5 Northeast Arctic saithe[1]

5.1 The fishery (Table 5.1 and Table 5.2, Figure 5.1)

Currently, the main fleets targeting saithe are trawl, purse-seine, gillnet, handline, and Danish seine. Landings of saithe were highest in 1970–1976 with an average of 239 000 t and a maximum of 265 000 t in 1970. This period was followed by a sharp decline to a level of about 160 000 t in the years 1978–1984, while in 1985 to 1991 the landings ranged from 67 000–123 000 t. After 1991 landings increased, ranging between 136 000 t (in 2000) and 212 000 t (in 2006), followed by a decline to 132 000 t in 2015. In 2020 landings were 169 405 t and 188 176 t in 2020.

Discarding, although illegal, occurs in the saithe fishery, but is not considered a major problem in the assessment. Due to its nearshore distribution saithe is virtually inaccessible for commercial gears during the first couple of years of life and there are no reports indicating overall high discard rates in the Norwegian fisheries. There are reported incidents of slipping in the purse-seine fishery, mainly related to minimum landing size. Observations from non-Norwegian commercial trawlers indicate that discarding may occur when vessels targeting other species catch saithe, for which they may not have a quota or have filled it. However, there are no quantitative estimates of the level of discarding available.

5.1.1 ICES advice applicable to 2021 and 2022

The advice from ICES for 2021 was as follows:

- ICES advised that catches in 2021 should be no more than 197 779 t.

The advice from ICES for 2022 was as follows:

- ICES advised that catches in 2022 should be no more than 197 212 t.

5.1.2 Management applicable in 2021 and 2022

Management of Saithe in subareas 1 and 2 is by TAC and technical measures. For 2021, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 197 779 t.

For 2022, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 197 212 t.

5.1.3 The fishery in 2021 and expected landings in 2022

Provisional figures show that the landings in 2021 were approximately 188 176 t, which is 9603 t lower than the TAC of 197 779 t.

Since the WG does not have any prognosis of total landings in 2022 available, the TAC of 197 212 t is used in the projections.

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[1] Saithe (*Pollachius virens*) in subareas 1 and 2 (Northeast Arctic); pok.27.1-2.

5.2 Commercial catch-effort data and research vessel surveys

5.2.1 Catch-per-unit-effort

The NEA saithe interbenchmark protocol (IBP; ICES CM 2014/ACOM: 53) recommended leaving out the CPUE time-series in the model tuning (see section 5.3.5). A detailed description of the Norwegian trawl CPUE and its previous use is given in the stock annex.

5.2.2 Survey results (Figure 5.1–5.2)

An *ad hoc* subgroup of the AFWG was held to review proposed changes to several survey series using the new "StoX" survey computation methodology on 16 and 17 April 2017 at the JRC, Italy. The survey series reviewed included the coastal survey for saithe for the period 2003 to 2017. StoX is a new program developed at IMR Norway, to produce a more robust, transparent, and automated method of computing survey series. The method is currently used in ICES assessments (for example for NSS herring). For the saithe survey series, a WD was presented to the group (Mehl *et al.*, 2018a), examining the differences between the previous survey series and those resulting from StoX in survey indices by age, as well as mean weight and mean length. During the meeting consistency plots were produced for each survey and showed to have a better fit with the StoX series compared to the old series. The meeting concluded that the new StoX survey series should be used to replace the previous survey series in AFWG stock assessment, but that once the assessment model is run the residuals and fits to the data should be examined to check for unexpected detrimental effects on model performance. The resulting SAM model fits using the old and the StoX survey series (using data for both survey series up to 2016, but excluding the 2003 StoX estimate, as this was considered abnormally high) were practically the same, without any detrimental effects on model performance.

The echo abundance observed in 2021 (Staby *et al.*, in press) increased by 30% compared to 2020 and was about 20% higher than the average for 2003–2020. The abundance estimated with StoX increased with 8% compared to 2020. This increase is the result of higher estimates of 5–9-year-old saithe, which were between 24–33% higher than in 2020. Only estimates of 3-year old saithe were below the 2020 estimate. The proportion of saithe in the southern part of the survey area (south of the Lofoten islands between 62^0–67^0N) increased from about 20% in 1997 to above 60% in 2008, decreased in later years and was 20% in 2021, similar to the 2020 proportion.

5.2.3 Recruitment indices

Owing to the nearshore distribution of juvenile saithe, obtaining early estimates of recruitment for ages 0–2 has not been possible so far. The survey recruitment indices are strongly dependent on the extent to which 2–4 year old saithe have migrated from the coastal areas and become available to the acoustic saithe survey on the banks, and this varies between years. Also, observations from an observer programme, established in 2000 to start a 0-group index series (Borge and Mehl, WD 21 2002) did not seem to reflect the dynamics in year-class strength very well. (Mehl, WD 6 2007; Mehl, WD 7 to WKROUND 2010). The programme was consequently terminated in 2010.

5.3 Data used in the assessment

5.3.1 Catch numbers-at-age (Table 5.3)

Total Norwegian landings by gear and landings data for all other countries from 2021 were updated based on the official total catch (preliminary) reported to ICES or to Norwegian authorities.

Age composition data for 2021 were available for Norwegian landings. The biological sampling of all gear groups, areas, and quarters was sufficient to produce a reliable catch-at-age matrix for 2021. As in previous years age data from the Danish seine and bottom-trawl fishery were combined to increase the number of samples by area and quarter, thereby improving the estimate of catch-at-age numbers.

Catch-at-age estimates (numbers and mean weight and length-at-age) were produced with StoX-Reca (version 3.4) for the 2021 assessment[2]. Comparative runs with the older ECA program were not possible for the 2021 data since data in the required format is not available anymore. This is the second year that catch-at-age estimates are produced with StoX-Reca for input in the SAM assessment. In previous years catch-at-age was estimated manually, and until 2020 with ECA.

5.3.2 Weight-at-age (Table 5.4)

Constant weights-at-age values for age groups 3–11 are used for the period 1960–1979, whereas estimated values for the 12+ group vary during this period. For subsequent years, annual estimates of weight-at-age in the catches are used. Weight-at-age in the stock is assumed to be the same as weight-at-age in the catch. Compared to 2020, estimated weight-at-age for age groups 3–12+ differed only slightly in 2021.

5.3.3 Natural mortality

A fixed natural mortality of 0.2 for all age groups was used both in the assessment and the forecast.

5.3.4 Maturity-at-age (Table 5.5)

A 3-year running average is used for the period from 1985 and onwards (2-year average for the first and last year). Inconsistencies between proportion mature fish and trends in SSB and recruitment since 2008 resulted in the NEA saithe IBP to recommend the use of a constant maturity ogive for the years from 2007 and onwards based on the average 2005–2007 (ICES CM 2014/ACOM: 53). Analysis are currently being done to investigate which method, i.e. macroscopic determination, otolith spawning rings or histological analysis, is the most reliable to determine the maturity stage.

5.3.5 Tuning data (Table 5.6)

Until the 2005 WG, the XSA tuning was based on three dataseries: CPUE from Norwegian purse-seine and Norwegian trawl and indices from a Norwegian acoustic survey. The 2005 WG found rather large and variable log q residuals and large S.E. log q for the purse-seine fleet, as well as strong year effects, and in the combined tuning the fleet got low scaled weights. The WG decided

[2] https://github.com/StoXProject/RstoxFDA/

not to include the purse-seine tuning fleet in the analysis. This was confirmed by new analyses at the 2010 benchmark assessment (ICES CM 2010/ACOM:36). The trawl CPUE series on the other hand did not show the trends in stock size abundance of NEA saithe in later years. In the more recent years there were signs of changes in fishing strategy, with fewer and shorter fishing periods and a smaller proportion of directed saithe fishery (Mehl and Fotland, WD 20 2013).

Analyses of the two remaining tuning series done at the 2010 benchmark assessment indicated that there had been a shift in catchability around year 2002. The survey was redesigned in 2003, and the fishery to a larger degree targeted older ages. Permanent breaks were made in both tuning series in 2002. The acoustic survey, compared with the trawl CPUE time-series, seemed to track the stock changes better, both in abundance and distribution.

The sensitivity runs presented to the IBP (Fotland WD 30 2014 IBP NEA saithe) clearly showed that the residual pattern got worse (strong year effects) when using both tuning series in SAM. It became obvious that SAM tries to fit something in between both contradicting data sources. Therefore, it had to be decided whether one data source was more reliable or whether both data sources should be considered leading to a fit in between both extremes. Given that CPUE series should not be used when larger changes in fishing patterns occur (selectivity, spatial distribution of the fleet, change between targeted and bycatch fishery) it was recommended to leave out the CPUE time-series in its current form for now (ICES CM 2014/ACOM: 53). Another reason was that the proportion of catches covered by the index had decreased steadily between 2002 and 2011, further questioning the representativeness of the CPUE index. However, it may be worth trying alternative CPUE indices (e.g. one index for the targeted fishery only and one index for the fishery with saithe bycatches) until the next benchmark.
The following two tuning fleets are thus used in the present assessment (by the time this report was written the new ICES name for this survey was not available)

- NOcoast-Aco-4Q: Indices from the Norwegian acoustic survey 1994–2001, age groups 3 to 7.
- NOcoast-Aco-4Q: Indices from the Norwegian acoustic survey 2002–2021, age groups 3 to 7.

5.4 SAM runs and settings (Table 5.7)

In connection with the NEA saithe IBP a number of exploratory SAM runs were performed. Model settings and results are presented in working documents included in the IBP report (ICES CM 2014/ACOM: 53).

SAM model settings and configuration in 2021 were the same as in previous simulations.

- Tuning data: Acoustic survey series (age 3–7) only, time-series split (1994–2001 and 2002–present);
- Maturity data: Ogives for the years 2007 and later based on the average of the 2005–2007 data;
- Flat exploitation pattern for age groups 8+;
- Correlated Fs between age groups and time;
- Beverton–Holt stock–recruitment relationship used to estimate recent recruitment.

5.5 Final assessment run (Table 5.8 to Table 5.11, Figure 5.3–5.6)

The state–space assessment model (SAM) was used for the final run. SAM catchabilities and negative log likelihood values are given in Table 5.8.

Figure 5.3 presents normalized residuals for the total catches and the two parts of the acoustic tuning series. There are both year- and age effects and the second part of the series seems to perform better than the first part. Figure 5.4 shows plots of the stock numbers from the SAM vs. tuning indices.

5.5.1 SAM F, N, and SSB results (Tables 5.9–5.11, Figures 5.5–5.6)

The estimated fishing mortality ($F_{4–7}$) in 2020 was 0.219 (AFWG 2021), which is higher than 0.187 from this year's assessment and below the F_{pa} of 0.35. The fishing mortality ($F_{4–7}$) in 2021 was estimated at 0.186. From 1997 to 2009 fishing mortality was below F_{pa}, but started to increase in 2005 and was above F_{pa} in 2010–2012.

Fishing mortality and stock size have in the last decade generally been considerably over- and underestimated respectively. Due to the changes made to the assessment following the benchmark assessment workshop in 2010 (ICES CM 2010/ACOM: 36) and later the NEA saithe IBP in 2014 (ICES CM 2014/ACOM: 53), the retrospective patterns have improved considerably, as is illustrated in Figure 5.7. Based on the 2021 assessment the SSB has in recent years been both slightly over and underestimated while $F_{4–7}$ has been generally overestimated.

The SAM-estimate of the 2014 year class was considered to be reliable enough to be used in the projections. In previous assessments the value of the 3-year olds in the last data year has been set to the long-term geometrical mean, and the value of the year class at age 4 were obtained by applying Pope's approximation. Since 2007 the 2007, 2010, 2013, and 2016 year classes have been above the long-term geometric mean, while in the other years, year-class strength has been considered average or below.

The total biomass (ages 3+) was above the long-term (1960–2021) average from 1997 to 2008, reached a local maximum in 2005, and declined below the average level between 2011 and 2015. Since 2016 it has been above the long-term average, and in 2021 was estimated at > 1 140 000 tonnes, the highest estimate in the time-series. The SSB was above the long-term mean from 2000 to 2009, decreased below the average between 2010 to 2013, and has been above the long-term average since 2014. SSB has been above B_{pa} (220 000 t) since 1996 (Figure 5.5).

5.5.2 Recruitment (Table 5.10, Figure 5.5)

Catches of age group 3 have varied considerably during the period 2004–2017 (Table 5.10). Until the 2005 WG, RCT3-runs were conducted to estimate the corresponding year classes, with 2 and 3 year olds from the acoustic survey as input together with XSA numbers. However, it was stated several times in the ACOM Technical Minutes that it would be more transparent to use the long-term geometric mean (GM) recruitment. GM values were therefore used in the 2005–2014 since the issue was not discussed at the IBP when SAM was adopted as assessment model. During the 2015 AFWG assessment, analyses were performed to investigate if the last year recruitment value from SAM could be used instead of the long-term GM (for method description refer to Stock Annex). Results from this analysis showed that the retrospective runs of SAM gave better estimates of recruitment than the geometric mean and consequently estimates of the recruiting year class (3 year olds in the last data year) from the SAM were accepted for the last year.

5.6 Reference points (Figure 5.5)

In 2010 the age span was expanded from 11+ to 15+ and important XSA parameter settings were changed (ICES CM 2010/ACOM: 36). LIM reference points were re-estimated at the 2010 WG according to the methodology outlined in ICES CM 2003/ACFM: 15, while the PA reference point estimation was based on the old procedure (ICES CM 1998/ACFM: 10). The results were not very much different from the previous analyses performed in 2005 (ICES CM 2005/ACFM: 20), and it was decided not to change the existing LIM and PA reference points. The shift from XSA to SAM resulted in only minor changes in estimated fishing mortality, spawning-stock-biomass and recruitment and no new reference points were estimated. Reference points were estimated as: B_{lim} 136 000 t, B_{pa} 220 000 t, F_{MP} 0.32 F_{lim} 0.58, and F_{pa} 0.35.

5.6.1 Harvest control rule

In 2007 ICES evaluated the harvest control rule for setting the annual fishing quota (TAC) for Northeast Arctic saithe. ICES concluded that the HCR was consistent with the precautionary approach for all simulated data and settings, including a rebuilding situation under the condition that the assessment uncertainty and error are not greater than those calculated from historic data. This also held true when an implementation error (difference between TAC and catch) equal to the historic level was included. The HCR was implemented the same year. It contains the following elements:

- Estimate the average TAC level for the coming 3 years based on F_{mp}. TAC for the next year will be set to this level as a starting value for the 3-year period.
- The year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development. However, the TAC should not be changed by more than 15% compared with the previous year's TAC.
- If the spawning-stock-biomass (SSB) at the beginning of the year for which the quota is set (first year of prediction), is below B_{pa}, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from F_{mp} at SSB = B_{pa} to 0 at SSB equal to zero. At SSB levels below B_{pa} in any of the operational years (current year and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.

In 2011 the evaluation was repeated taking into account the changes made to the assessment after the 2010 benchmark assessment (ICES CM 2010/ACOM: 36). The analyses indicate that the HCR still is in agreement with the precautionary approach (Mehl and Fotland, WD 11 2011).

The fishing mortality used in the harvest control rule (F_{mp}) was in 2007 set to F_{pa} = 0.35. In June 2013, after the ICES advice for 2014 for this stock had been given, F_{mp} was reduced to 0.32.

5.7 Predictions

5.7.1 Input data (Table 5.12)

The input data to the predictions based on results from the final model run are given in Table 5.12. The estimates for stock number-at-age in 2022 were taken from the final SAM run for ages 4+. The geometric mean (GM) for recruitment (age 3) of 161 659 thousand was used in 2022 and subsequent year classes. The natural mortality of 0.2 is the same as used in the assessment. For exploitation pattern the average of the 2019–2021 fishing mortalities estimated in the final SAM run for ages 3 to 12 was used, with mortalities for 8+ being constant. For weight-at-age in stock and catch the average of the last three years (2019–2021) from SAM input file was used. For maturity-at-age the average of the 2005–2007 annual ogives was applied.

5.7.2 Catch options for 2022 (short-term predictions; Tables 5.13–14)

The management option table (Table 5.13) shows that the expected landings of 197 212 t in 2022 will result in a fishing an adjusted mortality F_{bar} of 0.207, which is lower compared to 2021 of 0.265, but well below the F_{pa} of 0.35. A catch in 2023 corresponding to the $F_{status\ quo}$ level of 0.207 will be 189 690 t, while a catch in 2023 corresponding to the evaluated and implemented HCR of 226 794 t will result in F of 0.254 (Table 5.14).

For a catch in 2022 corresponding to the TAC of 197 212 t, the SSB is expected to decrease from about 745 913 t at the beginning of 2022 to 686 937 t at the beginning of 2023. At $F_{status\ quo}$ in 2023 SSB is estimated to decrease to 633 154 t at the beginning of 2024 and for a catch corresponding to the HCR it will decrease to about 597 899 in 2024.

5.7.3 Comparison of the present and last year's assessment

The current assessment estimated the total stock in 2022 to be 20% higher and the SSB 26% higher compared to the previous assessment. The F in 2020 from the current assessment is higher than the F from the previous assessment, and the realized F in 2021 is lower compared to the predicted one in 2021 based on the TAC.

	Total stock (3+) by 1 January 2021 (tonnes)	SSB by 1 January 2021 (tonnes)	F4–7 in 2021	F4–7 in 2020
WG 2021	954114	568972	0.23	0.22
WG 2022	1140302	715674	0.186	0.187

5.8 Comments to the assessment and the forecast (Figure 5.6)

A statistical model is less sensitive to +group setting than XSA. In addition, the results from XSA were more dependent on the input data (use or no use of CPUE, split of the tuning survey time-series), the shrinkage parameter and whether the number of iterations is capped or not. XSA only converged at a large number of iterations. In contrast, results from SAM are much more robust and depend to a lesser degree on subjective choice of model settings (such as shrinkage). In addition, SAM as a stochastic model is not treating catches as known without error. The fishing mortality rates could be considered correlated in time, and to reflect that neighbouring age groups have more similar fishing mortalities.

The retrospective pattern has been a major concern in the assessment, but due to the changes done at the benchmark assessment in 2010 (ICES CM 2010/ACOM: 36) and later at the NEA saithe IBP in 2014 (ICES CM 2014/ACOM: 53), the assessment has become stable (Figure 5.6)

The biological sampling from the fishery got critically low after the termination of the original Norwegian port-sampling program in 2009. In 2015 this was in particular the case for samples from trawl in quarter two and three in ICES area 1 and age samples from purse-seine fishery south of Lofoten (ICES area 2.a). In 2021 biological sampling from the saithe purse-seine fishery catches in Norwegian waters was adequate.

Lack of reliable recruitment estimates is a major problem. Prediction of catches will still, to a large extent, be dependent on assumptions of average recruitment in the intermediate year and the forecast period, since fish from age four to seven constitute major parts of the catches. Since the saithe HCR is a three-year-rule, the estimation of average F_{mp} catch in the HCR will affect stock numbers up to age five, and thereby affect the total prognosis of the fishable stock and the quotas derived from it. The recruitment-at-age 3 estimated by the SAM has on average been at about the long-term geometric mean level since 2005

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5.9 Tables and figures

Table 5.1. Saithe in subareas 1 and 2 (Northeast Arctic). Nominal catch (t) by countries as officially reported to ICES.

Year	Faroe Islands	France	Germany (Dem Rep)	Germany (Fed Rep)	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total: all countries
1960	23	1700		25 948		96050					9780	14	133515
1961	61	3625		19757		77875					4615	18	105951
1962	2	544		12651		101895			912		4699	4	120707
1963		1110		8108		135297					4112		148627
1964		1525		4420		184700			84		6511	186	197426
1965		1618		11387		165531			137		6746	181	185600
1966		2987	813	11269		175037			563		13078	41	203788
1967		9472	304	11822		150860			441		8379	48	181326
1968			1248	4753		96641					8782		111424
1969	20	193	6744	4355		115140					13585	23	140060
1970	1097		29200	23466		151759			43550		15690		264924
1971	215	14536	16840	12204		128499	6017		39397	13097	10467		241272
1972	109	14519	7474	24595		143775	1111		1278	9247	8348		210456
1973	7	11320	12015	30338		148789	23		2411	2115	6841		213859
1974	46	7119	29466	33155		152699	2521		28931	7075	3104	5	264121

Year	Faroe Islands	France	Germany (Dem Rep)	Germany (Fed Rep)	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total: all countries
1975	28	3156	28517	41260		122598	3860	6430	13389	11397	2763	55	233453
1976	20	5609	10266	49056		131675	3164	7233	9013	21661	4724	65	242486
1977	270	5658	7164	19985		139705	1	783	989	1327	6935		182817
1978	809	4345	6484	19190		121069	35	203	381	121	2827		155464
1979	1117	2601	2435	15323		141346			3	685	1170		164680
1980	532	1016		12511		128878			43	780	794		144554
1981	236	218		8431		166139			121		395		175540
1982	339	82		7224		159643			14		732		168034
1983	539	418		4933		149556			206	33	1251		156936
1984	503	431	6	4532		152818			161		335		158786
1985	490	657	11	1873		103899			51		202		107183
1986	426	308		3470		63090			27		75		67396
1987	712	576		4909		85710			426		57	1	92391
1988	441	411		4574		108244			130		442		114242
1989	388	460[2]		606		119625			506	506	726		122817
1990	1207	340[2]		1143		92397			52		709		95848
1991	963	77[2]	**Greenland**	2003		103283			504[4]		492	5	107327
1992	165	1980	734	3451		119763			964	6	541		127604

Year	Faroe Islands	France	Germany (Dem Rep)	Germany (Fed Rep)	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total: all countries
1993	31	566	78	3687	3	140604		1	9509	4 [2]	415	5	154903
1994	67 [2]	557	15	1863	4 [2]	141589		1 [2]	1640 [2]	655 [2]	557	2	146950
1995	172 [2]	358	53	935		165001		5	1148		688	18	168378
1996	248 [2]	346	165	2615		166045		24	1159	6	707	33	171348
1997	193[2]	560	363[2]	2915		136927		12	1774	41	799	45	143629
1998	366	932	437[2]	2936		144103		47	3836	275	355	40	153327
1999	181	638 [2]	655[2]	2473	146	141941		17	3929	24	339	32	150375
2000	224[2]	1438	651[2]	2573	33	125932		46	4452	117	454	8 [2]	135928
2001	537	1279	701[2]	2690	57	124928		75	4951	119	514	2	135853
2002	788	1048	1393	2642	78	142941		118	5402	37	420	3	154870
2003	2056	1022	929[2]	2763	80 [2]	150400		147	3894	18	265	18 [2]	161592
2004	3071	255	891[2]	2161	319	147975		127	9192	87	544	14	164636
2005	3152	447	817[2]	2048	395	162338		354	8362	25	630		178568
2006	1795	899.7	779[2]	2780	255	195462	88.9	101	9823	0	532	42	212557
2007	2048	965.6	801[2]	3019	219	178644	99.3	412	12168	22	557	11.8	198967
2008	2405	1008.6	513[2]	2264	113	165998	65.8	348	11577	33	506	9.7	184840
2009	1611	378.6	697	2021	69	144570	30.6	184.01	11899	2	379	24	161865
2010	1632	677.2	954	1592	124	175246	278.9	93	14664	8	283	2.5	195554

Year	Faroe Islands	France	Germany (Dem Rep)	Germany (Fed Rep)	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total: all countries
2011	306	504.2	445	1371	66	143314	0	45.34	10007	2	972	15.14	157048
2012	146	780.55	658	1371	126	143174	0	7.65	13607	4	1087	0	160960
2013	80	1900.92	972	1212	245	111961	2.21	17.24	14796	5	415	21.93	131629
2014	273	1674	407	259	659	115864	0.86	8.25	12396	12	518	0	132070
2015	766	515	393	424	248	115157	1143	10.42	13181	34	403	0	132275
2016	1148	526	613	952	702	121705	530	52	15203	26	301	10	141768
2017 [1]	639	680	407	865	589	126947	504	86	14551	88	439	24	145819
2018	626	937	448	1642		162460	404	51	14171	60	464	17	181280
2019	618	1472	424	1371		144076	46	131	13990	199	419	434	163180
2020		530	410	1544		151697	1.2	132	14082	0	517	118	169405
2021	573	684	449	600	148	171836	0.3	21	13836	3	2	23	188176

1 Provisional figures.

2 As reported to Norwegian authorities.

3 USSR prior to 1991.

4 Includes Estonia.

5 Includes Denmark. Netherlands. Ireland. and Sweden.

6 As reported by Working Group member.

Table 5.2 Saithe in subareas 1 and 2 (Northeast Arctic). Catch (´000) by fishing gear.

Year	Purse-seine	Trawl	Gillnet	Others	Total
1977	75.2	69.5	19.3	12.7	176.7
1978	62.9	57.6	21.1	13.9	155.5
1979	74.7	52.5	21.6	15.9	164.7
1980	61.3	46.8	21.1	15.4	144.6
1981	64.3	72.4	24.0	14.8	175.5
1982	76.4	59.4	16.7	15.5	168.0
1983	54.1	68.2	19.6	15.0	156.9
1984	36.4	85.6	23.7	13.1	158.8
1985	31.1	49.9	14.6	11.6	107.2
1986	7.9	36.2	12.3	8.2	64.6
1987	34.9	27.7	19.0	10.8	92.4
1988	43.5	45.4	15.3	10.0	114.2
1989	49.5	45.0	16.9	11.4	122.8
1990	24.6	44.0	19.3	7.9	95.8
1991	38.9	40.1	18.9	9.4	107.3
1992	27.1	67.0	22.3	11.2	127.6
1993	33.1	84.9	21.2	15.7	154.9
1994	30.2	82.2	21.1	13.5	147.0
1995	21.8	103.5	26.9	16.1	168.4
1996	46.9	72.5	31.6	20.3	171.3
1997	44.4	55.9	24.4	19.0	143.6
1998	44.4	57.7	27.6	23.6	153.3
1999	39.2	57.9	29.7	23.6	150.4
2000	28.3	54.5	29.6	23.5	135.9
2001	28.1	58.1	28.2	21.5	135.9
2002	27.4	75.5	30.4	21.5	154.8
2003	43.3	73.8	25.2	19.3	161.6
2004	41.8	74.6	26.9	21.3	164.6
2005	42.1	91.8	25.6	19.1	178.6

Year	Purse-seine	Trawl	Gillnet	Others	Total
2006	73.5	87.1	29.7	22.5	212.8
2007	41.8	100.7	33.3	23.2	199.0
2008	39.4	91.2	37.0	17.1	184.7
2009	35.5	81.1	33.2	12.1	161.9
2010	54.9	89.8	36.9	13.2	194.8
2011	45.3	67.1	32.1	12.2	156.7
2012	44.2	73.9	28.3	14.5	160.9
2013	34.7	65.2	19.2	12.7	131.8
2014	29.3	54.8	26.7	21.2	132.0
2015	30.4	55.4	23.5	22.5	131.8
2016	28.9	64.1	21.4	26.9	141.3
2017[1]	32.4	65.0	21.4	27.3	146.1
2018	36.0	83.6	28.8	33.2	181.5
2019	28.7	68.6	29.4	36.6	163.1
2020	26.8	74	30.3	38.3	169.4
2021	30.9	81.6	29.5	46	188

[1] **Provisional figures.**

[2] **Unresolved discrepancies between Norwegian catch by gear figures and the total reported to ICES for these years.**

[3] **Includes 4300 tonnes not categorized by gear. proportionally adjusted.**

[4] **Reduced by 1200 tonnes not categorized by gear. proportionally adjusted.**

Table 5.3 Catch numbers-at-age ('000) of northeast Arctic saithe.

	Age groups									
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1960	13517	16828	17422	6514	6281	3088	1691	956	481	1481
1961	25237	12929	17707	5379	1886	1371	736	573	538	1202
1962	45932	13720	5449	10218	2991	1262	1156	556	611	1518
1963	51171	35199	7165	5659	4699	1337	1308	848	550	1612
1964	10925	72344	15966	3299	4214	3223	1518	1482	1282	3038
1965	42578	5737	30171	11635	3282	2421	3135	802	1136	2986
1966	25127	61199	14727	14475	5220	1542	1047	1083	530	2724

	Age groups									
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1967	28457	23826	34493	3957	5388	2797	1356	1340	814	2536
1968	29955	21856	6065	9846	936	2274	1070	686	465	922
1969	76011	11745	16650	4666	4716	1107	1682	663	199	303
1970	43834	63270	14081	16298	5157	8004	2521	3722	1103	1714
1971	61743	47522	21614	7661	7690	2326	3489	1760	2514	1888
1972	55351	44490	24752	8650	4769	3012	1584	1817	1044	1631
1973	62938	20793	22199	13224	5868	3246	2368	2153	1291	1947
1974	36884	44149	15714	20476	12182	4815	3267	2512	1440	2392
1975	70255	13502	18901	5123	9018	7841	3365	2714	2237	2544
1976	135592	33159	8618	9448	3725	3483	2905	1870	1183	1940
1977	105935	36703	10845	2205	4633	1557	1718	1030	495	718
1978	56505	31946	14396	5232	1694	2132	1082	1126	756	1726
1979	75819	28545	17280	5384	3550	1178	1659	536	373	1086
1980	40303	36202	9100	6302	3161	1322	145	721	406	1204
1981	85966	22345	22044	3706	2611	2056	378	286	258	385
1982	35853	67150	13481	8477	1088	1291	476	271	124	338
1983	18216	25108	34543	3408	3178	1243	803	261	215	587
1984	43579	34927	12679	11775	1193	1862	589	585	407	537
1985	48989	11992	7200	5287	3746	776	879	134	274	427
1986	21322	12433	5845	4363	2704	1349	338	438	123	152
1987	18555	51742	4506	3238	3624	784	644	267	263	565
1988	8144	35928	32901	4570	2333	1222	968	321	73	30
1989	12607	19400	33343	18578	1762	352	177	189	1	205
1990	23792	16930	9054	10238	7341	1076	160	112	150	118
1991	68682	13630	5752	4883	3877	2381	383	61	90	89
1992	44627	33294	5987	5412	4751	3176	1462	286	93	350
1993	22812	61931	31102	3747	1759	1378	1027	797	76	71
1994	7063	32671	49410	19058	2058	724	421	278	528	129

	Age groups									
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1995	17178	52109	40145	30451	4177	483	125	259	31	263
1996	10510	54886	18499	18357	17834	2849	485	214	148	325
1997	11789	11698	35011	13567	13452	7058	812	55	48	98
1998	3091	16215	11946	31818	8376	5539	2873	727	111	282
1999	9655	12236	22872	10347	18930	3374	3343	2290	419	170
2000	9175	22768	7747	10676	6123	8303	2530	2652	1022	197
2001	3816	7946	26960	8769	7120	3146	4687	1935	1406	528
2002	6582	17492	11573	25671	5312	4276	2382	3431	965	1420
2003	2345	50653	13600	7123	9594	5494	3545	2519	2327	1813
2004	1002	6129	33840	10613	7494	8307	2792	3088	2377	3072
2005	26093	12543	9841	23141	10799	5659	7852	2674	713	1588
2006	1590	68137	12328	10098	16757	8080	5671	5127	1815	2529
2007	3144	4115	39889	15301	7963	11302	7749	4138	2157	849
2008	25259	18953	5969	24363	9712	5624	7697	4705	1606	1572
2009	9050	34311	9954	6628	15930	4766	3021	4224	2471	1426
2010	26382	43436	28514	7988	3129	12444	2749	1314	1212	1431
2011	6239	45213	13307	15157	6622	2901	5934	1730	647	1115
2012	30742	17841	33911	10496	7058	3522	1570	2586	557	890
2013	17151	15491	15946	21980	5512	3298	1149	729	885	653
2014	7650	24769	13822	9343	12331	3284	2130	904	378	763
2015	13185	15459	30159	9271	7324	7133	1697	723	433	620
2016	8278	20955	13044	15532	6621	4774	4363	1053	718	1382
2017	5421	34736	12901	7324	9032	3885	2562	1924	376	1999
2018	5260	19260	41425	12618	5903	5667	2843	1956	1112	1567
2019	12421	15078	15388	25177	8327	3243	2848	1357	619	1171
2020	6216	27602	13466	14054	17767	5031	2034	1469	564	1236
2021	5732	7938	26311	12418	11357	12295	3544	1580	954	1939

Table 5.4 Catch weight-at-age (kg) northeast Arctic saithe.

	Age groups								
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1960	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.55
1961	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.75
1962	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.52
1963	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.33
1964	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.35
1965	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.54
1966	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.43
1967	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.49
1968	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.36
1969	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.16
1970	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.03
1971	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	7.87
1972	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.14
1973	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.01
1974	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	7.69
1975	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	7.73
1976	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	7.86
1977	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.05
1978	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.00
1979	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.28
1980	0.79	1.27	2.03	2.55	3.29	4.34	5.15	5.75	6.11	7.22
1981	0.73	1.40	2.05	2.76	3.30	4.38	5.95	6.39	6.61	7.00
1982	0.77	1.12	2.02	2.61	3.27	3.91	4.69	5.63	7.18	7.69
1983	1.05	1.33	1.86	2.80	4.00	4.18	5.33	5.68	7.31	9.16
1984	0.71	1.26	2.02	2.70	3.88	4.47	5.36	6.06	6.28	7.88
1985	0.75	1.33	2.07	2.63	3.28	3.96	4.54	5.55	6.88	8.74
1986	0.59	1.22	1.97	2.30	2.87	3.72	4.30	4.69	5.84	7.21
1987	0.53	0.84	1.66	2.32	2.97	4.00	4.72	5.44	5.79	7.42

	Age groups									
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1988	0.62	0.87	1.31	2.43	3.87	5.38	5.83	5.36	6.92	8.82
1989	0.74	0.95	1.40	1.78	2.96	3.73	4.62	4.66	8.34	7.69
1990	0.71	1.00	1.45	2.09	2.49	3.75	3.90	6.74	4.94	7.34
1991	0.68	1.05	1.85	2.39	3.08	3.35	4.48	4.66	5.62	7.31
1992	0.67	1.01	1.92	2.28	2.77	3.20	3.73	6.35	6.90	7.83
1993	0.61	0.99	1.65	2.46	2.85	3.03	3.71	4.49	5.56	7.13
1994	0.52	0.76	1.24	2.12	3.22	3.83	4.69	5.31	5.66	7.29
1995	0.56	0.79	1.19	1.71	2.87	3.78	4.06	5.30	6.86	7.65
1996	0.59	0.82	1.33	1.84	2.48	3.73	4.32	5.34	5.98	7.58
1997	0.62	0.95	1.24	1.72	2.35	3.10	4.19	5.79	6.77	7.75
1998	0.68	1.00	1.48	1.87	2.58	3.07	4.13	5.44	6.70	8.59
1999	0.67	1.05	1.45	1.93	2.27	2.97	3.61	4.10	4.93	6.97
2000	0.60	1.03	1.63	2.10	2.67	3.14	3.81	4.41	5.76	8.07
2001	0.75	1.12	1.54	2.04	2.60	3.14	3.63	4.54	5.05	6.17
2002	0.69	1.01	1.50	1.97	2.54	3.25	3.77	4.31	4.91	6.11
2003	0.66	0.91	1.42	1.89	2.54	2.58	3.49	3.75	4.12	5.90
2004	0.70	1.03	1.37	1.90	2.41	2.98	3.44	3.73	4.14	5.47
2005	0.59	0.89	1.49	2.09	2.16	2.99	3.24	3.82	3.92	6.19
2006	0.63	0.83	1.43	1.78	2.27	2.73	3.02	3.90	4.06	5.82
2007	0.73	1.08	1.41	1.86	2.43	2.94	3.35	3.66	4.17	5.54
2008	0.63	0.98	1.38	1.92	2.31	2.83	3.16	3.43	3.82	4.75
2009	0.73	1.03	1.65	2.00	2.37	2.69	3.23	3.38	3.46	4.67
2010	0.70	0.99	1.45	2.14	2.50	3.13	3.34	3.81	3.99	5.17
2011	0.70	0.82	1.42	2.07	2.68	3.25	3.62	3.97	4.52	5.84
2012	0.59	1.07	1.35	2.15	2.82	3.20	3.67	4.16	4.60	5.70
2013	0.57	1.01	1.50	1.83	2.74	3.33	3.91	4.61	4.50	6.13
2014	0.66	0.92	1.58	2.12	2.54	3.49	4.01	4.22	4.71	5.80
2015	0.61	0.85	1.24	1.91	2.45	3.02	3.97	4.74	4.51	6.05

	Age groups									
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
2016	0.84	1.04	1.46	2.02	2.36	3.12	3.53	4.14	4.65	6.03
2017	0.89	1.12	1.68	2.18	2.63	3.13	3.63	4.16	4.5	5.9
2018	0.91	1.21	1.56	2.02	2.51	3.04	3.44	3.89	4.50	5.60
2019	0.83	1.17	1.64	2.06	2.62	3.18	3.71	4.13	4.88	6.14
2020	0.74	1.06	1.57	2.01	2.53	3.13	3.75	4.36	5.05	6.80
2021	0.77	1.16	1.61	2.14	2.68	3.15	3.65	4.14	4.7	6.3

Table 5.5. 3-year running average maturity ogive 1985–2006. Values for 2007–2020 average of 2005–2007.

Year	3	4	5	6	7	8	9	10	11	12+
1985	0	0.02	0.5	0.92	0.99	1	1	1	1	1
1986	0	0.02	0.51	0.94	0.99	1	1	1	1	1
1987	0	0	0.35	0.98	1	1	1	1	1	1
1988	0	0	0.25	0.96	1	1	1	1	1	1
1989	0	0	0.15	0.92	1	1	1	1	1	1
1990	0	0	0.2	0.85	0.99	1	1	1	1	1
1991	0	0.02	0.25	0.84	0.98	1	1	1	1	1
1992	0	0.02	0.3	0.83	0.93	0.92	0.9	0.95	1	1
1993	0	0.02	0.26	0.88	0.92	0.89	0.87	0.89	1	0.99
1994	0	0.02	0.26	0.84	0.9	0.82	0.87	0.89	1	0.99
1995	0	0.02	0.22	0.8	0.92	0.9	0.97	0.94	1	0.99
1996	0	0.03	0.21	0.65	0.91	0.93	1	1	1	1.00
1997	0	0.03	0.14	0.45	0.83	0.94	0.93	0.97	1	1.00
1998	0	0.04	0.07	0.33	0.74	0.93	0.92	0.96	1	1.00
1999	0	0	0.08	0.32	0.74	0.92	0.92	0.96	0.99	0.98
2000	0	0	0.08	0.46	0.82	0.96	0.98	0.99	0.97	0.95
2001	0	0	0.11	0.64	0.93	0.97	0.98	0.99	0.97	0.94
2002	0	0	0.13	0.78	0.95	0.98	0.98	0.99	0.98	0.97
2003	0	0	0.14	0.82	0.96	0.98	0.98	0.99	1	0.99
2004	0	0	0.21	0.8	0.97	0.99	0.99	1	1	0.98

Year	3	4	5	6	7	8	9	10	11	12+
2005	0	0.03	0.3	0.82	0.97	0.99	0.99	1	1	1.00
2006	0	0.04	0.4	0.86	0.98	0.99	1	1	1	1.00
2007	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2008	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2009	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2010	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2011	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2012	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2013	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2014	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2015	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2016	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2017	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2018	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2019	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2020	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2021	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00

Table 5.6 Northeast Arctic saithe. Tuning datasets applied in final SAM run

```
North-East Arctic saithe (Sub-areas I and II)
102
FLT13: Norway Ac Survey (Catch: Unknown) (Effort: Unknown)
19942001
1 1 0.75 0.85
3  7
   1    87.1   108.9    41.4     8.1     0.7
   1   166.1    86.5    46.5    16.5     2.4
   1   122.6   207.4    31.7    15.1     4.0
   1    38.0   184.8    79.8    50.6     9.6
   1    96.7   202.6    69.3    84.3     6.6
   1   233.8    72.9    62.2    21.0    19.2
   1   142.5   176.3    11.6    11.5     8.0
   1   275.9    45.9    53.8     5.6     6.1
FLT14: Norway Ac Survey (Catch: Unknown) (Effort: Unknown)
20022021
1 1 0.75 0.85
3  7
   1   230.2    92.6    18.9    10.6     2.2
   1    87.5   151.7    26.1     6.2     6.4
   1   191.2   107.6    44.3    15.2     4.25
   1   198.5    51.9    17.6    13.2     7.68
   1    40.9   129.9    14.4     4.62     9.49
   1   93.5    23.9    58.5     6.51     3.95
   1    55.9    15.9    7.84    9.99     3.06
   1   96.9    61.4     6.99     4.01     7.62
   1   143.0    22.5    17.1     3.95     1.68
   1    42.7    59.6     4.61     4.23     1.07
   1    69    29.7    18.8     3.48     2.83
   1   77.1    16.5    13.3    11.6     2.19
   1    40.1    70.8    8.73     5.6     5.44
   1    72.4    22.7    30.1     6.08     4.22
   1        145.7        32.0        10.5        11.2        4.15
   1        91.1         63.9        13.3        2.76        5.35
   1        30.6         61.1        45.4        12.3        4.2

   1        84.4         50.6        24.2        17.75       3.54
   1        48.23        90.45       28.85       12.33       6.52
   1        64.9         33.6        59.3        15.3        8.3
```

Table 5.7 SAM parameter settings

Model used: State-space assessment model SAM (https://www.stockassessment.org).

Software used: Template Model Builder (TMB) and R.

Visible stock on (https://www.stockassessment.org) "afwg_saithe_ 2018_001".

Model Options agreed upon at IBP saithe winter 2014.

$minAge

The minimium age class in the assessment

3

$maxAge

The maximum age class in the assessment

12

$maxAgePlusGroup

Is last age group considered a plus group (1 yes, or 0 no).

1

$keyLogFsta

Coupling of the fishing mortality states (nomally only first row is used).

0 1 2 3 4 5 5 5 5 5

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

$corFlag

Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)

2

$keyLogFpar

Coupling of the survey catchability parameters (nomally first row is not used, as that is covered by fishing mortality).

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

0 1 2 3 3 -1 -1 -1 -1 -1

4 5 6 7 7 -1 -1 -1 -1 -1

$keyQpow

Density dependent catchability power parameters (if any).

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

$keyVarF

Coupling of process variance parameters for log(F)-process (nomally only first row is used)

0 0 0 0 0 0 0 0 0 0

```
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1 1 1

$keyVarObs
# Coupling of the variance parameters for the observations.
  0  0  0  0  0  0  0  0  0  0
  1  1  1  1  1 -1 -1 -1 -1 -1
  2  2  2  2  2 -1 -1 -1 -1 -1
```

Table 5.7 SAM parameter settings continued

$obsCorStruct

Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"

"ID" "ID" "ID"

$keyCorObs

Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.

NA's indicate where correlation parameters can be specified (-1 where they cannot).

#3-4 4-5 5-6 6-7 7-8 8-9 9-10 10-11 11-12

NA NA NA NA NA NA NA NA NA

NA NA NA NA -1 -1 -1 -1 -1

NA NA NA NA -1 -1 -1 -1 -1

$stockRecruitmentModelCode

Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton–Holt).

2

$noScaledYears

Number of years where catch scaling is applied.

0

$keyScaledYears

A vector of the years where catch scaling is applied.

$keyParScaledYA

A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange

lowest and higest age included in Fbar

4 7

$keyBiomassTreat

To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).

-1 -1 -1

Table 5.8 SAM catchabilities, negative log likelihood values and number of parameters.

Index	Fleet number	Age	Catchability	Low	High
1	2	3	0.87	0.592	1.279
2	2	4	1.171	0.798	1.718
3	2	5	0.606	0.413	0.89
4	2	6	0.374	0.278	0.504
5	2	7	0.374	0.278	0.504
6	3	3	0.585	0.48	0.713
7	3	4	0.486	0.399	0.592
8	3	5	0.283	0.232	0.346
9	3	6	0.184	0.155	0.22
10	3	7	0.184	0.155	0.22

Model fitting.

Model	log(L)	#par	AIC
Current	-567.30	17	1168.61
base	-560.41	17	1154.81

Table 5.9 Estimated fishing mortalities.

Year Age	3	4	5	6	7	8	9	10	11	12
1960	0.236	0.284	0.321	0.278	0.222	0.164	0.164	0.164	0.164	0.164
1961	0.222	0.260	0.273	0.226	0.173	0.126	0.126	0.126	0.126	0.126
1962	0.222	0.261	0.267	0.225	0.177	0.132	0.132	0.132	0.132	0.132
1963	0.224	0.272	0.281	0.238	0.194	0.153	0.153	0.153	0.153	0.153
1964	0.237	0.298	0.318	0.277	0.240	0.207	0.207	0.207	0.207	0.207
1965	0.234	0.291	0.325	0.288	0.253	0.230	0.230	0.230	0.230	0.230
1966	0.260	0.320	0.344	0.289	0.244	0.223	0.223	0.223	0.223	0.223
1967	0.261	0.310	0.319	0.265	0.225	0.216	0.216	0.216	0.216	0.216
1968	0.222	0.241	0.230	0.185	0.152	0.147	0.147	0.147	0.147	0.147
1969	0.231	0.241	0.222	0.175	0.143	0.131	0.131	0.131	0.131	0.131
1970	0.330	0.362	0.342	0.285	0.251	0.240	0.240	0.240	0.240	0.240

Year Age	3	4	5	6	7	8	9	10	11	12
1971	0.360	0.385	0.357	0.295	0.270	0.259	0.259	0.259	0.259	0.259
1972	0.382	0.391	0.351	0.283	0.259	0.244	0.244	0.244	0.244	0.244
1973	0.421	0.428	0.386	0.317	0.299	0.284	0.284	0.284	0.284	0.284
1974	0.544	0.561	0.513	0.429	0.417	0.395	0.395	0.395	0.395	0.395
1975	0.597	0.620	0.567	0.478	0.489	0.478	0.478	0.478	0.478	0.478
1976	0.653	0.683	0.612	0.499	0.497	0.471	0.471	0.471	0.471	0.471
1977	0.578	0.614	0.541	0.430	0.417	0.378	0.378	0.378	0.378	0.378
1978	0.575	0.651	0.597	0.488	0.476	0.432	0.432	0.432	0.432	0.432
1979	0.554	0.677	0.639	0.529	0.509	0.454	0.454	0.454	0.454	0.454
1980	0.493	0.637	0.620	0.519	0.481	0.422	0.422	0.422	0.422	0.422
1981	0.456	0.629	0.622	0.521	0.460	0.393	0.393	0.393	0.393	0.393
1982	0.422	0.620	0.623	0.527	0.449	0.375	0.375	0.375	0.375	0.375
1983	0.402	0.629	0.655	0.595	0.531	0.453	0.453	0.453	0.453	0.453
1984	0.444	0.715	0.733	0.722	0.682	0.594	0.594	0.594	0.594	0.594
1985	0.351	0.589	0.611	0.648	0.679	0.592	0.592	0.592	0.592	0.592
1986	0.241	0.448	0.496	0.571	0.649	0.594	0.594	0.594	0.594	0.594
1987	0.224	0.454	0.530	0.664	0.809	0.756	0.756	0.756	0.756	0.756
1988	0.214	0.456	0.537	0.660	0.772	0.663	0.663	0.663	0.663	0.663
1989	0.201	0.423	0.471	0.525	0.534	0.402	0.402	0.402	0.402	0.402
1990	0.223	0.477	0.523	0.592	0.602	0.453	0.453	0.453	0.453	0.453
1991	0.191	0.426	0.477	0.551	0.568	0.43	0.43	0.43	0.43	0.43
1992	0.172	0.429	0.54	0.689	0.754	0.605	0.605	0.605	0.605	0.605
1993	0.13	0.354	0.475	0.62	0.679	0.542	0.542	0.542	0.542	0.542
1994	0.1	0.297	0.419	0.568	0.629	0.505	0.505	0.505	0.505	0.505
1995	0.081	0.249	0.339	0.438	0.471	0.372	0.372	0.372	0.372	0.372
1996	0.073	0.227	0.315	0.421	0.488	0.418	0.418	0.418	0.418	0.418
1997	0.053	0.163	0.226	0.297	0.338	0.291	0.291	0.291	0.291	0.291
1998	0.046	0.153	0.221	0.297	0.347	0.322	0.322	0.322	0.322	0.322
1999	0.045	0.157	0.228	0.298	0.338	0.321	0.321	0.321	0.321	0.321

Year Age	3	4	5	6	7	8	9	10	11	12
2000	0.038	0.139	0.205	0.267	0.295	0.29	0.29	0.29	0.29	0.29
2001	0.029	0.115	0.177	0.237	0.264	0.272	0.272	0.272	0.272	0.272
2002	0.026	0.108	0.168	0.228	0.261	0.289	0.289	0.289	0.289	0.289
2003	0.024	0.102	0.157	0.216	0.261	0.323	0.323	0.323	0.323	0.323
2004	0.022	0.095	0.148	0.206	0.261	0.348	0.348	0.348	0.348	0.348
2005	0.032	0.126	0.181	0.241	0.29	0.377	0.377	0.377	0.377	0.377
2006	0.039	0.154	0.214	0.285	0.344	0.455	0.455	0.455	0.455	0.455
2007	0.046	0.171	0.229	0.299	0.356	0.463	0.463	0.463	0.463	0.463
2008	0.07	0.248	0.299	0.365	0.42	0.531	0.531	0.531	0.531	0.531
2009	0.08	0.275	0.322	0.372	0.418	0.52	0.52	0.52	0.52	0.52
2010	0.097	0.328	0.373	0.405	0.431	0.505	0.505	0.505	0.505	0.505
2011	0.096	0.313	0.369	0.409	0.439	0.49	0.49	0.49	0.49	0.49
2012	0.101	0.303	0.353	0.384	0.408	0.437	0.437	0.437	0.437	0.437
2013	0.084	0.249	0.293	0.317	0.338	0.351	0.351	0.351	0.351	0.351
2014	0.074	0.219	0.265	0.288	0.313	0.325	0.325	0.325	0.325	0.325
2015	0.068	0.206	0.252	0.273	0.298	0.305	0.305	0.305	0.305	0.305
2016	0.058	0.185	0.239	0.273	0.311	0.331	0.331	0.331	0.331	0.331
2017	0.05	0.159	0.209	0.249	0.294	0.319	0.319	0.319	0.319	0.319
2018	0.051	0.156	0.206	0.251	0.304	0.333	0.333	0.333	0.333	0.333
2019	0.048	0.139	0.18	0.221	0.271	0.291	0.291	0.291	0.291	0.291
2020	0.045	0.129	0.164	0.203	0.254	0.274	0.274	0.274	0.274	0.274
2021	0.044	0.124	0.16	0.201	0.259	0.291	0.291	0.291	0.291	0.291

Table 5.10 Estimated stock numbers.

Year Age	3	4	5	6	7	8	9	10	11	12
1960	84026	103212	54063	28175	26072	14377	10474	7296	3627	12068
1961	116162	56676	68814	30180	17272	15941	8956	6995	5128	11294
1962	206835	67972	36513	44590	18691	12606	11345	6190	5188	12543
1963	273837	133053	38589	25467	28675	11916	9860	8217	4491	13419
1964	80835	192878	77533	22463	17668	18939	8050	7502	6155	13840

Year Age	3	4	5	6	7	8	9	10	11	12
1965	254979	49841	112584	45181	14490	11634	12341	5023	5213	13956
1966	134273	182245	34470	63060	26337	9323	7542	7296	3184	12731
1967	174211	83249	111131	20133	36539	16005	6325	5254	4560	10163
1968	143787	116727	47168	64268	12956	23786	10028	4120	3369	8278
1969	267366	88097	80560	31720	42494	10731	17821	6985	2677	6823
1970	220408	169181	58085	54888	22485	29924	9254	14125	5140	7175
1971	229850	143772	87223	35346	32832	14314	17677	6588	9316	7926
1972	154265	138705	86049	46349	22941	19544	9605	10385	4330	10127
1973	201294	80094	79530	52478	27745	15439	12675	6829	6372	8956
1974	100846	110892	41709	46327	32933	16776	10303	8264	4297	9026
1975	168309	44068	52917	19820	23857	17932	9298	6058	4796	7160
1976	220420	75068	19305	25739	10487	11393	8684	4696	3080	5760
1977	202624	90088	30935	8391	13327	5454	5692	4260	2303	4198
1978	136704	89616	38553	15022	4590	7301	3202	3088	2395	3966
1979	195867	60076	38732	17165	7704	2359	4023	1756	1536	3421
1980	118880	94852	23529	16838	8555	3654	1123	2060	963	2671
1981	232133	57025	43586	9993	8254	4418	1830	686	1062	1820
1982	127952	125404	24407	19554	4695	4369	2237	1031	397	1629
1983	100879	68200	54301	9874	9348	2589	2500	1240	604	1293
1984	94848	58223	30631	20737	4285	4557	1300	1334	710	1061
1985	104305	42143	23127	12843	7080	1920	2089	553	608	830
1986	178608	49257	17676	11011	5982	2441	945	954	268	630
1987	144151	132580	22527	8341	5503	2777	854	481	424	466
1988	80501	101647	76524	11120	3458	2046	1327	228	201	292
1989	78046	54928	56075	39182	4874	1188	817	616	51	290
1990	87261	47774	29573	26563	18844	2441	593	458	369	216
1991	226767	48317	22071	15097	11249	8480	1237	296	263	324
1992	281942	142737	22449	10926	7827	5050	4674	646	168	376
1993	211259	213473	76372	10118	4266	3120	1966	2308	279	238

Year Age	3	4	5	6	7	8	9	10	11	12
1994	150273	162581	132562	37440	4346	1719	1484	755	1243	269
1995	274143	132666	112259	75546	15576	1848	794	777	300	828
1996	158412	244059	88297	68551	40422	7966	1036	484	447	705
1997	164614	120139	178524	58072	40148	21591	4151	503	259	629
1998	104290	135570	83800	128048	32888	24116	12886	2554	332	632
1999	241011	78990	95788	53536	73974	18368	15028	7672	1477	581
2000	159210	193027	51166	55833	31213	40670	11326	9626	4373	1130
2001	212316	106590	140257	35446	33157	18987	24144	7251	6082	3184
2002	357911	178223	78274	93953	23958	20586	12629	15001	4495	5918
2003	150915	317001	123912	51622	56760	17215	12746	8645	9148	6508
2004	153670	121325	209984	86127	35543	36407	10979	7448	5520	9153
2005	436325	119168	79064	125579	56566	23815	22286	6916	3815	7598
2006	73821	345200	79938	48535	73946	34788	14872	12596	3933	6097
2007	113108	53944	216276	52597	29793	39911	19826	8324	6281	4403
2008	200409	76125	37793	114916	30173	16518	19969	10815	4207	5099
2009	145999	154224	46054	25005	62623	15713	7883	9287	5323	4258
2010	269620	98774	91079	28578	14178	33189	7780	3771	4152	4392
2011	113082	199262	50578	46919	15677	8135	15981	3933	1849	3951
2012	153896	91823	123730	31155	24749	9056	4398	7733	1916	2866
2013	209004	92107	63809	77806	18423	13253	5007	2445	3911	2504
2014	108650	170558	60363	42747	46061	11056	7654	3138	1446	3686
2015	165109	80832	121163	41909	28657	27070	6462	4433	1956	3238
2016	252926	119916	54779	73849	27556	17665	15680	3768	2878	3794
2017	178636	220533	82076	34542	41960	16410	10391	8671	2096	4721
2018	130677	151127	179261	60196	24652	23598	9822	6206	4995	4402
2019	257000	124197	112305	120744	36398	15055	12994	5636	3480	5550
2020	122722	233796	104193	82456	74786	23057	9465	7550	3336	5780
2021	147428	91131	190540	79694	56869	48629	14558	6074	4587	6134
pred		115519	65936	132944	53373	35935	29775	8914	3719	6565

Table 5.11 Estimated recruitment, total-stock biomass (TBS), spawning-stock biomass (SSB), and average fishing mortality for ages 4 to 7 (F4–7).

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4–7)	Low	High	TSB	Low	High
1960	84026	52561	134326	462688	338674	632112	0.276	0.198	0.387	686916	533851	883869
1961	116162	76540	176295	454708	335633	616028	0.233	0.170	0.319	661579	517022	846553
1962	206835	137011	312245	460869	343520	618305	0.233	0.172	0.315	725964	576883	913571
1963	273837	181598	412927	458340	345386	608234	0.246	0.184	0.330	837994	675845	1039045
1964	80835	53177	122880	483760	370183	632184	0.283	0.213	0.377	818944	659137	1017496
1965	254979	169260	384110	523809	405297	676974	0.289	0.218	0.384	858901	696125	1059738
1966	134273	89365	201748	482581	370844	627985	0.299	0.225	0.398	827172	670337	1020701
1967	174211	115695	262323	494141	382863	637762	0.280	0.210	0.373	800174	649854	985264
1968	143787	95615	216229	469782	362951	608057	0.202	0.151	0.270	758020	616216	932456
1969	267366	177243	403313	509859	402401	646012	0.195	0.147	0.259	869361	717880	1052806
1970	220408	146917	330662	568159	457854	705038	0.310	0.238	0.403	973772	817707	1159623
1971	229850	153927	343220	554682	452021	680661	0.327	0.253	0.422	954274	806359	1129321
1972	154265	103449	230043	535848	440342	652069	0.321	0.250	0.413	878566	745483	1035406
1973	201294	135058	300013	537224	446847	645881	0.358	0.280	0.457	846588	723212	991011
1974	100846	67415	150854	493712	412902	590337	0.480	0.380	0.606	736039	632146	857006
1975	168309	112918	250872	398963	334802	475420	0.539	0.429	0.677	614139	527453	715071
1976	220420	147490	329412	281331	234555	337436	0.573	0.457	0.718	544141	461430	641678
1977	202624	135938	302023	208941	173586	251498	0.500	0.398	0.630	478268	402502	568295
1978	136704	91625	203960	189086	158224	225968	0.553	0.442	0.692	418443	354574	493817
1979	195867	131462	291824	170439	142582	203739	0.588	0.471	0.735	410417	343590	490243
1980	118880	79764	177178	150189	125504	179728	0.564	0.451	0.706	391858	328104	468000
1981	232133	155017	347614	154449	128375	185819	0.558	0.446	0.698	447833	368831	543756
1982	127952	85652	191143	135715	112885	163162	0.555	0.442	0.696	403434	333787	487614
1983	100879	67291	151234	164048	135411	198741	0.603	0.483	0.752	410114	342736	490739
1984	94848	63020	142751	146889	121652	177361	0.713	0.575	0.885	323432	272348	384098
1985	104305	69193	157235	110715	92052	133162	0.632	0.507	0.788	270744	226156	324123
1986	178608	118543	269107	83490	69335	100536	0.541	0.432	0.677	266515	217251	326950
1987	144151	96320	215734	72061	59969	86591	0.614	0.495	0.761	284521	232275	348519

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4–7)	Low	High	TSB	Low	High
1988	80501	53240	121721	88318	72923	106963	0.606	0.488	0.753	302927	249183	368263
1989	78046	51493	118292	104092	80609	134415	0.488	0.388	0.615	286337	236432	346777
1990	87261	57160	133215	120178	95890	150620	0.549	0.437	0.689	273010	228545	326126
1991	226767	149759	343375	114661	93974	139901	0.506	0.402	0.636	355669	288542	438413
1992	281942	186702	425764	95211	80072	113212	0.603	0.483	0.753	464558	373132	578385
1993	211259	141268	315927	97293	80974	116900	0.532	0.425	0.666	533627	431635	659720
1994	150273	102344	220647	148467	120525	182887	0.478	0.379	0.603	485997	402285	587130
1995	274143	185154	405903	197554	158396	246391	0.374	0.294	0.476	588527	488899	708456
1996	158412	107589	233241	246590	200772	302864	0.363	0.284	0.463	682201	569882	816657
1997	164614	111990	241966	246211	200966	301643	0.256	0.198	0.331	725654	604353	871300
1998	104290	71230	152695	294713	240842	360634	0.254	0.196	0.329	803607	669600	964433
1999	241011	164532	353040	309916	250154	383956	0.255	0.196	0.332	806148	677769	958842
2000	159210	108688	233216	368993	298161	456652	0.226	0.174	0.295	825951	697965	977407
2001	212316	146303	308116	374833	307242	457293	0.198	0.153	0.257	883686	751264	1039450
2002	357911	251930	508475	450424	375437	540388	0.191	0.148	0.247	1027724	880623	1199397
2003	150915	106003	214855	437861	368459	520334	0.184	0.143	0.237	1003187	858533	1172213
2004	153670	106851	221003	518880	441074	610410	0.178	0.137	0.230	1016491	870454	1187028
2005	436325	305892	622375	602367	509925	711569	0.209	0.162	0.270	1097718	941847	1279385
2006	73821	52104	104591	535304	456254	628049	0.249	0.194	0.320	942032	809282	1096558
2007	113108	80112	159694	545628	466743	637846	0.264	0.206	0.338	880826	754665	1028077
2008	200409	142439	281971	468492	394737	556028	0.333	0.262	0.424	730583	629841	847439
2009	145999	103996	204967	361785	304858	429342	0.347	0.275	0.439	677268	585513	783402
2010	269620	192575	377489	327806	277143	387730	0.384	0.304	0.486	698709	600271	813290
2011	113082	80132	159583	292358	246890	346200	0.382	0.301	0.485	584827	501895	681463
2012	153896	109359	216571	301256	254999	355904	0.362	0.285	0.459	595305	510906	693647
2013	209004	148918	293333	323389	270270	386947	0.299	0.235	0.382	608668	520886	711244
2014	108650	77223	152865	348814	291208	417817	0.271	0.212	0.347	642313	549371	750979
2015	165109	117480	232047	357938	298395	429363	0.257	0.200	0.330	626740	534207	735301
2016	252926	178613	358158	391741	323101	474963	0.252	0.195	0.326	794025	671466	938953

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4–7)	Low	High	TSB	Low	High
2017	178636	126300	252660	401931	329879	489720	0.228	0.175	0.297	891948	751182	1059092
2018	130677	90890	187881	464929	378166	571597	0.229	0.175	0.300	940084	786349	1123876
2019	257000	179210	368558	560109	445368	704413	0.203	0.152	0.270	1055975	875840	1273157
2020	122722	83756	179818	616956	480534	792107	0.187	0.138	0.255	1069119	871949	1310875
2021	147428	92304	235474	715674	542678	943818	0.186	0.131	0.264	1140302	899686	1445270

Table 5.12 Northeast Arctic saithe. Prediction input data

rMFDP version
Run: r
F_{bar} age range: 4–7

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	161659	0.2	0	0	0	0.78	0.046	0.78
4	115519	0.2	0.05	0	0	1.128	0.131	1.128
5	65936	0.2	0.42	0	0	1.605	0.168	1.605
6	132944	0.2	0.87	0	0	2.088	0.208	2.088
7	53373	0.2	0.97	0	0	2.651	0.261	2.651
8	35935	0.2	0.98	0	0	3.192	0.285	3.192
9	29775	0.2	0.98	0	0	3.715	0.285	3.715
10	8914	0.2	0.97	0	0	4.16	0.285	4.16
11	3719	0.2	0.97	0	0	4.833	0.285	4.833
12	6565	0.2	0.99	0	0	6.434	0.285	6.434

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	161659	0.2	0	0	0	0.78	0.046	0.78
4	.	0.2	0.05	0	0	1.128	0.131	1.128
5	.	0.2	0.42	0	0	1.605	0.168	1.605
6	.	0.2	0.87	0	0	2.088	0.208	2.088
7	.	0.2	0.97	0	0	2.651	0.261	2.651
8	.	0.2	0.98	0	0	3.192	0.285	3.192

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
9	.	0.2	0.98	0	0	3.715	0.285	3.715
10	.	0.2	0.97	0	0	4.16	0.285	4.16
11	.	0.2	0.97	0	0	4.833	0.285	4.833
12	.	0.2	0.99	0	0	6.434	0.285	6.434

2024

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	161659	0.2	0	0	0	0.78	0.046	0.78
4	.	0.2	0.05	0	0	1.128	0.131	1.128
5	.	0.2	0.42	0	0	1.605	0.168	1.605
6	.	0.2	0.87	0	0	2.088	0.208	2.088
7	.	0.2	0.97	0	0	2.651	0.261	2.651
8	.	0.2	0.98	0	0	3.192	0.285	3.192
9	.	0.2	0.98	0	0	3.715	0.285	3.715
10	.	0.2	0.97	0	0	4.16	0.285	4.16
11	.	0.2	0.97	0	0	4.833	0.285	4.833
12	.	0.2	0.99	0	0	6.434	0.285	6.434

Input units are thousands and kg - output in tonnes

Table 5.13 Northeast Arctic saithe. Short-term prediction

rMFDP version
Run: r
F_{bar} age range: 4–7

2022

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
1103920	745913	1.0786	0.2071	197212

2023–2024

2023					2024	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
1050549	686937	0	0	0	1212129	815773
.	686937	0.1	0.0192	19638	1190491	796705

2023					2024	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
.	686937	0.2	0.0384	38826	1169356	778107
.	686937	0.3	0.0576	57575	1148713	759967
.	686937	0.4	0.0768	75895	1128549	742273
.	686937	0.5	0.096	93798	1108852	725014
.	686937	0.6	0.1152	111294	1089611	708179
.	686937	0.7	0.1344	128393	1070814	691758
.	686937	0.8	0.1536	145104	1052450	675738
.	686937	0.9	0.1728	161438	1034509	660112
.	686937	1	0.192	177402	1016980	644867
.	686937	1.1	0.2112	193007	999852	629995
.	686937	1.2	0.2304	208262	983117	615487
.	686937	1.3	0.2496	223174	966763	601332
.	686937	1.4	0.2688	237752	950783	587523
.	686937	1.5	0.288	252005	935166	574049
.	686937	1.6	0.3072	265940	919904	560904
.	686937	1.7	0.3264	279566	904988	548078
.	686937	1.8	0.3456	292888	890410	535564
.	686937	1.9	0.3648	305916	876161	523353
.	686937	2	0.384	318656	862233	511438

Input units are thousands and kg - output in tonnes

Table 5.14 Northeast arctic saithe. Short-term projection output HCR landings

rMFDP version
Run: r
F_{bar} age range: 4–7

2022

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
1103920	745913	1.0786	0.2071	197212

2023

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
1050549	686937	1.3246	0.254	226794

2024

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
962796	597899	1.667	0.32	246332

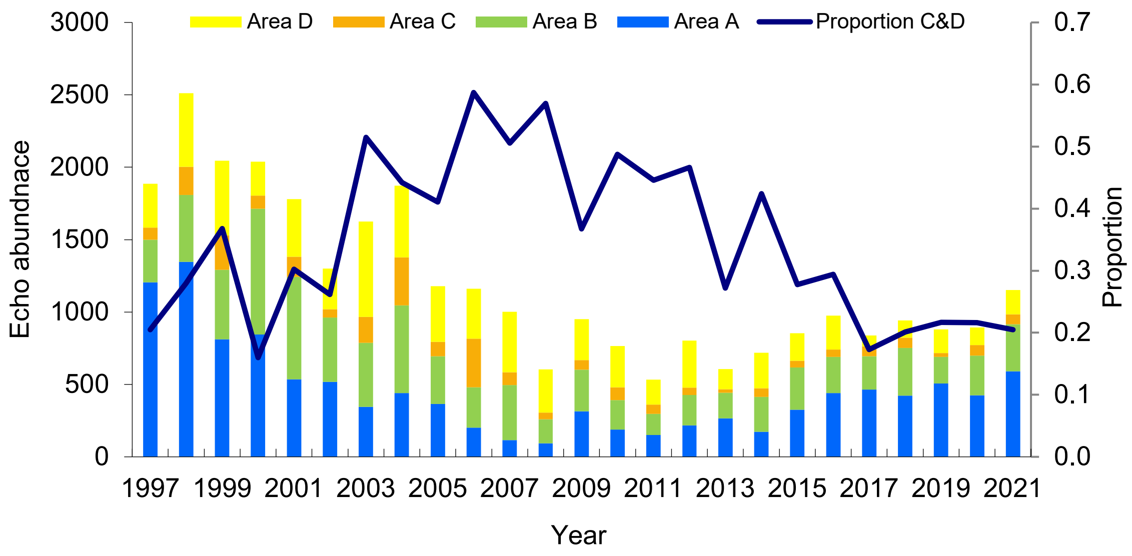

Figure 5.1. Northeast Arctic saithe. Echo abundance and proportion of saithe in the southern half of the survey area (subarea C+D).

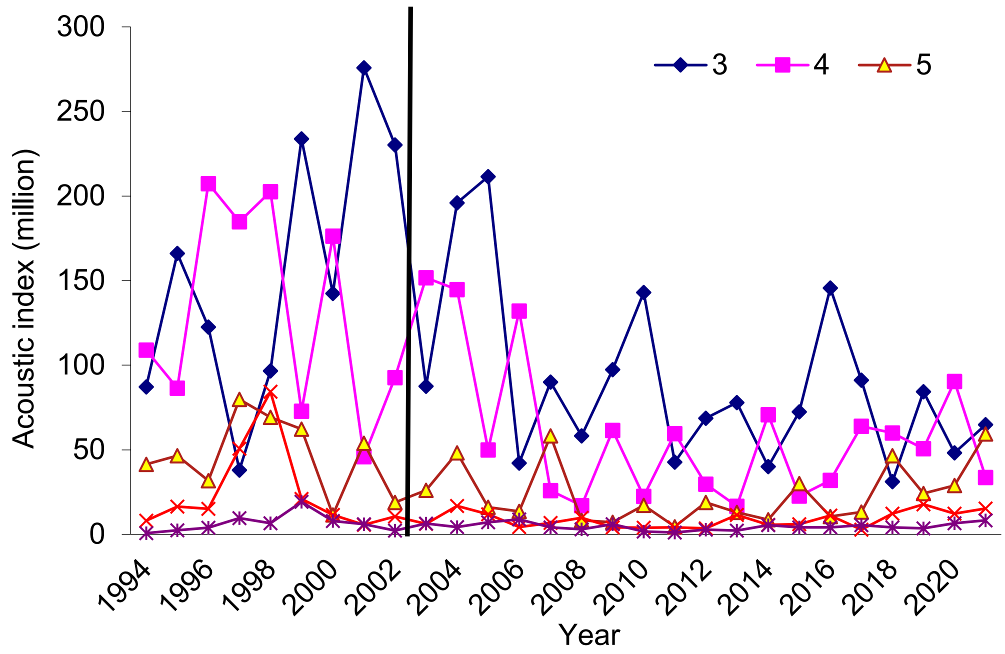

Figure 5.2. Northeast Arctic saithe. acoustic survey tuning indices by age class (3–7). break in 2002 black line.

Figure 5.3. Northeast Arctic saithe. Final run normalized residuals. Blue circles indicate positive residuals (larger than predicted) and filled red circles indicate negative residuals. The top figure shows residuals for the total catch series. the figure in the middle the residuals for the first survey series and the bottom figure the residuals for the survey series from 2002.

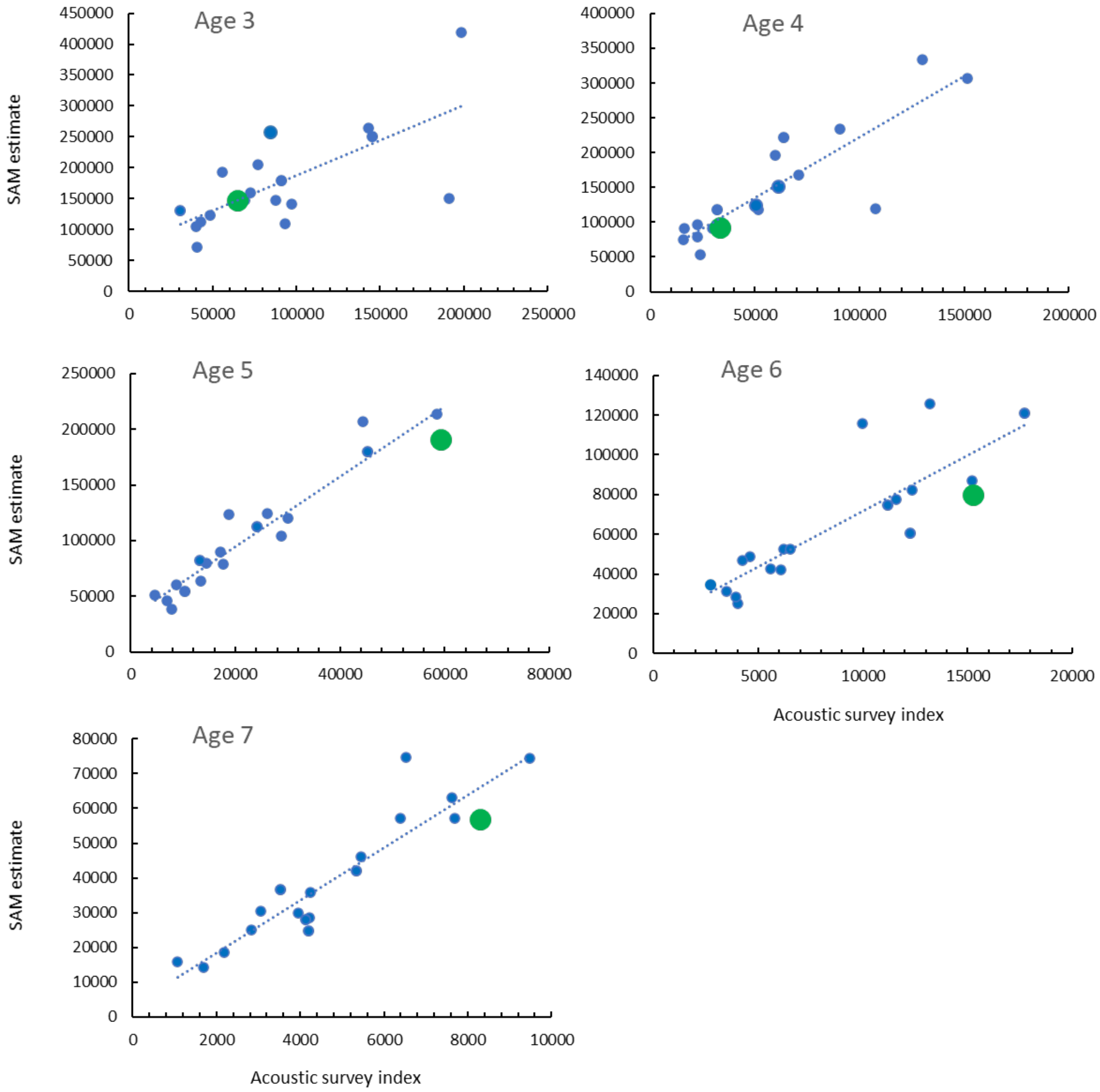

Figure 5.4. NEA saithe - Acoustic survey vs. SAM. Green point 2021 data.

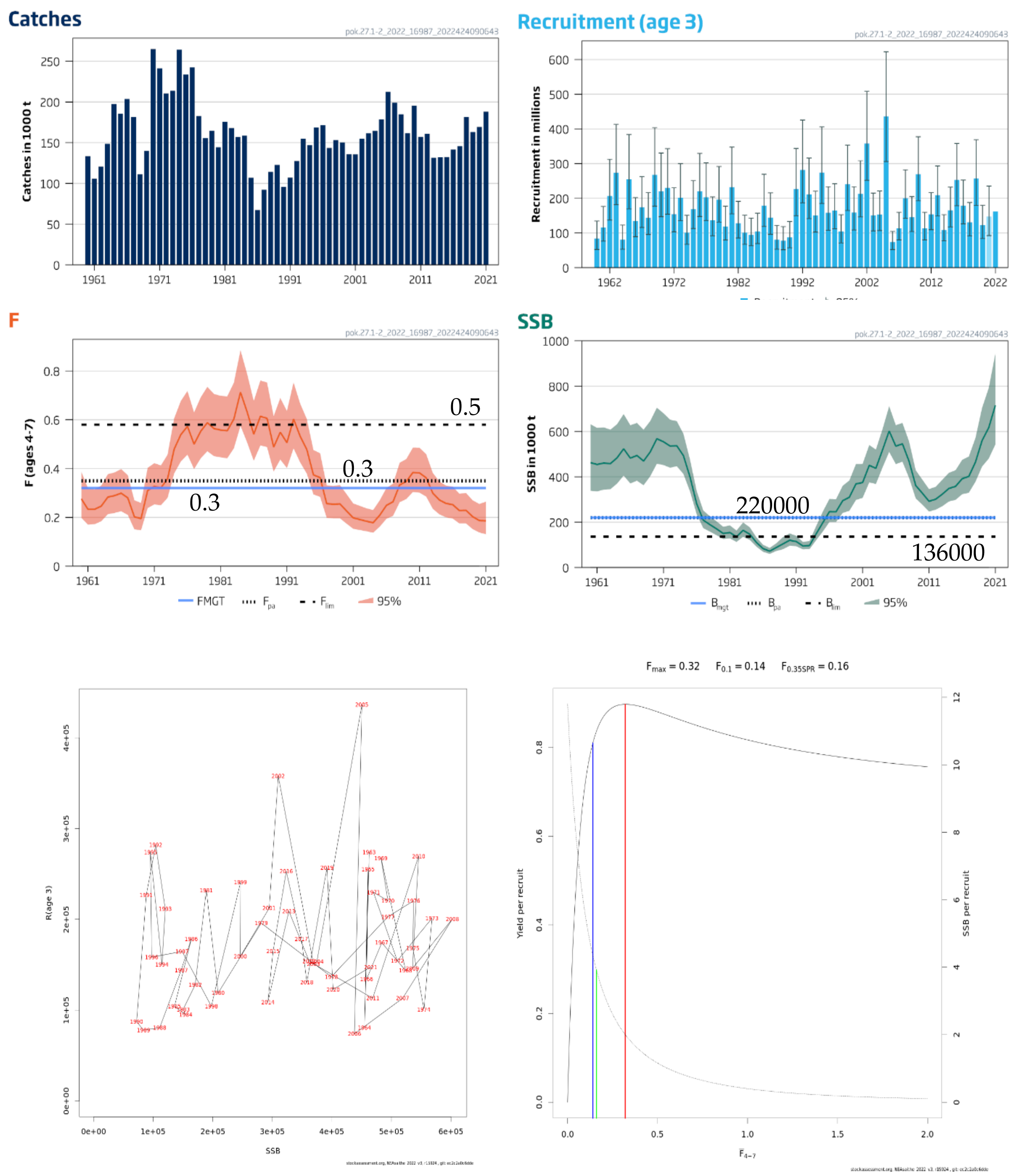

Figure 5.5. Northeast Arctic saithe (subareas 1 and 2).

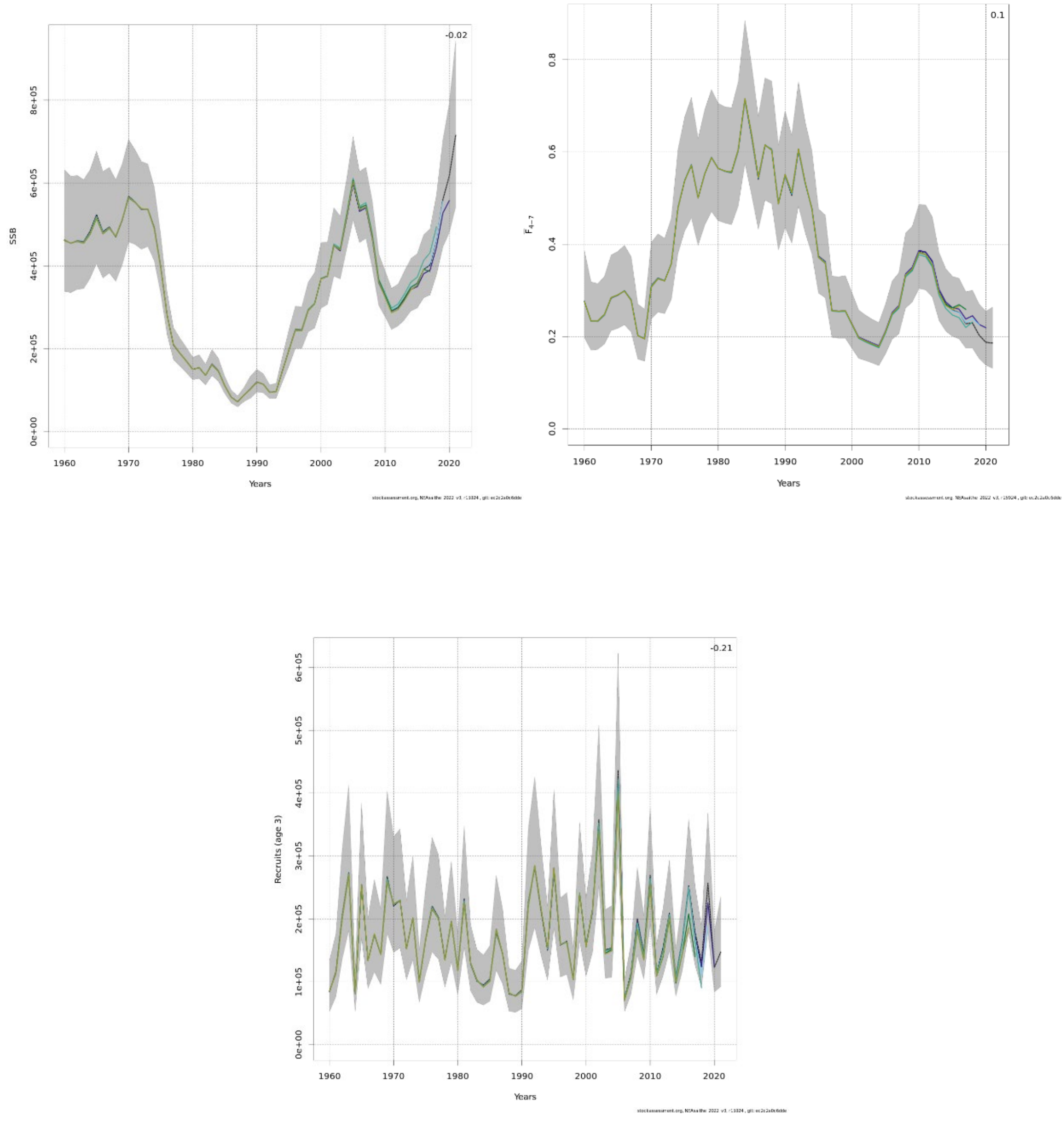

Figure 5.6. Saithe in subareas 1 and 2 (Northeast Arctic) RETROSPECTIVE SAM SSB. F4–7. and recruits.

Section contents