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**Results of the Greenland Bottom Trawl Survey for Northern shrimp (*Pandalus borealis*)
Off East Greenland (ICES Subarea XIV b), 2008-2020**

by

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Abstract

The 2020 survey for Northern Shrimp (*Pandalus borealis*) in East Greenland estimate the biomass of shrimp to be at the highest level in the current timeseries. The shrimp stock is concentrated in the area north of 64°N and in depth between 200 and 400 meter and the biomass for the entire survey area is low compared to West Greenland. Absence of the smaller male and juvenile shrimp in the survey area stresses that the total area of distribution and recruitment patterns of the stock are still unknown.

Introduction

Since 2008 a stratified-random trawl survey has been conducted to assess the stock status of northern shrimp in East Greenland. There were no surveys in 2017-2019. The main objectives were to obtain indices for stock biomass, abundance, recruitment and demographic composition. The area was also surveyed in 1985-1988 (Norwegian survey) and in 1989-1996 (Greenlandic survey), but the historic surveys is not directly comparably with the recent survey due to different area coverage, survey technique and trawling gear. However, both showed similar levels of biomass and abundance and the presence of large shrimps. Absence of the smaller male and juvenile shrimp in the survey area stresses that the total area of distribution and recruitment patterns of the stock are still unknown.

This document presents results on biomass, abundance and sex-composition from 2008 - 2020 surveys, and attempt to compare these results with survey conducted in 1989-1996.

Material and Methods

The survey is carried out with the same gear and survey protocols as used in West Greenland (Burmeister and Riget 2020). Stratification was based on the "Q-areas" used for the Greenland halibut survey (Fig. 1.) and the area are further depth stratified into 0-200 m, 200-400m and 400-600 m zones (area sizes are given in Tab. 1). Total survey area has been estimated to 118.107 km². Standard tow duration was set to 15 minutes at all stations. Towing speed have been about 2.5 knots in all cases.

Surveys in 2008-2016 were conducted using research trawler *Paamiut* (722 GRT), which is no longer in use. There were no surveys in 2017-2019, and in 2020 chartered fishing vessel *Helga Maria* was used for the survey. The fishing gear (cosmos trawl, doors, bridles, Marport sensors on doors and headlines) from *Paamiut* were used for the 2020 survey to ensure that fishing practices and handling of catch were exactly as on the research ship *Paamiut* (this was the same procedure as used for the survey for Northern shrimp in West Greenland, see



appendix 1 in Burmeister and Riget 2020). This set up has also been used for the survey in West Greenland in 2018-2020 (see Burmeister and Riget 2020).

Stations were randomly selected from historical known trawlable sites (101 planned stations), 9 of the selected positions were not deemed trawlable either due to poor seabed conditions, wrong depth at the location or ice. In most cases these stations were moved and a total of 98 valid hauls were in the 2020 estimates (table 2). Trawling has been carried out days and nights (24 hours). The influence of light induced nocturnal vertical migrations of shrimp has not been taken into account in the estimation of biomass.

Biomass estimation

For each tow, the catch was divided by the estimated swept area calculated from wingspread and track length to estimate haul by haul biomass density. Mean stratum densities were multiplied by the stratum area to compute stratum biomass, and corresponding coefficients of variation (CV, in %) for each stratum were calculated from the swept area estimate of the biomass (B) and the standard deviation of the density times the stratum area (STD) – see Burmeister 2020 for details.

Demography

From each catch a sample of about 0.5 to 3 kg of shrimp was taken and sorted to species, or in cases of a small catch of shrimp the full catch was sorted. All specimens of Northern shrimp were grouped into males, primiparous and multiparous females based on their sexual characteristics according to Allen (1959) and McCrary (1971). The oblique carapace length (CL) of each shrimp in the sub sample was furthermore measured to the nearest 0.1 mm using callipers.

Temperature

Bottom temperature was measured with a *Starmon* sensor mounted on one of the trawl doors. It records at intervals of 30 s with a resolution of 0.01°C. The average temperature for each haul was calculated after retrieval of the sensor. All measurements taken at greater depths than 150 m were used to calculate a mean bottom temperature weighted for the areas of the survey strata between 150 and 600 m depth.

Results and Discussion

Biomass and Stock composition

For all strata biomass estimates have been calculated (Tab.2 and Tab.3) on the basis of the nominal swept area (Burmeister and Riget 2020). Total biomass has been at a low level from 2012-2016 and has increase to the highest level seen in the timeseries in 2020. The CV of the total estimated biomass has improved from previous years and is at the lowest in the timeseries at 17.2 (Tab. 4). The stock is mainly located in the northern part in Q1 with 98% of total biomass in 2020 (Fig. 1 and Fig. 3). Shrimp biomass are at very low densities in the remaining southerly offshore areas (Q2-Q6) (Tab. 2 and Fig. 3). The shrimp occurs mainly between 200 - 400 meter and in 2020 more than 90% of the biomass is found in here.

Throughout the current survey timeseries the demographic structure in East Greenland find close to equal proportions of males and females (Tab. 6), exceptions being 2009 and 2020 were the proportion of females were 34.0 % and 36.9 %, respectively, of the total biomass (Tab. 6). Males are mostly large with 20mm CL as the smallest for several years (Fig. 4a and 4b). A calculation of the fishable biomass of individuals equal to and above 17 mm CL has therefore not been calculated. Smaller males between 10 and 17mm was registered in 2016 and again in 2020 - although in small numbers. Biomass and abundance of female and males weighted up to total biomass are presented in Tab 6 and Tab 7. Female biomass average 1,912 tons for the past 8 years. In 2020 female biomass was on 3,871 tons (Tab. 6) the highest in the timeseries.

Total numbers of shrimp (males and females) in 2020 was estimated to 1179 million, which is the highest in the current timeseries. The average on 430 million for the ten years in the time series. The abundance of males in 2020 is 853 million. The proportion of males relative to females is 72% and one of the highest in the timeseries and similar to the proportions in 2009. In 2020 large numbers of primiparous were recorded compared to previous years. Furthermore, the peak in numbers at carapace length for primiparous are at 28.5 mm whereas the multiparous peak at 27.5 mm, it would be expected that primiparous on average would be smaller than multiparous. There is no biological explanation for this, and it might be a result of misclassification.

Bottom temperature and biomass

The overall mean bottom temperature in the shrimp survey area was stable near 4°C from 2008 to 2020 (Fig. 7). From 2008-2020 the areas south of 65°30 N (Q2-Q6) all have an average temperature between 3°C and 5°C, however temperature in the north of 65°30 N (Q1) average temperature is between 1°C and 2°C. Almost all shrimp biomass is located in north of 65°30 N (Q1).

Comparison with earlier surveys

Stratified-random trawl surveys has been carried out in Denmark Strait in 1989-1992 and in 1994-1996 the surveys was conducted by a sampling technique based on the Spline Designer Software System. The surveys in the 1980s and 1990s was conducted in the shrimp fishing area north of 65N up to 67N. The recent surveys since 2008 covered the shelf area from Cap Farwell to Dorhn area up to 67N. To compare the two survey time series only the areas Q1 and Q2 in recent surveys are used. Table 8 list the biomass estimates, numbers of stations, area covered, cod-end mesh size and survey technique from all surveys in 1980s and 1990s and the recent surveys since 2008. It is difficult to compare the different surveys due to different survey technique and trawling gear. However, the low biomass estimate and the demographic structure in all surveys are similar.

Conclusions

The biomass of shrimp in East Greenland in 2020 is the highest in the series. The survey biomass is concentrated in Q1, similar to the other years in the survey time series. The 2012-2016 biomass were 20% of the estimated 2020 biomass. Absence of the smaller male and juvenile shrimp in the survey area stresses that the total area of distribution and recruitment patterns of the stock are still unknown.

References

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Table 1. Vessels, trawl types and rigging parameters used in the Greenland Bottom Trawl Survey for shrimp and fish, 2008–2020.

	Vessel	Trawl	Bridle length (m)	Wing-spread (m)
2008–2016	Paamiut	Cosmos	54.0	28.1-30
2020	Helga Maria	Cosmos	54.0	32.8

Table 2. Survey estimates of total biomass 2020.

Stratum	Area (km ²)	Stations	Biomass density (t/km ²)	Biomass (Kt)	Biomass error variance	Error coefft of variation (%)
Q1-0	0	1	0.000	0.000	0.000	0.00
Q1-2	35662	17	0.265	9.437	2.885	18.00
Q1-4	6975	5	0.123	0.856	0.366	70.66
Overall Q1	42637	23	0.241	10.293	3.251	17.52
Q2-0	93	2	0.000	0.000	0.000	0.00
Q2-2	7657	9	0.000	0.001	0.000	66.15
Q2-4	1246	2	0.000	0.000	0.000	100.00
Overall Q2	8996	13	0.000	0.001	0.000	57.23
Q3-0	3363	5	0.000	0.001	0.000	100.00
Q3-2	22547	14	0.004	0.097	0.004	63.30
Q3-4	9830	8	0.004	0.044	0.000	34.81
Overall Q3	35740	27	0.004	0.141	0.004	44.60
Q4-0	1337	3	0.000	0.000	0.000	100.00
Q4-2	7770	8	0.000	0.000	0.000	100.00
Q4-4	2054	2	0.001	0.003	0.000	100.00
Overall Q4	11161	13	0.000	0.003	0.000	91.90
Q5-0	469	1	0.001	0.000	0.000	95.00
Q5-2	2785	4	0.001	0.002	0.000	62.09
Q5-4	1819	2	0.000	0.001	0.000	12.98
Overall Q5	5073	7	0.001	0.003	0.000	39.99
Q6-0	6307	6	0.005	0.031	0.000	69.10
Q6-2	6130	8	0.001	0.005	0.000	40.16
Q6-4	2063	2	0.002	0.003	0.000	15.77
Overall Q6	14500	16	0.003	0.040	0.000	55.10
Survey totals	118107	99	0.089	10.481	3.255	17.21

Table 3. Biomass estimates (t) for survey subdivisions and standard errors for the entire survey, 2008–2016 and 2020. Please note that there was no survey in 2017–2019.

Year	Q1	Q2	Q3	Q4	Q5	Q6	Total	SE
2008	1,591	7	312	4	24	17	1,955	882
2009	6,945	325	1,157	1	1	17	8,446	1861
2010	4,307	44	1,882	1	3	2	6,240	1990
2011	5,701	0	367	0	0	9	6,077	1432
2012	2,044	5	335	0	3	1	2,388	687
2013	2,532	9	37	0	1	3	2,581	1041
2014	2,485	1	56	6	3	5	2,555	921
2015	1,559	15	103	1	3	8	1,688	451
2016	1,491	0	73	1	0	22	1,587	420
2020	10,293	1	141	3	3	40	10,481	1804

Table 4. Error coefficients of variation (%) for the biomass estimates for the entire survey area 2008–2016 and 2020.

Year	Q1	Q2	Q3	Q4	Q5	Q6	Total	Number of hauls
2008	54.7	69.3	45.2	100.0	62.9	30.7	45.1	52
2009	25.2	99.8	47.4	52.8	75.0	33.6	22.0	97
2010	22.4	79.0	92.6	75.0	92.5	42.4	31.9	82
2011	25.0		44.6	100.0		40.0	23.6	85
2012	30.7	100.0	83.4	100.0	93.7	60.0	28.8	99
2013	41.1	74.3	56.8	100.0	82.0	50.2	40.3	92
2014	37.1	66.7	41.9	42.6	49.4	41.6	36.0	80
2015	28.6	94.4	63.4	26.7	34.8	43.5	26.7	95
2016	28.0	100.0	53.6	100.0	65.4	76.2	26.4	101
2020	17.5	57.2	44.6	91.9	39.5	55.1	17.2	98
Mean 2008–2020							29.8	

Table 5. Estimated mean densities (kg/km²) for survey subdivisions in 2008–2016 and 2020.

Year	Q1	Q2	Q3	Q4	Q5	Q6	Total
2008	37.3	0.4	7.6	0.3	3.4	1.2	14.0
2009	162.9	17.0	28.2	0.1	0.2	1.2	60.6
2010	101.0	2.3	45.9	0.1	0.4	0.2	44.8
2011	133.7	0.0	8.9	0.0	0.0	0.6	43.6
2012	47.9	0.3	8.2	0.0	0.4	0.1	17.1
2013	59.4	0.5	0.9	0.0	0.1	0.2	18.5
2014	58.3	0.1	1.4	0.4	0.4	0.3	18.3
2015	36.6	0.8	2.5	0.0	0.4	0.5	12.1
2016	35.0	0.0	1.8	0.1	0.0	1.5	11.4
2020	241.4	0.0	3.4	0.2	0.4	2.7	75.3

Table 6. Survey biomass estimates (tons) by sex based on length-weight distributions 2008–2016 and 2020.

Year	Males	Females	Total	Males %	Females %
2008	1025	930	1955	52.4	47.6
2009	5572	2874	8446	66.0	34.0
2010	2940	3300	6240	47.1	52.9
2011	3414	2663	6077	56.2	43.8
2012	1230	1158	2388	51.5	48.5
2013	1425	1156	2581	55.2	44.8
2014	1081	1474	2555	42.3	57.7
2015	769	918	1687	45.6	54.4
2016	809	778	1587	51.0	49.0
2020	6610	3871	10481	63.1	36.9
Average	2487	1912	4400	53	47

Table 7. Estimated numbers ('000) by sex from length analyses 2008–2016 and 2020.

Year	Males	Females	Total	Males %	Females %
2008	129	72	202	64.1	35.9
2009	670	222	893	75.1	24.9
2010	320	244	564	56.7	43.3
2011	364	196	560	65.0	35.0
2012	127	84	211	60.2	39.8
2013	148	79	227	65.2	34.8
2014	97	94	191	50.8	49.2
2015	71	55	126	56.3	43.7
2016	96	49	145	66.2	33.8
2020	853	328	1181	72.3	27.7
Average	288	142	430	63	37

Table 8. Two Greenlandic surveys from 1989-1996, 2008-2016 and 2020 for comparison, for areas Q1 and Q2.

Q1-Q2 (N. for 65)	Biomass	No. Station	Area	Cod-end	Survey method
1989	4,879	87	33,971	44	Stratified random technique
1990	1,860	99	33,971	44	Stratified random technique
1991					
1992	1,044	37	43,439	44	Stratified random technique
1993					
1994	3,800	69		20	Spline Designer Designer
1995	4,558	72		20	Spline Designer Designer
1996	No estimate	40		20	Spline Designer Designer
2008	1,598	16	54,903	20	Stratified random technique
2009	7,270	33	51,633	20	Stratified random technique
2010	4,352	33	51,633	20	Stratified random technique
2011	5,701	31	51,633	20	Stratified random technique
2012	2,050	36	51,633	20	Stratified random technique
2013	2,541	37	51,633	20	Stratified random technique
2014	2,486	35	51,633	20	Stratified random technique
2015	1,574	37	51,633	20	Stratified random technique
2016	1,491	39	51,633	20	Stratified random technique
2020	10,294	35	51,633	20	Stratified random technique

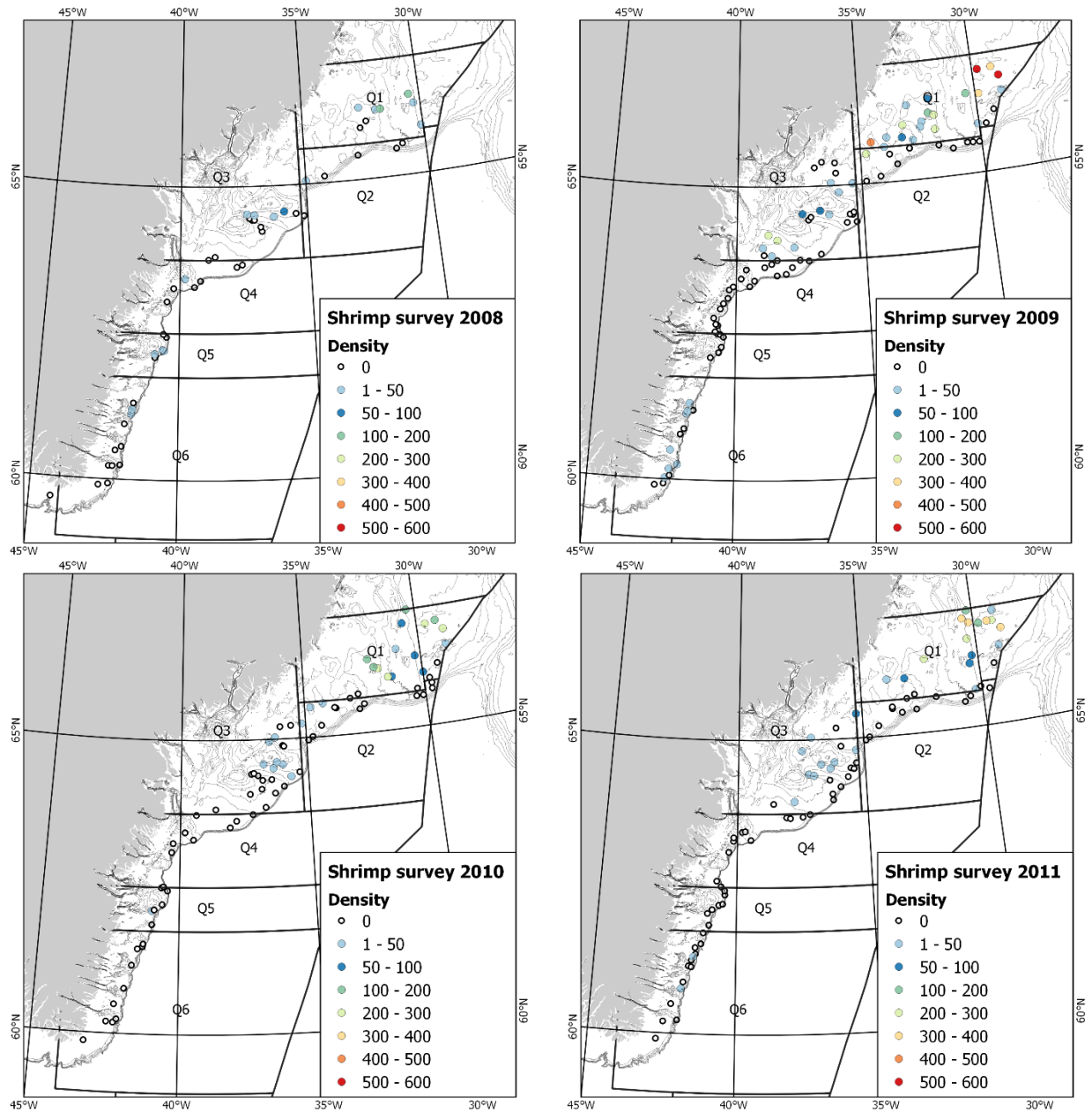


Figure 1a. Shrimp densitet (kg/km^2) in surveyarea in 2008-2011. Line marks depths of 100-600m.

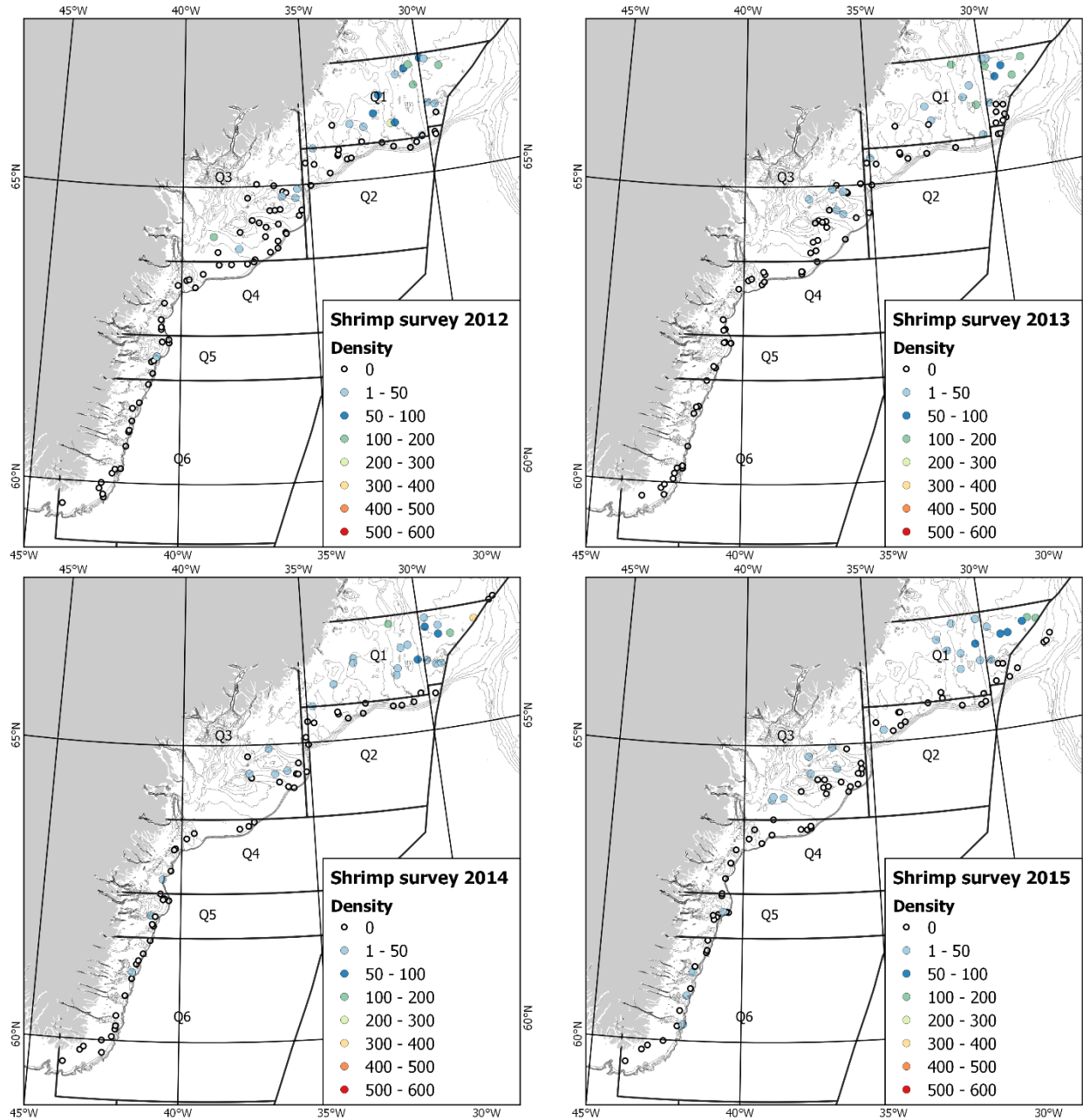


Figure 1b. Shrimp density (kg/km²) in survey area in 2012-2015. Line marks depths of 100-600m.

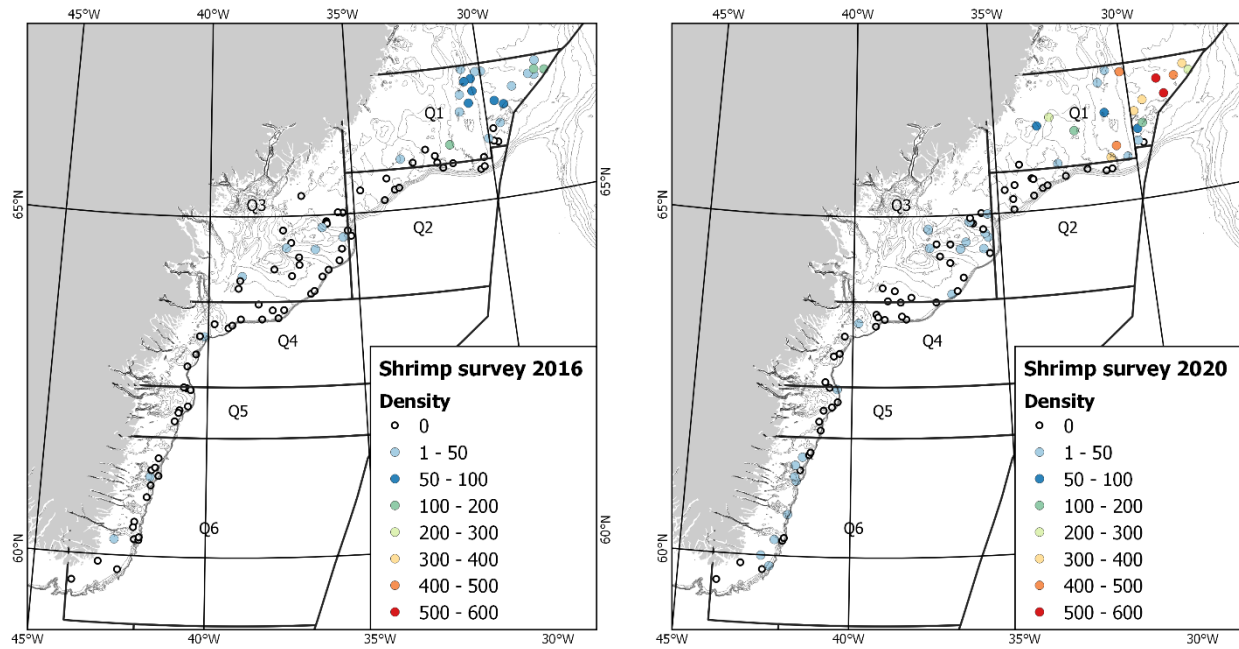


Figure 1c. Shrimp densitet (kg/km^2) in surveyarea in 2016 and 2020. Line marks depths of 100-600m.

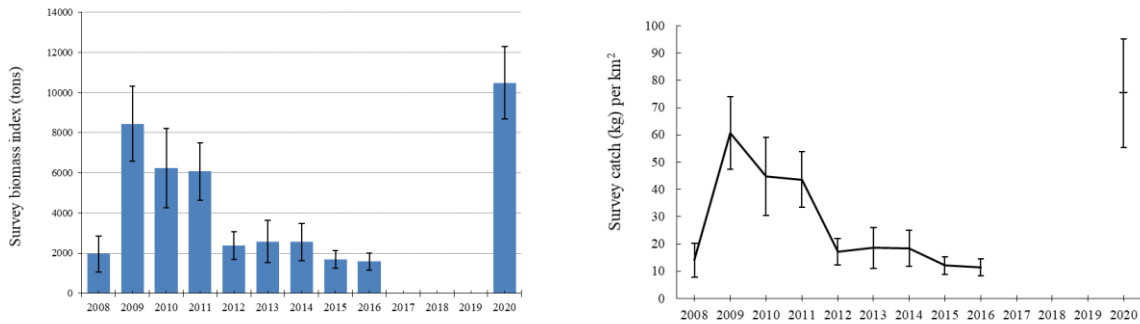


Figure 2. Estimated total survey biomass (t) and average survey biomass density (kg/km^2) of Northern shrimp with standard errors 2008-2016 and 2020.

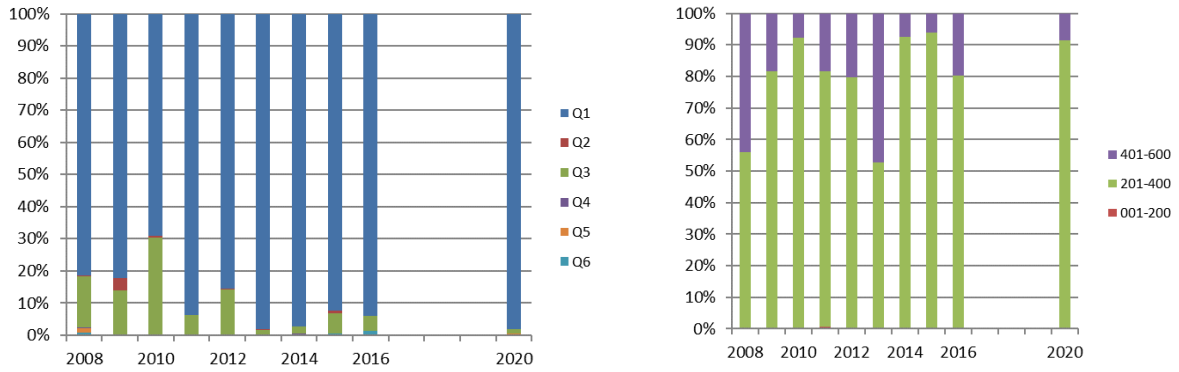


Figure 3. Survey biomass in percent in different areas (Q1-Q6) and depths (1-200m, 201-400m, 401-600m) 2008-2016 and 2020.

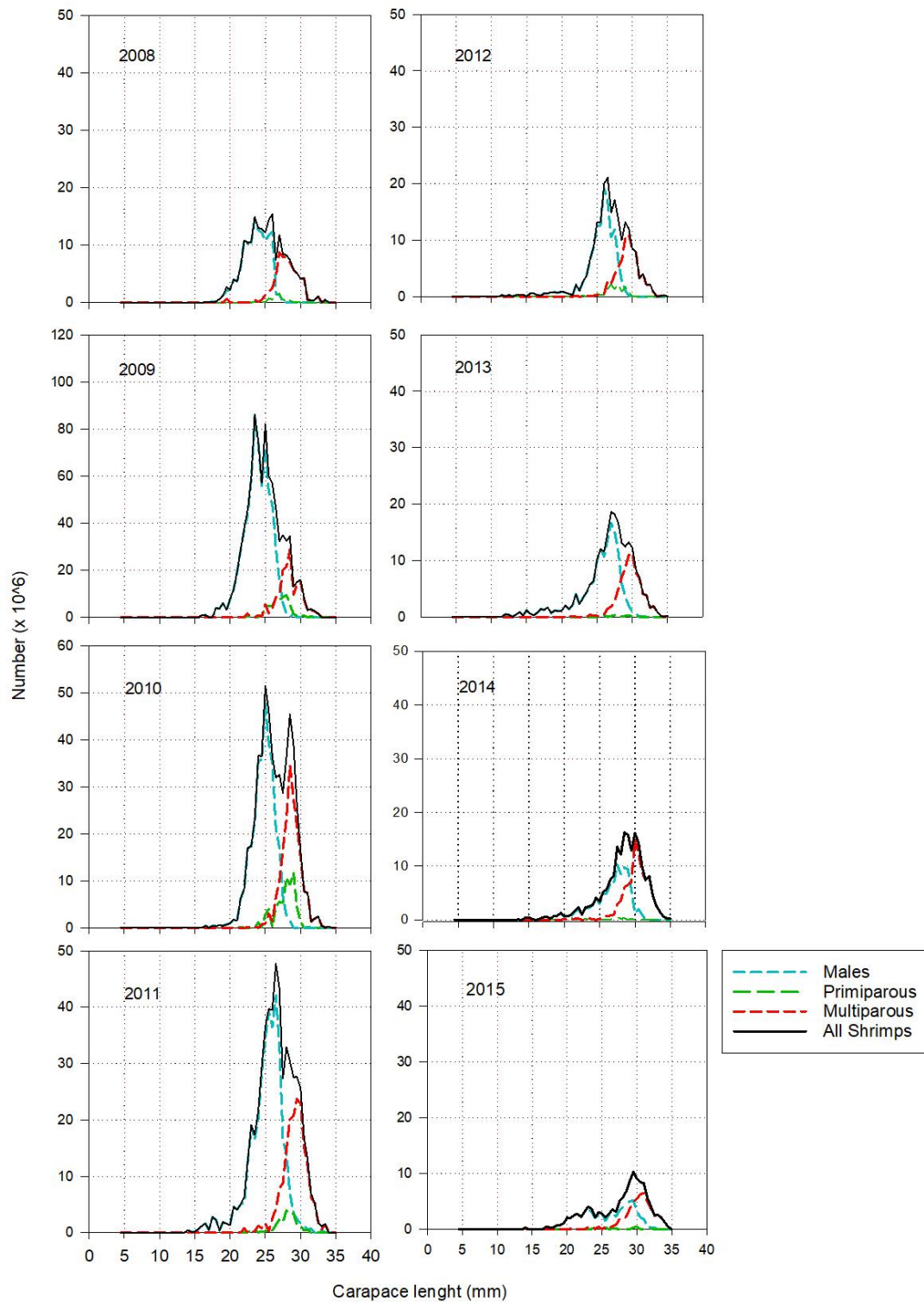


Figure 4a. Numbers of shrimp by length group (CL) in the total survey area in 2008 - 2015 (Please note that the scale in the figure for 2009 2010 differs from other years).

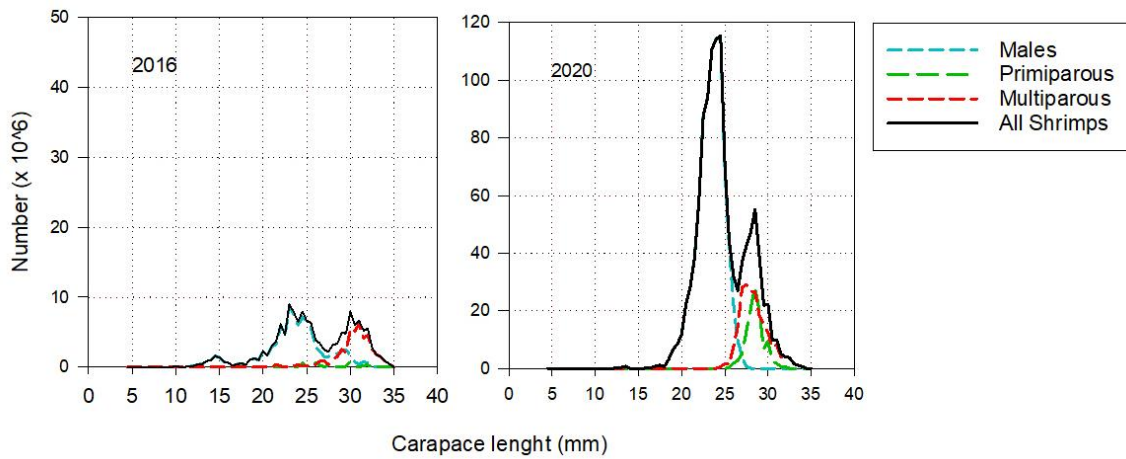


Figure 4b. Numbers of shrimp by length group (CL) in the total survey area in 2016 and 2020. (Please note that the scale in the figure for 2020 differs from other years).

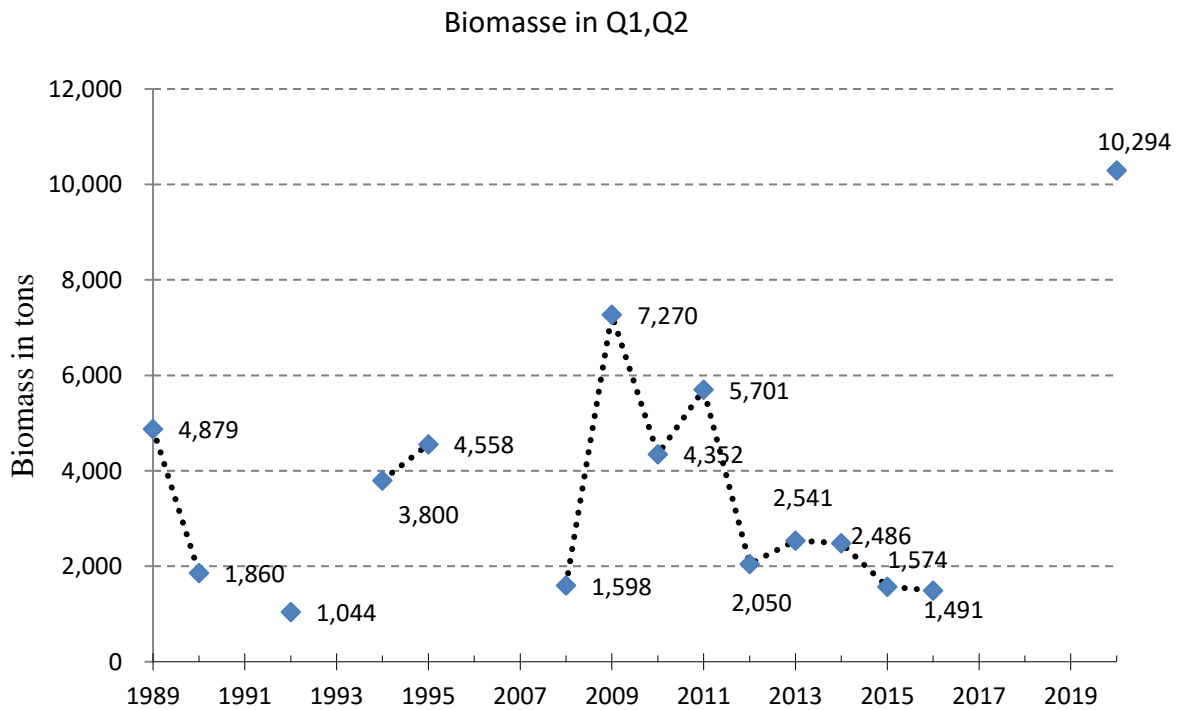


Figure 5. Biomass from two different surveys series from 1989-1995 and 2008-2020 for the areas North of 65°N and stratumarea Q1 and Q2 for comparison.

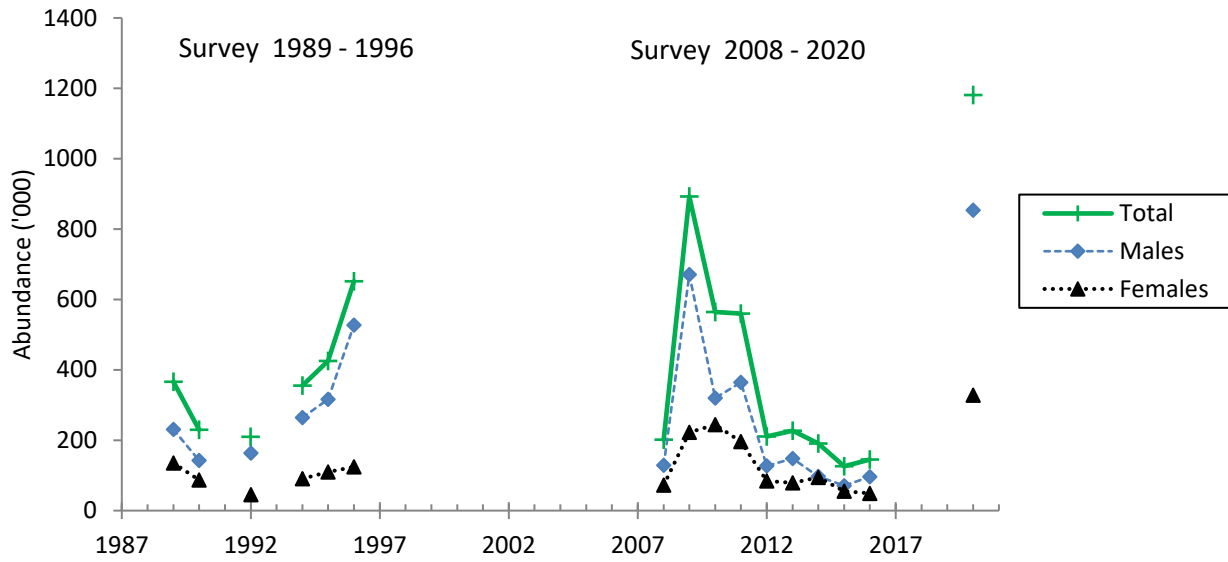


Figure 6. Abundance of males and females in two different surveys series from 1989-1995 and 2008-2020.

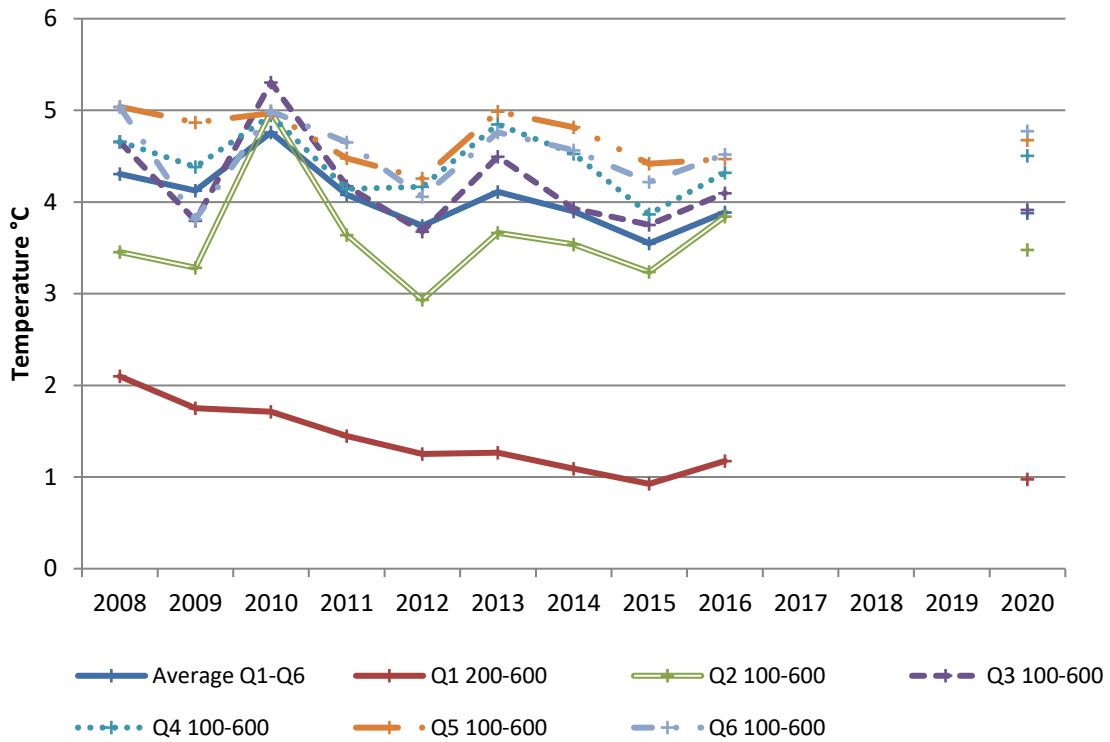


Figure 7. Temperature in the surveyarea Q1-Q6 from 2008-2020.