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Oceanographic conditions in the Estuary and the Gulf of St. Lawrence during 2006: zooplankton

Conditions océanographiques dans l'estuaire et le golfe du Saint-Laurent en 2006 : zooplancton

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ABSTRACT

Zooplankton biomass, abundance, and species composition in the Québec Region (Lower St. Lawrence Estuary [LSLE] and the Gulf of St. Lawrence) during 2006 are reviewed and compared to previous observations (1999–2005). In addition, this report gives an overview of the interannual variability in the mesozooplankton biomass and the macrozooplankton species composition, abundance, and biomass in the LSLE and the northwest Gulf of St. Lawrence (NWGSL) as measured in the fall of each year between 1994 and 2006.

The state of the zooplankton at the three Québec fixed stations in 2006 was estimated as normal (zooplankton biomass, zooplankton total abundance, and copepod total abundance) and above normal (*Calanus finmarchicus* abundance) at Anticosti Gyre (AG), normal at Gaspé Current (GC), and normal (zooplankton biomass, zooplankton abundance, *C. finmarchicus* abundance) and lower than normal (copepod abundance) at Shediac Valley (SV). In addition, some changes in the zooplankton community structure were observed over the time series at AG and GC, including some changes in the rank of the top ten taxa and the appearance for the first time of some new taxa in the dominant species (top ten): *Temora* spp. at GC and echinoderm larvae and larvacea at AG. Likewise, the zooplankton biomass along the seven Québec sections in 2006 was estimated as lower than normal along the Sept-Îles (TSI) and Bonne Bay (TBB) sections, normal along the Lower St. Lawrence Estuary (TESL) and the Centre Gulf of St. Lawrence (TCEN) sections, and above normal along the southwest Anticosti (TASO), Îles-de-la-Madeleine (TIDM), and Cabot Strait (TDC) sections. Concerning the total zooplankton abundance, anomalies were positive for all sections except along the Bonne Bay (TBB) section, where the total abundance of zooplankton was evaluated as normal. In addition, some changes in the zooplankton composition were observed over the time series in each region, including some changes in the rank order of the top ten taxa and the appearance of new taxa in the top ten species: *Temora* spp. and *Oncea* sp. in the LSLE; echinoderm larvae, larvacea, and *Temora* spp. in the NWGSL; and Cladocera in Cabot Strait.

The mean mesozooplankton biomass observed in November 2006 in the LSLE and NWGSL was 1.4 times lower than in 2005 and corresponds to the third lowest value observed over the last 13 years in the study area. Likewise, the mean macrozooplankton biomass decreased from 15.4 in 2005 to 5.9 ww g/m^2 in 2006; this corresponds to the lowest value observed over the last 13 years. The most notable feature observed in the LSLE and NWGSL was that 2006 had the lowest mean biomass of euphausiids of the last 13 years due to a strong decrease in the abundance of *Thysanoessa raschii,* which was 4.3 times less abundant in 2006 than over the last 13 years. In addition, the mean abundance of the hyperiid amphipod *Themisto libellula* estimated in both regions in 2006 corresponds to the lowest value observed over the last 13 years.

RÉSUMÉ

L'abondance, la composition en espèces et la biomasse de zooplancton dans la région du Québec (l'estuaire et le golfe du Saint-Laurent, GSL) en 2006 sont présentées en comparaison avec les conditions des années précédentes (1999-2005). De plus, le rapport présente une revue de la variabilité interannuelle de la biomasse de mésozooplancton et de l'abondance, la composition en espèces et la biomasse de macrozooplancton pour l'estuaire maritime et le nord-ouest du golfe du Saint-Laurent tel qu'évaluée chaque année à l'automne entre 1994 et 2006.

L'analyse des échantillons de zooplancton prélevés en 2006 dans les 3 stations fixes de la région du Québec indique que l'état du zooplancton (biomasse, abondance totale, abondance totale de copépodes, abondance de *C. finmarchicus*) dans la gyre d'Anticosti (GA), le courant de Gaspé (CG) et la vallée de Schédiac (VS) est comparable aux années précédentes (1999-2005) à l'exception de l'abondance de *C. finmarchicus* dans la GA et de l'abondance totale de copépodes dans la VS, qui ont été respectivement plus élevée et plus faible que la normale. Également, des changements dans la structure de la communauté de zooplancton ont été observés dans la GA et le CG en 2006. En plus d'un changement au niveau de l'ordre d'abondance des 10 espèces dominantes (top 10) échantillonnées à chacune des stations, de nouvelles espèces sont apparues pour la première fois dans le top 10: larves d'échinoderme et de larvacés dans la GA et *Temora* spp. dans le CG. Finalement, la biomasse du zooplancton observée au printemps et à l'automne 2006 le long des sept sections a été évaluée comme sous la normale dans le nord-ouest (TSI) et le nord-est du golfe (TBB), normale dans l'estuaire maritime (TESL) et le centre du golfe (TCEN) et au-dessus de la normale au sud-ouest de l'île d'Anticosti (TASO), dans le sud du golfe (TIDM) et dans le détroit de Cabot (TDC). À l'opposé, l'abondance totale de zooplancton a été évaluée comme au-dessus de la normale dans l'ensemble des régions sauf pour le nord-est du golfe où elle a été évaluée comme normale. En 2006, quelques changements dans la structure de la communauté de zooplancton ont aussi été observés le long des sept sections. En plus d'un changement au niveau de l'ordre d'abondance des 10 espèces dominantes (top 10), de nouvelles espèces sont apparues pour la première fois dans le top 10: *Temora* spp. et *Oncea* sp. dans l'estuaire maritime (TESL); larves d'échinoderme, de larvacés, et *Temora* spp. dans le nord-ouest du golfe (TSI et TASO); et de cladocères dans le détroit de Cabot (TDC).

La biomasse de mésozooplancton observée en novembre 2006 dans l'estuaire maritime et le nord-ouest du GSL était 1.4 fois plus faible qu'en 2005 et correspondait à la troisième plus faible valeur observée au cours des 13 dernières années dans ces deux régions. Par ailleurs, la biomasse moyenne de macrozooplancton a diminué de 15.4 à 5.9 g/m^2 (poids humide) de 2005 à 2006 et la valeur de 2006 correspond à la plus faible valeur observée au cours des 13 dernières années dans les deux régions. Un fait marquant de l'année 2006 est la plus faible biomasse d'euphausiacés (krill) observée au cours des 13 dernières années, dû à une forte diminution de l'abondance de l'espèce *Thysanoessa raschii* qui était 4.3 fois moins abondante qu'au cours des 13 dernières années dans les deux régions. Finalement, l'année 2006 correspond à la plus faible abondance moyenne de l'amphipode pélagique *Themisto libellula* des 13 dernières années.

INTRODUCTION

The Atlantic Zone Monitoring Program (AZMP) was implemented in 1998 (Therriault et al. 1998) with the aim of (1) increasing DFO's capacity to understand, describe, and forecast the state of the marine ecosystem and (2) quantifying changes in the ocean's physical, chemical, and biological properties and the predator–prey relationships of marine resources. A critical element of the AZMP observational program is an annual assessment of the distribution and variability of nutrients and the plankton they support.

The description of the distribution in time and space of nutrients dissolved in seawater (nitrate, silicate, phosphate) provides important information on the movements of water masses and on the location, timing, and magnitude of biological production cycles. Descriptions of the phytoplankton and zooplankton distributions provide important information on the organisms forming the base of the marine food web. An understanding of the plankton production cycles is an essential part of an ecosystem approach to fisheries management.

The AZMP derives its information on the state of the marine ecosystem from data collected at a network of sampling locations (e.g., fixed point stations, sections, multi-species surveys) in each region (Québec, Maritimes/Gulf, Newfoundland) sampled at frequencies ranging from twice a month to once a year. Furthermore, we have a zooplankton biomass survey in the Québec Region that has been carried out in the Lower Estuary and the northwest Gulf of St. Lawrence in September from 1994 to 2003 and at the beginning of November since 2004. The sampling design provides basic information on the natural variability in the physical, chemical, and biological properties of the northwest Atlantic continental shelf and the St. Lawrence marine system (SLMS). The annual zooplankton biomass survey and the AZMP sections provide detailed geographic information but are limited in their seasonal coverage. Strategically placed fixed stations complement the geographically based sampling by providing more detailed information on temporal (seasonal) changes in ecosystem properties.

The purpose of this document is to provide an overview of the temporal variability of the zooplankton biomass, abundance, and species composition in 2006 at three fixed stations and seven sections of the AZMP as well as an overview of the interannual variability of the macrozooplankton species composition, abundance, and biomass in the Lower St. Lawrence Estuary (LSLE) and the northwest Gulf of St. Lawrence (NWGSL) from 1994 to 2006.

SPATIAL AND TEMPORAL VARIABILITY OF ZOOPLANKTON SPECIES COMPOSITION, ABUNDANCE, AND BIOMASS AT THREE FIXED STATIONS AND SEVEN SECTIONS OF THE QUÉBEC REGION IN 2006

Materials and Methods

The location and the sampling dates of three fixed stations (Anticosti Gyre, Gaspé Current, and Shediac Valley) and along seven sections (St. Lawrence Estuary, Sept-Îles, Anticosti, Centre Gulf of St. Lawrence, Cabot Strait, Bonne Bay, Îles-de-la-Madeleine) are given in Figure 1 and Table 1. In 2006, zooplankton samples were collected on 10 instances at the Anticosti Gyre fixed station, on 11 instances at the Gaspé Current fixed station, on 9 instances at the Shediac Valley fixed station, and during two surveys (21–29 June and 1–9 November 2006). Collections and standard measurements of zooplankton biomass and abundance are based on protocols outlined by the AZMP steering committee (Mitchell et al. 2002).

We analyzed the monthly variations of several indices describing the state of the zooplankton community at each station in 2006. The indices are: 1) the depth-integrated zooplankton biomass, 2) the depth-integrated zooplankton abundance and community structure, 3) the depth-integrated abundance of copepods and community structure, and 4) the depth-integrated total abundance of *Calanus finmarchicus* as well as those of its developmental stages.

Time series of zooplankton biomass and abundance anomalies and other derived zooplankton indices (copepod abundance, *C. finmarchicus* abundance) were constructed by removing the annual cycle computed over the standard period (1999–2006). It should be noted that monthly and annual anomaly estimates are often based on a varying number of observations, so caution should be used when interpreting the short time-scale features of many of these indices. Annual anomalies were normalized by dividing the anomalies by the standard deviation of the data over the averaging period, usually 1999–2006 if the data permit. For example, a value of 2 indicates that the index was 2 standard deviations higher than the long-term average. Zooplankton biomass and abundance anomalies from the fixed stations and standard sections in Québec Region during 2006 are presented as normalized anomalies in 0.5 standard deviation units. The anomalies are colour-coded, with blues, white, and reds representing negative, normal, and positive zooplankton conditions, respectively.

Results

Fixed stations. Based on the samples collected at the three fixed stations, Anticosti Gyre (AG), Gaspé Current (GC), and Shediac Valley (SV), we can see that the zooplankton biomass follows the same seasonal pattern of variation as the seven previous years (1999–2005) (Fig. 2). Furthermore, the zooplankton biomass observed during the different months at all stations was comparable to that observed previously (1999–2005) at the same period of the year. The exceptions were SV in May, June, and July and AG in August, September, and November, for which the zooplankton biomass was slightly higher and lower, respectively, than the long-term average (Fig. 2).

The total abundance of zooplankton in 2006 varied between 94,966 and 981,123 ind/m^2 at AG, 68,646 and 285,640 ind/m^2 at GC, and 70,400 and 312,377 ind/m^2 at SV (Fig. 3). The zooplankton abundances observed during the different months at the three fixed stations were comparable to those observed previously (1999–2005) at the same period of the year. The exceptions in this case were AG in June, where a strong pulse of echinoderm larvae resulted in a total zooplankton abundance that was seven times higher than normal, and SV in October and November, where the total abundance of zooplankton was lower than normal (Fig. 3). Hierarchical community analysis revealed that copepods continued to numerically dominate the zooplankton year-round at the three fixed stations in 2006 except for the pulse of echinoderm larvae observed during the summer at AG (Fig. 4).

As was the case with zooplankton abundance, the total annual integrated copepod abundance at the three fixed stations in 2006 was comparable to levels observed during the seven previous years (1999–2005), although the total abundance was lower than the long-term average at SV (Fig. 5). The copepod abundances observed during the different months at the three stations were comparable to previous observations (1999–2005) at the same period of the year; however, an abundance peak occurred in June at AG and a lower abundance was observed late in the year (October–November) at SV. There was no apparent change in the copepod community structure in 2006 at either GC or AG (Fig. 6). The copepod community at AG and GC was dominated (>50% for much of the year) by the small *Oithona* spp., and the relative importance of the larger *Calanus* spp. was similar to the previous year.

The average abundance of *C. finmarchicus* in 2006 was estimated at 23,423 ind/m^2 at GC, 28,900 ind/m^2 at AG, and 45,600 ind/m^2 at SV. These levels are lower than the record peak abundance observed in 2003 in the three regions but higher than the typical levels observed during the seven previous years (1999–2005) in each region (15,500, 16,800, and 32,700 ind/m^2 at AG, GC, and SV respectively, excluding 2003) (Fig. 7). In addition, abundance of *C. finmarchicus* at the three fixed stations followed the same seasonal pattern of variation as during the seven previous years (1999–2005), except that the total abundance of *C. finmarchicus* was higher than the long-term average in June at AG and slightly higher in June and July at GC (Fig. 7). Finally, based on the relative abundance of the various developmental stages of *C. finmarchicus* in 2006, there was only one reproductive period in spring/early summer at AG (indicated by the presence of stages I–III) and two reproductive periods in spring/early summer and fall at GC and SV (Fig. 8).

This different pattern of *C. finmarchicus* reproduction in different regions of the Gulf of St. Lawrence was frequently observed during the previous seven years (1999–2005).

The abundance and percentage of the ten top most abundant taxa at AG and GC are shown in Tables 2 and 3. In 2006, we observed some changes in the zooplankton composition over the time series. In addition to some changes in the rank of the top ten species, some new groups appeared in the dominant species for the first time at both stations. The most numerically abundant new group was echinoderm larvae, which made up 27% of the total zooplankton abundance at AG in 2006. In addition, the large copepod *Calanus hyperboreus*, which has contributed *ca.* 10% of the total zooplankton abundance at AG since 2000, is not among the ten top taxa at GC.

In summary, the state of the zooplankton at the three Québec fixed stations in 2006 was estimated as normal (zooplankton biomass, zooplankton total abundance, and copepod total abundance) and above normal (*C. finmarchicus* abundance) at AG, normal at GC, and normal (zooplankton biomass, zooplankton abundance, *C. finmarchicus* abundance) and lower than normal (copepod abundance) at SV (Fig. 9). In addition, some changes in the zooplankton community structure were observed over the time series at AG and GC, including some changes in the rank of the top ten taxa and the appearance for the first time of some new taxa in the dominant species (top ten): *Temora* spp. at GC and echinoderm larvae and larvacea at AG.

Sections. The spatio-temporal variations of the total biomass and abundance of zooplankton and the abundances and percentages of the ten most abundant taxa sampled in June and November from 2000 to 2006 along the seven AZMP sections located in the St. Lawrence Marine System (SLMS) are presented in Figures 10 to 16. In the Lower St Lawrence Estuary (TESL section), both the total zooplankton biomass and the total zooplankton abundance have usually been higher in November than in June since 2000, although the zooplankton biomass has been at the same level in June and November since 2004. In addition, the mean annual (June and November) zooplankton abundance along the LSLE section increased slightly between 2000 and 2006 while the zooplankton biomass increased until 2003, decreased in 2004, and has shown no change since that time (Fig. 10). In 2006, the total mean annual zooplankton abundance was 1.5 times higher (107,800 ind/m^2) than during the six previous years (2000–2005) (73,700 ind/m^2). We ranked the ten most abundant taxa in the LSLE according to their annual mean proportion of the total zooplankton. In 2006, we observed some changes in the zooplankton composition within the top ten taxa over the time series. In addition to some changes in the rank order, the small copepod *Oithona* spp. was 1.8 times more abundant in 2006 than during the six previous years (2000–2005), whereas copepod nauplii and the young stages of euphausiids (eggs, nauplii, juveniles) were respectively 4.7 and 6.8 times less abundant in 2006 than during the long-term average. Finally, in 2006, *Temora* spp. and *Oncea* spp. appeared as new groups in the dominant species for the first time in the LSLE.

In the northwest Gulf of St. Lawrence (TSI section) and on the southwest side of Anticosti Island (TASO section), both the total zooplankton biomass and the total zooplankton abundance followed the same seasonal and interannual pattern of variation as in the LSLE, except for a pulse of echinoderm larvae that appeared in June 2006, causing the total abundance of zooplankton to increase by ~7 times compared to June 2000–2005

(Fig. 11 and 12). This pulse of echinoderms resulted in a mean annual total abundance of zooplankton that was ~ 2.8 times higher in 2006 than the long-term average (2000–2005) in both regions. Moreover, except for some differences in the rank order, both regions have the same list of the top ten taxa, and each top ten taxa was ~2.5 times more abundant in 2006 compared to the 2000–2005 average, except for *C. hyperboreus*, *Metridia* spp., and *Euchaeta norvegica,* whose abundances matched the long-term averages. The most notable change was in the two most abundant species, the small copepod *Oithona* spp. and the large copepod *C. finmarchicus*, which were respectively 2.1 and 4.3 times more abundant in 2006 compared to the 2000–2005 average in both regions. Finally, in 2006 echinoderm larvae, larvacea, and *Temora* spp. appeared on the list of dominant species for the first time along the TSI and the TASO sections

In the Centre Gulf of St. Lawrence section (TCEN), where we have only three years of data (2004–2006), both the total zooplankton biomass and the total zooplankton abundance followed the same seasonal and interannual patterns of variation as in the LSLE and the northwestern GSL (TESL, TSI, and TASO) (Fig. 13). There was no change in the zooplankton biomass and abundance in 2006 compared to 2004 and 2005. Moreover, except for some changes in the rank order, this section had the same top ten taxa as the previously described sections (TESL, TSI, and TASO) that all cross the Laurentien Channel.

The northeast GSL (TBB section), the southern GSL (TIDM section), and Cabot Strait (TDC section) showed no major changes in the zooplankton biomass or abundance in 2006 compared to the 2000–2005 average. However, some changes in the top ten zooplankton taxa were observed in comparison with the four regions already described (TESL, TSI, TASO, and TCEN). Among the species involved in these differences, *Temora* spp. and larvacea, which were included in the top ten taxa only in 2006 along the TESL, TSI, TASO, and TCEN sections, represented 9.8% and 2.7%, respectively, of the total zooplankton abundance between 2000–2006 for the TBB, TIDM, and TDC sections combined. On the other hand, *Microcalanus* spp. and *Metridia* spp., which represented more than 3.5% of the total zooplankton abundance along TESL, TSI, TASO, and TCEN from 2000–2006, were not among the top ten taxa for TIDM and represent less than 2.0% of the total zooplankton abundance in TBB and TDC (Fig. 14, 15, 16).

In summary, the zooplankton biomass along the seven Québec sections in 2006 was estimated as lower than normal along the Sept-Îles (TSI) and Bonne Bay (TBB) sections, normal along the Lower St. Lawrence Estuary (TESL) and the Centre Gulf of St. Lawrence (TCEN) sections, and above normal along the southwest Anticosti (TASO), Îles-de-la-Madeleine (TIDM), and Cabot Strait (TDC) sections (Fig. 17). Concerning the total zooplankton abundance, anomalies were above normal for all sections except along the Bonne Bay (TBB) section, where the total abundance of zooplankton was evaluated as normal (Fig. 17). In addition, some changes in the zooplankton composition were observed over the time series in each region, including some changes in the rank order of the top ten taxa and the appearance of new taxa in the top ten species: *Temora* spp. and *Oncea* sp. in the LSLE; echinoderm larvae, larvacea, and *Temora* spp. in the NWGSL; and Cladocera in Cabot Strait.

Conclusion

The time-series anomalies (1999–2006) of zooplankton biomass and abundance and other zooplankton indices (copepod abundance, *C. finmarchicus* abundance) indicate that 2006 was normal at the three fixed stations (AG, GC, and SV) and slightly above normal along the seven Québec sections. This continues the normal and above-normal trend observed since 2003 in the St. Lawrence Marine System (Fig. 18).

INTERANNUAL VARIATIONS IN THE MESOZOOPLANKTON BIOMASS AND THE MACROZOOPLANKTON SPECIES COMPOSITION, ABUNDANCE, AND BIOMASS IN THE LOWER ST. LAWRENCE ESTUARY AND THE NORTHWEST GULF OF ST. LAWRENCE FROM 1994 TO 2006

Materials and Methods

This survey, which was initiated in 1994, covers an area of 11,000 km^2 from Les Escoumins in the LSLE to Sept-Îles in the NWGSL (Fig. 19). The sampling design consists of 44 stations distributed along eight sections traversing the estuary. The survey has always been done using the BIONESS sampling gear, which is a multiple opening–closing 333µm mesh net system. In 1994, only sections K through T were surveyed. Sections G and I, at the head of the Laurentian Channel, have been sampled in since 1995 whereas section U in the Anticosti Gyre has only been sampled since 1997. Surveys took place on four different ships between 31 August and 26 September until 2003, after which sampling was delayed until 8–13 November; an average of six days has been required to survey the entire grid. At each station, the water column was sampled twice, each time with two nets (bottom–150 m and 150–0 m or bottom–0 for stations <150 m in depth). Since 2004, for practical reasons related to saving ship time and analytical costs, the water column has been sampled only once. In 2005, a new four-strata sampling scheme was adopted to reflect the physical properties of the water column: the hypoxic layer from the bottom up to 290 m, the deep layer from 290 m to the bottom of the cold intermediate layer (CIL, at 3°C), the CIL (≤3°C), and the surface layer from the top of the CIL to the surface. Approximately half the stations were sampled during the day and half at night until the later sampling that began in 2004, after which one third of the stations have been sampled during the day because of reduced daylight hours at that time of year.

Upon retrieval of the BIONESS, the total sample of each net was weighed (wet weight) and adult fishes (mostly *Melanostigma atlanticum*), pandalid shrimps, and gelatinous zooplankton were removed, counted, weighed, and released. If the volume of the remaining zooplankton was greater than 250 mL, the sample was split using a Motoda box splitter to get a maximum volume of 250 mL; the sample was preserved in buffered formalin (4%) and seawater. Since 2004, the whole sample has been preserved at sea without sorting or splitting. Back at the lab, zooplankton categories from all samples are sorted, counted, and weighed (wet weight) according to the following species or groups:

- **Macrozooplankton:** mainly adult and juvenile euphausids (*Meganyctiphanes norvegica*, *Thysanoessa inermis*, *T. raschii*). This category also includes mysids

(*Boreomysis arctica*, *Mysis mixta*, *Erythrops erythrophthalma*), which are commonly found in deep samples, hyperiid amphipods (*Themisto libellula*, *T. abyssorum*, *T. compressa*), and chaetognathes (*Sagitta elegans*, *S. maxima, Eukrohnia hamata*).

- **Mesozooplankton:** this category is predominantly composed of copepods but also includes other mesozooplankton organisms (e.g., invertebrate larvae, decapoda, ostracoda). We have not performed detailed identifications on the mesozooplankton samples.

Until 2003, two replicates per station were analyzed to determine the wet biomass (ww – g) and the abundance of the macrozooplankton species and the wet biomass of the mesozooplankton. Results are integrated over the water column and standardized to numbers or grams per square meter using the volume of water filtered by the nets, which was measured by a General Oceanics electronic flowmeter in the mouth of the BIONESS.

Results

The mean mesozooplankton biomass observed in November 2006 in the LSLE and in the NWGSL was 1.4 times lower than in 2005 and corresponds to the third lowest value observed over the last 13 years in the study area (Fig. 20). Likewise, the mean macrozooplankton biomass decreased from 15.4 in 2005 to 5.9 ww g/m^2 in 2006. This value corresponds to the lowest value observed over the last 13 years. The relative biomass of the four most important macrozooplankton groups in terms of biomass (euphausiids, mysids, hyperiid amphipods, and chaetognaths) varied over time. The relative biomass of euphausiids decreased from 87% to 50% between 1994 and 1998, slightly increased to ~65% between 1999 and 2003, drastically decreased to 26% in 2004, returned to a typical level of ~ 66% in 2005, and decreased again to 48% in 2006. The relative biomass of the mysids increased from 3% in 1994 to 29% in 2000, decreased to ~16% between 2001 and 2005, and increased again to 32% in 2006. This is the highest proportion of mysids that we have observed in the LSLE and the NWGSL over the time series. On the other hand, the relative biomass of the hyperiid amphipods increased from 8% in 1994 to 20% in 1995, stayed around 20% from 1996 to 1998, significantly decreased from 23% to 1% between 1998 and 2000, increased back to 20% in 2001 and 2002, 30% in 2003, and 40% in 2004, and decreased again to 4% between 2004 and 2006. Likewise, the relative biomass of the chaetognaths varied between 1% and 6% of the total macrozooplankton biomass from 1994 to 2003 and drastically increased to *ca*. 19% in 2004, reverted to a typical level of *ca.* 5% in 2005, and increased again to *ca*. 16% in 2006 (Fig. 20).

Fig. 21 shows the interannual variations in the total abundance and biomass of the various macrozooplankton species belonging to each of the groups previously discussed. From 1994 to 1996, the mean abundance of *T. raschii* and *M. norvegica* decreased from 250 to 40 ind/m^2 and from 35 to 5 ind/m^2, respectively. The mean abundance of *T. raschii* was stable at ~ 40 ind/m^2 from 1996 to 1999 and increased to 46 ind/m^2 in 2000. From 2000 to 2002, the mean abundance of *T. raschii* decreased from 46 to 25 ind/m^2 and increased slightly to ~32 ind/m^2 in 2003 and 2004, and to 68 ind/m^2 in 2005. In 2006, the mean abundance of *T. raschii* was evaluated at only 15 ind/m^2, making this the lowest value observed over the last 13 years in the study area. Concerning *M. norvegica*, the mean abundance increased from 5 to 22 ind/m^2 from 1996 to 1997 and decreased again to 5 ind/m^2 in 2000. From 2000 to 2001, the mean abundance of *M. norvegica* increased from 5 to 15 ind/m^2 and decreased to 10 ind/m^2 in 2002, to 7 ind/m^2 in 2003, and to 3 ind/m^2 in 2004, and slightly increased to 8 ind/m^2 in 2005 and 2006. The same temporal pattern of variation was observed for the biomass of euphausiids, with a strong increase in the total biomass of euphausiids (*T. raschii* + *M. norvegica*) from 3.9 in 2004 to 9.7 ww g/m^2 in 2005 and a decrease to 2.9 ww g/m^2 in 2006. This corresponds to the lowest biomass of euphausiids observed over the last 13 years in the LSLE and the NWGSL.

The mean abundance of the hyperiid amphipod *T. abyssorum* decreased from 18 ind/m^2 in 1994 to 3 ind/m^2 in 1995, increased slightly in 1997 and 1998, decreased again to reach 1 ind/m^2 in 2003 and 3 ind/m^2 in 2004, increased to 8 ind/m^2 in 2005, and decreased again to 4 ind/m^2 in 2006 (Fig. 21). Likewise, the mean abundance of *T. libellula* decreased from 15 to 5 ind/m^2 between 1995 and 1996, increased to 10 ind/m^2 in 1998, and decreased to 0.17 ind/m^2 in 2000. Thereafter, the mean abundance of *T. libellula* increased greatly, from 0.17 to 16 ind/m^2 from 2000 to 2004, and drastically decreased to 4 and 0.04 ind/m^2 in 2005 and 2006, respectively. The mean abundance of *T. libellula* observed in 2006 corresponded to the lowest values observed over the last 13 years. We hypothesize that the interannual variations of the mean abundance of *T. libellula* observed in the LSLE and the NWGSL since 1994 are associated with the intrusion of cold Labrador Shelf water into the Gulf of St. Lawrence via the Strait of Belle Isle. This hypothesis is supported by the significant positive relationship ($R^2 = 0.53$) between the abundance of *T. libellula* and the volume of the Labrador Shelf water advected to the GSL via the Strait of Belle Isle during winter (Galbraith 2006) (Fig. 22).

In contrast with all other macrozooplankton species, the mean abundance of the mysid *B. arctica* was lowest in 1994, 1995, and 1996 (*ca.* 18 ind/m^2) and increased significantly in 1997, 1998, and 1999 to reach a value that was three times higher in 1999 than in 1996. Between 1999 and 2001, the mean abundance of *B. artica* was stable at ~ 55 ind/m^2. In 2002, the mean abundance of *B. arctica* decreased to near the level observed in 1994–1996 (~ 20 ind/m^2), increased to 40 ind/m^2 in 2003, decreased again to 25 ind/m^2 in 2004, increased again to 58 ind/m^2 in 2005, and decreased to 39 ind/m^2 in 2006 (Fig. 21). Likewise, the mean abundance of the chaetognaths (*S. elegans* and *E. hamata*) decreased from 22 to 8 ind/m^2 between 1994 and 1997, increased to 25 ind/m^2 in 1998, and decreased again to *ca.* 10 ind/m^2 in 1999 and 2000. From 2000 to 2002, the mean abundance of chaetognaths increased significantly from 10 to 35 ind/m^2, decreased to 10 ind/m^2 in 2003, increased drastically to 141 ind/m^2 in 2004, and decreased again to 29 and 23 ind/m^2 in 2005 and 2006, respectively (Fig. 21). Finally, the mean abundance of gelatinous zooplankton (mostly cnidarians) followed the same pattern of temporal variations as the chaetognaths during the whole time series, including the drastic increase from 23 to 148 ind/m^2 from 2003 to 2004 and the decrease observed in 2005. The exception occurred in 2006, when there was an increase in the abundance of gelatinous zooplankton and a decrease in the abundance of chaetognaths.

Discussion and Conclusion

Two major trends have characterized the interannual variations of the macrozooplankton community structure and abundance in the LSLE and the NWGSL during the last decade (1994–2006). First, the biomass of macrozooplankton decreased from 33 ww g/m^2 in 1994 to 12 ww g/m^2 in 1998 (a 60% drop in four years), varied between 12 and 15 ww g/m^2 from 1998 and 2005, and decreased again to 6 ww g/m^2 in 2006 (a 50% drop in one year). The relative biomass of krill, which is essentially composed of two species, *M. norvergica* and *T. raschii*, decreased from 87% to 50% between 1994 and 1998, slightly increased to ~ 65% between 1999 and 2003, drastically decreased to 26% in 2004, reverted to a typical level of ca. 66% in 2005, and decreased again to 48% in 2006. This decline in the abundance of krill has also been measured elsewhere: 1) in the southern Gulf of St. Lawrence since 1987 (M. Harvey, analysis of zooplankton samples collected over 20 years [1982 to 2003], unpublished data; Hanson and Chouinard 2002, analysis of cod stomach contents over 40 years [1959 to 2000]), 2) in the Newfoundland and Labrador ecosystem (F. K. Mowbray and P. Lundrigan, Northwest Atlantic Fisheries Centre, capelin stomach content analysis over 20 years [unpublished data]), and 3) on the Scotian Shelf (Harrison et al., 2003, analysis of CPR data). This evidence suggests that the decline in krill abundance is not restricted to the GSL but is widespread over a large part of the Atlantic coast of Canada.

The second major change is the presence of the cold-water Arctic hyperiid amphipod *T. libellula* in the GSL waters since the early 1990s. Indeed, both a literature review going back to the early 1900s and a reanalysis of several zooplankton samples collected during the 1980s in different areas Gulf of St. Lawrence and Lower Estuary have shown that *T. libellula* was absent from the SLMS before the 1990s except for a few juvenile individuals occasionally observed in the northeast GSL, near of the Strait of Belle Isle (Bousfield 1951). On the other hand, different surveys carried out annually by the our institute since the beginning of the 1990s have shown that *T. libellula* has become an abundant, full-time resident of the SLMS, with an annual mean abundance varying between 0.17 and 16 ind/m^2. This geographic expansion of *T. libellula* into the SLMS during the 1990s coincides with the observations made by Drinkwater and Gilbert (2004) that the core temperature in the cold intermediate layer (CIL) in the GSL in the 1990s was on average the coldest of the last five decades. Furthermore, the interannual variations in the mean abundance of *T. libellula* observed in the this system since 1996 are positively correlated ($R^2 = 0.53$) with the volume of the Labrador Shelf water advected into the GSL through the Strait of Belle Isle during winter (Galbraith 2006). These two observations support the hypothesis that *T. libellula* was introduced into the GSL via the Strait of Belle Isle during the winter season and that their survivorship was helped by the fact that the 1990s corresponded to the coldest CIL of the last five decades. Relative to the CIL, *T. libellula* always remain (day and night, during all seasons) at temperatures <3°C in the GSL (Harvey et al., in preparation). According to Saucier et al. (2003), the CIL in the LSLE and the NWGSL is not formed in situ. A significant fraction of these waters enters through the Strait of Belle Isle in wintertime, eventually reaching the LSLE within about six months. This certainly contributes to the expansion of *T. libellula* throughout the different regions of the SLMS. Another factor that could have contributed to the geographic expansion of *T. libellula* in the SLMS is that this species was apparently more abundant on the Labrador Shelf during the 1990s than during the 1980s. A recent study comparing the stomach contents of Arctic charr on the Labrador Shelf over an 18-year period from 1982 to 1999 showed that *T. libellula* was four times more abundant during the 1990s than during the 1980s. (Dempson et al. 2002 and B. Dempsen, pers. comm.) This could be the result of a large-scale change in the circulation of the Arctic waters associated with climate change (Morison et al. 2000).

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Table 1. AZMP sampling missions in the study area in 2006. The fixed stations are Anticosti Gyre (AG), Gaspé Current (GC), and Shediac Valley (SV), and the sections are St. Lawrence Estuary (TESL), Sept-Îles (TSI), southwest Anticosti (TASO), Centre Gulf of St. Lawrence (TCEN), Bonne Bay (TBB), Cabot Strait (TDC), and Îles-de-la-Madeleine (TIDM). The total numbers of hydrographic (CTD) and biological (nutrients, chlorophyll, phytoplankton, and zooplankton) profiles for each seasonal section and fixed station survey are given.

Group	Location	Mission ID	Dates	# Hydro Stns	# Bio Stns
Fixed stations	AG	IML-06-01	03 Feb–04 Nov	11	10
	GC		03 Feb–04 Nov	11	11
	SV		28 Apr–06 Dec	9	9
Seasonal Sections	TESL, TSI, TASO, TCEN, TBB, TDC, TIDM	IML-06-08	21–29 Jun	46	46
	TESL, TSI, TASO, TCEN, TBB, TDC, TIDM	IML-06-60	01–09 Nov	45	45

Table 2. Percentages and averages of the ten top taxa at the Anticosti Gyre station from 2000–2005 compared to 2006 (upper) and for 2006 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2006.

Rank / Rang	Taxa /Taxon	% of total zooplankton % du total de zooplancton 2000–2005	% of total zooplankton % du total de zooplancton 2006	Yearly average / Moyenne annuelle 2000–2005 (ind/m^3)	2006 average / Moyenne 2006 (ind/m^3)
1	*Oithona* spp.	33.25	22.65	133.17	144.08
2	*Calanus finmarchicus*	16.37	13.09	65.56	83.25
3	*Calanus hyperboreus*	14.65	8.87	58.70	56.43
4	*Microcalanus* spp.	5.89	5.61	23.58	35.69
5	Ostracoda	5.28	4.84	21.13	30.79
6	*Metridia* spp.	5.21	3.11	20.89	19.78
7	Invertebrate eggs	4.26	1.63	17.05	10.34
8	*Pseudocalanus* spp.	3.48	2.08	13.93	13.25
9	*Oncea* spp.	2.67	1.74	10.71	11.07
10	*Euchaeta norvegica*	1.64	0.78	6.58	4.94
Total		92.69	64.40	371.30	409.63
Total abundance of zooplankton Abondance totale de zooplancton (N/m^3)				400.57	636.10

Rank / Rang	Taxa /Taxon	% of total zooplankton % du total de zooplancton 2006	2006 average / Moyenne 2006 (ind/m^3)
①	Echinoderm larvae	27.34	173.92
2	*Oithona* spp.	22.65	144.08
3	*Calanus finmarchicus*	13.09	83.25
4	*Calanus hyperboreus*	8.87	56.43
5	*Microcalanus* spp.	5.61	35.69
6	Ostracoda	4.84	30.79
⑦	Larvacea	3.46	22.00
8	*Metridia* spp.	3.11	19.78
9	*Pseudocalanus* spp.	2.08	13.25
10	*Oncea* spp.	1.74	11.07
Total		92.79	590.27
Total abundance of zooplankton Abondance totale de zooplancton (N/m^3)			636.10

Table 3. Percentages and averages of the ten top taxa at the Gaspé Current station, from 2000–2005 compared to 2006 (upper) and for 2006 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2006.

Rank / Rang	Taxa /Taxon	% of total zooplankton % du total de zooplancton 2000–2005	% of total zooplankton % du total de zooplancton 2006	Yearly average / Moyenne annuelle 2000–2005 (ind/m³)	2006 average / Moyenne 2006 (ind/m³)
1	*Oithona* spp.	54.38	38.96	388.04	274.85
2	*Calanus finmarchicus*	16.49	18.02	118.11	127.13
3	*Pseudocalanus* spp.	5.20	6.53	37.11	46.07
4	Euphausiacea (eggs, naup., juv.)	5.17	3.78	36.92	26.68
5	Invertebrate eggs	3.63	3.22	25.89	22.72
6	*Calanus hyperboreus*	2.44	2.06	17.41	14.54
7	*Metridia* spp.	2.14	2.56	15.29	18.03
8	Larvacea	1.90	2.25	13.56	15.89
9	*Microcalanus* spp.	1.81	3.28	12.91	23.17
10	*Acartia* spp.	1.38	2.95	9.86	20.70
Total		94.55	83.62	674.69	589.77
Total abundance of zooplankton Abondance totale de zooplancton (N/m³)				713.58	702.70

Rank / Rang	Taxa /Taxon	% of total zooplankton % du total de zooplancton 2006	2006 average / Moyenne 2006 (ind/m³)
1	*Oithona* spp.	38.96	274.85
2	*Calanus finmarchicus*	18.02	127.13
③	*Temora* spp.	8.90	62.76
4	*Pseudocalanus* spp.	6.53	46.07
5	Euphausiacea (eggs, naup., juv.)	3.78	26.68
6	*Microcalanus* spp.	3.28	23.17
7	Invertebrate eggs	3.22	22.72
8	*Acartia* spp.	2.95	20.70
9	*Metridia* spp.	2.56	18.03
10	Larvacea	2.25	15.89
Total		90.46	638.00
Total abundance of zooplankton Abondance totale de zooplancton (N/m³)			702.70

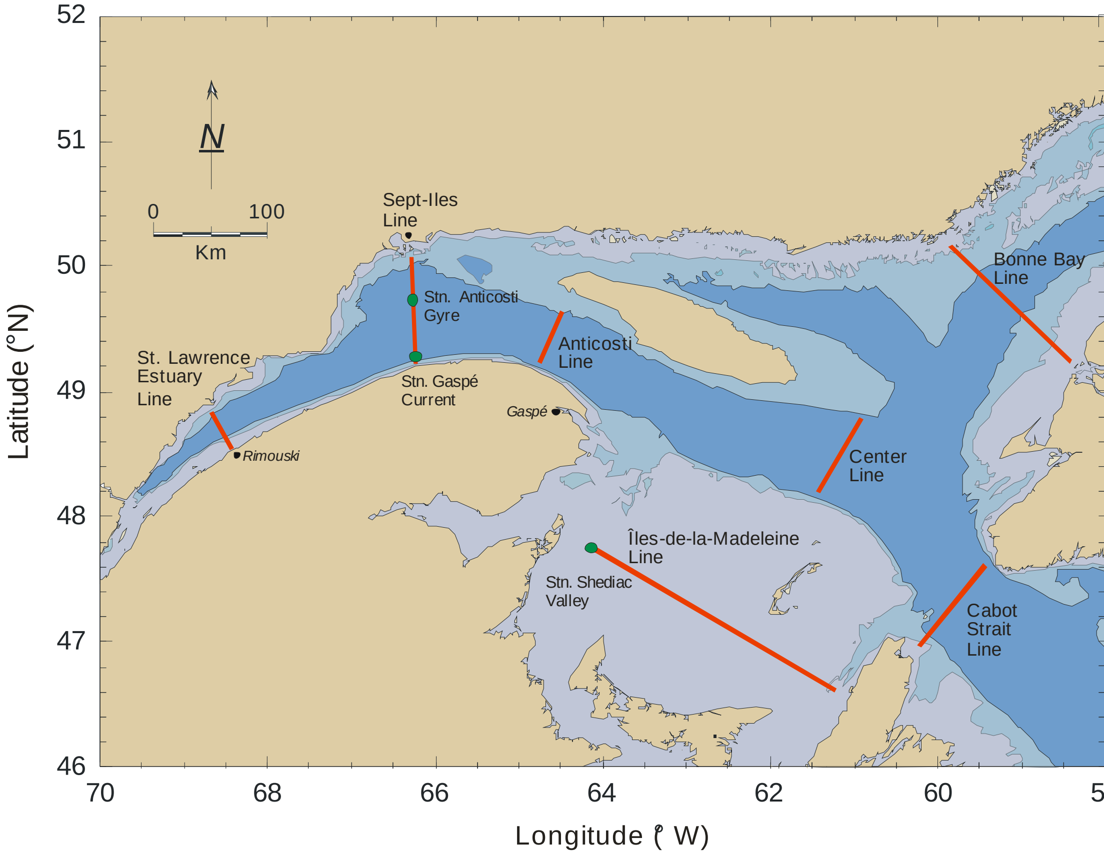


Figure 1. Sections (red lines) and fixed stations (green dots) sampled in the Québec region.

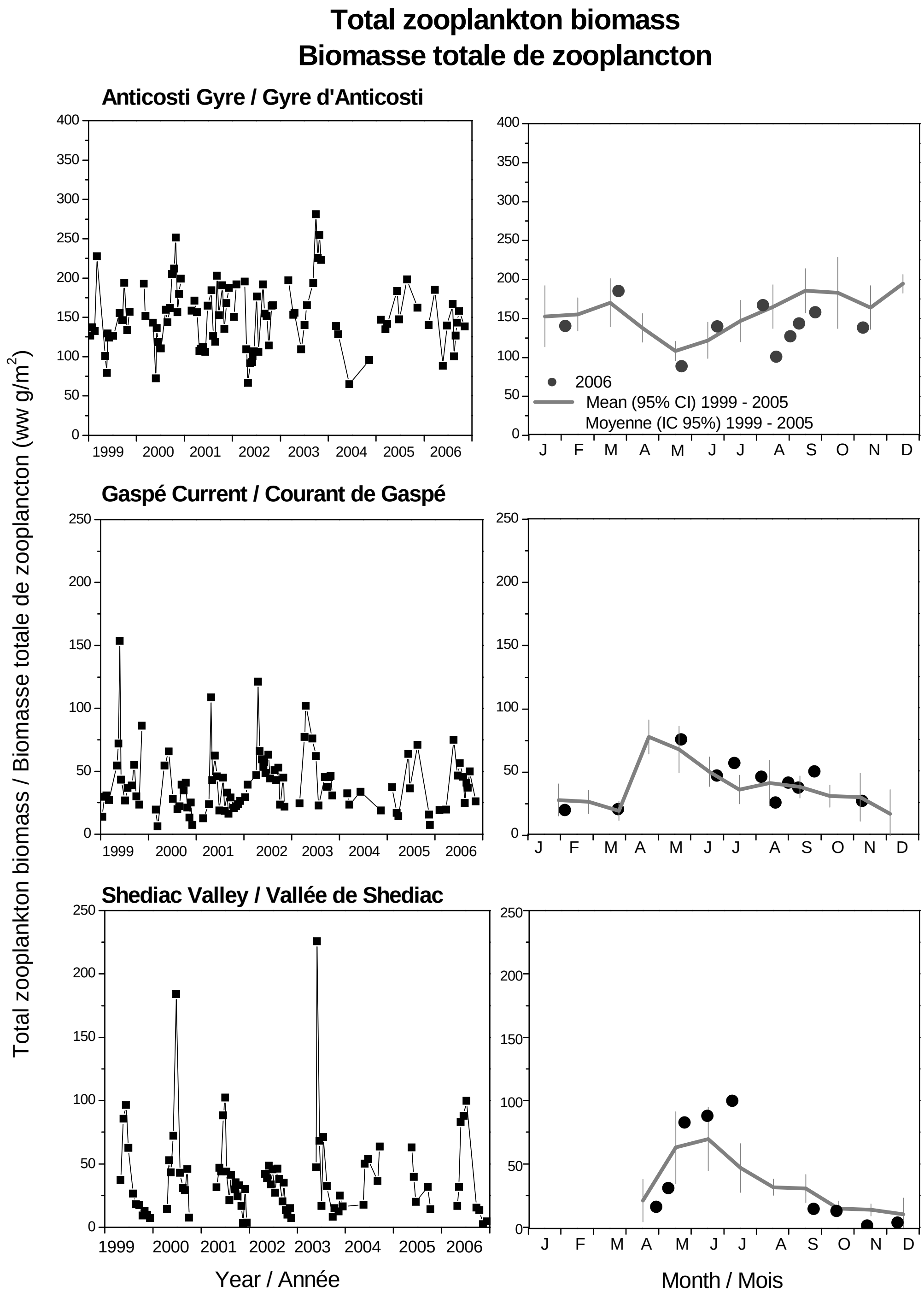


Figure 2. Time series of zooplankton biomass (surface–bottom) at the three fixed stations, 1999–2006. Right panels: 2006 (circles) compared with the 1999–2005 average (solid line). Vertical lines are the 95% confidence limits.

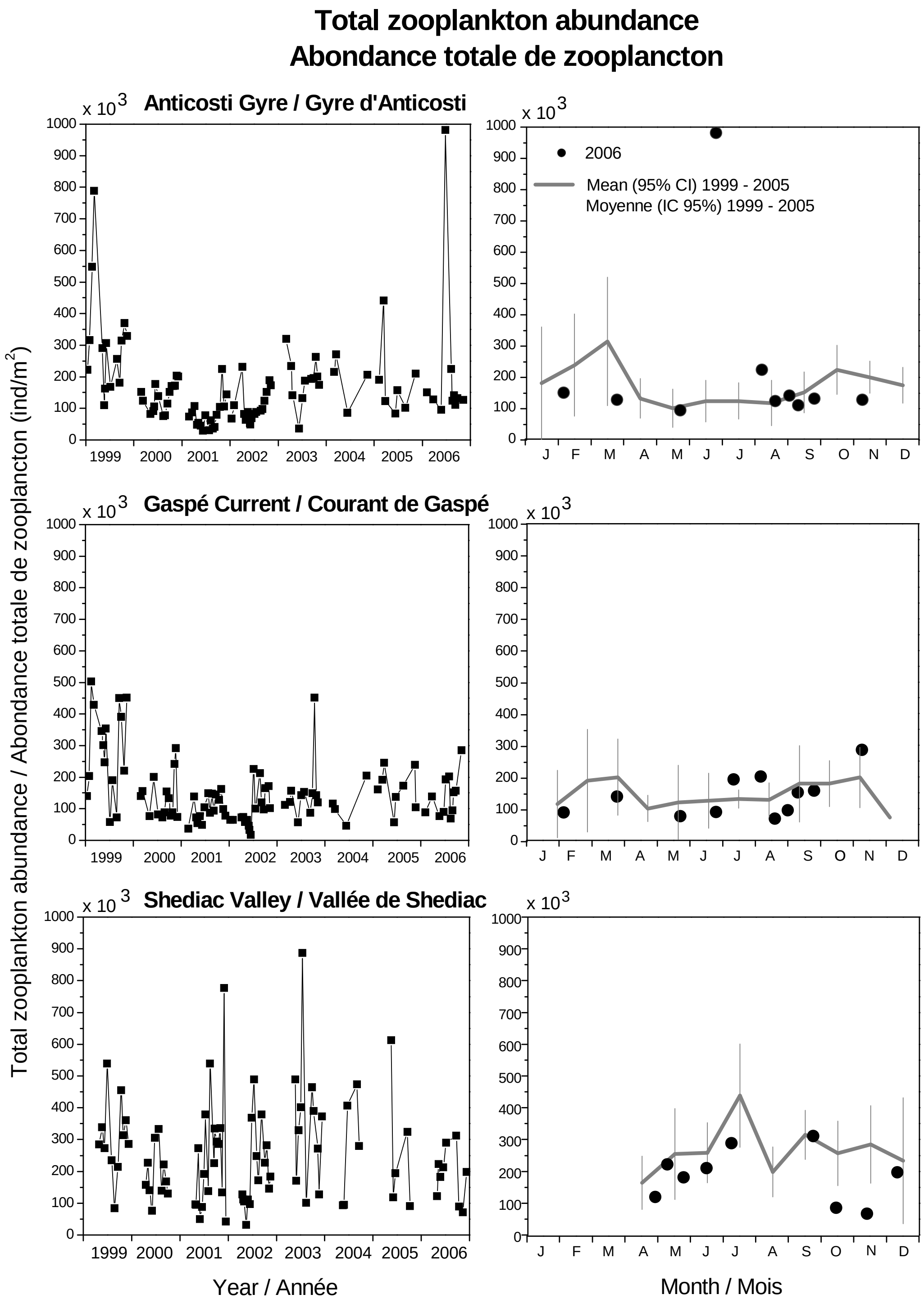


Figure 3. Time series of zooplankton abundance (surface–bottom) at the three fixed stations, 1999–2006. Right panels: 2006 (circles) compared with the 1999–2005 average (solid line). Vertical lines are the 95% confidence limits.

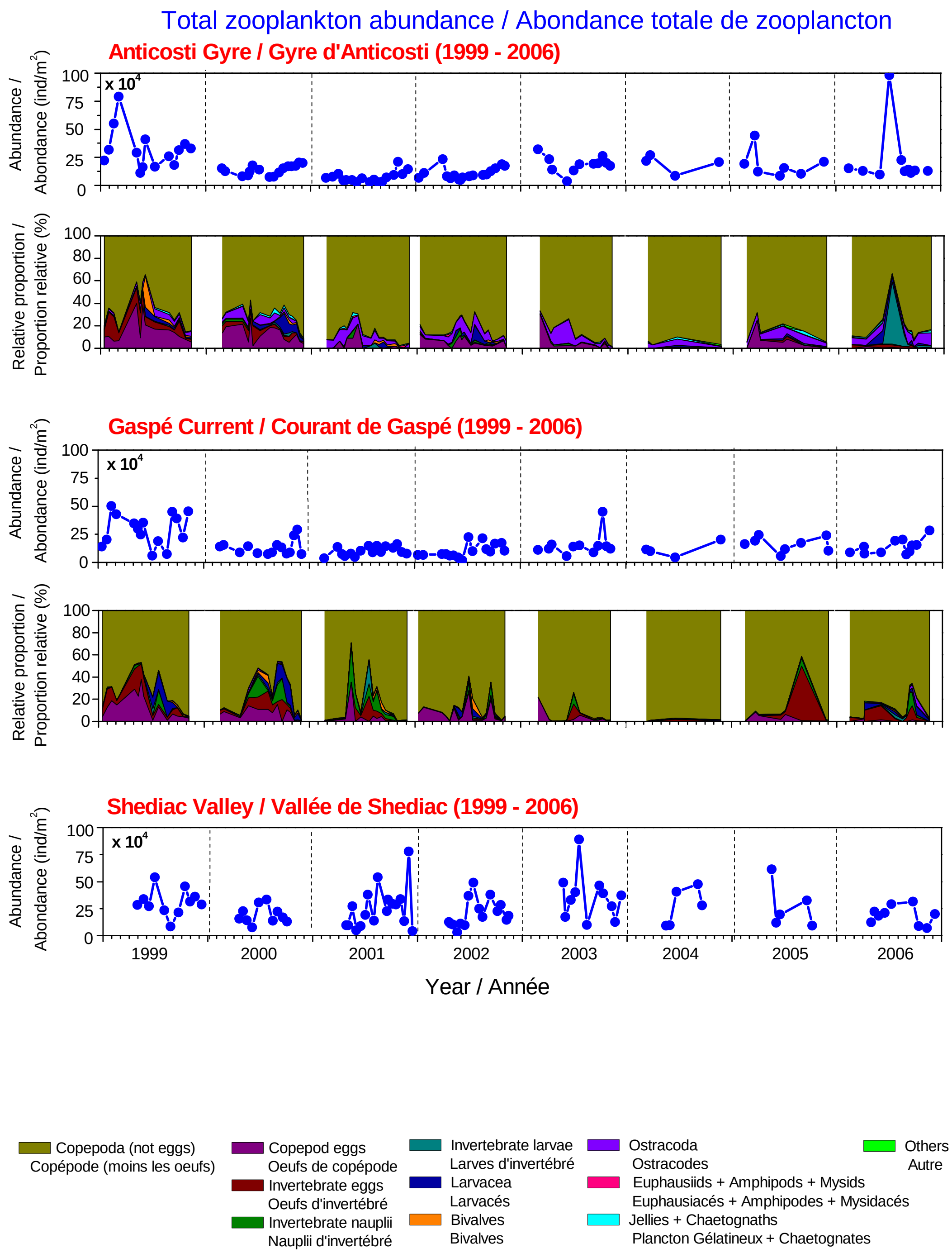


Figure 4. Seasonal cycle of total abundance and species composition of the zooplankton at the three fixed stations, 1999–2006.

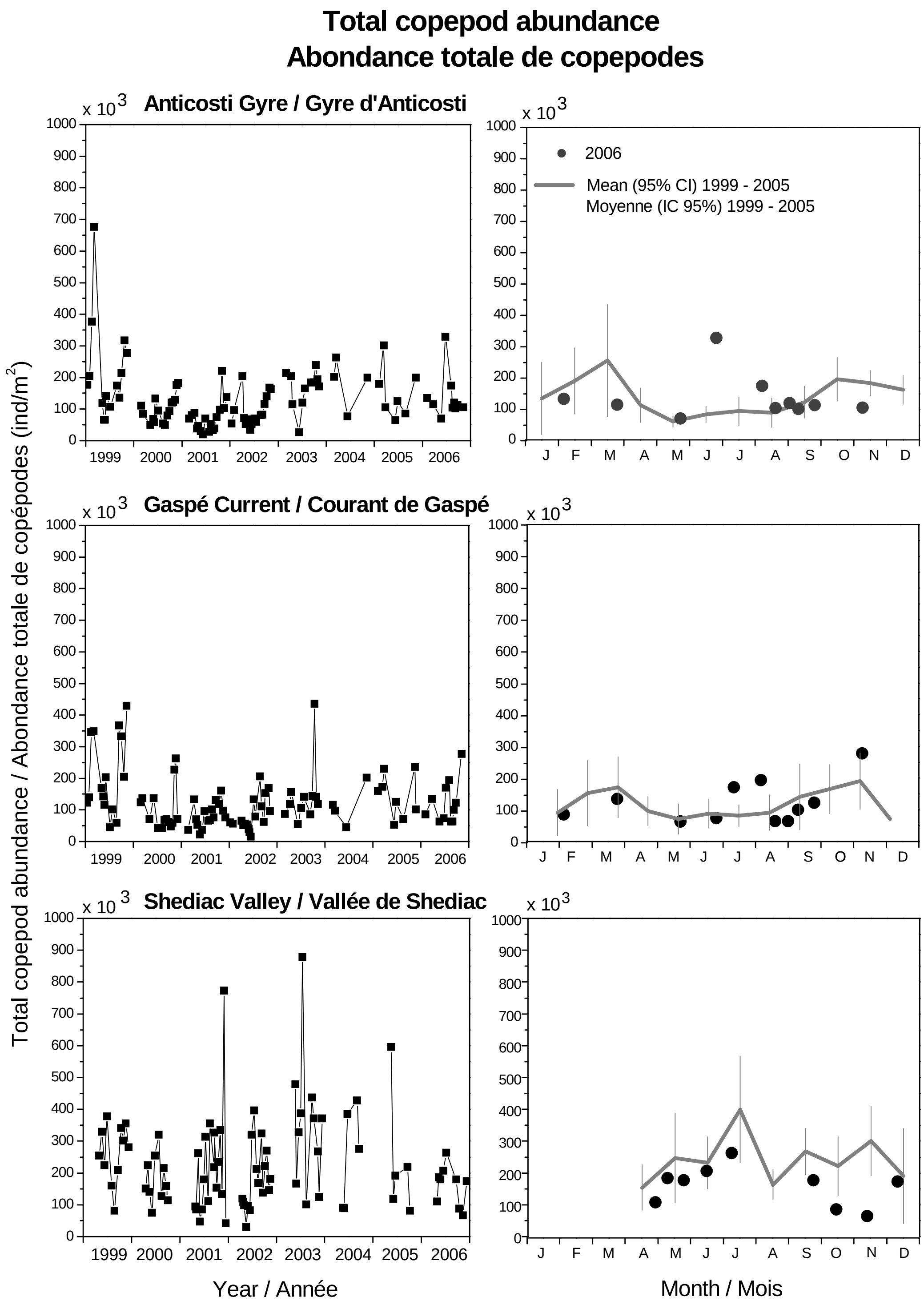


Figure 5. Time series of copepod abundance (surface–bottom) at the three fixed stations, 1999–2006. Right panels: 2006 (circles) compared with the 1999–2005 average (solid line). Vertical lines are the 95% confidence limits.

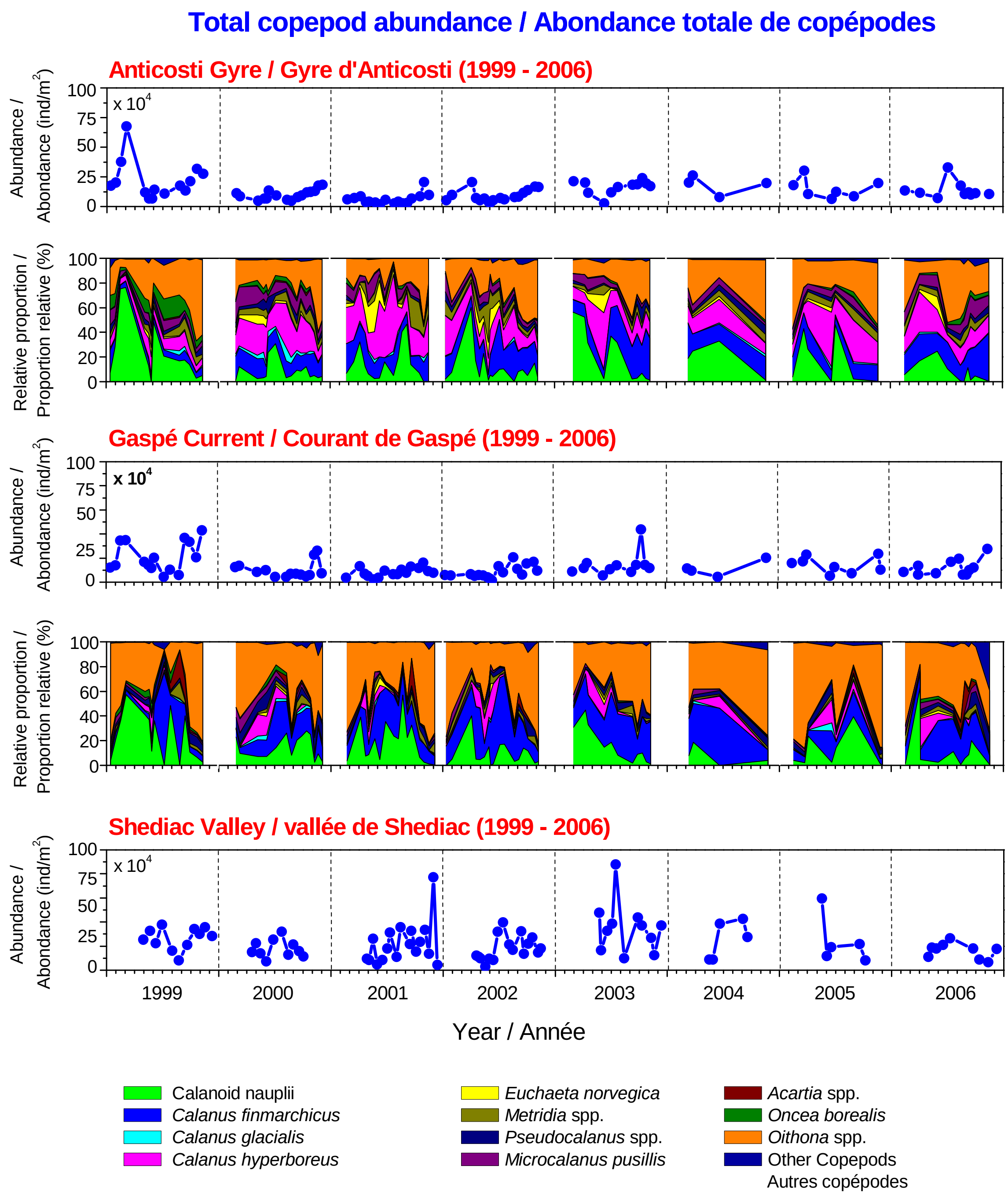


Figure 6. Seasonal cycle of total abundance and species distribution of the dominant copepods at the three fixed stations, 1999–2006.

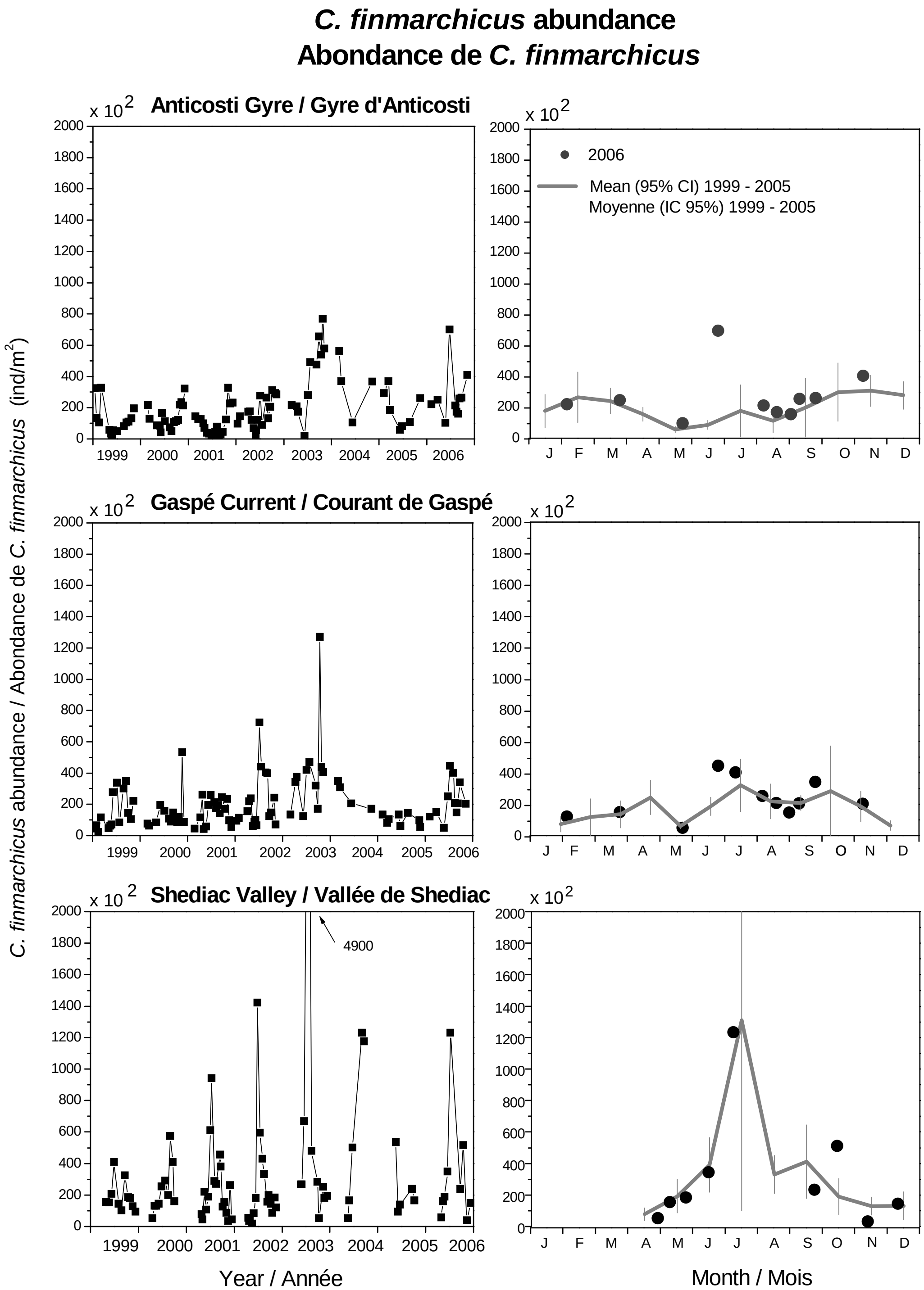


Figure 7. Time series of *C. finmarchicus* abundance (surface–bottom) at the three fixed stations, 1999–2006. Right panels: 2006 (circles) compared with the 1999–2005 average (solid line). Vertical lines are the 95% confidence limits.

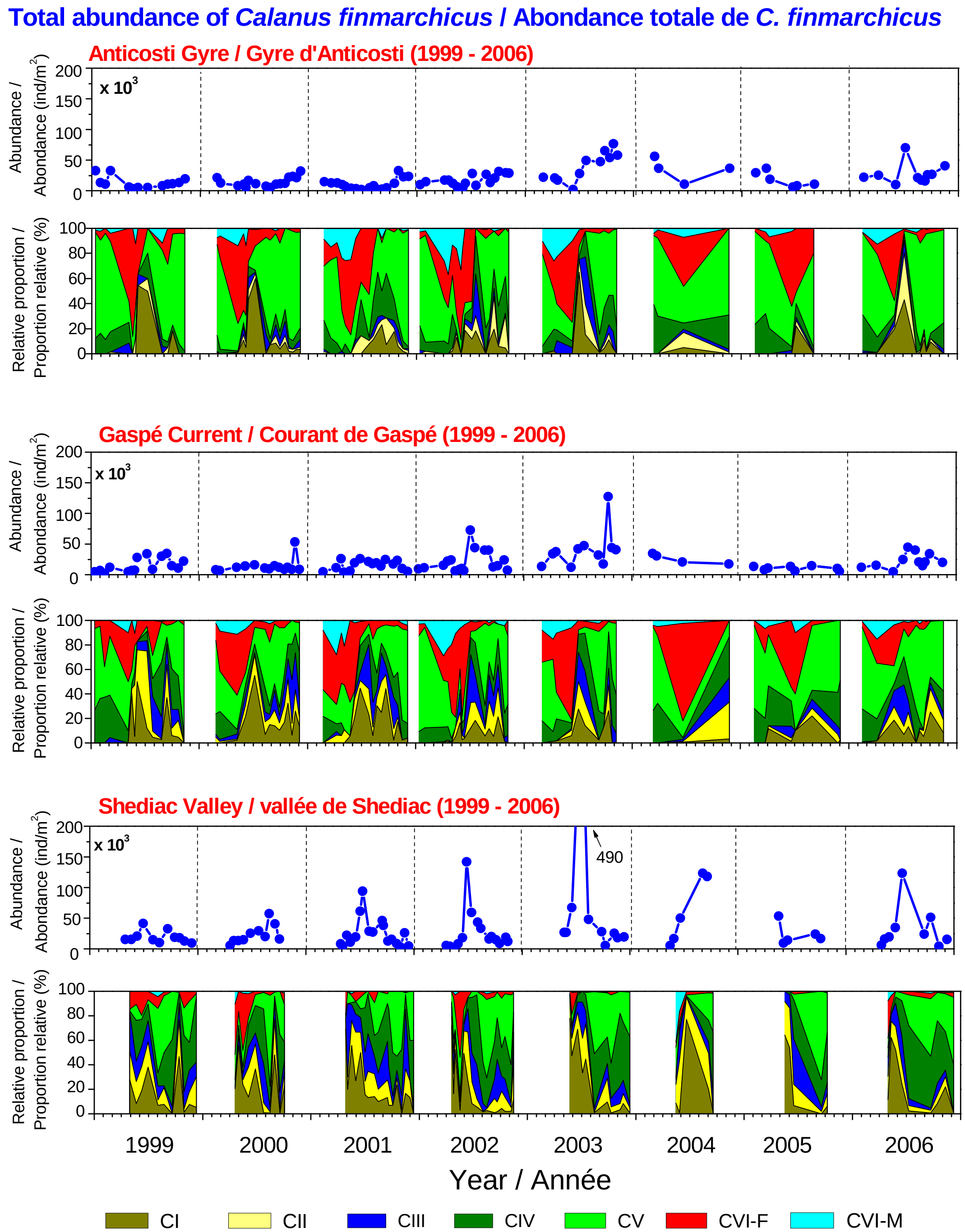


Figure 8. Seasonal cycle of total abundance and stage distribution of *Calanus finmarchicus* at the three fixed stations, 1999–2006.

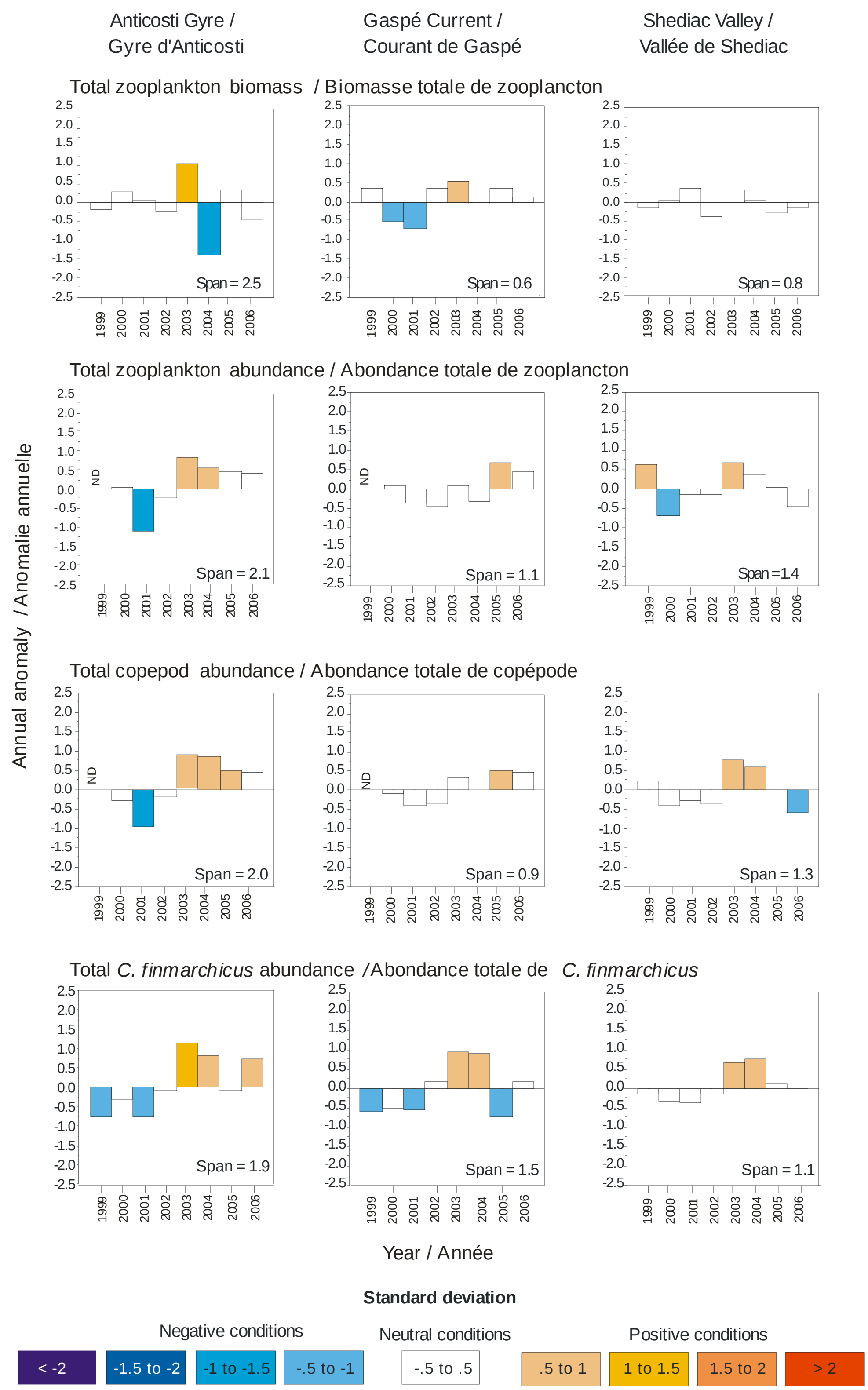
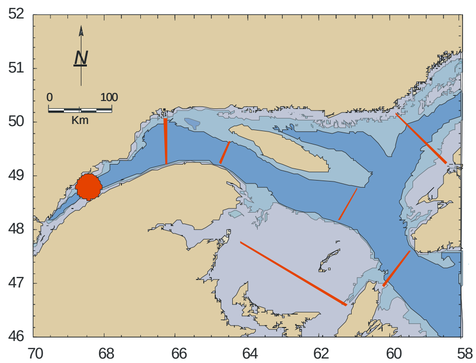
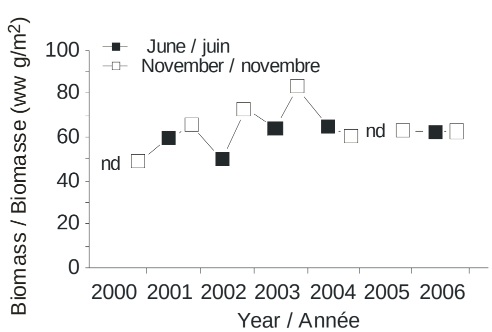
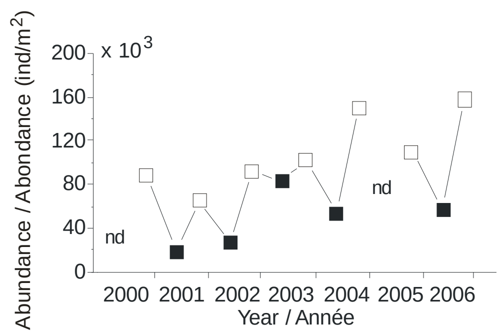


Figure 9. Time series of the annual anomaly of the zooplankton biomass and the total abundance of zooplankton, copepods, and *C. finmarchicus* at the three fixed stations, 1999–2006.



Lower St. Lawrence Estuary (TESL) /
Estuaire Maritime du Saint-Laurent (TESL)

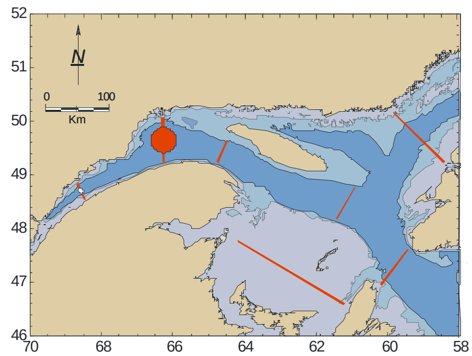




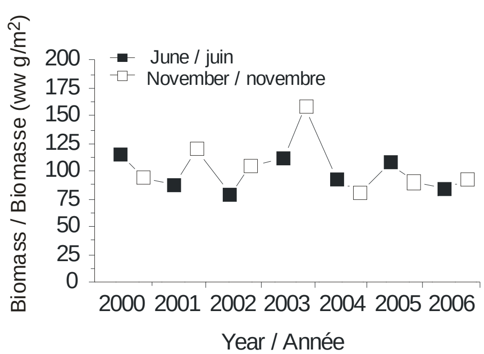
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2000-2005	% of total zooplankton % du total de zooplancton 2006	Yearly average / Moyenne annuelle 2000-2005 (ind/m^2 · 10^2)	2006 average / Moyenne 2006 (ind/m^2 · 10^2)
1	*Oithona* spp.	39.90	49.84	294	537
2	*C. finmarchicus*	16.59	10.75	122	116
3	Copepod nauplii	8.22	1.21	61	13
4	*Metridia* spp.	6.87	4.96	51	53
5	*C. hyperboreus*	6.51	5.95	48	64
6	Euph. (eggs, naup., juv.)	5.56	0.58	41	6
7	*Microcalanus* spp.	4.88	6.70	36	72
8	*Pseudocalanus* sp.	3.06	5.18	23	56
9	Ostracoda	2.66	2.70	20	29
10	*Acartia* spp.	1.38	1.56	10	17
Total		95.62	89.45	705.15	964.65
Total abundance of zooplankton Abondance totale de zooplancton	(N/m^2 · 10^2)			737.48	1078.09

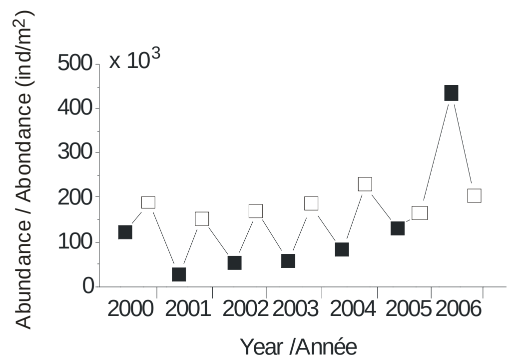
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2006	2006 average / Moyenne 2006 (ind/m^2 · 10^2)
1	*Oithona* spp.	49.84	537
2	*C. finmarchicus*	10.75	116
3	*Microcalanus* spp.	6.70	72
4	*C. hyperboreus*	5.95	64
5	*Pseudocalanus* sp.	5.18	56
6	*Metridia* spp.	4.96	53
7	Ostracoda	2.70	29
⑧	*Temora* spp.	2.54	27
9	*Acartia* spp.	1.56	17
⑩	*Oncea* spp.	1.52	16
Total		91.71	989.24
Total abundance of zooplankton Abondance totale de zooplancton	(N/m^2 · 10^2)		1078.09

Figure 10. Mean zooplankton biomass (wet weight) and abundance along the Lower St. Lawrence Estuary section (TESL) in June and November 2000–2006 and average species dominance for the 2000–2005 period compared with 2006. The circled numbers indicate the new taxa in the top ten species in 2006.



Northwest Gulf of St. Lawrence (TSI) /
Nord Ouest du golfe Saint-Laurent (TSI)

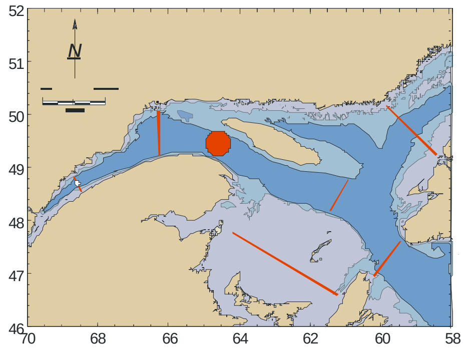




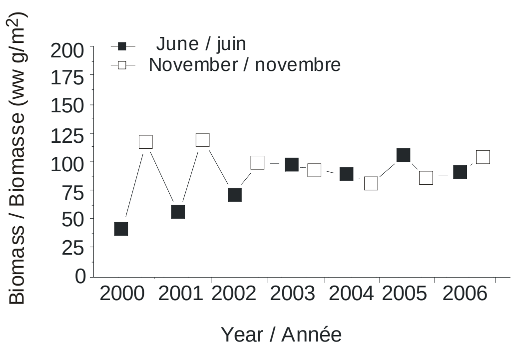
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2000-2005	% of total zooplankton % du total de zooplancton 2006	Yearly average / Moyenne annuelle 2000-2005 (ind/m^2 · 10^2)	2006 average / Moyenne 2006 (ind/m^2 · 10^2)
1	*Oithona* spp.	46.71	29.56	578	945
2	*C. finmarchicus*	13.48	14.61	167	467
3	*C. hyperboreus*	8.94	3.12	111	100
4	*Pseudocalanus* sp.	5.13	4.39	63	140
5	Copepod nauplii	4.74	3.89	59	124
6	*Metridia* spp.	4.35	1.40	54	45
7	*Microcalanus* spp.	3.10	2.43	38	78
8	Copepod eggs	2.79	2.52	35	81
9	Ostracoda	2.76	2.18	34	70
10	*E. norvegica*	1.07	0.36	13	12
Total		93.08	64.45	1151.05	2059.40
Total abundance of zooplankton Abondance totale de zooplancton	(N/m^2 · 10^2)			1236.58	3195.14

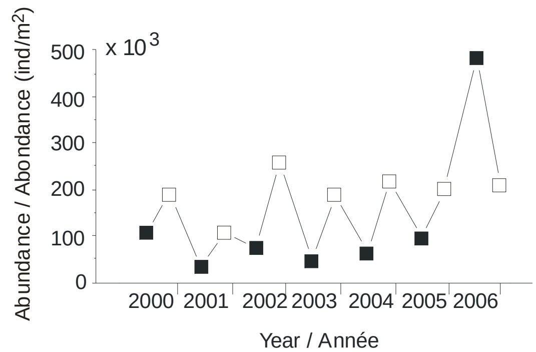
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2006	2006 average / Moyenne 2006 (ind/m^2 · 10^2)
1	*Oithona* spp.	29.56	945
(2)	Echinoderm larvae	17.93	573
3	*C. finmarchicus*	14.61	467
(4)	Larvacea	7.80	249
(5)	*Temora* spp.	5.48	175
6	*Pseudocalanus* sp.	4.39	140
7	Copepod nauplii	3.89	124
8	*C. hyperboreus*	3.12	100
9	Copepod eggs	2.52	81
10	*Microcalanus* spp.	2.43	78
Total		91.72	2930.70
Total abundance of zooplankton Abondance totale de zooplancton	(N/m^2 · 10^2)		3195.14

Figure 11. Mean zooplankton biomass (wet weight) and abundance along the Sept-Îles section (TSI) in June and November 2000–2006 and average species dominance for the 2000–2005 period compared with 2006. The circled numbers indicate the new taxa in the top ten species in 2006.



Southwest Anticosti (TASO) /
Anticosti Sud-Ouest(TASO)

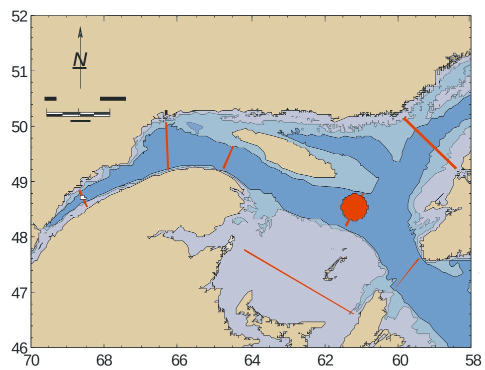




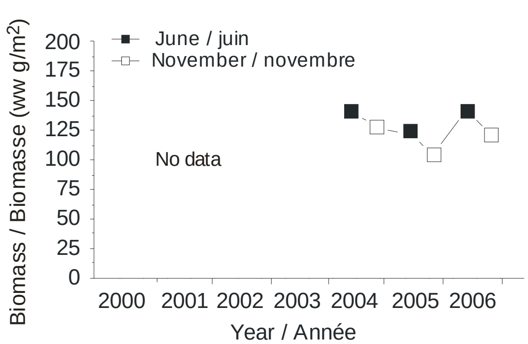
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2000-2005	% of total zooplankton % du total de zooplancton 2006	Yearly average / Moyenne annuelle 2000-2005 (ind/m^2 · 10^2)	2006 average / Moyenne 2006 (ind/m^2 · 10^2)
1	*Oithona* spp.	48.71	39.73	556	1375
2	*C. finmarchicus*	13.32	25.27	152	874
3	*C. hyperboreus*	7.62	2.82	87	98
4	*Pseudocalanus* sp.	4.80	3.51	55	121
5	*Metridia* spp.	4.77	1.24	54	43
6	Copepod nauplii	4.39	4.62	50	160
7	Copepod eggs	3.21	1.34	37	46
8	Ostracoda	3.20	2.48	36	86
9	*Microcalanus* spp.	2.64	2.30	30	80
10	*E. norvorvegica*	1.12	0.41	13	14
Total		93.78	83.71	1069.78	2896.01
Total abundance of zooplankton Abondance totale de zooplancton (N/m^2 · 10^2)				1140.75	3459.53

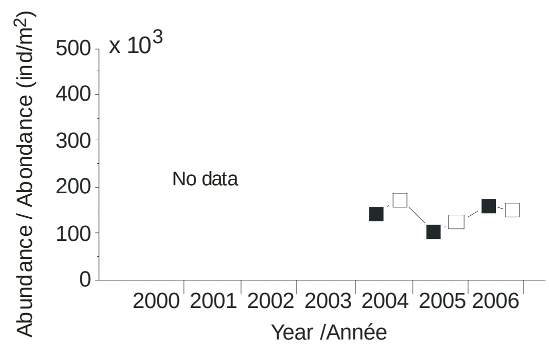
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2006	2006 average / Moyenne 2006 (ind/m^2 · 10^2)
1	*Oithona* spp.	39.73	1375
2	*C. finmarchicus*	25.27	874
③	*Temora* spp.	5.32	184
4	Copepod nauplii	4.62	160
5	*Pseudocalanus* sp.	3.51	121
6	*C. hyperboreus*	2.82	98
7	Ostracoda	2.48	86
⑧	*Echinoderm larvae*	2.33	81
9	*Microcalanus* spp.	2.30	80
⑩	Larvacea	2.13	74
Total		90.50	3130.94
Total abundance of zooplankton Abondance totale de zooplancton (N/m^2 · 10^2)			3459.53

Figure 12. Mean zooplankton biomass (wet weight) and abundance along the southwest Anticosti Island section (TASO) in June and November 2000–2006 and average species dominance for the 2000–2005 period compared with 2006. The circled numbers indicate the new taxa in the top ten species in 2006.



Centre Gulf of St. Lawrence (TCEN) / Centre du golfe Saint-Laurent (TCEN)

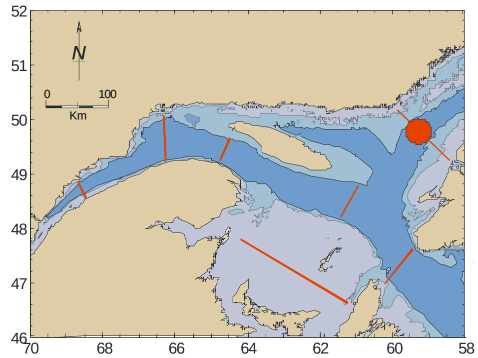




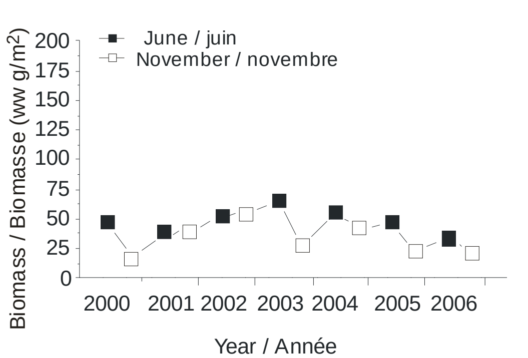
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2000-2005	% of total zooplankton % du total de zooplancton 2006	Yearly average / Moyenne annuelle 2000-2005 ($ind/m^2 \cdot 10^2$)	2006 average / Moyenne 2006 ($ind/m^2 \cdot 10^2$)
1	*Oithona* spp.	40.96	33.88	527	527
2	*C. hyperboreus*	17.32	12.72	223	198
3	*C. finmarchicus*	13.03	12.08	168	188
4	*Pseudocalanus* sp.	5.62	8.17	72	127
5	*Microcalanus* spp.	3.50	5.03	45	78
6	*Metridia* spp.	3.46	2.94	45	46
7	Ostracoda	3.36	3.83	43	60
8	Copepod eggs	2.44	5.85	31	91
9	*E. norvegica*	1.98	1.21	25	19
10	Larvacea	1.63	4.48	21	70
Total		93.29	90.19	1200.72	1402.62
Total abundance of zooplankton Abondance totale de zooplancton	($N/m^2 \cdot 10^2$)			1287.10	1555.12

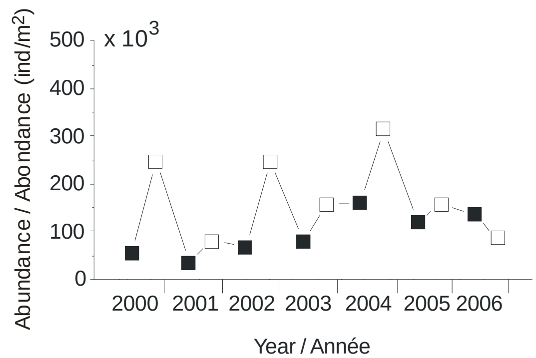
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2006	2006 average / Moyenne 2006 ($ind/m^2 \cdot 10^2$)
1	*Oithona* spp.	33.88	527
2	*C. hyperboreus*	12.72	198
3	*C. finmarchicus*	12.08	188
4	*Pseudocalanus* sp.	8.17	127
5	Copepod eggs	5.85	91
6	*Microcalanus* spp.	5.03	78
7	Larvacea	4.48	70
8	Ostracoda	3.83	60
9	*Metridia* spp.	2.94	46
⑩	*Oncæa* spp.	1.61	25
Total		90.60	1408.91
Total abundance of zooplankton Abondance totale de zooplancton	($N/m^2 \cdot 10^2$)		1555.12

Figure 13. Mean zooplankton biomass (wet weight) and abundance along the Centre Gulf of St. Lawrence section (TCEN) in June and November 2004–2006 and average species dominance for the 2004–2005 period compared with 2006. The circled numbers indicate the new taxa in the top ten species in 2006.



Northeast Gulf of St. Lawrence (TBB) / Nord Est du golfe Saint-Laurent (TBB)

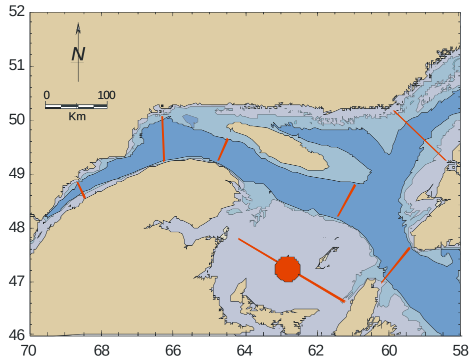




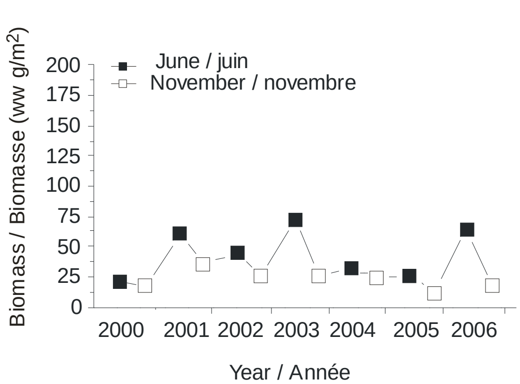
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2000-2005	% of total zooplankton % du total de zooplancton 2006	Yearly average / Moyenne annuelle 2000-2005 (ind/m^2 · 10^2)	2006 average / Moyenne 2006 (ind/m^2 · 10^2)
1	*Oithona* spp.	48.89	39.18	713	428
2	*Pseudocalanus* sp.	14.48	15.10	211	165
3	*C. finmarchicus*	11.64	10.45	170	114
4	*Temora* spp.	6.15	5.13	90	56
5	*C. hyperboreus*	4.66	3.42	68	37
6	Copepod nauplii	3.53	0.41	51	4
7	Larvacea	3.32	4.81	48	53
8	Copepod eggs	1.51	8.24	22	90
9	*Microcalanus* spp.	1.17	1.34	17	15
10	*Metridia* spp.	0.89	1.62	13	18
Total		96.24	89.70	1403.29	980.05
Total abundance of zooplankton Abondance totale de zooplancton	(N/m^2 · 10^2)			1458.10	1092.63

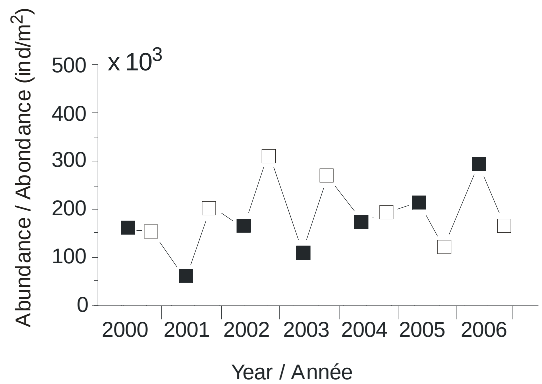
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2006	2006 average / Moyenne 2006 (ind/m^2 · 10^2)
1	*Oithona* spp.	39.18	428
2	*Pseudocalanus* sp.	15.10	165
3	*C. finmarchicus*	10.45	114
4	Copepod eggs	8.24	90
5	*Temora* spp.	5.13	56
6	Larvacea	4.81	53
7	*C. hyperboreus*	3.42	37
8	*Metridia* spp.	1.62	18
9	*Microcalanus* spp.	1.34	15
(10)	*Oncea* spp.	0.97	11
Total		90.26	986.23
Total abundance of zooplankton Abondance totale de zooplancton	(N/m^2 · 10^2)		1092.63

Figure 14. Mean zooplankton biomass (wet weight) and abundance along the northeast Gulf of St. Lawrence section (TBB) in June and November 2000–2006 and average species dominance for the 2000–2005 period compared with 2006. The circled numbers indicate the new taxa in the top ten species in 2006.



Southern Gulf of St. Lawrence (TIDM) /
Sud du golfe Saint-Laurent (TIDM)

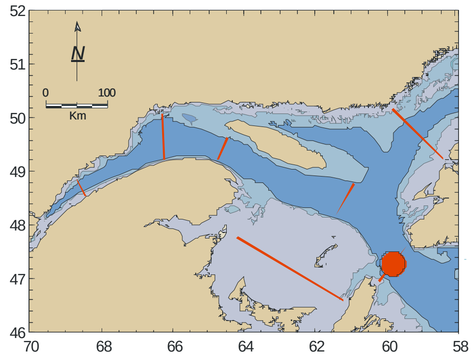




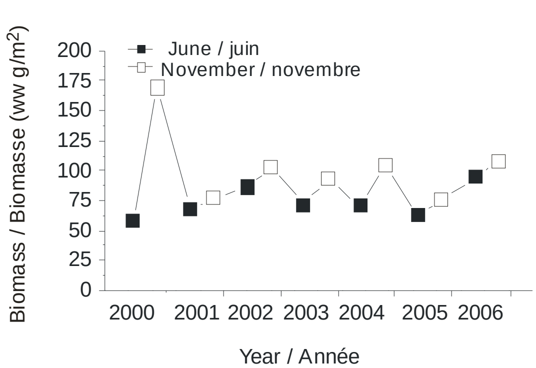
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2000-2005	% of total zooplankton % du total de zooplancton 2006	Yearly average / Moyenne annuelle 2000-2005 (ind/m^2 · 10 ^{2})	2006 average / Moyenne 2006 (ind/m^2 · 10 ^{2})
1	*Oithona* spp.	45.88	42.31	735	972
2	*Pseudocalanus* sp.	13.76	15.48	221	355
3	*Temora* sp.	11.56	15.58	185	358
4	*C. finmarchicus*	9.94	10.25	159	235
5	*C. hyperboreus*	5.22	3.84	84	88
6	Copepod nauplii	4.22	0.77	68	18
7	Larvacea	2.37	0.74	38	17
8	Copepod eggs	1.87	0.98	30	22
9	Euph. (eggs, naup., juv.)	1.61	3.00	26	69
10	Bivalve larvae	0.68	0.79	11	18
Total		97.10	93.74	1556.46	2152.76
Total abundance of zooplankton Abondance totale de zooplancton	(N/m^2 · 10^2)			1602.90	2296.48

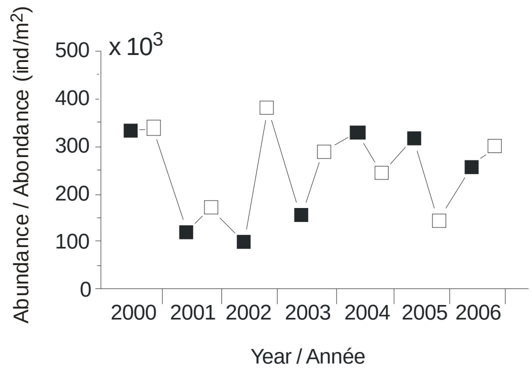
Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2006	2006 average / Moyenne 2006 (ind/m^2 · 10 ^{2})
1	*Oithona* spp.	42.31	972
2	*Temora* sp.	15.58	358
3	*Pseudocalanus* sp.	15.48	355
4	*C. finmarchicus*	10.25	235
5	*C. hyperboreus*	3.84	88
6	Euph. (eggs, naup., juv.)	3.00	69
7	Copepod eggs	0.98	22
8	Bivalve larvae	0.79	18
9	Copepod nauplii	0.77	18
10	Larvacea	0.74	17
Total		93.74	2152.76
Total abundance of zooplankton Abondance totale de zooplancton	(N/m^2 · 10^2)		2296.48

Figure 15. Mean zooplankton biomass (wet weight) and abundance along the southern Gulf of St. Lawrence section (TIDM) in June and November 2000–2006 and average species dominance for the 2000–2005 period compared with 2006. The circled numbers indicate the new taxa in the top ten species in 2006.



Cabot Strait (TDC) /
Détroit de Cabot (TDC)





Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2000-2005	% of total zooplankton % du total de zooplancton 2006	Yearly average / Moyenne annuelle 2000-2005 (ind/m² · 10²)	2006 average / Moyenne 2006 (ind/m² · 10²)
1	*Oithona* spp.	36.04	44.91	849	1245
2	*Pseudocalanus* sp.	16.23	14.37	382	398
3	*Temora* sp.	11.74	6.32	276	175
4	*C. finmarchicus*	10.57	8.60	249	238
5	*C. hyperboreus*	5.48	5.80	129	161
6	*Microcalanus* spp.	2.94	2.11	69	59
7	Copepod nauplii	2.57	0.39	61	11
8	Larvacea	2.50	1.83	59	51
9	Copepod eggs	1.78	1.62	42	45
10	Bivalve larvae	1.71	0.96	40	27
Total		91.56	86.92	2156.25	2409.47
Total abundance of zooplankton Abondance totale de zooplancton		(N/m² · 10²)		2355.10	2772.14

Rank / Rang	Taxa / Taxon	% of total zooplankton % du total de zooplancton 2006	2006 average / Moyenne 2006 (ind/m² · 10²)
1	*Oithona* spp.	44.91	1245
2	*Pseudocalanus* sp.	14.37	398
3	*C. finmarchicus*	8.60	238
4	*Temora* sp.	6.32	175
5	*C. hyperboreus*	5.80	161
⑥	Cladocera	2.35	65
7	*Microcalanus* spp.	2.11	59
8	Larvacea	1.83	51
⑨	*Metridia* spp.	1.70	47
10	Copepod eggs	1.62	45
Total		89.61	2484.24
Total abundance of zooplankton Abondance totale de zooplancton		(N/m² · 10²)	2772.14

Figure 16. Mean zooplankton biomass (wet weight) and abundance along the Cabot Strait section (TDC) in June and November 2000–2006 and average species dominance for the 2000–2005 period compared with 2006. The circled numbers indicate the new taxa in the top ten species in 2006.

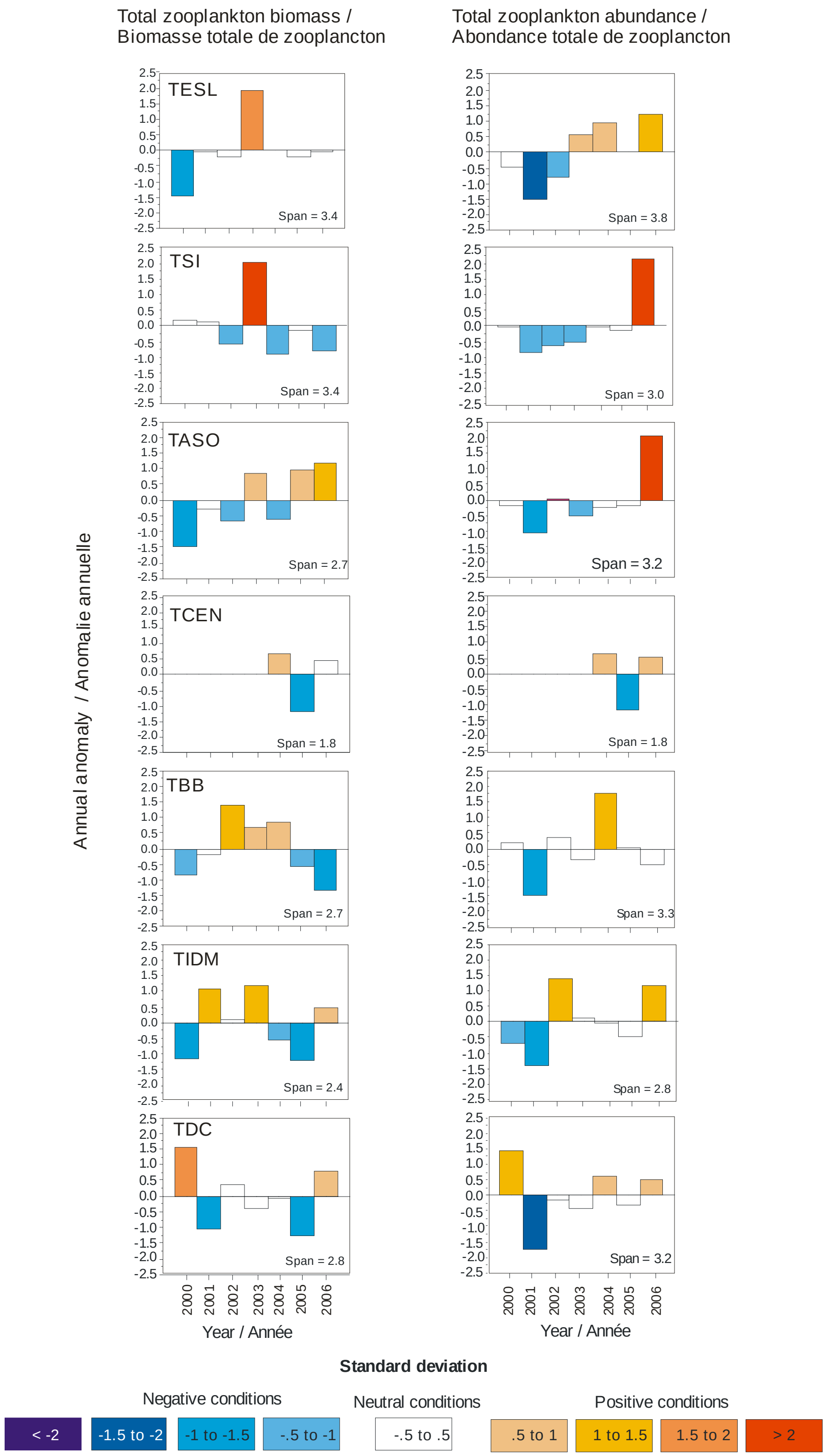


Figure 17. Zooplankton biomass and abundance anomalies from the Québec AZMP sections from 2000 to 2006. The anomalies are normalized with respect to their standard deviations over the 2000–2006 period.

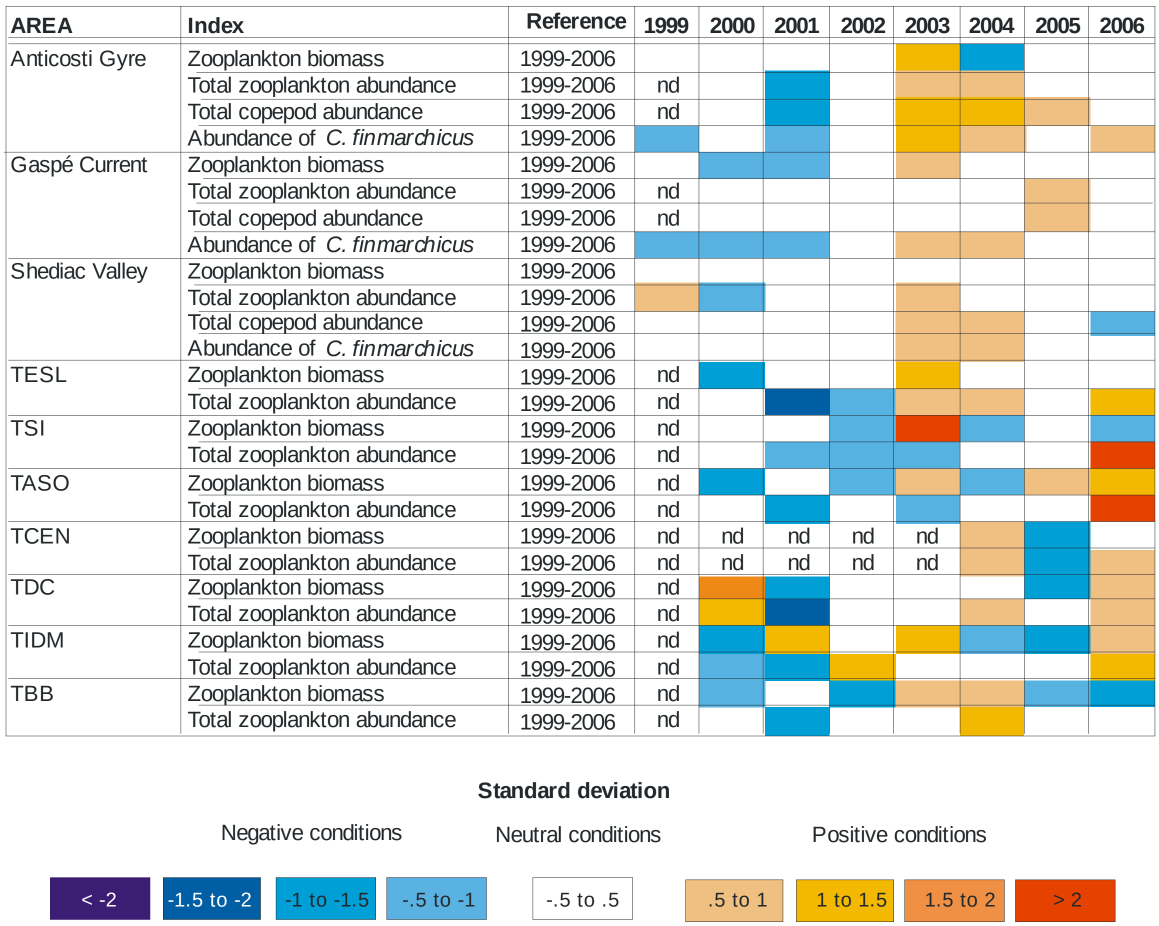


Figure 18. Anomalies in zooplankton biomass and abundance and other derived zooplankton indices (copepod abundance, *Calanus finmarchicus* abundance) from the Québec AZMP fixed stations and sections from 1999 to 2006. The anomalies are normalized with respect to their standard deviations over the 1999–2006 period.

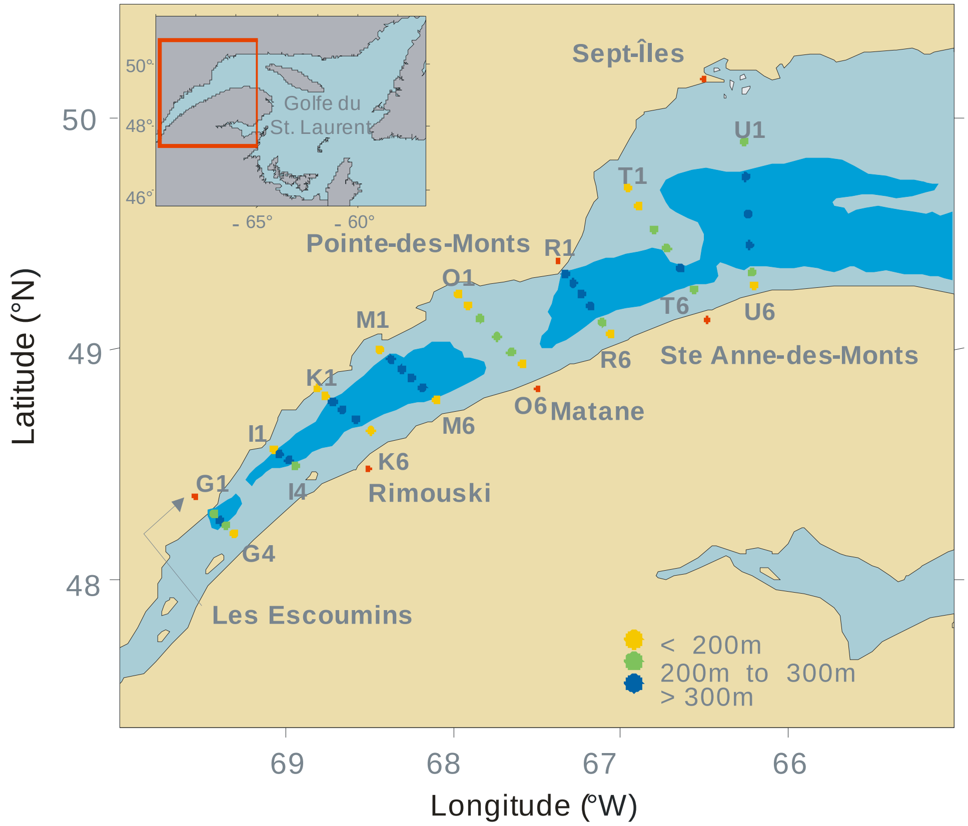
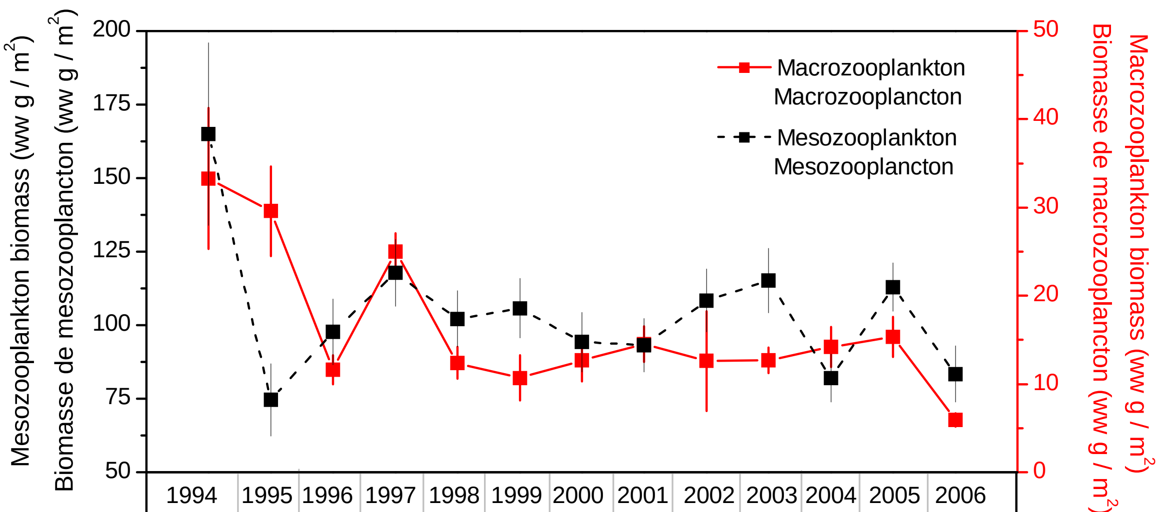


Figure 19. Map showing station locations of the annual zooplankton survey in the Lower St. Lawrence Estuary (sections G to O) and the northwest Gulf of St. Lawrence (sections R to U). The survey took place in September from 1994 until 2003 and in November from 2004 on.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Meso	164.9	74.6	97.8	117.8	102.2	105.7	94.3	93.2	108.4	115.1	82.0	113.0	83.4
Macro	33.3	29.6	11.6	25	12.4	10.7	12.7	14.5	12.6	12.7	14.2	15.4	5.9

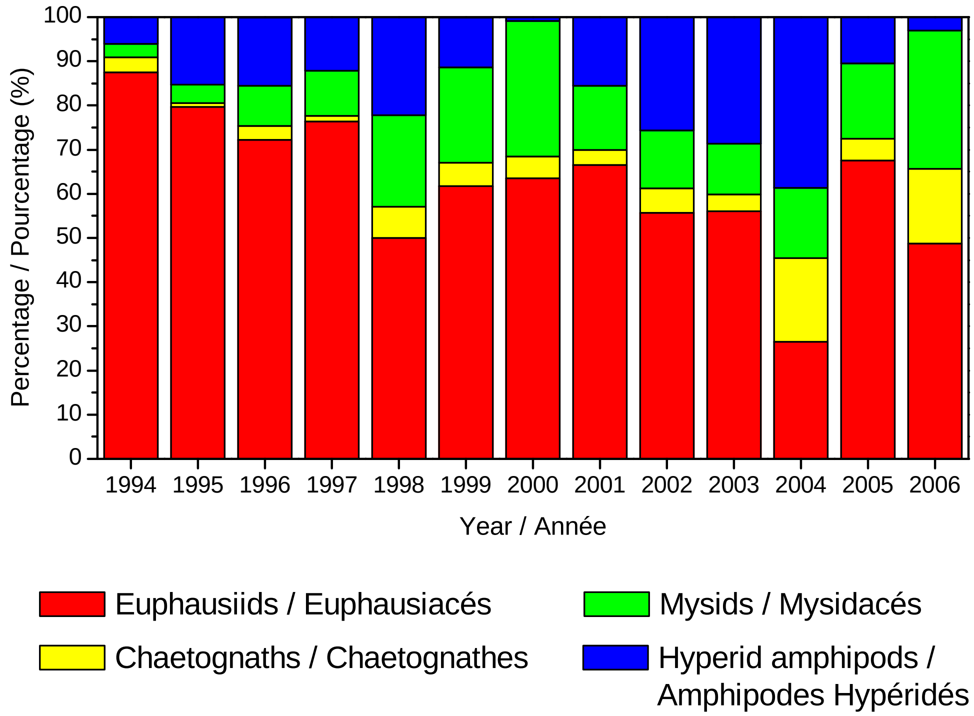


Figure 20. Mean biomass (± SE) of mesozooplankton and macrozooplankton in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence from 1994 to 2006 (upper panel) and the relative contribution of the four most important macrozooplankton groups to the biomass (lower panel).

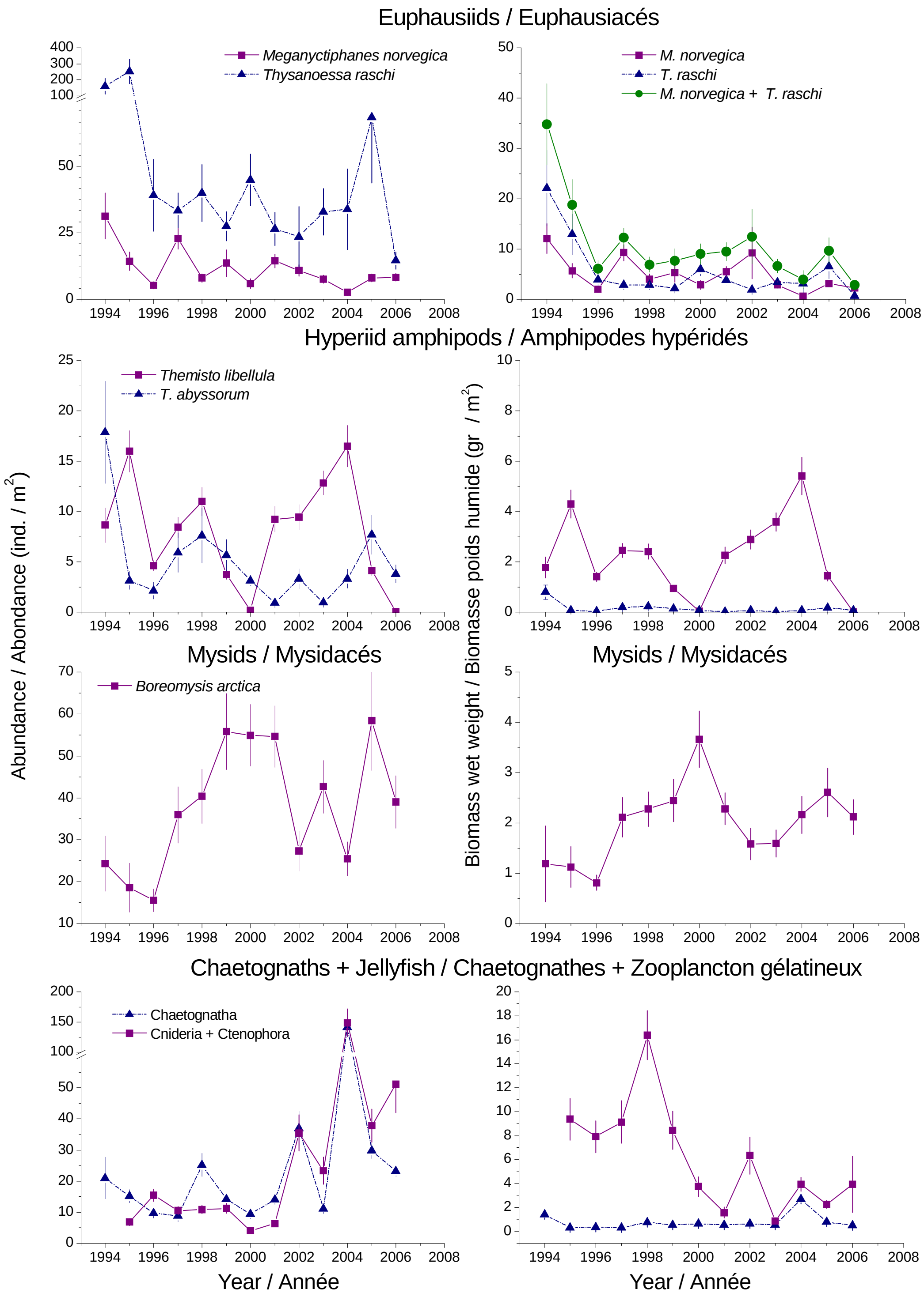


Figure 21. Mean abundance (± SE) of the most important species of macrozooplankton in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence from 1994 to 2006.

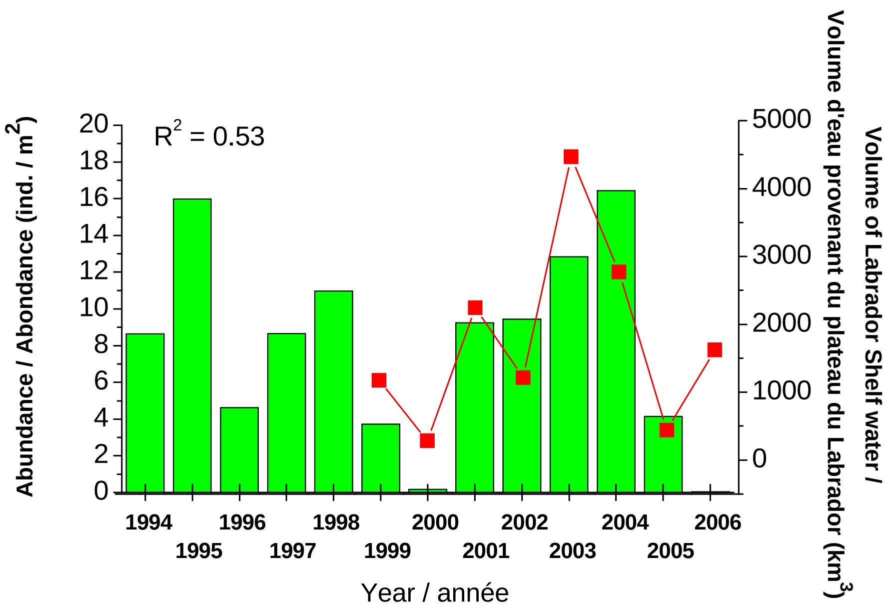


Figure 22. Relationship between the annual volumes of Labrador Shelf water advected into the Gulf of St. Lawrence in winter (symbols) and the annual mean abundance of the hyperiid amphipod *Themisto libellula* (bars) in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence from 1994 to 2006.