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Fish investigations in the Barents Sea Winter 2021

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Preface

Annual catch quotas and other regulations of the Barents Sea fisheries are set through negotiations between Norway and Russia. Assessment of the state of the stocks and quota advices are given by the International Council for the Exploration of the Sea (ICES). Their work is based on survey results and international landings statistics. The results from the demersal fish winter surveys in the Barents Sea are an important source of information for the annual stock assessment.

The development of the survey started in the early 1970s and focused on acoustic measurements of cod and haddock. Since 1981 it has been designed to produce both acoustic and swept area estimates of fish abundance. Some development has taken place since then, both in area coverage and in methodology. The development is described in detail by Jakobsen *et al*. (1997), Johannesen *et al*. (2009) and in Appendix 2, and the current survey design and methods for survey index calculation are presented in Appendix 1. At present the survey provides the main data input for several ongoing projects at the Institute of Marine Research, Bergen:

- monitoring abundance of the Barents Sea demersal fish stocks
- mapping fish distribution in relation to climate and prey abundance
- monitoring food consumption and growth
- estimating predation mortality caused by cod

This report presents the main results from the surveys in January-March 2021. The surveys were performed with the Norwegian research vessels “Helmer Hanssen”, “Kronprins Haakon” and “Johan Hjort”, and the Russian research vessel “Vilnyus”. Annual survey reports since 1981 are listed in Appendix 4, and names of scientific participants in 2021 are given in Appendix 3.

1 Survey operation

Table 1.1 presents the vessels participating in the survey in 2021 and IMR trawl station series numbers, and Figure 1.1 shows survey tracks, trawl stations and ice cover.

Table 1.1. Vessel participation by period and trawl station series numbers by vessel for the winter survey in 2021.

	Period	Series no.
Johan Hjort	27.01-18.03	70001-70220
Kronprins Haakon	22.01-07.02	70701-70746
Helmer Hanssen	20.01-08.02	70301-70411
Vilnyus	23.02-19.03	70501-70626

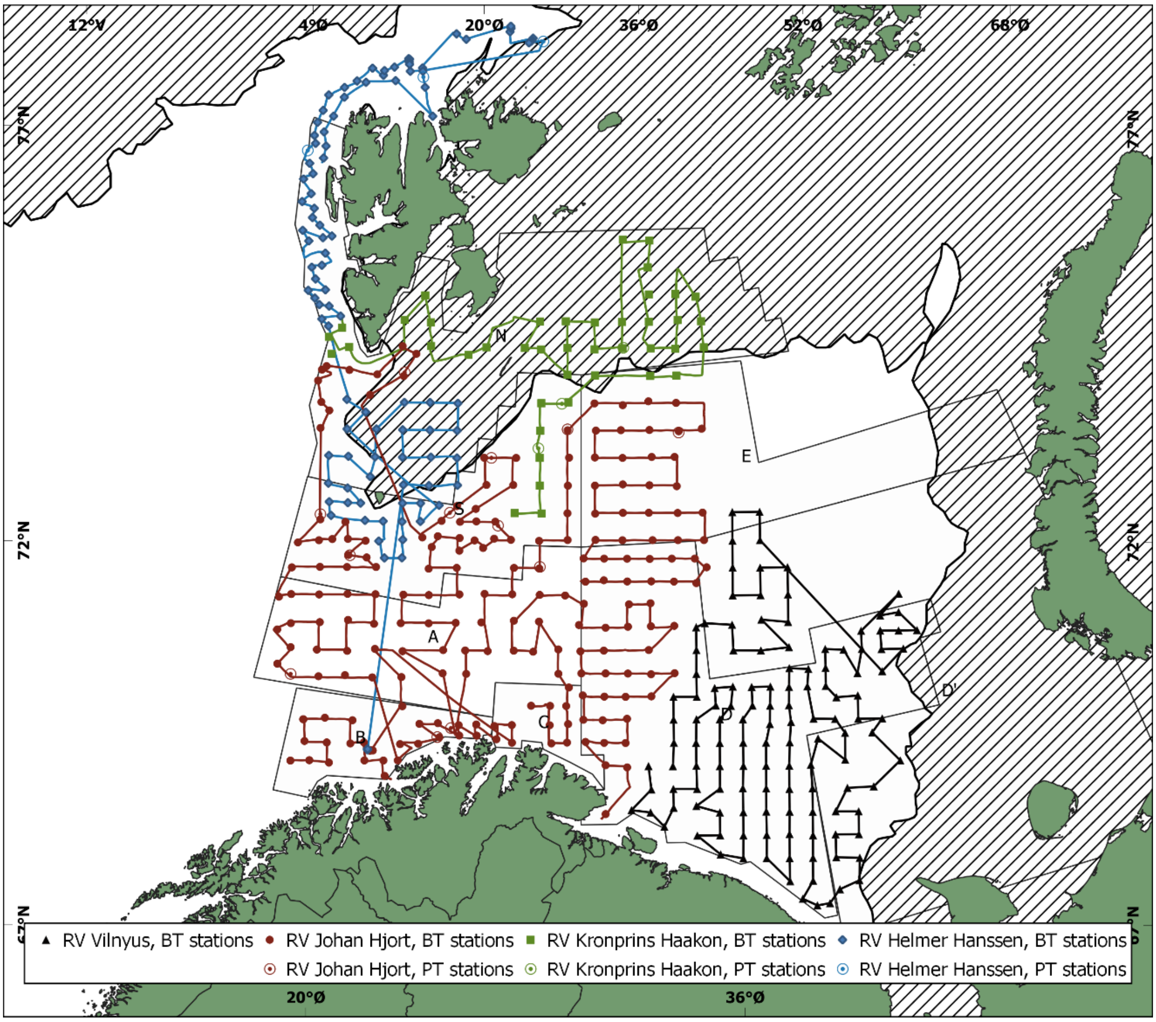

Figure 1.1. Survey tracks and all trawl stations in the winter survey 2021. Data source for the ice cover: https://cryo.met.no/archive/ice-service/icecharts/quicklooks/2021/ (19.03.21, the final day of the survey).

Table 1.2. Number of trawl stations by main area in the Barents Sea winter 2021. B_1= swept area bottom trawl (quality=1 and condition<3), B_2=other bottom trawl, P=pelagic trawl, N=trawl stations in new strata. Refer to Figure 1.1. or Appendix 1 for a map of the main areas.

Main area	Trawl type	
A	B_1	43
	B_2	-
	P	2
B	B_1	32
	B_2	2
	P	2
C	B_1	12
	B_2	-
	P	-
D	B_1	124
	B_2	1
	P	-
D'	B_1	31
	B_2	1
	P	-
E	B_1	32
	B_2	-
	P	1
S	B_1	70
	B_2	-
	P	8
Inside standard strata system	B_1	344
	B_2	4
	P	13
N	B_1	90
	B_2	2
	P	3
Outside strata system	B_1	33
	B_2	1
	P	2
Total	B_1+B_2	474
	P	18

The coverage of the most northern and most eastern strata differs from year to year. The areas of these strata are therefore calculated according to the coverage each year. Table 1.3 gives the area covered by the survey every year since 1981. In that table "Extrapolated area" reflects the size of areas where some kind of extrapolations/adjustments have been made to take account of incomplete coverage (see also section 3.1). Table 1.4 summarizes the degree of coverage and main reasons for incomplete coverage in the whole period.

Table 1.3. Area (NM^2) covered in the bottom trawl surveys in the Barents Sea winter 1981-2021, 1994-2021 are StoX estimates.

	Main Area									**Extra-polated area**
Year	**A**	**B**	**C**	**D**	**D'**	**E**	**S**	**N**	**Total excluding N**	
1981-92	23299	8372	5348	51116	-	-	-		88135	
1993	23929	8372	5348	51186	23152	8965	16690		137642	
1994	27180	9854	5165	53394	36543	11417	17557		161110	
1995	26797	9854	5165	53394	58605	13304	24783		191904	
1996	26182	9854	5165	53394	54047	5738	11809		166190	
1997[1]	27785	9854	5165	23964	2670	0	18932		88371	56200
1998[1]	27785	9854	5165	23964	5911	3829	23931		100440	51100
1999	27785	9854	5165	43230	8031	5742	18737		118545	
2000	27173	9854	5165	52314	29438	14207	25053		163204	
2001	26609	9854	5165	53394	29694	15777	24157		164652	
2002	26594	9854	5165	53394	21914	15757	24689		157369	
2003	26621	9897	5165	52072	23947	6259	23400		147361	
2004	27785	9854	5165	53394	42731	4739	20760		164428	
2005	27785	9854	5165	53394	39104	19931	24648		179883	
2006[2]	27785	9854	5165	53394	35302	13872	24691		170064	18100
2007[1]	27785	9854	5165	23911	8498	20822	27858		123894	56700
2008	27785	9854	5165	53394	23792	18873	26313		165176	
2009	27785	9854	5165	53394	31978	15739	27858		171774	
2010	27785	9854	5165	53394	17882	18562	27858		160501	
2011	27785	9854	5165	53394	33432	16835	27858		174324	
2012[2]	27785	9854	5165	53394	9917	17289	27858		151263	16700
2013	27785	9854	5165	53394	58183	21118	27858		203358	
2014[3]	27785	9854	5165	53394	54800	29897	27858	58048	208754	
2015	27785	9854	5165	53394	45449	26541	27858	47263	196047	
2016	27785	9854	5165	53526	29266	20342	27630	54387	173568	
2017[2]	27785	9854	5165	45493	12223	18524	27858	38786	146903	37460
2018	27785	9854	5165	53394	45193	23095	27630	44186	192117	
2019	27785	9854	5165	53394	56452	26788	27630	34035	207121	
2020[2]	27785	9854	5165	53394	47002	11475	26881	21614	181557	25148
2021[2]	27785	9854	5165	52848	33050	26897	27630	48777	183230	10933

[1]REZ not covered

[2]REZ not completely covered (Strata 7 and 13 in 2006, Area D' in 2012, strata 7, 13, 15, 7 and 20 in 2017, strata 17, 19, and 20 in 2020, and strata 16, 19, and 20 in 2021).

[3] Additional northern areas (N) covered from this year.

Table 1.4. Barents Sea winter surveys 1981-2021. Main Areas covered, and comments on incomplete coverage.

Year	Coverage	Comments
1981-1992	ABCD	
1993-1996	ABCDD'ES	
1997	Norwegian EEZ (NEZ), S	Not allowed access to Russian EEZ (REZ)
1998	NEZ, S, minor part of REZ	Not allowed access to most of REZ
1999	ABCDD'ES	Partly limited coverage due to westerly ice extension
2000	ABCDD'ES	Russian participation starts
2001-2005	ABCDD'ES	Russian vessel covered where Norwegians had no access
2006	ABCDD'ES	No Russian vessel, not allowed access to Murman coast
2007	NEZ, S	No Russian vessel, not allowed access to REZ
2008	ABCDD'ES	Russian vessel covered where Norwegians had no access
2009	ABCDD'ES	Reduced Norwegian coverage of REZ due to catch handling
2010	ABCDD'ES	Reduced Norwegian coverage of REZ due to bad weather
2011	ABCDD'ES	Russian vessel covered where Norwegians had no access
2012	ABCDD'ES	No Norwegian coverage of REZ due to vessel problems
2013	ABCDD'ES	No Norwegian coverage of REZ due to vessel shortage
2014	ABCDD'ESN	Strata 24-26 (N) covered for the first time
2015	ABCDD'ESN	Slightly reduced/more open coverage due to bad weather
2016	ABCDD'ESN	No access to REZ, Russian vessel covered most of REZ
2017	ABCDD'ESN	No Russian vessel, not allowed access to southwestern REZ
2018	ABCDD'ESN	Russian vessel covered where Norwegians had no access
2019	ABCDD'ESN	Russian vessel covered where Norwegians had no access
2020	ABCDD'ESN	Reduced coverage of D', E, and N due to bad weather, reduced survey time (medical emergency), and ice-cover
2021	ABCDD'ESN	Reduced coverage of D' and E due to ice cover and time constraints, and of area N due to ice cover.

2 Length and age material

Individual lengths are collected from all target species, while otoliths for age determination are taken from cod, haddock, and capelin. For cod and haddock, the otolith readings are key for splitting the survey indices by age.

Table 2.1 gives an account of the sampled length- and age material from bottom hauls and pelagic hauls from 1994 onwards.

Table 2.1. Number of fish measured for length (L) and age (A) in the Barents Sea winter survey 1994-2021.

	Cod		Haddock		Golden redfish	Beaked redfish	Greenland halibut	Blue whiting	Capelin		Polar cod
Year	**L**	**A**	**L**	**A**	**L**	**L**	**L**	**L**	**L**	**A**	**L**
1994	57290	3400	40608	1808	3157	12389	525				
1995	66264	3547	37775	1692	3785	9622	583				
1996	61559	3304	34497	1416	2510	10206	587				
1997	35381	2381	30054	1003	5429	10997	675				
1998	39044	2843	12512	859	1739	9664	649				
1999	22971	2321	12752	926	1266	6677	397				
2000	31543	2871	25881	1426	1161	8739	546		9172	1860	3702
2001	36789	2998	30921	1657	1173	7323	499		8079	2402	5955
2002	45399	3730	58464	2057	1143	6660	688		10643	2387	7283
2003	59573	2857	54838	1883	1102	4654	657		10390	1742	2510
2004	40851	3175	51705	1874	1438	5507	459		11633	1994	6080
2005	33582	3216	67921	2060	835	5166	832		12482	1892	6052
2006	19319	2683	23611	1899	728	3356	962		6851	2232	1362
2007	16556	2954	26610	2023	798	4544	973	4657	5475	1186	203
2008	26844	3809	50195	2490	897	8568	1020	1350	13772	886	3166
2009	22528	3486	40872	2433	455	9205	807	891	7636	776	617
2010	30209	4085	35881	2367	429	8564	984	626	12337	1189	551
2011	26913	3959	29180	2260	286	6885	607	105	11073	829	1492
2012	17139	3020	33524	1854	574	5721	354	2441	11047	1256	601
2013	14525	2451	19142	1671	479	6087	263	1091	15962	1591	3517
2014	22624	4501	35940	2586	563	9310	444	1846	32811	3647	6879
2015	25401	3795	18483	2038	395	8933	541	1991	15578	300	408
2016	16636	3368	25423	2067	614	8668	425	2396	11423	150	681
2017	12402	2851	15689	1955	576	8898	448	4799	5140	671	578
2018	42462	5178	43294	3307	1211	11500	548	1443	16219	788	876
2019	16217	5260	15967	3072	761	8981	413	886	13771	821	748
2020	19971	3770	11047	1641	1040	11853	711	866	16801	745	1569
2021	13714	4020	15253	1950	810	11292	1076	1722	16179	1377	5567

Table 2.2. shows the number of age readings per age for cod from 1994 onwards, while table 2.3 shows the same for haddock. The number of age samples for fish age 10+ increased in the second half of the time series, reflecting changing age composition in the stocks.

Table 2.2. Number of age samples from cod by age in the Barents Sea winter survey 1994-2021. Year-age combinations with < 5 aged individuals are highlighted in yellow. Abundance indices are still presented for ages with < 5 age samples but note the uncertainty level (c. f. tables 5.4 and 5.8). Biological parameters by age are presented for ages with a minimum of 3 age readings (c. f. tables 5.10-5.13).

Age/Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**20**
1994	283	354	392	652	571	363	124	54	37	16	19	3	2	-	-	-	-	-
1995	409	360	461	528	714	532	268	47	16	13	8	6	-	-	-	-	-	-
1996	304	564	359	400	462	584	384	108	23	8	6	5	3	1	-	-	-	-
1997	257	322	321	224	264	310	310	108	27	5	2	-	-	-	-	-	-	-
1998	331	311	445	425	220	242	257	193	39	6	3	-	1	-	2	-	-	-
1999	250	323	365	450	334	185	159	110	38	5	1	1	1	-	-	-	-	-
2000	256	365	470	491	578	340	119	66	50	12	4	2	1	-	-	-	-	-
2001	437	259	440	544	513	484	201	44	19	13	3	-	-	-	1	-	-	-
2002	162	650	478	661	607	506	345	90	16	7	3	-	-	-	1	-	-	-
2003	246	108	545	391	434	456	304	175	48	7	3	-	2	2	-	-	-	-
2004	311	493	260	599	368	407	387	254	87	17	6	1	1	-	-	-	-	-
2005	341	386	619	309	565	306	388	196	56	21	3	2	4	1	-	-	-	-
2006	291	364	423	521	234	430	194	162	68	18	6	3	-	-	-	-	-	-
2007	295	258	474	358	453	205	369	159	95	22	10	6	1	-	-	-	-	-
2008	169	366	676	866	471	532	246	300	72	17	2	1	1	-	-	-	-	-
2009	319	276	445	635	695	420	292	124	120	24	9	2	1	-	-	-	-	-
2010	429	369	292	489	571	745	371	247	93	64	25	2	2	3	-	-	1	-
2011	373	526	484	319	436	621	677	226	76	34	14	7	4	2	1	-	-	-
2012	275	214	319	330	198	303	504	415	100	47	25	10	9	2	1	1	-	-
2013	149	251	232	330	296	188	282	426	215	38	20	8	5	1	1	-	-	-
2014	414	301	571	387	415	341	186	368	308	89	18	12	4	1	2	1	-	-
2015	479	413	369	589	396	457	290	173	267	176	51	11	3	2	1	-	-	-
2016	235	529	405	484	678	437	418	323	164	178	86	20	15	3	3	1	1	-
2017	296	248	449	299	323	494	274	191	110	44	37	33	9	7	1	1	-	-
2018	508	762	592	901	438	491	673	338	186	91	45	51	23	4	4	3	1	-
2019	465	632	892	651	839	435	356	508	149	66	17	10	6	8	2	1	-	-
2020	265	523	755	830	585	673	432	305	310	88	41	11	16	10	10	7	-	-
2021	270	235	537	630	683	503	445	226	145	103	32	12	6	1	6	3	-	1

Table 2.3. Number of age samples from haddock by age in the Barents Sea winter survey 1994-2021. Year-age combinations with < 5 aged individuals are highlighted in yellow. Abundance indices are still presented for ages with < 5 age samples but note the uncertainty level (c. f. tables 6.4 and 6.8). Biological parameters by age are presented for ages with a minimum of 3 age readings (c. f. tables 6.10-6.13).

Age/Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1994	212	192	250	432	219	40	4	5	8	5	13	1	-	-	-	-	-	-
1995	289	177	131	241	543	156	15	1	2	1	-	5	1	-	-	-	-	-
1996	225	236	155	106	228	343	52	9	-	1	-	2	1	-	-	-	-	-
1997	169	62	147	86	44	113	163	19	4	-	-	-	2	1	-	-	-	-
1998	151	178	68	147	74	38	73	112	12	1	1	-	-	-	2	1	-	-
1999	251	112	238	81	98	44	19	23	24	1	-	1	-	-	-	-	-	-
2000	327	321	138	344	64	72	16	3	20	9	2	1	1	-	-	-	-	-
2001	388	339	430	99	315	26	23	3	3	3	8	1	2	-	-	1	-	-
2002	445	354	382	450	84	123	19	7	1	2	5	3	2	-	-	-	-	-
2003	376	234	154	268	298	42	32	5	3	3	3	1	1	-	-	-	-	-
2004	303	464	254	232	277	251	50	22	7	4	3	1	2	3	-	-	-	-
2005	487	263	437	247	189	284	125	4	4	1	-	-	-	-	-	-	-	-
2006	458	516	141	356	166	108	104	45	4	2	-	2	-	-	1	1	-	-
2007	422	404	372	116	257	107	51	34	15	4	2	-	-	-	1	-	-	-
2008	317	525	584	470	168	237	46	23	8	1	2	1	-	-	-	-	-	-
2009	298	318	562	488	473	114	78	13	2	5	-	1	-	-	-	-	-	-
2010	448	190	272	519	462	294	41	19	8	7	2	2	-	-	-	-	-	-
2011	337	394	123	205	494	440	159	15	3	-	-	2	1	-	-	-	-	-
2012	355	112	338	58	116	408	291	73	4	6	1	3	-	-	-	-	-	-
2013	176	377	134	328	56	75	286	204	35	3	-	-	-	-	-	-	-	-
2014	449	116	455	98	202	57	96	202	90	11	4	-	-	1	-	-	-	-
2015	429	371	88	524	81	160	43	110	123	55	6	3	1	-	-	-	-	-
2016	430	282	430	99	452	88	126	87	175	129	39	6	-	2	2	1	-	-
2017	449	385	250	294	43	236	54	62	21	68	48	26	3	-	-	-	-	-
2018	704	696	596	372	424	62	160	45	44	35	56	48	19	3	-	-	-	-
2019	644	630	679	486	211	187	39	46	14	24	7	12	8	3	-	1	-	1
2020	219	359	498	622	339	141	80	22	16	10	8	13	15	10	1	-	-	-
2021	439	68	244	373	501	172	51	19	5	5	4	3	6	2	-	1	-	-

3 Survey index calculation

Details on the calculation of survey indices, including StoX settings for different species are found in Appendix 1.

In 2021, the swept area and acoustic[1] estimation in StoX was based on the following biotic snapshot files (versioned trawl data):

Table 3.1: Snapshot files used in the 2021 swept area estimation, by species.

Cod and haddock
biotic_cruiseNumber_0153_2021_UFJN_VILN_Vilnyus_UFJN_2021-04-08T00.02.42.991Z
biotic_cruiseNumber_2021203_Johan+Hjort_2021-03-24T00.07.59.564Z
biotic_cruiseNumber_2021701_Kronprins+Haakon_2021-03-27T00.03.00.532Z
biotic_cruiseNumber_2021846_Helmer+Hanssen_2021-03-26T00.03.35.488Z
Redfish (three species)
biotic_cruiseNumber_0153_2021_UFJN_VILN_Vilnyus_UFJN_2021-05-26T22.06.21.681Z
biotic_cruiseNumber_2021203_Johan+Hjort_LDGJ_2021-06-09T22.02.32.960Z
biotic_cruiseNumber_2021701_Kronprins+Haakon_3YYQ_2021-05-26T22.06.49.166Z
biotic_cruiseNumber_2021846_Helmer+Hanssen_LAHV_2021-06-09T22.00.55.646Z
Greenland halibut
biotic_cruiseNumber_0153_2021_UFJN_VILN_Vilnyus_UFJN_2021-04-08T00.02.42.991Z.xml
biotic_cruiseNumber_2021203_Johan+Hjort_LDGJ_2021-04-20T00.06.09.393Z.xml
biotic_cruiseNumber_2021701_Kronprins+Haakon_3YYQ_2021-04-21T00.08.41.965Z.xml
biotic_cruiseNumber_2021846_Helmer+Hanssen_LAHV_2021-04-17T00.01.30.897Z.xml
Blue whiting
biotic_cruiseNumber_0153_2021_UFJN_VILN_Vilnyus_UFJN_2021-04-08T00.02.42.991Z.xml
biotic_cruiseNumber_2021203_Johan+Hjort_LDGJ_2021-04-20T00.06.09.393Z.xml
biotic_cruiseNumber_2021701_Kronprins+Haakon_3YYQ_2021-04-21T00.08.41.965Z.xml
biotic_cruiseNumber_2021846_Helmer+Hanssen_LAHV_2021-04-17T00.01.30.897Z.xml

[1]Acoustic estimation is done for cod and haddock only. The biotic files are used in the acoustic StoX projects to split the acoustic backscatter by age. For acoustic data, the latest version was used. Versioned acoustic files will be available in 2022.

3.1 Raising of indices

In 1997, 1998 and 2007 only the Norwegian EEZ (NEZ) and parts of the Svalbard area (S) was covered. The swept-area indices for cod, haddock, golden redfish, beaked redfish and Greenland halibut have therefore been raised to also represent the Russian EEZ (REZ) (Mehl *et al*. 2016).

In 2006, there was not a complete coverage in southeast due to restrictions. The observations in the partially covered strata 7 were extrapolated to the full strata, and the observations in the partially covered strata 13 were extrapolated to the same area as covered in 2005.

In 2012 the coverage was incomplete in the eastern areas, and the cod and haddock swept area estimates within the covered area were raised by the “index ratio by age” observed for the same area in 2008-2011 (ICES 2012). The scaling factor (“index ratio”) for estimating adjusted total from <Total – area D’> was the average ratio by age for Total/(Total – area D’) in the years 2008-2011 (Aglen et al. 2012).

In 2017, the Norwegian vessel was not allowed to operate south of 70º 10’ N and west of 41º 00 º E, and no Russian vessel participated in the survey. Only a small part of strata 7 was covered, and strata 13, 15, 17 and 20 were not covered. The cod, haddock, Greenland halibut and beaked redfish swept area estimates and cod and haddock acoustic estimates within the covered area were raised following the same procedure as for 2012. The scaling factor for estimating adjusted total from <Total –strata 7 > was the average ratio by age for Total/(Total – (strata 7+13+15+17+20)) swept area indices in the years 2014-2016.

In 2020, coverage was incomplete in strata 17, 19, and 20, and the cod and haddock acoustic and swept area estimates were raised by the “index ratio by age” observed for these strata in 2018-2019. The scaling factor for estimating adjusted total from <Total –strata 17, 19 and 20> was the average ratio by age for Total/(Total – (strata 17+19+20)) in the years 2018-2019.

In 2021, coverage was incomplete in strata 16, 19, and 20. Indices in the partly covered stratum 19 were extrapolated to the entire strata. No trawling was done in stratum 20. As cod and haddock abundances generally are low there, the stratum was partly ice covered and did not have coverage in the last two years, this stratum was excluded from estimation. Only one trawl station was taken in stratum 16. Here the cod and haddock acoustic and swept area estimates were raised by the “index ratio by age” observed for these strata in 2019-2020. The scaling factor for estimating adjusted total from <Total –strata 16> was the average ratio by age for Total/(Total – strata 16) in the years 2019-2020.

4 Total echo abundance of cod and haddock

Table 4.1 presents the time series of total echo abundance (mean s_A multiplied by strata area and summed over all strata) of cod and haddock in the investigated areas.

Table 4.1. Cod and haddock. Total echo abundance in the Barents Sea winter 1994-2021 (m^2 reflecting surface · 10^3) estimated by StoX. Observations outside main areas A-S are not included.

	StoX		
Year	**Cod**	**Haddock**	**Sum**
1994	5282	3898	9180
1995	3671	2948	6619
1996	2789	1248	4037
1997[1]	1355	832	2187
1998[1]	2254	543	2797
1999	1517	771	2288
2000	2833	1534	4367
2001	2158	1488	3646
2002	1976	2247	4223
2003	3717	3570	7287
2004	1174	2087	3261
2005	1370	2519	3889
2006	1116	2541	3657
2007[1]	675	2311	2986
2008	3510	6195	9705
2009	2452	5300	7752
2010	3526	5939	9465
2011	2967	3715	6682
2012	3478	4182	7660
2013	5026	3604	9656
2014	4847	2915	7762
2015	5245	2161	7406
2016	2879	1587	4466
2017[1]	2139	2588	4732
2018	3537	2851	6388
2019	3282	3039	6321
2020[1]	2676	2199	4875
2021[1]	1128	983	2111

[1] not scaled for uncovered areas

Since 1993 the acoustic values have been split between the two species during the scrutinizing. The values for cod have shown an increasing trend since the late 2000s, with a peak in 2013-2015. Total echo abundance was 40% lower in 2016 compared to 2015 and decreased further from 2016 to 2017, while there was an increase of more than 50% from 2017 to 2018-2019 and then a decrease in 2020 to a level similar to that in 2017. The 2021 echo abundance is the third lowest in the time series, and the lowest observed since 2006 (the lower value in 2007 likely reflects the lack of coverage of the Russian zone and is not directly comparable).

The values for haddock increased gradually from the end of the 1990s to 2008, decreased gradually to less than one third of the 2008 value in 2016 but increased considerably in 2017 and further in 2018 and 2019 before decreasing in 2020. The 2021 echo abundance is the fourth lowest in the time series, and the lowest observed since 1999.

5 Distribution and abundance of cod

5.1 Acoustic estimation

Surveys in the Barents Sea at this time of the year mainly cover the immature part of the cod stock. Most of the mature cod (age 7 and older) have started on their spawning migration southwards out of the investigated area and are therefore to a lesser extent covered. There are indications that a higher proportion than normal spawned along Finnmark in some years, e.g., 2004-2006. Thereby a higher proportion of spawners might have been covered by the survey in those years. Figure 5.1 shows the spatial distribution of acoustic registrations assigned to cod in 2021. The registrations reflect the general distribution of cod in the central and southwestern Barents Sea. The NASC values in 2021 were low, reflecting the overall low echo abundance.

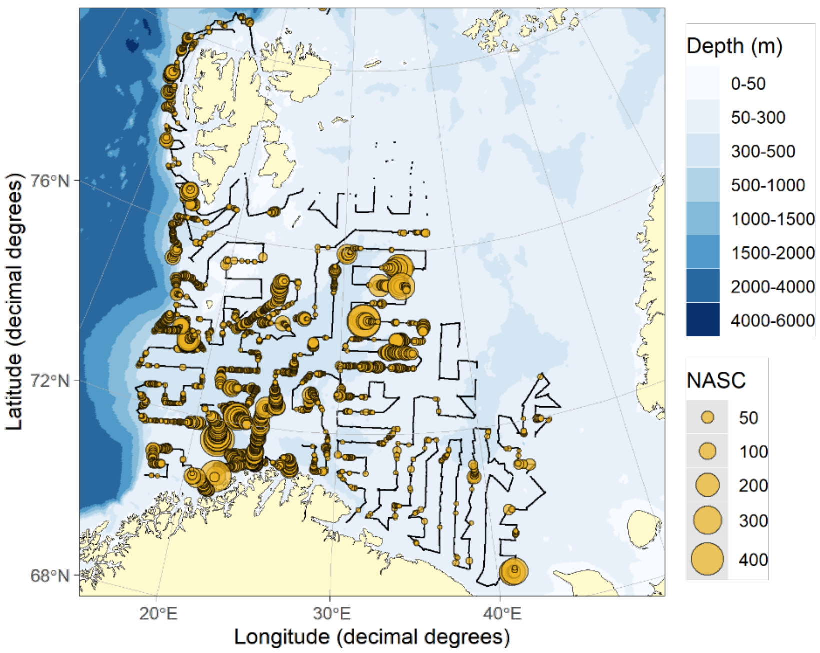

Figure 5.1. COD NASC. Distribution of acoustic backscatter (m^2/nmi^2) assigned to cod in 2021. The black lines without yellow circles represent parts of the cruise track where the acoustic backscatter was scrutinized but not assigned to cod. NASC values < 5 was set to zero for this illustration.

Table 5.1 shows the acoustic indices for each age group by main areas in 2021. 7 % of the 1-year olds were found in the extended area (N) in 2021 compared to 16 % in 2021. Age 4 cod had the highest percentage of total abundance in area N with 12 %. The time series of total abundance at age (1994-2021) is presented in Table 5.2. The entire series was revised during the 2021 WKBARFAR benchmark (ICES 2021) and is therefore not identical to previous reports. The main revisions concerned using bootstrap mean abundance and including area N in the main index. The biological parameters (growth, maturity) presented in this report are also bootstrap mean estimates.

The acoustic estimates have been variable and increasing in later years, with a peak in biomass in 2013, and this may partly be explained by variable and not complete coverage of the distribution area towards north and east in several years. As cod grow older it gets a more south-westerly distribution during winter, so that it "grows" into the incomplete survey. This is especially evident for the strong 2004 and 2005 year-classes, which as 6-11-year-olds stand out as the strongest in the time series. Of more recent year-classes, 2014 seemed strong at age 1, while at age 2 and 3 it appeared rather moderate. However, at age 4 and 5 it again appears to be strong. Both year class 2017 and 2018 seem strong at age 1, while the number of 1-year-olds in 2020 was the lowest observed since 2008. The number of 1-year olds in 2021 is half of the 2020 estimate and the second lowest in the time series. Table 5.3 shows time series for strata 24-26 (area N) in 2014-2021, which are included in the main time series. The 2021 abundance and biomass in area N are the lowest observed in the time series.

Table 5.4 presents estimated coefficients of variation (CV) for cod age groups 1-14 in 1994-2021. These estimates were obtained by using StoX with a stratified bootstrap routine treating each transect as the primary sampling unit. In addition, a bootstrap routine for all trawl stations by strata was carried out within each run. The estimated CV (Standard Deviation · 100/mean) is estimated from 500 iterations. A CV of 20% or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). In 2020 the age groups 5-10 fall into this category. Values above this indicate higher uncertainty of the estimated index, with reduced information regarding year class strength. In all years, CVs for age groups older than 10 years are above what could be considered as acceptable. This is to a large degree related to low catch rates resulting in fewer age samples for these age groups (Table 2.2). In 2021, CVs for ages 1-4 are unusually high, which is likely caused by patchy distributions resulting from the low abundance.

Table 5.1. COD. Abundance indices (numbers in millions) for the main areas of the Barents Sea from acoustic survey winter 2021 estimated by StoX software. Bootstrap mean estimates.

Age group																**Total**	**Biomass ('000 t)**
Area	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**		
A	2.98	1.48	5.38	8.48	15.8	16.1	15.5	6.12	2.53	1.41	0.99	0.00	0.00	0.00	0.00	76.7	147.4
B	0.65	0.11	0.35	1.21	2.71	1.88	3.10	2.23	1.46	1.96	0.73	0.22	0.05	0.00	0.06	16.7	65.9
C	0.68	0.19	0.70	0.83	1.42	1.46	1.00	0.60	0.41	0.33	0.18	0.00	0.00	0.00	0.03	7.84	17.5
D	8.6	2.80	7.1	7.8	8.7	3.1	2.13	0.71	0.37	0.21	0.05	0.04	0.00	0.00	0.04	41.6	32.6
D'[1]	0.91	0.50	0.8	0.8	1.0	0.51	0.54	0.35	0.09	0.13	0.04	0.02	0.10	0.00	0.07	5.77	10.5
E	21.1	18.8	39.3	25.1	8.42	4.84	3.02	0.54	0.62	0.09	0.10	0.00	0.00	0.00	0.00	122.0	46.3
S	7.0	2.21	4.73	7.1	12.5	6.9	3.87	1.37	0.63	0.34	0.08	0.00	0.02	0.00	0.00	46.7	49.7
N	3.35	1.85	4.11	6.72	4.13	3.70	1.61	0.45	0.20	0.21	0.01	0.01	0.00	0.00	0.01	26.4	24.2
ABCD	12.9	4.59	13.5	18.3	28.6	22.5	21.7	9.67	4.78	3.92	1.94	0.26	0.05	0.00	0.14	142.9	263.4
AN	45.3	28.0	62.4	58.1	54.6	38.4	30.8	12.4	6.32	4.67	2.17	0.29	0.18	0.00	0.21	343.8	394.2
Scaling	1.015	1.019	1.040	1.018	1.015	1.002	1.001	1.002	1.001	1.000	1.000	1.000	1.000	1.000	1.000		
AN (total) adjusted	45.9	28.5	64.9	59.1	55.5	38.5	30.8	12.4	6.32	4.67	2.17	0.29	0.18	0.00	0.21	349.4	400.67[2]

[1]Excluding estimate for stratum 16, where the age split was based on one trawl station only.

[2]Based on ratio between unraised biomass and unraised numbers at age

Table 5.2. COD. Abundance indices (numbers in millions) from acoustic surveys in the Barents Sea standard area winter 1994-2021 estimated by StoX software. Boostrap mean estimates.

Age group																**Total**	**Biomass ('000 t)[4]**
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**		
1994	902.64	624.38	323.88	374.47	205.53	70.24	13.00	3.59	2.60	0.71	1.15	0.11	0.13	0.00	0.00	2522.43	1060.26
1995	2175.25	212.29	137.74	139.49	197.08	66.38	15.73	2.43	0.91	0.32	0.48	0.17	0.00	0.00	0.00	2948.27	665.14
1996	1826.33	271.71	99.40	89.62	111.34	82.96	22.17	2.22	0.30	0.10	0.07	0.05	0.10	0.01	0.00	2506.38	504.47

1997[1]	1698.49	565.31	158.57	44.22	49.91	40.91	23.48	5.02	0.84	0.27	0.09	0.00	0.00	0.01	0.00	2587.12	346.39
1998[1]	2523.56	475.15	391.16	189.79	44.87	41.22	27.85	16.06	1.81	0.50	0.04	0.00	0.00	0.00	0.06	3712.07	563.03
1999	364.84	231.51	147.62	130.29	52.03	11.93	6.94	4.13	1.47	0.24	0.01	0.03	0.01	0.00	0.00	951.05	262.81
2000	153.42	262.81	294.83	167.25	145.55	50.75	11.33	4.70	2.75	0.85	0.18	0.11	0.03	0.00	0.00	1094.56	545.52
2001	363.55	51.45	177.44	160.63	80.80	44.47	11.10	1.73	0.46	0.19	0.08	0.00	0.00	0.00	0.01	891.91	435.40
2002	19.22	209.10	61.37	106.23	98.78	52.18	20.07	2.90	0.32	0.52	0.09	0.00	0.00	0.00	0.02	570.8	428.50
2003	1505.00	52.53	306.71	116.80	124.62	116.52	37.69	10.05	1.93	0.31	0.07	0.00	0.08	0.07	0.00	2272.38	755.03
2004	161.20	117.19	33.41	85.21	32.96	28.03	18.14	5.33	1.16	0.31	0.08	0.00	0.01	0.00	0.00	483.03	244.57
2005	499.71	138.66	125.03	33.28	65.94	21.21	15.02	4.95	1.01	0.25	0.05	0.07	0.05	0.03	0.00	905.26	259.70
2006[2]	411.21	157.95	64.77	53.82	18.35	29.52	9.50	4.90	1.28	0.20	0.13	0.30	0.00	0.00	0.00	751.93	227.27
2007[1]	85.13	47.09	58.49	30.40	29.35	9.04	18.07	6.41	2.67	0.53	0.24	0.07	0.00	0.00	0.00	287.49	213.63
2008	50.87	94.20	199.85	288.71	116.17	72.91	21.82	14.43	2.80	0.81	0.04	0.01	0.01	0.00	0.00	862.63	822.87
2009	204.90	25.46	107.83	182.54	138.08	41.48	13.87	4.69	4.32	0.50	0.14	0.02	0.01	0.00	0.00	723.84	536.93
2010	620.25	43.56	22.82	87.98	160.16	154.39	44.56	14.57	3.90	2.89	0.94	0.11	0.12	0.09	0.01	1156.35	885.82
2011	266.00	91.00	40.36	28.32	65.20	106.97	101.80	19.76	6.11	1.70	0.92	0.25	0.15	0.09	0.02	728.65	787.82
2012[3]	496.49	40.23	82.79	49.38	33.77	72.53	132.31	65.59	8.37	4.39	1.21	0.66	0.47	0.04	0.10	988.33	969.09
2013	313.11	89.17	60.55	84.49	72.18	47.75	98.41	130.54	55.32	5.41	4.02	1.30	0.73	0.20	0.07	963.25	1494.33
2014	1758.58	211.04	286.89	124.18	111.14	74.47	39.41	89.89	61.31	22.64	2.56	1.31	0.16	0.05	0.19	2783.82	1437.38
2015	1903.54	211.41	138.71	235.58	128.80	140.36	80.55	35.07	53.80	24.38	7.91	0.80	0.13	0.05	0.01	2961.1	1469.58
2016	240.80	201.89	56.29	76.91	119.38	64.84	50.17	25.80	13.49	17.83	7.35	2.15	0.72	0.22	0.10	877.94	873.17
2017[3]	439.40	73.30	111.54	42.35	44.25	65.30	35.75	24.31	11.97	4.00	2.88	3.15	0.67	0.19	0.11	859.17	680.62
2018	2057.60	280.29	109.03	149.94	53.40	54.93	66.09	34.35	10.78	6.27	1.73	2.25	1.50	0.15	0.23	2828.54	883.80
2019	1437.21	362.38	203.63	125.42	144.06	60.98	34.99	37.86	9.64	3.47	0.55	0.32	0.18	0.28	0.24	2421.21	842.03
2020[3]	92.68	157.92	117.32	117.32	81.36	90.60	42.35	26.57	21.41	6.23	1.75	0.67	0.66	0.51	0.89	758.24	809.18
2021[3]	45.92	28.51	64.86	59.08	55.48	38.54	30.80	12.41	6.32	4.67	2.17	0.29	0.18	0.00	0.21	349.45	400.67

[1]Indices raised to also represent the Russian EEZ.

[2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005.

[3]Indices raised to also represent uncovered parts of the Russian EEZ.

[4]1994-2020: bootstrap mean biomass estimated based on relationship between (unraised) numbers-at-age and biomass-at-age from StoX baseline run. From 2021: bootstrap mean biomass estimated directly in StoX; in years with adjustments for lack of coverage it is estimated based on relationship between unraised bootstrap mean numbers-at-age and unraised bootstrap mean biomass-at-age.

Table 5.3. COD. Abundance indices (numbers in millions) for new strata 24-26 from acoustic surveys in the Barents Sea winter 2014-2021 estimated by StoX software. 2014-2020: baseline estimates, from 2021: bootstrap mean estimates.

Age group																**Biomass**
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**('000 t)**
2014	1112.50	53.97	54.53	11.67	14.62	7.31	2.26	4.73	2.98	0.27	0.02	0.00	0.00	0.00	0.00	1264.87	103.44
2015	589.67	88.32	25.22	49.00	12.68	11.24	5.34	1.08	3.40	1.16	0.77	0.05	0.00	0.00	0.00	787.93	122.36
2016	104.90	84.60	17.95	14.58	16.83	2.47	2.94	1.86	0.30	0.67	0.17	0.02	0.01	0.00	0.00	247.30	60.15
2017	31.09	28.70	26.54	5.44	5.68	4.13	1.54	0.65	0.24	0.05	0.28	0.04	0.00	0.00	0.00	104.37	40.15
2018	514.18	50.59	16.17	16.74	6.96	4.35	8.64	0.99	0.76	0.25	0.08	0.12	0.01	0.00	0.00	619.85	76.08
2019	371.39	75.30	20.87	27.74	20.56	7.98	3.63	5.27	0.42	0.44	0.14	0.04	0.01	0.03	0.00	533.82	112.10
2020	12.66	13.01	16.05	11.60	12.75	7.53	3.10	1.87	2.67	0.44	0.25	0.09	0.06	0.00	0.08	82.15	71.84
2021	3.35	1.85	4.11	6.72	4.13	3.70	1.61	0.45	0.20	0.21	0.01	0.01	0.00	0.00	0.01	26.36	24.23

Table 5.4. COD. Estimates of coefficients of variation (%) for acoustic abundance indices. Barents Sea standard area winter 1994-2021.

Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1994	30	41	29	12	7	10	13	19	20	29	29	69	89	-
1995	14	24	15	9	7	8	12	23	26	35	54	50	-	-
1996	11	15	14	10	10	11	14	16	29	43	58	54	100	110
1997[1]	33	29	14	11	10	10	8	13	22	54	63	-	-	129
1998[1]	23	18	11	9	10	8	8	11	22	36	45	-	101	-
1999	22	23	17	15	10	11	11	13	25	58	114	121	107	-
2000	31	26	17	10	7	10	17	21	22	42	72	68	110	-
2001	13	15	11	9	10	9	13	22	32	36	78	-	-	-
2002	18	16	10	6	7	10	15	17	32	78	73	-	-	-
2003	26	31	15	13	8	8	13	17	20	40	59	-	99	94
2004	18	16	13	10	10	10	9	13	16	45	58	95	125	-
2005	26	49	19	14	14	14	12	20	26	24	62	90	49	91
2006[2]	24	14	11	8	8	10	16	18	19	37	61	66	-	-
2007[1]	27	24	14	14	11	17	21	24	27	36	42	44	92	-
2008	18	24	15	16	13	10	16	14	20	44	75	65	100	-
2009	21	20	26	22	18	17	13	14	19	32	45	71	112	-
2010	36	17	19	25	17	12	11	13	17	22	28	86	74	70
2011	13	27	12	11	11	10	9	15	28	29	35	39	66	86
2012[2]	36	14	53	11	19	19	17	13	19	35	33	55	52	81
2013	15	21	13	9	11	11	14	11	18	35	44	55	66	108
2014	15	10	11	10	13	8	11	11	14	21	30	53	59	96
2015	27	22	15	15	10	14	18	21	19	29	48	55	63	70
2016	36	20	13	13	11	15	17	16	23	23	32	46	55	87
2017[2]	15	19	12	11	10	8	11	14	21	22	19	25	31	58
2018	11	9	9	9	9	8	8	13	15	24	24	33	53	51
2019	12	12	8	7	6	11	12	10	14	23	32	55	49	60
2020[2]	15	15	10	7	10	11	15	16	18	23	29	38	31	38
2021[2]	32	42	34	21	13	13	17	16	20	20	29	44	69	175

[1]REZ not covered

[2]REZ partly covered

5.2. Swept area estimation

Figures 5.2 - 5.5 show the geographic distribution of bottom trawl catch rates (number of fish per NM^2, for cod size groups < 20 cm, 20-34 cm, 35-49 cm and ≥ 50 cm. Usually, a high proportion of the smallest cod (less than 35 cm) are found in the eastern part of the survey area within the Russian EEZ and near the northern borders of the standard strata system (strata 1-23). While this general pattern was still there in 2021, the smallest cod was nearly absent from the southern and south-eastern areas (Fig. 5.2). Catch rates of medium and large sized cod (35-50+ cm) were particularly low in the central Barents Sea (Figs 5.4-5.5). The highest catch rates of large cod are usually found along the Norwegian coast and around Svalbard and the ice edge in the north, but in 2021 there were relatively lower catch rates in the south (Fig. 5.5).

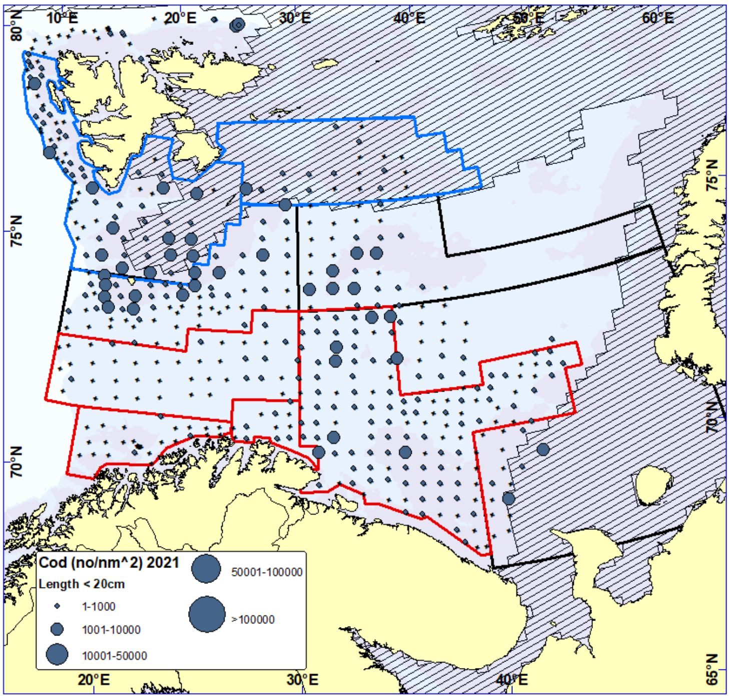

Figure 5.2. COD < 20 cm. Distribution in valid bottom trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches. Data source for the ice cover: https://cryo.met.no/archive/ice-service/icecharts/quicklooks/2021/

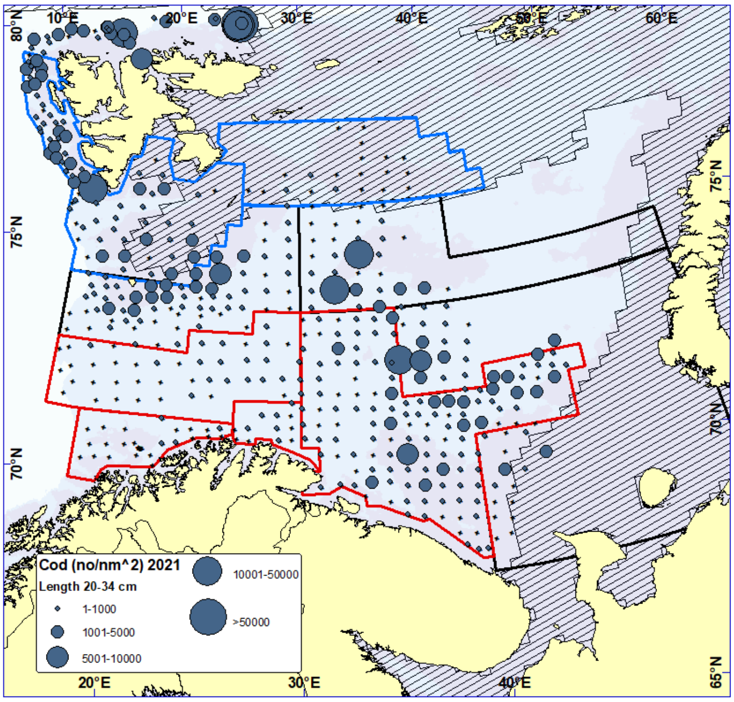

Figure 5.3. COD 20-34 cm. Distribution in valid bottom trawl catches winter 2021 (number per nm²). Black crosses indicate zero catches.

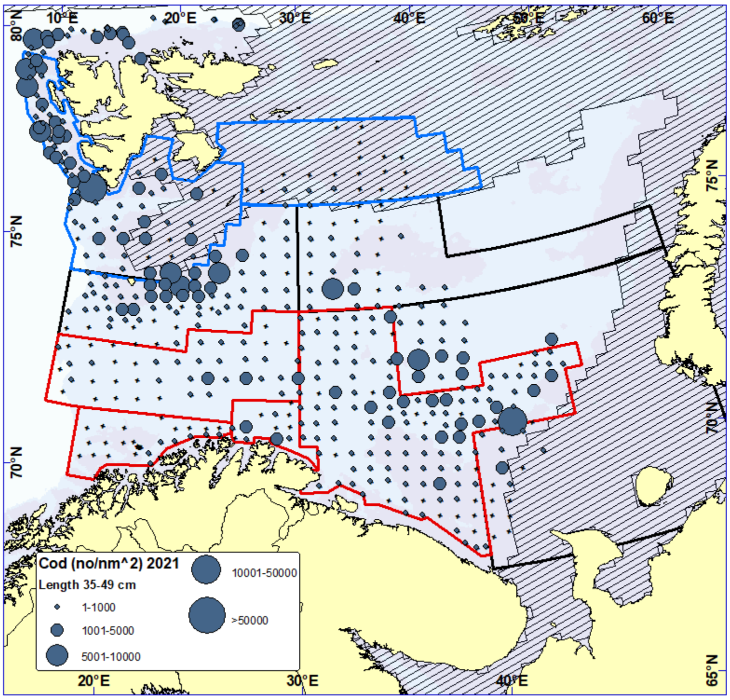

Figure 5.4. COD 35-49 cm. Distribution in valid bottom trawl catches winter 2021 (number per nm²). Black crosses indicate zero catches.

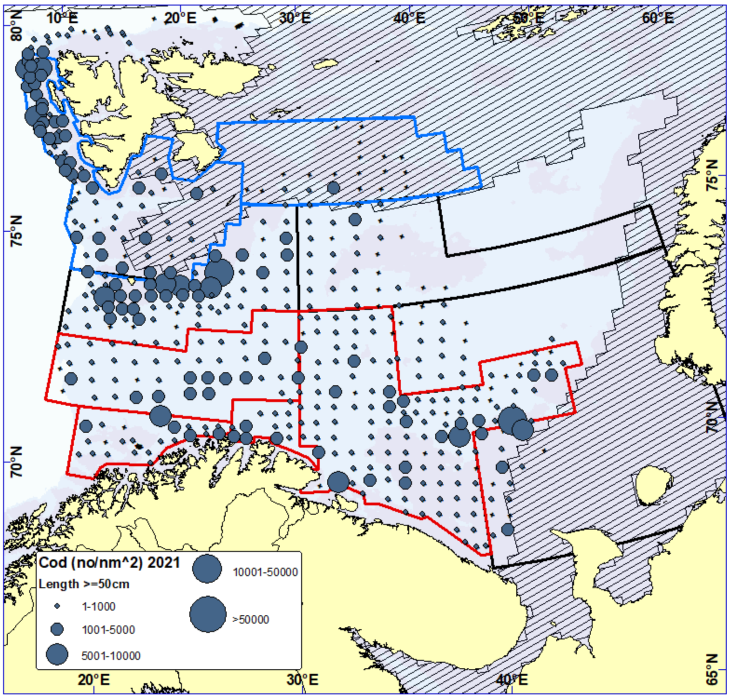

Figure 5.5. COD ≥ 50 cm. Distribution in valid bottom trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

Table 5.5 presents abundance indices by main areas and age, and the full time series 1994-2021 is shown in Table 5.6. The bottom trawl indices have fluctuated somewhat due to the same reasons as for the acoustic indices, and the 2004 and 2005 year-classes stand out as the strongest in the time series. The 2009, 2011 and 2014 year-classes seemed to be strong as 1-year olds but have later been reduced to average level or below. The year classes 2017 and 2018 also seemed strong at age one but are more average as 2- and 3-year-olds. The abundance of 1-year-olds in 2021 is less than half of the abundance in 2020, and the third lowest in the time series. A considerable number of cod was found in the extended survey area N (Table 5.7), which from 2021 was included in the official indices used for stock assessment. Looking at total estimates, about 28% of cod by numbers and about 23% by biomass were found in this area in 2021. Tables 5.7 present swept area abundance indices by age for area N in 2014-2021. As in the previous years, fair amounts of cod were also observed northeast of the extended area, outside of the survey stratification.

Table 5.8 presents estimated coefficients of variation (CV) for cod age groups 1-15 in 1994-2021. In 2021, age groups 1-10 have CVs below or equal to 20 %. Values above this indicate higher uncertainty of the estimated index, with reduced information regarding year class strength. In all years, CVs for age groups older than 10 years are above what could be considered as acceptable. This is to a large degree related to low catch rates resulting in fewer age samples for these age groups (Table 2.2). The high CVs for ages 1-3 in the acoustic index are not reflected in the bottom trawl index, suggesting that the variation in the acoustic index is related to variation in the acoustic values allocated to these age groups rather than variation in the bottom trawl catches themselves.

Table 5.5. COD. Abundance indices from bottom trawl hauls for main areas of the Barents Sea winter 2021 (numbers in millions). Bootstrap mean estimates.

Age group																**Biomass**
Area	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**('000 t)**
A	1.44	0.66	2.18	3.16	7.59	6.54	6.66	2.36	1.26	0.63	0.42	0.00	0.00	0.00	0.00	32.9	62.6
B	0.14	0.02	0.08	0.18	0.42	0.37	1.11	0.82	0.31	0.48	0.18	0.03	0.01	0.00	0.01	4.17	16.7
C	0.67	0.12	0.59	0.97	1.47	1.31	0.68	0.52	0.27	0.17	0.23	0.00	0.00	0.00	0.03	7.04	15.3
D	13.4	7.64	21.3	25.9	30.8	11.8	9.50	3.61	1.91	0.62	0.17	0.15	0.00	0.04	0.06	126.9	129.0
D'[1]	5.11	4.28	17.5	16.9	16.3	3.48	4.25	1.87	0.83	0.20	0.14	0.16	0.20	0.00	0.20	71.4	58.5
E	10.5	4.68	28.6	20.6	4.22	2.65	1.62	0.19	0.33	0.04	0.04	0.00	0.00	0.00	0.00	73.5	26.4
S	14.2	3.34	8.94	12.8	18.6	13.0	6.45	2.46	1.19	0.54	0.03	0.00	0.04	0.00	0.00	81.5	78.6
N	32.0	12.5	22.7	32.5	26.6	14.8	7.51	1.66	1.13	0.86	0.04	0.08	0.0	0.0	0.02	152.5	115.8
ABCD	15.7	8.45	24.1	30.2	40.3	20.0	17.9	7.31	3.75	1.90	1.00	0.18	0.01	0.04	0.10	171.0	223.6
AN	77.5	33.3	101.9	113.0	106.0	54.0	37.8	13.5	7.23	3.53	1.25	0.42	0.25	0.04	0.32	549.9	502.8
Scaling	1.044	1.049	1.095	1.056	1.059	1.006	1.006	1.005	1.005	1.000	1.000	1.000	1.000	1.000	1.000		
AN (total) adjusted	80.9	34.9	111.5	119.3	112.3	54.3	38.0	13.6	7.27	3.53	1.25	0.42	0.25	0.04	0.32	577.8	528.4[2]

[1]Excluding estimate for stratum 16, which was based on one trawl station only.

[2]Based on ratio between unraised biomass and unraised numbers at age

Table 5.6. COD. Abundance indices (numbers in millions) from bottom trawl surveys in the Barents Sea standard area winter 1994-2021. Bootstrap mean estimates.

Age group																	**Biomass**
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**('000 t)**
1994	1043.78	556.68	293.92	307.04	153.33	45.72	7.95	2.61	1.48	0.55	0.55	0.08	0.05	0	0	2413.74	763.41
1995	5356.43	541.25	282.84	242.36	251.01	76.42	17.98	2.42	1.07	0.50	0.61	0.19	0	0	0	6773.08	937.79
1996	5899.23	791.62	163.08	117.43	138.59	108.88	24.43	2.64	0.37	0.17	0.12	0.07	0.07	0.02	0	7246.72	718.00
1997[1]	5044.09	1422.92	317.99	68.44	74.26	59.99	26.67	4.85	0.64	0.91	0.08	0	0	0	0	7020.84	558.85
1998[1]	2490.54	496.48	355.10	166.94	31.67	26.15	17.52	8.16	0.79	0.52	0.04	0	0	0	0.04	3593.95	432.77

1999	473.04	350.21	188.48	180.75	61.39	12.71	6.81	5.14	1.01	0.26	0.02	0.04	0.02	0	0	1279.88	322.68
2000	128.57	242.33	245.81	130.03	111.73	26.75	4.56	1.84	1.21	0.33	0.10	0.03	0.02	0	0	893.31	363.23
2001	712.77	78.03	182.79	195.11	82.90	37.96	9.45	1.17	0.44	0.19	0.04	0	0	0	0.01	1300.86	436.57
2002	34.11	418.73	118.36	137.56	108.95	45.79	14.40	2.20	0.32	0.18	0.05	0	0	0	0.02	880.67	447.43
2003	3022.23	65.78	376.70	126.31	93.93	66.88	17.50	4.67	1.02	0.17	0.04	0	0.02	0.02	0	3775.27	546.13
2004	322.87	242.94	63.88	184.62	53.46	43.24	30.59	6.85	1.65	0.28	0.07	0.01	0.01	0	0	950.47	415.07
2005	853.43	216.67	248.88	55.06	102.97	22.38	16.36	3.81	0.92	0.30	0.04	0.02	0.04	0.04	0	1520.92	359.76
2006[2]	674.21	289.39	116.49	115.38	28.32	43.42	13.72	5.24	1.36	0.24	0.18	0.18	0	0	0	1288.13	334.94
2007[1]	594.69	369.74	361.13	127.73	68.51	13.65	23.60	6.82	2.30	0.41	0.11	0.10	0	0	0	1568.79	444.84
2008	68.83	101.96	194.37	300.59	111.90	40.24	17.34	8.11	1.79	0.36	0.03	0.02	0.01	0	0	845.55	686.98
2009	389.48	35.59	126.28	196.70	220.23	60.69	17.90	9.02	5.24	0.51	0.17	0.03	0.04	0	0	1061.88	757.32
2010	1027.59	95.14	36.81	114.25	154.80	144.50	39.56	11.24	3.67	1.60	0.58	0.04	0.02	0.04	0.02	1629.86	827.36
2011	617.18	225.81	85.40	50.37	129.70	138.66	103.51	16.37	4.36	1.20	0.82	0.19	0.14	0.04	0.02	1373.77	891.44
2012[3]	702.97	100.30	75.72	64.59	33.71	90.69	132.58	48.61	9.02	2.26	0.88	0.55	0.44	0.07	0.05	1262.44	879.93
2013	435.72	142.96	68.84	114.09	63.18	40.43	64.54	76.38	33.52	2.22	2.87	0.40	0.35	0.06	0.03	1045.59	951.73
2014	1245.71	191.48	226.85	93.79	88.59	56.39	32.74	53.05	36.19	9.81	1.01	0.95	0.15	0.02	0.08	2036.81	897.87
2015	1642.00	342.76	144.07	228.25	147.29	113.53	74.43	29.22	53.51	18.08	3.38	0.75	0.12	0.07	0.04	2797.50	1338.73
2016	312.16	305.57	99.37	135.48	188.31	113.47	72.33	28.56	13.17	16.06	6.77	0.97	0.52	0.17	0.14	1293.05	1085.06
2017[3]	644.51	128.92	179.25	62.15	84.54	90.16	37.82	26.33	8.18	3.26	2.61	3.70	0.58	0.17	0.06	1272.24	753.67
2018	2714.35	500.69	139.41	184.78	61.81	64.17	73.88	25.88	9.28	5.87	1.29	2.46	1.23	0.13	0.37	3785.60	908.45
2019	1790.57	559.44	281.57	179.15	221.90	79.65	32.96	38.31	8.15	2.62	0.54	0.24	0.16	0.18	0.12	3195.56	974.96
2020[3]	164.75	273.82	237.73	160.24	131.56	114.88	49.83	24.26	20.44	4.53	1.66	0.93	0.51	0.26	0.73	1186.13	857.96
2021[3]	80.88	34.87	111.50	119.35	112.31	54.28	37.98	13.57	7.27	3.53	1.25	0.42	0.25	0.04	0.32	577.83	528.35

[1]Indices raised to also represent the Russian EEZ. [2]Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005

[3]Indices raised to also represent uncovered parts of the Russian EEZ.

[4]1994-2020: bootstrap mean biomass estimated based on relationship between (unraised) numbers-at-age and biomass-at-age from StoX baseline run. From 2021: bootstrap mean biomass estimated directly in StoX; in years with adjustments for lack of coverage it is estimated based on relationship between unraised bootstrap mean numbers-at-age and unraised bootstrap mean biomass-at-age

Table 5.7. COD. Abundance indices (numbers in millions) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2021. 2014-2020: baseline estimates, from 2021: bootstrap mean estimates.

Age group																
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**Biomass ('000 t)**
2014	748.12	42.98	48.57	10.06	20.35	9.31	1.32	5.43	4.64	0.30	0.03	0.00	0.00	0.00	0.00	891.11	116.75
2015	348.99	146.89	19.05	56.40	12.38	14.08	5.43	1.59	2.22	1.27	0.42	0.05	0.00	0.00	0.00	608.77	132.51
2016	102.21	77.94	37.57	23.57	37.16	4.30	6.17	2.73	0.50	1.24	0.30	0.02	0.02	0.00	0.00	293.73	108.95
2017	181.92	52.35	58.10	20.59	33.39	30.97	9.20	7.25	0.58	0.23	0.33	0.05	0.00	0.00	0.00	394.96	183.60
2018	1024.86	106.25	32.71	34.23	15.81	8.09	19.87	1.82	1.96	0.56	0.15	0.24	0.02	0.00	0.00	1246.56	166.65
2019	500.26	115.39	30.10	47.19	33.93	13.65	5.99	9.58	0.54	0.82	0.19	0.07	0.04	0.05	0.00	757.78	187.54
2020	27.72	36.74	38.43	21.19	27.97	18.53	5.18	5.45	5.84	0.67	0.63	0.62	0.10	0.00	0.25	189.32	161.70
2021	31.98	12.50	22.74	32.50	26.64	14.80	7.51	1.66	1.13	0.86	0.04	0.08	0.00	0.00	0.02	152.45	115.76

Table 5.8. COD. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2021.

Age group															
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1994	7	15	10	10	10	9	13	24	23	25	18	72	69	-	-
1995	8	14	11	12	10	10	12	23	33	27	42	39	-	-	-
1996	7	12	19	10	12	9	13	13	25	40	50	39	48	92	-
1997[1]	27	29	17	14	13	10	9	15	21	56	70	-	-	-	-
1998[1]	8	12	15	11	11	11	8	10	17	48	61	-	95	-	68
1999	18	28	17	14	9	10	14	29	22	62	106	95	91	-	-
2000	12	18	15	8	9	10	12	11	15	32	55	65	84	-	-
2001	11	15	17	14	10	11	16	23	28	36	57	-	-	-	96
2002	13	23	24	7	9	13	9	14	26	40	63	-	-	-	93
2003	25	33	26	19	8	7	10	12	17	40	55	-	71	69	-
2004	12	13	19	14	10	12	14	12	14	36	40	106	101	-	-
2005	9	18	27	20	18	14	11	10	16	23	61	66	49	94	-
2006[2]	12	13	14	27	17	13	21	12	17	27	55	63	-	-	-
2007[1]	25	21	16	25	7	10	10	14	19	19	34	47	84	-	-
2008	9	16	16	23	31	9	37	14	25	24	70	83	99	-	-
2009	10	10	16	11	19	13	16	23	22	31	33	61	91	-	-
2010	33	10	13	19	13	10	21	11	22	21	25	71	57	60	-
2011	6	24	11	15	16	10	9	10	26	19	48	36	58	64	99
2012[2]	9	14	13	12	15	20	20	12	24	19	23	39	52	76	100
2013	10	19	14	17	12	10	12	10	17	21	55	34	43	102	94
2014	11	9	10	11	11	7	16	12	11	19	26	33	61	117	68
2015	7	19	12	13	15	16	27	21	40	16	21	28	74	71	82
2016	9	11	15	11	8	17	19	11	15	25	20	33	31	53	52
2017[2]	10	11	12	14	26	15	19	23	11	18	20	26	43	37	96
2018	6	14	7	9	8	12	8	12	12	29	20	34	48	46	48
2019	8	8	9	9	16	16	12	8	14	15	24	35	40	35	82
2020[2]	14	10	13	16	11	11	12	10	12	14	21	52	29	39	30
2021[2]	15	10	16	11	10	12	10	16	15	13	24	38	68	91	46

[1]REZ not covered

[2]REZ partly covered

5.3 Survey mortalities

Table 5.9 gives the time series of survey-based mortalities (natural log ratios between survey indices of the same year class in two successive years) for the acoustic and swept area indices since 1994. These mortalities are influenced by natural and fishing mortality, age reading errors, and the catchability and availability (coverage) at age for the survey. In the period 1994-1999 there was an increasing trend in the survey mortalities. Most later surveys show lower mortalities, but there are some fluctuations for the same reasons as mentioned for the acoustic and swept area indices. Presumably the mortality of the youngest age groups (ages 1-3) is mainly caused by predation, while for the older age groups the fishery is the main cause. Although the survey mortalities are noisy, the mortalities for age 4 and older correspond well with the strong decrease in fishing mortality around 2007 in the stock assessment. The low survey mortalities in the 2010s, even with “impossible” negative values, could partly be caused by fish gradually “growing into” the covered area at increasing age. 2019-2020 and 2020-2021 estimates suggest higher survey mortalities than in previous years, and mortality increased for most age groups in 2020-2021.

Table 5.9. COD. Survey mortality from surveys in the Barents Sea standard area winter 1994-2021.

	Age							
Year	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**	**7-8**	**8-9**
				Acoustic investigations				
1994-95	1.45	1.51	0.84	0.64	1.13	1.50	1.68	1.37
1995-96	2.08	0.76	0.43	0.23	0.87	1.10	1.96	2.09
1996-97	1.17	0.54	0.81	0.59	1.00	1.26	1.49	0.97
1997-98	1.27	0.37	-0.18	-0.01	0.19	0.38	0.38	1.02
1998-99	2.39	1.17	1.10	1.29	1.32	1.78	1.91	2.39
1999-00	0.33	-0.24	-0.12	-0.11	0.02	0.05	0.39	0.41
2000-01	1.09	0.39	0.61	0.73	1.19	1.52	1.88	2.32
2001-02	0.55	-0.18	0.51	0.49	0.44	0.80	1.34	1.69
2002-03	-1.01	-0.38	-0.64	-0.16	-0.17	0.33	0.69	0.41
2003-04	2.55	0.45	1.28	1.27	1.49	1.86	1.96	2.16
2004-05	0.15	-0.06	0.00	0.26	0.44	0.62	1.30	1.66
2005-06	1.15	0.76	0.84	0.60	0.80	0.80	1.12	1.35
2006-07	2.17	0.99	0.76	0.61	0.71	0.49	0.39	0.61
2007-08	-0.10	-1.45	-1.60	-1.34	-0.91	-0.88	0.22	0.83
2008-09	0.69	-0.14	0.09	0.74	1.03	1.66	1.54	1.21
2009-10	1.55	0.11	0.20	0.13	-0.11	-0.07	-0.05	0.18
2010-11	1.92	0.08	-0.22	0.30	0.40	0.42	0.81	0.87
2011-12	1.89	0.09	-0.20	-0.18	-0.11	-0.21	0.44	0.86
2012-13	1.72	-0.41	-0.02	-0.38	-0.35	-0.31	0.01	0.17
2013-14	0.39	-1.17	-0.72	-0.27	-0.03	0.19	0.09	0.76
2014-15	2.12	0.42	0.20	-0.04	-0.23	-0.08	0.12	0.51

2015-16	2.24	1.32	0.59	0.68	0.69	1.03	1.14	0.96
2016-17	1.19	0.59	0.28	0.55	0.60	0.60	0.72	0.77
2017-18	0.45	-0.40	-0.30	-0.23	-0.22	-0.01	0.04	0.81
2018-19	1.74	0.32	-0.14	0.04	-0.13	0.45	0.56	1.27
2019-20	2.21	1.13	0.55	0.43	0.46	0.36	0.28	0.57
2020-21	1.41	0.93	0.73	0.79	0.77	1.11	1.26	1.54
	Bottom trawl investigations							
1994-95	0.66	0.68	0.19	0.20	0.70	0.93	1.19	0.89
1995-96	1.91	1.20	0.88	0.56	0.84	1.14	1.92	1.88
1996-97	1.42	0.91	0.87	0.46	0.84	1.41	1.62	1.42
1997-98	2.32	1.39	0.64	0.77	1.04	1.23	1.18	1.81
1998-99	1.96	0.97	0.68	1.00	0.91	1.35	1.23	2.09
1999-00	0.67	0.35	0.37	0.48	0.83	1.03	1.31	1.45
2000-01	0.50	0.28	0.23	0.45	1.08	1.04	1.36	1.43
2001-02	0.53	-0.42	0.28	0.58	0.59	0.97	1.46	1.30
2002-03	-0.66	0.11	-0.07	0.38	0.49	0.96	1.13	0.77
2003-04	2.52	0.03	0.71	0.86	0.78	0.78	0.94	1.04
2004-05	0.40	-0.02	0.15	0.58	0.87	0.97	2.08	2.01
2005-06	1.08	0.62	0.77	0.66	0.86	0.49	1.14	1.03
2006-07	0.60	-0.22	-0.09	0.52	0.73	0.61	0.70	0.82
2007-08	1.76	0.64	0.18	0.13	0.53	-0.24	1.07	1.34
2008-09	0.66	-0.21	-0.01	0.31	0.61	0.81	0.65	0.44
2009-10	1.41	-0.03	0.10	0.24	0.42	0.43	0.47	0.90
2010-11	1.52	0.11	-0.31	-0.13	0.11	0.33	0.88	0.95
2011-12	1.82	1.09	0.28	0.40	0.36	0.04	0.76	0.60
2012-13	1.59	0.38	-0.41	0.02	-0.18	0.34	0.55	0.37
2013-14	0.82	-0.46	-0.31	0.25	0.11	0.21	0.20	0.75
2014-15	1.29	0.28	-0.01	-0.45	-0.25	-0.28	0.11	-0.01
2015-16	1.68	1.24	0.06	0.19	0.26	0.45	0.96	0.80
2016-17	0.88	0.53	0.47	0.47	0.74	1.10	1.01	1.25
2017-18	0.25	-0.08	-0.03	0.01	0.28	0.20	0.38	1.04
2018-19	1.58	0.58	-0.25	-0.18	-0.25	0.67	0.66	1.16
2019-20	1.88	0.86	0.56	0.31	0.66	0.47	0.31	0.63
2020-21	1.55	0.90	0.69	0.36	0.89	1.11	1.30	1.21

5.4 Growth and maturity

Tables 5.10 and 5.11 present the time series for mean length and mean weight at age for the standard area. There have previously only been moderate fluctuations, but with a decreasing trend for older fish (8+) in later years. However, in 2020, both length and weight at age was considerably reduced for several age groups, with length at age 3 and 8 and weight at age 2, 3, 7, and 12 in 2020 and length at age 4 and 5 and weight at age 4, 5, 6 and 8 in 2021 being the lowest observed in the time series. For all age groups, weight at age is below average in 2021. The reduced weights in the latest years are reflected in the annual weight increments, where ages 1-5 in 2020 were at or near the lowest observed and while growth was higher between 2020 and 2021 except for age (4-)5, it was still below average for most ages (Table 5.12). Note that the patterns described here are similar, but not identical, to those described in the 2020 report due to the change to bootstrap mean weights that better account for uncertainty around the estimates.

The proportion mature at age is presented in Table 5.13. Since 2010, the proportion mature at ages 6 and 7 have declined. The trends in length and weight at age are not as clear, suggesting that the change in maturation may be related to other factors than body size.

The degree of coverage of the Russian zone (REZ) may also influence the biological parameters, as body size tends to decrease towards the northeast in the survey area. In addition, length, weight and maturity at age of older ages has higher uncertainty due to fewer samples (c.f. table 2.2).

Table 5.10 COD. Mean length (cm) at age from bottom trawl surveys in the Barents Sea standard area winter 1994-2021. Bootstrap mean estimates. "–" indicates no samples. Lengths are not adjusted for incomplete coverage.

Age/ Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1994	11.3	17.9	30.2	44.6	55.2	65.7	73.9	78.9	87.4	97.2	97.6	104.7	122.4	-
1995	12.2	18.1	29.0	42.2	53.9	63.9	75.4	80.4	85.9	99.1	90.1	109.0	-	-
1996	12.1	18.8	28.8	40.5	49.4	60.9	71.8	85.1	92.4	94.9	96.1	104.2	103.9	121.0
1997[1]	10.8	16.9	29.7	41.0	50.6	59.4	69.6	81.2	92.3	80.4	103.2	-	-	-
1998[1]	10.5	17.8	30.8	40.9	50.9	58.5	67.7	76.7	87.2	103.0	111.4	-	105.9	-
1999	12.0	18.4	29.0	40.0	50.4	59.4	70.4	78.4	88.5	87.6	117.0	62.0	108.0	-
2000	12.8	20.7	28.4	39.7	51.5	61.4	70.4	76.3	84.9	84.3	100.0	116.2	90.0	-
2001	11.6	22.6	33.0	41.2	52.2	63.3	70.4	78.3	86.0	95.7	104.7	-	-	-
2002	12.0	19.6	28.9	43.6	52.1	61.9	71.4	79.5	91.2	89.7	103.7	-	-	-
2003	11.4	18.1	29.1	39.7	53.4	61.7	70.6	80.8	89.1	90.1	105.4	-	104.3	110.5
2004	10.6	18.4	31.7	40.6	51.7	61.6	68.6	79.7	90.9	90.4	92.2	116.0	112.0	-
2005	11.2	18.3	29.5	43.4	51.1	60.4	71.0	79.6	89.0	96.4	109.3	113.7	129.6	107.0
2006[2]	12.0	19.4	30.9	42.1	53.8	60.3	66.7	76.7	84.9	98.9	95.4	84.9	-	-
2007[1]	13.2	20.7	29.6	41.1	52.8	62.5	70.4	78.2	87.5	92.7	101.8	121.6	110.0	-
2008	12.1	22.3	33.0	43.2	51.8	64.0	69.9	81.3	88.7	95.3	108.9	103.0	102.0	-
2009	11.2	21.1	32.1	42.6	53.2	61.9	76.6	81.8	89.5	97.8	99.5	94.2	110.0	-
2010	11.2	18.4	31.4	42.7	52.4	60.7	70.5	80.4	88.8	96.3	102.2	99.8	100.8	126.0
2011	11.9	19.5	29.4	41.9	51.0	60.7	68.1	78.3	86.1	95.4	102.2	110.4	114.3	116.9
2012[2]	10.6	18.4	29.7	41.0	52.4	58.1	66.5	75.6	86.0	91.8	105.9	114.0	119.0	115.5
2013	11.2	19.3	31.1	41.1	51.7	62.0	69.7	76.5	81.2	95.3	93.7	110.7	110.8	145.0
2014	9.7	17.1	29.5	40.5	52.0	59.6	70.2	76.8	81.8	87.1	97.4	98.9	107.8	91.1
2015	10.5	15.9	30.0	40.3	51.1	60.2	68.8	77.5	81.2	88.7	94.0	101.9	127.5	121.1
2016	12.2	18.3	27.7	40.6	49.8	60.5	68.3	76.6	85.5	86.5	90.5	94.1	112.0	122.5
2017[2]	12.3	22.2	31.2	42.5	51.2	60.5	69.6	75.5	85.2	90.9	96.0	92.6	108.6	108.7
2018	11.2	19.1	32.7	42.4	51.2	61.6	69.0	77.5	83.4	87.6	97.0	99.3	101.8	106.8
2019	11.7	17.5	31.2	42.4	51.0	59.6	69.7	77.0	84.1	87.1	99.3	103.4	104.6	109.8
2020[2]	12.0	17.5	25.5	39.5	50.2	58.6	66.7	74.8	83.0	90.0	93.9	92.4	111.2	113.9
2021[2]	11.6	19.9	26.5	37.4	48.0	58.5	66.7	74.9	84.0	91.7	97.7	102.1	105.8	115.0

[1] REZ not covered

[2] REZ partly covered

Table 5.11. COD. Mean weight (g) at age from bottom trawl surveys in the Barents Sea standard area winter 1994-2021. Bootstrap mean estimates. "+" indicates few samples (< 3), while "–" indicates no samples. Weights are not adjusted for incomplete coverage.

Age/ Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1994	13	56	262	796	1470	2386	3481	4603	6777	8195	8516	13972	+	-
1995	15	54	240	658	1336	2207	3570	4715	5712	8816	6817	12331	-	-
1996	15	62	232	627	1084	1980	3343	5514	7722	8873	9613	12865	12556	+
1997[1]	13	52	230	638	1175	1797	2931	4875	7529	5739	+	-	-	-
1998[1]	11	52	280	635	1182	1728	2588	4026	6076	11257	14391	-	+	-
1999	14	59	231	592	1178	1829	2991	4128	6321	7342	+	+	+	-
2000	16	74	210	558	1210	1963	3036	3867	5401	6154	10023	+	+	-
2001	14	106	336	646	1288	2233	3088	4439	5732	8442	11429	-	-	-
2002	14	67	238	747	1229	2063	3199	4578	7525	6598	12292	-	-	-
2003	13	61	234	597	1316	2014	2989	4715	6517	7500	12812	-	+	+
2004	11	59	275	608	1143	1947	2623	4137	6673	7368	8109	+	+	-
2005	13	61	246	723	1146	1866	2949	4226	6436	8646	12537	+	24221	-
2006[2]	13	69	280	669	1420	1970	2641	4260	5914	10179	9439	8328	-	-
2007[1]	19	73	235	639	1302	2190	3039	4411	6394	8056	10826	20104	+	-
2008	15	90	335	798	1399	2442	3235	5210	6981	9641	+	+	+	-
2009	13	83	294	704	1302	2065	4067	5087	6874	9460	9511	+	+	-
2010	12	64	304	700	1296	2033	3162	4743	6562	8984	10315	+	+	22766
2011	15	66	246	668	1131	1940	2726	4013	5969	8275	10309	13159	14868	+
2012[2]	13	62	252	609	1276	1681	2489	3764	5920	7809	12199	15006	17582	+
2013	11	65	269	602	1208	2055	2809	3843	4822	8447	9101	15108	14743	+
2014	8	50	246	603	1226	1780	2866	3930	4927	6203	8570	9566	12239	+
2015	10	44	242	602	1221	1929	2741	4043	4804	6817	7759	11544	21652	+
2016	13	53	200	593	1049	1928	2674	3830	5540	6129	7110	8272	15256	21945
2017[2]	15	102	292	720	1178	1972	3056	3962	5901	7429	9301	8599	12958	14894
2018	12	69	320	688	1228	2062	2803	4154	5409	6632	9156	10510	11810	12443
2019	12	48	273	685	1164	1870	2916	3974	5394	6068	9637	11507	12371	13993
2020[2]	14	44	153	548	1077	1692	2476	3625	5074	6758	8040	8107	14892	15793
2021[2]	14	68	164	462	910	1682	2484	3620	5379	7160	9313	10923	12410	+

[1] REZ not covered

[2] REZ partly covered

Table 5.12. COD. Yearly weight increment (g) from bottom trawl surveys in the Barents Sea standard area winter 1994-2021.

Year\Age	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1994-95	41	184	396	540	737	1184	1234	1109	2039
1995-96	47	178	387	426	644	1136	1944	3007	3161
1996-97	37	168	406	548	713	951	1532	2015	-1983
1997-98	39	228	405	544	553	791	1095	1201	3728
1998-99	48	179	312	543	647	1263	1540	2295	1266
1999-00	60	151	327	618	785	1207	876	1273	-167
2000-01	90	262	436	730	1023	1125	1403	1865	3041
2001-02	53	132	411	583	775	966	1490	3086	866
2002-03	47	167	359	569	785	926	1516	1939	-25
2003-04	46	214	374	546	631	609	1148	1958	851
2004-05	50	187	448	538	723	1002	1603	2299	1973
2005-06	56	219	423	697	824	775	1311	1688	3743
2006-07	60	166	359	633	770	1069	1770	2134	2142
2007-08	71	262	563	760	1140	1045	2171	2570	3247
2008-09	68	204	369	504	666	1625	1852	1664	2479
2009-10	51	221	406	592	731	1097	676	1475	2110
2010-11	54	182	364	431	644	693	851	1226	1713
2011-12	47	186	363	608	550	549	1038	1907	1840
2012-13	52	207	350	599	779	1128	1354	1058	2527
2013-14	39	181	334	624	572	811	1121	1084	1381
2014-15	36	192	356	618	703	961	1177	874	1890
2015-16	43	156	351	447	707	745	1089	1497	1325
2016-17	89	239	520	585	923	1128	1288	2071	1889
2017-18	54	218	396	508	884	831	1098	1447	731
2018-19	36	204	365	476	642	854	1171	1240	659
2019-20	32	105	275	392	528	606	709	1100	1364
2020-21	54	120	309	362	605	792	1144	1754	2086

Table 5.13. COD. Proportion mature at age from bottom trawl surveys in the Barents Sea standard area winter 1994-2021. Bootstrap mean estimate. The proportion mature is the number of fish classified as maturity category 2 and 3, divided by the total number of fish assigned categories 1-3.

Age/ Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1994	0.00	0.00	0.00	0.00	0.06	0.14	0.31	0.71	0.92	1.00	0.83	1.00	+	-
1995	0.00	0.00	0.00	0.01	0.05	0.26	0.32	0.51	0.85	0.91	1.00	1.00	-	-
1996	0.00	0.00	0.00	0.00	0.01	0.16	0.33	0.51	1.00	1.00	1.00	1.00	1.00	+
1997	0.00	0.00	0.00	0.00	0.01	0.08	0.38	0.80	1.00	0.83	+	-	-	-
1998	0.00	0.00	0.00	0.01	0.04	0.18	0.33	0.64	0.84	1.00	-	+	-	-
1999	-	0.00	0.00	0.00	0.01	0.12	0.37	0.70	0.88	+	+	+	-	+
2000	0.00	0.00	0.00	0.00	0.05	0.28	0.85	0.86	1.00	1.00	+	+	-	+
2001	0.00	0.00	0.00	0.01	0.05	0.27	0.43	0.70	0.91	1.00	-	-	-	-
2002	-	0.00	0.00	0.01	0.04	0.29	0.47	0.56	0.87	1.00	-	-	-	-
2003	-	0.00	0.00	0.00	0.05	0.21	0.40	0.69	0.94	1.00	-	+	+	-
2004	-	0.00	0.00	0.01	0.05	0.25	0.53	0.72	0.87	0.88	+	+	-	+
2005	0.00	0.00	0.00	0.00	0.04	0.18	0.49	0.80	0.92	1.00	1.00	+	1.00	-
2006	0.00	0.00	0.00	0.03	0.05	0.20	0.39	0.74	0.72	1.00	1.00	1.00	-	-
2007	0.00	0.00	0.00	0.01	0.05	0.33	0.57	0.84	0.98	1.00	1.00	1.00	+	-
2008	0.00	0.00	0.01	0.01	0.12	0.32	0.54	0.74	0.82	1.00	1.00	+	+	-
2009	0.00	0.00	0.00	0.00	0.08	0.25	0.49	0.64	0.91	0.96	0.86	+	+	-
2010	-	0.00	0.01	0.01	0.10	0.37	0.50	0.79	0.89	0.95	0.93	+	+	1.00
2011	0.00	0.00	0.00	0.00	0.03	0.22	0.43	0.54	0.84	0.88	1.00	1.00	1.00	+
2012	0.00	0.00	0.00	0.00	0.09	0.21	0.42	0.67	0.85	0.93	1.00	1.00	1.00	+
2013	0.00	0.00	0.00	0.00	0.01	0.11	0.40	0.69	0.79	0.98	0.95	1.00	1.00	+
2014	0.00	0.00	0.00	0.00	0.03	0.10	0.41	0.76	0.87	0.97	0.98	0.96	1.00	+
2015	0.00	0.00	0.00	0.00	0.00	0.06	0.16	0.65	0.91	0.97	0.95	1.00	1.00	+
2016	0.00	0.00	0.00	0.00	0.00	0.04	0.16	0.54	0.78	0.95	0.95	1.00	1.00	1.00
2017	0.00	0.00	0.00	0.02	0.00	0.09	0.34	0.65	0.89	1.00	1.00	0.97	1.00	1.00
2018	0.00	0.00	0.00	0.00	0.02	0.13	0.32	0.56	0.84	0.96	1.00	0.97	0.97	1.00
2019	0.00	0.00	0.00	0.00	0.01	0.12	0.34	0.76	0.89	0.86	0.95	1.00	1.00	1.00
2020	0.00	0.00	0.00	0.00	0.01	0.11	0.29	0.63	0.82	0.89	1.00	1.00	1.00	1.00
2021	0.00	*0.01*[*]	0.00	0.00	0.00	0.14	0.33	0.58	0.84	0.95	0.96	1.00	1.00	+

[*]Based on one sample only.

5.5 Stomach sampling

Since 1984, cod stomachs have been sampled regularly during the winter survey. The sampling strategy has generally been the same as that for sampling otoliths. Stomach have been frozen on board and analysed in the laboratory, except for the period 1994-2000, when some of the stomachs were analysed on board and only the main prey categories were identified. For details about the sampling methodology and the Norwegian-Russian cooperation on diet investigations in the Barents Sea, see Mehl and Yaragina (1992) and Dolgov *et al*. (2007).

The number of stations and stomachs sampled as well as the proportion of empty stomachs and the mean stomach fullness index (SFI, see below) for each of 4 size groups (≤ 19 cm, 20-34 cm, 35-49 cm, ≥ 50 cm) is given in Table 5.14. Tables 5.15 - 5.18 show the mean diet composition by prey species/groups by year for each size group. Note that in the years 1994-2000, blue whiting, long rough dab and Norway pout were included in the category 'other fish' when stomachs were analysed on board.

The stomach fullness index is calculated as $SFI_i=100*\Sigma WS_i/W_i$, where WS_i is the weight (g) of the stomach of fish *i*, and W_i is the weight (g) of fish *i*. For 1987 SFI has not been calculated, because very few fish were weighed that year due to technical problems. The distribution on prey groups has been adjusted by distributing the unidentified component of the diet proportionally among the various components, taking into account the level of identification.
The proportion of empty stomachs is largest for the smallest fish (Table 5.14), a pattern seen for all years. The stomach fullness in 2020 was higher than in 2019, particularly for fish >= 35 cm. Capelin is the dominating prey for cod ≥ 20cm (Tables 4.16-4.18), while krill dominates for the smallest cod (Table 5.15). However, in many years capelin is also an important prey for the smallest cod. The proportion of capelin in the diet decreased for cod >=50cm while it increased for 35-49 cm cod. Cod cannibalism has increased from 2019 for cod >=50 cm and decreased for smaller cod, while the proportion of haddock in the diet continued to decrease for all size groups of cod (Table 5.15-5.18).

Table 5.14. Number of stations and stomachs sampled, % empty stomachs, and mean stomach fullness by length group in the Barents Sea winter 1984-2020.

Year	Stations	<20cm	20-34cm	35-49cm	>=50cm	<20cm	20-34cm	35-49cm	>=50cm	<20cm	20-34cm	35-49cm	>=50cm
1984	31	176	288	242	381	18.8	14.9	5.0	4.5	1.59	2.05	1.80	1.46
1985	49	106	494	582	612	44.3	34.0	19.8	20.6	1.55	3.58	4.46	3.43
1986	73	231	309	398	427	43.3	32.4	26.9	19.0	0.73	2.48	2.90	2.94
1987	52	133	415	501	409	32.3	48.9	45.3	48.9				
1988	79	29	418	844	704	34.5	40.2	31.6	29.7	1.01	1.29	0.91	0.84
1989	82	82	378	890	1132	40.2	21.2	16.3	20.6	1.45	2.28	2.12	1.47
1990	60	177	300	450	870	39.0	22.7	18.4	16.4	1.84	2.18	2.01	1.60
1991	70	271	463	450	1107	40.6	25.5	11.3	9.5	0.95	2.28	3.73	4.27
1992	100	229	382	471	922	65.9	45.8	31.4	38.2	1.79	3.15	3.05	1.92
1993	117	139	393	570	1073	76.3	38.4	21.2	26.7	1.86	3.34	2.99	3.05
1994	138	296	370	580	1163	64.9	34.9	25.0	24.3	0.76	2.04	2.00	1.63
1995	161	452	517	638	1482	52.2	36.4	32.0	30.8	1.16	1.39	0.93	0.80
1996	254	483	507	540	1338	55.7	39.1	28.0	27.4	0.92	1.32	1.38	1.02
1997	149	305	337	358	1105	57.0	34.1	20.7	29.5	0.98	1.60	1.81	1.48
1998	197	496	492	564	1042	64.7	48.2	29.3	28.6	2.20	1.93	1.67	1.22
1999	211	310	471	554	849	61.3	38.6	27.4	25.9	2.11	1.90	2.06	1.76
2000	243	413	645	669	1069	53.8	28.7	21.2	21.1	1.36	1.98	2.41	1.74
2001	361	644	728	884	1485	72.4	42.3	29.3	32.2	2.32	2.98	3.33	2.79
2002	345	393	704	799	1423	69.2	42.8	30.9	30.9	1.57	2.78	2.36	1.88
2003	285	325	499	637	1468	61.5	39.5	22.6	24.4	5.55	2.78	2.55	2.28
2004	329	508	525	663	1522	51.8	37.9	24.1	27.6	1.94	2.02	1.76	1.55
2005	335	509	651	648	1423	43.6	34.7	26.5	25.4	2.29	2.22	1.79	1.65
2006	259	402	464	534	1059	59.2	42.5	21.9	24.5	1.80	1.88	2.56	1.80
2007	273	386	483	592	1341	60.6	45.3	30.7	30.1	1.68	1.87	1.83	1.50
2008	326	260	733	933	1655	61.9	38.5	26.0	23.0	1.94	2.42	2.93	2.19
2009	319	385	547	798	1657	56.1	35.1	22.3	23.9	1.57	1.89	2.02	1.58
2010	360	594	552	748	2079	51.5	38.6	23.0	25.5	1.83	2.19	2.72	2.49
2011	359	515	628	506	1821	56.7	37.7	17.2	23.9	2.08	2.06	2.47	2.49
2012	297	373	408	431	1626	42.6	27.5	13.9	21.0	1.80	2.45	2.28	1.67
2013	279	209	352	425	1435	44.0	28.4	12.7	17.2	1.49	2.25	2.36	1.93
2014	434	570	686	686	2004	42.8	26.7	18.4	19.8	1.59	2.17	2.11	1.33
2015	356	664	562	670	1735	45.8	29.9	20.1	23.1	1.53	2.09	1.96	1.59
2016	387	427	616	728	1971	52.5	32.0	25.4	24.2	1.51	1.92	2.03	1.56
2017	293	339	465	529	1416	46.0	35.5	28.5	28.2	1.90	1.99	1.66	1.50
2018	432	638	850	935	2086	44.8	28.1	19.4	17.5	1.50	2.07	2.29	1.74
2019	506	787	974	1095	2302	46.1	29.6	19.1	17.2	1.60	1.95	2.04	1.87
2020	458	633	952	992	2369	38.1	28.2	18.2	18.0	1.71	1.98	2.33	2.16

Table 5.15. Mean stomach content composition (% of total SFI) of cod ≤ 19 cm from the survey in the Barents Sea winter 1984-2020.

Year	Amphipods	Krill	Shrimp	Other invertebrates	Capelin	Herring	Polar cod	Blue whiting	Cod	Haddock	Redfish	Long rough dab	Norway pout	Other fish	
1984	1.2	7.7	37.5	4.5	13.3						35.8				100.0
1985	15.5	7.9	27.9	44.4										4.3	100.0
1986	14.3	3.8	34.0	14.4	15.2									18.3	100.0
1987	24.8	17.7	10.9	0.2	25.4		21.0								100.0
1988	3.5	19.2		64.3							13.0				100.0
1989	41.1	27.9		31.0											100.0
1990	5.5	14.2	38.4	3.7	3.8						3.2			31.2	100.0
1991	12.2	18.7	6.9	8.4	53.8										100.0
1992	3.7	3.8	6.9	54.3	17.7									13.6	100.0
1993	35.3	59.0		5.7											100.0
1994	19.1	40.8	10.9	11.6										17.6	100.0
1995	12.9	6.7	33.9	3.5	7.4		27.8		6.2					1.6	100.0
1996	16.3	25.4	15.0	27.4	9.4									6.5	100.0
1997	23.3	35.9	26.5	0.3										14.0	100.0
1998	20.9	30.3	17.2	12.4	16.9							2.3			100.0
1999	9.9	18.4	34.0	6.5		18.0	13.2								100.0
2000	3.3	57.1	17.8	0.0	17.3									4.5	100.0
2001	7.0	31.2	10.1	10.7	26.8	8.6								5.6	100.0
2002	15.0	32.1	21.1	13.9	17.9										100.0
2003	1.6	80.0	10.4	1.4	6.6										100.0
2004	11.0	44.7	5.9	9.1	14.3	4.2	10.8								100.0
2005	17.2	22.8	16.2	0.3	35.8									7.7	100.0
2006	9.7	49.9	7.8	20.5	12.1										100.0
2007	6.0	74.6	6.1	0.5	11.6							1.2			100.0
2008	7.3	47.6	31.3	8.7	0.7							0.3		4.1	100.0
2009	4.7	61.4	1.9	8.8	18.1									5.1	100.0
2010	3.5	41.7	1.4	1.6	48.2						0.7			2.9	100.0
2011	1.5	24.8	14.6	4.0	29.6						8.2			17.3	100.0
2012	4.7	20.2	8.5	4.0	53.0									9.6	100.0
2013	2.2	66.2		17.8										13.8	100.0
2014	8.9	42.6	12.7	8.9	26.8									0.1	100.0
2015	2.8	44.8	10.6	13.6	22.1									6.1	100.0
2016	15.7	39.7	9.6	5.6	21.5									7.9	100.0
2017	12.7	6.9	1.0	38.0	0.9						31.0			9.5	100.0
2018	9.0	43.9	11.2	9.6	19.0									7.3	100.0
2019	7.5	34.9	13.9	9.8	27.7								2.2	4.0	100.0
2020	10.4	53.9	4.4	9.1	13.2				2.2			1.4		5.4	100.0

Table 5.16. Mean stomach content composition (% of total SFI) of cod 20-34 cm from the survey in the Barents Sea winter 1984-2020.

Year	Amphipods	Krill	Shrimp	Other invertebrates	Capelin	Herring	Polar cod	Blue whiting	Cod	Haddock	Redfish	Long rough dab	Norway pout	Other fish	
1984	0.1	0.1	21.0	2.7	40.2		8.1				26.3	0.2		1.3	100.0
1985	0.2	0.1	17.0	2.0	69.2	9.3				1.1	0.2			0.9	100.0
1986	2.0	1.1	5.9	2.8	56.2	7.0				0.8	23.3			0.9	100.0
1987	0.5	1.9	25.2	0.3	53.7				6.6		11.4			0.4	100.0
1988	0.9	0.2	20.7	7.0	52.9						18.3				100.0
1989	11.9	7.1	9.0	5.6	33.2		5.4		1.6		25.4	0.5		0.3	100.0
1990	0.6	0.5	18.5	0.7	66.7						8.4			4.6	100.0
1991	0.1	0.2	4.3	0.2	92.5						2.0			0.7	100.0
1992	0.4	0.8	6.4	1.2	88.1				0.4		2.5			0.2	100.0
1993	0.1	0.6	8.1	0.3	78.4	5.9	3.8		0.9	1.1	0.1			0.7	100.0
1994	1.2	10.2	8.3	1.7	54.9	14.2	4.8		1.7		1.2			1.8	100.0
1995	1.4	1.5	9.4	1.8	45.8		10.8	0.6	13.3	3.4	9.3			2.7	100.0
1996	1.9	0.5	13.6	1.3	48.9		5.3		24.9		1.8	0.3	0.8	0.7	100.0
1997	1.1	3.4	17.6	1.6	42.6		1.2	5.4	10.0					17.1	100.0
1998	2.2	2.6	23.5	1.6	47.8	3.4			10.3			5.6		3.0	100.0
1999	2.3	4.0	24.5	3.4	45.6	13.5	0.8		3.2	2.7					100.0
2000	0.7	8.0	14.2	0.3	59.4	4.2	5.3		3.6	2.1		0.1		2.1	100.0
2001	0.9	2.8	8.5	2.8	69.4	4.7	5.6		4.0					1.3	100.0
2002	0.5	1.6	12.2	2.9	71.2	0.7	7.0			1.9				2.0	100.0
2003	0.5	2.4	7.3	0.7	71.9	14.4			2.1			0.1	0.5	0.1	100.0
2004	2.1	5.2	9.7	1.9	60.6	5.9	6.4		1.9	4.2				2.1	100.0
2005	0.6	2.3	12.0	0.9	61.2	3.6	7.7		5.7				4.9	1.1	100.0
2006	1.4	1.5	11.8	3.2	66.6	1.6	2.8	2.1		3.4			4.9	0.7	100.0
2007	2.3	4.8	15.0	7.3	58.8	0.1				7.7	3.7			0.3	100.0
2008	0.5	3.8	11.1	4.7	63.3		3.5			2.4	4.2	1.0		5.5	100.0
2009	0.5	6.6	8.8	5.6	71.2		2.4		1.5		0.2			3.2	100.0
2010	0.7	5.2	7.4	1.8	74.2	1.0			6.4		2.2			1.1	100.0
2011	0.9	3.3	8.3	3.7	74.3				1.1		6.0	0.1	1.1	1.2	100.0
2012	0.4	2.6	7.2	2.3	77.1	0.4			7.7					2.3	100.0
2013	0.3	7.2	10.4	3.4	68.0		2.1		4.3		0.3	0.1		3.9	100.0
2014	2.6	3.5	6.3	5.8	74.7	1.7			1.5	0.1				3.8	100.0
2015	0.9	2.4	9.8	3.4	75.9				3.7	1.6		0.3		2.0	100.0
2016	2.7	5.8	9.1	6.0	65.2					3.7	0.7			6.8	100.0
2017	0.4	3.3	7.8	4.6	67.0	1.7				4.5	2.0	6.7		2.0	100.0
2018	1.2	6.5	4.9	6.5	64.6	3.0			7.8	1.7	0.1		2.0	1.7	100.0
2019	0.6	4.4	9.2	9.1	64.7	0.5			7.6	1.4				2.5	100.0
2020	2.8	12.4	7.4	7.0	64.5				1.4	0.5	0.7	0.4		2.9	100.0

Table 5.17. Mean stomach content composition (% of total SFI) of cod 35-49 cm from the survey in the Barents Sea winter 1984-2020.

Year	Amphipods	Krill	Shrimp	Other invertebrates	Capelin	Herring	Polar cod	Blue whiting	Cod	Haddock	Redfish	Long rough dab	Norway pout	Other fish	
1984	0.5		18.2	1.3	41.5				0.7	2.6	34.5	0.1	0.6		100.0
1985	0.5		4.7	0.2	88.7	4.2			0.5	0.2	0.9			0.1	100.0
1986	0.8	2.5	6.8	3.6	58.4	12.4					15.3			0.2	100.0
1987	0.5	0.2	22.9	1.7	47.9	9.2	1.8		4.4	2.0	5.5		3.8	0.1	100.0
1988	1.0	1.9	29.1	6.3	51.2			1.5			8.8			0.2	100.0
1989	4.1	1.8	11.3	3.3	50.2		7.9		0.2		18.6	0.8	0.2	1.6	100.0
1990	0.1	0.1	7.4	1.6	84.8	2.0				1.3	2.5		0.2		100.0
1991	0.1	0.1	1.8	0.6	94.0					1.5	1.2	0.1		0.6	100.0
1992		0.1	3.3	3.7	79.7	9.1			0.3	0.3	1.2		1.7	0.6	100.0
1993	0.1	0.2	6.0	0.6	85.4	5.6	0.5		0.2	0.4		0.2	0.8		100.0
1994	0.9	14.2	6.9	1.2	48.9	13.5	9.1		2.2	0.4	0.3			2.4	100.0
1995	0.9	0.6	12.8	2.2	44.7	6.2	1.2		17.9	8.6	4.7			0.2	100.0
1996	1.8	0.7	10.0	2.2	21.6	1.5	2.1	5.5	37.4	6.7	2.5		6.9	1.1	100.0
1997	0.9	0.3	14.8	4.3	40.3		5.2	3.6	17.1	3.7	0.5	0.1	1.2	8.0	100.0
1998	1.1	0.4	23.2	6.8	50.3	8.5	1.2	1.8	4.1	1.5	0.8			0.3	100.0
1999	0.3	0.4	28.0	1.8	44.9	12.0	2.4		1.9	5.7	0.5	0.1	0.4	1.6	100.0
2000	0.9	0.3	8.2	0.6	83.5	4.1	0.4		0.7	0.3				1.0	100.0
2001	0.4	0.2	6.3	3.3	73.6	5.2	7.3	1.4	1.1	0.5		0.3		0.4	100.0
2002	0.2	0.6	10.4	4.2	68.3	2.3	4.8	0.8	3.2	3.9		0.5	0.4	0.4	100.0
2003	0.3	1.1	8.2	1.6	68.4	11.1	1.2	0.2	2.7	4.9				0.3	100.0
2004	0.9	1.6	14.5	4.5	61.7	6.5	2.3	1.0	4.1	1.5			1.0	0.4	100.0
2005	0.7	0.7	13.7	2.1	58.3	3.1	3.6	1.9	0.2	13.2		0.3	1.4	0.8	100.0
2006	0.1	0.2	13.1	1.5	64.8	2.0	1.3	1.6	1.1	12.7		0.2	0.3	1.1	100.0
2007	3.5	0.8	18.7	2.4	47.6	7.8		0.2	1.1	13.1	0.4	0.4	3.3	0.7	100.0
2008	0.3	0.9	11.7	1.3	71.9	2.7	7.4			0.9	1.1	0.3	0.4	1.1	100.0
2009	0.8	1.7	6.9	6.9	75.9	1.8	2.4		1.7	0.4	0.6	0.1	0.8		100.0
2010	1.0	1.2	6.3	1.3	81.2	0.4	0.3		2.2	3.6	1.4	0.1	0.6	0.4	100.0
2011	0.1	0.7	7.5	3.2	76.0	1.5		1.4	4.2	0.9	2.3	0.1	1.4	0.7	100.0
2012	0.5	0.9	7.7	4.3	71.2	0.5	0.8	0.3	4.2	4.4	0.8	0.3	2.6	1.5	100.0
2013	0.4	1.5	7.9	4.6	77.9		1.1		3.3	1.6	0.3	0.1	0.3	1.0	100.0
2014	0.3	0.6	10.5	3.9	74.4	1.8			1.6	4.3	0.6	0.1	0.9	1.0	100.0
2015	0.5	3.2	7.9	2.3	77.1	1.3	0.2	2.3	2.4	1.1	0.3	0.4		1.0	100.0
2016	3.3	1.0	8.8	5.7	68.2	1.3			2.2	5.7	1.1	0.7	0.7	1.3	100.0
2017	0.1	1.1	12.3	4.1	70.5				0.4	5.6	0.7		2.6	2.6	100.0
2018	0.2	2.0	6.5	2.4	70.0	5.9			7.0	5.0	0.3		0.2	0.5	100.0
2019	0.5	1.1	9.8	3.0	69.8	3.9			6.1	4.0	0.4	0.1		1.3	100.0
2020	1.6	2.5	7.5	3.1	81.1	2.0			1.5	0.1	0.2	0.2		0.2	100.0

Table 5.18. Mean stomach content composition (% of total SFI) of cod ≥ 50 cm from the survey in the Barents Sea winter 1984-2020.

Year	Amphipods	Krill	Shrimp	Other invertebrates	Capelin	Herring	Polar cod	Blue whiting	Cod	Haddock	Redfish	Long rough dab	Norway pout	Other fish	
1984	0.4		16.3	1.3	48.1		0.6		3.5	2.4	26.4	0.3		0.7	100.0
1985	0.2		5.2	0.4	85.8	3.0		0.3	2.1	0.6	1.2	1.1	0.1		100.0
1986	0.6	0.2	4.4	3.9	53.9	3.2		2.5	9.5	7.9	7.7	0.1	4.1	2.0	100.0
1987	1.9	0.1	7.4	6.5	2.2	3.6	3.1	3.3	15.6		35.3	0.3	18.9	1.8	100.0
1988	0.9	0.7	11.7	7.0	11.9			4.8	0.0		16.3	4.7		42.0	100.0
1989	0.8	1.0	10.1	7.2	50.9		1.1		0.0	0.5	25.1	1.2	0.8	1.3	100.0
1990	0.1	0.3	5.2	1.8	74.4	1.1		5.2	0.1	4.8	4.0	0.9	1.8	0.3	100.0
1991			1.2	0.5	94.1	0.4			0.6	0.9	1.0	0.1	0.4	0.8	100.0
1992	0.2	0.1	5.6	3.8	56.7	17.6	0.1		2.3	4.1	3.7	2.3	2.6	0.9	100.0
1993		0.3	2.2	11.4	54.9	16.0	0.3	0.6	5.2	4.3	0.9	0.0	3.8	0.1	100.0
1994	0.5	12.9	5.9	2.8	35.4	7.1	4.4	0.2	12.0	4.3	5.8	1.1		7.6	100.0
1995	0.5	0.3	5.0	2.2	8.4	8.0	0.7		18.3	20.4	18.8	2.2	0.2	15.0	100.0
1996	0.5	0.2	4.1	2.7	9.3	14.6	2.5	0.4	27.2	27.8	6.2	1.8	2.6	0.1	100.0
1997	0.2	0.2	10.1	0.8	45.8	5.0	1.1	3.4	5.3	8.2	4.3	0.8	0.6	14.2	100.0
1998	1.2	0.2	22.7	3.8	34.5	7.3	1.0	1.2	6.2	6.6	4.1	3.7	2.6	4.9	100.0
1999	0.2	0.1	25.8	6.3	26.5	9.8	2.5	0.7	10.3	5.0	0.4	1.4	0.5	10.5	100.0
2000	0.9	0.4	7.9	1.6	68.9	6.5	0.8	2.3	2.8	3.4	0.7	1.5		2.3	100.0
2001	0.7	0.2	4.4	4.6	71.7	4.4	1.6	2.5	3.3	2.6	0.3	1.9	0.4	1.4	100.0
2002	0.2	0.7	5.9	6.5	50.9	3.0	4.2	2.0	9.0	13.0	1.0	1.7	0.7	1.2	100.0
2003	0.1	0.2	5.5	4.9	59.1	10.6	1.5	1.1	4.3	9.1	0.5	1.4	0.4	1.3	100.0
2004	0.2	0.2	6.5	3.2	48.2	4.9	0.5	2.6	7.6	17.0	1.6	2.7	1.6	3.2	100.0
2005	0.3	0.3	5.8	4.2	33.2	2.9	0.8	5.6	7.9	31.2		1.5	2.5	3.8	100.0
2006	0.1	0.1	4.6	4.8	45.8	1.8	0.6	6.1	1.8	28.3	1.6	1.8	1.5	1.1	100.0
2007	0.5	0.2	8.3	5.0	29.2	18.4		1.9	7.8	20.8	2.0	2.3	2.7	0.9	100.0
2008	0.1	0.4	4.9	2.7	60.7	7.5	0.3	0.4	0.9	17.4	0.8	1.8	0.9	1.2	100.0
2009	0.2	0.3	5.5	4.2	53.0	8.6	0.8	0.4	4.1	12.9	1.5	2.9	3.9	1.7	100.0
2010	0.6	0.3	2.5	2.3	72.7	1.7	0.2	0.1	3.5	10.6	0.9	2.0	2.5	0.1	100.0
2011	0.1	0.3	3.1	2.9	82.0	0.4	0.6		2.6	5.2	0.9	0.5	1.1	0.3	100.0
2012	0.1	0.2	4.0	7.1	60.9		0.1	0.1	2.6	16.7	0.5	1.1	3.8	2.8	100.0
2013	0.3	0.7	4.1	7.6	67.9	0.2	0.4	0.6	5.1	8.3	0.9	1.4	1.8	0.7	100.0
2014	0.5	0.5	5.6	10.4	55.4	2.2		0.2	6.3	10.9	1.0	3.1	1.6	2.3	100.0
2015	0.2	0.1	4.1	6.7	69.9	1.1		1.1	2.9	6.8	2.1	1.3	2.4	1.3	100.0
2016	1.0	0.9	3.4	14.8	60.0	2.9	0.1	0.7	5.3	6.5	0.7	2.7	0.4	0.6	100.0
2017	0.1	0.6	2.9	4.2	74.2	1.4		1.5	0.6	10.7	1.3	1.2	1.0	0.3	100.0
2018	0.1	0.9	3.7	9.5	51.7	2.5	0.1	0.1	8.1	19.3	0.7	2.0	0.7	0.6	100.0
2019	0.4	0.5	3.8	6.6	68.4	2.8	0.1	0.2	5.5	7.4	1.0	0.5	1.9	0.9	100.0
2020	0.4	0.8	2.6	7.5	59.3	5.5	0.0	0.2	13.4	4.8	1.8	1.9	1.0	0.8	100.0

6 Distribution and abundance of haddock

6.1 Acoustic estimation

As for cod, it is expected that the survey best covers the immature part of the haddock stock. At this time of the year a large proportion of the mature haddock (age 6 and older) is on its spawning migration south-westwards out of the investigated area. In some earlier years, e.g. 2004 and 2005, concentrations of mature haddock have been observed pelagically rather far above bottom along the shelf edge. The bottom trawl sampling poorly covers these concentrations. There are indications that the distribution of age groups 1 and 2 in some years are concentrated in coastal areas not well covered by the survey. This occurred in the late 1990s and will have strongest effect on poor year-classes. In the later surveys, small haddock have been widely distributed, and the strong year-classes have been found unusually far to the north. Favourably hydrographic conditions and/or density dependent mechanisms might cause this. However, it is difficult to separate the two factors.

Figure 6.1 shows the spatial distribution of acoustic registrations assigned to haddock in 2021. The registrations reflect the general distribution of haddock in the southern and eastern Barents Sea. Despite large registrations in a small area in the Russian sector with local NASC values as high as ~4000 m^2/nmi^2, the overall echo abundance in 2021 was low.

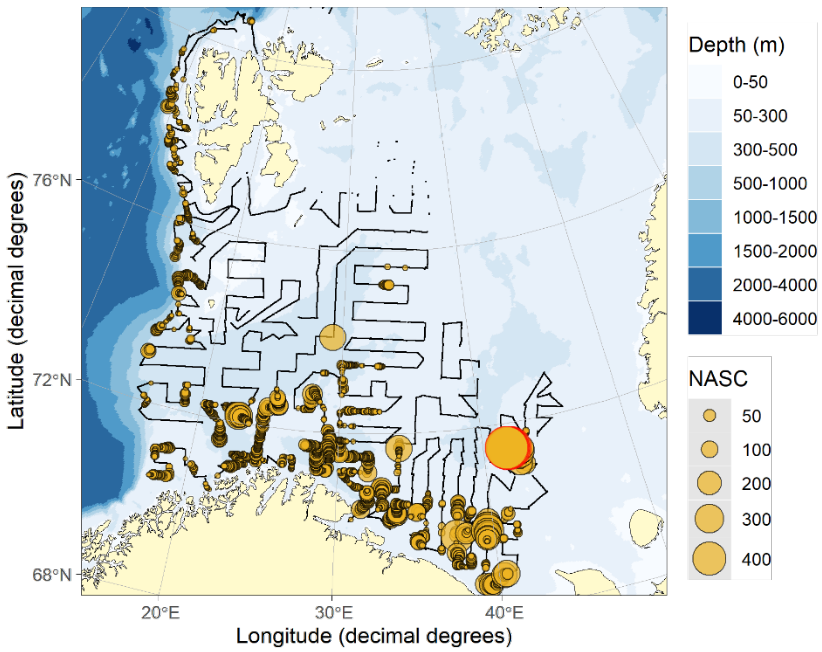

Figure 6.1. HADDOCK NASC. Distribution of acoustic backscatter (m^2/nmi^2) assigned to haddock in 2021. The black lines without yellow circles represent parts of the cruise track where the acoustic backscatter was scrutinized but not assigned to haddock. NASC values < 5 was set to zero for this illustration. Circles with red outline represent NASC > 500.

Table 6.1 shows the acoustic abundance indices by age within the main areas. As in most of the previous years the highest abundance was observed in main area D. The time series (1994-2021) is presented in Table 6.2. Abundances of all ages except ages 1 and 5 are lower in 2021 than in 2020.

The strong 2004-2006 year-classes can be followed through the time series. In later years, the 2009, 2011, and 2013-2018 year-classes seem to be fairly strong. In particular the year classes 2016 and 2017 have high indices at age 1-2. The year class 2019 appears to be much weaker as the abundance of 1-year-olds observed in 2020 is the third lowest in the time series. The estimate of this year class as 2-year-olds in 2021 are only half of the previously lowest estimate in the time series. Abundance of the 2020 year class, while still on the low side, is nearly 60 % higher than the 2019 year class.

The abundance of old fish (particularly age 14) was higher in 2020 than previously observed. This likely reflects the surviving individuals from the 2005-2006 year-classes. However, few of these fish appear to have survived and become part of the 15+ group in 2021.

Table 6.3 shows indices for strata 24-26 in 2014-2021, which are also included in the full time series (Table 6.2). The contribution from main area N was rather low in all years, except in 2018 when 29% of age 1 haddock (by number) was found in the extended area, contributing 13 % of the total stock biomass index. The total abundance in area N in 2021 is the lowest observed in the time series.

Table 6.4 presents estimated coefficients of variation (CV) for haddock age groups 1-14 in 1994-2021. In most years, CVs for age groups older than 7 years are above what could be considered as acceptable (approximately 20 %). In 2020-2021, younger ages also have relatively high CVs, which may indicate patchier distributions.

Table 6.1. HADDOCK. Abundance indices (numbers in millions) for the main areas of the Barents Sea from acoustic survey winter 2021 estimated by StoX software. Baseline estimates. The scaling factor for estimating adjusted AN is the average ratio by age for AN/(AN-strata 16) swept area indices in the years 2019-2020.

Age group																
Area	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**Biomass ('000 t)**
A	162.7	3.66	7.94	26.0	16.9	4.98	4.05	0.48	0.68	0.39	0.00	0.00	0.00	0.00	0.00	227.8	48.3
B	60.4	7.86	2.19	5.62	3.06	1.23	0.41	0.11	0.06	0.04	0.00	0.00	0.00	0.00	0.08	81.1	11.1
C	64.1	1.03	2.75	10.5	8.76	3.21	0.12	0.11	0.00	0.02	0.02	0.00	0.00	0.03	0.00	90.6	18.6
D	96.9	2.47	34.6	78.8	136.9	7.09	0.45	0.08	0.00	0.00	0.00	0.19	0.02	0.02	0.00	357.6	153.1
D'[1]	0.91	0.02	1.53	2.28	5.69	0.66	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.2	6.4
E	17.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.9	0.4
S	22.2	0.00	0.40	0.69	2.84	1.45	0.05	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	27.6	5.9
N	5.47	0.44	0.23	4.87	7.44	0.73	0.28	0.14	0.08	0.01	0.05	0.02	0.05	0.00	0.00	19.8	13.4
ABCD	384.1	15.0	47.5	120.9	165.7	16.5	5.04	0.78	0.74	0.46	0.02	0.19	0.02	0.05	0.08	757.1	231.0
AN	430.5	15.5	49.7	128.8	181.7	19.3	5.44	0.94	0.81	0.48	0.07	0.21	0.07	0.05	0.08	833.6	257.2
Scaling	1.003	1.014	1.022	1.012	1.001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		
AN adjusted	431.7	15.7	50.8	130.4	181.8	19.3	5.44	0.94	0.81	0.48	0.07	0.21	0.07	0.05	0.08	837.8	258.5[2]

[1]Lacking estimates in stratum 16.

[2]Based on ratio between unraised biomass and unraised numbers at age

Table 6.2. HADDOCK. Abundance indices (numbers in millions) from acoustic surveys in the Barents Sea winter 1994-2021 estimated by StoX software. Baseline estimates.

Age group																	
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**Biomass ('000 t)**
1994	887.82	187.96	348.73	626.65	121.38	8.55	0.70	0.33	0.61	0.48	1.46	0.16	0.00	0.00	0.00	2184.83	643.51
1995	1198.18	88.59	41.47	121.49	395.37	47.61	2.80	0.05	0.12	0.03	0.00	0.54	0.14	0.00	0.00	1896.39	508.78
1996	132.60	94.52	29.97	22.09	68.65	143.69	5.67	0.93	0.00	0.01	0.00	0.02	0.04	0.00	0.00	498.19	248.35
1997[1]	508.87	26.51	57.27	22.22	15.47	56.13	62.77	4.68	0.07	0.00	0.00	0.01	0.05	0.06	0.00	754.11	201.67
1998[1]	210.96	150.99	33.78	58.79	24.20	7.70	14.06	20.69	1.44	0.02	0.04	0.00	0.00	0.00	0.12	522.78	150.98

1999	653.40	30.11	83.67	21.64	22.10	6.17	1.55	3.88	2.72	0.03	0.00	0.02	0.00	0.00	0.00	825.29	107.86
2000	1063.01	404.77	36.39	75.53	14.01	12.61	1.57	0.53	2.01	0.69	0.17	0.13	0.02	0.00	0.00	1611.44	189.81
2001	753.01	266.12	233.45	40.20	41.38	2.20	1.61	0.15	0.09	0.14	0.28	0.09	0.09	0.00	0.02	1338.83	206.40
2002	1315.15	267.90	255.20	201.84	18.47	11.70	1.59	0.29	0.03	0.13	0.26	0.09	0.05	0.00	0.00	2072.70	298.25
2003	2743.74	362.35	203.68	184.57	136.04	12.26	6.01	0.26	0.14	0.26	0.34	0.09	0.07	0.00	0.00	3649.81	444.48
2004	528.97	466.54	151.01	101.85	107.82	57.68	7.61	1.15	0.29	0.04	0.05	0.05	0.04	0.08	0.00	1423.18	322.95
2005	2276.46	143.98	221.33	115.67	57.43	56.71	12.69	0.38	0.32	0.01	0.00	0.00	0.00	0.00	0.00	2884.98	305.99
2006[2]	2091.11	624.78	56.32	123.84	47.37	19.26	13.64	3.23	0.08	0.15	0.00	0.03	0.00	0.00	0.09	2979.90	297.84
2007[1]	2015.71	953.50	209.28	46.14	80.57	28.92	10.00	5.05	2.26	0.30	0.18	0.00	0.00	0.00	0.05	3351.97	401.72
2008	778.39	1753.54	812.41	303.04	90.02	74.12	7.41	12.77	1.63	0.14	0.16	0.18	0.00	0.00	0.00	3833.81	920.38
2009	443.93	209.05	883.68	629.98	266.65	38.87	14.57	1.26	0.34	0.66	0.00	0.05	0.00	0.00	0.00	2489.04	865.44
2010	1559.42	86.03	128.07	631.03	603.99	166.96	12.07	2.94	0.96	0.99	0.10	0.06	0.00	0.00	0.00	3192.62	1035.93
2011	428.46	288.27	54.16	84.23	313.02	292.21	54.91	1.71	0.96	0.23	0.00	0.20	0.07	0.00	0.00	1518.43	712.08
2012[3]	1583.44	94.54	191.63	48.84	88.12	310.60	172.52	30.09	0.52	0.34	0.02	0.13	0.00	0.00	0.00	2520.79	814.60
2013	292.71	407.16	67.29	146.77	35.41	53.03	223.77	102.68	14.12	0.25	0.00	0.00	0.00	0.00	0.00	1343.19	759.62
2014	1838.71	109.92	334.82	39.12	108.72	23.18	34.77	86.36	36.63	1.66	0.52	0.00	0.00	0.01	0.00	2614.42	583.94
2015	1593.12	246.59	24.35	189.40	26.63	46.13	9.22	22.45	21.33	9.86	0.56	0.15	0.09	0.00	0.00	2189.88	387.71
2016	1276.00	107.18	71.81	12.08	59.62	12.52	17.28	7.48	17.21	12.74	2.76	0.48	0.00	0.03	0.02	1597.21	274.45
2017[3]	3343.93	331.42	81.15	65.05	4.81	34.81	6.24	7.93	1.78	7.06	6.10	2.34	0.44	0.00	0.00	3893.06	338.87
2018	2925.90	810.16	171.03	62.74	64.40	6.77	15.57	2.75	2.57	1.56	5.56	2.99	1.87	0.14	0.00	4074.01	410.39
2019	1544.96	687.80	507.61	146.22	31.73	21.88	4.72	3.46	1.37	1.57	0.38	0.39	0.33	0.06	0.09	2952.57	396.54
2020[3]	272.94	260.72	286.32	306.38	79.18	22.38	11.59	1.84	1.36	0.83	0.85	1.22	0.99	0.96	0.12	1247.68	381.58
2021[3]	431.68	15.69	50.76	130.37	181.80	19.35	5.44	0.94	0.81	0.48	0.07	0.21	0.07	0.05	0.08	837.80	258.47

[1]Indices raised to also represent the Russian EEZ. [2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005

[3]Indices raised to also represent uncovered parts of the Russian EEZ.

Table 6.3. HADDOCK. Abundance indices (numbers in millions) for new strata 24-26 from acoustic surveys in the Barents Sea winter 2014-2021 estimated by StoX software. In 2020, the main index was revised to include these strata. Baseline estimates.

Age group																**Biomass**
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**('000 t)**
2014	135.0	0.88	10.3	0.92	0.81	0.80	0.96	1.84	1.31	0.20	0.02	0	0	0	0	153.0	17.9
2015	71.2	22.2	0.71	17.9	1.10	6.77	0.90	1.31	4.01	3.03	0.14	0	0.09	0	0	129.4	48.2
2016	15.7	1.77	3.32	0.26	3.67	0.70	0.71	0.62	1.75	0.83	0.33	0	0	0	0	29.7	16.1
2017	80.1	8.20	1.23	2.28	0.40	2.60	0.40	0.92	0.29	0.64	0.61	0.33	0	0	0	98.0	18.1
2018	855.7	46.4	11.7	2.57	3.48	1.15	2.97	0.45	0.33	0.25	0.54	0.39	0.38	0	0	926.4	54.6
2019	67.68	25.50	16.12	5.59	1.07	1.01	0.13	0.11	0.05	0.03	0.03	0.09	0.03	0.05	0.00	118.11	17.84
2020	1.54	1.18	12.6	12.4	3.09	2.40	0.55	0.49	0.16	0.09	0.04	0.08	0.08	0.05	0	34.8	22.7
2021	5.47	0.44	0.23	4.87	7.44	0.73	0.28	0.14	0.08	0.01	0.05	0.02	0.05	0.00	0.00	19.8	13.4

Table 6.4. HADDOCK. Estimates of coefficients of variation (%) for acoustic abundance indices. Barents Sea standard area winter 1994-2021.

Age group														
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1994	11	12	10	9	12	21	44	53	39	55	31	103	-	-
1995	16	22	24	15	10	15	34	128	85	114	-	55	90	-
1996	20	27	31	23	16	15	22	44	-	120	-	98	108	-
1997[1]	12	17	14	16	16	12	14	33	53	-	-	121	63	74
1998[1]	14	15	15	13	14	21	17	15	50	107	109	-	-	-
1999	19	24	21	28	22	23	32	34	26	118	-	123	-	-
2000	9	9	21	12	18	17	28	45	30	39	72	102	104	-
2001	17	16	16	25	16	30	35	65	66	96	62	94	86	-
2002	8	10	12	10	16	16	29	51	111	69	60	53	71	-
2003	11	11	11	9	15	25	38	80	106	90	76	102	107	-
2004	37	23	23	30	33	17	21	26	45	65	65	86	64	66
2005	10	16	11	15	12	16	19	59	76	104	-	-	-	-
2006[2]	12	10	27	20	12	15	20	33	66	67	-	78	-	-
2007[1]	9	7	9	12	12	15	21	29	40	52	88	-	-	-
2008	13	10	10	10	21	24	29	62	94	263	84	137	-	-
2009	14	13	9	11	14	19	19	43	79	48	-	107	-	-
2010	15	17	10	10	9	13	27	34	49	49	108	92	-	-
2011	15	13	16	12	11	10	15	40	58	94	-	84	115	-
2012[2]	16	28	16	35	24	20	20	27	86	50	105	68	-	-
2013	14	13	22	11	22	16	13	15	26	59	-	-	-	-
2014	13	19	12	20	18	17	16	15	15	44	79	-	-	109
2015	14	17	24	13	23	21	27	23	20	55	64	65	-	-
2016	11	15	15	19	12	14	15	19	17	15	30	43	-	70
2017[2]	6	9	15	13	22	16	22	23	34	29	24	36	67	-
2018	8	8	9	13	17	29	22	29	34	30	27	28	54	81
2019	9	8	8	8	13	14	29	26	48	35	64	35	72	115
2020[2]	15	14	11	12	12	14	19	26	30	48	54	49	43	50
2021[2]	15	25	19	34	45	21	37	48	78	94	61	121	57	87

[1]REZ not covered
[2]REZ partly covered

6.2. Swept area estimation

Figures 6.2 - 6.5 show the geographic distribution of bottom trawl catch rates (number of fish per NM^2) for haddock size groups < 20 cm, 20-34 cm, 35-49 cm and ≥ 50 cm. Like in previous years, the distribution extends further to the north and to the east than what was usual in the 1990s.

Table 6.5 presents the indices for each age group by main areas. The time series (1994-2021) is shown in Table 6.6. The swept area estimates, too, are highest in the east in area D. The 2016-2018 year-classes currently dominate the bottom trawl indices. The weak 2019 year class noted for the acoustic index is evident also in the swept area estimates, which is not surprising given that the same biological data used to calculate swept area indices are used to allocate acoustic backscatter to age groups. Overall, this survey tracks both strong and poor year-classes fairly well. Compared to cod a lower proportion of haddock is found in the extended survey area (Table 6.7). In 2021, the extended area contributed about 4 % of total abundance and about 7 % of total biomass.

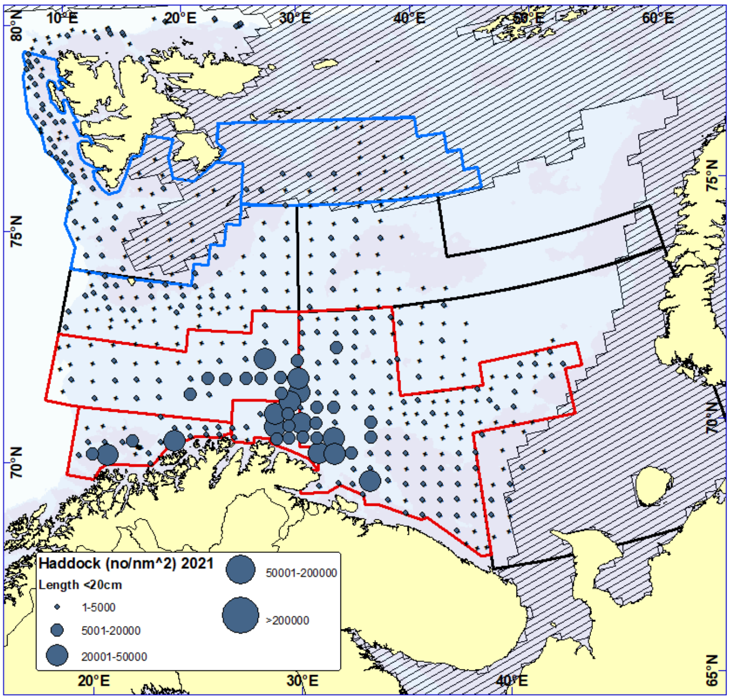

Figure 6.2. HADDOCK < 20 cm. Distribution in valid bottom trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

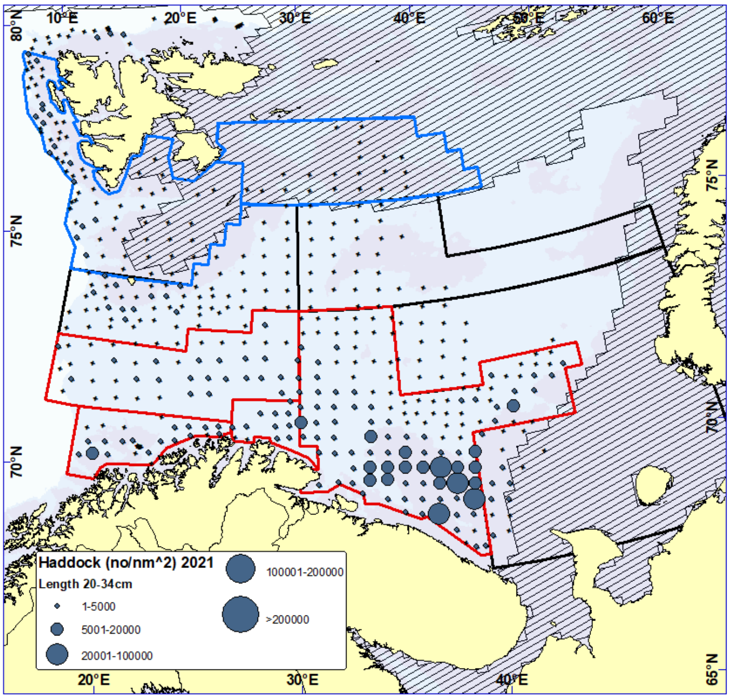

Figure 6.3. HADDOCK 20-34 cm. Distribution in valid bottom trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

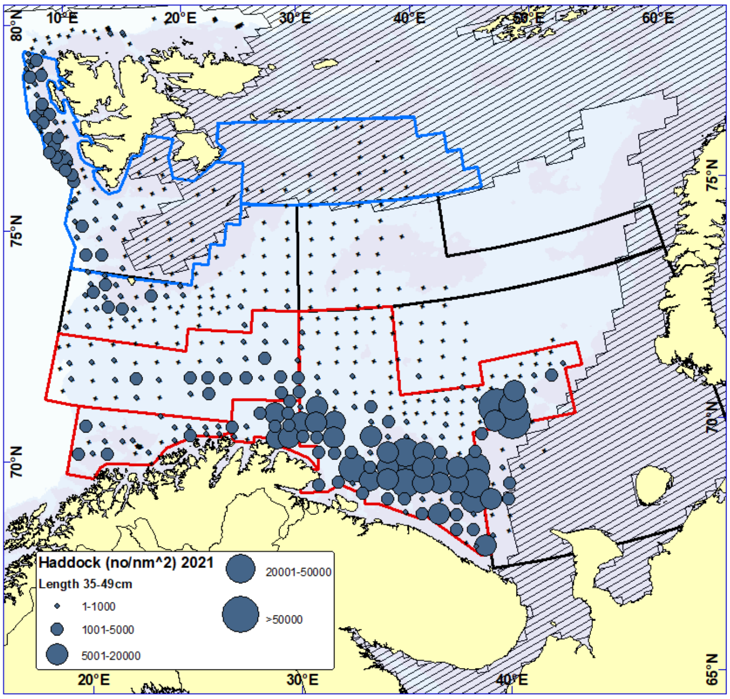

Figure 6.4. HADDOCK 35-49 cm. Distribution in valid bottom trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

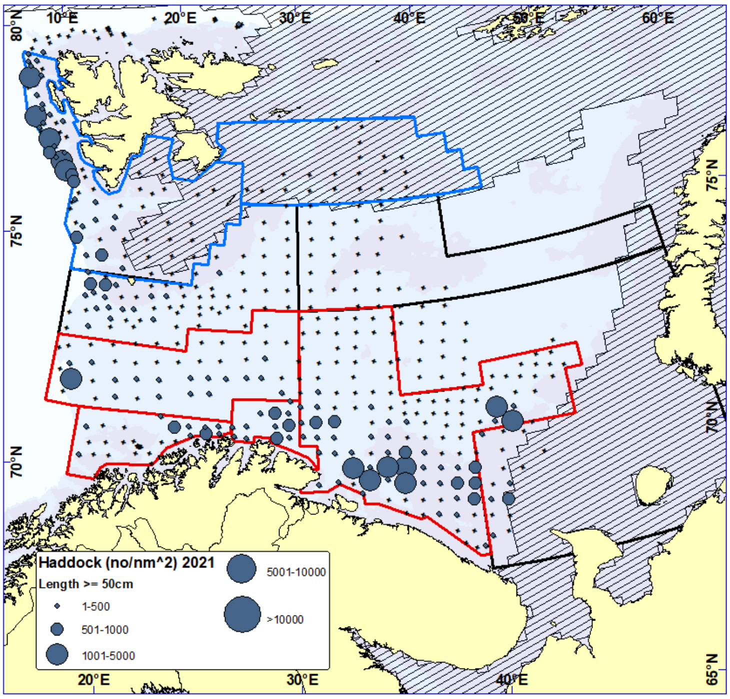

Figure 6.5. HADDOCK ≥ 50 cm. Distribution in valid bottom trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

Table 6.8 presents estimated coefficients of variation (CV) for haddock age groups 1-14 in 1994-2021. In most years, CVs for age groups older than 7 years are above what could be considered as acceptable (approximately 20 %).

Table 6.5. HADDOCK. Abundance indices from bottom trawl hauls for main areas of the Barents Sea winter 2021 (numbers in millions). Bootstrap mean estimates. The scaling factor for estimating adjusted AN is the average ratio by age for AN/(AN-strata 16) swept area indices in the years 2019-2020.

Age group																	**Biomass**
Area	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**(‘000 t)**
A	102.1	5.43	4.7	15.9	7.92	2.12	1.32	0.15	0.09	0.05	0.00	0.00	0.01	0.00	0.00	139.8	22.3
B	44.8	7.57	1.1	3.04	1.74	0.42	0.26	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.03	59.0	6.51
C	67.2	2.67	3.3	8.22	10.4	3.35	0.11	0.10	0.00	0.03	0.02	0.00	0.00	0.02	0.00	95.4	18.6
D	159.4	7.45	91.2	134.7	217.9	10.6	1.17	0.14	0.00	0.00	0.00	0.21	0.05	0.02	0.00	622.8	253.5
D'[1]	3.04	0.00	3.53	3.29	8.31	0.70	0.07	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.1	9.63
E[1]	5.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.62	0.15
S	8.88	0.00	0.26	1.05	2.77	0.73	0.10	0.02	0.00	0.02	0.00	0.00	0.01	0.00	0.00	13.8	4.90
N	12.6	1.08	0.40	7.74	13.4	1.29	0.61	0.14	0.09	0.02	0.06	0.09	0.11	0.00	0.00	37.6	22.8
ABCD	373.6	23.1	100.3	161.9	237.9	16.5	2.87	0.42	0.10	0.09	0.03	0.21	0.05	0.05	0.03	917.0	301.0
AN	403.7	24.2	104.4	173.9	262.3	19.2	3.65	0.71	0.20	0.13	0.08	0.31	0.18	0.05	0.03	993.2	338.5
Scaling	1.006	1.038	1.051	1.008	1.001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		
AN adjusted	406.3	25.1	109.8	175.3	262.6	19.2	3.65	0.71	0.20	0.13	0.08	0.31	0.18	0.05	0.03	1003.6	342.0[2]

[1]Lacking estimates in stratum 16.

[2]Based on ratio between unraised biomass and unraised numbers at age

Table 6.6. HADDOCK. Abundance indices (numbers in millions) from bottom trawl surveys in the Barents Sea standard area winter 1994-2021. Bootstrap mean estimates.

Age group																**Total**	**Biomass (‘000 t)[4]**
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**		
1994	604.20	224.79	314.53	436.25	46.18	3.54	0.16	0.13	0.20	0.15	0.47	0.03	0.00	0.00	0.00	0.00	403.7
1995	1429.04	199.52	54.86	167.10	343.38	29.62	1.44	0.03	0.04	0.02	0.00	0.29	0.09	0.00	0.00	0.00	443.9
1996	300.78	265.08	55.84	31.33	150.77	238.11	16.13	1.15	0.00	0.01	0.00	0.03	0.03	0.00	0.00	0.00	431.9
1997[1]	1117.83	90.81	79.63	39.86	18.25	61.57	88.41	3.28	0.08	0.00	0.00	0.00	0.03	0.02	0.00	0.00	273.3

1998[1]	248.27	196.70	21.68	36.75	11.84	1.29	9.20	7.21	0.65	0.02	0.02	0.00	0.00	0.00	0.03	0.03	91.7
1999	1207.98	83.20	56.92	15.87	9.42	2.83	0.81	1.28	0.77	0.02	0.00	0.02	0.00	0.00	0.00	0.00	86.7
2000	832.30	437.22	24.08	35.24	6.79	4.13	0.68	0.08	0.80	0.22	0.03	0.03	0.01	0.00	0.00	0.00	124.1
2001	1230.98	446.84	294.00	26.25	23.00	1.63	0.75	0.06	0.06	0.05	0.16	0.09	0.02	0.00	0.00	0.01	227.7
2002	1700.19	475.31	312.87	185.45	12.42	8.04	0.85	0.22	0.01	0.09	0.16	0.04	0.04	0.00	0.00	0.00	308.4
2003	3327.32	471.68	352.24	174.45	72.71	5.10	1.68	0.12	0.10	0.10	0.10	0.01	0.01	0.00	0.00	0.00	411.5
2004	700.86	706.61	173.13	100.52	77.02	51.28	7.41	0.91	0.13	0.04	0.05	0.04	0.04	0.07	0.00	0.00	307.6
2005	4473.16	386.39	317.89	141.06	50.66	61.19	10.08	0.25	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	431.0
2006[2]	4944.60	1310.22	78.80	130.76	46.05	20.87	16.21	3.18	0.09	0.15	0.00	0.05	0.00	0.00	0.04	0.03	454.2
2007[1]	3731.19	1684.83	443.27	81.78	84.67	26.28	5.41	2.20	1.38	0.80	0.07	0.00	0.00	0.00	0.03	0.00	594.8
2008	853.09	2042.01	1591.03	583.61	53.08	54.73	6.79	10.25	0.23	0.05	0.08	0.05	0.00	0.00	0.00	0.00	1100.5
2009	562.61	317.05	1230.43	751.01	368.33	25.41	12.44	0.85	0.09	0.35	0.00	0.01	0.00	0.00	0.00	0.00	976.7
2010	1634.82	79.89	102.45	510.45	443.76	139.32	7.99	1.02	0.39	0.47	0.05	0.05	0.00	0.00	0.00	0.00	759.4
2011	676.31	353.87	52.88	123.63	469.48	290.04	65.24	1.42	1.12	0.00	0.00	0.15	0.03	0.00	0.00	0.00	827.5
2012[3]	1866.96	137.38	316.08	28.79	74.71	267.94	154.60	24.77	3.11	0.28	0.04	0.08	0.00	0.00	0.00	0.00	740.3
2013	344.58	490.28	57.44	143.98	22.02	33.62	191.14	69.38	6.11	0.08	0.00	0.00	0.00	0.00	0.00	0.00	600.9
2014	1281.40	123.95	381.17	32.73	104.40	23.26	50.04	97.54	38.69	1.82	0.59	0.00	0.00	0.02	0.00	0.00	656.0
2015	1133.97	342.02	30.61	187.04	43.60	39.44	14.67	18.73	30.74	9.70	0.33	0.14	0.02	0.00	0.00	0.00	404.4
2016	2299.37	561.96	163.38	34.34	115.60	22.41	41.95	12.44	32.40	27.64	4.34	0.98	0.00	0.14	0.05	0.02	569.4
2017[3]	5065.43	770.04	134.94	105.48	7.55	55.34	9.69	15.60	2.53	10.33	8.74	4.06	0.73	0.00	0.00	0.00	566.0
2018	3823.29	1675.64	336.31	86.66	65.76	7.77	15.59	3.62	2.56	1.70	4.72	4.00	1.38	0.13	0.00	0.00	574.8
2019	1898.20	1125.27	1075.55	187.22	49.40	17.00	4.04	2.95	0.74	1.08	0.19	0.35	0.20	0.05	0.00	0.02	600.0
2020[3]	110.62	267.79	424.22	586.99	99.12	22.08	6.06	2.61	1.04	0.67	0.23	0.71	0.70	0.49	0.02	0.00	537.8
2021[3]	406.30	25.12	109.80	175.26	262.62	19.19	3.65	0.71	0.20	0.13	0.08	0.31	0.18	0.05	0.00	1003.6	342.0

[1]Indices raised to also represent the Russian EEZ.

[2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005.

[3]Indices raised to also represent uncovered parts of the Russian EEZ.

[4]1994-2020: for years with raising, estimated based on relationship between unraised numbers-at-age and biomass-at-age from StoX baseline run. From 2021: estimated based on relationship between unraised numbers-at-age and biomass-at-age bootstrap mean estimates from StoX.

Table 6.7. HADDOCK. Abundance indices (numbers in millions) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2021. 2014-2020: baseline estimates, from 2021: bootstrap mean estimates.

Age group																**Biomass**
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**(‘000 t)**
2014	128.7	1.26	12.3	0.65	2.22	0.12	3.38	1.16	0.74	0.07	0.0	0.0	0.0	0.0	0	150.6	20.9
2015	49.0	17.4	0.33	13.2	0.46	4.30	0.88	0.56	3.51	2.16	0.0	0.0	0.0	0.0	0	91.8	34.5
2016	42.6	4.50	10.2	0.51	9.69	2.45	1.43	2.41	4.80	3.13	0.36	0.0	0.0	0.0	0	82.0	45.7
2017	199.6	15.7	3.76	5.83	2.18	7.56	0.80	2.07	1.06	1.82	2.39	0.72	0.0	0.0	0	243.5	51.6
2018	1141.9	65.3	17.9	3.20	5.03	2.27	3.66	0.90	0.54	0.35	0.72	0.48	0.56	0.0	0	1242.8	77.9
2019	115.3	45.6	30.1	7.74	3.03	1.13	0.15	0.14	0.0	0.07	0.0	0.06	0.0	0.0	0.02	203.4	29.9
2020	3.61	3.93	35.1	33.1	8.11	7.89	1.93	1.05	0.54	0.28	0.13	0.25	0.27	0.11	0	96.3	63.2
2021	12.6	1.08	0.40	7.74	13.4	1.29	0.61	0.14	0.09	0.02	0.06	0.09	0.11	0.00	0.00	37.6	22.8

Table 6.8. HADDOCK. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2021.

Age group														
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1994	11	13	15	13	15	29	52	45	33	52	38	97	-	-
1995	12	19	28	29	16	21	38	180	75	97	-	58	97	-
1996	14	13	12	25	30	24	61	64	-	98	-	95	96	-
1997[1]	13	35	13	15	17	21	18	57	54	-	-	-	64	92
1998[1]	15	13	13	14	16	25	18	16	34	107	106	-	-	-
1999	15	37	14	24	21	24	25	31	22	89	-	97	-	-
2000	9	9	18	9	16	14	34	51	31	34	63	91	105	-
2001	12	17	12	20	11	36	33	47	59	51	47	86	62	-
2002	9	11	10	10	22	17	27	39	81	60	48	51	75	-
2003	16	24	28	13	11	19	31	59	60	71	56	92	93	-
2004	9	12	15	16	10	13	28	24	43	56	58	93	60	54
2005	9	17	12	22	14	22	14	70	48	93	-	-	-	-
2006[2]	14	14	18	12	13	16	21	30	44	70	-	63	-	-
2007[1]	10	8	9	19	12	17	24	26	44	50	61	-	-	-
2008	12	17	15	13	19	30	27	81	42	81	68	88	-	-
2009	13	20	15	21	24	18	32	27	91	68	-	94	-	-
2010	10	17	18	22	18	18	25	29	42	55	144	167	-	-
2011	10	10	14	25	18	13	20	38	73	-	-	81	84	-
2012[2]	19	28	17	16	15	13	15	33	73	48	83	61	-	-
2013	12	12	13	14	27	24	27	14	26	50	-	-	-	-
2014	7	26	12	22	16	22	20	14	24	40	55	-	-	99
2015	7	13	26	14	44	11	25	18	21	28	40	51	97	-
2016	22	25	13	42	11	15	20	15	15	19	27	51	-	62
2017[2]	5	13	15	12	20	14	21	27	25	18	21	36	77	-
2018	7	16	13	12	10	17	15	23	18	18	18	20	32	52
2019	9	11	15	12	27	12	40	20	30	30	35	29	35	46
2020[2]	16	9	11	14	14	19	22	29	27	40	39	29	24	37
2021[2]	12	22	17	16	22	13	21	25	47	46	47	66	42	69

[1] REZ not covered

[2]REZ partly covered

6.3 Survey mortalities

Survey mortalities based on the acoustic indices (Table 6.9) have varied between years, and for most age groups there are no obvious trends. However, there are signs of co-variability within years. Survey mortalities based on the bottom trawl indices increased considerably from 2016 to 2017 to among the highest in the ten last years and has since then remained high for some age groups. Survey mortalities from 2019-2020 and 2020-2021 stand out as some of the highest in the time series for several age groups.

Table 6.9. HADDOCK. Survey mortality from surveys in the Barents Sea standard area winter 1994-2020.

Year	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
	Acoustic investigations							
1994-95	2.30	1.51	1.05	0.46	0.94	1.12	2.64	1.01
1995-96	2.54	1.08	0.63	0.57	1.01	2.13	1.09	-
1996-97	1.61	0.50	0.30	0.35	0.20	0.83	0.19	2.60
1997-98	1.21	-0.24	-0.03	-0.09	0.70	1.38	1.11	1.18
1998-99	1.95	0.59	0.45	0.98	1.37	1.60	1.29	2.03
1999-00	0.48	-0.19	0.10	0.43	0.56	1.37	1.07	0.66
2000-01	1.38	0.55	-0.10	0.60	1.85	2.06	2.28	1.77
2001-02	1.03	0.04	0.15	0.78	1.26	0.32	1.71	1.67
2002-03	1.29	0.27	0.32	0.39	0.41	0.67	1.81	0.73
2003-04	1.77	0.88	0.69	0.54	0.86	0.48	1.65	-0.11
2004-05	1.30	0.75	0.27	0.57	0.64	1.51	3.00	1.28
2005-06	1.29	0.94	0.58	0.89	1.09	1.43	1.37	1.56
2006-07	0.79	1.09	0.20	0.43	0.49	0.66	0.99	0.36
2007-08	0.14	0.16	-0.37	-0.67	0.08	1.36	-0.25	1.13
2008-09	1.31	0.69	0.25	0.13	0.84	1.62	1.77	3.63
2009-10	1.64	0.49	0.34	0.04	0.47	1.17	1.60	0.27
2010-11	1.69	0.46	0.42	0.70	0.73	1.11	1.95	1.12
2011-12	1.51	0.41	0.10	-0.05	0.01	0.53	0.60	1.20
2012-13	1.36	0.34	0.27	0.32	0.51	0.33	0.52	0.76
2013-14	0.98	0.20	0.54	0.30	0.42	0.42	0.95	1.03
2014-15	2.01	1.51	0.57	0.39	0.86	0.92	0.44	1.40
2015-16	2.70	1.23	0.70	1.16	0.76	0.98	0.21	0.26
2016-17	1.35	0.28	0.10	0.92	0.54	0.69	0.78	1.43
2017-18	1.42	0.67	0.25	0.01	-0.36	0.79	0.82	1.13
2018-19	1.45	0.46	0.15	0.68	1.08	0.34	1.57	0.70
2019-20	1.78	0.88	0.50	0.61	0.35	0.64	0.98	0.88
2020-21	2.86	1.64	0.79	0.52	1.41	1.41	2.51	0.82

	Bottom trawl investigations							
1994-95	1.11	1.41	0.63	0.24	0.44	0.90	1.87	1.10
1995-96	1.68	1.27	0.56	0.10	0.37	0.61	0.23	-
1996-97	1.20	1.20	0.34	0.54	0.90	0.99	1.59	2.64
1997-98	1.74	1.43	0.77	1.21	2.65	1.90	2.51	1.62
1998-99	1.09	1.24	0.31	1.36	1.43	0.47	1.97	2.24
1999-00	1.02	1.24	0.48	0.85	0.82	1.42	2.27	0.47
2000-01	0.62	0.40	-0.09	0.43	1.42	1.70	2.47	0.33
2001-02	0.95	0.36	0.46	0.75	1.05	0.66	1.24	1.84
2002-03	1.28	0.30	0.58	0.94	0.89	1.56	1.96	0.74
2003-04	1.55	1.00	1.25	0.82	0.35	-0.37	0.61	-0.11
2004-05	0.60	0.80	0.20	0.69	0.23	1.63	3.39	2.43
2005-06	1.23	1.59	0.89	1.12	0.89	1.33	1.15	0.97
2006-07	1.08	1.08	-0.04	0.43	0.56	1.35	2.00	0.84
2007-08	0.60	0.06	-0.28	0.43	0.44	1.35	-0.64	2.25
2008-09	0.99	0.51	0.75	0.46	0.74	1.48	2.08	4.73
2009-10	1.95	1.13	0.88	0.53	0.97	1.16	2.50	0.79
2010-11	1.53	0.41	-0.19	0.08	0.43	0.76	1.73	-0.10
2011-12	1.59	0.11	0.61	0.50	0.56	0.63	0.97	-0.79
2012-13	1.34	0.87	0.79	0.27	0.80	0.34	0.80	1.40
2013-14	1.02	0.25	0.56	0.32	-0.05	-0.40	0.67	0.58
2014-15	1.32	1.40	0.71	-0.29	0.97	0.46	0.98	1.15
2015-16	0.70	0.74	-0.11	0.48	0.67	-0.06	0.17	-0.55
2016-17	1.09	1.43	0.44	1.51	0.74	0.84	0.99	1.59
2017-18	1.11	0.83	0.44	0.47	-0.03	1.27	0.98	1.81
2018-19	1.22	0.44	0.59	0.56	1.35	0.65	1.67	1.59
2019-20	1.96	0.98	0.61	0.64	0.81	1.03	0.44	1.04
2020-21	1.48	0.89	0.88	0.80	1.64	1.80	2.15	2.58

6.4 Growth and maturity

Tables 6.10 and 6.11 present the time series (1994-2021) for mean length and mean weight at age. Length and weight estimates have been variable with no specific trends in the latest years. Lengths in 2021 were below average for ages 1-6 but above average for older fish, while mean weights were below average for ages 2-6 and above average for older fish. Annual weight increments are shown in Table 6.12, these are highly variable and show no trends. The proportion mature at age also shows large variations between years (Table 6.13). The large variation is one of the reasons that length, weight and maturity at age are modelled from the empirical data in the haddock stock assessment to account for inconsistencies due to high sampling variance and to fill in missing age-year combinations. The assessment input data for these variables may therefore differ somewhat from tables 6.10, 6.11 and 6.13.

The degree of coverage of the Russian zone (REZ) may influence the biological parameters, as body size tends to decrease towards the northeast in the survey area. In addition, length, weight and maturity at age of older ages has higher uncertainty due to fewer samples (c.f. table 2.3).

Table 6.10. HADDOCK. Mean length (cm) at age from bottom trawl surveys in the Barents Sea standard area winter 1994-2021. Bootstrap mean estimates. "+" indicates few samples (< 3), while "–" indicates no samples. Lengths are not adjusted for incomplete coverage.

Age/ Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1994	14.5	19.9	29.3	38.1	47.8	54.0	61.0	64.3	70.4	64.8	64.1	+	-	-
1995	15.1	18.2	28.6	34.0	42.8	51.3	58.9	+	+	+	-	+	+	-
1996	15.3	20.8	28.0	36.9	41.2	47.2	55.0	59.9	-	+	-	+	+	-
1997	15.7	19.7	27.4	34.1	39.5	47.3	50.7	55.0	62.8	-	-	-	+	+
1998	14.5	22.5	29.3	37.3	43.1	48.4	52.1	53.3	58.2	+	+	-	-	-
1999	14.4	18.3	32.3	38.8	46.5	51.9	56.0	55.2	58.8	+	-	+	-	-
2000	15.5	21.6	29.9	42.0	47.0	51.1	53.4	59.1	59.3	62.0	+	+	+	-
2001	14.6	22.1	32.1	37.6	48.0	50.4	59.1	56.2	64.6	66.5	68.2	+	+	-
2002	15.1	20.8	29.1	39.8	45.2	51.7	57.8	60.7	+	+	64.6	68.0	+	-
2003	15.8	23.9	26.4	36.6	45.8	49.7	54.8	60.9	63.9	61.6	67.3	+	+	-
2004	14.2	22.1	30.1	35.7	42.8	49.8	49.8	59.0	63.0	73.5	75.9	+	+	74.1
2005	14.8	20.5	29.9	36.1	40.5	48.3	51.6	55.7	60.8	+	-	-	-	-
2006	14.5	22.0	30.7	37.9	43.3	47.3	50.7	56.7	60.4	+	-	+	-	-
2007	15.5	22.9	29.0	35.7	45.8	48.0	53.5	57.4	57.3	68.7	+	-	-	-
2008	15.7	23.8	29.6	37.8	42.8	46.5	53.1	53.8	59.5	+	+	+	-	-
2009	14.3	22.3	29.7	35.5	41.7	48.1	49.7	56.5	+	62.8	-	+	-	-
2010	14.4	19.9	30.8	36.9	41.1	45.3	49.7	58.9	59.4	62.0	+	+	-	-
2011	13.6	23.2	28.5	39.4	42.9	46.1	48.3	62.5	53.8	-	-	+	+	-
2012	14.7	19.3	31.6	35.1	43.6	47.1	50.1	51.2	53.4	65.3	+	71.7	-	-
2013	14.5	22.9	30.0	40.9	42.8	48.7	52.2	52.9	55.7	67.3	-	-	-	-
2014	15.4	18.5	31.9	38.4	46.4	52.4	53.6	55.3	55.2	61.0	58.9	-	-	+
2015	14.5	20.4	26.2	39.8	45.7	52.5	53.6	57.5	57.0	59.9	59.9	67.3	+	-
2016	14.9	18.4	30.9	36.8	47.8	53.1	56.0	58.6	61.1	60.4	60.1	63.6	-	+
2017	15.8	20.5	30.5	40.0	49.6	52.9	56.1	60.6	61.2	63.2	62.5	64.7	67.3	-
2018	14.5	21.7	30.4	39.6	47.8	54.4	58.0	61.3	64.2	65.6	64.6	63.9	66.5	68.9
2019	14.8	21.5	29.7	37.1	46.1	52.5	53.6	60.5	64.3	65.7	67.5	67.3	69.5	69.3
2020	15.4	21.9	30.0	36.3	42.7	52.1	57.4	62.2	63.7	68.1	69.7	67.4	69.0	70.3
2021	14.4	19.5	29.1	36.2	42.7	49.2	55.0	60.5	66.7	69.4	73.0	71.6	71.7	+

Table 6.11. HADDOCK. Mean weight (g) at age from bottom trawl surveys in the Barents Sea standard area winter 1994-2021. Bootstrap mean estimates. "+" indicates few samples (< 3), while "–" indicates no samples. Weights are not adjusted for incomplete coverage.

Age/ Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1994	25	85	244	539	1060	1599	2146	2719	3349	2722	2662	+	-	-
1995	30	69	219	382	775	1357	1954	+	+	+	-	2537	+	-
1996	32	92	218	473	669	1022	1627	1948	-	+	-	+	3626	-
1997	35	82	193	381	616	1051	1300	1680	2476	-	-	-	+	+
1998	27	113	247	543	863	1166	1417	1583	2046	+	+	-	-	-
1999	28	77	334	580	1020	1445	1775	1730	2020	+	-	+	-	-
2000	33	109	275	736	1050	1367	1586	2093	2219	2575	+	+	+	-
2001	28	106	337	582	1146	1422	2140	2029	2939	3139	3105	+	+	-
2002	30	85	244	621	923	1388	1927	2242	+	+	2692	3280	+	-
2003	36	128	192	492	959	1204	1534	1982	2580	2675	3179	+	+	-
2004	23	98	271	458	752	1162	1222	1978	2611	3875	4186	+	+	4036
2005	29	97	263	471	669	1087	1376	1881	2120	+	-	-	-	-
2006	26	109	301	559	812	1086	1362	1925	2075	+	-	+	-	-
2007	32	109	253	519	1016	1193	1718	2043	2258	3443	+	-	-	-
2008	32	114	247	551	835	1115	1573	1599	2167	+	+	+	-	-
2009	26	94	227	444	746	1147	1315	1732	+	2567	-	+	-	-
2010	28	87	275	473	677	957	1261	1889	2204	2492	+	+	-	-
2011	21	117	220	520	729	943	1171	2264	1641	-	-	+	+	-
2012	29	75	306	432	819	1015	1280	1313	1700	2693	+	3287	-	-
2013	25	114	272	645	782	1138	1351	1502	1850	3117	-	-	-	-
2014	32	68	352	589	1002	1428	1566	1674	1704	2212	2156	-	-	+
2015	23	88	200	590	885	1418	1501	1915	1848	2085	2298	3148	+	-
2016	27	74	285	495	1058	1466	1754	2089	2290	2263	2402	2716	-	+
2017	33	95	293	637	1247	1542	1822	2294	2420	2640	2633	2890	3241	-
2018	26	95	275	627	1051	1663	1967	2349	2699	2820	2681	2648	3011	3415
2019	25	90	242	510	968	1411	1618	2083	2722	2916	3072	3220	3475	3229
2020	27	89	244	458	806	1385	1863	2426	2658	2887	3334	3013	3366	3600
2021	27	86	208	447	735	1159	1591	2201	3156	3172	3835	3533	3771	+

Table 6.12. HADDOCK. Yearly weight increment (g) from bottom trawl surveys in the Barents Sea standard area winter 1994-2021.

Year\Age	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1994-95	44	134	137	235	297	355	-	-	-
1995-96	61	148	253	287	247	270	-5	-	-
1996-97	50	101	164	143	382	278	53	528	-
1997-98	78	165	349	481	550	366	283	366	-
1998-99	50	221	333	478	582	609	313	437	-
1999-00	81	198	403	470	347	141	318	489	554
2000-01	74	227	308	409	372	773	444	846	920
2001-02	57	138	285	341	242	505	102	-	-
2002-03	98	106	248	338	281	146	54	338	-
2003-04	62	143	267	261	203	18	444	629	1295
2004-05	74	165	200	210	335	214	660	142	-
2005-06	80	204	296	341	417	275	550	194	-
2006-07	84	144	218	457	381	632	681	333	1368
2007-08	82	138	298	316	99	380	-119	124	-
2008-09	62	113	197	196	311	199	160	-	400
2009-10	61	181	246	233	211	115	574	472	-
2010-11	89	133	245	256	266	214	1003	-248	-
2011-12	53	189	212	299	285	337	142	-565	1052
2012-13	85	197	339	349	319	336	221	537	1418
2013-14	43	238	317	357	646	428	323	202	362
2014-15	56	132	238	296	416	73	348	175	381
2015-16	51	197	295	468	580	337	588	375	414
2016-17	68	219	352	753	483	356	540	331	350
2017-18	61	180	334	414	416	426	527	405	400
2018-19	64	148	235	341	361	-45	116	373	217
2019-20	64	155	216	296	417	452	808	575	165
2020-21	58	120	202	278	350	199	337	733	519

Table 6.13. HADDOCK. Proportion mature at age from bottom trawl surveys in the Barents Sea standard area winter 1994-2021. Bootstrap mean estimates. The proportion mature is the number of fish classified as maturity category 2 and 3, divided by the total number of fish assigned categories 1-5. "+" indicates few samples (< 3), while "–" indicates no samples.

Age/ Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1994	0.00	0.00	0.00	0.02	0.15	0.41	0.43	1.00	0.82	0.50	0.64	+	-	-
1995	0.00	0.00	0.00	0.03	0.18	0.38	0.38	+	+	+	-	0.78	+	-
1996	0.00	0.00	0.00	0.05	0.08	0.28	0.39	0.80	-	+	-	+	0.00	-
1997	0.00	0.00	0.00	0.00	0.15	0.33	0.64	0.22	0.71	-	-	-	+	+
1998	0.02	0.00	0.00	0.04	0.15	0.54	0.50	0.78	0.95	+	+	-	-	-
1999	0.00	0.00	0.00	0.06	0.24	0.38	0.76	0.82	0.98	+	-	+	-	-
2000	0.00	0.00	0.00	0.25	0.54	0.65	0.89	1.00	0.91	0.88	+	+	+	-
2001	0.00	0.00	0.00	0.21	0.54	0.45	0.88	1.00	1.00	0.75	1.00	+	+	-
2002	0.00	0.00	0.01	0.12	0.45	0.61	0.96	0.91	+	+	0.80	1.00	+	-
2003	0.00	0.00	0.00	0.04	0.40	0.59	0.70	0.60	0.67	0.67	1.00	+	+	-
2004	0.00	0.00	0.02	0.03	0.14	0.61	0.56	0.43	0.89	1.00	1.00	+	+	1.00
2005	0.00	0.00	0.01	0.06	0.19	0.43	0.76	0.22	1.00	+	-	-	-	-
2006	0.00	0.00	0.00	0.12	0.41	0.59	0.84	0.86	0.50	+	-	+	-	-
2007	0.00	0.00	0.02	0.19	0.46	0.67	0.82	0.95	0.86	1.00	+	-	-	-
2008	0.13	0.02	0.02	0.09	0.47	0.66	0.84	0.85	1.00	+	+	+	-	-
2009	0.00	0.00	0.00	0.04	0.15	0.29	0.65	0.68	+	0.40	-	+	-	-
2010	0.00	0.00	0.05	0.08	0.20	0.40	0.59	0.77	0.92	0.91	+	+	-	-
2011	-	0.00	0.00	0.07	0.14	0.40	0.38	0.38	0.92	-	-	+	+	-
2012	0.00	0.00	0.01	0.06	0.40	0.51	0.60	0.69	0.05	1.00	+	0.67	-	-
2013	0.00	0.00	0.01	0.04	0.16	0.49	0.61	0.61	0.64	1.00	-	-	-	-
2014	0.00	0.01	0.02	0.15	0.29	0.75	0.72	0.71	0.71	0.95	0.94	-	-	+
2015	0.00	0.00	0.03	0.04	0.15	0.47	0.68	0.66	0.43	0.65	1.00	0.67	+	-
2016	0.00	0.00	0.00	0.02	0.29	0.73	0.83	0.83	0.89	0.84	0.96	1.00	-	+
2017	0.00	0.00	0.01	0.12	0.48	0.66	0.75	0.96	0.90	0.98	0.99	1.00	1.00	-
2018	0.00	0.00	0.01	0.11	0.32	0.62	0.92	0.82	0.93	0.86	0.91	0.95	0.96	1.00
2019	0.00	0.00	0.02	0.07	0.20	0.60	0.69	0.86	0.90	0.97	1.00	1.00	1.00	1.00
2020	0.00	0.00	0.01	0.04	0.19	0.56	0.76	0.83	0.92	0.92	1.00	1.00	0.89	0.94
2021	0.00	0.00	0.00	0.06	0.14	0.47	0.65	0.73	0.81	1.00	1.00	0.79	0.88	+

7 Distribution and abundance of redfish

Earlier reports from this survey have presented distribution maps and abundance indices based on acoustic observations of redfish. In later years, blue whiting has dominated the acoustic records in some of the main redfish areas. Due to incomplete pelagic trawl sampling the splitting of acoustic records between blue whiting and redfish has been very uncertain. The uncertainty relates mainly to the redfish, since it only makes up a minor proportion of the total value. This has been the case since the 2003 survey, and the acoustic results for redfish are therefore not included in the reports.

7.1 Golden redfish (*Sebastes norvegicus*)

Figure 7.1 shows the geographical distribution of golden redfish based on the catch rates in bottom trawl. In most years, the distribution is completely covered except towards the northwest. Table 7.1 presents the time series (1994-2021) of swept area indices by 5 cm length groups for the standard area (strata 1-23). The indices were low in many years since 1999 for all length groups. However, in 2016 and 2017 there was an increase in the indices of fish above 25 cm, and in 2018 the total index was at the same level as in 2017, while the total biomass was slightly lower. In 2019 the indices for fish between 35 and 50 cm increased further, and the total abundance and biomass were the highest since 1998. The index for most length groups declined in 2020 and further in 2021 when the abundance of fish < 20 cm was particularly low. Table 7.2 present swept area abundance indices by length groups for area N in 2014-2021. Golden redfish was found in this extended survey area in 2014-2021, mainly west of Spitsbergen (strata 24). 21% of the total abundance and 7 % of total biomass was found in the extended area in 2021.

Table 7.3 presents estimates of coefficients of variation (%) by length groups. In all years, CVs for most length groups are above what could be considered as acceptable in stock assessment (approximately 20 %).

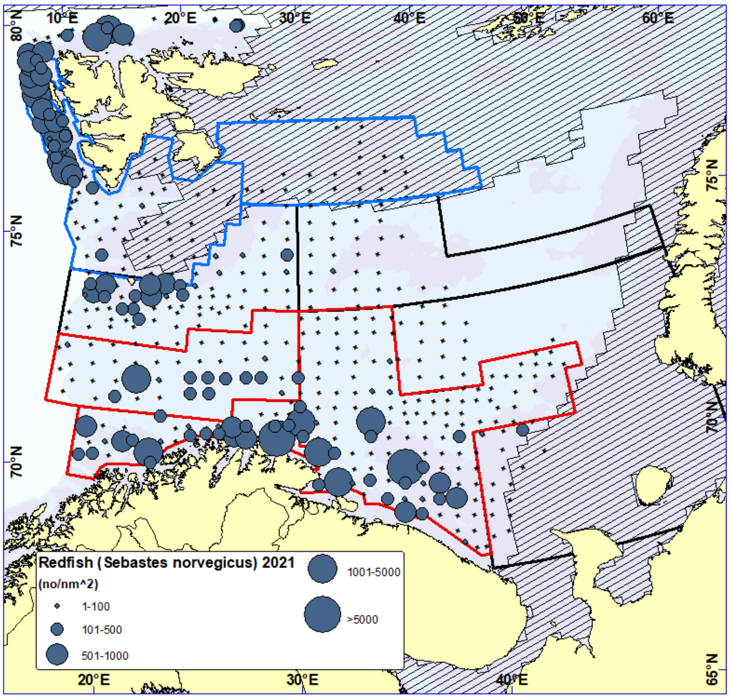

Figure 7.1. GOLDEN REDFISH (*Sebastes norvegicus)*. Distribution in the trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

Table 7.1. GOLDEN REDFISH (S*ebastes norvegicus)*. Abundance indices (numbers in thousands) from bottom trawl surveys in the Barents Sea standard area winter 1994-2021.

	Length group (cm)													**Biomass**
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**≥60**	**Total**	**(tons)**
1994	675	7493	10100	12840	10914	17834	10065	4799	1645	937	202	121	77623	31841
1995	387	4658	13515	13118	10398	15429	16223	10587	3112	852	455	148	88883	42151
1996	40	715	3291	5983	8863	14089	15709	7502	2692	893	168	165	60010	35775
1997[1]	0	500	1197	2809	6522	22751	28797	8235	1747	1092	239	97	73985	44977
1998[1]	51	4525	2043	10795	73085	30862	14707	6984	1712	456	142	0	145363	49253
1999	181	928	2070	4002	4351	6275	6143	5474	2618	738	75	0	32854	20330
2000	533	1122	1506	4196	4895	5146	3611	1908	620	466	89	0	24092	10946
2001	55	411	398	2452	5802	5463	4509	3239	1154	343	96	37	23960	13896
2002	133	1053	2043	1854	3955	4204	3335	3654	1656	619	192	28	22726	13242
2003	0	478	1303	1538	4192	4081	2765	3204	1996	548	123	327	20554	13399
2004	700	195	420	973	2842	4365	5404	3858	2281	562	140	45	21786	15758
2005	0	119	203	362	1110	2090	3849	4664	2730	1276	299	128	16831	16389
2006[2]	0	0	0	178	2495	5534	6307	4155	3179	950	124	12	22934	18790
2007[1]	0	97	453	214	772	1526	2823	4275	2742	1194	197	58	14351	14553
2008	1736	2540	201	171	440	710	1969	2547	3049	1231	157	19	14768	12647
2009	0	0	86	0	39	436	1745	3779	4200	1959	267	101	12728	17237
2010	372	2017	1168	527	136	60	833	1062	2073	1596	205	128	10175	9787
2011	342	3187	2068	288	402	125	274	2329	3030	1912	131	243	14332	13302
2012[3]	805	4375	3995	1835	550	316	881	3645	4083	1775	320	85	22664	16011
2013	75	7418	4896	3952	1550	355	878	821	1284	1594	384	451	23658	11456
2014	128	1043	1440	3005	3363	1023	507	1427	2139	1176	633	193	16077	12087
2015	139	881	1467	3019	2603	2013	458	720	1237	1216	874	82	14710	10120
2016	748	1291	1484	2396	4290	3673	3391	1658	2147	2307	1114	250	24749	19847
2017[3]	341	1304	898	1065	4462	9060	6661	2980	2087	1776	604	498	31735	25050
2018	1129	2750	1799	1678	3282	4693	6335	4323	2012	1630	715	299	30645	22871
2019	671	3248	1700	2409	2515	3910	9024	9693	6709	1544	477	415	42279	36241
2020[3]	971	650	1498	1041	1891	2424	6450	8786	6426	2773	503	151	33496	33564
2021[3]	43	303	872	1172	1093	1523	4090	5938	5323	2753	1190	239	24539	29317

[1] Indices raised to also represent the Russian EEZ

[2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005

[3]Indices not raised to also represent uncovered parts of the Russian EEZ.

Table 7.2. GOLDEN REDFISH (S*ebastes norvegicus)*. Abundance indices (numbers in thousands) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2021.

	Length group (cm)										**Biomass**
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**≥45**	**Total**	**(tons)**
2014	35	333	358	1440	2594	1315	211	501	379	7166	2913
2015	0	202	197	127	804	804	363	0	154	2651	1261
2016	0	0	103	300	597	1186	828	107	32	3151	1405
2017	0	66	93	587	519	679	547	96	66	2654	1053
2018	58	824	750	647	639	964	1855	546	50	6331	2598
2019	76	974	1445	567	666	1445	1043	519	102	6838	2525
2020	37	277	1239	934	1315	2498	2027	993	375	9695	4850
2021	25	305	1051	1173	437	893	857	389	126	5256	2004

Table 7.3. GOLDEN REDFISH (S*ebastes norvegicus)*. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2021.

	Length group (cm)										
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**
1994	51	42	22	27	18	34	13	29	20	23	40
1995	47	39	38	31	16	33	31	33	21	22	34
1996	68	51	47	25	16	27	25	20	16	24	46
1997[1]	-	40	30	28	20	64	71	37	14	19	34
1998[1]	67	28	25	56	82	64	48	42	27	28	44
1999	62	38	37	35	33	25	33	59	57	29	70
2000	46	27	21	24	22	28	28	26	22	21	56
2001	53	28	31	24	31	27	38	50	29	26	45
2002	54	61	51	25	29	23	28	39	49	26	41
2003	-	29	34	34	27	23	16	20	27	36	70
2004	72	38	26	32	35	54	52	26	30	22	54
2005	-	73	46	32	20	25	31	22	23	34	65
2006[2]	-	-	-	46	46	45	37	30	22	18	43
2007[1]	-	69	61	56	31	21	23	27	23	17	32
2008	33	30	41	60	42	27	22	23	17	24	64
2009	-	-	69	-	73	31	30	24	23	24	29
2010	54	31	45	51	41	70	31	34	17	19	31
2011	45	37	23	48	30	55	40	66	44	33	48
2012[2]	38	41	21	21	35	40	28	40	45	29	43
2013	55	40	27	17	22	45	38	39	38	27	44
2014	61	35	31	22	21	26	37	35	28	26	26
2015	64	44	33	29	26	24	30	36	27	18	37
2016	50	28	22	24	26	25	19	23	28	20	29
2017[2]	100	40	45	31	33	71	40	32	31	41	30
2018	37	24	19	25	20	17	22	19	23	21	24
2019	43	33	22	27	21	19	22	32	32	19	36
2020[2]	90	36	37	29	24	19	33	46	33	27	44
2021[2]	103	43	26	25	24	37	36	36	36	31	38

[1] REZ not covered

2 REZ partly covered

7.2 Beaked redfish (*Sebastes mentella*)

Figure 7.1 shows the geographical distribution of beaked redfish based on the catch rates in bottom trawl. Table 7.4 presents the time series (1994-2021) of swept area abundance indices by 5 cm length group for beaked redfish in the standard area (strata 1-23), while table 7.5 present indices for new strata 24-26 in 2014-2021.

In 2015 and 2016, the estimated indices for 20-39 cm beaked redfish were among the highest in the time series, and in 2017 the indices for 30-39 cm beaked redfish were the highest in the time series, as were the total index and total biomass. The indices for most length groups decreased somewhat from 2017 to 2018 and remained at about the same level in 2019 and 2020 before decreasing further in 2021. However, the 2020 year class appears to have been strong as the 2021 estimate of fish < 10 cm were the highest in the time series. The coverage of the beaked redfish distribution was not complete west and north of Spitsbergen (Fig. 7.2). The extended survey area contributed about 10% of the total abundance index, compared to around 3 % in 2019 and 2020. Only 2018 had a similar proportion of beaked redfish in area N.

Table 7.6 presents estimates of coefficients of variation (%) by length groups. In most years, CVs for length groups between 10 and 29 cm are at a level that could be considered as acceptable for stock assessment, and in most recent years up to 44 cm.

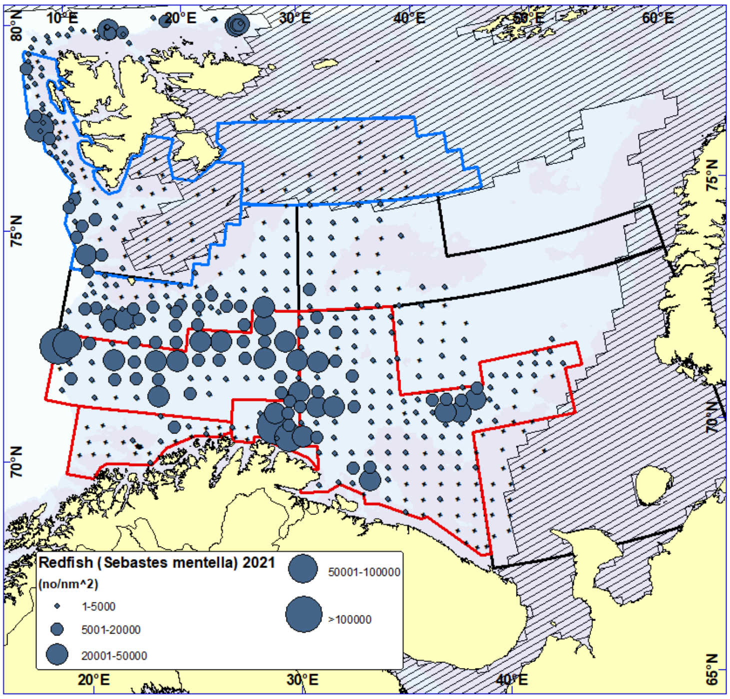

Figure 7.2. BEAKED REDFISH (*Sebastes mentella)*. Distribution in the trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

Table 7.4. BEAKED REDFISH *(Sebastes mentella)*[1]. Abundance indices (numbers in millions) from bottom trawl surveys in the Barents Sea standard area winter 1994-2021.

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	≥45	Total	Biomass ('000 t)
1994	8.3	295.7	479.4	488.4	74.4	74.4	17.1	2.6	0.1	1440.4	161.2
1995	310.1	83.9	570.6	390.5	82.7	57.7	23.9	2.8	0.4	1522.5	153.0
1996	214.6	101.5	198.5	342.9	136.0	42.0	16.6	1.4	0.2	1053.8	127.9
1997[2]	64.6	118.45	22.0	242.4	258.2	70.2	39.1	4.4	0.1	819.4	165.3
1998[2]	1.0	88.0	62.4	101.4	203.2	40.0	12.9	1.7	0.2	510.7	96.1
1999	2.1	6.8	69.5	36.8	171.2	73.9	21.8	3.2	0.7	385.4	98.8
2000	9.2	12.9	40.2	78.0	142.2	94.8	24.5	7.0	1.5	410.3	111.5
2001	9.8	23.1	7.2	56.8	78.8	74.7	9.6	0.6	0.1	260.8	65.3
2002	16.5	7.5	19.3	36.5	96.2	116.7	23.9	1.4	0.03	318.1	90.2
2003	3.8	4.1	10.3	12.6	70.4	198.1	45.9	5.7	0.3	351.1	139.4
2004	2.2	3.0	6.9	18.5	32.8	86.3	31.6	1.9	0.8	183.4	68.4
2005	0	6.3	7.4	10.7	28.4	153.7	86.2	3.8	0.2	296.6	131.3
2006[3]	100.0	1.9	9.6	14.6	22.8	103.8	82.8	2.7	0.7	338.8	108.2
2007[2]	374.2	121.8	2.8	6.7	12.3	121.0	120.7	7.1	0	766.7	136.6
2008	858.2	359.1	26.8	4.6	11.5	103.6	165.4	4.7	0.1	1533.9	169.3
2009	95.3	324.7	135.5	5.4	8.8	67.1	162.6	5.8	0.4	805.7	155.1
2010	652.2	276.0	214.7	64.2	7.1	73.6	191.3	5.9	0.4	1485.4	198.1
2011	501.6	229.7	212.5	149.0	14.1	46.6	157.3	4.9	0.2	1315.8	177.8
2012[4]	129.4	280.1	86.4	125.3	47.3	14.4	153.9	17.7	0.2	854.7	170.7
2013	249.6	226.6	245.4	159.2	143.2	35.2	193.3	27.1	0.3	1279.8	242.2
2014	90.7	175.3	250.1	113.7	124.6	50.6	115.1	13.8	0.2	934.1	170.2
2015	175.2	110.7	216.2	302.2	289.8	214.8	170.9	18.1	0.2	1498.0	344.6
2016	615.1	105.3	148.6	331.5	213.1	162.7	123.6	14.1	0.6	1714.6	262.5
2017[5]	603.6	201.9	70.4	198.5	286.9	308.9	231.5	10.6	0.23	1914.9	403.9
2018	189.9	253.3	83.2	110.1	191.3	270.4	216.6	22.6	1.14	1338.5	348.6
2019	42.4	294.4	270.0	92.0	158.1	255.1	210.8	20.0	0.3	1343.2	340.3
2020[4]	196.0	123.2	207.0	92.2	118.0	230.6	209.2	24.7	0.7	1201.5	312.8
2021[4]	889.4	132.4	142.5	123.9	80.9	186.5	172.4	22.8	1.0	1751.7	267.7

[1] Includes unidentified *Sebastes* specimens, mostly less than 10cm

[2] Indices raised to also represent the Russian EEZ

[3] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005

[4] Indices not raised to represent uncovered parts of the Russian EEZ

[5]Indices raised to also represent uncovered parts of the Russian EEZ

Table 7.5. BEAKED REDFISH (*Sebastes mentella)*[1]. Abundance indices (numbers in millions) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2021.

	Length group (cm)										Biomass
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**>45**	**Total**	**('000 t)**
2014	19.6	9.2	11.5	6.8	5.4	1.7	2.3	0.4	0	56.9	5.5
2015	13.5	5.5	8.3	11.3	11.4	5.2	3.4	0.1	0.03	58.9	9.4
2016	54.6	3.1	2.2	4.5	4.8	4.2	1.4	0.3	0	75.0	4.5
2017	81.9	13.1	1.3	4.5	6.0	6.4	3.6	0.6	0.03	117.4	7.8
2018	47.9	74.0	2.3	1.8	4.6	5.9	5.8	0.6	0	143.0	8.6
2019	10.9	10.1	7.0	0.7	1.4	1.3	2.1	0.2	0.03	33.7	3.0
2020	12.8	3.1	4.5	1.7	2.0	7.3	4.9	0.6	0.04	36.8	7.9
2021	136.1	1.0	4.3	6.0	3.2	15.2	9.4	0.5	0.05	175.7	14.5

[1] Includes unidentified *Sebastes* specimens, mostly less than 10cm

Table 7.6. BEAKED REDFISH (*Sebastes mentella)*[1]. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2021.

	Length group (cm)								
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**
1994	40	14	25	28	20	23	26	49	53
1995	18	25	23	25	17	20	18	34	39
1996	18	23	27	22	19	36	23	37	58
1997[2]	18	15	13	11	14	17	26	53	53
1998[2]	28	16	21	14	17	16	21	31	77
1999	20	17	15	11	18	22	29	56	65
2000	16	12	17	12	16	21	31	64	76
2001	17	14	14	12	13	19	17	26	67
2002	57	13	15	18	16	21	19	31	65
2003	56	17	18	17	18	27	27	43	88
2004	19	15	15	19	16	14	18	21	59
2005	-	23	15	16	16	17	21	38	40
2006[3]	11	49	25	28	18	17	16	24	85
2007[2]	15	23	18	13	15	24	19	41	59
2008	14	15	29	23	20	23	22	24	45
2009	13	10	18	22	40	28	22	24	46
2010	14	12	12	18	22	31	31	22	80
2011	10	12	10	15	16	32	25	27	56
2012[3]	16	12	13	11	21	32	37	54	44
2013	15	15	35	23	32	29	39	41	49
2014	10	12	11	15	21	22	30	27	48
2015	14	11	14	18	26	22	19	29	52
2016	10	11	13	20	16	16	18	18	58
2017[3]	10	16	16	14	17	16	16	15	97
2018	8	9	11	14	11	14	17	21	33
2019	11	12	15	12	16	18	19	21	59
2020[3]	10	14	10	11	18	14	12	17	47
2021[3]	12	32	10	14	17	20	17	20	66

[1] Includes unidentified Sebastes specimens, mostly less than 10cm

[2] REZ not covered

3 REZ partly covered

7.3 Norway redfish (*Sebastes viviparus*)

Figure 7.3 shows the geographical distribution of Norway redfish and Table 7.7 presents the time series (1994-2021) of swept area indices by 5 cm length groups in the standard area (strata 1-23). Almost all Norway redfish are found in areas ABCD, mainly in main area B, and almost nothing in the extended survey area (Table 7.8). In 2021, the smallest fish (< 10 cm) were found in the extended survey area for the first time.

A few large catches often drive the indices for Norway redfish. There was a large and unexplained increase in the indices of most length groups from 2013 to 2015 to among the highest levels in the time series. Apart from a dip in 2016, the total abundance has remained relatively high since then. The total abundance increased with nearly 50 % in 2021 to the highest observed since 1994, driven by high abundance of 15-30 cm fish.

Table 7.9 presents estimates of coefficients of variation (%) by length groups. In most years, CVs for most length groups are far above what could be considered as acceptable for stock assessment.

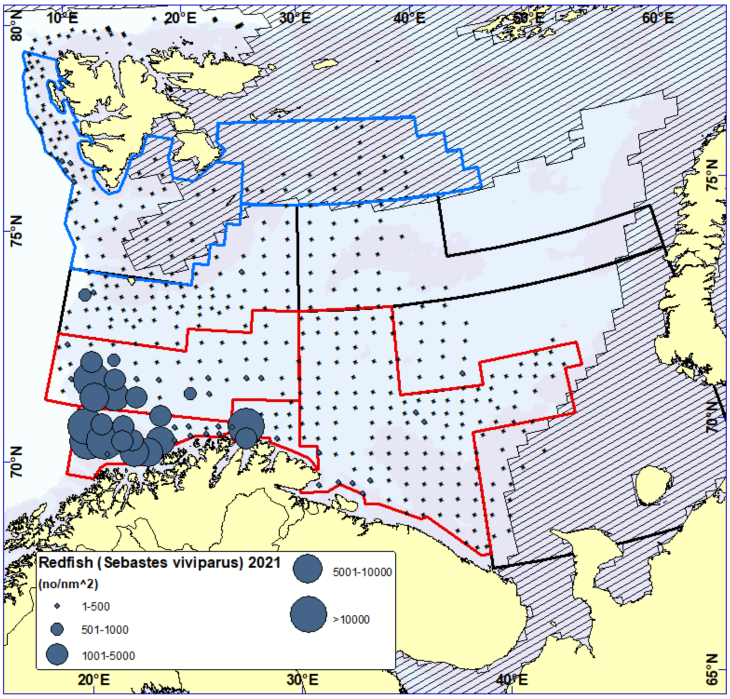

Figure 7.3. NORWAY REDFISH (*Sebastes viviparus)*. Distribution in the trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

Table 7.7. NORWAY REDFISH *(Sebastes viviparus)*. Abundance indices (numbers in thousands) from bottom trawl surveys in the Barents Sea standard area winter 1994-2021.

	Length group (cm)						
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**≥30**	**Total**
1994	75355	94809	17218	12818	1377	279	201857
1995	10716	68713	22737	9349	3306	503	115325
1996	439	45798	43673	35921	5498	87	131417
1997[1]	898	24202	28857	18768	4397	0	77122
1998[1]	703	9835	42183	20801	2939	91	76102
1999	1577	10134	11675	2921	707	35	27049
2000	1011	5127	37429	22122	2118	140	67947
2001	249	2243	30082	34405	3802	120	70901
2002	332	3345	17674	15168	1276	88	37884
2003	234	4306	22603	31019	4277	181	62619
2004	102	1794	24462	32769	3294	291	62712
2005	172	1582	16444	37360	6153	356	62068
2006[2]	819	4480	3653	10381	2244	205	21782
2007[1]	704	5238	15652	34395	2448	80	58517
2008	0	1882	5910	21022	4561	30	33344
2009	506	528	3096	11032	3405	419	18988
2010	1712	455	10134	53181	7572	22	73076
2011	533	1250	2169	7758	2197	106	14013
2012[1]	586	3950	4080	29157	6212	74	44059
2013	1211	9522	3302	23464	8545	100	46144
2014	11388	17755	21079	64094	15135	1990	131441
2015	7384	27351	30768	65870	9048	88	140509
2016	2795	26824	18396	29229	11286	933	89464
2017[1]	3848	58422	21556	22580	5685	426	112518
2018	700	24371	61515	37470	26283	1344	151763
2019	730	14679	58653	31991	6469	1250	113773
2020[1]	603	3485	58704	46850	15290	907	125840
2021[1]	1256	8858	82510	74664	19302	676	187411

[1] Indices not raised to represent the Russian EEZ or uncovered parts, *Sebastes viviparus* is mainly found in NEZ

[2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005

Table 7.8. NORWAY REDFISH (*Sebastes viviparus)*. Abundance indices (numbers in thousands) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2021.

	Length group (cm)						
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**≥30**	**Total**
2014	0	87	44	0	0	0	131
2015	0	0	35	0	0	0	35
2016	0	0	111	0	0	0	111
2017	0	0	0	0	0	0	0
2018	0	0	160	126	32	0	318
2019	0	0	51	0	0	0	51
2020	0	0	54	54	0	0	108
2021	51	0	0	74	0	0	125

Table 7.9. NORWAY REDFISH (*Sebastes viviparous)*. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2021.

	Length group (cm)					
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**
1994	34	52	25	39	41	70
1995	42	31	43	34	70	89
1996	62	24	31	36	51	57
1997[1]	84	31	27	48	56	-
1998[1]	39	20	43	68	71	79
1999	78	58	32	25	37	65
2000	52	29	47	48	41	51
2001	39	26	31	30	34	85
2002	61	34	20	23	46	83
2003	73	34	35	30	31	76
2004	57	36	38	35	24	66
2005	69	35	40	31	34	69
2006[2]	75	75	25	30	21	58
2007[1]	75	78	39	39	29	87
2008	-	58	32	28	42	73
2009	61	48	25	24	27	61
2010	47	42	47	52	57	97
2011	51	59	50	48	45	75
2012[2]	45	30	48	45	43	100
2013	58	32	25	41	51	98
2014	43	36	40	40	41	79
2015	38	32	34	43	53	100
2016	37	28	29	28	23	46
2017[2]	46	62	23	30	27	52
2018	46	46	47	54	40	60
2019	64	57	44	29	32	68
2020[2]	67	34	39	41	59	46
2021[2]	46	30	45	42	45	79

[1] REZ not covered, [2]REZ partly covered

8 Distribution and abundance of Greenland halibut

Figure 8.1 shows the distribution of bottom trawl catch rates of Greenland halibut. The most important distribution areas for the adult fish (depths between 500 and 1000 m along the western slope), are not covered by the survey. The observed distribution pattern in 2021 was similar to those observed in previous years' surveys. However, in 2021 some trawling was also performed in or close to the ice in the central Barents Sea (stratum 26), revealing large concentrations of Greenland halibut < 35 cm in this area.

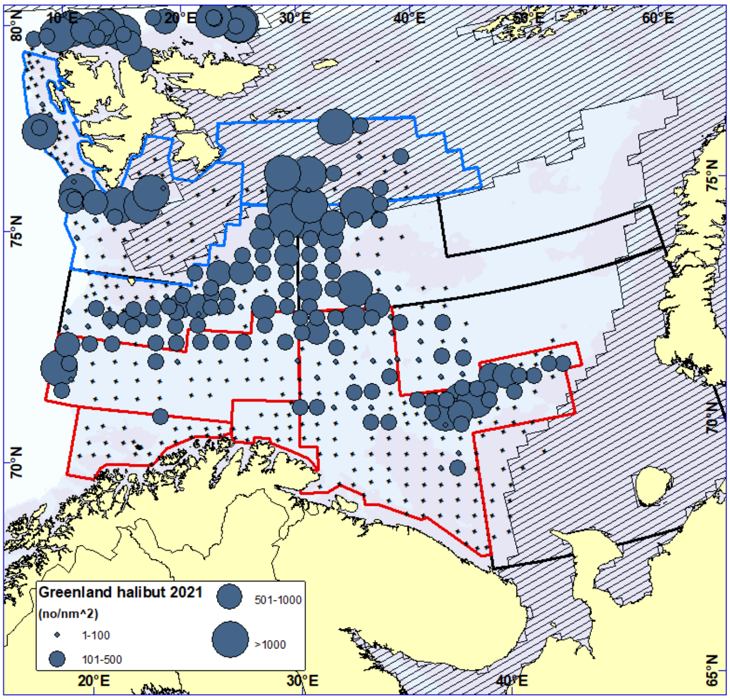

Figure 8.1 GREENLAND HALIBUT. Distribution in the trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

The time series (1994-2021) of swept area abundance indices by 5 cm length groups in the standard area is presented in Table 8.1. Abundance indices have been low in the whole period, with few signs of improved recruitment in the covered area. However, recruitment from more northern areas has led to an increase in abundance indices of length groups above 30 cm since about 2005. There was a large increase in the indices of most length groups between 30 and 79 cm from 2014 to 2015, and the total index was the highest in the time series back to 1994. After decreasing indices from 2016-2018, the 2019 indices of all length groups above 34 cm increased, and the total index and biomass were at the same level as in 2015 and among the highest in the time series. The total index remained high in 2020 but with higher numbers and lower biomass than in 2019 due to a higher proportion of fish < 50 cm. In 2021, there was an increase of individuals < 40 cm, and a decrease of individuals > 40 cm compared to 2020. The total index dropped by 7% compared to the previous year.

Table 8.2 presents swept area abundance indices by length groups for new strata 24-26 in 2014-2021. The index for 2021 was much higher than in all previous years for individuals smaller than 35 cm, which is related to the coverage of areas close to/inside the ice that has not previously been covered in the survey.

Table 8.3 presents estimates of coefficients of variation (%) for length groups. In most years, only CVs for length groups between 40 and 59 cm are at a level that could be considered as acceptable for stock assessment.

Table 8.1. GREENLAND HALIBUT. Abundance indices (numbers in thousands) from bottom trawl surveys in the Barents Sea standard area winter 1994-2021.

	Length group (cm)																**Biomass**
Year	**≤14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**≥ 80**	**Total**	**(tons)**
1994	0	0	21	76	148	1117	3139	4740	3615	1941	889	541	21	0	0	16248	19228
1995	298	0	0	0	90	129	2877	7182	5739	2027	1622	839	489	86	0	21378	27459
1996	4121	0	0	0	62	124	1214	4086	4634	1871	1112	638	337	74	12	18285	20256
1997[1]	0	68	0	0	55	163	949	4313	5629	2912	1609	643	300	65	21	16728	24214
1998[1]	68	220	945	578	481	487	1088	4016	6591	3076	1798	707	326	93	44	20518	27248
1999	43	84	241	436	566	269	784	1701	3097	1669	1094	491	89	75	0	10640	14681
2000	140	184	344	836	1722	3857	2253	1560	2144	1714	1191	615	249	76	0	16883	17246
2001	68	49	147	179	737	1525	3716	3271	2302	2010	1088	529	160	50	39	15871	18224
2002	271	0	70	34	382	1015	1916	3803	3250	2279	1138	976	242	159	114	15648	21198
2003	51	0	74	19	304	715	1842	3008	4765	2235	714	561	245	146	0	14678	19635
2004	106	104	15	0	319	1253	1229	1717	2277	1227	798	298	148	94	26	9615	11872
2005	263	70	159	1139	2235	2621	4206	3782	3847	2037	917	585	336	118	0	22314	22293
2006[2]	0	72	94	414	1968	5149	4613	5743	4283	2132	891	449	258	34	18	26118	25579
2007[1]	0	18	146	1869	1418	3114	5710	5947	4287	2205	963	658	391	80	89	26896	28006
2008	0	0	0	243	1708	5974	4654	6136	5198	3403	827	638	174	82	50	29088	30153
2009	55	0	0	26	1044	4327	8133	4551	4084	2266	996	627	442	253	154	26960	28919
2010	0	0	0	99	678	3648	5729	6560	4897	2467	1064	552	229	128	41	26092	25979
2011	51	0	0	0	216	4396	5864	5498	5237	3698	699	936	327	252	97	27271	31552
2012[3]	77	0	0	0	51	1145	4524	5366	4517	2774	1147	195	73	0	48	19917	22656

2013	0	0	0	0	0	511	5368	4868	5374	3687	1944	939	348	313	154	23504	31748
2014	0	0	46	92	156	368	2271	5587	5903	3555	2251	1369	154	260	79	22090	31112
2015	367	0	61	0	284	1612	3187	6452	7249	6752	3350	1936	587	334	0	32172	46828
2016	205	0	124	511	950	1953	3486	4539	5479	5613	1999	1973	646	98	80	27657	35831
2017[4]	52	0	0	78	592	1328	1885	3850	4852	4550	1721	1455	317	190	23	20827	29756
2018	0	0	62	0	383	1333	2049	3445	4258	3573	1904	1366	736	196	20	19325	28688
2019	0	0	0	375	272	1671	3285	4034	5177	4265	3570	2526	1328	535	137	27176	45912
2020[3]*	80	91	246	442	790	2272	4391	5136	4929	4613	3278	1803	894	384	250	29599	43631
2021[3]	0	154	927	927	2370	2976	3869	4265	3516	2991	2378	1649	670	682	238	27613	37090

[1] Indices raised to also represent the Russian EEZ

[2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005

[3]Indices not raised to also represent uncovered parts of the Russian EEZ.

[4]Indices raised to also represent uncovered parts of the Russian EEZ

*The 2020 indices were updated in 2021 after an error was discovered in the calculations

Table 8.2. GREENLAND HALIBUT. Abundance indices (numbers in thousands) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2021.

	Length group (cm)																**Biomass**
Year	**≤14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**≥ 80**	**Total**	**(tons)**
2014	0	134	141	0	138	453	1350	1443	1351	293	803	39	117	0	0	6261	7366
2015	0	0	0	269	30	263	550	863	597	567	555	66	107	38	0	3903	5092
2016	678	933	607	436	336	431	331	728	340	254	68	34	140	0	34	5349	3059
2017	31	0	0	193	583	861	662	456	301	33	298	30	0	34	0	3485	2990
2018	136	28	0	434	775	1840	1099	1042	776	634	360	511	0	0	0	7636	7528
2019	296	92	81	78	137	1072	1144	1384	896	649	638	297	24	40	0	6826	8118
2020*	36	0	0	0	0	169	160	322	32	31	66	62	0	0	0	878	889
2021	1807	3961	3859	2159	1207	863	564	1612	1127	885	495	190	23	0	0	19704	10187

*The 2020 indices were updated in 2021 after an error was discovered in the calculations.

Table 8.3. GREENLAND HALIBUT. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2021.

Year	**Length group (cm)**														
	10-14	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**
1994	0	0	105	57	46	28	17	20	17	15	20	26	97	-	-
1995	91	-	-	-	71	40	18	22	25	24	27	41	63	94	-
1996	33	-	-	-	69	45	22	25	18	19	36	29	40	58	-
1997[1]	-	53	-	-	82	48	26	23	18	16	16	24	28	73	101
1998[1]	66	53	26	44	42	18	22	23	28	26	28	31	33	50	101
1999	91	54	53	26	32	31	24	21	18	16	18	25	52	51	-
2000	71	66	72	83	56	58	41	20	22	23	21	36	45	54	-
2001	92	99	85	47	40	48	44	46	37	14	17	34	43	56	-
2002	71	-	70	104	29	27	17	13	16	16	14	27	24	37	55
2003	66	-	63	95	30	27	20	44	34	32	44	28	38	37	-
2004	78	59	97	-	26	17	16	16	17	17	15	29	39	46	92
2005	66	70	37	46	33	15	19	17	16	20	25	24	28	64	-
2006[2]	-	81	81	67	32	18	18	11	11	16	22	22	30	67	-
2007[1]	-	99	52	23	20	13	12	12	14	14	24	37	26	44	99
2008	-	-	-	36	20	21	15	14	18	14	22	20	43	56	68
2009	98	-	-	103	23	14	16	16	19	18	17	21	26	46	53
2010	-	-	-	57	26	18	13	12	14	18	19	23	45	57	101
2011	66	-	-	-	43	18	15	14	17	14	25	26	33	46	70
2012[2]	93	-	-	-	100	23	13	14	14	11	24	70	72	-	-
2013	-	-	-	-	-	44	39	12	16	20	19	33	50	50	-
2014	-	-	99	68	68	37	20	14	20	18	18	24	53	51	72
2015	83	-	99	-	49	24	22	15	13	18	34	37	33	46	-
2016	-	-	101	50	43	31	21	34	26	31	16	20	36	70	98
2017[2]	102	-	-	72	42	25	23	13	14	17	21	26	45	65	95
2018	-	-	107	-	51	24	15	18	18	15	17	23	32	54	93
2019	-	-	-	54	37	20	20	24	21	17	16	17	23	31	68
2020[2]	90	73	101	62	42	21	14	14	14	15	14	15	24	51	51
2021[2]	-	67	46	40	46	27	15	16	12	15	16	20	26	28	50

1 REZ not covered [2] REZ partly covered.

9 Distribution and abundance of capelin, polar cod and blue whiting

9.1 Capelin

Although capelin is primarily a pelagic species, small amounts of capelin are normally caught in the bottom trawl throughout most of the investigated area. In Figure 9.1 catch rates of capelin smaller and larger than 14 cm are shown for the winter survey in 2021. Catches in the south-eastern part of the survey area were lower than in previous years. Capelin smaller than 14 cm during this period will mainly comprise the immature stock component, while the larger capelin constitutes the prespawning capelin stock. Some few trawl hauls show large capelin catches (numbers exceeding 100 000 individuals) and these can probably not be considered representative for the density in the area, because such hauls will either result from hitting a capelin school at the bottom or up in the water column. For this reason, we choose not to present swept area-based indices for capelin in this report.

At this time of the year, mature capelin has started their approach to the spawning areas along the coast of Troms, Finnmark and the Kola peninsula, while immature capelin will normally be found further north and east, in the wintering areas. This is reflected on the maps of capelin distribution, even though some large capelin is always found north of 75°N, and smaller capelin are found sporadically in near-coastal areas. The geographical coverage of the total capelin stock is incomplete, but the maturing component is probably best covered.

It has been noted during several surveys that when sampling capelin from demersal and pelagic trawls, the individuals from demersal trawls are normally larger (and older) than those sampled pelagically. This has led to formation of a hypothesis saying that larger individuals tend to stay deeper than smaller individuals and some even to take up a demersal life. This hypothesis has not been tested, and during the winter surveys there are probably too few pelagic hauls to study the vertical distribution of capelin in a systematic way.

9.2 Polar cod

Polar cod are not well represented in the trawl hauls conducted during the winter surveys (Figure 9.2). This is because this endemic arctic species has a more northern and eastern distribution area in the Barents Sea. During this time of the year, polar cod is known to be spawning under the ice-covered areas of the Pechora Sea and close to Novaya Zemlya. It is not clear whether the concentrations found in open water this time of the year are mature fish either on their way to spawning or from the spawning areas, or if this is immature fish. In 2021, catch rates of polar cod were high in the central Barents Sea close to/inside the ice possibly reflecting the increased abundance of this species in the last years.

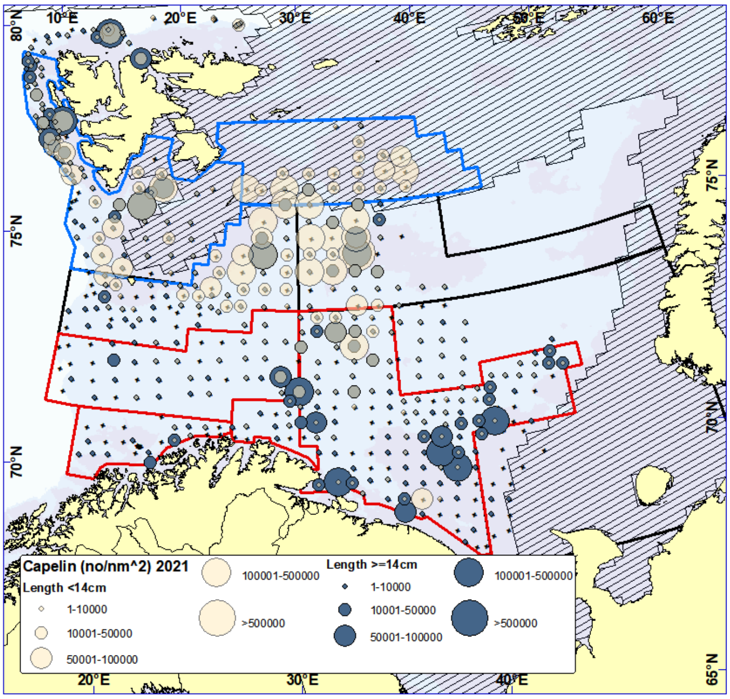

Figure 9.1. CAPELIN. Distribution in the trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

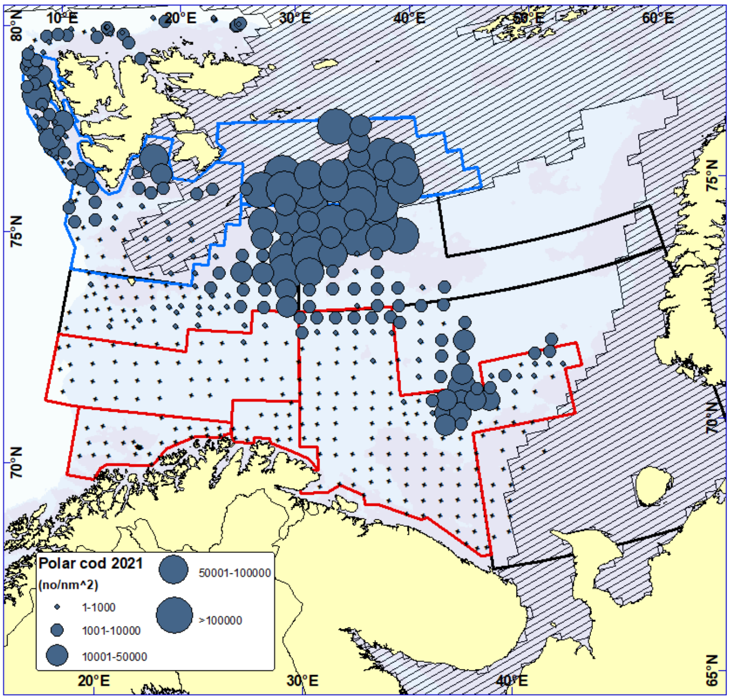

Figure 9.2 POLAR COD. Distribution in the trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

9.3 Blue whiting

Since the second part of the 1990s, blue whiting has shown a wider distribution than previously, and echo recordings have indicated higher abundance in the Barents Sea. Figure 9.3 shows the geographical distribution of the bottom trawl catch rates of blue whiting in 2021. Since the fish is mainly found pelagically, the bottom trawl does not reflect the real density distribution but gives some indication of the distribution limits. Acoustic observations would better reflect the relative density distribution. The number of pelagic hauls has, however, been too low to properly separate the pelagic recordings. During the years with high abundance of blue whiting, dense concentrations of blue whiting might have masked recordings of pelagic redfish, haddock and small cod.

Table 9.1 shows the bottom trawl swept area estimates by 5 cm length groups for the years 1994-2021. High abundance of fish below 20 cm in 2001, 2002, 2004, 2005, 2012, 2015, and 2021 reflects abundant recruiting (age 1) year classes. These recruits are observed in the survey as larger fish in the following years. As for some of the other target species in the survey, there was a large increase in the indices for most length groups from 2014 to 2015. The recruitment signal was less in 2017, while the total index of fish above 20 cm and total biomass were the largest since 2006. In 2018 and 2019 the indices were the lowest since 2011. In 2020, the abundance of recruits was higher than in 2018 and 2019, leading to a near doubling of the total index by number compared to the previous year. In 2021, abundance of recruits was the highest since 2015, leading to an increase in the total index to the highest level observed since 2017. Relatively high abundance of blue whiting was found in the extended survey area, similar to the situation in other years with abundant recruiting year-classes (Tables 9.2). Table 9.3 presents estimates of coefficients of variation (%) by length groups. In most years, CVs for most length groups are above what could be considered as acceptable for stock assessment.

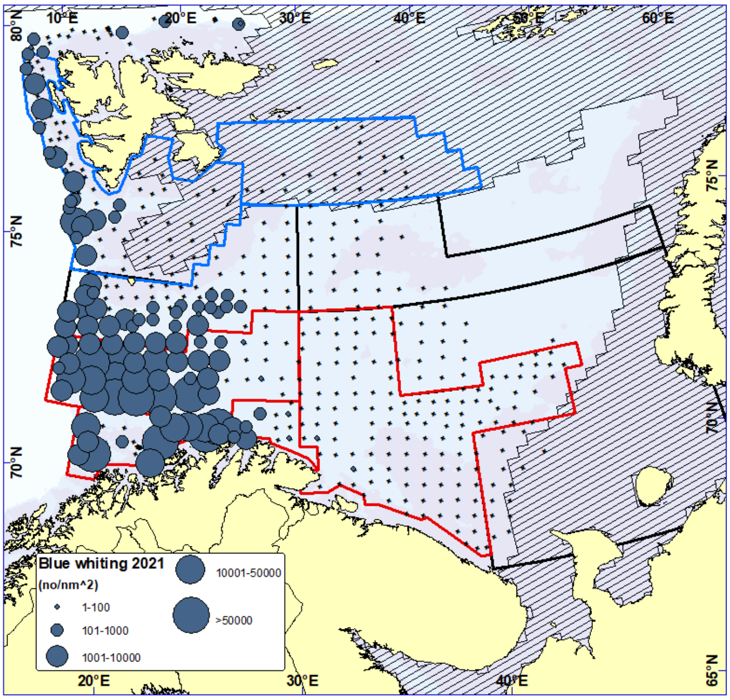

Figure 9.3 BLUE WHITING. Distribution in the trawl catches winter 2021 (number per nm^2). Black crosses indicate zero catches.

Table 9.1. BLUE WHITING. Abundance indices (numbers in millions) from bottom trawl surveys in the Barents Sea standard area winter 1994-2021.

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34	35-39	≥40	Total	Biomass ('000 t)
1994	0	0	1.2	13.6	25.7	10.9	1.1	0.1	52.6	NA
1995	0	0.5	0.8	2.4	10.3	10.8	3.9	0.2	29.0	NA
1996	0	80.0	1371.8	8.4	18.6	7.1	3.8	0.1	1489.9	38.2
1997[1]	0	608.7	681.5	273.8	3.1	5.3	1.8	0.1	1574.3	NA
1998[1]	0	1.2	34.5	42.2	3.6	1.5	1.4	0.1	84.5	NA
1999	0	0.02	11.0	40.0	16.1	5.0	1.7	0.1	74.0	NA
2000	0	12.3	557.5	44.1	25.7	4.4	0.7	0.1	644.9	NA
2001	0.04	311.6	1420.8	631.5	46.0	5.4	1.6	0.1	2417.0	NA
2002	0	0.9	428.9	636.3	77.6	17.5	3.2	0.1	1164.4	56.6
2003	0	3.9	220.5	493.4	73.4	28.0	4.0	0.3	823.4	48.1
2004	0	7.1	712.0	821.6	276.2	37.8	1.1	0.2	1856.0	95.8
2005	0	125.1	717.2	984.7	223.3	31.8	0.1	0.1	2082.4	105.0
2006[2]	0	0	164.4	1500.5	598.0	69.0	2.0	0.1	2333.9	172.9
2007[1]	0	0	4.0	628.0	299.3	23.5	1.6	0.4	956.8	79.8
2008	0	0	0.3	12.1	126.1	19.8	1.3	0.1	159.7	20.6
2009	0	0	0.02	2.7	50.6	21.2	1.5	0.02	76.1	11.4
2010	0	0	0.5	1.6	9.4	16.9	1.0	0	29.4	5.2
2011	0	0	0.1	0.3	2.8	5.1	2.5	0	10.6	2.2
2012[1]	0	85.6	674.6	1.1	1.8	5.3	2.0	0.3	770.7	18.2
2013	0	0	75.3	395.9	12.6	11.5	6.8	0.1	502.2	28.6
2014	0	0	182.1	34.2	9.7	1.6	1.5	0.04	229.2	8.5
2015	0	115.6	907.4	141.2	40.8	8.8	7.4	0	1221.3	34.2
2016	0	0.1	260.0	367.6	38.0	6.3	3.0	0.1	674.9	39.1
2017[1]	0	0	29.1	939.6	279.2	26.1	11.5	0.05	1285.6	99.7
2018	0	0.02	0.8	45.4	50.2	8.3	1.7	0	106.5	10.5
2019	0.1	1.7	54.4	4.5	35.9	13.0	1.0	0.09	110.7	9.2
2020[1]	0.2	14.3	154.9	25.4	7.9	8.1	0.6	0	212.8	11.5
2021[1]	0	1.5	857.8	88.9	11.1	2.1	0.2	0	961.9	37.5

[1] Indices not raised to represent the Russian EEZ or uncovered parts, blue whiting is mainly found in areas A, B, C and S

[2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005

Table 9.2. BLUE WHITING. Abundance indices (numbers in millions) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2021.

Year	Length group (cm)								Total	Biomass
	5-9	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**≥40**		**('000 t)**
2014	0	0	0.29	0.28	0.10	0.19	0.13	0	1.0	0.12
2015	0	0	0.16	0.10	0.25	0.78	0.42	0	1.7	0.27
2016	0	0	2.12	5.35	1.54	0.46	0.35	0	9.8	0.84
2017	0	0	0.08	20.91	4.10	1.34	0.39	0	26.8	1.98
2018	0	0	0	0.16	0.37	0.23	0.16	0	0.9	0.13
2019	0	0	0.03	0.21	0.71	0.70	0.24	0	1.9	0.34
2020	0	0	0.11	0.27	0	0.13	0	0	0.5	0.05
2021	0	0	9.60	3.53	0.48	0.41	0.07	0	14.1	0.63

Table 9.3. BLUE WHITING. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2021.

	Length group (cm)							
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**
1994	-	-	94	68	51	28	31	49
1995	-	59	55	51	66	32	28	48
1996	-	49	79	56	49	30	33	59
1997[1]	-	30	29	33	36	29	37	70
1998[1]	-	91	60	33	35	33	28	70
1999	-	98	26	27	28	31	43	71
2000	-	37	21	20	25	29	31	95
2001	69	21	18	25	26	35	39	90
2002	-	56	25	17	20	33	52	69
2003	-	87	47	23	17	27	58	83
2004	-	86	23	19	15	14	30	61
2005	-	28	25	16	24	24	71	90
2006[2]	-	-	17	12	13	26	46	61
2007[1]	-	-	50	16	12	17	42	84
2008	-	-	51	59	27	22	47	82
2009	-	-	97	60	21	20	61	95
2010	-	-	91	80	29	25	33	-
2011	-	-	100	88	45	48	62	-
2012[2]	-	32	30	39	45	38	29	98
2013	-	-	70	31	57	44	44	99
2014	-	-	23	23	24	27	18	137
2015	-	50	21	21	31	31	37	-
2016	-	96	33	24	17	27	29	97
2017[2]	-	-	24	16	16	16	42	101
2018	-	102	49	25	17	19	32	-
2019	68	37	38	29	35	31	50	101
2020[2]	94	90	39	27	28	29	46	-
2021[2]	-	48	23	30	32	24	45	-

[1] REZ not covered

[2] REZ partly covered

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Appendix 1. Survey design and methods for target species index calculation

Introduction

The Institute of Marine Research (IMR), Bergen, has performed acoustic measurements of demersal fish in the Barents Sea since 1976. Since 1981 a bottom trawl survey has been combined with the acoustic survey. Typical effort of the combined survey has been 10-14 vessel-weeks, and about 350 bottom trawl hauls have been made each year. After 2018, the Russian zone has been relatively well-covered and around 500 bottom trawl hauls have been made each year. Most years three vessels have participated from about February 1 to March 15.

The purpose of the investigations is presently:

- Obtain acoustic abundance indices by length and age for cod and haddock
- Obtain swept area abundance indices by age for cod and haddock
- Obtain swept area abundance indices by length for redfish, Greenland halibut and blue whiting
- Map the geographical distribution of those fish stocks
- Estimate length, weight and maturity at age for cod and haddock
- Collect stomach samples from cod, for estimating predation by cod.
- Map the distribution of maturing/prespawning capelin

Data and results from the survey are used both for stock assessments in the ICES Arctic Fisheries Working Group (AFWG) and by several research projects at IMR and PINRO, the Polar branch of the Russian Federal Research Institute of Fisheries and Oceanography (VNIRO).

From 1981 to 1992 the survey area was fixed (strata 1-12, main areas ABCD in Fig. 2.1). Due to warmer climate and increasing stock size in the early 1990s, the cod distribution area increased. Consequently, in 1993 and further in 1994 the survey area was extended to the north and east (strata 13-23, main areas D'ES in Fig. 2.1) to obtain a more complete coverage of the younger age groups of cod, and since then the survey has aimed at covering the whole cod distribution area in open water. For the same reason, the survey area was extended further northwards in the western part in 2014 (strata 24-26 in Fig. 2.1). In many years since 1997 Norwegian research vessels have had limited access to the Russian EEZ, and in 1997, 1998, 2007 and 2016 the vessels were not allowed to work in the Russian EEZ. In 1999 a rather unusually wide ice-extension partly limited the coverage. Since 2000, except in 2006, 2007 and 2017, Russian research vessels have participated in the survey and the coverage has been better, but for various reasons incomplete in most years. In 2008-2015 and 2018-2020 Norwegian vessels had access to major parts of the Russian EEZ. The coverage was more complete in these years, especially in 2008, 2011 and 2014. Table 3.5 summarizes degree of coverage and main reasons for incomplete coverage in the Barents Sea winter 1981-2021.

According to the joint IMR-PINRO long-term monitoring plan for the Barents Sea, developed during a series of meeting between the institutes, and agreed to be implemented at the annual meeting between Russian and Norwegian scientists in Tromsø, 13-15 March 2018, the winter survey is from 2019 a joint IMR-PINRO survey with commitments from both institutes jointly to seek obtaining a total coverage of the main demersal fish resources in the area.

Methods

Swept area measurements

All vessels were equipped with the standard research bottom trawl Campelen 1800 shrimp trawl with 80 mm (stretched) mesh size in the front. Prior to 1994 a cod-end with 35-40 mm (stretched) mesh size and a cover net with 70 mm mesh size were mostly used. Since this mesh size may lead to considerable escapement of 1-year-old cod, the cod-ends were in 1994 replaced by cod-ends with 22 mm mesh size. At present a cover net with 116 mm meshes is mostly used. The trawl is now equipped with a rockhopper ground gear (Engås and Godø 1989). Until and including 1988 a bobbins gear was used, and the cod and haddock indices from the period 1981-1988 have since been recalculated to 'rockhopper indices' and adjusted for length dependent catch efficiency and/or sweep width (Godø and Sunnanå 1992, Aglen and Nakken 1997). The sweep wire length is 40 m, plus 12 m wire for connection to the doors.

In the Norwegian Barents Sea shrimp survey (Aschan and Sunnanå 1997) the Campelen trawl has been rigged with some extra floats (45 along the ground rope and 18 along the under belly and trunk, all with 20mm diameter) to reduce problems on very soft bottom. This rigging has been referred to as "Tromsø rigging". When the shrimp survey was terminated 2004 and later merged with the Barents Sea Ecosystem survey in 2005, improved shrimp data were also requested from the winter survey, and the "Tromsø rigging" was used in parts of the shrimp areas in 2004 (11 stations) and 2005 (9 stations). In 2006-2014 "Tromsø rigging" was used for nearly all bottom trawl stations taken by Norwegian vessels in the winter survey, while since 2015 "Tromsø rigging" has not been applied.

Vaco doors (6 m^2, 1500kg), were previously standard trawl doors on board the Norwegian research vessels. On the Russian vessels and hired vessels V-type doors (ca 7 m^2) have been used. In 2019 the Russian vessel used 5 m^2 "Sparrow" trawl doors weighing 2000 kg. In 2004, R/V "Johan Hjort" and R/V "G.O. Sars" started using a V-type door for bottom trawling (Steinshamn W-9, 7.1m^2, 2050 kg), the same type as used on the Russian research vessels. In 2010 the V-doors were replaced by 125" Thyborøn trawl doors. R/V "Helmer Hanssen" has used Thyborøn trawl doors since the 2008 survey. To achieve constant sampling width of a trawl haul independent of e.g. depth and wire length, a 10-15 m rope "locks" the distance between the trawl wires 80-150 m in front of the trawl doors on the Norwegian vessels. This is called "strapping". The distance between the trawl doors is then in most hauls restricted to the range 48-52 m regardless of depth (Engås and Ona 1993, Engås 1995). Strapping was first attempted in the 1993 survey on board one vessel, in 1994 it was used on every third haul and in 1995-1997 on every second haul on all vessels. Since 1998 it has been used on all hauls when weather conditions permitted. Strapping is not applied on the Russians vessels, but the normal distance between the doors is about 50 m (D. Prozorkevich, pers. comm.).

Standard tow duration is now 15 minutes (until 1985 the tow duration was 60 min. and from 1986 to 2010 30 min.). Trawl performance is constantly monitored by Scanmar trawl sensors, i.e., distance between the doors, vertical opening of the trawl and bottom contact control. In 2005-2008 sensors monitoring the roll and pitch angle of the doors were used due to problems with the Steinshamn W-9 doors. The data is logged on files but have so far not been used for further evaluation of the quality of the trawl hauls.

At the start of the survey at least two of the trawls on the Norwegian vessels should go through a "sea test". The purpose of the test is to check that the geometry of the trawl is within the specified limits and that the trawl performance is satisfactory, especially that the bottom contact is stable. It is further checked that the trawl sensors operate as they should.

The positions of the trawl stations are pre-defined. When the swept area investigations started in 1981 the survey area was divided into four main areas (A, B, C and D, Fig 2.1) and 35 strata.

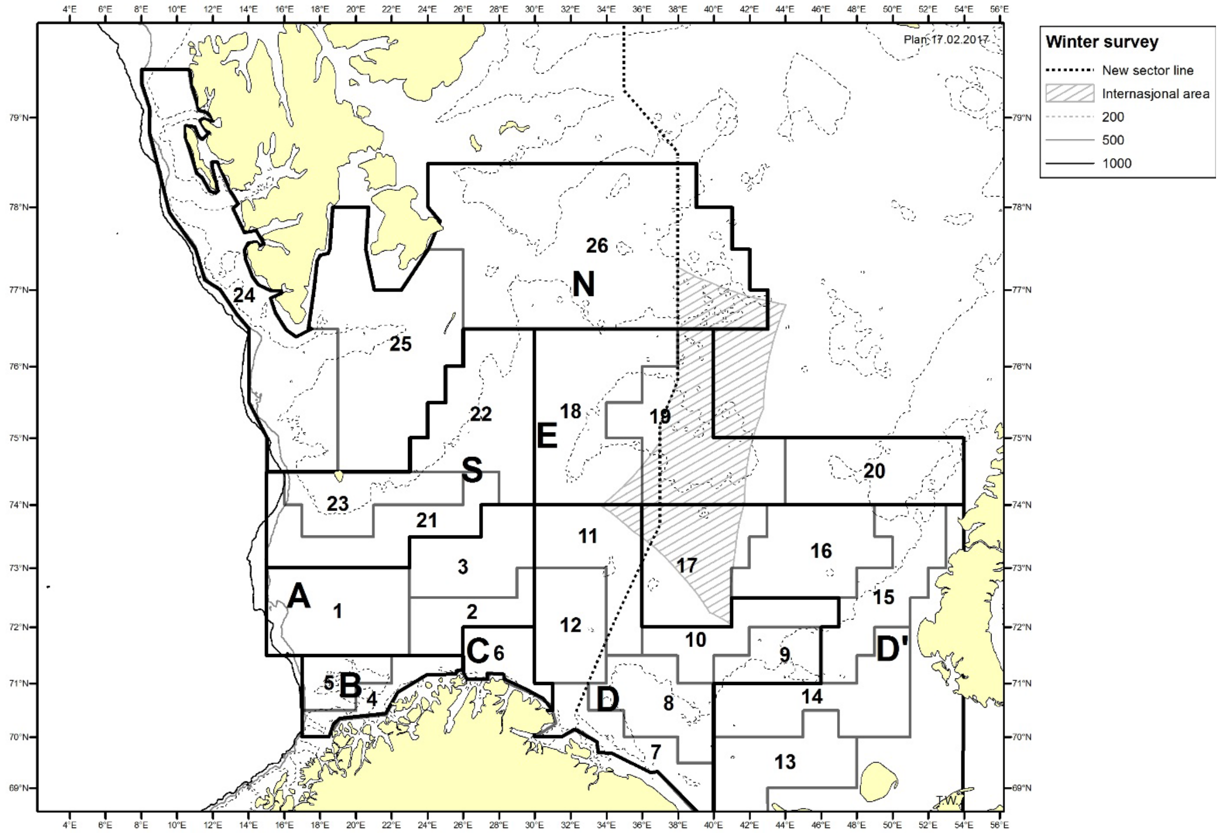

Figure 2.1. Strata (1-23) and main areas (A,B,C,D,D',E and S) used for swept area estimations and acoustic estimations with StoX. Additional strata (24-26, main area N) are covered since 2014, and are from 2020 included in the standard time series for haddock and from 2021 in the time series for cod.

During the first years, the number of trawl stations in each stratum was set based on expected fish distribution to reduce the variance, i.e., more hauls in strata where high and variable fish densities were expected to occur. During the 1990s trawl stations were spread out more evenly, yet the distance between stations in the most important cod strata is shorter (16 or 20 NM) compared to the less important strata (24, 30 or 32 NM). Considerable amounts of young cod were now distributed outside the initial four main areas, and in 1993 the investigated area was therefore enlarged by areas D', E, and the ice-free part of Svalbard (S) (Fig. 2.1 and Table 1.4 in main report), 28 strata altogether. In the 1993-1995 survey reports, the Svalbard area was included in area A' and the western part of area E (west of 30°E). Since 1996 a revised strata system with 23 strata has been used (Figure 2.1). The main reason for reducing the number of strata was the need for enough trawl stations in each stratum to get reliable estimates of density and variance. In 2014 the investigated area was enlarged by three new strata in northwest, 24-26 (main area N, Fig. 2.1). From 2020, these strata were included in the swept area and acoustic indices for haddock and from 2021, they were included for cod (see next section). They are not yet included in the standard time series for the other species.

Sampling of catch and age-length keys

Sorting, weighing, measuring and sampling of the catch are done according to instructions given in Mjanger *et al*. (2021). Since 1999 all data except age are recorded electronically by Scantrol Fishmeter measuring board, connected to stabilized scales. The whole catch or a representative sub sample of most species was length measured on each station.

At each trawl station, one cod and haddock per 5 cm length-group is sampled for age (otoliths), individual weights, sex, and maturity. For cod, stomach samples are also taken from the same individuals. For the largest cod, other sampling schemes have been used in some years; in 2007-2009, all cod above 80 cm were sampled, and in 2010 all above 90 cm were sampled, limited to 10 per station. The stomach samples from cod are frozen and analysed after the survey. Greenland halibut otoliths are also sampled from one specimen per 5 cm length-group, while otoliths from the redfish species *Sebastes norvegicus* and *S. mentella* are sampled from two fish in every 5-cm length-group on every station. Table 2.1 in the annual report gives an account of the sampled material, and further details on the sampling protocol can be found in the sampling manual for the Winter survey (updated annually).

Swept area fish density estimation

Swept area fish density estimates ($\rho_{k,l,s}$) for each station *s* in stratum *k* are first estimated by length (*l*) for each bottom trawl haul by the equation:

$$\rho_{k,l,s} = \frac{f_{k,l,s}}{a_{k,l,s}}$$

$\rho_{k,l,s}$ number of fish of length *l* per n.m.^{2} observed on trawl station *s* in stratum *k*

$f_{k,l,s}$ estimated frequency of length *l*

$a_{k,l,s}$ swept area:

$$a_{k,l,s} = \frac{d_{k,s} \cdot EW_l}{1852}$$

d_s towed distance (nm)

EW_l length dependent effective fishing width. The fishing width was previously fixed to 25 m = 0.0135 nm. Based on Dickson (1993a,b, Table 1), length dependent effective fishing width was included in the calculations for cod and haddock from 1995 (Korsbrekke *et al*., 1995) as such:

$$EW_l = \alpha \cdot l^{\beta} \text{ for } l_{min} l < l_{max}$$

$$EW_l = EW_{l_{min}} = \alpha \cdot l_{min}^{\beta} \text{ for } l \leq l_{min}$$

$$EW_l = EW_{l_{max}} = \alpha \cdot l_{max}^{\beta} \text{for } l \geq l_{max}$$

Table 1: Species-specific parameters from Dickson (1993a, b) used to calculate length-dependent effective fishing width for cod and haddock.

Species	α	β	l_{min}	l_{max}
Cod	5.91	0.43	15 cm	62 cm
Haddock	2.08	0.75	15 cm	48 cm

For redfish, Greenland halibut and other species, a fishing width of 25 m is applied, independent of fish length.

After applying the length-dependent effective fishing width, the station-specific length distributions (swept area density by length) are aggregated into 5 cm length groups.

Next, the abundance (N individuals) by 5 cm length group l and stratum k are calculated as:

$$N_{k,l} = \rho_{k,l} A_k$$

Where A is the area (nmi^2) of stratum k and $\rho_{k,l}$ is the average swept area density by l in the stratum, given by:

$$\rho_{k,l} = (1/n) \sum_{s=1}^{n} \rho_{k,l,s}$$

Where n is the number of stations in the stratum.

A two-stage conversion process is used to convert the abundance of fish by length group to abundance of fish by age group. First, the abundance ($N_{k,l}$) by length group and stratum is distributed the length-measured individuals (j) to generate so-called "Super-individuals" (super-individuals represent fractions of a total; our use corresponds to a probability based design where $w_{k,l,s,j}$ is the inverse of the inclusion probability for a single fish sample), each representing an abundance estimated as:

$$N_{k,l,s,j} = N_{k,l} w_{k,l,s,j}$$

Where,

$$w_{k,l,s,j} = \rho_{k,l,s} / \left(\sum_{s=1}^{n} \rho_{k,l,s}\right) \times 1/m_{k,l,s}$$

and m is the number of length-measured individuals.

Second, in instances where a super-individual is not aged, the missing age is filled in by a random data imputation. The imputation of missing age is first carried out at the station level, randomly selecting the value from aged super-individuals within the same length group. If no aged super-individual is available at the station level, the imputation is attempted at strata level, or lastly at survey level. In instances where no age information is available at any level for a specific length group, the abundance estimate is presented with unknown age (Johnsen et al., 2019).

Acoustic measurements

The method is explained by Dalen and Smedstad (1979, 1983), Dalen and Nakken (1983), MacLennan and Simmonds (1991) and Jakobsen et al. (1997). The acoustic equipment has been continuously improved. Since the early 1990s Simrad EK500 echo sounder and Bergen Echo Integrator (BEI, Knudsen 1990) were used. The Simrad EK60 echo sounder replaced the EK500 on R/V “Johan Hjort” in 2005 and on R/V “Helmer Hanssen” since the 2008 survey. The latest R/V “G.O. Sars” has used EK60 since it replaced R/V “Sarsen” (former R/V “G.O. Sars”) in 2004. The Large Scale Survey System (LSSS, Korneliussen *et al*. 2016) replaced BEI on R/V “G.O. Sars” and R/V “Johan Hjort” in 2007 and on R/V “Helmer Hanssen” since the 2008 survey. On the Russian vessels EK 500 was used from 2000 to 2004 and ER60 since 2005. In 2021 the Russian vessel used EK60 with software ER60 v 2.2.1, and LSSS v. 1.9.0 The new Simrad EK80 echo sounder has been used on R/V “G.O. Sars” since 2017 and on R/V “Johan Hjort” since 2018. In 2021 LSSS v. 2.10.0 was used on “Johan Hjort”, while version 2.9.0 was used on “Helmer Hanssen” and “Kronprins Haakon”.

In the mid-1990s the echo sounder transducers were moved from the hull to a retractable centreboard, on R/V “Johan Hjort” since the 1994 survey, on R/V “Sarsen” (former R/V “G.O. Sars”) since 1997, on the latest R/V “G.O. Sars in 2004 and on R/V “Helmer Hanssen” since the 2008 survey. This latter change has largely reduced the signal loss due to air bubbles in the close to surface layer. None of the Russian vessels have retractable centreboards.

On both Norwegian and Russian vessels, acoustic backscattering values (s_A = nautical area scattering coefficient NASC) are stored at high resolution in LSSS. After scrutinizing and allocating the values to species or species groups, the values are stored with 10 m vertical resolution and 1 nautical mile (NM) horizontal resolution. The procedure for allocation by species is based on:

- composition in trawl catches (pelagic and demersal hauls)
- the appearance of the echo recordings
- inspection of target strength distributions
- inspection of target frequency responses

For each trawl catch the relative s_A-contribution from each species is calculated (Korsbrekke 1996) and used as a guideline for the allocation. In these calculations, the fish length dependent catching efficiency of cod and haddock in the bottom trawl (Aglen and Nakken 1997) is taken into account. There is no reason to believe that trawl catches give an accurate representation of species composition in the sea, so the calculated s_A-contribution from the trawl hauls are used as a guidance only.

Acoustic fish density estimation

The new Sea2Data software StoX has been applied to estimate acoustic indices with CVs for cod and haddock. Acoustic estimates for the period 1994-2017 were re-estimated using StoX (Mehl *et al*. 2018). The main difference between the SAS based BEAM Program (Totland and Godø 2001) used until 2017 and StoX acoustic abundance estimation is that in BEAM the survey area is divided into rectangles, and for each rectangle an average acoustic density (s_A) is calculated, while in StoX transects are defined within each stratum (Figure 2.1) as primary sampling units (PSUs) and used to calculate acoustic density (Jolly and Hampton 1990).

Within each stratum, the acoustic course tracks are divided into transects, separated by the trawl stations in the stratum since the course tracks run through the net of fixed bottom trawl stations in the bottom trawl survey. A distance of about 2 nautical miles around each station is not included in the transects. For the time series 1994-2017 this was done by first running a R-script tagging all the transects and then the transects were inspected and edited manually in StoX if necessary. Minimum length of a transect was set to 4 nautical miles. In this process miles with obvious errors in the s_A-values, e.g. bottom contribution, were removed from the transects. From 2018, all transects have been defined manually using the built-in functionality in the StoX software following the same rules as described above.

For each transect and stratum, an arithmetic mean s_A is calculated for the water column. The conversion of mean NASC (m^2 nmi^{-2}) to density of fish follows a standard procedure where all trawl stations within a stratum with a catch of more than 5 individuals are assigned to each PSU. If less than 3 trawl stations had been carried out in a stratum, stations in neighbouring strata is assigned to the PSUs such that at least 3 stations are assigned to each PSU. From 2021, the criterion of having minimum 5 individuals in the catch was excluded as this type of filtration is not implemented in the new StoX version.

The combined length distribution (d) is calculated for each transect (PSU (j)) as:

$$d_{l,j} = \sum_{s=1}^{S} d_{l,s,j}$$

where $d_{l,s,j}$ is density (number by 1 NM tow distance) by 1 cm length group (l) for the stations (s) assigned to PSU (j).

The trawl catches are normalised to 1 NM towing distance and adjusted for length dependent catch efficiency as describe for swept area estimation above.

The areal density of fish (ρ) (n per nmi^2) by length group l by transect j is calculated as

$$\rho_{j,l} = \frac{\text{NASC}_{j,l}}{\sigma_l}$$

where $\text{NASC}_{j,l}$ is the mean nautical area scattering coefficient by transect (j) and length group (l) and σ_l is the acoustic backscattering cross-section for a fish of length l.
$\text{NASC}_{j,l}$ is calculated as:

$$\text{NASC}_{j,l} = \text{NASC}_j \frac{\sigma_{l,p}}{\sum_l \sigma_{l,p}}$$

where $\sigma_{l,p}$ is the acoustic backscattering cross-section for a fish of length l multiplied with the proportion (p) of a fish of length l in the total length distribution and NASC_j is the mean nautical area scattering coefficient in transect j.

The acoustic backscattering cross-section (m^2) for a fish of length l is calculated as

$$\sigma_l = 4\pi 10^{\left(\frac{TS_l}{10}\right)}$$

where the target strength, *TS*, for a fish of length l (cm) is calculated as

$$TS_l = m \log_{10}(l) + a$$

Where m and a are constants. For cod and haddock, we apply:

$$TS = 20 \log(l) - 68$$ (Foote, 1987)

The fish abundance (N) by length group (l) for stratum k is then:

$$N_{k,l} = \rho_{k,l} A_k \,,$$

where A is stratum area and the mean density of fish of length group l and stratum k is:

$$\rho_{k,l} = \frac{1}{n_k} \cdot \sum_{k=1}^{n_k} w_{kj} \, \rho_{kj,l}$$

where $w_{kj} = L_{kj}/\bar{L}_k$ (j= 1,2, n_k) are the lengths of the n_k sample transects.

Estimates by length are converted to estimates by age using the same age imputation method described for the swept area index estimation. The abundance by stratum is then summed for defined main areas (Figure 2.1).

Software for index estimation

The Sea2Data software StoX (Johnsen et al. 2019) has been applied to estimate swept area indices with CVs for cod, haddock, golden redfish, beaked redfish, Norway redfish, Greenland halibut and blue whiting. Swept area estimates for the period 1994-2016 was re-estimated using StoX (Mehl *et al*. 2016). The entire haddock time series was revised again in 2020 using StoX, in connection with the ICES Benchmark Workshop for Demersal Species (ICES 2020). This involved including strata 24-26 in the official time series from 2014, the use of bootstrap mean instead of baseline estimates for abundance at age, and standardising the length groups used in the length-dependent sweep width function (Fall 2020). The additional strata were also included in the acoustic index for haddock, while the other changes were made to the swept area index only. In 2021, the same changes were made to the cod time series (ICES 2021). The revised swept area index for haddock was produced with R version 3.5.3 (years 1994-2013) and R version 3.6.2 (years 2014-2019). In the update of R to 3.6.X, the random seed generator was changed, which means that the same seed will give slightly different results compared to 3.5.X. This results in minor differences to the bootstrapped estimates if old StoX projects are run with the new R version. In 2019 and 2020 StoX version 2.7 and RStoX 1.11 were used to produce indices. The same version was used for blue whiting, Greenland halibut and redfish in 2021, while StoX version 3.3.0 was used for cod and haddock.

The main difference between the SAS based Survey Program previously used (years 1981-1993 of the time-series, see earlier survey reports for results and method details) and StoX swept area estimation is in the use of the age-length data. StoX does not use age-length keys (ALK) in the traditional sense with ALKs estimated for large areas. Missing age information is imputed from known age-length data within station, strata, or the entire survey (see below). StoX also allows for uncertainty estimation by bootstrapping primary sampling units (PSUs).

StoX input, filters and settings for cod and haddock

Input data for survey index estimation were downloaded from DatasetExplorer: https://datasetexplorer.hi.no/apps/datasetexplorer/v2/navigation. See section 3 in main report for information on what snapshot files were used in the current year.

The different functions and settings used in swept area estimation for cod and haddock in StoX 3.3.0 are detailed in Table 2. The functions are divided into the three parts of the StoX estimation process: baseline, analysis, and report.

Table 2: StoX functions and settings used in the cod and haddock swept area estimations, split on the three parts of the StoX estimation process; baseline, analysis, and report.

Function	**Settings**	**Purpose**
Baseline		
`ReadBiotic`	`FileNames:` paths to xml-files in biotic folder	Reads in versioned biotic files.
`StoxBiotic`	-	Converts and trims data (only keeps key variables, standardises variable names etc.) to a common format used in StoX.

`AddToStoxBiotic`	`StoxBioticData: StoxBiotic`
	
	`BioticData: ReadBiotic`
	
	`VariableNames: gearcondition, samplequality, stationtype, length, maturationstage, otolithtype`
		Add variables required for filtering or that are needed in output data.

`FilterStoxBiotic (1)`	`StoxBioticData: AddToStoxBiotic`
	
	`FilterExpression: {"Haul": "Gear %in% c(\"3270\", \"3271\") & gearcondition %in% c(\"1\", \"2\") & samplequality %in% c(\"1\", \"3\")"}`
	
	`FilterUpwards: true`
		Data filtering; removes extra hauls taken on acoustic registrations and unsuccessful hauls, selecting data from bottom trawl only.
		
		See https://kvalitet.hi.no/docs/pub/DOK06839.pdf for explanation of the different codes used in the data.

`FilterStoxBiotic (2)`	`StoxBioticData: FilterStoxBiotic (1)`
	
	`FilterExpression: {"SpeciesCategory": "SpeciesCategory %in% \"torsk/164712/126436/Gadus morhua\""}`
	
	`FilterUpwards: false`
		Data filtering; selecting data for the target species. For haddock, the SpeciesCategory is: "hyse/164744/126437/Melanogrammus aeglefinus\"

`DefineStratumPolygon`	`DefinitionMethod: ResourceFile`
	
	`FileName: input/vintertokt_barentshavny.txt`
		The resource file contains polygon definitions for the strata used in the Winter survey.

`StratumArea`	`StratumPolygon: DefineStratumPolygon`
	
	`AreaMethod: Accurate`
		Calculates the area of each stratum.

`LengthDistribution`	`StoxBioticData: FilterStoxBiotic (2)`
	
	`LengthDistributionType: Normalized`
		Calculates length frequency distributions for each station and haul. 'Normalized' refers to a length distribution that is standardised to one nautical mile towing distance (i.e., weighted by CPUE). The

	`RaisingFactorPriority: Weight`	RaisingFactorPriority relates to how weighting is handled when the haul contains different subsamples for the same species. See StoX documentation for more details on length distributions.

`RegroupLengthDistribution (1)`	`LengthDistributionData: LengthDistribution`
	
	`LengthInterval: 1`
		Sets the length distribution resolution to 1 cm, i.e., 1 cm length groups. There may be length distributions with finer resolution, this will standardise it.

`LengthDependentCatch-Compensation`	`LengthDistributionData: RegroupLengthDistribution (1)`
	
	`CompensationMethod: LengthDependentSweepWidth`
	
	`LengthDependentSweepWidth-Parameters: [{"SpeciesCategory": "torsk/164712/126436/Gadus morhua","Alpha":5.91, "Beta":0.43, "LMin":15,"LMax":62}]`
		Adjusts the length distributions for increasing catchability with length (based on the Dixon experiments). For haddock, the parameters are:
		
		`[{"SpeciesCategory": "hyse/164744/126437/Melanogrammus aeglefinus","Alpha": 2.08, "Beta": 0.75, "LMin": 15, "LMax": 48}`

`RegroupLengthDistribution (2)`	`LengthDistributionData: LengthDependentCatch-Compensation`
	
	`LengthInterval: 5`
		Regroups the length distribution to the same resolution as the age sample stratification: 5 cm length groups.

`MeanLengthDistribution`	`LengthDistributionData: RegroupLengthDistribution (2)`
	
	`StratumPolygon: DefineStratumPolygon`
	
	`LayerDefinition: FunctionParameter`
	
	`LayerDefinitionMethod: WaterColumn`
	
	`SurveyDefinition: FunctionParameter`
	
	`SurveyDefinitionMethod: AllStrata`
	
	`PSUDefinition: FunctionParameter`
	
	`PSUDefinitionMethod: StationToPSU`
		Calculates the mean length distribution for each PSU by summing vertically and averaging horizontally. This allows mean length distributions to be calculated across e.g., hauls taken at the same PSU (station) but different depths. For the cod and haddock projects there is only one haul per PSU, which means that the purpose of this function is to define PSUs and convert the LengthDistribution object to a MeanLengthDistribution object for use in further calculations.

`SweptAreaDensity`	`MeanLengthDistributionData : MeanLengthDistribution`	Calculates the area density of fish (number of individuals per square nautical mile).

	`SweptAreaDensityMethod: LengthDistributed`
	
	`SweepWidthMethod: PreDefined`
	
	`DensityType: "AreaNumberDensity"`
		The sweep width method is set to pre-defined since this is already taken care of by the LengthDependentCatchCompensation process.

`MeanDensity`	`DensityData: SweptAreaDensity`	Calculates the average swept area density in each stratum. The average is weighted by the number of hauls per PSU, meaning that for a standard swept area project with one haul per PSU, this will be an unweighted average. For acoustic projects, the mean acoustic density is weighted by the effective log distance.
`Abundance`	`MeanDensityData: MeanDensity` `StratumAreaData: StratumArea`	Calculates the total abundance of each length group (also species category and layer when relevant) in each stratum based on the mean swept area density and stratum area.

`Individuals`	`StoxBioticData: FilterStoXBiotic (2)`
	
	`MeanLengthDistributionData : MeanLengthDistribution`
	
	`AbundanceType: SweptArea`
		Defines the individual data that will be used to distribute the abundance on super individuals.

`SuperIndividuals`	`IndividualsData: Individuals`
	
	`AbundanceData: Abundance`
	
	`LengthDistributionData: RegroupLengthDistribution (2)`
	
	`DistributionMethod: HaulDensity`
		Distributes abundance on the individuals, turning them into “Superindividuals”, each representing a part of the total abundance. Abundance can be divided equally on all individuals, or it can be divided proportionally to den density of the individual’s length group in the haul in which it was caught. Needed to get indices by age and to weigh biological parameters by abundance.

`ImputeSuperIndividuals`	`SuperIndividualsData: SuperIndividuals`
	
	`ImputationMethod: RandomSampling`
	
	`ImputeAtMissing: [“IndividualAge”]`
	
	`ImputeByEqual: ["Survey", "SpeciesCategory", "IndividualTotalLength"]`
		Identifies individuals that have missing data for a specified variable (here: age, as specified in “ImputeAtMissing”), and assigns the missing variables (and possibly others specified in “ToImpute”) by random sampling from other individuals in the same length group. First, the function looks for suitable individuals from the same haul. If there are none, the random draw extends to other hauls in the stratum, and lastly to the entire survey. Will return NA if no other individuals in the same length group have been aged in the survey. This has the advantage over a traditional age-length key

	ToImpute: ["IndividualAge", "maturationstage", "IndividualRoundWeight", "otolithtype"] Seed: 1	in that it allows imputation of other variables than age.
Analysis		
Bootstrap	BootstrapMethodTable: [{"ResampleFunction": "ResampleMeanLength-DistributionData", "ProcessName": "MeanLengthDistribution", "Seed":1}] NumberOfBootstraps: 500 OutputProcesses: ["ImputeSuperIndividuals", "SuperIndividuals"] UseOutputData: FALSE (not ticked) NumberOfCores: 6 BaselineSeedTable: [{"ProcessName": "ImputeSuperIndividuals", "Seed":1}]	This function runs a subset of the baseline model several times (as specified in "NumberOfBootstraps") after resampling trawl hauls in each stratum (with replacement). Here, the baseline model is rerun from MeanLengthDistribution to ImputeSuperIndividuals, calculating new length distributions based on the resampled trawl hauls and redoing the age imputation. The "UseOutputData" option can be used if, e.g., new reports are to be generated from a bootstrap object that has already been run – this option reads in the bootstrap object rather than running it again. The number of cores can be set higher if relevant (will use max number of cores if less than 6).
Report		
ReportBootstrap	BootstrapData: Bootstrap BaselineProcess: ImputeSuperIndividuals TargetVariable: Abundance AggregationFunction: sum BootstrapReportFunction: summaryStox GroupingVariables: ["Survey", "SpeciesCategory", "IndividualAge"] RemoveMissingValues: FALSE	Report bootstrap abundance. This function gives the 5 %, 50 % and 95 % quantiles and mean, sd and CV of abundance by age. The bootstrap mean abundance is used as the official estimate of swept area abundance for cod and haddock.
ReportBootstrap	BootstrapData: Bootstrap BaselineProcess: ImputeSuperIndividuals TargetVariable: Biomass AggregationFunction: sum	Report bootstrap biomass.

	BootstrapReportFunction: summaryStox GroupingVariables: ["Survey", "SpeciesCategory", "IndividualAge"] RemoveMissingValues: FALSE	
ReportBootstrap	BootstrapData: Bootstrap BaselineProcess: ImputeSuperIndividuals TargetVariable: Abundance AggregationFunction: sum BootstrapReportFunction: summaryStox GroupingVariables: ["Survey","SpeciesCategory", "Stratum", "IndividualAge"] RemoveMissingValues: FALSE	Report bootstrap abundance by stratum and age.
ReportBootstrap	BootstrapData: Bootstrap BaselineProcess: ImputeSuperIndividuals TargetVariable: Biomass AggregationFunction: sum BootstrapReportFunction: summaryStox GroupingVariables: ["Survey","SpeciesCategory", "Stratum", "IndividualAge"] RemoveMissingValues: FALSE	Report bootstrap biomass by stratum and age.
ReportBootstrap	BootstrapData: Bootstrap BaselineProcess: ImputeSuperIndividuals TargetVariable: length AggregationFunction: weighted.mean BootstrapReportFunction:	Report bootstrap mean length at age. The mean lengths are weighted by superindividual abundance at age (i.e., individuals from abundant length groups get higher weight).

	summaryStox GroupingVariables: ["Survey","SpeciesCategory", "IndividualAge"] RemoveMissingValues: TRUE AggregationWeightingVariable: Abundance	
	BootstrapData: Bootstrap BaselineProcess: ImputeSuperIndividuals TargetVariable: IndividualRoundWeight AggregationFunction: weighted.mean BootstrapReportFunction: summaryStox GroupingVariables: ["Survey","SpeciesCategory", "IndividualAge"] RemoveMissingValues: TRUE AggregationWeightingVariable: Abundance	Report bootstrap mean weight at age. The mean weights are weighted by superindividual abundance at age (i.e., individuals from abundant length groups get higher weight).

*Note that this is the function name, not the process name – the latter can be freely decided by the user. If a function is used more than once, unique processes names must be given and care must be taken to refer to the right process in subsequent steps of the estimation process (as indicated by numbers after the function name).

Table 3 details the functions and settings used for cod and haddock acoustic estimation in StoX.

Table 3: StoX functions and settings used in the cod and haddock acoustic estimations, split on the three parts of the StoX estimation process; baseline, analysis, and report. For details on functions used also in the swept area index, refer to table 2.

Function	**Settings**	**Details**
Baseline		
`ReadAcoustic`	`FileNames:` paths to xml-files in acoustic folder	Reads in versioned acoustic files.
`StoxAcoustic`	-	Converts and trims data (only keeps key variables, standardises variable names etc.) to a common format used in StoX.

`FilterStoxAcoustic (1)`	`StoxAcousticData: StoxAcoustic`
	
	`FilterExpression: {"Beam":"Frequency %in% 38000","ChannelReference": "ChannelReferenceType %in% \"P\""}`
	
	`FilterUpwards: FALSE`
		Select data from 38 kHz only (in case data is stored on multiple frequencies) and select only pelagic channel data (contains data from entire water column).

`FilterStoxAcoustic (2)`	`StoxAcousticData: FilterStoxAcoustic(1)`
	
	`FilterExpression: {"AcousticCategory": "AcousticCategory %in% \"31\""}`
	
	`FilterUpwards: FALSE`
		For haddock: `"AcousticCategory %in% \"30\""`

`DefineTranslationBeam`	`DefinitionMethod: TranslationTable`
	
	`TranslationTable: [{"VariableName":"Beam", "Value":"38000/1", "NewValue":"38000/2"}]`
	
	`Conditional: FALSE`
		In some cases, the beam names are different on Norwegian and Russian vessels. This defines a key that connects the two names and is used to make sure all data from 38 kHz are included.

`TranslateStox-AcousticBeam`	`StoxAcousticData: FilterStoxAcoustic(2)`
	
	`Translation: DefineTranslationBeam`
		Apply the translation to the acoustic data.

`ReadBiotic`	`FileNames:` paths to xml-files in biotic folder	As above.
`StoxBiotic`	-	As above.

`AddToStoxBiotic`	`StoxBioticData: StoxBiotic`
	
	`BioticData: ReadBiotic`
	
	`VariableNames: ["stationtype"]`	

`FilterStoxBiotic (1)`	`StoxBioticData: AddToStoxBiotic`	

	FilterExpression: {"Station":"stationtype %notin% \"2\""} FilterUpwards: TRUE	
FilterStoxBiotic (2)	StoxBioticData: FilterStoxBiotic(1) FilterExpression: {"SpeciesCategory": "SpeciesCategory %in% \"torsk/164712/126436/Gadus morhua\""} FilterUpwards: TRUE	
LengthDistribution	StoxBioticData: FilterStoxBiotic(2) LengthDistributionType: Normalized RaisingFactorPriority: Weight	
RegroupLength-Distribution	LengthDistributionData: LengthDistribution LengthInterval: 1	
LengthDependentCatch-Compensation	LengthDistributionData: RegroupLengthDistribution CompensationMethod: LengthDependentSweepWidth LengthDependentSweep-WidthParameters: [{"SpeciesCategory": "torsk/164712/126436/Gadus morhua","Alpha":5.91, "Beta":0.43, "LMin":15,"LMax":62}]	For haddock, the parameters are: [{"SpeciesCategory": "hyse/164744/126437/-Melanogrammus aeglefinus", "Alpha": 2.08, "Beta": 0.75, "LMin": 15, "LMax": 48}
RelativeLength-Distribution	LengthDistributionData: LengthDependentCatch-Compensation	Converts the length distribution to a relative one (in %).
DefineStratumPolygon		As above
StratumArea		As above
DefineAcousticPSU	StoxAcousticData: TranslateStoxAcousticBeam DefinitionMethod: “Manual”	Set to manual to define the transects by clicking in the GUI. After doing this once, the transect definitions are stored in the process data.
NASC	StoxAcousticData: TranslateStoxAcousticBeam	Converts the acoustic data to NASC data format.
MeanNASC	NASCData: NASC	Sums the NASC data vertically. Here: throughout the entire water column.

	AcousticPSU: DefineAcousticPSU LayerDefinition: FunctionParameter LayerDefinitionMethod: WaterColumn SurveyDefinition: FunctionParameter SurveyDefinitionMethod: AllStrata PSUDefinition: "FunctionInput"	
BioStationAssignment	StoxBioticData: FilterStoxBiotic(2) StratumPolygon: DefineStratumPolygon AcousticPSU: DefineAcousticPSU StoxACousticData: TranslateStoxAcousticBeam DefinitionMethod: Stratum LayerDefinition: FunctionParameter LayerDefinitionMethod: WaterColumn	Assigns trawl stations to each acoustic PSU; all trawl stations within the same strata as the acoustic PSU will be assigned to that PSU. In the case of few trawl stations in a strata, additional trawls from neighbouring strata can be added manually in the map window.
BioStationWeighting	BioticAssignment: BioStationAssignment LengthDistributionData: RegroupLengthDistribution WeightingMethod: SumWeightedCount	How to weight the trawl stations when calculating length distributions for each PSU. The "SumWeightedCount" option give weighting values that are proportional to the normalized length distribution count (i.e., cpue) in the haul.
AssignmentLength-Distribution	LengthDistributionData: RelativeLengthDistribution BioticAssignment: BioStationAssignment	Calculates weighted average length distributions for each PSU (and layer).
DefineAcousticTarget-Strength	DefinitionMethod: TargetStrengthTable TargetStrengthMethod: LengthDependent	Specifies the target strength-length relation for the target species. The same settings are used for cod and haddock, except that the AcousticCategory is set to "30".

	TargetStrengthTable: [{"AcousticCategory":"31", "Frequency": 38000, "TargetStrength0": -68, "LengthExponent": 20}]	
AcousticDensity	MeanNASCData: MeanNASC AssignmentLength-DistributionData: AssignmentLength-Distribution AcousticTargetStrength: DefineAcousticTarget-Strength SpeciesLink: [{"AcousticCategory":"31", "SpeciesCategory": "torsk/164712/126436/Gadus morhua"}]	Calculate number density based on the acoustic target strength-length relationship. For haddock: SpeciesLink: [{"AcousticCategory": "30","SpeciesCategory": "hyse/164744/126437/-Melanogrammus aeglefinus"}]
MeanDensity	DensityData: AcousticDensity	Calculates the weighted average density in each stratum. The weights are the effective log distance of each acoustic PSU.
Abundance	MeanDensityData: MeanDensity StratumAreaData: StratumArea	Calculates abundance as the product of mean density and area of the stratum.
Individuals	StoxBioticData: FilterStoxBiotic(2) BioticAssignment: BioStationWeighting AbundanceType: Acoustic	As above.
SuperIndividuals	IndividualsData: Individuals AbundanceData: Abundance LengthDistributionData: LengthDependentCatch-Compensation DistributionMethod: HaulDensity	As above. Currently, the length distribution data is not regrouped to 5 cm length bins in the acoustic projects. This should be considered in the next revision.
ImputeSuperIndividuals	SuperIndividualsData: SuperIndividuals ImputationMethod: RandomSampling ImputeAtMissing: ["IndividualAge"]	As above.

	ImputeByEqual: ["Survey","SpeciesCategory", "IndividualTotalLength"] ToImpute: ["IndividualRoundWeight", "LengthResolution", "WeightMeasurement", "IndividualSex", "IndividualAge"] Seed: 1	
Analysis		
Bootstrap	BootstrapMethodTable: [{"ResampleFunction": "ResampleMeanNASCData", "ProcessName": "MeanNASC", "Seed":1}, {"ResampleFunction": "ResampleBioticAssignment", "ProcessName": "BioStationWeighting", "Seed":2}] NumberOfBootstraps: 500 OutputProcesses: ["SuperIndividuals", "ImputeSuperIndividuals"] UseOutputData: FALSE NumberOfCores: 6 BaselineSeedTable: [{"ProcessName": "ImputeSuperIndividuals", "Seed":1}]	As above.

For cod and haddock swept area and cod acoustic indices, the bootstrap mean estimate is used as the official index in stock assessment, while the haddock acoustic index is based on the baseline run (ICES 2020, 2021). To get baseline numbers, a report is generated based on SuperIndividualsData from the baseline run according to Table 4.

Table 4: Function used to generate a baseline abundance report.

Report		

`ReportSuperIndividuals`	`SuperIndividualsData: ImputeSuperIndividuals`
	
	`TargetVariable: Abundance`
	
	`ReportFunction: sum`
	
	`GroupingVariables: ["Survey", "SpeciesCategory", "IndividualAge"]`
	
	`RemoveMissingValues: FALSE`
		Report on variables from the superindividuals data, such as abundance at age or mean weight at age. This is based on the single baseline run rather than the 500 bootstrap iterations.

Estimation of variance

The acoustic and swept area survey indices are presented together with an estimate of uncertainty (coefficient of variation; CV). These estimates are obtained from the bootstrap routine presented under the analysis section of Table 2. In the bootstrap of acoustic indices, each transect is treated as the primary sampling unit. In addition, a bootstrap routine for all trawl stations by strata is carried out within each run. The estimated CV (Standard Deviation · 100/mean) is estimated from 500 iterations.

References

See section 10 in main report.

Appendix 2. Changes in survey design, methods, gear etc.

Year	Change from	To
1984	Representative age sample, 100 per station	Stratified age sample, 5 per 5-cm length group
1986	1 research vessel, 2 commercial trawlers	2 research vessels, 1 commercial trawler
1987	60 min. tow duration	30 min. tow duration
1989	Bobbins gear	Rock-hopper gear (time series adjusted for cod and haddock)
1990	Random stratified bottom trawl stations	Fixed station grid, 20 nm distance
	Simrad EK400 echo sounder	Simrad EK500 echo sounder and BEI post processing
1993	TS = 21.8 log L – 74.9 for cod and haddock	TS = 20 log L – 68 for all demersal species (time series corrected)
	Fixed survey area (ABCD), 1 strata system,	Extended, variable survey area (ABCDD'ES)
	35 strata	2 strata systems, 53 + 10 strata
	Fixed station grid, 20 nm distance	Fixed station grid, 20/30/40 nm distance
	No constraint technique (strapping) on bottom trawl doors	Constraint technique on some bottom trawl hauls
	5 age samples per 5-cm group, 2 per stratum	2 age samples per 5-cm group, 4 per stratum
		(cod and haddock)
	Weighting of age-length keys by total catch	Weighting of ALK by swept area estimate
1994	35-40 mm mesh size in cod-end	22 mm mesh size in cod-end
	Strapping on some hauls	Strapping on every 3. haul
	Hull mounted transducers	Keel mounted transducers Johan Hjort
1995	Variable use of trawl sensors	Trawl manual specifying use of sensors
	Constant effective fishing width of the trawl	Fish size dependent effective fishing width (time series corrected)
	Strapping on every 3. haul	Strapping on every 2. haul
	2 research vessels, 1 commercial trawler	3 research vessels
1996	2 strata systems and 63 strata, 20/30/40 nm distance	1 strata system and 23 strata, 16/24/32 nm distance
	2 age samples per 5-cm group, 4 per stratum	1 age sample per 5-cm group, all stations with > 10 specimens (cod and haddock)
1997	16/24/32 nm distance	20 nm distance
	Hull mounted transducers	Keel mounted transducers G.O. Sars
1998	Strapping on every 2. haul	Strapping on every haul
	20 nm distance	20/30 nm distance

2000	3 Norwegian research vessels	2 Norwegian and 1 Russian research vessel
2002	20/30 nm distance station grid	16/20/24/32 nm distance station grid
2003	Height trawl sensor for opening and bottom contact	Trawl eye for opening and bottom contact
2004	Vaco trawl doors	V- doors G.O. Sars and Johan Hjort
	EK 500 Sarsen	ER60 G.O. Sars
2005	EK 500	ER60 Johan Hjort and Russian vessels
2006	Standard Campelen rigging	"Tromsø rigging" on Norwegian vessels
2007	BEI	LSSS Norwegian vessels
2008	V trawl doors	Thyborøn doors Jan Mayen/Helmer Hanssen
2010	V trawl doors	Thyborøn doors G.O. Sars and Johan Hjort
2011	30 min. tow duration	15 min. tow duration
2014	1 strata system and 23 strata	1 strata system and 26 strata (extended area N)
2015	"Tromsø rigging" on Norwegian vessels	Standard Campelen rigging
2017	Swept area estimates by the Survey Program	Swept area and CV estimates by StoX software
	EK 60 on G.O. Sars	EK80 in EK 60 modus on G.O. Sars
2018	Acoustic estimates by the BEAM Program	Acoustic and CV estimates by StoX software
	EK 60 on Johan Hjort	EK80 in EK 60 modus on Johan Hjort
2020	Area N not included in standard time series	Area N included in haddock survey indices
2021	Area N not included in standard time series	Area N included in cod survey indices

Appendix 3. Scientific participants 2021

Research vessel	Participants
"Helmer Hanssen" (20.01-08.02)	**T. Wenneck (cruise leader)**, E. Langhelle, I. Dias Bernardes, A. Storaker, R. Smestad, G. Thorsheim, J. Kristiansen, J. F. Wilhelmsen
"Kronprins Haakon" (22.01-07.02)	**K. Korsbrekke (cruise leader)**, E. Eidset, F. Midtøy, H. Senneset, S. E. Seim, R. H. Robertsen, J. V. Nordstrand
"Johan Hjort" (27.01-18.03)	Part 1 (27.01-03.02) **A. Staby (cruise leader)**, V. Fauskanger, D. Zaera-Perez, H. Mjanger, C. E. Bjånes, M. Mjanger, T. Haugland, R. Korneliussen Part 2 (03.02-18.02) **J. A. Godiksen (cruise leader)**, H. Mjanger, C. E. Bjånes, S. Glindtvad, E. Odland, M. Mjanger, T. Haugland Part 3 (18.02-03.03) **A. Aglen (cruise leader)**, E. Odland, E. Holm, G. Thorsheim, E. Eidset, J. Nesheim, T. Haugland Part 4 (03.03-08.03, Vardø-Nord plankton transect) **E. Hermansen (cruise leader)**, A. F. Rasmussen, H. Arnesen, J. Nesheim, B. Kvinge Part 5 (08.03-18.03) **E. Fuglebakk (cruise leader)**, V. Fauskanger, H. Senneset, G. Thorsheim, E. Langhelle, S. Gundersen, E. Hermanssen, B. Kvinge, J. Nesheim
"Vilnyus" (23.02-19.03)	**A. Russkikh (cruise leader)**, M. Osipov, M. Rybakov, T. Gavrilik, A. Amelkin, A. Pronuk, Z. Ostapenko, M. Gubanischev, E. Sentiabov, S. Harlin, S. Shmelev, M. Kalashnikova, N. Lukin

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