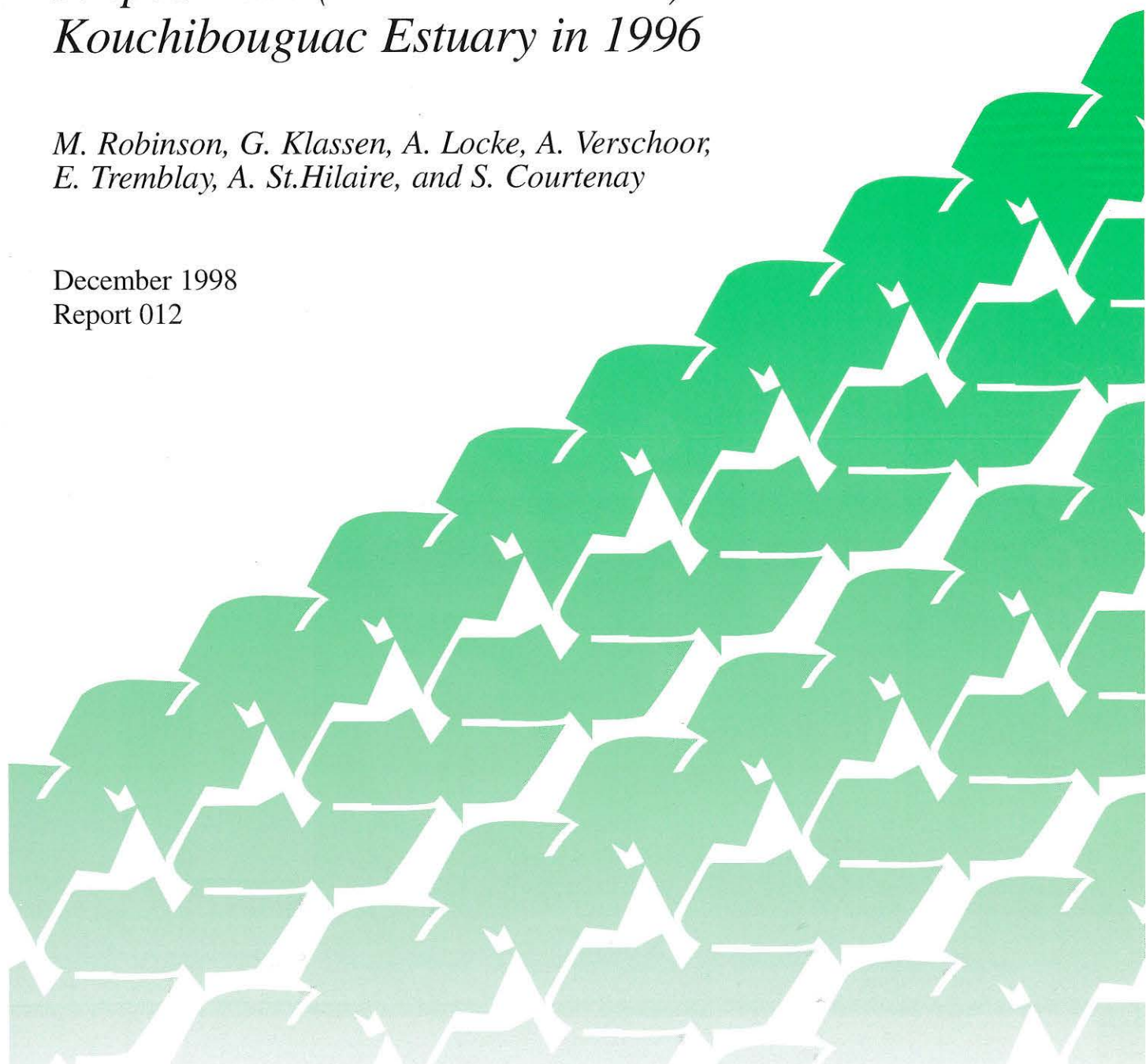




*A Preliminary Survey of the Early Life History of Striped Bass (*Morone saxatilis*) in the Kouchibouguac Estuary in 1996*

*M. Robinson, G. Klassen, A. Locke, A. Verschoor,
E. Tremblay, A. St.Hilaire, and S. Courtenay*

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A preliminary survey of the early life history of striped bass (*Morone saxatilis*) in the Kouchibouguac Estuary in 1996

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ABSTRACT:

A 15.5 km stretch of the Kouchibouguac River and Estuary was sampled for eggs, larvae, and juveniles of striped bass (*Morone saxatilis*) from May 17 to August 26 1996. Physico-chemical data were collected to provide spatial overviews of temperature and salinity stratification within the estuary. No striped bass eggs or larvae were found during ichthyoplankton surveys. Their absence does not rule out the Kouchibouguac Estuary as a spawning site for striped bass, but may indicate that striped bass spawn here only occasionally. Eggs and larvae of other pelagic species, primarily gaspereau (*Alosa* spp.) and rainbow smelt (*Osmerus mordax*), were caught throughout the sampling season, thus indicating that sampling techniques were effective for the collection of pelagic larvae. Young-of-the-year striped bass were collected by beach seining in the lower reaches of the estuary in August. The origin of these underyearling striped bass is unknown but they may be migrants from nearby larger estuaries known or suspected to support striped bass such as the Miramichi or Richibucto.

RÉSUMÉ:

Une région de 15.5 km de l'estuaire de la rivière Kouchibouguac a été échantillonnée afin de vérifier la présence et énumérer les oeufs, larves, et juveniles du Bar rayé (*Morone saxatilis*) entre le 17 mai et le 26 août 1996. Des données physico-chimiques ont aussi été récoltées afin de donner un aperçu spatio-temporel de la stratification de la température et de la salinité dans l'estuaire. Les traits exécutés avec un filet à plancton n'ont révélé la présence d'aucun oeuf ou larve. Cette absence d'oeufs n'exclut pas la possibilité que le bar rayé fraie dans l'estuaire. Cependant, les résultats démontrent que les bars ne fraient pas dans cet l'estuaire de façon systématique. Les oeufs et larves d'autres espèces pélagiques tels que le gaspareau (*Alosa* spp.) et l'éperlan arc-en-ciel (*Osmerus mordax*) ont été pêchés durant toute la saison d'échantillonnage, ce qui démontre l'efficacité des techniques utilisées. Des bars rayés juvéniles de l'année ont été récoltés en août, surtout dans la portion avale de l'estuaire. Leur présence pourrait indiquer une émigration hors de plus larges estuaires avoisinants, dans lesquels le soutien du bar rayé est soupçonné ou confirmé, tels ceux des rivières Richibouctou ou Miramichi.

INTRODUCTION:

The striped bass (*Morone saxatilis*) is an anadromous fish native to the east coast of North America (Scott and Scott, 1988). Some populations remain in salt water and migrate into fresh water only to spawn in spring, while others may spend most of their lives in estuarine or freshwater systems (Scott and Scott, 1988). Previous studies have indicated that striped bass usually spawn just above the head of tide (Scott and Scott, 1988; Robichaud-LeBlanc et al., 1996). The species has been important in Aboriginal food fisheries in the area for well over two thousand years (S. Augustine, Big Cove First Nation, pers. comm., 1996). In recent times, the striped bass has been sold locally as bycatch of smelt (*Osmerus mordax*) and gaspereau (*Alosa* spp.) commercial fisheries of the region. Striped bass is also a highly prized recreational fish species. There are at least two genetically distinct stocks in New Brunswick, one in the Bay of Fundy and the other in the Gulf of St. Lawrence (Wirgin et al., 1993). The Gulf of St. Lawrence stock has recently been characterized as declining (Chaput and Randall, 1990), and as a result recreational fishing has been restricted to catch and release in New Brunswick rivers (Bradford et al., 1995).

The Miramichi Estuary is the only confirmed spawning area of striped bass in the southern Gulf of St. Lawrence to date (Robichaud-LeBlanc et al., 1996). Spawner abundance in this system is highly variable, ranging between 50,000 and 8,905 fish in 1995-96 (Bradford and Chaput, 1997). Tag recoveries have also supported this hypothesis (Bradford and Chaput, 1995).

Neither of the two previous studies of striped bass in the Kouchibouguac Estuary (Melvin, 1979; Hogans and Melvin, 1984) confirmed spawning activity by the collection of striped bass eggs and larvae. Hogans and Melvin (1984) observed what they believed to be spawning behaviour of striped bass at a location approximately 5.3 km upriver of Loggiecroft Wharf (Figure 1) in 1984. Melvin (1979) found that both adult and juvenile striped bass remained near the head of tide throughout June and July. In August, juvenile bass were found to leave the head of tide and move throughout all the brackish waters of the park inside the barrier islands. In 1984, age 0, 1, and 2 striped bass were found to be most abundant in the brackish lower portion of the Kouchibouguac River (Hogans and Melvin, 1984), presumably near Kouchibouguac Bay. Based on studies available at the time, Hogans and Melvin (1984) characterized young-of-the-year and age 1 and 2 striped bass as non-migratory. It was therefore assumed that these fish were spawned in the Kouchibouguac River (Hogans and Melvin, 1984). However, Bradford et al. (1995) recovered both adult and juvenile (age 2) striped bass in the Miramichi River that had been tagged in the Kouchibouguac River, indicating that both adult and juvenile fish from the Kouchibouguac Estuary are indeed migratory.

Despite uncertainty as to the reproductive status of striped bass in the Park, the maintenance of a viable population of striped bass is one of the highest conservation priorities in Kouchibouguac National Park (Environment Canada, 1993). The need to better understand the biology of this species has been prioritized in the Ecosystem Conservation Plan (Tremblay and Beach, 1994).

The present study was designed to determine if striped bass use the Kouchibouguac Estuary as a spawning ground or a nursery area for young-of-the-year fish. In addition to sampling for striped bass eggs, larvae, and juveniles, the physico-chemical characteristics of the estuary were measured. This work represents the first study in Kouchibouguac National Park to examine the early planktonic life stages of fishes present within the Kouchibouguac River and its estuary.

MATERIALS AND METHODS:

STUDY AREA:

The Kouchibouguac River system is comprised of two rivers, Kouchibouguac River and Black River, which together drain into Kouchibouguac Bay. The Kouchibouguac River system has one of the smallest estuaries in New Brunswick, draining approximately 228 km² (Ambler, 1975; Kerekes, 1977). Drainage areas of Kouchibouguac River and Black River are 177 km² and 51 km² respectively. Kouchibouguac Bay is a shallow coastal lagoon separated from the Northumberland Strait by a 25 km long chain of barrier islands. It has a total surface area of approximately 15 km² and a maximum width of 600 m (Ambler, 1975; Kerekes, 1977). Kouchibouguac River is approximately 150 m wide at its mouth and narrows to between 10 m and 15 m approximately 15.5 km upriver, where the water flow is restricted by a defunct hydroelectric dam. The tidal effects in the system are of a mixed semidiurnal type, with a mean tidal amplitude of 0.67 m (Ambler, 1975; Kerekes, 1977). Tidal incursion in Kouchibouguac River varies depending on the time of year and the amount of surface runoff, but the tidal effects generally extend to the derelict dam 15.5 km up the river (Ambler, 1975; Kerekes, 1977), just below Kouchibouguac Village. Thirteen sampling sites (Figure 1) were established along this 15.5 km length of river. A navigational channel has been dredged through Kouchibouguac Bay and the first 5 km of Kouchibouguac River. River depth in the channel ranges from 2 m to 5 m depending on tidal stage. River depth outside the channel varies from less than 1 m to 2 m. The entire system is covered by ice from late December to early April. The annual mean daily discharge for Kouchibouguac River from 1930 to 1990 is 3.74 m³/sec (Beach, 1988). The peak discharge rates (in spring) in Kouchibouguac River range from 27.5 m³/sec to 59.1 m³/sec, with an average peak discharge rate of 41.1 m³/sec (years 1931 to 1982).

Based on bottom salinity (see Results), substrate type (unpub. data), and dominant macrophyte species (Beach, 1988) at each station, the 13 ichthyoplankton stations were grouped in four general categories: marine, brackish, near-freshwater, and freshwater. Substrate grain sizes were classed according to the Wentworth Scale of particle size description. Stations 1 through 4 represent the marine stations. They typically have a sandy (0.125-0.5 mm grain size) or mud and silt (0.063-0.0039 mm grain size) substrate, and the vegetation is dominated by beds of eelgrass (*Zostera marina*). The bottom salinity of these stations ranged from 18 PSU (Practical Salinity

Units) to 27 PSU. These stations represent the first 4.2 km of the river and lagoon, up to and including the lookout at La Source (Figure 1). Stations 5 through 8 are the brackish water stations. Bottom salinity in these stations ranged from 10 PSU to 21 PSU. The substrate is almost exclusively made up of mud and silt, and the dominant aquatic vegetation species are eelgrass and ditchgrass (*Ruppia maritima*). These stations are located from 5.3 to 9.8 km upriver. The near-freshwater stations are stations 9 through 12. The dominant plant species is ditchgrass, and the substrate is made up of cobble and rock (> 64 mm grain size) or sand. The bottom salinity of these stations ranged from 0 PSU to 10 PSU. Stations 9 through 12 are located from 11.0 to 14.4 km upriver of Loggiecroft. Salt water was never detected 15.5 km upriver at station 13 (see Results) and thus it was considered freshwater.

PHYSICO-CHEMICAL DATA:

Near-surface and bottom water samples were collected in mid-channel at the ichthyoplankton stations using a Van Dorn bottle. A thermometer (VWR No. C 1067-855, Halifax, N.S.) and hand held refractometer with automatic temperature compensation (#A366ATC Ben Meadows Co., No. 221192, Atlanta, GA) were used to immediately measure temperature (°C) and salinity (PSU) of each water sample. A SBE-19 Seabird Profiler (Seabird Electronics Inc., Belle, WA) was deployed at each station from an anchored boat to generate temperature and salinity profiles of the water column. The profiler was held at the surface for approximately one minute to equilibrate before deployment at each station. Only the data recorded as the profiler was lowered through the water column were used in subsequent analysis. The resulting data were used to build isohaline and isothermal curves for each sampling day.

Near surface temperature and salinity were recorded at beach seining sites approximately 2 m from shore with the same thermometer and refractometer used during the ichthyoplankton surveys.

Isocline curves plotted from vertical temperature and salinity profiles (Seabird profiler) provide a spatial overview of stratification in the estuary. Close horizontal lines indicate a strong vertical gradient while vertical lines show a well mixed water column with longitudinal (upstream-downstream) stratification. Isoclines were derived using a matrix of salinity or temperature, depth, and distance from a known point (km 0, station 1).

The data were entered into Systat 7.0 (SPSS Inc., 1997) and contour lines were plotted using a Distance Weighted Least Square algorithm. This algorithm provides a crude mathematical smoothing of the data. Although there may be small discrepancies between CTD profiles and isocline plots in the salinity or temperature data at a given point of the distance-depth matrix, the DWLS algorithm facilitates quick identification of the presence of a salt wedge or thermocline. Actual temperature and salinity profiles will be provided in a subsequent publication. The maximum depths recorded by the profiler at each station for a given date were used to plot the

bottom contour.

Isohaline curves were examined to determine the presence and location of an area where fresh water overlaid a "wedge" of salt water. This salt wedge is where striped bass are suspected to concentrate their spawning activity (Robichaud-LeBlanc et al., 1996). Temperature data were examined to identify rapid temperature changes which may act as an environmental cue triggering spawning of striped bass (Robichaud-LeBlanc et al., 1996).

ICHTHYOPLANKTON:

Pelagic larvae were sampled approximately twice weekly from May 17 to June 28 and biweekly until August 5 1996 during fourteen ichthyoplankton surveys. Fish larvae were routinely sampled from the gully in Kouchibouguac Bay (station 1) to just below the bridge at highway 117 (station 10) (Figure 1), and were occasionally sampled above the highway 117 bridge at stations 11, 12, and 13. Ichthyoplankton sampling was concentrated during the months of May and June, when striped bass were expected to be spawning (Hogans and Melvin, 1984; Robichaud-LeBlanc et al., 1996).

A 500 μm mesh conical net with a 0.5 m ring diameter was towed for 5 minutes against the current to collect ichthyoplankton at each station. The velocity of the boat was increased and decreased during each tow to allow the net to undulate and sample the entire water column. The volume of water sampled during each tow (mean 59.45 m^3 , range 12.75-164.73 m^3) was estimated using a flowmeter (Tusurumi-Seiki-Kosakusho Co., Yokohama, Japan) mounted off-centre in the mouth of the net. Ichthyoplankton samples were immediately preserved in 10% buffered formalin in ambient estuary water. Plankton samples were examined with a Wild M3 dissecting microscope in the laboratory and all larval fish were removed and identified to genus and species where possible using taxonomic descriptions (Hardy, 1978) and reference samples collected from the Miramichi Estuary in 1992 (Robichaud-LeBlanc et al., 1996; Locke and Courtenay 1995b).

BEACH SEINING:

The shallow nearshore habitat was sampled during seven beach seining surveys carried out approximately fortnightly from May 16 to August 20 1996. Twelve beach seining stations were located along Kouchibouguac River (Figure 1); each sample consisted of one haul per station. The wings of the 30 m by 1.8 m bag seine were constructed with 6 mm mesh, and the purse was fitted with a 950 μm mesh liner in order to trap specimens as small as fish eggs or larvae.

The seine was deployed by securing one end to shore while the net was towed (manually or by

boat) perpendicular from the shore for a distance of 20 to 30 m. The net was then brought into shore in a quarter circle sweep against the current. An area of approximately 500 m² was sampled with this method (Hanson & Courtenay, 1995; Robichaud-LeBlanc et al., 1997). The entire catch was examined for larval and young-of-the-year striped bass, and a 1 to 2 l random subsample of the catch was frozen for later laboratory analysis. Subsamples were thawed, and fish were enumerated and identified to genus and species where possible using taxonomic keys (Scott & Scott, 1988).

RESULTS:

PHYSICO-CHEMICAL DATA:

Isohalines and isotherms (Figures 2-14) obtained during the sampling season between May 13 and August 5 showed a high variability in the degree of stratification on the Kouchibouguac Estuary. A general increase in the stratification was observed from May 13 (Figure 2) to May 17 and 24 (Figures 3 and 4). Vilks and Krauel (1982) defined a salt wedge as the presence of a halocline of 8 PSU, and such a halocline was present in the top 1 m on June 4 (Figure 5). Isohalines for the remainder of the sampling period (Figures 6-14) showed a high variability in the stratification of the system which did not remain stable between any two sampling days. Important longitudinal (upstream-downstream) migrations of the more saline water mass were observed between surveys, as well as vertical movement of the halocline (when present).

Isotherm profiles indicate that surface temperatures of 11.5 °C (the temperature at which Dadswell (1976) observed initiation of striped bass spawning in the St. John River) were not present until May 24 (Figure 4). Temperatures throughout the water column fluctuated from 9.5 to 20 °C between May 24 (Figure 4) and June 7 (Figure 7) and continuously rose until June 24 (Figure 11), after which they remained approximately stable at 20 °C for the rest of the sampling period. Vertical stratification of salinity within the water column did not reflect similar stratification with regards to temperature for a given sampling day. This suggests that stratification in the Kouchibouguac Estuary is mostly driven by density contrasts between tidally advected waters and freshwater discharge.

ICHTHYOPLANKTON:

No striped bass eggs or larvae were found during the four months of sampling; however taxa representing seven families were identified from the ichthyoplankton, with gaspereau (*Alosa*

pseudoharengus and *A. aestivalis*) and rainbow smelt (*Osmerus mordax*) being the most abundant species (Table 1; Appendix A).

Gaspereau larvae were first found in the ichthyoplankton samples on June 14 at a surface salinity range of 1-10 PSU and a bottom salinity range of >20 PSU. They were captured throughout the summer until August 5, generally in waters with a surface salinity range 0-10 PSU and a bottom salinity range of 0- >25 PSU. These larvae were captured only once outside this surface salinity range, on June 28 (Table 1; Appendix A).

Smelt larvae were first captured on May 17, and were present in the ichthyoplankton samples until July 8. They were typically found in areas of 0-10 PSU surface salinity and 15-25 PSU bottom salinity, and were only captured outside this range on May 17 and June 14 (Table 1; Appendix A).

BEACH SEINING:

Young-of-the-year striped bass were collected in the Kouchibouguac River during beach seining surveys on August 6, 7, and 20 (Table 2). Taxa representing nine other families were identified from the samples, of which sticklebacks (*Apeltes quadracus*, *Gasterosteus aculeatus*, *Gasterosteus wheatlandi*, and *Pungitius pungitius*), banded killifish (*Fundulus diaphanus*), and mummichogs (*Fundulus heteroclitus*) were the most abundant.

On August 6 and 7 young-of-the-year striped bass were present at stations 3, 6, and 8. The nearshore surface salinity at these stations ranged from 0 PSU (at station 8) to 2 PSU (at stations 3 and 6) (Table 2; Appendix B). Surface temperatures ranged from 22.0 °C to 23.5 °C. On August 20 striped bass were collected at stations 1, 5, and 8. Surface temperatures at these stations ranged from 21.0 °C to 24.0 °C. Salinity measurements are not available for August 20.

The mean fork length of young-of-the-year striped bass was 49.8 mm on August 6-7, and 69.9 mm on August 20 (Figure 15). The smallest striped bass collected had a fork length of 33.0 mm.

DISCUSSION:

SPAWNING:

No evidence of striped bass spawning activity in the form of eggs or larvae was found through ichthyoplankton sampling in the Kouchibouguac River although young-of-the-year striped bass

were present in August beach seining samples. If striped bass did spawn in the Kouchibouguac River in the spring of 1996, the absence of eggs and larvae in ichthyoplankton samples could be explained through five potential sampling errors. First, the techniques and equipment used may not have been effective in sampling for pelagic eggs and larvae. Second, the spawning event could have occurred before ichthyoplankton surveys began. Third, the eggs and larvae could have been present in a part of the water column which was not reached by our sampling gear. Fourth, spawning could have occurred in between sampling surveys. Fifth, the spawning site could have been located at a point greater than 15.5 km upriver, and therefore outside our sampling range. None of these five scenarios were likely, for the following reasons:

High concentrations of gaspereau and smelt larvae in our samples throughout the summer suggest that pelagic ichthyoplankton were successfully sampled. Smelt and gaspereau are similar to striped bass in that all three taxa usually spawn just above the salt wedge. Both gaspereau and smelt larvae were usually associated with waters having a surface salinity equal to or less than 5 PSU (Table 1). The presence of smelt and gaspereau larvae in the ichthyoplankton samples is important because it shows that pelagic larvae which commonly co-occur with striped bass were effectively caught by our gear in the Kouchibouguac Estuary in the summer of 1996 at the salinities predicted from the literature (Locke & Courtenay, 1995a; Robichaud-LeBlanc et al., 1996).

It is unlikely that striped bass had finished spawning in the Kouchibouguac River when our ichthyoplankton sampling began. Striped bass are known to spawn in Canadian rivers at surface water temperatures above 11.5 °C (Dadswell, 1976; Parker & Doe, 1981; Williams et al., 1984; Robichaud-LeBlanc et al., 1996). Our ichthyoplankton sampling began on May 17 when the surface temperature at station 8 was 11.5 °C (Appendix A). Furthermore, it is believed that rapidly rising water temperature and not absolute temperature induces spawning activity (Williams et al., 1984; Robichaud-LeBlanc et al., 1996). In Kouchibouguac River in 1996, such a rapid change of temperature did not occur until May 31, two weeks after ichthyoplankton sampling had begun (Appendix A).

It is unlikely that striped bass eggs and larvae were present in parts of the water column not sampled by the plankton net. The only way this could have happened is if the net did not sample the entire water column. Substrate from the river bottom was found in the ichthyoplankton net after many hauls. This indicates that we were indeed successful in sampling the entire water column during the ichthyoplankton tows. Thus, striped bass eggs or larvae would have been found if they had been present at the stations sampled during this investigation.

It is unlikely that striped bass spawning took place in between sampling dates. The most likely period for spawning was between May 27 (Fig. 5) and June 4 (Fig. 6) when surface water temperatures ranged from 8.0 °C to 20.0 °C (Appendix A). Striped bass eggs hatch in 70-74 h at 14.5-15.6 °C and in approximately 48 h at 17.8-19.4 °C (Scott and Scott, 1988). Sampling of ichthyoplankton occurred on May 27, May 31, and June 4, however no eggs or larvae were found and no juvenile striped bass were found until August 6. Had juvenile striped bass been present in

the system, it is highly unlikely that they would have been missed by our July beach seining surveys.

Finally, it is unlikely that spawning took place upriver of the sampling stations. Flushing events, due to heavy rain storms, were frequent in Kouchibouguac National Park during June when non-pelagic larval fish taxa, such as *Fundulus* spp. (mummichog and banded killifish) and gasterosteids (sticklebacks) were frequently captured. Sticklebacks are nest builders and are usually associated with shallow inshore waters and thick vegetation (Scott & Scott, 1988). These larval fish were captured in June ichthyoplankton sampling, presumably because they were flushed out from the shallow inshore waters and into the river channel where sampling took place. Had striped bass larvae been associated with upriver areas or with vegetation, they would most likely have been washed offshore and downstream and should therefore have been found in ichthyoplankton samples following these flushing events.

We must therefore conclude that the absence of striped bass eggs or larvae is probably not attributable to sampling error, but likely reflects biological reality. It remains unclear as to whether this absence indicates that the Kouchibouguac River is not a spawning site for striped bass, or only an occasional one.

Although this evidence suggests that striped bass did not spawn in the Kouchibouguac River in 1996, past work in the Park (Hogans & Melvin, 1984) reported anecdotal evidence (spawning behaviour) of striped bass spawning activity. It may be possible that the Kouchibouguac River acts as an overflow for spawning striped bass from nearby rivers, such as the Miramichi and Richibucto systems. In years when the spawning stock is very large in these systems, some fish may migrate to Kouchibouguac River to spawn. In 1996, the striped bass spawning stock was only about 16% the size of the stock in 1995 (Bradford and Chaput, 1997), thus there may have been no excess spawners available for systems other than the Miramichi. It is also possible that spawning fidelity is not strong for striped bass in the southern Gulf of St. Lawrence and that only one large population exists.

YOUNG-OF-THE-YEAR STRIPED BASS:

The absence of striped bass eggs and larvae in the ichthyoplankton samples suggests that the young-of-the-year striped bass captured were migratory fish spawned outside the Kouchibouguac River. Two likely sources for such migrant fishes are the Miramichi River, 120 km to the north, and the Richibucto River, 35 km to the south (Figure 16). Large and small striped bass are commonly found in the Richibucto Estuary (Rulifson & Dadswell, 1995), although spawning has yet to be confirmed. The chain of barrier islands which separates Kouchibouguac Bay from the Northumberland Strait continues into the northern portion of the Richibucto Estuary. Young-of-the-year striped bass could reach the Kouchibouguac system from the Richibucto Estuary without ever having to leave the shelter of the lagoon. It is also possible that the migrants originated from

the St. Charles River or the St. Louis-de-Kent River which lie between the Kouchibouguac and Richibucto estuaries. Although young-of-the-year striped bass are generally considered to be non-migratory (Scott and Scott, 1988; Rulifson & Dadswell, 1995), they have been found to range extensively in the brackish waters of their home estuary (Hogans & Melvin, 1984; Robichaud-LeBlanc et al., 1997). It is also suspected that young-of-the-year striped bass from the Hudson River migrate along the coast adjoining the Hudson Estuary for as much as 40 miles (Waldman, Hudson River Foundation, pers. comm., 1996). However, the Miramichi River is currently the only river in the southern Gulf of St. Lawrence which is known to support a large spawning population of striped bass (Robichaud-LeBlanc et al., 1996). If Bradford (pers. comm., 1996) is correct in believing the Miramichi to be the primary (perhaps the only) spawning site for striped bass in the southern Gulf, then this is the most likely source of the young-of-the-year fish found in the Kouchibouguac River. Despite the small spawning population of striped bass in the Miramichi River in 1996, the abundance of young-of-the-year striped bass sampled there by beach seine in summer 1996 was among the highest in this decade (Bradford and Chaput, 1997).

NURSERY AREAS:

Our results did not identify a clear habitat preference for young-of-the-year striped bass in the Kouchibouguac River although there was a tendency for association with areas of thick aquatic vegetation. There are many large beds of eelgrass and ditchgrass located along the banks of the Kouchibouguac River. These areas provide important habitats for juvenile mummichogs, killifish, and sticklebacks, which in turn provide a potential food source for young-of-the-year striped bass (Robichaud-LeBlanc et al., 1997).

A preliminary examination of the gut contents of 10 young-of-the-year striped bass from the Kouchibouguac River found that they contained mysids, sand shrimp (*Crangon septemspinosa*), juvenile killifish, and juvenile sticklebacks. Young-of-the-year striped bass (> 50 mm total length) in the Miramichi estuary prey almost exclusively on mysids, and *Crangon*, with small fishes making up a smaller portion of the diet (Robichaud-LeBlanc et al., 1997). Because vegetated nearshore environments provide important habitat for many of the taxa on which striped bass potentially prey, they must be considered important nursery areas for young-of-the-year striped bass whether spawned in the Kouchibouguac River or immigrants from elsewhere.

RECOMMENDATIONS FOR FUTURE WORK:

This study has demonstrated that the Kouchibouguac Estuary serves as a nursery area for a diverse and abundant fish community, including species which support substantial commercial and recreational fisheries. Although striped bass eggs and larvae were not present in 1996 in the Kouchibouguac River, this does not rule out the possibility that striped bass spawn here intermittently. Specific recommendations for future work are as follows:

*The study of striped bass spawning and early life history should be repeated to verify whether intermittent spawning takes place within Kouchibouguac National Park. The temporal coverage should include at least one year with a large spawning population in the Miramichi River. The spatial scale of the study should be expanded to examine watersheds of the greater Kouchibouguac area, including the nearby Richibucto River. This would verify if striped bass spawning does occur in the Richibucto River. This would also provide data which could be used to determine the origin of the migrant young-of-the-year striped bass found in Kouchibouguac River. If young-of-the-year striped bass are found in nearby river systems, nuclear DNA technology could be used to determine their distinctiveness and to provide a genetic basis for comparison with those found in the Kouchibouguac River.

*Exploratory ichthyoplankton surveys should be conducted in the Black and St. Louis Rivers to determine the role that these rivers play in maintaining the recruitment of recreational and commercial fish species within Kouchibouguac National Park.

*Seasonal cycles and annual variability in composition, distribution and recruitment of the estuarine fish fauna should be studied in order to provide a baseline for long-term monitoring of the fish populations. Trophodynamic studies should be carried out for basic knowledge of the estuarine food web.

*Integration of biological findings with physico-chemical data is necessary. Biological data could include other indications of fish or ecosystem health, such as parasitic infections. Anthropogenic changes, e.g., dredging, fishing, boating, etc., should also be considered in this context.

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Table 1: Mean abundance (no. / 1000 m³) of ichthyoplankton taxa in the Kouchibouguac Estuary in summer 1996 by surface salinity and date. Taxa are organized according to phylogeny. Only dates when taxa were collected are shown. A hyphen (-) indicates a salinity range which was not sampled on a particular date.

Taxon and date	Surface salinity (PSU)						
	0	1-5	6-10	11-15	16-20	21-25	>25
CLUPEIDAE							
<i>Alosa</i> spp. (<i>A. pseudoharengus</i> (Wilson, 1811) and <i>A. aestivalis</i> (Mitchill, 1815): gaspereau							
June 14	0	149	27.7	-	0	-	-
June 18	0	217.4	-	0	0	-	-
June 21	300.1	318.5	0	-	-	-	-
June 24	144.9	350.7	-	-	-	-	-
June 28	98.5	710.4	-	-	-	19.3	-
July 8	0	3040.7	98.2	-	0	-	-
August 5	20.8	61.6	-	-	-	-	-
OSMERIDAE							
<i>Osmerus mordax</i> (Mitchell, 1815): rainbow smelt							
May 17	0	0	0	169.7	-	-	-
May 24	351.5	378.5	-	-	0	-	0
May 27	426.5	0	-	-	0	-	-
May 31	22.9	-	-	-	-	-	-
June 4	27	533.5	265.4	-	-	-	-
June 10	346.7	185.9	64	-	-	-	-
June 14	29.1	101	27.7	-	21.5	-	-
June 18	0	92.8	-	0	0	-	-
June 21	786.6	0	0	-	-	-	-
June 28	1444.3	15.8	-	-	-	0	-
July 8	20	0	0	-	0	-	-
GADIDAE							
<i>Microgadus tomcod</i> (Walbaum, 1792): Atlantic tomcod							
May 17	40.8	0	0	0	-	-	-

Table 1: continued

Taxon and date	Surface salinity (PSU)						
	0	1-5	6-10	11-15	16-20	21-25	>25
CYPRINODONTIDAE							
<i>Fundulus</i> spp. (<i>F. diaphanus</i> (Lesueur, 1817): banded killifish, <i>F. heteroclitus</i> (Linnaeus, 1766): mummichog)							
June 14	0	13.2	0	-	0	-	-
June 28	0	41.8	-	-	-	0	-
ATHERINIDAE							
<i>Menidia menidia</i> (Linnaeus, 1766): Atlantic silverside							
May 24	0	0	-	-	0	-	65.4
June 10	0	22.1	-	-	-	-	-
June 18	0	61.9	-	52.9	0	-	-
June 21	0	315.8	53.5	-	-	-	-
June 24	0	90.2	-	-	-	-	-
June 28	0	205.3	-	-	-	0	-
GASTEROSTEIDAE							
<i>G. aculeatus</i> (Linnaeus, 1758): threespine stickleback, <i>G. wheatlandi</i> (Putnam, 1866): blackspotted stickleback, <i>Apeltes quadracus</i> (Mitchell, 1815): fourspine stickleback, <i>Pungitius pungitius</i> (Linnaeus, 1758): ninespine stickleback							
June 10	166.7	22.1	-	-	-	-	-
June 14	14.5	29.6	0	-	0	-	-
June 18	28.8	399.5	-	0	0	-	-
June 21	537.5	20.4	35.7	-	-	-	-
June 24	64.5	25.3	-	-	-	-	-
July 22	171.5	-	-	-	-	-	-
AMMODYTIDAE							
<i>Ammodytes americanus</i> (DeKay, 1842): American sand lance							
May 24	0	0	-	-	0	-	26.2
June 28	0	0	-	-	-	19.3	-

Table 2: Counts of fishes captured by beach seine in Kouchibouguac River in summer 1996. Counts constitute the contents of a 1 l to 2 l random subsample of the fishes present in the seine. Taxa are organized according to phylogeny. Counts marked with an asterisk (*) are absolute counts. A hyphen (-) indicates a station which was not sampled on a particular date.

Taxon and date	Station									
	1	3	5	6	7	8	9	10	11	12
ANGUILLIDAE*										
<i>Anguilla rostrata</i> (Lesueur, 1817): American eel										
July 15	-	-	-	-	-	1	0	-	1	-
CLUPEIDAE										
<i>Alosa</i> spp. (<i>A. pseudoharengus</i> (Wilson, 1811) and <i>A. aestivalis</i> (Mitchell, 1815): gaspereau										
August 6 & 7	2	0	-	0	-	0	-	0	-	0
August 20	1	0	0	0	-	4	-	1	-	-
SALMONIDAE*										
<i>Salvelinus fontinalis</i> (Mitchill, 1815): brook trout										
May 16	0	0	0	0	-	1	-	0	-	-
CYPRINIDAE*										
<i>Rhinichthys atratulus</i> (Hermann, 1804): blacknose dace										
July 15	-	-	-	-	-	0	0	-	2	-
CATOSTOMIDAE*										
<i>Catostomus commersoni</i> (Lacépède, 1803): white sucker										
May 16	0	0	0	0	-	13	-	0	-	-
GADIDAE										
<i>Microgadus tomcod</i> (Walbaum, 1792): Atlantic tomcod										
July 23	14	2	0	0	-	0	-	0	-	-
August 6 & 7	1	0	-	0	-	0	-	0	-	0
August 20	0	2	2	1	-	0	-	1	-	-

Table 2: continued

Taxon and date	Station									
	1	3	5	6	7	8	9	10	11	12
CYPRINODONTIDAE										
<i>Fundulus diaphanus</i> (Lesueur, 1817): banded killifish										
June 11	1	1	0	42	9	0	25	-	-	-
June 25	0	33	-	42	-	0	-	0	-	-
July 15	-	-	-	-	-	25	0	-	8	-
July 23	0	1	20	22	-	46	-	-	-	-
August 6 & 7	0	3	-	2	-	22	-	0	-	3
August 20	0	2	89	67	-	57	-	69	-	-
<i>F. heteroclitus</i> (Linnaeus, 1766): mummichog										
June 11	0	5	15	158	110	-	130	-	-	-
June 25	0	81	-	27	-	0	-	14	-	-
July 15	-	-	-	-	-	0	14	-	0	-
July 23	0	52	92	25	-	118	-	-	-	-
August 6 & 7	0	46	-	9	-	77	-	1	-	0
August 20	0	38	20	0	-	78	-	57	-	-
ATHERINIDAE										
<i>Menidia menidia</i> (Linnaeus, 1766): Atlantic silverside										
June 11	1	5	6	1	2	-	4	-	-	-
June 25	17	31	-	10	-	0	-	0	-	-
July 23	8	0	0	0	-	0	-	-	-	-
August 6 & 7	291	5	-	0	-	0	-	0	-	0
August 20	30	20	6	63	-	16	-	2	-	-

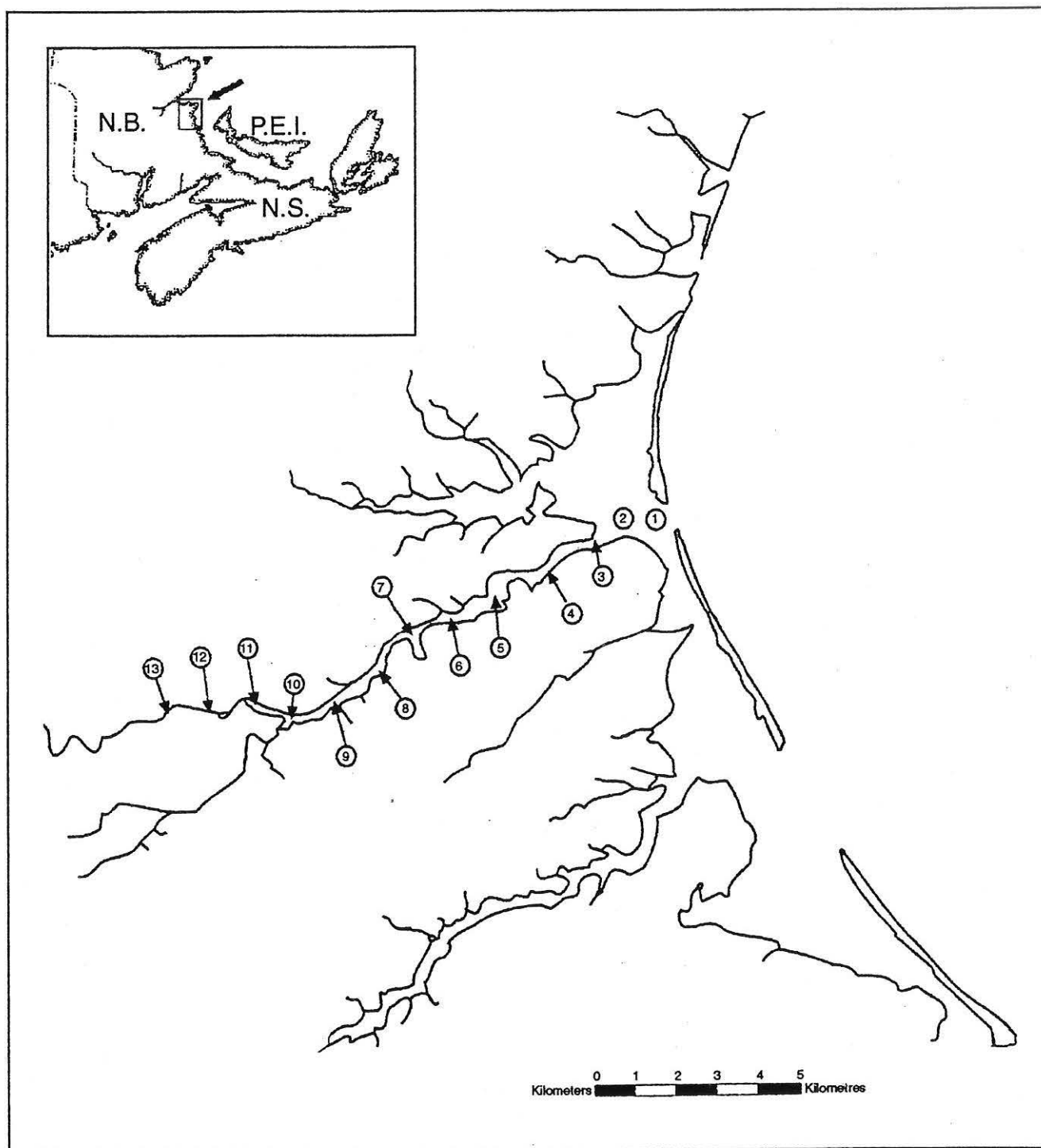
Table 2: continued

Taxon and date	Station									
	1	3	5	6	7	8	9	10	11	12
GASTEROSTEIDAE										
<i>Gasterosteus aculeatus</i> (Linnaeus, 1758): threespine stickleback										
June 11	210	149	112	136	107	-	97	-	-	-
June 25	95	240	-	68	-	81	-	167	-	-
July 15	-	-	-	-	-	37	7	-	3	-
July 23	834	71	217	196	-	22	-	-	-	-
August 6 & 7	314	6	-	23	-	11	-	52	-	0
August 20	3	12	4	31	-	28	-	33	-	-
<i>G. wheatlandi</i> (Putnam, 1866): blackspotted stickleback										
June 11	65	19	67	61	14	-	11	-	-	-
June 25	79	66	-	29	-	56	-	30	-	-
July 23	20	69	127	28	-	9	-	-	-	-
August 6 & 7	22	0	-	0	-	3	-	0	-	0
<i>Apeltes quadracus</i> (Mitchell, 1815): fourspine stickleback										
June 11	0	7	12	9	8	-	8	-	-	-
June 25	1	0	-	8	-	13	-	0	-	-
July 15	-	-	-	-	-	1	1	-	0	-
July 23	21	27	25	29	-	10	-	-	-	-
August 6 & 7	0	5	-	5	-	1	-	11	-	0
August 20	1	7	6	8	-	3	-	9	-	-

Table 2: continued

Taxon and date	Station									
	1	3	5	6	7	8	9	10	11	12
<i>Pungitius pungitius</i> (Linnaeus, 1758): ninespine stickleback										
June 11	0	0	67	19	14	-	11	-	-	-
June 25	0	1	-	4	-	16	-	4	-	-
July 15	-	-	-	-	-	0	0	-	0	-
July 23	16	3	14	18	-	11	-	-	-	-
August 6 & 7	10	3	-	2	-	5	-	1	-	0
August 20	2	2	0	7	-	4	-	14	-	-
PERCICHTHYIDAE*										
<i>Morone saxatilis</i> (Walbaum, 1792): striped bass										
August 6 and 7	0	12	-	4	-	69	-	0	-	0
August 20	64	0	11	0	-	25	-	0	-	-
LABRIDAE										
<i>Tautoglabrus adspersus</i> (Walbaum, 1792): cunner										
June 11	4	0	0	0	0	-	0	-	-	-
July 23	7	0	0	0	-	0	-	-	-	-
PLEURONECTIDAE*										
<i>Pseudopleuronectes americanus</i> (Walbaum, 1792): winter flounder										
June 11	0	4	1	3	0	-	0	-	-	-
June 25	4	0	-	0	-	0	-	0	-	-
July 23	2	0	0	0	-	0	-	-	-	-
August 20	0	2	2	0	-	0	-	0	-	-

Figure 1: Map of Kouchibouguac River showing the 13 sampling stations for summer 1996.



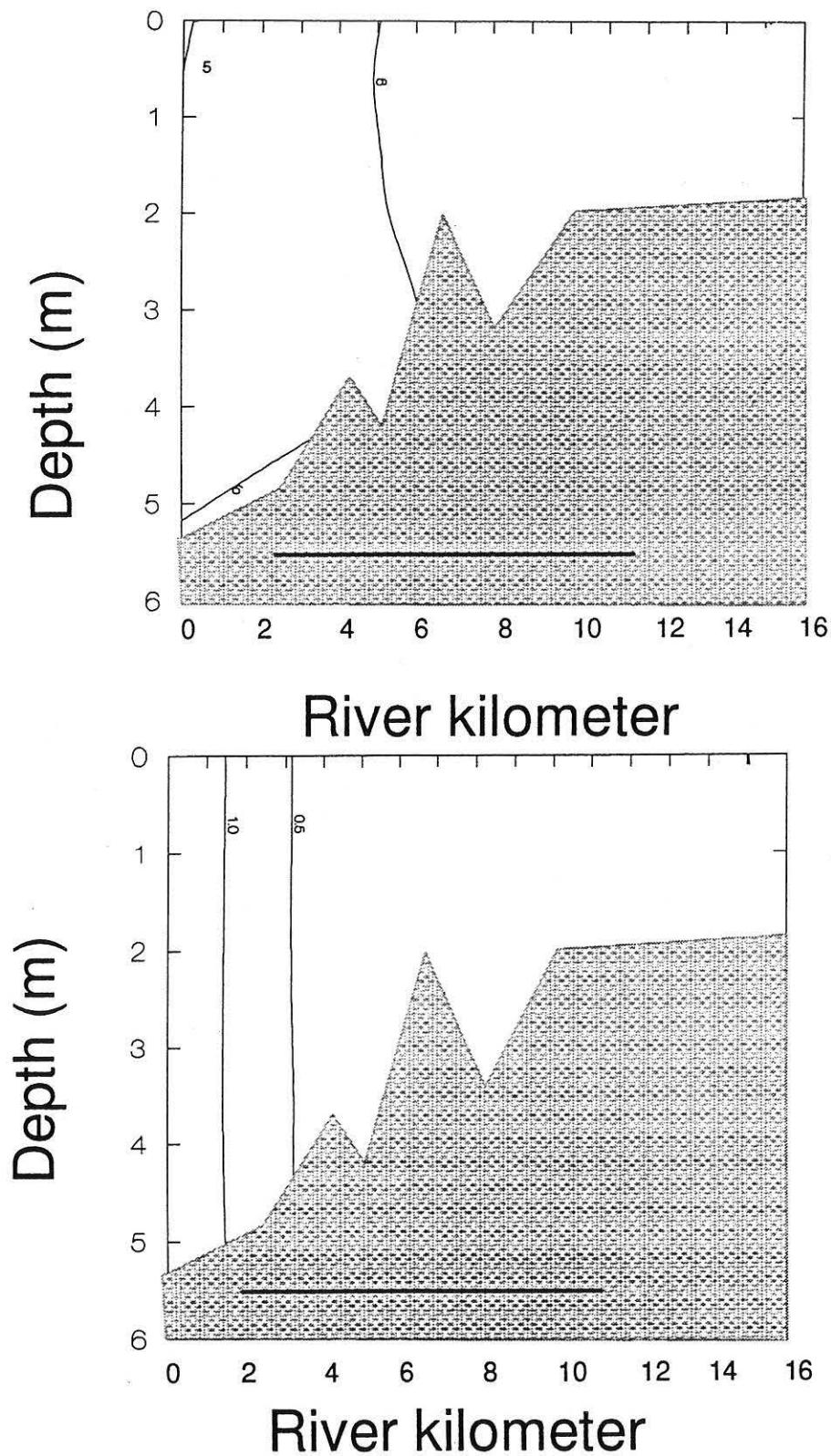


Figure 2. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 13 May 1996. Bold line above X axis shows actual area surveyed.

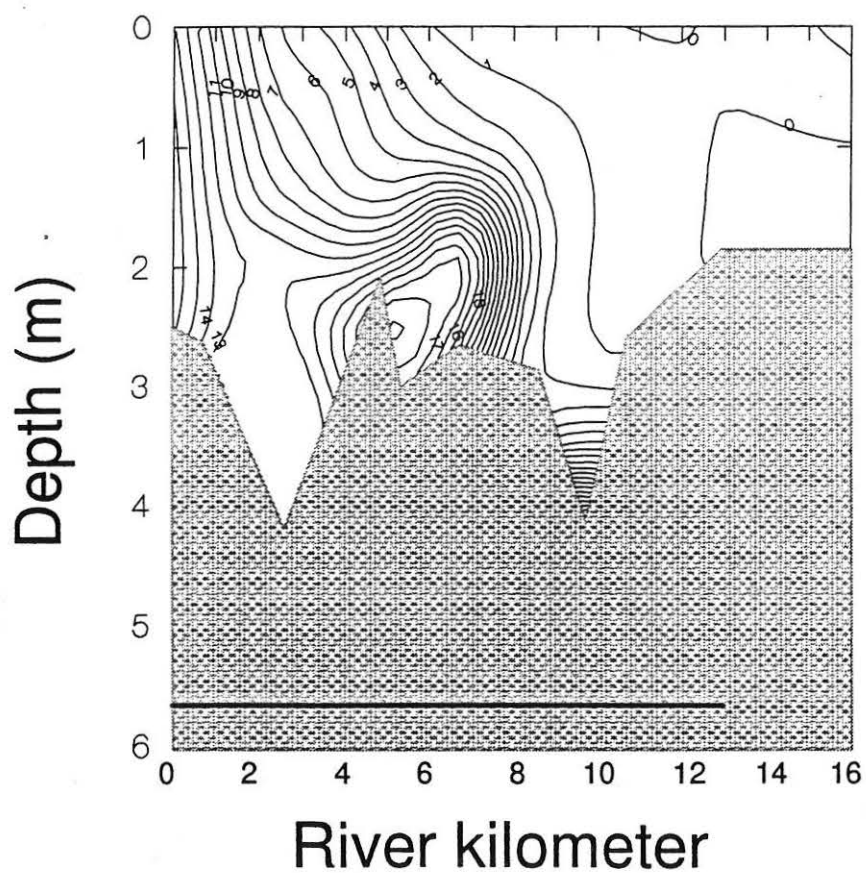
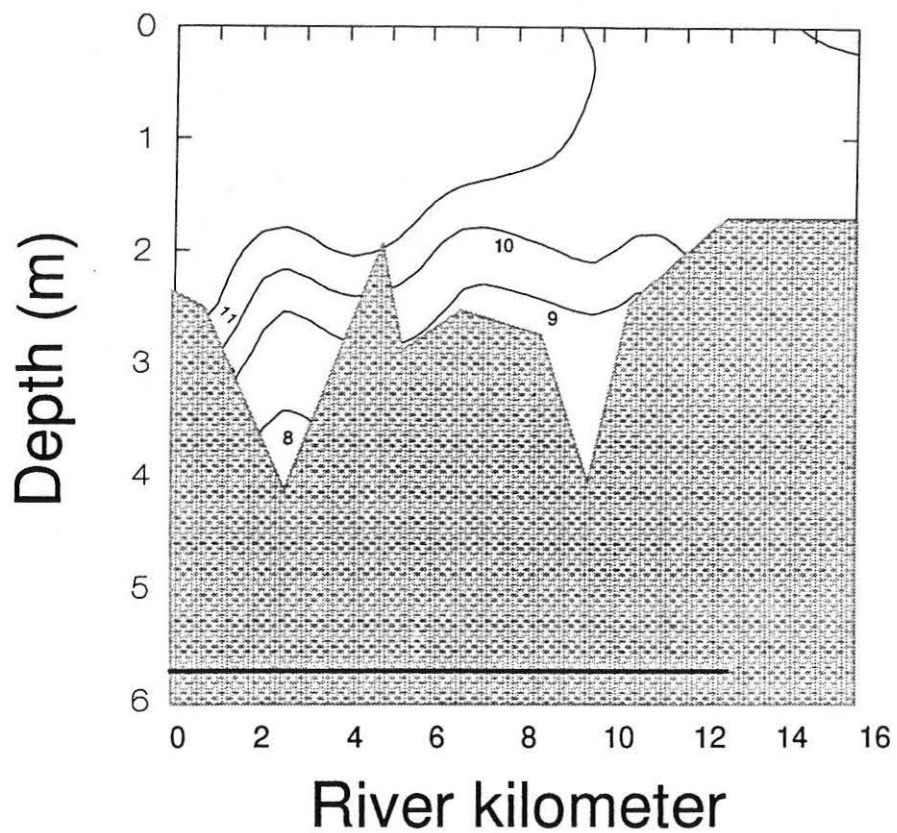


Figure 3. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 17 May 1996. Bold line above X axis shows actual area surveyed.

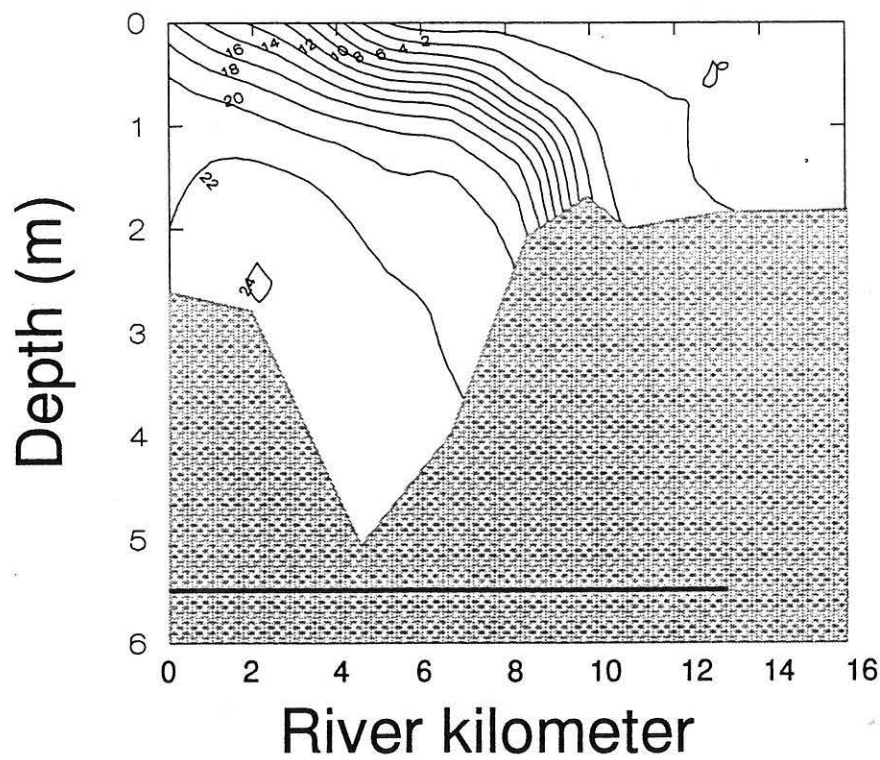
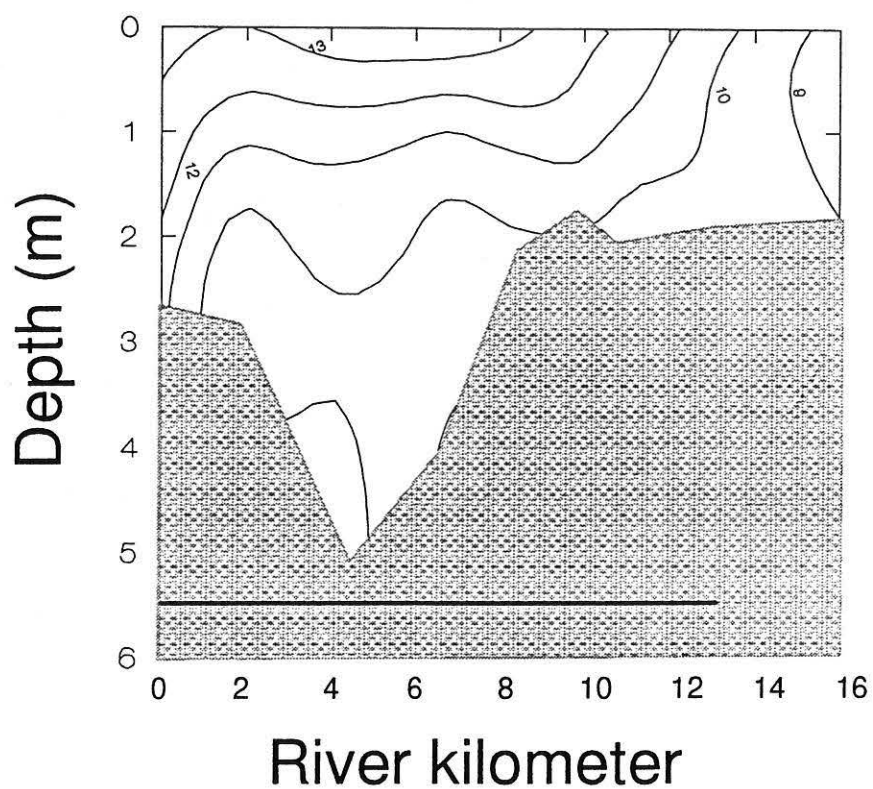


Figure 4. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 24 May 1996. Bold line above X axis shows actual area surveyed.

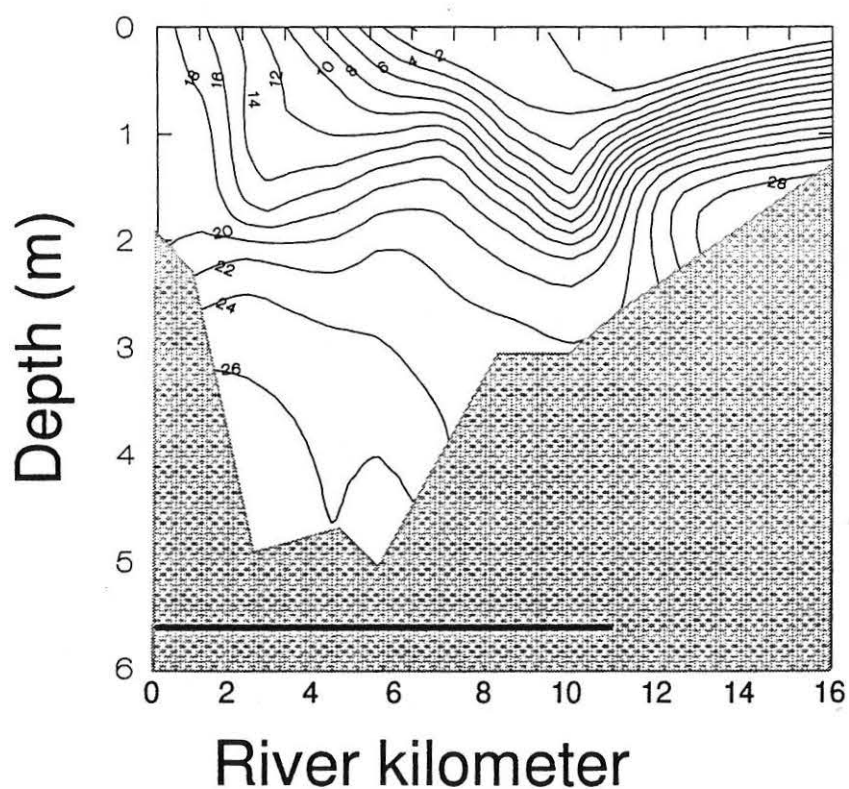
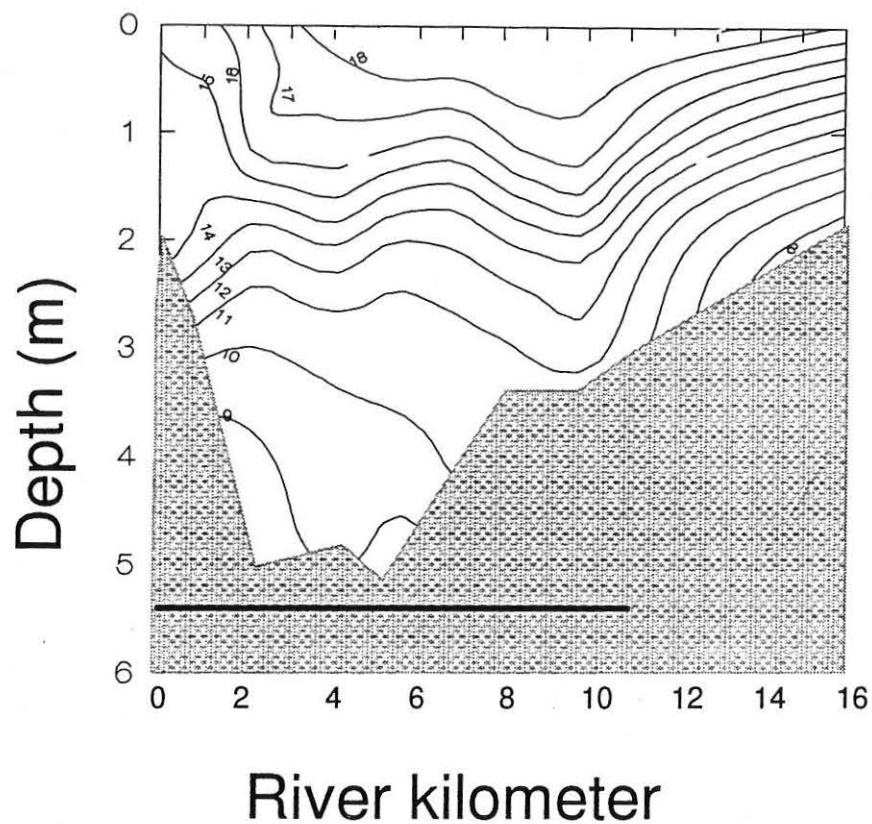


Figure 5. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 4 June 1996. Bold line above X axis shows actual area surveyed.

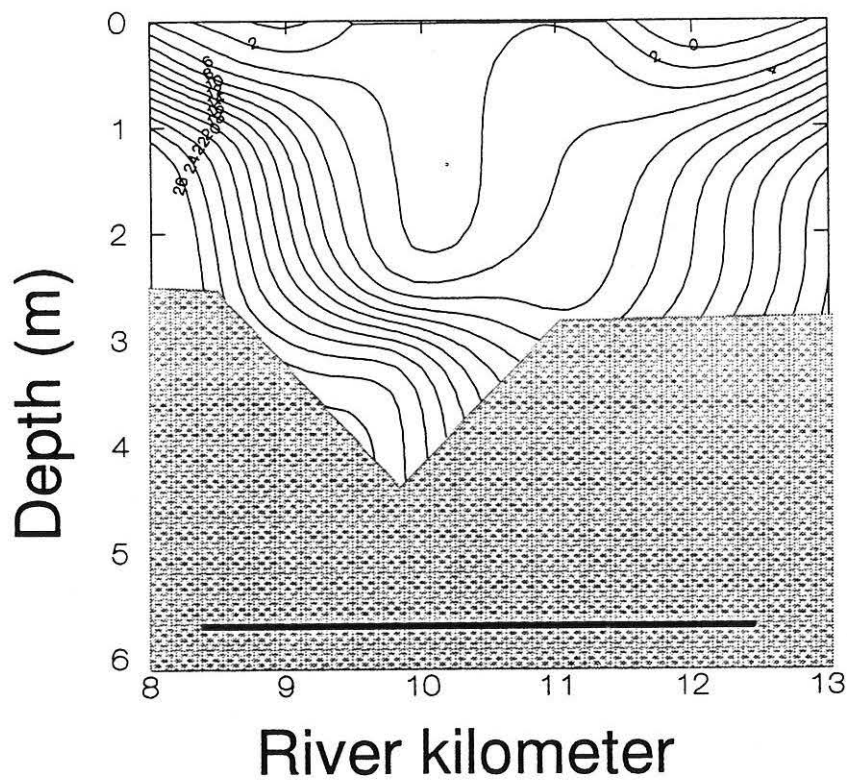
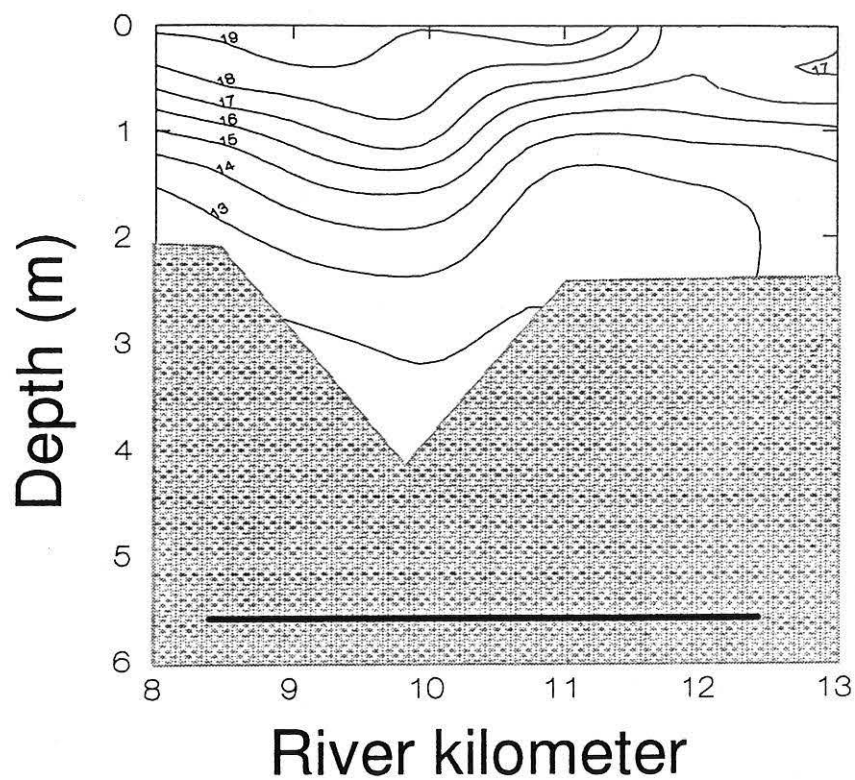


Figure 6. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 7 June 1996. Bold line above X axis shows actual area surveyed.

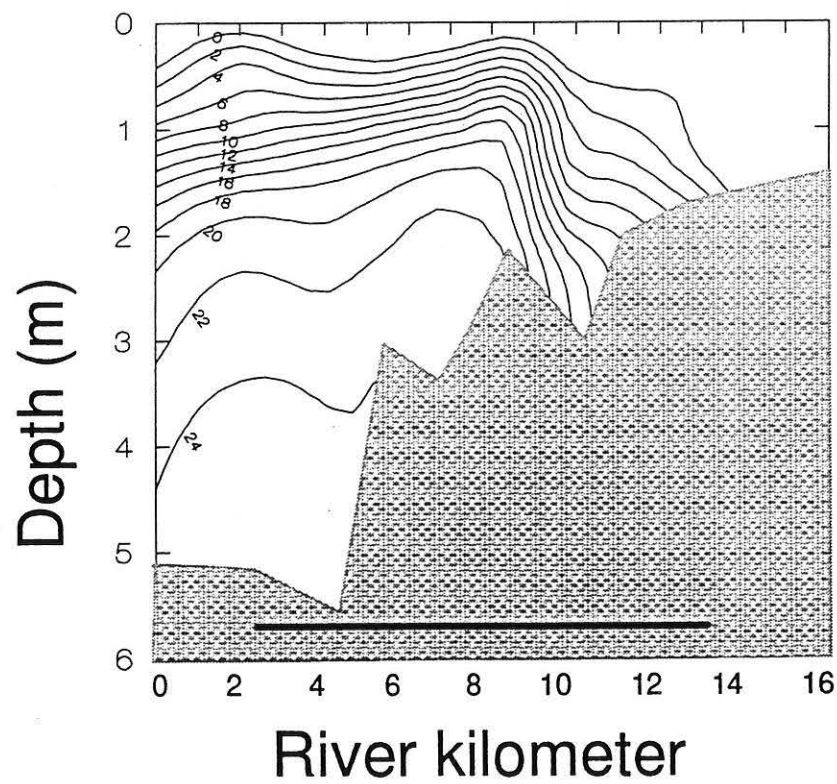
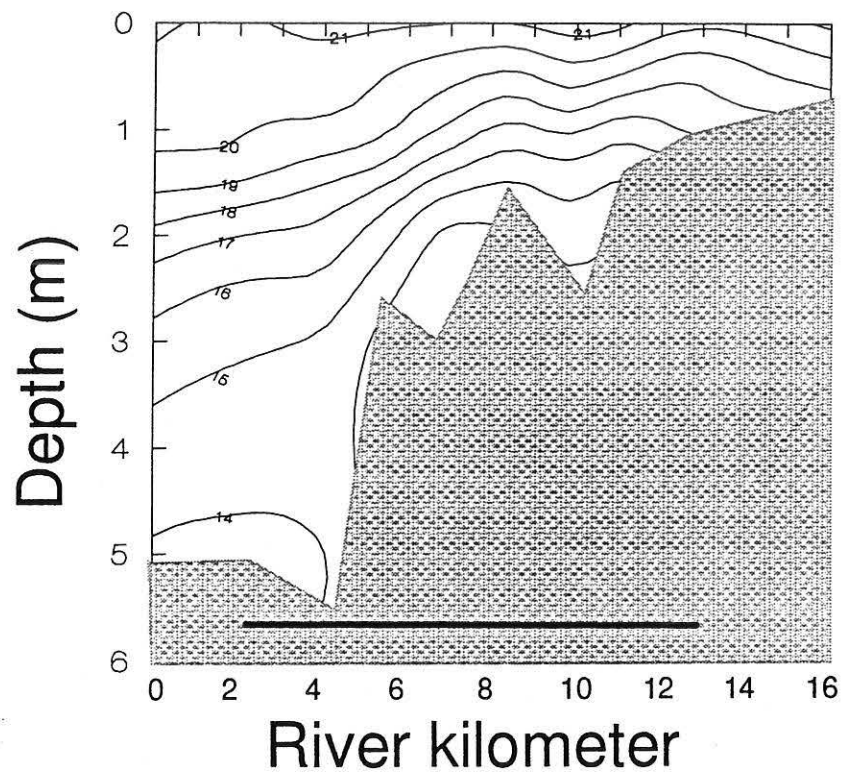


Figure 7. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 10 June 1996. Bold line above X axis shows actual area surveyed.

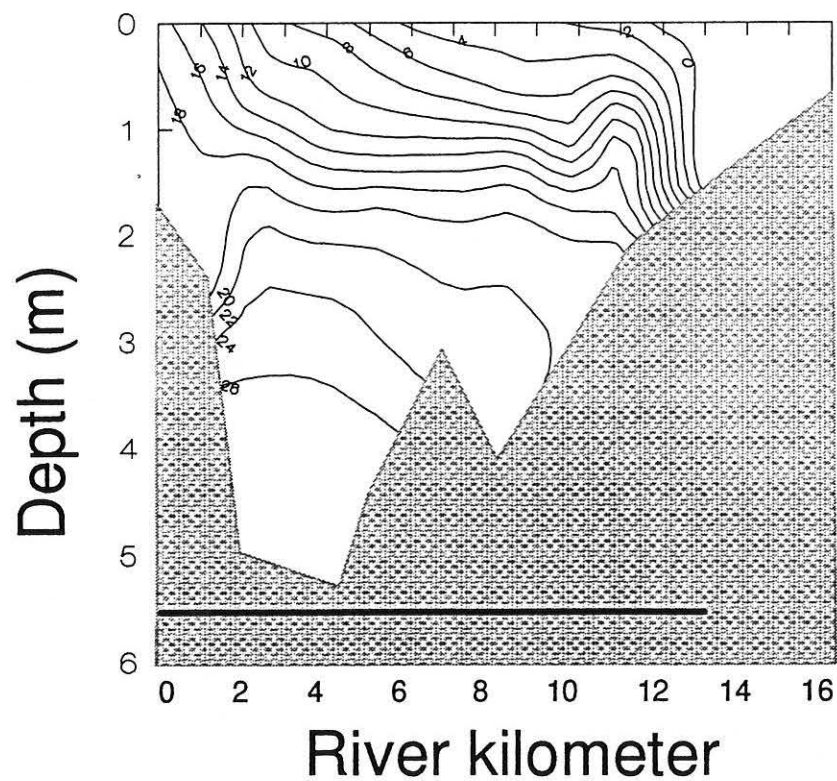
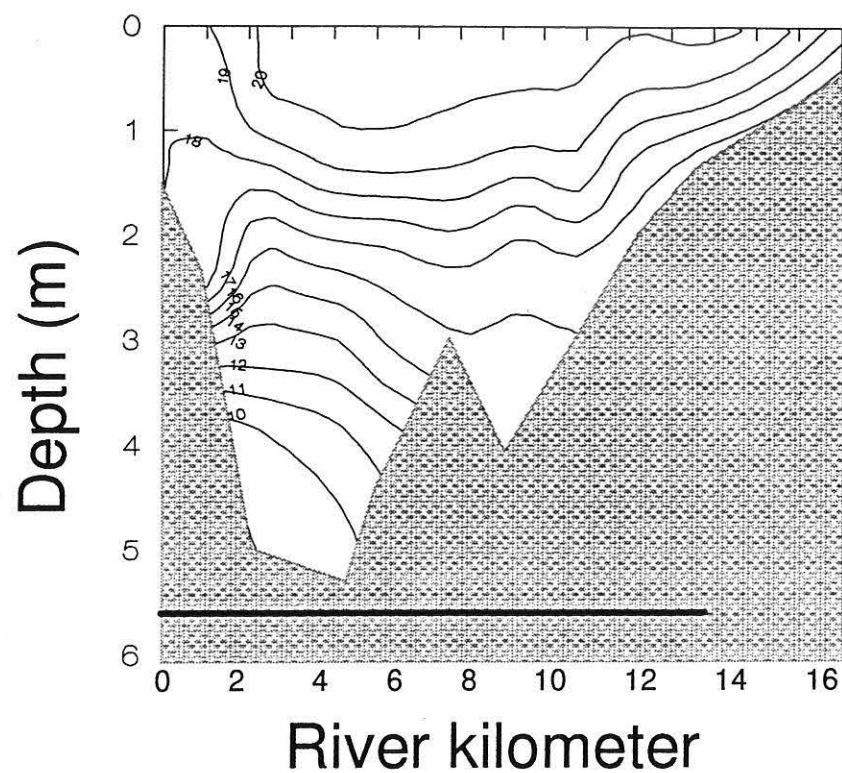


Figure 8. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 14 June 1996. Bold line above X axis shows actual area surveyed.

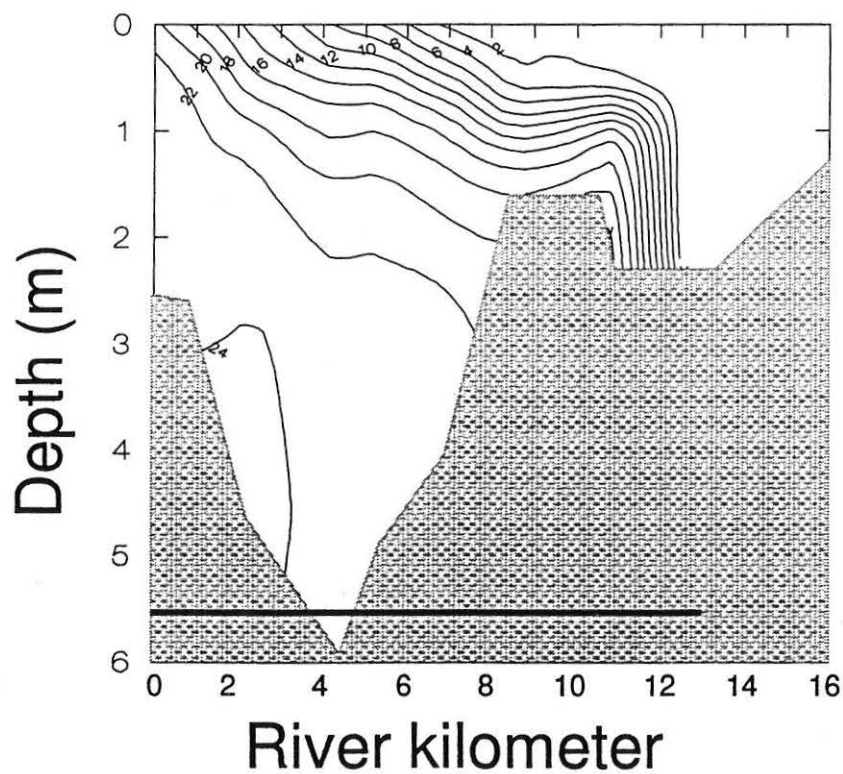
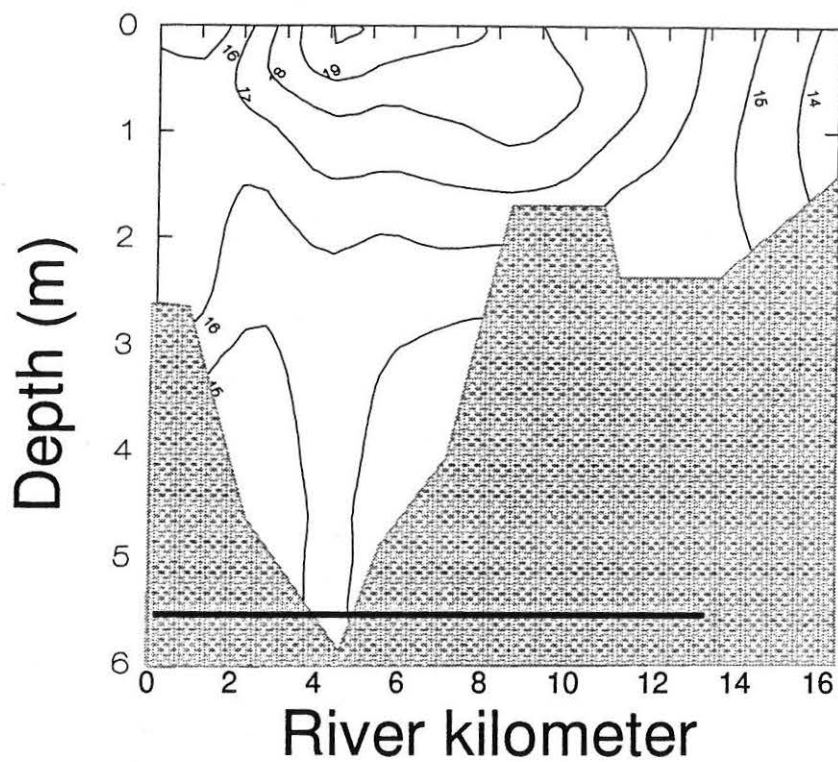


Figure 9. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 18 June 1996. Bold line above X axis shows actual area surveyed.

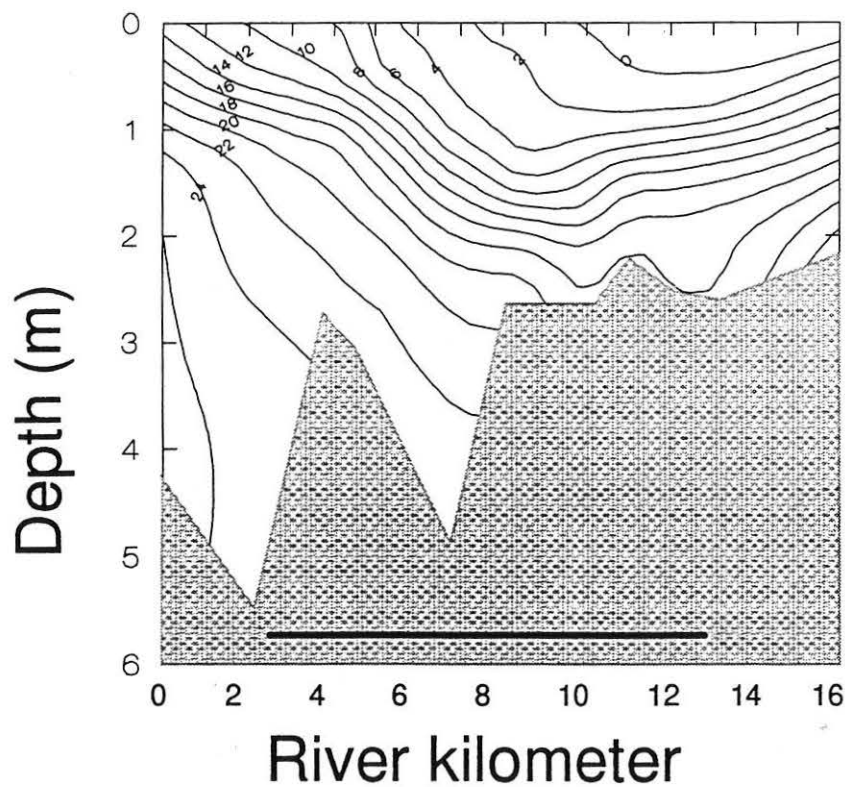
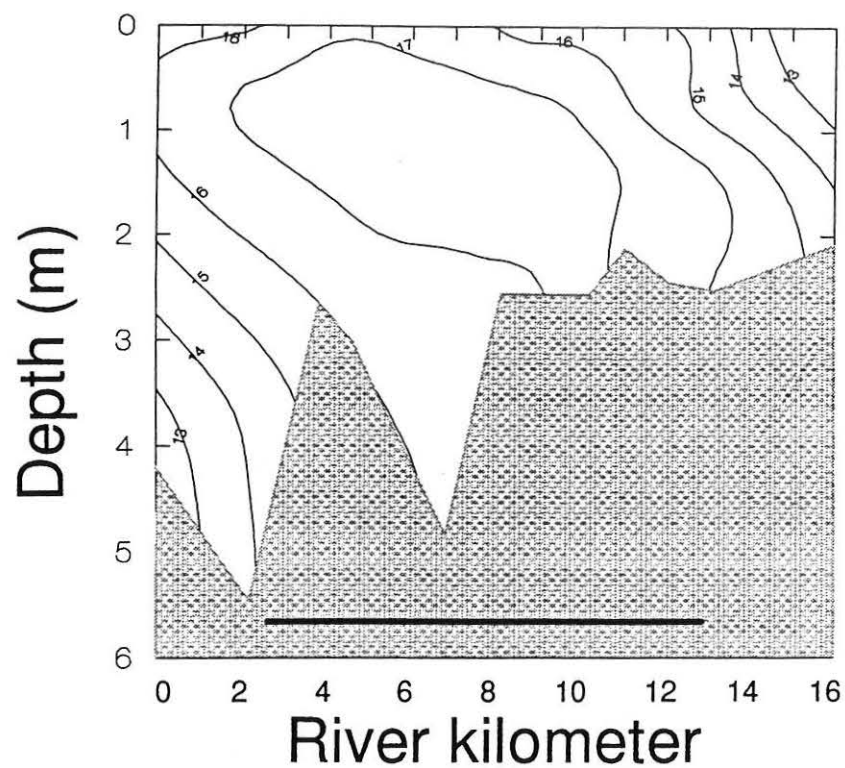


Figure 10. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 21 June 1996. Bold line above X axis shows actual area surveyed.

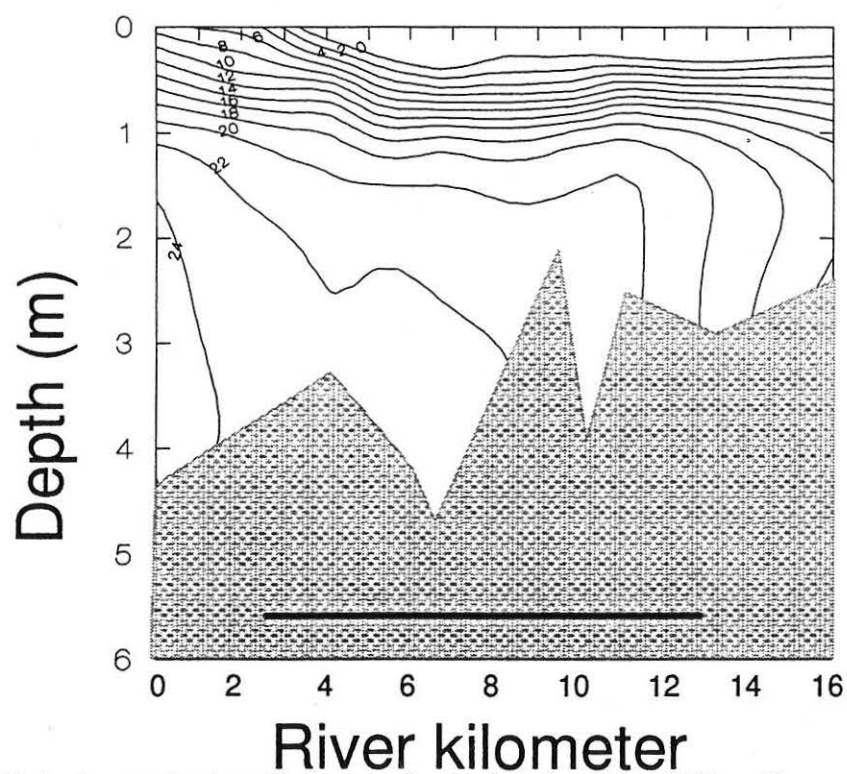
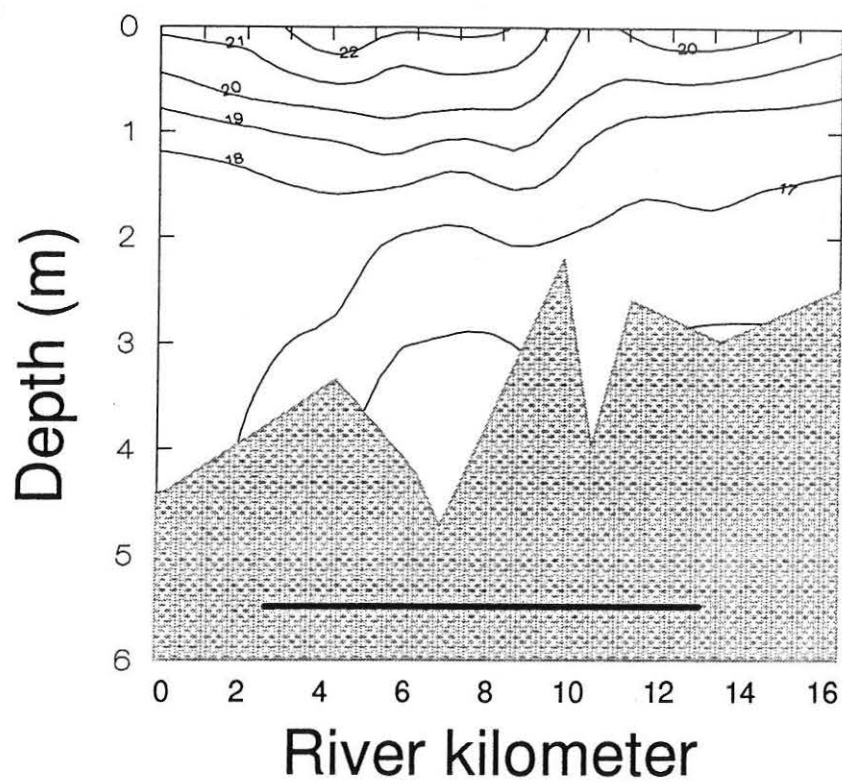


Figure 11. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 24 June 1996. Bold line above X axis shows actual area surveyed.

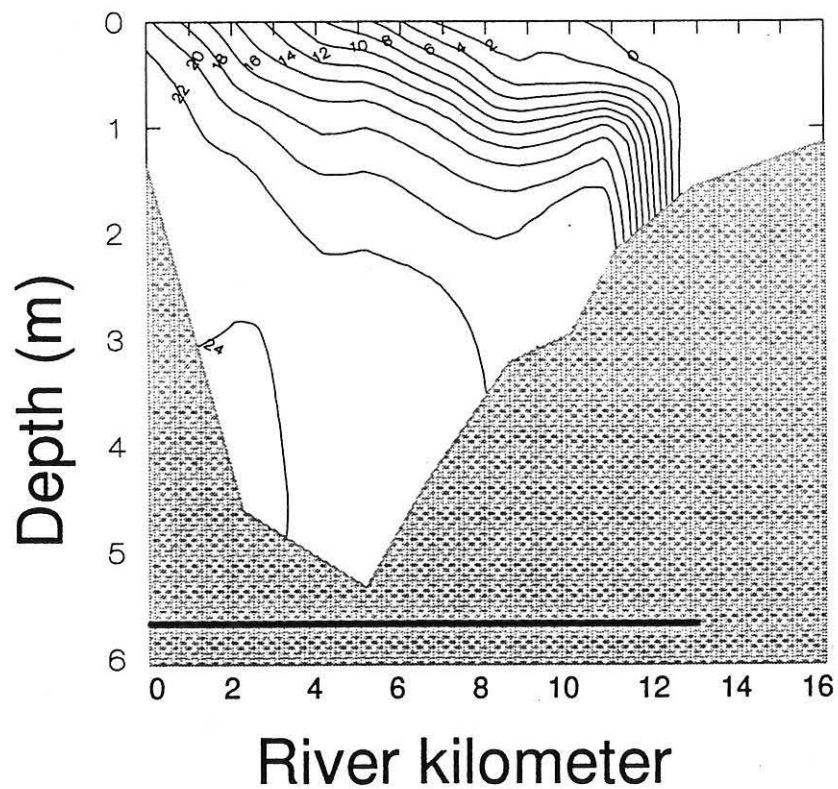
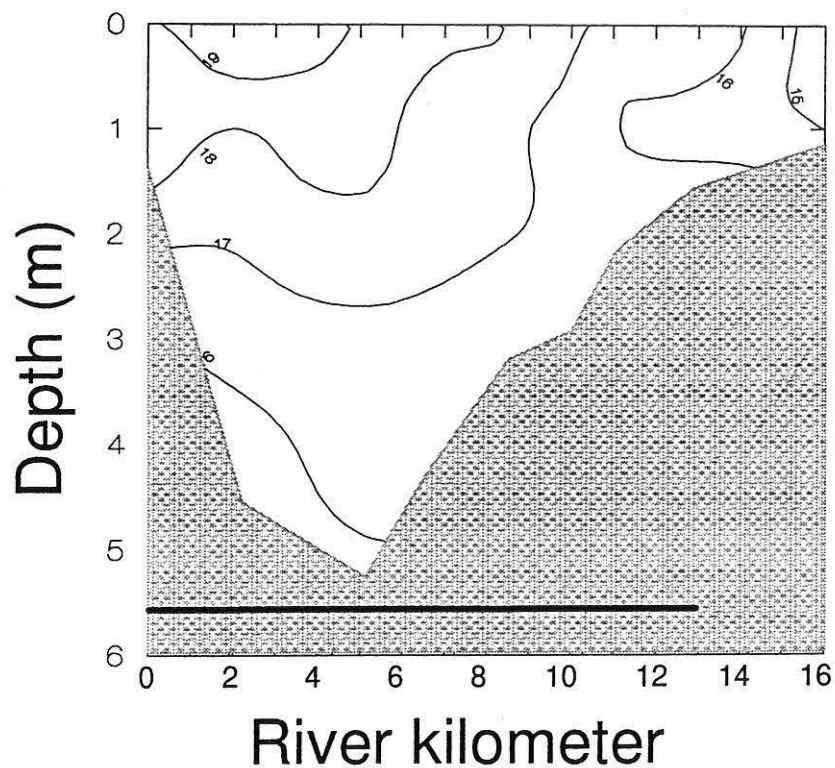


Figure 12. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 28 June 1996. Bold line above X axis shows actual area surveyed.

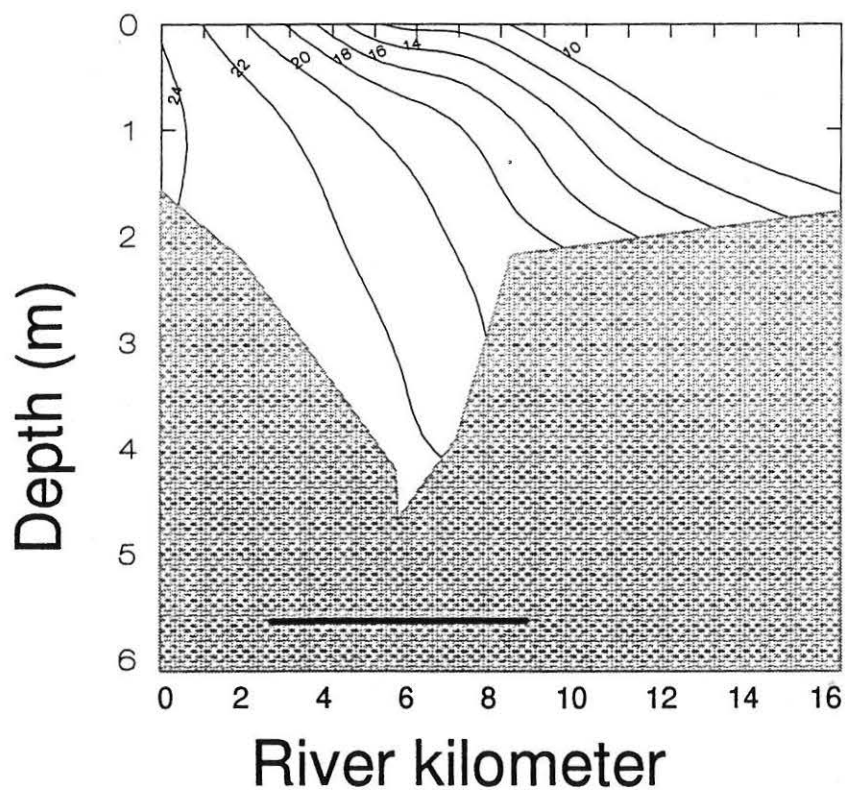
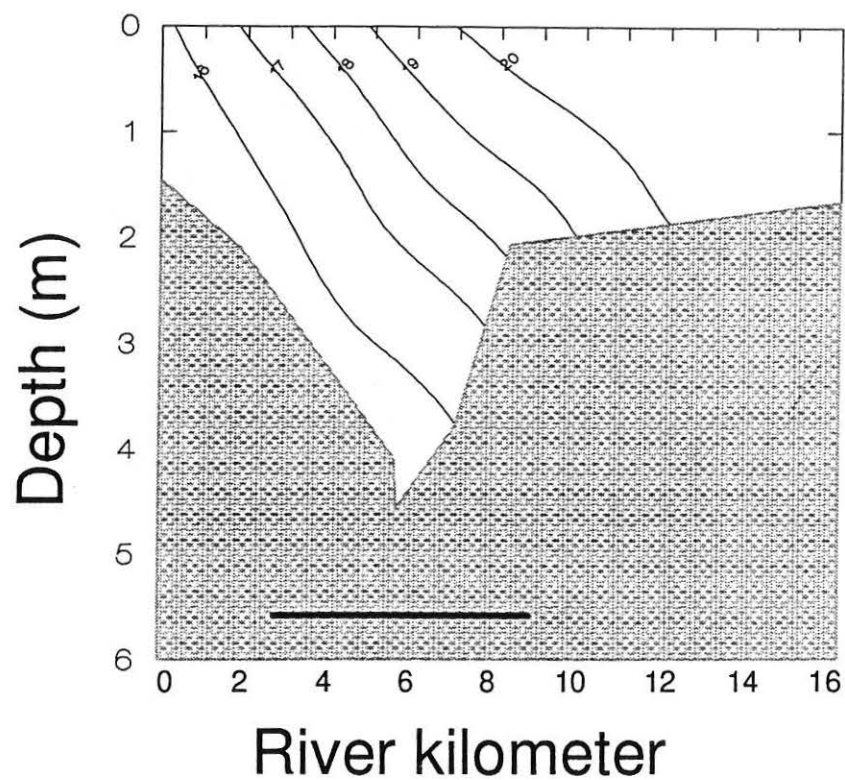


Figure 13. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 8 July 1996. Bold line above X axis shows actual area surveyed.

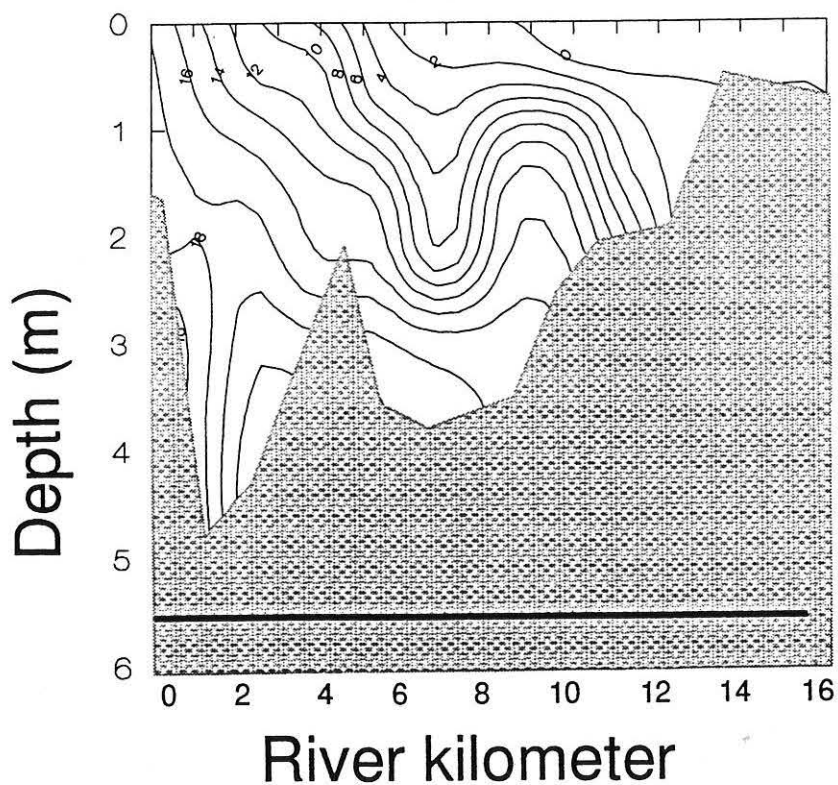
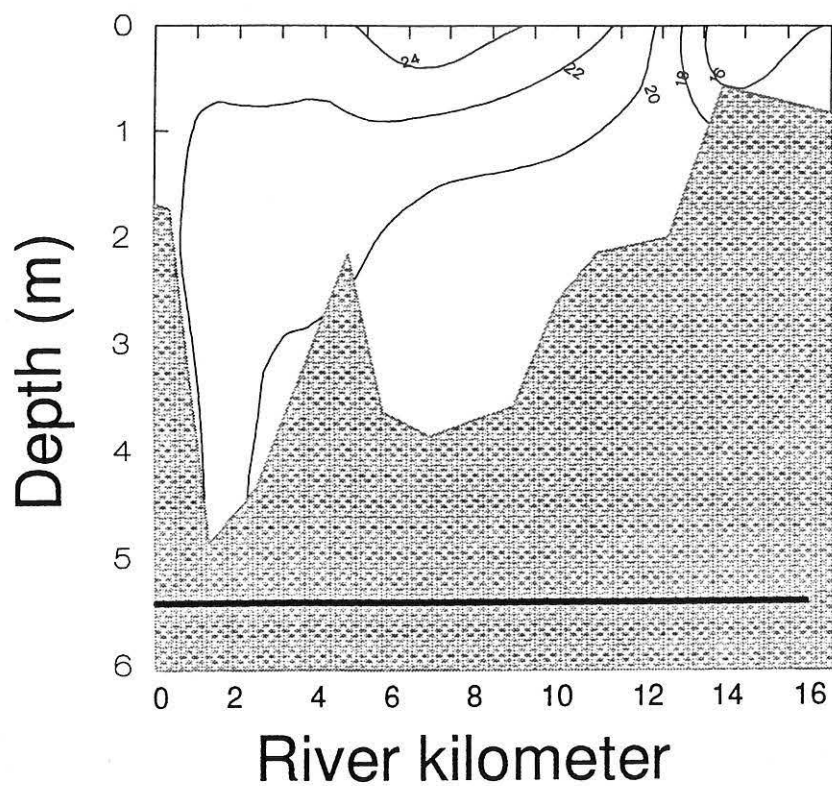


Figure 14. Isotherms (top) and isohalines (bottom) derived from CTD profiles recorded during the ichthyoplankton survey carried out in Kouchibouguac River between the dunes (km 0) and above highway 117 bridge (km 12.5) on 5 August 1996. Bold line above X axis shows actual area surveyed.

Figure 15: Length frequencies of young-of-the-year striped bass captured by beach seine in the Kouchibouguac Estuary in summer 1996.

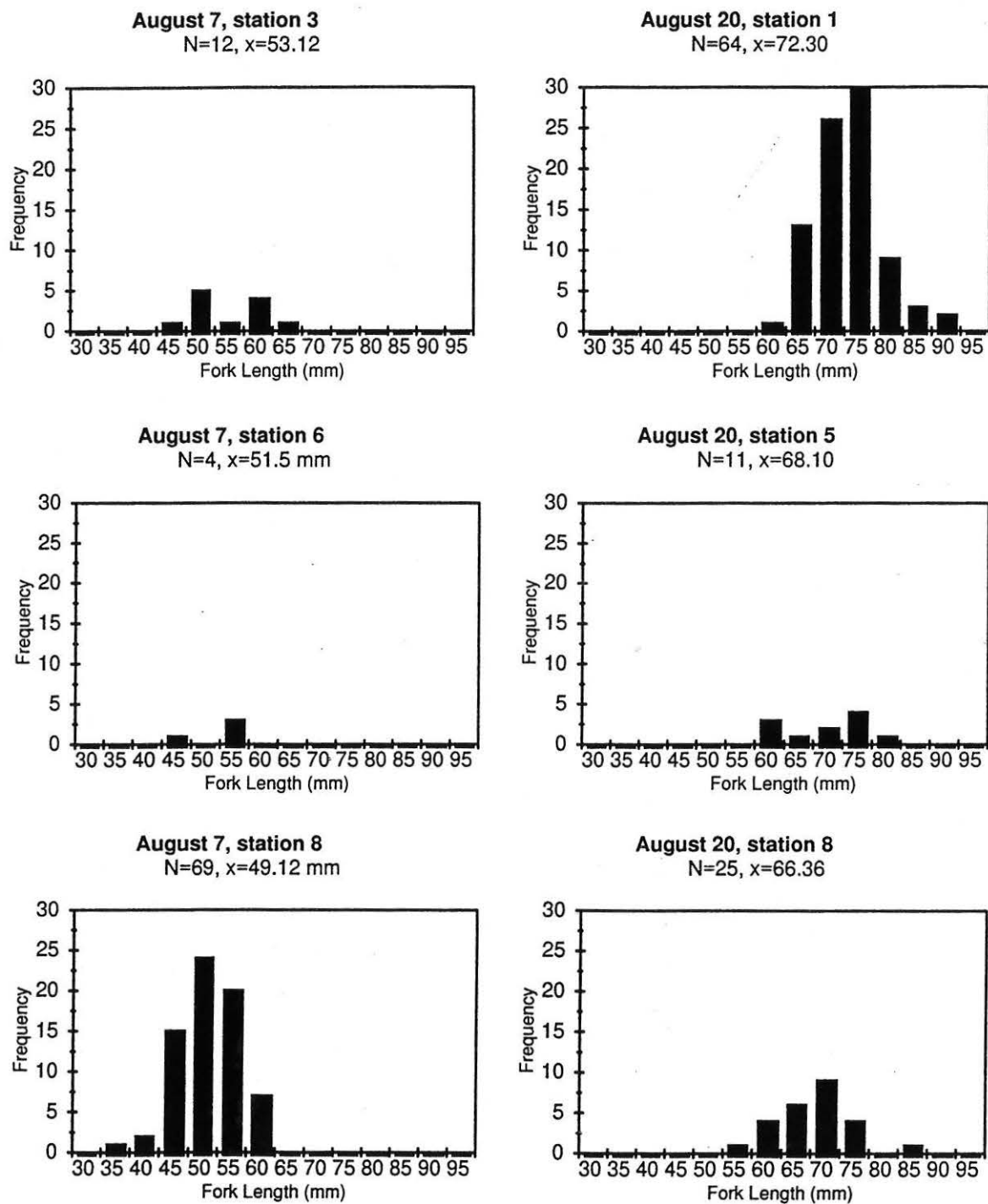
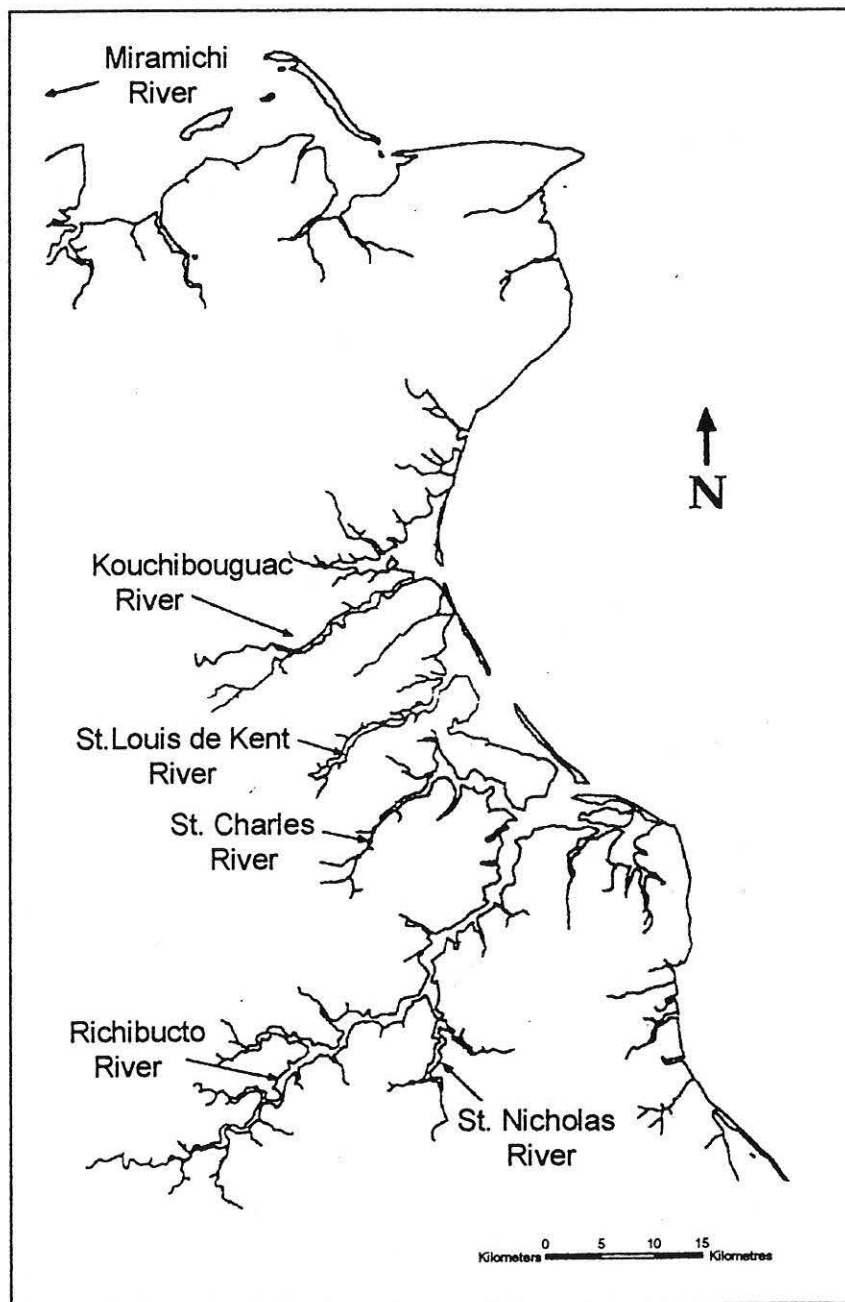


Figure 16: Map of the southern Gulf of St. Lawrence showing rivers which may support striped bass spawning.



Appendix A: Raw Ichthyoplankton Data from summer 1996.

Date	Station #	Flowmeter Reading	Volume H2O Sampled (m3)	Surface Temp.	Bottom Temp.	Surface Sal.	Bottom Sal.	<i>Alosa</i> sp.	<i>Osmerus mordax</i>	<i>Microgadus tomcod</i>	<i>Fundulus</i> sp.	<i>Gasterosteus</i> sp.	<i>Ammodytes americanus</i>	<i>Menidia menidia</i>
05/17	1	76	17.67	12.0	11.5	15.0	17.0	0	3	0	0	0	0	0
05/17	8	210	48.84	11.5	9.0	0.0	14.0	0	0	2	0	0	0	0
05/24	1	328	76.28	12.5	10.0	25.0	27.0	0	0	0	0	0	2	5
05/24	3	241	56.05	13.0	9.5	5.0	27.0	0	4	0	0	0	0	0
05/24	5	507	117.91	16.0	9.5	0.0	25.0	0	7	0	0	0	0	0
05/24	7	471	109.53	11.5	10.0	0.0	20.0	0	32	0	0	0	0	0
05/24	9	126	29.30	11.0	9.5	5.0	21.0	0	9	0	0	0	0	0
05/27	10	242	56.28	9.5	9.5	0.0	22.0	0	24	0	0	0	0	0
05/31	10	376	87.44	8.0	8.5	0.0	0.0	0	2	0	0	0	0	0
06/04	4	247	57.44	18.0	14.0	10.0	18.0	0	8	0	0	0	0	0
06/04	5	409	95.12	18.0	9.0	7.0	27.0	0	12	0	0	0	0	0
06/04	6	357	83.02	18.0	11.0	5.0	25.0	0	41	0	0	0	0	0
06/04	8	324	75.35	18.5	14.0	2.0	18.0	0	3	0	0	0	0	0
06/04	10	318	73.95	17.0	12.0	0.0	20.0	0	2	0	0	0	0	0
06/10	3	336	78.14	20.0	15.0	7.0	27.0	0	5	0	0	0	0	0
06/10	5	195	45.35	18.5	15.0	2.0	22.0	0	1	0	0	1	0	1
06/10	7	315	73.26	18.5	14.0	2.0	22.0	0	12	0	0	0	0	0
06/10	8	247	57.44	19.0	14.5	0.0	25.0	0	18	0	0	0	0	0
06/10	10	387	90.00	18.5	15.0	0.0	15.0	0	3	0	0	15	0	0
06/14	1	200	46.51	18.5	n/a	17.0	n/a	0	1	0	0	0	0	0
06/14	4	155	36.05	20.5	11.0	9.0	26.0	1	1	0	0	0	0	0
06/14	5	325	75.58	20.5	15.5	4.0	22.0	0	2	0	1	1	0	0
06/14	6	148	34.42	20.5	15.5	4.0	20.0	4	2	0	0	0	0	0
06/14	8	262	60.93	20.5	15.0	4.0	22.0	2	1	0	0	1	0	0
06/14	10	296	68.84	20.0	15.0	0.0	22.0	0	2	0	0	1	0	0
06/18	3	244	56.74	19.5	15.0	11.0	26.0	0	0	0	0	0	0	3
06/18	5	329	76.51	20.0	15.0	3.0	23.0	8	0	0	0	0	0	0
06/18	7	139	32.33	19.0	18.0	3.0	10.0	1	3	0	0	1	0	2
06/18	8	105	24.42	17.5	16.0	2.0	17.0	2	0	0	0	9	0	0
06/18	10	299	69.53	16.0	16.0	0.0	20.0	0	0	0	0	2	0	0
06/21	3	241	56.05	17.0	15.5	10.0	24.0	0	0	0	0	2	0	3
06/21	5	425	98.84	16.0	16.5	3.0	24.0	9	0	0	0	2	0	21
06/21	6	208	48.37	17.0	16.5	2.0	25.0	11	0	0	0	0	0	5
06/21	8	232	53.95	16.5	16.0	0.0	20.0	13	2	0	0	29	0	0
06/21	10	218	50.70	15.0	15.0	0.0	10.0	3	38	0	0	0	0	0
06/24	3	218	50.47	21.5	16.0	5.0	25.0	4	0	0	0	0	0	2
06/24	5	170	39.53	20.5	16.5	2.0	21.0	5	0	0	0	1	0	2
06/24	6	200	46.51	20.5	18.0	0.0	19.0	1	0	0	0	3	0	0
06/24	8	178	41.40	20.0	18.0	2.0	11.0	6	0	0	0	0	0	0
06/24	10	48	11.16	19.5	17.0	0.0	15.0	14	0	0	0	0	0	0
06/28	1	223	51.86	18.0	18.0	22.0	25.0	1	0	0	0	0	1	0
06/28	3	237	55.12	19.5	15.0	5.0	23.0	7	0	0	0	0	0	7
06/28	5	273	63.49	20.0	17.5	1.0	25.0	0	1	0	0	0	0	3
06/28	6	277	64.42	18.0	18.0	5.0	17.0	8	0	0	0	0	0	2
06/28	8	103	23.95	18.0	18.0	5.0	15.0	11	0	0	1	0	0	0
06/28	10	131	30.47	17.0	17.0	0.0	16.0	3	44	0	0	0	0	0
07/08	6	394	91.63	19.5	17.0	8.0	22.0	9	0	0	0	0	0	0
07/08	8	200	46.51	19.0	19.0	5.0	18.0	56	0	0	0	0	0	0
07/08	10	199	46.28	17.0	6.0	1.0	12.0	85	0	0	0	0	0	0
07/08	Y	200	46.51	16.5	16.5	0.0	0.0	0	1	0	0	0	0	0
07/22	3	200	46.51	n/a	n/a	n/a	n/a	2	0	0	0	0	0	0
07/22	Y	200	46.51	16.0	16.0	0.0	0.0	0	0	0	0	1	0	0
07/22	Z	172	40.00	16.0	16.0	0.0	0.0	0	0	0	0	6	0	0
08/05	6	279	64.88	24.0	22.5	1.0	10.0	4	0	0	0	0	0	0
08/05	8	620	114.19	22.0	20.5	0.0	7.0	3	0	0	0	0	0	0
Species Totals=								273	284	2	2	75	3	56

Appendix B: Thermometer and refractometer measurements of surface temperature (°C) and surface salinity (PSU) from bech seine samples in the Kouchibouguac Estuary, summer 1996. A hyphen (-) indicates a value which was not measured.

Date	Station	Surface Temperature (°C)	Surface Salinity (PSU)
June 11	1	15	25
June 11	3	21	8
June 11	5	21	5
June 11	6	23	7
June 11	7	21	15
June 11	9	-	-
June 25	1	16	25
June 25	3	18	7
June 25	6	18	2
June 25	8	17	2
June 25	10	17	2
July 15	8	18	0
July 15	9	18	0
July 15	11	17	0
July 23	1	18	25
July 23	3	22	0
July 23	5	20	0
July 23	6	18	0
July 23	8	19	0
August 6	1	22	5
August 6	3	22	2
August 6	6	24	2
August 7	8	24	0
August 7	10	24	0
August 7	12	-	0
August 20	1	21	-
August 20	3	24	-
August 20	5	24	-
August 20	6	21	-
August 20	8	22	-



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