

## 8 Saithe in Icelandic waters

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### 8.1 Summary

- The assessment model is a separable statistical catch-at-age model implemented in AD Model Builder. Selectivity is age-specific and varies between three periods: 1980-1996, 1997-2003, and 2004 onwards. This is the same model used in last year's assessment, with the addition of one more selectivity period. The old model had two selectivity periods: 1980-1996 and 1997 onwards.
- Icelandic saithe stock biomass has declined sharply since 2004, by around 41%, with an associated rise in fishing mortality.
- Year classes 1998-2000 and 2002 were strong, but year classes after 2003 have fluctuated around the long-term geometric mean.
- The stock size ( $B_{4+}$  and SSB) is below the long-term average. The current SSB of 88 kt is close to  $B_{\text{trigger}}$  (80 kt), the point where fishing mortality should start to be reduced below  $F_{\text{MSY}}$ .
- Biological reference points were estimated in a recent benchmark (ICES 2010):  $F_{\text{MSY}} = 0.28$ ,  $B_{\text{trigger}} = 80$  kt (candidate for  $B_{\text{pa}}$ ), and  $B_{\text{loss}} = 65$  kt (candidate for  $B_{\text{lim}}$ ).
- The NWWG recommends that the advice for 2012 is based on the estimated  $F_{\text{msy}}$  corresponding to landings of 45 kt.

### 8.2 Stock description and management units

Description of the stock and management units is provided in the stock annex.

### 8.3 Fisheries-dependent data

#### 8.3.1 Landings, advice and TAC

Landings of saithe in Icelandic waters in 2010 are estimated to have been 53,772 t (Table 8.1 and Figure 8.1). Of the landings, 42,324 t were caught by trawl, 4,453 t caught by gillnets, and 6,995 t caught by other means. The domestic as well as ICES advice for the fishing year 2010/2011 was based on  $F_{\text{MSY}}$  resulting in 40,000 t. The TAC issued was 50,000 t. The trajectory of the landings in the current fishing year and calendar year is shown in Figure 2.

Most of the catch is caught in bottom trawl (82% in 2006-2010), with gillnet and jiggers taking the majority of the rest (Figure 8.1). The share taken by the gillnet fleet was larger in the past, 25% in 1982-1996 compared to 9% in 1997-2010.

#### 8.3.2 Landings by age

Catch in numbers by age based on landings are listed in Table 8.2. Discarding is not considered to be a problem in the Icelandic saithe fisheries, for which monitoring programmes have been in place (annual reports by Pálsson *et al.* 2003 and later). Comparison of sea and harbour samples indicate that discards have been small in most years since 2000. The sea samples constitute about 60-70% of the length samples used in the calculation of the catch in number. Since the amount of discard is likely to

be small, not taking discards into account in the total catches and catch in numbers is not considered to have major effect on the stock dynamics estimated.

The sampling program and sampling intensity in 2010, as well as the approach used for calculating catch in numbers is the same as in preceding years. The sampling level in 2010 is indicated in the following text table:

Gear/nation	Landings (t)	No. of otolith samples	No. of otoliths read	No. of length samples	No of length measurements
Gillnets	4453	11	550	36	4958
Jiggers	3573	7	265	22	2164
Danish seine	1093	6	178	9	584
Bottom trawl	42324	98	4887	307	39923
Other gear	2275	1	50	70	556
Foreign landings	500	-	-	-	-
Total	54218	123	5930	444	48185

Gillnet catches are split according to a gear-specific age-length key, the rest of the catches are split according to a key based on all samples from commercial gear except those from gillnets. The length-weight relationship used ( $W = 0.02498 * L^{2.75674}$ ) is applied to length distributions from both fleets.

### 8.3.3 Mean weight and maturity at age

Weight-at-age in recent years have been below average, but some increase is observed since 2007 and the weights of ages 3-7 are now close to the long-term average (Table 8.3 and Figure 8.3). Weight at age in the landings is also used as weight at age in the stock. Weights for 2011 are estimated by applying a model using survey weights and the weight of a year class in the previous year as numeric predictors, as well as a year factor (see stock annex).

A model using maturity-at-age data from the Icelandic groundfish spring survey (Table 8.4 and Figure 8.4) is used to derive smoothed trends in maturity by age and year (see stock annex).

### 8.3.4 Logbook data

Commercial CPUE indices are not used for tuning in this assessment. Although these indices have been explored for inclusion in the past, they were not considered for inclusion in the benchmark (ICES 2010), as the trends in CPUE are considered unreliable as an indicator of changes in abundance.

## 8.4 Scientific surveys

In the benchmark, spring survey data were considered superior to the autumn survey for calibrating the assessment. Saithe is among the most difficult demersal fishes to get reliable information on from bottom trawl surveys. In the spring survey, which has 500-600 stations, large proportion of the saithe is caught in relatively few hauls and there seems to be considerable inter-annual variability in the number of these hauls.

The survey biomass indices were high in the beginning of the period, low in the period 1995-2001, high in the period around 2005, but declining to a low level in the most recent years (Table 8.5 and Figure 8.5).

Internal consistency in the surveys measured by the correlation of the indices for the same year class in 2 adjacent surveys is poor, with  $R^2$  close to 0.3 for the best-defined age groups, and much lower for some other.

Young saithe tend to live very close to shore, so it is not surprising that survey indices for ages 1 and 2 are poor measures of recruitment, and the number of those saithe caught in the survey is very low.

## 8.5 Assessment method

In accordance with the recommendation from the benchmark (ICES 2010), a separable forward-projecting statistical catch-age model, developed in AD Model Builder, is used to fit commercial catch-at-age data (ages 3-14, years 1980-2010) with the spring bottom-trawl survey index (ages 1-10, years 1985-2011) as a tuning series. Natural mortality is set at 0.2 for all age groups.

Selectivity is age-specific, and varies between three periods: 1980-1996, 1997-2003, and 2004 onwards. The selectivity pattern is constant within each period. This is the same model used in last year's assessment, with the addition of one more selectivity period. The old model had two selectivity periods: 1980-1996 and 1997 onwards.

In the current three-period model, 1997 was chosen as a starting year of the 2nd period to reflect the one-time shift away from gillnet use, that occurred around that time. Gillnets select older fish than bottom trawl, so this shift was expected to affect the combined selectivity pattern for the fishing fleet.

The possibility of adding a 3rd period, allowing for recent changes in the fleet selectivity, was explored to remedy a lack of model fit to the large observed number of 4-year-olds in recent catches. Diagnostic state-space model runs by Gudmundsson (2011) indicated that 2004 would be an appropriate year to start this 3rd selectivity period.

Changing from two selectivity periods to three (Figure 8.6) improved the fit to 4-year-olds (Figure 8.7) in the catch data, and also improved the overall model fit by 24.1 units of log-likelihood, at the cost of 8 additional parameters, which is a significant improvement in terms of AIC and likelihood-ratio test. Interestingly, the second selectivity period 1997-2003 is estimated to be quite similar to the first period 1980-1996, suggesting that the shift away from gillnets in the late 1990s did not change the overall fleet selectivity very much. Combining these periods into one selectivity would not alter the conclusions about the stock status. The third period 2004 onwards

The commercial catch-at-age residuals (Table 8.6 and Figure 8.8) are relatively small in recent years, owing to the model flexibility provided by the two recent selectivity periods 1997-2003 and 2004 onwards. The survey catch-at-age residuals (Table 8.7 and Figure 8.8) have year blocks with all residuals being only negative or only positive in a given year. The survey residuals are modelled as multivariate normal distribution with the correlation estimated (one coefficient).

## 8.6 Reference points and MSY considerations

The benchmark workshop (ICES 2010) concluded that the simulations included enough uncertainty to estimate  $F_{MSY}$ , and that 0.28 can be used as a target fishing mortality. The estimated breakpoint of 80 kt is a candidate for  $B_{trigger}$ , the point where fishing mortality should start to be reduced below  $F_{MSY}$ . This could also be a candidate for  $B_{pa}$ . The estimated value of  $B_{loss}$  of 65 kt was regarded as a candidate for  $B_{lim}$ .

## 8.7 Harvest control rule candidates

The benchmark workshop also concluded that a harvest control rule will probably not be based on  $F$ , but rather set up as a proportion of stock biomass, provided it will lead to fishing mortalities similar to  $F_{MSY}$ .

## 8.8 State of the stock

The results of the principal stock quantities (Table 8.8 and Figure 8.9) show that fishing mortality has been high in recent years, peaking around 0.40 in 2008 and 2009. A sharp decline in biomass is observed at the same time, with the estimated  $B_{4+}$  biomass at 311 kt in 2004 and 184 kt in 2011, a 41% decrease (Figure 8.9). The spawning stock at the beginning of 2011 is estimated to be 88 kt, which is just above  $B_{trigger}$ , and considerably below the long-term average of 116 kt.

Year classes 1998-2000 and 2002 were strong, but the year classes after 2003 have fluctuated around the long-term geometric mean. The details of the fishing mortality and stock in numbers are presented in Tables 8.9 and 8.10.

## 8.9 Short-term forecast

The input for the short-term forecast is shown in Table 8.11. Future weights, maturity, and selectivity are assumed to be the same as in the assessment year, as described in the stock annex. Recruitment predictions are based on the segmented stock-recruitment function estimated in the assessment model.

A "TAC-constraint" of 50 kt landings is applied in the assessment year, based on best estimates of catches in 2011. This results in a fishing mortality somewhat lower than the terminal value ( $F_{2011}=0.33$  compared with  $F_{2010}=0.37$ ).

Results from the short-term forecast are shown in Table 8.12. They indicate that if  $F_{MSY} = 0.28$  is applied in 2012, the landings in 2012 will be 45 kt and the SSB in 2013 will be 93 kt. If the 20% Icelandic cod harvest control rule is applied, the outcome is very similar, with landings in 2012 at 43 kt.

For the calendar year 2012 the NWWG recommends that advice is based on  $F_{4.9} = 0.28$ , which is the estimated  $F_{MSY}$ , corresponding to landings of 45 kt.

## 8.10 Uncertainties in assessment and forecast

The assessment of Icelandic saithe is relatively uncertain due to lack of good tuning data. The internal consistency in the survey that is used for the assessment is very low. This is not surprising, considering the nature of the species that is partly pelagic, schooling, and relatively widely migrating.

The retrospective pattern (Figure 8.10) reveals some of the assessment uncertainty, but is relatively good on the whole, supporting the use of the survey data rather than just the commercial catch at age. The retrospective patterns (Figure 8.9) indicate more inner consistency in recent years than in the 1990s. For retrospective analysis further back than 2007, the old model with two selectivity periods is used.

Landings in recent years have shown more than expected of young fish and less of older fish than expected. Some of it is likely to reflect changes in selectivity, and some can be due to less abundance than predicted of older age groups, or changes in behavior of the older fish.

The benchmark evaluation of  $F_{MSY}$  and the 20% harvest control rule incorporated uncertainties about assessment estimates, among other sources of uncertainty (ICES 2010).

### 8.11 Comparison with previous assessment and forecast

Compared to last year's NWWG 2010 estimates, the reference biomass  $B_{4+}$  in 2010 has decreased from 198 to 186 kt, SSB 2010 has increased from 86 to 96 kt,  $F_{bar}$  2009 has decreased from 0.47 to 0.39, and the age composition has changed slightly as shown below. These changes are partly due to changes in the recent selectivity pattern.

	NWWG2010	NWWG2011
$B_{4+}(2010)$	198	186
SSB(2010)	86	96
$F_{4-9}(2009)$	0.47	0.39
$N_3(2010)$	27	34
$N_4(2010)$	39	31
$N_5(2010)$	16	12

### 8.12 Ecosystem considerations

Changes in the distribution of large pelagic stocks (blue whiting, Norwegian spring-spawning herring) may affect the propensity of saithe to migrate off shelf and between management units. The evidence from tagging experiments (ICES 2008) show some migrations along the Faroe-Iceland Ridge, as well as onto the East Greenland shelf. It is possible that due to migratory behavior, larger saithe become partially out of reach from the fishery. A hypothesis of a descending right limb on the selectivity curve for saithe might have some merit, increasing the saithe resilience to fishing if enough saithe 'escape' from the fishery onto the niche where the large pelagic stocks are available.

### 8.13 Changes in fishing technology and fishing patterns

There are indications that the fleet may be increasingly targeting younger fish in recent years.

The proportion of saithe landings taken in gillnets has increased slightly in recent years (the average increasing from 5% in 2005-2007 to 11% in 2008-2010) in spite of the fact that in recent years the total effort of gillnetters has gone down around Iceland.

## References

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- ICES 2008. Report of the North-Western Working Group (NWWG). ICES CM 2008/ACOM:03.
- ICES 2010. Report of the Benchmark Workshop on Roundfish (WKROUND). ICES CM 2010/ACOM:36.
- Palsson, O.K., G. Karlsson, A. Arason, G.R. Gislason, G. Johannesson, and S. Adalsteinsson. 2003. Discards in demersal Icelandic fisheries 2002. Mar. Res. Inst. Rep. 94.

**Table 8.1. Saithe in division Va. Nominal catch (t) by countries, as officially reported to ICES.**

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Faroe Islands	716	997	700	228	128	366	143	214	322	415	392	196	269	499
Germany		3	2	1	14	6	56	157	224	33				
Iceland	36 548	30 531	30 583	32 914	31 854	41 687	51 857	62 614	67 283	75 197	64 008	69 992	61 391	53 772
Norway			6	1	44	3	164	1	2	2	3	2	3	1
UK (E/W/NJ)			1	2	23	7		105						
UK (Scotland)			1			2								
United Kingdom							35		312	16	30			
Total	37 264	31 531	31 293				52 091	63 091	68 143	75 663	64 433	70 190	61 663	54 272
Bycatch							403	1 700	1 000					
WG estimate				33 146	32 063	42 071	52 494	64 791	69 143					

**Table 8.2. Saithe in division Va. Commercial catch at age (millions).**

	3	4	5	6	7	8	9	10	11	12	13	14
1980	0.275	2.540	5.214	2.596	2.169	1.341	0.387	0.262	0.155	0.112	0.064	0.033
1981	0.203	1.325	3.503	5.404	1.457	1.415	0.578	0.242	0.061	0.154	0.135	0.128
1982	0.508	1.092	2.804	4.845	4.293	1.215	0.975	0.306	0.059	0.035	0.048	0.046
1983	0.107	1.750	1.065	2.455	4.454	2.311	0.501	0.251	0.038	0.012	0.002	0.004
1984	0.053	0.657	0.800	1.825	2.184	3.610	0.844	0.376	0.291	0.135	0.185	0.226
1985	0.376	4.014	3.366	1.958	1.536	1.172	0.747	0.479	0.074	0.023	0.072	0.071
1986	3.108	1.400	4.170	2.665	1.550	1.116	0.628	1.549	0.216	0.051	0.030	0.014
1987	0.956	5.135	4.428	5.409	2.915	1.348	0.661	0.496	0.498	0.058	0.027	0.048
1988	1.318	5.067	6.619	3.678	2.859	1.775	0.845	0.226	0.270	0.107	0.024	0.001
1989	0.315	4.313	8.471	7.309	1.794	1.928	0.848	0.270	0.191	0.135	0.076	0.010
1990	0.143	1.692	5.471	10.112	6.174	1.816	1.087	0.380	0.151	0.055	0.076	0.037
1991	0.198	0.874	3.613	6.844	10.772	3.223	0.858	0.838	0.228	0.040	0.006	0.005
1992	0.242	2.928	3.844	4.355	3.884	4.046	1.290	0.350	0.196	0.056	0.054	0.015
1993	0.657	1.083	2.841	2.252	2.247	2.314	3.671	0.830	0.223	0.188	0.081	0.012
1994	0.702	2.955	1.770	2.603	1.377	1.243	1.263	2.009	0.454	0.158	0.188	0.082
1995	1.573	1.853	2.661	1.807	2.370	0.905	0.574	0.482	0.521	0.106	0.035	0.013
1996	1.102	2.608	1.868	1.649	0.835	1.233	0.385	0.267	0.210	0.232	0.141	0.074
1997	0.603	2.960	2.766	1.651	1.178	0.599	0.454	0.125	0.095	0.114	0.077	0.043
1998	0.183	1.289	1.767	1.545	1.114	0.658	0.351	0.265	0.120	0.081	0.085	0.085
1999	0.989	0.732	1.564	2.176	1.934	0.669	0.324	0.140	0.072	0.025	0.028	0.022
2000	0.850	2.383	0.896	1.511	1.612	1.806	0.335	0.173	0.057	0.033	0.017	0.007
2001	1.223	2.619	2.184	0.591	0.977	0.943	0.819	0.186	0.094	0.028	0.028	0.013
2002	1.187	4.190	3.147	2.970	0.519	0.820	0.570	0.309	0.101	0.027	0.015	0.011
2003	2.262	4.320	5.973	2.448	1.924	0.282	0.434	0.287	0.195	0.027	0.029	0.015
2004	0.952	7.841	7.195	5.363	1.563	1.057	0.211	0.224	0.157	0.074	0.039	0.011
2005	2.607	3.089	7.333	6.876	3.592	0.978	0.642	0.119	0.149	0.089	0.046	0.012
2006	1.380	10.051	2.616	5.840	4.514	1.989	0.667	0.485	0.118	0.112	0.086	0.031
2007	1.244	6.552	8.751	2.124	2.935	1.817	0.964	0.395	0.190	0.043	0.036	0.020
2008	1.432	3.602	5.874	6.706	1.155	1.894	1.248	0.803	0.262	0.176	0.087	0.044
2009	2.820	5.166	2.084	2.734	2.883	0.777	1.101	0.847	0.555	0.203	0.134	0.036
2010	2.146	6.284	3.058	0.997	1.644	1.571	0.514	0.656	0.522	0.231	0.114	0.064



Table 8.5. Saithe in division Va. Survey catch-at-age indices.

	1	2	3	4	5	6	7	8	9	10
1985	0.05	0.61	0.58	2.99	5.11	1.74	1.06	0.50	1.37	0.16
1986	0.02	2.33	2.40	2.06	2.09	1.42	0.62	0.28	0.19	0.32
1987	0.10	0.39	11.52	12.93	6.42	3.95	3.07	0.79	0.36	0.26
1988	0.69	0.31	0.49	2.72	2.81	1.71	0.95	0.40	0.07	0.08
1989	0.20	1.43	3.96	5.05	6.57	2.49	1.77	0.91	0.40	0.00
1990	0.01	0.35	1.69	4.86	6.37	12.33	3.30	1.21	0.64	0.12
1991	0.01	0.22	1.40	1.72	2.22	1.13	2.50	0.30	0.02	0.03
1992	0.01	0.15	0.91	5.73	5.52	2.79	2.68	1.91	0.28	0.06
1993	0.00	1.27	11.04	2.00	6.80	2.41	2.25	1.02	4.02	0.64
1994	0.04	0.82	0.73	1.89	1.74	1.95	0.53	0.84	1.00	3.62
1995	0.06	0.48	1.98	1.12	0.51	0.28	0.34	0.10	0.15	0.15
1996	0.03	0.13	0.51	3.76	1.12	0.99	0.58	1.00	0.05	0.09
1997	0.16	0.32	0.90	4.72	3.95	0.94	0.40	0.16	0.10	0.05
1998	0.01	0.11	1.64	2.33	2.53	1.23	0.71	0.31	0.08	0.07
1999	0.57	0.75	3.71	0.93	1.25	1.64	0.57	0.17	0.02	0.02
2000	0.00	0.38	2.02	2.54	0.61	0.84	0.53	0.47	0.07	0.03
2001	0.00	0.89	1.90	2.64	1.60	0.20	0.23	0.40	0.13	0.07
2002	0.02	1.05	2.23	2.97	3.08	2.15	0.42	0.49	0.32	0.22
2003	0.01	0.05	9.62	5.06	2.94	1.34	0.77	0.21	0.05	0.10
2004	0.01	0.91	1.38	9.39	6.04	4.35	1.48	0.81	0.17	0.16
2005	0.00	0.26	4.32	2.39	7.42	4.66	2.31	0.86	0.44	0.12
2006	0.01	0.00	2.18	6.69	1.98	8.91	3.52	1.21	0.29	0.25
2007	0.00	0.06	0.31	1.73	3.22	0.81	1.62	0.70	0.29	0.16
2008	0.01	0.08	2.25	1.79	2.85	4.01	0.61	0.78	0.34	0.15
2009	0.01	0.21	2.43	1.80	0.68	0.91	0.84	0.12	0.26	0.15
2010	0.00	0.07	1.23	4.99	2.49	0.63	0.60	0.48	0.07	0.13
2011	0.00	0.15	3.83	4.20	3.06	1.15	0.41	0.39	0.44	0.17

Table 8.6. Saithe in division Va. Commercial catch-at-age log residuals from the fitted model.

	3	4	5	6	7	8	9	10	11	12	13	14
1980	-0.283	-0.298	0.127	0.076	-0.038	0.102	-0.017	0.072	-0.083	-0.097	-0.123	-0.004
1981	-0.164	-0.120	-0.285	0.183	-0.075	0.029	0.048	0.089	-0.153	0.221	0.252	0.345
1982	0.316	-0.112	0.063	-0.189	0.120	-0.011	0.163	-0.127	-0.209	-0.137	-0.071	-0.012
1983	-0.791	0.449	-0.319	0.056	0.231	0.102	-0.005	-0.297	-0.459	-0.248	-0.193	-0.177
1984	-1.286	-0.761	-0.613	0.107	0.234	0.395	-0.212	0.167	0.334	0.256	0.736	0.960
1985	-0.111	0.617	0.285	0.041	0.131	-0.088	-0.535	-0.317	-0.321	-0.449	0.103	0.281
1986	1.086	-0.344	0.123	-0.162	-0.037	0.047	-0.172	0.426	-0.364	-0.226	-0.222	-0.112
1987	-0.444	0.082	0.155	0.112	0.043	0.034	0.025	-0.063	-0.032	-0.560	-0.173	-0.024
1988	0.397	-0.159	0.034	0.018	-0.063	0.091	0.315	-0.186	0.129	-0.375	-0.359	-0.145
1989	-0.269	0.302	0.001	0.121	-0.271	0.024	0.108	-0.048	0.142	0.063	-0.170	-0.204
1990	-0.428	-0.253	0.040	0.001	0.176	0.028	0.051	-0.119	0.014	-0.081	0.018	-0.148
1991	-0.560	-0.470	0.026	0.170	0.017	-0.030	0.005	0.272	0.051	-0.125	-0.135	-0.116
1992	-0.061	0.277	0.511	0.209	0.036	-0.411	-0.104	-0.136	-0.071	-0.163	0.047	-0.038
1993	0.387	-0.072	-0.170	-0.070	-0.100	-0.035	0.200	0.023	0.096	0.192	0.099	-0.063
1994	0.445	0.482	-0.058	-0.347	-0.208	-0.220	0.098	0.196	0.198	0.193	0.431	0.244
1995	0.739	0.137	0.050	-0.011	0.021	-0.037	-0.088	-0.076	-0.109	-0.227	-0.088	-0.137
1996	0.664	0.087	-0.059	-0.250	-0.159	0.089	0.107	0.007	0.133	-0.055	0.339	0.348
1997	0.102	0.156	-0.158	0.038	-0.010	0.131	-0.040	-0.111	-0.071	0.105	-0.277	0.036
1998	-0.149	-0.038	-0.240	-0.382	0.094	0.004	0.351	0.273	0.349	0.266	0.353	0.208
1999	0.177	0.006	-0.003	0.037	0.004	-0.086	-0.143	0.106	-0.170	-0.078	0.033	0.015
2000	-0.033	-0.105	0.044	0.039	-0.076	0.241	-0.200	-0.093	-0.044	-0.155	-0.012	-0.057
2001	-0.039	0.119	-0.137	-0.066	-0.006	-0.084	0.183	0.020	0.029	-0.001	0.032	0.046
2002	-0.287	-0.035	0.091	0.177	-0.073	0.055	-0.113	-0.131	-0.024	-0.140	-0.010	-0.021
2003	0.200	-0.128	0.218	-0.012	-0.007	-0.210	0.013	-0.067	0.007	-0.124	0.012	0.034
2004	-0.010	-0.189	0.006	0.095	-0.110	0.087	0.155	0.152	0.035	-0.035	0.053	-0.003
2005	-0.137	-0.093	-0.113	0.157	0.109	-0.113	-0.008	0.028	0.074	-0.003	-0.025	-0.012
2006	-0.222	-0.044	-0.081	-0.099	0.189	0.018	-0.077	0.023	0.102	0.108	0.092	-0.004
2007	0.337	0.174	0.131	0.078	-0.171	-0.059	-0.114	-0.099	-0.213	0.007	-0.004	-0.028
2008	-0.135	0.159	0.187	0.061	-0.090	-0.158	-0.063	-0.032	-0.165	-0.016	0.214	0.079
2009	0.108	0.036	-0.007	-0.116	-0.101	0.158	-0.081	0.062	0.092	0.098	0.157	0.111
2010	0.097	-0.125	-0.072	-0.224	0.073	0.028	0.316	-0.027	0.121	0.018	0.140	0.106



**Table 8.7. Saithe in division Va. Survey catch-at-age log residuals from the fitted model.**

	1	2	3	4	5	6	7	8	9	10
1985	0.000	-0.222	-0.944	-0.317	0.424	0.110	0.179	-0.132	0.501	-0.376
1986	0.000	0.329	-0.497	-0.480	-0.569	-0.353	-0.261	-0.247	-0.290	-0.175
1987	0.000	-0.238	0.632	0.613	0.575	0.305	0.767	0.379	0.200	0.103
1988	0.000	-0.127	-1.325	-1.117	-0.712	-0.219	-0.365	-0.245	-0.350	-0.123
1989	0.000	0.612	0.557	-0.013	-0.262	-0.456	0.290	0.162	0.135	-0.351
1990	0.000	-0.071	0.176	0.354	0.268	0.702	0.309	0.508	0.317	-0.125
1991	0.000	-0.004	-0.232	-0.164	-0.249	-0.800	-0.549	-0.838	-0.634	-0.426
1992	0.000	-0.124	-0.028	0.577	0.907	0.297	0.430	-0.068	-0.355	-0.241
1993	0.000	0.582	1.875	0.224	0.816	0.507	0.660	0.236	1.199	0.493
1994	0.000	0.225	-0.281	-0.043	0.194	0.096	-0.114	0.432	0.705	1.595
1995	0.000	0.063	0.030	-0.337	-0.809	-0.532	-0.569	-0.333	-0.084	-0.020
1996	0.000	-0.105	-0.750	0.198	-0.245	-0.066	0.232	0.704	-0.157	0.004
1997	0.000	0.154	-0.115	0.532	0.327	-0.053	-0.212	-0.039	-0.128	-0.017
1998	0.000	-0.272	0.710	0.265	0.083	-0.280	0.139	0.059	-0.018	-0.030
1999	0.000	0.176	0.552	0.046	-0.147	0.036	-0.440	-0.236	-0.335	-0.089
2000	0.000	-0.266	0.019	-0.141	-0.148	-0.132	-0.375	-0.082	-0.205	-0.143
2001	0.000	-0.021	-0.476	-0.133	-0.426	-0.387	-0.537	-0.075	-0.292	-0.039
2002	0.000	-0.006	-0.482	-0.511	0.074	0.106	0.153	0.252	0.112	0.121
2003	0.000	-0.252	0.711	-0.176	-0.434	-0.276	-0.274	0.103	-0.288	-0.098
2004	0.000	-0.039	-0.046	0.293	0.084	0.254	0.206	0.227	0.182	0.147
2005	0.000	-0.191	0.041	0.062	0.242	0.245	0.187	0.226	0.099	0.153
2006	0.000	-0.219	-0.006	0.076	0.077	0.841	0.529	0.165	-0.146	0.026
2007	0.000	-0.286	-0.631	-0.525	-0.372	-0.193	-0.138	-0.259	-0.404	-0.156
2008	0.000	-0.409	0.217	0.133	0.087	0.272	0.036	-0.157	-0.327	-0.380
2009	0.000	-0.225	-0.060	-0.266	-0.324	-0.330	-0.434	-0.313	-0.401	-0.352
2010	0.000	-0.443	-0.427	0.238	0.221	-0.018	-0.139	-0.249	-0.205	-0.355
2011	0.000	-0.240	0.275	0.244	0.025	0.018	0.108	0.039	0.048	0.179

**Table 8.8. Saithe in division Va. Main population estimates from the fitted model.**

	Landings	F	SSB	N3	B4+	HR
1980	57.7	0.294	121.7	28.2	312.0	0.185
1981	57.5	0.263	130.0	20.1	304.7	0.189
1982	67.9	0.303	148.7	21.5	294.3	0.231
1983	56.5	0.243	147.4	32.2	269.7	0.210
1984	60.4	0.232	149.1	41.7	287.0	0.210
1985	53.7	0.246	140.0	35.4	298.9	0.180
1986	65.2	0.283	145.9	66.5	318.1	0.205
1987	80.2	0.352	144.1	91.8	334.1	0.240
1988	77.2	0.323	144.6	50.2	414.9	0.186
1989	82.3	0.307	146.2	32.0	396.9	0.207
1990	97.5	0.350	148.6	20.8	376.7	0.259
1991	102.2	0.375	152.9	29.6	335.6	0.304
1992	79.6	0.366	140.8	14.8	287.7	0.277
1993	71.5	0.398	115.0	19.8	230.4	0.310
1994	63.6	0.452	94.6	17.6	187.0	0.340
1995	48.3	0.461	70.5	29.8	152.7	0.316
1996	39.4	0.404	61.1	25.6	148.7	0.265
1997	36.7	0.364	61.2	16.8	155.8	0.235
1998	30.7	0.296	66.4	8.7	153.4	0.200
1999	30.9	0.309	70.8	30.1	131.9	0.234
2000	32.8	0.327	71.5	30.8	142.0	0.231
2001	31.6	0.276	76.1	52.6	161.0	0.196
2002	42.0	0.303	90.3	61.2	215.9	0.194
2003	51.8	0.297	110.7	69.8	272.6	0.190
2004	64.7	0.267	128.7	23.0	311.1	0.208
2005	69.1	0.299	139.3	64.8	273.2	0.253
2006	75.5	0.333	143.9	34.5	288.2	0.262
2007	64.3	0.326	135.3	16.1	248.9	0.258
2008	69.4	0.400	127.9	27.0	212.2	0.327
2009	60.3	0.394	110.2	41.1	185.4	0.325
2010	53.9	0.367	95.5	33.8	185.7	0.290
2011	50.0	0.334	87.9	43.8	183.5	0.272





Table 8.12. Saithe in division Va. Output from the short-term projections.

2011					2012						2013		Rationale	
B4+	SSB	Fmult	Fbar	Landings	B4+	SSB	%SSB change <sup>1)</sup>	%TAC change <sup>2)</sup>						
184	88	0.91	0.334	50	199	88	0.00	0.000	0	253	124	41%	-100%	Zero catch
							0.03	0.010	2	250	123	40%	-96%	
							0.05	0.020	4	248	122	39%	-92%	
							0.08	0.030	5	246	121	38%	-90%	
							0.11	0.040	7	244	120	36%	-86%	
							0.14	0.050	9	242	118	34%	-82%	
							0.16	0.060	11	240	117	33%	-78%	
							0.19	0.070	12	238	116	32%	-76%	
							0.22	0.080	14	236	115	31%	-72%	
							0.25	0.090	16	234	114	30%	-68%	
							0.27	0.100	18	233	113	28%	-64%	
							0.30	0.110	19	231	111	26%	-62%	
							0.33	0.120	21	229	110	25%	-58%	
							0.35	0.130	23	227	109	24%	-54%	
							0.38	0.140	24	225	108	23%	-52%	
							0.41	0.150	26	223	107	22%	-48%	
							0.44	0.160	27	222	106	20%	-46%	
							0.46	0.170	29	220	105	19%	-42%	
							0.49	0.180	30	218	104	18%	-40%	
							0.52	0.190	32	216	103	17%	-36%	F <sub>0.1</sub>
							0.54	0.200	34	214	102	16%	-32%	
							0.57	0.210	35	213	101	15%	-30%	
							0.60	0.220	37	211	100	14%	-26%	
							0.63	0.230	38	209	99	13%	-24%	
							0.65	0.240	40	208	98	11%	-20%	
							0.68	0.250	41	206	97	10%	-18%	
							0.71	0.260	42	204	96	9%	-16%	20% HCR <sup>3)</sup>
							0.74	0.270	44	203	95	8%	-12%	
							0.76	0.280	45	201	94	7%	-10%	F <sub>MSY</sub>
							0.79	0.290	47	200	93	6%	-6%	
							0.82	0.300	48	198	92	5%	-4%	
							0.84	0.310	49	196	91	3%	-2%	
							0.87	0.320	51	195	90	2%	2%	
							0.90	0.330	52	193	89	1%	4%	F <sub>2011</sub>
							0.93	0.340	54	192	89	1%	8%	
							0.95	0.350	55	190	88	0%	10%	
							0.98	0.360	56	189	87	-1%	12%	
							1.01	0.370	57	187	86	-2%	14%	F <sub>2010</sub>
							1.04	0.380	59	186	85	-3%	18%	
							1.06	0.390	60	184	84	-5%	20%	
							1.09	0.400	61	183	83	-6%	22%	
							1.12	0.410	63	182	83	-6%	26%	
							1.14	0.420	64	180	82	-7%	28%	
							1.17	0.430	65	179	81	-8%	30%	
							1.20	0.440	66	177	80	-9%	32%	
							1.23	0.450	68	176	79	-10%	36%	
							1.25	0.460	69	175	79	-10%	38%	
							1.28	0.470	70	173	78	-11%	40%	
							1.31	0.480	71	172	77	-13%	42%	
							1.33	0.490	72	171	76	-14%	44%	
							1.36	0.500	73	169	76	-14%	46%	

1) SSB 2013 relative to SSB 2012

2) TAC 2012 relative to TAC 2011

3) HCR candidate:  $(0.2B_{4+,11} + TAC_{10/11}) / 2$

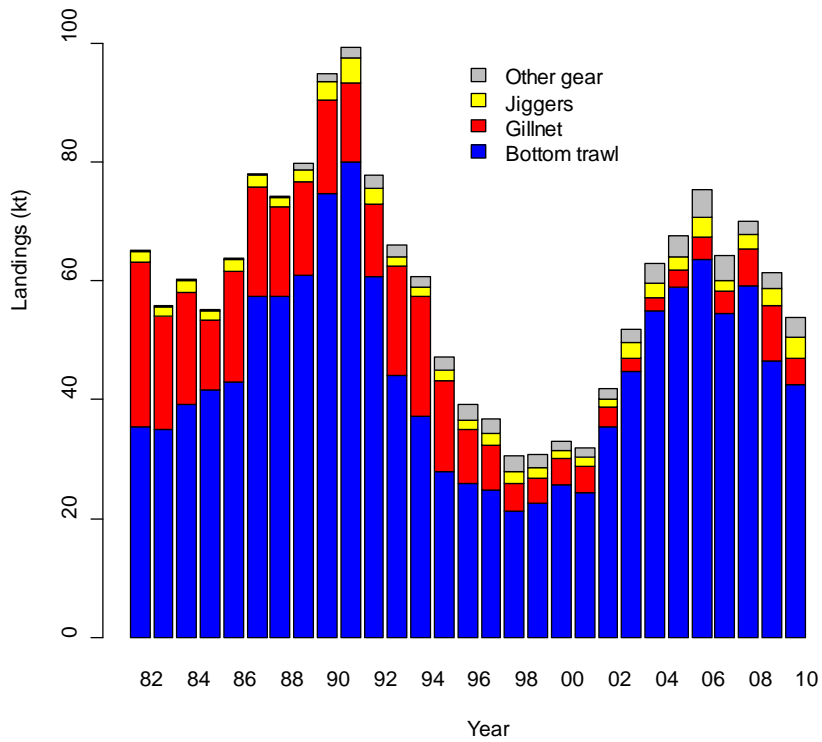


Figure 8.1 Saithe in Division Va. Landings by gear.

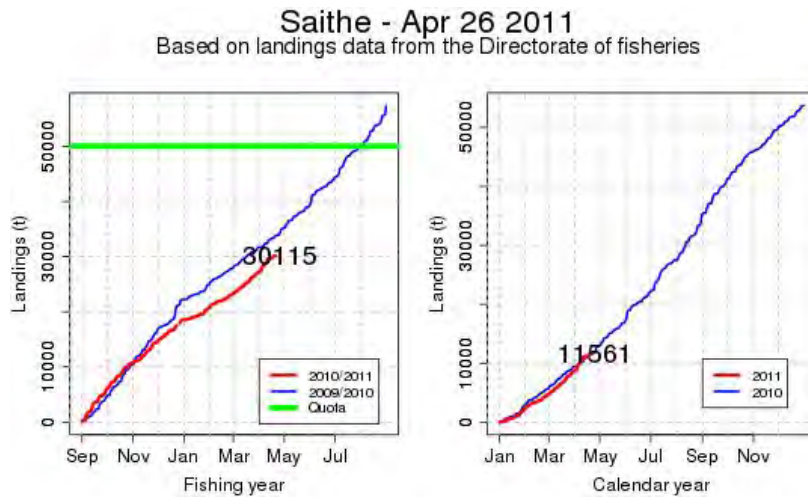


Figure 8.2 Saithe in division Va. Cumulative landings in the current fishing year (left) and calendar year (right). The vertical (green line) in the left figure shows the quota for the current fishing year.

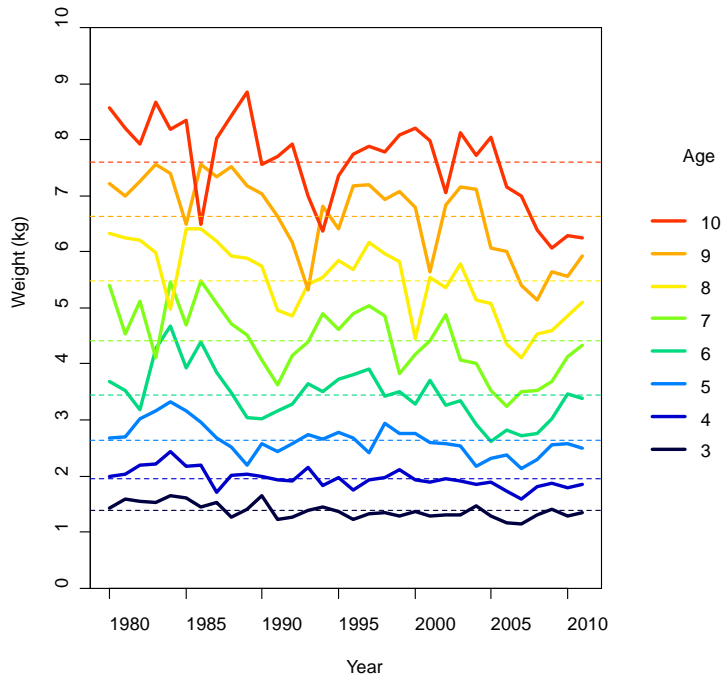


Figure 8.3 Saithe in division Va. Weight at age in the catches. The dotted horizontal lines show the long-term mean.

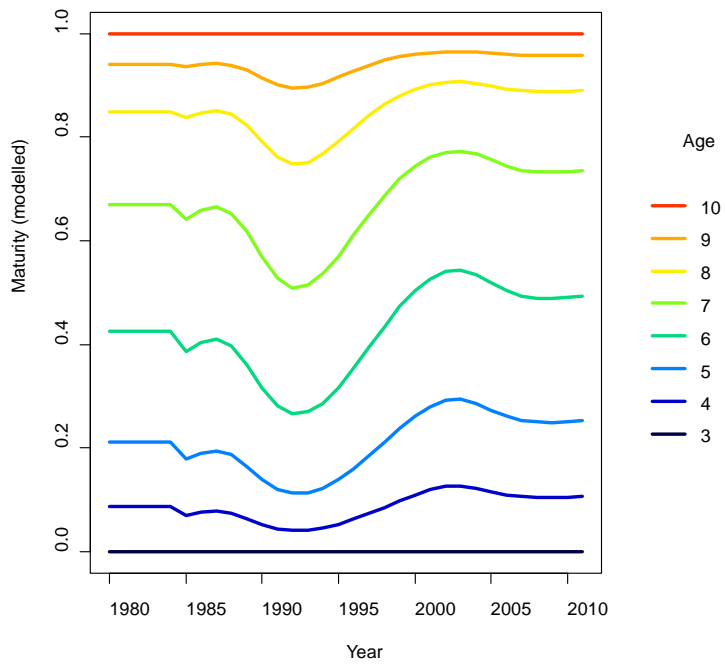


Figure 8.4 Saithe in division Va. Maturity at age used for calculating the SSB.

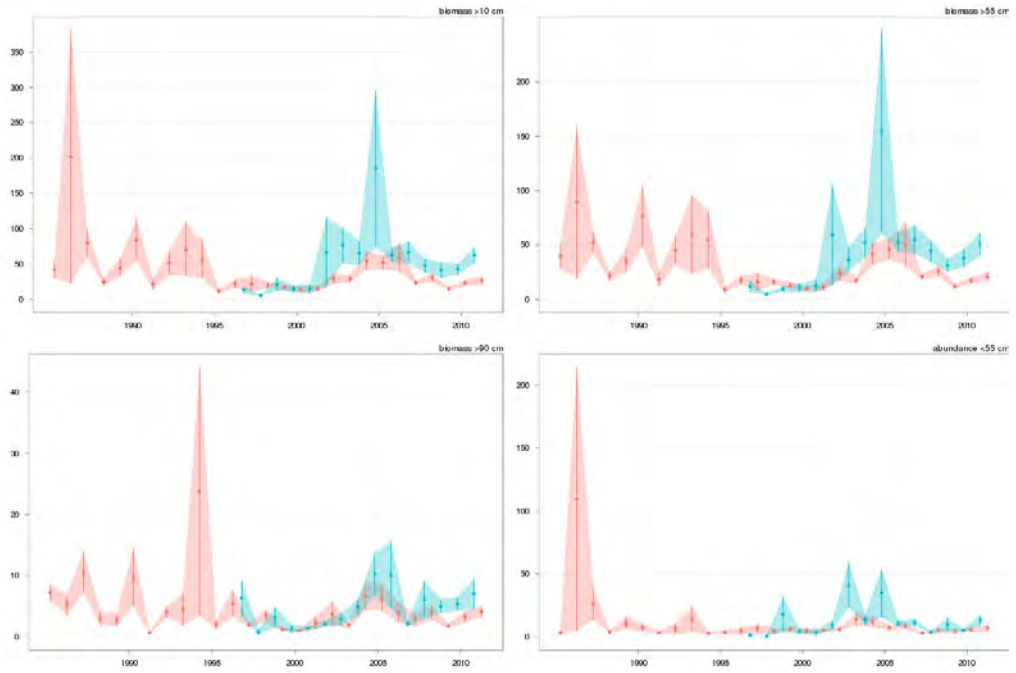


Figure 8.5 Saithe in division Va. Survey indices. The panels show a) total biomass indices, b) biomass indices larger than 55 cm, biomass indices smaller than 90 cm and d) abundance indices smaller than 55 cm. Red trajectories are spring survey indices from 1985 and blue trajectories are fall survey indices from 1997. The shades and the vertical lines indicate +/- 1 standard error.

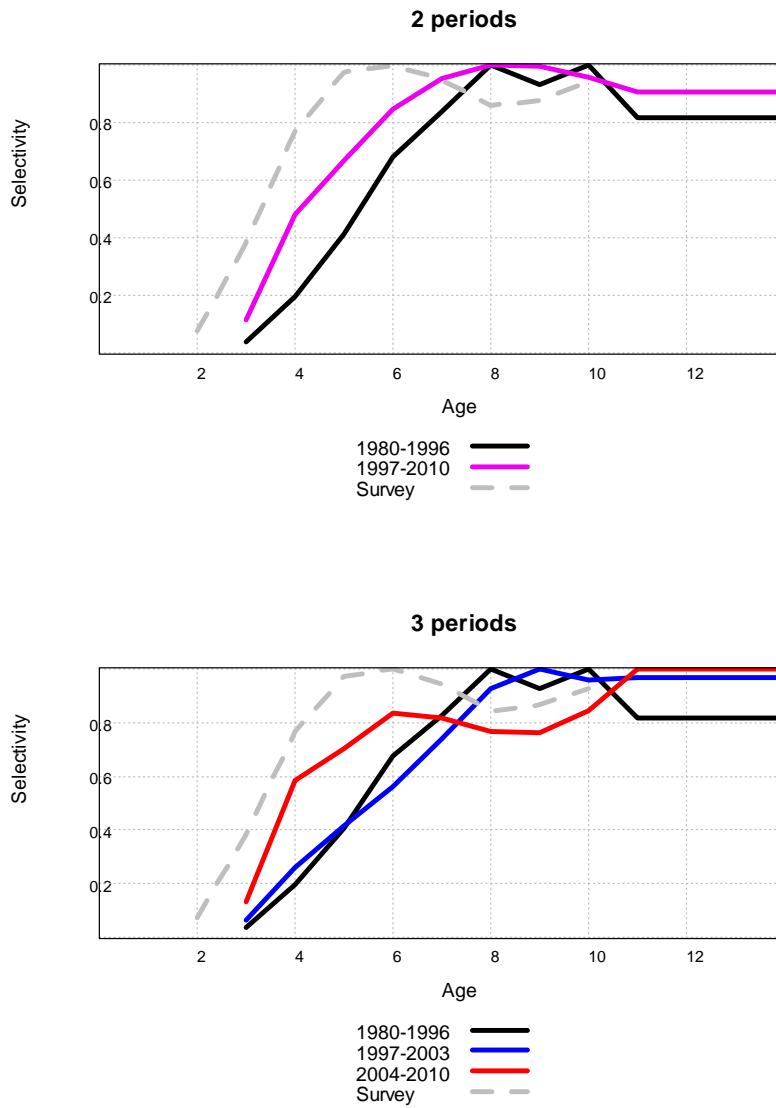


Figure 8.6. Estimated selectivity patterns from the old 2-period and new 3-period assessment model.



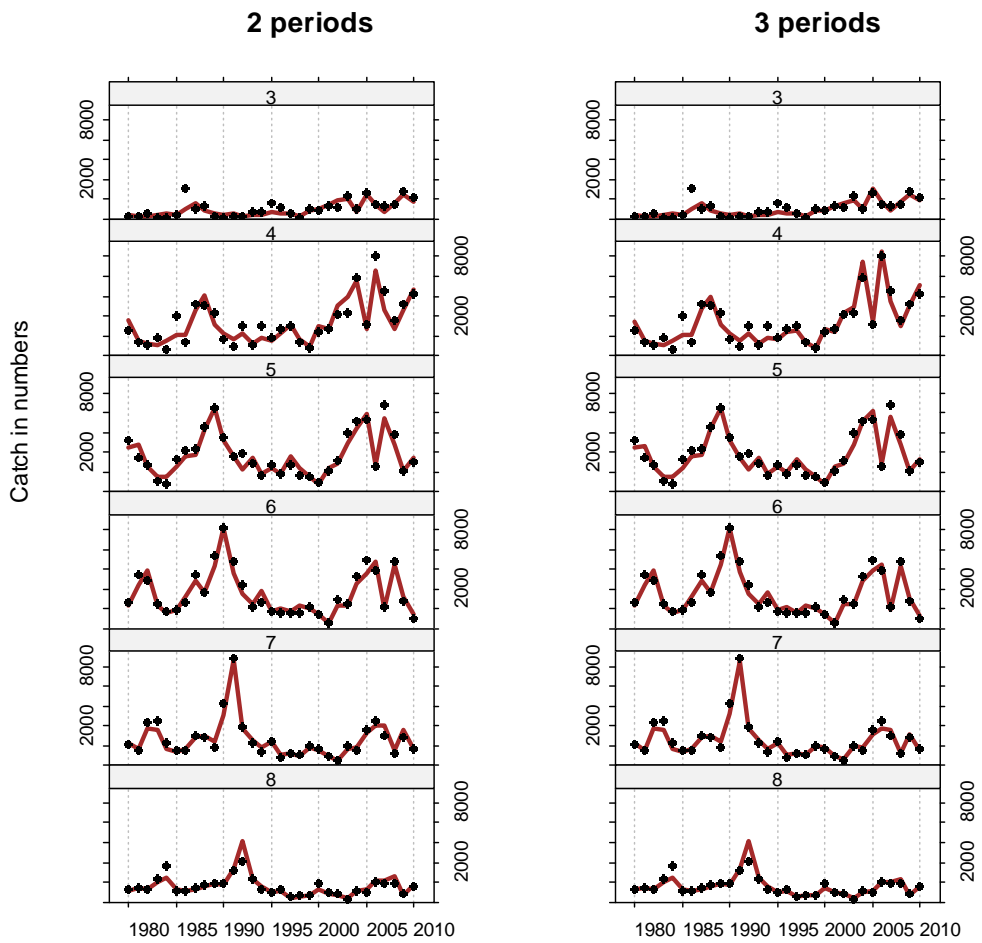


Figure 8.7. Observed and fitted commercial catch at age from the old 2-period and new 3-period assessment model.

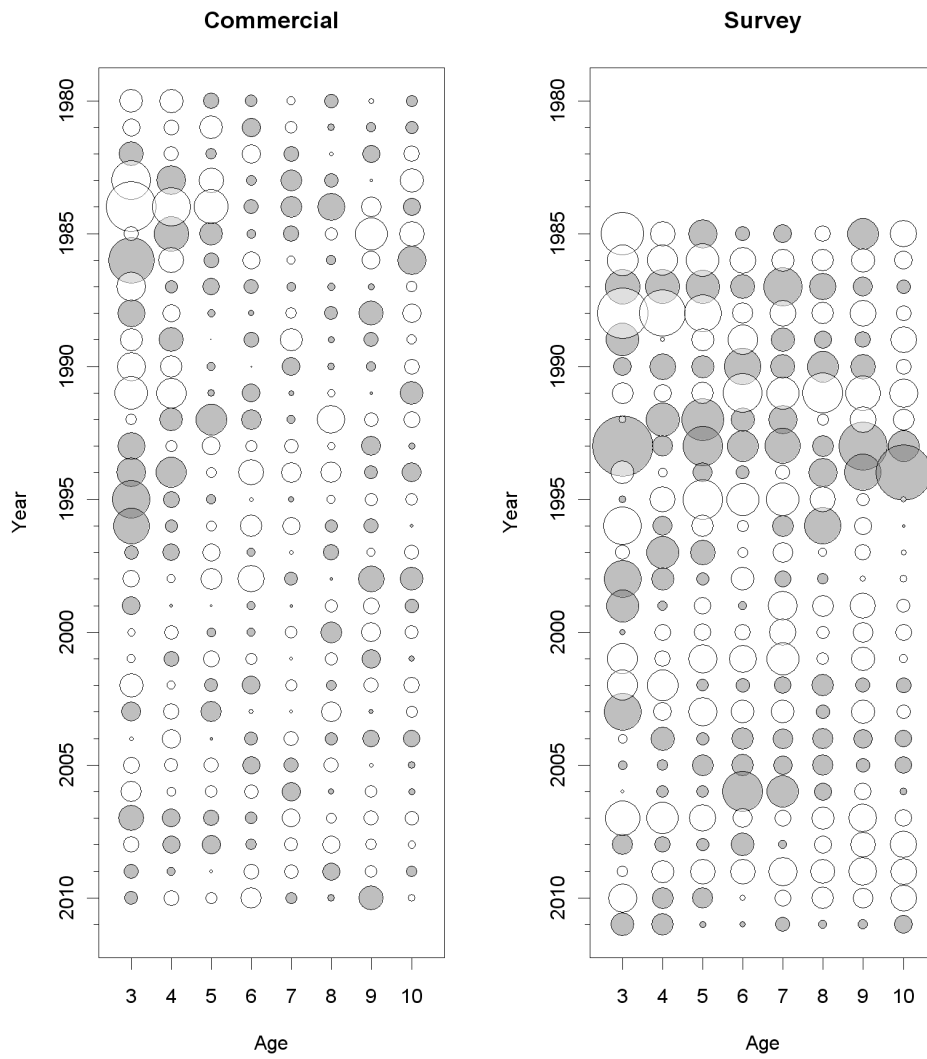


Figure 8.8. Saithe in division Va. Commercial and survey catch-at-age residuals from the fitted model. Filled circles are positive log residuals and hollow circles are negative log residuals.

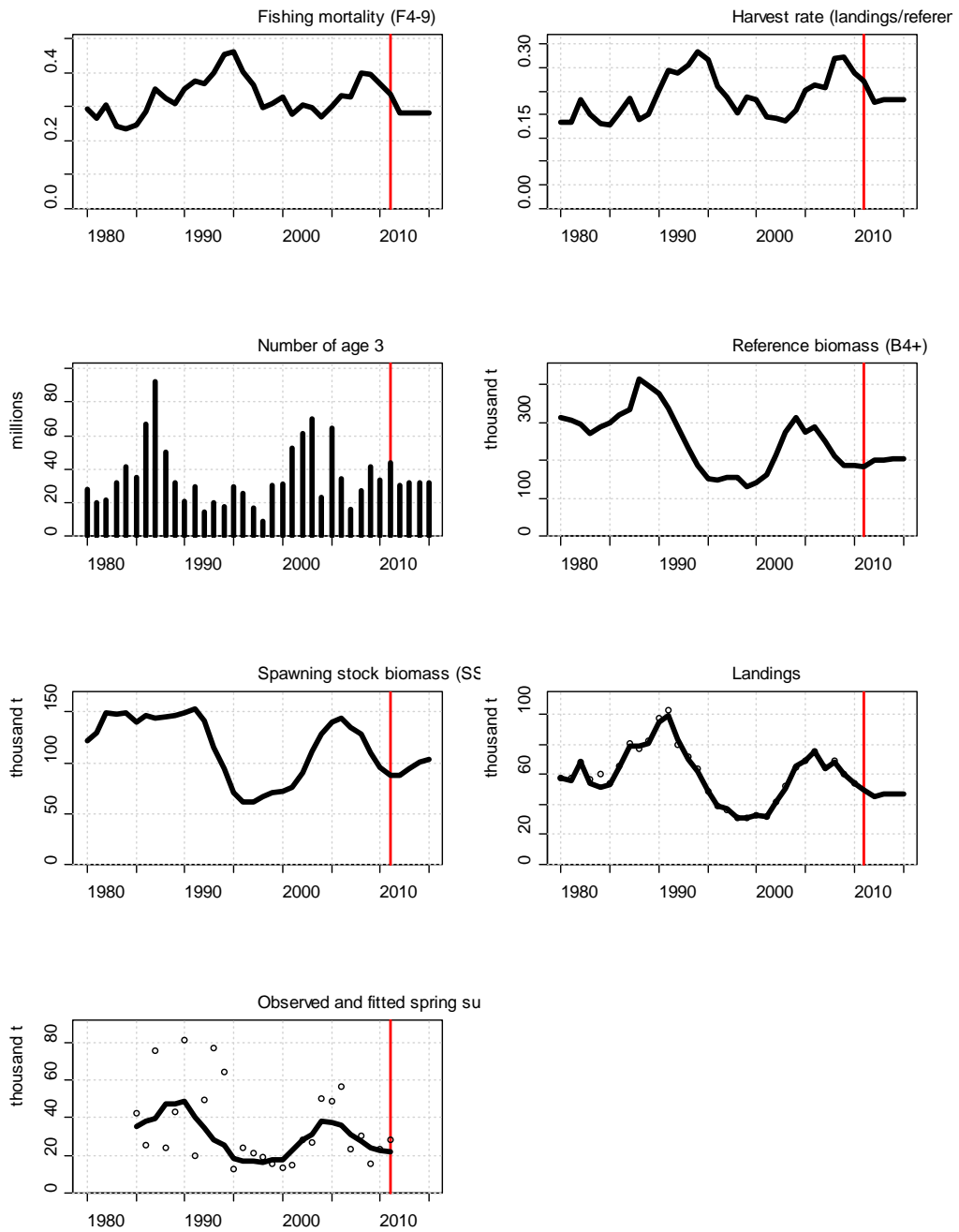


Figure 8.9. Saithe in division Va. Results from the fitted model and short-term forecast. The red line indicates the time of the current assessment.

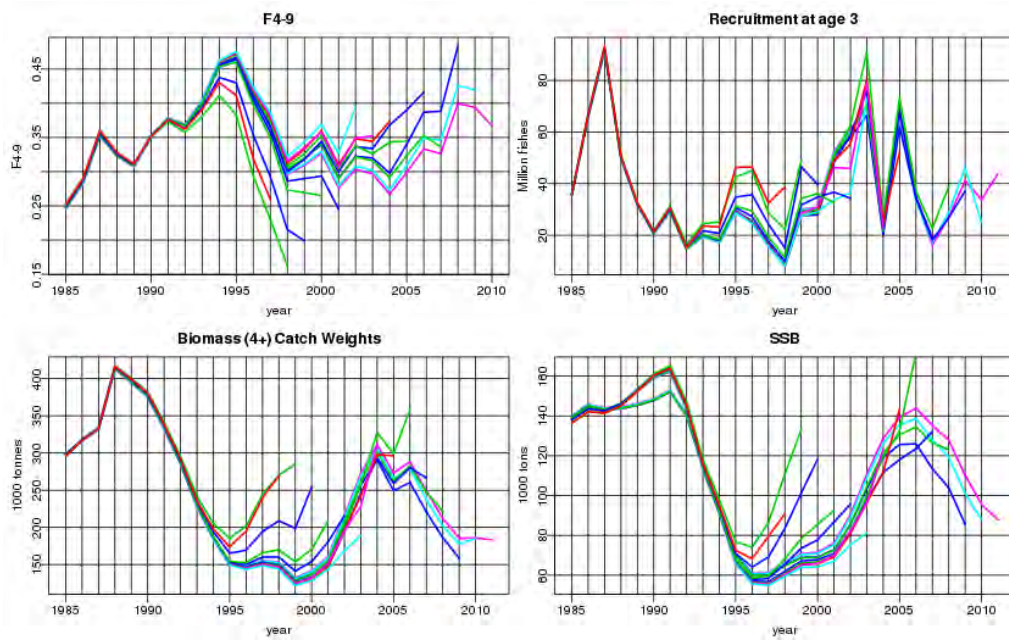


Figure 8.10. Saithe in division Va. Retrospective pattern for the assessment model. Trajectories to 2007 and later use three selectivity periods, and older trajectories use two selectivity periods.