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Estimation of acoustic indices with CVs for cod and haddock in the Barents Sea winter survey 1994 – 2017 applying the Sea2Data StoX software

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Estimering av akustiske indekser med CV for torsk og hyse fra vintertoktet i Barentshavet 1994-2017 med Sea2Data programvaren StoX

Estimation of acoustic indices with CVs for cod and haddock in the Barents Sea winter survey 1994 – 2017 applying the Sea2Data StoX software

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Summary (Norwegian):
Sea2Data programmet StoX er brukt til å estimere akustiske indekser med CV for nordøstarktisk torsk og hyse fra vintertoktet i Barentshavet i 1994 til 2017. Indeksene er sammenlignet med indekser tidligere estimert med programmet BEAM. I de fleste år er StoX indeksene for torsk nokså like BEAM indeksene, mens de er noe høyere for hyse. De største forskjellene var hovedsakelig for aldersgrupper med lave indekser og/eller i år med skalering av indeksene.

Summary (English):
The Sea2Data software StoX was applied to estimate acoustic indices with CVs for Northeast Arctic cod and haddock from the Barents Sea winter survey in 1994 to 2017. The indices are compared to indices previously estimated by the BEAM software. In most years the StoX indices for cod are quite similar to those obtained by BEAM, while they are somewhat higher for haddock. The largest deviations were mainly found for age groups with low indices and/or in years with raising of the indices.

Emneord (norsk):
1. Nordøstarktisk torsk og hyse
2. Akustiske indekser
3. Barentshavet
4. StoX programvare

Subject heading (English):
1. Northeast Arctic cod and haddock
2. Acoustic indices
3. Barents Sea
4. StoX software

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1 Background

The Institute of Marine Research (IMR), Bergen, has performed acoustic measurements of demersal fish in the Barents Sea since 1976, and in 1981 a bottom trawl survey was combined with the acoustic survey. From 1981 to 1992 the survey area was fixed (strata 1-12, Main Areas ABCD in Fig. 2.1). Due to warmer climate and an increasing cod stock in the early 1990s, the distribution area increased. The survey area was extended towards north and east, beginning in 1993 and continuing in 1994 (strata 13-23, Main Areas D'ES in Fig. 2.1). This should allow for a more complete coverage of younger age groups of cod, and since 1994 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 not complete in most years. In 2008-2015 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. In 2009, 2010, 2012, 2013, 2015 and 2017 the coverage in eastern areas was more limited due to strict rules regarding handling of the catch, bad weather or vessel problems. Table 2.4 presents further comments to the annual coverages. The annual survey reports (references in Annex I) presents survey tracks and trawl stations.

The new Sea2Data software StoX was applied to estimate acoustic indices with CVs for cod and haddock for the period 1994 to 2017. The main difference between the SAS based BEAM Program (Totland and Godø 2001) used until 2017and StoX acoustic abundance estimation is that in BEAM the survey area is divided into rectangles, and for each rectangle an average acoustic density (sA) 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).

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. If age information is still missing StoX searches within strata, or lastly within all strata. If no age is available for a length group, the abundance estimate is presented as unknown age. StoX does also allow for uncertainty estimation by bootstrapping the transects and assigned trawl stations.

2 Material and Methods

2.1 Survey operation and data sampled

Table 2.1 presents the vessels participating in the survey in 1994-2017 with some basic trawl information. Catch data and biological samples from the Russian vessels were first converted to the IMR SPD-format, and then exported as xml-files from the NMD biotic data base. The column with number of trawl stations includes both valid swept area hauls, other bottom trawl hauls and pelagic trawl hauls.

Table 2.1. Sea2Data cruise number, start and end data, serial numbers, number of trawl stations and valid swept area hauls for Norwegian and Russian vessel participation in the Barents Sea winter survey in 1994-2017.

Year	Vessel	Cruice number	Start	End	Serial number		No. trawl stations	Valid swept area hauls
					From	To		
1994	Johan Hjort	1994202	21.01	06.03	80001	80161	161	284
	G.O. Sars	1994002	01.02	10.03	80301	80404	104	
	Anny Kræmer	1994001	01.02	01.03	80501	80663	163	
1995	G.O. Sars	1995901	28.01	27.02	80001	80146	146	298
	Johan Hjort	1995901	01.02	02.03	80201	80360	160	
	Jan Mayen	1995901	01.02	23.02	80401	80529	129	
1996	G.O. Sars	1996901	06.02	05.03	80001	80129	129	312
	Johan Hjort	1996901	06.02	02.03	80201	80337	137	
	Jan Mayen	1996901	05.02	29.02	80401	80527	127	
1997	G.O. Sars	1997901	06.02	04.03	80001	80075	75	167
	Johan Hjort	1997901	06.02	01.03	80201	80322	122	
	Jan Mayen	1997901	03.02	27.02	80401	80498	98	
1998	G.O. Sars	1998002	31.01	27.02	80001	80096	96	200
	Johan Hjort	1998202	31.01	01.03	80201	80286	86	
	Jan Mayen	1998825	31.01	24.02	80401	80477	77	
1999	G.O. Sars	1999002	27.01	27.02	80001	80144	144	223
	Johan Hjort	1999203	27.01	22.02	80201	80321	121	
2000	G.O. Sars	2000002	29.01	24.02	80001	80167	167	313
	Johan Hjort	2002202	01.02	29.02	80201	80333	133	
	Varegg	2000805	28.01	28.02	80401	80556	156	
	Persey-3	0119-2000	06.02	11.02	70701	70716	16	
2001	G.O. Sars	2001002	27.01	07.03	80001	80193	193	349
	Johan Hjort	2001202	20.01	28.02	80201	80375	175	
	Persey-4	0079-2001	01.02	21.02	70701	70739	39	
2002	G.O. Sars	2002002	30.01	02.03	80001	80165	165	392
	Johan Hjort	2002203	29.01	04.03	80201	80364	164	
	Persey-3	0083-2002	29.01	27.02	70701	70829	129	
2003	G.O. Sars/Sarsen	2003002	27.01	05.03	80001	80164	164	312
	Johan Hjort	2003202	27.01	05.03	80301	80450	150	
	Percey-3	0085-2003	30.01	26.02	70701	70833	133	
2004	Johan Hjort	2004203	31.01	14.03	70001	70256	256	355
	G.O. Sars	2004106	31.01	15.03	70301	70471	171	
	Smolensk	0090-2004	23.02	12.03	70701	70790	90	

Year	Vessel	Cruice number	Start	End	Serial number		No. trawl stations	Valid swept area hauls
					From	To		
2005	Johan Hjort G.O. Sars Smolensk	2005203 2005104 0091-2005	01.02 01.02 08.02	15.03 07.03 04.03	70001 70303 70701	70203 70475 70815	203 173 115	370
2006	Johan Hjort G.O. Sars	2006203 2006103	01.02 01.02	15.03 09.03	70001 70251	70182 70424	182 173	271
2007	Johan Hjort G.O. Sars	2007203 2007103	01.02 07.02	15.03 14.03	70001 70301	70181 70464	181 164	258
2008	Johan Hjort Jan Mayen Fritjof Nansen Smolensk	2008202 2008701 0101-2008 0102-2008	01.02 01.02 04.02 25.01	14.03 06.03 05.03 13.02	70001 70301 70501 70701	70174 70471 70591 70745	174 171 91 45	345
2009	Johan Hjort Jan Mayen Fritjof Nansen Vilnyus	2009202 2009701 0104-2009 0121-2009	06.02 01.02 02.02 26.02	13.03 08.03 05.03 13.03	70001 70301 70501 70701	70152 70474 70537 70744	152 174 37 44	331
2010	Johan Hjort Jan Mayen Fritjof Nansen	2010202 2010701 0122-2010	04.02 01.02 26.02	17.03 05.03 11.03	70001 70301 70501	70159 70480 70564	159 180 64	349
2011	Johan Hjort Jan Mayen Fritjof Nansen	2011202 2011702 0108-2011	03.02 01.02 02.02	14.03 01.03 19.02	70001 70301 70501	70154 70486 70585	154 186 85	381
2012	Helmer Hanssen Libas Fritjof Nansen	2012839 2012841 0111-2012	22.01 19.02 03.02	21.02 15.03 18.02	70301 70001 70501	70473 70073 70573	173 73 73	284
2013	Johan Hjort Vilnyus	2013201 0113-2013	31.01 07.02	13.03 08.03	70001 70701	70187 70828	187 128	295
2014	Johan Hjort Helmer Hanssen Fritjof Nansen	2014202 2014805 0114-2014	31.01 22.01 29.01	16.03 02.03 17.02	70001 70301 1	70196 70490 113	196 190 113	404
2015	Johan Hjort Helmer Hanssen Fritjof Nansen	2015202 2015841 0120-2015	27.01 20.01 22.02	14.03 16.02 03.03	70001 70301 70501	70221 70431 70538	221 131 38	292
2016	Johan Hjort Helmer Hanssen Fritjof Nansen	2016202 2016846	24.01 25.01 05.02	16.03 08.02 26.02	70001 70301 1	70283 70377 101	283 177 101	341
2017	G.O. Sars Helmer Hanssen	2017102 2017849	07.02 18.01	24.03 23.02	70001 70301	70181 70438	181 138	246

Table 2.2 gives an account of the sampled length- and age material from all trawl hauls. Table 2.3 gives the area covered by the survey every year since 1994. 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 2.6). Table 2.4 summarizes the coverage and main reasons for incomplete coverage in the whole period.

Table 2.2. Number of cod and haddock measured for length and age in the Barents Sea winter survey 1994-2017.

	Cod		Haddock	
Year	**Length**	**Age**	**Length**	**Age**
1994	57290	3400	40608	1808
1995	66264	3547	37775	1692
1996	61559	3304	34497	1416
1997	35381	2381	30054	1003
1998	39044	2843	12512	859
1999	22971	2321	12752	926
2000	31543	2871	25881	1426
2001	36789	2998	30921	1657
2002	45399	3730	58464	2057
2003	59573	2857	54838	1883
2004	40851	3175	51705	1874
2005	33582	3216	67921	2060
2006	19319	2683	23611	1899
2007	16556	2954	26610	2023
2008	26844	3809	50195	2490
2009	22528	3486	40872	2433
2010	30209	4085	35881	2367
2011	26913	3959	29180	2260
2012	17139	3020	33524	1854
2013	14525	2451	19142	1671
2014	22624	4501	35940	2586
2015	25401	3795	18483	2038
2016	16636	3368	25423	2067
2017	12402	2851	15689	1955

Table 2.3. Area (NM^2) covered (StoX estimates) in the bottom trawl surveys in the Barents Sea winter 1994-2017

	Main Area								Total excluding N	Extra-polated area
Year	**A**	**B**	**C**	**D**	**D'**	**E**	**S**	**N**		
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[3]	27785	9854	5165	53394	45449	26541	27858	47263	196047	
2016[3]	27785	9854	5165	53526	29266	20342	27630	54387	173568	
2017[2,3]	27785	9854	5165	45493	12223	18524	27858	38786	146903	37410

[1]REZ not covered, [2]REZ (Murman coast and Area D' in 2006 and 2017 and Area D' in 2012 not completely covered
[3] Additional northern areas (N) covered, not included in total and survey index calculations.

Table 2.4. Barents Sea winter surveys 1981-2017. Main Areas covered, and comments on incomplete coverage.

Year	Main Areas covered	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	
2001-2005	ABCDD'ES	Russian vessel covered where Norwegians had no access
2006	ABCDD'ES	Not access to Murman coast, no Russian vessel
2007	NEZ, S	Not allowed access to REZ, no Russian vessel
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

2.2 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 2017 R/V "G.O. Sars" used the new Simrad EK80 echo sounder

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 the Norwegian vessels, acoustic backscattering values (s_A) 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. If

the trawl catch gives the true composition of the species contributing to the observed s_A value, those catch-based s_A - proportions could be used directly for the allocation. In the scrutinizing process, the scientists should evaluate to what extent these catch-based s_A - proportions are reasonable, or if they should be modified based on knowledge about the fish behaviour and the catching performance of the gear.

The survey area is divided into eight Main Areas (A, B, C, D, D', E, S and N, Fig 2.1) and 26 strata. In 2014, the investigated area was enlarged by three new strata in northwest, 24-26 (Main Area N, Fig. 2.1). Within each stratum, the acoustic course tracks are divided into transects, separated by the trawl stations in the stratum since the course tracks runs through the net of fixed bottom trawl stations in the bottom trawl survey. An area of about 2 nautical miles around each station is not included in the transects. 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 is 4 nautical miles. In this process miles with obvious error in the s_A-values, e.g. bottom contribution, were removed from the transects.

For each transect and stratum, an arithmetic mean s_A is calculated for the demersal layer (less than 10 m above bottom) and the pelagic layer (more than 10 m above bottom).

The conversion of mean nautical area scattering coefficient (NASC) (m^2 nmi^{-2}) to density of fish followed a standard procedure where all trawl stations within a stratum with a catch of more than 5 individuals were assigned to each PSU. If less than 3 trawl stations had been carried out in a stratum, stations in neighboring strata were assigned to the PSUs such that at least 3 stations were assigned to each PSU.

The combined length distribution (d) was 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 dependant fishing efficiency (Aglen and Nakken 1997, Dickson 1993a,) using the parameters given in the text table below:

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

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

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

where $NASC_{j,l}$ 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.

$NASC_{j,l}$ is calculated as:

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

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.

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

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

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 applied

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

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

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

where *A* is stratum area and the mean fish density 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 $w_{kj} = L_{kj} / \overline{L}_k$ (j= 1,2, n_k) are the lengths of the n_k sample transects.

Estimates by length are converted to estimates by age using available age-length data from all selected (filtered) stations in the stratum, weighted by station density. The total biomass is estimated by multiplying the numbers at age by weight at age. The abundance by stratum is then summed for defined main areas (Figure 2.1).

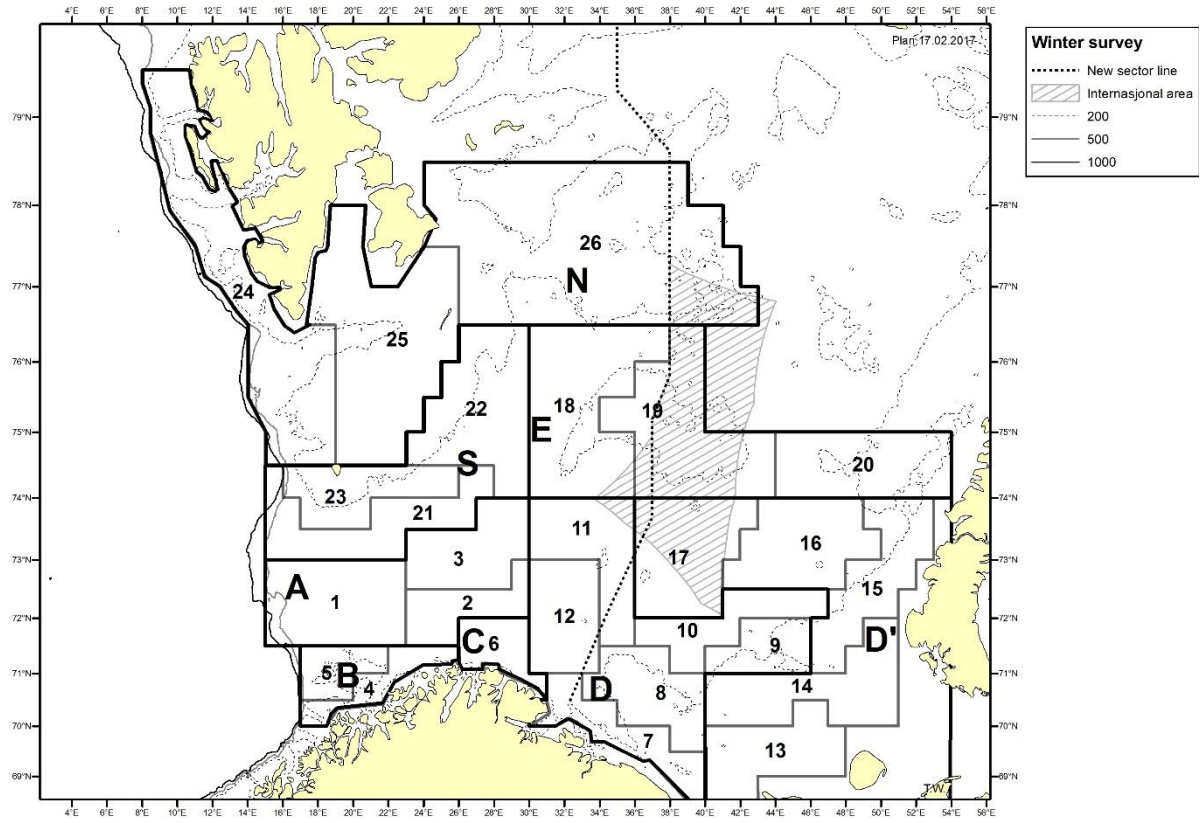

Figure 2.1. Strata (1-23) and Main Areas (A,B,C,D,D',E and S) used for swept area estimations and acoustic estimations with StoX. The Main Areas are also used for acoustic estimations with BEAM. Additional strata (24-26, Main Area N) are covered since 2014, but not included in the full time series.

2.3 Sampling of catch and use of age-length data

Sorting, weighing, measuring and sampling of the catch are done according to instructions given in Mjanger *et al*. (2017). 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 age (otoliths) were sampled from 1 cod and 1 haddock per 5 cm length-group. In 2007-2009, all cod above 80 cm were sampled, and in 2010 all above 90 cm, limited to 10 per station.

2.4 Estimation of variance

The acoustic survey indices of cod and haddock made with StoX are presented together with an estimate of uncertainty (coefficient of variation; CV). 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 and is strongly dependent on the choice of estimator for the indices.

2.5 StoX input, settings and filters

StoX version 2.5 and Rstox 1.8 was used for estimation of acoustic indices and CVs (http://www.imr.no/forskning/prosjekter/stox/en). R for Windows version 3.4.3 was used in the R calls (https://www.r-project.org/).

Biotic and acoustic XML-files were downloaded from:

http://tomcat7.imr.no:8080/DatasetExplorer/v1/html/main.html.

In **FilterAcoustic, FreqExpr** was set to **frequency=38000 or frequency=37879**. In **NASCExpr, acocat** was **31** for cod and **30** for haddock.

In **NASC and LayerType** was set to **DepthLayer**.

Under **FilterBiotic** and **FishStationExpr**, the following filter were applied: **fs.getLengthSampleCount('TORSK') > 5** for cod and **fs.getLengthSampleCount('HYSE') > 5 for haddock** and **fishstationtype != 2** or **!~ ['1', '2', '3']** prior to 2006, filtering out stations with less than six specimen and stations with experiments, (see Johnsen et al. 2016 and Mjanger et al. 2017 for more info about filters and codes).

Under **StationLengthDist** and **LengthDistType**, **NormLengthDist** was used, and under **RegroupLengthDis**t and **LengthInterval**, **1.0** is applied.

Under **Catchability** and **Catchability Method**, **LengthDependentSweepWidth** was used, using the parameters given above.

In **DefineStrata**, adjusted **vintertokt_barentshavny.txt** like the ones used for swept-area estimations was used for each year. Nodes for strata towards north and east have been adjusted to reduce the strata according to coverage and ice border in each year.

In **StratumArea** and **AreaMethod**, **Accurate** was applied.

Under **BioStationAssignment** and **AssignmentMethod**, **Stratum** was used. **EstLayers** was set to **1~PEL 2~BOT**.

Under **BioStationWeighting** and **WeightingMethod, SumWeightedCount** was used.

In Acustic**Density**, **m** was set to **20** and **a** to **-68**.

Under **SuperIndAbundance** and **AbundWeightMethod**, **StationDensity** was used, with **LengthDist** set to **RegroupLengthDist**.

2.6 Raising of indices

In 1997, 1998 and 2007 only the Norwegian EEZ (REZ) and parts of the Svalbard area (S) was covered. The acoustic indices for cod and haddock has therefore been raised by the same procedure as for the swept-area estimates 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 acoustic 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 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)) in the years 2014-2016.

3 Results

3.1 Total echo abundance of cod and haddock

Table 3.1 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 for StoX and BEAM estimates, and ratio between StoX and BEAM echo abundance estimates.

In 2013 unusual high NASC values were found for cod in the southwestern part of main area B, strata 4 and 5. This was considered to be spawning, migrating fish normally outside the winter survey area, and in the BEAM estimates for 2013 the sA values for rectangles 7000N 1700E and 7030N 1700E were set to 0.1 for the bottom and pelagic layers. In StoX the NASC values for the transects within the corresponding rectangles were also set to 0.1 for the bottom and pelagic layers.

Table 3.1. Cod and haddock. Total echo abundance in the Barents Sea winter 1994-2017 (m^2 reflecting surface · 10^{-3}) estimated by StoX and BEAM software, and ratio StoX/BEAM. Observations outside main areas A-S are not included.

	StoX			BEAM			Ratio StoX/BEAM		
Year	**Cod**	**Haddock**	**Sum**	**Cod**	**Haddock**	**Sum**	**Cod**	**Haddock**	**Sum**
1994	5282	3898	9180	5076	3650	8726	1.04	1.07	1.05
1995	3671	2948	6619	4125	3051	7176	0.89	0.97	0.92
1996	2789	1248	4037	2729	1556	4285	1.02	0.80	0.94
1997[1]	1355	832	2187	1354	995	2349	1.00	0.84	0.93
1998[1]	2254	543	2797	2406	581	2987	0.94	0.93	0.94
1999	1517	771	2288	1364	704	2068	1.11	1.10	1.11
2000	2833	1534	4367	2596	1487	4083	1.09	1.03	1.07
2001	2158	1488	3646	2085	1440	3525	1.04	1.03	1.03
2002	1976	2247	4223	1943	2329	4272	1.02	0.96	0.99
2003	3663	3570	7233	3699	3398	7097	0.99	1.05	1.02
2004	1174	2087	3261	1162	1985	3147	1.01	1.05	1.04
2005	1370	2519	3889	1299	2873	4172	1.05	0.88	0.93
2006	1116	2541	3657	1195	2755	3950	0.93	0.92	0.93
2007[1]	675	2311	2986	681	2515	3196	0.99	0.92	0.93
2008	3510	6195	9705	3636	5981	9617	0.97	1.04	1.01
2009	2452	5300	7752	2513	6326	8839	0.98	0.84	0.88
2010	3526	5939	9465	3712	5905	9617	0.95	1.01	0.98
2011	2967	3715	6682	3044	3790	6834	0.97	0.98	0.98
2012	3478	4182	7660	3762	4157	7919	0.92	1.01	0.97
2013[2]	5026	3604	9656	5105	4078	9183	0.98	0.88	1.05
2014	4847	2915	7762	4722	3176	7898	1.03	0.92	0.98
2015	5243	2161	7404	4868	1862	6731	1.08	1.16	1.10
2016	2879	1587	4466	2884	1701	4585	1.00	0.93	0.97
2017[1]	2139	2588	4732	2251	2641	4892	0.95	0.98	0.97

[1] not scaled for uncovered areas
[2] Cod NASC values in the southwestern part of main area B reduced

For cod, the highest and lowest total echo abundance ratio StoX/BEAM was 1.11 and 0.89, while the average ratio over all years was 1.00. The highest and lowest ratio for haddock was 1.16 and 0.80. with an average of 0.97. For the sum of cod and haddock the average total echo abundance ratio StoX/BEAM was 0.98.

3.2 Cod

Table 3.2.1 presents acoustic abundance indices for cod age groups 1 – 15+, where 15+ is the sum of indices for age groups 15 and older, for the standard area (strata 1-23) in 1994 to 2017, and Table 3.2.2 gives the ratio between StoX and BEAM indices by age, total index and total biomass. The highest and lowest single index ratio was 4.83 and 0.53, while the highest and lowest average ratio over all age groups in one year was 1.68 and 0.84, and the highest and lowest average ratio for one age group over all years was 1.40 and 0.87. The overall average index ratio was 1.04, the average total index ratio was 0.93 and the average total biomass ratio was 1.04. The acoustic index ratios were on average slightly higher (4%) than the swept area ratios.

Table 3.2.3 presents estimates of coefficients of variation (%) for age groups 1-14. Estimates are based on a stratified bootstrap approach with 500 replicates (with transects being primary sampling unit). 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). Values above this indicate a highly uncertain index with little information regarding year class strength. In most years CVs for age groups older than 9 years are above what could be considered as acceptable.

Table 3.2.4 shows indices for new strata 24-26 in 2014-2017.

Table 3.2.1. COD. Abundance indices (numbers in millions) from acoustic surveys in the Barents Sea standard area winter 1994-2017 estimated by StoX software.

	Age group															Total	Biomass ('000 t)
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+		
1994	823.5	586.9	307.2	384.4	207.0	68.0	12.1	3.53	2.55	0.81	1.11	0.11	0.12	0	0	2397.4	1053.8
1995	2106.6	217.9	143.0	138.0	198.3	67.0	16.1	2.46	0.90	0.32	0.53	0.16	0	0	0	2891.2	669.3
1996	1748.9	261.1	110.0	89.5	115.0	83.3	23.0	2.20	0.27	0.08	0.05	0.05	0.06	0.01	0	2433.4	509.2
1997[1]	2832.9	842.9	209.2	49.2	51.5	43.1	24.9	5.73	1.00	0.23	0.22	0	0	0.03	0	4060.9	358.6
1998[1]	2633.1	555.8	444.5	210.8	46.6	44.4	28.6	16.90	1.85	0.46	0.16	0	0.02	0	0.07	3983.2	572.9
1999	351.1	227.0	151.6	133.3	51.8	12.0	7.02	3.98	1.54	0.32	0.02	0.01	0.01	0	0	939.6	265.4
2000	142.4	248.1	301.1	168.8	147.1	49.0	12.1	4.48	2.85	0.80	0.18	0.12	0.03	0	0	1077.0	546.7
2001	348.3	50.8	179.0	162.3	81.1	44.0	11.3	1.73	0.47	0.18	0.10	0	0	0	0.01	879.4	436.9
2002	18.4	208.8	62.4	105.5	98.0	53.4	20.2	2.96	0.30	0.53	0.12	0	0	0	0.02	570.6	430.7
2003	1399.7	52.0	307.0	120.6	121.8	118.7	39.1	9.32	1.84	0.33	0.07	0	0.07	0.05	0	2170.5	756.7
2004	147.1	111.2	33.3	85.2	33.5	28.5	18.0	5.35	1.15	0.36	0.06	0.01	+	0	0	463.8	245.5
2005	438.2	123.2	129.8	34.9	69.1	21.2	15.0	4.95	0.95	0.27	0.04	0.06	0.05	0.03	0	837.7	263.5
2006[2]	369.5	158.3	64.4	54.5	18.6	29.7	9.57	4.83	1.22	0.19	0.11	0.22	0	0	0	711.2	226.4
2007[1]	88.9	53.7	63.9	35.7	32.7	9.68	18.8	6.57	2.74	0.51	0.24	0.09	0.04	0	0	313.6	239.2
2008	48.5	91.9	196.1	292.0	116.0	73.7	21.1	14.1	2.62	0.72	0.05	0.02	0.01	0	0	856.8	819.8
2009	195.5	23.2	104.6	191.6	139.7	40.9	14.1	4.70	4.38	0.48	0.13	0.02	0.01	0	0	719.4	543.8
2010	696.1	41.8	21.8	86.9	161.8	153.8	46.2	14.4	3.87	2.86	0.91	0.11	0.14	0.09	0.01	1230.9	890.2
2011	248.5	88.7	39.1	28.7	65.4	106.6	102.4	19.4	6.71	1.49	1.07	0.28	0.13	0.10	0.02	708.5	790.0
2012[3]	508.1	45.3	87.8	47.6	35.1	70.9	135.8	60.3	8.19	5.19	1.26	0.66	0.45	0.01	0.10	1006.7	961.8
2013[4]	293.3	82.4	59.1	85.4	70.6	50.2	100.0	129.9	57.0	5.37	3.98	1.63	0.70	0.21	0.05	939.8	1511.9
2014	582.2	154.2	234.0	115.9	96.0	68.4	37.7	84.7	55.3	24.1	2.46	1.51	0.17	0.04	0.16	1456.8	1336.6
2015	1183.0	107.6	110.2	188.0	119.5	130.2	84.9	33.8	51.7	23.0	6.27	0.57	0.14	0.04	0.01	2038.9	1374.6
2016	106.2	111.5	35.2	61.6	101.2	64.5	49.2	23.1	11.9	16.3	7.37	2.25	0.69	0.25	0.09	591.4	806.1
2017[3]	381.5	42.8	80.6	33.0	37.6	58.0	33.0	22.3	10.3	3.81	3.00	3.15	0.59	0.20	0.10	710.0	610.3

[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] Cod NASC values in the southwestern part of main area B reduced.

Table 3.2.2. COD. Ratio StoX/BEAM acoustic abundance indices and total biomass in the Barents Sea winter 1994-2017.

	Age group										Total	Biomass
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**		
1994	0.96	1.02	0.88	0.95	1.07	1.07	1.00	0.95	1.50	2.38	0.97	1.11
1995	0.80	0.74	0.86	0.86	0.94	0.97	0.96	1.17	1.28	1.00	0.82	0.94
1996	0.73	0.77	1.18	1.27	1.34	1.11	1.11	0.78	0.90	0.62	0.79	1.13
1997	1.74	1.96	1.11	0.95	1.04	1.16	1.12	1.43	1.43	4.83	1.69	1.11
1998	0.77	0.88	1.04	1.15	1.10	1.33	1.06	1.24	1.09	2.07	0.84	1.13
1999	0.98	0.75	1.01	1.38	1.15	1.16	1.10	0.97	1.92	1.21	0.96	1.18
2000	0.92	1.12	1.23	1.06	1.04	1.08	1.26	0.95	0.95	1.03	1.09	1.14
2001	0.55	0.79	1.30	0.95	1.05	1.11	0.95	1.24	0.94	1.40	0.78	1.07
2002	1.01	0.97	0.90	0.94	0.96	1.14	1.12	0.99	0.75	2.23	0.97	1.04
2003	0.83	0.84	1.01	1.05	0.94	1.03	1.14	1.21	0.97	1.03	0.88	1.04
2004	0.93	1.06	0.99	0.92	1.09	1.03	1.06	0.91	0.95	2.16	0.98	1.02
2005	0.94	1.03	1.05	1.04	1.10	1.26	1.04	1.18	0.95	1.12	0.99	1.06
2006	0.68	0.73	0.81	0.92	1.20	1.16	1.09	1.07	0.87	1.03	0.74	1.02
2007	0.71	0.87	0.80	0.96	1.08	1.06	1.34	1.31	1.31	1.25	0.86	1.21
2008	0.71	0.94	0.93	0.95	0.82	1.06	0.98	1.16	0.85	0.99	0.92	0.97
2009	0.61	0.76	0.57	1.07	1.02	1.17	1.13	0.90	1.18	0.70	0.79	1.01
2010	1.43	0.70	0.63	0.71	0.93	0.95	1.04	1.05	1.11	1.18	1.12	0.96
2011	0.64	0.71	0.83	0.99	0.81	0.99	0.97	1.13	1.49	1.03	0.78	1.02
2012	0.53	0.62	0.66	0.90	0.93	1.02	1.08	0.78	0.79	1.28	0.66	0.93
2013	0.62	0.74	0.92	1.00	1.00	0.97	1.16	1.05	0.81	0.96	0.82	0.98
2014	0.92	1.11	1.06	0.98	1.05	1.05	1.00	1.10	0.88	1.09	0.99	1.03
2015	1.04	0.85	1.16	1.22	1.01	1.33	1.06	1.65	0.76	1.15	1.04	1.04
2016	0.74	0.92	0.86	1.06	1.05	1.02	0.96	1.06	0.80	1.12	0.93	0.98
2017	0.96	0.88	0.88	0.82	0.78	0.86	0.89	0.85	0.75	0.72	0.90	0.85

Table 3.2.3. COD. Estimates of coefficients of variation for acoustic abundance indices. Barents Sea standard area winter 1994-2017.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1994	0.33	0.40	0.29	0.12	0.07	0.10	0.12	0.18	0.20	0.29	0.27	0.73	0.97	-
1995	0.14	0.20	0.11	0.09	0.07	0.09	0.11	0.21	0.25	0.31	0.55	0.48	-	-
1996	0.10	0.15	0.14	0.11	0.11	0.10	0.13	0.15	0.29	0.43	0.61	0.60	1.11	1.17
1997[1]	0.33	0.22	0.13	0.12	0.11	0.09	0.09	0.13	0.25	0.55	0.74	-	-	1.18
1998[1]	0.24	0.17	0.10	0.08	0.10	0.09	0.08	0.10	0.21	0.44	0.57	-	0.97	-
1999	0.22	0.23	0.17	0.15	0.10	0.11	0.11	0.13	0.25	0.58	1.14	1.21	1.07	-
2000	0.31	0.26	0.17	0.10	0.07	0.10	0.17	0.21	0.22	0.42	0.72	0.68	1.10	-
2001	0.13	0.15	0.11	0.09	0.10	0.09	0.13	0.22	0.32	0.35	0.77	-	-	-
2002	0.18	0.16	0.10	0.06	0.07	0.10	0.15	0.17	0.32	0.78	0.72	-	-	-
2003	0.26	0.31	0.15	0.13	0.08	0.08	0.13	0.17	0.20	0.40	0.59	-	0.99	0.94
2004	0.17	0.16	0.13	0.10	0.10	0.10	0.09	0.13	0.16	0.45	0.58	0.95	1.25	-
2005	0.26	0.50	0.19	0.14	0.14	0.14	0.12	0.20	0.26	0.24	0.62	0.90	0.49	0.91
2006[2]	0.21	0.15	0.13	0.10	0.10	0.11	0.15	0.15	0.23	0.37	0.57	0.68	-	-
2007[1]	0.32	0.27	0.14	0.13	0.11	0.17	0.19	0.21	0.24	0.29	0.40	0.46	0.94	-
2008	0.18	0.24	0.15	0.16	0.13	0.10	0.16	0.14	0.20	0.44	0.75	0.65	1.00	-
2009	0.21	0.20	0.26	0.22	0.18	0.17	0.13	0.14	0.19	0.32	0.45	0.71	1.12	
2010	0.36	0.17	0.19	0.25	0.16	0.12	0.11	0.12	0.17	0.22	0.28	0.86	0.74	0.70
2011	0.13	0.27	0.12	0.11	0.11	0.10	0.09	0.15	0.28	0.29	0.35	0.39	0.66	0.86
2012[2]	0.36	0.14	0.53	0.11	0.19	0.19	0.17	0.13	0.19	0.35	0.33	0.55	0.52	0.81
2013	0.12	0.24	0.15	0.09	0.21	0.25	0.21	0.18	0.22	0.41	0.49	0.59	0.75	1.11
2014	0.13	0.10	0.11	0.12	0.12	0.08	0.11	0.13	0.15	0.19	0.33	0.53	0.58	0.95
2015	0.17	0.24	0.16	0.16	0.12	0.20	0.18	0.20	0.24	0.25	0.50	0.64	0.71	0.82
2016	0.21	0.15	0.13	0.12	0.11	0.15	0.15	0.16	0.23	0.23	0.29	0.47	0.58	0.87
2017[2]	0.15	0.21	0.13	0.09	0.10	0.11	0.14	0.11	0.18	0.34	0.43	0.55	0.66	1.08

[1] REZ not covered

[2] REZ partly covered

Table 3.2.4. COD. Abundance indices (numbers in millions) for new strata 24-26 from acoustic surveys in the Barents Sea winter 2014-2017 estimated by StoX software.

	Age group															Total	Biomass ('000 t)
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**		
2014	1112.5	54.0	54.5	11.7	14.6	7.31	2.26	4.73	2.98	0.27	0.02	0	0	0	0	1264.9	103.4
2015	589.7	88.3	25.2	49.0	12.7	11.2	5.34	1.08	3.40	1.16	0.77	0.05	0	0	0	787.9	122.4
2016	104.9	84.6	18.0	14.6	16.8	2.47	2.94	1.86	0.30	0.67	0.17	0.02	0.01	0	0	247.3	60.2
2017	31.1	28.7	26.5	5.44	5.68	4.13	1.54	0.65	0.24	0.05	0.28	0.04	0	0	0	104.4	40.1

3.3 Haddock

Table 3.3.1 presents acoustic abundance indices for haddock age groups 1 – 15+ for the standard area in 1994 to 2017, and Table 3.3.2 gives the ratio between StoX and BEAM indices by age, total index and total biomass. The highest and lowest single index ratio was 4.66 and 0.31. The highest and lowest average ratio over all age groups in one year was 1.65 and 0.70, and the highest and lowest average ratio for one age group over all years was 1.68 and 0.82. The overall average index ratio was 1.17, the average total index ratio was 0.90 and the average total biomass ratio was 1.08. The acoustic index ratios were on average higher (20%) than the swept area ratios reported by Mehl et al. (2016).

Table 3.3.3 presents estimates of coefficients of variation (%) for age groups 1-14. Estimates are based on a stratified bootstrap approach with 500 replicates (with transects being primary sampling unit). 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). Values above this indicate a highly uncertain index with little information regarding year class strength. In most years CVs for age groups older than 7 years are above what could be considered as acceptable.

Table 3.3.4 shows indices for new strata 24-26 in 2014-2017.

Table 3.3.1. HADDOCK. Abundance indices (numbers in millions) from acoustic surveys in the Barents Sea standard area winter 1994-2017 estimated by StoX software.

	Age group															Total	Biomass ('000 t)
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**		
1994	887.8	188.0	348.7	626.6	121.4	8.55	0.70	0.33	0.61	0.48	1.46	0.16	0	0	0	2184.8	643.5
1995	1198.2	88.6	41.5	121.5	395.4	47.6	2.80	0.05	0.12	0.03	0.00	0.54	0.14	0	0	1896.4	508.8
1996	132.6	94.5	30.0	22.1	68.7	143.7	5.67	0.94	0	0.01	0	0.02	0.04	0	0.0	498.2	248.3
1997[1]	508.9	26.5	57.3	22.2	15.5	56.1	62.8	4.68	0.07	0	0	0.01	0.05	0.06	0	754.1	217.2
1998[1]	211.0	151.0	33.8	58.8	24.2	7.70	14.1	20.7	1.44	0.02	0.04	0	0	0	0.12	522.8	152.1
1999	653.4	30.1	83.7	21.6	22.1	6.17	1.55	3.88	2.72	0.03	0	0.02	0	0	0	825.3	107.9
2000	1063.0	404.8	36.4	75.5	14.0	12.6	1.57	0.53	2.01	0.69	0.17	0.13	0.02	0	0	1611.5	189.8
2001	753.0	266.1	233.5	40.2	41.4	2.20	1.61	0.16	0.09	0.14	0.28	0.09	0.09	0	0.02	1338.8	206.5
2002	1315.2	267.9	255.2	201.8	18.5	11.7	1.59	0.29	0.03	0.13	0.26	0.09	0.05	0	0	2072.7	298.2
2003	2743.7	362.3	203.7	184.6	136.0	12.3	6.01	0.26	0.14	0.26	0.34	0.09	0.07	0	0	3649.8	444.5
2004	529.0	466.5	151.0	101.8	107.8	57.7	7.62	1.15	0.29	0.04	0.05	0.05	0.04	0.08	0	1423.2	323.0
2005	2276.5	144.0	221.3	115.7	57.4	56.7	12.7	0.38	0.32	0.01	0	0	0	0	0	2885.0	306.0
2006[2]	2091.1	624.8	56.3	123.8	47.4	19.3	13.6	3.23	0.08	0.15	0	0.03	0	0	0.09	2979.9	297.9
2007[1]	2015.7	953.5	209.3	46.1	80.6	28.9	10.00	5.05	2.26	0.30	0.18	0.00	0.00	0.00	0.05	3352.0	406.0
2008	778.4	1753.5	812.4	303.0	90.0	74.1	7.41	12.8	1.63	0.14	0.16	0.18	0	0	0	3833.8	920.4
2009	443.9	209.1	883.7	630.0	266.6	38.9	14.6	1.26	0.34	0.66	0.66	0	0.05	0	0	2489.0	865.4
2010	1559.4	86.0	128.1	631.0	604.0	167.0	12.1	2.94	0.96	0.99	0.10	0.06	0	0	0	3192.6	1035.9
2011	428.5	288.3	54.2	84.2	313.0	292.2	54.9	1.72	0.96	0.23	0	0.21	0.07	0	0	1518.4	712.1
2012[3]	1583.4	94.5	191.6	48.8	88.1	310.6	172.5	30.1	0.52	0.34	0.02	0.13	0	0	0	2520.8	814.6
2013	292.7	407.2	67.3	146.8	35.4	53.0	223.8	102.7	14.1	0.25	0	0	0	0	0	1343.2	759.6
2014	1703.7	109.0	324.5	38.2	107.9	22.4	33.8	84.5	35.3	1.46	0.50	0	0	0.01	0	2461.4	566.4
2015	1521.9	224.4	23.6	171.5	25.5	39.4	8.32	21.1	17.3	6.83	0.42	0.15	0	0	0	2060.5	339.5
2016	1260.3	105.4	68.5	11.8	56.0	11.8	16.6	6.86	15.5	11.9	2.43	0.48	0	0.03	0.02	1567.5	258.3
2017[3]	3263.8	323.2	79.9	62.8	4.4	32.2	5.84	7.01	1.50	6.43	5.48	2.01	0.44	0	0	3795.1	308.6

[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 3.3.2. HADDOCK. Ratio StoX/BEAM acoustic abundance indices and total biomass in the Barents Sea standard area winter 1994-2017.

	Age group											
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**	**Biomass**
1994	1.58	0.97	1.37	0.99	1.09	0.71	-	-	-	-	1.24	1.12
1995	0.87	0.31	1.15	1.09	1.02	1.13	1.40	-	-	-	0.85	1.09
1996	0.53	0.41	0.68	0.71	0.90	0.95	0.71	-	-	-	0.63	0.89
1997	0.73	1.10	1.12	1.31	1.29	1.31	1.46	2.34	-	-	0.85	1.40
1998	0.96	1.24	1.69	2.10	2.02	1.54	1.08	1.29	1.44	-	1.20	1.65
1999	0.76	0.66	1.46	1.65	1.59	1.72	1.10	2.04	1.70	1.67	0.83	1.33
2000	1.04	0.80	1.13	1.16	0.76	1.20	0.98	1.07	1.12	2.53	0.97	1.03
2001	0.77	0.84	1.11	1.74	1.92	1.69	1.79	1.55	2.23	1.25	0.86	1.18
2002	0.64	0.95	1.18	1.35	1.37	1.00	1.59	1.44	0.90	0.75	0.76	1.13
2003	1.15	1.30	1.40	0.93	0.81	0.71	1.20	1.31	1.39	0.69	1.14	0.98
2004	0.70	0.98	1.19	1.34	1.42	0.88	1.15	0.58	2.89	0.87	0.90	1.13
2005	0.68	0.69	1.01	1.14	1.57	1.41	1.41	3.77	3.17	-	0.72	1.01
2006	0.76	0.78	1.04	1.44	1.57	1.66	1.52	1.47	0.86	1.30	0.79	1.06
2007	0.63	1.10	0.55	0.85	0.92	1.31	1.67	1.01	1.13	-	0.73	0.88
2008	0.61	0.96	1.12	1.20	1.57	1.00	0.73	2.20	4.66	0.47	0.91	1.09
2009	0.52	0.85	0.86	0.81	0.66	1.24	0.98	0.79	2.63	1.34	0.75	0.86
2010	0.77	1.05	0.93	1.06	1.08	0.87	1.17	1.01	1.42	1.59	0.88	1.06
2011	0.54	0.71	1.14	1.24	1.00	1.11	1.05	1.07	2.14	0.80	0.78	1.04
2012	0.71	0.54	0.85	1.63	1.51	1.06	1.28	0.95	0.62	1.18	0.79	1.10
2013	0.56	0.67	1.27	1.11	1.20	1.36	0.92	0.98	0.99	0.87	0.77	0.98
2014	1.09	0.96	1.02	0.87	1.30	1.22	0.77	0.98	0.94	0.56	1.06	1.02
2015	1.31	1.33	1.39	1.17	0.70	1.28	0.72	1.14	0.98	1.40	1.27	1.09
2016	1.01	0.87	0.98	1.23	0.91	0.84	0.68	0.87	1.17	0.80	0.99	0.90
2017	0.84	0.98	1.02	0.82	0.98	0.82	0.81	0.78	1.15	1.04	0.85	0.85

Table 3.3.3. HADDOCK. Estimates of coefficients of variation for acoustic abundance indices. Barents Sea standard area winter 1994-2017.

	Age group													
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1994	0.11	0.12	0.10	0.09	0.12	0.21	0.44	0.53	0.39	0.55	0.31	1.03	-	-
1995	0.16	0.22	0.24	0.15	0.10	0.15	0.34	1.28	0.85	1.14	-	0.55	0.90	-
1996	0.20	0.27	0.31	0.23	0.16	0.15	0.22	0.44	-	1.20	-	0.98	1.08	-
1997[1]	0.12	0.17	0.14	0.16	0.16	0.12	0.14	0.33	0.53	-	-	1.21	0.63	0.74
1998[1]	0.14	0.15	0.15	0.13	0.14	0.21	0.17	0.15	0.50	1.07	1.09	-	-	-
1999	0.19	0.24	0.21	0.28	0.22	0.23	0.32	0.34	0.26	1.18	-	1.23	-	-
2000	0.09	0.09	0.21	0.12	0.18	0.17	0.28	0.45	0.30	0.39	0.72	1.02	1.04	-
2001	0.17	0.16	0.16	0.25	0.16	0.30	0.35	0.65	0.66	0.96	0.62	0.94	0.86	-
2002	0.08	0.10	0.12	0.10	0.16	0.16	0.29	0.51	1.11	0.69	0.60	0.53	0.71	-
2003	0.11	0.11	0.11	0.09	0.15	0.25	0.38	0.80	1.06	0.90	0.76	1.02	1.07	-
2004	0.37	0.23	0.23	0.30	0.33	0.17	0.21	0.26	0.45	0.65	0.65	0.86	0.64	0.66
2005	0.10	0.16	0.11	0.15	0.12	0.16	0.19	0.59	0.76	1.04	-	-	-	-
2006[2]	0.12	0.10	0.27	0.20	0.12	0.15	0.20	0.33	0.66	0.67	-	0.78	-	-
2007[1]	0.09	0.07	0.09	0.12	0.12	0.15	0.21	0.29	0.40	0.52	0.88	-	-	-
2008	0.13	0.10	0.10	0.10	0.21	0.24	0.29	0.62	0.94	2.63	0.84	1.37	-	-
2009	0.14	0.13	0.09	0.11	0.14	0.19	0.19	0.43	0.79	0.48	-	1.07	-	-
2010	0.15	0.17	0.10	0.10	0.09	0.13	0.27	0.34	0.49	0.49	1.08	0.92	-	-
2011	0.15	0.13	0.16	0.12	0.11	0.10	0.15	0.40	0.58	0.94	-	0.84	1.15	-
2012[2]	0.16	0.28	0.16	0.35	0.24	0.20	0.20	0.27	0.86	0.50	1.05	0.68	-	-
2013	0.14	0.13	0.22	0.11	0.22	0.16	0.13	0.15	0.26	0.59	-	-	-	-
2014	0.13	0.19	0.12	0.20	0.18	0.17	0.16	0.15	0.15	0.44	0.79	-	-	1.09
2015	0.14	0.17	0.24	0.13	0.23	0.21	0.27	0.23	0.20	0.55	0.64	0.65	-	-
2016	0.11	0.15	0.15	0.19	0.12	0.14	0.15	0.19	0.17	0.15	0.30	0.43	-	0.70
2017[2]	0.06	0.09	0.15	0.13	0.22	0.16	0.22	0.23	0.34	0.29	0.24	0.36	0.67	-

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

Table 3.3.4. HADDOCK. Abundance indices (numbers in millions) for new strata 24-26 from acoustic surveys in the Barents Sea winter 2014-2017 estimated by StoX software.

	Age group															Total	Biomass ('000 t)
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**		
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

4 Conclusions

In most years the StoX acoustic estimates for cod are quite similar to those obtained by the BEAM Program, while they are somewhat higher for haddock, about 20% on average over all years and age groups. This higher overall average is caused by a few large ratios. The largest deviations were mainly found for age groups with low indices and/or in years with raising of the indices.

It is recommended that the present time series obtained by StoX become the “official” time series that are used for stock assessment and other purposes. The CV estimates show that some indices should be used with care for assessment purposes, i.e. for older age groups of cod and haddock. It is further recommended that StoX is used to estimate acoustic indices with CVs from future demersal fish winter surveys in the Barents Sea.

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