

Working Document to the
Arctic Fisheries Working Group
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REVISED TUNING DATA FOR NORTHEAST ARCTIC SAITHE

by

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1. BACKGROUND

In the two last years there has been some inconsistency between the CPUE in the commercial fishery and the survey data (Table 1).

Table 1. North-East Arctic saithe (run name: XSASME10). Tuning fleet data.

FLT01: Norway Ac Survey (Catch: Thousands) (Effort: Unknown)

1988 1999

1 1 0.75 0.85

2 5

1	15.7	22.5	19.0	7.1
1	24.8	28.4	17.0	10.1
1	99.6	31.9	14.7	5.1
1	87.8	104.0	4.6	4.0
1	163.5	273.6	57.5	6.2
1	106.9	227.7	103.9	12.7
1	34.4	87.8	112.4	39.5
1	38.7	165.2	87.0	46.8
1	37.0	118.9	214.7	32.1
1	5.1	36.7	185.8	79.8
1	43.6	96.5	200.6	70.0
1	61.1	233.8	72.9	62.2

FLT02: Norway Purse Seine (Catch: Unknown) (Effort: Unknown)

1977 1999

1 1 0.00 1.00

2 7

206	30547	81152	8964	2144	133	9
214	43402	37652	8788	2126	456	88
199	23054	41942	6706	6575	1362	363
215	15615	23353	15280	3280	1683	681
203	10325	68716	5770	2219	154	36
213	14490	28360	43980	250	140	0
161	8924	12402	9775	12090	463	179
124	8576	21699	3842	2144	1363	21
98	632	28815	2688	1096	340	95
96	1408	9869	593	181	108	51
94	1848	12364	32183	386	19	2
103	875	3253	27063	13169	72	6
131	4231	5250	8521	18211	2880	24
96	8551	7207	3319	2582	1845	673
107	3694	43110	1907	453	162	95
90	3954	29527	5214	89	45	38
79	1762	8010	24251	1302	39	23
71	1099	6365	16182	8997	1151	90
90	14	5524	13357	4368	1335	105
105	231	4053	36274	6022	2610	589
109	202	9665	6691	18403	1852	1329
189	2	1988	9487	5131	10178	1224
211	0	5979	5831	10123	2282	2834

FLT03: Norway Trawl (Catch: Unknown) (Effort: Unknown)

1976 1999

1 1 0.00 1.00

3 10

36.8	11184	583	1080	1137	869	612	332	284
52.7	4557	9047	3260	202	660	322	361	209
51.3	488	3104	3440	1400	319	591	254	304
42.7	7374	6538	2340	762	845	419	294	129
57.4	10270	10301	1726	2891	1392	406	24	108
71.0	5698	12137	10877	1901	1053	1351	83	108
58.2	1719	10344	10006	5519	420	306	215	134
57.7	3341	10024	14949	2189	1720	535	181	60
85.5	14876	25819	7038	7161	656	744	180	176
63.7	10070	6177	3844	3877	2446	441	564	66
45.2	4388	8150	4078	3172	2044	779	208	215
30.1	470	7862	2452	1169	1405	189	153	67
50.4	1539	2241	14077	3031	1438	609	346	137
59.8	3923	9038	9226	8659	1154	178	83	150
60.4	8909	7960	3932	3722	3967	479	54	66
51.5	20741	7106	2683	2456	1516	1044	139	37
57.6	10361	13228	3067	2269	2660	2029	890	214
68.0	10746	26279	17961	1947	657	604	190	240
78.7	1456	16229	28224	10542	1045	151	68	83
106.4	7626	27085	24940	21565	2560	329	18	61
74.7	3663	13890	8701	9304	10312	763	152	3

41.4	3754	3968	16671	5899	4059	1910	179	20
65.3	418	3077	3485	12286	3600	1875	399	159
69.7	2254	3250	6725	4306	9090	1586	989	262

The estimated catch rates showed a considerable reduction in 1998 while the survey showed an opposite trend. And fishermen reported high saithe abundance with extremely good catchability. One explanation may be that the number of vessels participating in the purse seine fishery doubled from 1997 to 1998 and 1999, while the quota was slightly higher in 1998 than in 1997 and about 15% lower in 1999. The trawlers, on the other side, have perhaps been looking for cod but ended up with saithe, spending more time than they really needed for catching this amount of saithe.

In order to eliminate this perhaps somewhat artificial reduction in estimated commercial CPUE, some work has been done to improve the purse seine and trawl CPUE tuning series.

2. TRAWL CPUE

Table 2 gives catch, effort and catch per unit effort for Norwegian trawlers since 1976.

Table 2 Northeast Arctic saithe. Catch, effort, and catch per unit effort for Norwegian trawlers directing for saithe.

Year	Catch ¹ (t)	Effort ¹ (h)	CPUE ¹ (kg/h)
1976	12 982	21 615	601
1977	15 583	29 308	532
1978	12 506	27 094	462
1979	16 609	24 258	685
1980	27 618	39 290	703
1981	43 682	49 191	888
1982	30 358	33 164	915
1983	38 846	37 856	1026
1984	56 128	60 282	931
1985	29 260	39 894	733
1986	20 897	25 037	835
1987	8 631	11 860	728
1988	16 589	21 034	789
1989	28 753	40 813	705
1990	28 445	42 689	666
1991	26 362	35 680	739
1992	42 785	43 885	975
1993	47 468	46 613	1018
1994	54 402	57 612	944
1995	72 846	76 732	949
1996	39 594	43 788	904
1997	21 839	18 312	1193
1998	18 607	25 046	743
1999	² 18 498	25 233	733

¹ Including only days with more than 50% saithe on trips with more than 50% saithe in the catches.

² Provisional figures

This summarises hauls where the effort has almost certainly been directed towards saithe, i.e., days with more than 50% saithe and only on trips with more than 50% saithe in the catch. The effort estimated for the directed fishery was raised by the total Norwegian trawl catches to give total effort of Norwegian trawlers (Table 3). This index more than doubled from 1991 to maximum recorded level in 1995, and then decreased by more than 60% towards 1997 to the lowest effort during the last ten years. From 1997 to 1998 the effort increased by more than 50%, but due to regulations the catches were slightly lower in 1998 and the CPUE decreased by almost 40% from 1997 to 1998 (Table 2). From 1998 to 1999 there was a further decrease. This may at least partly be explained by the increasing problem with bycatch of saithe in the declining cod fishery. It is uncertain whether hauls from days with more than 50% saithe and trips with more than 50% saithe in the catch were directed only towards saithe.

Table 3 Northeast Arctic saithe. Norwegian effort indices.

Year	Purse seine ¹	Trawl ²	Combined ³
1976	-	36,8	-
1977	206	52,7	351
1978	214	51,3	355
1979	199	42,7	316
1980	215	57,4	373
1981	203	71,0	398
1982	213	58,2	373
1983	161	57,7	320
1984	124	85,5	359
1985	98	63,7	273
1986	96	45,2	220
1987	94	30,1	177
1988	103	50,4	242
1989	131	59,8	295
1990	96	60,4	262
1991	107	51,5	249
1992	90	57,6	248
1993	76	68,0	266
1994	78	78,7	294
1995	90	106,4	383
1996	105	74,7	310
1997	109	41,4	222
1998	189	65,8	370
1999 ⁴	211	69,7	403

¹ No. of vessels 20-24.9 m. length in Table C.1, scaled by total purse seine catch.

² Hours trawling ('000). Effort in Table C-2 scaled by total Norwegian trawl catch.

³ Trawl indices scaled up to give the same average for 1977-1990 as the purse seine indices (i.e. x 2.75) before adding the two.

⁴ Provisional figures.

New trawl CPUE series

New estimates are based on the logbook database, with a resolution on day level. One single CPUE observation from a given vessel is the total catch per day divided by the duration of all the trawl hauls that day. This was done for all hauls with 70% or more saithe. The effort (hours trawling) for each CPUE observation is standardised or calibrated to a standard vessel. A yearly index is calculated by first averaging all CPUE observations for each month, and then averaging over the year.

The CPUE indices for trawl able biomass is splitted on age groups (a):

$$CPUE_{biom,a} = CPUE_{biom,tot} * weight-fraction_a$$

The *weight-fraction* is estimated by multiplying “catch at age” by “catch weights at age” from the WG-report (ICES 2000/ACFM:3) and dividing by the total catch (or the SOP per year).

In order to calculate number-indices, the splitted biomass indices are divided by the “catch weight at age” (w_a) (because average weight at age for a given age may vary from year to year):

$$CPUE_{number,a} = CPUE_{biom,a} / w_a$$

Table 4. Northeast Arctic saithe. New CPUE number indices for Norwegian trawlers directing for saithe.

Year	age3	age4	age5	age6	age7	age8	age9	age10
85	216,2	54,1	24,6	28,2	30,1	14,9	50,1	11,0
86	116,8	88,6	32,4	28,6	31,2	32,6	22,9	44,3
87	18,5	126,6	28,9	15,6	31,8	11,7	25,0	20,5
88	36,0	21,4	98,5	24,1	19,3	22,4	33,5	24,8
89	100,6	94,6	70,7	75,3	17,0	7,2	8,8	29,8
90	169,5	61,8	22,3	24,0	43,3	14,3	4,2	9,7
91	358,2	50,1	13,8	14,4	15,0	28,3	9,9	4,9
92	237,3	123,7	21,0	17,6	35,0	73,0	84,3	37,9
93	261,5	261,1	130,6	16,1	9,2	23,1	19,1	45,2
94	25,0	114,0	145,0	61,4	10,3	4,1	4,8	11,1
95	132,7	192,4	129,6	127,1	25,6	9,0	1,3	8,2
96	114,0	176,5	80,9	98,1	184,2	37,3	19,6	0,7
97	163,5	70,5	216,8	87,0	101,5	130,7	32,2	6,7
98	23,2	57,3	36,1	117,1	56,0	66,3	26,4	9,1
99	21,2	14,1	39,3	22,7	82,4	32,3	61,7	19,3

3. PURSE SEINE CPUE

Table 5 shows the number of vessels of different size categories, which have taken part in the purse seine fishery since 1977, with corresponding catches and catch per vessel. On the basis of these data, indices of fishing effort are calculated. The unit of

effort is the number of vessels of 20-24.9 m length. This category has in recent years accounted for approximately half of the purse seine landings, decreasing to 35-45% in the three last years, and constitutes most of the specialised saithe purse seiners. The effort of this length category is raised by the total purse seine catches to represent the total purse seine effort. A decreasing trend in the purse seine effort was observed from 1991 to 1993 with a reduction of about 29% during this period. The 1993 figure was the lowest on record. From 1994 to 1997 fishing effort increased by nearly 40% and from 1997 to 1998 by over 70% to the same level as around 1980 (Table 3). The number of vessels taking part in the fishery almost doubled from 1997 to 1998, but due to regulations the catches were almost the same as in 1997. In such a situation the number of vessels participating in a fishery is perhaps not a good measure of effort.

Table 5. Northeast Arctic saithe. Norwegian purse seiners taking part in the saithe fishery.

Data given are: number of vessels, catch in tonnes, catch per vessel.

Year	Vessel length (m)								
	< 19,9			20.0-24.9			> 25.0		
	Number	Catch	C/V	Number	Catch	C/V	Number	Catch	C/V
1977	208	21 398	103	66	25 324	384	19	5 655	298
1978	184	16 288	89	72	21 224	295	19	6 094	321
1979	250	21 224	85	72	27 057	376	25	9 122	365
1980	269	21 243	79	96	27 551	287	39	10 234	262
1981	312	25 984	83	89	29 108	327	23	7 354	320
1982	308	30 228	98	98	35 969	367	23	9 303	404
1983	222	19 925	90	80	28 348	354	12	5 524	460
1984	168	8 834	53	69	20 668	300	15	6 713	448
1985	90	4 150	46	57	18 328	322	16	8 391	524
1986	55	1 281	23	43	3 581	83	21	2 643	126
1987	106	9 084	86	46	16 766	364	15	8 185	546
1988	120	13 111	109	48	20 413	425	13	8 981	691
1989	195	14 993	77	61	23 000	377	13	10 466	805
1990	89	2 533	28	53	13 360	252	19	8 406	442
1991	122	8 726	72	56	20 378	364	19	9 797	516
1992	100	7 076	71	49	14 783	302	20	5 020	251
1993	48	6 110	127	45	19 502	433	19	7 433	391
1994	76	9 086	120	39	14 579	374	18	5 672	315
1995	67	3 502	52	34	8 290	244	19	10 108	532
1996	105	12 441	118	37	16 459	445	21	17 931	854
1997	87	10 153	117	48	20 135	419	32	14 012	438
1998	125	10 274	82	82	19 216	234	102	14 871	146
1999 ¹	113	9 983	88	76	14 135	186	112	13 902	124

¹ Preliminary data per 24.10.99.

New purse seine CPUE series

Many of the vessels which have taken part in the fishery the last years have accounted for only a small fraction of the purse seine catches. This is summarised in Table 6

Table 6. Northeast Arctic saithe. Norwegian purse seiners taking part in the saithe fishery, grouped in < 100 or > 100 tonnes total catch per vessel

Year	No. of vessels with catch		Catch (tonnes) from vessels with catch			Catch in % from vessels with		No. vessels with > 100 tonnes, raised to total catch
	<100 tonnes	> 100 tonnes	<100 tonnes	> 100 tonnes	Total	<100 tonnes	> 100 tonnes	
1989	160	109	4165	44309	48474	9	91	119
1990	110	51	2341	22278	24618	10	90	56
1991	105	92	2569	36329	38898	7	93	99
1992	89	80	2671	24206	26877	10	90	89
1993	41	69	1319	31832	33151	4	96	72
1994	56	75	1601	27746	29348	5	95	79
1995	72	48	1762	20138	21900	8	92	52
1996	83	79	1654	45195	46848	4	96	82
1997	69	88	1943	42358	44301	4	96	92
1998	193	118	4142	40234	44376	9	91	130
1999	212	115	5263	33792	39055	13	87	133

Roughly half of the vessels have caught less than 100 tonnes per year, and the sum of these catches are only about 5 – 10% of the total purse seine catch. Therefore the number of vessels catching more than 100 tonnes annually seems to be a more representative and more stable measure of effort in the purse seine fishery. These numbers have been raised to the total purse seine catch, and the new numbers are given in the last column of Table 6.

4. NORWEGIAN ACOUSTIC SURVEY

Table 7. Acoustic abundance indices by age October-November 1985-1999. The area coverage was incomplete in 1985-1987. (Numbers in millions).

(Year)	Age					Total
	2	3	4	5	6+	
1985	3.1	4.9	2.4	0.5	0.0	10.9
1986	19.5	40.8	3.6	1.8	1.8	70.3
1987	1.8	22.0	48.4	1.8	1.7	75.9
1988	15.7	22.5	19.0	7.1	0.6	64.9
1989	24.8	28.4	17.0	10.1	12.4	92.6
1990	99.6	31.9	14.7	5.1	7.4	158.7
1991	87.8	104.0	4.6	4.0	7.1	207.5
1992	163.5	273.6	57.5	6.2	8.8	509.7
1993	106.9	227.7	103.9	12.7	3.2	454.9
1994	34.4	87.8	112.4	39.5	10.0	284.6
1995	38.7	165.2	87.0	46.8	20.0	357.7
1996	37.0	118.9	214.7	32.1	19.3	422.0
1997	5.1	36.7	185.8	79.8	61.7	369.1
1998	43.6	96.5	200.6	70.0	96.7	507.5
1999	61.1	233.8	72.9	62.2	47.8	478.3

In the three last years the survey indices of age 6+ have showed a large increase (Table 7), and at the last WG-meeting it was mentioned that the tuning series should be expanded from age 2-5 to age 2-6. Due to very small indices of age 6 and older age groups in the beginning of the period and also difficulties with rerunning the estimates and splitting age 6+ into age 6 and 7+, the oldest age group in the new time series is treated as a plus group (6+).

5. TRIAL XSA-RUNS

The new effort, CPUE and survey indices series have been tested in XSA-runs, with new input data for 1998 and 1999. First a run with standard tuning was performed, and then the three new tuning series was included one by one, keeping two of them in the old version in each run. The youngest age groups (2 and 3) have usually not been well estimated by the XSA, and a run was done with catchability dependent of stock size for these age groups. At last a run including all changes was performed. Some output from the tuning diagnostics presented below.

Table 8. Tuning diagnostics. Scaled weights. Actual age groups in each series in bold.									
Age group									
Fleet	2	3	4	5	6	7	8	9	10
1. Standard tuning									
Norwegian trawl	0,000	0,080	0,142	0,331	0,500	0,501	0,535	0,469	0,356
Norw. purse seine	0,000	0,153	0,271	0,193	0,134	0,113	0,076	0,063	0,035
Acoustic survey	0,238	0,335	0,246	0,192	0,107	0,071	0,047	0,037	0,020
F-shrinkage mean	0,762	0,432	0,342	0,284	0,259	0,314	0,341	0,431	0,590
2. New trawl CPUE									
Norwegian trawl	0,000	0,088	0,176	0,432	0,550	0,553	0,577	0,545	0,416
Norw. purse seine	0,000	0,157	0,265	0,167	0,122	0,109	0,077	0,071	0,043
Acoustic survey	0,239	0,319	0,224	0,157	0,092	0,066	0,046	0,041	0,023
F-shrinkage mean	0,761	0,435	0,335	0,245	0,236	0,272	0,300	0,344	0,518
3. New purse seine CPUE									
Norwegian trawl	0,000	0,077	0,126	0,309	0,480	0,485	0,524	0,458	0,353
Norw. purse seine	0,000	0,176	0,347	0,240	0,163	0,145	0,098	0,080	0,045
Acoustic survey	0,236	0,331	0,226	0,185	0,107	0,071	0,048	0,037	0,020
F-shrinkage mean	0,764	0,416	0,301	0,266	0,250	0,299	0,331	0,425	0,582
4. Acoustic 6+									
Norwegian trawl	0,000	0,080	0,141	0,322	0,476	0,485	0,524	0,457	0,354
Norw. purse seine	0,000	0,151	0,270	0,195	0,135	0,113	0,077	0,062	0,035
Acoustic survey	0,238	0,338	0,249	0,198	0,146	0,097	0,067	0,052	0,028
F-shrinkage mean	0,762	0,431	0,341	0,285	0,243	0,304	0,322	0,428	0,583
5. Catchability dependent on stock size for ages < 4									
Norwegian trawl	0,000	0,046	0,133	0,336	0,505	0,507	0,539	0,472	0,358
Norw. purse seine	0,000	0,152	0,304	0,210	0,140	0,119	0,079	0,064	0,035
Acoustic survey	0,125	0,185	0,179	0,158	0,088	0,058	0,039	0,029	0,016
F-shrinkage mean	0,551	0,422	0,384	0,295	0,267	0,316	0,343	0,435	0,592
P-shrinkage mean	0,325	0,195							
6. Combination of run 2 – 5 (all changes included)									
Norwegian trawl	0,000	0,031	0,145	0,404	0,512	0,521	0,553	0,515	0,407
Norw. purse seine	0,000	0,174	0,377	0,227	0,156	0,148	0,105	0,094	0,058
Acoustic survey	0,122	0,179	0,150	0,128	0,110	0,078	0,057	0,048	0,029
F-shrinkage mean	0,557	0,424	0,328	0,240	0,223	0,252	0,285	0,343	0,506
P-shrinkage mean	0,321	0,192							

For each of the three tuning series their scaled weights increased when the new series were included, both when included one by one and also for runs with all three new together. For trawl the change was largest for the oldest age groups and for purse seine for the intermediate age groups. The changes were smaller for the acoustic series. When catchability dependent of stock size for age groups 2 and 3 was introduced, the scaled weights were reduced for the three tuning series, and most pronounced for the youngest age groups in the acoustic series. This occurred both when catchability dependent of stock size for age groups 2 and 3 was used together with the old tuning series and in the run combining all three new series. Therefore a last run with only the three new tuning series was performed (Table 9). Here the acoustic survey got somewhat higher weights for age groups 2-5, other vice the changes were small.

		Age group							
Fleet	2	3	4	5	6	7	8	9	10
Norwegian trawl	0,000	0,084	0,155	0,400	0,506	0,516	0,549	0,512	0,404
Norw. purse seine	0,000	0,180	0,341	0,212	0,151	0,142	0,101	0,091	0,057
Acoustic survey	0,238	0,318	0,210	0,157	0,127	0,091	0,066	0,057	0,034
F-shrinkage mean	0,762	0,418	0,294	0,231	0,216	0,252	0,284	0,339	0,504

The next table presents the R-Squares of the regression statistics. There is not much difference between the standard tuning and the other runs, and no clear trends. The R-Square for age 6 when including a 6+ group in the acoustic series is equal to the R-Square of the 5 group. When introducing catchability dependent of stock size for age groups 2 and 3, the R-Square for age 2 in the acoustic series increases somewhat.

		Age group							
Fleet	2	3	4	5	6	7	8	9	10
1. Standard tuning									
Norwegian trawl		,20	,23	,77	,88	,75	,77	,57	,36
Norw. purse seine	,19	,41	,83	,78	,81	,69			
Acoustic survey	,30	,41	,36	,46					
2. New trawl CPUE									
Norwegian trawl		,17	,48	,88	,87	,78	,76	,48	,17
Norw. purse seine	,20	,42	,83	,77	,80	,70			
Acoustic survey	,31	,37	,34	,45					
3. New purse seine CPUE									
Norwegian trawl		,19	,22	,76	,87	,75	,77	,57	,36
Norw. purse seine	,25	,46	,82	,69	,79	,77			
Acoustic survey	,29	,42	,37	,46					
4. Acoustic 6+									
Norwegian trawl		,20	,23	,76	,87	,75	,76	,56	,36
Norw. purse seine	,17	,40	,83	,78	,82	,69			
Acoustic survey	,30	,41	,37	,47	,48				
5. Catchability dependent on stock size for ages < 4									
Norwegian trawl		,20	,23	,77	,88	,75	,77	,57	,36
Norw. purse seine	,19	,41	,83	,78	,81	,69			
Acoustic survey	,38	,40	,36	,46					
6. Combination of run 2 – 5 (all changes included)									
Norwegian trawl		,17	,46	,87	,86	,78	,75	,48	,17
Norw. purse seine	,28	,47	,82	,69	,79	,78			
Acoustic survey	,38	,39	,37	,47	,48				

The last table presents the recruits at age 2, total biomass, spawning stock biomass and $F_{\text{BAR}} 3-6$ in the two last years for all runs. Some corresponding results/predictions from last years' assessment are also given. All runs with new tuning data gave an increase in biomasses compared to the run with standard tuning. The increase was largest in the run including all changes. The estimates of recruits at age 2 varied little between the runs. In the two runs (5 and 6) with catchability dependent of stock size for age groups 2 and 3, the estimate for 1999 increased somewhat. The XSA-estimate of recruits in the two last years have normally been unreliable and low and have been replace by RCT3-estimates in the predictions. The estimated $F_{\text{BAR}} 3-6$ was also very similar from run to run, only slightly lower in the two runs including all new tuning series.

All differences were, however, small compared to the differences between last years assessment and the new standard with 1999-data included. $F_{\text{BAR}} 3-6$ for 1998 was reduced from 0.39 to 0.30, and the SSB increased from 250 000 t to 330 000 t. (32%). Last years' prediction for SSB in 1999 was 186 000 t, while this years estimate was 266 000 t. (30% increase). These changes was mainly due to one more year with data, while revision of data for 1998 only gave minor changes.

Table 11. Main results of the two last years (1998 and 1999) in trial runs				
Year	Recruits age 2	Total biomass	Spawn. biomass	$F_{\text{BAR}} 3-6$
Last years result (with 1998-data)				
1998	8983	394073	252335	0,39
1999 (prediction)			186079	0,42
1. Standard tuning (with 1999-data)				
1998	138765	552610	330006	0,30
1999	35835	450855	266001	0,41
2. New trawl CPUE				
1998	126069	569764	353554	0,30
1999	35350	460780	285802	0,43
3. New purse seine CPUE				
1998	144470	559527	332114	0,29
1999	36302	459895	269192	0,40
4. Acoustic 6+				
1998	140583	560199	334434	0,29
1999	36132	459311	272035	0,40
5. Catchability dependent on stock size for ages < 4				
1998	132143	553464	331231	0,30
1999	55333	463200	267951	0,41
6. Combination of run 2 – 5 (all changes included)				
1998	130308	587981	363441	0,28
1999	55120	493728	298995	0,40
7. Combination of run 2 – 4 (all new tuning series included)				
1998	133630	585371	360958	0,28
1999	36194	479533	296084	0,40

6. CONCLUDING REMARKS

The new tuning series seems to perform a little better than the older ones, though the differences are small and the effect on the assessment relatively little. At the moment one more year of data gives larger changes, and the stock seems to be underestimated.