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A preliminary estimate of Atlantic cod (*Gadus morhua*) biomass in West Greenland offshore waters (NAFO Subarea 1) for 2013 and recent changes in the spatial overlap with Northern shrimp (*Pandalus borealis*)

by

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Abstract

Catches of Atlantic cod in West Greenland waters were compared between the German groundfish survey and the Greenland survey for shrimp and fish. The analysis was restricted to years with regions included in both surveys. The two survey's estimates of cod biomass were closely correlated ($r^2 = 0.88$, $P < 0.001$). Linear regression analysis using data from 20 years revealed that the biomass index of Atlantic cod biomass estimated from the Greenland survey for 2013 would correspond to 98 600 tons in the German survey. This 2012 and 2013 offshore biomass of Atlantic cod is at the same level as the 2006–2007. The spatial overlap between Atlantic cod and Northern shrimp has decreased in 2013 as the cod biomass was primarily observed in South West Greenland.

Introduction

Hvingel (2002, 2003) incorporated the effect of cod predation into a surplus-production model for assessing the stock of Northern shrimp (*Pandalus borealis*) in West Greenland (Hvingel and Kingsley, 2002). Tests of the assessment model showed that including cod predation markedly improved the fit to the data. STACFIS and the Scientific Council of NAFO have adopted this model, including predation by cod, since 2002 (Anon., 2004) for the assessment of the shrimp stock. No consistent time series of Atlantic cod biomass exist for the different stock components and therefore Hvingel and Kingsley (2002) constructed a cod biomass series for West Greenland based on VPA estimates of stock size for East and West Greenland combined for the period 1955 to 1991 and separate survey indices for East and West Greenland offshore waters available since 1982. From 1993 and forward the time series used in the model was derived from a German offshore cod survey in West Greenland waters alone. This survey is conducted each year in autumn (October-November) and its results are not available at the time the assessment for Northern shrimp is carried out. Instead, information on Atlantic cod abundance and biomass from a Greenland bottom trawl survey for shrimp and fish, which commenced in 1988 and which is carried out in summer (July-September), could be used to assess the actual impact of predation by Atlantic cod on the stock of Northern shrimp. The two surveys, however, do not survey exactly the same area and in some years, area coverage or data sampling has been insufficient in one or the other survey.

Wieland and Storr-Paulsen (2004) compared different time series of Atlantic cod biomass in West Greenland offshore waters and concluded that either of the two methods used by Hvingel and Kingsley (2002) could lead to a substantial overestimation of the impact of predation by Atlantic cod on Northern shrimp. They recommended a time series of Atlantic cod biomasses based on VPA estimates by Buch et al. (1994) and survey indices, which

avoided some of the inconsistencies of the data series used in Hvingel & Kingsley (2002). The survey index series has recently been revised, so the factor used by Wieland and Storr-Paulsen to convert survey-index values to equivalent VPA values for years after 1989 was recalculated for 2013 as $\sum\limits_{1982}^{1989} VPA \Big/ \sum\limits_{1982}^{1989} Survey$ using the revised survey index.

This paper presents an update of a comparison of Atlantic cod biomass estimates from the Greenland survey for shrimp and fish and the German groundfish survey from the last year (Retzel 2012). It provides a preliminary estimate of Atlantic cod biomass in West Greenland waters for 2013 that is comparable to the biomass indices from previous years for the area covered by the German survey. Furthermore, the paper examines changes in the spatial overlap between Atlantic cod and Northern shrimp and suggests an alternative time series of Atlantic cod biomass for consideration in the assessment of Northern shrimp.

Materials and Methods

The Greenland bottom-trawl survey for fish and shrimps ('Greenland survey') covers the offshore areas at West Greenland and has been conducted annually from 1988. The area has been expanded through time and since 1992 the survey has covered the area between 72°30'N and 59°15'N (NAFO Division 1A–1F) from the 3 nautical mile limit to the 600 m depth contour (Fig. 1) and the inshore area Disko Bay. The survey area is divided into NAFO Divisions, which are further subdivided into four depth strata (≤ 150 m, 151–200 m, 201–400 m and 401–600 m). The survey was originally designed as a shrimp survey and sampling of fish data was not complete in 1988–1991. Since 1992 the sampling of fish has improved and it is now considered as a combined survey for shrimp and fish (Nygaard and Jørgensen, 2011). The survey is designed as a stratified random trawl survey with a minimum of two hauls per stratum. The sampling period is June to August and throughout the entire time period the survey has been conducted by the Greenland Institute of Natural Resources with the research trawler RV *Pâmiut.* Shrimp trawls with a 10–12 m vertical opening have been used, equipped with a heavy bobbin chain ground gear until 2004 (Skjervøy 3000) or a rockhopper bobbin/rubber disc ground gear since 2005 (Cosmos 2600). Towing speed has been about 2.5 knots (see Kingsley 2011 for further details on the survey design).

The 'German survey' is a stratified-random trawl survey for groundfish covering the shelf area outside the 3 nautical mile limit and the continental slope down to a depth of 400 m off East and West Greenland between 67°00'N and 59°00'N (ICES area 14 and NAFO Divs. 1B–1F, Fig. 1). The Institute for Sea Fisheries, Germany, has conducted this survey annually since 1982. The primary target is cod, and the fishing gear used is a groundfish trawl rigged with heavy ground gear. Towing speed is 4 knots. The survey provides swept-area estimates of numbers (by age) and biomass (all ages pooled) for the East and the West Greenland offshore component, which form the primary basis for the evaluation of the status of the offshore cod stock (ICES, 2013). This survey index series has recently been revised.

Area coverage was incomplete in one or the other surveys the following years and areas:

- NAFO Div. 1A and 1BN have always been covered by the Greenland survey only,
- the northern areas, i.e. 1B and NAFO Div. 1C, were not covered in the German survey in 1995, in 2001 to 2003, in 2005 and 2011,
- In 1995 NAFO Div. 1D was not covered by the German survey.

Consequently, new annual indices of Atlantic cod abundance and biomass were calculated for the Greenland survey for all years since 1992 excluding areas for which no corresponding data have been available from both surveys.

Final factors for converting cod catches from 2005 to 2013 made with the Cosmos trawl to Skjervøy catches from the period 1998–2004 are yet not available. Therefore the 2005 to 2013 estimates were converted preliminarily to the old trawl standard using a size-independent conversion of total catches and an adjustment for the smaller average swept area fished with the old trawl (Nygaard and Jørgensen, 2012).

$$Cod_{Skjervøy} = 1/1.78 * 1.15 * Cod_{Cosmos} = 0.65 * Cod_{Cosmos}.$$

The major difference between the two trawls is the ground gear, and Lewy *et al*. (2004) reported a conversion factor of about 0.5 in such a case, which is close to the value used here.

The changes in the geographical distribution of Atlantic cod and Northern shrimp were examined using data from the fishery and from the two surveys described above. Commercial catches reported by NAFO Division have been available for Atlantic cod from Horsted (2000) for the period 1953–1991 and for Northern shrimp from Kingsley and Hvingel (2005) for the period 1975–2005. These values were used to calculate mean latitude of the catches based on the midpoints of the geographical boundaries of the NAFO Divisions (Fig. 1) weighted by the aggregated catches. Here, the northern limit of NAFO Division 1A was set to 73°00' N and the southern limit of NAFO Division 1F was set to 59°30' N considering the main distributional range of the fishery for the two species.

Wieland et al. (2006) have applied a geostatistical tool, the global index of collocation (GIC) developed by Bez and Rivoirard (2000), to examine the spatial overlap of Atlantic cod and Northern shrimp based on geo-referenced survey data. These results were used to establish a regression between the GIC and the mean latitude of survey biomass of Atlantic cod. This relationship was used to estimate GIC values back in time, i.e. for the periods in which only commercial catch data by NAFO division and no survey data by set were available or the survey appeared to insufficient due to poor area coverage either in the German or the Greenland survey.

The German survey is considered to provide the key series of cod biomass indices for the assessment of the West Greenland shrimp stock, but its results are not available in time for the current year's assessment, whereas a result from the Greenland survey is. An interim prediction of the current year's German survey index is obtained by calibrating the Greenland survey result with a log-log regression of past German survey results on Greenland survey results, which experience has shown to be well correlated.

Results and Discussion

The recalculated factor for converting survey to VPA estimates of cod biomass was 1.785.

The Greenland index for 2013 with the 'Cosmos' trawl was 84 145 t for the surveyed area and 76 955 t for the area covered by the German survey. A 'Skjervøy' equivalent to the latter value was 49 787 t. For 1992–2012 a log-log regression of the German survey index on the Greenland index had a slope of 94.05%, an intercept of 0.5761, and a coefficient of determination of 89.1%. Applied to the 2013 Greenland 'Skjervøy' index, this predicted 98 609 t for the German survey in 2013 in NAFO Divs 1Bs (south of 67°N) to 1F (Tab. 2 and Figure 4). This is similar to the estimate for 2012 and about 25% higher than the 2006 and 2007 values when a strong 2003 year class was found offshore.

For the most recent years, the survey estimates of stock biomass indicated a pronounced southern distribution of Atlantic cod. In 2011 however increased numbers of small cod (25-30 cm, age 2, YearClass 2009) have been found in the northern NAFO subarea 1B. In 2012 and 2013 the '2009 YearClass' were observed in the southern NAFO subarea 1E and 1F (Tab. 1 and Figure 3) and no longer in the northern NAFO subarea 1B. The spatial overlap between shrimp and cod has been reduces since 2011 and the 'effective' 2013 cod biomass at 36.2 ttons is therefore lower compared to the 2012 value at 54.9 ttons.

Acknowledgements

References

ANON. 2004. Scientific Council Meeting –October/November 2004. *NAFO SCS Doc.*, No. 20, Serial No. N5061.

BURMEISTER, A, M.C.S. KINGSLEY AND H. SIEGSTAD 2013. The West Greenland trawl survey for *Pandalus borealis*, 2013, with reference to earlier results. *NAFO SCR Doc.*, No. 13/056 Serial No. N6217.

BEZ, N., and J. RIVOIRARD. 2000. Indices of collocation between populations. In: Checkley, DM, Hunter, LR, Motos, L, van der Lingen, CD (eds.). Report of a workshop on the use of the Continuous Underway Fish Egg Sampler (CUFES) for mapping spawning habitats of pelagic fish. GLOBEC Report 14: 48-52.

FOCK, H. 2013. Update of Groundfish Survey Results for the Atlantic Cod Greenland offshore component. After re-stratification of the survey 1982-2012. WD27 ICES NWWG 1-23.

BUCH, E, S.A. HORSTED, and H. HOVGÅRD. 1994. Fluctuations in the occurrence of cod in Greenland waters and their possible causes. ICES Marine Science Symposia 198: 158-174.

HORSTED, S.A. 2000. A review of the cod fisheries at Greenland, 1910-1995. Journal of Northwest Atlantic Fishery Science 28: 1-112.

HVINGEL, C. 2002. Assessment, prediction and risk analysis of stock development: Shrimp off West Greenland, 2002. *NAFO SCR Doc.*, No. 157, Serial No. N4786.

HVINGEL, C. 2003. Assessment, prediction and risk analysis: Stock development and production of northern shrimp off West Greenland. *NAFO SCR Doc.*, No. 73, Serial No. N4912.

HVINGEL, C., and M. C. S. KINGSLEY. 2002. A framework for the development of management advice on a shrimp stock using a Bayesian approach. *NAFO SCR Doc.*, No. 158, Serial No. N4787.

ICES 2013. Report of the North Western Working Group. *ICES C.M.* 2013/ACOM:07

KINGSLEY, MCS. and C. HVINGEL. 2005. The fishery for Northern shrimp (P*andalus borealis*) off West Greenland, 1970-2005. *NAFO SCR Doc.*, No. 83, Serial No. N5188.

LEWY, P., J.R. NIELSEN and H. HOVGÅRD. 2004. Survey gear calibration independent of spatial fish distribution. Can. J. Fish. Aquat. Sci. 61:636-647

NYGAARD, R. and O. JØRGENSEN. 2012. Biomass and Abundance of Demersal Fish Stocks off West Greenland Estimated from the GINR Shrimp Fish Survey, 1988-2011. *NAFO SCR Doc.*, No. 12/016, Serial No. N6040.

WIELAND, K. and M. STORR-PAULSEN, 2004. A comparison of different time series of Atlantic cod (*Gadus morhua*) biomass at West Greenland and their potential use for the assessment of Northern Shrimp (*Pandalus borealis*) in NAFO Subarea 1. *NAFO SCR Doc.*, No. 71, Serial No. N5051.

WIELAND, K., M. STORR-PAULSEN, and K. SÜNKSEN. 2007. Response in stock size and recruitment of northern shrimp (*Pandalus borealis*) to changes in predator biomass and distribution in West Greenland waters. Journal of Northwest Atlantic Fishery Science 39: 21-33.

Retzel, A. 2012. A preliminary estimate of Atlantic Cod (*Gadus morhua*) biomass in West Greenland offshore waters (NAFO Subarea 1) for 2012 and recent changes in the spatial overlap with Northern shrimp (*Pandalus borealis*). *NAFO SCR Doc.*, No. 12/057, Serial No. N6119.

Tab. 1: Observed Cod biomass (tons) by survey and area. Greenland survey as observed, i.e. without conversion
-: not covered. +: covered but not to be included in the comparison.

Year	German survey Stratum					Greenlandic survey Stratum (without > 400 m depth)				
	1BS+1C	1D	1E	1F	Sum	1BS+1C	1D	1E	1F	Sum
1992	169	48	17	129	363	109	118	0	2	229
1993	122	54	36		212	30	39	124	5	193
1994	30	15	16	9	70	47	0	1	0	48
1995			20	10	30	+	+	3	4	7
1996	48	23	28	101	200	15	23	27	49	114
1997	21	11	53	53	138	55	0	0	0	55
1998	38	8	1	23	70	0	47	50	3	100
1999	27	9	68	39	143	6	17	1	0	24
2000	125	94	78	22	319	75	9	2	46	132
2001		180	1029	93	1302	+	178	98	100	376
2002		105	143	976	1224	+	1489	42	150	42
2003		142	768	378	1288	+	453	118	46	555
2004	255	319	733	2122	3429	183	680	685	305	1853
2005		729	1942	10925	13596	+	1317	1047	38765	41129
2006	240	45866	2660	32297	81063	420	5180	545	19111	25256
2007	1204	1823	7847	75716	86590	223	582	471	21091	22367
2008		399	11654	18887	30940	1051	2133	4106	23719	31010
2009		602	525	860	1987	458	314	361	308	1441
2010	1256	2546	2876	3902	10580	419	2058	787	2728	5991
2011		317	1234	12783	14334	1806	3849	179	3902	9736
2012	53085	4425	9051	34241	100802	1416	228	14104	15804	31552
2013						1999	4335	19015	51606	76955

Tab. 2:   Time series of Atlantic cod biomass (tons) (*☺

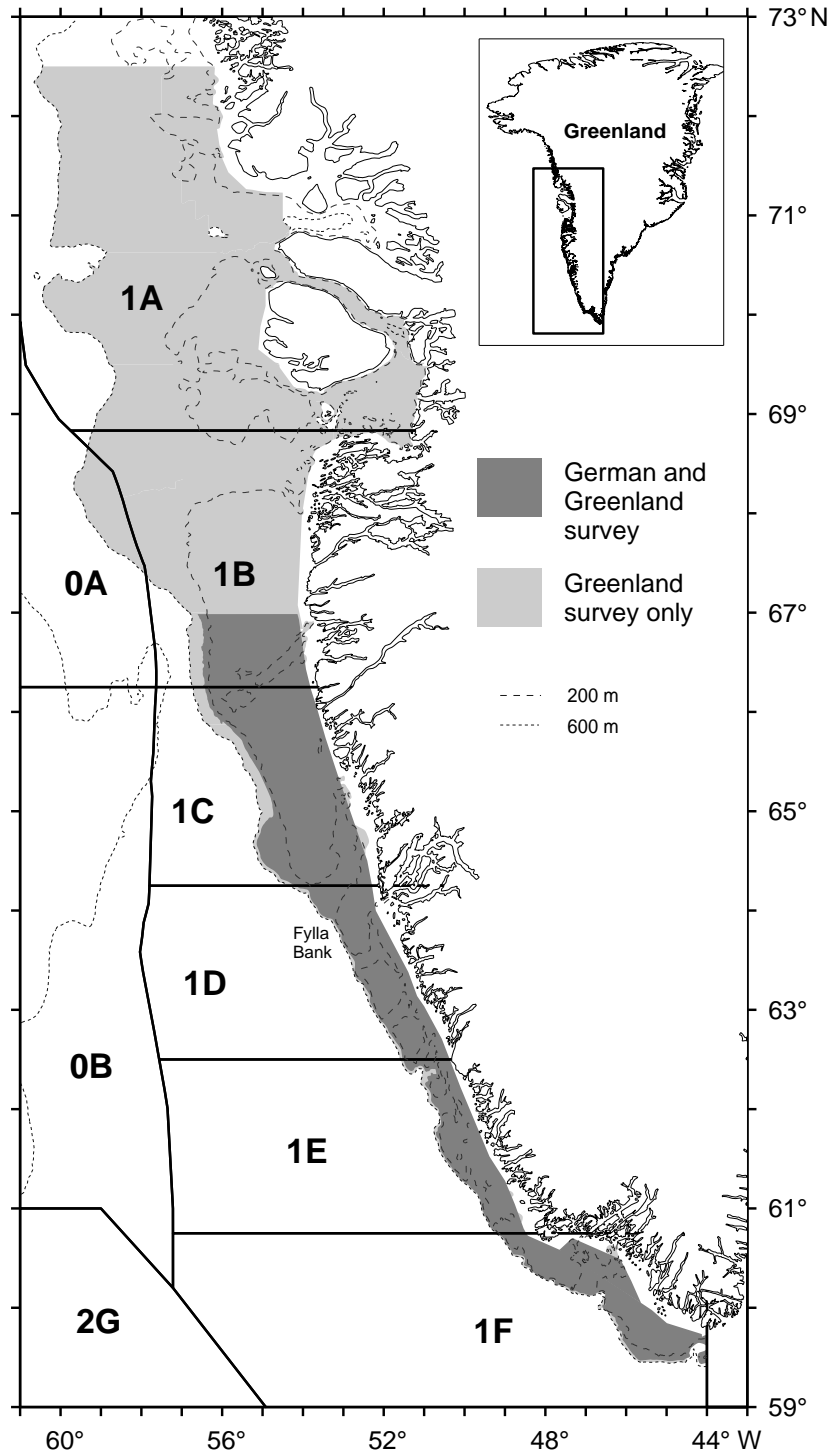| Year	Cod biomass VPA (Buch et al. 1984)	Survey (ICES 2013)	VPA and survey combined *	Spatial overlap GIC Cod - Shr observed	'estimated'	'effective' Cod biomass
1950	4076.5		4076.5			
1951	3722.9		3722.9			
1952	3285.7		3285.7			
1953	2855.3		2855.3		0.692	1977.1
1954	2848.3		2848.3		0.714	2033.9
1955	2731.4		2731.4		0.703	1919.1
1956	2298.7		2298.7		0.693	1592.7
1957	2037.5		2037.5		0.684	1392.9
1958	1866.2		1866.2		0.674	1258.3
1959	1687.7		1687.7		0.719	1212.6
1960	1823.1		1823.1		0.706	1287.3
1961	1793.9		1793.9		0.704	1263.1
1962	1469.2		1469.2		0.716	1051.3
1963	1328.4		1328.4		0.686	911.2
1964	1327.6		1327.6		0.676	898.1
1965	1345.3		1345.3		0.706	950.2
1966	1254.9		1254.9		0.709	889.2
1967	1167.5		1167.5		0.683	797.4
1968	904.9		904.9		0.639	578.1
1969	637.4		637.4		0.611	389.7
1970	442.2		442.2		0.554	244.9
1971	372.8		372.8		0.587	218.7
1972	283.0		283.0		0.678	191.9
1973	179.5		179.5		0.643	115.4
1974	132.1		132.1		0.642	84.7
1975	108.5		108.5		0.629	68.2
1976	228.8		228.8		0.579	132.5
1977	251.7		251.7		0.574	144.5
1978	253.5		253.5		0.672	170.3
1979	217.3		217.3		0.670	145.6
1980	240.4		240.4		0.680	163.4
1981	178.3		178.3		0.619	110.4
1982	190.9	72.7	190.9		0.518	98.8
1983	134.0	46.6	134.0		0.461	61.7
1984	79.0	14.2	79.0		0.479	37.8
1985	51.7	19.0	51.7		0.482	25.0
1986	38.4	38.9	38.4		0.510	19.6
1987	466.7	316.5	466.7		0.604	282.1
1988	481.2	323.4	481.2		0.618	297.3
1989	403.2	202.3	403.2		0.370	149.1
1990		21.1	37.6		0.289	10.9
1991		3.4	6.0		0.313	1.9
1992		0.4	0.6		0.523	0.3
1993		0.2	0.4	0.633	0.658	0.2
1994		0.1	0.1	(0.356)	0.599	0.1
1995		0.0	0.1	(0.120)	0.483	0.0
1996		0.2	0.4	0.280		0.1
1997		0.1	0.2	0.490		0.1
1998		0.1	0.1	0.390		0.0
1999		0.1	0.3	0.496		0.1
2000		0.3	0.6	0.643		0.4
2001		1.3	2.3	0.462		1.1
2002		1.2	2.2	0.278		0.6
2003		1.3	2.3	0.398		0.9
2004		3.4	6.1	0.257		1.6
2005		13.6	24.3	0.074		1.8
2006		81.1	144.7	0.220		31.8
2007		86.6	154.6	0.139		21.5
2008		31.8	56.8	0.156		8.9
2009		2.0	3.6	0.602		2.2
2010		10.6	18.9	0.315		5.9
2011		14.3	25.6	0.888		22.7
2012		100.8	179.9	0.305		54.9
2013		98.6	176.0	0.206		36.2

Fig. 1.   Survey coverage for the Greenland fish and shrimp survey and the German ground fish survey in West Greenland offshore waters. (*: NAFO divisions 1B and 1C were not covered by the German survey in 1995, in 2001 to 2003, in 2005 and 2011).
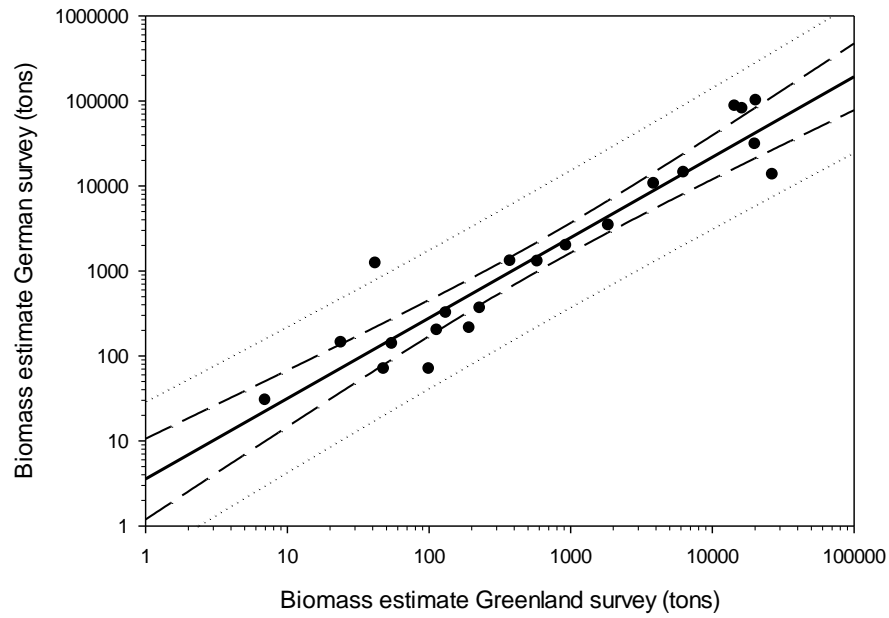
Fig. 2. Relationship between estimates of cod biomass in the overlapping area of the German groundfish survey and the Greenland Bottom Trawl Survey, 1992-2013. Dashed and dotted lines indicate limits of the 95% confidence and prediction intervals, respectively.

Fig. 3.   Geographical distribution of cod density (in kg/km^2) in the Greenland Bottom Trawl Survey in 2013. Numbers in parentheses denotes number of tows.
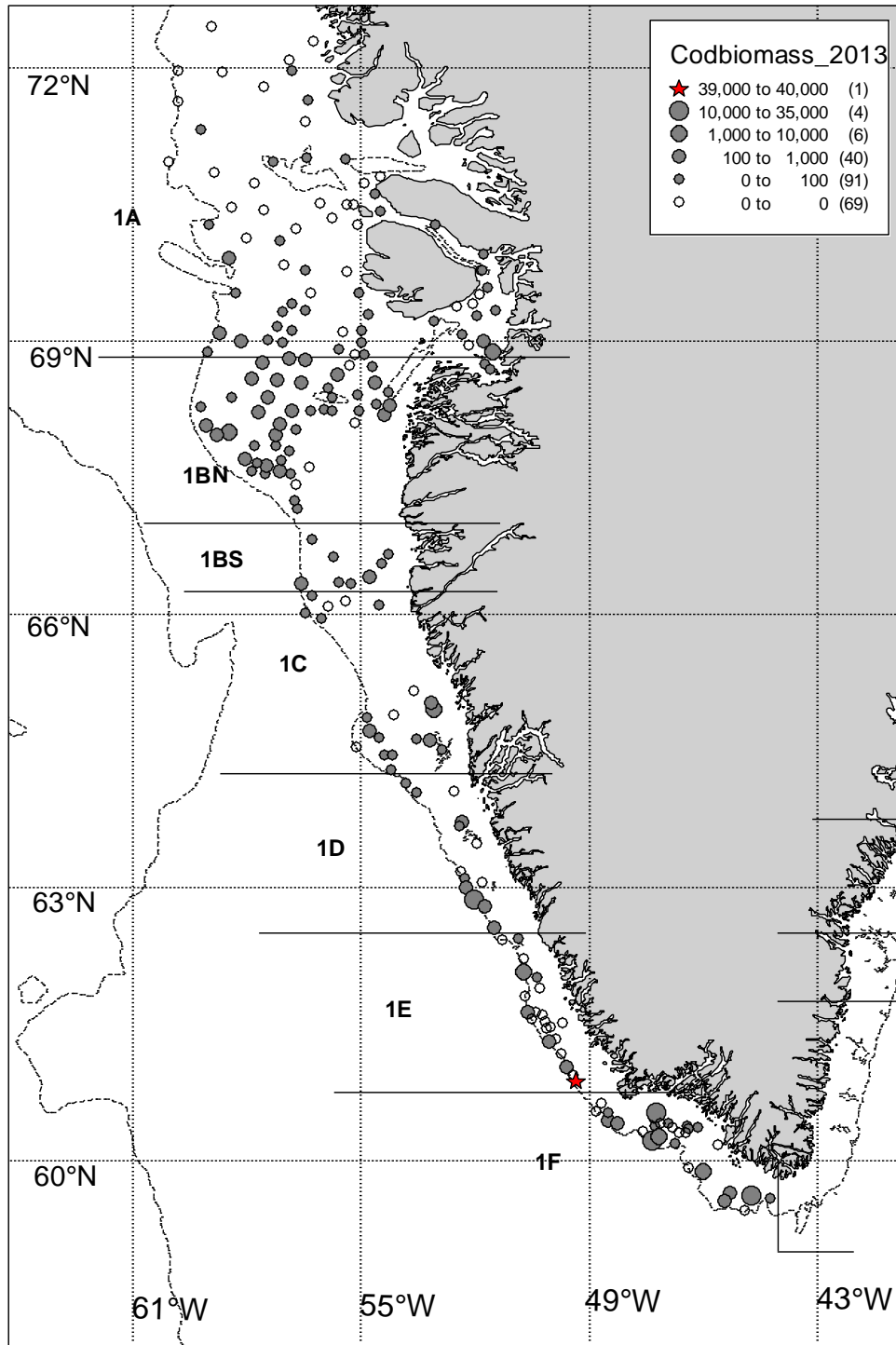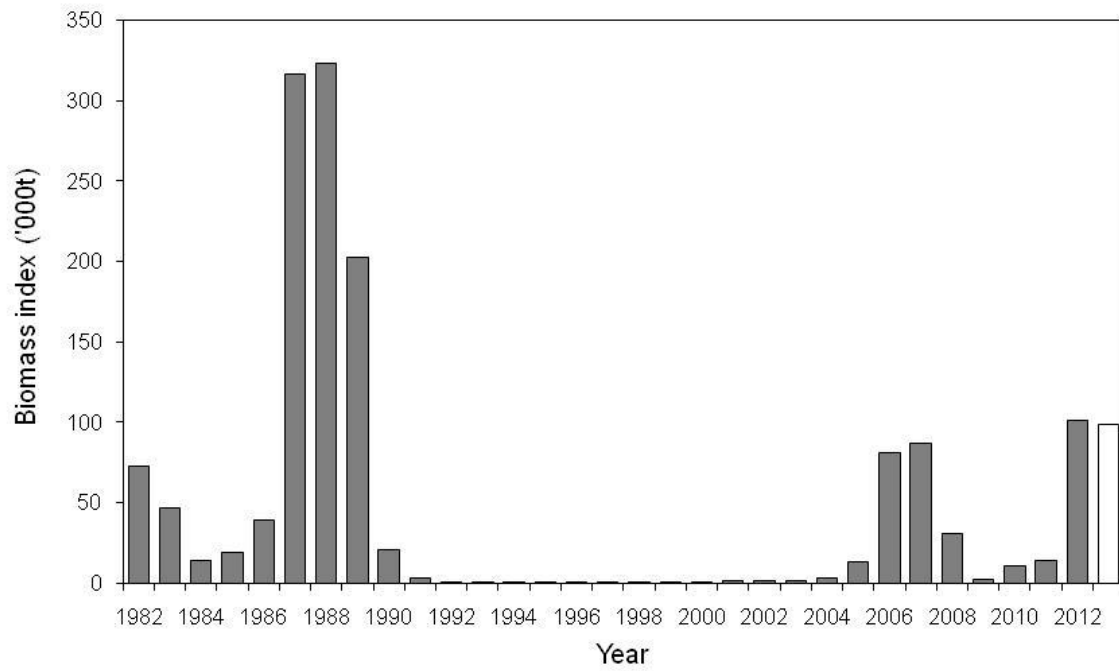
Fig. 4.   Survey indices of Atlantic cod biomass for West Greenland offshore waters, 1982-2013 (1982-2012: original estimates from the German groundfish survey; 2013: estimate based on the Greenland Bottom Trawl Survey).