shark Update Stock Assessment

September 7, 2016



What is an update?

- Uses only the same data inputs that were vetted in the previous benchmark assessment
- Uses the same stock assessment model
- Typically updates only base run



What was done in the 2016 Dusky shark update?

- Used the same data inputs that were vetted in the previous benchmark assessment (SEDAR 21) updated from 2010 to 2015:
 - Five indices of relative abundance (CPUEs)
 - Effort series
- Nothing else was updated:
 - Same life history inputs
 - Same selectivities
 - Same stock assessment model (catch-free age-structured production model) and projection methodology



What was done in the 2016 Dusky shark update?

- Updated the five states of nature identified by the SEDAR 21 peer reviewers:
 - Base
 - High M
 - U-shape M
 - High productivity
 - Low productivity

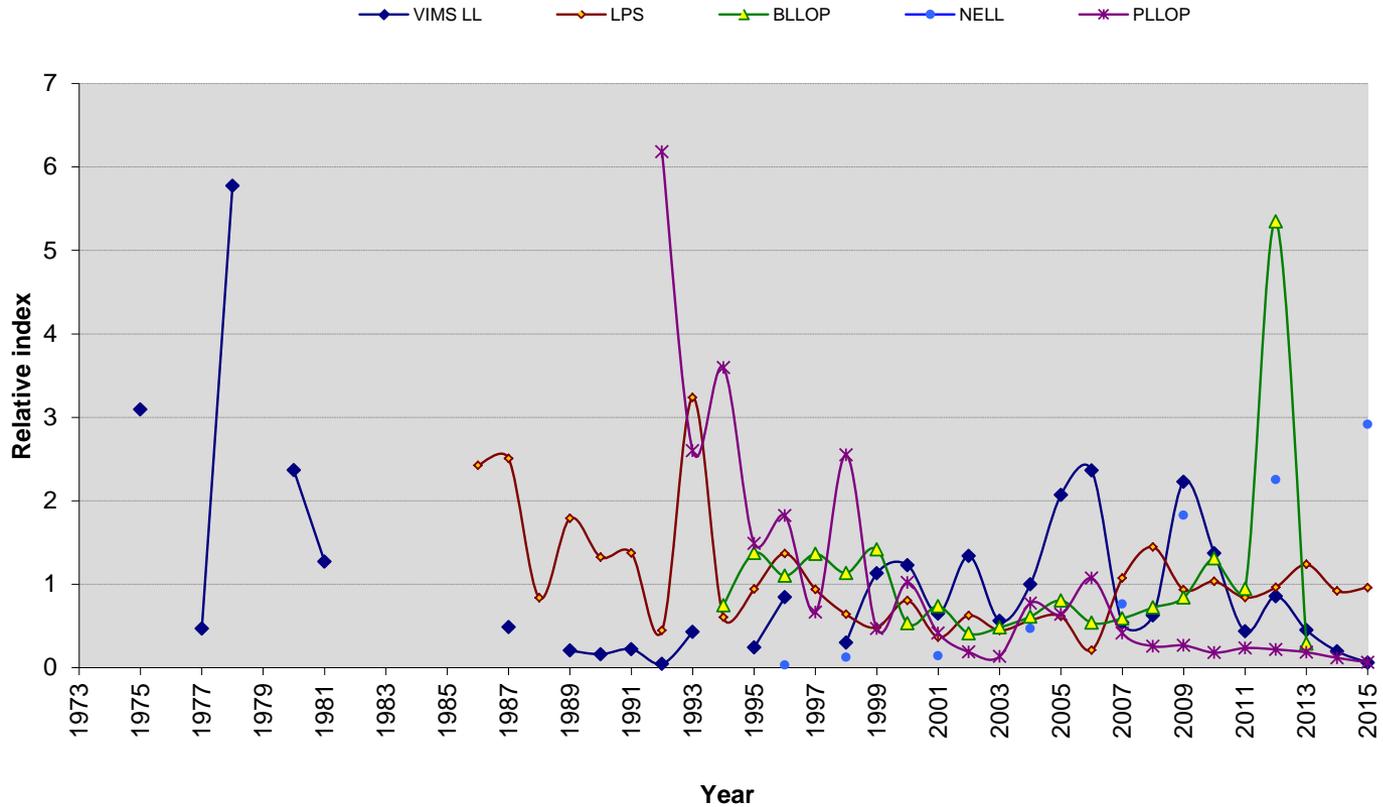


2016 Dusky shark update inputs

- Five CPUEs:
 - VIMS LL (1975-2015, n=31)
 - LPS (1986-2015, n=30)
 - BLLOP (1994-2015, n=20)
 - NELL (1996-2015, n=8)
 - PLLOP (1992-2015, n=24)

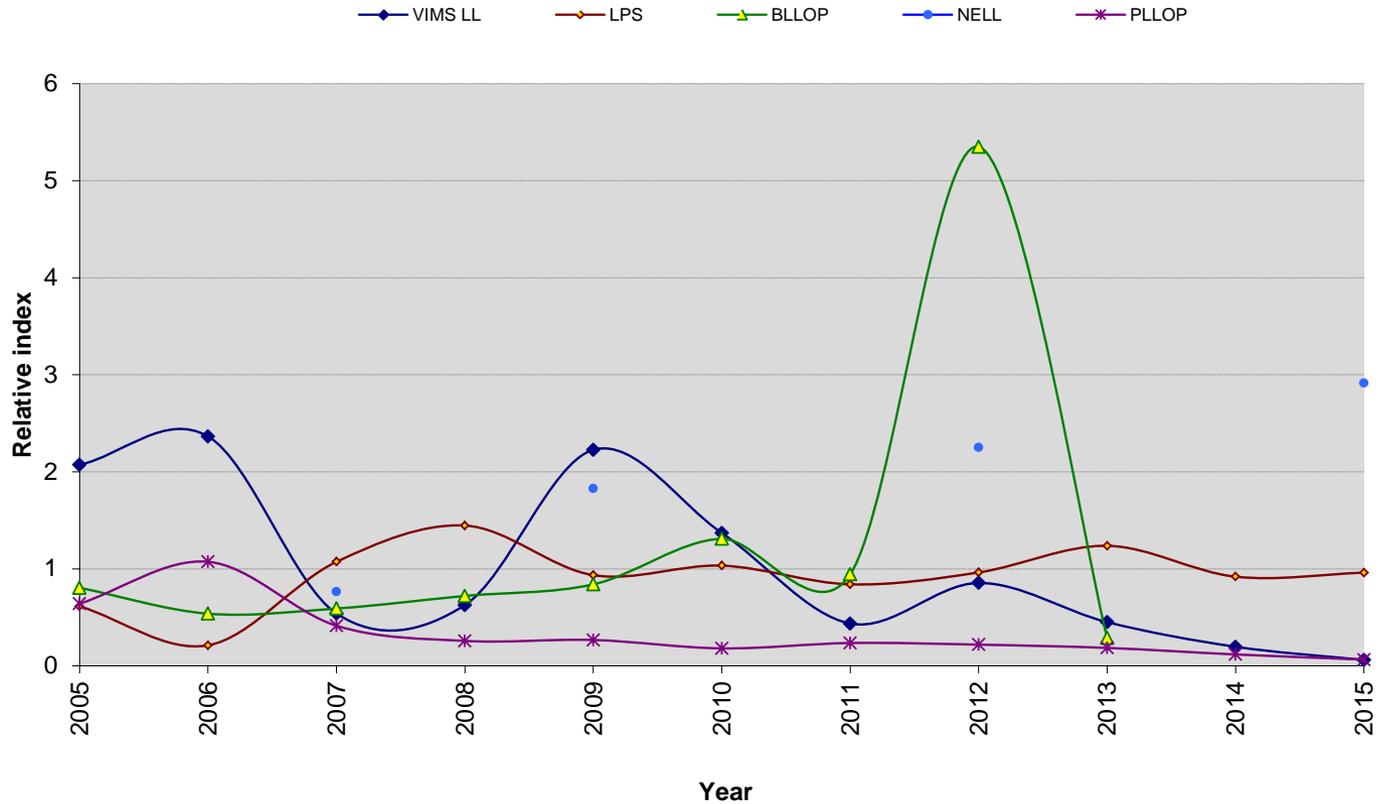


Indices of relative abundance



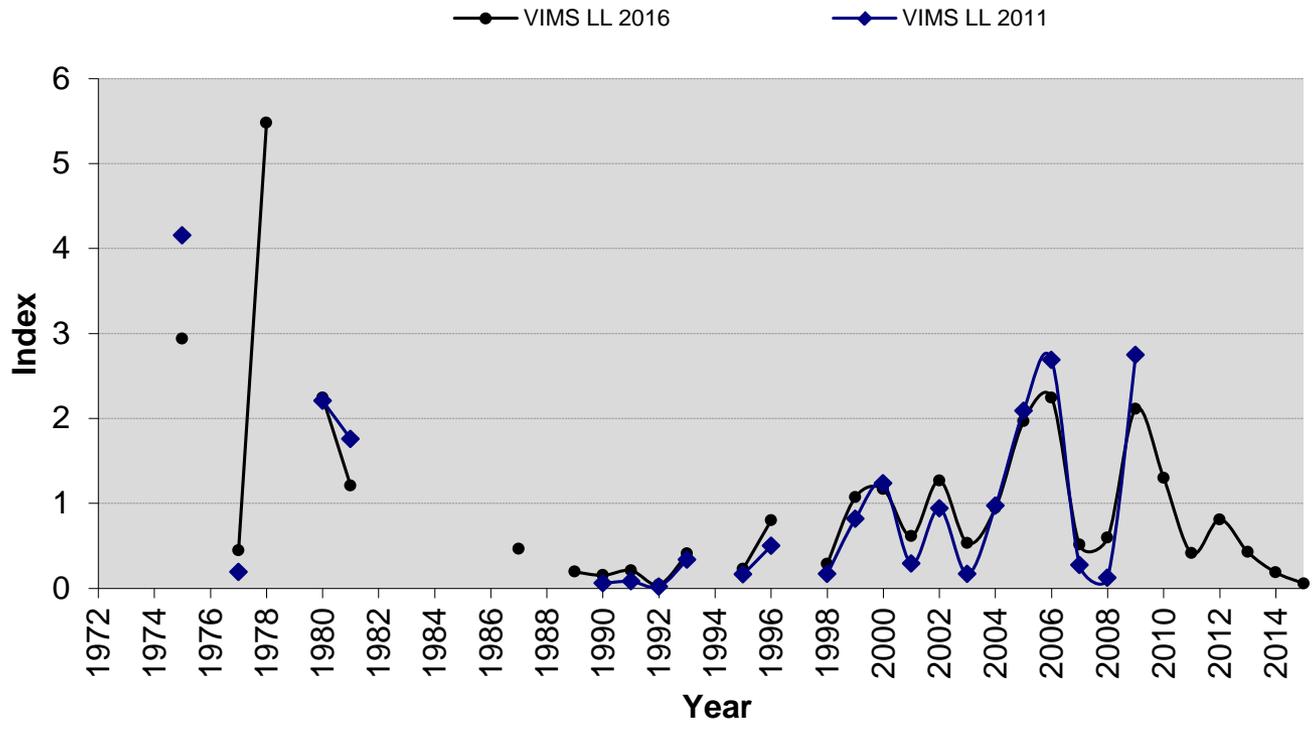


Indices of relative abundance



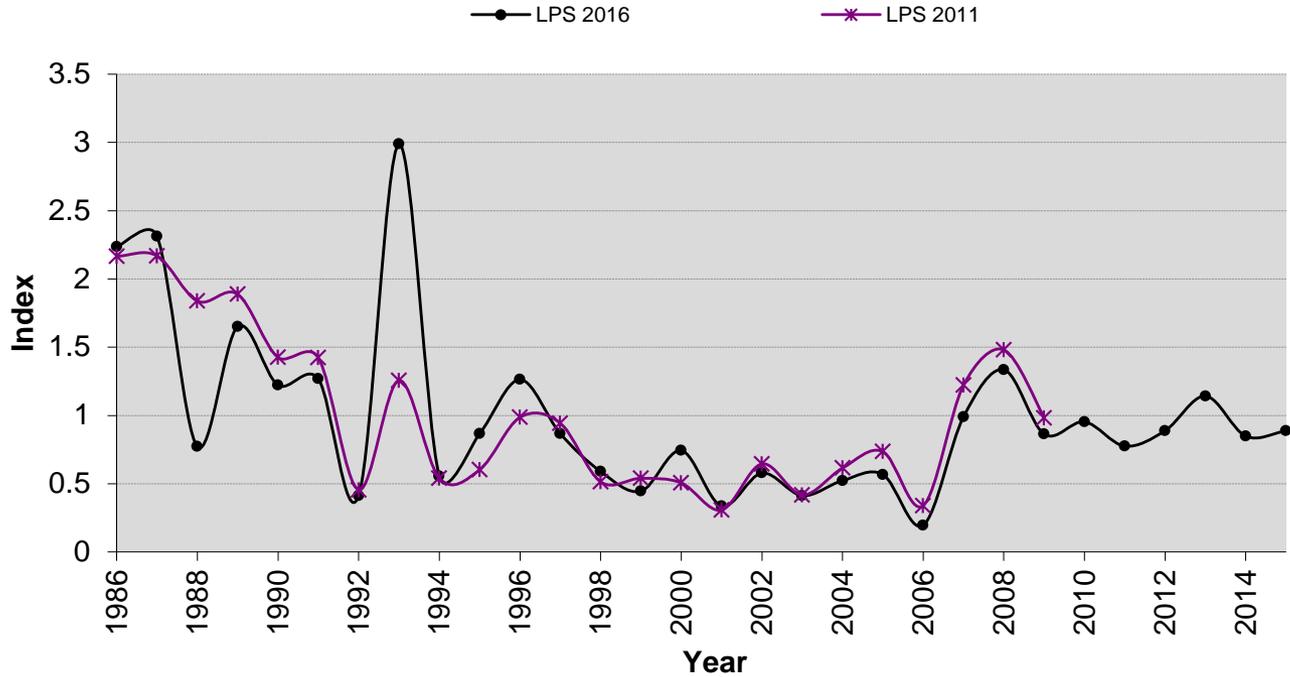


Indices of relative abundance: VIMS LL



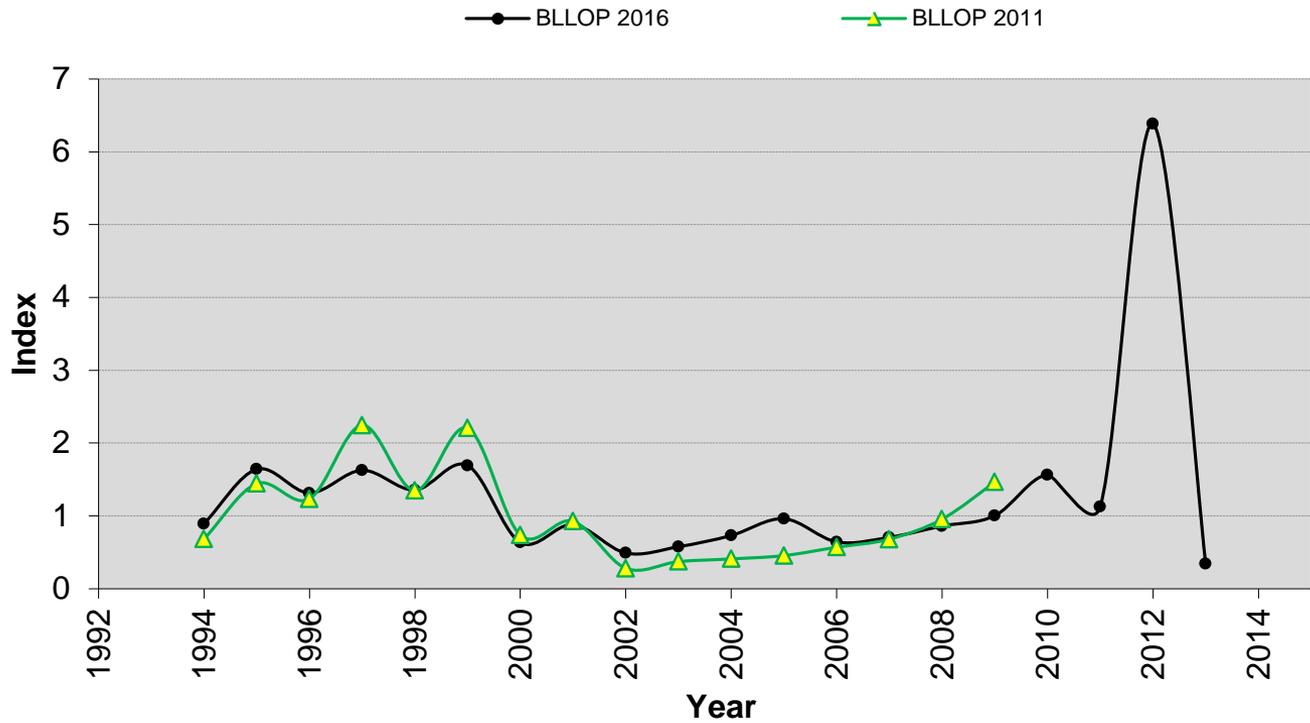


Indices of relative abundance: LPS



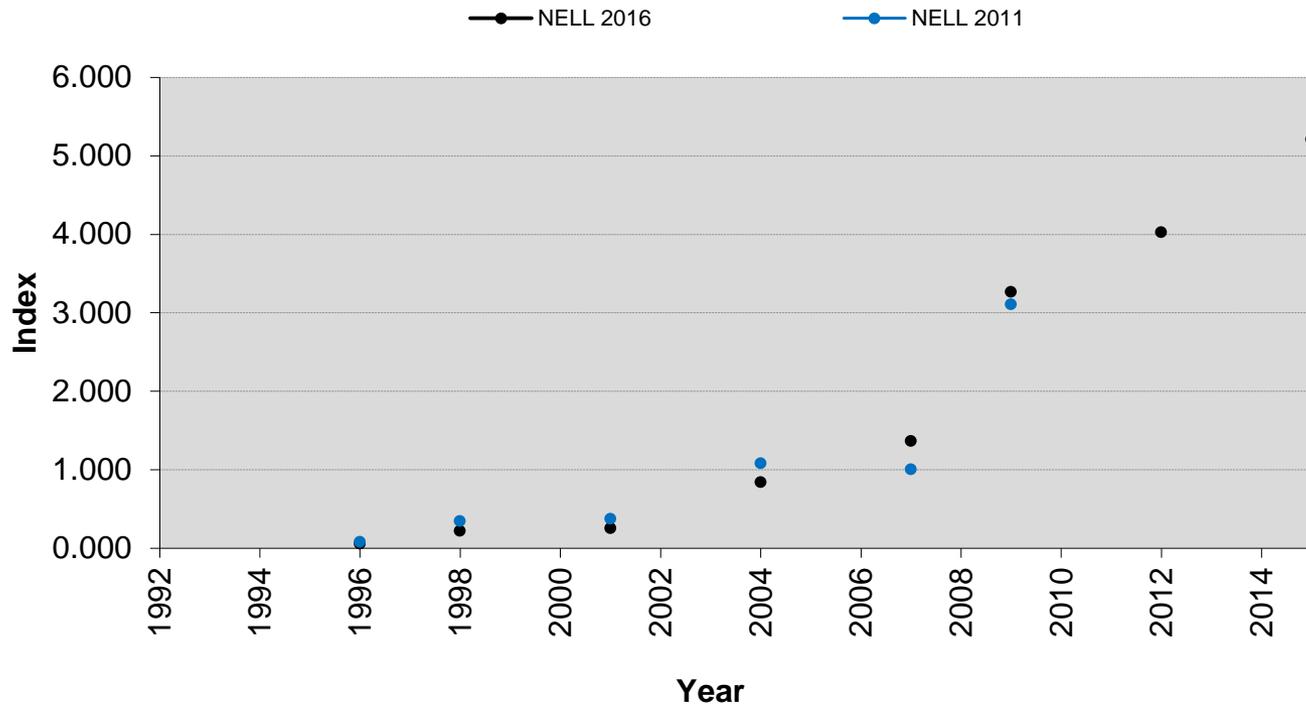


Indices of relative abundance: BLLOP



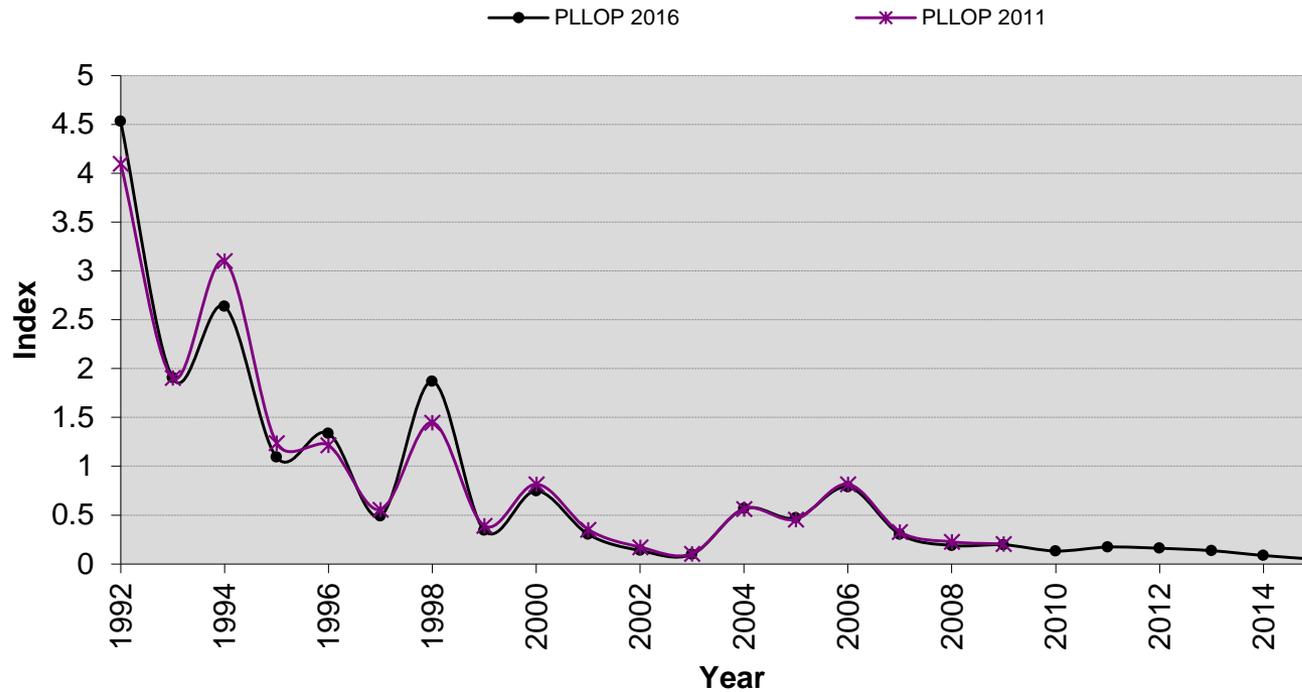


Indices of relative abundance: NELL





Indices of relative abundance: PLLOP





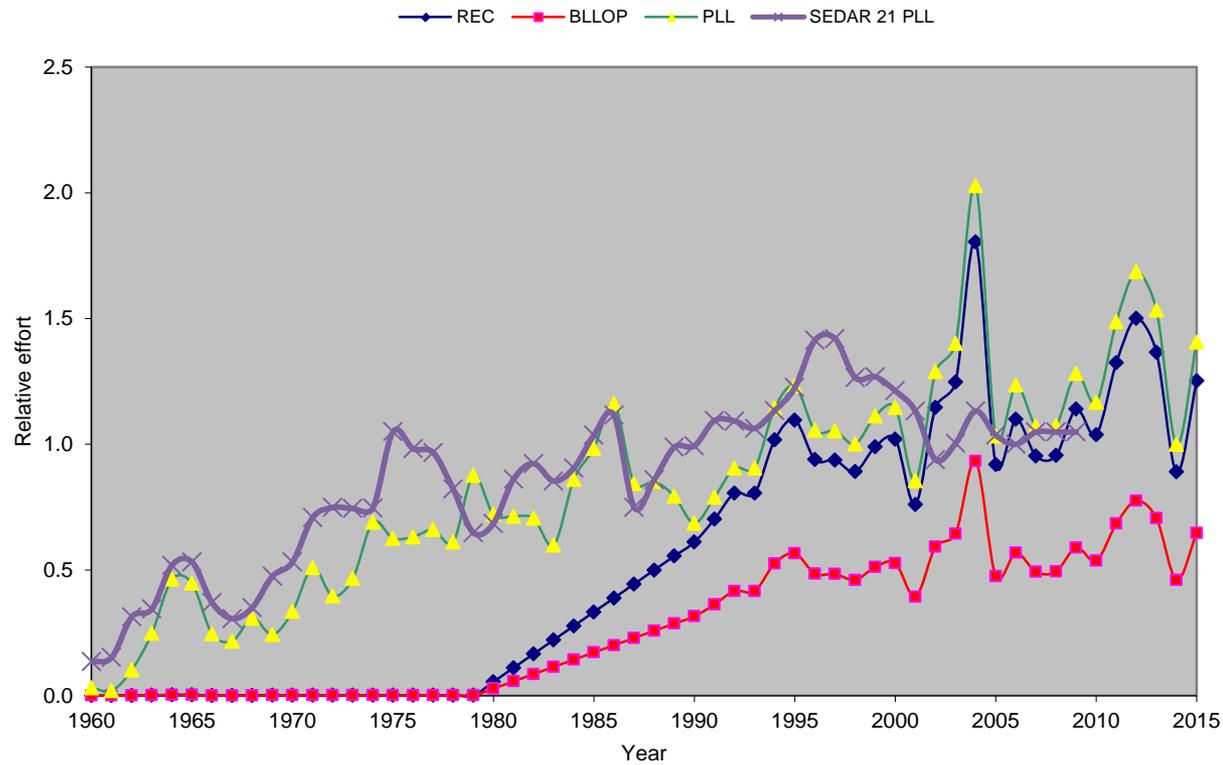
2016 Dusky shark update inputs

- Three fleets (effort series):
 - PLL: Pelagic longline effort (only series available, from ICCAT NWA, 1960-2014)
 - BLL: Bottom longline effort (scaled to PLL)
 - REC: Recreational effort (scaled to PLL)



Relative fishing effort series

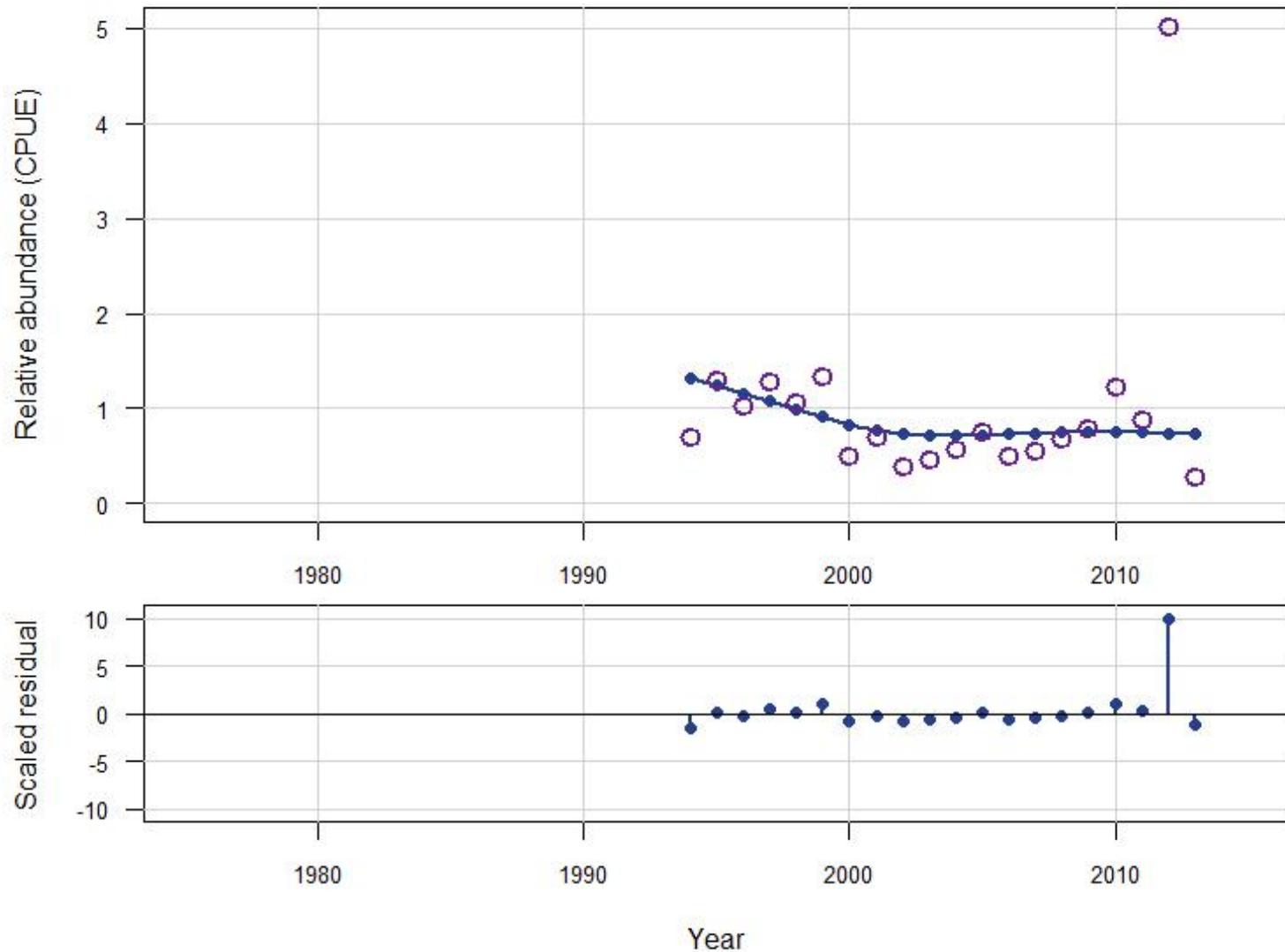
Relative effort series for dusky sharks



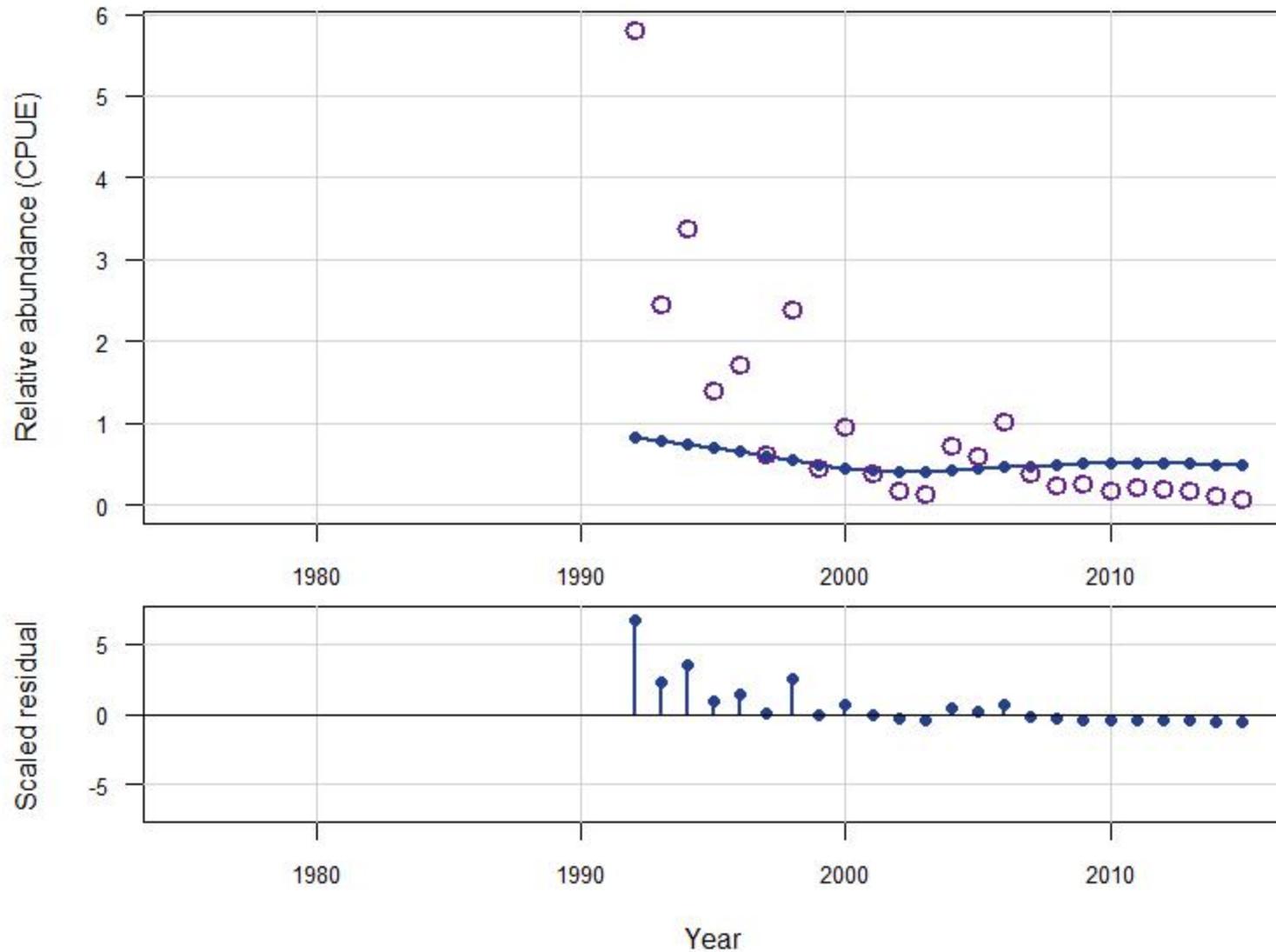


Main results

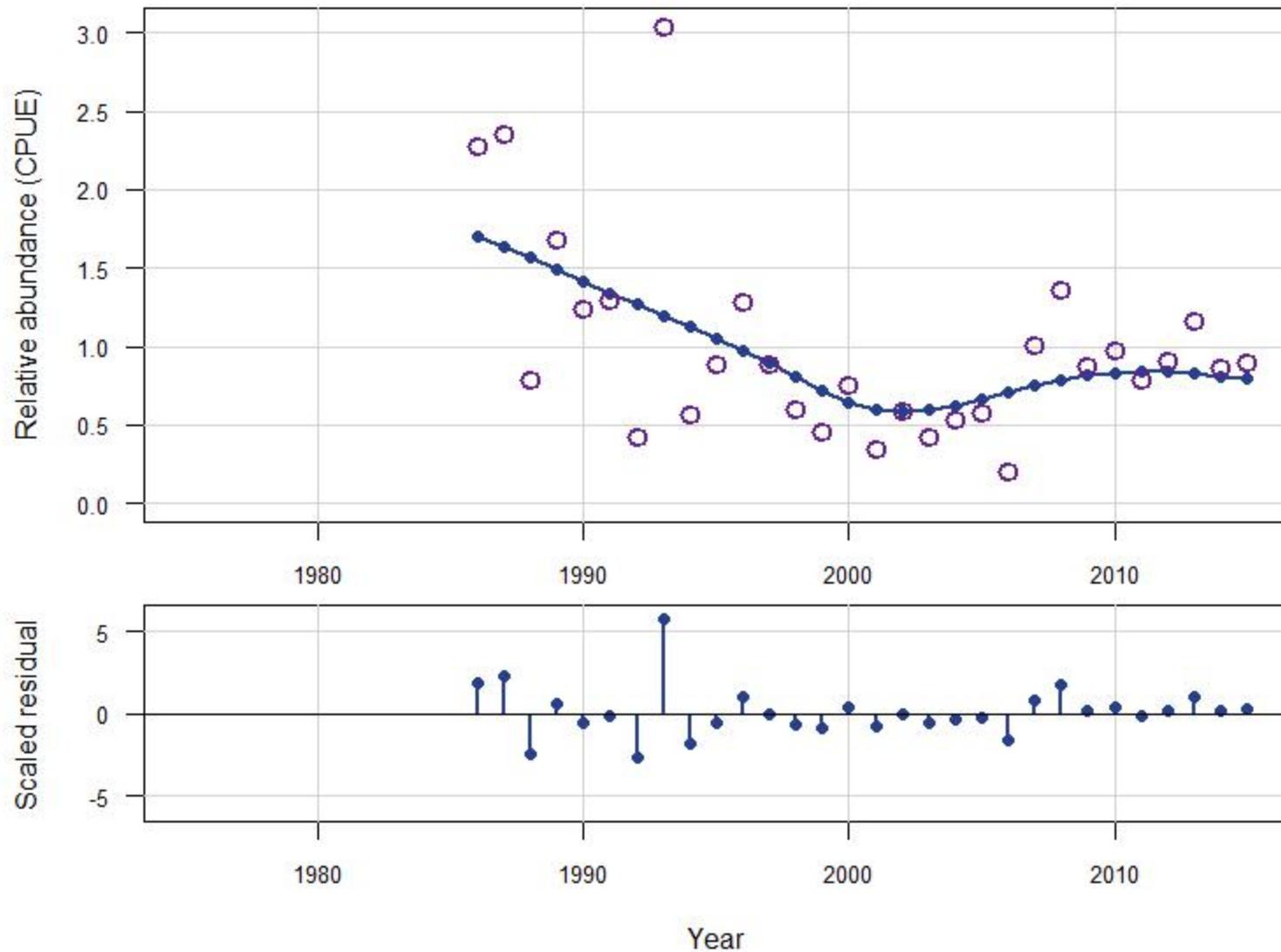
Model fit to BLLOP index



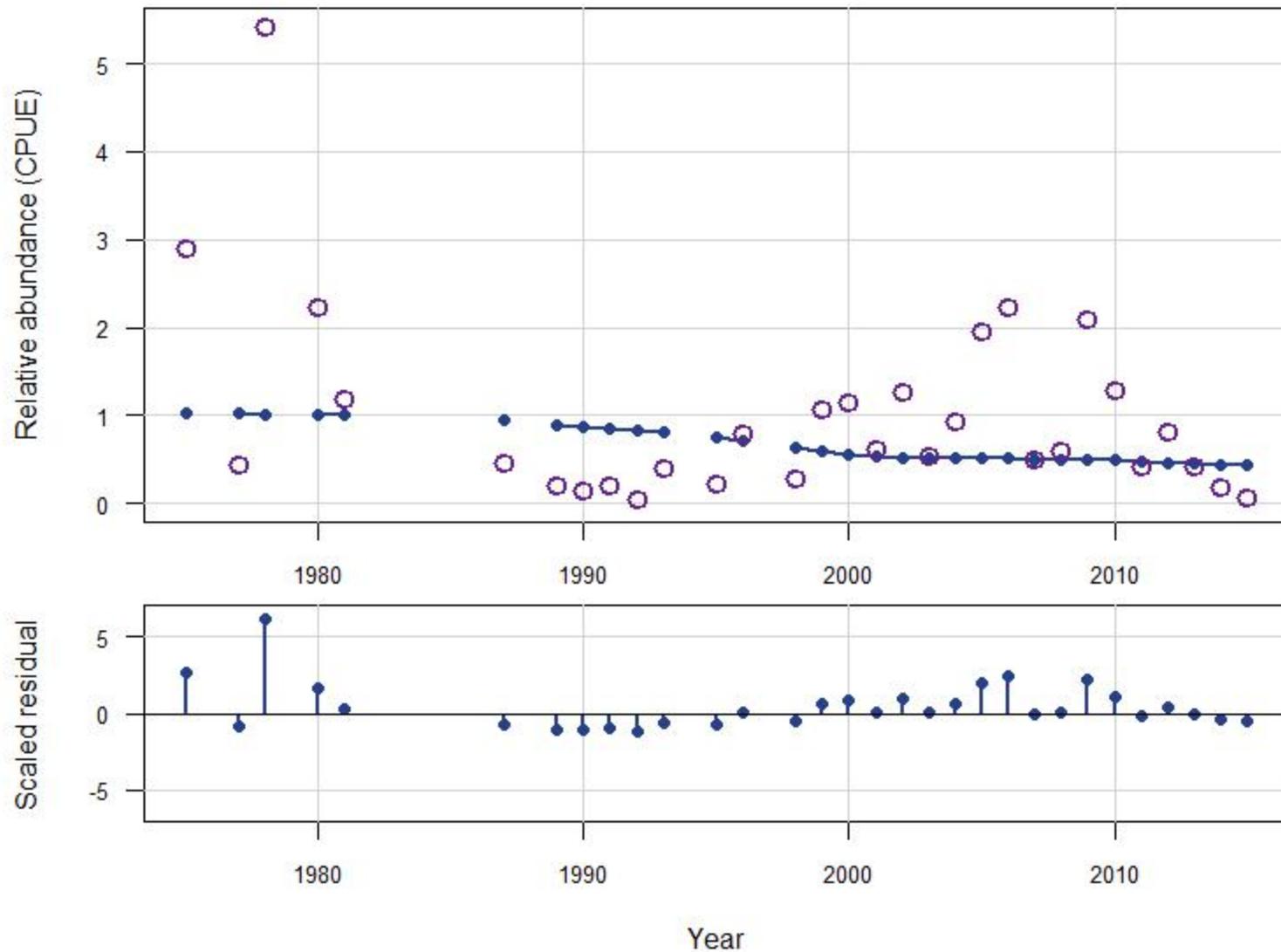
Model fit to PLLOP index



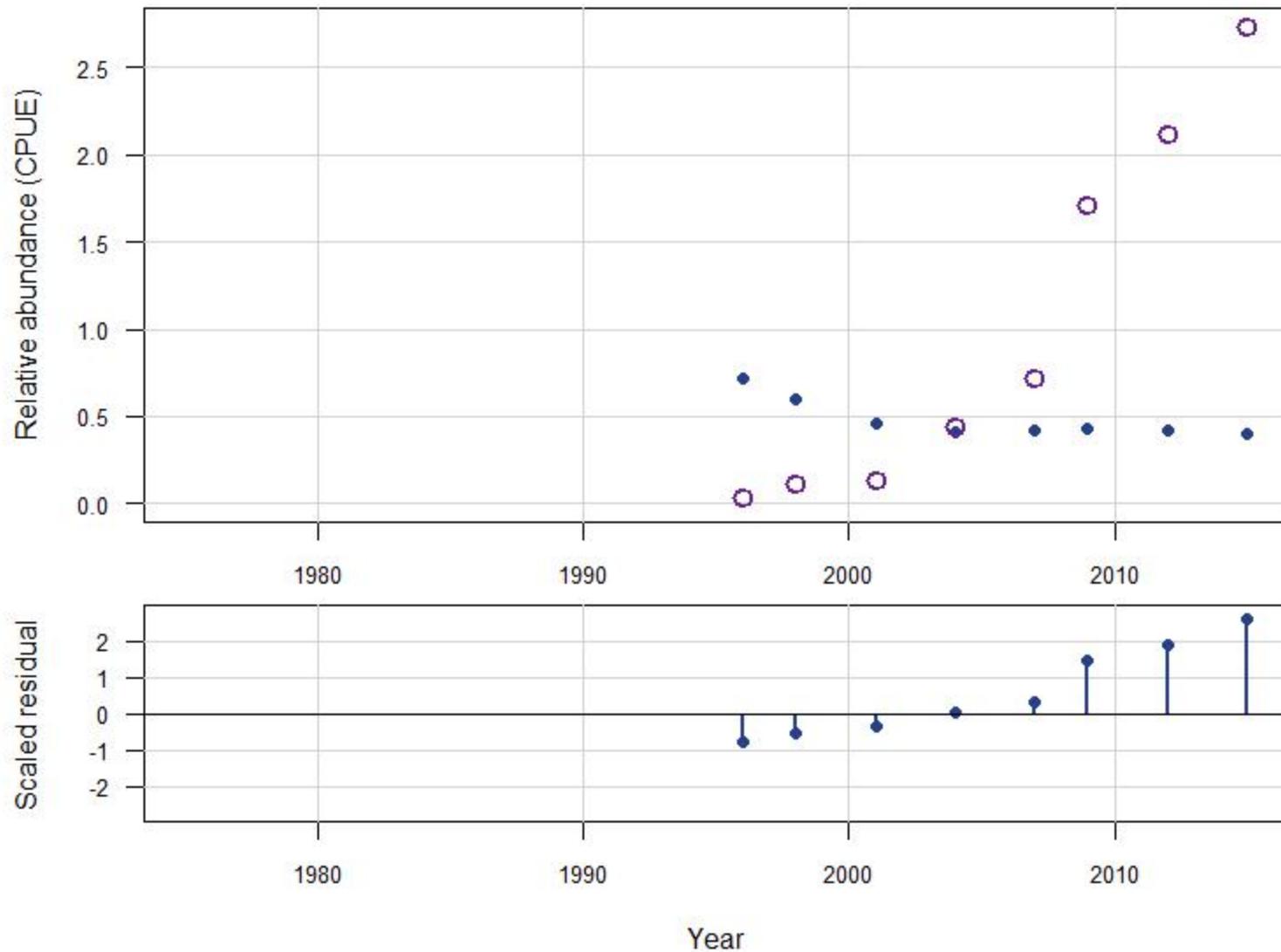
Model fit to LPS index

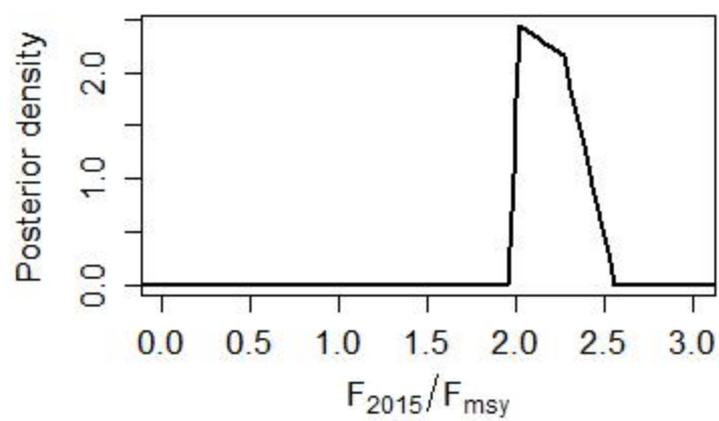
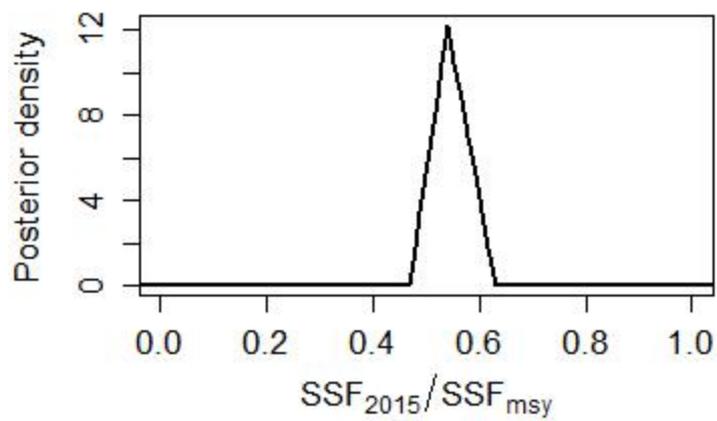
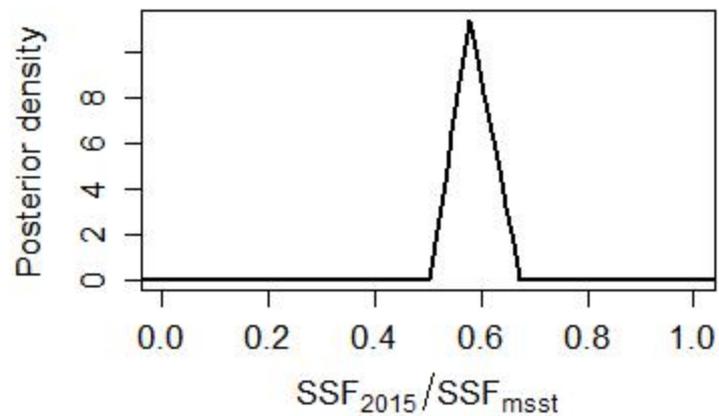
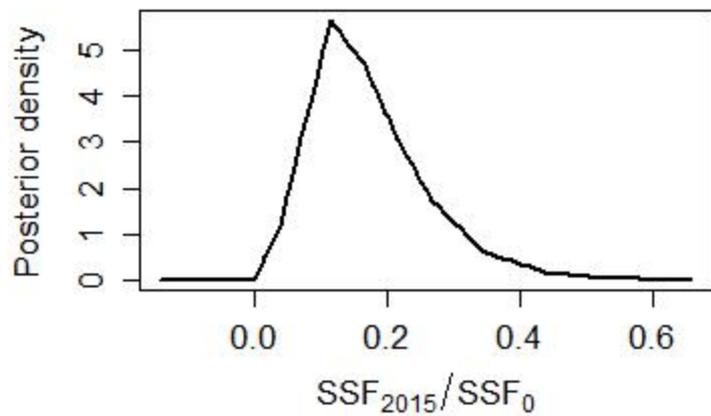


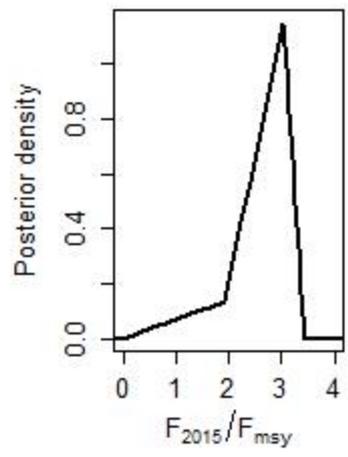
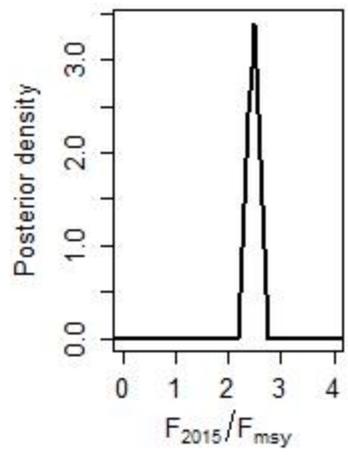
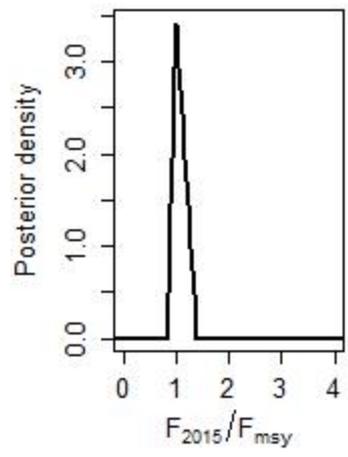
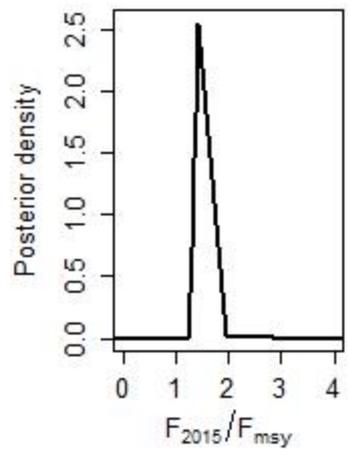
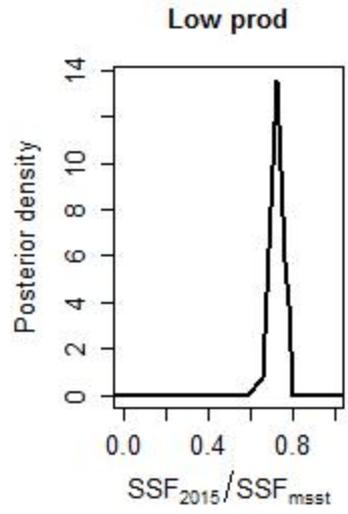
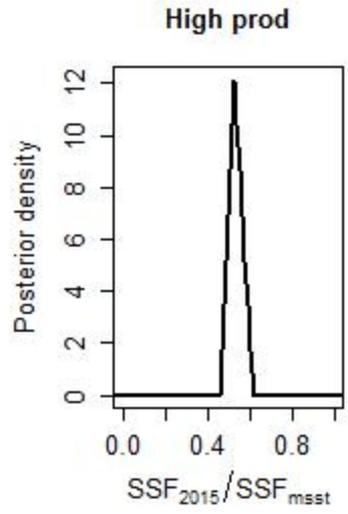
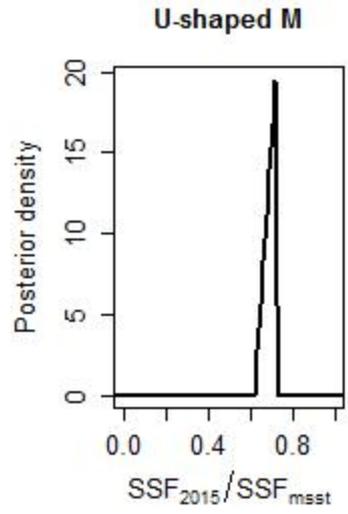
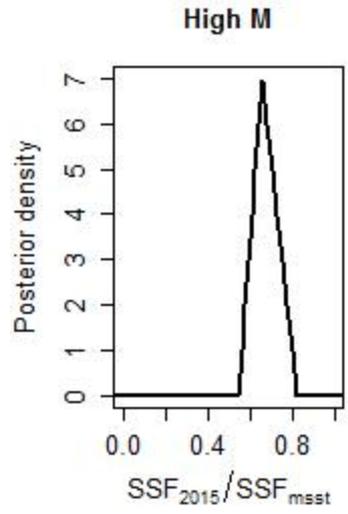
Model fit to VIMS LL index



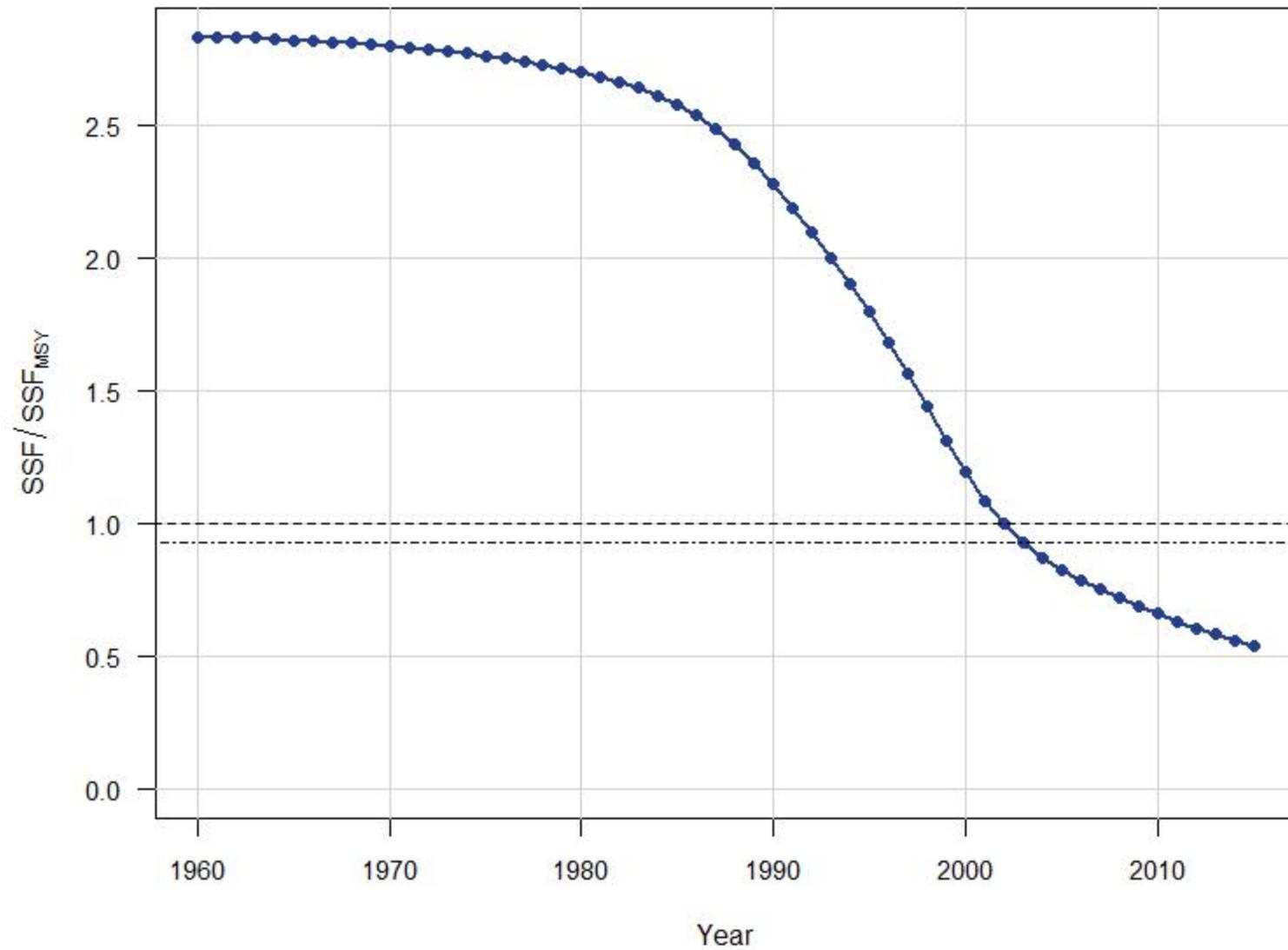
Model fit to NELL index



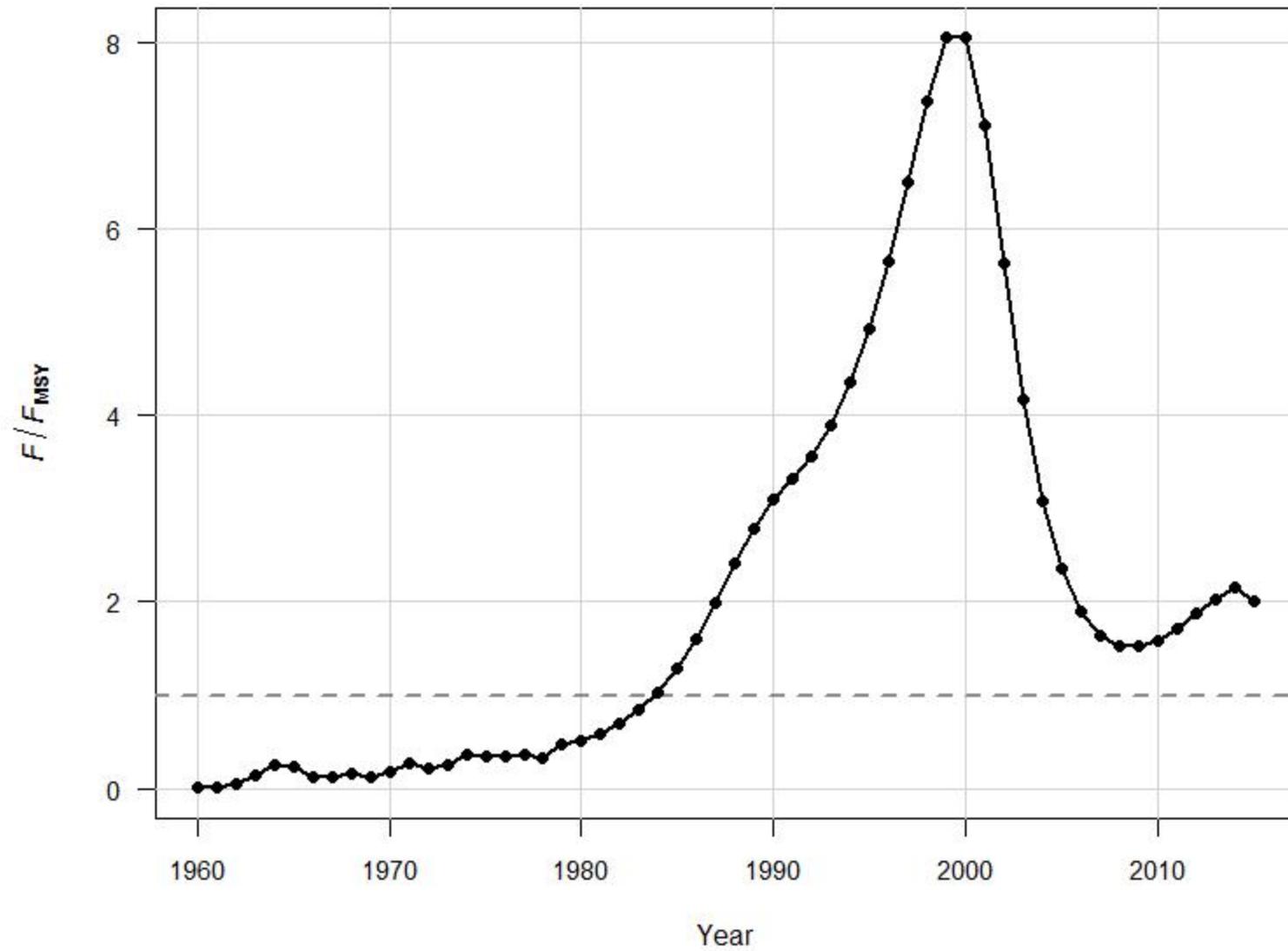




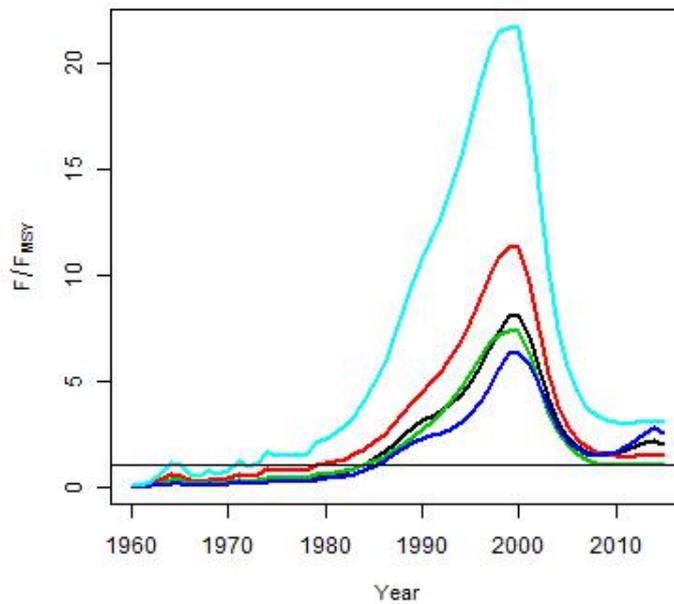
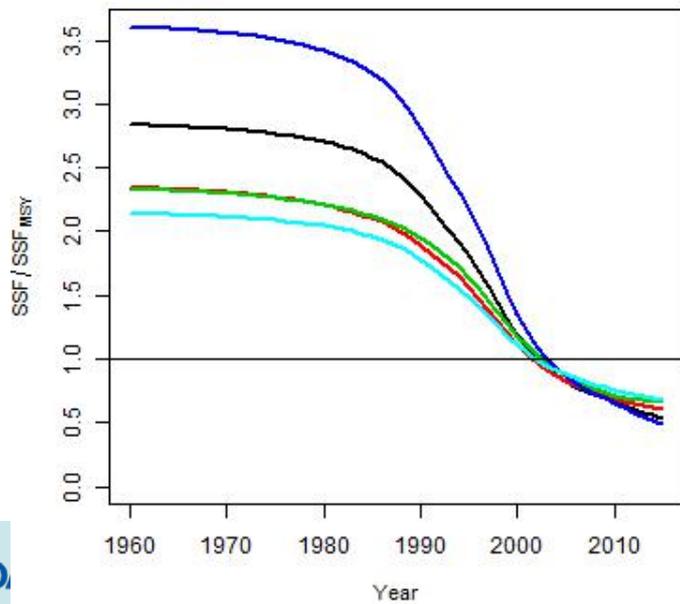
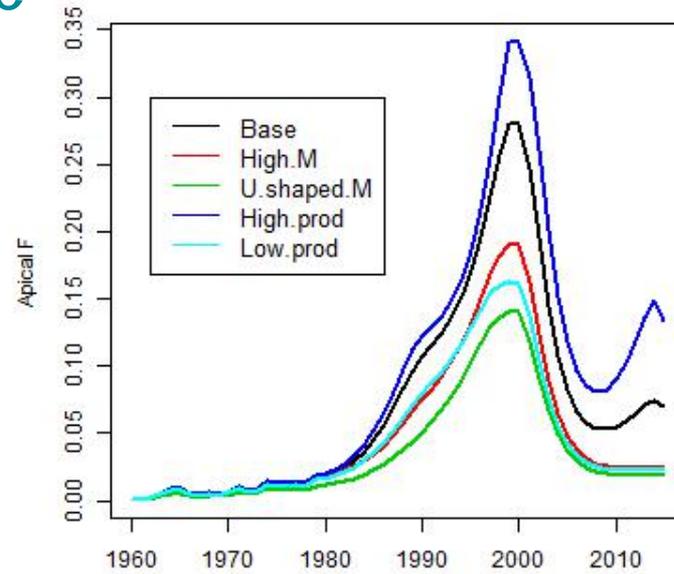
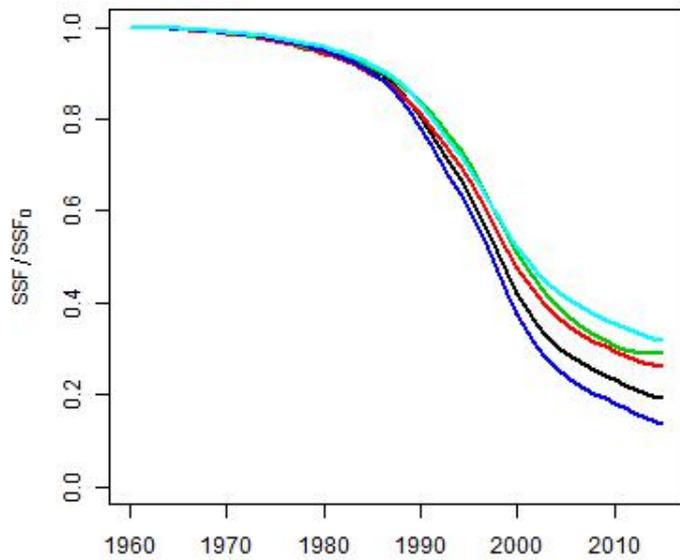
Base run



Base run



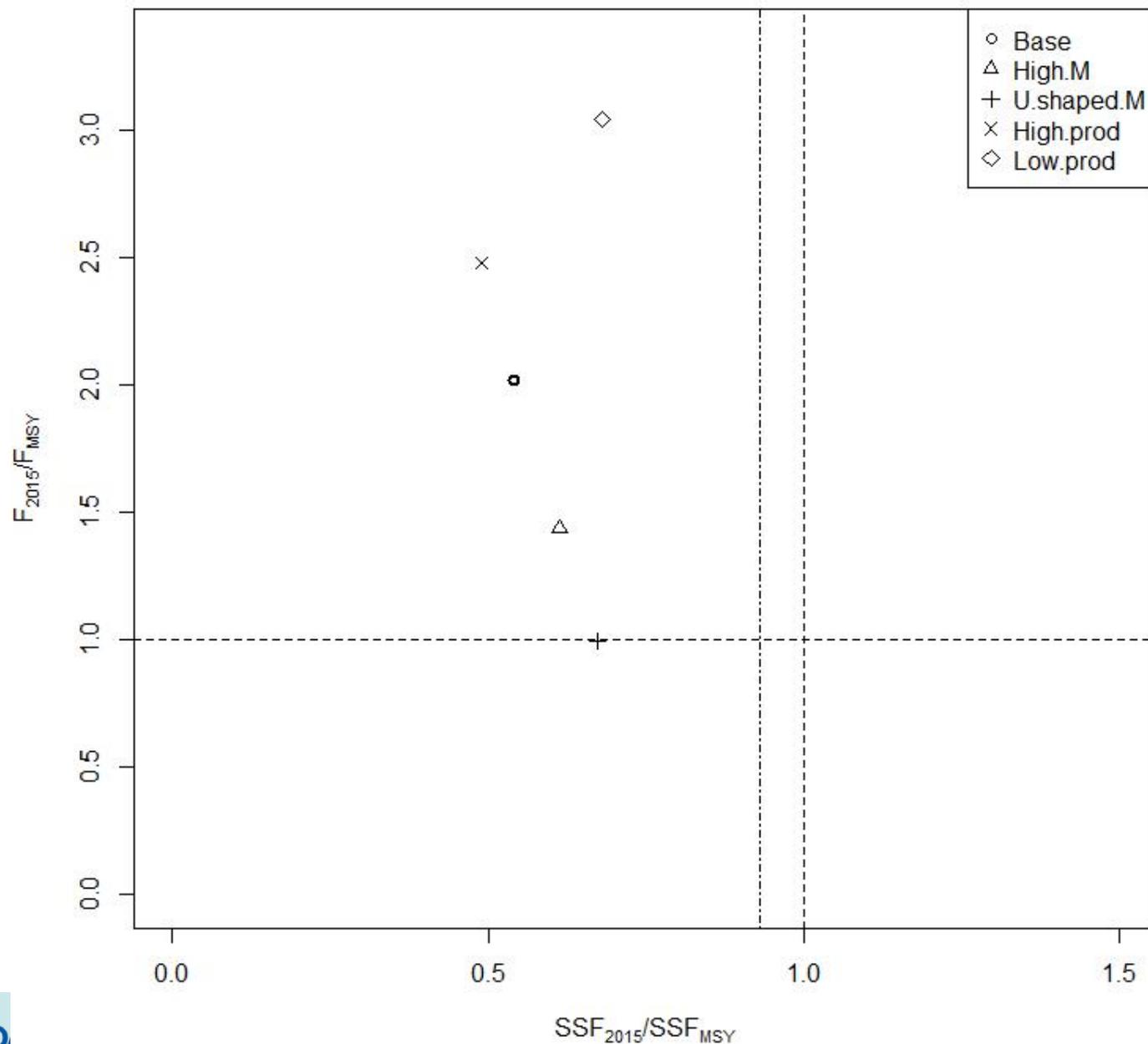
All 5 states of nature



Stock status: summarized results

	Base		High M		U-shaped M		High productivity		Low productivity	
	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
F_{MSY}	0.035	0.062	0.017	0.062	0.019	0.061	0.054	0.052	0.007	0.062
SSF_{MSY}/SSF_0	0.35	0.19	0.43	0.45	0.43	0.45	0.28	0.08	0.47	0.06
SSF_{2015}/SSF_0	0.19	0.53	0.26	0.36	0.29	0.36	0.14	0.65	0.32	0.37
SSF_{2015}/SSF_{MSST}	0.58	0.61	0.66	0.69	0.72	0.69	0.52	0.66	0.73	0.37
SSF_{2015}/SSF_{MSY}	0.54	0.61	0.61	0.69	0.67	0.69	0.49	0.66	0.68	0.37
F_{2015}/F_{MSY}	2.02	1.23	1.44	1.48	0.99	1.51	2.48	0.83	3.04	1.49
Pup survival	0.88	0.29	0.93	0.29	0.94	0.29	0.97	NA	0.51	NA
Steepness	0.51	0.14	0.32	0.20	0.32	0.20	0.71	NA	0.25	NA

Stock status plot for all 5 states of nature



Projection methods

- Proceeded using the same set of governing population dynamics equations as the ASCFM
- Monte Carlo simulation used to incorporate uncertainty
- For each simulation, values for 2015 biomass (B_{2015}), fishing mortality (F_{2015}), and pup survival at low biomass ($\exp(-M_0)$) were sampled from a multivariate normal distribution centered on the posterior mode; posterior covariance estimated from Hessian.



Projection methods

- Projections assumed the selectivity function for 2015
- Projections also assume that the current allocation of effort within the fishery (between fleets) stays the same
- Projections also assume that any change in management would not take effect until 2019 (so estimated fishing levels for 2015 were assumed for 2016-2018)

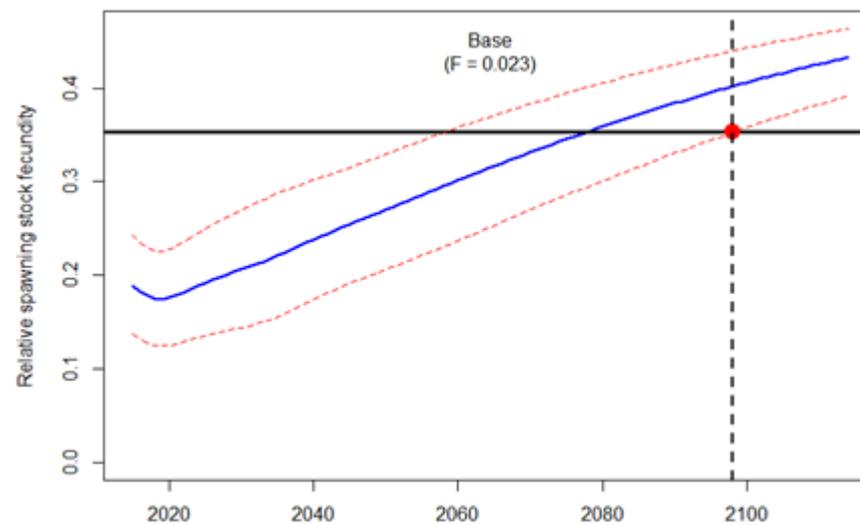
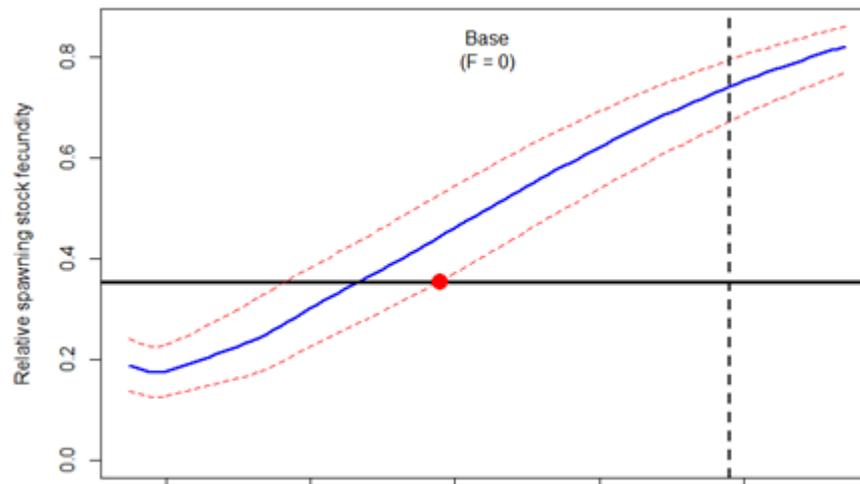


Projections: estimated quantities

- The year in which $F = 0$ would result in a 70% chance of recovery ($\text{Year}_{F=0_{p70}}$)
- The target rebuilding year, which was calculated as $\text{Year}_{\text{rebuild}}$ + the generation time: $(\text{Year}_{F=0_{p70}}) + 40$
- The fixed annual fishing mortality rate (apical F) that would allow recovery of the stock with a probability of 0.5 by $\text{Year}_{\text{rebuild}}$ ($F - \text{Year}_{\text{rebuild}}$ P50)
- The fixed annual fishing mortality rate (apical F) that would allow recovery of the stock with a probability of 0.7 by $\text{Year}_{\text{rebuild}}$ ($F - \text{Year}_{\text{rebuild}}$ P70)
- The fixed annual level of total removals in lb dressed weight (total allowable catch) that would allow recovery of the stock with a probability of 0.5 by $\text{Year}_{\text{rebuild}}$ ($\text{TAC} - \text{Year}_{\text{rebuild}}$ P50)
- The fixed annual level of total removals in lb dressed weight (total allowable catch) that would allow recovery of the stock with a probability of 0.7 by $\text{Year}_{\text{rebuild}}$ ($\text{TAC} - \text{Year}_{\text{rebuild}}$ P70)



Projections of future stock status: base run



Catch-free model projections: summarized results

Scenario	Terminal conditions			Year _{F=0p70}	Year _{rebuild}	<i>F</i> - Year _{rebuild}		TAC - Year _{rebuild} (lb dressed weight)	
	F ₂₀₁₅	F ₂₀₁₅ /F _{MSY}	SSF ₂₀₁₅ /SSF _{MSY}			P50	P70	P50	P70
Base	0.070	2.02	0.54	2058	2098	0.027	0.023	33149	23802
High M	0.024	1.44	0.61	2087	2127	0.011	0.007	18772	10512
U-shaped M	0.019	0.99	0.67	2056	2096	0.014	0.01	29459	20349
Hi Prod	0.134	2.48	0.49	2046	2086	0.047	0.042	49533	37226
Low Prod	0.023	3.04	0.68	2160	2200	0.004	0.002	6944	3227

Catch-free model projections: summarized results

Scenario	Required reductions in F to achieve rebuilding in Year _{rebuild} with a 70%	
	2011 assessment	2016 assessment
Base	62%	67%
High M	85%	71%
U-shaped M	81%	47%
Hi Prod	47%	69%
Low Prod	97%	91%

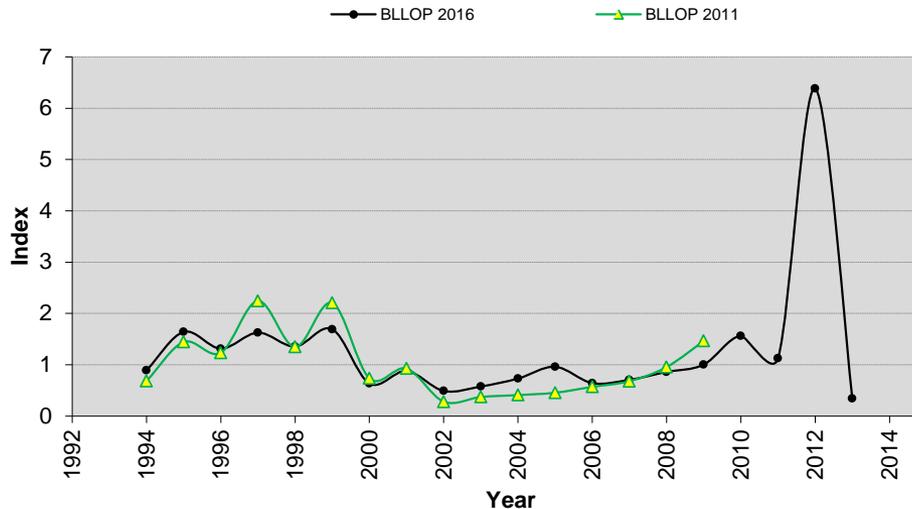
Indices of relative abundance: Post-assessment changes to BLLOP series

Indices of relative abundance: BLLOP

- In 2013, HMS implemented changes to the Shark Research Fishery that included the implementation of the regional dusky shark bycatch cap
- In 2014, HMS allocated the North Carolina region, an area known for higher dusky shark interactions in previous years, more dead dusky shark quota so that fishing could continue
- However, in order to still allow fishing all vessels fishing in the North Carolina or southern Atlantic region were limited to one main set with the soak time not to exceed 3 hours.
- This regulation resulted in high dusky shark catch per unit effort for many hauls in 2014, which led to the GLM model not converging
- As a result, the series was truncated to 2013

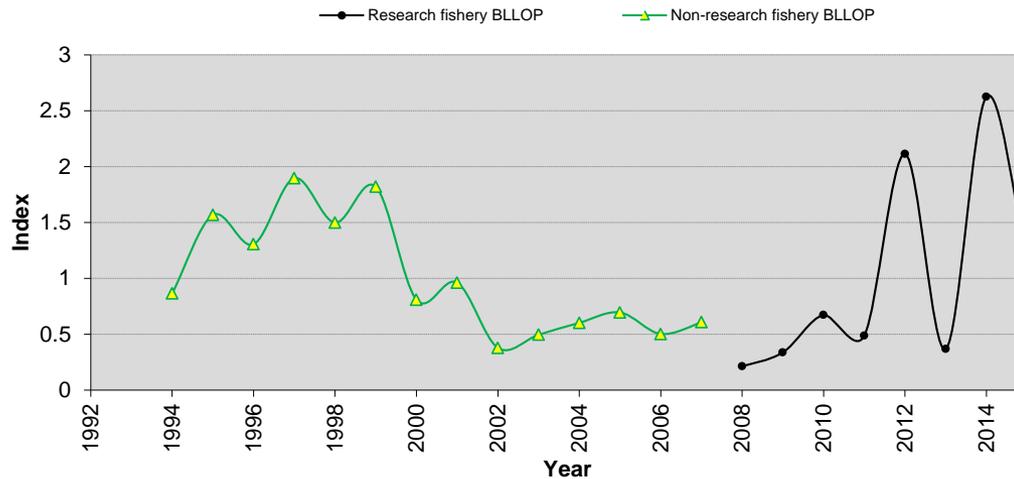


Indices of relative abundance: BLLOP



- The analytical team was later informed that the peak in 2012 and the ensuing low in 2013 were likely not reflective of real abundance, but that instead they reflected the fact that fishing was allowed inside the HMS bottom longline closed area in 2012 and disallowed in 2013
- Thus, there had been management changes introduced that invalidated the use of a single series

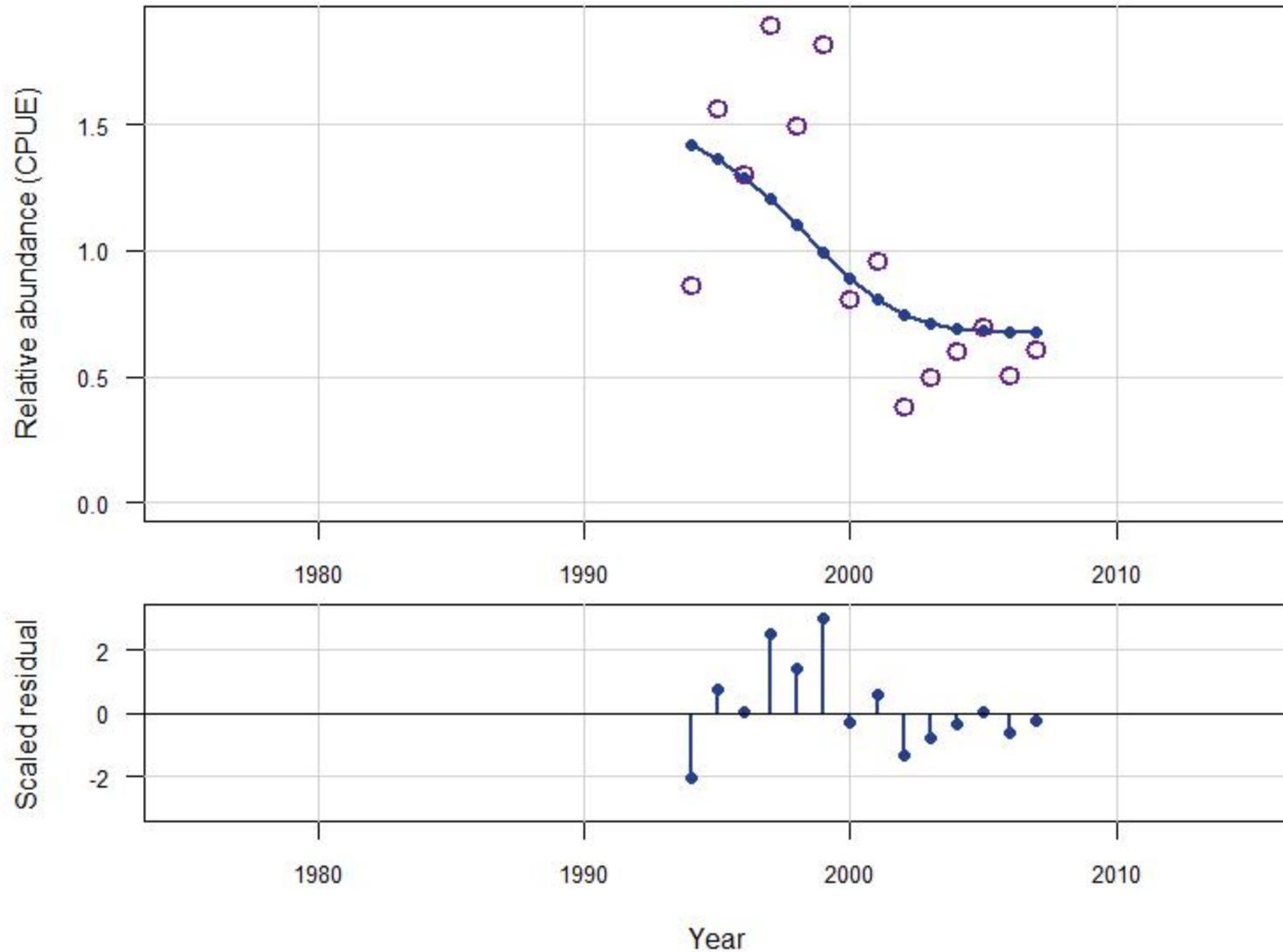
Indices of relative abundance: BLLOP



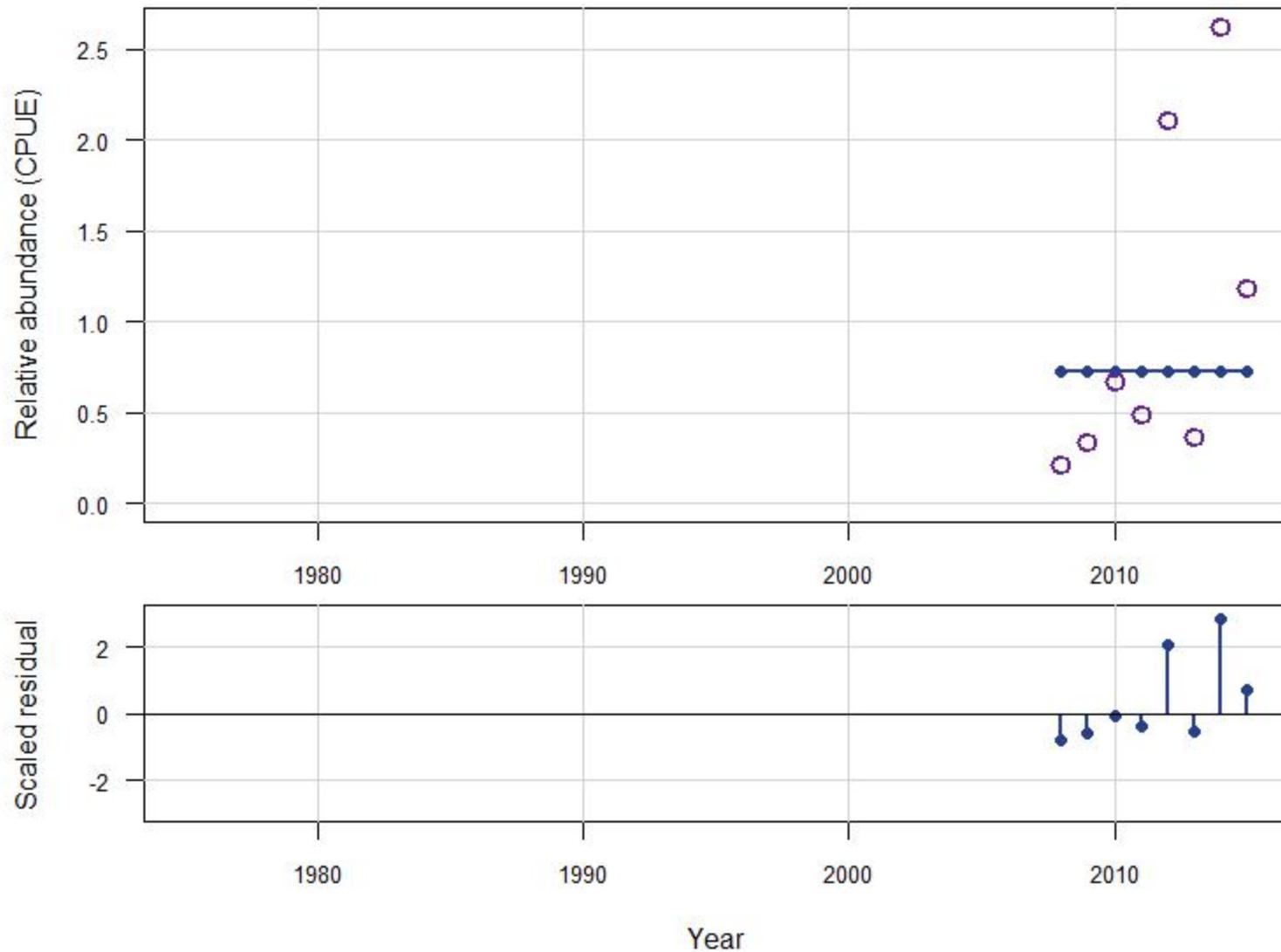
- This meant that the BLLOP series had to be split into two series: 1) a non-research shark fishery up to 2007 and 2) a shark-research only fishery from 2008-2015
- Thus, the assessment was re-run with the now six CPUE series

Addendum: Main results (now using 2 BLLOP indices)

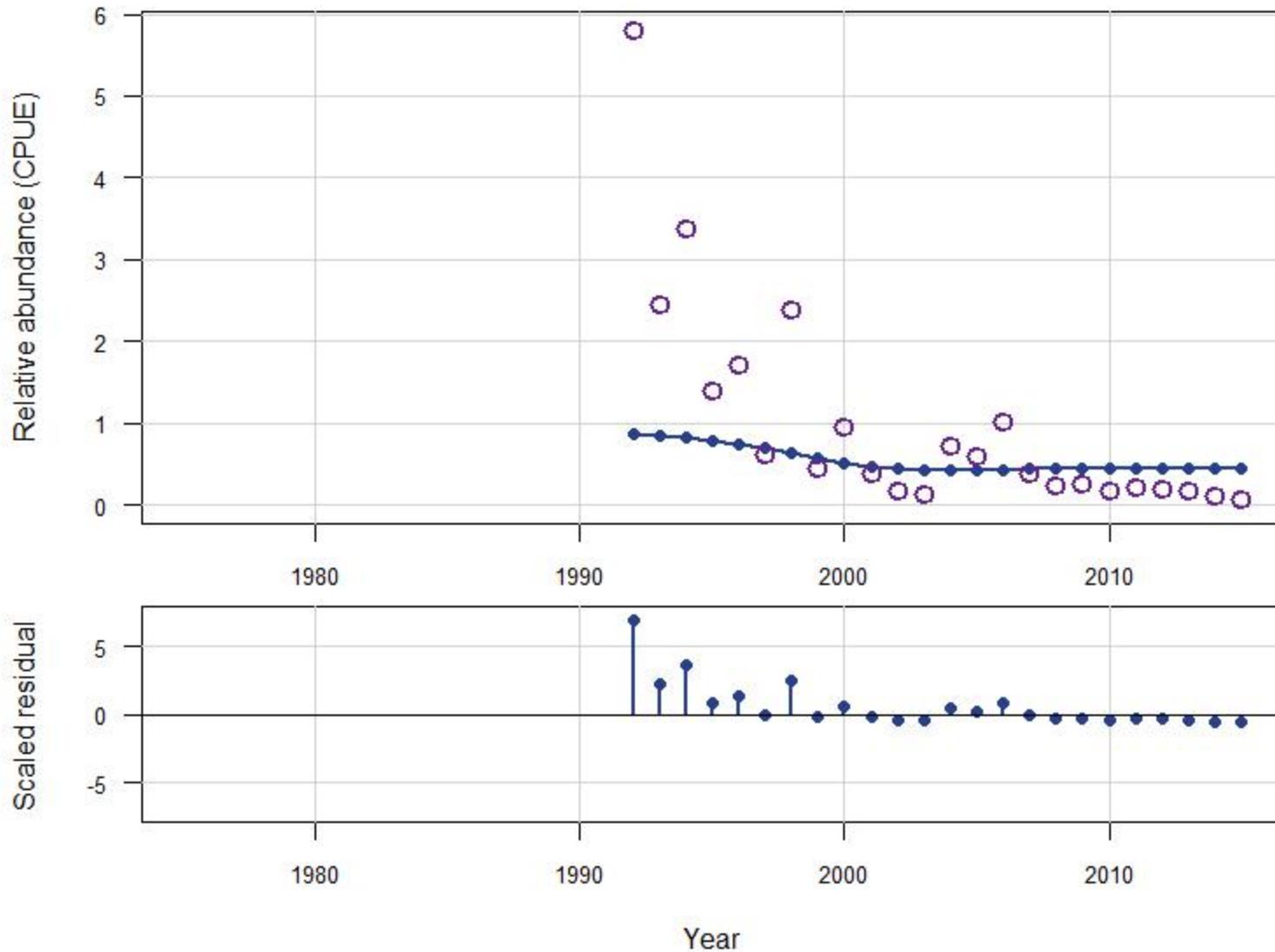
Model fit to BLLOP index (non shark-research)



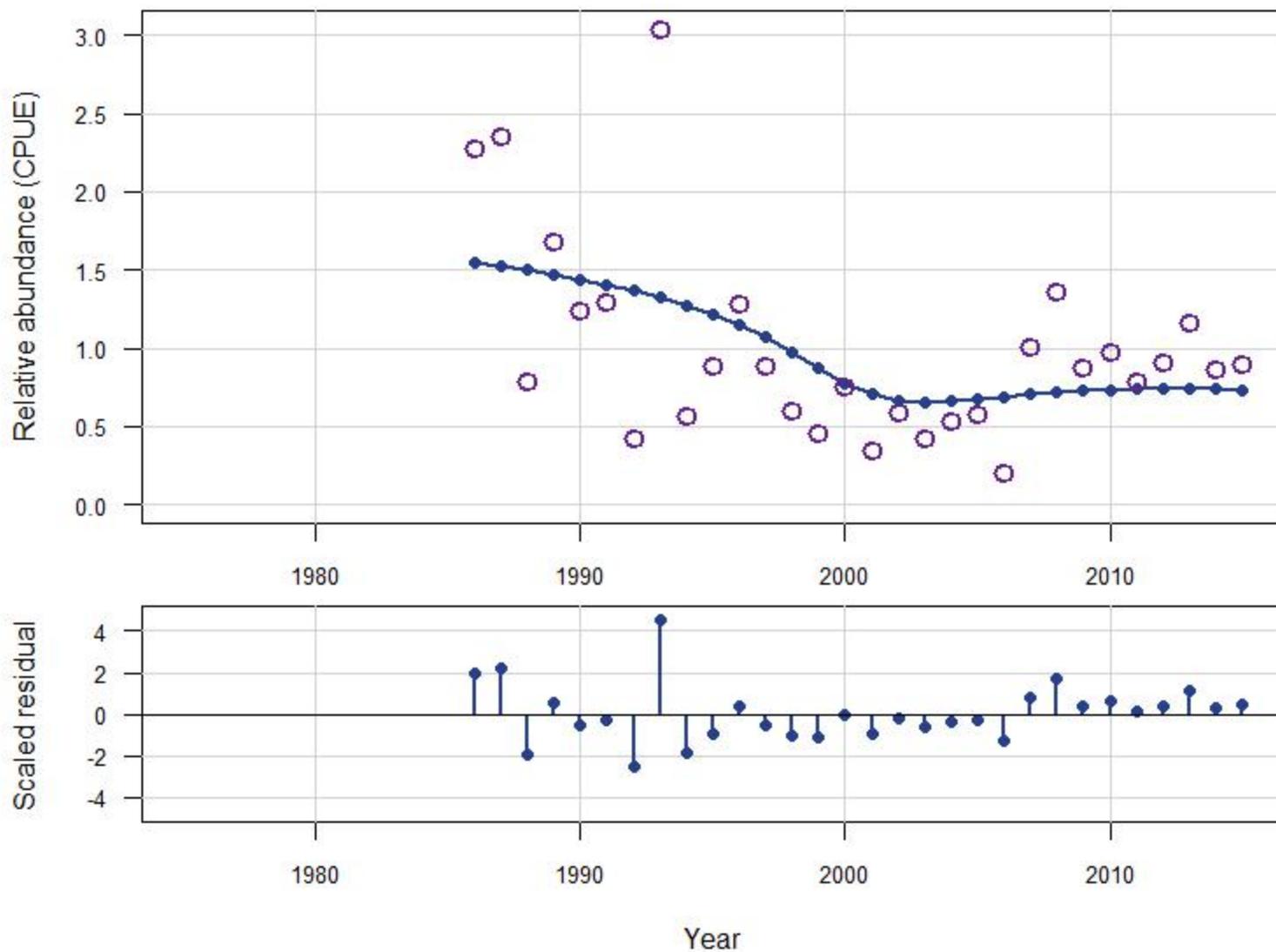
Model fit to BLLOP index (shark research only)



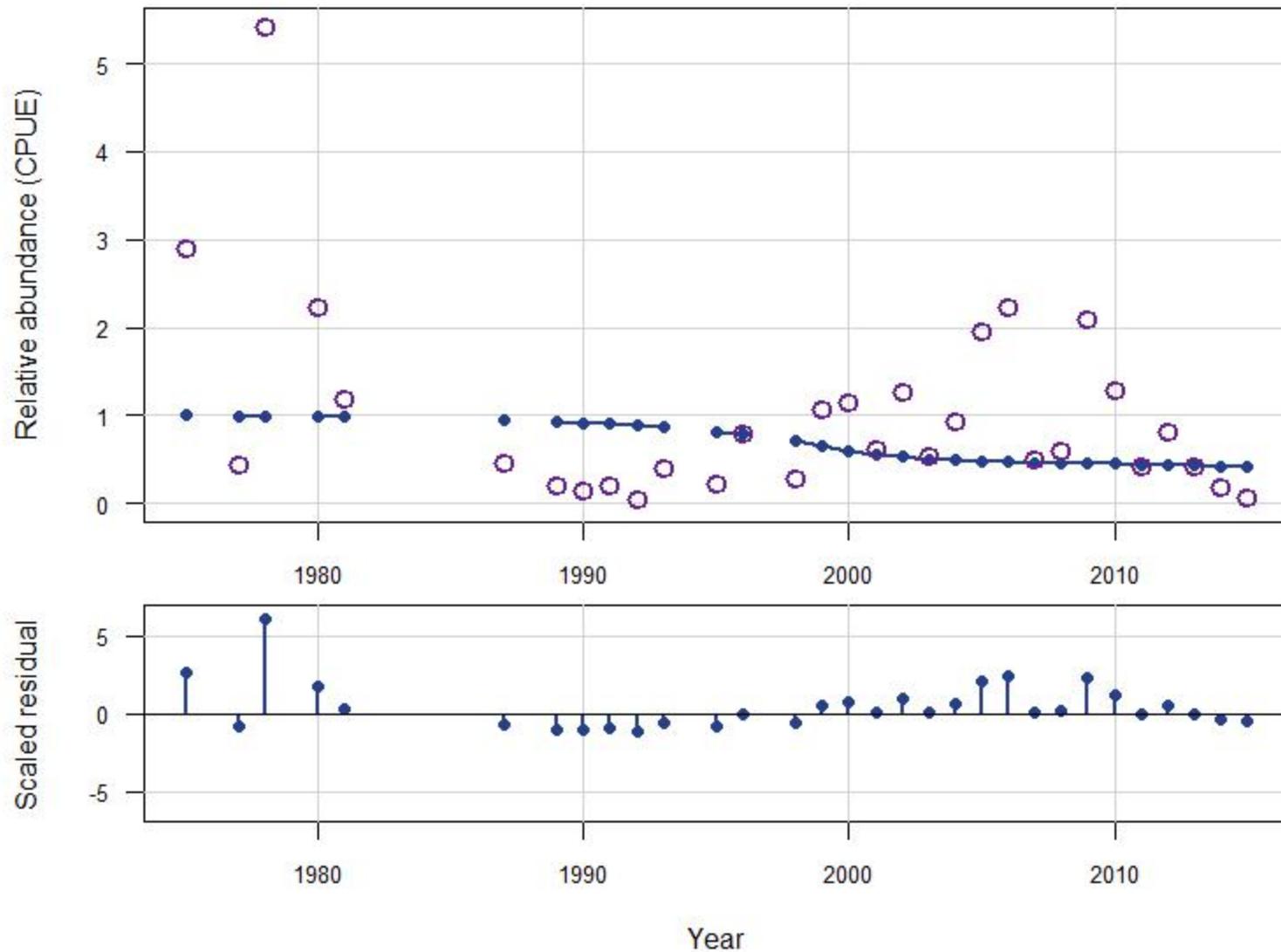
Model fit to PLLOP index



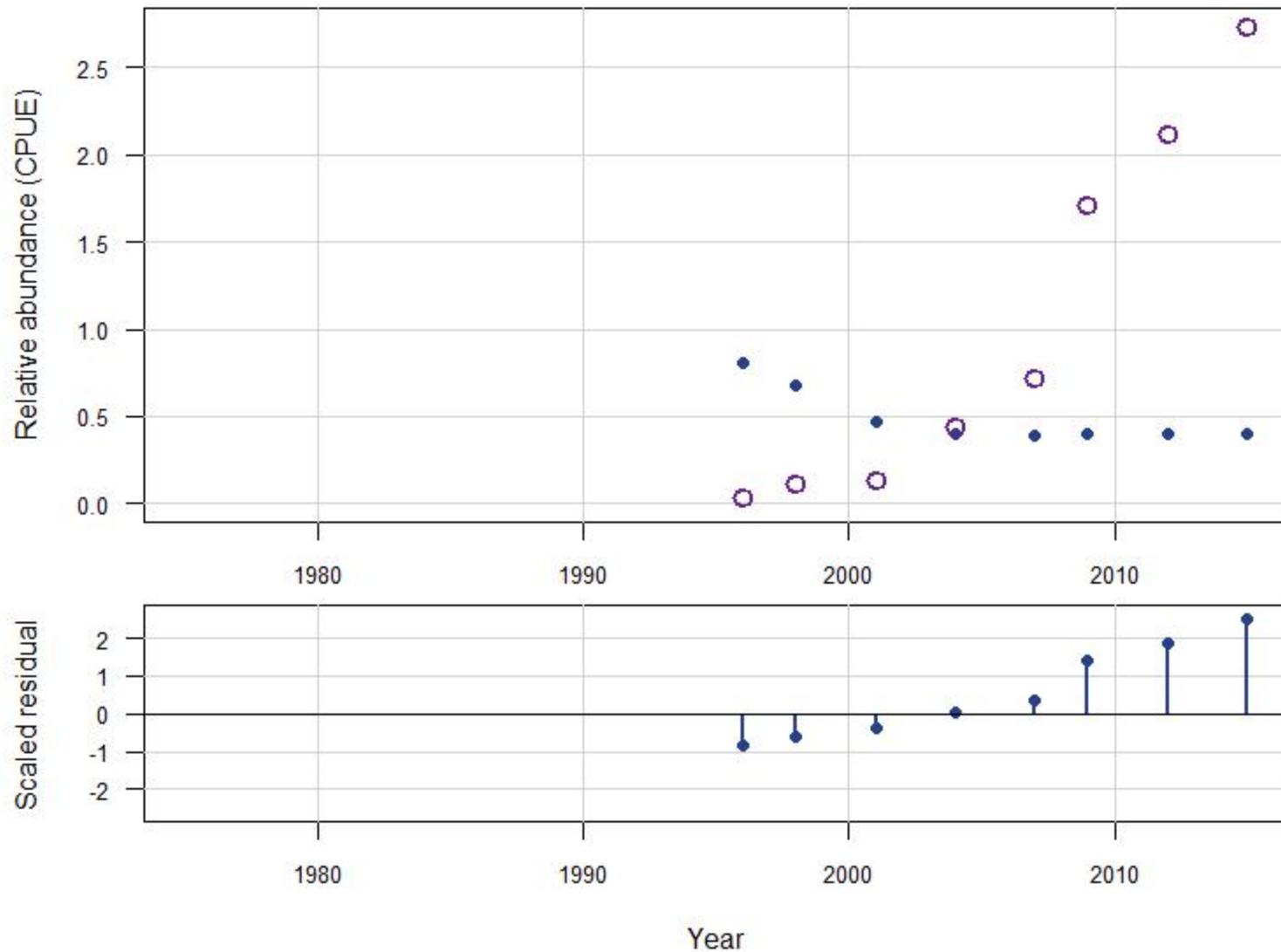
Model fit to LPS index

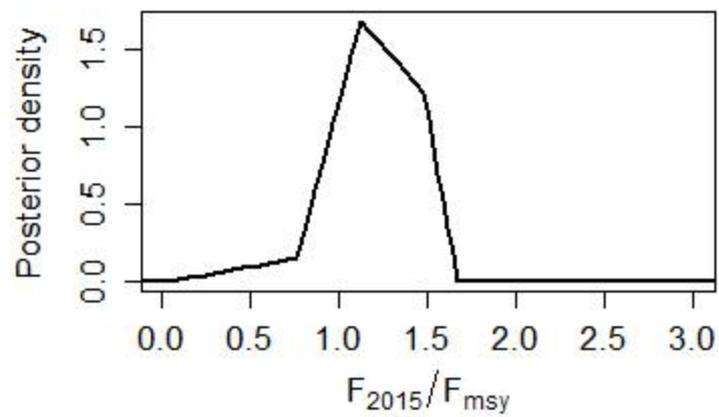
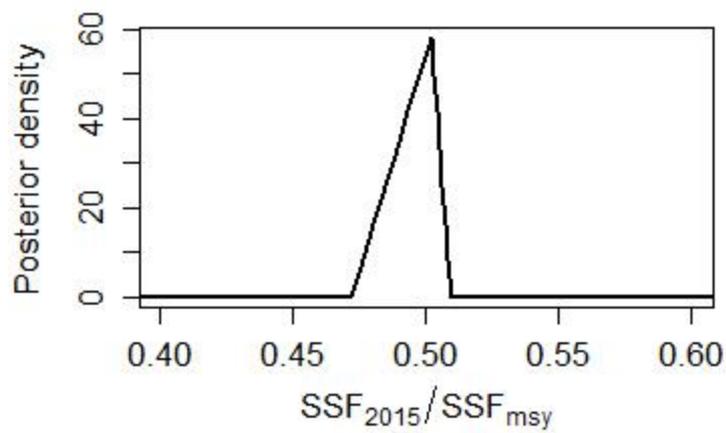
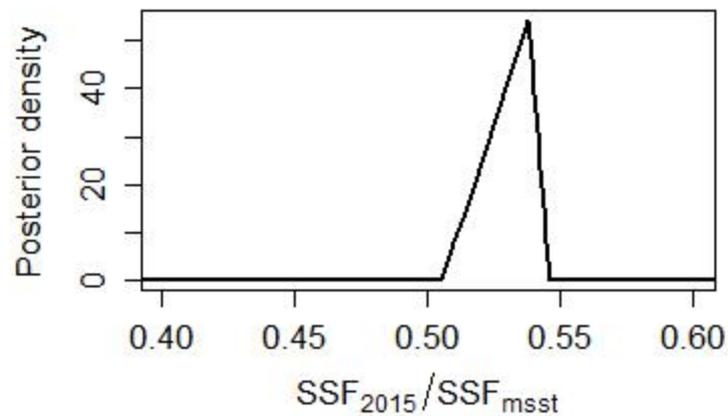
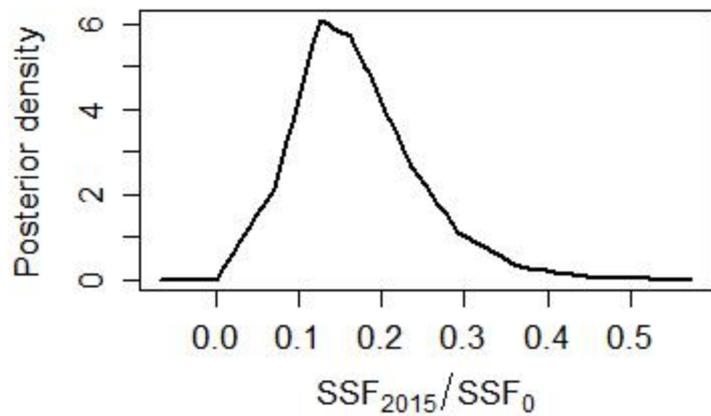


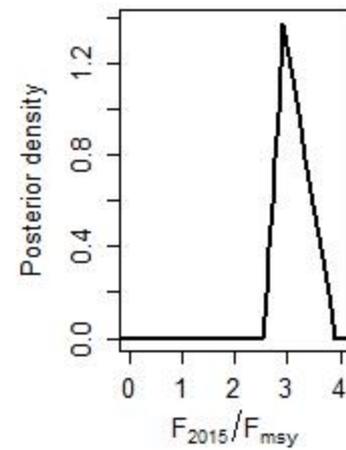
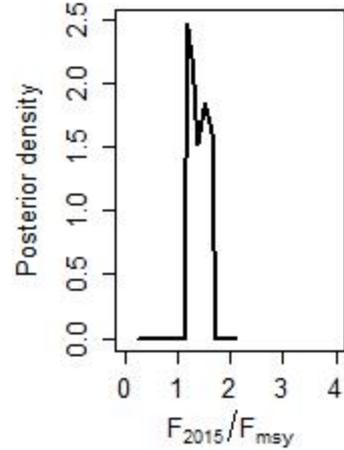
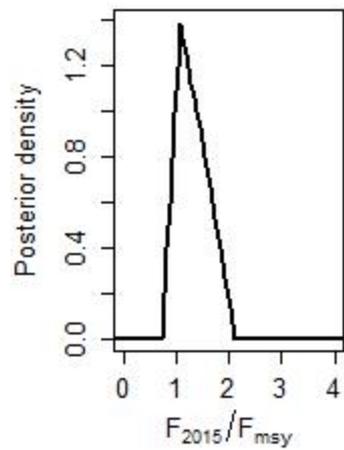
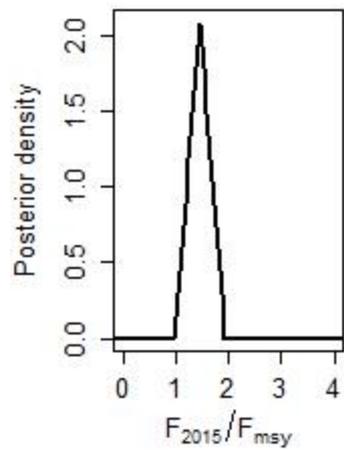
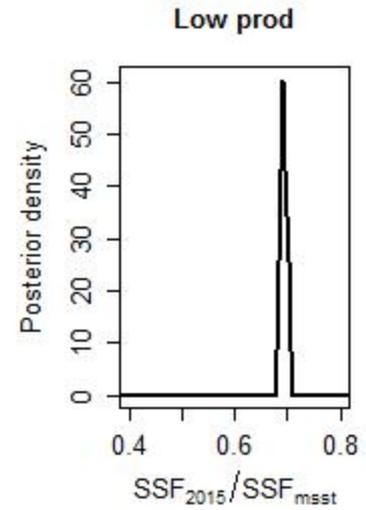
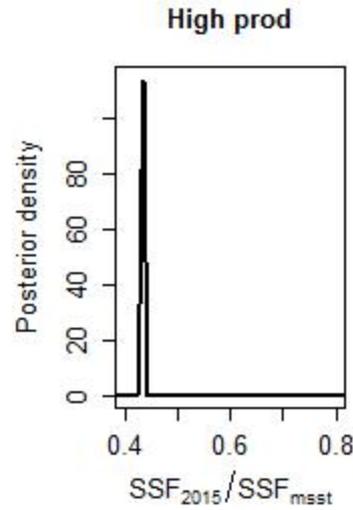
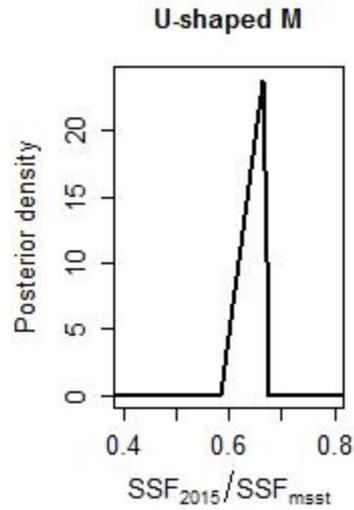
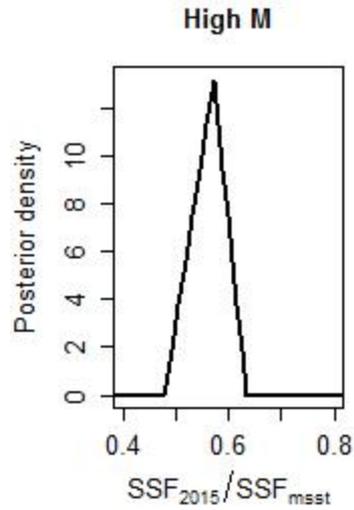
Model fit to VIMS LL index



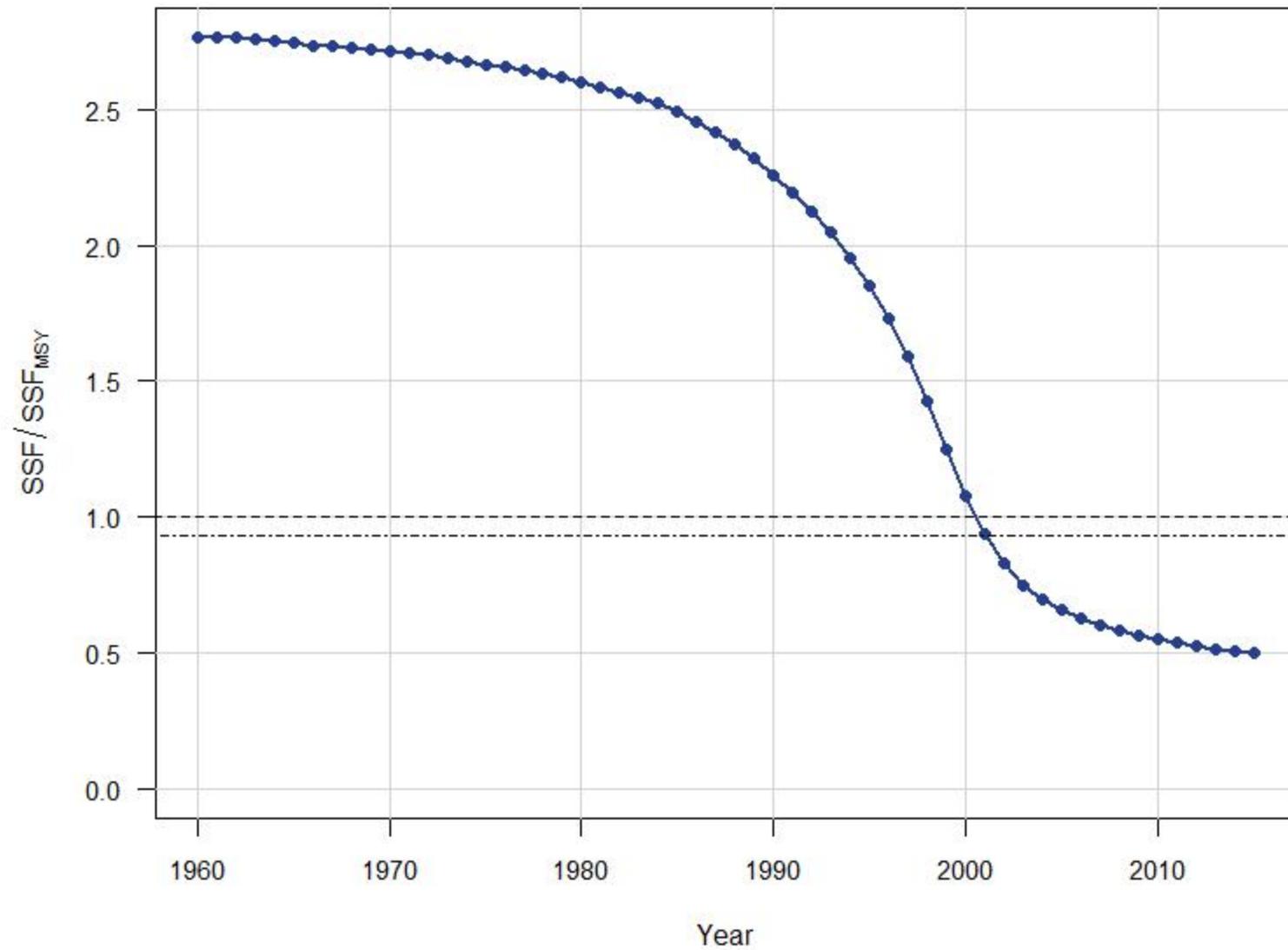
Model fit to NELL index



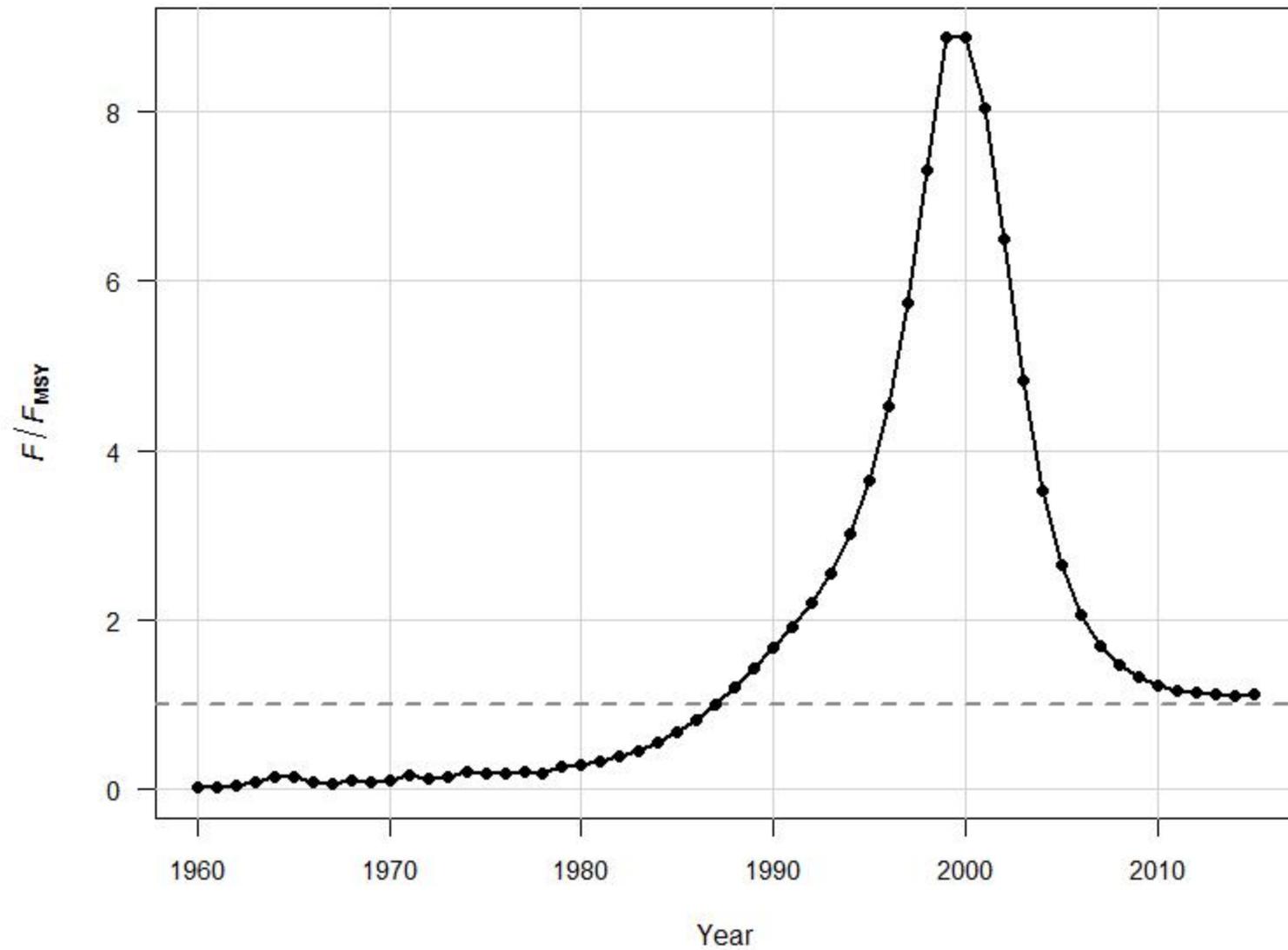




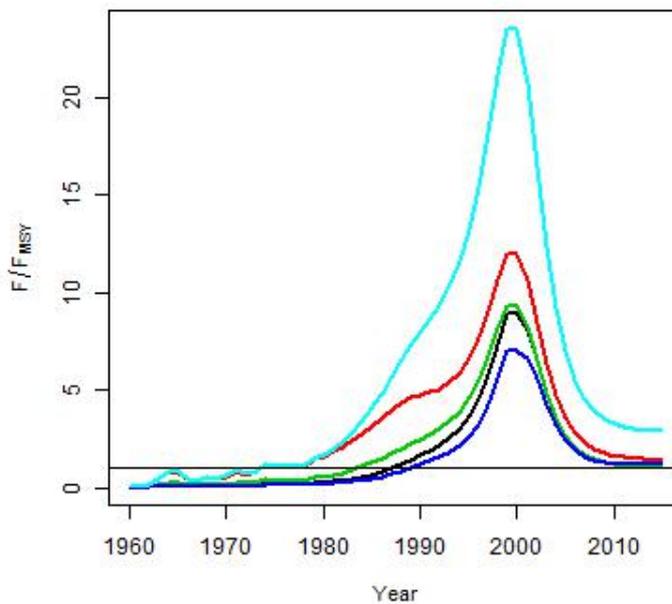
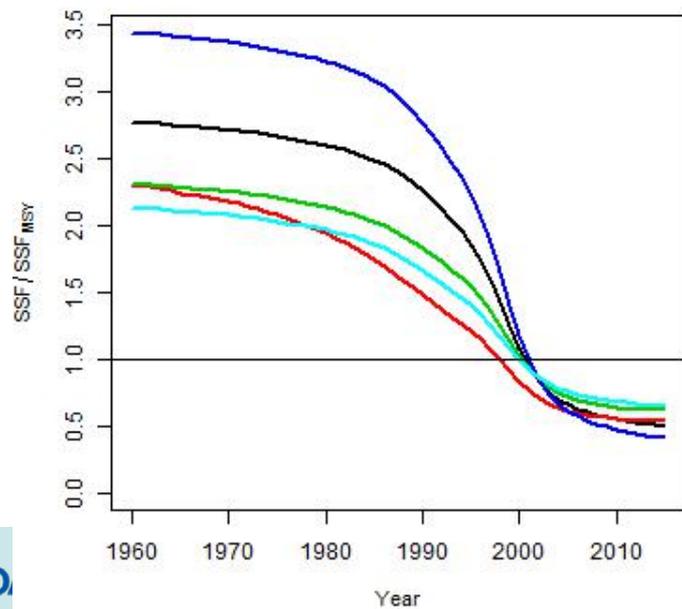
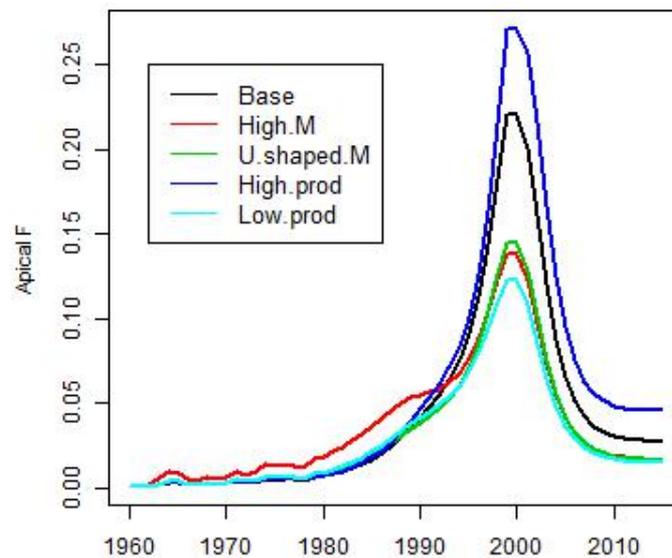
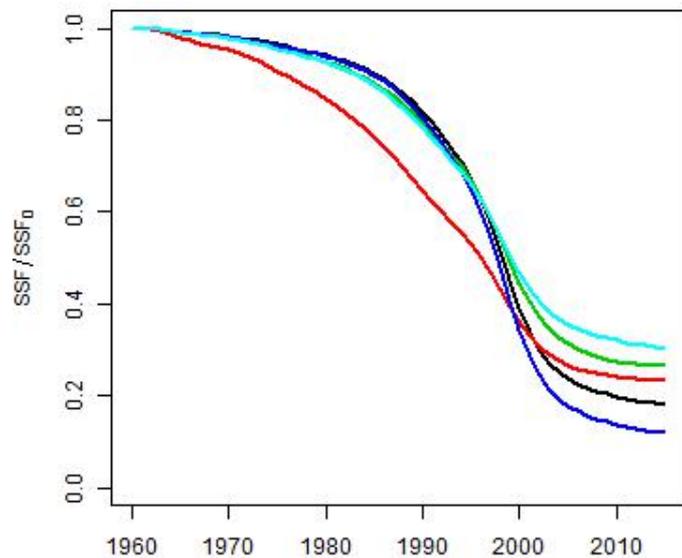
Base run

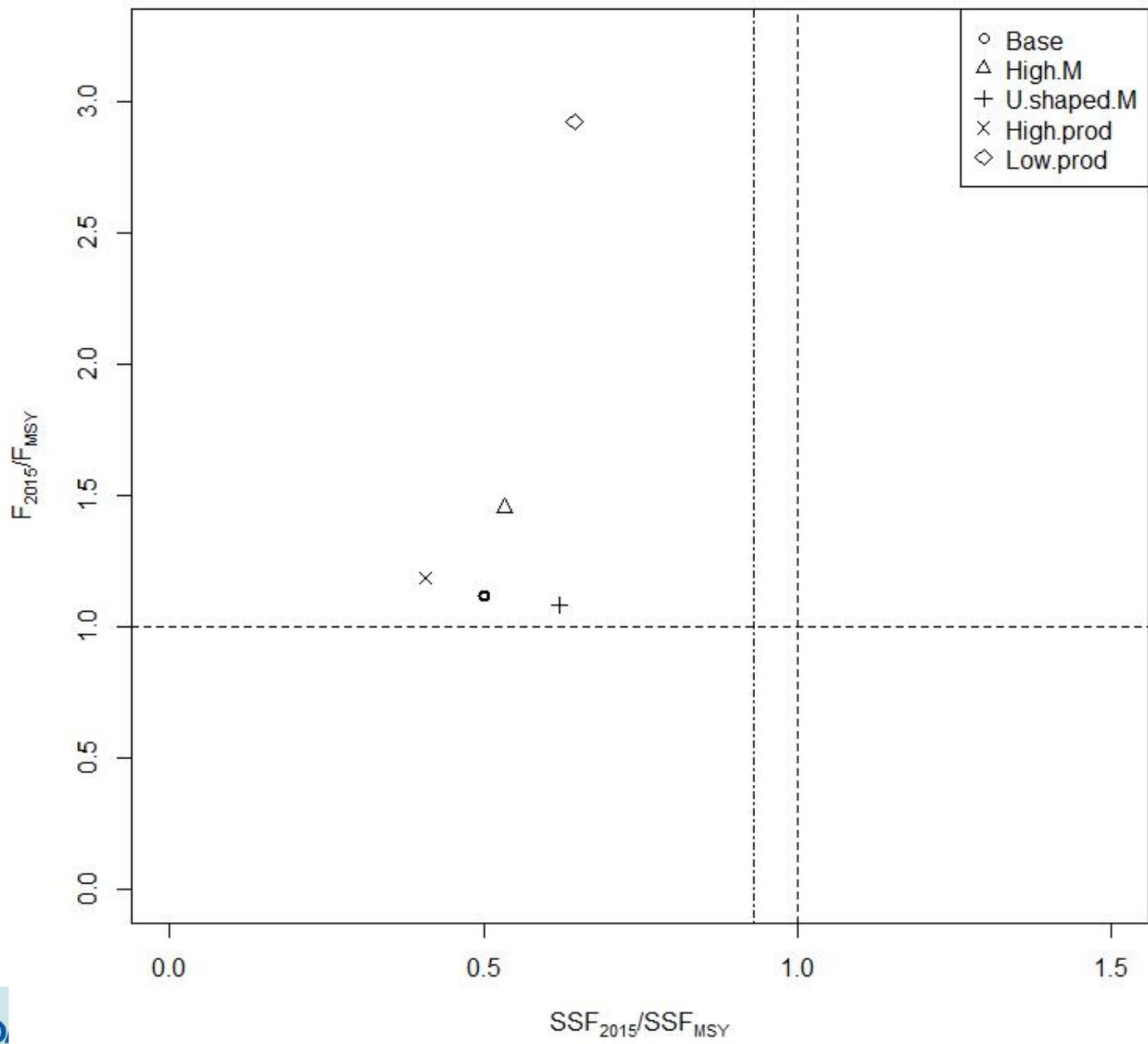


Base run

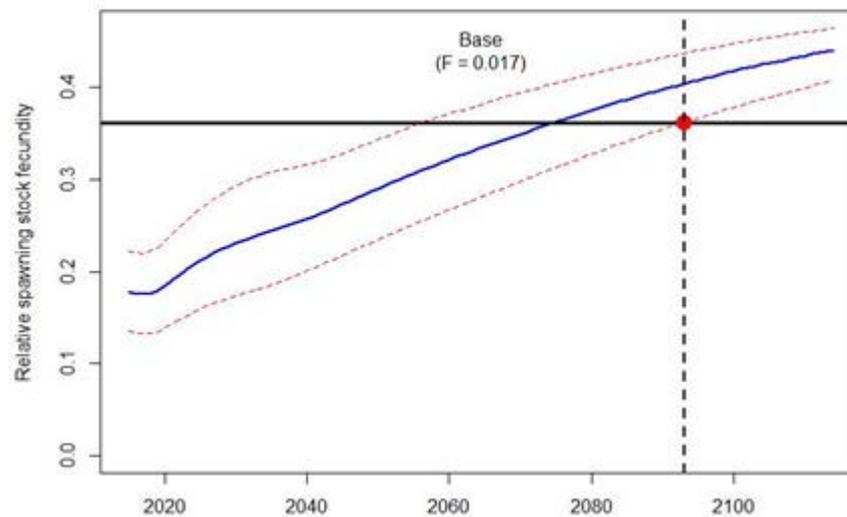
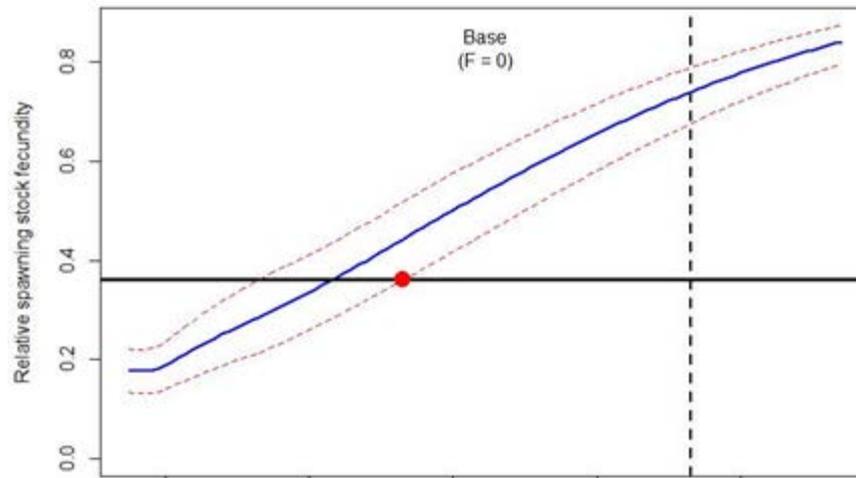


All 5 states of nature





Projections of future stock status: base run



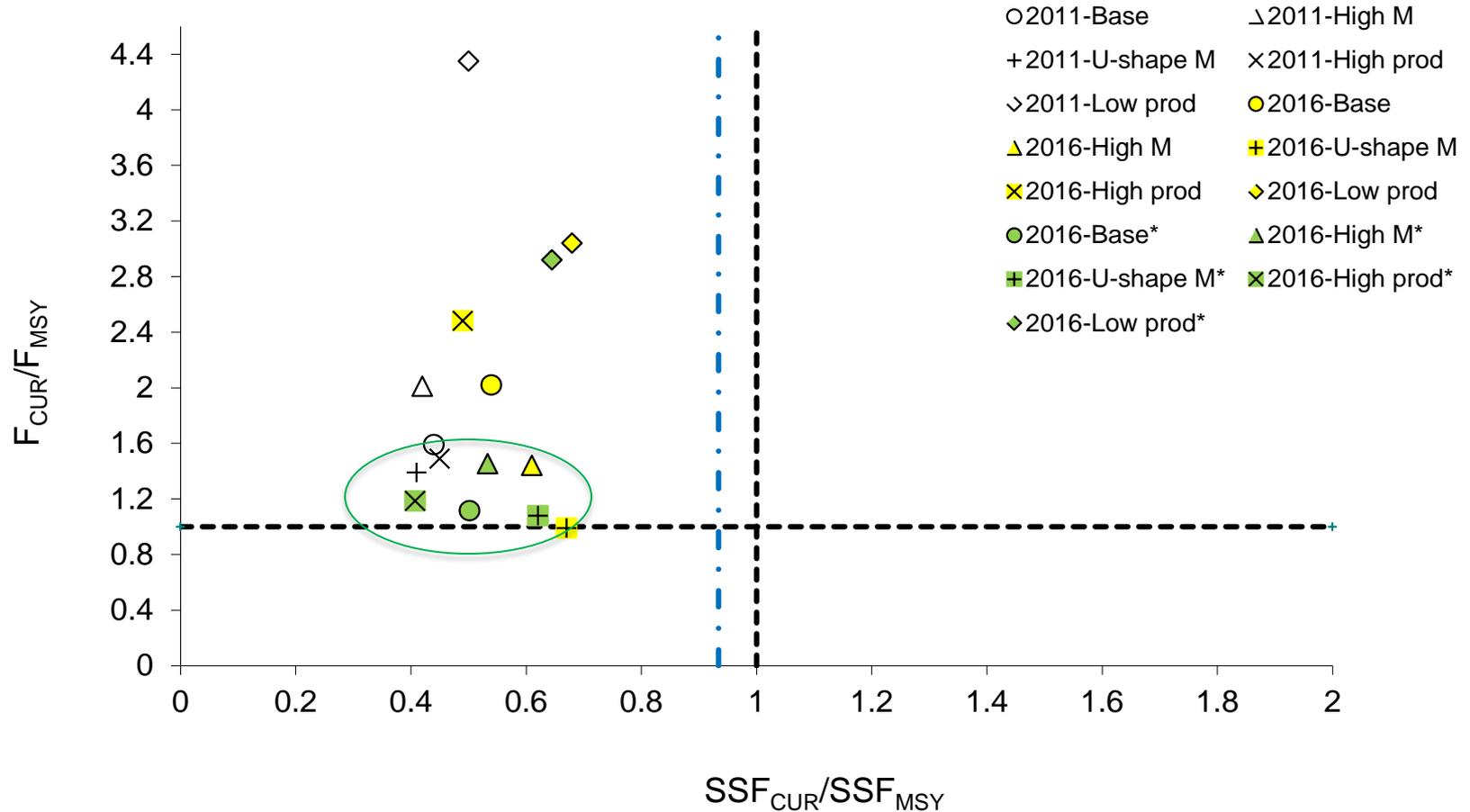
Catch-free model projections: summarized results (2 BLLOP indices)

Scenario	Terminal conditions			Year _{F=0p70}	Year _{rebuild}	<i>F</i> -Year _{rebuild}		TAC-Year _{rebuild} (lb dressed weight)	
	F ₂₀₁₅	F ₂₀₁₅ /F _{MSY}	SSF ₂₀₁₅ /SSF _{MSY}			P50	P70	P50	P70
Base	0.028	1.12	0.5	2053	2093	0.02	0.017	32413	24188
High M	0.017	1.45	0.53	2097	2137	0.007	0.004	18984	10956
U-shaped M	0.017	1.08	0.62	2067	2107	0.011	0.008	27346	17711
Hi Prod	0.046	1.18	0.41	2044	2084	0.035	0.032	47400	36101
Low Prod	0.015	2.92	0.64	2164	2204	0.003	0.001	7117	3507

Stock status: summarized results for SEDAR 21, SAR 2016, SAR 2016 addendum*

	Base			High <i>M</i>			U-shaped <i>M</i>			High productivity			Low productivity		
	Est (2 BLOP)	Est (Update)	Est (SEDAR 21)	Est (2 BLOP)	Est (Update)	Est (SEDAR 21)	Est (2 BLOP)	Est (Update)	Est (SEDAR 21)	Est (2 BLOP)	Est (Update)	Est (SEDAR 21)	Est (2 BLOP)	Est (Update)	Est (SEDAR 21)
F_{MSY}	0.025	0.035	0.035	0.012	0.017	0.017	0.015	0.019	0.019	0.039	0.054	0.054	0.005	0.007	0.007
SSF_{MSY}/SSF_0	0.36	0.35	0.35	0.44	0.43	0.43	0.43	0.43	0.43	0.29	0.28	0.28	0.47	0.47	0.47
$SSF_{terminal}/SSF_0$	0.18	0.19	0.15	0.23	0.26	0.18	0.27	0.29	0.17	0.12	0.14	0.13	0.30	0.32	0.23
$SSF_{terminal}/SSF_{MSST}$	0.54	0.58	0.47	0.57	0.66	0.45	0.66	0.72	0.44	0.44	0.52	0.49	0.69	0.73	0.53
$SSF_{terminal}/SSF_{MSY}$	0.50	0.54	0.44	0.53	0.61	0.42	0.62	0.67	0.41	0.41	0.49	0.45	0.64	0.68	0.50
$F_{terminal}/F_{MSY}$	1.12	2.02	1.59	1.45	1.44	2.01	1.08	0.99	1.39	1.18	2.48	1.49	2.92	3.04	4.35
Pup survival	0.89	0.88	0.89	0.89	0.93	0.95	0.92	0.94	0.96	0.97	0.97	0.97	0.51	0.51	0.51
Steepness	0.51	0.51	0.51	0.31	0.32	0.32	0.32	0.32	0.32	0.71	0.71	0.71	0.25	0.25	0.25

Stock status plot for all 5 states of nature: SEDAR 21, SAR 2016, SAR 2016 addendum*



Catch-free model projections: summarized results

Scenario	Required reductions in F to achieve rebuilding in Year _{rebuild} with a 70% probability			Required reductions in F to achieve rebuilding in Year _{rebuild} with a 50% probability		
	2011 assessment	2016 assessment	2016 assessment (addendum)	2011 assessment	2016 assessment	2016 assessment (addendum)
Base	62%	67%	39%	54%	61%	29%
High M	85%	71%	76%	71%	54%	59%
U-shaped M	81%	47%	53%	65%	26%	35%
Hi Prod	47%	69%	30%	42%	65%	24%
Low Prod	97%	91%	93%	90%	83%	80%

Caveats / Conclusions (1)

- Assessment results on overfishing status are uncertain (as they were in SEDAR 21): F_{2015}/F_{MSY} imprecisely estimated (large CVs)
- Poor fit to several CPUE series, presumably because of conflicting signals from indices of abundance but also because of conflict between interannual changes in relative abundance that are incompatible with the biology of the species



Caveats / Conclusions (2)

- Indices of abundance may not sample the whole population
- Species ID is an issue (the reason why we had to use a catch-free model in the first place), particularly for recreational fisheries
- In general, we must remember this is a data-limited assessment