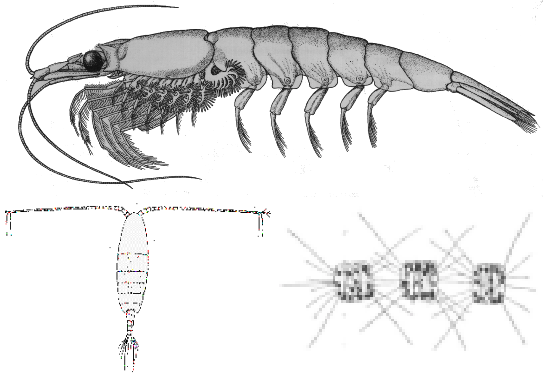


State of phytoplankton and zooplankton in the Estuary and northwestern Gulf of St. Lawrence during 1999

Background

Phytoplankton are microscopic plants that form the base of the aquatic food web, occupying a position in the marine environment analogous to terrestrial plants on land. They use light to synthesize organic matter from inorganic carbon and nutrients dissolved in marine waters. Thus, they are responsible for ocean productivity. The rate at which phytoplankton produce new organic matter in the marine environment is determined by nutrient availability (especially nitrogen compounds), light intensity, and temperature. The maximum potential level of primary productivity in a system also depends on additional factors such as the freshwater runoff and the stratification of the water column. Because the spatio-temporal variability in the phytoplankton abundance may have an important impact on harvestable fisheries, a principal objective of the Atlantic Zonal Monitoring Program (AZMP) is to quantify the changes in nutrients and the plankton they support, including zooplankton.

Zooplankton are animals that range in size from smaller than 1 mm (e.g. copepods) to about 4 cm (e.g. krill). Because zooplankton are the principal consumers of phytoplankton, they represent a critical link in the food web between phytoplankton and larger animals. Zooplankton are fed on by all species of fish at some time in the fishes' life cycle.

This SSR presents the state of phytoplankton and zooplankton in the Estuary and northwestern Gulf of St. Lawrence during 1999. Information are derived from AZMP data collected at a network of stations (fixed point stations, cross-shelf sections, groundfish and zooplankton surveys) sampled at a frequency of weekly to once annually.

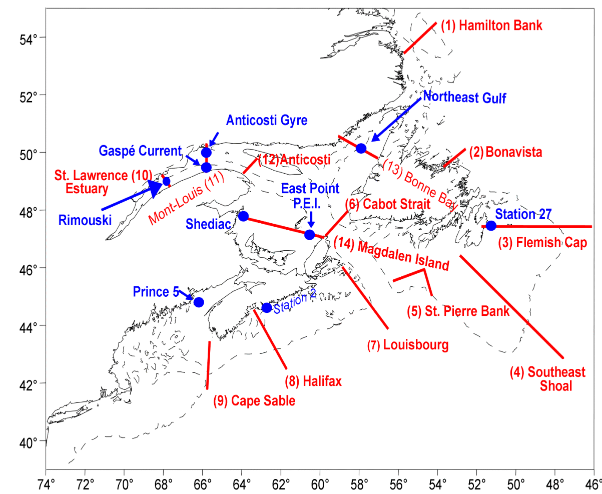


Figure 1. Atlantic Zonal Monitoring Program (AZMP) sections (lines) and fixed stations (dots).

Summary

- In 1999, for the second consecutive year, the initiation of the major phytoplankton bloom in the lower St. Lawrence Estuary occurred several weeks earlier than usual. This is believed to be due to above-normal air temperatures observed during the winter-spring which in turn caused earlier snow melting in the St. Lawrence Estuary drainage basin.
- The major phytoplankton bloom was longer and more intense in 1999 than in 1998 for most areas of the lower St. Lawrence Estuary.
- In the Gaspé Current, phytoplankton biomass levels were generally higher throughout most of 1999 compared to recent years (1996-1998). Although the phytoplankton concentrations in 1999 were not notably different within the Anticosti Gyre compared to recent years, the seasonal evolution of nutrients indicates that the new spring production was 1.5 – 2 times higher during 1999 compared to 1998 and 1997.

- The biomass of both mezooplankton and krill in the lower St. Lawrence Estuary were similar in 1999 compared to 1995-1998 but were respectively 2 and 5 times lower than in 1994.
- In the northwestern Gulf of St. Lawrence, the total zooplankton biomass was much higher in the Anticosti Gyre than in the Gaspé Current for all seasons in 1999. Copepods were clearly dominant.
- Overall, there were higher stocks of phytoplankton in the Estuary and northwestern Gulf of St. Lawrence compared to recent years, and the year as a whole appears to have been more productive. Nevertheless, zooplankton biomass levels were similar in 1999 compared to the previous four years.

Lower St. Lawrence Estuary

Timing, duration, and magnitude of the primary bloom in the lower St. Lawrence Estuary

In most marine waters, phytoplankton undergo spring-summer population explosions called blooms. In the lower St. Lawrence Estuary, the primary phytoplankton bloom is a well-established seasonal event representing the major net input of carbon into the food web in the estuary as well as in the southern part of the Gulf of St. Lawrence via the Gaspé Current. To follow the inter-annual variability in timing, duration, and magnitude of the spring phytoplankton bloom, Station Rimouski (Figure 1) has been visited on a weekly basis from May to September since 1995.

In 1999, the standing stock of phytoplankton at Station Rimouski, as reflected by the amount of chlorophyll *a*, showed high levels from early May to mid August (Figure 2), with integrated values in the upper 50 m ranging from 200 to 1100 mg of chlorophyll *a* · m^{-2}. A secondary bloom was observed during August-September, following the primary bloom by only 2 weeks.

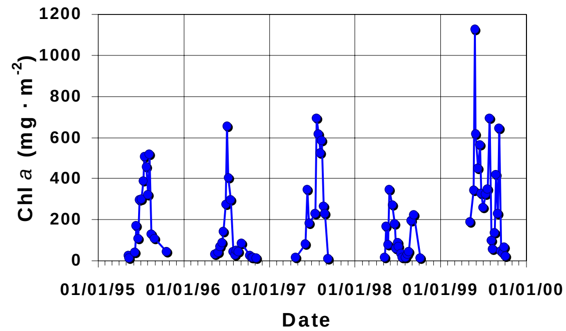


Figure 2. Chlorophyll a *concentrations integrated over the upper 50 m at Station Rimouski during spring-summer 1995-1999.*

Compared to recent years, the onset of the primary bloom at Station Rimouski in 1999 was about the same time as in 1998 (early May) but several weeks earlier compared to the 1995-1997 period (mid-June; Figure 3). A comparison of these results with historical data on phytoplankton biomass in the lower St. Lawrence Estuary suggests that the primary bloom development in early May, as observed in 1999 and 1998, is unusual for this region.

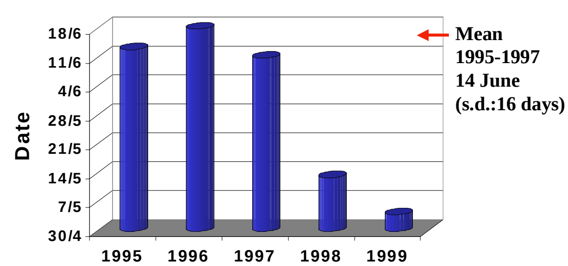


Figure 3. Date of onset of the primary bloom defined by the first incidence of chlorophyll concentrations greater than 100 mg of chlorophyll a · *m^{-2} at Station Rimouski, 1995-1999.*

Typically, the spring phytoplankton bloom in the lower St. Lawrence Estuary starts just after the spring-summer runoff peak. The warmer-than-normal air temperatures observed during the winter-spring of both 1998 and 1999, which in turn caused earlier snow melting in the St. Lawrence Estuary drainage basin, could be responsible for this recent shift seen in the timing of the phytoplankton cycle.

The primary bloom duration at Station Rimouski in 1999 (90 days) was approximately twice as long as in 1998 and 1996 but similar to 1995 and 1997 (Figure 4). On the other hand, the average phytoplankton biomass levels were approximately 3 times higher during spring-summer (May-August) 1999 compared to 1998 and 2 times higher than the mean for the 1995-1997 period (see Figure 5).

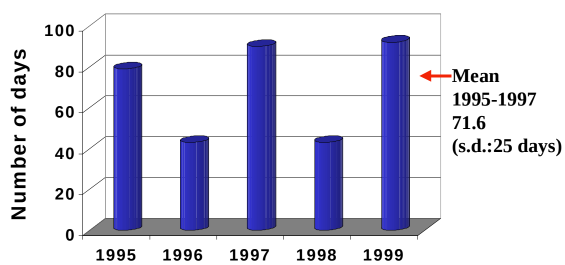


Figure 4. Primary bloom duration (number of days) at Station Rimouski, 1995-1999.

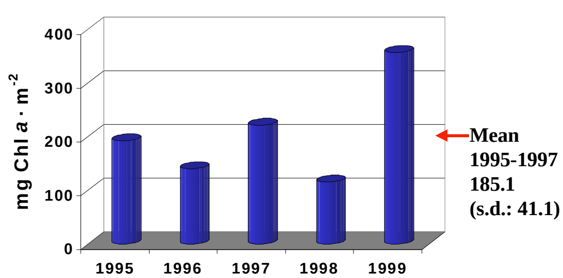


Figure 5. Mean integrated (surface to 50 m depth) chlorophyll a *levels at Station Rimouski from May to August, 1995-1999.*

Phytoplankton biomass was also assessed from ocean color data collected by the Sea-viewing Wide Field-of-View (SeaWiFS) satellite sensor launched by NASA in late summer 1997. Satellite data do not give information for the water column but provide high-resolution (1 km) data on the geographical distribution of phytoplankton in surface waters over a large scale. The satellite data indicate that the major phytoplankton bloom was somewhat earlier, longer and more intense in 1999 than in 1998 for most areas of the St. Lawrence Estuary, consistent with the observations from Station Rimouski.

Zooplankton biomass in the lower St. Lawrence Estuary

An annual zooplankton survey was initiated in 1993 to follow the spatio-temporal variability in zooplankton abundance in the lower St. Lawrence Estuary. This survey is conducted in September and involves sampling (with a 1 m^2 BIONESS equipped with 333-µm mesh nets) at up to 44 stations along 8 transects covering the Lower Estuary from Les Escoumins to Sept-Îles.

During the zooplankton survey of 1999, the integrated mesozooplankton biomass varied between 18 and 273 g wet weight m^{-2} with the highest values found in the western part of the sampled area (Figure 6). Furthermore, the integrated biomass increased with station depth, reflecting the abundance of large copepod species (*Calanus hyperboreus*, *C. finmarchicus*) at depth in the Laurentian Channel.

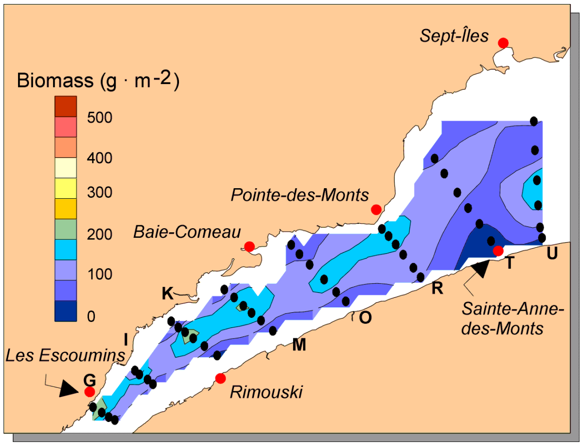


Figure 6. Total wet biomass of mesozooplankton (g · m^{-2}) in the lower St. Lawrence Estuary in 1999.

The krill biomass is less dependent on depth than mesozooplankton biomass, as euphausid species are found at the shallower stations, particularly along the north shore of the estuary. The estimates of krill biomass varied between 0 and 89 g ww · m^{-2}, with the highest values found in the western part of the sampled area (Figure 7).

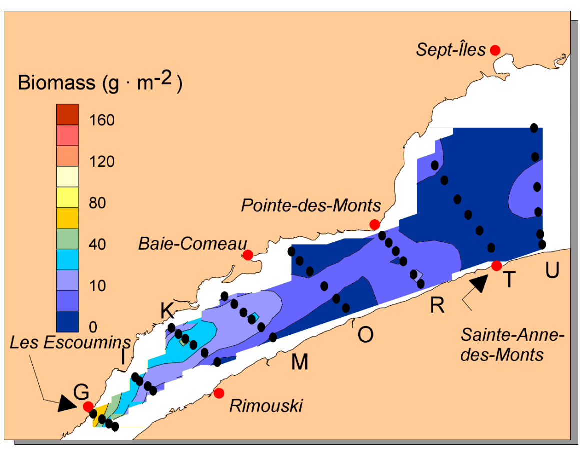


Figure 7. Total wet biomass of krill (g · m^{-2}) in the lower St. Lawrence Estuary in 1999.

Mesozooplankton and krill biomasses for the entire sampled area in 1999 were estimated at 115.6 and 8.2 t·km^{2}, respectively (Table 1). Mesozoplankton and krill biomass levels in September 1999 were not notably different compared to the 1995-1998 period but were respectively 2 and 5 times lower than in September 1994.

Table 1. Standardized wet biomass (in tons) of mesozooplankton and krill for the whole Lower St. Lawrence Estuary from 1994 to 1999.

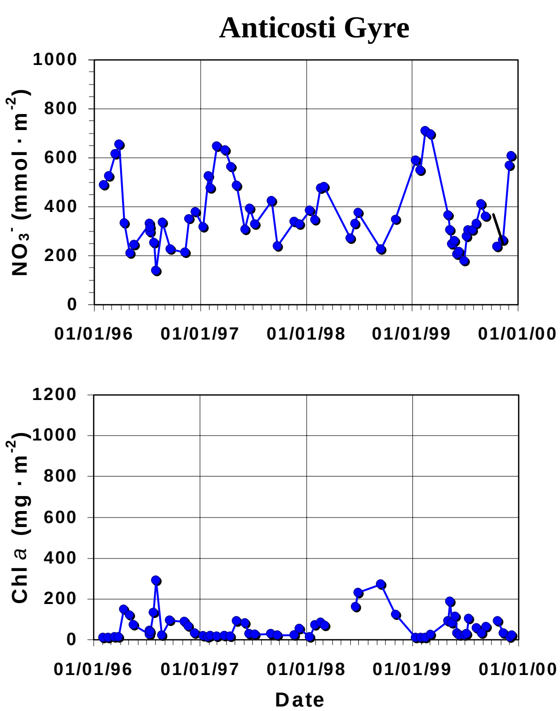
Year	Total area sampled (km^{2})	Standardized biomass (t·km^{-2})	
		Mesozoo-plankton	Krill
1994	9,422	209.2	38.1
1995	10,287	126.7	18.8
1996	10,628	106.5	7.2
1997	12,706	150.4	13.3
1998	13,960	129.1	10.3
1999	11,396	115.6	8.2

Northwest Gulf of St. Lawrence

The northwestern Gulf of St. Lawrence is characterized by a quasi-permanent cyclonic gyre, the Anticosti Gyre. The Anticosti Gyre is separated from the Gaspé Current by a frontal system; the Gaspé Current is a coastal jet resulting from the seaward advection of the low salinity waters of the St. Lawrence estuary along the Gaspé Peninsula. These two systems represent two identifiable pelagic ecosystems. The biological and chemical properties of the Gaspé Current primarily reflect the conditions developing in the lower estuary whereas those found in the Anticosti Gyre are more typical of the conditions prevailing over the Gulf of St. Lawrence proper. Within the AZMP, these two systems are monitored at a frequency of 9 to 16 times per year. Nutrient and chlorophyll sampling was initiated in 1995 whereas zooplankton sampling did not begin until 1999.

Variations in phytoplankton biomass and nutrients in the northwestern Gulf of St. Lawrence

In 1999, nutrient concentrations in near-surface waters (upper 50 m) followed a similar seasonal pattern at both stations in the northwestern Gulf of St. Lawrence: nitrate concentrations were high in late fall-winter and low in spring-summer due to biological consumption by phytoplankton (Figure 8). In the Gaspé Current in 1999, the spring decrease of nitrate coincided with the phytoplankton bloom in the lower St. Lawrence Estuary and also with the marked increase in the chlorophyll concentration in the Current's low salinity surface waters. A second phytoplankton peak was observed at the base of the jet current during summer (July) which is typical. In contrast, no distinct phytoplankton bloom was observed in the Anticosti Gyre in 1999, and chlorophyll concentrations were typically lower compared to the Gaspé Current and the lower St. Lawrence Estuary.



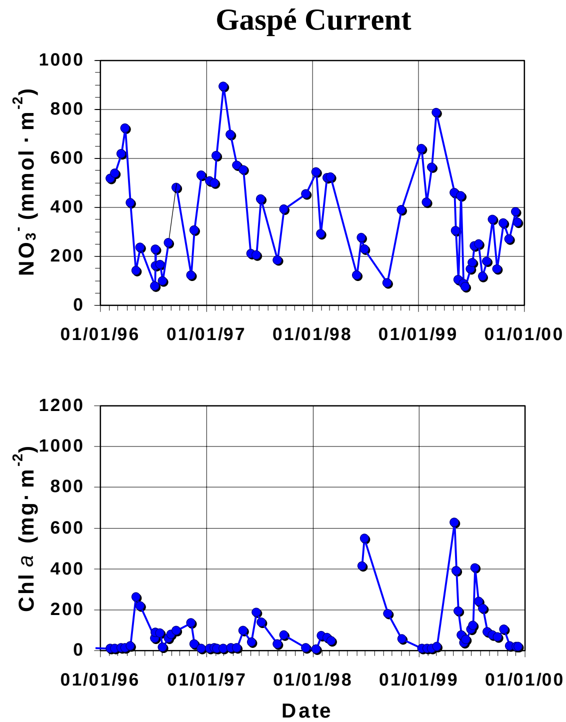


Figure 8. Nitrate (mmol · m^{-2}) and chlorophyll a *(mg · m^{-2}) concentrations in the Anticosti Gyre and Gaspé Current, 1996-1999. Values are integrated over the upper 50 m of the water column.*

Compared to previous years, phytoplankton biomass levels in the Gaspé Current were higher throughout most of 1999 (Figure 8). In particular, the phytoplankton biomass levels were especially high during spring 1999 (May), reflecting the intense bloom in the lower St. Lawrence Estuary. Although the phytoplankton concentrations in 1999 were not notably different in the Anticosti Gyre compared to recent years (Figure 8), the reduction of nitrate during spring of 1999 was much more pronounced compared to 1998 (2 times) and 1997 (1.5 times), suggesting a much higher spring phytoplankton production. The lower phytoplankton biomass in the Anticosti Gyre compared to the Gaspé Current is believed to be a result of greater consumption by the higher zooplankton biomass (see below).

Temporal variability of zooplankton species composition and biomass in the northwestern Gulf of St. Lawrence

In 1999, the total zooplankton biomass varied between 103 and 228 g ww · m^{-2} at the Anticosti Gyre station and between 9 and 83 g ww · m^{-2} at the Gaspé Current station (Figure 9). The maximum and the minimum biomass occurred in March and May respectively at the Anticosti Gyre station while the minimum and the maximum biomass were observed in February and May respectively in the Gaspé Current. The mean biomass for 1999 was 4 times higher in the Anticosti Gyre (146.2 ± 34.4 g ww · m^{-2}) than in the Gaspé Current (37.7 ± 22.4 g ww · m^{-2}). The higher biomass at the Anticosti Gyre station was largely due to the higher abundance of *Calanus hyperboreus*.

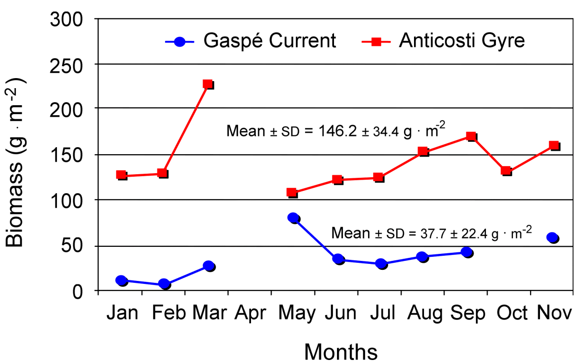


Figure 9. Monthly variations of the zooplankton biomass in the Anticosti Gyre and the Gaspé Current in 1999.

Copepod eggs, juveniles and adults were clearly dominant, accounting for more than 80 % of the zooplankton community at all sampling dates in the Anticosti Gyre and the Gaspé Current (Figure 10). During summer and fall, the relative abundance of copepod eggs and nauplii decreased while the relative abundance of copepodite stages and adult copepods increased.

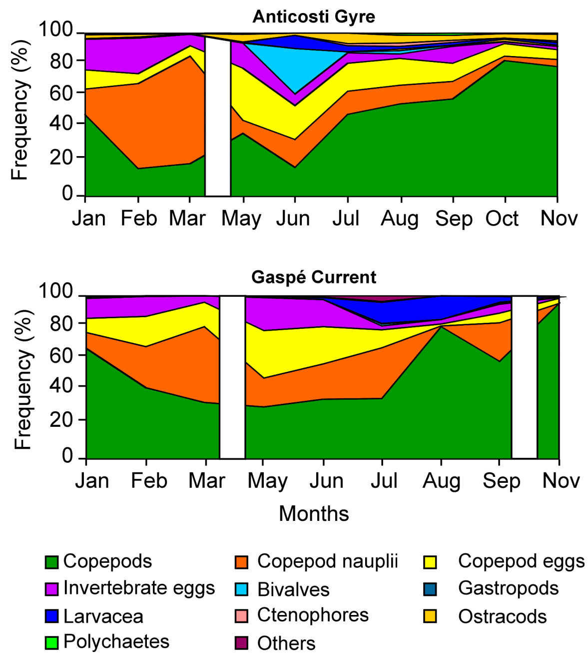


Figure 10. Monthly variations in the zooplankton community structure in the Anticosti Gyre and the Gaspé Current in 1999.

In 1999, the abundance of copepod eggs integrated over the water column varied between 27,000 and 84,500 eggs · m^{-2} in the Anticosti Gyre and between 800 and 86,000 eggs · m^{-2} in the Gaspé Current (Figure 11). The maximum egg abundance occurred in June in the Anticosti Gyre and in May in the Gaspé Current.

Similarly, the abundance of copepod nauplii in 1999 varied between 9,600 and 427,000 ind. · m^{-2} in the Anticosti Gyre and between 500 and 200,000 ind. · m^{-2} in the Gaspé Current (Figure 11). There were two peaks of abundance of copepod nauplii at the Anticosti Gyre station. The first occurred in February and coincided with the reproductive period of *Calanus hyperboreus*; the second occurred in June and coincided with the reproductive period of most other copepod species. At the Gaspé Current station, the first peak of abundance of copepod nauplii occurred in March, one month later than in the Anticosti Gyre, and the second in September, three months later than in the gyre.

Finally, the total abundance of juvenile (copepodites CI-CV) and adult copepods in 1999 varied between 76,000 and 534,000 ind. · m^{-2} in the Anticosti Gyre and between 71,000 and 254,000 ind. · m^{-2} in the Gaspé Current (Figure 11). At both stations the Anticosti Gyre and the Gaspé Current, the minimum and the maximum abundances occurred in spring (April–May) and fall (August–November) respectively.

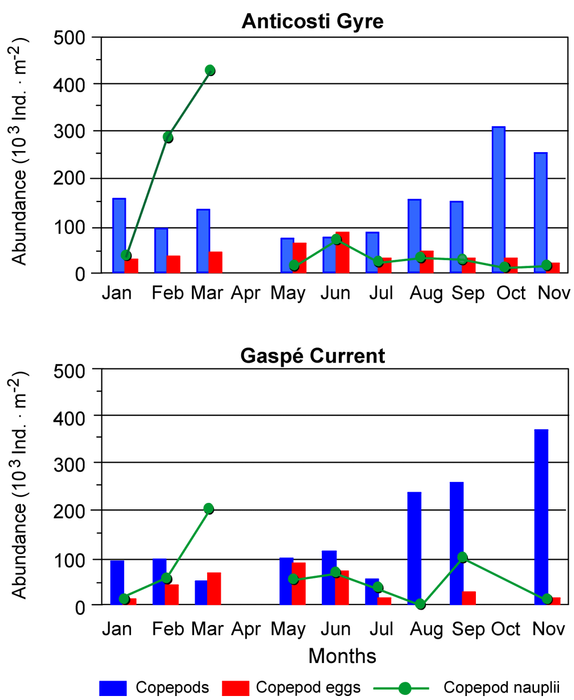


Figure 11. Monthly variations of the integrated copepod abundance in the Anticosti Gyre and the Gaspé Current stations in 1999.

Close examination of the monthly variations of the copepod community structure reveals that small copepods (*Oithona similis*, *Oncea borealis*) were dominant at all sampling dates at both stations except in the Gaspé Current in July and August, when larger species (*Calanus finmarchicus*, *C. glacialis*, *Metridia longa*, *Acartia* sp.) were more abundant (Figure 12). *Oithona similis* and *Oncea borealis* accounted for an average of 54 % of the copepod community at all sampling dates in the Anticosti Gyre and between 7 and 87 % in the Gaspé Current. The large increase in the relative abundance of larger copepod species during the summer months in the Gaspé Current corresponds to the situation observed in 1979 in the lower St. Lawrence Estuary. Finally, *Calanus hyperboreus*, *Eucheata norvegica*, *Microcalanus pusillis*, and *Metridia longa* showed a greater relative abundance in the Anticosti Gyre than in the Gaspé Current while the inverse was true for *Acartia* sp., *C. finmarchicus*, *C. glacialis*, and *Pseudocalanus* sp. (Figure 12).

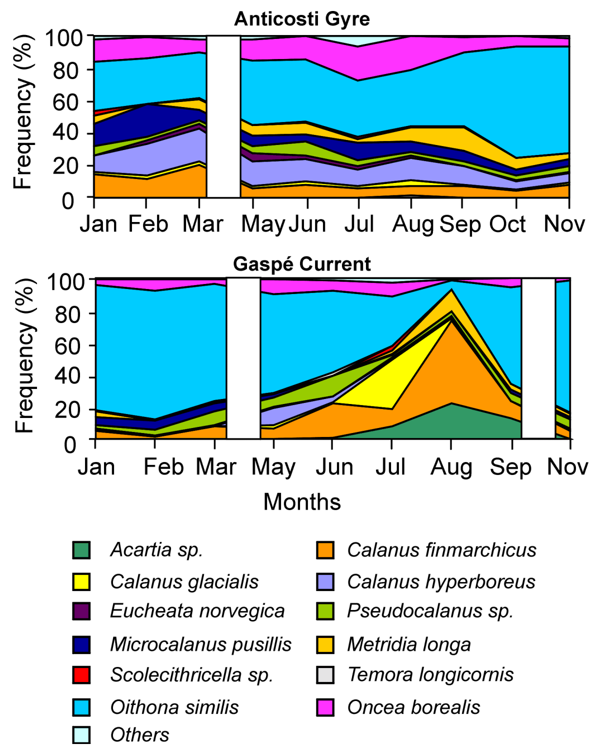


Figure 12. Monthly variations of the copepod community structure in the Anticosti Gyre and the Gaspé Current stations in 1999.

Conclusions

Overall, the environmental conditions in 1999 seem to have supported higher stocks of phytoplankton in the lower Estuary and the northwestern Gulf of St. Lawrence compared to recent years, and the year as a whole was probably more productive. Nevertheless, the copepod and krill biomass levels were not notably different in 1999 compared to recent years, suggesting that others organisms, such as benthos, may have benefited from this higher phytoplankton production.

References:

Gilbert D. (1999). Oceanographic conditions in the Gulf of St. Lawrence in 1998: physical oceanography. DFO Science Stock Status Report G4-01 (1999).

Harvey, M., J.A. Runge, J.F. St-Pierre and P. Joly (2000). Oceanographic conditions in the Estuary and the Gulf of St. Lawrence in 1999 : zooplankton. DFO Can. Stock assessment Sec. Res. Doc. 2000/117, 19 p.

Plourde J. (2000). Oceanographic conditions in the Gulf of St. Lawrence in 1999: physical oceanography. DFO Science Stock Status Report (in preparation).

Therriault, J.-C. and 11 co-authors (1998). Proposal for a Northwest Atlantic Zonal Monitoring Program. Can. Tech. Rep. Hydrogr. Ocean Sci. 194, 57 pp.

For more Information:

Michel Starr
Maurice Lamontagne Institute
850 route de la Mer
P.O. Box 1000
Mont-Joli (Québec)
G5H 3Z4
Tél. (418) 775-0611
Fax. (418) 775-0546
Email: StarrM@dfo-mpo.gc.ca

or:

Michel Harvey
Maurice Lamontagne Institute
850 route de la Mer
P.O. Box 1000
Mont-Joli (Québec)
G5H 3Z4
Tél. (418) 775-0677
Fax. (418) 775-0546
Email: HarveyM@dfo-mpo.gc.ca

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Regional Stock Assessment Office,
Department of Fisheries and Oceans,
Maurice-Lamontagne Institute,
P.O. Box. 1000, Mont-Joli,
Quebec, Canada
G5H 3Z4

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