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Spatial and Temporal Patterns of Habitat Utilization by Young-of-Year Walleye (Stizostedion v. vitreum) in the St. Louis River Estuary

Spatial and Temporal Patterns of Habitat Utilization by Young-of-Year Walleye (Stizostedion v. vitreum) in the St. Louis River Estuary

by

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INTRODUCTION

The 11,500 acre St. Louis River estuary provides the westernmost port in the Great Lakes system. Its well protected harbor and proximity to the Iron Range, the Minnesota and Wisconsin forest lands, and the grain-producing areas of the Great Plains have established the area as one of the nation's largest ports for both Great Lakes and international shipping. The estuary is also one of the unique natural resources in the Great Lakes area. Its broad, shallow expanses and extensive marshy vegetation make it an ideal wetland habitat for birds, as well as many fish species. Though water quality problems have plagued the estuary since development of paper mills at the turn of the century, the major habitat areas critical for production of waterfowl and fish have not experienced the extensive alteration and destruction which has characterized many of the nation's productive estuarine environments.

One of the major resource populations utilizing the estuary is the southwestern Lake Superior walleye (Stizostedion v. vitreum). This walleye population historically provided a commercial fishery (Kaups, 1978), but water quality problems have severely limited their use since the early 1900's. Recent dramatic improvements in water quality have, however, allowed this fishery to return to its status as a valuable regional resource. The estuary provides the only important spawning area for walleye from Duluth-Superior to the Apostle Islands and an undetermined portion of the north shore of Lake Superior (DeVore, 1978). It therefore serves as a very important nursery area for these walleye during their first year of life.

The type of waters which serve as effective young-of-year walleye habitat has been an important issue during recent years as dredge spoil disposal and commercial and industrial development eliminate or change bays and channels within the estuary. Adequate estuarine habitat for the early life stages of the walleye is important as growth and survival of the young-of-year is largely responsible for the success and ultimate numbers of that year-class as it enters the fishery (Forney, 1976).

This study was therefore initiated with two objectives in mind. The first was to refine methodologies for sampling young-of-year walleye throughout the range of estuarine habitats they select as the season progresses. The second objective was to identify the nature and extent of suitable habitat within the estuary and near-shore Lake Superior. This is important so that adequate protection and, perhaps, mitigation for these habitats can occur as development proceeds in the area. It also offers an opportunity to identify important selection criteria. Habitat selection and preference during this early life stage is the most poorly understood for this and associated species. The estuary offers an ideal study situation for identifying these habitat selection criteria due to the extremely diverse habitats available. There are regional differences in regimes of depth, turbidity, substrate, vegetation, character of the shoreline, and fish forage densities (food supply). An important contrast is further provided by the potential for use of Lake Superior as an alternate habitat which greatly contrasts with the estuary proper in temperature and food supply.

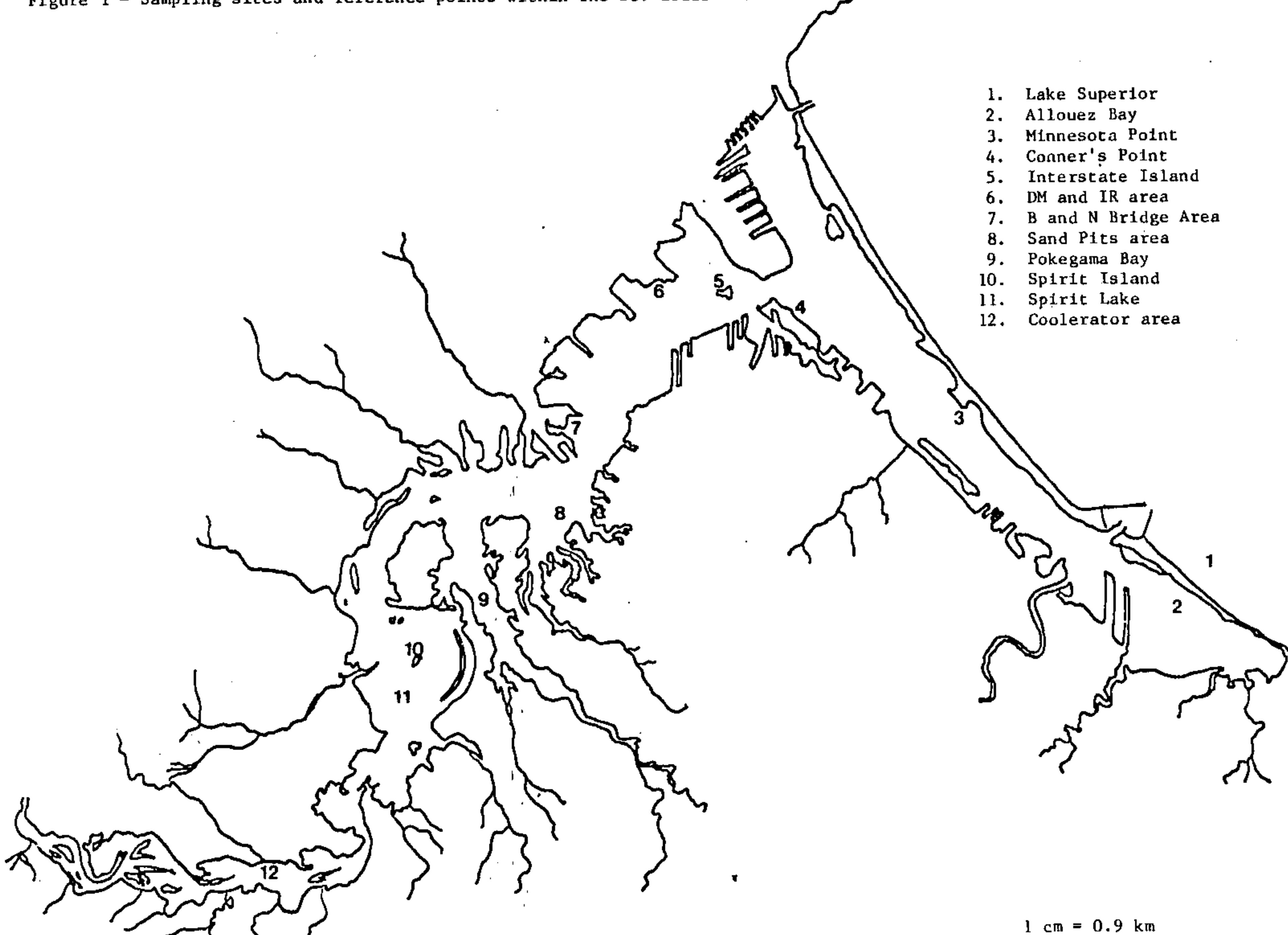
METHODS

During approximately the first month of life (from lengths of 10 to 35 mm) young-of-year walleye are pelagic (free swimming in the water column). Initial sampling techniques therefore require fine mesh nets which can be towed in open water. This study employed a 180 micron ½ meter plankton net and Miller High-Speed Samplers with 250 micron mesh. Sampling was initiated May 2 and continued one to three times per week until the end of June. Tows were 10 minutes in duration and were metered to determine total volume filtered. Daily sampling routines included up to 12 tows from the spawning area to the Superior, Wisconsin entry, a total distance of about 48 km (30 miles) (Figure 1).

After young walleye exceed 35 mm in length they become demersal (associated with the lake bottom), and generally move to relatively shallow inshore waters. As they continue to grow through the summer, they move to greater water depths (Johnson, 1969). Shoreline sampling was therefore initiated in early July with a 7.6 m bag seine with 3 mm mesh. August seining was conducted with a 15 m bag seine with 6 mm mesh. Eleven seining sites were selected on the basis of region within the estuary, turbidity, submerged vegetation, and site seinability. Sites were seined three times, July 20-24, August 4-7, and August 24-28. Three hauls were made at each site during each seining period.

Many areas of the estuary have shorelines which cannot be seined. Small mesh (6 mm) fyke nets were therefore used to assess their effectiveness in capturing young-of-year. Ten sites were selected which represented both seinable and unseinable areas. Seinable sites were

Figure 1 - Sampling sites and reference points within the St. Louis River Estuary



1. Lake Superior
2. Allouez Bay
3. Minnesota Point
4. Conner's Point
5. Interstate Island
6. DM and IR area
7. B and N Bridge Area
8. Sand Pits area
9. Pokegama Bay
10. Spirit Island
11. Spirit Lake
12. Coolerator area

1 cm = 0.9 km

used to assess fyke net catch effectiveness in "known" fish densities. Netting was conducted concurrently with the third seining period (August 24-28).

A 4.9 meter try trawl with 3.2 cm square mesh and 6 mm cod liner was used to sample offshore areas when young walleye moved to deeper water. It was also used to sample adjacent to marshy and vegetated shorelines which could not be seined. The trawl was pulled behind a 20 foot pram at a speed of two knots. Hauls were usually 10 minutes in duration. Trawling areas were selected based upon location within the estuary and turbidity. Within each area replicate hauls were made along depth contours, if such contours were present, or at different distances from shore. Depth and bottom conformity were recorded for each haul using a President's 410 chart recorder. Sampling was conducted during two periods, August 17-27 and October 7-17.

Temperature and turbidity measurements were made at all sites regardless of fishing gear utilized. Also recorded were depth (maximum depth for seining sites), amount and type of vegetation, substrate, and distance from shore. All fish of all species collected were identified and counted in the field. Twenty-five randomly selected individuals of each species were returned to the lab for length measurement.

RESULTS AND DISCUSSION

The spring sampling which was intended to monitor dispersal of walleye frv throughout the estuary gave an early indication of a very poor 1981 year class. One hundred thirty-seven tows were made between May 1 and June 25 with a ½ meter plankton net. These tows produced only two larval walleye. A number of weather-related factors were likely contributors to poor year class production relative to previous years' catches with this method (DeVore, 1978). Spring water temperatures began rising early, initiating movement of walleye through the estuary to the spawning area. Cool weather through late April and May however, caused water temperatures to stabilize and remain low. The walleye were thus not induced to spawn quickly, and the spawning period was quite prolonged. Temperatures for egg incubation were subsequently low, resulting in slow rates of egg development and high egg mortalities. After spawning was essentially complete (as assessed by the two state Departments of Natural Resources who were tagging spawning walleye), the river flooded. Walleye broadcast their eggs during the spawning act and the adhesive eggs attach to rocks in the riffle areas. The eggs are thus exposed to scouring action caused by the high water velocities associated with spring flood conditions. As if this were not enough, any eggs which survived the long incubation period and flood conditions hatched when water temperatures were still unseasonably cold. Low water temperatures result in high mortalities to larval fish due to physical stress (Smith and Koenst, 1975) and low food supplies from delayed plankton blooms (Colby et al, 1979). Poor year class production was confirmed when seining was initiated and the density of young-of-year walleye was the lowest of any year for which records are available (Table 1).

Table 1 - Density of walleye fingerlings as assessed by June and July beach seining between 1975 and 1981. Data supplied by the Minnesota and Wisconsin Departments of Natural Resources, the University of Wisconsin - Superior, and this project.

Year	Hectares Seined	Walleye/hectare
1975	1.1	67.8
1976	0.7	195.0
1977	2.3	45.8
1978	1.3	297.8
1980	1.3	622.5
1981	1.0	25.0

Despite the very low walleye densities which prevented effective assessments of habitat selection, the project was successful in evaluating sampling gear, in establishing baseline data for forage fish densities, and in identifying some of the developing changes in species composition which are occurring within the estuary since the dramatic improvements in water quality with the opening of the Western Lake Superior Sanitary District treatment plant in 1979.

Gear Selection

The complex array of habitats within the estuary and near-shore Lake Superior dictated that a number of gear types be used. Young-of-year walleye habitat progresses from a pelagic state to inshore habitat to a more offshore habitat. During the early pelagic state comparisions were to be made between a ½ meter conical plankton net and Miller High Speed Samplers. Normally there are a number of co-habiting pelagic species in the spring which provide high densities of larval fish. These species include suckers (Catostomus sp.), rainbow smelt (Osmerus mordax), and yellow perch (Perca flavescens). Unfortunately, the same spring water temperatures which severely impacted walleye fry production also affected these species, resulting in extremely low fry densities and preventing meaningful comparisions of the two techniques.

Seining sites were established in early June. Though seinable areas are rare in much of the estuary, seining provides valuable information due to the reliability of the estimates and the availability of comparable data from other agencies. Fyke nets with 6 mm mesh were used to evaluate shallow but unseinable habitats as well as areas beyond seinable depths. These deeper areas were also evaluated using a 4.9 m try trawl. Early seining confirmed, as previously mentioned, that the 1981 walleye year class was very weak. It also provided our best information on changes occuring in species dominance within the estuary, and good information on forage densities.

The fyke nets proved to be very disappointing in terms of information gained vs. time expended. The fyke nets were very selective in that there is a great differential between species and their willingness to follow the leads into the net. Bullheads (Ictalurus sp.) and white suckers (Catostomus commersoni) were most easily captured. Forage size fish were captured, but not in the numbers that adjacent seining sites indicated should occur. Those minnows and young-of-year which did enter the nets were generally subjected to very high levels of predation by the bullheads, some of which were found to consume as many as 40 young-of-year perch. Between poor catch rates, heavy preda-

Table 2

Forage densities (fish/hectare) in different areas of the St. Louis River estuary as assessed by shoreline seining during 1981

	fish/hectare														
	Lake Superior			Allouez Bay			Minn. Point			Conner's Point			Interstate Island		
	7/20	8/5	9/1	7/20	8/5	9/1	7/20	8/5	9/1	7/20	8/5	9/1	7/20	8/5	9/1
YOY perch	72	24	0	812	591	134	119	214	265	233	48	9	1313	2340	1083
Yr. 1 perch	0	0	0	72	0	60	96	191	133	304	24	36	358	0	411
Yr. 2+ perch	0	0	0	0	0	0	0	0	239	0	0	0	0	0	0
YOY Walleye	48	191	9	0	27	0	0	72	0	36	24	0	24	0	9
Spottail shiner	0	0	367	35	484	313	72	1241	4881	1092	191	492	2173	4226	1370
Emerald shiner	0	358	376	13	1692	3313	358	119	119	54	979	260	191	0	0
Golden shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YOY White sucker	0	0	0	1027	322	284	143	215	106	107	24	63	358	215	197
Logperch	0	0	0	310	644	119	119	1839	3568	0	0	36	119	478	546
Johnny darter	0	0	0	24	242	149	72	358	636	18	0	0	191	24	81
Troutperch	0	0	0	478	1128	2909	0	5038	5332	72	0	0	0	0	0
YOY Alewife	0	0	81	0	0	9923	0	0	18040	0	24	931	0	191	45
YOY Smelt	0	883	45	0	0	161	0	191	0	0	72	0	0	0	0
YOY Bluegill	0	0	0	0	0	0	0	24	0	0	0	0	0	0	18
YOY Black crappie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
YOY White bass	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0
YOY Smallmouth bass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* Misc.	167	214	27	191	27	15	0	191	80	0	0	0	0	0	18

Table 2 (continued)

	fish/hectare														
	DM & IR Area			B & N Bridge Area			Sand Pits Area			Pokegama Area			Spirit Island		
	7/20	8/5	9/1	7/20	8/5	9/1	7/20	8/5	9/1	7/20	8/5	9/1	7/20	8/5	9/1
YOY perch	5147	1791	1759	3486	72	2227	2292	1528	430	7521	1624	1800	501	691	413
Yr. 1 perch	294	287	201	48	0	176	0	0	0	466	119	0	394	179	723
Yr. 2+ perch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YOY Walleye	0	24	27	71	0	39	24	0	10	36	0	27	0	0	0
Spottail shiner	11985	3104	11349	1289	3558	2120	3653	5529	1846	10422	5874	2203	11174	32464	5600
Emerald shiner	1618	3152	739	119	334	68	1567	0	0	72	0	0	36	0	41
Golden shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YOY White sucker	441	263	134	382	239	20	454	263	29	4548	1027	886	716	1944	41
Logperch	0	167	739	1170	0	826	191	2579	987	286	72	188	322	179	1074
Johnny darter	74	48	201	406	119	1026	287	692	137	0	143	376	72	26	21
Troutperch	0	0	0	0	72	10	0	0	20	0	96	134	0	0	0
YOY Alewife	0	263	4257	0	119	2481	0	48	0	0	0	0	0	0	0
YOY Smelt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YOY Bluegill	0	0	94	0	96	166	0	0	1439	36	0	537	0	0	0
YOY Black crappie	0	0	0	0	48	615	0	860	0	0	0	376	0	0	0
YOY White bass	0	0	40	0	0	0	0	0	20	0	0	0	0	0	0
YOY Smallmouth bass	0	0	0	0	0	0	0	0	20	0	0	0	36	26	41
* Misc.	0	0	13	478	24	29	143	72	1690	537	96	2390	0	486	0

Table 2 (continued)

	fish/hectare			
	Spirit Lake		Coolerator Area	
	7/20	8/5	8/5	9/1
YOY perch	931	48	0	0
Yr. 1 perch	466	215	287	806
Yr. 2+ perch	0	0	0	54
YOY Walleye	0	0	72	0
Spottail shiner	7260	645	0	430
Emerald shiner	36	72	0	0
Golden shiner	0	0	0	0
YOY White sucker	394	24	143	0
Log perch	179	24	716	54
Johnny darter	0	24	143	54
Trout perch	0	0	2221	0
YOY Alewife	0	0	0	0
YOY Smelt	0	0	0	0
YOY Bluegill	0	0	0	0 *
YOY Black crappie	0	0	0	0
YOY White bass	0	0	0	0
YOY Smallmouth bass	0	96	143	54
Misc.	0	96	287	860

* Misc. includes bullheads, tadpole madtoms, northern pike, lake chub, carp, common shiner, fathead mnnow, long-nose dace, channel catfish, rock bass, freshwater drum, and individuals of the above species which ere too large to be considered "forage" fish.

Table 3

Forage densities (fish/hectare)* in different areas of the St. Louis River estuary as assessed by trawling during 1981

fish/hectare

	Lake Superior		Allouez Lake		Minn. Point		Interstate Island		Sand Pits Area		Pokegama Bay					
	Aug.	Oct.	Aug.	Oct.	Aug.	Oct.	Aug.	Oct.	Aug.	Oct.	Aug.	Oct.	Aug.	Oct.	Aug.	Oct.
YOY perch	0	0	0	15	26	13	246	11	1329	292	462	151	443	425	363	817
Yr. 1 perch	0	0	329	582	316	120	137	85	1032	456	303	103	2607	474	568	1187
Yr. 2+ perch	0	0	160	176	0	40	139	34	189	167	95	79	118	72	44	99
YOY Walleye	26	0	4	4	15	2	11	3	19	2	0	0	42	11	26	4
Spottail shiner	44	0	59	245	413	13	4279	254	1322	161	1531	0	447	2	39	36
Emerald shiner	15	25	72	117	301	0	464	5	4578	10	234	0	274	72	227	0
Golden shiner	0	0	0	0	0	0	0	0	0	2	108	36	13	2	17	44
YOY White sucker	3	0	0	0	5	0	4	3	6	8	32	20	135	93	507	214
Logperch	6	0	0	0	31	0	91	0	12	0	0	0	55	0	44	0
Johnny darter	3	0	4	4	0	11	127	37	6	8	0	0	51	23	52	16
Troutperch	498	0	937	560	985	106	211	167	781	156	6	24	700	53	2059	24
YOY Alewife	0	38	0	4	0	59	42	87	0	48	51	0	0	0	0	0
YOY Smelt	1004	22	17	132	107	1056	257	542	0	0	0	0	0	0	0	0
YOY Bluegill	0	0	0	0	0	0	11	0	0	2	0	0	8	2	4	0
YOY Black crappie	0	0	0	0	0	0	7	0	38	14	32	56	13	83	4	20
YOY white bass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YOY Smallmouth bass	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
* Misc.	97	0	190	505	11	0	7	3	32	24	184	2615	63	4	135	24

* Misc. includes bullheads, tadpole madtoms, northern pike, lake chub, carp, common shiner, fathead minnow, longnose dace, channel catfish, rock bass, freshwater drum, and individuals of the above species which were too large to be considered "forage" fish.

tion, and the necessity of visiting a site for two consecutive days, the fyke nets were found to be generally unsatisfactory. Most areas where fyke nets were used could be sampled with either a seine or trawl.

The most versatile and productive piece of gear proved to be the 4.9 meter try trawl. The trawl was effective in a surprising variety of habitats and in depths from less than 1 to 10 meters. Shorelines with very dense vegetation could not be seined and fyke nets proved inefficient. The estuarine vegetation generally stops abruptly at the one meter contour. This was felt to be an important area to sample and the trawl proved well suited for these areas. It was also very effective in the broad shallow (1.5 - 2 meter) expanses which characterize much of the unperturbed areas of the estuary, although submerged logs and uneven bottoms sometimes caused sampling difficulties. Most of these problems were averted by careful planning of the course to be trawled and by close attention to the chart recorder during sampling.

Forage Densities

Forage densities were assessed regionally and through the season with seines and trawl. Seining was begun in July after the walleye and perch had transformed from their pelagic to demersal habits. Trawling was initiated in late August after the young-of-year walleye normally disappear from inshore seining sites. Although the low number of young walleye precluded good definition of habitat use, qualitative data on forage fish availability was collected throughout the estuary via trawling. Forage fish densities (as tabulated in Tables 2 and 3) include fish which would be available to larger predators (e.g. adult walleye and northern pike).

The extensive sampling capability of the trawl allowed the first estuarine-wide assessments of forage densities. We have provided baseline information for comparisons to future years and to other bodies of water. The importance of estuaries to the large water bodies which they adjoin is well documented in saltwater systems, but is poorly documented in freshwater. Studies initiated in 1981 could therefore form a framework for future studies on fish productivity in freshwater estuarine systems.

Changes in species composition

The 1979 opening of the Western Lake Superior Sanitary District treatment plant resulted in diversions and treatment of wastewater which had previously had profound effects on water quality and fish within the estuary. The benefits of this treatment were evidenced by the immediate recovery of late summer and winter dissolved oxygen levels, major changes in summer distribution of adult walleye, and the elimination of taste and odor problems in harvested fish. The more long-term benefits in term of fish population recovery should first be evident by changes in species composition and species dominance in young-of-year populations. Our project was well-suited to document the initial stage of recovery. Bluegills (Lepomis macrochirus) and black crappie (Pomoxis nigromaculatus) young were found in densities which were orders of magnitude higher than in any previous year (unpublished data). This is not surprising given the high reproductive potential of these panfish and the extent of ideal habitat which was so markedly improved. Also found in record numbers, though still not greatly abundant, were smallmouth bass (Micropterus dolomieui) and white bass (*Morone chrysops*) young-of-year. The young-of-year of channel catfish (*Ictalurus punctatus*) are reported here for the first time in this estuary.

Although some of these species were not abundant, the appearance of young so soon after improvement in water quality indicated the possibility of a rapid change in species composition and species dominance. The early identification of this transition made possible by this project promises a unique opportunity to examine and document these water quality related species changes as they occur.

Summary

This program development project was quite successful although a poor 1981 year class prevented detailed evaluation of habitat selection by young-of-year walleye. Effective sampling techniques were developed and evaluated for the variety of habitats which occur within the estuary. Data provided by this project will also be valuable baselines, since changes are apparently rapidly occurring in species dominance within the estuary. The combination of seining and trawling to assess estuarine-wide forage fish and young-of-year densities may provide the most useful approach to documenting changes in fish populations following dramatic alterations in water quality such as have occured since 1979.

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