

## 14 Cod (*Gadus morhua*) in NAFO Subdivisions 1A–1E (Offshore West Greenland)

### 14.1 Stock definition

The cod found in Greenland is derived from four separate “stocks” that each is labelled by their spawning areas: I) offshore West Greenland waters; II) West Greenland fiords; III) offshore East Greenland and Icelandic waters and IV) inshore Icelandic waters (Therkildsen *et al.*, 2013), (Figure 14.1).

From 2012, the inshore component (West Greenland, NAFO Subarea 1) was assessed separately from all offshore components. From 2015 the offshore West Greenland (NAFO subdivisions 1A–E) and East Greenland (NAFO subdivision 1F and ICES Subarea 14) components was assessed separately. The Stock Annex provides more details on the stock identities including the references to the primary literature.

### 14.2 Fishery

#### 14.2.1 The emergence and collapse of the Greenland offshore cod fisheries

The Greenland commercial cod fishery in West Greenland started in the 1920s. The fishery gradually developed culminating with catch levels at 400 000 tonnes annually in the 1960s. Due to overfishing and deteriorating environmental conditions, the stock size declined and the fishery completely collapsed in the early 1990s (Table 14.2.1, Figure 14.2.1). More details on the historical development in the fisheries are provided in the Stock Annex.

In the period 2015–2018 a TAC of 5 000 tonnes was introduced as an experimental fishery. In 2019 the start TAC was 0 tons, but during the year 2,000 tons were allocated from the inshore TAC. Since 2015 it has been allowed to fish offshore on the inshore quota. The offshore catches on the inshore quota have been between 400–600 t annually in the period 2015–2019.

#### 14.2.2 The fishery in 2020

In 2020 TAC was 0 tons, however 103 tons were fished offshore on the inshore quota.

Main fishing ground was Tovqussaq Bank (NAFO division 1C, between 66°15–66°30N, Table 14.2.2.1, figures 14.2.2.1 and 14.2.2.2).

The fishery was conducted from July to October with 82 % caught in August–September. One small trawler (<25 m) participated in the fishery (table 14.2.2.2).

No biological sampling (i.e. length measurement and otoliths) were taken from the fishery in 2020. Catch at age and Weight at age in the period 2007–2019 can be seen in table 14.2.3.1.

A detailed description of the fishery is available in Retzel 2021a.

## 14.3 Surveys

At present, two offshore trawl surveys (Greenland and German) provide the core information relevant for stock assessment purposes.

The German survey targets cod and has since 1982 covered the main cod grounds off West Greenland up to 67°N at depths down to 400 m, thus including periods of both high and low cod abundance. The German survey has not been conducted in the area in the period 2015-2019. However in 2019 the southern part of the survey area (NAFO 1E) was covered.

The Greenland survey targets shrimp and cod off West Greenland up to 72°N and from 0 to 600 m from 1992, hereby extending into northern areas where large cod concentrations are not expected. Although most of the effort has previously been allocated towards shrimp, but since 2005 the addition of additional fish stations implies a fair coverage of the West Greenland cod habitat in this survey.

For details of survey design, see stock annex.

In 2018, 2019 and 2020 the annual trawl survey was conducted with a chartered vessel. All the standard gear from the research vessel *Paamiut* (such as cosmos trawl, doors, all equipment such as bridles ect., Marport sensors on doors and headlines) were used, in attempt to make the chartered surveys as identical as possible with the previous years' survey (Burmeister and Riget, 2018; Burmeister and Riget, 2019; Burmeister and Riget, 2020).

In 2020 trawling was conducted primarily at night-time in the shallow strata (51-100 + 101-150), whereas previously trawling was restricted to between 08.00 UTC and 20.00 UTC. In total 37 of the hauls was conducted during night-time and 3 during daytime. Preliminary analyses of commercial logbooks showed that standardized CPUE was 9-10% higher during daytime than during the nightline, however, the difference was not significant ( $p = 0.32$ ). The introduction of night hauls in 2020 is evaluated to have a minor effect on the estimated abundance and biomass estimates. The gain by trawling around the clock instead of only daytime, by increased strata coverage is evaluated to be larger than the possible day and night influence, which may be able to correct for in the future.

### 14.3.1 Results of the Greenland Shrimp and Fish Survey

The numbers valid hauls were 208 in 2020 (Table 14.3.1.1, figures 14.3.1.1 and 14.3.1.2).

The 2020 survey abundance of Atlantic cod in West Greenland was estimated at 24 million individuals and the survey biomass at 15,000 tons (tables 14.3.1.2 and 14.3.1.3). Survey abundance and biomass are on the same low level as the period 2016-2018.

Overall the 3 year olds (2017 YC) dominated the survey in 2020 (Table 14.3.1.4, Figure 14.3.1.3). However the 2015 YC is more abundant in the southern part of the survey (NAFO 1E), whereas younger yearclasses, at size ranges < 40 cm, are more abundant in the northern part of the survey area (NAFO 1A to 1D, table 14.3.1.5, figure 14.3.1.4).

The distribution pattern is similar with previous years with younger cod in the northern part of the survey area, and at older ages moving further to the south. Length distribution is similar to 2018 with few cod larger than 40 cm (figure 14.3.1.5).

The main part of cod found offshore in West Greenland have since the beginning of the survey been younger than 5 years. However, since 2017 increasing numbers of older cod (especially the 2009 and 2010 YC) have been registered in the survey (table 14.3.1.4).

**Genetics.** In the 2019 survey samples for genetic analysis were taken from each NAFO division. In total 527 samples were analysed for genetic assignment. Samples with assignment probability > 70% (499) were used in the data analysis. In the northern area of the survey (NAFO 1A and 1B) the WestGreenland offshore component dominated (60%) followed by the EastGreenland-Iceland offshore component (30%, figure 14.3.1.6). The composition changed with latitude with the EastGreenland-Iceland offshore component dominating in the southern area (80 %, NAFO 1E and 1F), followed by the WestGreenland offshore component (10%). The dominating YC in 2019 survey catches was the 2015 YC and the genetic composition showed that the overall majority belonged to the EastGreenland-Iceland offshore component (75%, figure 14.3.1.7). In general the EastGreenland-Iceland offshore component is found in varying amounts in all yearclasses.

The survey biomass in 2019 was weighted with the genetic split in each NAFO area. This resulted in 75% of the total biomass index was assigned to the EastGreenland-Iceland component, followed by the WestGreenland offshore component with 20% (figure 14.3.1.8).

The genetic composition between yearclasses between NAFO divisions reveals a pattern of West Greenland offshore component dominating the yearclasses in the north (NAFO 1A and 1B, figure 14.3.1.9) and EastGreenland-Iceland offshore component dominating in the south (NAFO 1D, 1E and 1F).

The overall patterns identified from the Greenland surveys are that a) Old and large cod (>6 yrs) are found off East Greenland primarily north of 63°N, b) Cod at ages 4-6 yrs are found primarily in Southwest Greenland and c) Young cod (<3 yrs) are primarily found in the northern part of West Greenland. This pattern suggest that West Greenland is a nursing area for the East Greenland cod stock, and that the West Greenland cod stock is at a very low level. The increasing trend in the biomass in the southern part of the survey (NAFO 1E) in 2014 and 2015 with record high numbers of especially the 2009 YC has reversed in the period 2016 – 2018. In 2019 a massive increase in numbers and biomass was registered in the southern part of the survey (NAFO 1D and 1E), however interpretation of these findings must be precautionous as they are caused by two very large hauls located in each NAFO division. The dominating yearclass in 2019 is the 2015 YC, and this YC is also dominating the same region in 2020 but not in the same high numbers. The genetic composition within the survey in 2019 revealed a north-south gradient with the WestGreenland offshore stock dominating in the northern areas corresponding to NAFO divisions 1A and 1B, whereas the EastGreenland-Iceland offshore stock is dominating in the southern region corresponding to NAFO divisions 1D and 1E.

A detailed description of the survey is available in Retzel (2021b).

### 14.3.2 Results of the German groundfish survey

Due to technical problems and weather issues, the German survey did not manage to cover the West Greenland area in 2016, 2017 and 2018. In 2019, the survey managed to cover the southern part (NAFO 1E, strata 3).

The numbers valid hauls were 37 in 2020 (Table 14.3.2.1, figures 14.3.2.1).

The German survey in 2020 confirmed the findings of the Greenland survey, i.e. low abundance and biomass indices (table 14.3.2.2 and 14.3.2.3), a 2017 YC dominating the area especially in the northern part (NAFO 1C and 1D) and the presence of older year-classes (Table 14.3.2.4 and 14.3.2.6).

A detailed description of the survey is available in Werner & Fock (2021).

## 14.4 Information on spawning

Before 2017, no spawning of significance has been documented on the banks in West Greenland (Retzel, 2015).

In 2017 and 2018, fishing was allowed outside a box covering Dana Bank in April and May with requirements of increased collection of biological sampling in order to investigate the maturity stage of the fish caught. In addition, samples of whole cod was sent to GINR for investigation of maturity. In general, the majority of the cod sent to GINR from the commercial fishery in NAFO division 1C and 1D were spawning (Retzel, 2018).

In 2019 (just prior to the NWWG meeting), a pilot cruise with GINR small research vessel Sanna was undertaken on Tovqussaq Bank in NAFO 1C with the objective to locate and investigate spawning on the bank in combination with tagging of spawning cod. The survey found actively spawning cod with several year-classes being part of the spawning stock (Retzel, 2020).

## 14.5 Tagging experiments

A total of 25 377 cod have been tagged in different regions of Greenland in the period of 2003–2020 (Table 14.5.1). Cod on two banks in West Greenland have been tagged; 2 667 on Tovqussaq bank in NAFO division 1C and 6 649 on Dana Bank in NAFO division 1D+1E.

40% of recaptured fish tagged recently on the West Greenland banks are recaptured in the same area as tagged, 20 % are recaptured inshore and 40% are recaptured in East Greenland/Iceland (table 14.5.2). The majority of recaptures are tagged on the southern Dana Bank (NAFO 1E) while very few recaptures are tagged on Tovqussaq Bank which is located further to the north in NAFO 1C. None of the recaptured cod tagged on Tovqussaq Bank (NAFO 1C) have been recaptured in East Greenland or Iceland.

Limited fishing in several areas and years influences the signal from the recaptures, and more analysis needs to be performed taking the fishing effort into account in order to investigate magnitude of the eastward migration rate.

## 14.6 State of the stock

The West Greenland offshore stock component has been severely depleted since the 1970s and collapsed in the 1990s. The surveys showed only an increase in biomass until 2015 and has since 2016 been low. Abundance however has fluctuated since 2005, indicating that small fish enter the survey but are not caught at older ages. This is caused by an eastward migration out of the area, and the area is presently considered to act mainly as a nursing area for the East Greenland and Icelandic stock components.

Until 2015, the 2009 and 2010 YCs have been caught in considerable numbers in the survey. Since then few cod older than 3 yrs and larger than 40 cm have been caught especially in 2018. The fishery between 3000–5000 tonnes in 2015–2017 primarily fished the 2009 and 2010 YC's. The reason for the reduction of the 2009 and the 2010 YC in 2016 is considered to be caused by a combined effect of migration out of the area and fishery. However, abundance indices in the Greenland survey of these year-classes are highest observed in the survey in 2017–2019 compared to same ages in previous years.

The stock is considered to be at a very low level compared to historic.

As described in Section 1.3, MSY proxies should be evaluated to determine stock status. ICES suggested four methods for this purpose, and all methods were tested on the stock (Hedeholm,

2017; ICES, 2017). All the length-based indicators rely heavily on length distributions from the commercial fishery. For this stock, the fishery has been very limited since the early 1990 collapse. Hence, commercial data are limited and not really suited for such analysis; especially with the general assumptions of no migration underlying most of the approaches.

With these shortcomings, the results from all analysis support the general notion from surveys: this stock is at a low level and no fishing should take place until a spawning component is established that is composed of a number of year classes. Spawning investigations in 2017-2019 indicate that a spawning stock composed of several year classes is recovering.

## **14.7 Implemented management measures for 2021**

No fishery is allowed in 2021 in NAFO subdivision 1A–1E. It is however allowed to fish parts of the inshore West Greenland quota in the offshore West Greenland areas.

## **14.8 Management plan**

There is no management plan for the offshore fishery in NAFO Subdivision 1A–1E.

## **14.9 Management considerations**

The fishery in West Greenland should be considered a mixed stock fishery, containing fish from both Greenland and Iceland stocks. There is currently no standardized procedure to determine the proportional contribution of each stock to the landings.

The traditional spawning grounds in West Greenland are well described and if any fishing is allowed such areas should be protected. This will both protect any present spawning stock and minimize the proportion of the West Greenland stock in the catches.

From 2015, it is allowed to fish parts of the inshore West Greenland quota in the offshore West Greenland areas. These catches are additional to the offshore TAC, and have been between 400-600 tonnes annually.

### **14.10 Basis for advice**

Basis for advice is the precautionary approach where biomass is extremely low and ICES advised zero catch for 2022 and 2023.

### **14.11 Benchmark 2022**

The stock is proposed to go through a benchmark in 2022.

Survey indices are variable and recent decline in offshore indices coincides with historic high catches inshore. Genetic analysis of inshore commercial and survey catches reveals a mix of different stocks. Genetics from inshore areas on the west coast reveal that the offshore stock may contribute a large part to the catches in these areas. Further analysis of the genetic composition in combination with tagging studies is needed to gain further insight into migration pattern across areas and year classes.

Survey trends are basis for advice. Zero advice have been given for several decades. Data on spawning indicate stock is reproducing and spawning stock is established. Genetic data suggest

large migration and mixing with the inshore cod stock (cod.21.1, Christensen, 2019; Buch *et al.* 2021).

The main aim of the benchmark is to move away from using the current simplified geographical borders to separate the three cod stocks in Greenland waters. This will be done by developing a modelling approach that can use genetic data based on samples covering the distribution of the three stocks (Buch *et al.* 2021). The model will utilize the spatial resolution of the genetics data to estimate the split between the stocks along a spatial gradient. The catch and survey data will then be split into separate stocks and used as input into an analytical assessment models for each stock. This would account for differences in stock dynamics between stocks and may improve the understanding of migration patterns.

The benchmark also aims to improve the estimation of the survey indices available for the stocks. There are currently two offshore surveys in Greenland waters. One Greenlandic survey, covering the West and East coast up to and including the Dohrn bank area. One German survey covers a similar area on the east coast and some of the west coast. A spatial model will be developed to allow combination of the survey data and allow incorporation of spatial patterns. The new model will also be able to better account for occasionally large catches.

## 14.12 References

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## 14.13 Tables

**Table 14.2.1. Offshore catches (t) divided into NAFO divisions in West Greenland. 1924–1991: Horsted 2000, 2004–present: Greenland Fisheries License Control.**

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A–1E
1924							200	
1925							1871	
1926							4452	
1927							4427	
1928							5871	
1929							22304	
1930							94722	
1931							120858	
1932							87273	
1933							54351	
1934							88422	
1935							65796	
1936							125972	
1937							90296	
1938							90042	
1939							62807	
1940							43122	
1941							35000	
1942							40814	
1943							47400	
1944							51627	
1945							45800	
1946							44395	
1947							63458	
1948							109058	
1949							156015	



Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A–1E
1950							179398	
1951							222340	
1952	0	261	2996	18188	707	37905	257488	117126*
1953	4546	46546	10611	38915	932	25242	98225	180220*
1954	2811	97306	18192	91555	727	15350	60179	266682*
1955	773	50106	32829	87327	3753	4655	68488	241499*
1956	15	56011	38428	128255	8721	4922	66265	296315*
1957	0	58575	32594	62106	29093	16317	47357	225836*
1958	168	55626	41074	73067	21624	26765	75795	258062*
1959	986	74304	10954	30254	12560	11009	67598	191343*
1960	35	58648	18493	35939	16396	9885	76431	200522*
1961	503	78018	43351	70881	16031	14618	90224	293104*
1962	1017	122388	75380	57972	25336	17289	125896	400719*
1963	66	70236	73142	76579	46370	16440	122653	381917*
1964	96	49049	49102	82936	33287	13844	99438	307878*
1965	385	80931	66817	71036	15594	15002	92630	321829*
1966	12	99495	43557	62594	19579	18769	95124	313044*
1967	361	58612	78270	122518	34096	12187	95911	385949*
1968	881	12333	89636	94820	61591	16362	97390	350870*
1969	490	7652	31140	65115	41648	11507	35611	179055*
1970	278	3719	13244	23496	23215	15519	18420	78775*
1971	39	1621	28839	21188	9088	20515	26384	80501*
1972	0	3033	42736	18699	7022	4396	20083	90410*
1973	0	2341	17735	18587	10581	2908	1168	50347*
1974	36	1430	12452	14747	8701	1374	656	37999*
1975	0	49	18258	12494	6880	3124	549	38188*
1976	0	442	5418	10704	8446	2873	229	25215*
1977	127	301	4472	7943	8506	2175	35477 <sup>1</sup>	53546*
1978	0	0	11856	2638	3715	549	34563 <sup>1</sup>	51760*

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A–1E
1979	0	16	6561	4042	1115	537	51139 <sup>1</sup>	60635*
1980	0	1800	2200	2117	1687	384	7241 <sup>1</sup>	14705*
1981	0	0	4289	4701	4508	255	0	13498
1982	0	133	6143	10977	11222	692	1174	29621*
1983	0	0	717	6223	16518	4628	293	23703*
1984	0	0	0	4921	5453	3083	0	10374
1985	0	0	0	145	1961	1927	2402	3360*
1986	0	0	0	2	72	24	1203	982*
1987	0	0	5	815	67	43	3041	3787*
1988	0	0	919	17463	10913	6466	8101	35931*
1989	0	0	0	11071	48092	14248	2	59165
1990	0	0	2	563	21513	10580	7503	27151*
1991	0	0	0	0	104	1942	0	104
1992	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0
2004	0	0	0	5	3	1	0	8
2005	0	0	1	0	0	71	0	1
2006	0	0	0	0	0	414	0	0
2007	0	0	0	31	435	2011 <sup>2</sup>	0	466

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A–1E
2008	0	0	0	23	526	11370 <sup>2</sup>	0	549
2009	0	0	0	0	6	3323 <sup>2</sup>	0	6
2010	0	0	0	0	2	281	0	2
2011	0	0	0	0	8	542	0	8
2012	0	0	1	95	236	1470	0	332
2013	0	0	0	209	270	1405	0	479
2014	0	0	30	68	18	1833	0	116
2015	0	0	341	954	3564	3984	0	4860
2016	0	0	67	1911	1762	2335	0	3740
2017	0	1	1442	730	852	2560	0	3025
2018	0	0	1988	678	1521	1820	0	4187
2019	0	0	656	57	186	916	0	899
2020	0	0	102	0	1	675	0	103

<sup>1</sup> Estimates for assessment include estimates of unreported catches. The total estimated value for West Greenland (inshore + offshore) was 73 000 t in 1977 and 1978, 1979: 99 000 t, 1980: 54 000 t. The value given in the table are these values minus the inshore catches minus known offshore NAFO Division catches.

<sup>2</sup> Include catches taken with small vessels and landed to a factory in South Greenland (Qaqortoq), 2007: 597 t, 2008: 2262 t, 2009: 136 t.

\* Unknown NAFO Division catches added accordingly to the proportion of known catch in NAFO divisions 1A–1E to known total catch in all NAFO divisions.

Table 14.2.2.1: Cod catches (t) divided into month and NAFO areas, caught by the offshore fisheries.

NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
1C							9	41	43	8	1		102	99%
1D														
1E				1									1	1%
<b>Total</b>				<b>1</b>			<b>9</b>	<b>41</b>	<b>43</b>	<b>8</b>	<b>1</b>		<b>103</b>	
%				1%			9%	40%	42%	8%	1%			

Table 14.2.2.2: Cod catches (t) by gear, area and month in West Greenland.

Gear	NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Trawl	1C							9	41	43	8	1		102
	1D													
	1E				1									1
	Total				1			9	41	43	8	1		103

**Table 14.2.3.1. Cod in Greenland. Catch at age ('000) and Weight at age (kg) for offshore fleets in West Greenland (NAFO 1A–1E). No samples from commercial fishery in 2008–2011 and 2020.**

CATCH AT AGE								
Year/age	3	4	5	6	7	8	9	10+
2007	6	167	66	42	6	1		
2008								
2009								
2010								
2011								
2012	8	33	107	38	18	2	0.01	0.003
2013		15	44	113	29	15	4	1
2014	1	18	45	7	9	2	0.02	
2015	6	67	502	1061	240	158	45	16
2016	1	12	198	923	490	69	20	5
2017	2	20	132	340	532	272	55	23
2018		37	130	521	600	434	173	51
2019		29	56	54	74	80	32	15
2020								
WEIGHT AT AGE								
2007	0.647	0.906	1.949	3.440	5.817	6.053		
2008								
2009								
2010								
2011								
2012	0.560	0.935	1.395	2.139	3.232	4.194	8.325	12.500
2013		1.120	1.462	1.947	2.978	3.754	6.398	7.342
2014	0.488	0.693	1.199	1.738	3.040	4.817	5.318	
2015	0.474	0.734	1.316	1.982	3.186	5.043	7.167	10.329
2016	0.345	0.810	1.237	1.931	2.560	4.299	5.573	7.947
2017	0.404	0.776	1.230	1.580	2.138	2.830	4.340	7.091
2018		0.813	1.114	1.562	1.988	2.807	3.259	4.445
2019	0.390	1.008	1.500	1.997	2.646	3.126	4.006	6.895
2020								

**Table 14.3.1.1. Number of hauls in the Greenland Shrimp and Fish survey in West Greenland by year and NAFO sub-divisions.**

WEST GREENLAND							
Year/NAFO	0A	1A	1B	1C	1D	1E	Total
1992		92	44	18	18	11	183
1993		69	49	21	15	12	166
1994		76	58	23	8	9	174
1995		83	61	29	13	14	200
1996		71	57	29	12	9	178
1997		84	56	32	12	12	196
1998		77	80	27	19	14	217
1999		84	81	33	16	14	228
2000		56	62	37	23	14	192
2001		60	75	36	24	15	210
2002		50	80	32	18	20	200
2003		51	63	30	18	15	177
2004		54	55	24	22	20	175
NEW SURVEY GEAR INTRODUCED							
2005	6	65	56	26	19	23	195
2006	5	86	60	26	20	21	218
2007	8	73	58	26	27	31	223
2008	6	69	61	28	23	25	212
2009	8	74	75	28	22	24	231
2010	10	95	76	30	23	25	259
2011	0	73	64	24	18	12	191
2012	0	73	64	21	18	18	194
2013	4	73	52	20	13	21	183
2014	0	78	57	19	17	23	194
2015	0	70	49	24	22	21	186
2016	0	59	38	26	14	19	156
2017	3	99	52	25	18	25	222
2018	0	78	42	26	23	20	189
2019	0	86	36	20	18	14	174
2020	0	84	51	29	21	23	208

**Table 14.3.1.2 Cod abundance indices ('000) from the Greenland Shrimp and Fish survey in West Greenland by year and NAFO subdivisions.**

WEST GREENLAND								
Year	0A	1A	1B	1C	1D	1E	Total	CV
1992		4	53	243	345	0	645	
1993		2	16	54	135	286	493	
1994		10	41	87	0	6	144	
1995		0	51	380	44	62	537	
1996		0	0	46	68	87	201	
1997		0	7	31	0	0	38	
1998		0	4	0	26	26	56	
1999		32	136	16	23	6	213	
2000		585	437	71	58	9	1160	
2001		26	305	110	448	305	1194	
2002		13	203	78	3294	114	3702	
2003		492	1395	351	727	214	3179	
2004		197	152	379	2630	1538	4896	
NEW SURVEY GEAR INTRODUCED								
2005	143	198	871	1845	4796	6683	14537	25
2006	453	371	4454	2564	15703	3359	26905	45
2007	737	1318	3302	7353	3624	3296	19628	31
2008	1209	897	4185	4068	9008	11553	30913	27
2009	881	889	4195	3272	2788	1252	13277	12
2010	338	720	2837	2712	8295	2745	17647	23
2011		8756	47092	2179	26510	1013	85549	14
2012		7661	10228	3017	1270	27081	49258	54
2013	4613	8951	12864	5673	7887	29924	69911	43
2014		6911	5670	78854	2456	16254	110145	67
2015		6542	11213	27248	31703	26980	103685	33
2016		4892	3243	6961	1564	3437	20096	26
2017	451	2562	4302	15723	4877	6305	34220	35
2018		2725	14808	8019	6449	5889	37890	16
2019		3818	9126	19836	170252	112712	315744	61
2020		1203	10456	3684	1987	6834	24164	24

**Table 14.3.1.3. Cod biomass indices (tonnes) from the Greenland Shrimp and Fish survey in West Greenland by year and NAFO subdivisions.**

WEST GREENLAND								
	0A	1A	1B	1C	1D	1E	Total	CV
1992		23	54	75	118	0	270	
1993		2	5	25	39	124	195	
1994		3	9	38	0	1	51	
1995		5	6	120	23	3	157	
1996		0	0	15	23	27	65	
1997		0	2	53	0	0	55	
1998		1	1	0	47	50	99	
1999		29	28	1	17	1	76	
2000		226	130	21	9	2	388	
2001		140	155	56	178	98	627	
2002		67	128	41	1489	42	1767	
2003		444	323	264	453	118	1602	
2004		542	53	176	680	685	2136	
NEW SURVEY GEAR INTRODUCED								
2005	38	69	364	458	1084	1141	3155	26
2006	114	62	677	537	5131	525	7046	64
2007	247	387	872	1562	628	659	4355	31
2008	413	377	2046	929	1633	3227	8625	28
2009	208	230	1251	711	439	253	3092	14
2010	180	263	999	543	2426	908	5319	22
2011		1569	9654	408	5316	191	17140	14
2012		1932	2938	1125	464	14103	20562	69
2013	2395	2692	3960	1732	4551	19017	34345	53
2014		2639	2305	56061	2511	21381	84897	64
2015		3463	4456	19705	33169	40525	101318	36
2016		2256	1174	5817	1347	2697	13290	32
2017	697	1273	1254	14111	3032	4721	25088	49
2018		1084	2108	2369	2796	2289	10646	20
2019		1350	1778	7123	170822	84352	265425	69
2020		490	2824	1043	774	9842	14973	58



**Table 14.3.1.4: Abundance indices ('000) by year-class/age from the Greenland Shrimp and Fish survey in West Greenland (NAFO 1A–1E).**

WEST GREENLAND											
Year/age	0	1	2	3	4	5	6	7	8	9	10+
2005	134	815	10247	1604	1514	186	35	2	0	0	0
2006	249	6543	3577	12677	3395	401	47	16	0	0	0
2007	152	270	13792	3439	1934	37	4	0	0	0	0
2008	31	3472	2692	18780	4904	868	121	44	0	0	0
2009	0	124	9442	1666	1717	326	3	0	0	0	0
2010	209	2703	2094	10566	1252	775	42	7	0	0	0
2011	19	4940	71837	4453	3735	391	175	0	0	0	0
2012	0	204	11264	31593	3648	2427	116	7	0	0	0
2013	0	2904	8912	15168	36226	5665	848	142	22	25	0
2014	0	471	4792	8088	56469	35839	2597	1718	125	35	11
2015	0	2210	3932	15038	21509	34766	21117	1196	348	70	12
2016	0	1155	5103	2746	5680	3487	1442	418	56	0	0
2017	0	1214	6926	7128	3917	7452	5384	1905	288	6	0
2018	26	9205	9008	13155	4312	639	601	264	564	123	28
2019	290	136	14793	45862	107027	89246	22279	20476	12341	1971	1322
2020	31	3008	1670	10563	3150	3127	1328	562	533	115	76

**Table 14.3.1.5 Abundance indices ('000) by age and NAFO divisions from the Greenland Shrimp and Fish survey in West Greenland. NAFO division 1E furthest to the south.**

WEST GREENLAND											
Year class	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	<2010
Age	0	1	2	3	4	5	6	7	8	9	10+
Div. 0A											
Div. 1A	31	101	22	342	601	95	0	0	0	10	0
Div. 1B	0	2557	883	5652	1009	233	110	0	13	0	0
Div. 1C	0	83	282	2966	335	0	19	0	0	0	0
Div. 1D	0	79	44	1106	571	164	12	12	0	0	0
Div. 1E	0	188	440	498	634	2636	1188	550	521	105	76

**Table 14.3.1.6 Mean weight of cod from the Greenland Shrimp and Fish survey in West Greenland (NAFO 1A–1E).**

WEST GREENLAND											
Year/age	0	1	2	3	4	5	6	7	8	9	10+
2005	0.002	0.031	0.146	0.298	0.596	1.208	1.800	3.338			
2006	0.004	0.025	0.120	0.338	0.477	0.680	2.581	2.714			
2007	0.002	0.026	0.138	0.320	0.601	1.446	4.375				
2008	0.006	0.025	0.098	0.239	0.497	0.939	1.774	2.742			
2009		0.024	0.104	0.329	0.620	1.353	2.103				
2010	0.003	0.017	0.136	0.291	0.683	1.191	1.952	3.066			
2011	0.001	0.038	0.164	0.377	0.626	1.151	2.081				
2012		0.019	0.137	0.419	0.763	1.200	1.371	3.396			
2013		0.038	0.112	0.337	0.611	0.781	1.722	2.905	3.560	6.460	
2014		0.014	0.133	0.300	0.675	0.977	1.708	2.704	4.108	5.710	9.245
2015		0.011	0.102	0.349	0.623	1.062	1.594	2.478	4.276	5.308	9.065
2016		0.028	0.094	0.314	0.711	1.145	1.742	2.542	3.844		
2017		0.015	0.097	0.262	0.622	1.009	1.404	1.843	3.254	5.345	
2018	0.003	0.012	0.078	0.272	0.551	0.867	1.409	1.923	2.536	3.419	3.529
2019	0.000	0.015	0.096	0.305	0.575	0.911	1.227	1.745	2.057	2.357	5.020
2020	0.004	0.020	0.101	0.284	0.530	1.192	1.796	3.148	3.427	4.492	4.666

**Table 14.3.2.1 German survey. Numbers of valid hauls by stratum in West Greenland (NAFO 1C–E): No survey in 2016, 2017 and 2018. 2019: only strata 3 covered.**

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum
	Str. 1.1	Str. 1.2	Str. 2.1	Str. 2.2	Str. 3.1	Str. 3.2	
1981	1	1	13	2	3	1	21
1982	20	11	16	7	9	6	69
1983	26	11	25	11	17	5	95
1984	25	13	26	8	19	6	97
1985	10	8	26	10	17	5	76
1986	27	9	21	9	16	7	89
1987	25	19	21	4	18	4	91
1988	34	21	28	5	18	5	111
1989	25	14	30	9	8	3	89
1990	19	7	23	8	16	3	76
1991	19	11	23	7	13	6	79
1992	6	6	6	5	6	6	35
1993	9	7	9	6	10	8	49
1994	16	13	13	8	10	6	66
1995	.	.	3	.	10	7	20
1996	5	5	8	5	12	5	40
1997	5	6	5	5	6	5	32
1998	9	5	10	7	11	6	48
1999	8	7	14	8	13	6	56
2000	13	6	15	6	14	5	59
2001	.	.	15	7	15	5	42
2002	.	.	7	2	5	6	20
2003	.	.	7	6	7	7	27
2004	8	8	11	9	9	5	50
2005	.	.	9	7	8	6	30
2006	6	5	7	5	7	7	37
2007	5	5	7	5	6	5	33
2008	5	.	7	7	7	9	35
2009	2	.	5	5	6	6	24
2010	5	5	10	5	7	9	41
2011	.	.	5	5	5	5	20
2012	5	5	10	8	9	7	44
2013	6	6	8	6	10	7	43
2014	5	5	10	8	10	7	45
2015	7	7	7	4	5	5	35
2016	.	.	.	.	3	2	.
2017	.	.	.	.	.	.	.
2018	.	.	.	.	.	.	.

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum
	Str. 1.1	Str. 1.2	Str. 2.1	Str. 2.2	Str. 3.1	Str. 3.2	
2019	.	.	.	.	9	7	
2020	9	6	12	4	2	4	37

**Table 14.3.2.2 German survey.** Cod abundance indices ('000) from the German survey in West Greenland (NAFO 1C– 1E) by year and stratum: No survey in 2016, 2017 and 2018. 2019: only strata 3 covered. \* Calculated by Greenland.

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum	SD
	str1_1	str1_2	str2_1	str2_2	str3_1	str3_2		
1982	2364	408	27594	920	7401	1801	40488	18605
1983	177	196	7079	2230	8678	1230	19590	7266
1984	189	90	2524	98	2666	364	5931	3629
1985	8094	1107	7237	2348	4984	840	24610	10809
1986	4716	630	22985	108	16570	609	55618	29631
1987	3517	482	115172	3790	72349	186	365496	331763
1988	6027	1106	186523	43090	21037	51	297834	216925
1989	1362	483	16280	325	129005	678	148133	65933
1990	619	299	2279	235	3827	61	7320	5462
1991	142	116	88	92	474	387	1299	412
1992	274	334	72	127	57	38	902	314
1993	327	243	105	109	53	21	858	195
1994	95	53	16	17	34	11	226	79
1995	.	.	27	.	72	34	133	60
1996	82	70	42	20	65	0	279	80
1997	0	24	17	0	57	3	101	45
1998	793	0	23	28	7	0	851	573
1999	103	33	33	11	197	7	384	171
2000	205	250	50	174	288	9	976	383
2001	.	.	584	36	3020	9	3649	3481
2002	.	.	238	21	342	23	624	257
2003	.	.	625	99	1625	73	2422	945
2004	503	213	1522	123	2709	638	5708	1592
2005	.	.	1586	264	5666	419	7935	3115
2006	495	485	87439	858	4481	1323	95081	99523
2007	1430	3261	3417	687	9861	71	18727	8645
2008	2666	.	916	911	23527	616	28636	26712
2009	72	.	1370	850	1068	378	3738	879
2010	2644	464	4451	631	5148	274	13612	6231
2011	.	.	716	375	1242	337	2670	782
2012	99609	1253	6007	442	8455	1251	117017	68441
2013	4457	1585	20122	221	7138	252	33775	22438

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum	SD
	str1_1	str1_2	str2_1	str2_2	str3_1	str3_2		
2014	9952	2008	28102	413	1261	86	41822	38616
2015	13315	906	73434	471	2432	102	90660	73453
2016	.	.	.	.	.	.	.	.
2017	.	.	.	.	.	.	.	.
2018	.	.	.	.	.	.	.	.
2019*					13032	59		
2020	1744	355	1455	212	476	48	4290	1997

**Table 14.3.2.3 German survey, Cod biomass indices (tonnes) from the German survey in West Greenland (NAFO 1C–1E) by year and stratum: No survey in 2016, 2017 and 2018. 2019: only strata 3 covered.**

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum	SD
	str1_1	str1_2	str2_1	str2_2	str3_1	str3_2		
1982	1113	163	37404	1280	9970	4483	54413	26014
1983	144	87	9052	3381	12953	5015	30632	10295
1984	406	104	3998	137	3643	551	8839	5507
1985	1046	112	6543	1181	4700	506	14088	18209
1986	4858	254	11787	36	12381	651	29967	13885
1987	148896	156	93292	2446	54178	107	299075	299459
1988	47085	579	190073	39548	19663	54	297002	227428
1989	384	124	15061	211	113614	710	130104	55334
1990	130	66	1948	123	3652	56	5975	4986
1991	45	38	36	28	549	374	1070	529
1992	65	104	15	33	10	7	234	97
1993	77	45	27	27	30	6	212	53
1994	13	17	3	12	11	5	61	17
1995	.	.	14	.	13	7	34	12
1996	13	35	12	11	28	0	99	29
1997	0	21	11	0	50	3	85	43
1998	38	0	1	7	1	0	47	25
1999	16	11	6	3	63	5	104	57
2000	54	71	11	83	73	5	297	117
2001	.	.	163	17	1024	5	1209	1212
2002	.	.	89	16	136	7	248	108
2003	.	.	98	44	736	32	910	461
2004	172	83	274	45	547	186	1307	342
2005	.	.	605	124	1796	146	2671	1057
2006	102	138	45616	250	2046	614	48766	52298
2007	319	885	1579	244	7804	43	10874	7524
2008	872	.	193	206	11479	175	12925	13686
2009	19	.	309	293	372	153	1146	255
2010	1012	244	2234	312	2703	173	6678	3057
2011	.	.	189	128	1040	194	1551	602
2012	52497	588	4185	240	8203	848	66561	35693
2013	2703	1670	17316	142	11251	544	33626	18801

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum	SD
	str1_1	str1_2	str2_1	str2_2	str3_1	str3_2		
2014	10597	2154	35741	422	3561	397	52872	47451
2015	17221	1105	109073	522	5999	216	134136	108717
2016	.	.	.	.	.	.	.	.
2017	.	.	.	.	.	.	.	.
2018	.	.	.	.	.	.	.	.
2019	.	.	.	.	20577	130		
2020	2817	314	1655	145	2588	51	7570	3802

**Table 14.3.2.4 German survey, West Greenland (NAFO 1C–E). Age disaggregated abundance indices ('1000): No survey in 2016, 2017 and 2018. 2019: only strata 3 covered.**

Year	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
1982		77	505	14266	5195	14798	4144	908	178	344	35	34	40484
1983*)													
1984	80	3	13	709	604	3495	289	628	32	61	13	0	5927
1985	202	16823	623	330	2271	1100	2982	112	164	2	3	0	24612
1986		3600	45772	1686	321	2386	652	1098	22	74	3	1	55615
1987		147	22578	318948	13977	2930	4603	649	1506		131	13	365482
1988		124	1357	44364	247618	2660	311	521	318	529	12	15	297829
1989	0	163	1293	3821	79642	62126	1008		47	7	24	0	148131
1990	11	17	595	1242	368	4089	990	6	0	0		1	7319
1991		86	94	193	350	36	461	57	2			0	1279
1992		88	672	100	17	25		0				0	902
1993		8	499	318	12	21						0	858
1994		98	18	90	14	3		2				0	225
1995			111	6	16							0	133
1996		76	6	193	5		0					0	280
1997		6	13	7	76							0	102
1998	0	845		3	3	0						0	851
1999	8	165	166	36	3		3					0	381
2000		60	524	328	62							0	974
2001		266	2753	527	65	20						0	3631
2002	0	6	309	290	17							0	622
2003		1368	205	511	284	36	9					0	2413
2004	132	3078	2008	307	108	55	15	0				0	5703
2005	91	156	6893	653	40	16	14	0	0			0	7863
2006	157	1949	6961	83106	2708	45	51	67	0			0	95044
2007	139	229	9402	1655	6989	227	35	38	12			0	18726
2008	8	1224	2317	20080	3747	1235	20	3	2	0	0	0	28636
2009	36	326	2513	363	406	37	40	14				0	3735

Year	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
2010	208	1531	1726	9201	577	259	51	48	3	3		5	13612
2011		195	1572	385	368	68	33	26	24	0	0	0	2671
2012	142	1191	37872	66947	7682	2847	227	76	8	18		0	117010
2013		152	1562	12824	15859	1783	1135	234	86	23	18	4	33680
2014			880	4629	17021	17863	1080	277	32	0	4	0	41786
2015	159	189	1353	10921	16208	43991	16909	708	87	117	8	12	90660
2016	.	.	.	.	.	.	.	.	.	.	.	.	.
2017	.	.	.	.	.	.	.	.	.	.	.	.	.
2018	.	.	.	.	.	.	.	.	.	.	.	.	.
2019	17	0	0	1191	8374	1843	381	365	328	348	217	27	13091
2020	54	317	157	1376	963	532	130	49	131	243	188	148	4290

\*) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (ICES, 1984).

**Table 14.3.2.5 German survey, West Greenland (NAFO 1C–E). Mean weight at age. No survey in 2016, 2017 and 2018. 2019: only strata 3 covered.**

Year	0	1	2	3	4	5	6	7	8	9	10	11+
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989		34	144	278	874	1636	1456				6535	
1990		20	135	288	474	877	2076					3935
1991		52	157	371	586	873	1173	1711	1260			
1992		61	220	332	797	974						
1993		35	119	356	457	832						
1994		50	157	418	573	1090		2240				
1995			172	410	511							
1996		51	90	480	690							
1997		65	288	360	1032							

Year	0	1	2	3	4	5	6	7	8	9	10	11+
1998		49		610	1320							
1999		67	354	658	950		2985					
2000		36	228	431	821							
2001		62	297	651	1229	1063						
2002		55	231	548	821							
2003		114	412	669	1169	1572	2415					
2004		78	314	534	1105	1508	3007					
2005		67	292	830	1254	3066	5383					
2006	21	49	226	543	1166	2314	4099	8710				
2007	21	121	227	540	937	3051	6899	5600	8010			
2008		52	143	449	738	1581	5246	0	5192			
2009		50	183	431	694	1453	3252	4796				
2010	59	102	294	540	944	1608	2010	6019	3729	8870		11360
2011		234	228	542	1041	1201	3356	4562	6962			
2012	93	135	355	665	1145	2147	3827	5337	7299	9150		
2013		71	269	706	1145	1907	3333	5707	8445	8907	18270	18200
2014			271	574	1099	1698	4118	4929	6418			28180
2015		57	216	697	1242	2003	2597	3211	6428	3145		
2016	.	.	.	.	.	.	.	.	.	.	.	.
2017	.	.	.	.	.	.	.	.	.	.	.	.
2018	.	.	.	.	.	.	.	.	.	.	.	.
2019	.	.	.	.	.	.	.	.	.	.	.	.

**Table 14.3.2.6 German survey, The abundance indices ('000) by year class/age, 2019. West Greenland. Calculated by Greenland.**

Year class	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	<2010
Age	0	1	2	3	4	5	6	7	8	9	10+
Strat 1 (NAFO 1C)	49	78	128	787	500	215	51	20	51	131	
Strat 2 (NAFO 1D)	4	214	22	570	445	243	55	11	31	43	
Strat 3 (NAFO 1E)	0	25	6	18	19	74	24	16	49	128	165



**Table 14.5.1. Number of tagged cod in the period of 2003 to 2019 in different regions. Bank (West) = NAFO Division 1D+1E. East Greenland = NAFO Division 1F + ICES Division 14.b.**

Year	TAGGED			
	Fjord	Bank (West) NAFO 1C Tovqussaq	Bank (West) NAFO 1D+1E Dana	East Greenland
2003	599		1061	
2004	658			
2005	565			
2006	41			
2007	1137			1047
2008	231			1296
2009	633			526
2010	88			
2011	28			403
2012	86		1563	2359
2013	186		2321	
2014				1203
2015		57		1220
2016		299	998	1912
2017	350	1871	706	
2018		115		
2019	1040	325		
2020				458

**Table 14.5.2: Number of recaptured cod in the period of 2003 to 2019 in different regions. Fjord (West) = NAFO divisions 1B–1F. Bank (West) = NAFO Division 1D+1E. East Greenland = NAFO division 1F + ICES Division 14.**

	RECAPTURES			
	Fjord (West)	Bank (West) NAFO 1C Tovqussaq	Bank (West) NAFO 1D+1E Dana	East Greenland
Fjord (West)	547	3	29	8
Bank (West) NAFO 1C, Tovqussaq		1		4
Bank (West) NAFO 1D+1E, Dana		2	69	
East Greenland			35	118
Iceland	3		45	192

14.14 Figures

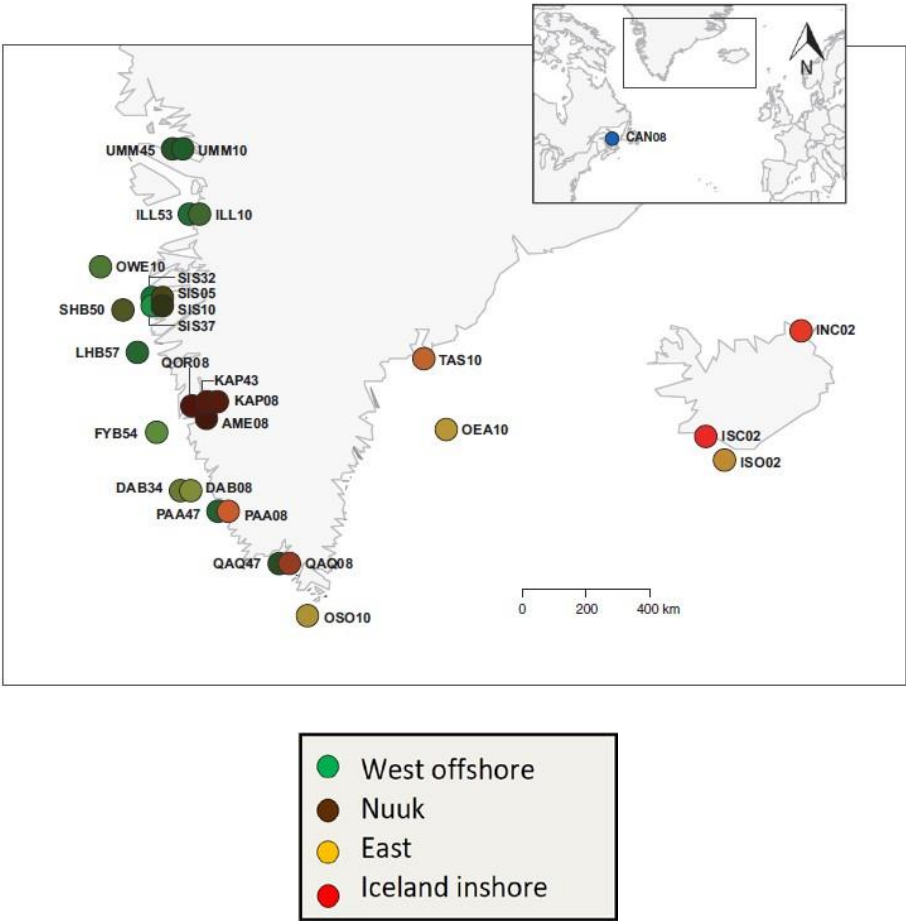


Figure. 14.1. Sampling location of spawning cod in Greenland and Iceland in the genetic project. The colours of the dots represent the blends of sample mean of the different spawning population: West offshore, Nuuk (inshore), East (Greenland and offshore Iceland) and Iceland inshore as signal intensities of green and red, respectively. After Therkildsen *et al.* (2013).

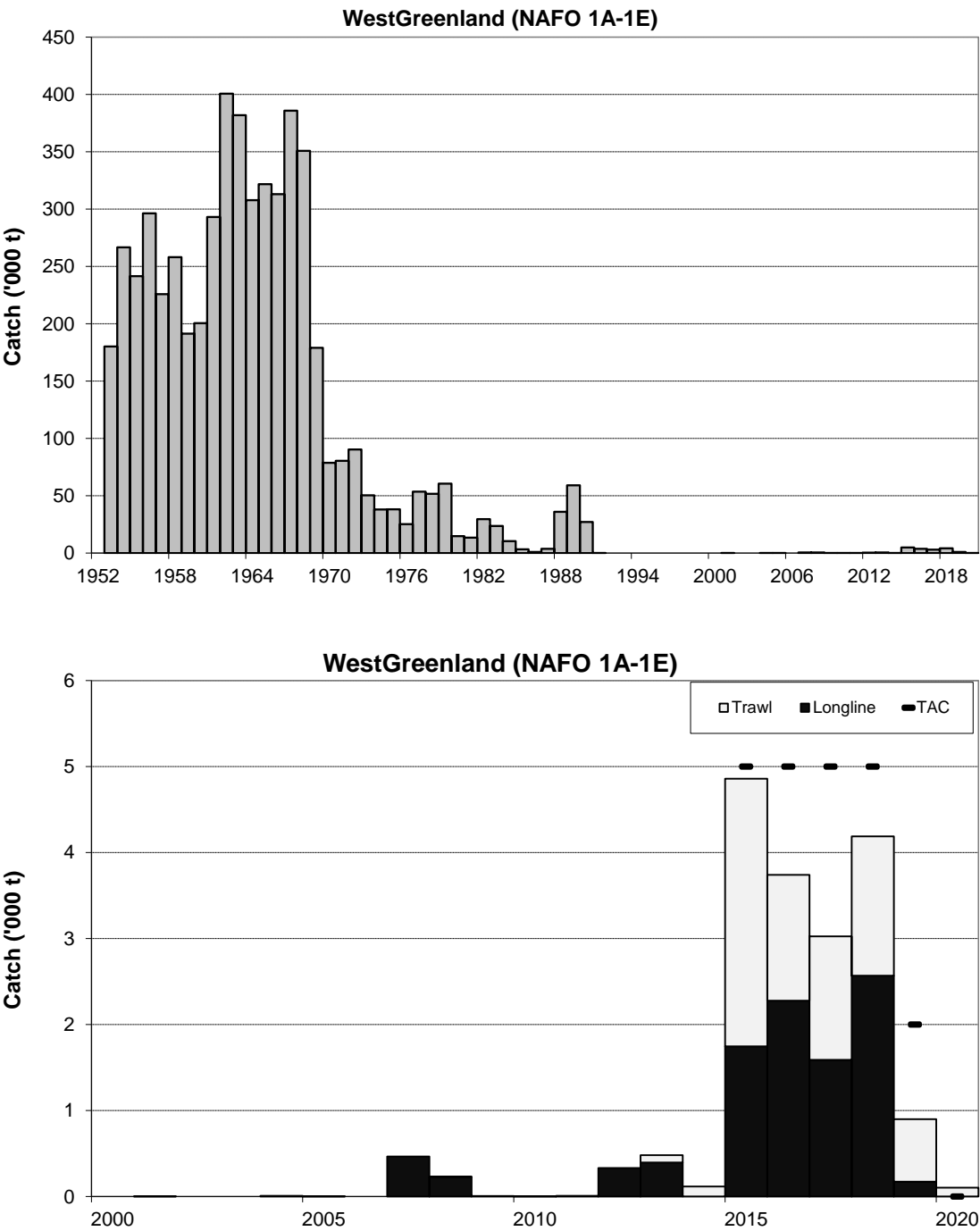


Figure 14.2.1. Annual catch of cod in offshore West Greenland (NAFO subdivisions 1A–1E) used by the Working Group. Top: from 1952, bottom from 2000.

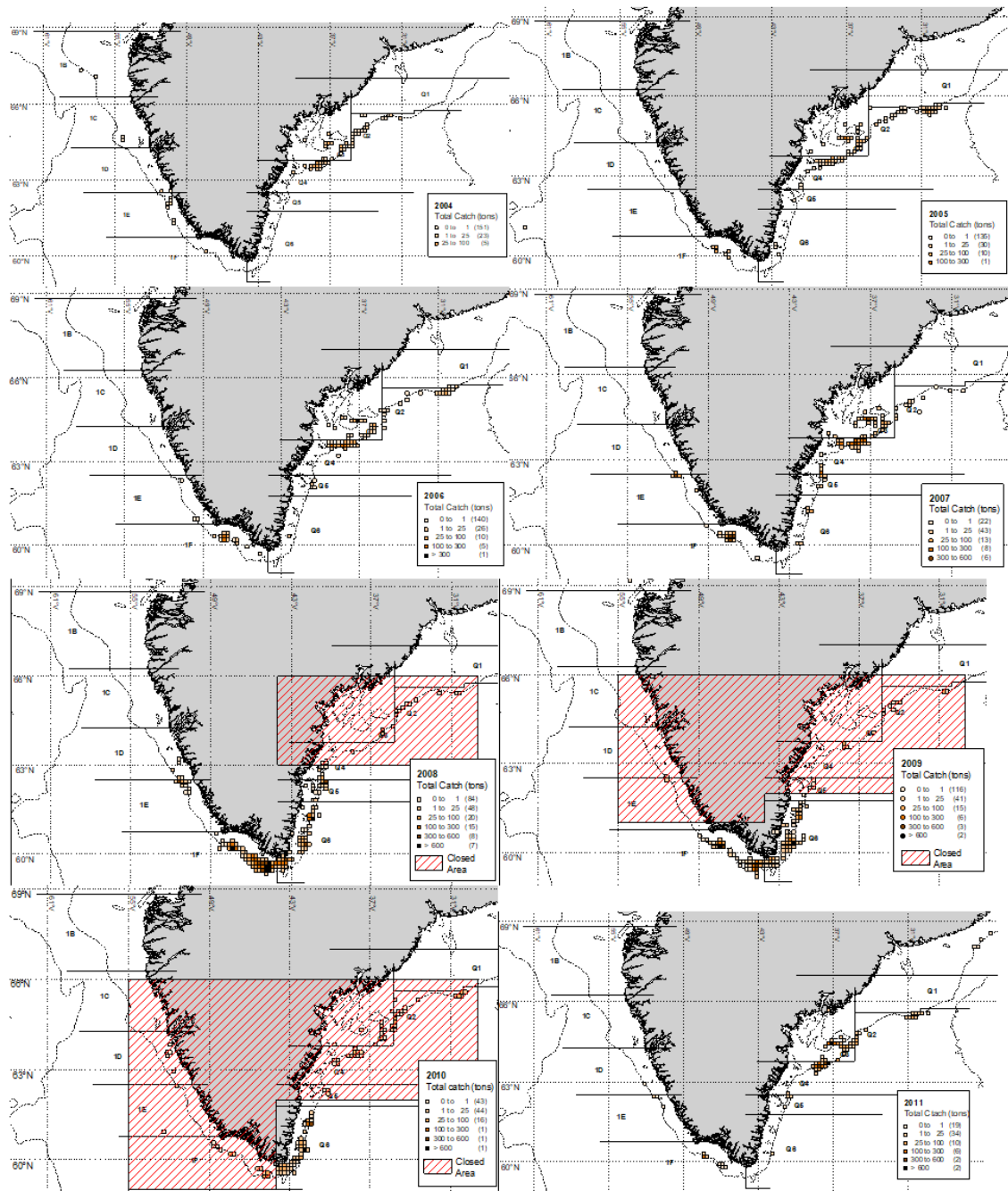


Figure 14.2.2.1: Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

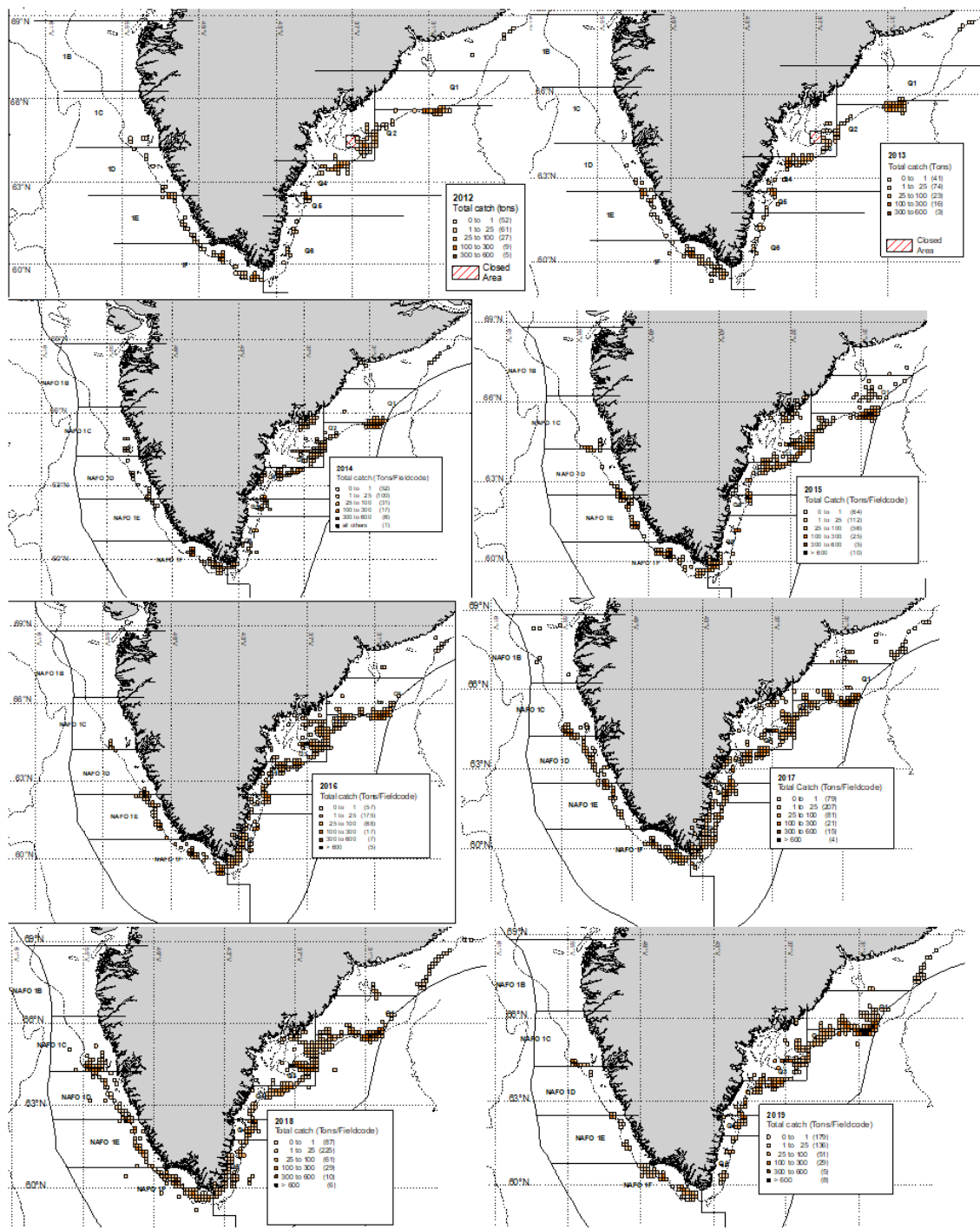


Figure 14.2.2.1: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

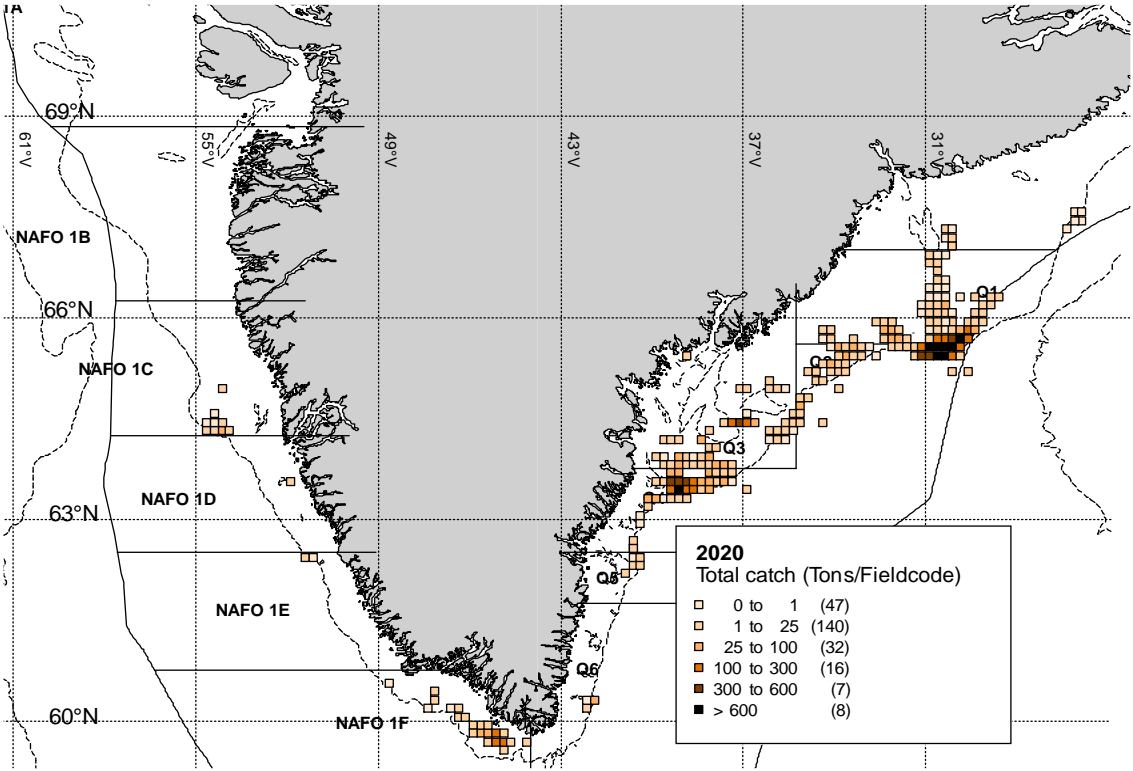


Figure 14.2.2.1: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

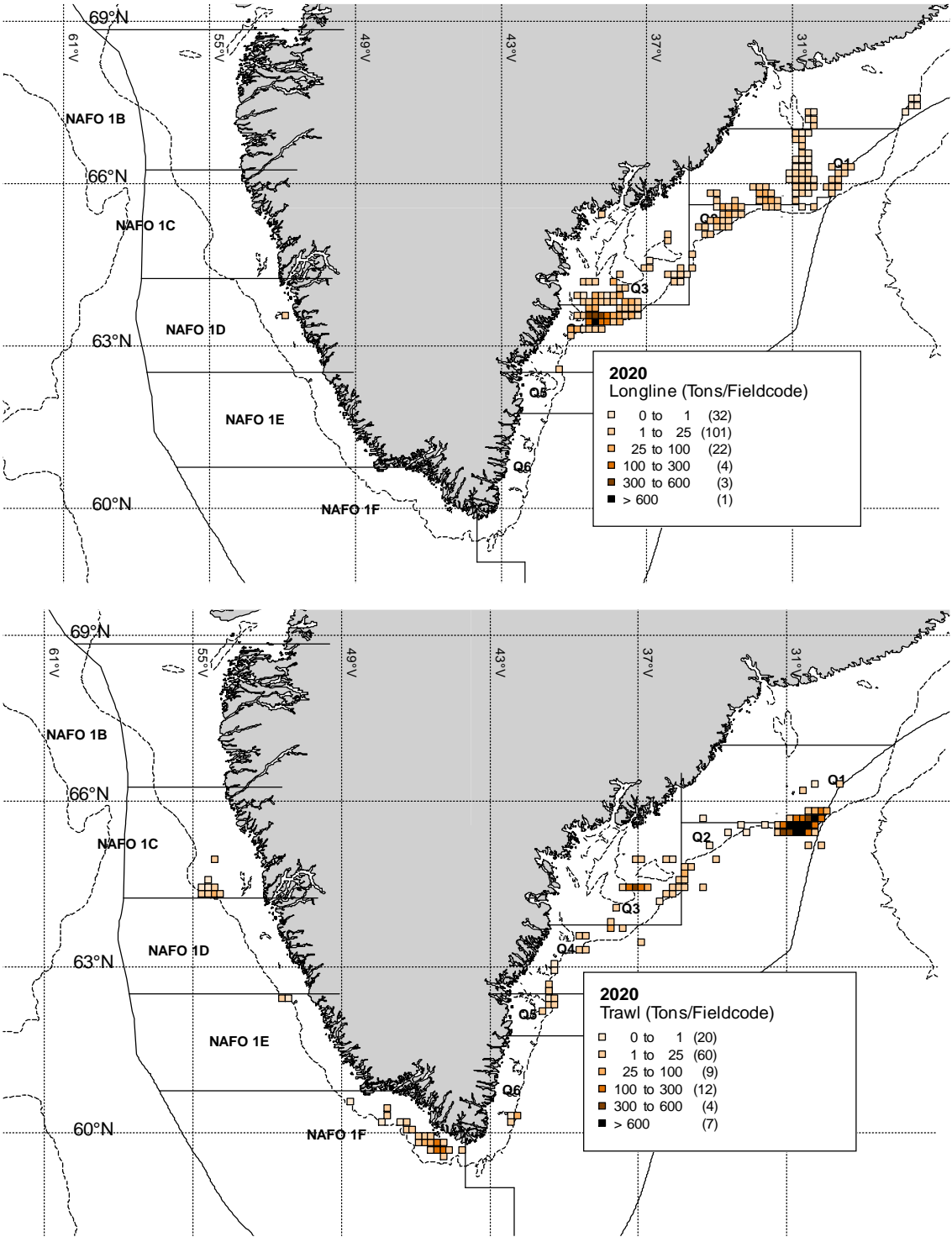


Figure 14.2.2.2: Distribution of Longline and Trawl catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.



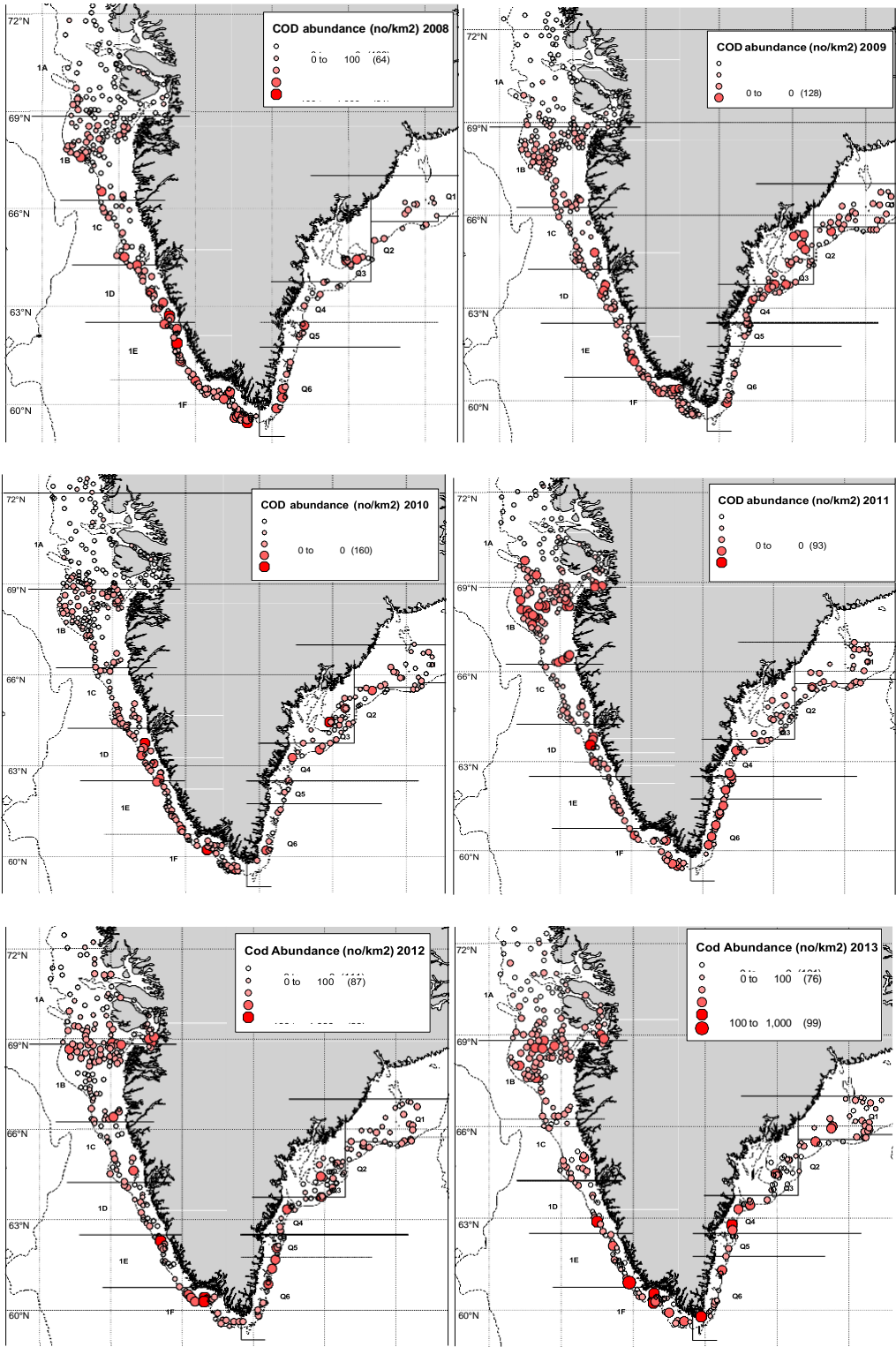


Figure 14.3.1.1. Greenland shrimp and fish survey. Abundance per km².



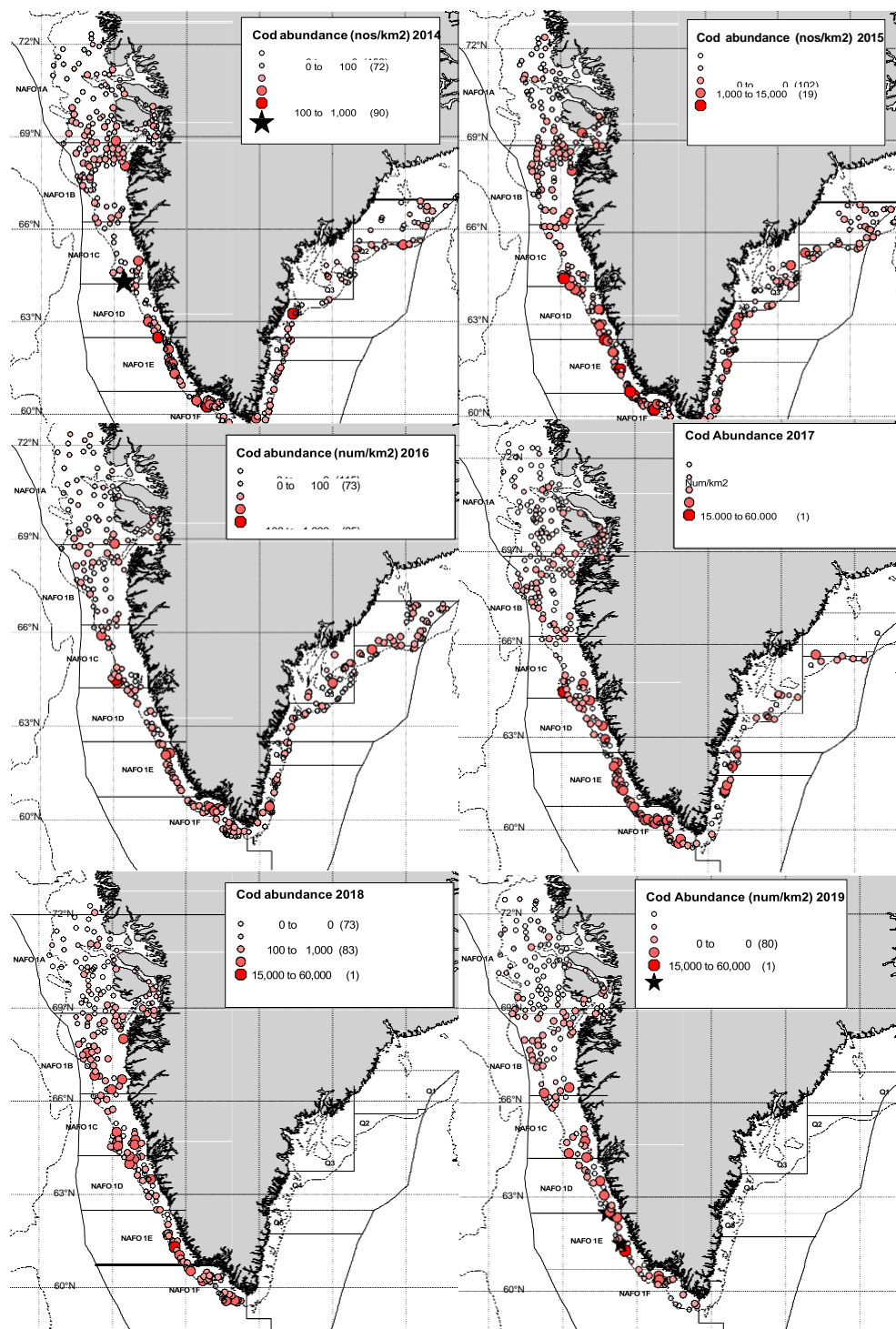


Figure14.3.1.1. continued. Greenland shrimp and fish survey. Abundance per km<sup>2</sup>.

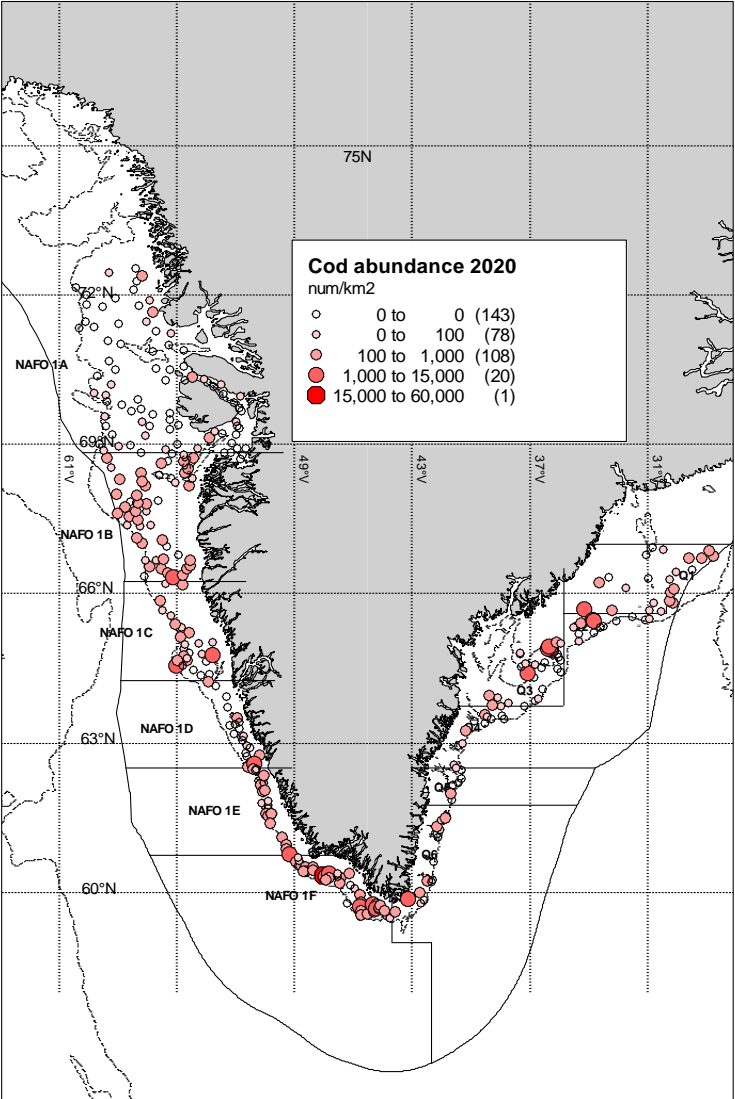


Figure 14.3.1.1. continued. Greenland shrimp and fish survey. Abundance per km<sup>2</sup>.

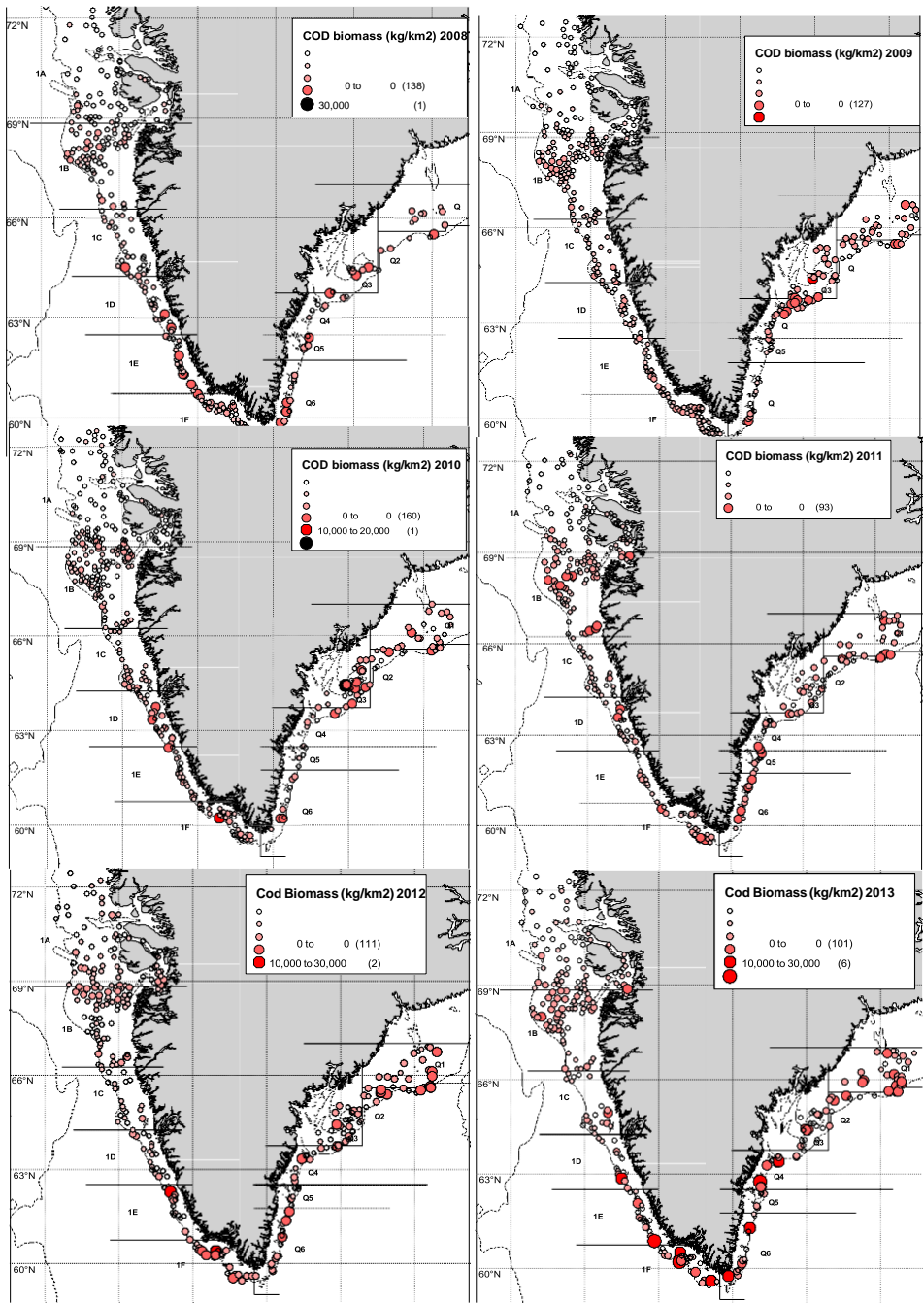


Figure 14.3.1.2. Greenland shrimp and fish survey. Catch weight kg per km<sup>2</sup>.

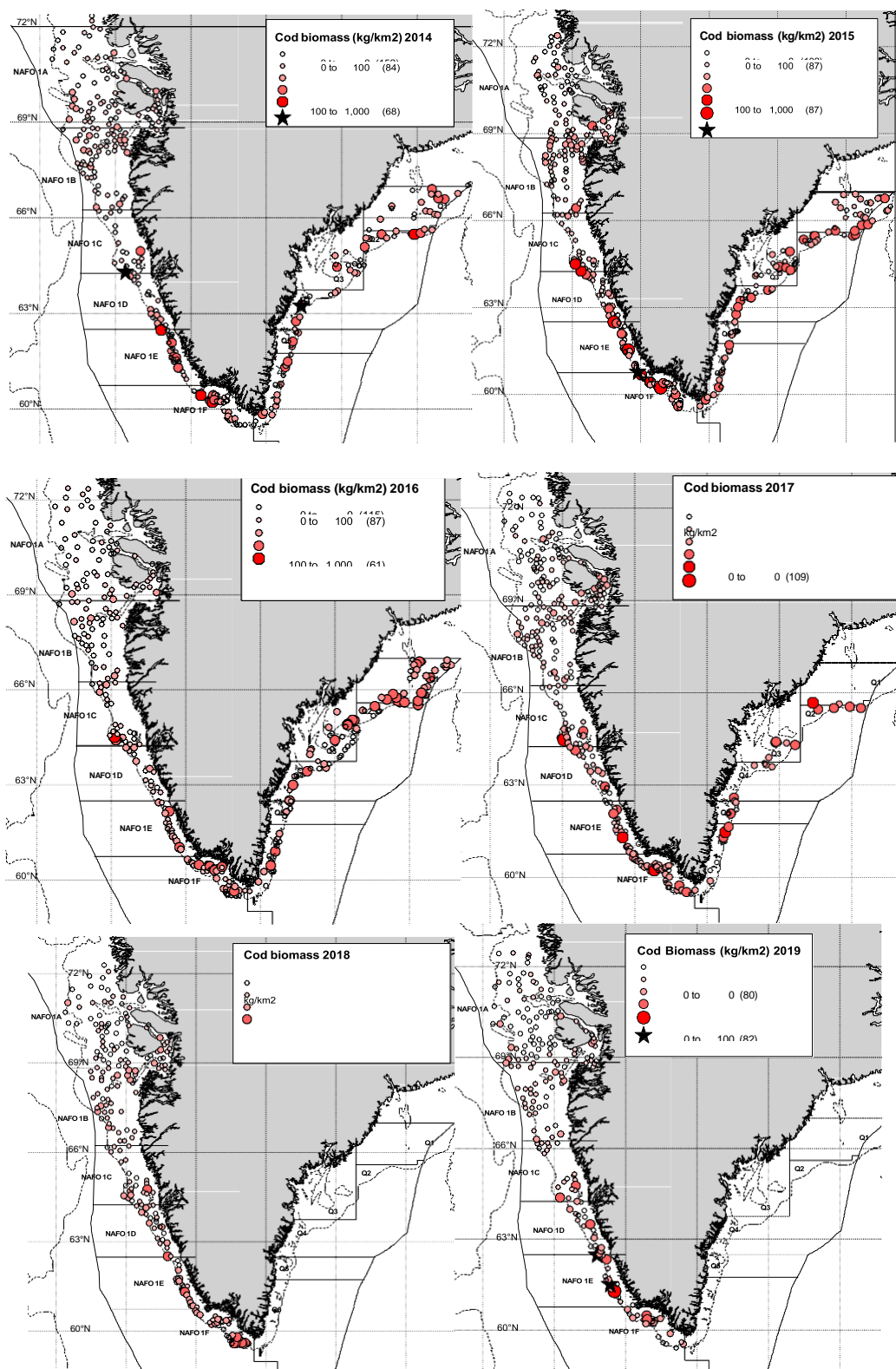


Figure 14.3.1.2. continued. Greenland shrimp and fish survey. Catch weight kg per km<sup>2</sup>.

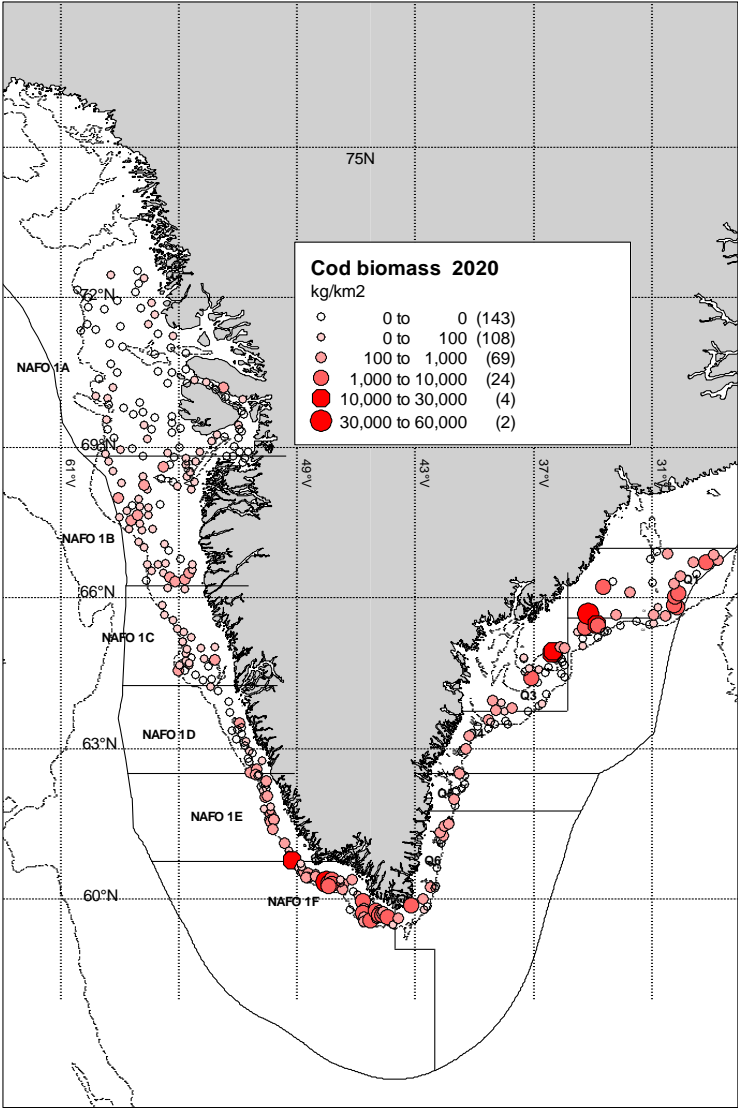


Figure 14.3.1.2. continued. Greenland shrimp and fish survey. Catch weight kg per km<sup>2</sup>.

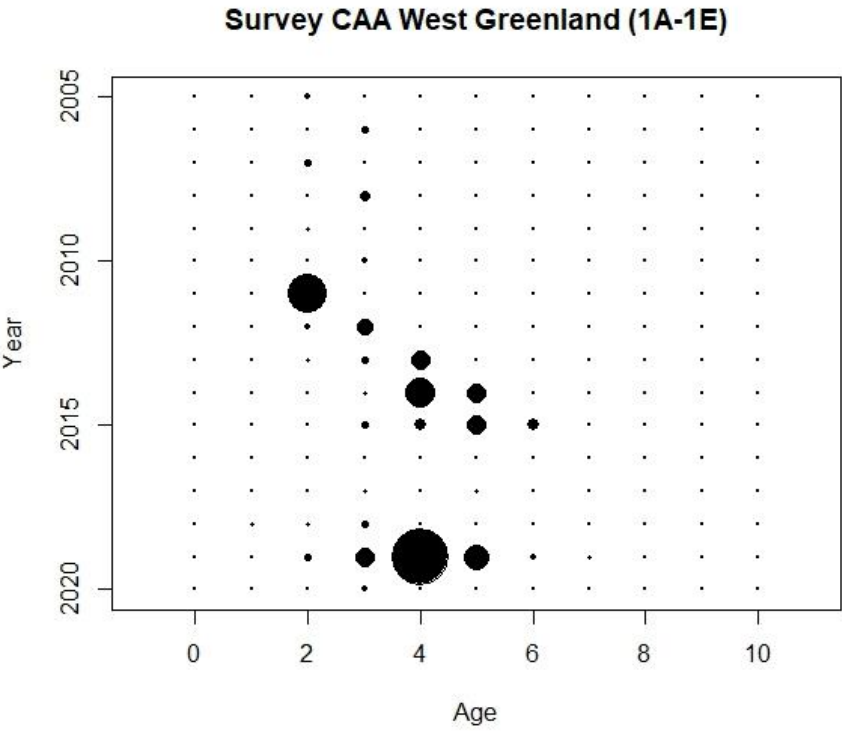
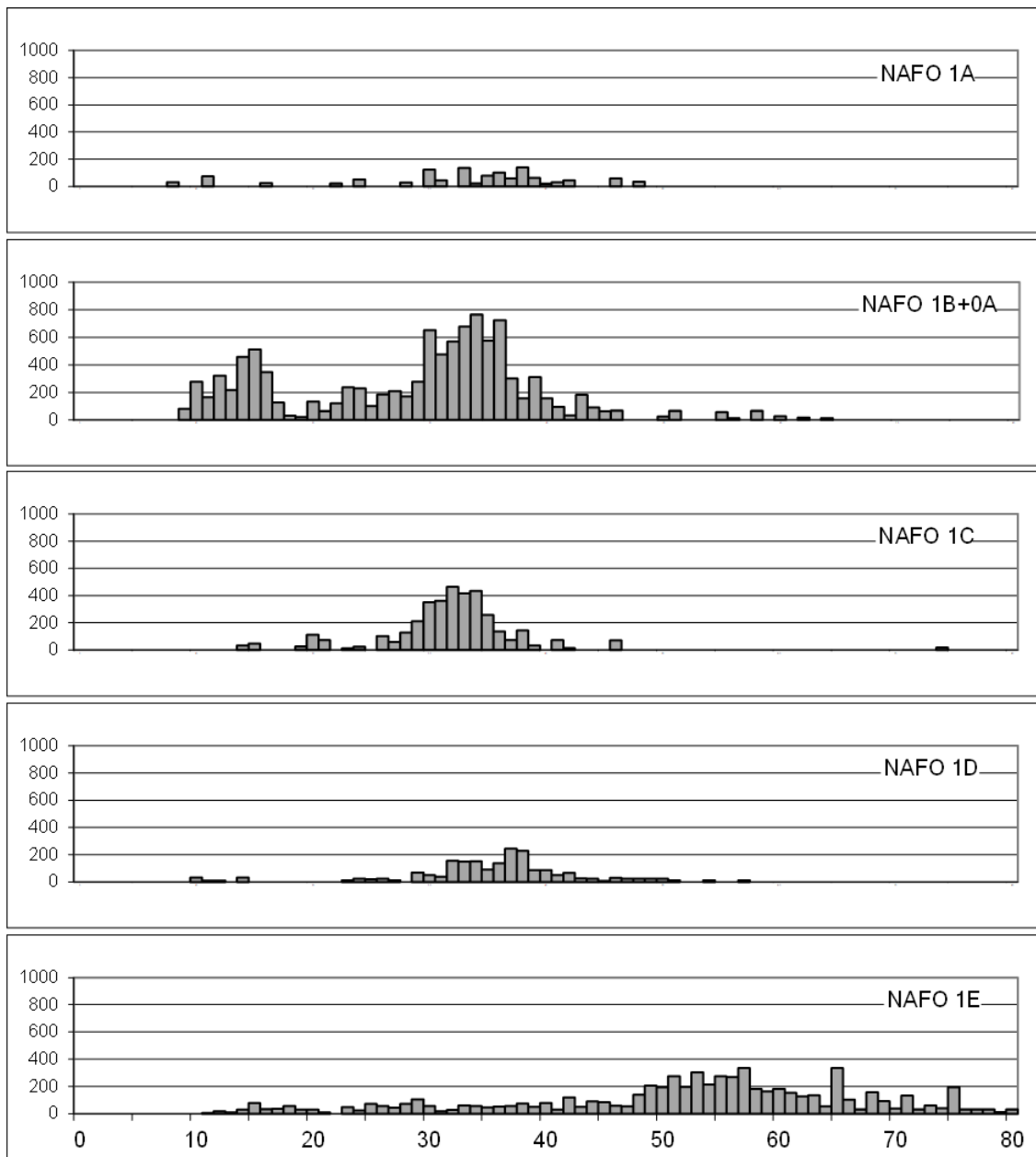


Figure 14.3.1.3: Abundance index by age in NAFO 1A–1E combined. Size of circles represents index size of index.



**Figure 14.3.1.4: West Greenland Shrimp and fish survey. Abundance index by length (cm) and area. Areas from north (top) to south (bottom ) are: NAFO division 1A; 1B+0A; 1C, 1D, 1E.**

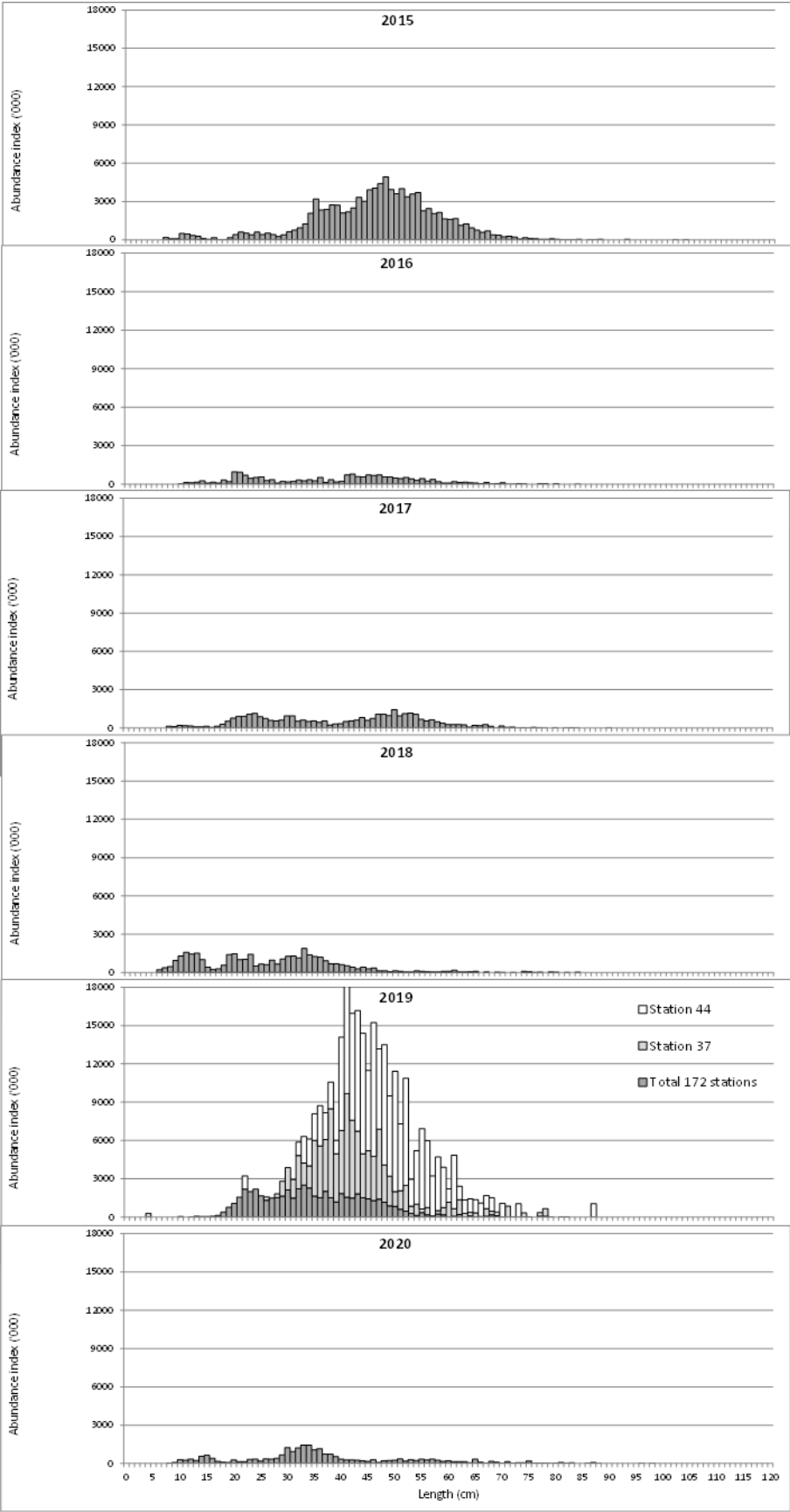


Figure 14.3.1.5: Total abundance indices by length in West Greenland shrimp and fish survey (NAFO 1A–1E).



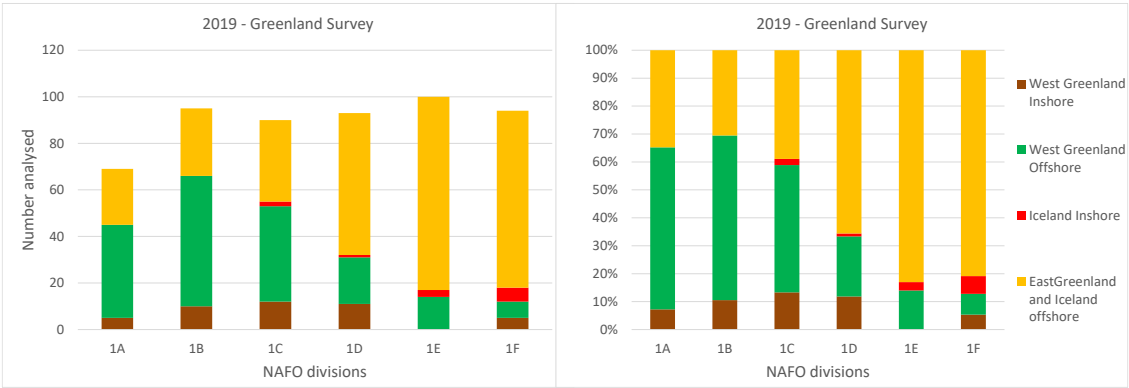


Figure 14.3.1.6: Genetic split in the 2019 trawl survey by NAFO divisions in numbers analyzed and %.

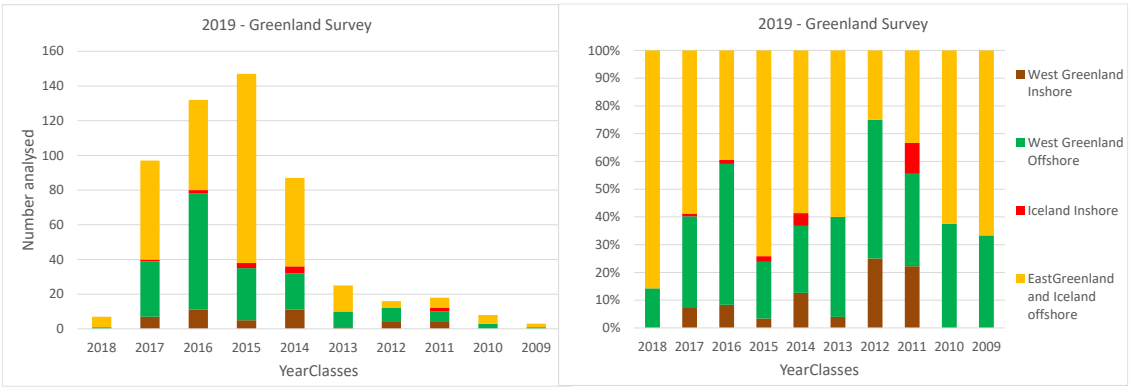


Figure 14.3.1.7: Genetic split in 2019 trawl survey by year-class in numbers analyzed and %.

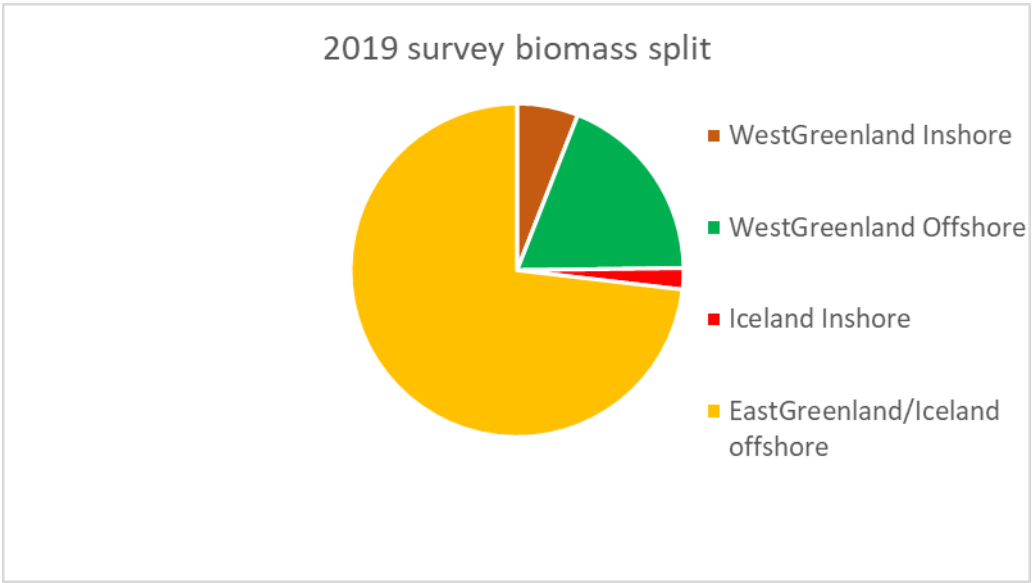


Figure 14.3.1.8: Genetic split weighted with biomass from each NAFO area in the 2019 survey biomass indices.



Figure 14.3.1.9: Genetic split in 2019 trawl survey by year class within NAFO divisions in numbers analyzed and %.

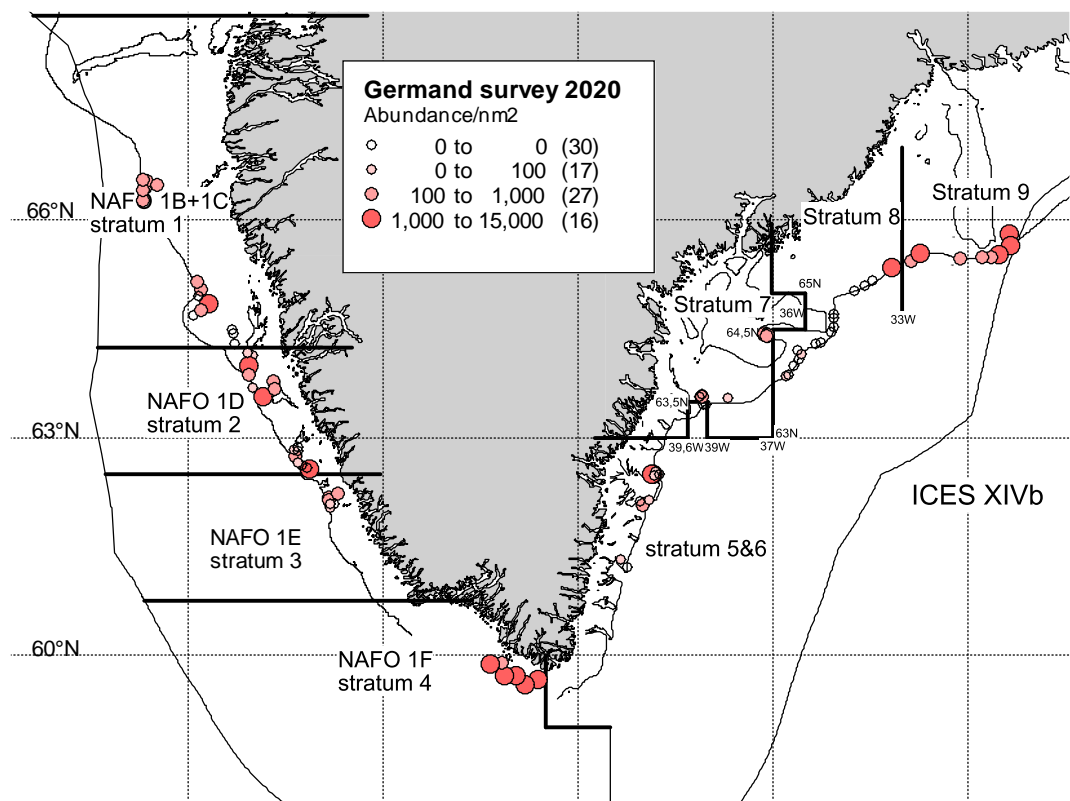


Figure 14.3.2.1. German ground fish survey. Abundance per nm<sup>2</sup>.