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Oceanographic conditions in the Estuary and the Gulf of St. Lawrence during 2008: zooplankton

Conditions océanographiques dans l'estuaire et le golfe du Saint-Laurent en 2008 : zooplancton

Michel Harvey and Laure Devine

Institut Maurice-Lamontagne / Maurice Lamontagne Institute
Pêches et Océans Canada /Fisheries and Oceans Canada
850, route de la Mer
CP / P.O. Box 1000
Mont-Joli, QC
G5H 3Z4

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ABSTRACT

This document provides an overview of the temporal variability of zooplankton biomass, abundance, and species composition in 2008 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 2008.

Compared to the 1999–2007 average, the state of the zooplankton at the four Québec fixed stations in 2008 was estimated as lower than normal (zooplankton biomass) and above normal (total non-copepod abundance, total copepod abundance, *Calanus finmarchicus* abundance, *Pseudocalanus* spp. abundance) at AG and GC; lower than normal (zooplankton biomass), normal (total non-copepod abundance, total copepod abundance, *Pseudocalanus* spp. abundance), and above normal (*C. finmarchicus* abundance) at RS; and normal (zooplankton biomass, *C. finmarchicus* abundance, *Pseudocalanus* spp. abundance) and above normal (total non-copepod abundance, total copepod abundance) at SV. In addition, some changes in the zooplankton community structure were observed over the time series, including some changes in the rank of the top ten taxa and the appearance of new taxa in the dominant species (top ten): *Temora* spp. and appendicularians at AG; *Temora* spp., cladocera, and bivalve larvae at GC; *Paraeuchaeta norvegica* and *Calanus glacialis* at SV; and polychaete larvae at RS.

The biomass indices of *Calanus hyperboreus* and the mesozooplankton along the seven Québec sections in spring and fall 2008 were estimated to be normal or below normal except in the LSLE (TESL), where the *C. hyperboreus* biomass was evaluated as above normal. For the nine zooplankton abundance indices, most were evaluated as normal or above normal in spring 2008 except that below normal abundances were found for copepod nauplii along the TESL and TIDM sections, for mesozooplankton (excluding copepods) in the centre and the northeast GSL (TCEN, TBB), and for krill larvae in Cabot Strait (TDC). The situation was very different for the fall period: some of the abundance indices were still evaluated as normal or above normal (total copepods, copepod nauplii, small copepods, carnivorous zooplankton, mesozooplankton excluding copepods, krill larvae) and some others as normal or below normal (large copepods, *C. finmarchicus* CIV–CV, meroplankton). 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: *Eurytemora* spp. and *C. glacialis* in the LSLE (TESL); *Temora* spp. and copepod eggs in the northwest GSL (TSI); copepod eggs southwest of Anticosti Island (TASO); *Paraeuchaeta norvegica* and *C. glacialis* in the centre GSL (TCEN); *C. glacialis* in the northeast and southern GSL (TBB, TIDM); and Ostracoda in Cabot Strait (TDC).

The mean mesozooplankton biomass observed in November 2008 in the LSLE and in the NWGSL was 1.8 and 1.4 times higher than in 2006 and 2007, respectively. This corresponds to the second highest value observed in the last 15 years in the study area. The mean macrozooplankton biomass decreased from 15.4 ww g/m^2 in 2005 to 5.9 (2006), 8.6 (2007), and 6.2 (2008). The macrozooplankton biomass values observed in 2006, 2007, and 2008

correspond to the lowest values observed over the last 15 years. The most notable feature observed in the LSLE and NWGSL was the sharp decrease in the abundance of *Thysanoessa raschii,* which was 5.3 times less abundant in 2006, 2007, and 2008 compared to the previous 15 years. In addition, the mean abundance of the hyperiid amphipod *Themisto libellula* estimated in both regions in 2006, 2007, and 2008 corresponds to the lowest value observed over the previous last 15 years (except 2000).

RÉSUMÉ

Ce document donne un aperçu de la variabilité temporelle de la biomasse de zooplancton, l'abondance et la composition des espèces en 2008 à quatre stations fixes et sept sections du PMZA ainsi qu'un aperçu de la variabilité interannuelle de la composition spécifique, l'abondance et la biomasse du macrozooplancton dans l'estuaire maritime et le nord-ouest du golfe du Saint-Laurent de 1994 à 2008.

Par rapport aux années précédentes (1999–2007) l'état du zooplancton aux quatre stations fixes de la région en 2008 est considéré inférieur (biomasse) et supérieure (abondance totale de zooplancton autre que copépode, abondance totale de copépodes, abondance de *Calanus finmarchicus*, abondance de *Pseudocalanus* spp.) à la normale dans la AG et GC; inférieure à la normale (biomasse de zooplancton), normale (abondance totale de zooplancton autre que copépode, abondance totale de copépodes, abondance de *Pseudocalanus* spp.) et supérieure à la normale (abondance de *C. finmarchicus*) dans la RS; et normale (biomasse de zooplancton, abondance de *C. finmarchicus*, abondance de *Pseudocalanus* spp.) et supérieure à la normale (abondance totale de zooplancton autre que copépode, abondance totale de copépodes) dans la SV. Également, des changements dans la structure de la communauté de zooplancton ont été observés en 2008. 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 parmi les 10 espèces dominantes («top 10») : appendiculaires et *Temora* spp. dans la AG, *Temora* spp., cladodère et larves de bivalve dans le GC, *Paraeuchaeta norvegica* et *Calanus glacialis* à la SV et larves de polychète dans la RS.

Les indices de biomasse de *Calanus hyperboreus* et du mesozooplancton observés le long des sept sections du Québec au printemps et à l'automne 2008 ont été évalués comme normal ou inférieure à la normale, excepté dans l'estuaire maritime (TESL) où la biomasse de *C. hyperboreus* a été évaluée supérieure à la normale. En ce qui concerne les neuf indices d'abondance, la plupart ont été évalués à la normale ou supérieur à la normale au printemps 2008 excepté dans certains cas qui ont été évalués inférieure à la normale comme les nauplii de copépodes le long des sections TESL et TIDM, l'abondance du mésozooplancton (excluant les copépodes) dans le centre et le nord-est du golfe (TCEN, TBB) et les larves de krill dans le détroit de Cabot (TDC). Cependant, la situation a été différente pendant l'automne 2008 : quelques indices ont également été évalués à la normale ou supérieur à la normale (l'ensemble des copépodes, les nauplii de copépode, les petits copépodes, le zooplancton carnivore, le mésozooplancton [excluant les copépodes] et les larves de krill) et d'autres à la normale ou inférieure à la normale (les larges copépodes, *C. finmarchicus* CIV–CV, le meroplancton). En 2008, 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» : *Eurytemora* spp. et *C. glacialis* le long de la section TESL; *Temora* spp. et les oeufs de copepode dans le nord-ouest du GSL (TSI); les œufs de copépodes dans le sud-ouest de l'île d'Anticosti (TASO); *P. norvegica* et *C. glacialis* dans le centre du GSL (TCEN); *C. glacialis* dans le nord-est et le sud du GSL (TBB, TIDM); et Ostracoda dans le détroit de Cabot (TDC).

La biomasse de mésozooplancton observée en novembre 2008 dans l'estuaire maritime et le nord-ouest du GSL était 1.8 et 1.4 fois plus élevée qu'en 2006 et 2007 et correspond à la seconde valeur la plus élevée observée au cours des 15 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 en 2006, à 8.6 en 2007 et 6.2 en 2008. Les valeurs observées en 2006, 2007 et 2008 correspondent aux plus faibles valeurs observées au cours des 15

dernières années dans les deux régions. Un fait marquant des années 2006, 2007 et 2008 est la forte diminution de l'abondance de l'espèce *Thysanoessa raschii* qui était 5.3 fois moins abondante en 2006–2008 qu'au cours des 15 années précédentes. Finalement, les années 2006, 2007 et 2008 correspondent aux plus faibles abondances moyennes de l'amphipode pélagique *Themisto libellula* des 15 dernières années excepté en 2000.

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. In addition, 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 2008 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 2008.

SPATIAL AND TEMPORAL VARIABILITY OF ZOOPLANKTON SPECIES COMPOSITION, ABUNDANCE, AND BIOMASS AT FOUR FIXED STATIONS AND SEVEN SECTIONS OF THE QUÉBEC REGION IN 2008

MATERIALS AND METHODS

The location and the sampling dates of the four fixed stations (Anticosti Gyre, Rimouski, Gaspé Current, and Shediac Valley) and seven sections (St. Lawrence Estuary, Sept-Îles, Southwest Anticosti, Centre Gulf of St. Lawrence, Cabot Strait, Bonne Bay, Îles-de-la-Madeleine) are given in Figure 1 and Table 1. In 2008, zooplankton samples were collected on 14 occasions at the Anticosti Gyre and Gaspé Current fixed stations, on 27 occasions at the Rimouski fixed station, on eight occasions at the Shediac Valley fixed station, and during two surveys (14 June – 01 July; 24 October – 17 November) for the sections. The collection 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 2008 and developed different indices for the fixed stations and the sections. At the fixed stations, the indices are the depth-integrated 1) zooplankton biomass, 2) abundance of zooplankton other than copepods, 3) abundance of copepods and their community structure, 4) total abundance of *Calanus finmarchicus* as well as those of its developmental stages, and 5) total abundance of *Pseudocalanus* spp. Concerning the sections, the new indices are the depth-integrated 1) *Calanus hyperboreus* biomass, 2) mesozooplankton biomass (excluding *C. hyperboreus*), 3) copepod abundance, 4) copepod nauplius abundance, 5) small copepod abundance (smaller than *Metridia* spp.), 6) large copepod abundance (*Metridia* spp. + *Calanus* spp. + *Paraeuchaeta norvegica*), 7) *C. finmarchicus* CIV–CV abundance, 8) meroplankton abundance (bivalve, echinoderm, polychaete, cirripedia, and decapod larvae), 9) carnivorous zooplankton abundance including only the different chaetognath species, small cnidarian species (*Aglantha digital* and *Dimophyes arctica*), and the small hyperiid amphipod *Themisto abyssorum*, 10) mesoplankton abundance (excluding copepods), and 11) krill larva abundance (furcilia and calyptopis).

Time-series anomalies of the different zooplankton indices estimated at the fixed stations and along the sections were constructed by removing the annual cycle computed over the standard period (fixed stations: 1999–2007; sections: 2000–2007). It should be noted that monthly and annual anomaly estimates are often based on varying numbers 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 1999–2007 if data are available. For example, a value of two indicates that the index was two standard deviations higher than the long-term average. Zooplankton biomass and abundance anomalies from the fixed stations and standard sections in Québec Region during 2008 are presented as normalized anomalies in 0.5 standard deviation units; these normalized anomalies are colour-coded, with blue, white, and red representing negative, normal, and positive zooplankton conditions, respectively.

RESULTS AND DISCUSSION

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 nine previous years at the Anticosti Gyre (AG), Gaspé Current (GC), and Shediac Valley (SV) stations (1999–2007) and the three previous years at the Rimouski station (RS; 2005–2007) (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 and early summer (April, May, June), for which the zooplankton biomass was lower than the long-term average (Fig. 2), and AG during the summer and the fall seasons, for which the zooplankton biomass was slightly lower than the long-term average. At RS, the zooplankton biomass was higher than the three previous years during the spring (April, May) and slightly lower in July.

The total abundance of zooplankton other than copepods (hereafter referred to as "non-copepod abundance") in 2008 varied between 4,911 and 69,303 ind/m^2 at AG, 409 and 12,328 ind/m^2 at RS, 761 and 147,152 ind/m^2 at GC, and 910 and 172,384 ind/m^2 at SV (Fig. 3). Non-copepod abundances observed during the different months at the four fixed stations were comparable to those observed previously (1999–2007) at the same period of the year. The exceptions in this case were in October and November at AG, November at RS, May, August, and November at GC, and September at SV, when there were peaks of abundance between three and five times higher than normal at the four stations (Fig. 3). In addition, non-copepod abundance was lower than normal in November and December at SV.

As was the case with non-copepod abundance, the total annual integrated copepod abundance at the four fixed stations in 2008 was comparable to levels observed during the previous years (Fig. 4). 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, higher than normal abundances occurred in September and November at AG, GC, and SV, with the peak values at AG and GC being the highest total copepod abundances of the whole time series. There was no apparent change in the copepod community structure in 2008 at AG, RS, GC, or SV (Fig. 5). The copepod community at AG, GC, and SV was dominated numerically by the small species *Oithona* spp. and other copepods (>50% for much of the year and higher than normal in the fall), and the relative importance of the larger species (*Calanus* spp.) was similar to previous years. In contrast, the copepod community at RS was dominated by the larger calanoid species, *C. finmarchicus* and *C. hyperboreus,* while the relative importance of *Metridia* spp. in 2008 (4.5% of the total copepod abundance) was four and two times lower than in 2005 and 2006–2007 respectively.

The average abundance of *C. finmarchicus* in 2008 was estimated at 21,218 ind/m^2 at AG, 22,455 ind/m^2 at GC, 17,073 ind/m^2 at RS, and 26,953 ind/m^2 at SV. These levels are lower than the record peak abundances observed in 2003 at the three stations (AG, GC, SV), slightly higher than levels observed during the nine previous years (1999–2007) at AG and GC (19,818 and 19,078 ind/m^2, respectively, excluding 2003), and lower at SV (30,153 ind/m^2, excluding 2003) (Fig. 6). The average abundance of *C. finmarchicus* at RS in 2008 was 1.6 times lower than in 2007 (26,904 ind/m^2) and 1.6 times higher than in 2005–2006 (10,355 ind/m^2). In addition, the abundance of *C. finmarchicus* at the four fixed stations followed the same seasonal pattern as the previous years except that total abundance was higher than the long-term average in August (RS), September (GC), and November (SV) (Fig. 6). Finally, based on the relative abundance of the various developmental stages of *C. finmarchicus* in 2008, there were two reproductive periods, in spring and fall, at AG, GC, and SV (as indicated by the presence of stages I–III) and one reproductive period in early summer at RS (Fig. 7). This different pattern of *C. finmarchicus* reproduction in different regions of the Gulf of St. Lawrence was frequently observed over the last nine years (1999–2007).

The average abundance of *Pseudocalanus* spp. in 2008 was estimated at 8,701 ind/m^2 at AG, 21,070 ind/m^2 at GC, 1,406 ind/m^2 at RS, and 18,842 ind/m^2 at SV. These levels are higher than levels observed between 1999 and 2007 in AG and GC (4,255 and 6,790, respectively), similar to 2005–2007 values at RS (1,526 ind/m^2), and lower than the 1999–2007 value at SV (22,862 ind/m^2) (Fig. 8). In addition, the abundance of *Pseudocalanus* spp. at the four fixed stations followed the same seasonal pattern as during the previous years (1999–2007 at AG, GC, and SV; 2005–2007 at RS), except that total abundance was higher than the long-term average in February, June, October, and November at AG and in September in GC (Fig. 8).

The abundance and percentage of the ten top most abundant taxa at AG, GC, RS, and SV are shown in Tables 2, 3, 4, and 5. In 2008, 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 the nearshore species *Temora* spp., which made up 17%, 12%, and 36% of the total zooplankton abundance at AG, GC, and SV, respectively, in 2008; this species largely accounts for the high abundance of “other copepods” that is seen in Figure 5. In addition, the dominant species at all stations was the small copepod *Oithona* spp. except at RS, which has been dominated by the larger calanoid species *C. finmarchicus* for the last four years (2005–2008), and at SV, which was dominated by *Temora* spp. for the first time.

In summary, the state of the zooplankton at the four Québec fixed stations in 2008 was estimated as lower than normal (zooplankton biomass) and above normal (total non-copepod abundance, total copepod abundance, *C. finmarchicus* abundance, *Pseudocalanus* spp. abundance) at AG and GC; lower than normal (zooplankton biomass), normal (total non-copepod abundance, total copepod abundance, *Pseudocalanus* spp. abundance), and above normal (*C. finmarchicus* abundance) at RS; and normal (zooplankton biomass, *C. finmarchicus* abundance, *Pseudocalanus* spp. abundance) and above normal (total non-copepod abundance, total copepod abundance) at SV (Fig. 9). In addition, some changes in the zooplankton community structure were observed over the time series, including some changes in the rank of the top ten taxa and the appearance of new taxa in the dominant species (top ten): *Temora* spp. and appendicularians at AG, *Temora* spp., cladocera, and bivalve larvae at GC, *P. norvegica* and *Calanus glacialis* at SV, and polychaete larvae at RS. While these newly appearing species may not have been abundant for the whole year (e.g., *Temora* spp. was very abundant only in October and November at AG, GC, and SV), they may nevertheless represent important predators or sources of food during certain periods.

Sections. The spatio-temporal variations of the 11 new zooplankton biomass and abundance indices along the sections in the St. Lawrence Marine System (SLMS) are presented in Figures 10a to 10g and 11.

In the Lower St. Lawrence Estuary (TESL section), there was a large increase in the *C. hyperboreus* biomass in 2008 and a strong decrease in the mesozooplankton biomass (excluding *C. hyperboreus*). However, there was no marked change between June and November in terms of biomass in either group; this has been the case for most of the earlier years (Fig. 10a). Concerning the total abundance of copepods, there were twice as many individuals during the fall (143,395 ind/m^2) compared to the spring (61,957 ind/m^2)—as has been seen in the past—but the overall long-term increasing tendency observed since the first sampled year (2000) continues. This seasonal and interannual pattern of variation in total copepod abundance is largely due to the total abundance of small copepods (total and small copepod abundances are highly correlated; $R^2 = 0.97$, $p<0.001$), confirming that this group largely dominated the whole copepod assemblage in abundance. There were 3,151 and 1,834 copepod nauplii/m^2 in June and November 2008, respectively; these levels are lower than the record peak abundances observed in June 2003 and 2007 (34,789 and 47,918 ind/m^2, respectively) but are slightly higher than levels observed during other years (mean = 1,174 [June] and 1,198 [Nov.] ind/m^2).

Data from June 2008 on the total abundance of large copepods continue the long-term increasing tendency, from 12,031 to 45,441 ind/m^2, observed since the first sampled year (2001) ($R^2 = 0.75$, $p = 0.01$; June 2001–2008) (Fig. 10a). This has not been the case in November, when we observed no tendency in the interannual variation. However, prior to 2007, large copepods were more numerous in November (mean = 28,948 ind/m^2) than in June (mean = 17,458 ind/m^2) while the reverse is observed after 2007 (June mean 2007–2008 = 39,557 ind/m^2; November mean 2007–2008 = 33,603 ind/m^2) (Fig. 10a). This reversing tendency is increasingly apparent in the more easterly sections of the NWGSL (TSI and TASO sections; see below).

There were twice as many *C. finmarchicus* CIV–CV in November (9,009 ind/m^2) than in June (4,431 ind/m^2). Compared to previous years, this index was *ca.* 1.6 times higher in June (mean = 2,683 ind/m^2) and 1.6 times lower in November (mean = 13,757 ind/m^2). For the last four indices—meroplankton, carnivorous zooplankton, mesozooplankton other than copepods, and krill larvae—their total abundances were usually higher in June than in November; this is the opposite of what was observed for the biomass and abundance of copepods, which were usually higher in November than in June. There is no notable tendency in interannual change for any of these last four indices, all of which showed relatively low abundances in June and November 2000–2008 along the TESL section except in June 2007, when there were record abundances of mesozooplankton and krill larvae (40,364 and 413,298 ind/m^2, respectively) (Fig. 10a).

Contrary to the observations made along the TESL section in June and November 2008, there was no increase in the *C. hyperboreus* biomass in the Northwest Gulf of St. Lawrence (TSI section) or on the southwest side of Anticosti Island (TASO section); we rather observed a strong decrease in the mesozooplankton biomass (Fig. 10b and 10c). Concerning the total copepod abundance, there were 2.6 and 3.0 times more individuals during the fall (291,795 and 329,583 ind/m^2) than in spring (110,658 and 110,874 ind/m^2) along the TSI and the TASO sections, respectively. As in the TESL section, we note a continuation of the overall long-term increasing tendency in total copepod abundance since 2000, the seasonal and interannual pattern of variation of which is reflected by the total abundance of small copepods ($R^2 = 0.96$ [TSI] and 0.93 [TASO], $p<0.001$); this again confirms that this group largely dominates the whole copepod assemblage in abundance. The record peak abundance of total copepods observed in June 2006 was related to both a higher abundance of the small copepod *Oithona similis* as well as *C. finmarchicus* CI–CIII copepodites in both areas. Concerning the copepod nauplius index, there were respectively 18,890 and 5,329 ind/m^2 in June and November 2008 along TSI and 33,367 and 13,028 ind/m^2 along TASO, again continuing the long-term increasing tendency observed in June since 2001 along TSI ($R^2 = 0.81$, $p = 0.002$; June 2001–2008) and since 2000 along TASO ($R^2 = 0.61$, $p = 0.01$; June 2000–2008).

The total abundance of large copepods along both these sections in 2008 was slightly higher (36,819 [TSI] and 39,038 [TASO] ind/m^2) than during the previous June samplings except for 2006 and 2007 (mean = 26,395 [TSI] and 21,958 [TASO] ind/m^2 excluding June 2006 and 2007). This suggests an overall continuation of the long-term increasing tendency in total large copepod abundance during the spring since 2000 that is similar to the copepod nauplius index

(Fig. 10b and 10c). As noted for the TESL transect, we observed no particular interannual variation in November except that large copepods were more numerous in November prior to 2006 (mean = 45,130 [TSI] and 47,036 [TASO] ind/m^2) than in June (mean = 26,395 [TSI] and 21,958 [TASO] ind/m^2) while the reverse has been observed since 2006 (June mean 2006–2008 = 59,420 [TSI] and 92,084 [TASO] ind/m^2; November mean 2006–2008 = 43,886 [TSI] and 49,288 [TASO] ind/m^2) (Fig. 10b and 10c). Concerning the total abundance of *C. finmarchicus* CIV–CV, there were respectively 4.8 and 2.8 as many individuals in November (13,035 [TSI] and 13,017 [TASO] ind/m^2) as in June 2008 (2,731 [TSI] and 4,562 [TASO] ind/m^2) along these transects. Compared to previous years, the total abundance of *C. finmarchicus* CIV–CV in both areas was similar in June (mean = 2,584 [TSI] and 4,465 [TASO] ind/m^2) and 1.7 times lower in November (mean = 23,041 [TSI] and 23,119 [TASO] ind/m^2).

There has been a slight increase in the total abundance of meroplankton sampled in June and November since 2006 at the TSI and TASO transects, including a record peak abundance of echinoderm larvae (11,894 [TSI] and 28,321 [TASO] ind/m^2) in June 2006 (Fig. 10b and 10c). The total abundance carnivorous zooplankton is higher in June than in November, as was the case along the TESL section, except that there were 3.1 times more individuals at the TSI and TASO sections (June and November 2000–2008 mean = 2,493 [TSI] and 2,480 [TASO] ind/m^2) than at the TESL section (June and November 2000–2008 mean = 811 ind/m^2) (Fig. 10b and 10c). Concerning the index of mesozooplankton other than copepods in 2008, there were 1.9 and 5.0 times more individuals during the fall (21,514 and 66,412 ind/m^2) than in spring (11,083 and 13,107 ind/m^2) along the TSI and the TASO sections, respectively. Contrary to the TESL section, we observed a continuation of the overall long-term increasing tendency for this index in June since 2000 along TSI ($R^2 = 0.79$, $p = 0.008$; June 2000–2005, 2008) and TASO ($R^2 = 0.86$, $p = 0.002$; June 2000–2005, 2008). In 2006 and 2007, there were two record peak abundances of Appendicularia and Ostracoda (Fig. 10b and 10c). Finally, the krill larva index at these two sections showed no seasonal or interannual patterns that were similar to the TESL section except for record peak abundances in June 2006 along TASO (379,775 ind/m^2) and June 2007 along both transects (90,770 [TSI] and 357,952 [TASO] ind/m^2) (Fig. 10b and 10c).

We have only six years of data (2003–2008) for the Centre Gulf of St. Lawrence section (TCEN). None of the zooplankton biomass or abundance indices shows any seasonal or interannual pattern of variation except for the *C. finmarchicus* CIV–CV, carnivorous zooplankton, and mesozooplankton (excluding copepods) indices, which show lower (*C. finmarchicus* CIV–CV) or higher (carnivorous, mesozooplankton) abundances in June than in November (Fig. 10d). Compared to observations at the TESL, TSI, and TASO sections, TCEN has a higher biomass of *C. hyperboreus* and higher abundances of large copepods, *C. finmarchicus* CIV–CV, and carnivorous zooplankton in June 2004–2008 and November 2003–2008. The TCEN section cuts across the Laurentian Channel, as do the TESL, TSI, and TASO sections; because of this, one might expect these four sections to show similarities because of water circulation patterns. However, TCEN shows a very different pattern of interannual variation in the examined zooplankton indices compared to the more westerly stations. This suggests that zooplankton biomass and abundance along TCEN are also influenced by other circulation patterns, probably originating from Atlantic waters entering the Gulf through Belle Isle and Cabot straits.

In the northeast GSL region (TBB section), there were slight decreases in both biomass indices (*C. hyperboreus* and mesozooplankton excluding *C. hyperboreus*) in spring and fall between June 2002 and November 2008 (Fig. 10e). Moreover, contrary to what was observed along the TESL, TSI, TASO, and TCEN sections, both biomass indices were slightly higher in June than in November since sampling began in 2000 (except for mesozooplankton biomass in 2002).

Concerning the total abundance of copepods, there were between 1.5 and 4.5 times more individuals during the fall than in spring except in 2006 and 2008, when there were 1.5 and 2.0 times more individuals in June than in November, respectively (Fig. 10e). The June 2008 data suggest the continuation of the long-term increasing tendency in total copepod abundance that has been observed since 2000. However, once again (as noted for TESL, TSI, and TASO) this increasing tendency was not observed in November and the seasonal and interannual patterns are reflected by the total abundance of small copepods (R^2 = 0.97, $p < 0.001$), confirming that this group largely dominated the whole copepod assemblage in abundance. There were 21,078 and 732 copepod nauplii /m^2 in June and November 2008, respectively. This continues the long-term increasing tendency observed in June since 2000 (excluding 2005 and 2006) (Fig. 10e) that is significantly reflected by the large copepod abundance index (R^2 = 0.66, p = 0.008). This suggests that the copepod nauplii sampled in June in the northeast GSL originated principally from different large copepod species. Concerning the total abundance of *C. finmarchicus* CIV–CV, the long-term tendency indicated a slightly increasing tendency in June and a decreasing tendency in November, except in 2000 (R^2 = 0.62, p = 0.02; R^2 = 0.88, $p < 0.001$; June and November 2001–2008, respectively) (Fig. 10e). Several physical and biological factors could explain this inverted long-term tendency in *C. finmarchicus* CIV–CV abundance in June and November, in particular the circulation pattern and some biological aspects such as the appearance of new individuals and their survival success. For the last four indexes—meroplankton, carnivorous zooplankton, mesozooplankton other than copepods, and krill larvae—there are no notable interannual tendencies. All four showed relatively low abundances over the sampling period and there were no peaks in abundance as we observed in TESL, TSI, and TASO (Fig. 10e).

The southern GSL (TIDM section), which is the shallowest area of the GSL, has consistently had a very low biomass of *C. hyperboreus* during the fall, a trend that has continued in November 2008 (mean = 2 g/m^2 ww) (Fig. 10f). This low biomass is probably because this species may not be in diapause during fall and winter in this area. During spring (June), the *C. hyperboreus* biomass index is higher (mean = 28.7 g/m^2 ww) than in fall but still half the value observed along the sections described above (TESL, TSI, TASO, and TCEN; mean = 50.7 g/m^2 ww). Some individuals were probably introduced into the southern GSL via the Gaspé Current, which is stronger in the springtime because of increased freshwater runoff from the St. Lawrence River. Similarly, the mesozooplankton (excluding *C. hyperboreus*) biomass index (mean = 16.4 g/m^2 ww; 2000–2008) is globally lower than the average calculated for the TESL, TSI, TASO, and TCEN sections (mean = 33.5 g/m^2 ww) during spring and fall, and there was no marked change between June and November except in 2006, 2007, and 2008, when it was 2.3 times higher in June (mean = 27.4 g/m^2 ww) than in November (mean = 12.4 g/m^2 ww) (Fig. 10f).

The data obtained in June for the total abundance of copepods indicate a continuation of the long-term increasing tendency: numbers have risen from 50,000 to 300,000 ind/m^2 since the second sampled year (2001) (R^2 = 0.78, $p < 0.001$; June 2001–2008) (Fig. 10f). As pointed out for all sections heretofore discussed, the seasonal and interannual patterns of total copepod abundance along the TIDM section are strongly correlated with the total abundance of small copepods (R^2 = 0.97, $p < 0.001$), confirming again that this group largely dominated the whole copepod assemblage in abundance. There were 3,322 and 1,691 copepod nauplii/m^2 in June and November 2008, respectively; these levels are lower than the peak abundances observed in June 2002 and 2004 (23,015 and 29,784 ind/m^2, respectively) but are at the same levels as those observed during other years (mean = 3,621 [June] and 1,708 [Nov.] ind/m^2). These very low abundances of copepod nauplii during spring and fall, with some peak abundances during the spring, were also observed in the Lower St. Lawrence Estuary (TESL) (Fig. 10a) and in the Gulf's centre (TCEN) (Fig. 10d). Contrary to our observations for the TESL, TSI, TASO, and TCEN sections during the springtime, we saw no long-term increasing tendency in the total abundance of large copepods, except that we have seen a higher abundance for the last three years including June 2008, which had the highest total abundance of large copepods of the time series (80,204 ind/m^2). We noted a long-term decreasing tendency in the November samples except in 2000 (R^2 = 0.90, p < 0.001 for 2001–2008; from 29,929 to 11,125 ind/m^2); once again, this trend is dissimilar to what we noted for TESL, TSI, TASO, TBB, and TCEN.

The total abundance of *C. finmarchicus* CIV–CV shows the same interseasonal and interannual pattern of variation as the total abundance of large copepods: no long-term increasing tendency except for a higher abundance in June for the last three years and a decreasing tendency in November except in 2000 (R^2 = 0.88, p < 0.001, 2001–2008; from 21,952 to 6,788 ind/m^2) (Fig. 10f). There has been a slight increase in the total abundance of meroplankton sampled in June since 2001 (R^2 = 0.73, p = 0.007), including a record abundance (9,667 ind/m^2) in June 2008 that was largely composed of bivalve larvae. The total abundance of carnivorous zooplankton showed relatively low abundances over the sampling period in June and November except for a slight increase during the spring since 2006. The index of mesozooplankton other than copepods in June and November 2008 was within the average range compared to the overall time series excluding the peak abundances in June 2005 and November 2007 (Fig. 10f). Finally, the krill larva index along this section showed numerous springtime peaks compared with the TESL, TSI, TASO, TCEN, and TBB sections. The upper part of the LSLE is known to have a very high abundance of adult krill, thus the peak krill larva abundances observed in the southern GSL were probably introduced via the Gaspé Current, which flows strongly during the spring because of high freshwater runoff.

Unlike the other six sections, none of the zooplankton biomass or abundance indices shows any seasonal or interannual pattern of variation in Cabot Strait (TDC) except for the copepod nauplii, *C. finmarchicus* CIV–CV, carnivorous zooplankton, and krill larva indices, which show lower (*C. finmarchicus* CIV–CV) or higher (nauplii, carnivorous zooplankton, krill) abundances in June than in November (Fig. 10g). The overall absence of an interannual pattern in the biomass and abundance indices here is probably related to the fact that there is both an inflow (north side) and an outflow (south side) in the strait. We again found that the total copepod abundance here is mainly influenced by the total abundance of small copepods (R^2 = 0.98; p < 0.001).

Figure 11 shows the mean (±95%) zooplankton biomass (ww g/m^2) and abundance (ind/m^2) along the six AZMP sections (TESL, TSI, TASO, TBB, TIDM, TDC) sampled in June and November 2000–2008 and along the TCEN section in November 2003–2008 and June 2004–2008. The two biomass indices (*C. hyperboreus*; mesozooplankton excluding *C. hyperboreus*) show a gradual increase from the upper part of the LSLE (TESL) toward the northwest GSL (TASO and TCEN) during both spring and fall. Both these indices were lower in the northeast and southern GSL (TBB and TIDM) in both seasons and intermediate (*C. hyperboreus*) and high (mesozooplankton) in Cabot Strait (TDC). In terms of seasonal variability, there was no notable difference in either biomass index between spring and fall along any section except for *C. hyperboreus* biomass in the southern GSL (TIDM), which was 12 times higher in June (28.7 ww g/m^2) than in November (2.3 ww g/m^2). Both the total copepod and the small copepod abundances, which are highly correlated (R^2 = 0.96, p < 0.001), also show a gradual increase from the TESL section to the TASO section during both spring and fall, no increase in the central and the northeastern GSL regions (TCEN and TBB), and a continuation of the gradual increase in the southern GSL and Cabot Strait (TIDM and TDC) (Fig. 11). In all cases, the mean numbers of total copepods and small copepods were higher during the fall than the spring along all sections. On the contrary, the mean interannual abundance (2000–2008) of copepod nauplii indicates that there were more nauplii produced during spring in the LSLE (TESL) and the NWGSL (TSI, TASO) and a gradual decrease toward the northeast and southern GSL (TBB, TIDM) and Cabot Strait (TDC) (this pattern does not hold completely for the TCEN section, but this might be due to the shorter time series of data available). There are much fewer copepod nauplii in all regions in the fall with a slight increase in the LSLE, TSI, and TASO. The large copepod index is highly correlated with the biomass of both *C. hyperboreus* and mesozooplankton during the spring and fall (R^2 = 0.72, $p < 0.001$ [*C. hyper.*]; R^2 = 0.76, $p < 0.001$ [meso]), while *C. finmarchicus* CIV–CV abundance is highly correlated with mesozooplankton biomass (R^2 = 0.93, $p < 0.001$) only during the fall. In both cases, we see the same interregional pattern of variation as described above for the biomass indices.

Concerning the number of *C. finmarchicus* CIV–CV, there were fewer individuals during spring—as expected—but with slightly higher abundances in the Gulf sections compared to those sections nearer the estuary (TESL, TSI, TASO) (Fig. 11). There was no difference between the spring and fall for the meroplankton index along any transect except for TSI and TASO, where there were peaks of echinoderm larvae during spring 2007. If we exclude these peaks, there was a gradual increase in meroplankton abundance during spring and fall from the LSLE to Cabot Strait, including the northeast and southern GSL (TBB, TIDM). The total abundance of carnivorous zooplankton was higher during spring than fall along all sections. Moreover, during spring we note a gradual increase from the upper part of the LSLE (TESL) toward the northwest and central GSL (TASO and TCEN), the lowest abundances in the northeast and southern GSL (TBB and TIDM), and an intermediate value in Cabot Strait (TDC); the same pattern was also observed during fall but at lower values.

There were relatively more mesoplankton during spring than fall (except at TBB), and there were more individuals in the northwestern and central Gulf (TESL, TSI, TASO, TCEN) and Cabot Strait (TDC) than in the northeast and southern GSL (TBB, TIDM) during spring and fall (except TESL in fall). The krill larva index showed several peaks during the springtime along the TESL, TASO, TIDM, and TDC sections; this suggests that krill were introduced into the southern GSL via the strong springtime Gaspé Current.

Finally, we ranked the ten most abundant taxa in each area according to their annual mean proportion of the total zooplankton (Tables 6 to 12). In 2008, we observed some changes in over the time series. In addition, the small copepods *Oithona* spp. were between 1.4 and 1.8 times more abundant in 2008 compared to the long-term average (2000–2007) along all sections. Likewise, both the large arctic copepod *C. hyperboreus* and the small copepod *Microcalanus* sp. were *ca.* 1.8 times more abundant in 2008 compared to the long-term average in the LSLE (TESL) and northwest GSL (TSI, TASO). This was also observed for the nearshore species *Temora* spp., which was 11.2 and 6.2 times more abundant in 2008 compared to 2000–2007 in the northwest GSL (TSI, TASO). In addition, *Pseudocalanus* spp. and *C. finmarchicus* occupied higher positions in the rank order in the northeast and southern GSL (TBB, TIDM), being between 1.4 and 2.2 times more abundant in 2008 compared to the 2000–2007 average. Finally, the cold-water species *C. glacialis* appeared in the dominant species for the first time in 2008 in the central, northeast, and southern GSL (TCEN, TBB, TIDM).

In summary, the biomass indices of *C. hyperboreus* and the mesozooplankton along the seven Québec sections in spring and fall 2008 were estimated to be normal or below normal except in the LSLE (TESL), where the *C. hyperboreus* biomass was evaluated as above normal (Fig. 12). For the nine zooplankton abundance indices examined along sections in the St. Lawrence Marine System (Fig. 13), most were evaluated as normal or above normal in spring 2008 except that below normal abundances were found for copepod nauplii along the TESL and TIDM sections, for mesozooplankton (excluding copepods) in the centre and the northeast GSL (TCEN, TBB), and for krill larvae in Cabot Strait (TDC). The situation was very different for the fall period: some of the abundance indices were still evaluated as normal or above normal (total copepods, copepod nauplii, small copepods, carnivorous zooplankton, mesozooplankton excluding copepods, krill larvae) and some others as normal or below normal (large copepods, *C. finmarchicus* CIV–CV, meroplankton) (Fig. 13). 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: *Eurytemora* spp. and *C. glacialis* in the LSLE (TESL); *Temora* spp. and copepod eggs in the northwest GSL (TSI); copepod eggs southwest of Anticosti Island (TASO); *P. norvegica* and *C. glacialis* in the centre GSL (TCEN); *C. glacialis* in the northeast and southern GSL (TBB, TIDM); and Ostracoda in Cabot Strait (TDC).

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 2008

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. 14). 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 in 2004–2005 and 27 October–4 November in 2006–2008; 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. A new sampling protocol was tested in 2007. This new protocol includes the use of a stroboscope (Novatech, ST 400A Xenon Flasher; 55 LUX) fixed in the mouth of the BIONESS. This setup was found by others (Sameoto et al. 1980; Wiebe et al. 2004) to improve euphausiid catches by *ca.* 10 times. In 2007, all stations were sampled twice, once with the strobe on and once with the strobe off (the order of which—strobe on first or off first—was determined randomly). We sampled the entire grid using the strobe in 2008.

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 are 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*, *T. abyssorum*, *T. compressa*), and chaetognaths (*Parasagitta 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 fixed in the mouth of the BIONESS. The data obtained in 2007 (strobe on and off) and 2008 (strobe on) are presented as part of the whole time series, which started in 1994. A correction factor was estimated using the 2007 data, and this factor was used to correct the 2008 data so that interannual comparisons on the whole time series (1994–2008) were possible.

RESULTS

There was no marked change in the mean mesozooplankton biomass sampled with the strobe on or off in 2007, and the mean mesozooplankton biomass observed in November 2008 in the LSLE and in the NWGSL was 1.8 and 1.4 times higher than in 2006 and 2007, respectively. This corresponds to the second highest value observed in the last 15 years in the study area (Fig. 15). On the contrary, the mean macrozooplankton biomass obtained with the strobe on in 2007 (29.2 ww g/m^2) was 3.4 times higher than the biomass obtained with the strobe off (8.6 ww g/m^2). There was a large decrease in the macrozooplankton biomass in 2008 compared to 2007 with the strobe on (29.2 ww g/m^2 in 2007 to 21.2 ww g/m^2 in 2008). If we apply the correction factor (3.4x) to the data, the macrozooplankton biomass decreased from 15.4 in 2005 to 5.9 (2006), 8.6 (2007), and 6.2 ww g/m^2 (2008). The macrozooplankton biomass values observed in 2006, 2007, and 2008 correspond to the lowest values observed over the last 15 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 use of the strobe on and off in 2007 resulted in a strong increase in the relative biomass of euphausiids, from 60 to 87% of the whole macrozooplankton biomass. As mentioned earlier for abundance, there was a high decrease in the relative biomass of euphausiids from 2007 (87%) to 2008 (70%). The relative mysid biomass increased from 3% in 1994 to 27% in 2000, decreased to ~16% between 2001 and 2005, and increased again to ~30% in 2006, 2007, and 2008 (after application of the correction factor); these values are the highest observed in the LSLE and the NWGSL since the start of the survey.

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; slightly increased to 8% in 2007, and decrease again to 4% in 2008. 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, 2007, and 2008 (Fig. 15).

Figure 16 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 was estimated to be only 15 and 10 ind/m^2, respectively, making these the lowest values observed over the last 15 years in the study area. The use of the strobe off and on in 2007 resulted in a strong increase in the mean abundance of *T. raschii*, from 10 to 42 ind/m^2 (correction factor = 4.2). In 2008, there was a marked increase (65 ind/m^2) in comparison with strobe-on data from 2007 (42 ind/m^2). If we apply the 2007 correction factor to the 2008 data, we obtain 15.5 ind/m^2, which is similar to the lowest values observed over the last 15 years in 2006 and 2007 (no strobe). 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, it 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. We observed a striking increase in the mean abundance of *M. norvegica* with the strobe trial in 2007, from 10 (strobe off) to 53 (strobe on) ind/m^2 (correction factor = 5.3). In 2008 (during which the strobe was used), the mean abundance decreased strongly from 53 ind/m^2 in 2007 to 27 ind/m^2. If we apply the correction factor from 2007 to the 2008 data, we obtain 5.1 ind/m^2, which is similar to the low values observed in 1996, 1998, 2000, and 2004. Another interesting point concerns the small euphausiid species *T. inermis,* which showed a strong increase in abundance from *ca.* 1 ind/m^2 in 1994–2004 to *ca.* 5 ind/m^2 in 2005–2007. Here again, the use of the strobe on the BIONESS increased catches: 4.9 times more individuals (37.4 ind/m^2) were captured with the strobe on. There was a slight decrease in abundance in 2008, with a mean of 5.9 ind/m^2 after application of the correction factor (4.9); this gives the highest abundance observed since 2005.

Contrary to what was observed for euphausiids, comparisons with the strobe on and off in 2007 showed no notable change in abundance and biomass for all other macrozooplankton groups (hyperiid amphipods, mysids, chaetognaths, and jellyfish) except for a small increase in the catch rate of the large hyperiid amphipod *T. libellula* with the strobe on (Fig. 16).

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, largely increased to 11.8 ind/m^2 in 2007, and decreased again to 4 ind/m^2 in 2008 (Fig. 16). 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 15 years. The use of the strobe in 2007 resulted in a slight increase of the mean abundance of *T. libellula*, from 1.4 to 2.8 ind/m^2 (correction factor = 2.0); no change was observed in 2008 (2.5 ind/m^2). If we apply the 2007 correction factor to the 2008 data, we obtain 1.3 ind/m^2, which is the third lowest value observed over the last 15 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. 17). However, even though there were strong intrusions of Labrador Shelf water into the GSL during the winters of 2006, 2007, and 2008, there appears to have been little or no influx of *T. libellula* during these three years. When we include the data from these last three years, the strength of the relationship declines, with only 33% of the variation being explained by this relationship ($R^2 = 0.33$).

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 while it decreased in 2002 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 and 104.6 ind/m^2 in 2007 and 2008, respectively, making these the highest values observed over the last 15 years in the study area (Fig. 16). Likewise, the mean abundance of chaetognaths (*P. 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, decreased again to 29, 23, and 29 ind/m^2 in 2005, 2006, and 2007, respectively, and strongly increased to 66 ind/m^2 in 2008 (Fig. 16). Finally, the mean abundance of gelatinous zooplankton (mostly the cnidarian *Aglantha digitale*) followed the same pattern of temporal variations as the chaetognaths over the whole time series, including the dramatic increase from 23 to 148 ind/m^2 from 2003 to 2004 and the decrease observed in 2005. The exception occurred in 2006, 2007, and 2008, when there was an increase in *A. digitale* abundance compared with 2005, no change in chaetognath abundance (2006, 2007), and a decrease in *A. digitale* in 2008 compared with a marked increase in chaetognath abundance.

The same temporal pattern of variation was observed for the biomass of all macrozooplankton groups (euphausiids, hyperiid amphipods, mysids, chaetognaths, and jellyfish) except for the euphausiid species *T. raschii,* which sometimes showed an increase in abundance and a decrease in biomass during the same year (1995, 1998, 2008). This is probably related to the arrival of a high number of smaller juvenile *T. raschii* during the fall of some years.

The spatial distribution patterns of each macrozooplankton species sampled with the strobe on in 2007 and 2008 are presented in Figures 18a and b. In 2007, the higher numbers (≥25 ind/m^2) of the larger euphausiid species *M. norvegica* were mostly sampled in the centre and/or on the northern sides of transects G, I, K, M, O, R, and T in the LSLE and the NWGSL and on the southern side of transect U. Fewer *M. norvegica* were sampled in 2008, but the stations with more than 25 ind/m^2 showed the same distribution pattern as in 2007.

There were only two stations with more than 25 *T. raschii*/m^2 along transects R, T, and U (NWGSL) in 2007 while several hundred individuals were sampled on the northern side of transects O, M, K, and I (LSLE). Abundances were much higher in 2008 in the NWGSL, with comparatively high concentrations on the southern side (principally along transect T). This will likely lead to part of the population being exported toward the southern GSL and Cabot Strait via the Gaspé Current. Nevertheless, most of the individuals were concentrated on the northern side of the LSLE. It is likely that most of these individuals will be transported toward the upper part of the LSLE, an area that is known to be rich in krill and whales (Simard and Lavoie 1999; Descroix et al. 2005). Concerning the third euphausiid species (*T. inermis*), which has shown a strong increase in abundance since 2005 (see above), this species showed a pattern of distribution in 2007 and 2008 that was similar to the other small euphausiid species *T. raschii* (Fig. 18a).

The mysid *Boreomysis arctica,* which lives mainly in deep water (> 200 m) and makes no diel vertical migration (Harvey et al. 2009), was mostly sampled in the centres of each transect—the Laurentian Channel—in 2007 and 2008. Individuals were slightly more abundant in the LSLE than in the NWGSL in 2007 while the reverse was true in 2008. The large hyperiid amphipod *T. libellula*, which, contrary to the small euphausiid *T. enermis*, has shown a strong decrease in abundance since 2005 (see above), was mostly caught on the northern side of the LSLE and on both the northern and the southern sides of the NWGSL during both years (Fig. 18b). As observed since the beginning of this monitoring program (1994), the small hyperiid amphipod *T. abyssorum* was more abundant in the NWGSL than in the LSLE in 2007 and 2008. It was mostly distributed in the centre and on the south side of the NWGSL and on the north side in the LSLE, in particular in 2007 (the second most abundant year of the 1994–2008 time series). The chaetognaths (*P. elegans* and *E. hamata*) showed a distribution pattern similar to *T. abyssorum* in 2007: more abundant in the NWGSL than in the LSLE, distributed in the centre and on both sides of the NWGSL and on the north side in the LSLE. In 2008, which was the second most abundant year for this group in the 1994–2008 time series, chaetognaths were very abundant (≥25 ind/m^2) at almost all stations, with higher concentrations (≥100 ind/m^2) at the head of the LSLE (Fig. 18b). Finally, the small jellyfish *A. digitale* was found at concentrations greater than 25 ind/m^2 at many stations in the LSLE and the NWGSL in 2007 and 2008 but were more scarce at near-shore stations (north and south) in both the LSLE and NWGSL. There were slightly more individuals in the NWGSL than in the LSLE in 2007 while the reverse was true in 2008.

DISCUSSION AND CONCLUSION

Two major trends have characterized the interannual variations of the macrozooplankton community structure and abundance in the LSLE and the NWGSL over the last 15 years (1994–2007). First, from 1994 to 1996, the mean abundance of *T. raschii* decreased markedly, was fairly stable from 1996 to 2004, and increased again in 2005; subsequently, the mean abundances in 2006, 2007, and 2008 were the lowest values observed in the time series. *M. norvegica* also underwent a sharp decline from 1994 to 1996 followed by an increase in 1997 and lower but fairly stable levels for the rest of the time series. The 2008 value is similar to the low values observed in 1996, 1998, 2000, and 2004. This decline in krill abundance has also been measured elsewhere: 1) in the southern Gulf of St. Lawrence since 1987 (Hanson and Chouinard 2002), 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). This evidence suggests that the decline in krill abundance is not restricted to the GSL but is widespread over a larger part of Canada's Atlantic coast.

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, various 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 ($R^2 = 0.65$) 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. *T. libellula* always remain (day and night, during all seasons) at temperatures <3°C in the GSL (Harvey et al. 2009). 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, B. Dempsen, pers. comm.). However, even though there were strong intrusions of Labrador Shelf water into the GSL during the winters of 2006, 2007, and 2008, there appears to have been little or no influx of *T. libellula* during these three years. When we include the data from these last three years, the strength of the relationship declines, with only 33% of the variation being explained by this relationship ($R^2 = 0.33$).

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 (see the Environmental Review in AZMP Bulletin No. 7; http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/documents/docs/bulletin_7_01.pdf).

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Table 1. AZMP sampling missions in the study area in 2008. 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-08-01	17 Jan–13 Nov	15	15
	GC	IML-08-01	17 Jan–13 Nov	14	14
	SV	BIO-18VA08668	6 May–3 Dec	8	8
	RS	IML-08-05	18 Apr–27 Nov	27	27
Seasonal Sections	TESL, TSI, TASO, TCEN, TBB, TDC, TIDM	IML-08-36	14 Jun–01 Jul	46	46
	TESL, TSI, TASO, TCEN, TBB, TDC, TIDM	IML-08-57	24 Oct–17 Nov	46	46

Table 2. Percentages and averages of the ten top taxa at the Anticosti Gyre station in 2000–2007 compared to 2008 (upper) and for 2008 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2008.

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2000-2007	% total zooplankton / % du total de zooplancton 2008	Yearly average / Moyenne annuelle 2000 - 2007 (N/m^2 · 10^2)	2008 average / Moyenne 2008 (N/m^2 · 10^2)
1	*Oithona* spp.	24.88	42.10	440.90	914.64
2	Copepod nauplii (N3-N6)	13.88	4.89	245.98	106.32
3	*Calanus finmarchicus*	12.45	6.75	220.54	212.19
4	*Calanus hyperboreus*	10.68	8.16	189.35	177.36
5	Copepod eggs (> 202 μm)	8.13	1.22	144.08	26.42
6	*Microcalanus* spp.	5.03	5.40	89.18	117.39
7	Ostracoda	4.32	3.76	76.56	81.61
8	*Metridia* spp.	3.69	1.96	65.35	42.62
9	Echinoderm larvae	3.66	0.08	64.93	1.78
10	*Pseudocalanus* spp.	2.67	4.01	47.36	87.01
Total		89.40	78.34	1584.24	1767.34
Total zooplankton Abondance totale de zooplancton		(N/m^2 · 10^2)		1772.13	2430.34

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2008	2008 average / Moyenne 2008 (N/m^2 · 10^2)
1	*Oithona* spp.	42.10	914.64
②	*Temora* spp.	16.64	361.42
3	*Calanus finmarchicus*	6.75	212.19
4	*Calanus hyperboreus*	8.16	177.36
5	*Microcalanus* spp.	5.40	117.39
⑥	Appendicularia	5.15	111.94
7	Copepod nauplii (N3-N6)	4.89	106.32
8	*Pseudocalanus* spp.	4.01	87.01
9	Ostracoda	3.76	81.61
10	*Metridia* spp.	1.96	42.62
Total		98.83	2212.51
Total zooplankton Abondance totale de zooplancton		(N/m^2 · 10^2)	2430.34

Table 3. Percentages and averages of the ten top taxa at the Gaspé Current station in 2000–2007 compared to 2008 (upper) and for 2008 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2008.

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2000-2007	% total zooplankton / % du total de zooplancton 2008	Yearly average / Moyenne annuelle 2000-2007 (N/m^2 · 10^2)	2008 average / Moyenne 2008 (N/m^2 · 10^2)
1	*Oithona* spp.	41.83	44.74	639.46	1290.33
2	*Calanus finmarchicus*	14.04	7.79	214.68	224.55
3	Copepod nauplii (N3-N6)	12.76	5.31	195.08	153.21
4	Copepod eggs (> 202 µm)	7.33	0.76	111.99	21.78
5	*Pseudocalanus* spp.	4.66	7.31	71.18	210.71
6	Euphausiacea (eggs, nau, juv.)	4.01	1.15	61.30	33.04
7	Appendicularia	2.64	4.98	40.34	143.70
8	*Calanus hyperboreus*	1.84	2.01	28.20	57.89
9	*Metridia* spp.	1.71	0.49	26.12	14.07
10	*Microcalanus* spp.	1.61	1.62	24.62	46.83
Total		92.42	76.14	1412.99	2196.11
Total zooplankton Abondance totale de zooplancton		(N/m^2 · 10^2)		1528.30	2884.14

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2008	2008 average /Moyenne 2008 (N/m^2 · 10^2)
1	*Oithona* spp.	44.74	1290.33
②	*Temora* spp.	12.44	358.71
3	*Calanus finmarchicus*	7.79	224.55
4	*Pseudocalanus* spp.	7.31	210.71
5	Copepod nauplii (N3-N6)	5.31	153.21
6	Appendicularia	4.98	143.70
⑦	Cladocera	3.85	110.99
⑧	Bivalve larvae	2.20	63.41
9	*Calanus hyperboreus*	2.01	57.89
10	*Microcalanus* spp.	1.62	46.83
Total		92.24	2660.33
Total zooplankton Abondance totale de zooplancton		(N/m^2 · 10^2)	2884.14

Table 4. Percentages and averages of the ten top taxa at the Rimouski station in 2005–2007 compared to 2008 (upper) and for 2008 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2008.

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2005-2007	% total zooplankton / % du total de zooplancton 2008	Yearly average / Moyenne annuelle 2005 - 2007 $(N/m^2 \cdot 10^2)$	2008 average / Moyenne 2008 $(N/m^2 \cdot 10^2)$
1	*Calanus finmarchicus*	23.94	27.09	157.17	170.61
2	*Calanus hyperboreus*	17.91	24.42	117.55	153.79
3	*Oithona* spp.	10.61	15.58	69.64	98.13
4	*Metridia* spp.	8.84	3.93	58.03	24.76
5	Copepod nauplii (N3-N6)	7.21	1.79	47.35	11.30
6	Ostracoda	6.88	5.51	45.18	34.72
7	*Microcalanus* spp.	5.74	8.34	37.70	52.52
8	Invertebrate eggs	2.73	0.00	17.90	0.00
9	*Pseudocalanus* spp.	2.22	2.36	14.58	14.86
10	*Oncea* spp.	1.65	1.32	10.86	8.29
Total		87.75	90.34	575.96	568.98
Total zooplankton Abondance totale de zooplancton		$(N/m^2 \cdot 10^2)$		656.37	629.79

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2008	2008 average /Moyenne 2008 $(N/m^2 \cdot 10^2)$
1	*Calanus finmarchicus*	27.09	170.61
2	*Calanus hyperboreus*	24.42	153.79
3	*Oithona* spp.	15.58	98.13
4	*Microcalanus* spp.	8.34	52.52
5	Ostracoda	5.51	34.72
6	*Metridia* spp.	3.93	24.76
7	*Pseudocalanus* spp.	2.36	14.86
⑧	*Paraeuchaeta norvegica*	1.86	11.72
9	Copepod nauplii (N3-N6)	1.79	11.30
⑩	*Calanus glacialis*	1.61	10.15
Total		92.50	582.56
Total zooplankton Abondance totale de zooplancton		$(N/m^2 \cdot 10^2)$	629.79

Table 5. Percentages and averages of the ten top taxa at the Shediac Valley station in 1999–2007 compared to 2008 (upper) and for 2008 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2008.

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 1999-2007	% total zooplankton / % du total de zooplancton 2008	Yearly average / Moyenne annuelle 1999-2007 ($N/m^2 \cdot 10^2$)	2008 average / Moyenne 2008 ($N/m^2 \cdot 10^2$)
1	*Oithona* spp.	32.09	33.54	1410.59	1274.74
2	*Calanus finmarchicus*	14.64	7.09	643.50	269.53
3	Copepod nauplii (N3-N6)	12.85	3.32	564.80	126.20
4	*Pseudocalanus* spp.	6.25	4.96	274.73	188.42
5	*Temora* spp.	4.79	35.46	210.56	1347.51
6	*Calanus hyperboreus*	3.76	1.06	165.20	40.12
7	Bivalve larvae	1.93	2.28	84.85	86.67
8	Appendicularia	1.29	0.37	56.85	13.90
9	Euphausiacea (eggs, nau, juv.)	1.18	1.42	51.75	53.98
10	*Calanus glacialis*	0.99	0.81	43.69	30.84
Total		79.77	90.30	3506.53	3431.92
Total zooplankton Abondance totale de zooplancton		($N/m^2 \cdot 10^2$)		4395.90	3800.45

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2008	2008 average /Moyenne 2008 ($N/m^2 \cdot 10^2$)
1	*Temora* spp.	35.46	1347.51
2	*Oithona* spp.	33.54	1274.74
3	*Calanus finmarchicus*	7.09	269.53
4	*Pseudocalanus* spp.	4.96	188.42
5	Copepod nauplii (N3-N6)	3.32	126.20
6	Bivalve larvae	2.28	86.67
7	Euphausiacea (eggs, nau, juv.)	1.42	53.98
8	*Calanus hyperboreus*	1.06	40.12
⑨	*Centropages hamatus*	0.95	36.15
⑩	Polychaeta larvae	0.86	32.54
Total		90.93	3455.86
Total zooplankton Abondance totale de zooplancton		($N/m^2 \cdot 10^2$)	3800.45

Table 6. Percentages and averages of the ten top taxa along the TESL section in 2000–2007 compared to 2008 (upper) and for 2008 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2008.

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2000-2007	% total zooplankton / % du total de zooplancton 2008	Yearly average / Moyenne annuelle 2000-2007 ($N/m^2 \cdot 10^2$)	2008 average / Moyenne 2008 ($N/m^2 \cdot 10^2$)
1	*Oithona* spp.	38.20	51.82	370.87	558.37
2	*C. finmarchicus*	15.71	11.14	152.49	120.08
3	Copepod nauplii (N3-N6)	8.89	2.31	86.33	24.93
4	*C. hyperboreus*	5.80	11.34	56.34	122.20
5	*Microcalanus* spp.	5.13	8.88	49.80	95.65
6	*Metridia* spp.	5.04	2.01	48.97	21.70
7	Euph. (eggs, nau, juv.)	4.72	0.05	45.78	0.59
8	Appendicularia	3.48	0.07	33.75	0.72
9	*Pseudocalanus* spp.	3.36	1.88	32.61	20.23
10	Ostracoda	2.31	2.63	22.40	28.32
Total		92.63	92.14	899.35	992.80
Total zooplankton Abondance totale de zooplancton		($N/m^2 \cdot 10^2$)		970.92	1098.31

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2008	2008 average / Moyenne 2008 ($N/m^2 \cdot 10^2$)
1	*Oithona* spp.	51.82	558.37
2	*C. hyperboreus*	11.34	122.20
3	*C. finmarchicus*	11.14	120.08
4	*Microcalanus* spp.	8.88	95.65
5	Ostracoda	2.63	28.32
6	Copepod nauplii (N3-N6)	2.31	24.93
7	*Metridia* spp.	2.01	21.70
⑧	*Eurytemora* spp.	1.93	20.81
9	*Pseudocalanus* spp.	1.88	20.23
⑩	*C. glacialis*	1.15	12.36
Total		95.10	1024.67
Total zooplankton Abondance totale de zooplancton		($N/m^2 \cdot 10^2$)	1098.31

Table 7. Percentages and averages of the ten top taxa along the TSI section in 2000–2007 compared to 2008 (upper) and for 2008 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2008.

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2000-2007	% total zooplankton / % du total de zooplancton 2008	Yearly average / Moyenne annuelle 2000-2007 ($N/m^2 \cdot 10^2$)	2008 average / Moyenne 2008 ($N/m^2 \cdot 10^2$)
1	*Oithona* spp.	40.33	46.73	637.57	1128.17
2	*C. finmarchicus*	14.31	6.56	226.25	158.36
3	*C. hyperboreus*	6.90	5.64	109.05	136.24
4	*Pseudocalanus* spp.	5.23	3.90	82.69	94.26
5	Copepod nauplii (N3-N6)	4.87	5.02	77.06	121.10
6	Echinodermata larvae	4.81	0.17	76.02	4.21
7	Appendicularia	4.10	3.67	64.74	88.70
8	*Metridia* spp.	3.17	1.30	50.17	31.46
9	*Microcalanus* spp.	2.99	4.21	47.19	101.61
10	Ostracoda	2.70	2.87	42.61	69.21
Total		89.41	80.09	1413.37	1933.32
Total zooplankton Abondance totale de zooplancton		($N/m^2 \cdot 10^2$)		1580.78	2415.43

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2008	2008 average /Moyenne 2008 ($N/m^2 \cdot 10^2$)
1	*Oithona* spp.	46.73	1128.17
②	*Temora* spp.	11.20	270.44
3	*C. finmarchicus*	6.56	158.36
4	*C. hyperboreus*	5.64	136.24
5	Copepod nauplii (N3-N6)	5.02	121.10
6	*Microcalanus* spp.	4.21	101.61
7	*Pseudocalanus* spp.	3.90	94.26
8	Appendicularia	3.67	88.70
9	Ostracoda	2.87	69.21
⑩	Copepod eggs	2.07	49.86
Total		91.88	2217.95
Total zooplankton Abondance totale de zooplancton		($N/m^2 \cdot 10^2$)	2415.43

Table 8. Percentages and averages of the ten top taxa along the TASO section in 2000–2007 compared to 2008 (upper) and for 2008 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2008.

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2000-2007	% total zooplankton / % du total de zooplancton 2008	Yearly average / Moyenne annuelle 2000-2007 ($N/m^2 \cdot 10^2$)	2008 average / Moyenne 2008 ($N/m^2 \cdot 10^2$)
1	*Oithona* spp.	45.47	42.76	697.18	1271.51
2	*C. finmarchicus*	17.05	7.08	290.65	210.41
3	*C. hyperboreus*	5.93	4.17	101.16	123.88
4	*Pseudocalanus* spp.	4.65	3.50	83.39	104.03
5	Copepod nauplii (N3-N6)	4.27	7.80	73.20	231.98
6	*Metridia* spp.	3.56	1.18	55.97	35.11
7	Appendicularia	2.88	11.31	52.20	336.21
8	*Microcalanus* spp.	2.75	3.27	49.84	97.34
9	*Ostracoda*	2.65	1.96	47.31	58.27
10	*Temora* spp.	2.39	8.66	41.32	257.54
Total		91.60	91.69	1492.22	2726.29
Total zooplankton Abondance totale de zooplancton		($N/m^2 \cdot 10^2$)		1673.6	2973.29

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2008	2008 average /Moyenne 2008 ($N/m^2 \cdot 10^2$)
1	*Oithona* spp.	42.76	1271.51
2	Appendicularia	11.31	336.21
3	*Temora* spp.	8.66	257.54
4	Copepod nauplii (N3-N6)	7.80	231.98
5	*C. finmarchicus*	7.08	210.41
6	*C. hyperboreus*	4.17	123.88
7	*Pseudocalanus* spp.	3.50	104.03
8	*Microcalanus* spp.	3.27	97.34
⑨	Copepod eggs	2.30	68.32
10	*Ostracoda*	1.96	58.27
Total		92.81	2759.50
Total zooplankton Abondance totale de zooplancton		($N/m^2 \cdot 10^2$)	2973.29

Table 9. Percentages and averages of the ten top taxa along the TCEN section in 2004–2007 compared to 2008 (upper) and for 2008 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2008.

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2004-2007	% total zooplankton / % du total de zooplancton 2008	Yearly average / Moyenne annuelle 2004-2007 $(N/m^2 \cdot 10^2)$	2008 average / Moyenne 2008 $(N/m^2 \cdot 10^2)$
1	*Oithona* spp.	35.55	46.51	471.89	808.23
2	*C. finmarchicus*	16.09	13.81	213.60	240.01
3	*C. hyperboreus*	12.07	12.60	160.20	218.91
4	*Pseudocalanus* spp.	6.18	6.04	82.10	104.89
5	Copepod eggs	5.31	2.60	70.51	45.22
6	*Microcalanus* spp.	4.02	2.49	53.35	43.23
7	Ostracoda	3.56	3.67	47.29	63.71
8	Appendicularia	3.17	0.88	42.02	15.22
9	*Metridia* spp.	2.72	1.12	36.09	19.39
10	Copepod nauplii (N3-N6)	2.51	1.35	33.30	23.53
Total		91.18	91.06	1210.35	1582.34
Total zooplankton Abondance totale de zooplancton		$(N/m^2 \cdot 10^2)$		1327.46	1737.61

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2008	2008 average / Moyenne 2008 $(N/m^2 \cdot 10^2)$
1	*Oithona* spp.	46.51	808.23
2	*C. finmarchicus*	13.81	240.01
3	*C. hyperboreus*	12.60	218.91
4	*Pseudocalanus* spp.	6.04	104.89
5	Ostracoda	3.67	63.71
6	Copepod eggs	2.60	45.22
7	*Microcalanus* spp.	2.49	43.23
⑧	*P. norvegica*	1.63	28.29
⑨	*C. glacialis*	1.44	24.97
10	Copepod nauplii (N3-N6)	1.35	23.53
Total		92.14	1600.99
Total zooplankton Abondance totale de zooplancton		$(N/m^2 \cdot 10^2)$	1737.61

Table 10. Percentages and averages of the ten top taxa along the TBB section in 2000–2007 compared to 2008 (upper) and for 2008 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2008.

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2000-2007	% total zooplankton / % du total de zooplancton 2008	Yearly average / Moyenne annuelle 2000-2007 $(N/m^2 \cdot 10^2)$	2008 average / Moyenne 2008 $(N/m^2 \cdot 10^2)$
1	*Oithona* spp.	48.84	45.28	627.16	913.95
2	*Pseudocalanus* spp.	12.84	16.69	164.91	336.84
3	*C. finmarchicus*	11.62	15.99	149.24	322.83
4	*Temora* spp.	5.03	1.82	64.54	36.77
5	*C. hyperboreus*	4.53	2.06	58.12	41.51
6	Copepod nauplii (N3-N6)	3.64	5.40	46.72	109.05
7	Appendicularia	3.31	2.17	42.55	43.80
8	Copepod eggs	2.63	3.51	33.74	70.91
9	*Microcalanus* spp.	1.26	0.95	16.14	19.19
10	*Metridia* spp.	1.08	0.46	13.83	9.19
Total		94.76	94.33	1216.94	1904.04
Total zooplankton Abondance totale de zooplancton		$(N/m^2 \cdot 10^2)$		1284.18	2018.54

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2008	2008 average / Moyenne 2008 $(N/m^2 \cdot 10^2)$
1	*Oithona* spp.	45.28	913.95
2	*Pseudocalanus* spp.	16.69	336.84
3	*C. finmarchicus*	15.99	322.83
4	Copepod nauplii (N3-N6)	5.40	109.05
5	Copepod eggs	3.51	70.91
6	Appendicularia	2.17	43.80
7	*C. hyperboreus*	2.06	41.51
8	*Temora* spp.	1.82	36.77
9	*Microcalanus* spp.	0.95	19.19
10	*C. glacialis*	0.92	18.51
Total		94.79	1913.36
Total zooplankton Abondance totale de zooplancton		$(N/m^2 \cdot 10^2)$	2018.54

Table 11. Percentages and averages of the ten top taxa along the TIDM section in 2000–2007 compared to 2008 (upper) and for 2008 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2008.

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2000-2007	% total zooplankton / % du total de zooplancton 2008	Yearly average / Moyenne annuelle 2000-2007 (N/m^2 · 10^2)	2008 average / Moyenne 2008 (N/m^2 · 10^2)
1	*Oithona* spp.	46.13	46.51	782.23	1425.36
2	*Pseudocalanus* spp.	13.91	10.54	235.85	322.97
3	*Temora* sp.	12.16	19.07	206.28	584.49
4	*C. finmarchicus*	9.68	11.85	164.14	363.27
5	*C. hyperboreus*	4.64	2.33	78.61	71.35
6	Copepod nauplii (N3-N6)	3.08	0.82	52.29	25.06
7	Appendicularia	2.40	0.94	40.67	28.87
8	Euph. (eggs, nau, juv.)	1.77	1.20	30.05	36.86
9	Copepod eggs	1.60	0.54	27.14	16.51
10	Bivalve larvae	0.71	1.61	12.05	49.25
Total		96.08	95.40	1629.29	2924.01
Total zooplankton Abondance totale de zooplancton		(N/m^2 · 10^2)		1695.74	3064.87

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2008	2008 average /Moyenne 2008 (N/m^2 · 10^2)
1	*Oithona* spp.	46.51	1425.36
2	*Temora* sp.	19.07	584.49
3	*C. finmarchicus*	11.85	363.27
4	*Pseudocalanus* spp.	10.54	322.97
5	*C. hyperboreus*	2.33	71.35
6	Bivalve larvae	1.61	49.25
7	Euph. (eggs, nau, juv.)	1.20	36.86
8	Appendicularia	0.94	28.87
9	Copepod nauplii (N3-N6)	0.82	25.06
⑩	*C. glacialis*	0.56	17.07
Total		95.42	2924.57
Total zooplankton Abondance totale de zooplancton		(N/m^2 · 10^2)	3064.87

Table 12. Percentages and averages of the ten top taxa along the TDC section in 2000–2007 compared to 2008 (upper) and for 2008 alone (lower). The circled numbers indicate the new taxa in the top ten species in 2008.

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2000-2007	% total zooplankton / % du total de zooplancton 2008	Yearly average / Moyenne annuelle 2000-2007 $(N/m^2 \cdot 10^2)$	2008 average / Moyenne 2008 $(N/m^2 \cdot 10^2)$
1	*Oithona* spp.	39.07	47.95	924.30	1419.42
2	*Pseudocalanus* spp.	14.68	14.00	347.28	414.34
3	*C. finmarchicus*	10.00	7.53	236.59	222.96
4	*Temora* sp.	9.19	7.92	217.50	234.33
5	*C. hyperboreus*	6.01	5.22	142.15	154.65
6	*Microcalanus* spp.	3.01	2.40	71.14	71.02
7	Appendicularia	2.47	1.51	58.54	44.63
8	Copepod nauplii (N3-N6)	1.93	1.20	45.71	35.63
9	Copepod eggs	1.81	1.10	42.91	32.62
10	*Metridia* spp.	1.70	1.03	40.29	30.36
Total		89.89	89.86	2126.41	2659.95
Total zooplankton Abondance totale de zooplancton		$(N/m^2 \cdot 10^2)$		2365.54	2960.17

Rank / Rang	Taxa / Taxon	% total zooplankton / % du total de zooplancton 2008	2008 average / Moyenne 2008 $(N/m^2 \cdot 10^2)$
1	*Oithona* spp.	47.95	1419.42
2	*Pseudocalanus* spp.	14.00	414.34
3	*Temora* sp.	7.92	234.33
4	*C. finmarchicus*	7.53	222.96
5	*C. hyperboreus*	5.22	154.65
6	*Microcalanus* spp.	2.40	71.02
⑦	Ostracoda	2.06	60.95
8	Appendicularia	1.51	44.63
9	Copepod nauplii (N3-N6)	1.20	35.63
10	Copepod eggs	1.10	32.62
Total		90.89	2690.54
Total zooplankton Abondance totale de zooplancton		$(N/m^2 \cdot 10^2)$	2960.17

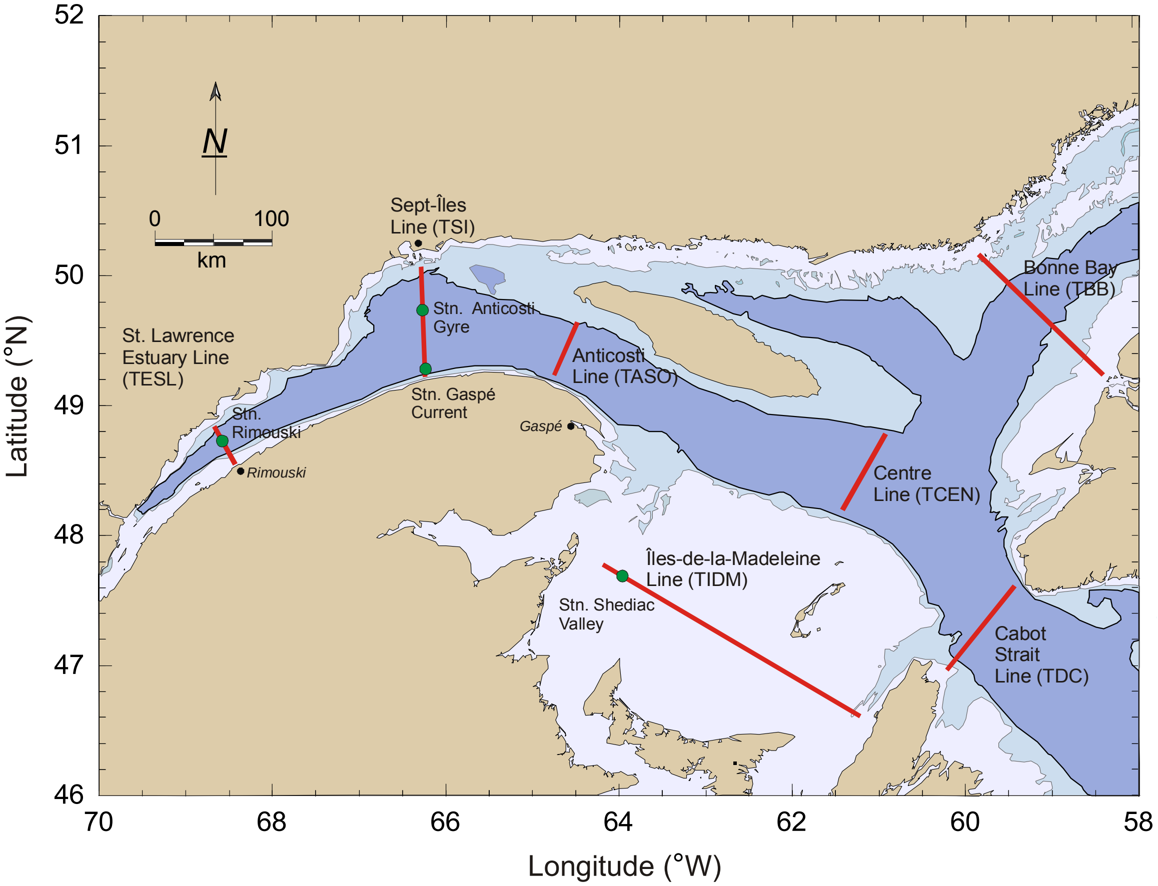


Figure 1. Sections (red lines) and fixed stations (green dots) sampled in the Québec region.

Total zooplankton biomass
Biomasse totale de zooplancton

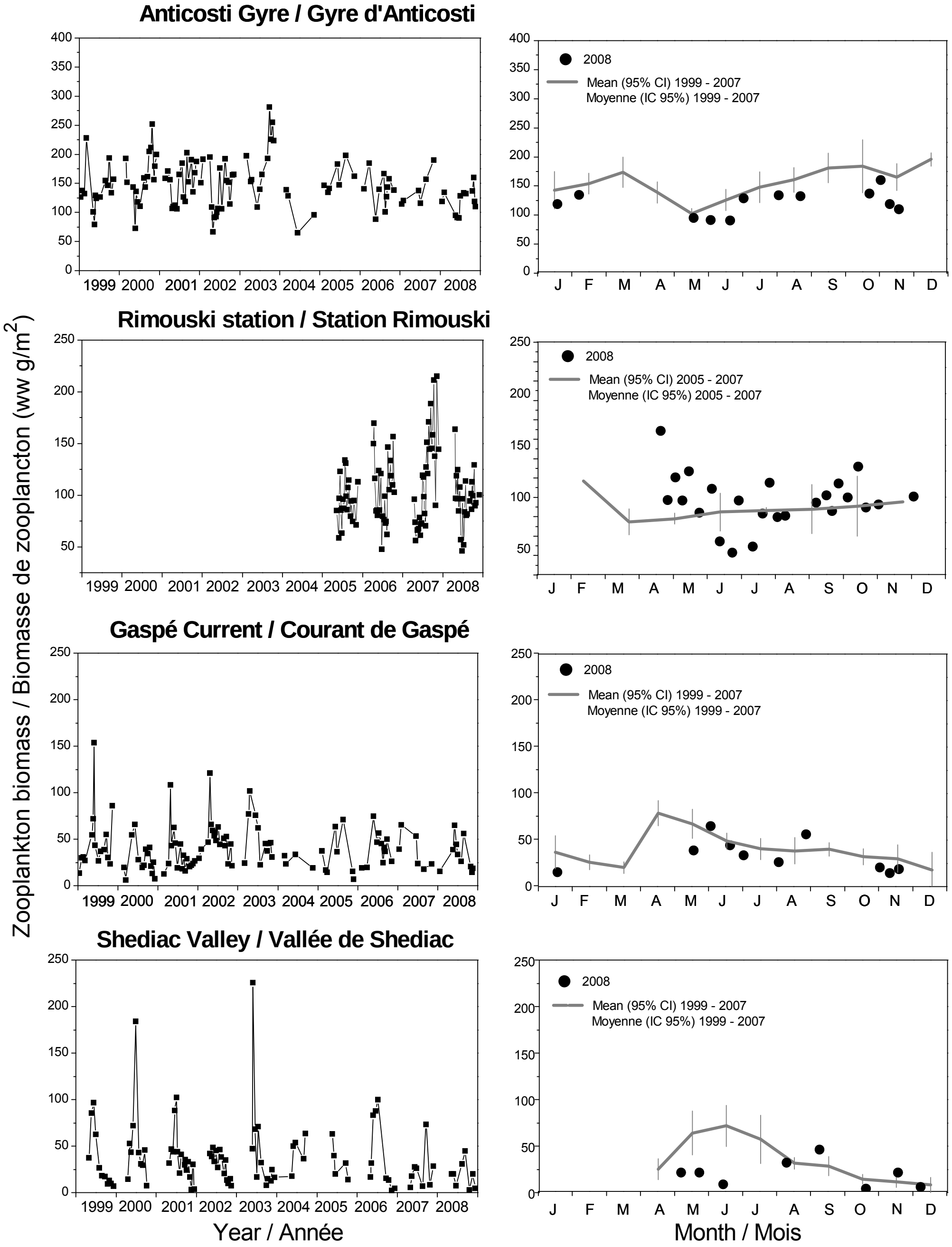


Figure 2. Time series of zooplankton biomass (surface–bottom) at the four fixed stations, 1999–2008 (2005–2008 for Rimouski). Right panels: 2008 (circles) compared with the 1999–2007 (Rimouski 2005–2007) average (solid line). Vertical lines are the 95% confidence limits.

Total non-copepod zooplankton abundance
Abondance totale de zooplancton non-copépodes

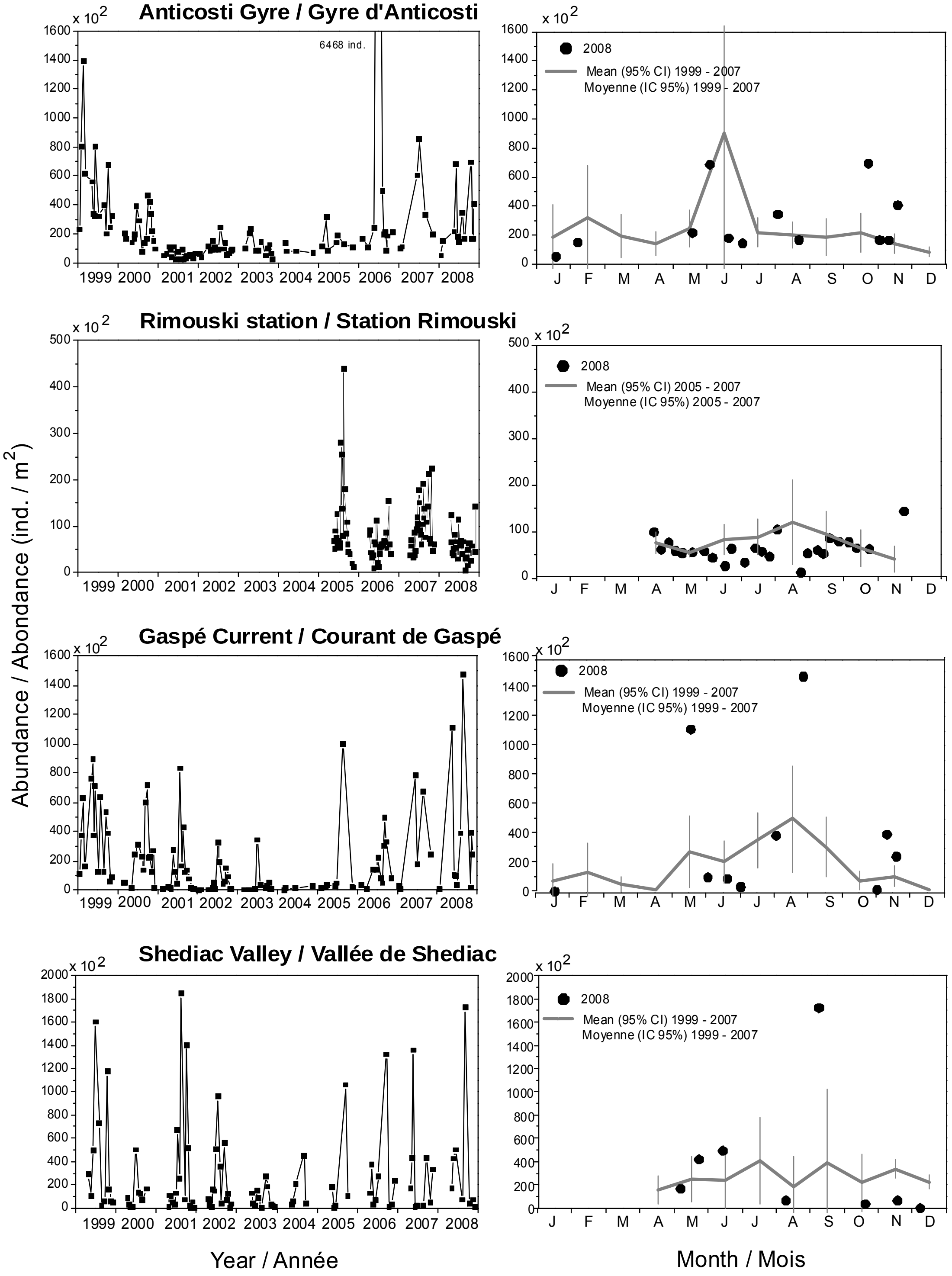


Figure 3. Time series of non-copepod zooplankton abundance (surface–bottom) at the four fixed stations, 1999–2008 (2005–2008 for Rimouski). Right panels: 2008 (circles) compared with the 1999–2007 (Rimouski 2005–2007) average (solid line). Vertical lines are the 95% confidence limits.

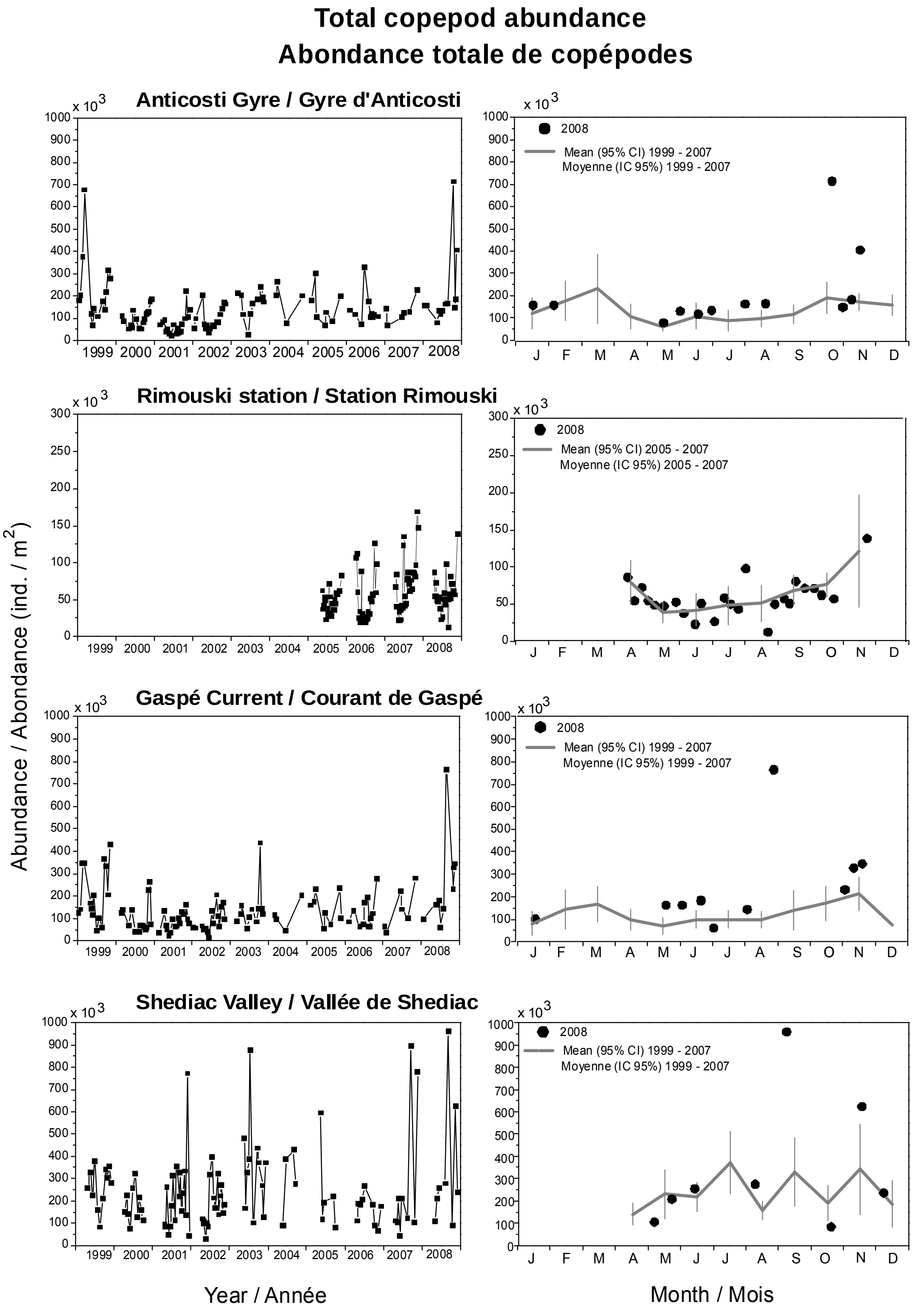


Figure 4. Time series of copepod abundance (surface–bottom) at the four fixed stations, 1999–2008 (2005–2008 for Rimouski). Right panels: 2008 (circles) compared with the 1999–2007 (Rimouski 2005–2007) average (solid line). Vertical lines are the 95% confidence limits.

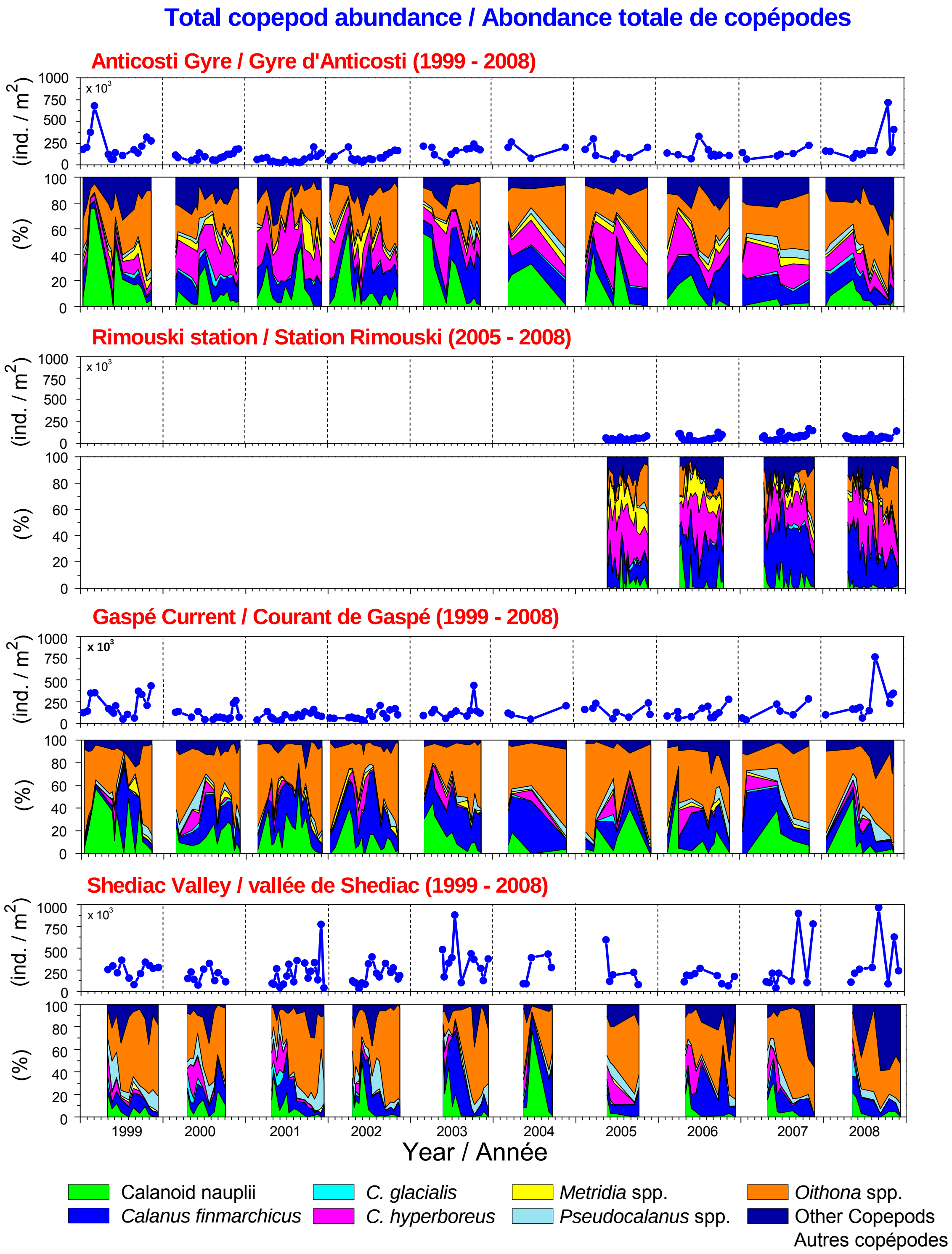
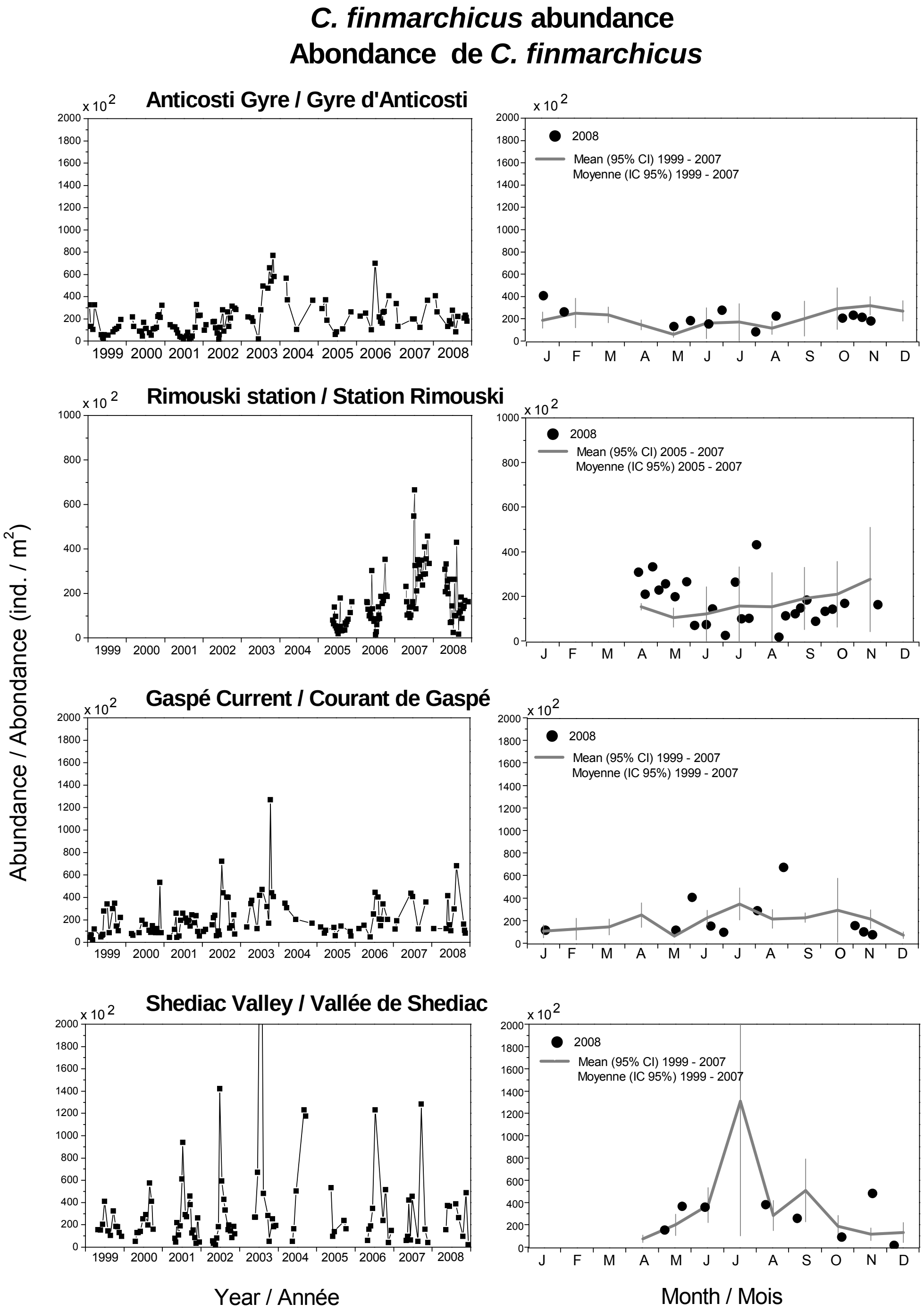


Figure 5. Seasonal cycle of total abundance and species distribution of the dominant copepods at the four fixed stations, 1999–2008 (Rimouski 2005–2008).



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

Anticosti Gyre / Gyre d'Anticosti

Rimouski station / Station Rimouski

Gaspé Current / Courant de Gaspé

Shediac Valley / Vallée de Shediac

Figure 6. Time series of *C. finmarchicus* abundance (surface–bottom) at the four fixed stations, 1999–2008 (2005–2008 for Rimouski). Right panels: 2008 (circles) compared with the 1999–2007 (Rimouski 2005–2007) average (solid line). Vertical lines are the 95% confidence limits.

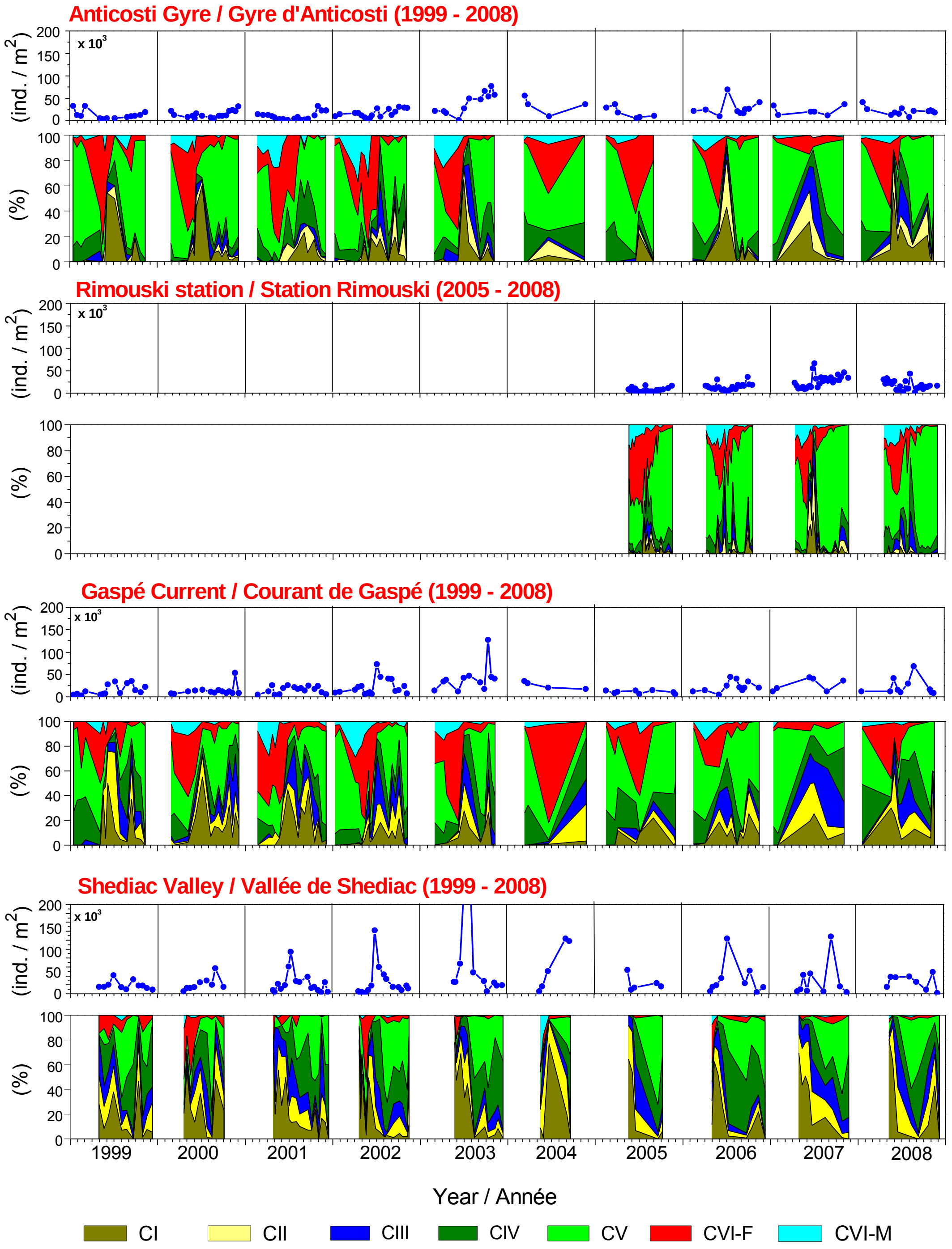


Figure 7. Seasonal cycle of total abundance and stage distribution of *Calanus finmarchicus* at the four fixed stations, 1999–2008 (Rimouski 2005–2008).

Pseudocalanus spp. abundance
Abondance de *Pseudocalanus* spp.

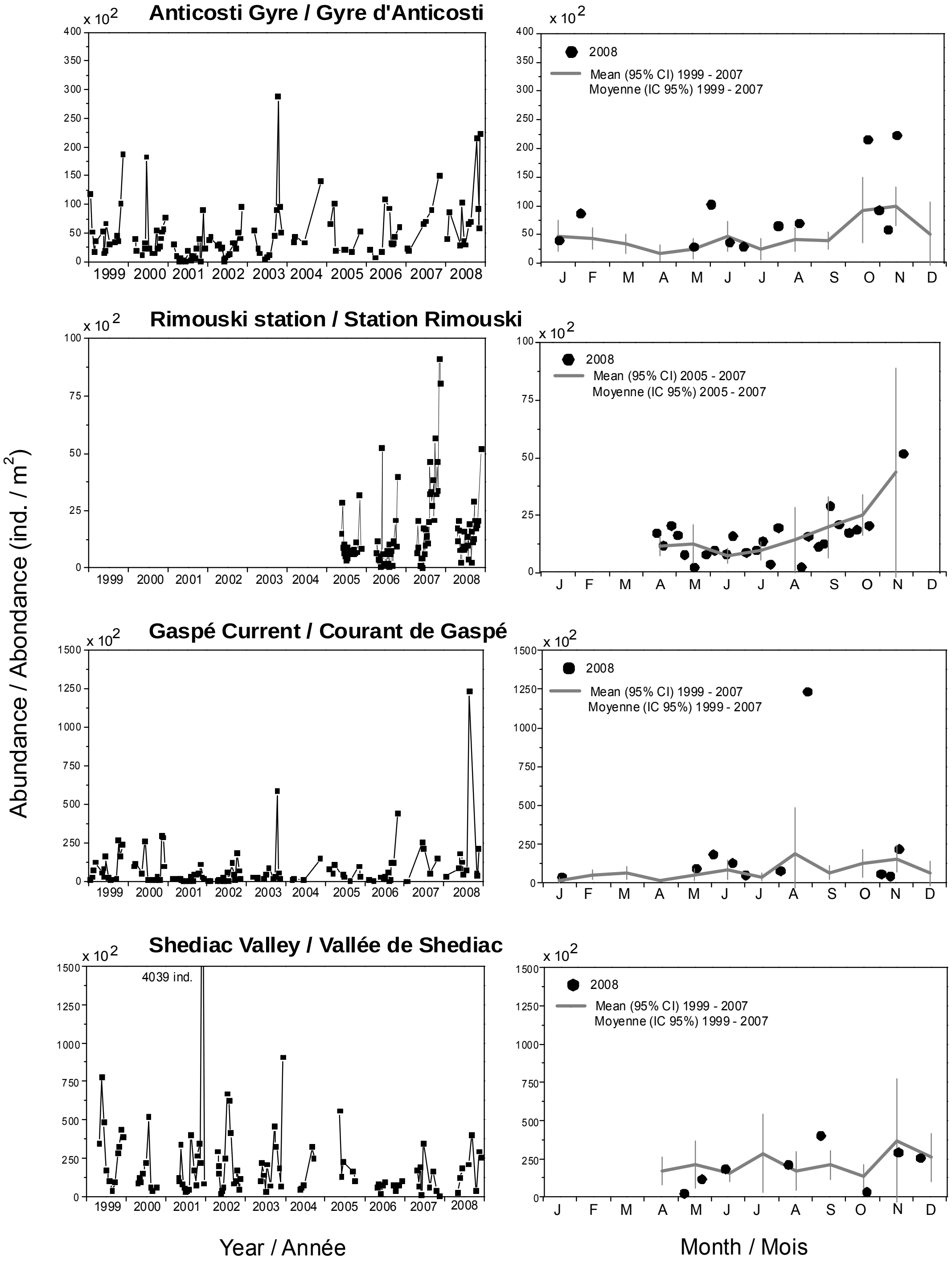
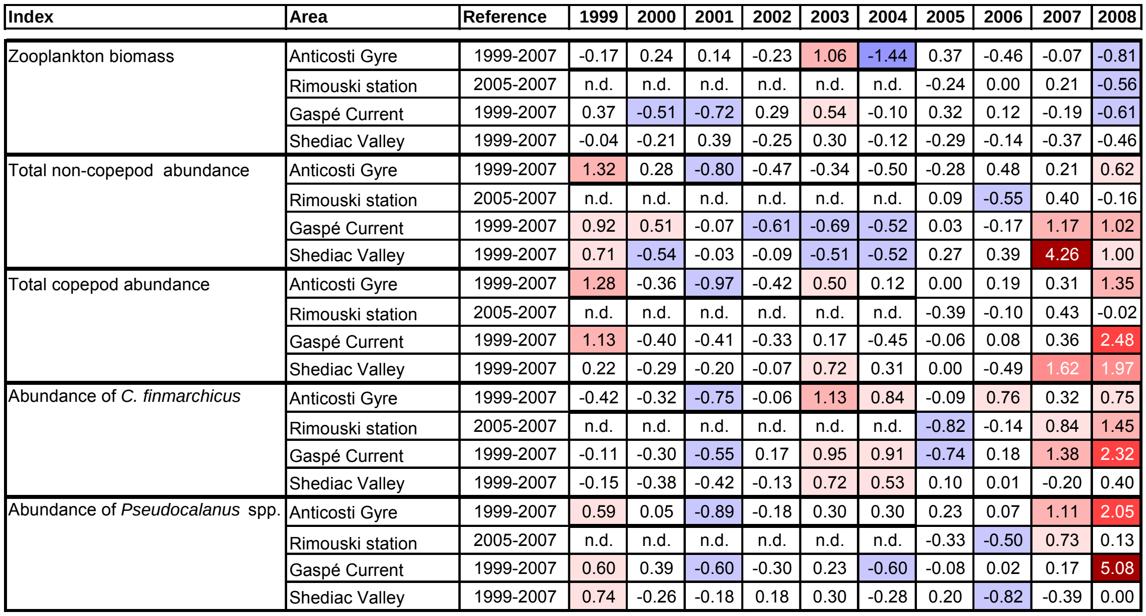


Figure 8. Time series of *Pseudocalanus* spp. abundance (surface–bottom) at the four fixed stations, 1999–2008 (2005–2008 for Rimouski). Right panels: 2008 (circles) compared with the 1999–2007 (Rimouski 2005–2007) average (solid line). Vertical lines are the 95% confidence limits.



Index	Area	Reference	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Zooplankton biomass	Anticosti Gyre	1999-2007	-0.17	0.24	0.14	-0.23	1.06	-1.44	0.37	-0.46	-0.07	-0.81
	Rimouski station	2005-2007	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	-0.24	0.00	0.21	-0.56
	Gaspé Current	1999-2007	0.37	-0.51	-0.72	0.29	0.54	-0.10	0.32	0.12	-0.19	-0.61
	Shediac Valley	1999-2007	-0.04	-0.21	0.39	-0.25	0.30	-0.12	-0.29	-0.14	-0.37	-0.46
Total non-copepod abundance	Anticosti Gyre	1999-2007	1.32	0.28	-0.80	-0.47	-0.34	-0.50	-0.28	0.48	0.21	0.62
	Rimouski station	2005-2007	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.09	-0.55	0.40	-0.16
	Gaspé Current	1999-2007	0.92	0.51	-0.07	-0.61	-0.69	-0.52	0.03	-0.17	1.17	1.02
	Shediac Valley	1999-2007	0.71	-0.54	-0.03	-0.09	-0.51	-0.52	0.27	0.39	4.26	1.00
Total copepod abundance	Anticosti Gyre	1999-2007	1.28	-0.36	-0.97	-0.42	0.50	0.12	0.00	0.19	0.31	1.35
	Rimouski station	2005-2007	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	-0.39	-0.10	0.43	-0.02
	Gaspé Current	1999-2007	1.13	-0.40	-0.41	-0.33	0.17	-0.45	-0.06	0.08	0.36	2.48
	Shediac Valley	1999-2007	0.22	-0.29	-0.20	-0.07	0.72	0.31	0.00	-0.49	1.62	1.97
Abundance of *C. finmarchicus*	Anticosti Gyre	1999-2007	-0.42	-0.32	-0.75	-0.06	1.13	0.84	-0.09	0.76	0.32	0.75
	Rimouski station	2005-2007	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	-0.82	-0.14	0.84	1.45
	Gaspé Current	1999-2007	-0.11	-0.30	-0.55	0.17	0.95	0.91	-0.74	0.18	1.38	2.32
	Shediac Valley	1999-2007	-0.15	-0.38	-0.42	-0.13	0.72	0.53	0.10	0.01	-0.20	0.40
Abundance of *Pseudocalanus* spp.	Anticosti Gyre	1999-2007	0.59	0.05	-0.89	-0.18	0.30	0.30	0.23	0.07	1.11	2.05
	Rimouski station	2005-2007	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	-0.33	-0.50	0.73	0.13
	Gaspé Current	1999-2007	0.60	0.39	-0.60	-0.30	0.23	-0.60	-0.08	0.02	0.17	5.08
	Shediac Valley	1999-2007	0.74	-0.26	-0.18	0.18	0.30	-0.28	0.20	-0.82	-0.39	0.00

Figure 9. Anomalies in zooplankton biomass and abundance and other derived zooplankton indices (abundances of non-copepods, copepods, *Calanus finmarchicus*, and *Pseudocalanus* spp.) from the Québec AZMP fixed stations 1999–2008 (2005–2008 for Rimouski station). The anomalies are normalized with respect to their standard deviations over the 1999–2007 period (2005–2007 for Rimouski).

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

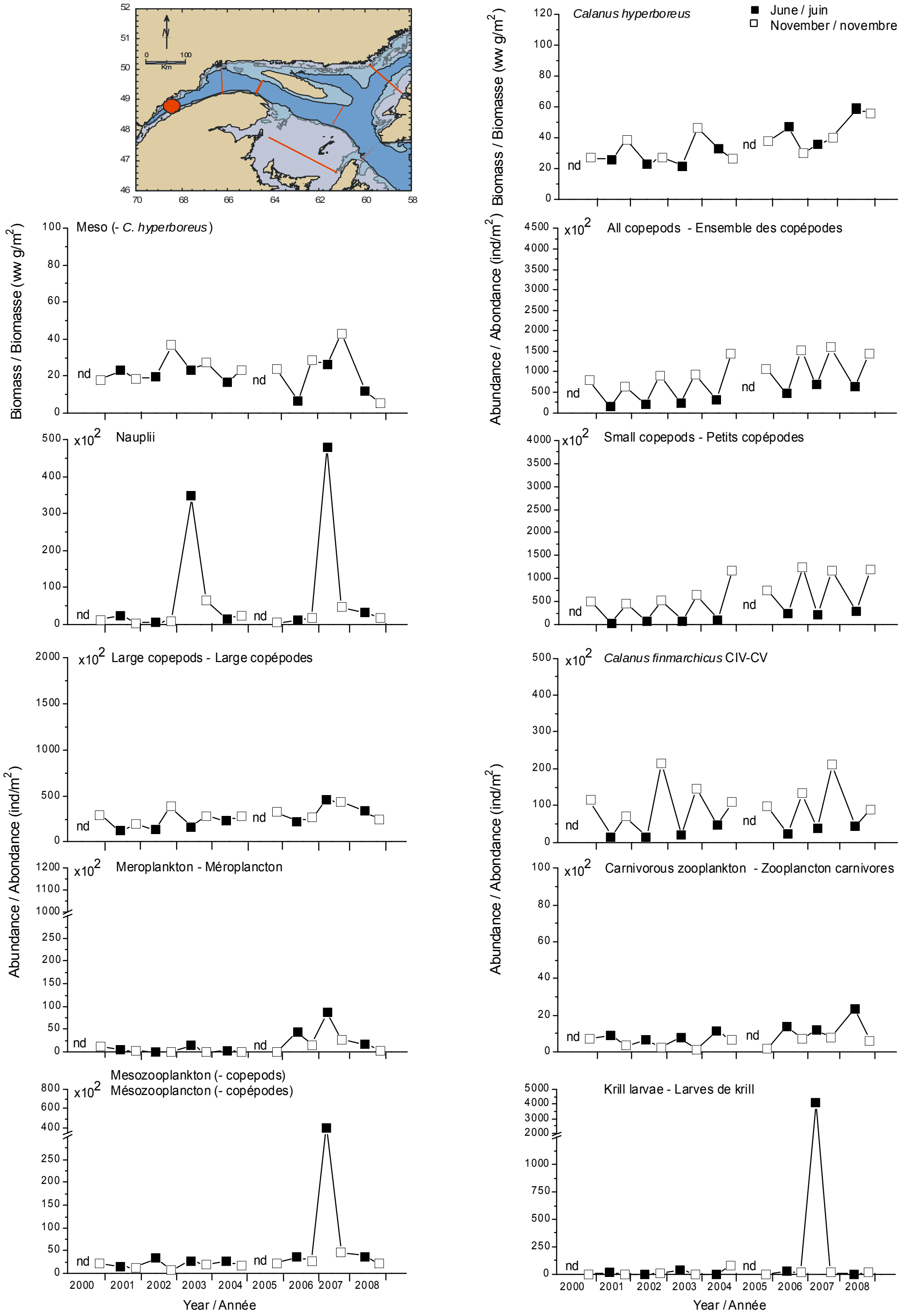


Figure 10a. Mean zooplankton wet weight biomass (*C. hyperboreus*, mesozooplankton excluding *C. hyperboreus*) and abundance (copepods, copepod nauplii, small copepods, large copepods, *C. finmarchicus* CIV–CV, meroplankton, carnivorous zooplankton, mesoplankton, krill larvae) along the Lower St. Lawrence Estuary section (TESL) in June and November 2000–2008.

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

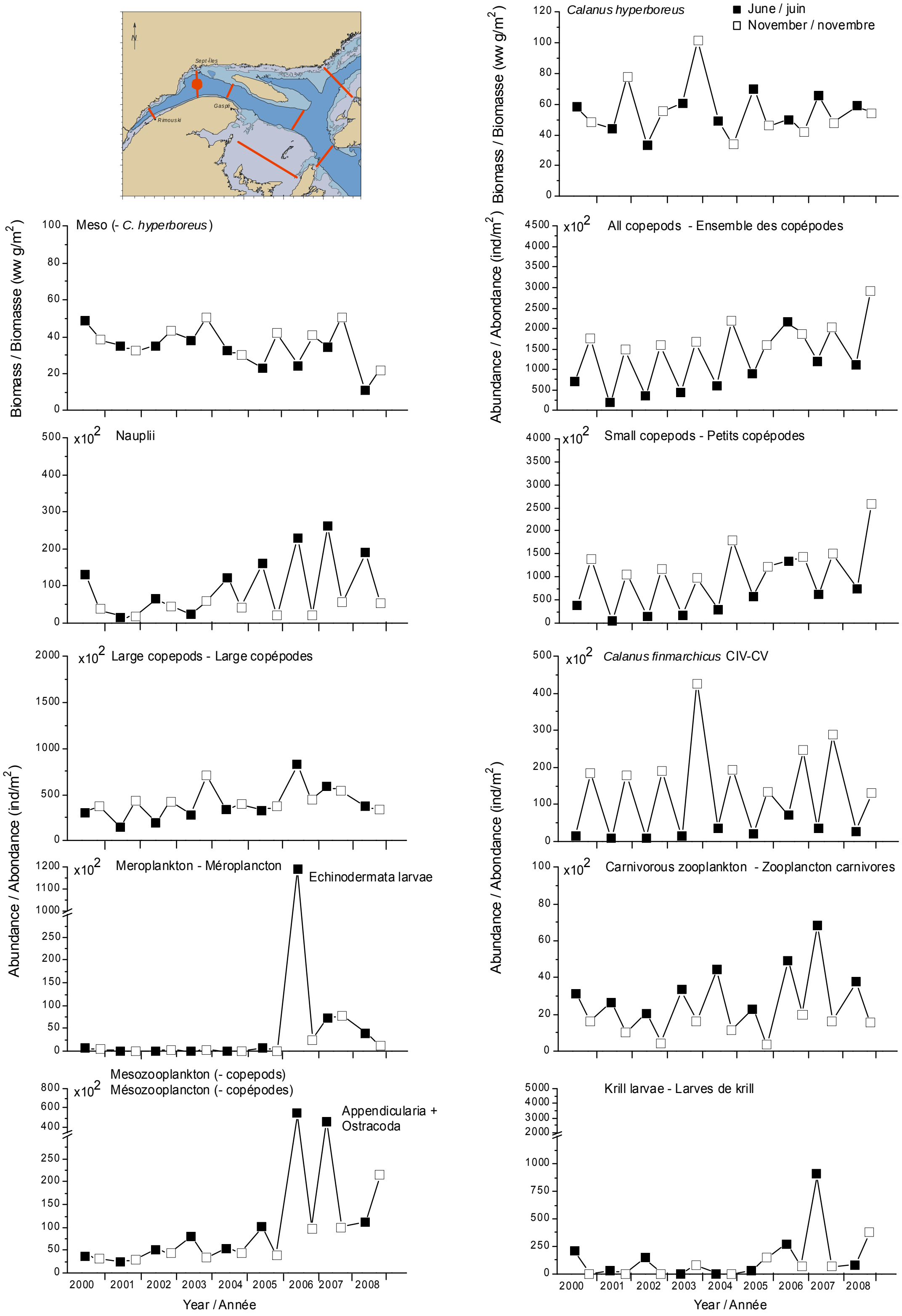


Figure 10b. Sept-Îles section (TSI), June and November 2000–2008.

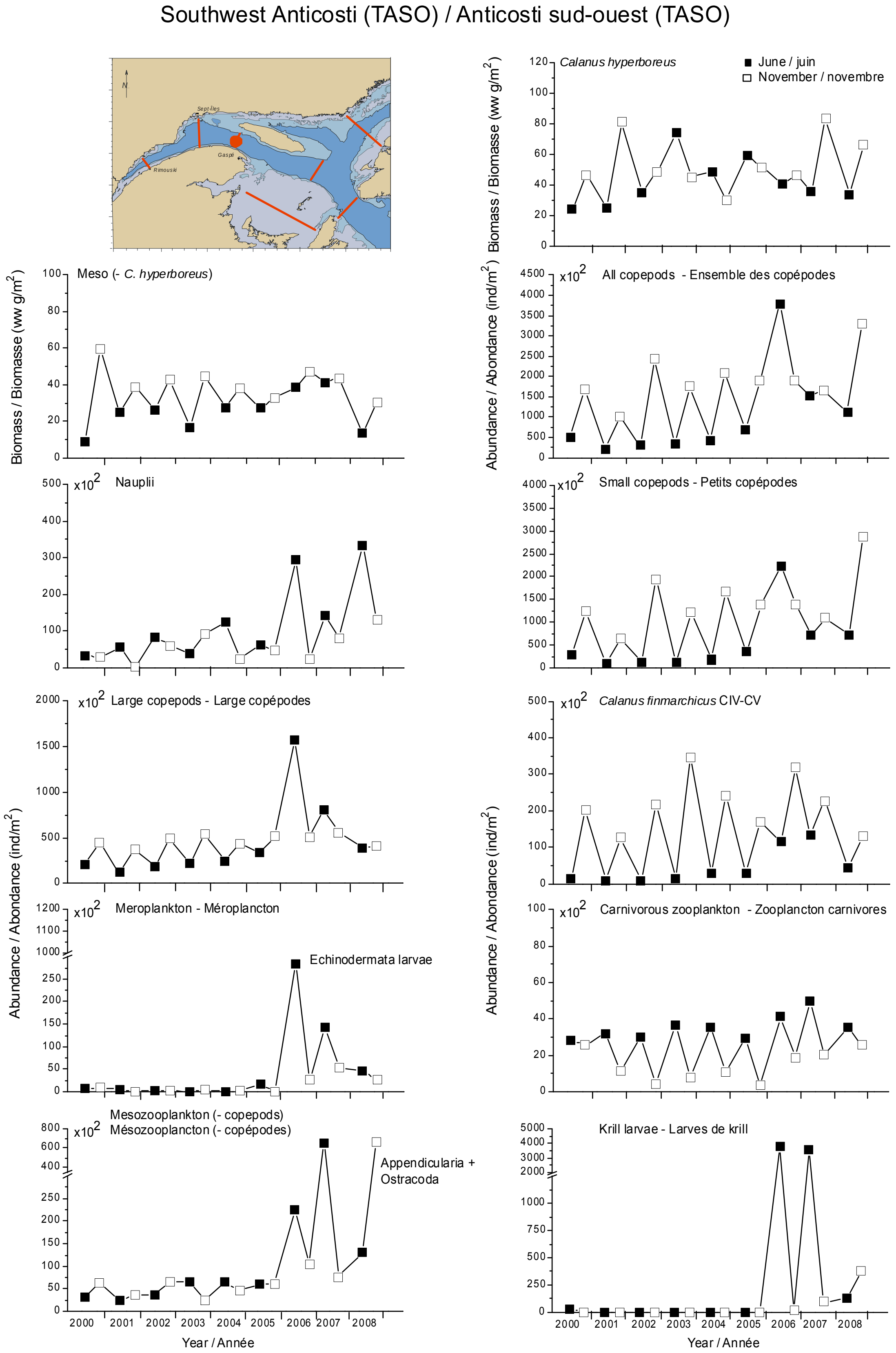


Figure 10c. Southwest Anticosti Island section (TASO), June and November 2000–2008.

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

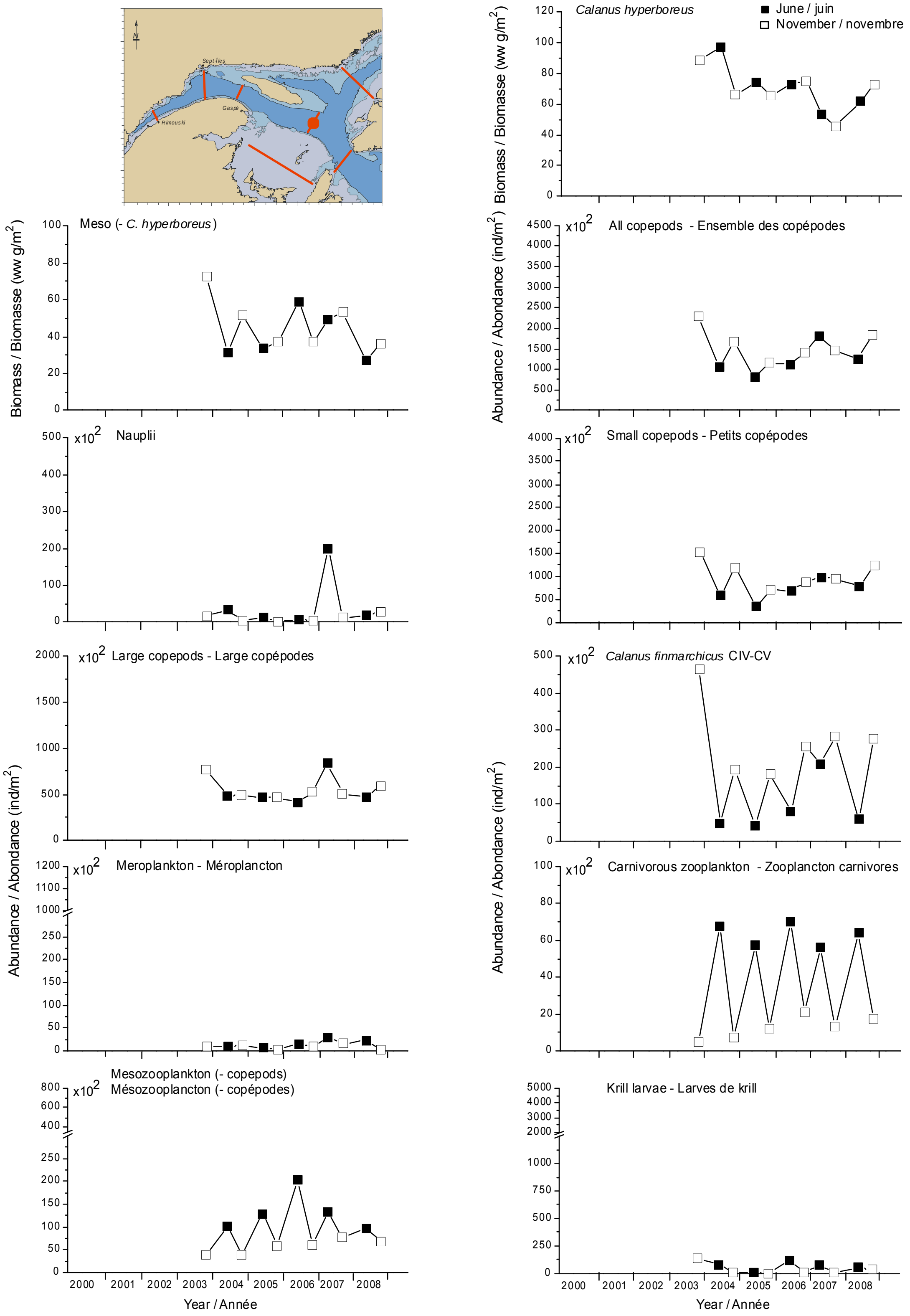


Figure 10d. Centre Gulf of St. Lawrence section (TCEN), June 2004–2008 and November 2003–2008.

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

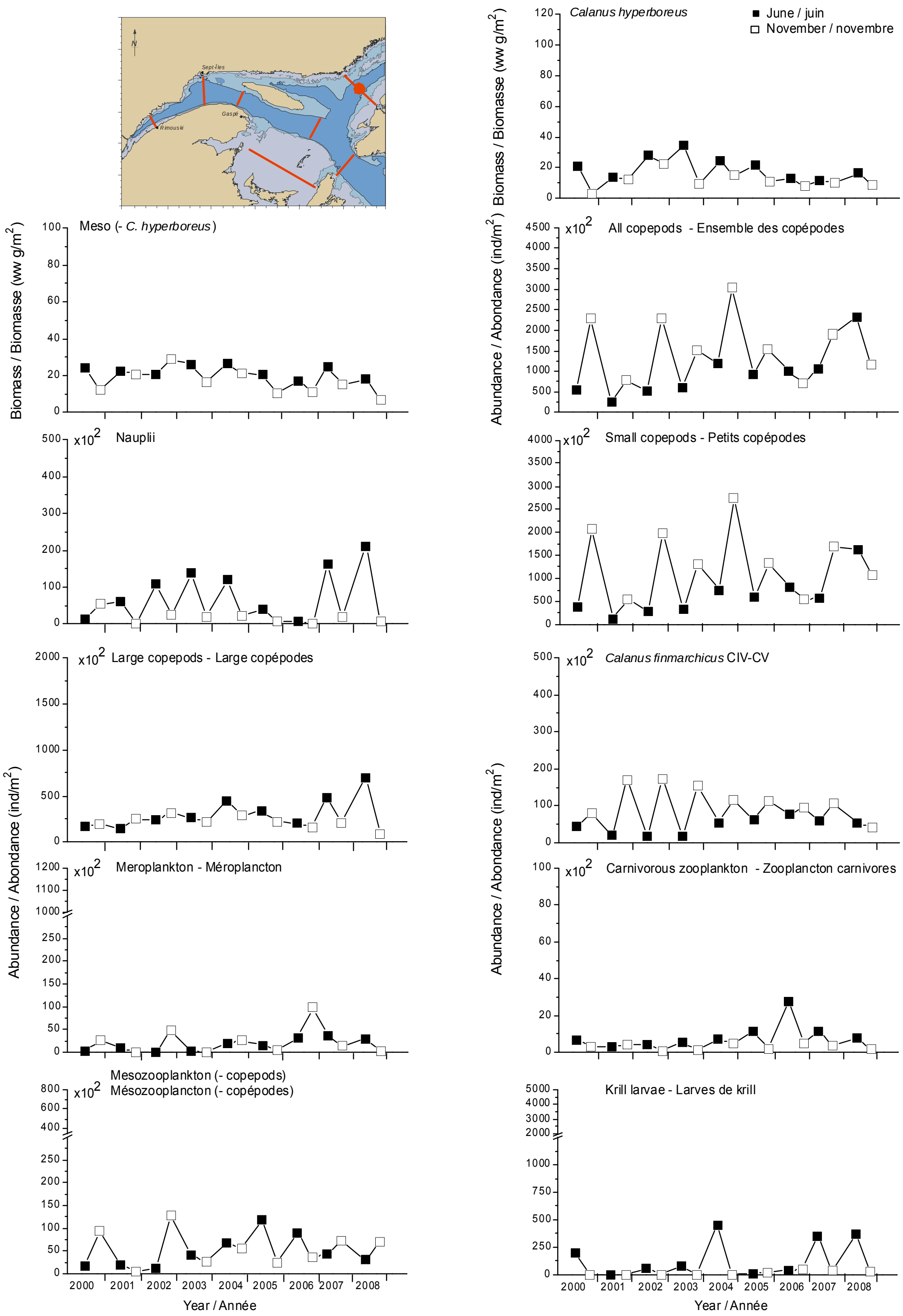


Figure 10e. Northeast Gulf of St. Lawrence section (TBB), June and November 2000–2008.

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

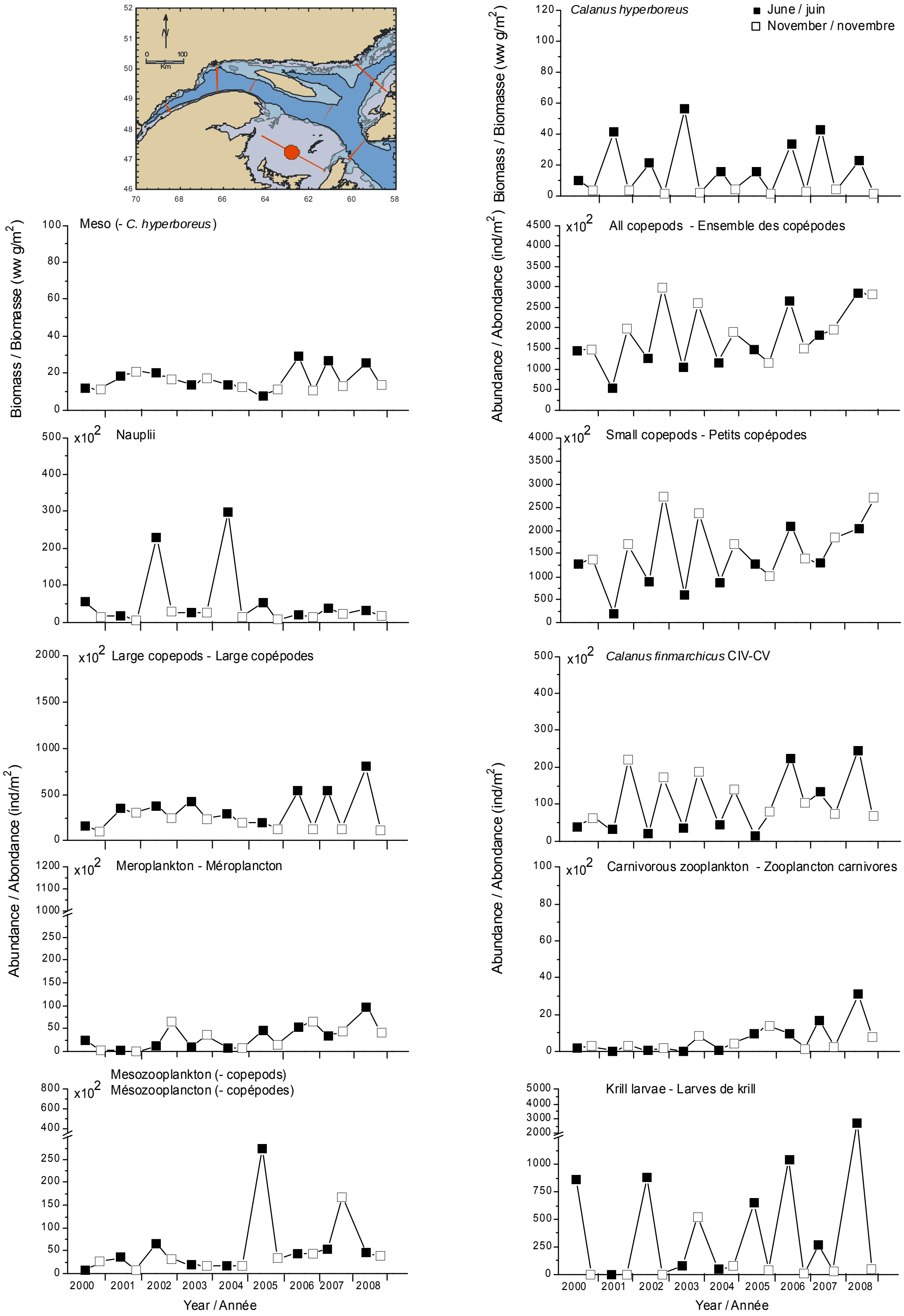


Figure 10f. Southern Gulf of St. Lawrence section (TIDM), June and November 2000–2008.

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

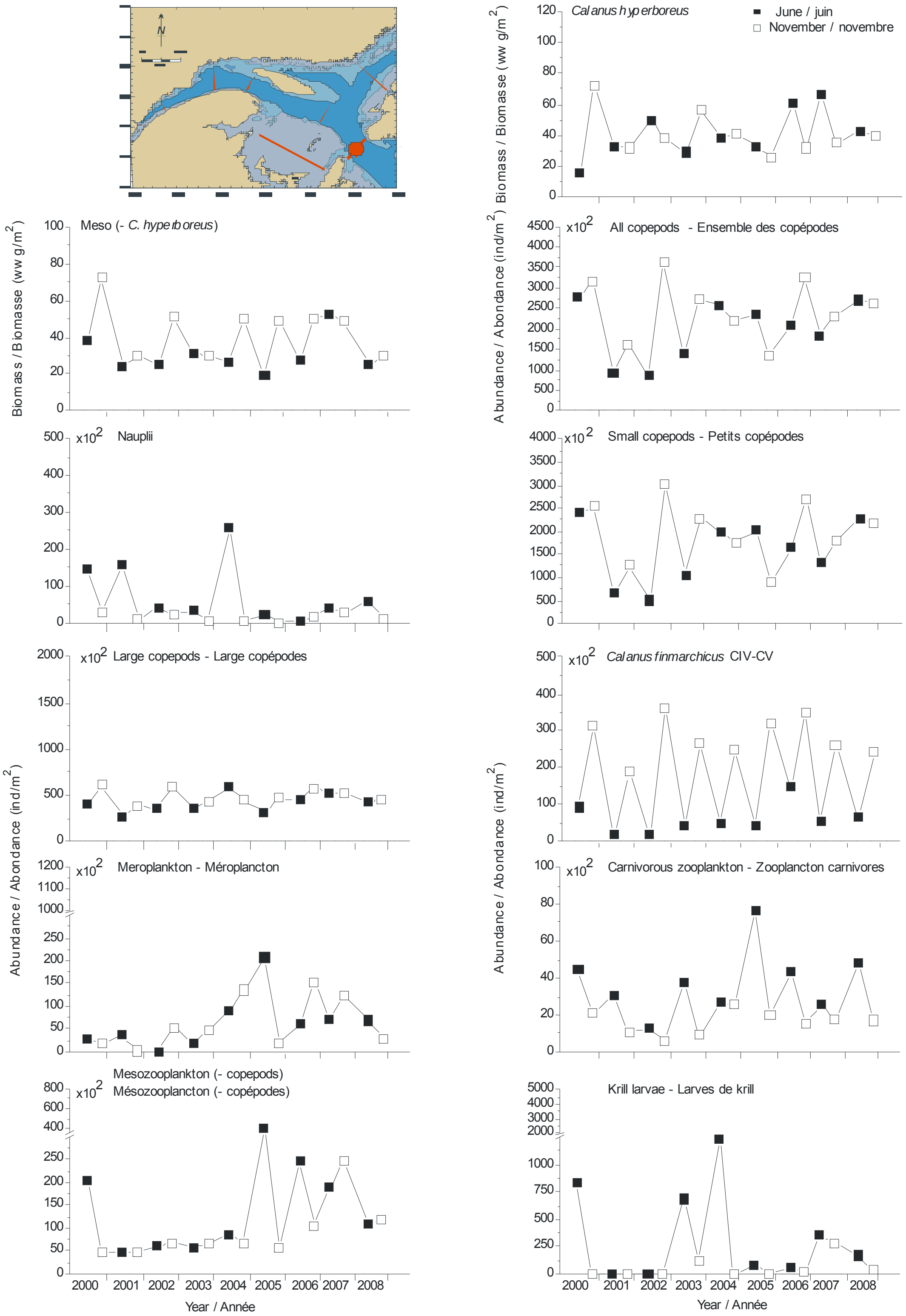


Figure 10g. Cabot Strait section (TDC), June and November 2000–2008.

2000/2008 - (Mean ± 95%, ww g/m^2 - ind/m^2)

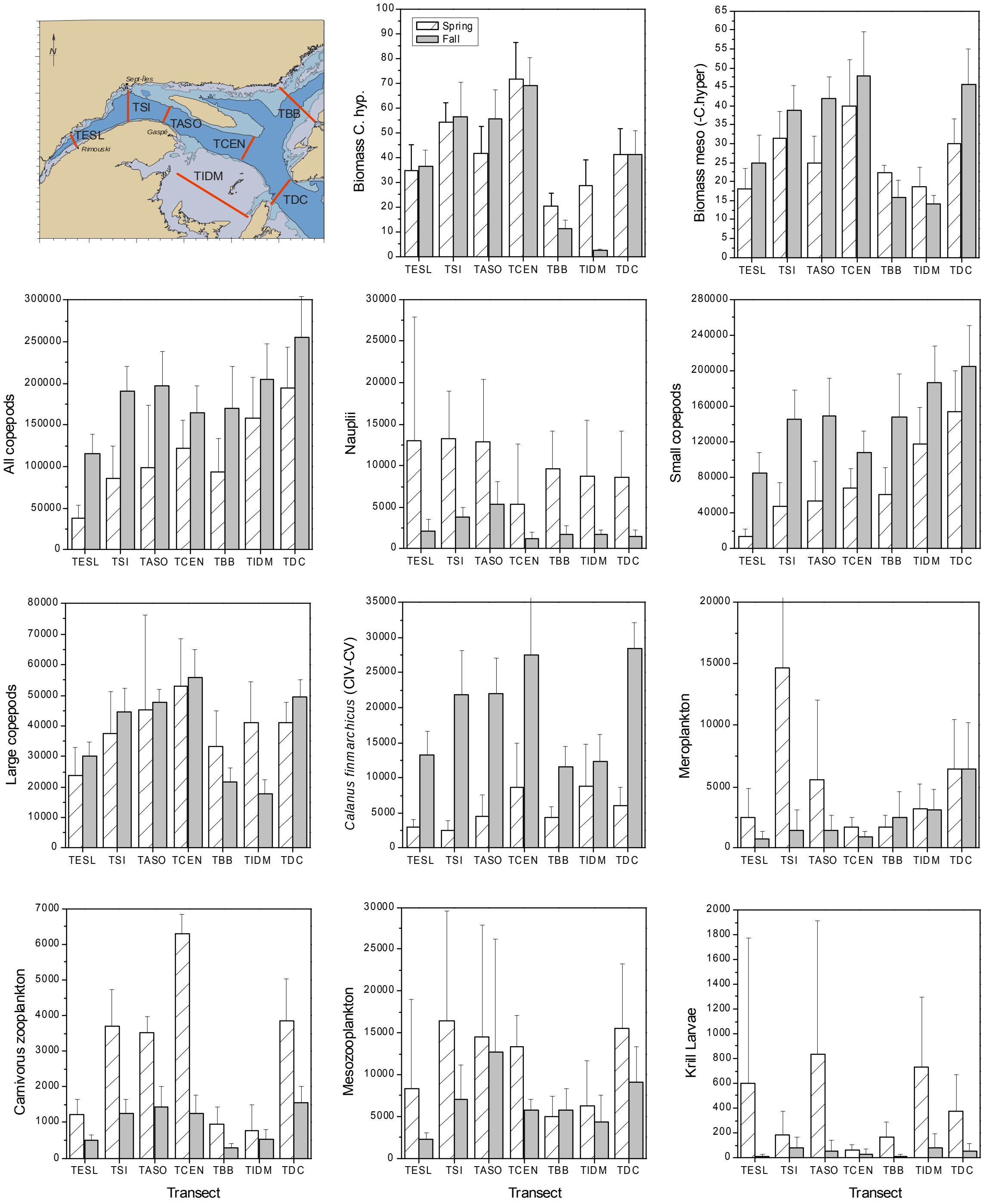
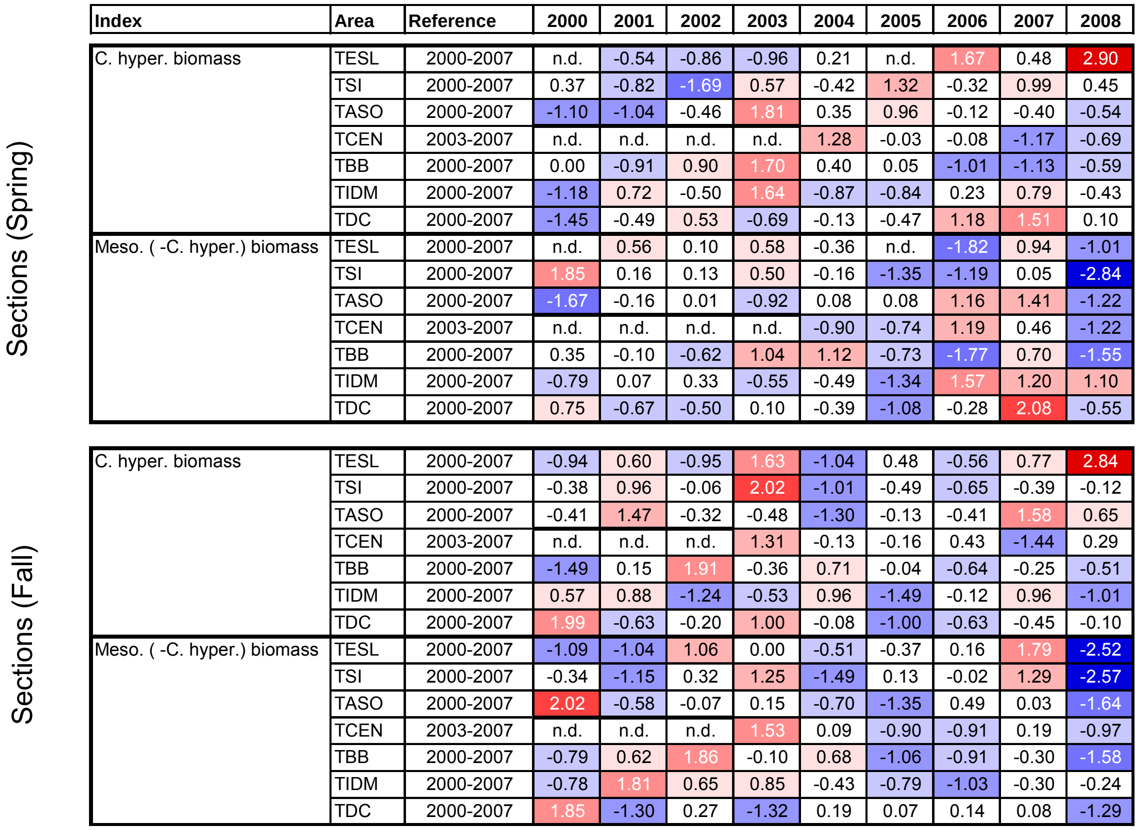
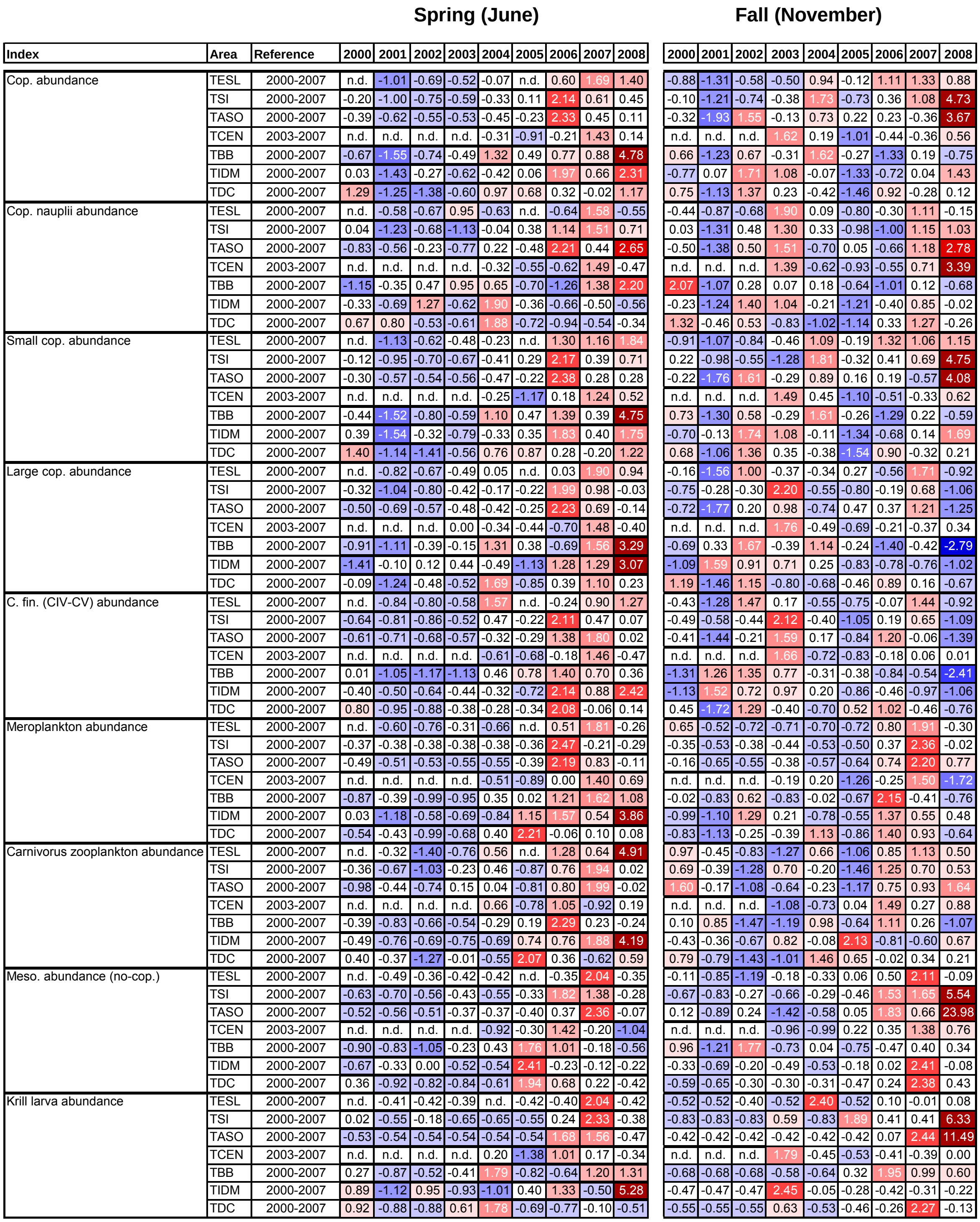


Figure 11. Mean (±95%) zooplankton biomass (ww mg/m^2; top centre and left) and abundance (ind/m^2; all others), 2000–2008, along the seven AZMP sections sampled in June and November (Nov. 2003–2008 for TCEN).



	Index	Area	Reference	2000	2001	2002	2003	2004	2005	2006	2007	2008
Sections (Spring)	C. hyper. biomass	TESL	2000-2007	n.d.	-0.54	-0.86	-0.96	0.21	n.d.	1.67	0.48	2.90
		TSI	2000-2007	0.37	-0.82	-1.69	0.57	-0.42	1.32	-0.32	0.99	0.45
		TASO	2000-2007	-1.10	-1.04	-0.46	1.81	0.35	0.96	-0.12	-0.40	-0.54
		TCEN	2003-2007	n.d.	n.d.	n.d.	n.d.	1.28	-0.03	-0.08	-1.17	-0.69
		TBB	2000-2007	0.00	-0.91	0.90	1.70	0.40	0.05	-1.01	-1.13	-0.59
		TIDM	2000-2007	-1.18	0.72	-0.50	1.64	-0.87	-0.84	0.23	0.79	-0.43
		TDC	2000-2007	-1.45	-0.49	0.53	-0.69	-0.13	-0.47	1.18	1.51	0.10
	Meso. (-C. hyper.) biomass	TESL	2000-2007	n.d.	0.56	0.10	0.58	-0.36	n.d.	-1.82	0.94	-1.01
		TSI	2000-2007	1.85	0.16	0.13	0.50	-0.16	-1.35	-1.19	0.05	-2.84
		TASO	2000-2007	-1.67	-0.16	0.01	-0.92	0.08	0.08	1.16	1.41	-1.22
		TCEN	2003-2007	n.d.	n.d.	n.d.	n.d.	-0.90	-0.74	1.19	0.46	-1.22
		TBB	2000-2007	0.35	-0.10	-0.62	1.04	1.12	-0.73	-1.77	0.70	-1.55
		TIDM	2000-2007	-0.79	0.07	0.33	-0.55	-0.49	-1.34	1.57	1.20	1.10
		TDC	2000-2007	0.75	-0.67	-0.50	0.10	-0.39	-1.08	-0.28	2.08	-0.55
Sections (Fall)	C. hyper. biomass	TESL	2000-2007	-0.94	0.60	-0.95	1.63	-1.04	0.48	-0.56	0.77	2.84
		TSI	2000-2007	-0.38	0.96	-0.06	2.02	-1.01	-0.49	-0.65	-0.39	-0.12
		TASO	2000-2007	-0.41	1.47	-0.32	-0.48	-1.30	-0.13	-0.41	1.58	0.65
		TCEN	2003-2007	n.d.	n.d.	n.d.	1.31	-0.13	-0.16	0.43	-1.44	0.29
		TBB	2000-2007	-1.49	0.15	1.91	-0.36	0.71	-0.04	-0.64	-0.25	-0.51
		TIDM	2000-2007	0.57	0.88	-1.24	-0.53	0.96	-1.49	-0.12	0.96	-1.01
		TDC	2000-2007	1.99	-0.63	-0.20	1.00	-0.08	-1.00	-0.63	-0.45	-0.10
	Meso. (-C. hyper.) biomass	TESL	2000-2007	-1.09	-1.04	1.06	0.00	-0.51	-0.37	0.16	1.79	-2.52
		TSI	2000-2007	-0.34	-1.15	0.32	1.25	-1.49	0.13	-0.02	1.29	-2.57
		TASO	2000-2007	2.02	-0.58	-0.07	0.15	-0.70	-1.35	0.49	0.03	-1.64
		TCEN	2003-2007	n.d.	n.d.	n.d.	1.53	0.09	-0.90	-0.91	0.19	-0.97
		TBB	2000-2007	-0.79	0.62	1.86	-0.10	0.68	-1.06	-0.91	-0.30	-1.58
		TIDM	2000-2007	-0.78	1.81	0.65	0.85	-0.43	-0.79	-1.03	-0.30	-0.24
		TDC	2000-2007	1.85	-1.30	0.27	-1.32	0.19	0.07	0.14	0.08	-1.29

Figure 12. Anomalies in zooplankton biomass (*Calanus hyperboreus*, mesozooplankton excluding *C. hyperboreus*) from the Québec AZMP sections stations from 2000 to 2008 (Nov. 2003–2008 for TCEN). The anomalies are normalized with respect to their standard deviations over the 2000–2007 period (2003–2007 for TCEN).



			Spring (June)									Fall (November)								
Index	**Area**	**Reference**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Cop. abundance	TESL	2000-2007	n.d.	-1.01	-0.69	-0.52	-0.07	n.d.	0.60	1.69	1.40	-0.88	-1.31	-0.58	-0.50	0.94	-0.12	1.11	1.33	0.88
	TSI	2000-2007	-0.20	-1.00	-0.75	-0.59	-0.33	0.11	2.14	0.61	0.45	-0.10	-1.21	-0.74	-0.38	1.73	-0.73	0.36	1.08	4.73
	TASO	2000-2007	-0.39	-0.62	-0.55	-0.53	-0.45	-0.23	2.33	0.45	0.11	-0.32	-1.93	1.55	-0.13	0.73	0.22	0.23	-0.36	3.67
	TCEN	2003-2007	n.d.	n.d.	n.d.	n.d.	-0.31	-0.91	-0.21	1.43	0.14	n.d.	n.d.	n.d.	1.62	0.19	-1.01	-0.44	-0.36	0.56
	TBB	2000-2007	-0.67	-1.55	-0.74	-0.49	1.32	0.49	0.77	0.88	4.78	0.66	-1.23	0.67	-0.31	1.62	-0.27	-1.33	0.19	-0.75
	TIDM	2000-2007	0.03	-1.43	-0.27	-0.62	-0.42	0.06	1.97	0.66	2.31	-0.77	0.07	1.71	1.08	-0.07	-1.33	-0.72	0.04	1.43
	TDC	2000-2007	1.29	-1.25	-1.38	-0.60	0.97	0.68	0.32	-0.02	1.17	0.75	-1.13	1.37	0.23	-0.42	-1.46	0.92	-0.28	0.12
Cop. nauplii abundance	TESL	2000-2007	n.d.	-0.58	-0.67	0.95	-0.63	n.d.	-0.64	1.58	-0.55	-0.44	-0.87	-0.68	1.90	0.09	-0.80	-0.30	1.11	-0.15
	TSI	2000-2007	0.04	-1.23	-0.68	-1.13	-0.04	0.38	1.14	1.51	0.71	0.03	-1.31	0.48	1.30	0.33	-0.98	-1.00	1.15	1.03
	TASO	2000-2007	-0.83	-0.56	-0.23	-0.77	0.22	-0.48	2.21	0.44	2.65	-0.50	-1.38	0.50	1.51	-0.70	0.05	-0.66	1.18	2.78
	TCEN	2003-2007	n.d.	n.d.	n.d.	n.d.	-0.32	-0.55	-0.62	1.49	-0.47	n.d.	n.d.	n.d.	1.39	-0.62	-0.93	-0.55	0.71	3.39
	TBB	2000-2007	-1.15	-0.35	0.47	0.95	0.65	-0.70	-1.26	1.38	2.20	2.07	-1.07	0.28	0.07	0.18	-0.64	-1.01	0.12	-0.68
	TIDM	2000-2007	-0.33	-0.69	1.27	-0.62	1.90	-0.36	-0.66	-0.50	-0.56	-0.23	-1.24	1.40	1.04	-0.21	-1.21	-0.40	0.85	-0.02
	TDC	2000-2007	0.67	0.80	-0.53	-0.61	1.88	-0.72	-0.94	-0.54	-0.34	1.32	-0.46	0.53	-0.83	-1.02	-1.14	0.33	1.27	-0.26
Small cop. abundance	TESL	2000-2007	n.d.	-1.13	-0.62	-0.48	-0.23	n.d.	1.30	1.16	1.84	-0.91	-1.07	-0.84	-0.46	1.09	-0.19	1.32	1.06	1.15
	TSI	2000-2007	-0.12	-0.95	-0.70	-0.67	-0.41	0.29	2.17	0.39	0.71	0.22	-0.98	-0.55	-1.28	1.81	-0.32	0.41	0.69	4.75
	TASO	2000-2007	-0.30	-0.57	-0.54	-0.56	-0.47	-0.22	2.38	0.28	0.28	-0.22	-1.76	1.61	-0.29	0.89	0.16	0.19	-0.57	4.08
	TCEN	2003-2007	n.d.	n.d.	n.d.	n.d.	-0.25	-1.17	0.18	1.24	0.52	n.d.	n.d.	n.d.	1.49	0.45	-1.10	-0.51	-0.33	0.62
	TBB	2000-2007	-0.44	-1.52	-0.80	-0.59	1.10	0.47	1.39	0.39	4.75	0.73	-1.30	0.58	-0.29	1.61	-0.26	-1.29	0.22	-0.59
	TIDM	2000-2007	0.39	-1.54	-0.32	-0.79	-0.33	0.35	1.83	0.40	1.75	-0.70	-0.13	1.74	1.08	-0.11	-1.34	-0.68	0.14	1.69
	TDC	2000-2007	1.40	-1.14	-1.41	-0.56	0.76	0.87	0.28	-0.20	1.22	0.68	-1.06	1.36	0.35	-0.38	-1.54	0.90	-0.32	0.21
Large cop. abundance	TESL	2000-2007	n.d.	-0.82	-0.67	-0.49	0.05	n.d.	0.03	1.90	0.94	-0.16	-1.56	1.00	-0.37	-0.34	0.27	-0.56	1.71	-0.92
	TSI	2000-2007	-0.32	-1.04	-0.80	-0.42	-0.17	-0.22	1.99	0.98	-0.03	-0.75	-0.28	-0.30	2.20	-0.55	-0.80	-0.19	0.68	-1.06
	TASO	2000-2007	-0.50	-0.69	-0.57	-0.48	-0.42	-0.25	2.23	0.69	-0.14	-0.72	-1.77	0.20	0.98	-0.74	0.47	0.37	1.21	-1.25
	TCEN	2003-2007	n.d.	n.d.	n.d.	0.00	-0.34	-0.44	-0.70	1.48	-0.40	n.d.	n.d.	n.d.	1.76	-0.49	-0.69	-0.21	-0.37	0.34
	TBB	2000-2007	-0.91	-1.11	-0.39	-0.15	1.31	0.38	-0.69	1.56	3.29	-0.69	0.33	1.67	-0.39	1.14	-0.24	-1.40	-0.42	-2.79
	TIDM	2000-2007	-1.41	-0.10	0.12	0.44	-0.49	-1.13	1.28	1.29	3.07	-1.09	1.59	0.91	0.71	0.25	-0.83	-0.78	-0.76	-1.02
	TDC	2000-2007	-0.09	-1.24	-0.48	-0.52	1.69	-0.85	0.39	1.10	0.23	1.19	-1.46	1.15	-0.80	-0.68	-0.46	0.89	0.16	-0.67
C. fin. (CIV-CV) abundance	TESL	2000-2007	n.d.	-0.84	-0.80	-0.58	1.57	n.d.	-0.24	0.90	1.27	-0.43	-1.28	1.47	0.17	-0.55	-0.75	-0.07	1.44	-0.92
	TSI	2000-2007	-0.64	-0.81	-0.86	-0.52	0.47	-0.22	2.11	0.47	0.07	-0.49	-0.58	-0.44	2.12	-0.40	-1.05	0.19	0.65	-1.09
	TASO	2000-2007	-0.61	-0.71	-0.68	-0.57	-0.32	-0.29	1.38	1.80	0.02	-0.41	-1.44	-0.21	1.59	0.17	-0.84	1.20	-0.06	-1.39
	TCEN	2003-2007	n.d.	n.d.	n.d.	n.d.	-0.61	-0.68	-0.18	1.46	-0.47	n.d.	n.d.	n.d.	1.66	-0.72	-0.83	-0.18	0.06	0.01
	TBB	2000-2007	0.01	-1.05	-1.17	-1.13	0.46	0.78	1.40	0.70	0.36	-1.31	1.26	1.35	0.77	-0.31	-0.38	-0.84	-0.54	-2.41
	TIDM	2000-2007	-0.40	-0.50	-0.64	-0.44	-0.32	-0.72	2.14	0.88	2.42	-1.13	1.52	0.72	0.97	0.20	-0.86	-0.46	-0.97	-1.06
	TDC	2000-2007	0.80	-0.95	-0.88	-0.38	-0.28	-0.34	2.08	-0.06	0.14	0.45	-1.72	1.29	-0.40	-0.70	0.52	1.02	-0.46	-0.76
Meroplankton abundance	TESL	2000-2007	n.d.	-0.60	-0.76	-0.31	-0.66	n.d.	0.51	1.81	-0.26	0.65	-0.52	-0.72	-0.71	-0.70	-0.72	0.80	1.91	-0.30
	TSI	2000-2007	-0.37	-0.38	-0.38	-0.38	-0.38	-0.36	2.47	-0.21	-0.29	-0.35	-0.53	-0.38	-0.44	-0.53	-0.50	0.37	2.36	-0.02
	TASO	2000-2007	-0.49	-0.51	-0.53	-0.55	-0.55	-0.39	2.19	0.83	-0.11	-0.16	-0.65	-0.55	-0.38	-0.57	-0.64	0.74	2.20	0.77
	TCEN	2003-2007	n.d.	n.d.	n.d.	n.d.	-0.51	-0.89	0.00	1.40	0.69	n.d.	n.d.	n.d.	-0.19	0.20	-1.26	-0.25	1.50	-1.72
	TBB	2000-2007	-0.87	-0.39	-0.99	-0.95	0.35	0.02	1.21	1.62	1.08	-0.02	-0.83	0.62	-0.83	-0.02	-0.67	2.15	-0.41	-0.76
	TIDM	2000-2007	0.03	-1.18	-0.58	-0.69	-0.84	1.15	1.57	0.54	3.86	-0.99	-1.10	1.29	0.21	-0.78	-0.55	1.37	0.55	0.48
	TDC	2000-2007	-0.54	-0.43	-0.99	-0.68	0.40	2.21	-0.06	0.10	0.08	-0.83	-1.13	-0.25	-0.39	1.13	-0.86	1.40	0.93	-0.64
Carnivorus zooplankton abundance	TESL	2000-2007	n.d.	-0.32	-1.40	-0.76	0.56	n.d.	1.28	0.64	4.91	0.97	-0.45	-0.83	-1.27	0.66	-1.06	0.85	1.13	0.50
	TSI	2000-2007	-0.36	-0.67	-1.03	-0.23	0.46	-0.87	0.76	1.94	0.02	0.69	-0.39	-1.28	0.70	-0.20	-1.46	1.25	0.70	0.53
	TASO	2000-2007	-0.98	-0.44	-0.74	0.15	0.04	-0.81	0.80	1.99	-0.02	1.60	-0.17	-1.08	-0.64	-0.23	-1.17	0.75	0.93	1.64
	TCEN	2003-2007	n.d.	n.d.	n.d.	n.d.	0.66	-0.78	1.05	-0.92	0.19	n.d.	n.d.	n.d.	-1.08	-0.73	0.04	1.49	0.27	0.88
	TBB	2000-2007	-0.39	-0.83	-0.66	-0.54	-0.29	0.19	2.29	0.23	-0.24	0.10	0.85	-1.47	-1.19	0.98	-0.64	1.11	0.26	-1.07
	TIDM	2000-2007	-0.49	-0.76	-0.69	-0.75	-0.69	0.74	0.76	1.88	4.19	-0.43	-0.36	-0.67	0.82	-0.08	2.13	-0.81	-0.60	0.67
	TDC	2000-2007	0.40	-0.37	-1.27	-0.01	-0.55	2.07	0.36	-0.62	0.59	0.79	-0.79	-1.43	-1.01	1.46	0.65	-0.02	0.34	0.21
Meso. abundance (no-cop.)	TESL	2000-2007	n.d.	-0.49	-0.36	-0.42	-0.42	n.d.	-0.35	2.04	-0.35	-0.11	-0.85	-1.19	-0.18	-0.33	0.06	0.50	2.11	-0.09
	TSI	2000-2007	-0.63	-0.70	-0.56	-0.43	-0.55	-0.33	1.82	1.38	-0.28	-0.67	-0.83	-0.27	-0.66	-0.29	-0.46	1.53	1.65	5.54
	TASO	2000-2007	-0.52	-0.56	-0.51	-0.37	-0.37	-0.40	0.37	2.36	-0.07	0.12	-0.89	0.24	-1.42	-0.58	0.05	1.83	0.66	23.98
	TCEN	2003-2007	n.d.	n.d.	n.d.	n.d.	-0.92	-0.30	1.42	-0.20	-1.04	n.d.	n.d.	n.d.	-0.96	-0.99	0.22	0.35	1.38	0.76
	TBB	2000-2007	-0.90	-0.83	-1.05	-0.23	0.43	1.76	1.01	-0.18	-0.56	0.96	-1.21	1.77	-0.73	0.04	-0.75	-0.47	0.40	0.34
	TIDM	2000-2007	-0.67	-0.33	0.00	-0.52	-0.54	2.41	-0.23	-0.12	-0.22	-0.33	-0.69	-0.20	-0.49	-0.53	-0.18	0.02	2.41	-0.08
	TDC	2000-2007	0.36	-0.92	-0.82	-0.84	-0.61	1.94	0.68	0.22	-0.42	-0.59	-0.65	-0.30	-0.30	-0.31	-0.47	0.24	2.38	0.43
Krill larva abundance	TESL	2000-2007	n.d.	-0.41	-0.42	-0.39	n.d.	-0.42	-0.40	2.04	-0.42	-0.52	-0.52	-0.40	-0.52	2.40	-0.52	0.10	-0.01	0.08
	TSI	2000-2007	0.02	-0.55	-0.18	-0.65	-0.65	-0.55	0.24	2.33	-0.38	-0.83	-0.83	-0.83	0.59	-0.83	1.89	0.41	0.41	6.33
	TASO	2000-2007	-0.53	-0.54	-0.54	-0.54	-0.54	-0.54	1.68	1.56	-0.47	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	0.07	2.44	11.49
	TCEN	2003-2007	n.d.	n.d.	n.d.	n.d.	0.20	-1.38	1.01	0.17	-0.34	n.d.	n.d.	n.d.	1.79	-0.45	-0.53	-0.41	-0.39	0.00
	TBB	2000-2007	0.27	-0.87	-0.52	-0.41	1.79	-0.82	-0.64	1.20	1.31	-0.68	-0.68	-0.68	-0.58	-0.64	0.32	1.95	0.99	0.60
	TIDM	2000-2007	0.89	-1.12	0.95	-0.93	-1.01	0.40	1.33	-0.50	5.28	-0.47	-0.47	-0.47	2.45	-0.05	-0.28	-0.42	-0.31	-0.22
	TDC	2000-2007	0.92	-0.88	-0.88	0.61	1.78	-0.69	-0.77	-0.10	-0.51	-0.55	-0.55	-0.55	0.63	-0.53	-0.46	-0.26	2.27	-0.13

Figure 13. Anomalies in zooplankton abundance from the Québec AZMP sections from 2000 to 2008 (Nov. 2003–2008 for TCEN). The anomalies are normalized with respect to their standard deviations over the 2000–2007 periods (2003–2008 for TCEN). (cop.= copepod, meso = mesozooplankton).

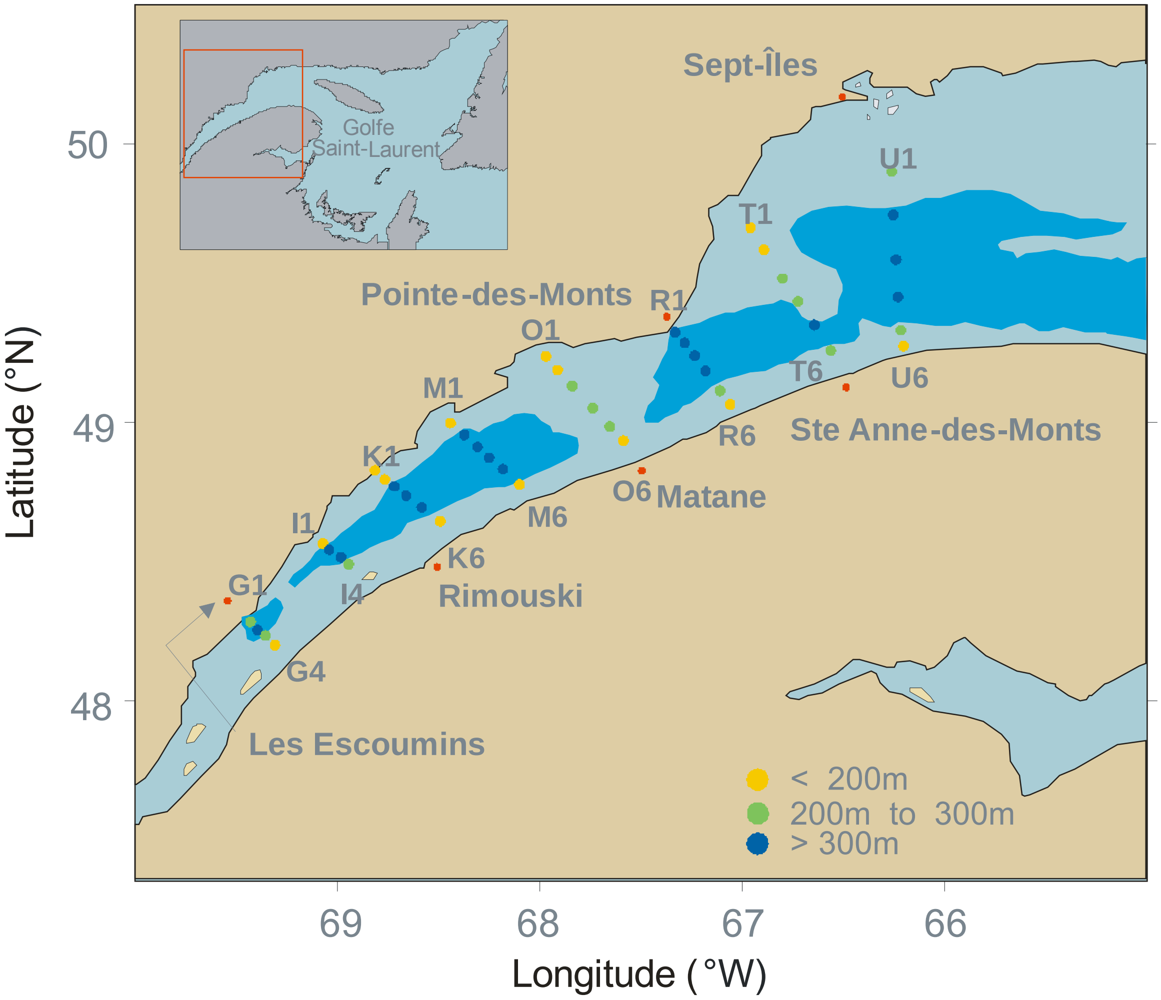
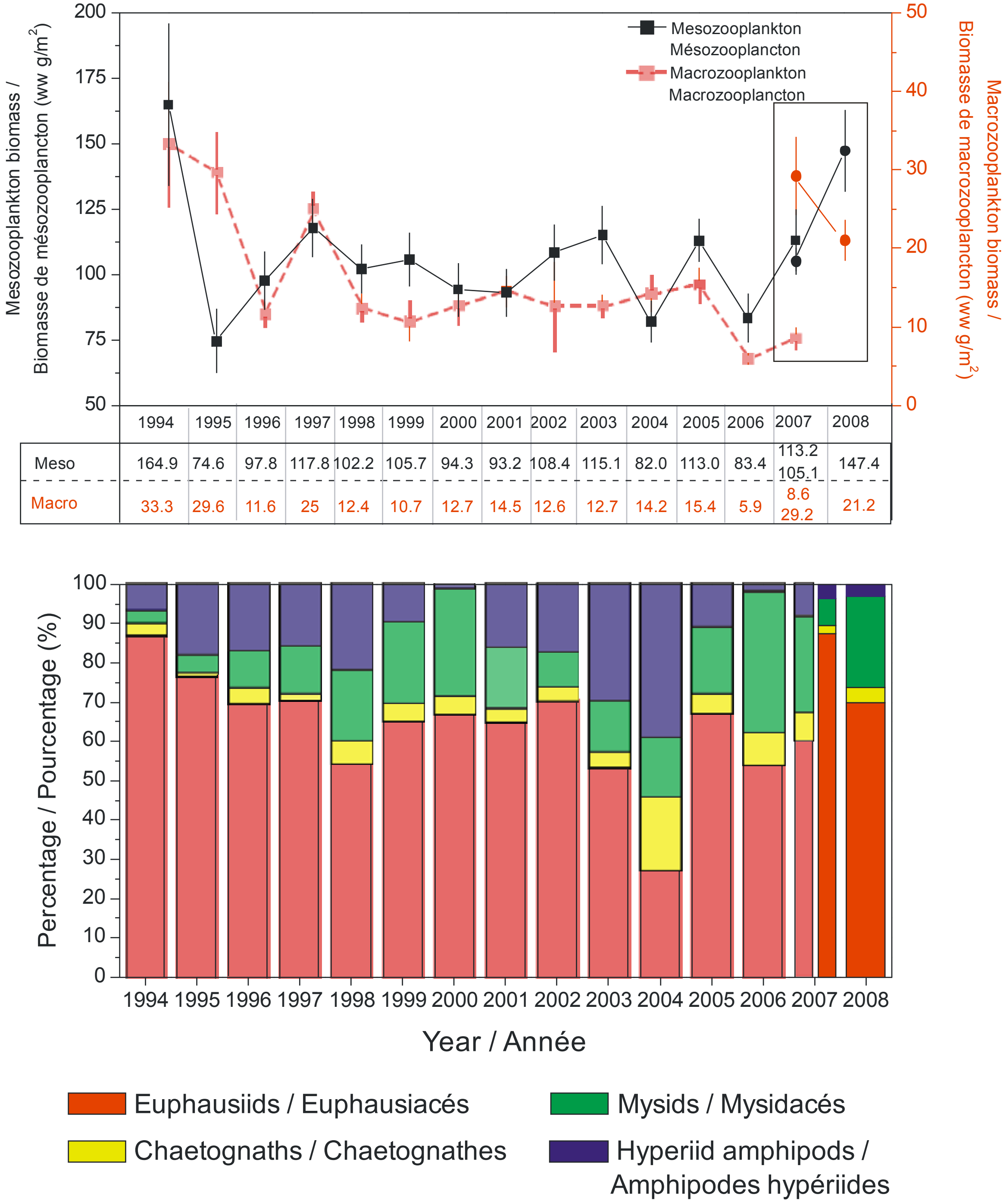


Figure 14. Map showing station locations of the annual zooplankton survey in the Lower St. Lawrence Estuary (sections G to O) and the northwest Gulf of St. Lawrence (sections R to U). The survey took place in September from 1994 until 2003 and in late October–November since 2004.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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	113.2 105.1	147.4
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	8.6 29.2	21.2

Figure 15. Mean mesozooplankton and macrozooplankton biomass (± SE) in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence from 1994 to 2008 (upper panel) and the relative contribution of the four most important macrozooplankton groups to the biomass (lower panel). A comparative sampling was done in 2007 (strobe on or strobe off; see text for details). The change in symbol shape (outlined in the upper panel) and slight colour change in the bars (lower panel) identify data collected with the strobe on in 2007 and 2008.

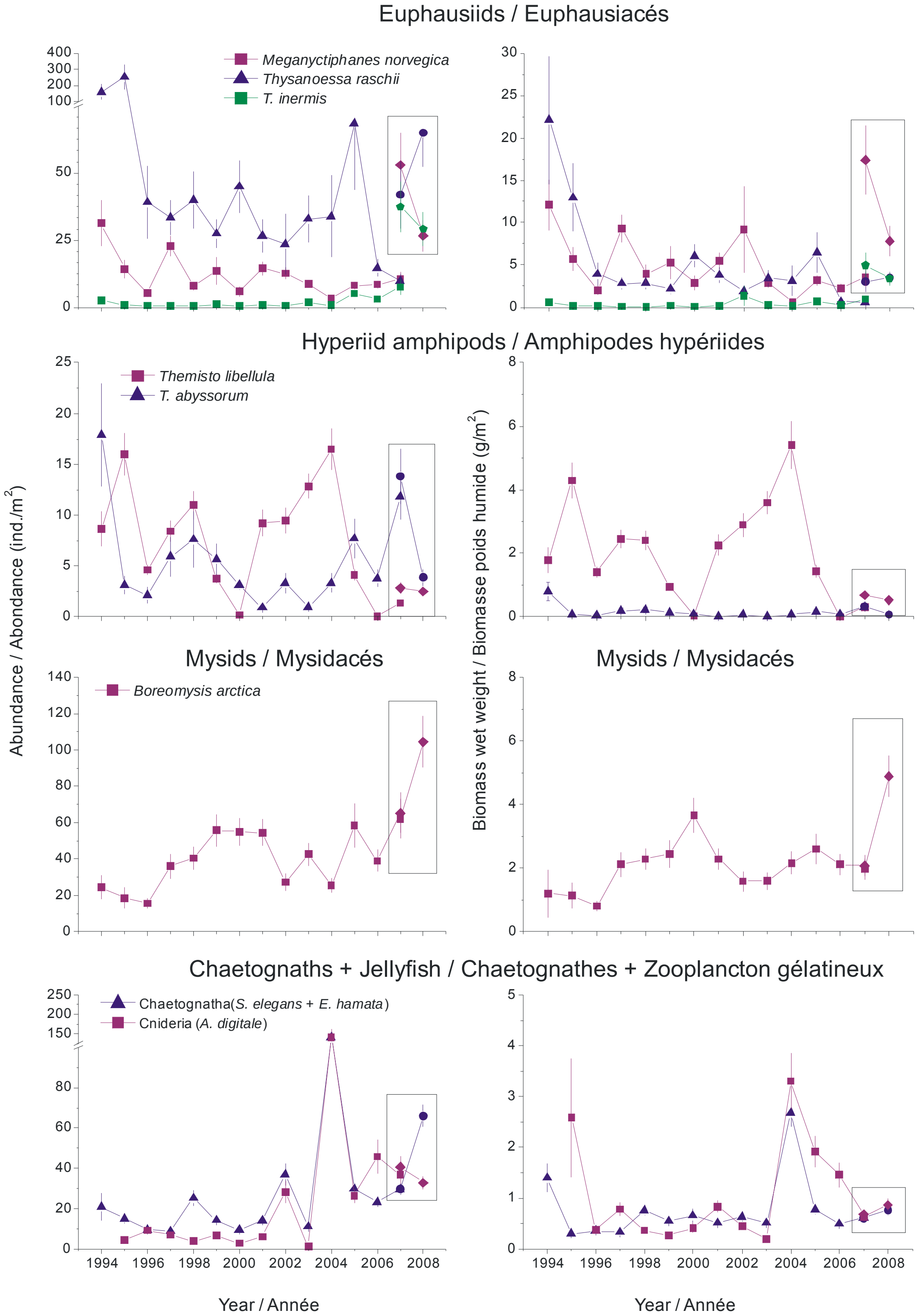


Figure 16. Mean abundance (left panels) and biomass (right panels) (± SE) of the most important species of macrozooplankton in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence from 1994 to 2008. A comparative sampling was done in 2007 (strobe on or strobe off; see text for details). The change in symbol shape (outlined) identifies data collected with the strobe on in 2007 and 2008.

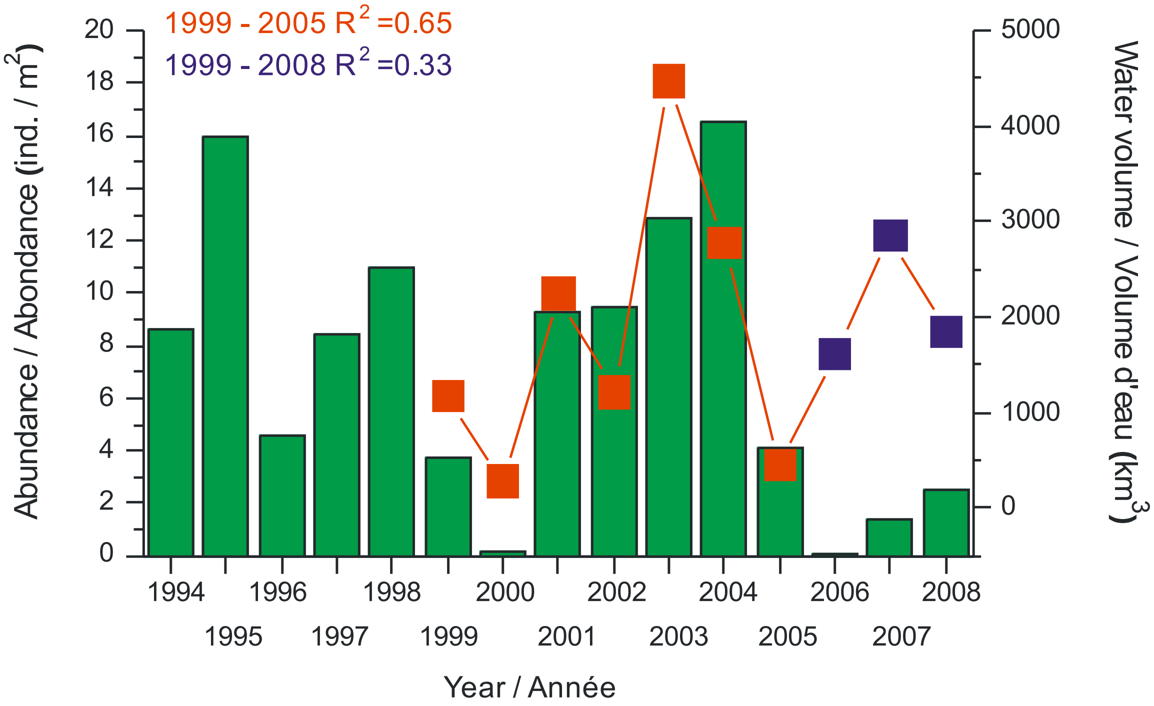
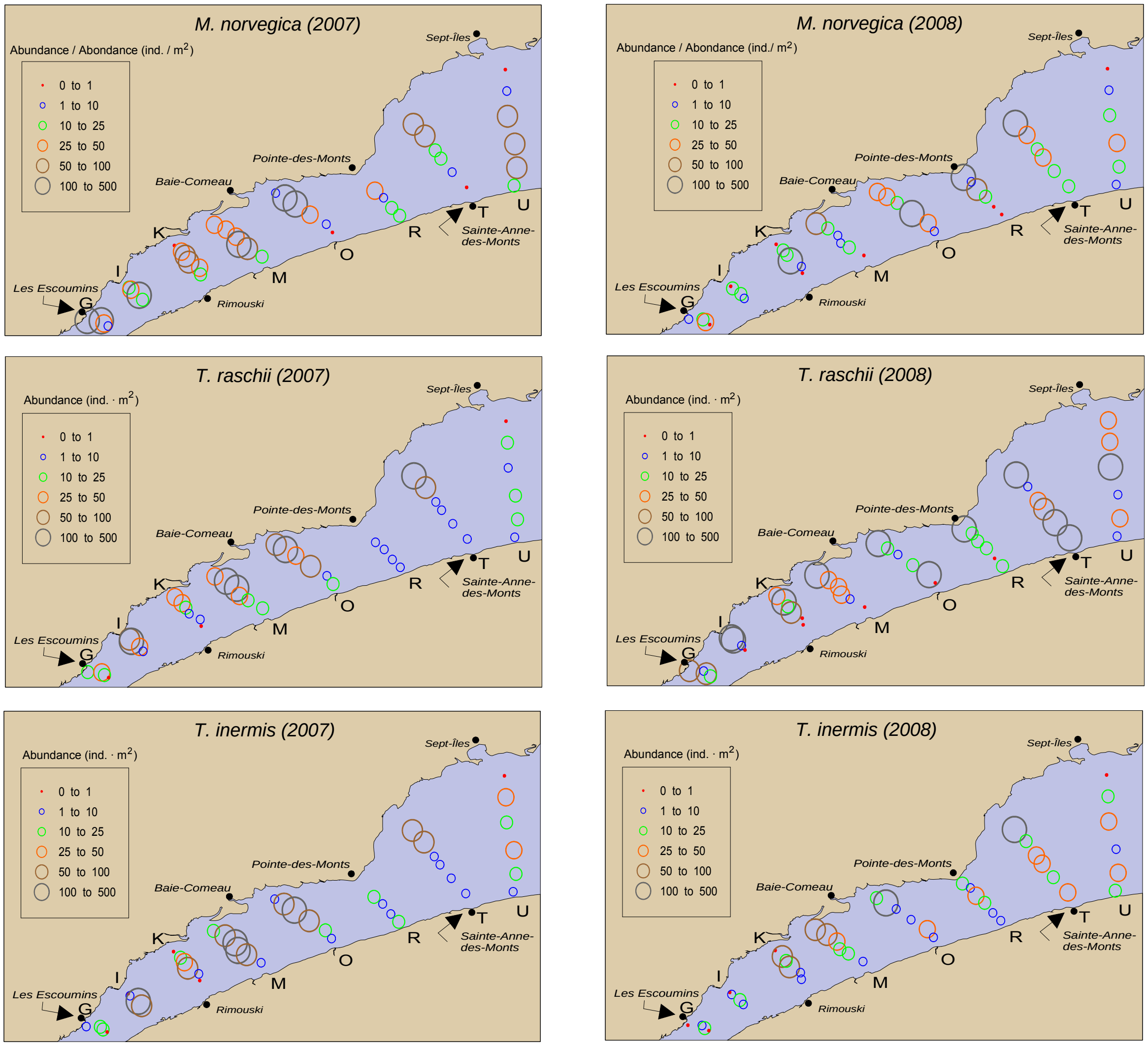


Figure 17. Relationship between the annual volumes of Labrador Shelf water advected into the Gulf of St. Lawrence in winter (symbols) and the annual mean abundance of the hyperiid amphipod *Themisto libellula* (bars) in the Lower St. Lawrence Estuary and northwest Gulf of St. Lawrence from 1994 to 2008.

Euphausiids / Euphausiacés



Mysids / Mysidacés

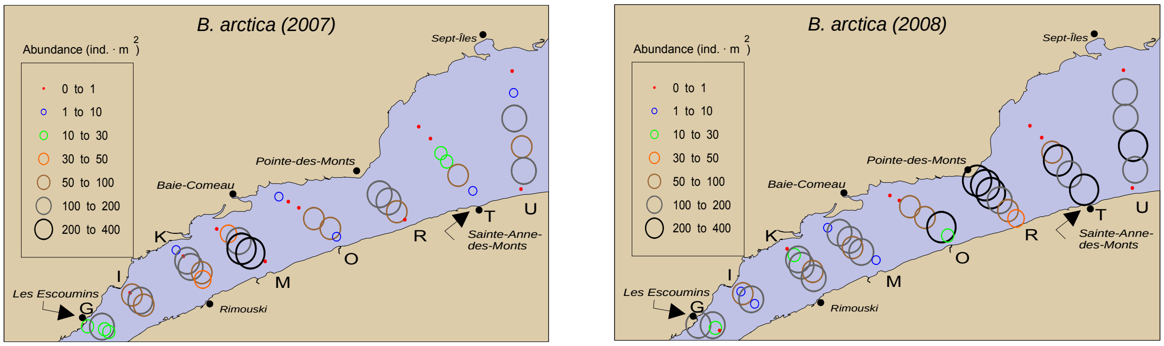
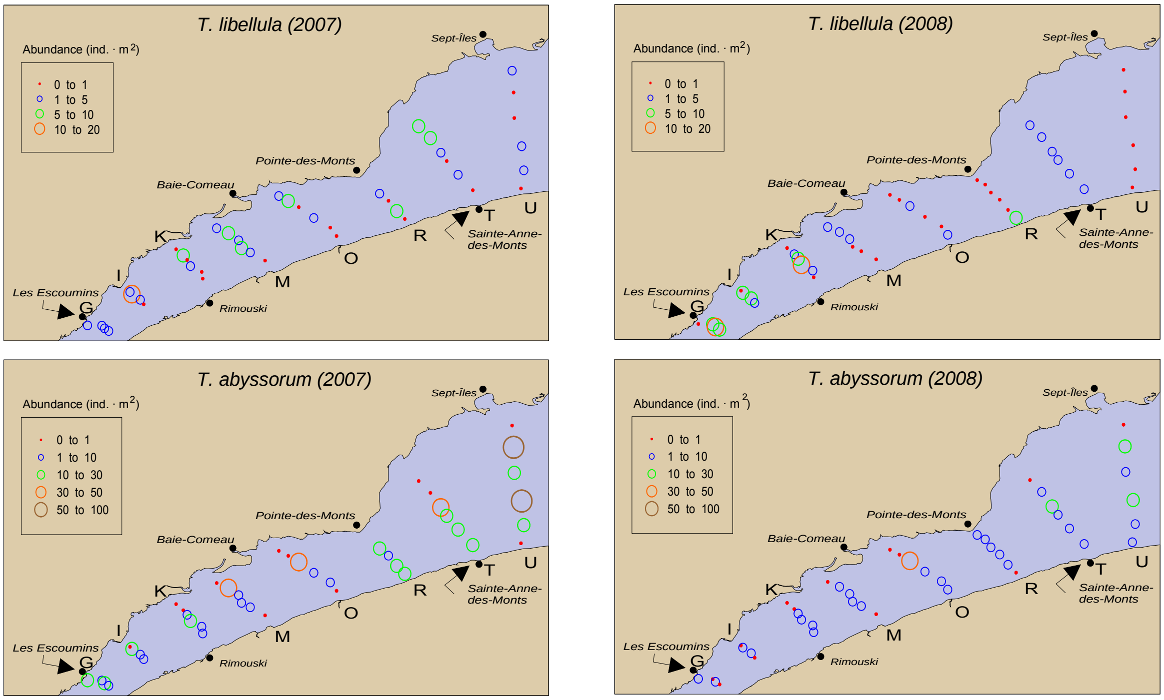
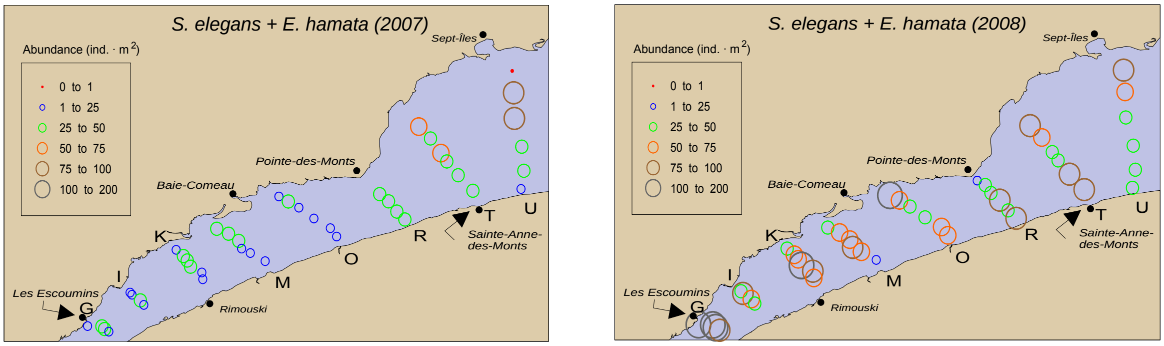


Figure 18a. Abundance (ind/m^2) and spatial distribution of the most important species of macrozooplankton sampled in the Lower St. Lawrence Estuary and the northwest Gulf of St. Lawrence in 2007 and 2008 with the use of a stroboscope. Euphausiids and mysids.

Hyperiid amphipods / Amphipodes hypériids



Chaetognaths / Chaetognathes



Jellyfish / Zooplancton gélatineux

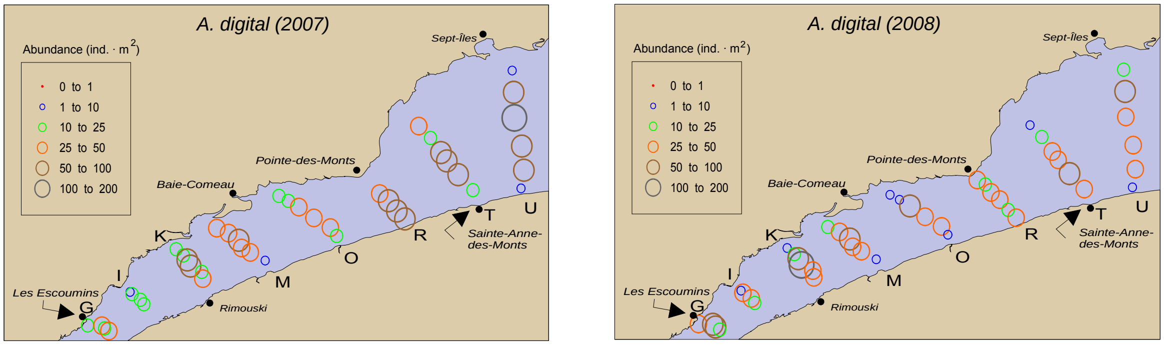


Figure 18b. Hyperiid amphipods, chaetognaths, and Jellyfish.