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Feeding Ecology of Atlantic Sturgeon and Lake Sturgeon Co-Occurring in the St. Lawrence Estuarine Transition Zone

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Abstract.—Atlantic sturgeon *Acipenser oxyrinchus* and lake sturgeon *A. fulvescens* live in sympatry in the St. Lawrence estuarine transition zone (ETZ). To describe their feeding ecology and compare their diets in this zone, sturgeons were sampled during the summer and fall of 2000 by trawling in the main channel and by gill netting in the shallower nearshore habitat. Stomach contents were sampled by gastric lavage of live specimens (trawling) and by digestive tract sampling (gill netting). Relative importance by taxonomic group was based on percent occurrence and percentage of the diet by number and weight for three sturgeon size-classes that corresponded to age-0, juvenile, and subadult stages. Spatial, seasonal, and life stage variations were observed in the diet composition of both sturgeon species. Age-0 fish of both species fed mainly on gammarids. Juveniles and subadults from both species fed mainly on oligochaetes and

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† Réjean Fortin died prematurately in 2001. He was an excellent scientist and pedagogue, and a great colleague. His contribution to the knowledge of sturgeon biology will remain pertinent for future decades.

gammarids, but in opposite proportions: gammarids were the dominant prey for lake sturgeon and oligochaetes for Atlantic sturgeon. Subadult Atlantic sturgeon also fed on fish in the summer and on insects and mollusks in the nearshore habitat in fall. Vegetal matter was frequent and abundant in the stomach contents of Atlantic sturgeon subadults, especially in the nearshore habitat, and vegetal mass in the diet was correlated with gammarid biomass. In addition to gammarids, the lake sturgeon diet included insects, oligochaetes, and mollusks, whose proportions increased with sturgeon size-class. The proportion of amphipods decreased with size-class during both summer and fall. In the St. Lawrence ETZ, Atlantic sturgeon appear to be specialist feeders while lake sturgeon appear to be more often generalists. Diet diversity was higher in lake sturgeon, which fed on all of the 15 taxa identified in the macrobenthos of the ETZ; the diet of Atlantic sturgeon consisted of 10 taxa. In the main channel in fall, dietary overlap between Atlantic sturgeon and lake sturgeon was low for the juvenile and subadult life stages. The strong dependence of Atlantic sturgeon and lake sturgeon on oligochaetes and gammarids suggests that the areas where these benthic assemblages are found, near the freshwater–saltwater limit, are important feeding habitats for the age-0, juvenile, and subadult stages of both sturgeon species.

Introduction

Several sturgeon species use estuaries during some or most stages of their life histories. These important ecosystems often harbor more than one sturgeon species (Bemis and Kynard 1997). Large rivers connected to the ocean generally have one anadromous with one amphidromous (McDowall 1992) or semianadromous (Doroshov 1985) species. As pointed out by Bemis and Kynard (1997), only a few of such cooccurrences are well documented in terms of habitat and resource partitioning, one good example being that of the Atlantic sturgeon *Acipenser oxyrinchus* and shortnose sturgeon *A. brevirostrum* in some rivers of the North American Atlantic coast (Appy and Dadswell 1978; Kieffer and Kynard 1993; Moser and Ross 1995; Bain 1997; Haley 1999).

Explanations for estuarine sympatry in sturgeon species with closely related life histories had been initially based on fine segregation across salinity gradients (Dadswell et al. 1984; Dovel et al. 1992; Kieffer and Kynard 1993). Bain (1997) challenged this view based on a review of Atlantic sturgeon and shortnose sturgeon life history attributes in the Hudson estuary. He concluded that there was considerable overlap in their river distributions and diets. Haley (1999) provided the first field study conducted simultaneously on both species within the same river reaches. She concluded that there was no overlap in the use of space and food resources by the two species, despite their occurrence in the same channel habitats.

In the St. Lawrence River, Atlantic sturgeon and lake sturgeon *A. fulvescens* cooccur (Caron et al. 2001; Fournier 2002) in the upper portion of the estuarine transition zone (ETZ) (Simons 2004). This area has been identified as an important habitat for several life history stages of the two sturgeon species (Caron et al. 2001; Fournier 2002; Hatin et al. 2002 and 2007, this volume; Nilo et al. 2006); it is also the location of a regional sturgeon fishery that targets the subadults of both species (Dumont et al. 2000; Trencia et al. 2002). This area is of great importance since the St. Lawrence populations of both sturgeon species are considered sensitive (Dumont et al. 2000; Trencia et al. 2002). Hatin et al. (2007) recently demonstrated that this habitat should be considered as "essential habitat" for early juvenile Atlantic sturgeon.

Most Atlantic sturgeon diet studies have been conducted in riverine or marine habitats (Mason and Clugston 1993; Johnson et al. 1997; Savoy 2007, this volume), but little work has been done in estuarine habitats (Haley 1999). Similarly, lake sturgeon diets have been examined in detail in inland lakes and rivers (Magnin and Harper 1970; Magnin 1977; Hay-Chmielewski 1987; Kempinger 1996; Chiasson et al. 1997; Beamish et al. 1998; Jackson et al. 2002) but little studied in large rivers or estuaries. Vladykov (1948) described the diet of 205 Atlantic sturgeon sampled over several years in the fresh and saltwater sectors of the St. Lawrence estuary. More recently, Hatin et al. (2002) reported data on the diet of nine adults in two important aggregation areas. Lake sturgeon diet was also studied by Vladykov (1948) in the fluvial estuary as well as by Mongeau et al. (1982) and Nilo et al. (2006) in the St. Lawrence watershed.

The first objective of this study was to describe and quantify the diet components of Atlantic sturgeon and lake sturgeon in the St. Lawrence ETZ by life stage and season. The second objective was to use this information to compare and measure the degree of overlap of Atlantic sturgeon and lake sturgeon feeding regimes by life stage. The results are discussed with respect to (i) our knowledge of the life stage distributions of both species, (ii) the macrobenthic community organization within the ETZ, and (iii) the management implications.

Study Area

The ETZ is the region where freshwater from a river mixes with seawater from the ocean (Simons 2004). In the St. Lawrence River ecosystem, this zone covers about 65 km from Île d'Orléans to Île aux Coudres (Figure 1A) (i.e., the upper part of the middle estuary, including the oligohaline[0.5–5.0‰] and mesohaline [5.0–18.0‰] zones). The St. Lawrence ETZ is characterized by bathymetric, current, and tidal conditions that lead to the periodic formation of a well-defined salt wedge, with upstream bottom currents and sediment and zooplankton retention properties (Ouellet and Cerceau 1976; Winkler et al. 2003; Simons 2004). Surface water temperatures measured in the ETZ in the area where the two sturgeon species cooccurred varied in summer from 20.8°C to 22.6°C and in fall from 15.8°C to 20.0°C. Extensive demersal fish inventories conducted in the St. Lawrence ETZ by Caron et al. (2001) and by Fournier (2002) have shown that Atlantic sturgeon and lake sturgeon cooccur within a transverse zone located at the upstream end of the ETZ. More specifically the cooccurrence zone extends over about 10 km, between the high tide and low tide limits of the 0.5‰ isohaline, which is from the northeastern tip of Île d'Orléans on the north shore to the city of Montmagny on the south shore (Figure 1B). Depths in this area are generally less than 10 m but reach 10–15 m in the main channels. Substrate in the upper ETZ is characterized by hardened Goldwaithe clay and pebbles upstream, followed more or less regularly by coarse and medium sand formations in the middle part, especially on the north side of the islands, and by muddy sands or mud in the channels and further downstream (Drapeau et al. 2001).

Methods

Fish Sampling

Most stomach contents were sampled from sturgeons captured in the summer (June 28 to July 6) and fall (September 18–26) of 2000 during demersal fish inventories conducted with a small Yankee experimental trawl with graded mesh size, from 100 mm to 80, 50, and 14 mm. Details about the trawling parameters can be found in Caron et al. (2001) and Hatin et al. (2007). Additional samples of subadult sturgeon were provided in summer (lake sturgeon) and in fall (Atlantic sturgeon and lake sturgeon) by commercial fishermen who used 203-mm stretched mesh gill nets set for 24 h in shallower waters along the upper islands of the Île aux Grues archipelago and the river's south shore (Figure 1B). Analyses conducted to compare Atlantic sturgeon and lake sturgeon diets were based on the trawl and gill-net samples collected in the cooccurrence zone (Figure 1B). Smaller samples were also obtained from gill netting by fishermen at downstream and upstream lo-

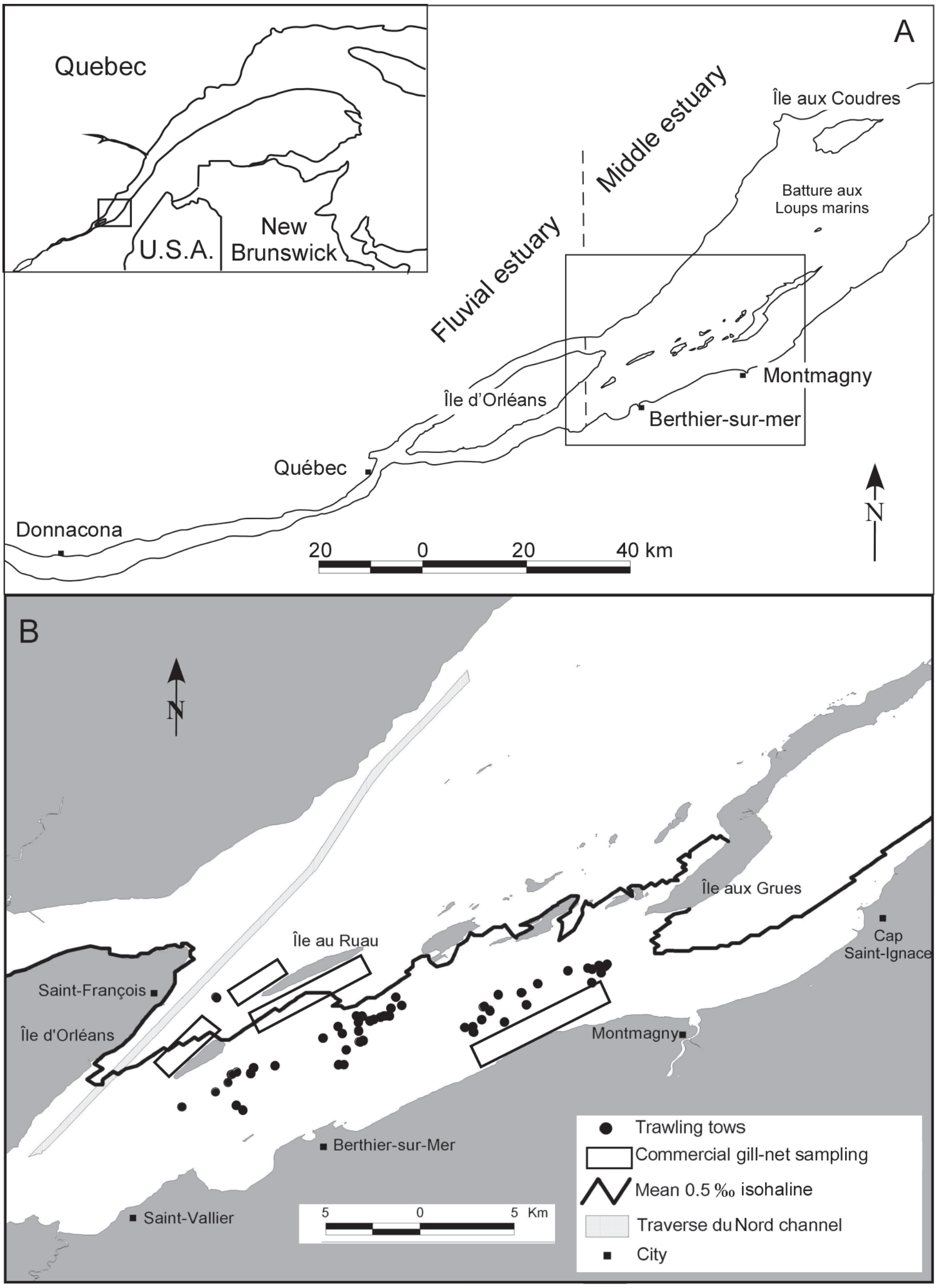

FIGURE 1. (A) Location of the study area in the St. Lawrence estuarine transition zone; also shown are the sampling sites for lake sturgeon (Donnacona) and Atlantic sturgeon (Batture aux Loups marins) out of the main study area. (B) Distribution of trawl tow sampling sites and gill netting commercial fishing areas within Atlantic sturgeon–lake sturgeon cooccurrence area, upstream from the freshwater–saltwater limit (0.5‰).

cations, away from the cooccurrence zone. The latter were analyzed separately to provide indications of the diet in zones where Atlantic sturgeon and lake sturgeon occur separately. In summer, 17 Atlantic sturgeon were gill netted near Batture aux Loups marins, about 40 km downstream from the cooccurrence zone, and 20 lake sturgeon were caught near Donnacona, about 100 km upstream (Figure 1A).

Size-Classes

Atlantic sturgeon and lake sturgeon were grouped into size-classes representing different growth and maturation stages, to facilitate diet comparisons. Three size classes were chosen based on fork lengths (FL): size-class I (<200 mm), size-class II (200–599 mm), and size-class III (>600 mm). Atlantic sturgeon in our samples ranged from 111 to 1530 mm FL and lake sturgeon from 148 to 1310 mm FL. Considering the growth characteristics of Atlantic sturgeon (Caron et al. 2002; Hatin et al. 2007) and lake sturgeon (Fortin et al. 1993) in the St. Lawrence River system, those size categories would correspond approximately to (I) age-0, (II) juvenile, and (III) subadult life stages. We will use these terms (age 0, juvenile, and subadult) throughout the paper to simplify our presentation of the results.

Stomach Contents Analysis

During trawling operations, stomach contents were recovered from live specimens by gastric lavage following the methods of Brosse et al. (2002) and Nilo et al. (2006), modified by using an electric pump with variable flow. Digestive tracts obtained from fish collected by the commercial fishermen were frozen at landing and examined within a few days. Samples were fixed with 10% formalin and kept in 70% ethanol. Prey were sorted by taxon and identified to the most accurate taxonomic level possible using the identification guides of Pennak (1989), Merritt and Cummings (1984), Clarke (1981), Emerson and Jacobson (1976), and Edmonson (1959). For statistical analysis, sets of taxa showing very low abundance or occurrence were grouped into higher taxonomic categories. Thus, the gastropods included pleurocerids, viviparids, *Bittium* sp., bithyniids, *Bithynia tentacula*, and *Littorina obtusata*; diptera included chaoborids and tipulids; and "other insects" represented nonidentifiable items (five taxa) or items in very low abundance: gomphids, odonata, elmid larvae, and hemipters. The total number of taxa found in the stomach contents of Atlantic sturgeon and lake sturgeon was 31, while the contracted set used in the analyses consisted of 16 taxa, ranging from phylum (nematodes) to species (zebra mussel *Dreissena polymorpha*), and not counting capelin (*Mallotus villosus*), which were found only in the stomach contents of fish captured at Batture aux Loups marins. Vegetal matter included filamentous algae and aquatic plants; occasionally, small quantities of thin wood shavings were observed.

Prey abundance and occurrence were noted by taxon. After drying the prey for 24 h in a drying oven, weight was measured with a precision of 10^{-4} g. When taxon counts were higher than 500, we subsampled by weight. For the most abundant gammarids and oligochaetes, 10 samples of more than 300 specimens each were enumerated and weighed. Tests showed that subsampling underestimated the total count by 7.2% (SD = 2.3%). As this bias only applied to stomach contents dominated by gammarids and oligochaetes, it had little effect on the balance between abundant and rare prey. Abundance and dry-weight values were corrected using the recovery rate of each taxon in the gastric lavage procedure (Table 1). Taxon recovery rates (prey recovered by gastric lavage/total number of prey in digestive tract) were calculated from the digestive tracts obtained by sacrificing 10 fish of each sturgeon species. The distribution of sizes within a prey taxon was found to be uniform and allowed us to create a global correction index for both weight and abundance. A few minor taxa, which were absent from the stomach contents of sacrificed fish, could not be given a correction index.

TABLE 1. Mean prey recovery rates in stomach contents of Atlantic sturgeon and lake sturgeon collected in the St. Lawrence estuarine transition zone in 2000 and sampled by gastric lavage.

	Recovery rate (%)	
Prey type	Atlantic sturgeon $n = 10$	Lake sturgeon $n = 10$
Gammarids	97.1	100.0
Oligochaetes	88.3	100.0
Chironomids	99.7	99.9
Baetiscids	98.2	100.0
Brachycentrids	97.2	100.0
Sphaeriids	88.9	98.2
Nematodes	92.1	n/a
Atlantic tomcod *Microgadus tomcod*	100.0	100.0

Data Analysis

The diet of an individual fish was quantified using the relative abundance (%*N*) and relative dry weight (%*W*) of each taxon (Bowen 1996), excluding vegetal matter. The %*W* of vegetal matter was calculated over the total dry weight of prey and vegetal matter combined. For every size-class, the mean %*N*, mean %*W*, and the percent occurrence (%*O*) per taxon as well as the total number of taxa, mean number of prey, mean number of taxa, and mean dry weight were computed using only fish that had food in their stomach. The number of empty stomachs was counted and reported per size-class.

The taxonomic diversity of stomach contents was measured by the Shannon-Wiener index, H' (Legendre and Legendre 1984), which was calculated for each size-class as

$$H' = -\sum_{i}^{n} p_i \ln p_i$$

where p_i is the mean $\%W \times 0.01$ of taxon *i*. The diet overlap between species was measured by size-class using Schoener's overlap index (SI) (Schoener 1968). The SI value is given by

$$SI = 1 - 0.5\left(\sum_{i=1}^{n} \left|p_{xi} - p_{yi}\right|\right)$$

where p_{xi} is the mean %*W* of prey type *i* for species *x*, and p_{yi} is the mean %*W* of prey type *i* for species *y*. This index varies from 0 (no overlap) to 1 (complete overlap). The Shannon-Wiener diversity and Shoener overlap indices were calculated using the standard set of 16 taxa. The relationship between prey weight and vegetation weight was measured using Pearson's correlation coefficient and Rohlf and Sokal's (1969) statistical tables for the critical *P*-values (0.05 and 0.01).

Results

Diet of Atlantic Sturgeon

In fall, 4 age-0, 8 juvenile, and 34 subadult Atlantic sturgeon were captured by trawling (Tables 2 and 3). All age-0 and juvenile fish had food items in their stomachs, while nine of the subadults had empty stomachs. The mean number (20) and mean weight (0.01 g) of prey among age-0 fish were very low, while the same variables were at their highest (>80 000 and >9 g) for the juveniles and subadults. The age 0 had the least diverse diet, composed of only two taxa: gammarids were the most important prey, contributing more than 90% of occurrence, abundance, or weight, while oligochaetes made up the rest of the diet. Oligochaetes were the dominant prey of the juvenile and the subadult stages, with values of relative occurrence, abundance, and weight all exceeding 87% (Table 3). For the juvenile

TABLE 2. Relative occurrence (%*O*), mean abundance (%*N*), and mean dry weight (%*W*) of taxa collected in the stomach contents of age-0 Atlantic sturgeon and lake sturgeon during the summer and fall of 2000 in the St. Lawrence estuarine transition zone.

	Atlantic sturgeon			Lake sturgeon					
	Fall			Summer			Fall		
Age-0	%*O*	%*N*	%*W*	%*O*	%*N*	%*W*	%*O*	%*N*	%*W*
Nematodes				50.0	15.5	24.5			
Oligochaetes	25.0	9.4	5.1						
Gammarids	100.0	90.6	94.9	50.0	8.3	6.9	100.0	57.2	78.6
Baetiscids				100.0	43.4	52.3			
Chironomids				50.0	32.8	16.3	50.0	42.8	21.4
N with food		4			2			2	
N empty		0			0			0	
Total *N* taxa		2			4			2	
Mean *N* prey		20			18			838	
Mean total prey *W* (g)		0.01			0.01			0.30	

stage, gammarids ranked second, occurring in more than one-third of the samples and having a mean percentage by weight of 12.3%. No other prey type played an important role for those two life stages, although additional taxa increased the diet diversity. Nematodes and insects made up part of both juvenile and subadult diets, being more frequent among juveniles. Gastropod opercula and age-0 Atlantic tomcod (mean W = 0.25 g) appeared only in the subadult diet, but as rare prey.

In fall, subadults captured by gill net in shallower waters near the islands or the south shore had a high occurrence of empty stomachs (17/41) (Table 3). Moreover, for those that had food in their stomachs, the mean number of prey was only 157 and the mean total prey weight was only 0.1 g. Their diet differed markedly from that of trawl-caught subadults, most notably by the high prey diversity. While the number of taxa (7) in the diets of fish was similar for the two fishing methods, the H' index was 1.69 for subadults sampled by gill net and 0.19 for fish sampled by trawl. The relatively high diversity came from the regularity of the weight distribution among the different prey types. The main prey were the gammarids (38.5%*W*), which together with other malacostracan crustaceans comprised 50.8% of the total prey weight. The chironomids were the second most important single prey by weight (17.2%). However, the mollusks, as a group, including gastropod opercula and sphaeriid bivalves, contributed 21.5% by weight. Contrary to the subadult stage sampled by trawl, the subadults captured by gill net had only a minor oligochaete component (9.0%*W*). The relative abundance and occurrence of prey followed the same general pattern as the relative weight, with gammarids and chironomids playing the major roles.

In summer, only four subadult Atlantic sturgeon were captured by the trawling operations conducted in the cooccurrence zone (Table 3). For those individuals, the mean number (30) and mean weight (0.1 g) of animal prey in the stomach contents were low. The diet was made up of four taxa: oligochaetes were present in all samples, Atlantic tomcod larvae (mean W = 0.03 g) had been eaten by two individuals, and two had also eaten some gammarids.

In both seasons and with both sampling gears, the subadult Atlantic sturgeon had vegetal matter in their stomach content (Table 3). Thirty eight percent of the subadults had in-

TABLE 3. Relative occurrence (%*O*), mean relative abundance (%*N*), and mean relative dry weight (%*W*) of taxa collected in the stomach contents of juvenile and subadult Atlantic sturgeon captured by trawling and gill netting during summer and fall 2000 in the St. Lawrence estuarine transition zone.

	Summer			Fall								
	Subadult - trawl			Juvenile - trawl			Subadult - trawl			Subadult - gill net		
Atlantic sturgeon	%*O*	%*N*	%*W*[a]	%*O*	%*N*	%*W*	%*O*	%*N*	%*W*	%*O*	%*N*	%*W*
Nematodes	25.0	1.0	13.6	12.5	<0.1	<0.1	8.0	<0.1	0.4			
Oligochaetes	100.0	68.8	24.2	100.0	93.8	87.3	100.0	99.9	96.3	16.7	9.8	9.0
Opercula[b]							8.0	<0.1	<0.1	50.0	13.1	10.8
Sphaeriids										25.0	7.5	10.7
Gammarids	50.0	10.6	24.3	37.5	5.5	12.3	12.0	0.1	1.4	62.5	39.6	38.5
Other malacostracans										20.8	2.2	12.3
Baetiscids										4.2	1.4	1.5
Brachycentrids				12.5	<0.1	0.1						
Chironomids				75.0	0.7	0.3	16.0	<0.1	<0.1	79.2	26.5	17.2
Atlantic tomcod	50.0	19.7	37.9				4.0	<0.1	1.8			
N with food		4			8			25			24	
N empty		0			0			9			17	
Mean *N* prey		30			81,788			104,866			157	
Mean total prey *W* (g)		0.1			11.0			9.6			0.1	
Total *N* taxa		4			5			6			7	
Mean *N* taxa		2.25			2.38			1.48			2.58	
Diversity H’		1.33			0.40			0.19			1.69	
N with vegetal matter		1			0			6			13	
Mean *W* vegetal matter (g)		0.2			n/a			3.5			12.7	

[a] %*W* as a percent of total animal prey.
[b] Opercula: gastropod opercula retrieved without shell or flesh.

gested vegetation, which amounted to 5–99%*W* (mean = 85.7%*W*). Vegetal matter was much more common in the subadults captured by gill net (54.2%) than by trawl (24.5%). The mean vegetation weight was also greater in the subadult gill-net sample (12.7 g) compared to the trawl sample (3.5 g). As vegetal debris generally contained some gastropod opercula, gammarids, and insects, we looked for a potential relationship between prey weight and vegetation weight for those three taxa in the subadult group captured by gill net. The gammarids were the only taxon significantly ($P < 0.05$) related to the quantity of vegetal debris, both when considering all fish in the group ($N = 24$, $r = 0.47$) or only fish having some vegetal material ($N = 13$, $r = 0.65$).

Downstream from the cooccurrence zone, near Batture aux Loups marins (Figure 1A), all of the 17 subadult Atlantic sturgeon gill netted in summer by commercial fishermen had eaten capelin, which was the only prey found in the stomach contents. The mean number of prey was 16.8, totaling 21.0 g dry weight; the mean weight per prey was 1.25 g.

Diet of Lake Sturgeon

In summer, 2 age-0, 56 juvenile, and 33 subadult lake sturgeon were captured by trawling (Tables 2 and 4). Only four juveniles did not have prey in their stomachs. The mean number of prey per fish increased markedly between life stages, from 18 in the age 0 to 1,771 in the subadult. The mean total weight of prey followed a similar trend, from 0.01 to 2.83 g. The juvenile and subadult diets were composed of a high number of taxa (14–15) and were highly diverse (H' = 1.90–1.60). By comparison, the age-0 diet was composed of only four taxa. Vegetal matter was observed in only 4 of the 33 subadult stomach contents, with a mean weight of 4.49 g.

The age-0 fish fed mostly on insects (baetiscids and chironomids) and nematodes (Table 2). The dominant prey taxon for the juvenile stage in summer was gammarids, but the diet also included a substantial proportion of Atlantic tomcod, possibly a transient prey (Table 4). The Atlantic tomcod recovered from the stomach content samples were young of the year (mean $W = 0.17$ g; $N = 24$). Insect taxa (19.9%*W*) and worms (17.8%*W*) were also important components of the juvenile diet. Within those groups, the main taxa were baetiscids and chironomids (insects) and oligochaetes and nematodes (worms). The subadult diet was strongly dominated by oligochaetes, with mollusks, especially sphaeriid bivalves and gastropods, being the second major prey type by weight. Insects were third, with a substantial weight contribution by chironomids.

In summer, a total of 19 subadult lake sturgeon were gill netted in the shallower waters of the cooccurrence zone (Table 4). Only two had empty stomachs. The mean number of prey was much lower than for the subadults captured by trawl. However, the mean total weight of prey was much higher, mostly due to gastropods. Zebra mussels and chironomids were the second most important taxa by weight. The mean weight of vegetal matter was twice as high among the fish sampled by gill net compared to subadults sampled by trawl.

In fall, 2 age-0, 69 juvenile, and 28 subadult lake sturgeon were captured by trawling in the cooccurrence zone (Tables 2 and 5). The frequency of empty stomachs and stomachs with vegetation was very low (≤6%). Compared with the summer diet, the mean number of prey and mean total prey weight increased considerably in all life stages. The total number of taxa decreased, especially in the subadult diet (from 15 to 11), as did the number of taxa contributing 5% or more in weight. The diets of all life stages were dominated by gammarids, which had the highest occurrence, abundance, and weight. The chironomids were the complementary prey for age-0 fish. Oligochaetes and chironomids ranked second and third in importance (by weight) in the diets of juveniles and subadults.

All five subadults sampled in fall by gill net had food in their stomach (Table 5). Compared to subadults captured by trawl, they had a lower mean prey number and mean prey weight, a comparable total number of taxa,

TABLE 4. Relative occurrence (%*O*), mean relative abundance (%*N*), and mean relative dry weight (%*W*) of juvenile and subadult lake sturgeon captured by trawling or by gill netting during summer 2000 in the St. Lawrence estuarine transition zone.

	Juvenile - trawl			Subadult - trawl			Subadult - gill net		
Lake sturgeon - summer	%*O*	%*N*	%*W*[a]	%*O*	%*N*	%*W*	%*O*	%*N*	%*W*
Nematodes	32.7	3.2	5.1	24.2	0.4	2.3	5.9	0.2	0.1
Oligochaetes	34.6	20.3	12.7	72.7	60.5	54.1	58.8	12.8	4.2
Polychaetes				3.0	0.1	0.1	5.9	0.1	0.3
Physids	9.6	0.4	1.3	21.2	1.2	1.8	17.6	0.8	0.7
Opercula[b]	1.9	<0.1	0.4	6.1	<0.1	<0.1	<0.1	<0.1	<0.1
Other gastropods	3.9	0.3	2.0	18.2	1.6	5.7	94.1	31.9	58.2
Sphaeriids	5.8	0.1	0.5	39.4	6.8	10.4	58.8	7.6	4.5
Zebra mussels				3.0	<0.1	0.1	35.3	5.2	13.8
Gammarids	84.6	37.8	29.5	75.8	13.1	9.0	76.5	17.5	4.0
Other malacostracans	3.9	0.1	1.0	3.0	0.6	0.7	17.6	0.4	0.2
Baetiscids	63.5	8.4	9.5	15.2	0.3	0.3	29.4	1.7	0.5
Brachycentrids	32.7	1.8	2.9	6.1	1.7	1.9	47.1	0.8	1.2
Chironomids	71.2	15.5	6.9	75.8	13.4	10.2	82.4	20.4	10.5
Other diptera	11.5	1.4	0.2	3.0	<0.1	<0.1			
Other insects	5.8	0.1	0.4				17.6	0.6	1.9
Atlantic tomcod	42.3	10.7	27.6	12.1	0.3	3.4			
N with food		52			33			17	
N empty		4			0			2	
Mean *N* prey		197			1,771			342	
Mean total prey *W* (g)		0.22			2.83			14.91	
Total *N* taxa		14			15			14	
Mean *N* taxa		4.04			3.79			5.47	
Diversity H'		1.90			1.60			1.45	
N with vegetal matter		0			4			3	
Mean *W* vegetal matter (g)		n/a			4.49			9.00	

[a] %W as a percent of total animal prey.
[b] Opercula: gastropod opercula retrieved without shell or flesh.

but a higher diversity and mean number of taxa. Their diet was dominated (by weight) by mollusks (gastropods and bivalves), followed by oligochaetes, chironomids, and, to a lesser extent, gammarids. Vegetal matter occurred in two fish.

Upstream from the cooccurrence zone, near Donnacona (Figure 1A), 6 of the 20 subadult lake sturgeon captured by gill net had food in their stomach. The mean number of prey was 83.2, distributed among nine taxa. The mean prey weight was 6.62 g. Gastropods were dominant (mean N = 74.0; mean W = 5.1 g), followed by malacostracans (including gammarids) (mean N = 5.0; mean W = 1.3 g). The other taxa (mean W < 0.2 g) were sphaeriids, zebra mussels (only one, weighing 0.13 g), gastropod opercula, chironomids, baetiscids, and nematodes.

Comparison of Atlantic Sturgeon and Lake Sturgeon Diets

The comparison of Atlantic sturgeon and lake sturgeon diets was done for the fall period only. Although few age 0 of each species were captured, it is interesting to compare their diets as this life stage is generally the most difficult to capture. In fall, age-0 Atlantic sturgeon and lake sturgeon had very similar diets that were highly dominated by gammarids but

TABLE 5. Relative occurrence (%*O*), mean relative abundance (%*N*), and mean relative dry weight (%*W*) of juvenile and subadult lake sturgeon captured by trawling and gill netting during fall 2000 in the St. Lawrence estuarine transition zone.

	Juvenile - trawl			Subadult - trawl			Subadult - gill net		
Lake sturgeon - fall	%*O*	%*N*	%*W*[a]	%*O*	%*N*	%*W*	%*O*	%*N*	%*W*
Nematodes	2.9	<0.1	0.2						
Oligochaetes	24.6	11.7	13.6	35.7	24.8	23.4	40.0	17.9	20.7
Physids				3.6	<0.1	<0.1	40.0	1.4	14.4
Opercula[b]	1.4	<0.1	<0.1						
Other gastropods				7.1	<0.1	0.8	20.0	2.0	14.8
Sphaeriids	4.4	<0.1	0.1	17.9	0.9	4.5	100.0	14.2	18.8
Gammarids	95.7	78.9	78.0	92.9	62.3	57.1	80.0	18.8	5.7
Other malacostracans				17.9	0.7	3.8			
Baetiscids	5.8	<0.1	<0.1	10.7	<0.1	<0.1	20.0	0.1	0.1
Brachycentrids	7.3	<0.1	<0.1	3.6	0.1	0.2	20.0	0.3	0.2
Chironomids	33.3	6.5	3.4	50.0	11.2	10.1	100.0	45.2	19.8
Other insects	5.8	1.4	3.2	7.1	<0.1	<0.1	20.0	0.2	5.6
Atlantic tomcod	1.5	1.4	1.4	3.6	<0.1	0.1			
N with food	69			28			5		
N empty	2			0			0		
Mean *N* prey	4,956			5,390			94		
Mean total prey *W* (g)	1.69			3.67			0.28		
Total *N* taxa	10			11			9		
Mean *N* taxa	1.83			2.50			4.40		
Diversity H’	0.76			1.21			1.87		
N with vegetal matter	1			0			2		
Mean *W* veg. matter (g)	4.48			n/a			2.06		

[a] %W as a percent of total animal prey.
[b] Opercula: gastropod opercula retrieved without shell or flesh.

complemented by oligochaetes for Atlantic sturgeon and chironomids for lake sturgeon (Table 2).

We compared the juvenile and subadult diets of both sturgeon species using five taxa groupings, each including 2–4 of the 16 taxa (Table 6). Generally, all three stomach content analysis methods (%*O*, %*N*, and %*W*) gave similar results by species and life stage. Both juvenile and subadult Atlantic sturgeon and lake sturgeon fed on two main types of prey, worms (mostly oligochaetes) and crustaceans (mostly gammarid malacostracans). However, the relative importance of the two taxa showed an opposite trend between species: worms were the main prey for Atlantic sturgeon, whereas crustaceans dominated lake sturgeon diet. Compared to Atlantic sturgeon, the lake sturgeon diet in fall also differed due to a minor contribution of insects (Atlantic tomcod) for the juvenile stage and by a minor contribution of mollusks for the subadult stage. The diets of both juvenile and subadult lake sturgeon were more diverse compared to Atlantic sturgeon. The total number of prey was twice as high in lake sturgeon and the diversity index H’ was from two to six times higher in lake sturgeon. In agreement with these observations, Schoener’s overlap index revealed a low degree of diet overlap between Atlantic sturgeon and lake sturgeon, both for the juvenile (0.26) and the subadult (0.25) stages.

Discussion

This study is the first extensive effort to document the feeding ecology of Atlantic sturgeon

TABLE 6. Comparison of diets from trawl-caught Atlantic sturgeon and lake sturgeon juveniles and subadults captured in the St. Lawrence estuarine transition zone in fall 2000. SI is Schoener's overlap index.

	Juvenile						Subadult					
	Atlantic sturgeon (*N* = 8)			Lake sturgeon (*N* = 69)			Atlantic sturgeon (*N* = 25)			Lake sturgeon (*N* = 28)		
	%*O*	%*N*	%*W*	%*O*	%*N*	%*W*	%*O*	%*N*	%*W*	%*O*	%*N*	%*W*
Worms	100.0	93.9	87.4	26.1	11.7	13.9	100.0	99.9	96.7	35.7	24.8	23.4
Mollusks				5.8	0.1	0.1	8.0	<0.1	<0.1	25.0	0.9	5.3
Crustaceans	37.5	5.5	12.3	95.7	78.9	78.0	12.0	0.1	1.4	92.9	63.0	60.9
Insects	75.0	0.7	0.4	46.4	7.9	6.7	16.0	<0.1	<0.1	60.7	11.3	10.3
Fishes				1.4	1.4	1.4	4.0	<0.1	1.8	3.6	<0.1	0.1
Total *N* taxa		5			10			6			11	
Mean *N* taxa		2.38			1.83			1.48			2.50	
Diversity H'		0.40			0.76			0.19			1.21	
Overlap SI				0.26						0.25		

and lake sturgeon in the area of the St. Lawrence River where they co-occur. Together with Haley's (1999) study on shortnose sturgeon and Atlantic sturgeon, it represents the only detailed account of the feeding ecology of cooccurring sturgeons in estuarine waters using same-period and same-site sampling. Our results are based on samples gathered in early summer and early fall. Sturgeons from the river channels, comprising the largest part of the sample, were caught by trawl. Their stomach contents were collected rapidly by gastric lavage. Sturgeons captured in shallower waters by gill net had more time to digest their stomach contents, which probably explains the higher frequency of empty stomachs. Except for Atlantic sturgeon in summer, samples included a relatively large number of specimens that spanned a wide size range. Captures were made in the middle of the cooccurrence zone, located mainly in the freshwater–tidal saltwater intrusion zone south of the Île aux Grues Archipelago (Figure 1B) (Caron et al. 2001; Fournier 2002).

Atlantic Sturgeon Diet

In the estuarine environment, characterized by the presence of a salinity gradient or by the tidal intrusion of salt water, the diversity of benthic food resources available for sturgeon is low, generally including 20 family taxa or fewer (McCabe et al. 1997; Haley 1999; Fox et al. 2002; Brooks and Sulak 2005). In the St. Lawrence ETZ, 15 benthic families were identified by Nellis et al. (2007a, this volume). This low diversity was reflected in the Atlantic sturgeon diet described in our study, as only 10 taxa were identified in the stomach contents. Haley (1999) and Mason and Clugston (1993) reported similar numbers of taxa in the diets of Atlantic sturgeon in the Hudson and Suwannee estuaries, respectively. In the past, Vladykov (1948) reported 14 taxa in the stomach contents of Atlantic sturgeon sampled in a larger area of the freshwater and brackish zones of the St. Lawrence estuary, suggesting that diet diversity has remained essentially the same over the past 50 years.

Atlantic sturgeon captured in fall in deeper waters fed on two main prey, oligochaetes and gammarids. Feeding behavior changed with age, with age 0 fed mainly on gammarids and the two older life stages, mainly on oligochaetes. Gammarids are found in association with drifting vegetal matter or sand (Nellis et al. 2007a), the main substrate categories used by age-0 Atlantic sturgeon (Hatin et al. 2007), whereas oligochaetes are found in association with silt–clay (Nellis et al. 2007a), the main substrate used by older juvenile and subadult Atlantic sturgeon (Hatin et al. 2002, 2007). The spatial location of age-0 and age-2 Atlantic sturgeon in the ETZ closely corresponds with the gammarid zooplankton/benthos and oligochaete (tubificid) benthic assemblages, respectively (Laprise and Dodson 1994; Hatin et al. 2007; Nellis et al. 2007a). The gammarid and tubificid benthic assemblages described by Nellis et al. (2007a) are positioned in succession in the ETZ, with the former located upstream in waters less influenced by tidal salinity incursion.

In habitats located further upstream, like the lower reaches of rivers and the freshwater–saltwater front, juvenile and subadult diets generally include more insects and amphipods. In Vladykov's (1948) study, insect larvae, crustaceans, and worms showed the highest occurrence in diets of Atlantic sturgeon collected in the freshwater part of the St. Lawrence estuary. Mason and Clugston (1993) made similar observations for Gulf sturgeon *A. o. desotoi* in the Suwannee River, where worms, insect larvae, and amphipods were most important for early juveniles and large migrant subadults and adults.

In fall, oligochaetes largely dominated the juvenile and subadult Atlantic sturgeon diet in the cooccurrence zone. Oligochaetes were also the main food of adult Atlantic sturgeon sampled by Hatin et al. (2002) in two important staging–feeding areas in the fluvial and middle estuaries. In marine and brackish waters, the diet of juvenile and subadult Atlantic sturgeon is frequently reported to be based on worms, particularly polychaetes, while complementary prey include isopods or amphipods and, to a lesser extent, shrimp or decapods. This is true in the marine coastal waters off New Jersey, where polychaetes and isopods were the most important prey items in terms of weight with decapods an important complement (Johnson et al. 1997). Similarly, Savoy (2007) found the subadult diet in Long Island Sound to be dominated by polychaetes followed by decapods, amphipods, and shrimp (by number), or by polychaetes and shrimp (by weight). In the Hudson estuary, polychaetes were dominant in the juvenile and subadult Atlantic sturgeon diets followed by isopods and amphipods, as measured by abundance and occurrence (Haley 1999). In the Connecticut River estuary, the subadult diet was made up nearly exclusively of polychaetes (Savoy 2007). Polychaetes were also the most common prey in the stomach contents of Atlantic sturgeon from the lower Cape Fear River in North Carolina (Moser and Ross 1995). Spatial variation in the dominant prey of juveniles was also observed in the St. Lawrence ETZ: polychaetes (85%) and oligochaetes (14%) were dominant (by number) in the diet of 10 sturgeons captured in 2001 in the two core areas of early juveniles (Hatin et al. 2007). In the mesohaline part of the estuary, Vladykov (1948) also reported a strong dominance of polychaetes (*Nereis virens*) in Atlantic sturgeon stomach contents. In the mesohaline part of the Gironde estuary, juvenile European sturgeon *A. sturio* fed nearly exclusively on polychaetes (91–98% by number) and sparsely on crustaceans (Brosse et al. 2000).

We suggest that the dominance of oligochaetes in the worm component of juvenile and subadult diets in the St. Lawrence estuary, replacing polychaetes in other estuaries, can be explained by the position of the mud substrate within the salinity gradient. The St. Lawrence ETZ is characterized by a tidally recurrent salt wedge responsible for the presence of organic silt–clay substrates at and upstream from the 0.5‰ freshwater limit, with salinities of less than 0.5–2.0‰ depending on the tide (Ouellet and Cerceau 1976; Simons 2004; Nellis et al. 2007a). Under this salinity regime, oligochaetes are generally found in large numbers (Diaz 1980; Ysebaert et al. 2000). In the St. Lawrence ETZ, Nellis et al. (2007a) found that the polychaete assemblage began further downstream, around the 5.0‰ isohaline.

In comparison with their near-exclusive dependence on oligochaetes in deeper waters in the fall, subadults showed feeding plasticity in three different contexts. Most striking was the high diet diversity of the subadults captured by gill nets in shallower waters near the islands or south shore. Admittedly, oligochaetes could have been underrepresented in the samples due to their higher digestibility. However, malacostracans, mollusks, and insects far surpassed the oligochaetes in relative weight, whereas these taxa were absent from the trawl-caught subadults. In the downstream stations (near Montmagny) of their fluvial benthos inventory, Eco-Recherches (1974) found a higher diversity nearshore (H' = 1.18; 1 km) than offshore (H' = 0.18; 2 km). They also reported higher densities of bivalves nearshore and oligochaetes offshore. The vegetation–gammarid relationship found for the stomach contents would explain the large dietary presence of malacostracans in a nearshore habitat richer in vegetation. However, the low biomass found in the stomachs of individuals sampled by gill nets suggests that feeding near the shore is not a long-term sustainable strategy for the subadult. The second case where fish showed feeding plasticity was in the very small sample of subadults captured in summer in the cooccurrence zone: the diets of these sturgeon included fish and nematodes, which are taxa seldom found in the fall diet. The third case is that of the subadult sampled downstream from the cooccurrence zone near Batture aux Loups marins, which had fed only on capelin. This feeding on a single prey suggests an opportunistic behavior related to capelin spawning aggregations (Jangaard 1974), as supported by on-site observations of moribund capelin and surfacing sturgeon (D. Fournier and D. Hatin, Ministère des Resources naturelles et de la Faune du Québec, personal observations). The presence of fish in the Atlantic sturgeon diet is not unusual (Scott and Crossman 1973; Mason and Clugston 1993; Johnson et al. 1997), but fish prey are generally reported in low proportions. About 50 years ago, Vladykov (1948) reported fish in only 4.5% of the stomach contents collected in the same general area.

Lake Sturgeon Diet

The diversity of the lake sturgeon diet is generally related to the diversity and productivity of their river systems (Chiasson et al. 1997; Beamish et al. 1998; Nilo et al. 2006). In rivers of the Canadian Shield, the lake sturgeon diet is composed of only about 10 prey groups (Magnin and Harper 1970; Magnin 1977; Chiasson et al. 1997; Beamish et al. 1998). In the changing environment of the St. Lawrence ETZ, Nellis et al. (2007a) identified only 15 benthos taxa, all used by lake sturgeon during our study. In contrast, 74 taxa were identified in sturgeon stomach contents in the fluvial section of the St. Lawrence and in the benthic fauna by Nilo et al. (2006), of which approximately 50 contributed significantly to the diet of juvenile lake sturgeon. These studies confirm that lake sturgeon has a high diet diversity with respect to the local benthic diversity. However, we found that the number of prey taxa as well as the diet diversity decreased between summer and fall for all life stages while macrobenthos diversity increased in the ETZ during the same period (Nellis et al. 2007b, this volume). Apparently, lake sturgeon concentrated their feeding in fall by selecting fewer prey taxa. In the St. Lawrence River, Nilo et al. (2006) found that juvenile lake sturgeon preferred malacostracan and drifting prey while avoiding mollusk prey. These authors stated that while lake sturgeon are generalist and opportunistic feeders, their diet composition is only partly determined by benthos availability.

In the ETZ, the diet of lake sturgeon varied according to season, life stage, and sampling location. Both the number of taxa and diversity index H' revealed that lake sturgeon diets are more diversified in summer for every life stage. In both seasons, the number of taxa and diversity increased sharply between age-0 and the juvenile–subadult size-classes; in fall, it also increased between juveniles and subadults. Nilo et al. (2006) also observed an increase in the number of prey taxa with increasing juvenile size-class in three of their five St. Lawrence fluvial stations. In contrast, in the Groundhog and Mattagami rivers (northern

Ontario), which are characterized by low benthic invertebrate densities, diets were highly similar across all size-classes (Beamish et al. 1998). Our study also revealed that subadult lake sturgeons captured by gill nets in shallow waters had much larger mollusk and insect components in their diet than their counterparts captured by trawling in the channels.

Lake sturgeon diet in the ETZ can be tentatively summarized as follows. Considering both seasons and all three life history stages, gammarids and insects (chironomids) appear to be the most constant major diet components. Oligochaetes become complementary or important prey starting in the juvenile life stage. Finally, mollusks make up an important part of the diet only at the subadult stage. Fish larvae are a complementary prey in summer for juveniles. In the St. Lawrence River system, Nilo et al. (2006) also found that gammarids and insects (chironomids) made up the basic diet of three size-classes of juvenile lake sturgeon. Moreover, they, like Mongeau et al. (1982) for lac des Deux Montagnes (upper St. Lawrence River), revealed an increase in the mollusk prey and a decrease in the amphipod prey with increasing juvenile size. In the ETZ, we observed a similar pattern between the juvenile and subadult life stages for both prey groups during both seasons. The fish contribution to the summer diet of lake sturgeon was higher in the ETZ than in the riverine section of the St. Lawrence. In our study, the overall fish contribution was 18% (by weight) while the proportion found by Nilo et al. (2006) was 0–6% by weight, depending on the sampling location. In lac des Deux Montagnes, the proportion of fish in the stomach contents of lake sturgeon was 4% by volume (Mongeau et al. 1982). Ephemeropterans or dipterans dominated the diet in other river systems studied (Harkness and Dymond 1961; Magnin and Harper 1970; Magnin 1977; Choudhury et al. 1996; Kempinger 1996; Chiasson et al. 1997; Beamish et al. 1998).

Subadult lake sturgeon captured by gill nets in shallow waters fed much more on mollusks in both seasons than did those captured in the channels. The summer total prey weight was the highest among lake sturgeon samples due to the gastropod contribution. This suggests that, in summer, feeding on gastropods in the nearshore habitat is a profitable strategy in the ETZ. Gastropods and bivalves represented 20% by volume of the fish diets from lac des Deux Montagnes (Mongeau et al. 1982) and 4–23% by weight of the stomach contents from the main river section (Nilo et al. 2006), but they were absent from the lake sturgeon diet in the ETZ sample of Nilo et al. (2006). In Oneida Lake (New York), zebra mussels were the dominant prey of lake sturgeon larger than 900 mm between 1996 and 2000 (Jackson et al. 2002). In the ETZ, zebra mussels were found in small proportion (3%) and provided little weight contribution to the summer subadult diet in spite of their high abundance in some areas (Nellis et al. 2007a). Nilo et al. (2006) also found that zebra mussels were not selected by juvenile lake sturgeon.

Vegetal Matter

Vegetal matter—mainly filamentous algae and aquatic plants—was a common and important component in the stomach contents of subadult Atlantic sturgeon, reaching 50% occurrence in our nearshore samples. In comparison, it appeared only occasionally in the lake sturgeon diet. In the St. Lawrence estuary, 119 of the 205 Atlantic sturgeon sampled by Vladykov (1948) had plant material in their stomach contents. Fresh or decomposing vegetation (macrophyte fragments, algae, seeds) was observed in almost all stomach contents from juvenile lake sturgeon of the St. Lawrence River that were examined by Nilo et al. (2006). As reported by Mason and Clugston (1993), most North American sturgeons ingest organic and inorganic detritus incidentally during the feeding process (Semakula and Larkin 1968; Dadswell et al. 1984; Carlson and Simpson 1987; Nilo et al. 2006). Sand and organic debris were a major component (26–75% in weight) in the stomachs of Atlantic sturgeon collected off the New Jersey coast (Johnson et al. 1997). The presence of plant materials in

Atlantic sturgeon stomach contents was also mentioned by Smith (1985). A high occurrence of detritus and vegetal debris has also been reported in lake sturgeon stomach contents by Harkness and Dymond (1961) and Mongeau et al. (1982).

The incidental nature of this vegetal matter in the sturgeon diets is questionable. In fall, vegetal matter was highly dominant in 17 of the 19 Atlantic sturgeon stomach contents where it occurred. Moreover, vegetation biomass was correlated with gammarid biomass, suggesting a positive selection for gammarids by Atlantic sturgeon. MacNeil and Prenter (2000) showed that gammarids occurred mainly in "weed habitat" or swam freely in the water column. Large patches of drifting detached vegetation have been found entangled in gill nets used for sampling sturgeon in the St. Lawrence estuary; these clumps of vegetation were densely colonized by gammarids (Hatin, personal observation). Haley (1999) also observed high abundances of amphipods associated with vegetation wrapped in gill nets in the Hudson River estuary. Mason and Clugston (1993) suggested that digestible biofilm and substances extracted from the vegetal matter could constitute an additional nutritional source.

Comparison of Atlantic and Lake Sturgeon Diets

In the St. Lawrence ETZ, Atlantic sturgeon and lake sturgeon diets included organisms from all major taxa found in the benthos. Also, both species of sturgeon showed some degree of opportunistic feeding, for example, by taking advantage of larval fish abundance in summer. However, the two species showed important differences in diet diversity and their major prey. Atlantic sturgeon appeared as a specialist feeder and lake sturgeon as a generalist. In fall, lake sturgeon showed higher diet diversity at all life stages and locations. In the channel habitat, juveniles and subadults of both species used the same two main preys, but in opposite proportions: the dominant prey were the oligochaetes for Atlantic sturgeon and gammarids for lake sturgeon, the latter using insects as additional prey. Accordingly, the overlap index of the Atlantic sturgeon and lake sturgeon diets was low, suggesting effective resource partitioning in the cooccurrence zone of the St. Lawrence ETZ. In terms of functional communities in the ecosystem, Atlantic sturgeon concentrated its feeding on endobenthic prey while lake sturgeon mostly fed on epi- and supra-benthos. As their diet differences are based on taxa from different benthic strata, juvenile and subadult Atlantic sturgeon and lake sturgeon could theoretically use the same locations without depleting each other's main food resource. Diet differences found in the St. Lawrence cooccurrence zone were very similar to those found between Atlantic sturgeon and shortnose sturgeon cooccurring in the Hudson estuary (Haley 1999). In the Hudson estuary, spionid polychaetes were the dominant prey retrieved from the stomachs of juvenile and subadult Atlantic sturgeon, whereas gammarid amphipods were the major prey found in the stomachs of adult shortnose sturgeon. Haley (1999) also measured little overlap between Atlantic sturgeon and shortnose sturgeon diets in the Hudson River estuary.

We found two instances of higher diet overlap between Atlantic sturgeon and lake sturgeon. In fall, subadult diets appeared as moderately overlapping in the nearshore habitat, where both species used all major taxa. Yet, in this habitat, Atlantic sturgeon fed more on gammarids and lake sturgeon more on mollusks. The feeding on hard prey like mollusks could be more efficient in lake sturgeon: Guilbard (2002) showed this species to have a larger gizzard circumference and thickness at a comparable length. The second instance is that of age-0 sturgeon, which among all life stages showed the highest diet similarity. In fall, gammarids made up a dominant portion of both species' age-0 diets, with insects used as complementary prey by lake sturgeon. Therefore, in the St. Lawrence ETZ, the age-0 stage of Atlantic sturgeon and lake sturgeon appears susceptible to competition for food.

Haley (1999) found evidence of micro- and macrohabitat segregation between Atlantic sturgeon and shortnose sturgeon in the Hudson estuary. In our study, all Atlantic sturgeon and lake sturgeon captured in the channel came from the same limited trawling area. However, in the St. Lawrence ETZ, zooplankton communities (Laprise and Dodson 1994) and benthos communities (Nellis et al. 2007a) are organized in succession along the salinity gradient. The gammarid community is located a short distance upstream from the tubificid community (Nellis et al. 2007a). Therefore, the horizontal organization of the benthos could lead to some degree of habitat segregation between Atlantic sturgeon and lake sturgeon older life stages, as Atlantic sturgeon mostly feed on oligochaetes (tubificids) and lake sturgeon, on gammarids. Conversely, the limited width of the gammarid community across the salinity gradient (Laprise and Dodson 1994; Nellis et al. 2007a) could lead to some spatial concentration of the age-0 fish from both species.

The strong dependence of Atlantic sturgeon and lake sturgeon on oligochaetes and gammarids suggests that the corresponding benthic assemblages near the upper limit of the salt wedge are important feeding habitats for the age-0, juvenile, and subadult stages of both Atlantic sturgeon and lake sturgeon. The integrity of these habitats in the ETZ should be protected from anthropogenic disturbances such as dredging and sediment disposal operations.

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