1 Ecosystem information

The aim of this Section is to collect important ecosystem information influencing the assessment of fish stocks handled by AFWG. In general, such information is collected and updated by the ICES WGIBAR group (ICES CM 2019/SSGIEA:04), here we only provide information that is directly relevant to assessment of the AFWG stocks as well as information that is updated after the 2019 WGIBAR report was finished.

1.1 0-group abundance

The recruitment of the Barents Sea fish species measured as 0-group has shown a large year-to-year variability (Tables 1.1–1.2). The most important reasons for this variability are variations in the spawning biomass, hydrographic conditions, changes in circulation pattern, food availability and predator abundance, and distribution. In 2018, 0-group indices could not be calculated due to incomplete area coverage in the southeastern Barents Sea (section 0.7).

1.2 Consumption, natural mortality, and growth

Cod is the most important predator among fish species in the Barents Sea. It feeds on a wide range of prey, including larger zooplankton, most available fish species, including own juveniles and shrimp (Tables 1.3–1.7). Cod prefer capelin as a prey, and fluctuations of the capelin stock may have a strong effect on growth, maturation and fecundity of cod, as well as on cod recruitment because of cannibalism. The role of euphausiids for cod feeding increases in the years when capelin stock is at a low level (Ponomarenko and Yaragina, 1990). Also, according to Ponomarenko (1973; 1984) interannual changes of euphausiid abundance are important for the survival rate of cod during the first year of life.

The food consumption by NEA cod in 1984–2018, based on data from the Joint Russian-Norwegian stomach content database, is presented in Tables 1.3–1.4. The Norwegian calculations are based on the method described by (Bogstad and Mehl, 1997). The main prey items in 2018 were capelin, krill, haddock, polar cod, amphipods, cod, herring, and shrimp. The consumption calculations made by IMR show that the total consumption by age 1 and older cod in 2018 was 5.8 million tonnes, while PINRO estimates give a corresponding figure of 6.1 million tonnes. The consumption per cod by cod age groups is shown in Tables 1.5–1.6 (IMR and PINRO estimates), while the proportion of cod and haddock in the diet by cod age group (IMR estimates) is given in Tables 1.7 and 1.8. Consumption per cod and individual growth of cod has been stable in recent years.

One direct application for management of results from the trophic investigations in the Barents Sea is inclusion of predator's consumption into fish stock assessment. Predation on cod and haddock by cod has since 1995 been included in the assessment of these two species. These data, summarized in Tables 1.3, 1.5 and 1.7, are used for estimation of cod and haddock consumed by cod and further for estimation of their natural mortality within the SAM model (see sections 3.3.3 and 4.5.5). The average natural mortality for the last years is used as predicted M for the coming years for cod and haddock.

Cod consumption was used in capelin assessment for the first time in 1990, to account for natural mortality due to cod predation on mature capelin in the period January–March (Bogstad and Gjøsæter, 1994). This methodology has been developed further using the Bifrost and CapTool models (Gjøsæter *et al.*, 2002; Tjelmeland, 2005; ICES CM 2009/ACOM:34). CapTool is a tool (in

Excel with @RISK) for implementing results from Bifrost in the short-term (half-year) prognosis used for determining the quota.

In recent years the abundance of large cod and haddock has been very high, and although it is now decreasing, it is still at a high level for both stocks. There are a limited number of predators on such large fish. As predation is a likely to be a major source of natural mortality, it could thus be considered whether the natural mortality on older age groups should be reduced in such a situation. The assumption of reduced natural mortality on older cod was explored by IBPcod 2017, but no evidence of this was found based on available catch and survey data. To investigate this further, analyses on predator consumption and biomass flow at higher trophic levels like those done by Bogstad *et al.* (2000) should be updated, and such work is ongoing for marine mammals. For cod in particular, the fishing mortality in recent years has been so much lower than before that the relative impact of the natural mortality on the survival of older fish has increased considerably.

The amount of commercially important prey consumed by other fish predators (haddock, Greenland halibut, long rough dab, and thorny skate), has also been calculated (Dolgov *et al*., 2007), but these consumption estimates have not been used in assessment for any prey stocks yet. Marine mammals are not included in the current fish stock assessments. However, it has been attempted to extend the stock assessment models of Barents Sea capelin (Bifrost) by including the predatory effects of minke whales, and harp seals (Tjelmeland and Lindstrøm, 2005).

1.3 Maturation, condition factor, and fisheries–induced evolution

Data on maturity-at-age are one of the basic components for spawning-stock biomass (SSB) estimates. There have been substantial changes observed in maturity-at-age of NEA cod over large historical period (since 1946) showing an acceleration in maturity rates especially in the 1980s. They are thought to be connected both with compensatory density-dependence mechanisms and genetic changes in individuals (Heino *et al.,* 2002; Jørgensen *et al.*, 2008; Kovalev and Yaragina, 2009; Eikeset *et al.,* 2013; Kuparinen *et al.*, 2014) resulted from strong fishing pressure.

Studies on possible evolutionary effects for this stock should be updated with data for recent years to investigate the effects on population dynamics, including growth, maturation and evolutionary effects, of a prolonged period with low fishing mortality and high stock size.

Recent laboratory and fieldwork has shown that skipped spawning does occur in NEA cod stock (Skjæraasen *et al*., 2009; Yaragina, 2010). Experimental work on captive fish has demonstrated that skipped spawning is strongly influenced by individual energy reserves (Skjæraasen *et al*., 2009). This is supported by the field data, which suggest that gamete development could be interrupted by a poor liver condition especially. Fish which will skip spawning seem to remain in the Barents Sea and do not migrate to the spawning grounds. These fish need to be identified and excluded when estimating the stock recruitment potential as currently they are included in the estimate of SSB. However, more work needs to be undertaken to improve our knowledge of skipped spawning in cod (e.g. comparisons and intercalibration of Norwegian and Russian databases on maturity stages should be done) and other species in order to quantify its influence on the stock reproductive potential.

1.4 Recruitment prediction for northeast Arctic cod

Prediction of recruitment in fish stocks is essential to harvest prognosis. Traditionally, prediction methods have been based on spawning-stock biomass and survey indices of juvenile fish and have not included effects of ecosystem drivers. Multiple linear regression models can be used to incorporate both environmental and parental fish stock parameters. In order for such models to give predictions there need to be a time-lag between the predictor and response variables.

1.4.1 Historic overview

Several statistical models, which use multiple linear regressions, have been developed for recruitment of northeast Arctic cod. All models try to predict recruitment-at-age 3 (at 1 January), as calculated from the VPA, with cannibalism included. This quantity is denoted as R3. A collection of the most relevant models previously presented to AFWG is described below.

Stiansen *et al.* (2005) developed a model (JES1) with 2-year prediction possibility:

JES1: R3~ Temp(-3) + Age1(-2) + MatBio(-2)
JES2: R3~ Temp(-3) + Age2(-1) + MatBio(-2)
JES3: R3~ Temp(-3) + Age3(0) + MatBio(-2)

Temp is the Kola annual temperature (0–200 m, station 3–7), Age1 is the winter survey bottom-trawl index for cod age 1, and MatBio the maturing biomass of capelin on 1 October. The number in parentheses is the time-lag in years. Two other similar models (JES2, JES3) can be made by substituting the winter index term Age1(-2) with Age2(-1) and Age3(0), giving 1 and 0 year predictions, respectively.

Svendsen *et al.* (2007) used a model (SV) based only data from the ROMS numerical hydrodynamical model, with 3 year prognosis possibility:

SV: R3~ Phyto(-3) + Inflow(-3)

Where Phyto is the modelled phytoplankton production in the whole Barents Sea and Inflow is the modelled inflow through the western entrance to the Barents Sea in autumn. The number in parentheses is the time-lag in years. The model has not been updated since 2007.

The recruitment model (TB) suggested by T. Bulgakova (AFWG 2005, WD14) is a modification of Ricker's model for stock–recruitment defined by:

TB: R3~ m(-3) exp[-SSB(-3) + N(-3)]

Where R3 is the number of age 3 recruits for NEA cod, m is an index of population fecundity, SSB is the spawning-stock biomass and N is equal to the numbers of months with positive temperature anomalies (TA) on the Kola Section in the birth year for the year class. The number in parentheses is the time-lag in years. For the years before 1998 TA was calculated relatively to monthly average for the period 1951–2000. For intervals after 1998, the TA was calculated with relatively linear trend in the temperature for the period 1998–present. The model was run using two time intervals (using cod year classes 1984–2000 and year classes 1984–2004) for estimating the model coefficients. The models have not been updated since 2009.

Titov (Titov, AFWG 2010, WD 22) and Titov *et al.* (AFWG 2005, WD 16) developed models with 1 to 4 year prediction possibility (TITOV0, TITOV1, TITOV2, TITOV3, TITOV4, respectively), based on the oxygen saturation at bottom layers of the Kola section stations 3–7 (OxSat), air temperature at the Murmansk station (Ta), water temperature: 3–7 stations of the Kola section (layer 0–200 m) (Tw), ice coverage in the Barents Sea (I), spawning-stock biomass (SSB), annual values of 0-group cod abundance index, corrected for capture efficiency (CodC0) and the bottom-trawl swept-area abundance of cod at the age 1 and 2, 3 derived from the joint winter Barents Sea acoustic survey (CodB1, CodB2, CodB3). At the 2010 AFWG assessment it was suggested (Dingsør *et al.*, 2010, WD 19, and related discussions in the working group to try to simplify these models).

Hjermann *et al.*, (2007) developed a model with a one-year prognosis, which have been modified by Dingsør *et al.* (AFWG 2010, WD19) to four models with 2-year projection possibility.

H1: log(R3)~ Temp(-3) + log(Age0)(-3) +BM_{cod3-6} /$ABM_{capelin}$(-2,-1)
H2: log(R3)~ Temp(-2) +I(surv)+ Age1(-2) + BM_{cod3-6} /$ABM_{capelin}$ (-2,-1)
H3: log(R3)~ Temp(-1) + Age2(-1) + BM_{cod3-6} /$ABM_{capelin}$ (-1)
H4: log(R3)~ Temp(-1) + Age3(0)

Temp is the Kola yearly temperature (0–200 m), Age0 is the 0-group index of cod, Age1, Age2 and Age3 are the winter survey bottom-trawl index for cod age 1, 2 and 3, respectively, BM_{cod3-6} is the biomass of cod between age 3 and 6, and ABM is the maturing biomass of capelin. The number in parentheses is the time-lag in years. The models were not updated this year.

At AFWG 2008, Subbey *et al.* presented a comparative study (AFWG 2008, WD27) on the ability of some of the above models in predicting stock recruitment for NEA cod (Age 3). At the assessment in 2010 a WD by Dingsør *et al.* (AFWG 2010, WD19) was presented, which investigated the performance of some of the mentioned recruitment models. It was strongly recommended by the working group that a Study Group should be appointed to look at criteria for choosing/rejecting recruitment models suitable for use in stock assessment.

The "Study Group on Recruitment Forecasting" (SGRF; ICES CM 2011/ACOM:31, ICES CM 2012/ACOM:24, ICES CM 2013/ACOM:24) have had three meetings (in October 2011 and 2012, and November 2013). Their mandate is to give a "best practice" (Standards and guidelines) for choosing recruitment models after their next meeting, which may be implemented at the next AFWG.

The SGRF 2012 report addressed the problem of combining several model predictions to obtain a recruitment estimate with minimum variance. The method (involving a weighted average of individual model predictions) was proposed as a replacement for the hybrid method of Subbey *et al.* (2008). One major issue not addressed in ICES SGRF (2012) was how to choose the initial ensemble of models, whose weighted average is sought. There are practical constraints (with respect to time and personnel), which stipulates that not all plausible models can be included in the calculation of the hybrid recruitment value. A methodology for choosing models to include in the calculation of a hybrid, representative recruitment forecast was addressed in SGRF 2013. Details can be found in the SGRF 2013 ICES report.

1.4.2 Models used in 2019

In 2018 at the meeting of the AFWG, the correction and simplification of models was continued. Due to the fact that in 2017–2018 there was a significant correction of the initial biological data, which caused significant changes in the results of the prognostic models, in 2018 a complete audit of both prognostic models and the hybrid model combining the results of their work was carried out. The main purpose of the model revision was to increase the stability of the models, that is, to reduce the possibility of potential correction of the models due to correction of the biological data included in the model. The solution of the problem was found by increasing the retrospective database backwards in time, that is, from the beginning of the 1980s to the beginning of the 1960s. Accordingly, sets of predictor sets have been revised. The number of models was reduced from 5 to 2 and the names of the models were changed from Titov0(1,2,3,4) to TitovES (environment, short prediction) and TitovEL (environment, long prediction).

This has been conducted and has improved the statistical performance (details are shown in Titov, AFWG 2018, WD23):

TitovES: $R3^2$ ~ $DOxSat^2$(t-13) + ITw(t-43) + expIce(t-40) + Ice(t-15)
TitovEL: $R3^4$ ~OxSat(t-39)+ ITw(t-43)

Where DOxSat(t-13)~ expOxSat(t-13) + OxSat(t-39), ITw(t-43) ~ I(t-43) +Tw(t–46). The number in parentheses is the time-lag in months, relative to April 2019.

At the 2018 AFWG assessment a hybrid model (i.e. an average combination) of the best functioning statistical recruitment models were repeated. A statistical analysis of the accuracy of the model's work was carried out, which consisted in estimating the errors in the recovery of data on the number of NEA cod recruitment. Accuracy of the model's work was verified by calculation of standard deviations of the NEA cod recruitment predicted values from the SAM values for the period 2005–2015 when the model was adjusted for data from 1983 to 2004, which consisted in estimating the errors in the recovery of data on the number of NEA cod recruitment.

Figure 1.1 shows the standard deviations of the NEA cod recruitment prediction. It can be seen that the addition of biological parameters (CodB1, CodB2, CodB3, CodC0, SSB) to environmental models (TitovES, TitovEL) substantially increases the error.

Based on these calculations, after comparing the results of constructing independent retrospective forecasts using the methodology previously used in ICES SGRF (ICES CM 2013/ACOM:24), it was decided to abandon the use of biological predictors and to use only environmental data in the NEA cod recruitment forecasting models. It was also found that all models (TitovES, TitovEL, RCT3) satisfy the quality conditions with respect to the forecast for the mean values accepted as the criterion for entering into the calculation of the hybrid model adopted earlier (ICES CM 2013/ACOM:24). It was decided that all biological data will be included in calculations based on the RCT3 model, and the remaining 2 models (TitovES, TitovEL) will be used only to account for the effect of environmental conditions on NEA cod recruitment.

In AFWG-2018 the procedure for estimating weights for various models (TitovES, TitovEL, RCT3) was repeated using the same method as was made on Study Group on Recruitment Forecasting (SGRF) in 2013.

In summary, the SAM for age 3 from the AFWG 2019 assessment was used as historical R3. The recruitment forecast for 2019–2022 are based on a hybrid model with weighting estimated on AFWG-2018. The weights and forecasts for the 2019 AFWG assessment can be found in Tables 1.9a–b.

1.5 Biomass and exploitation levels of AFWG stocks.

Figure 1.2 shows the biomass development for northeast Arctic cod, haddock, and saithe. The combined biomass of these three stocks peaked in 2013, but is still at a high level. These three stocks have in recent years been harvested below or at the target fishing mortalities in the management plans (Figure 1.3), except for the fishing mortality on haddock in 2017–2018 which was above the target F.

Table 1.1. 0-group abundance indices (in millions) with 95% confidence limits, not corrected for catching efficiency.

Year	Capelin			Cod			Haddock			Herring			Redfish		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	197278	131674	262883	72	38	105	59	38	81	4	1	8	277873	0	701273
1981	123870	71852	175888	48	33	64	15	7	22	3	0	8	153279	0	363283
1982	168128	35275	300982	651	466	835	649	486	812	202	0	506	106140	63753	148528
1983	100042	56325	143759	3924	1749	6099	1356	904	1809	40557	19526	61589	172392	33352	311432
1984	68051	43308	92794	5284	2889	7679	1295	937	1653	6313	1930	10697	83182	36137	130227
1985	21267	1638	40896	15484	7603	23365	695	397	992	7237	646	13827	412777	40510	785044
1986	11409	98	22721	2054	1509	2599	592	367	817	7	0	15	91621	0	184194
1987	1209	435	1983	167	86	249	126	76	176	2	0	5	23747	12740	34755
1988	19624	3821	35427	507	296	718	387	157	618	8686	3325	14048	107027	23378	190675
1989	251485	201110	301861	717	404	1030	173	117	228	4196	1396	6996	16092	7589	24595
1990	36475	24372	48578	6612	3573	9651	1148	847	1450	9508	0	23943	94790	52658	136922
1991	57390	24772	90007	10874	7860	13888	3857	2907	4807	81175	43230	119121	41499	0	83751
1992	970	105	1835	44583	24730	64437	1617	1150	2083	37183	21675	52690	13782	0	36494
1993	330	125	534	38015	15944	60086	1502	911	2092	61508	2885	120131	5458	0	13543
1994	5386	0	10915	21677	11980	31375	1695	825	2566	14884	0	31270	52258	0	121547

Year	Capelin			Cod			Haddock			Herring			Redfish		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1995	862	0	1812	74930	38459	111401	472	269	675	1308	434	2182	11816	3386	20246
1996	44268	22447	66089	66047	42607	89488	1049	782	1316	57169	28040	86299	28	8	47
1997	54802	22682	86922	67061	49487	84634	600	420	780	45808	21160	70455	132	0	272
1998	33841	21406	46277	7050	4209	9890	5964	3800	8128	79492	44207	114778	755	23	1487
1999	85306	45266	125346	1289	135	2442	1137	368	1906	15931	1632	30229	46	14	79
2000	39813	1069	78556	26177	14287	38068	2907	1851	3962	49614	3246	95982	7530	0	16826
2001	33646	0	85901	908	152	1663	1706	1113	2299	844	177	1511	6	1	10
2002	19426	10648	28205	19157	11015	27300	1843	1276	2410	23354	12144	34564	130	20	241
2003	94902	41128	148676	17304	10225	24383	7910	3757	12063	28579	15504	41653	216	0	495
2004	16901	2619	31183	19408	14119	24696	19372	12727	26016	**136053**	97442	174664	862	0	1779
2005	42354	12517	72192	21789	14947	28631	**33637**	24645	42630	26531	1288	51774	12676	511	24841
2006	168059	103577	232540	7801	3605	11996	11209	7413	15005	68531	22418	114644	20403	9439	31367
2007	161594	87683	235504	9896	5993	13799	2873	1820	3925	22319	4517	40122	156548	46433	266663
2008	288799	178860	398738	52975	31839	74111	2742	830	4655	15915	4477	27353	9962	0	20827
2009	189747	113135	266360	54579	37311	71846	13040	7988	18093	18916	8249	29582	49939	23435	76443
2010	91730	57545	125914	40635	20307	60962	7268	4530	10006	20367	4099	36636	66392	3114	129669
2011	175836	3876	347796	**119736**	66423	173048	7441	5251	9631	13674	7737	19610	7026	0	17885

Year	Capelin			Cod			Haddock			Herring			Redfish		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
2012	**310519**	225728	395311	105176	37917	172435	1814	762	2866	26480	299	316769	58535	0	128715
2013	94673	28224	161122	90108	62788	117428	7235	4721	9749	70972	8393	133550	928	310	1547
2014	48933	5599	92267	102977	72975	132980	4185	2217	6153	16674	5671	27677	77658	35010	120306
2015	147961	87971	207951	8744	3008	14479	6005	2816	9194	11207	0	25819	101653	40258	163048
2016	274050	157185	390915	16872	9942	23801	4029	1952	6107	32956	15793	50119	12941	1713	24168
2017	72486	36535	108438	69371	46841	91901	9205	6081	12329	32112	11180	53045	43561	0	97558
Mean	93511			30280			4442			28586			60307		
Median	62721			17088			1760			19641			22075		

Table 1.1. (cont.). 0-group abundance indices (in millions) with 95% confidence limits, not corrected for catching efficiency.

Year	Saithe			Gr halibut			Long rough dab			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	3	0	6	111	35	187	1273	883	1664	28958	9784	48132	9650	0	20622
1981	0	0	0	74	46	101	556	300	813	595	226	963	5150	1956	8345
1982	143	0	371	39	11	68	1013	698	1328	1435	144	2725	1187	0	3298
1983	239	83	394	41	22	59	420	264	577	1246	0	2501	9693	0	20851
1984	1339	407	2271	31	18	45	60	43	77	127	0	303	3182	737	5628
1985	12	1	23	48	29	67	265	110	420	19220	4989	33451	809	0	1628
1986	1	0	2	112	60	164	6846	4941	8752	12938	2355	23521	2130	180	4081
1987	1	0	1	35	23	47	804	411	1197	7694	0	17552	74	31	117
1988	17	4	30	8	3	13	205	113	297	383	9	757	4634	0	9889
1989	1	0	3	1	0	3	180	100	260	199	0	423	18056	2182	33931
1990	11	2	20	1	0	2	55	26	84	399	129	669	31939	0	70847
1991	4	2	6	1	0	2	90	49	131	88292	39856	136727	38709	0	110568
1992	159	86	233	9	0	17	121	25	218	7539	0	15873	9978	1591	18365
1993	366	0	913	4	2	7	56	25	87	41207	0	96068	8254	1359	15148
1994	2	0	5	39	0	93	1696	1083	2309	267997	151917	384078	5455	0	12032
1995	148	68	229	15	5	24	229	39	419	1	0	2	25	1	49

Year	Saithe			Gr halibut			Long rough dab			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1996	131	57	204	6	3	9	41	2	79	70134	43196	97072	4902	0	12235
1997	78	37	120	5	3	7	97	44	150	33580	18788	48371	7593	623	14563
1998	86	39	133	8	3	12	27	13	42	11223	6849	15597	10311	0	23358
1999	136	68	204	14	8	21	105	1	210	129980	82936	177023	2848	407	5288
2000	206	111	301	43	17	69	233	120	346	116121	67589	164652	22740	14924	30556
2001	20	0	46	51	20	83	162	78	246	3697	658	6736	13490	0	28796
2002	553	108	998	51	0	112	731	342	1121	96954	57530	136378	27753	4184	51322
2003	65	0	146	13	0	34	78	45	110	11211	6100	16323	1627	0	3643
2004	1395	860	1930	70	28	113	36	20	52	37156	19040	55271	367	125	610
2005	55	36	73	9	4	14	200	109	292	6540	3196	9884	3216	1269	5162
2006	142	60	224	11	1	20	710	437	983	26016	9996	42036	2078	464	3693
2007	51	6	96	1	1	0	262	45	478	25883	8494	43273	2532	0	5134
2008	45	22	69	6	0	13	956	410	1502	6649	845	12453	91	0	183
2009	22	0	46	7	4	10	115	51	179	23570	9661	37479	21433	5642	37223
2010	402	126	678	14	8	20	128	18	238	31338	13644	49032	1306	0	3580
2011	27	0	59	20	11	29	58	23	93	37431	15083	59780	627	26	1228

Year	Saithe			Gr halibut			Long rough dab			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
2012	69	2	135	30	16	43	173	0	416	4173	48	8298	17281	0	49258
2013	3	1	5	21	13	28	5	0	14	1634	0	4167	148	28	268
2014	1	0	2	10	3	16	309	89	528	2779	737	4820	746	79	1414
2015	47	0	101	27	2	52	575	361	789	128	18	237	6074	2001	10146
2016	3	0	7	6	1	12	601	0	1267	258	0	624	1180	128	2231
2017	127	2	252	8	1	14	72	27	117	43	0	106	1009	0	2795
Mean	161			26			514			30388			7850		
Median	54			14			190			9453			3932		

Table 1.2. 0-group abundance indices (in millions) with 95% confidence limits, corrected for catching efficiency.

Year	Capelin			Cod			Haddock			Herring		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	740289	495187	985391	276	131	421	265	169	361	77	12	142
1981	477260	273493	681026	289	201	377	75	34	117	37	0	86
1982	599596	145299	1053893	3480	2540	4421	2927	2200	3655	2519	0	5992
1983	340200	191122	489278	19299	9538	29061	6217	3978	8456	195446	69415	321477
1984	275233	161408	389057	24326	14489	34164	5512	3981	7043	27354	3425	51284
1985	63771	5893	121648	66630	32914	100346	2457	1520	3393	20081	3933	36228
1986	41814	642	82986	10509	7719	13299	2579	1621	3537	93	27	160
1987	4032	1458	6607	1035	504	1565	708	432	984	49	0	111
1988	65127	12101	118153	2570	1519	3622	1661	630	2693	60782	20877	100687
1989	862394	690983	1033806	2775	1624	3925	650	448	852	17956	8252	27661
1990	115636	77306	153966	23593	13426	33759	3122	2318	3926	15172	0	36389
1991	169455	74078	264832	40631	29843	51419	13713	10530	16897	267644	107990	427299
1992	2337	250	4423	166276	92113	240438	4739	3217	6262	83909	48399	119419
1993	952	289	1616	133046	58312	207779	3785	2335	5236	291468	1429	581506
1994	13898	70	27725	70761	39933	101589	4470	2354	6586	103891	0	212765
1995	2869	0	6032	233885	114258	353512	1203	686	1720	11018	4409	17627

Year	Capelin			Cod			Haddock			Herring		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1996	136674	69801	203546	280916	188630	373203	2632	1999	3265	549608	256160	843055
1997	189372	80734	298011	294607	218967	370247	1983	1391	2575	463243	176669	749817
1998	113390	70516	156263	24951	15827	34076	14116	9524	18707	476065	277542	674589
1999	287760	143243	432278	4150	944	7355	2740	1018	4463	35932	13017	58848
2000	140837	6551	275123	108093	58416	157770	10906	6837	14975	469626	22507	916746
2001	90181	0	217345	4150	798	7502	4649	3189	6109	10008	2021	17996
2002	67130	36971	97288	76146	42253	110040	4381	2998	5764	151514	58954	244073
2003	340877	146178	535575	81977	47715	116240	30792	15352	46232	177676	52699	302653
2004	53950	11999	95900	65969	47743	84195	39303	26359	52246	773891	544964	1002819
2005	148466	51669	245263	72137	50662	93611	91606	67869	115343	125927	20407	231447
2006	515770	325776	705764	25061	11469	38653	28505	18754	38256	294649	102788	486511
2007	480069	272313	687825	42628	26652	58605	8401	5587	11214	144002	25099	262905
2008	995101	627202	1362999	234144	131081	337208	9864	1144	18585	201046	68778	333313
2009	673027	423386	922668	185457	123375	247540	33339	19707	46970	104233	31009	177458
2010	318569	201973	435166	135355	68199	202511	23669	14503	32834	117087	32045	202129
2011	594248	58009	1130487	448005	251499	644511	19114	14209	24018	83051	48024	118078
2012	988600	728754	1248445	410757	170242	651273	5281	2626	7936	177189	35046	2111493

Year	Capelin			Cod			Haddock			Herring		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
2013	316020	127310	504731	385430	269640	501219	16665	11161	22169	289391	67718	511064
2014	163630	31980	295280	464124	323330	604919	11765	6160	17371	136305	42164	230447
2015	457481	274631	640331	37474	17244	57704	15089	6204	23973	82749	0	160973
2016	778784	479130	1078348	53796	30790	76622	5504	2791	8216	79439	38415	120464
2017	213787	112459	315115	233275	150239	316310	19484	12902	26067	153763	34713	272813
LTM	311542			117579	117579		11944			162997		

Table 1.2 (cont.). 0-group abundance indices (in millions) with 95% confidence limits, corrected for catching efficiency.

Year	Saithe			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	21	0	47	203226	69898	336554	82871	0	176632
1981	0	0	0	4882	1842	7922	46155	17810	74500
1982	296	0	699	1443	154	2731	10565	0	29314
1983	562	211	912	1246	0	2501	87272	0	190005
1984	2577	725	4430	871	0	2118	26316	6097	46534
1985	30	7	53	143257	39633	246881	6670	0	13613
1986	4	0	9	102869	16336	189403	18644	125	37164
1987	4	0	10	64171	0	144389	631	265	996
1988	32	11	52	2588	59	5117	41133	0	89068
1989	10	0	23	1391	0	2934	164058	15439	312678
1990	29	4	55	2862	879	4846	246819	0	545410
1991	9	4	14	823828	366924	1280732	281434	0	799822
1992	326	156	495	49757	0	104634	80747	12984	148509
1993	1033	0	2512	297397	0	690030	70019	12321	127716
1994	7	1	12	2139223	1230225	3048220	49237	0	109432
1995	415	196	634	6	0	14	195	0	390

Year	Saithe			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1996	430	180	679	588020	368361	807678	46671	0	116324
1997	341	162	521	297828	164107	431550	62084	6037	118131
1998	182	91	272	96874	59118	134630	95609	0	220926
1999	275	139	411	1154149	728616	1579682	24015	3768	44262
2000	851	446	1256	916625	530966	1302284	190661	133249	248072
2001	47	0	106	29087	5648	52526	119023	0	252146
2002	2112	134	4090	829216	496352	1162079	215572	36403	394741
2003	286	0	631	82315	42707	121923	12998	0	30565
2004	4779	2810	6749	290686	147492	433879	2892	989	4796
2005	176	115	237	44663	22890	66436	25970	9987	41953
2006	280	116	443	182713	73645	291781	15965	3414	28517
2007	286	3	568	191111	57403	324819	22803	0	46521
2008	142	68	216	42657	5936	79378	619	25	1212
2009	62	0	132	168990	70509	267471	154687	37022	272351
2010	1066	362	1769	267430	111697	423162	12045	0	33370
2011	96	0	225	249269	100355	398183	4924	218	9629
2012	229	5	453	25026	1132	48920	125306	0	357381

Year	Saithe			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
2013	11	4	18	11382	0	29002	1011	262	1760
2014	4	0	9	17349	5184	29515	5298	500	10096
2015	406	0	930	795	107	1484	49584	15385	83784
2016	10	0	21	1544	0	3718	9288	459	18117
2017	379	18	740	64390	48	256	6580	0	18044
Mean	469			247135			63589		

Table 1.3. The Northeast arctic COD stock's consumption of various prey species in 1984–2018 (1000 tonnes) based on Norwegian consumption calculations.

Table 1.3. The North-east arctic COD stock's consumption of various prey species in 1984-2018 (1000 tonnes)															
Year	Other	Amphipods	Krill	Shrimp	Capelin	Herring	Polar cod	Cod	Haddock	Redfish	G. halibut	Blue whiting	Long rough c	Snow crab	Total
1984	486	28	119	439	724	78	15	22	51	364	0	0	26	0	2352
1985	1115	173	60	155	1617	183	3	31	47	224	0	1	44	0	3654
1986	595	1213	112	139	823	131	137	81	109	311	0	0	59	0	3711
1987	662	1067	66	189	226	32	202	25	4	318	1	0	9	0	2800
1988	399	1230	301	127	337	8	92	9	3	222	0	4	6	0	2738
1989	650	793	237	131	570	3	32	8	10	227	0	0	62	0	2723
1990	1341	137	85	195	1608	7	6	19	15	243	0	87	104	0	3849
1991	761	66	76	188	2890	8	12	26	20	312	8	10	296	0	4672
1992	893	98	151	370	2450	330	96	54	106	187	22	2	101	0	4860
1993	737	247	671	313	3025	162	276	283	70	100	2	2	28	0	5918
1994	611	548	692	501	1082	145	566	215	48	78	0	1	42	0	4529
1995	811	951	500	351	606	113	242	358	111	189	1	0	37	0	4271
1996	588	623	1138	334	530	46	101	520	67	96	0	10	38	0	4093
1997	427	372	502	302	875	5	111	331	40	36	0	32	16	0	3050
1998	401	348	448	314	690	82	144	152	31	9	0	13	17	0	2649
1999	377	143	271	246	1697	127	217	61	26	16	1	31	8	0	3218
2000	380	164	452	444	1706	53	191	75	50	8	0	37	20	0	3579
2001	693	172	375	278	1739	72	253	69	50	6	1	154	33	0	3894
2002	378	96	259	242	2012	87	282	110	128	1	0	240	16	0	3850
2003	561	291	548	243	2196	219	282	116	172	3	0	76	55	0	4763
2004	633	568	345	249	1265	212	357	129	202	3	12	57	66	1	4099
2005	776	577	525	268	1377	129	382	117	318	2	5	116	54	0	4646
2006	901	228	1102	371	1770	168	112	81	364	12	2	160	135	0	5405
2007	1358	326	1192	474	2333	293	281	90	395	51	0	44	79	0	6917
2008	1739	178	1024	432	3167	114	558	205	315	66	13	19	101	0	7932
2009	1690	273	681	302	4481	137	827	223	288	33	3	6	130	2	9076
2010	1816	464	1128	320	4412	60	374	280	308	159	12	16	150	8	9506
2011	1758	283	976	253	4657	93	484	330	325	131	0	29	141	10	9470
2012	2294	345	875	397	4240	56	608	436	260	59	41	10	146	8	9776
2013	2019	283	581	299	4210	58	162	457	245	140	1	25	207	17	8704
2014	1606	331	482	218	4183	78	36	408	102	36	14	21	125	10	7649
2015	1743	658	638	247	3530	135	169	243	196	147	55	62	101	36	7961
2016	1754	536	730	304	2338	104	371	228	229	59	7	92	142	12	6906
2017	961	90	531	232	2798	189	51	338	276	41	4	24	138	43	5715
2018	947	246	603	164	2685	186	247	224	260	33	79	46	51	48	5819

Table 1.4. The North-east arctic COD stock's consumption of various prey species in 1984-2018 (1000 tonnes) (Dolgov, WD 23)

Year	Other	Amphipods	Krill	Shrimp	Capelin	Herring	Polar cod	Cod	Haddock	Redfish	G. halibut	Blue whitin	Long rough dab		Total
1984	560	31	94	353	593	34	18	14	50	196	0	5	52		2000
1985	766	440	31	210	1039	26	0	89	35	100	0	18	22		2775
1986	615	948	66	159	855	51	169	26	99	166	1	3	26		3183
1987	541	592	79	233	175	9	117	23	2	120	1	10	5		1906
1988	545	196	239	146	348	21	0	21	77	133	0	0	22		1746
1989	497	324	191	117	768	4	37	35	2	178	0	0	64		2217
1990	278	31	105	266	1264	65	8	24	15	237	0	39	79		2410
1991	289	81	55	277	3205	26	45	52	22	142	5	6	46		4249
1992	787	38	211	257	2018	335	196	82	37	117	1	0	42		4119
1993	562	173	184	220	2739	170	170	144	148	40	5	4	47		4605
1994	447	296	358	458	1275	102	485	383	72	55	0	1	40		3972
1995	502	455	396	533	670	193	191	541	130	110	3	0	52		3775
1996	673	346	957	195	470	74	74	451	57	67	0	9	45		3416
1997	463	134	509	257	511	51	112	383	35	29	2	16	17		2518
1998	311	219	644	285	913	73	134	131	23	15	0	24	20		2791
1999	179	81	458	267	1536	80	176	49	16	14	0	27	9		2891
2000	242	122	437	393	1798	53	167	59	32	4	0	28	21		3356
2001	383	75	410	322	1521	93	147	62	52	4	2	145	31		3247
2002	225	45	286	201	2399	55	301	100	80	4	0	110	17		3823
2003	400	171	547	227	1219	153	221	132	331	2	0	28	52		3480
2004	496	393	477	256	1097	129	369	86	144	7	16	48	62		3579
2005	619	163	687	244	1022	168	320	113	271	7	2	67	47		3729
2006	785	86	1544	274	1340	268	125	96	286	17	1	103	149		5071
2007	829	192	1334	419	1875	275	289	68	330	29	1	32	73		5746
2008	1017	51	999	343	3264	122	662	157	333	60	13	17	122		7160
2009	1045	189	937	283	3349	229	827	142	348	28	0	8	285		7670
2010	973	329	1839	255	4116	143	513	181	248	163	1	16	137		8914
2011	1254	202	830	226	4469	85	423	260	362	143	2	58	172		8484
2012	1771	164	599	272	2984	97	440	291	419	41	7	33	134		7252
2013	1364	209	642	332	3652	45	146	450	277	178	2	39	218		7554
2014	1383	119	736	206	3297	55	96	390	171	20	7	27	156		6663
2015	1110	294	1135	426	2622	68	157	175	180	86	14	38	118		6421
2016	1508	643	750	205	2144	83	235	239	155	46	3	49	332		6393
2017	1000	81	649	297	2587	92	70	264	305	186	3	24	249		5807
2018	1153	149	1578	184	1614	271	114	353	484	43	43	38	121		6144
Sum	**25571**	**8062**	**20989**	**9595**	**64746**	**3793**	**7553**	**6063**	**5625**	**2786**	**135**	**1067**	**3079**		**159063**

Table 1.5. Consumption per cod by cod age group (kg/year), based on Norwegian consumption calculations.

Year/Age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.247	0.814	1.685	2.521	3.951	5.208	8.009	8.524	9.181	9.912	9.985
1985	0.304	0.761	1.831	3.107	4.675	7.361	11.247	11.971	12.498	13.751	13.865
1986	0.161	0.488	1.348	3.163	5.617	6.834	11.030	11.943	12.749	13.513	13.745
1987	0.219	0.601	1.275	2.055	3.537	5.462	7.044	8.111	8.922	9.344	9.295
1988	0.164	0.703	1.149	2.148	3.744	5.877	10.100	11.222	12.575	13.127	13.351
1989	0.223	0.716	1.609	2.713	3.981	5.612	7.680	8.499	9.599	10.199	10.643
1990	0.363	0.906	1.904	3.038	4.166	5.331	6.262	6.679	6.711	7.053	7.753
1991	0.293	0.972	2.178	3.536	5.318	7.073	9.470	10.238	11.292	12.339	11.983
1992	0.215	0.665	2.100	3.135	4.142	5.093	7.868	9.023	9.402	10.124	10.169
1993	0.112	0.528	1.547	3.045	4.811	6.288	9.422	11.268	11.793	12.284	12.909
1994	0.130	0.408	0.922	2.521	3.508	4.528	6.404	8.889	9.723	10.030	10.229
1995	0.103	0.296	0.921	1.841	3.362	5.263	7.718	10.435	12.383	12.787	13.235
1996	0.108	0.356	0.929	1.847	3.070	4.434	7.412	11.206	14.918	15.097	15.492
1997	0.140	0.319	0.940	1.768	2.710	3.537	5.257	8.185	12.672	13.578	13.182
1998	0.117	0.398	0.984	1.942	2.924	4.188	5.748	8.071	11.471	11.990	12.045
1999	0.163	0.505	1.093	2.718	3.719	5.446	6.968	9.185	11.019	12.023	12.125
2000	0.170	0.499	1.243	2.461	4.253	5.654	7.967	9.401	12.634	13.416	13.458
2001	0.171	0.456	1.309	2.440	3.684	5.300	7.541	11.221	13.604	14.310	14.641
2002	0.199	0.551	1.167	2.441	3.381	4.721	6.363	9.064	10.350	11.681	11.082
2003	0.207	0.653	1.313	2.390	3.999	5.958	8.433	10.430	12.907	13.523	14.549
2004	0.222	0.478	1.307	2.297	3.361	5.581	7.442	11.470	17.415	19.399	18.835
2005	0.203	0.661	1.387	2.744	4.255	6.414	7.677	10.289	13.935	14.916	15.709
2006	0.204	0.628	1.593	2.810	4.252	6.365	7.877	11.631	14.102	15.126	16.041
2007	0.256	0.653	1.748	3.087	4.461	6.222	8.246	10.249	12.705	13.296	13.933
2008	0.204	0.717	1.464	2.876	4.081	7.086	8.398	11.388	15.565	16.104	16.330
2009	0.192	0.618	1.479	2.755	4.446	5.798	8.432	11.562	12.719	13.671	13.711
2010	0.203	0.634	1.352	2.493	3.977	5.694	8.447	12.040	15.385	16.043	16.460
2011	0.219	0.653	1.421	2.594	4.003	5.331	7.230	9.659	15.165	16.320	16.332
2012	0.231	0.768	1.499	2.697	4.084	5.074	7.309	10.047	15.397	16.580	16.567
2013	0.182	0.682	1.457	2.539	3.926	5.019	5.960	7.564	11.498	12.422	13.451
2014	0.224	0.649	1.318	2.565	3.767	4.286	5.815	7.991	10.694	11.509	12.006
2015	0.218	0.674	1.424	2.546	4.262	5.693	7.405	8.575	13.071	13.851	15.093
2016	0.252	0.726	1.576	2.792	3.955	5.546	7.335	8.108	11.939	12.708	14.582
2017	0.237	0.755	1.445	2.541	3.764	5.380	6.636	7.582	10.684	12.596	16.259
2018	0.194	0.796	1.586	2.859	4.447	5.228	6.827	10.607	12.886	17.087	16.143
Average	**0.201**	**0.620**	**1.414**	**2.601**	**3.988**	**5.540**	**7.685**	**9.781**	**12.273**	**13.192**	**13.577**

Table 1.6		Consumption per cod by cod age group (kg/year), based on Russian consumption calculations.											
Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13+
1984	0.262	0.895	1.611	2.748	3.848	5.486	6.992	8.561	10.572	13.166	13.200	15.547	17.153
1985	0.295	0.753	1.658	2.681	4.264	6.599	8.241	9.745	10.974	14.448	17.327	17.391	19.186
1986	0.179	0.526	1.455	3.455	5.001	5.991	6.458	8.157	9.766	11.457	13.188	14.621	16.134
1987	0.145	0.432	0.852	1.558	3.073	4.380	7.357	9.667	12.705	14.481	15.899	16.616	18.318
1988	0.183	0.704	1.075	1.628	2.391	4.386	8.207	9.978	10.868	16.536	14.639	16.046	17.000
1989	0.282	0.909	1.465	2.207	3.243	4.798	6.578	8.725	11.134	15.798	16.313	18.436	18.041
1990	0.288	1.006	1.694	2.693	3.278	3.833	5.583	6.870	10.715	11.426	13.555	15.964	17.595
1991	0.241	0.936	2.670	4.472	6.037	7.844	9.590	11.543	14.969	19.292	18.590	21.720	23.960
1992	0.178	0.969	2.475	2.866	3.995	5.137	6.723	7.414	8.755	12.303	14.288	15.184	16.745
1993	0.133	0.476	1.512	2.865	3.944	5.108	7.372	8.945	10.343	11.600	14.835	16.536	18.249
1994	0.180	0.512	1.212	2.402	3.517	5.359	7.560	10.001	11.818	12.896	14.499	17.656	19.469
1995	0.194	0.497	0.962	1.801	3.204	4.847	7.332	9.688	13.835	15.247	16.899	19.273	21.254
1996	0.170	0.498	1.028	1.916	3.059	4.189	6.987	10.212	12.185	13.614	14.529	16.275	17.945
1997	0.119	0.341	0.992	1.908	2.668	3.503	4.954	7.980	12.174	16.762	16.710	18.410	20.308
1998	0.232	0.528	1.081	2.016	2.823	4.089	5.469	7.346	9.586	13.012	14.404	15.640	17.243
1999	0.261	0.431	1.128	2.490	3.676	5.222	6.398	8.220	9.194	13.364	15.268	16.990	18.727
2000	0.186	0.545	1.288	2.551	4.387	6.559	8.833	10.483	11.522	15.132	17.090	19.793	21.822
2001	0.150	0.413	1.163	2.110	3.430	5.571	6.835	10.233	12.457	15.130	17.341	19.307	21.345
2002	0.252	0.677	1.303	2.699	3.847	5.591	7.846	10.796	13.238	18.787	17.836	20.278	22.359
2003	0.228	0.618	1.296	2.028	3.547	4.716	6.684	8.905	13.418	14.492	19.480	19.309	21.292
2004	0.250	0.654	1.412	2.567	3.857	5.660	7.730	11.126	15.907	20.770	21.607	24.940	27.503
2005	0.255	0.687	1.514	2.504	3.896	5.264	7.192	9.395	13.163	15.981	20.628	21.448	23.639
2006	0.354	0.925	1.881	2.813	4.019	5.332	7.450	10.328	13.111	17.759	19.488	22.322	24.609
2007	0.234	0.681	1.874	3.128	4.459	5.893	7.563	9.178	12.032	15.919	19.961	21.644	23.863
2008	0.223	0.719	1.697	2.959	4.194	6.073	7.809	10.464	13.627	17.254	21.590	23.373	25.779
2009	0.217	0.624	1.495	2.526	4.304	5.623	7.855	11.490	13.341	15.988	18.770	21.866	24.111
2010	0.235	0.651	1.401	2.577	4.065	5.757	8.312	11.805	16.090	16.844	20.129	23.023	25.387
2011	0.248	0.721	1.497	2.513	3.859	4.963	6.848	9.213	13.799	19.074	20.784	23.791	26.241
2012	0.207	0.588	1.203	2.292	3.266	4.461	5.862	7.629	11.713	16.211	19.345	21.032	23.190
2013	0.190	0.656	1.641	2.552	3.809	4.952	5.791	7.757	10.881	14.989	19.785	22.386	24.691
2014	0.242	0.622	1.321	2.340	3.608	4.387	5.560	7.447	9.017	12.547	16.044	18.854	20.781
2015	0.234	0.745	1.390	2.406	3.915	4.922	5.960	7.505	10.265	12.116	16.245	19.978	22.023
2016	0.307	0.870	1.722	2.813	3.474	4.740	6.754	9.117	10.665	14.810	19.921	24.195	26.683
2017	0.244	0.779	1.582	2.531	3.748	4.943	6.601	9.180	11.302	16.016	20.086	23.464	25.870
2018	0.316	0.867	1.846	2.699	3.736	5.000	6.489	9.170	11.166	14.577	18.672	21.848	24.091
Average	**0.226**	**0.670**	**1.468**	**2.523**	**3.755**	**5.177**	**7.022**	**9.265**	**11.894**	**15.137**	**17.398**	**19.576**	**21.503**

Table 1.7 Proportion of cod in cod diet, based on Norwegian consumption calculations

Year/age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.0000	0.0000	0.0032	0.0000	0.0436	0.0263	0.0327	0.0358	0.0365	0.0388	0.0372
1985	0.0015	0.0009	0.0014	0.0017	0.0312	0.0076	0.0822	0.0828	0.0837	0.0841	0.0847
1986	0.0000	0.0022	0.0015	0.0004	0.0129	0.1755	0.1761	0.1760	0.1756	0.1751	0.1744
1987	0.0000	0.0000	0.0007	0.0051	0.0102	0.0250	0.0377	0.0400	0.0418	0.0405	0.0440
1988	0.0000	0.0000	0.0000	0.0002	0.0059	0.0014	0.0038	0.0036	0.0032	0.0038	0.0036
1989	0.0000	0.0006	0.0016	0.0019	0.0027	0.0040	0.0035	0.0035	0.0039	0.0038	0.0041
1990	0.0000	0.0000	0.0000	0.0007	0.0010	0.0010	0.0170	0.0175	0.0188	0.0187	0.0181
1991	0.0000	0.0005	0.0000	0.0003	0.0032	0.0020	0.0222	0.0230	0.0233	0.0236	0.0239
1992	0.0000	0.0021	0.0037	0.0128	0.0250	0.0476	0.0119	0.0158	0.0231	0.0231	0.0229
1993	0.0000	0.0409	0.0364	0.0515	0.0534	0.1156	0.0498	0.0799	0.0799	0.0799	0.0802
1994	0.0000	0.0037	0.0884	0.0344	0.0284	0.0776	0.1246	0.1333	0.2603	0.2620	0.2592
1995	0.0069	0.0813	0.0741	0.0800	0.0923	0.1121	0.1385	0.2525	0.2543	0.2550	0.2571
1996	0.0000	0.1502	0.2504	0.2070	0.1323	0.1265	0.1842	0.2071	0.2426	0.2436	0.2431
1997	0.0000	0.0690	0.0779	0.1142	0.1551	0.1554	0.2327	0.2257	0.2862	0.2796	0.2813
1998	0.0000	0.0135	0.0271	0.0417	0.1042	0.0985	0.1081	0.1490	0.2725	0.2734	0.2745
1999	0.0000	0.0000	0.0050	0.0137	0.0148	0.0338	0.0620	0.1117	0.1934	0.1937	0.1838
2000	0.0000	0.0000	0.0283	0.0147	0.0134	0.0266	0.0498	0.0564	0.2725	0.2694	0.2706
2001	0.0000	0.0159	0.0116	0.0082	0.0131	0.0240	0.0493	0.0383	0.3279	0.3286	0.3303
2002	0.0000	0.0385	0.0594	0.0143	0.0187	0.0284	0.0357	0.0622	0.1581	0.1557	0.1548
2003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2004	0.0081	0.0235	0.0280	0.0269	0.0297	0.0319	0.0380	0.0661	0.1064	0.1067	0.1071
2005	0.0000	0.0266	0.0230	0.0265	0.0144	0.0276	0.0439	0.0786	0.1482	0.1464	0.1463
2006	0.0000	0.0103	0.0007	0.0128	0.0288	0.0158	0.0390	0.0368	0.0807	0.0818	0.0804
2007	0.0000	0.0000	0.0011	0.0117	0.0119	0.0306	0.0282	0.0901	0.1412	0.1414	0.1396
2008	0.0000	0.0558	0.0256	0.0101	0.0157	0.0098	0.0766	0.0873	0.0966	0.0952	0.0958
2009	0.0116	0.0225	0.0262	0.0251	0.0152	0.0140	0.0219	0.0947	0.1082	0.1084	0.1080
2010	0.0000	0.0327	0.0580	0.0270	0.0243	0.0243	0.0205	0.0386	0.1370	0.1373	0.1354
2011	0.0129	0.0152	0.0493	0.0170	0.0361	0.0300	0.0238	0.0571	0.1281	0.1281	0.1280
2012	0.0274	0.0608	0.0639	0.0618	0.0274	0.0431	0.0412	0.0373	0.0685	0.0691	0.0684
2013	0.0214	0.0303	0.0458	0.0388	0.0276	0.0225	0.0478	0.0539	0.1174	0.1185	0.1347
2014	0.0824	0.0363	0.0447	0.0341	0.0213	0.0457	0.0662	0.0789	0.0660	0.0664	0.0755
2015	0.0000	0.0088	0.0308	0.0283	0.0266	0.0192	0.0233	0.0283	0.0556	0.0562	0.0559
2016	0.0157	0.0192	0.0063	0.0393	0.0145	0.0172	0.0267	0.0138	0.0906	0.0924	0.0936
2017	0.0464	0.0394	0.0373	0.0500	0.0414	0.0416	0.0613	0.1102	0.0825	0.1403	0.1444
2018	0.0000	0.0185	0.0679	0.0480	0.0351	0.0378	0.0562	0.0308	0.0246	0.0076	0.0254
Average	**0.0067**	**0.0234**	**0.0337**	**0.0303**	**0.0323**	**0.0429**	**0.0582**	**0.0748**	**0.1203**	**0.1214**	**0.1225**

Table 1.8 Proportion of haddock in cod diet, based on Norwegian consumption calculations

Year/age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.0443	0.0175	0.0053	0.0225	0.0457	0.0214	0.0022	0.0020	0.0019	0.0018	0.0019
1985	0.0205	0.0227	0.0052	0.0076	0.0207	0.0111	0.0000	0.0000	0.0000	0.0000	0.0000
1986	0.0000	0.0188	0.0015	0.0860	0.0005	0.0534	0.0246	0.0251	0.0264	0.0281	0.0302
1987	0.0000	0.0052	0.0003	0.0025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	0.0000	0.0000	0.0000	0.0000	0.0003	0.0033	0.0033	0.0035	0.0038	0.0032	0.0035
1989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0337	0.0336	0.0352	0.0348	0.0360
1990	0.0000	0.0000	0.0000	0.0024	0.0021	0.0007	0.0125	0.0121	0.0111	0.0112	0.0116
1991	0.0000	0.0000	0.0098	0.0079	0.0045	0.0051	0.0031	0.0029	0.0028	0.0026	0.0025
1992	0.0000	0.0000	0.0014	0.0681	0.0206	0.0272	0.0278	0.0316	0.0460	0.0460	0.0455
1993	0.0000	0.0000	0.0204	0.0073	0.0148	0.0143	0.0281	0.0262	0.0262	0.0262	0.0263
1994	0.0000	0.0000	0.0064	0.0133	0.0069	0.0142	0.0305	0.0499	0.0473	0.0468	0.0476
1995	0.0000	0.0355	0.0034	0.0438	0.0260	0.0239	0.0387	0.0954	0.1618	0.1623	0.1636
1996	0.0000	0.0000	0.0655	0.0150	0.0098	0.0168	0.0359	0.0473	0.0891	0.0977	0.0959
1997	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1998	0.0000	0.0000	0.0112	0.0116	0.0227	0.0192	0.0107	0.0324	0.0162	0.0164	0.0166
1999	0.0000	0.0000	0.0029	0.0078	0.0157	0.0124	0.0120	0.0139	0.0228	0.0229	0.0216
2000	0.0000	0.0000	0.0230	0.0102	0.0178	0.0116	0.0158	0.0517	0.0285	0.0285	0.0285
2001	0.0000	0.0081	0.0052	0.0163	0.0148	0.0172	0.0194	0.0199	0.0349	0.0352	0.0359
2002	0.0000	0.0000	0.0185	0.0339	0.0353	0.0470	0.0746	0.0761	0.1827	0.1788	0.1774
2003	0.0000	0.0000	0.0145	0.0311	0.0594	0.0436	0.0552	0.1215	0.1078	0.1077	0.1077
2004	0.0044	0.0419	0.0745	0.0389	0.0577	0.0501	0.0564	0.0997	0.0912	0.0915	0.0919
2005	0.0000	0.0853	0.1047	0.0596	0.0622	0.0647	0.1046	0.1088	0.1114	0.1102	0.1101
2006	0.0000	0.0409	0.0829	0.0871	0.0605	0.0900	0.0718	0.1064	0.0964	0.0959	0.0965
2007	0.0000	0.0035	0.0463	0.0417	0.0833	0.0984	0.1334	0.1151	0.1627	0.1626	0.1639
2008	0.0000	0.0045	0.0106	0.0156	0.0383	0.0753	0.1149	0.1328	0.2339	0.2355	0.2348
2009	0.0000	0.0218	0.0241	0.0182	0.0142	0.0363	0.1088	0.0597	0.1865	0.1860	0.1876
2010	0.0000	0.0031	0.0279	0.0181	0.0178	0.0217	0.0359	0.1426	0.1819	0.1805	0.1810
2011	0.0000	0.0049	0.0362	0.0284	0.0087	0.0205	0.0408	0.0917	0.1645	0.1647	0.1639
2012	0.0000	0.0000	0.0113	0.0282	0.0338	0.0273	0.0368	0.0335	0.0860	0.0847	0.0866
2013	0.0000	0.0074	0.0309	0.0112	0.0314	0.0234	0.0147	0.0363	0.0615	0.0615	0.0893
2014	0.0000	0.0090	0.0038	0.0255	0.0080	0.0047	0.0022	0.0339	0.0142	0.0140	0.0183
2015	0.0000	0.0175	0.0406	0.0253	0.0171	0.0166	0.0258	0.0197	0.0383	0.0381	0.0389
2016	0.0000	0.0051	0.0797	0.0769	0.0264	0.0259	0.0324	0.0420	0.0342	0.0345	0.0343
2017	0.0000	0.0450	0.0166	0.0447	0.0475	0.0594	0.0503	0.0635	0.0855	0.0809	0.0894
2018	0.0000	0.0000	0.0434	0.0365	0.0591	0.0661	0.0557	0.0592	0.0823	0.0300	0.1117
Average	**0.0020**	**0.0114**	**0.0237**	**0.0269**	**0.0252**	**0.0292**	**0.0375**	**0.0511**	**0.0707**	**0.0692**	**0.0729**

Table 1.9a. Overview of available prognoses of NEA cod recruitment (in million individuals of age 3) from different models (Section 1.4.2).

Model	Prognostic years (counting this year's assessment as first year	Updated	2019 Prognoses	2020 Prognoses	2021 Prognoses	2022 prognoses
TitovES	2	At assessment	598	504		
TitovEL	4	At assessment	543	460	570	585
RCT3	3	At assessment	977	742	728	
Hybrid model (Assessment 2019) *		At assessment	667 (660)	537 (524)	644 (644)	585 (582)

*** The results corresponding SPALY run are presented in brackets**

Table 1.9b. Related weights to the models used in the hybrid model

Model	Model weight 2019	Model weight 2020	Model weight 2021
TitovES	0.54	0.59	
TitovEL	0.25	0.23	0.53
RCT3	0.22	0.18	0.47

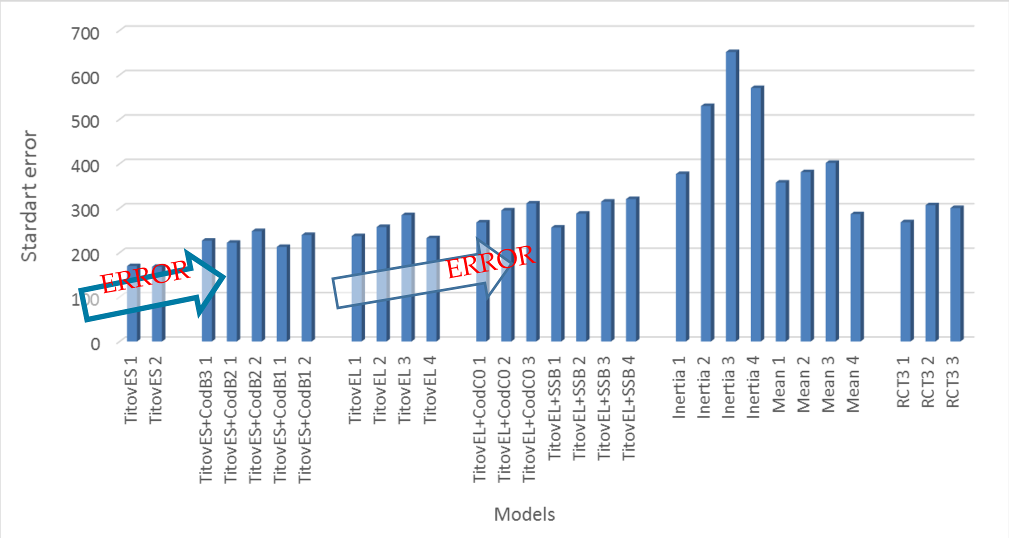

Figure 1.1. Standard errors of the NEA cod recruitment predicted values from the SAM values.

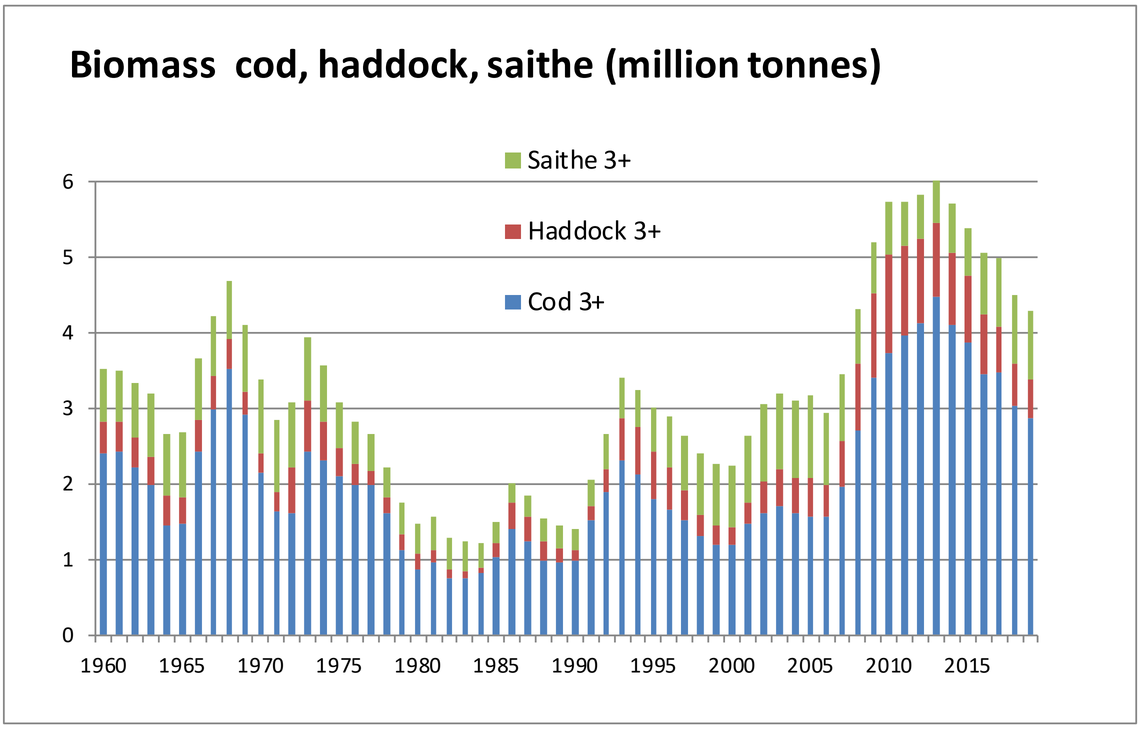

Figure 1.2. Biomass of northeast Arctic cod, haddock and saithe, from 2019 AFWG assessment.

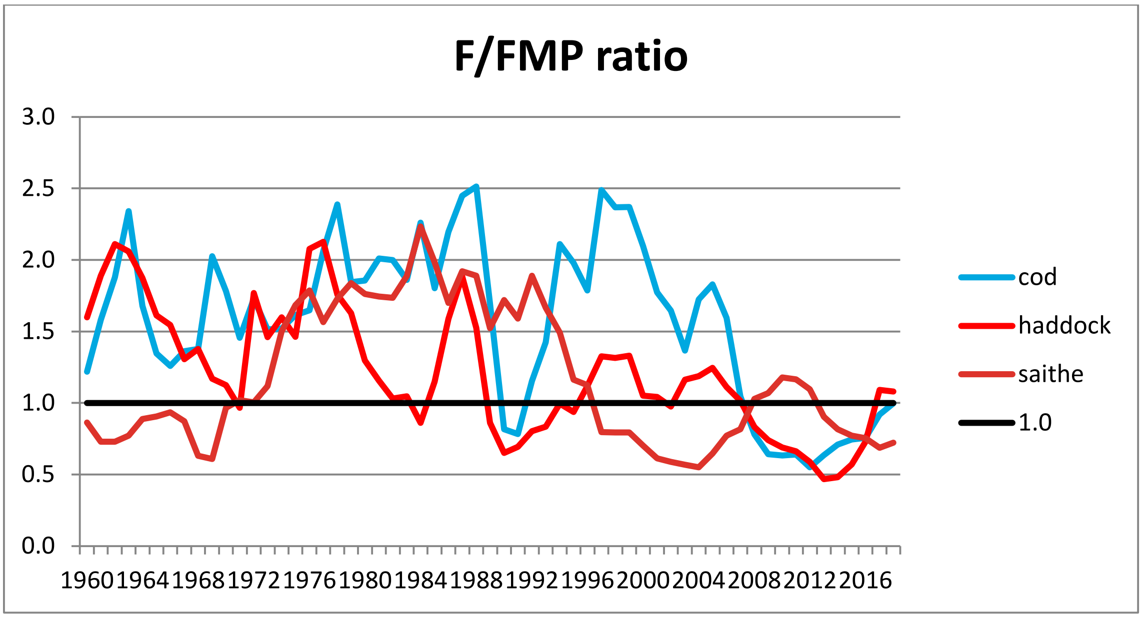

Figure 1.3. Annual fishing mortalities of the northeast Arctic cod, haddock and saithe stocks relative to F_{MP}, i.e. the level used in the management plans for these stocks when SSB > B_{pa}. For cod F_{MP} is not well-defined, as there is a two-step HCR. In this figure, the lower plateau (F = 0.40) is used in calculating the ratio. Harvest control rules were introduced for cod and haddock in 2004 onwards and for saithe in 2007.