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Canadian Science Advisory Secretariat — **Secrétariat canadien de consultation scientifique**

Research Document 2008/037 — **Document de recherche 2008/037**

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Oceanographic conditions in the Estuary and the Gulf of St. Lawrence during 2007: zooplankton

Conditions océanographiques dans l'estuaire et le golfe du Saint-Laurent en 2007 : zooplancton

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ISSN 1499-3848 (Printed / Imprimé)
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ABSTRACT

Zooplankton biomass, abundance, and species composition in DFO's Québec Region (Lower St. Lawrence Estuary [LSLE] and the Gulf of St. Lawrence) during 2007 are reviewed and compared to the eight previous observations (1999–2006) at the Anticosti Gyre (AG), the Gaspé Current (GC), and the Shediac Valley (SV) stations and to the two previous years (2005–2006) at the Rimouski station (RS). In addition, this report gives an overview of the interannual variability in the mesozooplankton biomass and macrozooplankton species composition, abundance, and biomass in the LSLE and northwest Gulf of St. Lawrence (NWGSL) as measured in the fall of each year from 1994 to 2007.

The state of the zooplankton at Québec's four fixed stations in 2007 was considered as normal (zooplankton total abundance and copepod total abundance) and lower than normal (zooplankton biomass and *Calanus finmarchicus* abundance) at the AG station; normal (zooplankton biomass, zooplankton total abundance, and copepod total abundance) and above normal (*C. finmarchicus* abundance) at the GC station; and normal (*C. finmarchicus* abundance), lower than normal (zooplankton biomass), and above normal (zooplankton and copepod abundance) at the SV station. The average abundance of *C. finmarchicus* at RS in 2007 was 2.6 times higher than during the two previous years. In addition, some changes in the zooplankton community structure were observed over the time series at AG, GC, SV, and RS, including some variations 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): appendicularia and *Oncaea* spp. at AG, echinoderm and bivalve larvae at GC, euphausiids (eggs, nauplii, juveniles) and *Calanus glacialis* at RS, and echinoderm and polychaete larvae at SV. Zooplankton biomass along the seven Québec sections in spring 2007 was estimated as higher than normal along the Lower St. Lawrence Estuary (TESL), Sept-Îles (TSI), Cabot Strait (TDC), and Îles-de-la-Madeleine (TIDM) sections; normal along the southwest Anticosti (TASO) section; and lower than normal along the Centre Gulf of St. Lawrence (TCEN) and the Bonne Bay (TBB) sections. Concerning the total zooplankton abundance, anomalies were above normal for all sections except for TSI, TDC, and TIDM, where the total abundance of zooplankton was evaluated as normal. On the other hand, during fall, both the total zooplankton biomass and total zooplankton abundance anomalies were normal for all sections except TESL, TSI, and TASO, where these were evaluated as above normal, and along TCEN, where the total biomass was evaluated as lower than 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: appendicularia, echinoderm larvae, and ostracods in the LSLE and NWGSL, *C. glacialis* in the NEGSL, pteropods and *Oncaea* spp. in the southern GSL, and pteropods and *Metridia* spp. in Cabot Strait.

The mean mesozooplankton biomass observed in November 2007 in the LSLE and NWGSL was 1.4 times higher than in 2006 and corresponds to the fourth highest value observed over the last 14 years in the study area. The mean macrozooplankton biomass decreased from 15.4 g/m^2 (wet weight) in 2005 to 5.9 and 8.6 ww g/m^2 in 2006 and 2007, respectively. The macrozooplankton biomass values observed in 2006 and 2007 correspond to the lowest values observed over the last 14 years. The most notable feature observed in the LSLE and NWGSL was that 2006–2007 had the lowest mean biomass of euphausiids in our dataset due to a strong decrease in the abundance of *Thysanoessa raschii,* which was 5.3 times less abundant in 2006–2007 compared to the last 14 years. In addition, the mean abundance of the hyperiid amphipod *Themisto libellula* estimated in both regions in 2007 corresponds to the lowest value observed over the last 14 years.

RÉSUMÉ

L'abondance, la composition en espèces et la biomasse de zooplancton dans la région du Québec du MPO (l'estuaire et le golfe du Saint-Laurent, GSL) en 2007 sont présentées en comparaison avec les conditions des huit années précédentes (1999-2006) dans la gyre d'Anticosti (AG), le courant de Gaspé (GC) et la vallée de Shediac (SV) et aux deux années précédentes (2005-2006) à la station Rimouski (RS). 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'évalué chaque année à l'automne entre 1994 et 2007.

Par rapport aux années précédentes (1999-2006) l'état du zooplancton aux quatre stations fixes de la région en 2007 est considéré normal (abondance totale de zooplancton, abondance totale de copépodes) et inférieur à la normale (biomasse, abondance de *Calanus finmarchicus*) dans la AG; normale (biomasse, abondance totale de zooplancton, abondance totale de copépodes) et supérieure à la normale (biomasse, abondance de *C. finmarchicus*) dans le GC; et normale (abondance de *C. finmarchicus*), inférieure à la normale (biomasse), et supérieure à la normale (abondance totale de zooplancton, abondance totale de copépodes) dans la SV. En ce qui concerne la RS en 2007, l'abondance de *C. finmarchicus* a été 2.6 fois plus élevée qu'au cours des deux années précédentes (2005-2006). Également, des changements dans la structure de la communauté de zooplancton ont été observés dans la AG, le GC, la SV et la RS en 2007. En plus d'un changement au niveau de l'ordre d'abondance des espèces dominantes à chacune des stations, de nouvelles espèces sont apparues pour la première fois parmis les 10 espèces dominantes («top 10») : appendiculaires et *Oncaea* spp. dans la AG, échinodermes et larves de bivalve dans le GC, euphausiids (œufs, nauplii, juvéniles) et *Calanus glacialis* à la RS et échinodermes et larves de polychète dans la SV. Finalement, la biomasse du zooplancton observée au printemps 2007 le long des sept sections a été évaluée comme supérieure à la normale dans l'estuaire maritime (TESL), le nord-ouest (TSI), le détroit de Cabot (TDC) et dans le sud du golfe (TIDM); normale au sud-ouest de l'île d'Anticosti (TASO), et inférieur à la normale dans le centre (TCEN) le nord-est du golfe (TBB) du golfe. En ce qui concerne l'abondance de zooplancton, les anomalies ont toutes été au-dessus de la normale pour l'ensemble des sections à l'exception de TSI, TDC et TIDM où l'abondance de zooplancton a été évaluée comme normale. Pendant l'automne, les anomalies de la biomasse et l'abondance totale de zooplancton ont été évaluées comme normale le long de l'ensemble des régions à l'exception de TESL, TSI et TASO où les deux indices ont été au-dessus de la normale, et TCEN où la biomasse a été évaluée comme inférieur à la normale. En 2007, 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 de nouvelles espèces sont apparues pour la première fois dans le «top 10» : appendiculaires, larves d'échinoderme et ostracodes dans l'estuaire maritime et le nord-ouest du golfe, *C. glacialis* dans le nord-est du golfe, ptéropodes et *Oncaea* spp. dans le sud du golfe, et ptéropodes et *Metridia* spp. dans le détroit de Cabot.

La biomasse de mésozooplancton observée en novembre 2007 dans l'estuaire maritime et le nord-ouest du GSL était 1.4 fois plus élevée qu'en 2006 et correspond à la quatrième valeur la plus élevée observée au cours des 14 dernières années dans ces deux régions. Par ailleurs, la biomasse moyenne de macrozooplancton a diminué de 15.4 g/m^2 (poids humide) en 2005 à 5.9 et 8.6 g/m^2 en 2006 à 2007 respectivement. Les valeurs observées en 2006 et 2007 correspondent aux plus faibles valeurs observées au cours des 14 dernières années dans les deux régions. Un fait marquant des années 2006-2007 est la plus faible biomasse d'euphausiacés (krill) en raison d'une forte diminution de l'abondance de l'espèce *Thysanoessa raschii* qui était 5.3 fois moins abondante en 2006-2007 qu'au cours des 14 dernières années dans les deux régions. Finalement, l'année 2007 correspond aux plus faibles abondances moyennes de l'amphipode pélagique *Themisto libellula* des 14 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 regarding the movements of water masses and the location, timing, and magnitude of biological production cycles. Descriptions of the phytoplankton and zooplankton distributions provide important information about 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 once a week 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) or 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 2007 at four 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 2007.

SPATIAL AND TEMPORAL VARIABILITY OF ZOOPLANKTON SPECIES COMPOSITION, ABUNDANCE, AND BIOMASS AT FOUR FIXED STATIONS AND SEVEN SECTIONS OF THE QUÉBEC REGION IN 2007

MATERIALS AND METHODS

The location and the sampling dates of four fixed stations (Anticosti Gyre, Rimouski, 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 2007, zooplankton samples were collected on six occasions at the Anticosti Gyre and Gaspé Current fixed stations, on 28 occasions at the Rimouski fixed station, on eight occasions at the Shediac Valley fixed station, and during two surveys (13–22 June and 28 October–10 November). 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 2007. 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 2007 are presented as normalized anomalies in 0.5 standard deviation units. The anomalies are colour-coded, with blue, white, and red representing negative, normal, and positive zooplankton conditions, respectively.

RESULTS

Fixed stations. Based on samples collected at the four fixed stations, we see that zooplankton biomass follows the same seasonal pattern of variation as the eight previous years at the Anticosti Gyre (AG), Gaspé Current (GC), and Shediac Valley (SV) stations (1999–2006) and the two previous years at the Rimouski station (RS; 2005–2006) (Fig. 2). Furthermore, the zooplankton biomass observed during the different months at all stations was comparable to those observed previously at the same period of the year. The exceptions were SV during spring (April, May), summer (June, August), and fall (September, November), for which the zooplankton biomass was lower (spring, summer) and higher (fall) than the long-term average (Fig. 2), and AG and GC in January, for which the zooplankton biomass was respectively lower and higher than the long-term average. At the RS station, the zooplankton biomass was lower than the two previous years during the spring and early summer (April, May, June) and 2–3 times higher during late summer and fall (July to November).

The total abundance of zooplankton in 2007 varied between 78,624 and 245,106 ind/m^2 at AG, 25,934 and 173,409 ind/m^2 at RS, 36,384 and 308,557 ind/m^2 at GC, and 43,823 and 939,412 ind/m^2 at SV (Fig. 3). Zooplankton abundances observed during the different months at the four fixed stations were comparable to those observed previously (1999–2006) at the same period of the year. The exceptions in this case were RS and SV during spring and early summer (April, May, June) and during late summer and fall, when the total abundance of zooplankton was respectively lower and higher than normal (Fig. 3). Hierarchical community analysis revealed that copepods continued to numerically dominate the zooplankton year-round at the four fixed stations in 2007 (Fig. 4).

As was the case with zooplankton abundance, the total annual integrated copepod abundance at the four fixed stations in 2007 was comparable to levels observed during the previous years, although the total abundance was higher than the two previous years at RS (Fig. 5). The copepod abundances observed during the different months at the four stations were comparable to previous observations at the same period of the year; however, abundance peaks occurred in June and November at RS and in September and November at SV. There was no apparent change in the copepod community structure in 2007 at AG, RS, GC, or SV (Fig. 6). The copepod community at AG, GC, and SV was dominated numerically (>50% for much of the year) by the small species *Oithona* spp., and the relative importance of the larger species (*Calanus* spp.) was similar to the previous years. On the other hand, the copepod community at RS was dominated by the larger calanoid species, *C. finmarchicus* and *C. hyperboreus*.

The average abundance of *C. finmarchicus* in 2007 was estimated at 22,495 ind/m^2 at AG, 27,179 ind/m^2 at GC, 26,904 ind/m^2 at RS, and 29,266 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 eight previous years (1999–2006) in AG and GC (18,744 and 17,652 ind/m^2, respectively, excluding 2003) and lower in SV (34,851 ind/m^2, excluding 2003) (Fig. 7). The average abundance of *C. finmarchicus* at RS in 2007 was 2.6 times higher than during the two previous years (10,556 ind/m^2). In addition, the abundance of *C. finmarchicus* at the four fixed stations followed the same seasonal pattern of variation as during the previous years (1999–2006 at AG, GC, and SV; 2005–2006 at RS), except that total abundance was higher than the long-term average in June, July, and November at AG and GC; in May, July, and September at SV; and in July–November at RS (Fig. 7). Finally, based on the relative abundance of the various developmental stages of *C. finmarchicus* in 2007, there was only one reproductive period in spring/early summer at AG, GC, and SV (as indicated by the presence of stages I–III) and two reproductive periods in spring/early summer and fall at RS (Fig. 8). This different pattern of *C. finmarchicus* reproduction in different regions of the Gulf of St. Lawrence was frequent in the last eight years (1999–2006).

The abundance and percentage of the ten top most abundant taxa at AG, GC, RS, and SV are listed in Tables 2, 3, 4, and 5. In 2007, we observed some changes in the zooplankton composition relative to 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 the four stations. The most numerically abundant new group was appendicularia, which made up 6% of the total zooplankton abundance at AG in 2007. In addition, the dominant species at all stations was the small copepod *Oithona* spp. except at RS, which was dominated by the larger calanoid species *C. finmarchicus* for the last three years (2005–2007).

In summary, the state of the zooplankton at three of Québec's fixed stations (AG, GC, and SV) in 2007 was estimated as normal (zooplankton total abundance and copepod total abundance) and lower than normal (zooplankton biomass and *C. finmarchicus* abundance) at AG; normal (zooplankton biomass, zooplankton total abundance, and copepod total abundance) and above normal (*C. finmarchicus* abundance) at GC; and normal (*C. finmarchicus* abundance), lower than normal (zooplankton biomass), and above normal (zooplankton and copepod abundance) at SV. All zooplankton variables from RS estimated in 2007 (depth-integrated zooplankton biomass, zooplankton total abundance, copepod total abundance, and total abundance of *C. finmarchicus*) were higher than during the two previous years (2005–2006). In addition, some changes in the zooplankton community structure were observed over the time series at AG, GC, SV, and RS, 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): appendicularia and *Oncaea* spp. at AG, echinoderm and bivalve larvae at GC, echinoderm and polychaete larvae at SV, and euphausiids (eggs, nauplii, juveniles) and *Calanus glacialis* at RS.

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 2007 along the seven AZMP sections located in the St. Lawrence Marine System (SLMS) are presented in Figures 9 to 15. 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 was at the same level in June and November between 2004 and 2006. In addition, the mean annual (June and November) zooplankton abundance along the LSLE section increased slightly between 2000 and 2007 while the zooplankton biomass increased until 2000, decreased in 2004, and increased again in 2007 (Fig. 9). In 2007, the total mean annual zooplankton abundance was 2.2 times higher (179,936 ind/m^2) than during the seven previous years (2000–2006) (80,523 ind/m^2). We ranked the ten most abundant taxa in the LSLE according to their annual mean proportion of the total zooplankton. In 2007, 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 copepods *Oithona* spp. and *Microcalanus* spp., the large copepod *Calanus finmarchicus*, copepod nauplii, and the young stages of euphausiids (eggs, nauplii, juveniles) were respectively 1.5, 1.9, 2.6, 5.1, and 3.0 times more abundant in 2007 than during the long-term average (2000–2006). Finally, in 2007, appendicularia and echinoderm larvae 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 total zooplankton biomass and total zooplankton abundance followed the same seasonal and interannual pattern of variation as in the LSLE (Figs 10 and 11). In 2007, the total mean annual zooplankton abundance was ~1.4 times higher (210,728 and 226,355 ind/m^2 in TSI and TASO respectively) than during the seven previous years (2000–2006) (149,257 and 158,840 ind/m^2 in TSI and TASO respectively) in both regions. Moreover, except for some differences in the rank order, both regions had the same list of the top ten taxa, except for the echinoderm larvae in TSI and *Temora* spp. in TASO, and each top ten taxon was ~2.0 times more abundant in 2007 compared to the 2000–2006 average, except for *Oithona* spp., echinoderm larvae, *Metridia* spp., and copepod eggs, whose abundances matched the long-term averages or were slightly lower. The most notable change was in the appendicularia, which were 4.6 times more abundant in 2007 compared to the 2000–2006 average along the TSI section. Finally, in 2007, ostracods and appendicularia appeared on the list of dominant species for the first time along the TSI and the TASO sections respectively.

In the Centre Gulf of St. Lawrence section (TCEN), where we have only four years of data (2004–2007), 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. 12). There was no change in the zooplankton biomass and abundance in 2007 compared to 2004, 2005, and 2006. 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), which all cross the Laurentian Channel.

The northeast GSL (TBB section), the southern GSL (TIDM section), and Cabot Strait (TDC section) showed no major changes in zooplankton biomass or abundance in 2007 compared to the 2000–2006 average. However, some changes in the top ten zooplankton taxa were observed compared to the four regions already described (TESL, TSI, TASO, and TCEN). Among the species involved in these differences, *Temora* spp. and appendicularia, which were included in the top ten taxa only in 2006 and 2007 along the TESL, TSI, TASO, and TCEN sections, represented 9.6% and 2.6%, respectively, of the total zooplankton abundance between 2000 and 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 (Figs 13, 14, 15).

In summary, the zooplankton biomass along the seven Québec sections in 2007 during spring was estimated as higher than normal along the Lower St. Lawrence Estuary (TESL), Sept-Îles (TSI), Cabot Strait (TDC), and Îles-de-la-Madeleine (TIDM) sections; normal along the southwest Anticosti (TASO) section, and lower than normal along the Centre Gulf of St. Lawrence (TCEN) and the Bonne Bay (TBB) sections. Concerning total zooplankton abundance, anomalies were above normal for all sections except along the Sept-Îles (TSI), Cabot Strait (TDC), and Îles-de-la-Madeleine (TIDM) sections, where the total abundance of zooplankton was evaluated as normal. On the other hand, during fall, both total zooplankton biomass and total zooplankton abundance were normal for all sections except the Lower St. Lawrence Estuary (TESL), Sept-Îles (TSI), and southwest Anticosti (TASO) sections, where total biomass and total abundance of zooplankton were evaluated as above normal, and along the Centre Gulf of St. Lawrence (TCEN) section, where the total biomass was evaluated as lower than normal. In addition, some changes in 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: appendicularia, echinoderm larvae, and ostracods in the LSLE and the NWGSL; *C. glacialis* in the NEGSL; pteropods and *Oncaea* spp. in the southern GSL; and pteropods and *Metridia* spp. in Cabot Strait.

CONCLUSION

The time-series anomalies (1999–2007) of zooplankton biomass and abundance and other zooplankton indices (copepod abundance, *C. finmarchicus* abundance) indicate that 2007 was normal or slightly above normal at three of the fixed stations (AG, GC, and SV), except for the zooplankton biomass in the Anticosti Gyre, and normal (spring) or above normal (fall) along the seven Québec sections. This continues the normal and above-normal trend observed since 2003 in the St. Lawrence Marine System (Fig. 16). Concerning the RS station, all zooplankton variables estimated in 2007 (depth-integrated zooplankton biomass, zooplankton total abundance, copepod total abundance, and total abundance of *C. finmarchicus*) were higher than during the two previous years (2005–2006).

INTERANNUAL VARIATIONS IN MESOZOOPLANKTON BIOMASS AND MACROZOOPLANKTON SPECIES COMPOSITION, ABUNDANCE, AND BIOMASS IN THE LOWER ST. LAWRENCE ESTUARY AND THE NORTHWEST GULF OF ST. LAWRENCE FROM 1994 TO 2007

MATERIALS AND METHODS

This survey, initiated in 1994, covers an area of 11,000 km^2 from Les Escoumins in the LSLE to Sept-Îles in the NWGSL (Fig. 17). The sampling design consists of 44 stations along eight sections traversing the estuary. The survey is done using the BIONESS, which is a multiple opening–closing 333 μm 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 since 1995 whereas section U in the Anticosti Gyre has only been sampled since 1997. Surveys took place on four different ships and were conducted between 31 August and 26 September until 2003, after which sampling was delayed until 8–13 November; an average of six days is 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 only one third of the stations were 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 is weighed (wet weight) and adult fishes (mostly *Melanostigma atlanticum*), pandalid shrimps, and gelatinous zooplankton removed, counted, weighed, and released. If the volume of the remaining zooplankton is greater than 250 mL, the sample is split using a Motoda box splitter to get a maximum volume of 250 mL; samples are 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*, *Thysanoessa raschii*). This category also includes mysids (*Boreomysis arctica*, *Mysis mixta*, *Erythrops erythrophthalma*), which are commonly found in deep samples, hyperiid amphipods (*Themisto libellula*, *Themisto abyssorum*, *Themisto compressa*), and chaetognathes (*Sagitta elegans*, *Pseudosagitta maxima, Eukrohnia hamata*).

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

From 1994 to 2003, two replicates per station were analyzed to determine the wet biomass (ww, in g) and the abundance of the macrozooplankton species and the wet biomass of the mesozooplankton. Starting in 2004, only a single set of samples per station was analyzed. Results are integrated over the water column and standardized to numbers or grams per square metre 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 2007 in the LSLE and in the NWGSL was 1.4 times higher than in 2006 and corresponds to the fourth highest value observed over the last 14 years in the study area (Fig. 18). The mean macrozooplankton biomass decreased from 15.4 ww g/m^2 in 2005 to 5.9 (2006) and 8.6 ww g/m^2 (2007). The macrozooplankton biomass values observed in 2006 and 2007 correspond to the lowest values observed over the last 14 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 55% between 1994 and 1998, slightly increased to ~65% between 1999 and 2003, dramatically decreased to 28% in 2004, and returned to a typical level of ~60% in 2005, 2006, and 2007. The relative biomass of the mysids increased from 3% in 1994 to 27% in 2000, decreased to ~16% between 2001 and 2005, and increased again to ~30% in 2006 and 2007, the highest observed in the LSLE and the NWGSL since the start of the survey. On the other hand, the relative biomass of the hyperiid amphipods increased from 6% in 1994 to 20% in 1995; stayed around 20% from 1996 to 1998; significantly decreased from 22% to 1% between 1998 and 2000; increased back to 16% in 2001 and 2002, 30% in 2003, and 40% in 2004; decreased again to 2% between 2004 and 2006; and slightly increased to 8% in 2007. The relative biomass of the chaetognaths varied between 1% and 6% of the total macrozooplankton biomass from 1994 to 2003, increased significantly to ~19% in 2004, and reverted to a typical level of ~6% in 2005, 2006, and 2007 (Fig. 18).

Figure 19 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 and 2007, the mean abundance of *T. raschii* was estimated to be only 15 and 10 ind/m^2, respectively, making these the lowest values observed over the last 14 years in the study area. The mean abundance of *M. norvegica* 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 8.0, 8.3, and 10.0 ind/m^2 in 2005, 2006, and 2007. 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, a decrease to 2.9 ww g/m^2 in 2006, and a slight increase to 4.2 ww g/m^2 in 2007. The lowest euphausiid biomass observed over the last 14 years in the LSLE and the NWGSL occurred in 2004, 2006, and 2007.

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, decreased again to 4 ind/m^2 in 2006, and largely increased to 11.8 ind/m^2 in 2007 (Fig. 19); this corresponds to the second highest value observed over the last 14 years in the study area and to the largest increase between two consecutive years. 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 between 2000 and 2004, drastically decreased to 4 and 0.04 ind/m^2 in 2005 and 2006, respectively, and slightly increased to 1.4 ind/m^2 in 2007. The mean abundance of *T. libellula* observed in 2007 corresponds to the third lowest value observed over the last 14 years. Based on data from 1994 to 2005, we had hypothesized that the interannual variations in *T. libellula* mean abundance observed in the LSLE and the NWGSL were associated with the intrusion of cold Labrador Shelf water into the Gulf of St. Lawrence via the Strait of Belle Isle. This hypothesis was supported by the significant positive relationship (R^2 = 0.65) 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 between 1999 and 2005

(Galbraith 2006) (Fig. 20). However, even though there were strong intrusions of Labrador Shelf water into the GSL during the winters of 2006 and 2007, there appears to have been little or no influx of *T. libellula* during these two years. When we include the data from these last two years, the strength of the relationship declines, with only 34% of the variation being explained by this relationship ($R^2 = 0.34$).

In contrast with all other macrozooplankton species, the mean abundance of the mysid *B. arctica* was lowest in 1994, 1995, and 1996 (~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. arctica* 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, decreased to 39 ind/m^2 in 2006, and drastically increased to 65.3 ind/m^2 in 2007, making this the highest value observed over the last 14 years in the study area (Fig. 19). Likewise, the mean abundance of 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 ~10 ind/m^2 in 1999 and 2000. From 2000 to 2002, the mean chaetognath abundance 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, 23, and 29 ind/m^2 in 2005, 2006, and 2007, respectively (Fig. 19). Finally, the mean abundance of gelatinous zooplankton (mostly the cnidarian *Aglantha digitale*) followed the same pattern of temporal variations as the chaetognaths during the whole time series, including a dramatic increase from 23 to 148 ind/m^2 between 2003 to 2004 and the decrease observed in 2005. The exception occurred in 2006 and 2007, when there was an increase in *A. digitale* abundance compared with 2005 and no change in chaetognath abundance.

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 14 years (1994–2007). First, 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 2000, decreased to ~25 ind/m^2 in 2003 and 2004, and increased again to 68 ind/m^2 in 2005. In 2006 and 2007, the mean abundance of *T. raschii* was evaluated at only 15 and 10 ind/m^2, respectively, making these the lowest values observed over the last 14 years in the study area. The mean abundance of *M. norvegica* 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 8.0, 8.3, and 10.0 ind/m^2 in 2005, 2006, and 2007. 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, a decrease to 2.9 ww g/m^2 in 2006, and a slight increase to 4.2 ww g/m^2 in 2007. The years 2004, 2006, and 2007 correspond to the lowest biomass of euphausiids observed over the last 14 years in the LSLE and the NWGSL. This decline in krill abundance 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 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). However, different surveys carried out annually by 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 0.05 and 16 ind/m^2. This geographic expansion of *T. libellula* into the SLMS during the 1990s coincides with observations made by Drinkwater and Gilbert (2004) that the core temperature in the cold intermediate layer (CIL) of the GSL in the 1990s was on average the coldest of the last five decades. Furthermore, between 1999 and 2005, the interannual variations in the mean abundance of *T. libellula* were positively correlated ($R^2 = 0.56$) 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 winter and that their survivorship was helped by the fact that the 1990s corresponded to the coldest CIL of the last five decades. *Themisto libellula* always remain (day and night, during all seasons) at temperatures <3°C in the GSL (Harvey et al. in press). 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 winter, eventually reaching the LSLE within about six months. This certainly contributes to the expansion of the *T. libellula* population 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). However, even though there were strong intrusions of Labrador Shelf water into the GSL during the winters of 2006 and 2007, there appears to have been little or no influx of *T. libellula* during these two years. When we include the data from these last two years, the strength of the relationship declines, with only 34% of the variation being explained by this relationship ($R^2 = 0.34$).

While local air temperatures and winds play the major role in the annual cycle of water temperatures throughout the region, Canadian east coast waters are also strongly influenced by flow from the arctic. Currents from the north bring not only cold water but also northern species of plankton. For example, we continue to observe cold-water copepods such as *C. glacialis* and *C. hyperboreus* in all regions. In addition, the arctic hyperiid amphipod *T. libellula* has continued to be a component of the macrozooplankton of the Gulf of St. Lawrence. In the last few years, however, the relative importance of some of these cold-water species (e.g., *C. glacialis* off Halifax and on the Grand Banks, *T. libellula* in the LSLE, NWGSL, and Grand Banks) has diminished, presumably as a result of the warming ocean conditions and reduction of the CIL (AZMP Bulletin No. 7; March 2008; http://www.meds-sdmm.dfo-mpo.gc.ca/zmp/docs_e.html).

ACKNOWLEDGEMENTS

The authors wish to thank the sea-going staff (Jean-Pierre Allard, Jean-Louis Beaulieu, Sylvain Cantin, Rémi Desmarais, Marie-Lyne Dubé, Alain Gagné, Yves Gagnon, Pierre Joly, Bernard Pelchat, Roger Pigeon, Jean-François St-Pierre, and Daniel Thibeault) of the Maurice Lamontagne Institute and experts in zooplankton identification and enumeration (Marie-France Beaulieu, Caroline Lebel, and Pierre Rivard) as well as the officers and crews of the CCGS *Martha L. Black, George R. Pearkes*, *Tracy*, *Pierre Radisson*, *Des Groseilliers,* and *Hudson*, who provided excellent support during the surveys. Glen Harrison (BIO) and Pierre Pepin (NAFC) provided comprehensive and constructive reviews of the manuscript. We also wish to thank G. Harrison, J. Spry, K. Pauley, H. Maass, M. Kennedy, C. Porter, and V. Soukhovtsev of BIO, who provided the zooplankton data for the Shediac Valley fixed station.

REFERENCES

Bousfield EL (1951) Pelagic Amphipoda of the Belle Isle Strait region. J Fish Res Board Can 8:134-163

Dempson JB, Shears M, Bloom M (2002) Spatial and temporal variability in the diet of anadromous Arctic charr, *Salvelinus alpinus*, in northern Labrador. Environ Biol Fish 64:49-62

Drinkwater KF, Gilbert D (2004) Hydrographic variability in the waters of the Gulf of St. Lawrence, the Scotian Shelf and the Eastern Gulf of Maine (NAFO Subarea 4) during 1991-2000. J Northwest Atl Fish Sci 34:85-101

Galbraith PS (2006) Winter water masses in the Gulf of St. Lawrence. J Geophys Res 111, C06022, DOI: 10.1029/2005JC003159:1-23

Hanson JM, Chouinard GA (2002) Diet of Atlantic cod in the southern Gulf of St. Lawrence as an index of ecosystem change, 1959-2000. J Fish Biol 60:902-922

Harrison G, Sameoto D, Spry J, Pauley K, Maass H, Soukhovtsev V (2003) Optical, chemical and biological oceanographic conditions in Maritimes/Gulf Regions in 2002. DFO Can Sci Adv Sec Res Doc 2003/072

Harvey M, Galbraith PS, Descroix A (in press) Vertical distribution and diel migration of macrozooplankton in the St. Lawrence marine system (Canada) in relation with the cold intermediate layer thermal properties. Prog Oceanogr

Mitchell MR, Harrison G, Pauley K, Gagné A, Maillet G, Strain P (2002) Atlantic Zonal Monitoring Program sampling protocol. Can Tech Rep Hydrogr Ocean Sci 223, 23 pp

Saucier FJ, Roy F, Gilbert D, Pellerin P, Ritchie H (2003) Modeling the formation and circulation processes of water masses and sea ice in the Gulf of St. Lawrence, Canada. J Geophys Res 108(C8), 3269, doi: 10. 1029/2000JC000686

Therriault J-C, Petrie B, Pepin P, Gagnon J, Gregory D, Helbig J, Hermann A, Lefaivre D, Mitchell M, Pelchat B, Runge J, Sameoto D (1998) Proposal for a Northwest Atlantic zonal monitoring program. Can Tech Rep Hydrogr Ocean Sci 194:57 pp

Table 1. AZMP sampling missions in the study area in 2007. The fixed stations are Anticosti Gyre (AG), Gaspé Current (GC), Shediac Valley (SV), and Rimouski (RS), 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-07-01	12 Jan–03 Nov	6	6
	GC	IML-07-01	12 Jan–03 Nov	6	6
	SV	BIO-18VA07668	26 Apr–20 Nov	8	8
	RS	IML-07-26	12 Apr–21 Nov	28	28
Seasonal Sections	TESL, TSI, TASO, TCEN, TBB, TDC, TIDM	IML-07-31	13–22 Jun	45	45
	TESL, TSI, TASO, TCEN, TBB, TDC, TIDM	IML-07-49	28 Oct–08 Nov	42	42

Table 2. Percentages and averages of the ten top taxa at the Anticosti Gyre station in 2000–2006 compared to 2007 (upper) and for 2007 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2007.

Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2000–2006	% of total zooplankton / % du total de zooplancton 2007	Yearly average / Moyenne annuelle 2000–2006 (ind/m^3)	2007 average / Moyenne 2007 (ind/m^3)
1	*Oithona* spp.	24.29	31.08	134.53	150.21
2	Copepod nauplii (N3-N6)	15.40	1.84	85.31	8.87
3	*Calanus finmarchicus*	12.24	14.16	67.77	68.46
4	*Calanus hyperboreus*	10.55	12.13	58.42	58.64
5	Copepod eggs (> 202 µm)	9.25	0.89	51.23	4.32
6	*Microcalanus* spp.	4.53	9.55	25.09	46.15
7	Ostracods	4.03	7.05	22.34	34.09
8	Echinoderm larvae	3.93	0.77	21.75	3.72
9	*Metridia* spp.	3.75	3.47	20.75	16.78
10	*Pseudocalanus* spp.	2.50	4.41	13.84	21.34
Total		90.47	85.36	501.05	412.57
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^3)				553.84	515.28

Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2007	2007 average / Moyenne 2007 (ind/m^3)
1	*Oithona* spp.	31.08	150.21
2	*Calanus finmarchicus*	14.16	68.46
3	*Calanus hyperboreus*	12.13	58.64
4	*Microcalanus* spp.	9.55	46.15
5	Ostracods	7.05	34.09
6	Appendicularia	5.83	28.17
7	*Pseudocalanus* spp.	4.41	21.34
8	*Metridia* spp.	3.47	16.78
9	*Oncaea* spp.	2.05	9.93
10	Copepod nauplii (N3-N6)	1.84	8.87
Total		91.58	442.62
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^3)			515.28

Table 3. Percentages and averages of the ten top taxa at the Gaspé Current station in 2000–2006 compared to 2007 (upper) and for 2007 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2007.

Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2000–2006	% of total zooplankton / % du total de zooplancton 2007	Yearly average / Moyenne annuelle 2000–2006 (ind/m^3)	2007 average / Moyenne 2007 (ind/m^3)
1	*Oithona* spp.	42.48	36.06	373.90	408.14
2	*Calanus finmarchicus*	13.51	16.74	118.88	189.43
3	Copepod nauplii (N3-N6)	12.76	13.66	112.31	154.55
4	Copepod eggs (> 202 µm)	8.60	2.01	75.72	22.75
5	*Pseudocalanus* spp.	4.34	7.37	38.23	83.42
6	Euphausiids (eggs, naup., juv.)	4.05	2.89	35.64	32.68
7	*Calanus hyperboreus*	1.94	1.15	17.05	13.03
8	*Metridia* spp.	1.78	0.96	15.63	10.87
9	*Microcalanus* spp.	1.61	1.36	14.19	15.39
10	Appendicularia	1.57	9.38	13.85	106.11
Total		92.64	91.57	815.40	1036.36
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^3)				880.13	1131.80

Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2007	2007 average / Moyenne 2007 (ind/m^3)
1	*Oithona* spp.	36.06	408.14
2	*Calanus finmarchicus*	16.74	189.43
3	Copepod nauplii (N3-N6)	13.66	154.55
4	Appendicularia	9.38	106.11
5	*Pseudocalanus* spp.	7.37	83.42
6	Euphausiids (eggs, naup., juv.)	2.89	32.68
7	Copepod eggs (> 202 µm)	2.01	22.75
8	Echinoderm larvae	1.83	20.74
9	*Microcalanus* spp.	1.36	15.39
10	Bivalve larvae	1.20	13.54
Total		92.49	1046.75
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^3)			1131.80

Table 4. Percentages and averages of the ten top taxa at the Rimouski station in 2005–2006 compared to 2007 (upper) and for 2007 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2007.

Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2005–2006	% of total zooplankton / % du total de zooplancton 2007	Yearly average / Moyenne annuelle 2005–2006 (ind/m^3)	2007 average / Moyenne 2007 (ind/m^3)
1	*Calanus finmarchicus*	16.87	33.38	65.60	182.44
2	*Calanus hyperboreus*	16.82	11.18	65.40	61.08
3	*Oithona* spp.	14.41	14.46	56.03	79.06
4	Copepod nauplii (N3-N6)	11.23	9.21	43.67	50.35
5	*Metridia* spp.	8.08	3.98	31.41	21.73
6	Invertebrate eggs	5.98	0.41	23.26	2.26
7	Ostracods	4.95	4.70	19.26	25.70
8	*Microcalanus* spp.	4.65	5.22	18.10	28.53
9	Copepod eggs (> 202 mm)	3.51	0.48	13.66	2.64
10	*Pseudocalanus* spp.	1.81	2.67	7.03	14.59
Total		88.33	85.70	343.43	468.38
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^3)				388.82	546.55

Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2007	2007 average / Moyenne 2007 (ind/m^3)
1	*Calanus finmarchicus*	33.38	182.44
2	*Oithona* spp.	14.46	79.06
3	*Calanus hyperboreus*	11.18	61.08
4	Copepod nauplii (N3-N6)	9.21	50.35
5	*Microcalanus* spp.	5.22	28.53
6	Ostracods	4.70	25.70
7	*Metridia spp.*	3.98	21.73
8	*Pseudocalanus* spp.	2.67	14.59
9	Euphausiids (eggs, naup., juv.)	2.59	14.13
10	*Calanus glacialis*	1.65	9.02
Total		89.04	486.63
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^3)			546.55

Table 5. Percentages and averages of the ten top taxa at the Shediac Valley station in 1999–2006 compared to 2007 (upper) and for 2007 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2007.

Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 1999–2006	% of total zooplankton / % du total de zooplancton 2007	Yearly average / Moyenne annuelle 1999–2006 (ind/m^3)	2007 average / Moyenne 2007 (ind/m^3)
1	*Oithona* spp.	30.79	46.25	1680.55	1851.09
2	*Calanus finmarchicus*	15.17	8.81	828.14	352.61
3	Copepod nauplii (N3-N6)	13.63	4.37	743.70	174.79
4	*Pseudocalanus* spp.	6.50	3.47	355.03	138.73
5	*Calanus hyperboreus*	3.86	2.59	210.95	103.77
6	*Temora* spp.	3.67	17.01	200.28	680.97
7	Bivalve larvae	2.06	0.47	112.66	18.81
8	Euphausiacea (eggs, naup., juv.)	1.17	1.27	63.77	51.00
9	*Calanus glacialis*	1.02	0.67	55.89	26.67
10	Appendicularia	1.02	4.28	55.62	171.47
Total		78.90	89.19	4306.58	3569.91
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^3)				5457.98	4002.61

Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2007	2007 average / Moyenne 2007 (ind/m^3)
1	*Oithona* spp.	46.25	1851.09
2	*Temora* spp.	17.01	680.97
3	*Calanus finmarchicus*	8.81	352.61
4	Copepod nauplii (N3-N6)	4.37	174.79
5	Appendicularia	4.28	171.47
6	*Pseudocalanus* spp.	3.47	138.73
7	*Calanus hyperboreus*	2.59	103.77
8	Euphausiids (eggs, naup., juv.)	1.27	51.00
9	Echinoderm larvae	0.73	29.07
10	Polychaete larvae	0.72	28.91
Total		89.50	3582.40
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^3)			4002.61

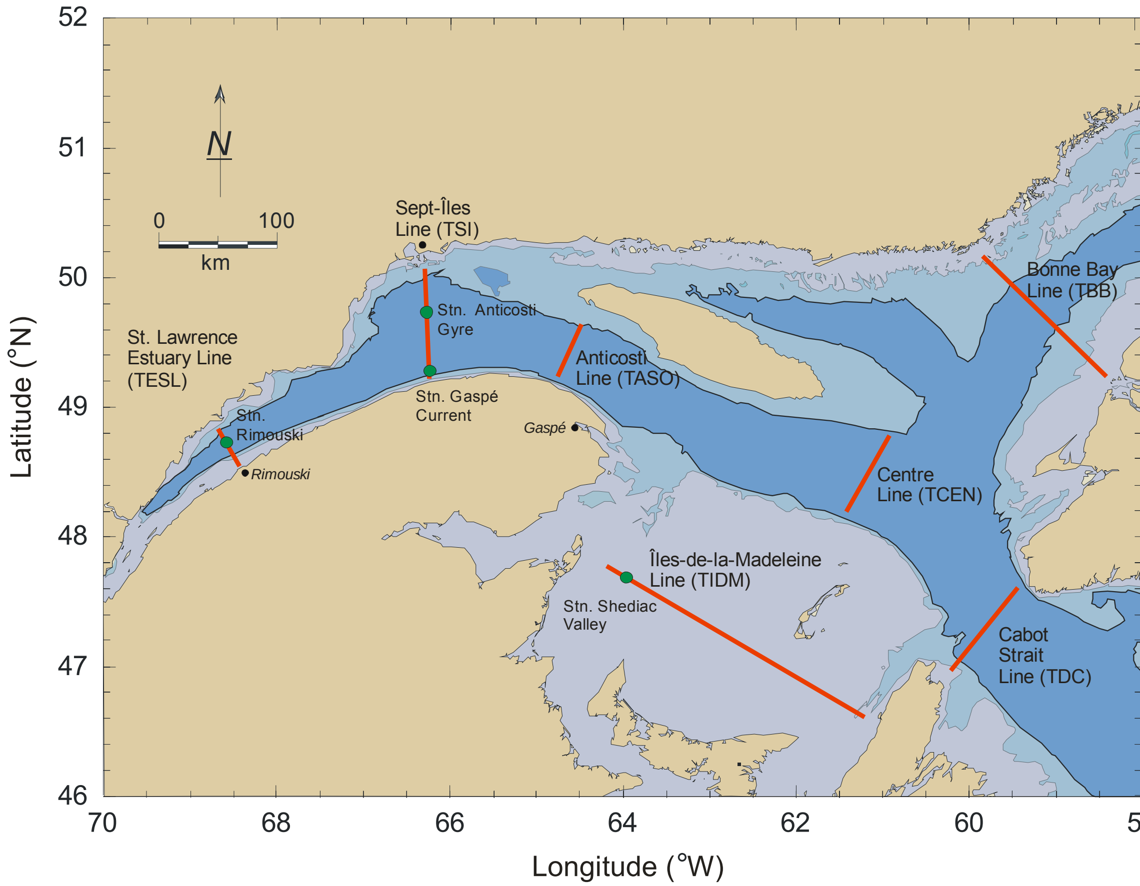


Figure 1. Sections (red lines) and fixed stations (green dots) sampled in the Québec region.

Total zooplankton biomass
Biomasse totale de zooplancton

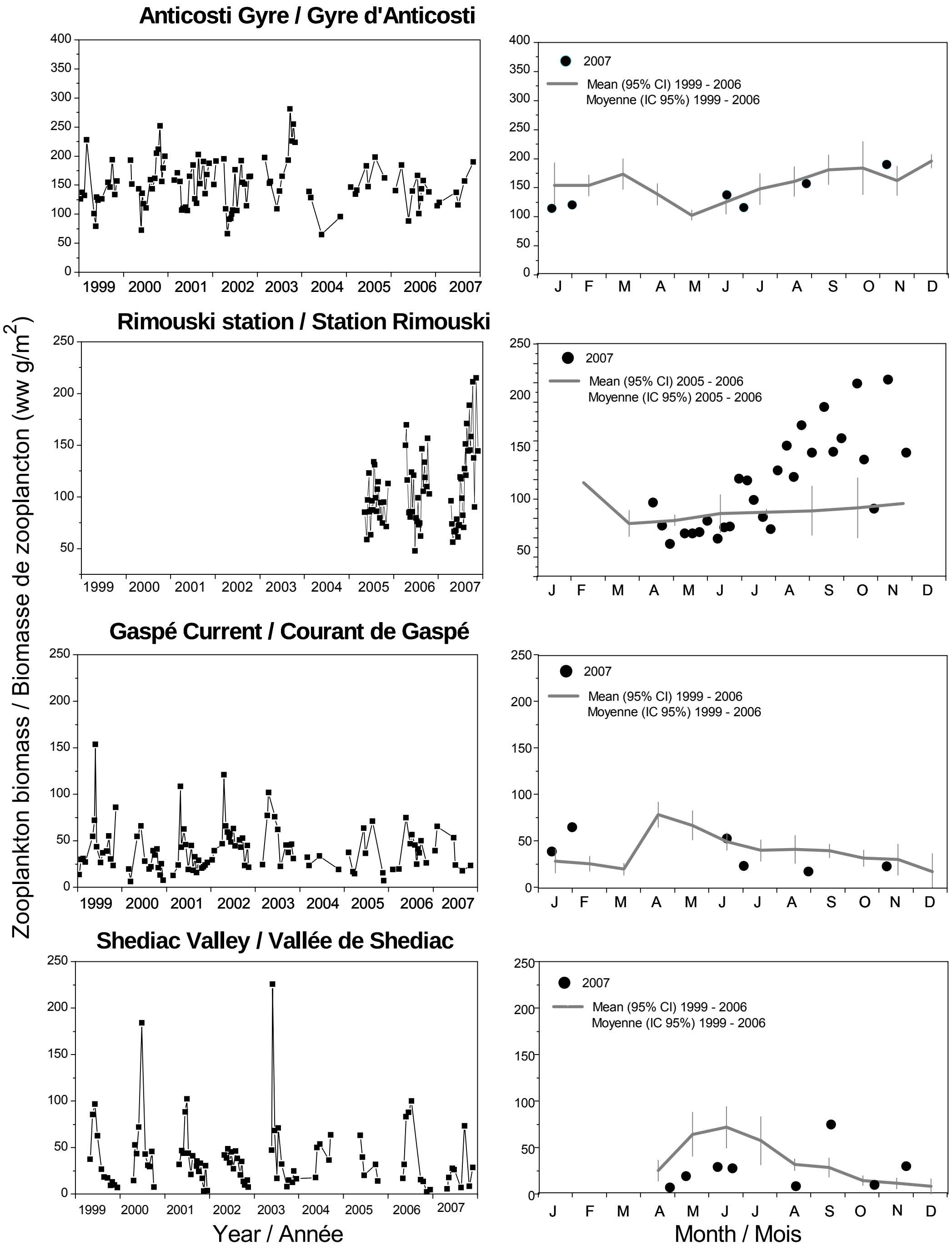


Figure 2. Time series of zooplankton biomass (surface–bottom) at the four fixed stations, 1999–2007 (2005–2007 for Rimouski). Right panels: 2007 (circles) compared with the 1999–2006 (Rimouski 2005–2006) average (solid line). Vertical lines are the 95% confidence limits.

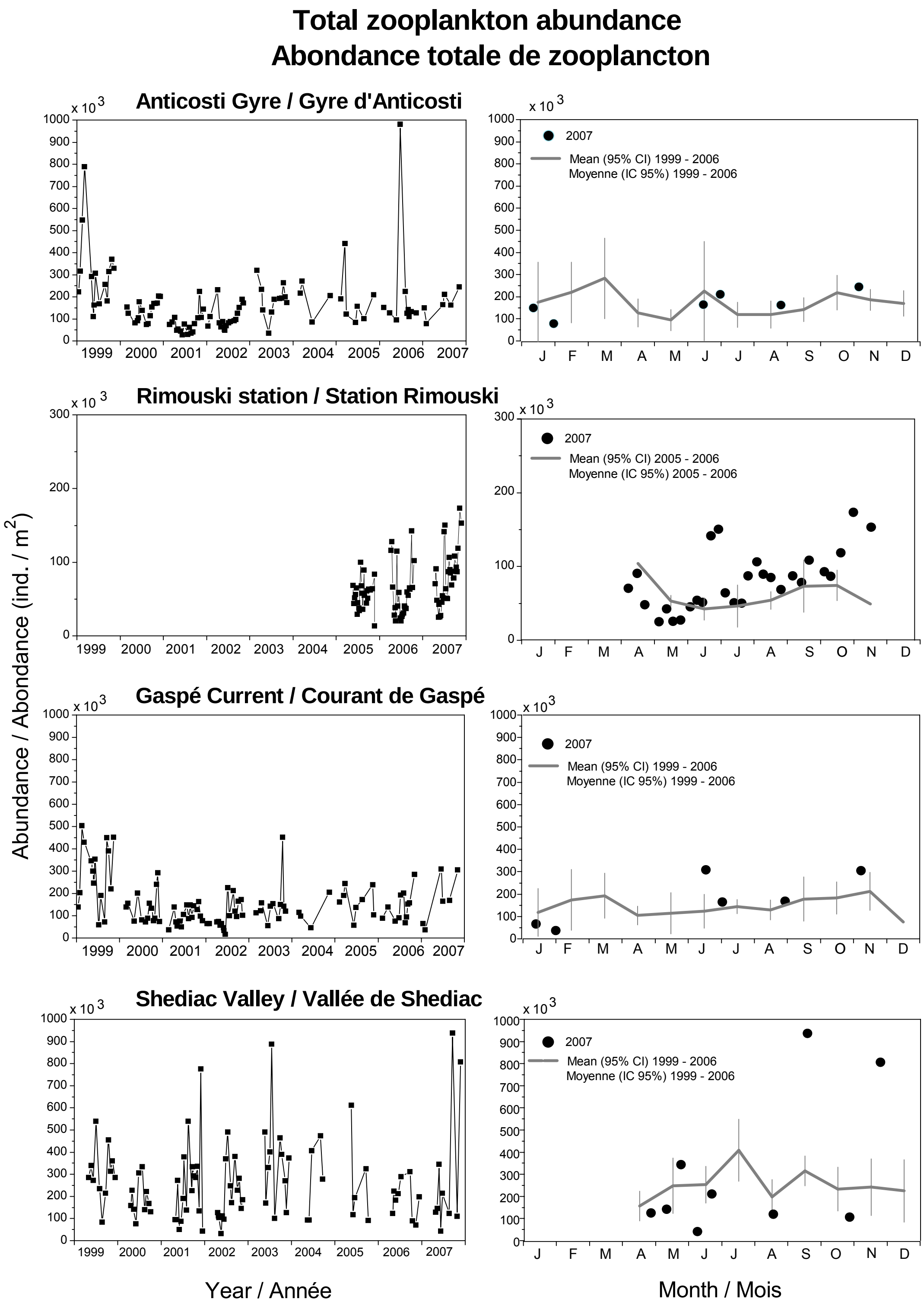


Figure 3. Time series of zooplankton abundance (surface–bottom) at the four fixed stations, 1999–2007 (2005–2007 for Rimouski). Right panels: 2007 (circles) compared with the 1999–2006 (Rimouski 2005–2006) average (solid line). Vertical lines are the 95% confidence limits.

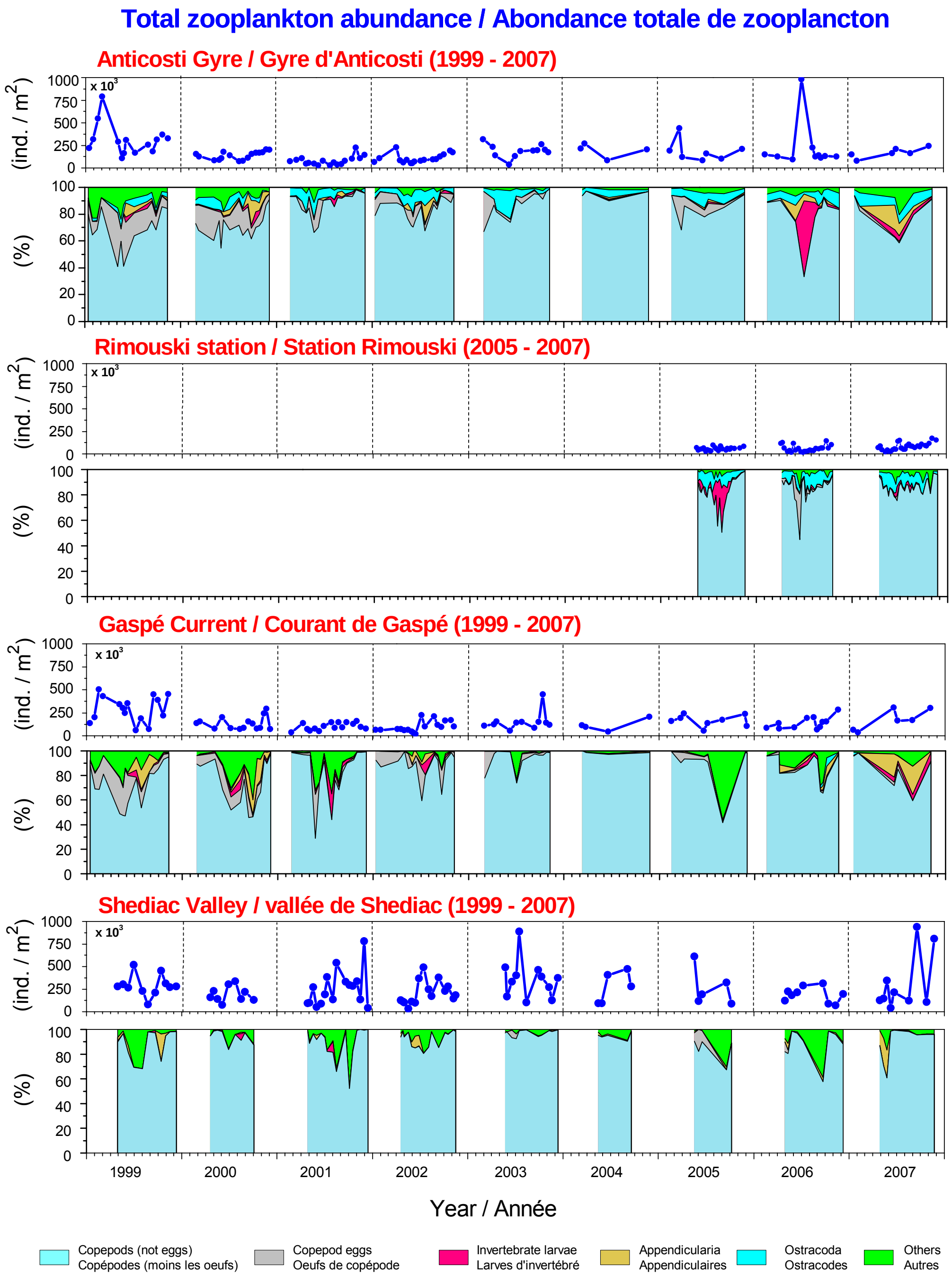


Figure 4. Seasonal cycle of zooplankton total abundance and species composition at the four fixed stations, 1999–2007.

Total copepod abundance
Abondance totale de copépodes

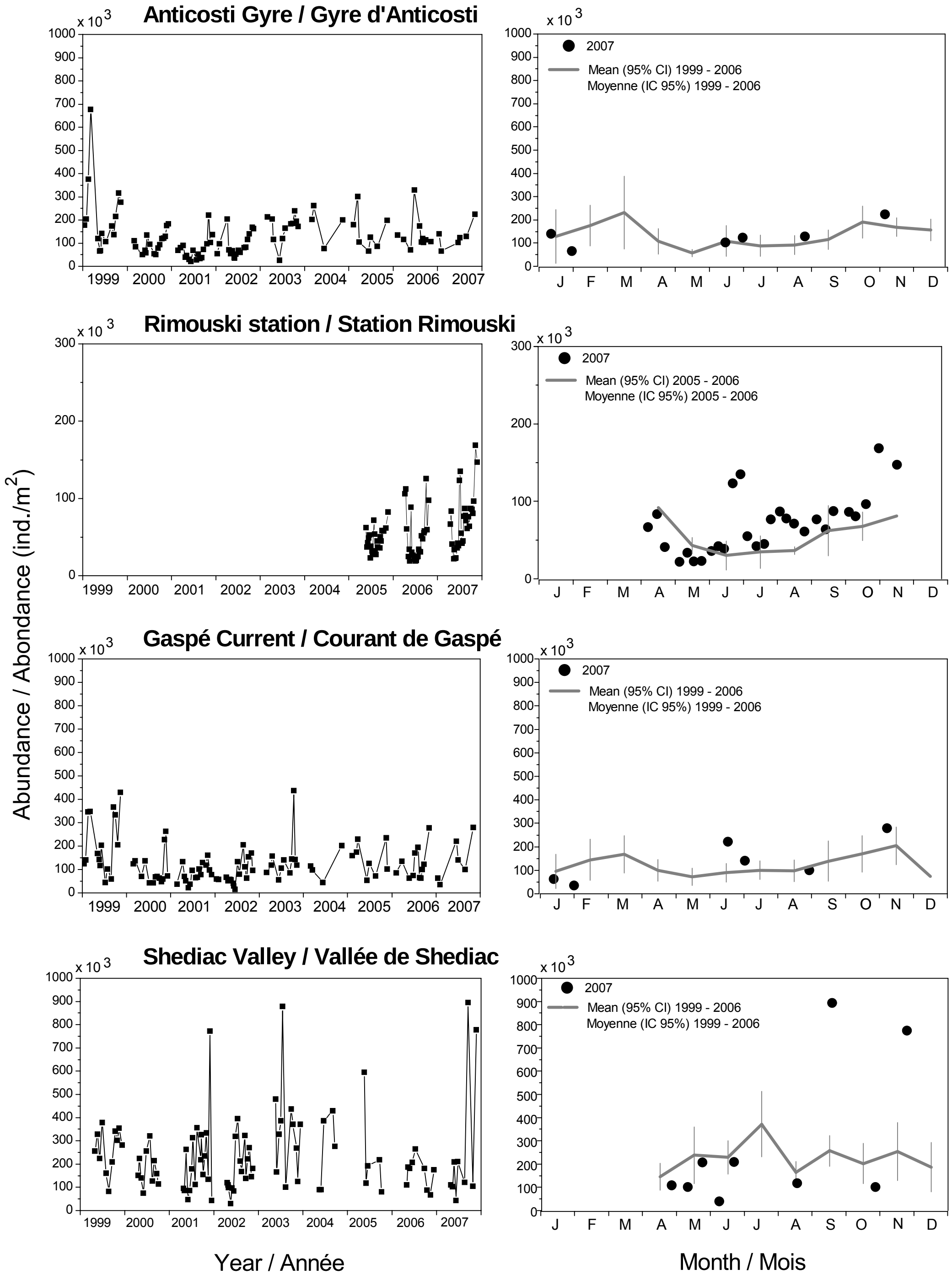


Figure 5. Time series of copepod abundance (surface–bottom) at the four fixed stations, 1999–2007 (2005–2007 for Rimouski). Right panels: 2007 (circles) compared with the 1999–2006 (Rimouski 2005–2006) average (solid line). Vertical lines are the 95% confidence limits.

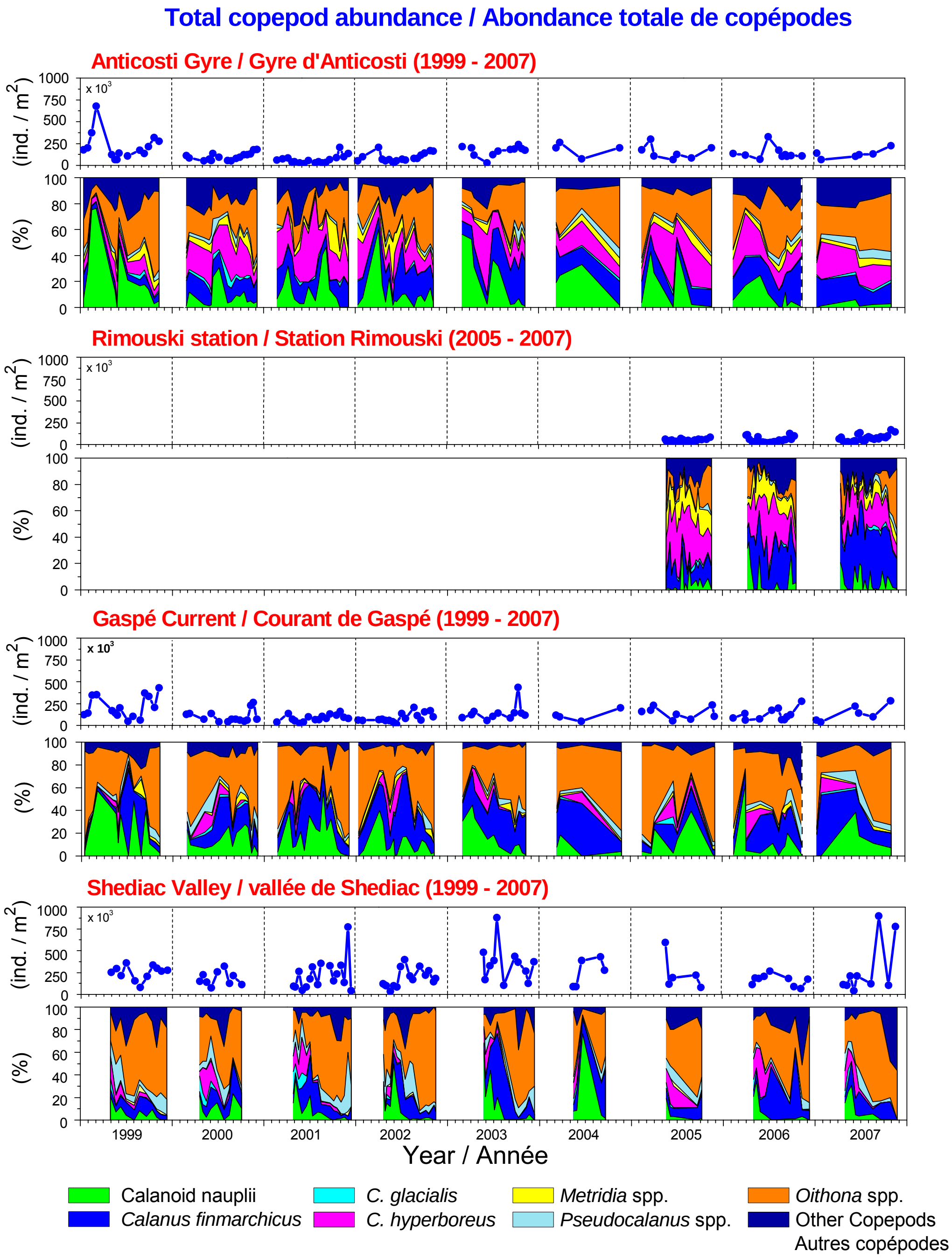


Figure 6. Seasonal cycle of total abundance and species distribution of the dominant copepods at the four fixed stations, 1999–2007.

***C. finmarchicus* abundance**
Abondance de *C. finmarchicus*

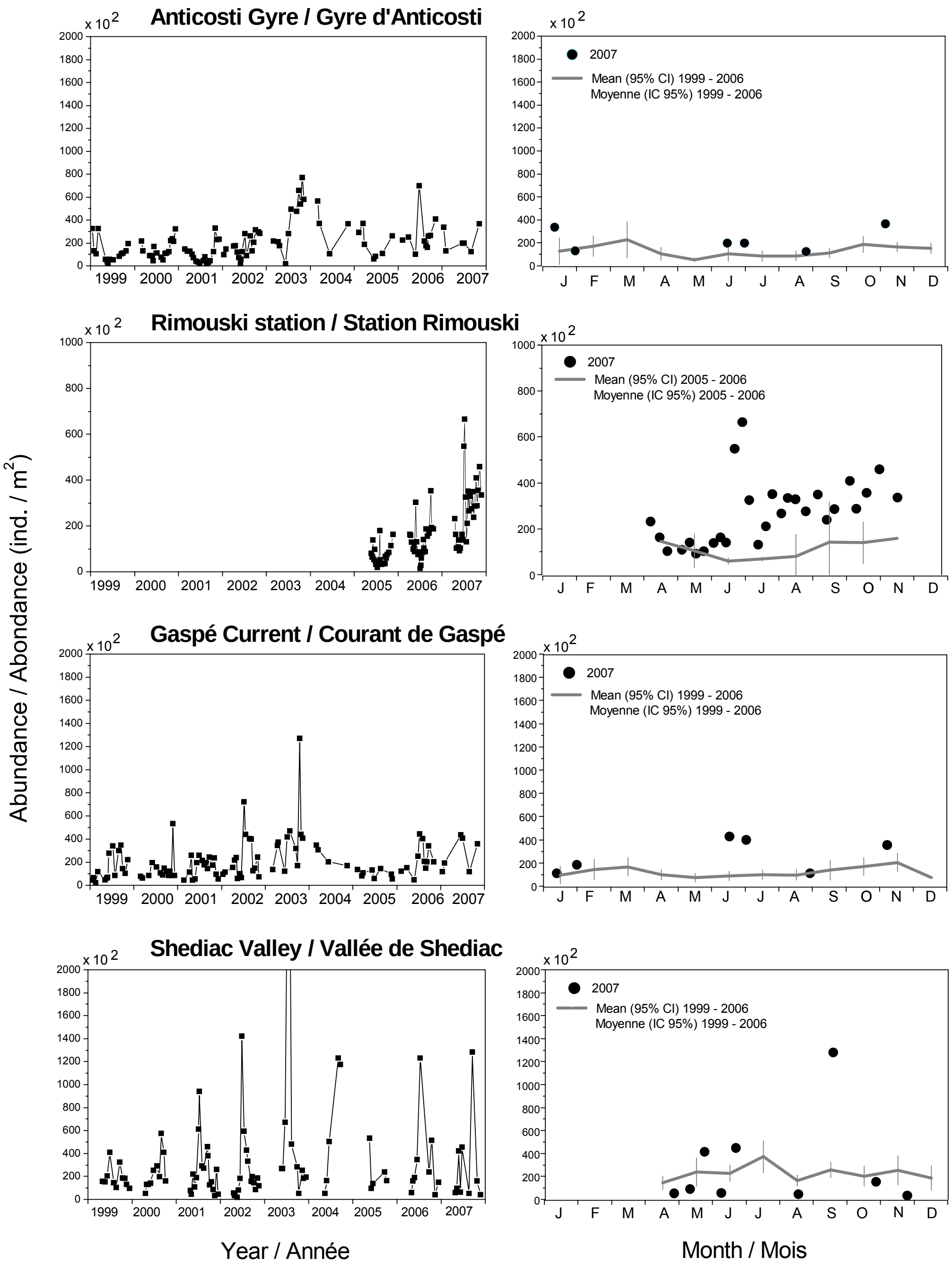


Figure 7. Time series of *C. finmarchicus* abundance (surface–bottom) at the four fixed stations, 1999–2007 (2005–2007 for Rimouski). Right panels: 2007 (circles) compared with the 1999–2006 (Rimouski 2005–2006) average (solid line). Vertical lines are the 95% confidence limits.

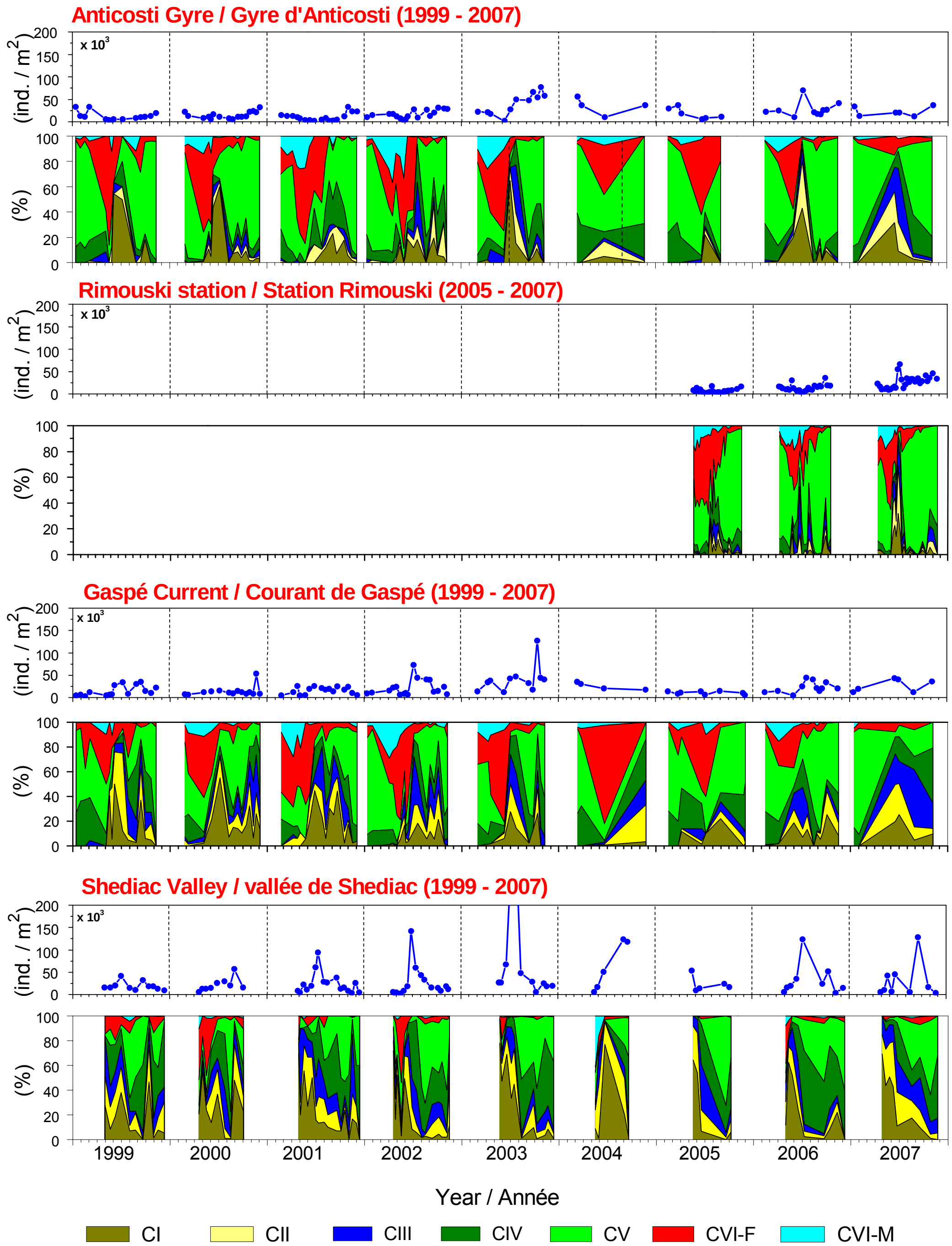
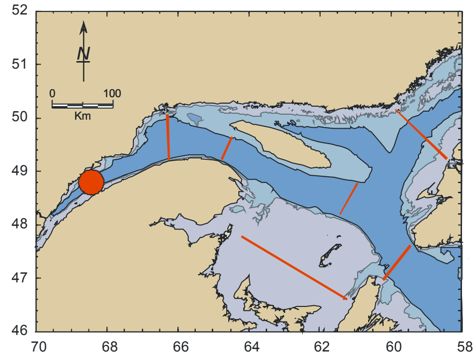
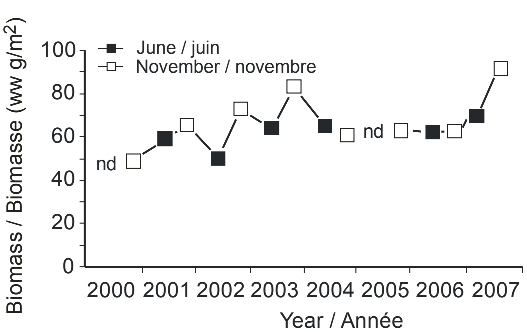
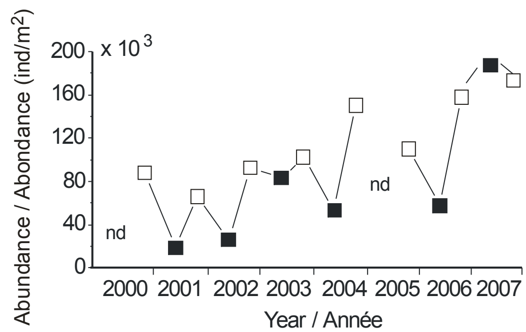


Figure 8. Seasonal cycle of total abundance and stage distribution of *Calanus finmarchicus* at the four fixed stations, 1999–2007.



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

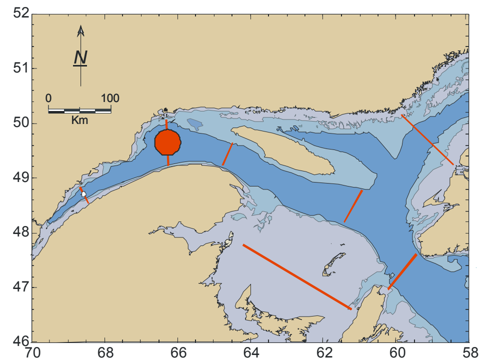




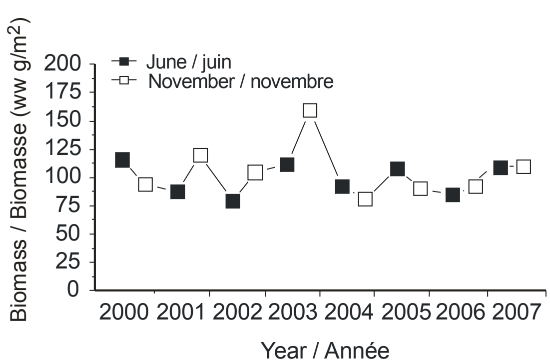
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2000-2006	% of total zooplankton / % du total de zooplancton 2007	Yearly average / Moyenne annuelle 2000-2006 (ind/m^2 · 10^2)	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona* spp.	42.92	28.54	342.70	511.75
2	*C. finmarchicus*	15.15	17.29	121.00	309.98
3	*C. hyperboreus*	6.41	4.57	51.19	82.00
4	*Metridia* spp.	6.41	2.11	51.05	37.90
5	Copepod nauplii	6.39	14.65	51.05	262.73
6	*Microcalanus* spp.	5.41	4.62	43.20	82.80
7	Euph. (eggs, nau, juv.)	4.27	5.82	34.06	104.38
8	*Pseudocalanus* spp.	3.66	2.76	29.22	49.52
9	Ostracods	2.69	1.50	21.50	26.94
10	*Acartia* spp.	0.49	0.52	11.49	13.26
Total		93.81	82.39	756.61	1481.26
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)				805.23	1799.30

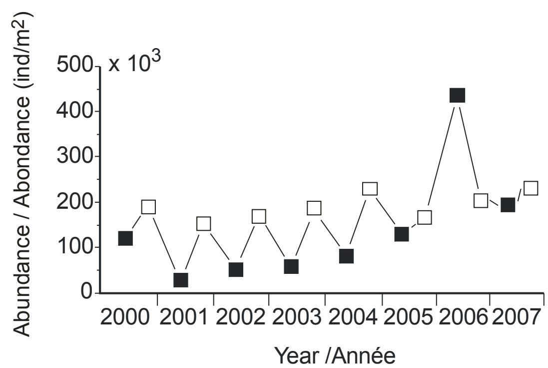
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2007	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona* spp.	28.44	511.75
2	*C. finmarchicus*	17.23	309.98
3	Copepod nauplii	14.60	262.73
4	Appendicularia	11.02	198.36
5	Euph. (eggs, nau, juv.)	5.80	104.38
6	*Microcalanus* spp.	4.60	82.80
7	*C. hyperboreus*	4.56	82.00
8	*Pseudocalanus* spp.	2.75	49.52
9	*Metridia* spp.	2.11	37.90
10	Echinoderm larvae	1.86	33.46
Total		92.97	1672.88
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)			1799.30

Figure 9. Mean zooplankton biomass (wet weight) and abundance along the Lower St. Lawrence Estuary section (TESL) in June and November 2000–2007 and average species dominance for the 2000–2006 period compared with 2007. The circled numbers indicate the new taxa in the top ten species in 2007.



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

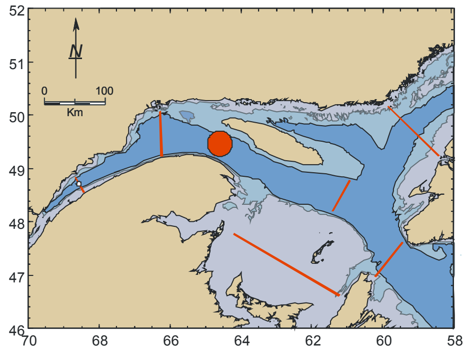




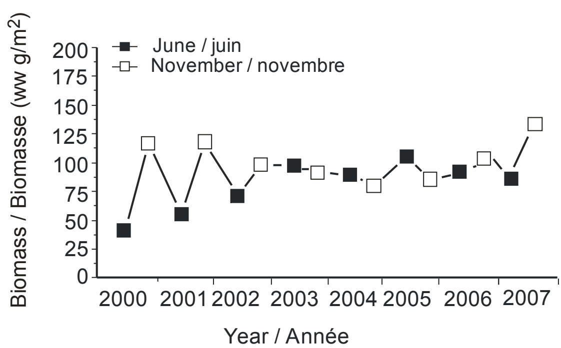
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2000-2006	% of total zooplankton / % du total de zooplancton 2007	Yearly average / Moyenne annuelle 2000-2006 (ind/m^2 · 10^2)	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona* spp.	41.55	35.12	620.11	759.75
2	*C. finmarchicus*	14.01	15.63	209.17	345.81
3	*C. hyperboreus*	7.05	5.75	105.26	135.59
4	*Pseudocalanus* spp.	5.49	1.64	81.95	34.51
5	Echinoderm larvae	4.91	6.81	73.24	148.87
6	Copepod nauplii	4.38	7.27	65.43	158.47
7	*Metridia* spp.	3.40	2.06	50.71	46.41
8	Appendicularia	2.99	9.77	44.58	205.88
9	*Microcalanus* spp.	2.84	3.22	42.35	81.09
10	Copepod eggs	2.76	0.72	41.19	15.12
Total		89.38	87.99	1333.99	1931.51
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)				1492.57	2193.99

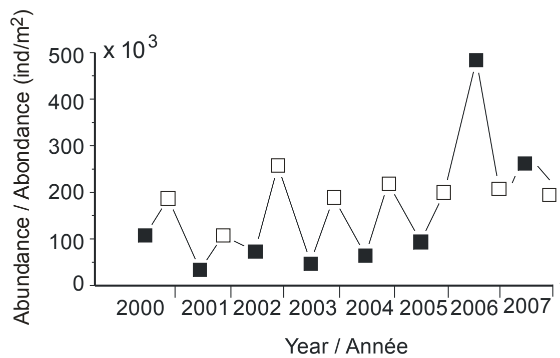
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2007	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona* spp.	35.12	759.75
2	*C. finmarchicus*	15.63	345.81
3	Appendicularia	9.77	205.88
4	Copepod nauplii	7.27	158.47
5	*Pseudocalanus* spp.	6.81	148.87
6	*C. hyperboreus*	5.75	135.59
7	Ostracods	3.45	81.09
8	*Microcalanus* spp.	3.22	72.77
9	*Metridia* spp.	2.06	46.41
10	Echinoderm larvae	1.64	34.51
Total		90.72	1989.16
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)			2193.99

Figure 10. Mean zooplankton biomass (wet weight) and abundance along the Sept-Îles section (TSI) in June and November 2000–2007 and average species dominance for the 2000–2006 period compared with 2007. The circled numbers indicate the new taxa in the top ten species in 2007.



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

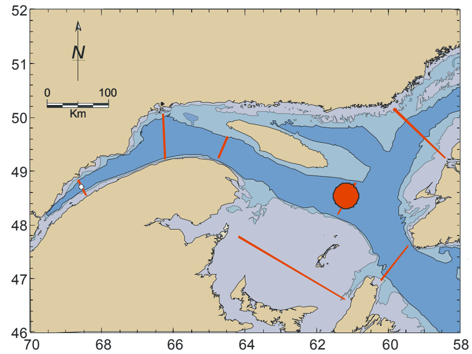




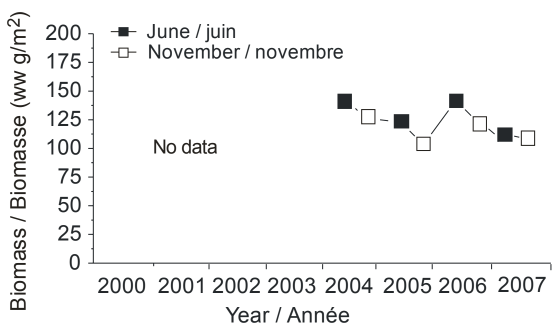
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2000-2006	% of total zooplankton / % du total de zooplancton 2007	Yearly average / Moyenne annuelle 2000-2006 (ind/m^2 · 10^2)	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona* spp.	45.47	23.06	722.21	521.94
2	*C. finmarchicus*	17.05	18.96	270.87	429.10
3	*C. hyperboreus*	5.93	6.64	94.12	150.40
4	*Pseudocalanus* spp.	4.65	6.65	73.79	150.55
5	Copepod nauplii	4.27	4.92	67.74	111.42
6	*Metridia* spp.	3.56	2.29	56.55	51.94
7	Ostracods	2.88	2.58	45.73	58.36
8	*Microcalanus* spp.	2.75	4.09	43.74	92.56
9	Copepod eggs	2.65	1.40	42.17	31.77
10	*Temora* spp.	2.39	2.87	37.95	64.95
Total		91.60	73.47	1457.87	1662.99
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)				1588.40	2263.55

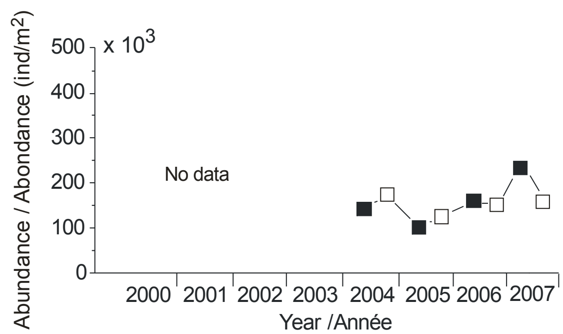
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2007	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona* spp.	23.06	521.94
2	*C. finmarchicus*	18.96	429.10
3	Appendicularia	13.43	304.10
4	*Pseudocalanus* spp.	6.65	150.55
5	*C. hyperboreus*	6.64	150.40
6	Copepod nauplii	4.92	111.42
7	*Microcalanus* spp.	4.09	92.56
8	*Temora* spp.	2.87	64.95
9	Ostracods	2.58	58.36
10	*Metridia* spp.	2.29	51.94
Total		85.56	1935.32
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)			2263.55

Figure 11. Mean zooplankton biomass (wet weight) and abundance along the southwest Anticosti Island section (TASO) in June and November 2000–2007 and average species dominance for the 2000–2006 period compared with 2007. The circled numbers indicate the new taxa in the top ten species in 2007.



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

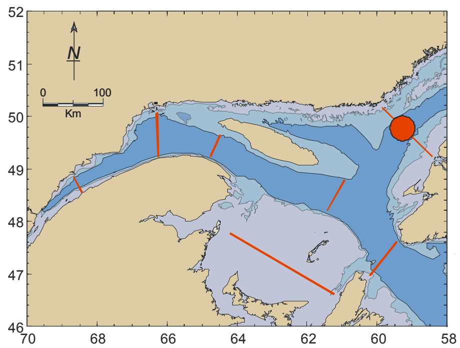




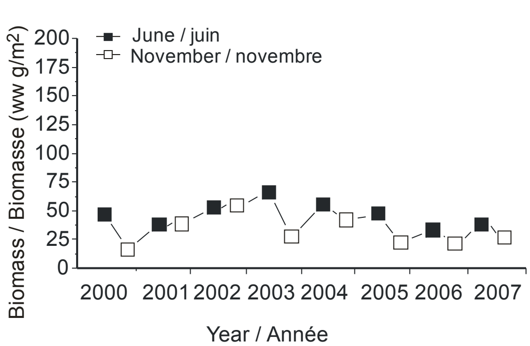
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2000-2006	% of total zooplankton / % du total de zooplancton 2007	Yearly average / Moyenne annuelle 2000-2006 (ind/m^2 · 10^2)	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona* spp.	34.64	37.32	405.19	671.99
2	*C. hyperboreus*	15.10	6.17	176.58	111.07
3	*C. finmarchicus*	12.24	23.59	143.22	424.75
4	*Pseudocalanus* spp.	6.71	5.17	78.45	93.06
5	Copepod eggs	6.04	3.89	70.67	70.06
6	*Microcalanus* spp.	4.38	3.31	51.25	59.65
7	Ostracods	3.84	3.02	44.90	54.45
8	Appendicularia	3.63	2.27	42.41	40.83
9	*Metridia* spp.	3.01	2.15	35.23	38.68
10	*E. norvegica*	1.80	1.20	21.04	21.52
Total		91.39	88.09	1068.94	1586.04
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)				1169.64	1798.98

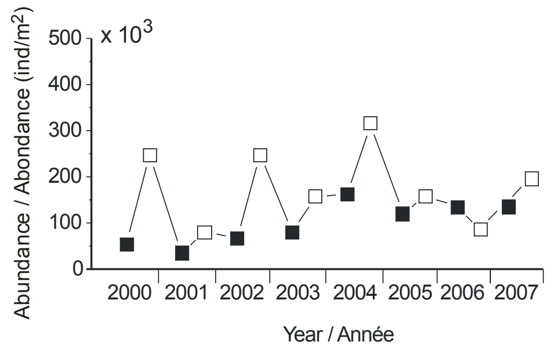
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2007	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona* spp.	37.32	671.99
2	*C. finmarchicus*	23.59	424.75
3	*C. hyperboreus*	6.17	111.07
4	Copepod nauplii	5.76	103.71
5	*Pseudocalanus* sp.	5.17	93.06
6	Copepod eggs	3.89	70.06
7	*Microcalanus* spp.	3.31	59.65
8	Ostracods	3.02	54.45
9	Appendicularia	2.27	40.83
10	*Metridia* spp.	2.15	38.68
Total		92.65	1668.24
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)			1798.98

Figure 12. Mean zooplankton biomass (wet weight) and abundance along the Centre Gulf of St. Lawrence section (TCEN) in June and November 2004–2007 and average species dominance for the 2004–2006 period compared with 2007. The circled numbers indicate the new taxa in the top ten species in 2007.



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

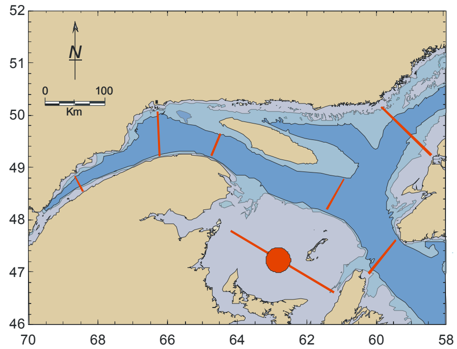




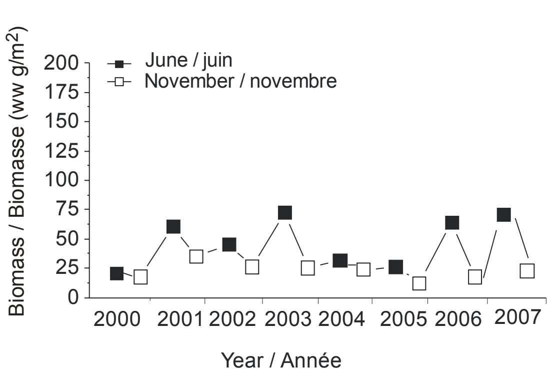
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2000-2006	% of total zooplankton / % du total de zooplancton 2007	Yearly average / Moyenne annuelle 2000-2006 ($ind/m^2 \cdot 10^2$)	2007 average / Moyenne 2007 ($ind/m^2 \cdot 10^2$)
1	*Oithona* spp.	48.08	52.58	589.57	890.22
2	*Pseudocalanus* spp.	13.46	9.70	165.01	164.25
3	*C. finmarchicus*	11.32	13.13	138.80	222.34
4	*Temora* spp.	5.59	2.16	68.53	36.64
5	*C. hyperboreus*	4.94	2.43	55.01	41.07
6	Appendicularia	3.34	3.16	40.93	53.57
7	Copepod nauplii	3.29	5.42	40.29	91.72
8	Copepod eggs	2.81	1.70	34.43	28.85
9	*Microcalanus* spp.	1.29	1.10	15.79	18.56
10	*Metridia* spp.	0.95	1.70	11.69	28.80
Total		95.05	93.09	1160.05	1576.02
Total abundance of zooplankton / Abondance totale de zooplancton ($N/m^2 \cdot 10^2$)				1226.32	1692.83

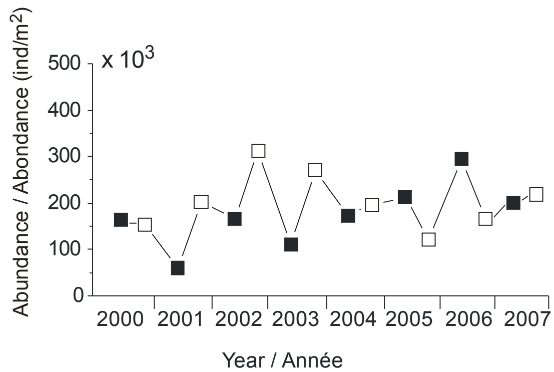
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2007	2007 average / Moyenne 2007 ($ind/m^2 \cdot 10^2$)
1	*Oithona* spp.	52.58	890.22
2	*C. finmarchicus*	13.13	222.34
3	*Pseudocalanus* spp.	9.70	164.25
4	Copepod nauplii	5.42	91.72
5	Appendicularia	3.16	53.57
6	*C. glacialis*	2.88	48.74
7	*C. hyperboreus*	2.43	41.07
8	*Temora* spp.	2.16	36.64
9	Copepod eggs	1.70	28.85
10	*Metridia* spp.	1.70	28.80
Total		94.88	1606.28
Total abundance of zooplankton / Abondance totale de zooplancton ($N/m^2 \cdot 10^2$)			1692.83

Figure 13. Mean zooplankton biomass (wet weight) and abundance along the northeast Gulf of St. Lawrence section (TBB) in June and November 2000–2007 and average species dominance for the 2000–2006 period compared with 2007. The circled numbers indicate the new taxa in the top ten species in 2007.



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

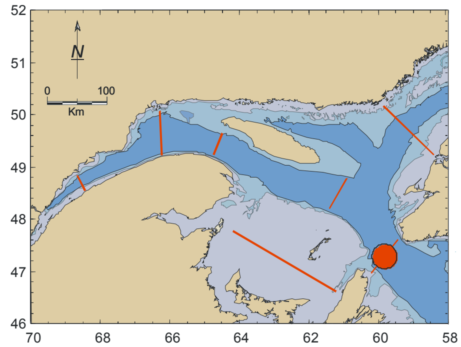




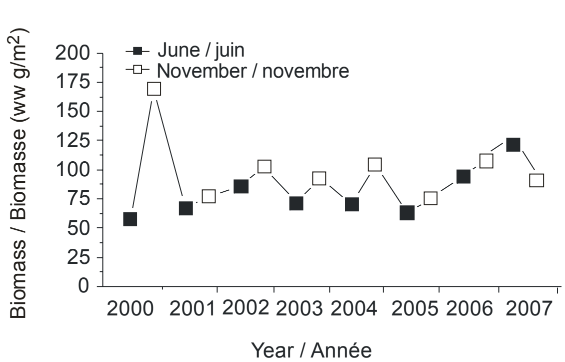
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2000-2006	% of total zooplankton / % du total de zooplancton 2007	Yearly average / Moyenne annuelle 2000-2006 (ind/m^2 · 10^2)	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona spp.*	44.46	55.10	725.30	1180.75
2	*Pseudocalanus* spp.	14.62	10.13	238.54	217.00
3	*Temora* spp.	13.34	5.93	217.59	127.09
4	*C. finmarchicus*	9.78	9.15	159.56	196.17
5	*C. hyperboreus*	4.42	5.80	72.08	124.33
6	Copepod nauplii	3.38	1.49	55.20	31.85
7	Appendicularia	2.21	3.42	35.97	73.37
8	Euph. (eggs, nau, juv.)	1.98	0.69	32.22	14.80
9	Copepod eggs	1.66	1.30	27.03	27.84
10	*C. hyperboreus*	0.73	0.59	11.97	12.60
Total		96.58	93.60	1575.47	2005.80
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)				1631.26	2142.88

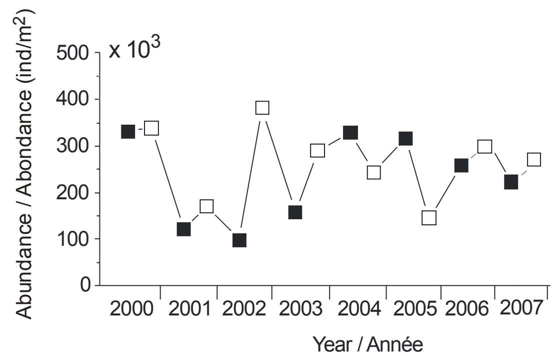
Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2007	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona* spp.	55.10	1180.75
2	*Pseudocalanus* spp.	10.13	217.00
3	*C. finmarchicus*	9.15	196.17
4	*Temora* spp.	5.93	127.09
5	*C. hyperboreus*	5.80	124.33
6	Appendicularia	3.42	73.37
7	Pteropods	1.69	36.23
8	Copepod nauplii	1.49	31.85
9	Copepod eggs	1.30	27.84
10	*Oncea* spp.	0.94	20.24
Total		94.96	2034.86
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)			2142.88

Figure 14. Mean zooplankton biomass (wet weight) and abundance along the southern Gulf of St. Lawrence section (TIDM) in June and November 2000–2007 and average species dominance for the 2000–2006 period compared with 2007. The circled numbers indicate the new taxa in the top ten species in 2007.



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





Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2000-2006	% of total zooplankton / % du total de zooplancton 2007	Yearly average / Moyenne annuelle 2000-2006 (ind/m^2 · 10^2)	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona* spp.	38.44	43.32	899.90	1095.10
2	*Pseudocalanus* spp.	15.63	8.55	366.02	216.08
3	*C. finmarchicus*	10.21	8.70	238.96	219.94
4	*Temora* spp.	9.99	4.07	233.86	102.95
5	*C. hyperboreus*	5.70	8.03	119.92	202.96
6	*Microcalanus* spp.	3.01	3.00	70.49	75.75
7	Appendicularia	2.22	4.08	52.07	103.21
8	Copepod nauplii	2.01	1.42	47.11	35.95
9	Copepod eggs	1.85	1.61	43.21	40.80
10	Bivalve larvae	1.58	1.79	37.03	45.15
Total		90.64	84.57	2108.57	2137.90
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)				2341.18	2523.51

Rank / Rang	Taxon	% of total zooplankton / % du total de zooplancton 2007	2007 average / Moyenne 2007 (ind/m^2 · 10^2)
1	*Oithona* spp.	43.32	1095.10
2	*C. finmarchicus*	8.70	219.94
3	*Pseudocalanus* spp.	8.55	216.08
4	*C. hyperboreus*	8.03	202.96
5	Appendicularia	4.08	103.21
6	*Temora* spp.	4.07	102.95
7	*Microcalanus* spp.	3.00	75.75
8	Pteropods	2.77	69.91
9	*Metridia* spp.	2.74	69.25
10	Bivalve larvae	2.33	45.15
Total		87.58	2200.30
Total abundance of zooplankton / Abondance totale de zooplancton (N/m^2 · 10^2)			2523.51

Figure 15. Mean zooplankton biomass (wet weight) and abundance along the Cabot Strait section (TDC) in June and November 2000–2007 and average species dominance for the 2000–2006 period compared with 2007. The circled numbers indicate the new taxa in the top ten species in 2007.

	AREA	Index	Reference	1999	2000	2001	2002	2003	2004	2005	2006	2007	
Fixed Stations	Anticosti Gyre	Zooplankton biomass	1999-2006	-0.17	0.29	0.07	-0.24	1.05	-1.40	0.32	-0.45	-1.20	154.4 ± 26.1 (g ww /m^2)
		Total zooplankton abundance	1999-2006		-0.20	-0.95	-0.46	0.34	-0.08	-0.10	0.07	0.18	176.2 ± 55.7 (10^3 ind / m^2)
		Total copepod abundance	1999-2006		-0.36	-0.97	-0.42	0.50	0.12	0.00	0.19	0.31	138.2 ± 48.8 (10^3 ind / m^2)
		Abundance of *C. finmarchicus*	1999-2006	-0.42	-0.32	-0.75	-0.06	1.13	0.84	-0.09	0.76	-0.62	204.9 ± 75.6 (10^2 ind / m^2)
	Gaspé Current	Zooplankton biomass	1999-2006	0.33	-0.51	-0.72	0.33	0.53	-0.09	0.34	0.12	0.10	38.6 ± 18.3 (g ww /m^2)
		Total zooplankton abundance	1999-2006		-0.32	-0.42	-0.44	0.07	-0.48	0.07	-0.01	0.41	143.7 ± 45.8 (10^3 ind / m^2)
		Total copepod abundance	1999-2006		-0.40	-0.41	-0.33	0.17	-0.45	-0.06	0.08	0.36	121.2 ± 42.7 (10^3 ind / m^2)
		Abundance of *C. finmarchicus*	1999-2006	-0.11	-0.30	-0.55	0.17	0.95	0.91	-0.74	0.18	1.38	185.8 ± 90.5 (10^2 ind / m^2)
	Shediac Valley	Zooplankton biomass	1999-2006	-0.38	-0.03	0.40	-0.25	0.33	-0.01	-0.30	-0.24	-0.53	34.8 ± 23.9 (g ww /m^2)
		Total zooplankton abundance	1999-2006	0.45	-0.40	-0.23	-0.14	0.95	0.36	0.09	-0.48	0.82	246.7 ± 47.8 (10^3 ind / m^2)
		Total copepod abundance	1999-2006	0.53	-0.41	-0.27	-0.20	0.75	0.57	-0.03	-0.62	0.99	227.5 ± 66.9 (10^3 ind / m^2)
		Abundance of *C. finmarchicus*	1999-2006	-0.14	-0.33	-0.39	-0.13	0.67	0.76	0.11	-0.03	-0.22	351.6 ± 378.4 (10^2 ind / m^2
Sections (Spring)	TESL	Zooplankton biomass	2000-2006			-0.16	-1.66	0.65	0.80		0.38	1.54	68.1 ± 6.5 (g ww /m^2)
		Total zooplankton abundance	2000-2006			-1.12	-0.83	1.37	0.21		0.37	5.38	71.1 ± 61.4 (10^3 ind / m^2)
	TSI	Zooplankton biomass	2000-2006		1.29	-0.63	-1.24	1.01	-0.32	0.74	-0.85	0.81	98.3 ± 14.4 (g ww /m^2)
		Total zooplankton abundance	2000-2006		-0.06	-0.73	-0.55	-0.51	-0.34	0.00	2.19	0.45	137.0 ± 131.6 (10^3 ind / m^2
	TASO	Zooplankton biomass	2000-2006		-1.59	-0.98	-0.34	0.80	0.48	1.11	0.52	0.25	79.5 ± 21.9 (g ww /m^2)
		Total zooplankton abundance	2000-2006		-0.13	-0.61	-0.35	-0.52	-0.41	-0.22	2.24	0.85	145.6 ± 154.0 (10^3 ind / m^2
	TCEN	Zooplankton biomass	2004-2006						0.56	-1.15	0.59	-2.02	129.4 ± 14.6 (g ww /m^2)
		Total zooplankton abundance	2004-2006						0.27	-1.11	0.84	3.34	160.1 ± 55.2 (10^3 ind / m^2)
	TDC	Zooplankton biomass	2000-2006		-1.19	-0.40	1.02	-0.12	-0.14	-0.81	1.64	3.88	78.9 ± 22.1 (g ww /m^2)
		Total zooplankton abundance	2000-2006		0.99	-1.07	-1.29	-0.71	0.97	0.84	0.27	-0.01	229.4 ± 95.0 (10^3 ind / m^2)
	TIDM	Zooplankton biomass	2000-2006		-1.19	0.71	-0.03	1.32	-0.70	-1.01	0.90	1.22	48.8 ± 20.6 (g ww /m^2)
		Total zooplankton abundance	2000-2006		1.42	-1.39	-0.27	-0.85	-0.21	0.22	1.08	0.14	193.6 ± 88.4 (10^3 ind / m^2)
	TBB	Zooplankton biomass	2000-2006		-0.10	-0.94	0.39	1.59	0.63	-0.16	-1.41	-0.91	47.5 ± 10.7 (g ww /m^2)
		Total zooplankton abundance	2000-2006		-0.84	-1.26	-0.56	-0.29	1.48	0.58	0.89	0.94	98.9 ± 45.5 (10^3 ind / m^2)
Sections (Fall)	TESL	Zooplankton biomass	2000-2006		-1.55	0.03	0.73	1.67	-0.41	-0.21	-0.25	2.41	68.5 ± 13.4 (g ww /m^2)
		Total zooplankton abundance	2000-2006		-0.64	-1.30	-0.52	-0.22	1.21	0.01	1.45	1.90	117.6 ± 38.2 (10^3 ind / m^2)
	TSI	Zooplankton biomass	2000-2006		-0.45	0.54	-0.05	2.00	-0.94	-0.59	-0.52	0.14	106.3 ± 24.8 (g ww /m^2)
		Total zooplankton abundance	2000-2006		0.22	-1.23	-0.58	-0.17	1.74	-0.71	0.74	1.75	190.5 ± 28.6 (10^3 ind / m^2)
	TASO	Zooplankton biomass	2000-2006		1.22	1.29	-0.04	-0.51	-1.29	-0.92	0.24	2.39	103.6 ± 18.5 (g ww /m^2)
		Total zooplankton abundance	2000-2006		-0.17	-1.94	1.36	-0.14	0.51	0.11	0.28	-0.12	194.7 ± 42.2 (10^3 ind / m^2)
	TCEN	Zooplankton biomass	2004-2006						0.81	-1.12	0.31	-0.70	115.7 ± 11.0 (g ww /m^2)
		Total zooplankton abundance	2004-2006						0.97	-1.02	0.05	0.29	152.4 ± 20.1 (10^3 ind / m^2)
	TDC	Zooplankton biomass	2000-2006		2.07	-0.87	-0.05	-0.37	0.00	-0.91	0.12	-0.43	102.6 ± 29.6 (g ww /m^2)
		Total zooplankton abundance	2000-2006		0.84	-1.13	1.32	0.27	-0.27	-1.41	0.38	0.14	217.6 ± 79.4 (10^3 ind / m^2)
	TIDM	Zooplankton biomass	2000-2006		-0.64	1.70	0.45	0.41	0.18	-1.28	-0.81	-0.21	22.5 ± 6.7 (g ww /m^2)
		Total zooplankton abundance	2000-2006		-0.73	-0.02	1.63	1.01	-0.11	-1.21	-0.56	0.31	205.2 ± 62.7 (10^3 ind / m^2)
	TBB	Zooplankton biomass	2000-2006		-1.16	0.51	1.66	-0.30	0.73	-0.68	-0.76	-0.32	31.2 ± 12.6 (g ww /m^2)
		Total zooplankton abundance	2000-2006		0.71	-1.18	0.72	-0.31	1.47	-0.29	-1.12	0.20	186.8 ± 82.7 (10^3 ind / m^2)

Figure 16. 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 2007. The anomalies are normalized with respect to their standard deviations over the reference period indicated. Numbers to the right of the table are means (± SD) for the reference period.

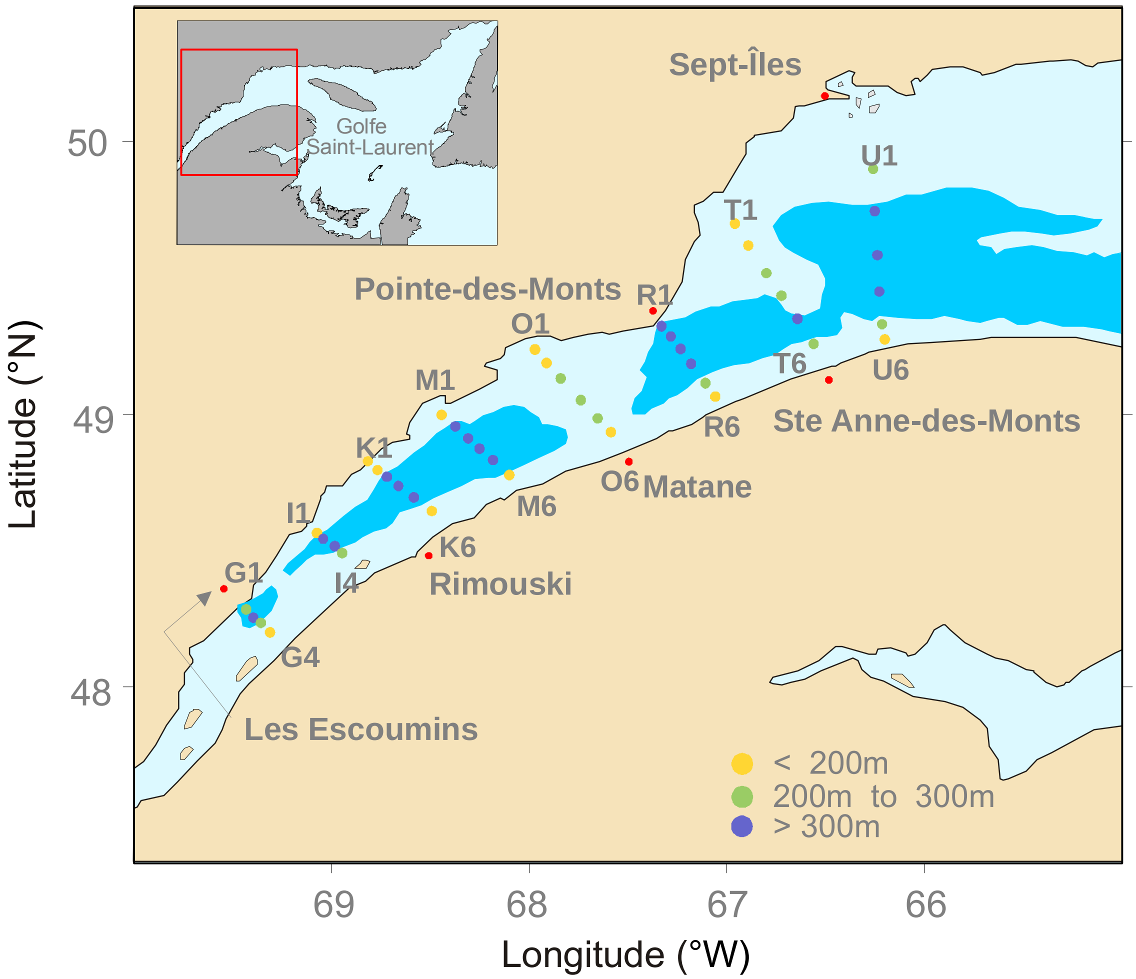
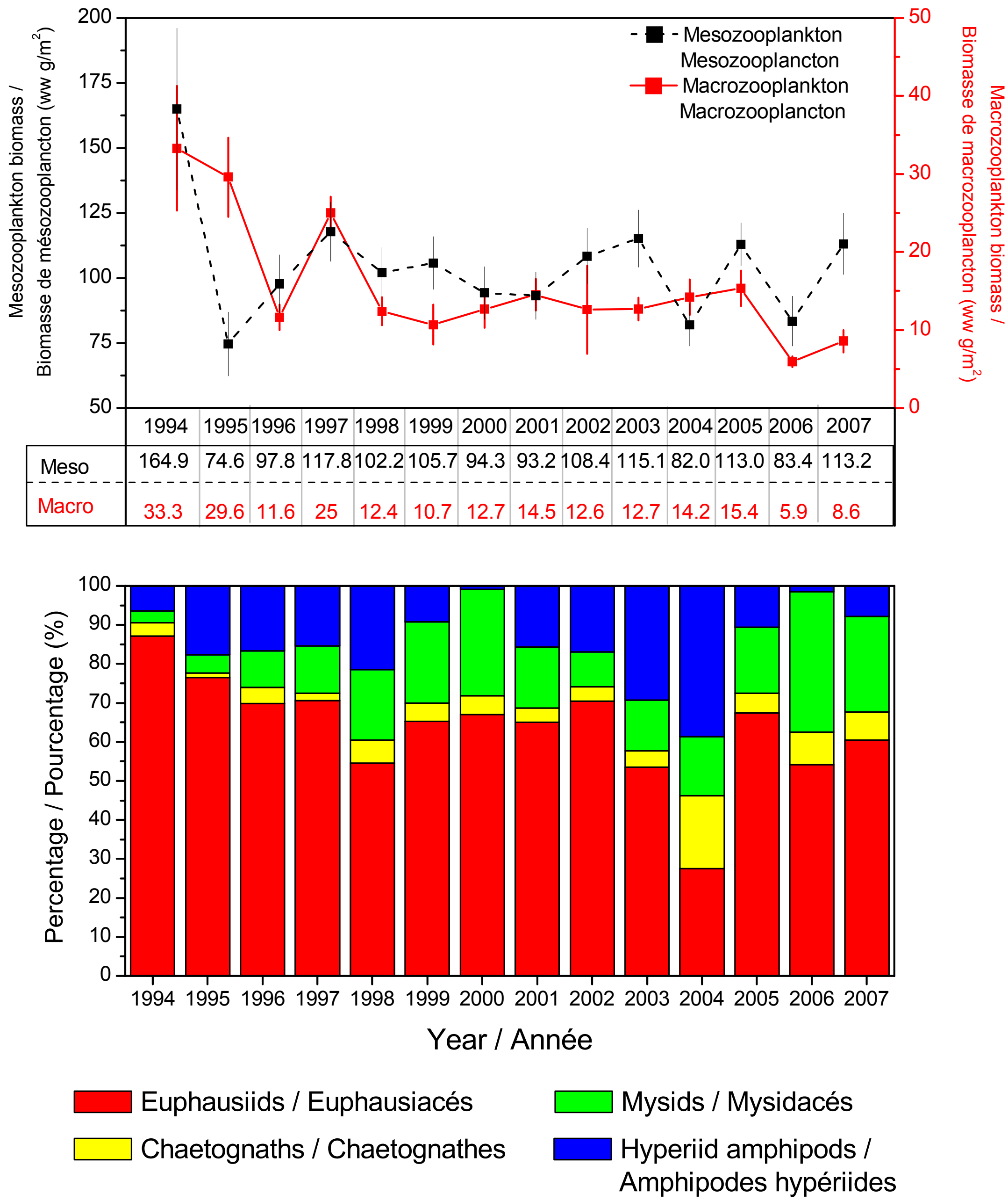


Figure 17. Map showing station locations of the annual zooplankton survey in the Lower St. Lawrence Estuary (sections G to O) and the northwest Gulf of St. Lawrence (sections R to U). The survey took place in September from 1994 until 2003 and in November since 2004.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
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	113.2
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	8.6

Figure 18. Mean biomass (± SE) of mesozooplankton and macrozooplankton in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence from 1994 to 2007 (upper panel) and the relative contribution of the four most important macrozooplankton groups to the biomass (lower panel).

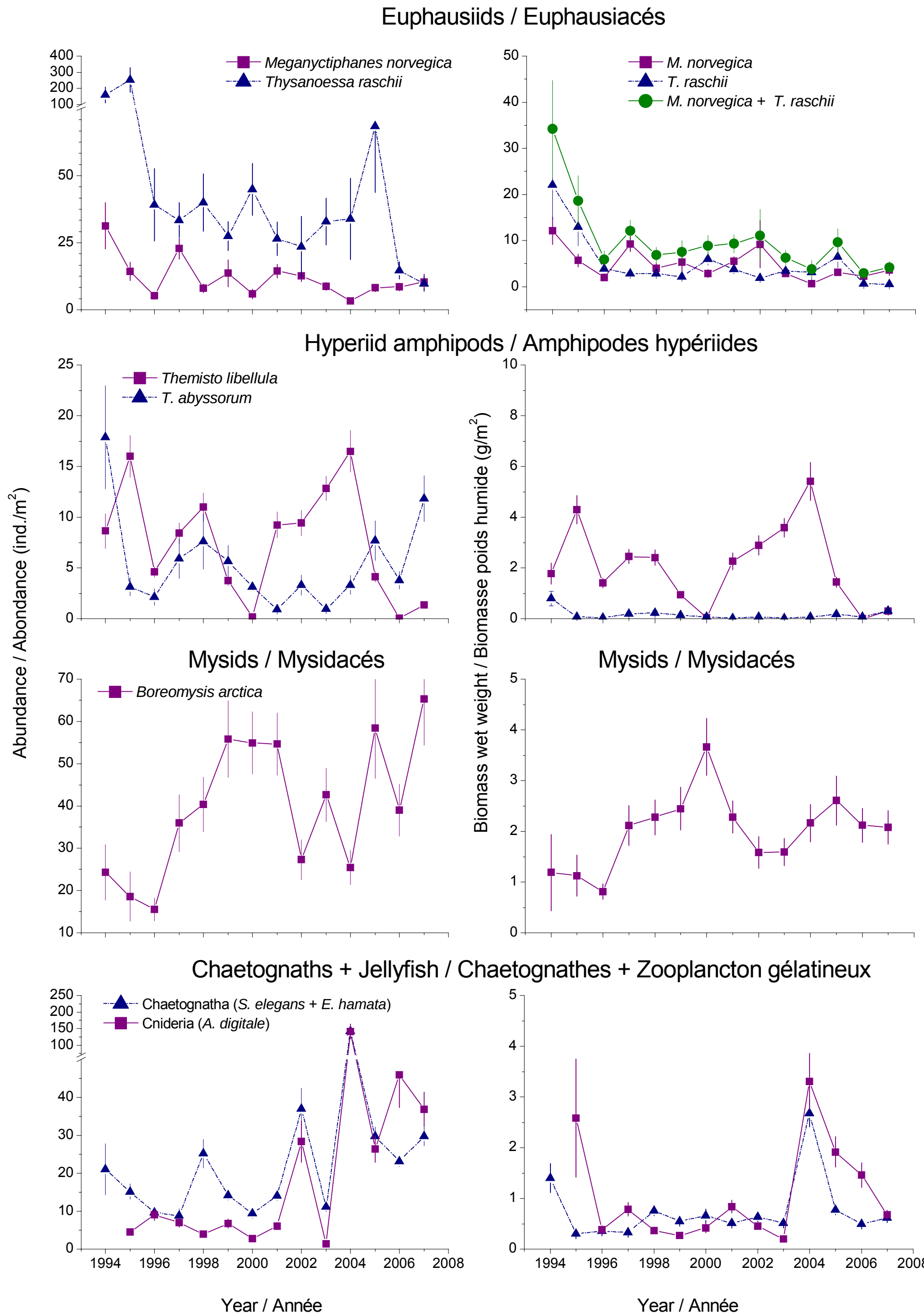


Figure 19. Mean abundance (left panels) and biomass (right panels) (± SE) of the most important species of macrozooplankton in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence from 1994 to 2007.

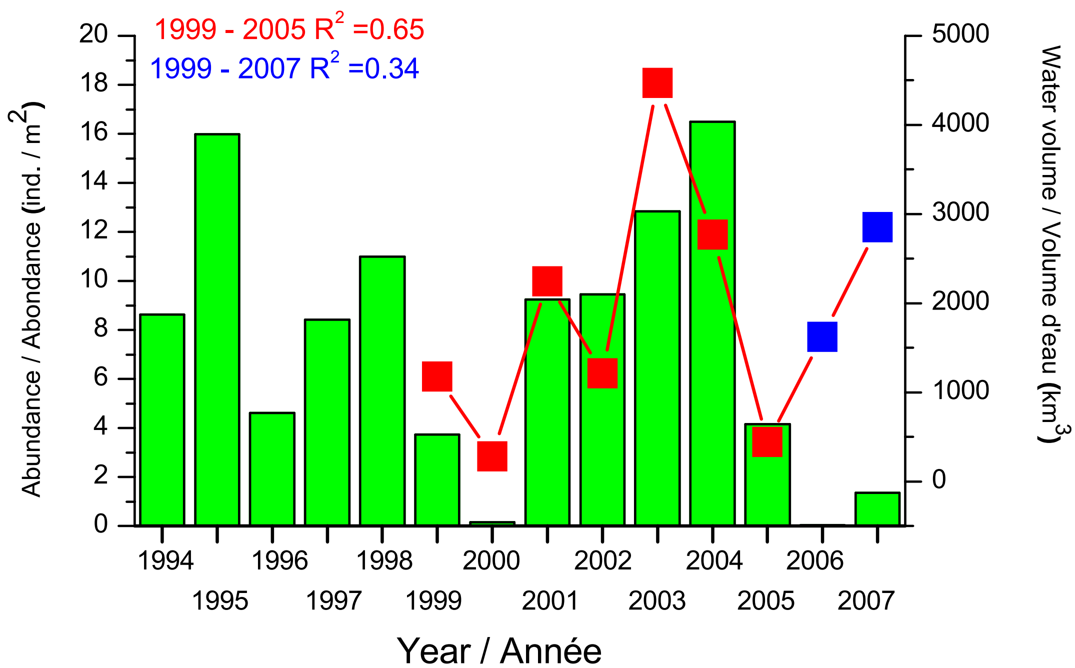


Figure 20. Relationship between the annual volumes of Labrador Shelf water advected into the Gulf of St. Lawrence in winter (symbols) and the annual mean abundance of the hyperiid amphipod *Themisto libellula* (bars) in the Lower St. Lawrence Estuary and northwest Gulf of St. Lawrence from 1994 to 2007.