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Temperature Conditions in the Southern Gulf of St. Lawrence during 2004 Relevant to Snow Crab

Conditions de température dans le sud du golfe du Saint-Laurent en 2004 et crabe des neiges

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Abstract

Temperatures during 2004 are presented for the waters of Southern Gulf of St. Lawrence inhabited by snow crab. Data were available from a number of sources including snow crab and multi-species surveys. Bottom conditions were variable but tended to have warmed over much of the deeper part of the Magdalen Shallows compared to 2003 although the shallow parts were cooler. Near bottom temperatures over a strip, extending from Chaleur Bay to Western Cape-Breton on the Magdalen Shallows, were below (colder) the long-term (1971-2000) average while the shallower parts along the coasts and the deeper parts along the Laurentian Channel exhibit warmer than normal conditions. A snow crab habitat index, defined by the area of the bottom covered by waters between -1° to 3°C, was calculated for the southern Gulf region. The index decreased compared to 2003 and is also below the long-term mean value. The average temperature within the area of -1° to 3°C slightly rose compared to last year but is still below normal. The crabs caught during the annual snow crab surveys were found in warmer waters in 2004 than in 2003, which is believed to reflect in large part the availability of slightly warmer temperatures as opposed to 2003 when cooler conditions were observed.

Resumé

On présente les températures enregistrées en 2004 dans les eaux du sud du golfe du Saint-Laurent habitées par le crabe des neiges. Les données proviennent d’un certain nombre de sources, dont les relevés sur le crabe des neiges et des relevés plurispécifiques. Les conditions observées sur le fond marin ont été variables, avec une tendance au réchauffement dans la majeure partie du secteur plus profond du plateau madelinien comparativement à 2003, bien que les zones peu profondes aient été plus fraîches. Les températures près du fond, mesurées sur une bande du plateau madelinien s’étendant de la baie des Chaleurs jusqu’à l’ouest du Cap-Breton, ont été inférieures (plus froides) aux moyennes à long terme (1971-2000), tandis que dans les parties moins profondes le long des côtes et les parties plus profondes le long du chenal Laurentien, les températures ont été plus chaudes que la normale. Un indice sur l’habitat du crabe des neiges, défini comme étant la zone de fond marin recouverte par des eaux entre -1 et 3 °C, a été calculé pour la région du sud du golfe. Cet indice a diminué comparativement à 2003 et est également inférieur à la valeur moyenne à long terme. La température moyenne dans la zone de -1 à 3 °C a augmenté légèrement comparativement à l’année dernière, mais demeure inférieure à la normale. Par rapport à 2003, les spécimens capturés dans le cadre des relevés annuels sur le crabe des neiges ont été trouvés dans des eaux plus chaudes en 2004, ce qui, à ce que l’on croit, reflète en grande partie la présence d’eaux légèrement plus chaudes par rapport à l’année précédente, où des conditions plus fraîches avaient été observées.

Introduction

Snow crab (*Chionoecetes opilio*) is a cold-water species typically inhabiting bottom depths of 20-400 m. It can be found in water with temperatures as low as -1°C. An active and very lucrative fishery presently exists in the Gulf of St. Lawrence (Fig.1), on Sydney Bight and on the northeastern Scotian Shelf. Annual assessments of the stock abundance, fishing effort, biological characteristics and the environment of the snow crab are undertaken by the combined efforts of the Gulf and Maritimes Regions of the Department of Fisheries and Oceans (DFO) and the snow crab fishing industry (some fishing areas). The purpose of this paper is to provide information on the sea temperature conditions during 2004 in areas (12, 19, E and F) occupied by snow crab in the Southern Gulf (Fig. 2) and to compare these temperatures to their long-term means. This includes areal indices of the ocean bottom covered by water temperatures between -1°C and 3°C. Monthly mean temperature profiles and time series of the monthly mean temperatures at specific depths within snow crab fishing areas provide further information on sea temperature trends. Finally, the catch of snow crab during the snow crab surveys as a function of temperature for the 2004 season is presented and compared to other years when temperature and catch data were available. We begin with a description of the temperature data, then provide details of the methods used to analyze the temperature fields and finally present the results.

Data

Near-bottom temperatures during 2004 in the areas of snow crab fishing were available from two main surveys in the Gulf of St. Lawrence. Around 340 stations were occupied during the snow crab survey conducted from July to early October (Fig. 3). The annual multi-species survey (formerly, the groundfish survey) was carried out in September and 172 stations were occupied (Fig. 4). The snow crab survey obtained near-bottom temperatures with a thermistor recorder attached to the trawl. Temperature and salinity data were collected with a conductivity-temperature-depth (CTD) instrument during the multi-species surveys. Other temperature data from the snow crab areas in 2004 were obtained from the Marine Environmental Data Service (MEDS) in Ottawa, Canada's national oceanographic data archive, and were derived from additional fisheries surveys, research surveys and measurements from ships-of-opportunity. Pre-2004 data were taken from the hydrographic database maintained at the Bedford Institute of Oceanography (BIO). This database contains an edited version of the entire MEDS holdings for the region. The catch information, i.e. the number of crabs per tow, is kept in a database maintained at the Gulf Fisheries Centre (GFC).

Methods

The near-bottom temperatures from data collected during the September and snow crab surveys were interpolated onto a specified grid using an objective analysis procedure known as optimal estimation. This is a 4-dimensional interpolation technique; i.e. three space dimensions, two horizontal and one vertical, and the time dimension. In this study the surveys were treated as synoptic and no interpolation in time was carried out. The details of the procedure are found in Drinkwater and Pettipas (1996). The maximum profile depth on the CTD for each station was assumed to be at the bottom. Checks against bathymetric charts were carried out to ensure no large errors occurred as a result of this assumption. The maximum depth in the grid for the slope of the Laurentian Channel Shelf was taken as 500 m. The temperature grid has a mesh size of 0.1° x 0.1° latitude-longitude. The bottom temperature data were slightly smoothed for the purpose of contouring, which tends to spread out the gridded values; thus the true gradients could be stronger than those depicted in the plots.

Long-term monthly climatological means of the near-bottom temperatures were estimated at each grid point based upon optimal estimations using all available data for the years 1971-2000 in the historical temperature, salinity database at the Bedford Institute. The 1971-2000 climatological means are then subtracted from the values derived from the 2004 survey. The differences are called temperature anomalies. A negative anomaly indicates that the 2004 temperature was colder than the long-term mean and a positive anomaly indicates that it was warmer than the long-term mean. We also examined the change in temperature since the previous year by subtracting the 2003 optimally estimated temperatures from the 2004 estimates. A negative value indicates that 2004 was cooler than 2003, a positive value that it was warmer.

The snow crab habitat index, defined by Drinkwater et al (1998) as the area of the bottom covered by temperatures between -1°C and 3°C (favorable temperature range for the adults snow crabs), was calculated from the gridded temperature fields derived from the multi-species survey. The temperature at each grid point was assigned the area of bottom (0.1° by 0.1°) associated with that particular grid point. The areas with temperatures between -1° and 3°C, inclusive, were then summed. The mean temperature within this area was also estimated. The 2004 indices were compared to those derived from earlier surveys but augmented by any additional temperature data available for the particular year and month in question. The time series of the indices began in 1971 for the Southern Gulf.

In addition to the bottom temperatures and habitat indices, monthly mean temperature profiles for 2004 were determined within each of the snow crab areas

(Fig. 2) from the BIO database. All available data within each of these areas were averaged by month at standard depths (0, 10, 20, 30, 50, 75, 100, 125, 150, 175, 200, 250, and 300 m, where possible). An "annual" anomaly profile was determined for each year by averaging the available monthly anomalies, regardless of how many months were available. Time series of monthly mean temperatures at representative depths for each area are also provided. Long-period trends represented by 5-year running averages of the "annual" anomalies are also shown.

We also examine the catch of snow crab as a function of temperature and depth for the Gulf and Shelf areas. The temperatures at which the crabs were caught were partitioned into 0.5°C bins and the depths into 20 m bins. The frequency distribution of the crab temperatures was expressed in percentages within each of the bins. These were then compared with the frequency distribution of the available temperatures at all of the stations sampled. Finally, comparisons were made between these 2004 results and those from 2003.

Results

<u>Bottom Temperatures</u>

Data acquired during the multi-species survey in September 2004 showed that bottom temperatures ranged from <0°C to over 17°C in the Southern Gulf of St. Lawrence (Fig. 5a). Most of the bottom was covered by waters <3°C with the largest portion of the Magdalen Shallows (50-80 m) covered by waters <1°C. A large area, in the southern portion of the shallows, shows sub-zero values. This is around half the area of the 2003 coverage for the same temperature threshold. Bottom temperatures tend to increase from the center of the Magdalen Shallows towards the shallower, nearshore regions and towards the deeper Laurentian Channel. This is because in the Gulf of St. Lawrence during summer, cold temperatures are found at intermediate depths (50-150 m), sandwiched between warm solar-heated upper layer waters and the relatively warm, salty deep waters in the Laurentian Channel. The latter originate from the slope water region off the continental shelf and are transported up the Channel. The cold waters are known as the cold intermediate layer (CIL). Although the deeper waters are warmer than the CIL, their density is greater because of higher salinities. In winter, the CIL merges with the upper layer as the latter cools. The primary origin of the waters in the CIL is from atmospheric cooling of the water within the Gulf of St. Lawrence in winter with additional input through advection of cold Labrador Shelf water through the Strait of Belle Isle. The latter varies annually but with a mean of approximately 35% of the total volume of the CIL (Petrie et al., 1988). In 2004, the warmest near-bottom temperatures in the southern Gulf were in Northumberland Strait and in St. Georges Bay where the analysis suggests they reached 15°-17°C (Fig. 5a).

Temperature anomalies over a strip, extending from Chaleur Bay to Western Cape Breton (on the Magdalen Shallows), were slightly below normal while the shallower parts along the coasts and the deeper parts along the Laurentian Channel exhibit warmer than normal conditions (Fig. 5b). The negative anomalies are mostly between 0 and -1°C which are not exceptional for the area. The highest positive anomalies (+2°C) appeared off northwestern PEI and in St. Georges Bay. However, the anomalies in shallowater areas must be viewed with caution since the largest uncertainties in the optimally estimated temperature fields are in the nearshore regions. There are two main reasons for this. First, there tends to be greater temporal variability at shallower depths because they lie close to the strong vertical gradient in temperature, called the thermocline. Indeed, in these regions the mixed layer may at times extend to the bottom in response to wind storms producing large variability in the near-bottom temperatures. Second, the optimal estimation routine extrapolates horizontal temperature gradients to the coast if there are no data inshore. This can lead to fictitious data, especially in regions of strong horizontal temperature gradients.

Relative to 2003, bottom temperatures during the 2004 multi-species survey were significantly warmer over the northern part of the Magdalen Shallows while the southern part was significantly cooler (Fig. 6). The region off northwestern PEI was especially cooler with a temperature departure of -3°C. This cooling might be partially due to the lack of data for year 2003 as discussed in the previous paragraph and in Chassé et al. (2004). The Northumberland Strait was warmer in 2004 than in 2003 with an anomaly of over 1°C in St. Georges Bay.

The spatial pattern of the bottom temperatures from the snow crab survey in July-October 2004 is slightly cooler compare to that from the 2004 multi-species survey, especially in the shallower regions around the coastal regions (Fig. 7). This might be due to an earlier sampling (some in August) in the case of the snow crab survey than for the case of the multi-species survey (all in September). Usually there is a seasonal deepening and warming of the upper mixed layer, especially in the shallower regions. Other possible causes of the differences, besides seasonal warming in the shallow regions, may be differences in instrument accuracy (the CTD being more accurate than the thermistor recorder), a relative rapid point measurement (CTD) versus an average over a trawl distance (snow crab survey), and the difference in depth of the measurement (the thermistor is on bottom while the CTD will be a few to several meters above the bottom).

Snow Crab Habitat Index

From the September multi-species survey, a time series of the snow crab habitat index (area of bottom covered with waters between -1°C and 3°C) based upon optimally estimated bottom temperatures is available from 1971 to 2004. The Southern Gulf grid contains a total area of 70039 km^2 (847 grid points). We also estimated the average temperature within the area covered by temperatures in the range -1°C to 3°C and correlated these with the habitat index.

In 2004, the area of the bottom of the Magdalen Shallows covered by waters between -1°C and 3°C during the multi-species survey slightly decreased compared to 2003. It was just over 49030 km^2 and, as in 2002 and 2003, was still below the long-term mean (1971-2000) of approximately 52300 km^2 (Fig. 8). The 2004 value represents 70% of the total Shallows area, and was 1% larger than in 2003 and 5% below the long-term mean. The snow crab habitat index in 2004 was the fifth lowest value over the 35-year record, with 1980 being the smallest followed by 2002. The highest values were observed in 1984 and 1992. Note, however, that the variability in the habitat index for the Shallows tends to be small. The index only varied between 66% and 84% of the total area available over all years. The mean temperature within the habitat area in 2004 (0.64°C) increased compared to 2003 (by 0.17°C). The value is still below the long term mean, as in 2003 when a drastic change was observed in comparison with the four previous years when warmer conditions prevailed. The 2004 mean temperature is the second lowest of the last six years. The minimum value (0.15°C) was reached in 1995. The correlation between the habitat index and the mean temperature over the years 1971-2004 within this area is -0.34 and is not statistically significant.

Monthly Mean Temperature Anomaly Profiles and Time Series

The monthly mean temperature anomaly profiles were determined for each of the snow crab fishing areas for the Southern Gulf (see Fig. 2 for the area boundaries used in the temperature analysis). The monthly mean temperatures at standard depths were estimated by averaging all of the available data within the area regardless of when in the month it was measured. Similarly, no adjustments were made for the spatial distribution of data or the amount of data that contributed to the average. In some cases the "average" was based upon only a few measurements while in other months it was over 200 stations. The long-term (1971-2000) mean was then subtracted to obtain a temperature anomaly. In addition to the profiles, temperature time series at depths considered representative of the near-bottom region within each of the fishing areas, are presented. Because of the limited amount of data within the areas over which the averages were made and the possibility of spatial variability in temperature within the areas, any one point or profile may not be truly representative of "average" conditions for the month. Interpretation of any anomalies therefore must be viewed with caution. While no significance should be placed on any individual monthly anomaly, persistent features are considered to be real.

Data for 2004 over the central Magdalen Shallows (Area 12 in Fig. 2) were available for March to December with the exceptions of April and October (Fig. 9). During March, the anomalies are very close to the normal in the first 50 m while warmer in the rest of the water column, excepted at around 120 m where colder than normal conditions are observed. May and June exhibit cooler than normal waters in the surface layer (0-20m) and while warmer conditions are seen a little deeper (20 to 60 m). Cooler conditions where evident in August in the surface layer while September and November were warmer at these depths. Cooler conditions could also be seen during these fall months between 70 m and 180 m while the last portion (180 -300 m) of the water column was warmer than normal. From 60 to 100 m, which covers a large area of the Magdalen Shallows, the annual means are significantly different from zero (lower) even while considering the error of the means. Below 150 m, which is primarily limited to the Laurentian Channel and the deep trough off Cape Breton (fishing area 19), monthly temperature anomaly profiles were slightly positive and the annual anomaly was above zero. In the top 20 m, temperature anomalies varied from month to month, but with a negative tendency. These conditions in 2004 are closer to normal compared to what was observed in 2003. The cold conditions in year 2003 contrasted sharply with the warmer ones that were observed in 2002 (see Drinkwater et al. 2003 for temperatures in 2002 and Chassé et al., 2004 for the temperatures in 2003). The time series of monthly mean temperatures at 75 m in Area 12 also shows high month-to-month variability with a definite tendency for below normal temperatures over most of the period since the mid-1980s to 1999 and closer to normal temperature since that time (Fig. 10). Part of the high month-to-month variability is believed to be due to differences in the extent of the spatial sampling but the long-term pattern matches that observed elsewhere and is considered real. In 2004, temperatures were cooler than the long-term mean except at the beginning of the year when they were warmer than the average.

Temperatures within fishing Area 19 along the Gulf side of Cape Breton Island were also used in this analysis. They include deep data (>150 m) from the Cape Breton Trough. Measurements were available during March, June, August, September and November in 2004 (Fig. 11). The conditions were slightly cooler than normal during the month of March in this Area. The surface of the ocean was cooler than normal in June and warmer in August and September. The large negative anomaly observed at 20 m in August was at the northeast limit of Area 19 and it seems that there was a water mass colder than normal in the area, maybe associated to localized tidal upwelling. The rest of the water column was around normal for most of these months. Maximum temperature anomalies appeared at 30 m being upwards of 2°C during the month of June. Another cold anomaly was recorded in March (-2°C, 75 m). The year average shows around normal conditions down to around 170 m (except for the large anomaly at 20 m) and significant warmer conditions in the Laurentian Channel. The cooler node between 70 and 140 m is consistent with the decreased CIL volume during 2004 compared to 2003. However, it should be noted that these means are based on few data and should be interpreted with cautiously. The time series at 100 m shows near normal temperatures during 2004, warmer than those recorded in 2003 (Fig. 12). The last value of the 5-year running mean at this depth is still close to zero, meaning that the average temperature for 2001-2004 was close to the 1971-2000 average temperature.

Data for June, August and September were available from Area F in 2004 (Fig. 13). No temperatures were recorded in the deeper part of this area (up to 300 m). The surface water was cooler than normal in June while the water between 20 and 150 m was clearly showing warmer than normal temperatures during that month. Temperatures were around normal in August. September was also warmer, except between 15 and 45 m were it was colder than normal with a negative anomaly of around -1.5°C. The time series at 100 m in Area F is similar to the one for Area 19 (Fig. 14), i.e. a strong tendency towards below normal anomalies from the mid-1980s to the late 1990s, a general warming starting around 1992 and a levelling off at the end of the 1990s and a slight cooling at the end of the timeseries. Warmer-than-normal temperatures were observed in 1999 and 2000, declined in 2001, rose in 2002, declined again in 2003 and slightly rose in 2004. For most years, the data at 100 m are reasonably representative of conditions from 75 to 150 m in Area F.

To the north in Area E, data were available for 6 months, March, May, June August, September and November. Monthly mean temperatures were close to normal in March, but a cold anomaly of -2.25°C is observed at the surface in June and cooler conditions there seemed to last until September although the water between 20 and 70 m was warmer than normal in June (Fig. 15). The largest positive anomaly (2.5°C) is observed at the surface in November. Most of the water column, below 50m, was around normal at the end of the summer and during fall. The temperature time series at 100 m for Area E shows the typical pattern of negative anomalies since the mid-1980s and a general upswing beginning in the mid-1990s (Fig. 16). The below normal temperatures at this depth in 2003 and 2004 contrast with the above normal values in 2002 and they were cooler that those observed in 2001.

The general trends in the temperature anomalies in the near-bottom waters throughout the Magdalen Shallows are quite similar. This is highlighted in Fig. 17 that shows the five-year running means of the temperature anomalies for Areas 12, 19, E and F. These show the continuously decreasing temperature from the last maximums in the early 1980s to the minimums in the early 1990s and then the general warming trend up to the early 2000s and a slight decrease at end of the timeseries, in recent years.

Snow Crab Catches by Temperature

The catches (from the trawl survey) of snow crab as a function of temperature during the 2004 snow crab survey in the Gulf are shown in Fig. 18. Over 92% of all of the crabs were caught in temperatures between -1° and 3°C. In 2004, there was a tendency for the snow crabs to be captured in the cooler portion of the favourable habitat (which is defined as waters with a temperature range of -

1°C to 3°C) but this is not as obvious as in 2003 when cooler conditions were observed. However, the snow crabs in 2004 were generally caught in warmer waters than in 2003, a situation that reflects the ambient temperatures. The top panel in figure 18 and the cumulative percentages of snow crab catches and bottom temperatures (Fig. 19) clearly show that snow crabs have a tendency to be caught in the cooler waters (<2°C).

Summary

Near-bottom temperatures in the southern Gulf of St. Lawrence (Magdalen Shallows) and in the northeastern Scotian Shelf during 2004 were examined primarily from data collected during the snow crab and multi-species surveys. The snow crab survey was conducted in July-October while the multi-species survey was in September only. Data from the multi-species survey, which are available for a much longer period than those from the snow crab survey, were compared to their normal conditions (1971-2000). Additional temperature data from other fisheries surveys and oceanographic studies in these same areas were also examined.

During 2004, conditions were variable but tended to have warmed over much of the deeper part of the Magdalen shallows compared to 2003 although the shallow parts were cooler. Near bottom temperatures over a strip, extending from Chaleur Bay to Western Cape-Breton on the of the Magdalen Shallows, were slightly below (colder) the long-term (1971-2000) average while the shallower parts along the coasts and the deeper parts along the Laurentian Channel exhibit warmer than normal conditions. The snow crab habitat index, based upon the area of bottom temperatures preferred by snow crab (-1°C to 3°C), decreased relative to 2003 and is still below the long-term average. The average temperature within the area of -1° to 3°C is still below normal and rose compared to last year. The crabs caught during the annual snow crab surveys were found in warmer waters in 2004 than in 2003, which is believed to reflect in large part the availability of slightly warmer temperatures as opposed to 2003 when cooler conditions were observed. The catch analysis again shows that the adult snow crabs have a preference for cooler water.

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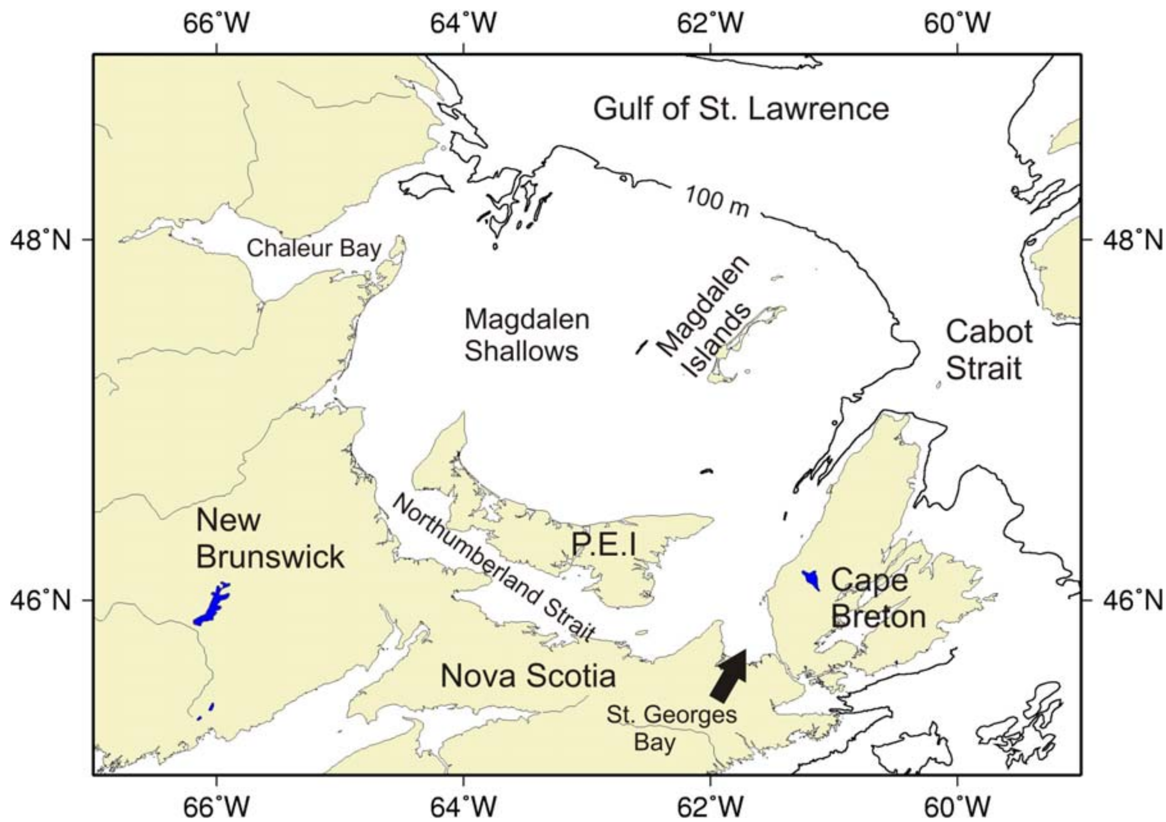


Fig. 1. Chart of the Southern Gulf of St. Lawrence showing geographic and topographic features referred to in the text.

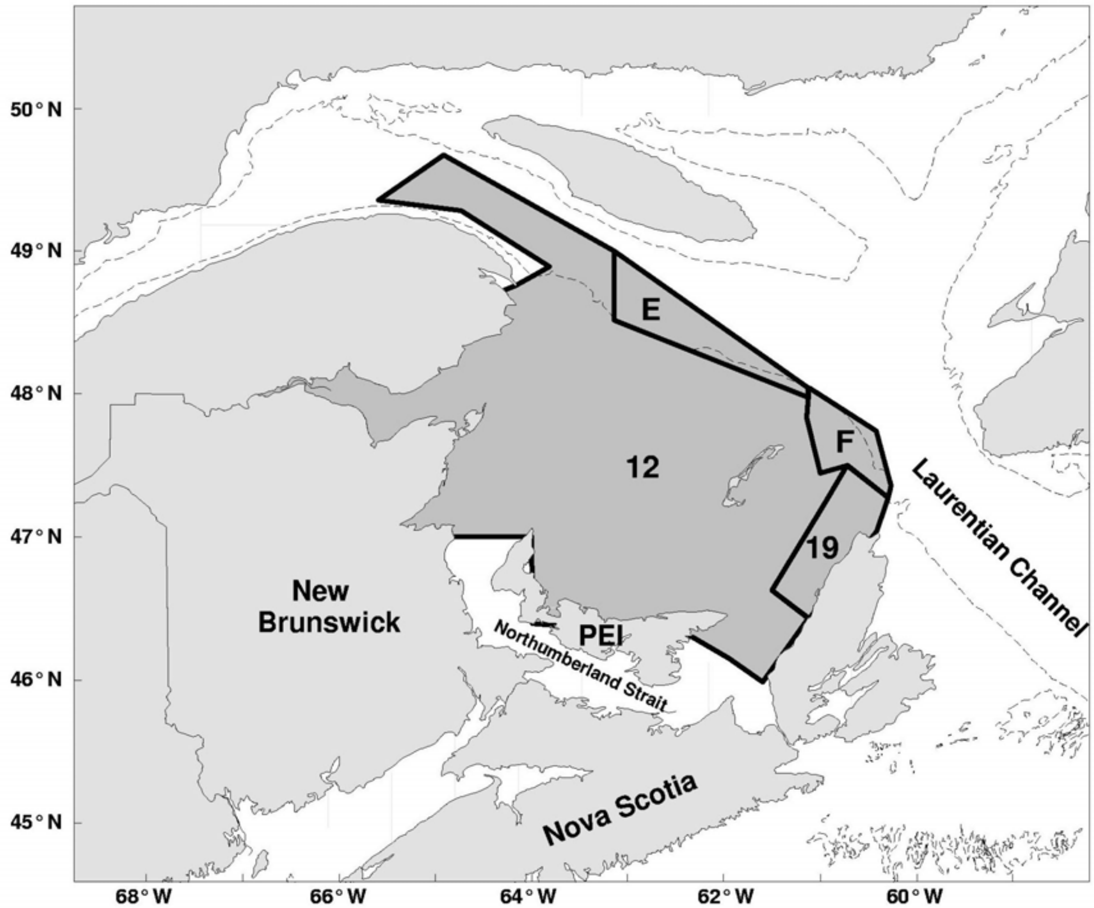


Fig. 2. The Southern Gulf of St. Lawrence showing the boundaries of snow crab fishing areas in which monthly mean temperature profiles were estimated.

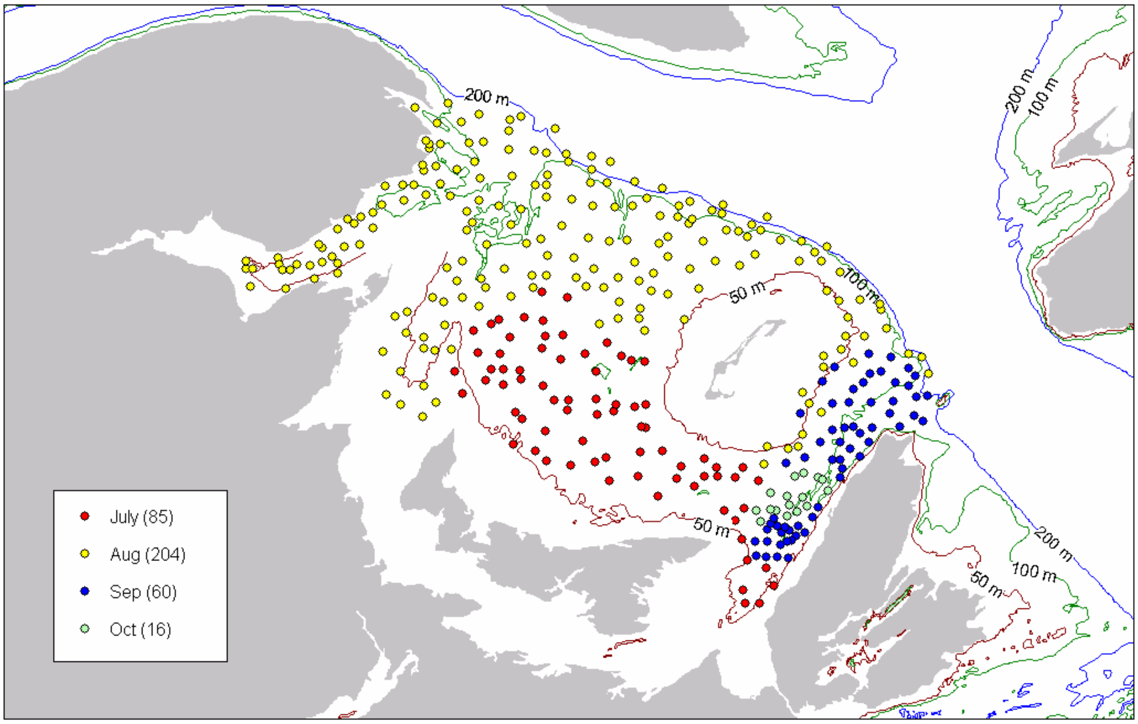


Fig. 3. The location of the bottom temperature stations during the July-October 2004 snow crab survey.

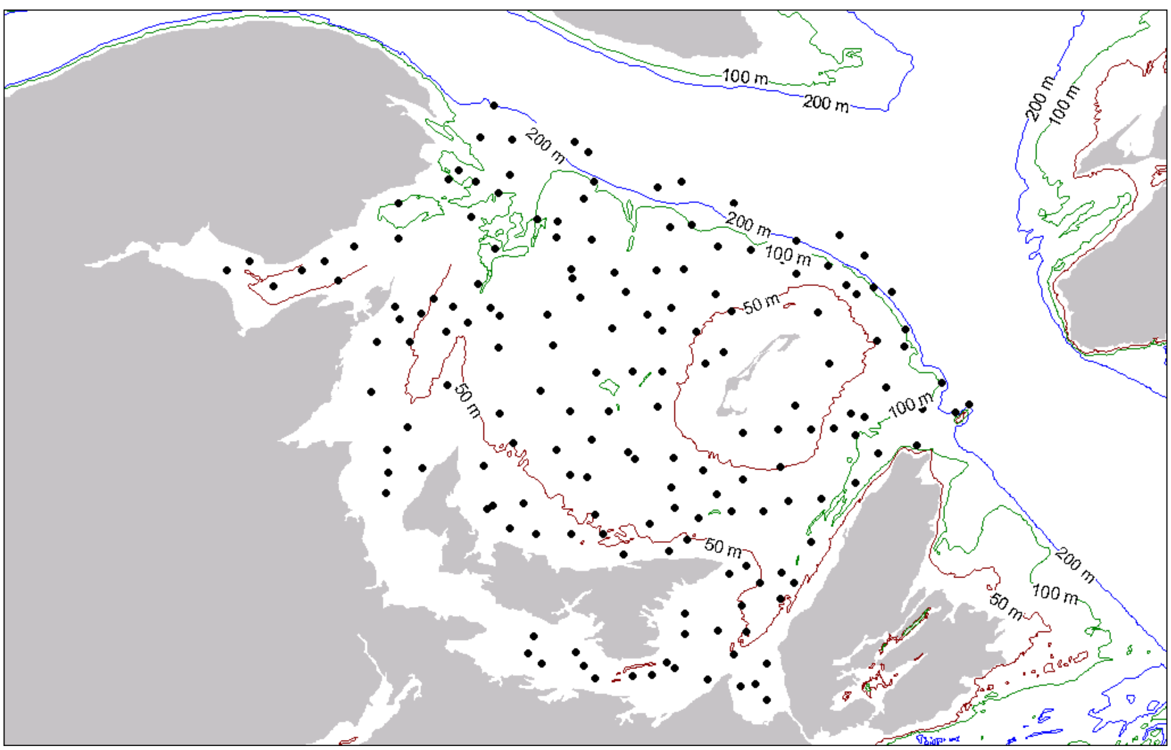


Fig. 4. The location of the CTD stations during the September 2004 multi-species survey.

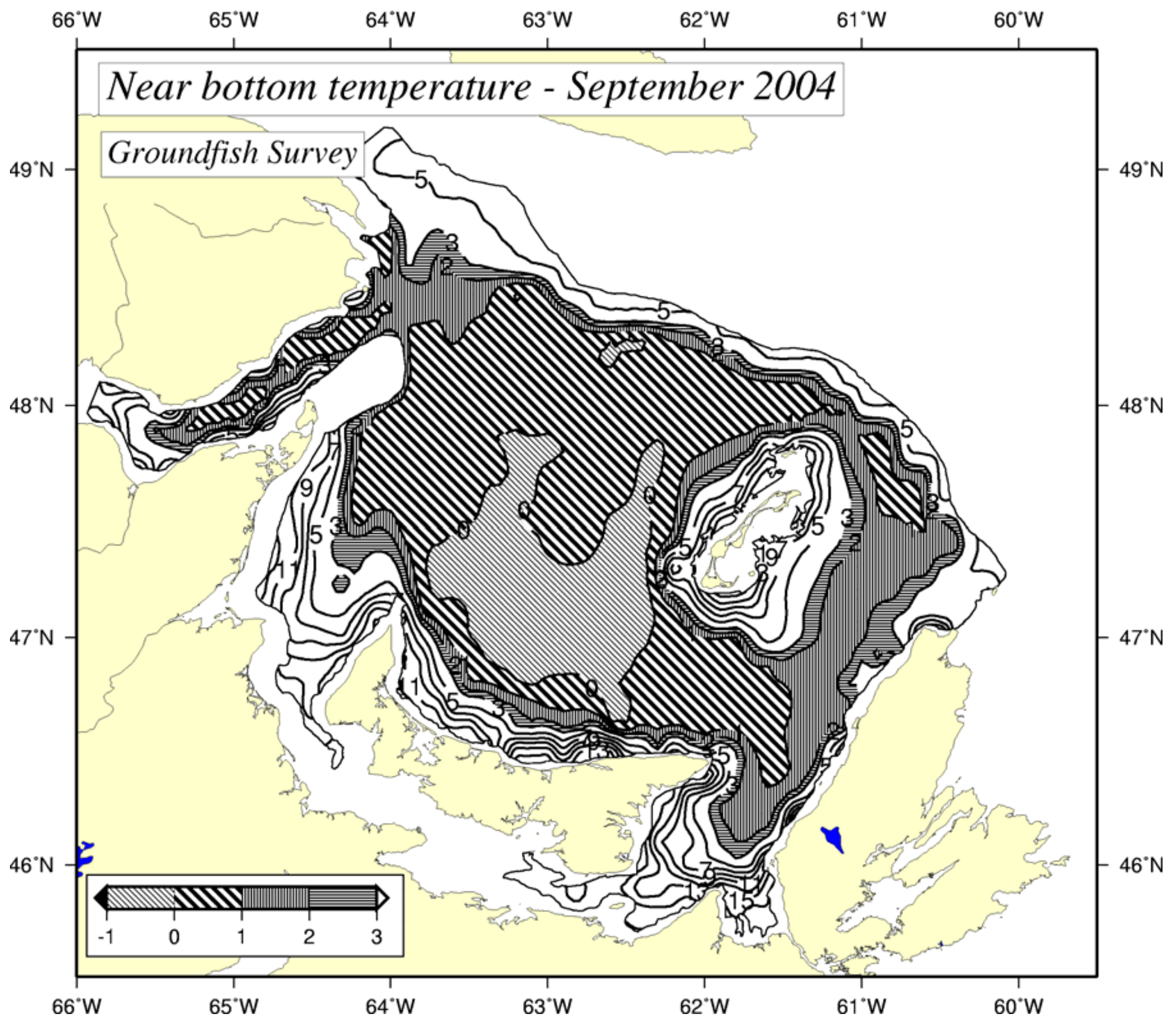


Fig. 5a. Near-bottom temperatures (°C) in the southern Gulf of St. Lawrence during the 2004 September multi-species survey. The hachure patterns show the suitable temperature range for the snow crab (-1 to 3°C).

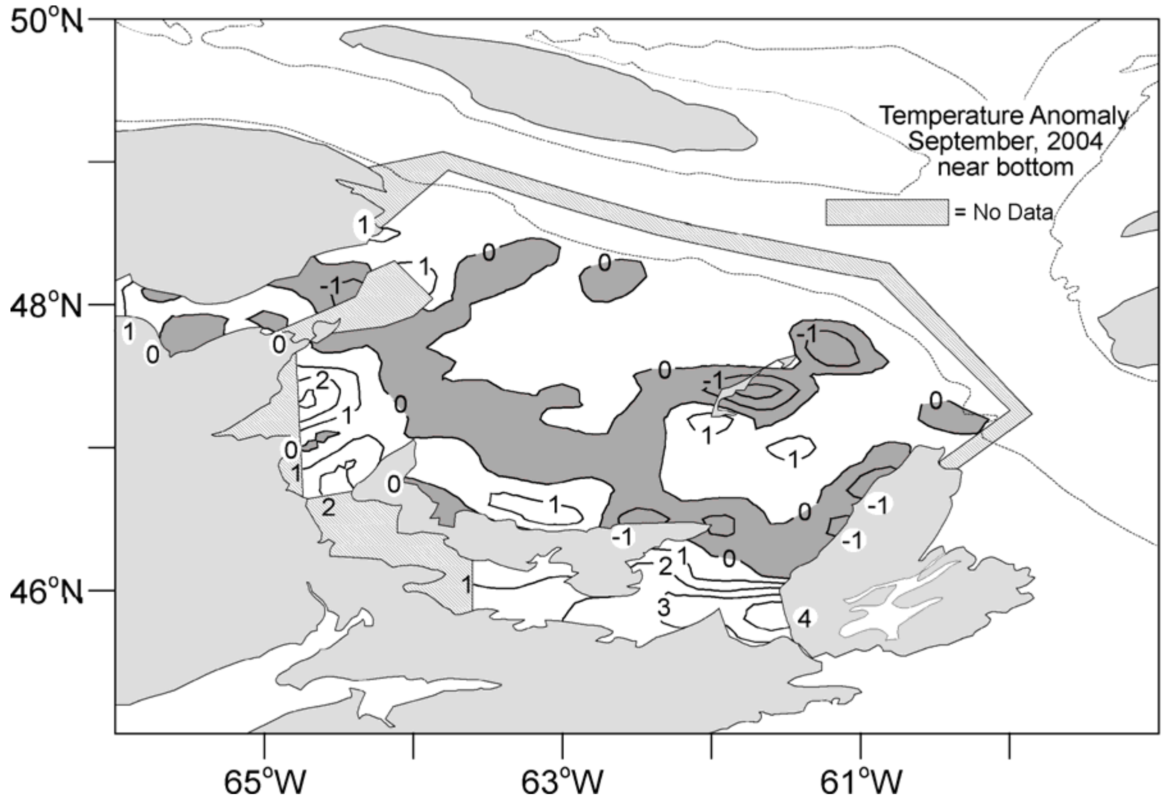


Fig. 5b. Near-bottom temperature departure (°C) from the long-term (1971-2000) means in the southern Gulf of St. Lawrence during the 2004 September multi-species survey. Shaded regions represent colder-than-normal temperatures.

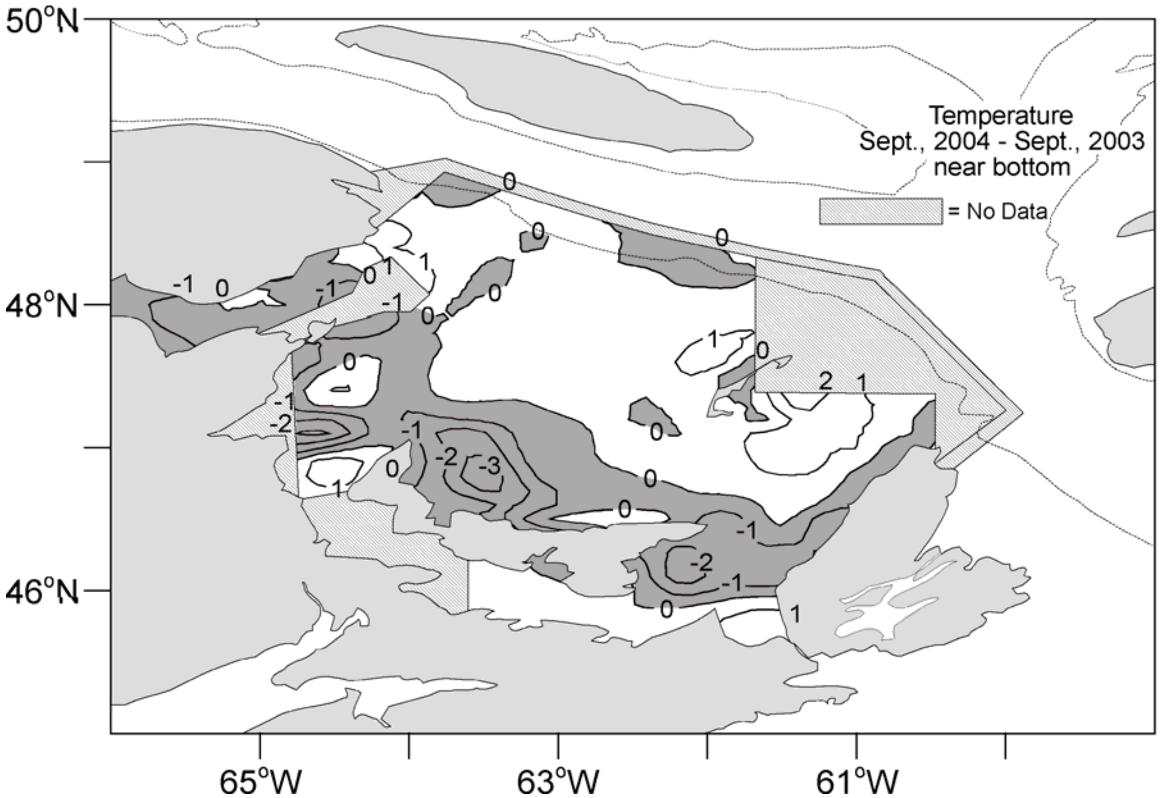


Fig. 6. The difference between the 2004 and 2003 temperature fields in the southern Gulf of St. Lawrence for the September multi-species survey. Positive values indicate temperatures in 2004 had warmed and negative values (shaded) that they had cooled.

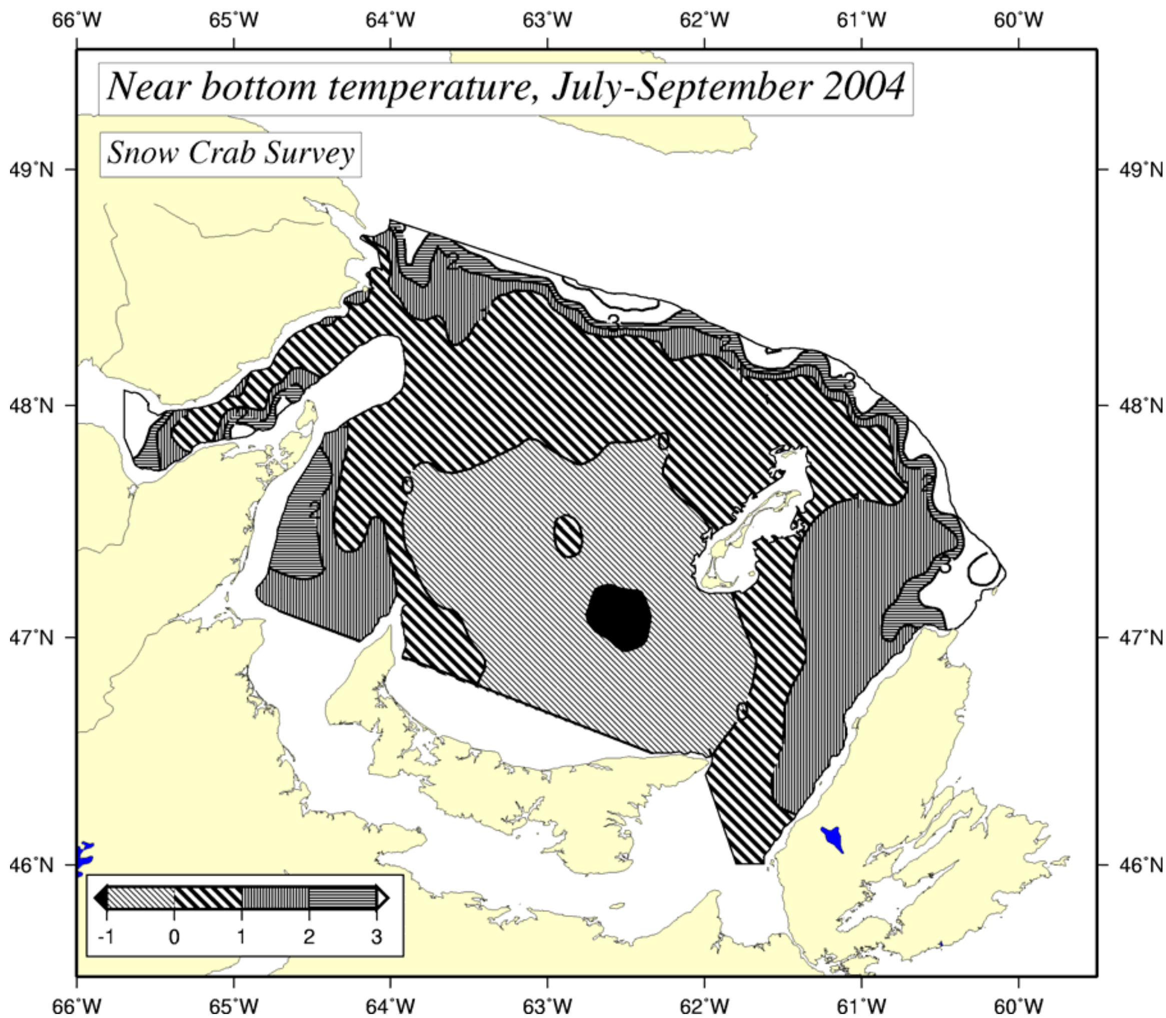


Fig. 7. Near-bottom temperatures in the southern Gulf of St. Lawrence during the 2004 July-October snow crab survey.

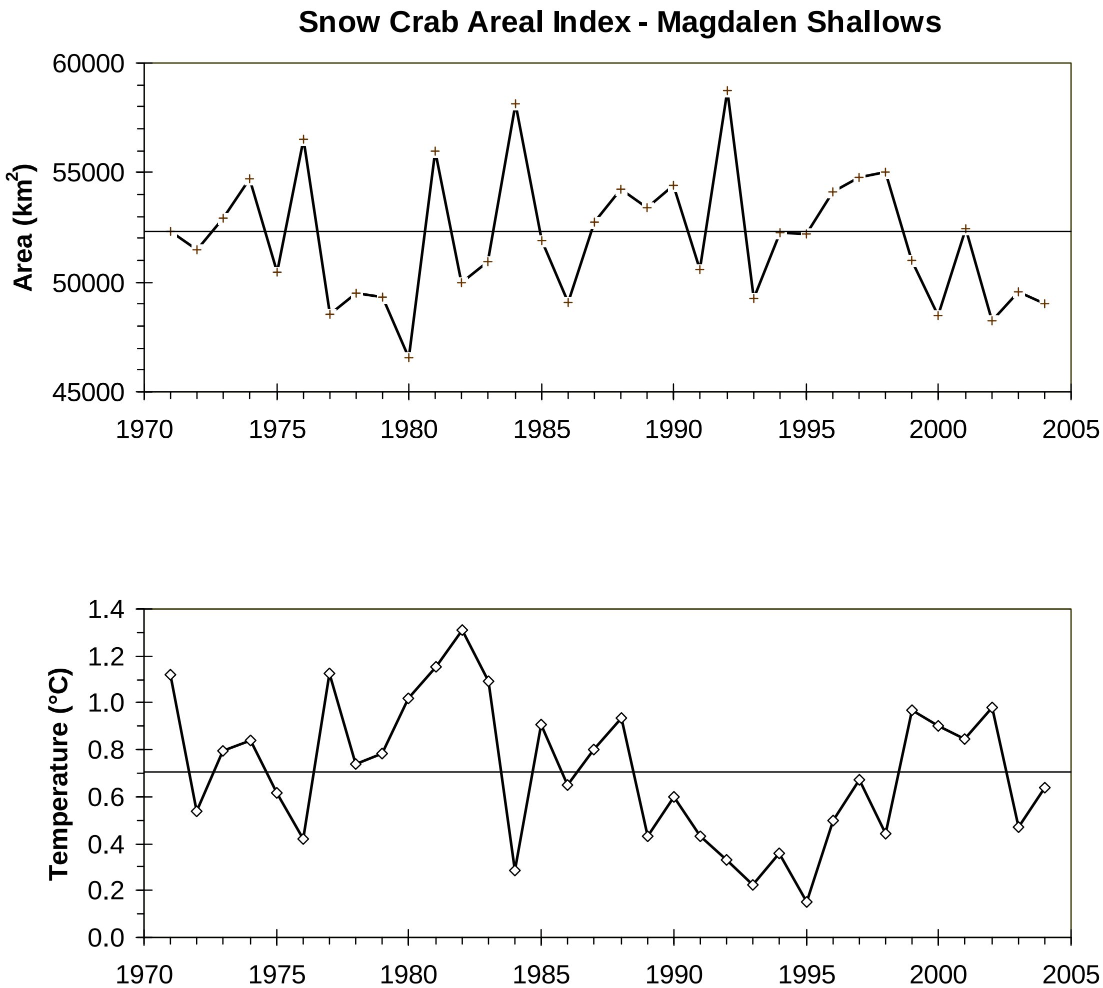


Fig. 8. Time series of the area of Magdalen Shallows covered by bottom temperatures between -1° and 3°C in September (top panel) and the mean temperature within that area (bottom panel).

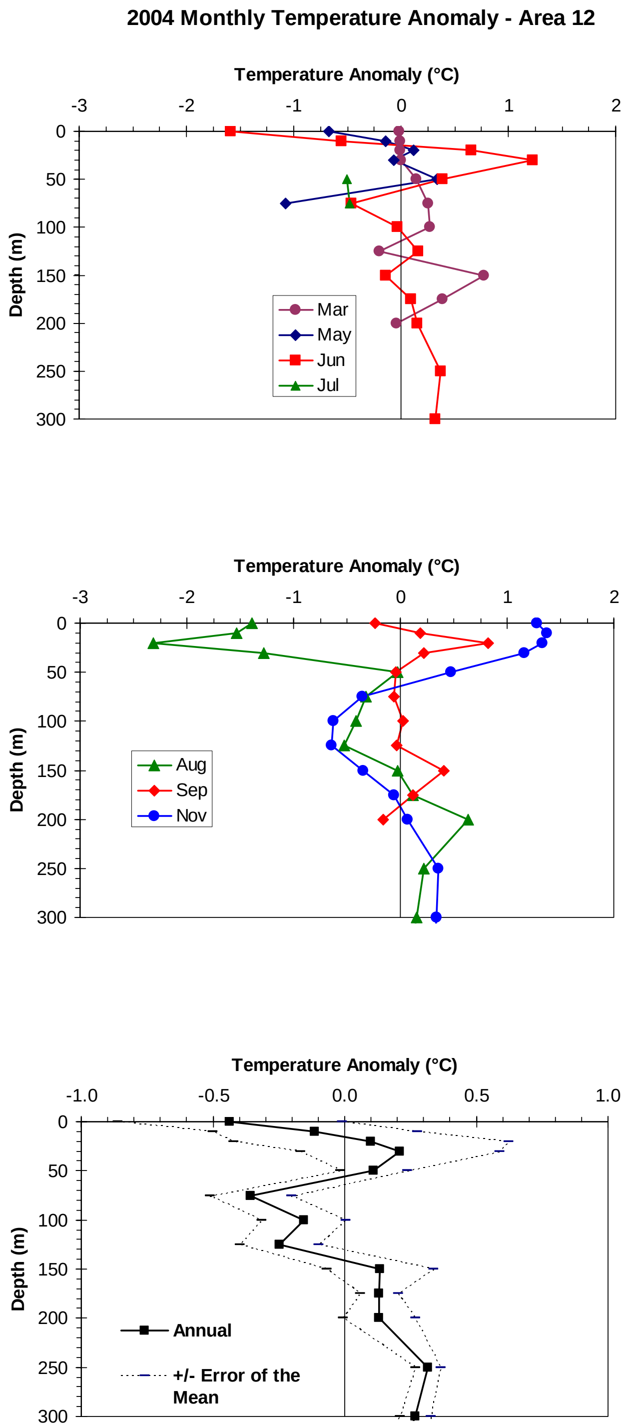


Fig. 9. Monthly (top two panels) mean temperature anomalies and annual temperature anomalies ± error of the mean (bottom panel) during 2004 for snow crab fishing Area 12.

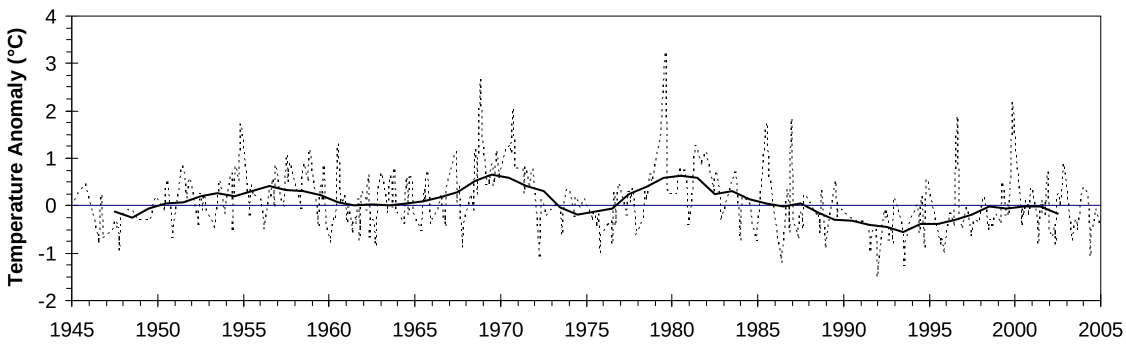
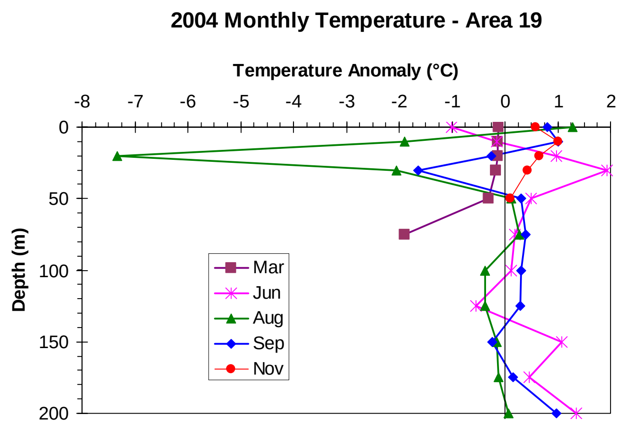


Fig.10. The time series of the monthly (dashed line) and the 5-year running mean of the annual temperature anomalies (solid line) at 75 m for snow crab fishing Area 12.



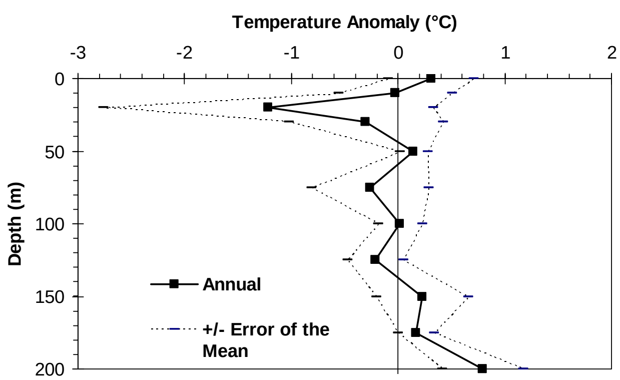


Fig.11. Monthly mean temperature anomalies (top panel) and annual temperature anomalies $\pm$ error of the mean (bottom panel) during 2004 for snow crab fishing Area 19.

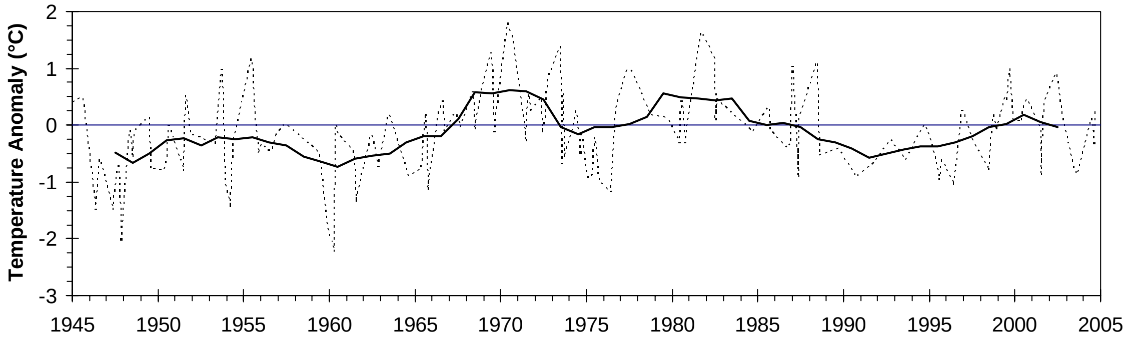


Fig.12. The time series of the monthly (dashed line) and the 5-year running means (solid line) of the annual anomalies at 100 m for snow crab fishing Area 19.

2004 Monthly Temperature Anomaly - Area F

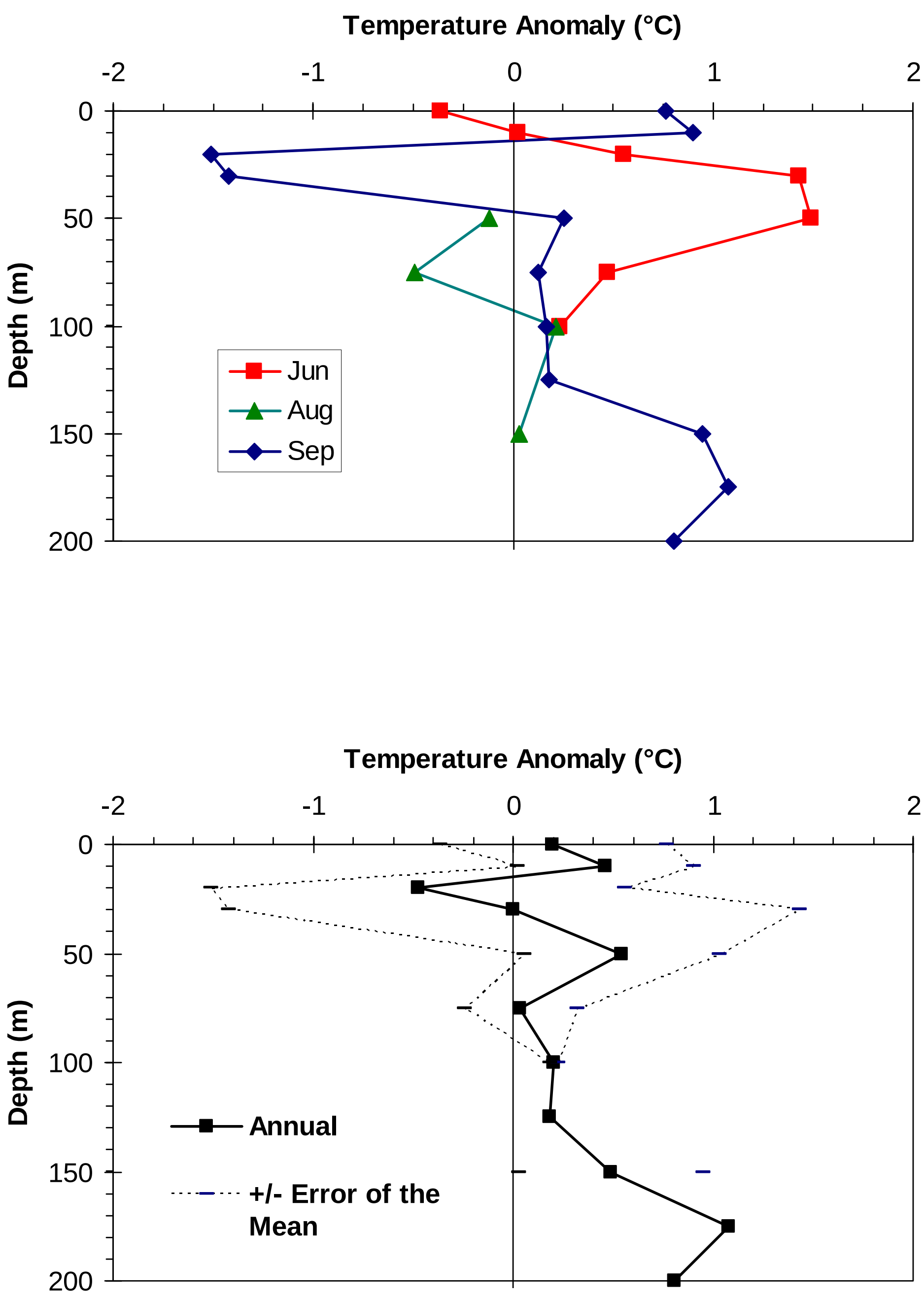


Fig.13. Monthly mean temperature anomalies (top panel) and annual temperature anomalies ± error of the mean (bottom panel) during 2004 for snow crab fishing Area F.

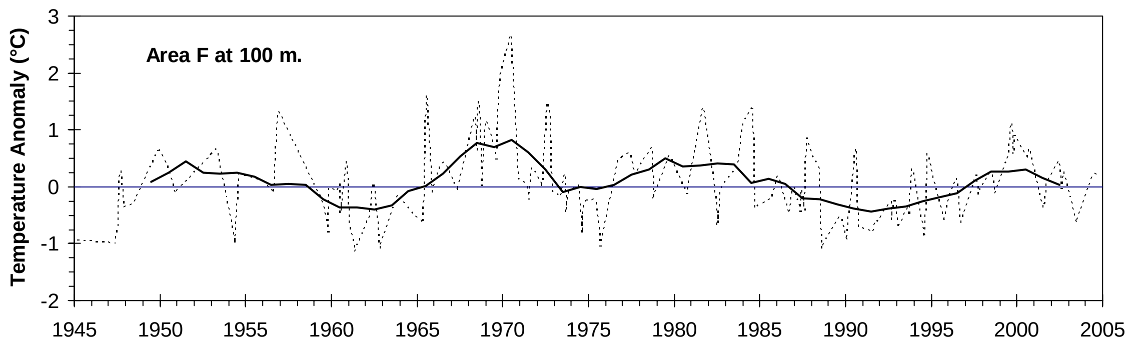


Fig.14. The time series of the monthly (dashed line) and the 5-year running means (solid line) of the annual temperature anomalies at 100 m for snow crab fishing Area F.

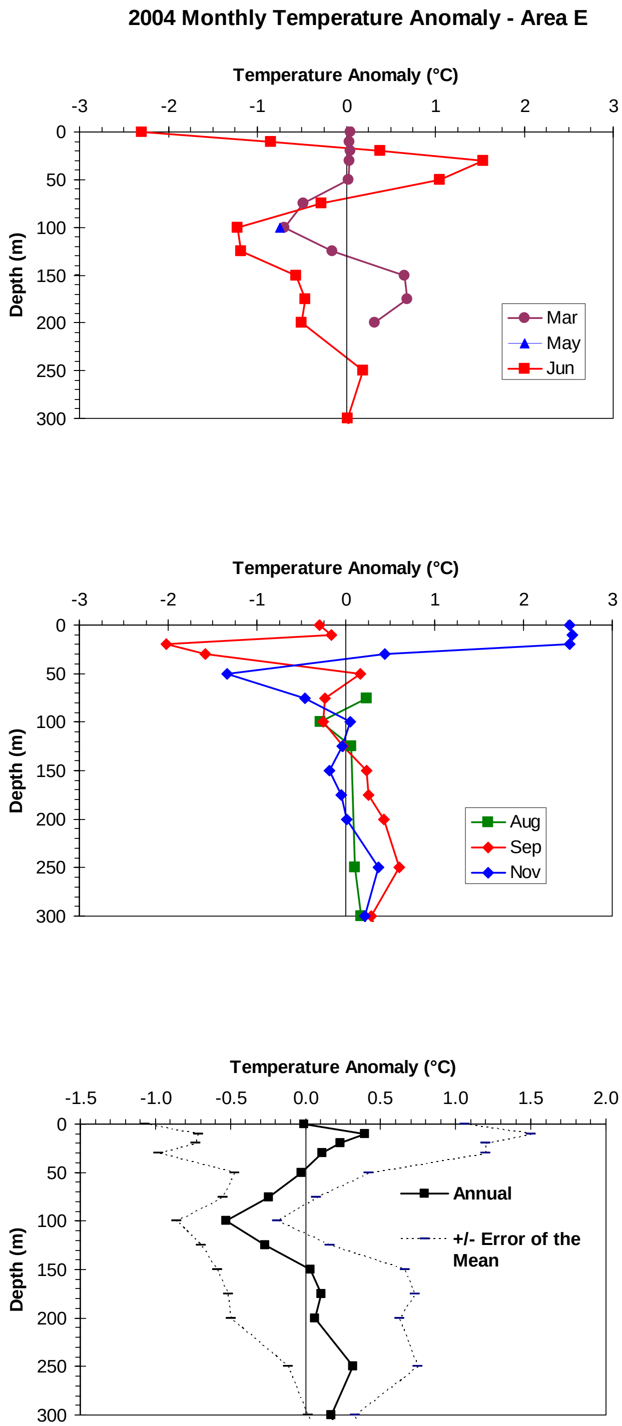


Fig.15. Monthly mean temperature anomalies (upper and mid panels) and annual temperature anomalies ± error of the mean (bottom panel) during 2004 for snow crab fishing Area E.

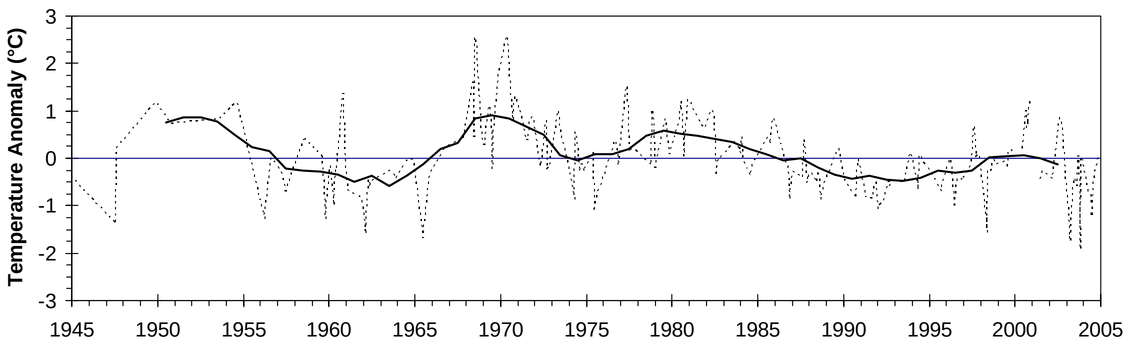


Fig.16. The time series of the monthly (dashed line) and the 5-year running mean of the annual anomalies (solid line) temperature anomalies at 100 m for snow crab fishing Area E.

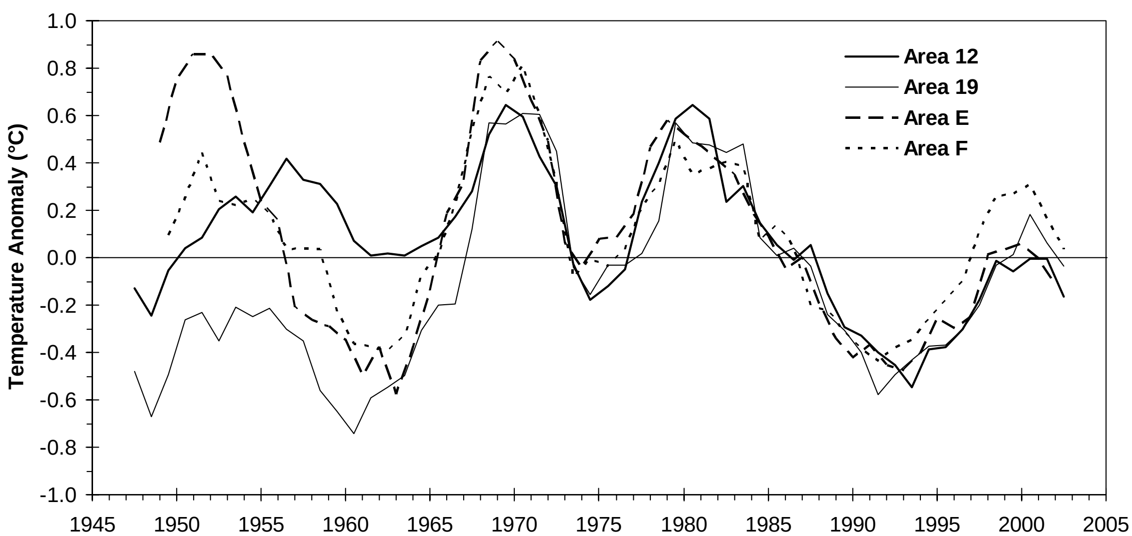


Fig.17. The five-year running means of the near bottom temperature anomalies for Areas 12, 19, E and F.

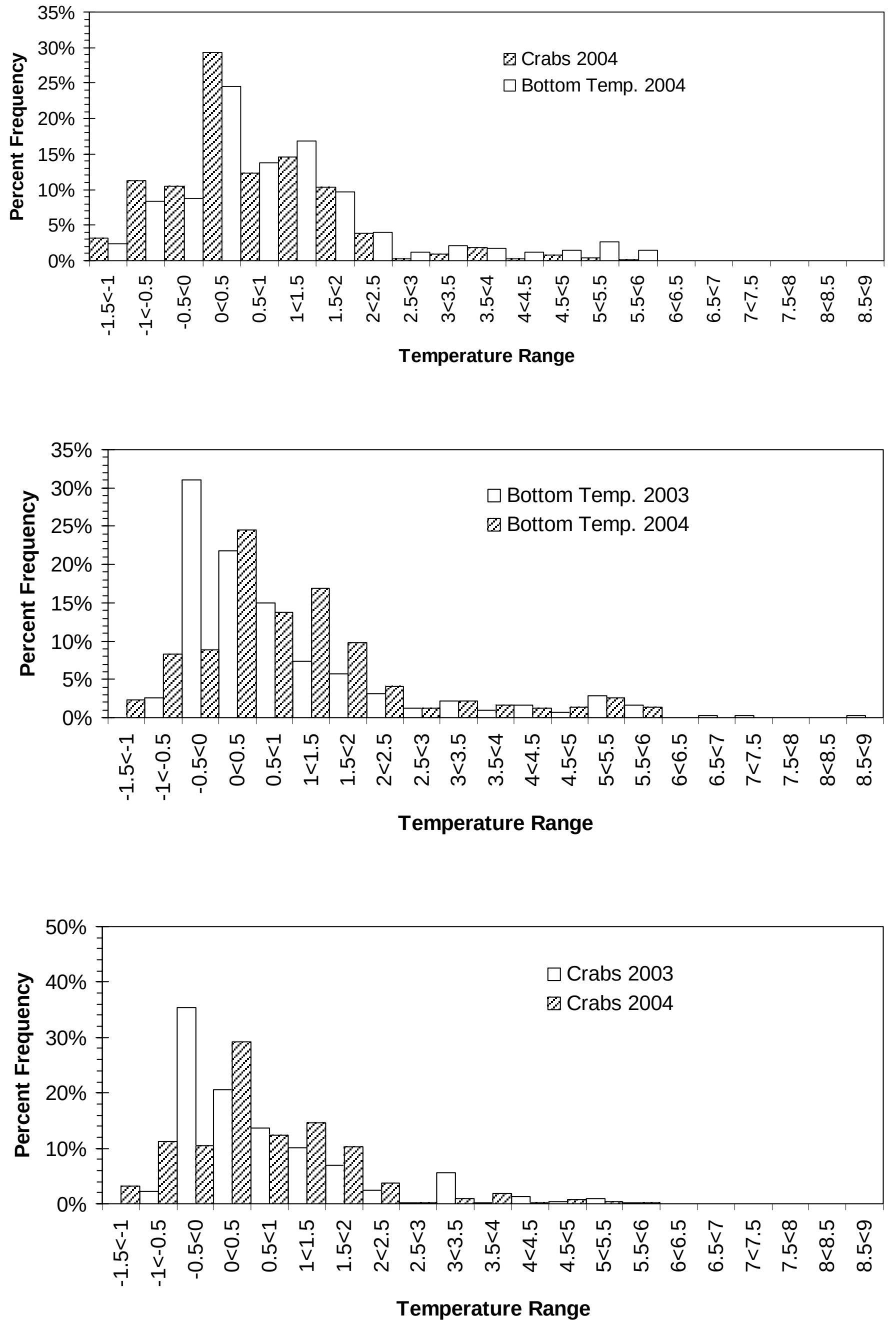


Fig.18. The frequency distribution as a function of temperature for the snow crab catches and for all of the station locations during the 2004 Gulf of St. Lawrence snow crab survey (top panel). The frequency distribution as a function of temperature for the stations occupied (middle panel) and for the snow crab catches (bottom panel) from the 2003 and 2004 Gulf of St. Lawrence snow crab surveys.

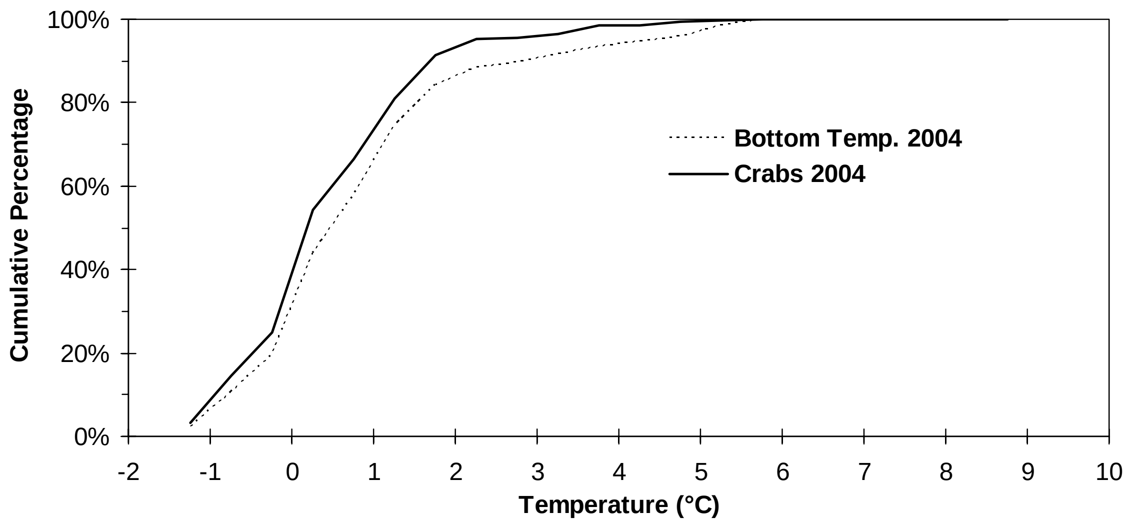


Fig.19. The frequency distribution as a function of temperature for the snow crab catches and for all of the station locations occupied during the snow crab survey in 2004.