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Fish Community Structure and the Utilization of Harsens Island Marsh–Bay Complex, Lake St. Clair

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FISH COMMUNITY STRUCTURE AND THE UTILIZATION OF HARSENS ISLAND MARSH-BAY COMPLEX, LAKE ST. CLAIR[1]

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This is a reprint of a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fisheries, in the School of Natural Resources, The University of Michigan, 1983.

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[1]Contribution from Dingell-Johnson Project F-35-R, Michigan

FISH COMMUNITY STRUCTURE AND THE UTILIZATION OF HARSENS ISLAND MARSH-BAY COMPLEX, LAKE ST. CLAIR

by

Pamela M. Cosentino

A thesis submitted in partial fulfillment
of the requirements for the degree of
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ABSTRACT

Fish samples were collected in the Harsens Island marsh-bay complex of Lake St. Clair to determine the species utilizing marsh and bay habitats. Fish were collected with a variety of gear over a 7-month period. Vegetation was surveyed and habitat parameters measured in 61 hectares of marsh and bay. The marsh extended approximately 77 m from the shoreline to a depth of 50-77 cm. It covered approximately 2 hectares and was dominated by emergent vegetation. The bay comprised the remaining 59 hectares of the total sampling area and was dominated by submergent vegetation occupying a water depth range of 78-186 cm. Water temperature values within the inner and outer marsh were similar, but values from 4 June to 2 July 1981 in the bay were 2-3 C higher. Secchi disk transparency exceeded water depth in all but two measurements, indicating low turbidity in both the marsh and bay. A total of 7,367 fish, representing 39 species, was collected. Four species assemblages were identified, based on seasonal catches of 18 species. The Resident Assemblage was most common, accounting for 90% of the numerical catch. The remaining groups--Spring, Summer, and Fall Assemblages--comprised 3%, 3%, and 1% of the total catch, respectively. Since the Harsens Island marsh-bay community structure was dominated by resident fish species, energy exchange within a freshwater marsh may be self-contained in comparison with an estuarine marsh. Spatial and temporal patterns of utilization in the marsh and bay were common among the species collected. The marsh was generally used as a nursery area, while the bay was used for both spawning and nursery purposes.

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INTRODUCTION

The edge effect created by transition between habitat types in aquatic environments is an important regulatory factor to productivity (Heck and Orth 1980). A marsh represents one distinct ecotone in shallow lotic and lentic aquatic systems. Marsh habitats are among the most productive areas for standing crops of fish, invertebrates, and waterfowl (Meredith and Lotrich 1979; Moore 1978; Tihansky and Meade 1976; Weinstein 1979; Weinstein et al. 1980). Some of the important attributes of marshes are their ability to serve as: (1) nursery areas containing high densities and diversities of fish, invertebrates, and waterfowl; (2) feeding grounds for fish and waterfowl; and (3) sediment stabilizers (Ginsburg and Lowenstam 1958; Heck and Orth 1980; Ricklefs 1979; Robertson 1977; Thayer et al. 1975).

Communities within the marsh and surrounding habitat are complex, with intricate and often subtle interactions among individuals and populations (Subrahmanyam and Coultas 1980). Such interactions may be further complicated by diel and seasonal changes in temperature, turbidity, and water depth, as well as variations in floral and faunal abundance and composition.

The fish community of a marsh consists of both resident and transient species (Subrahmanyam and Coultas 1980; Weinstein et al. 1980). Transient species may reside in the marsh only during early life stages, but they are important components of the marsh community. Upon leaving the marsh as juveniles, transient species export energy into neighboring ecosystems (Weinstein et al. 1980; Yanez-Arancibia and Linares 1980). Conversely, migrants into the marsh import energy from other ecosystems. Interactions within the marsh community are affected by spatial and temporal utilization of the marsh habitat by resident and transient species. Habitat selection appears to be governed mainly by water temperature and vegetation (Heck and Orth 1980; Weinstein et al. 1980).

There is a great amount of interest in the contribution marshes make to lacustrine communities but little study has been made of fish inhabiting freshwater marshes along the Great Lakes. The purpose of this study was to determine the seasonal composition and ecology of fish species inhabiting the freshwater marsh ecosystem of Little Muscamoot Bay, Lake St. Clair. This was done by: (1) evaluating seasonal changes in fish community structure; (2) monitoring water temperature and depth; and (3) measuring monthly gonad growth. Through the examination of fish community structure in a freshwater marsh ecosystem, I hoped to further establish the interdependence of the marsh-lake communities, and the spatial and temporal continuum that exists between them (Heck and Orth 1980; Subrahmanyam and Coultas 1980; Weinstein et al. 1980; Yanez-Arancibia and Linares 1980).

METHODS AND MATERIALS

Study Site

Harsens Island is one of the land masses comprising the Lake St. Clair delta formation. Located on the border of the United States and Canada, on the northeast side of Lake St. Clair, the arcuate delta covers a 120 km^2 area (Jaworski and Raphael 1978). Open interdistributary bays occur in the lower delta. Water depths within these bays, such as Little Muscamoot Bay, range from 0.6-2.0 m (Jaworski and Raphael 1973).

Approximately 61 hectares of Little Muscamoot Bay were sampled during the study (Fig. 1). The study area was divided into three sections, based on vegetation composition, density, distance from shore, and water depth.

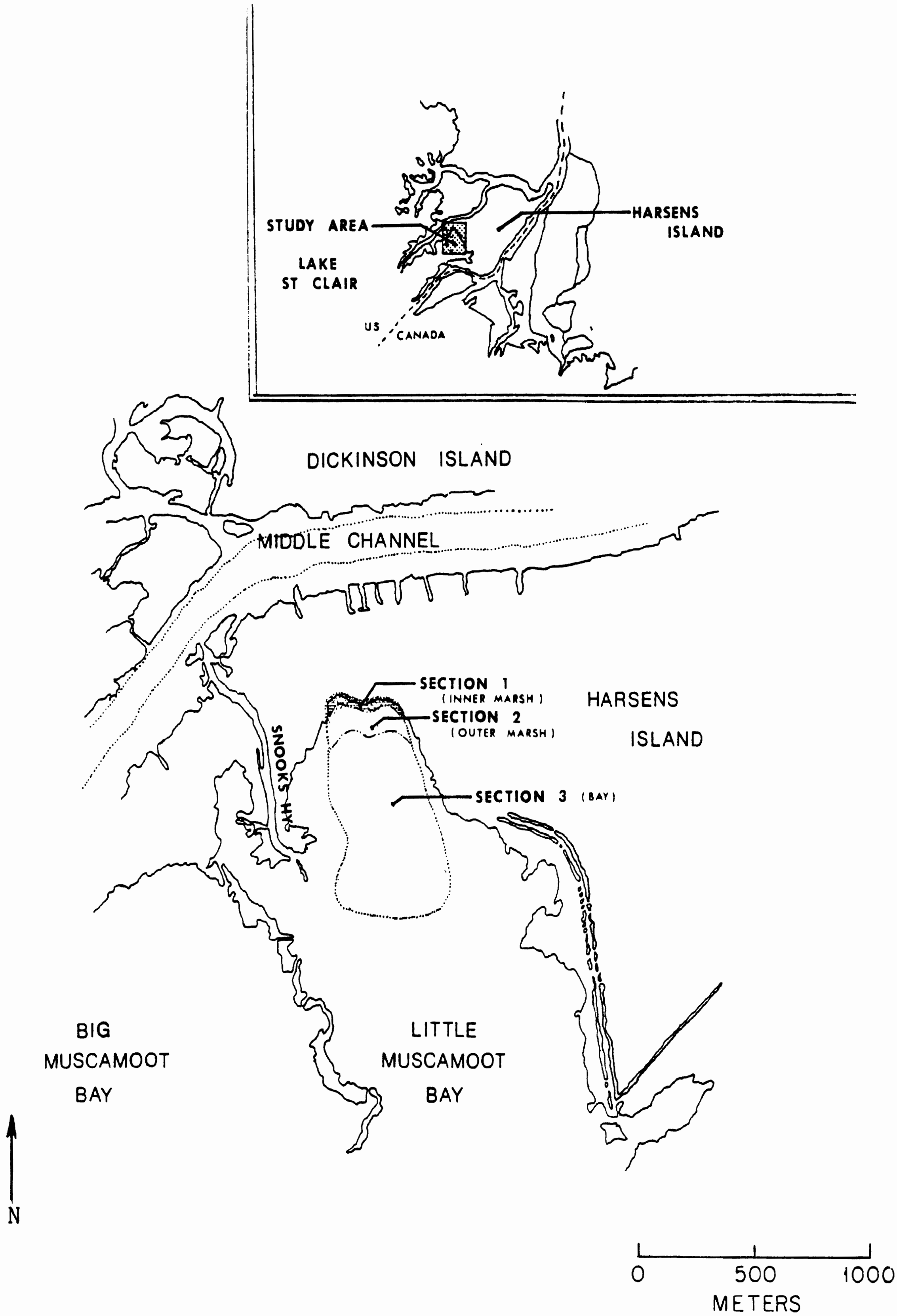

Figure 1. Map of the Harsens Island study area and sampling sites.

The inner marsh, Section 1, was characterized by dense, emergent vegetation. It extended from the shoreline to a depth of 50-62 cm, a distance of approximately 31 meters. The outer marsh, Section 2, was characterized by less dense, emergent vegetation. It extended from the edge of Section 1 to the outer edge of the emergent vegetation, in 63-77 cm of water. Sections 1 and 2 combined comprised only 2 hectares of the total sampling area. Section 3 comprised the remaining 59 hectares of the sampling area and consisted of the inner bay area of Little Muscamoot Bay. Submergent vegetation, which characterized this area, inhabited a water depth range of 78-186 cm. According to the U.S. National Wetland Classification System (Sather 1977), Sections 1 and 2 were classified as a type 3 wetland, which is described as a permanently flooded freshwater lacustrine system with an organic soil type and dominant emergent vegetation. Section 3 was a type 5 wetland, a permanently flooded freshwater lacustrine system with an organic soil type and dominant submergent vegetation.

Vegetation Survey

Information pertaining to plant species distribution, as related to depth of organic sediment and water depth, was collected over approximately 2 hectares of the inner and outer marsh areas. The following procedures were employed in collecting information on 14 August 1981: (1) Samples were collected using the linear plot method (Ricklefs 1979). One-square meter plots were marked at 31-m intervals along five lines extending north and south, beginning approximately 31 m from the shore and continuing to the edge of the emergent vegetation. A total of 34 plots was sampled in this grid configuration. (2) Depth of organic soil was measured by pushing a 2-meter length of plexiglass tube (3-cm diameter) through the soft organic sediment until it was stopped by the firmer underlying stratum. The tubing was inserted in five locations within each 1 m^2 plot. The five soil depth values were recorded in centimeters and averaged to yield a mean estimate of depth of organic sediment within each plot. (3) All plant species inside of the plots were collected, recorded, and assigned a value of abundance. Free-floating, floating-leaf, and submergent species were not counted, but described as "sparse", "common", and "abundant". Stems of emergent species were counted. (4) Plant species outside of the plots were collected and recorded in order to complete the species list. All plant species were then listed according to categories designated by the U.S. Department of Interior (Sather 1977). (5) Plant distribution was related to depth of organic sediment and water depth. Four divisions defining depth of organic sediment were designated: Division I (4-12 cm), II (13-27 cm), III (28-44 cm), and IV (45-100 cm). Three divisions were assigned to water depth ranges: Division I (32-49 cm), II (50-62 cm), III (63-77 cm).

Fish Population Analysis

Sampling

Fish samples were collected during 11 sampling periods from 23 April through 27 October 1981 in the study area. Samples were collected during a 2-3 day period every 2 weeks from 23 April through 14 August and once a month from 25 September through 27 October. Several types of gear were used to ensure that representative samples were collected.

Permanent fyke net stations were established in Section 1 (two stations) and in Section 2 (three stations). Nets were lifted at 24-hour intervals or after a one night set. The total fishing effort for each fyke net during a sampling period was two net nights. Catch per effort (CPE) was calculated as numerical catch per net night, while biomass per effort (BPE) was calculated as grams of fish per net night. Fyke nets were used to sample Sections 1 and 2 from 23 April through 14 August (Table 1). The fyke nets

Table 1. Fishing effort partitioned by gear category and study section, for collections made near Harsens Island from 22 April through 27 October 1981.

Dates	Fyke nets (Net nights)		Electrofishing (Minutes)					Trap nets (Net nights)	Trawling (Minutes)	
	Section		Day Section		Night Section			Section	Day Section	Night Section
	1	2	1	2	1	2	3	3	3	3
22 Apr	4	6	0	0	0	0	0	4	0	0
07 May	4	6	15	15	15	15	15	4	25	30
20 May	4	6	15	15	15	15	15	4	55	10
04 Jun	4	6	15	15	15	15	15	4	15	0
18 Jun	4	6	15	15	15	15	0	4	15	15
01 Jul	4	6	15	15	15	15	0	4	30	10
16 Jul	4	6	0	0	0	0	0	4	30	0
30 Jul	4	6	15	15	0	0	0	4	30	0
13 Aug	4	6	15	15	15	15	0	4	30	15
25 Sep	0	0	15	15	15	15	0	0	0	0
27 Oct	0	0	15	15	15	15	0	0	0	0
Total Effort	36	54	135	135	120	120	45	36	230	80

consisted of a pot approximately 2 m long of 1.5-cm stretch mesh netting, two wings approximately 2 m long, and a lead approximately 4 m long with 5-cm stretch mesh netting. The throat opening was covered with 10-cm stretch mesh netting to prevent turtles from entering the net.

Electrofishing equipment was used to sample Sections 1 and 2 from 7 May through 27 October. Sampling consisted of two 15-minute collections (one during daylight, one after sunset), for a total of 30 minutes of effort per sampling period per section. Electrofishing was not successful in Section 3, due to poor gear efficiency in the deeper water. Consequently, day sampling was not attempted in Section 3 after 7 May and night sampling was discontinued after 4 June (Table 1). Samples were not collected on two occasions because of malfunction of equipment. CPE and BPE values for electroshocking were scaled by minute of sampling. The electrofishing gear consisted of a fiberglass boat with two booms and five electrodes, generator, electrical control box, and safety net. Electrical output was 220-V AC, 3 phase, at 5-8 amps. Two dip nets with 1.5-cm stretch mesh netting were used to collect the stunned fish. Four 150-watt flood lights provided illumination for night shocking.

Two trap nets were used to sample Section 3 from 23 April through 14 August. Nets were fished overnight. The total fishing effort for each trap net during a sampling period was two net nights. CPE and BPE values for trap nets were scaled by net night (Table 1). Each net consisted of a 0.9 x 1.5 x 1.8 m pot of 3.8-cm stretch mesh netting, a 30-m long lead of 6.3-cm stretch mesh netting, and two wings approximately 3 m long with 6.3-cm stretch mesh netting.

Trawl samples were collected in Section 3 from 7 May through 14 August. Sampling time was variable in the beginning of the study, however, two 15-minute trawls were usually made during the day, and one at night (Table 1). CPE and BPE for trawling were scaled by minute of tow. An otter board trawl, approximately 9 m in length, composed of

3-cm stretch mesh netting with an aperture area of approximately 5 m by 1 m, was used. The bag, approximately 2 m in length, was lined with 1-cm stretch mesh netting.

Fish Measurements

Small- to medium-sized fish were preserved in 10% formalin. Large game species were collected, measured to 1 mm, weighed to 1 g, and released unharmed in the field. Initially, the same procedure was used for adult sunfish and bullhead; however, from 2 July onward, they were sacrificed. Their viscera were removed, tagged, and packaged in cheese cloth, preserved, and weighed to 0.01 g in the laboratory. Gonosomatic indices (GSI), defined as gonal weight as a percent of the total body weight, were calculated.

Collections of fish were subsampled in the laboratory. Non-game fish were sorted into 5-mm size classes and game species into 20-mm size classes. For each species, measurements were taken for up to 20 individuals within each size range. Lengths of these fish were measured to 1 mm, body weighed to 0.01 g, and gonads weighed to 0.001 g.

Species Assemblages

Four species assemblages were created, based on 18 species which comprised greater than 1% of the total number of fish collected in either Sections 1 and 2 or Section 3. Criteria for species classified into the Resident Assemblage were: (1) 75% of the catch was made during two or more seasons; (2) catches included both young-of-the-year (YOY) and adult individuals; and (3) similar habitat preferences (Scott and Crossman 1973). Transient species were placed in the Spring, Summer, or Fall Assemblage if: (1) greater than 85% of the total catch for that species was collected within one season; and (2) collections of a particular species consisted of one predominant age class (adult, juvenile, or YOY). All species comprising less than 1% of the total number of fish collected from Sections 1 and 2 (marsh) or Section 3 (bay) were classified as rare.

Total catch of each of the four species assemblages was statistically analyzed as a unit. A three-way analysis of variance (ANOVA) test was used to detect significant differences in catch between: (1) Section 1 and Section 2; (2) date of capture; and (3) time of day (day versus night). Differences were considered significant if $P \leq 0.05$.

Habitat Parameters

Water temperature and depth were noted just prior to deployment of sampling gear. Water temperature was measured with a mercury thermometer in F, and later converted to the nearest 1 C. Depths were measured with a yard stick, in inches, and later converted to the nearest 1 cm. Water transparency was tested with a Secchi disk; however, the readings were not used because the disk was visible on bottom in all but two instances.

RESULTS

Vegetation Cover

Data on vegetation composition and density were collected from 34 1-m^2 study plots within the marsh. Four types of vegetation were collected in the marsh: emergent, submergent, free-floating, and floating-leaf. Emergent vegetation predominated. Most emergent species were found in soft soils and protected inside waters, and water depth did not appear to be a major factor controlling species abundance and location (Table 2). However, one species, Scirpus americanus, was only found in areas with soil of low organic content and with deeper water. This species inhabited the outer edge of the marsh, indicating a tolerance of wave action. The position of this plant at the outer edge of the marsh indicates it is probably the species most responsible for advancement of marsh habitat into open water areas. Over time, the Scirpus americanus would be responsible for production and accumulation of organic deposits, thus allowing other species to advance toward the open water. Typha sp. (cattails) were commonly observed in the marsh, but were absent from the study plot. Cattails comprised a large portion of the vegetation present on Harsens Island, and generally inhabited the marsh-terrestrial margin (Lyon 1979). Visual observation suggested that cattails preferred soft soils and shallow water.

Submergent vegetation was fairly abundant in the marsh. Vegetation collections were not made in the bay, however, visual observation suggested that submergents were the dominant type there. The distribution of submergent species in the marsh was not related to depth of organic sediment or water (Table 2).

Free-floating plants were absent from the study plots (Table 2). Only one species in the floating-leaf category, Polygonum natans, was present and it was rare.

Table 2. Percentage of total numbers of plants collected in all study plots at different depths of organic sediment and water in the Harsens Island study area.

Plant species[1]	Number of plots	Organic sediment depth				Water depth		
		I	II	III	IV	I	II	III
Emergent species								
<u>Scirpus</u> <u>americanus</u>	1	100	0	0	0	0	0	100
<u>Scirpus</u> <u>acutus</u>	16	6	19	75	0	19	50	32
<u>Scirpus</u> <u>validus</u>	13	0	8	92	0	15	62	23
<u>Pontederia</u> <u>cordata</u>	2	0	0	0	100	0	0	100
Submergent species								
<u>Vallisneria</u> <u>americana</u>	6	0	0	67	33	0	17	83
<u>Najas</u> sp.	4	0	0	50	50	0	0	100
<u>Elodea</u> <u>canadensis</u>	4	0	50	50	0	0	50	50
<u>Ranunculus</u> sp.	2	0	0	50	50	0	50	50
<u>Heteranthera</u> <u>dubia</u>	1	0	0	0	100	0	0	100
<u>Potamogeton</u> <u>richardsonii</u>	2	0	0	100	0	0	0	100
<u>Chara</u> <u>vulgaris</u>	30	3	30	67	0	21	46	33
<u>Eleocharis</u> <u>ocicularis</u>	1	0	0	0	100	0	0	100
<u>Myriophyllum</u> sp.	6	0	33	50	17	0	17	83
Floating-leaf species								
<u>Polygonum</u> <u>natans</u>	2	0	0	100	0	50	50	0

[1] The following species were present in the study area but did not occur in the study plots: <u>Typha</u> sp., <u>Sagittaria</u> sp., <u>Sparganium</u> <u>eurycarpum</u>, <u>Scirpus</u> <u>hetorochaetus</u>, <u>Sagittaria</u> <u>latifolia</u>, <u>Eleocharis</u> <u>palustris</u>, <u>Lemna</u> <u>minor</u>, <u>Potamogeton</u> <u>natans</u>, <u>Numphar</u> <u>vareigatum</u>, and <u>Nymphaea</u> sp.

Three species dominated the study plots (Fig. 2). The most prevalent species, Chara vulgaris, (a submergent algae) was found in more than 85% of the plots sampled. The second and third most prevalent species, Scirpus acutus and Scirpus validus, respectively, were emergents. Scirpus acutus occurred in more than 45% of the study plots and Scirpus validus in more than 35% of the study plots. All other species occurring in more than 10% of the study plots were submergents.

Water Parameters

Water temperature, depth, and Secchi disk depth were monitored in each section at the time of each gear deployment, and then pooled by date (Table 3). Water temperature generally increased from April through August, then decreased in September and October. Maximum water temperatures were recorded in August; minimum values were recorded in April and October. Water temperatures were similar in Sections 1 and 2, but Section 3 was 2-3 C warmer from 4 June to 2 July.

Secchi disk transparency exceeded water depth on all but two occasions. These readings, 113 and 118 cm, indicate moderate turbidity in the study area.

Water depths at the netting stations varied from 55 to 70 cm in Section 1, 58 to 80 cm in Section 2, and 95 to 125 cm in Section 3. Water depths in this shallow coastal area could be greatly affected by wind current and direction (Langlois 1954).

Community Patterns

A total of 7,367 fish, representing 39 species, was captured from 23 April through 27 October 1981 (Table 4). Individuals from nine species comprised 85% of the total number captured; of these, five forage species contributed 53%. The term forage species was used to represent all

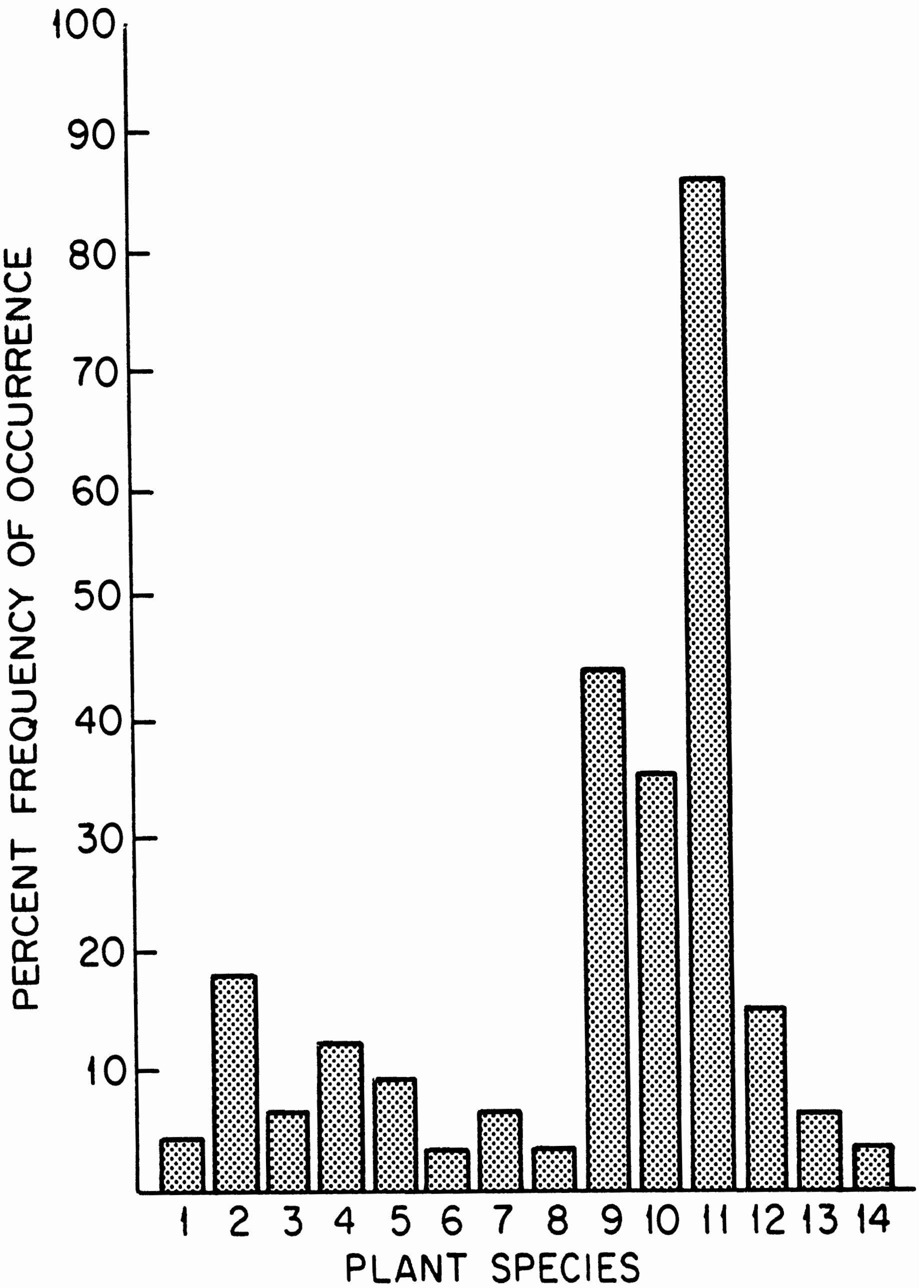

Figure 2. Frequency of occurrence, within 34 1-m² study plots, of following plant species: 1. Scirpus americanus; 2. Vallisneria americana; 3. Polygonum natans; 4. Najas sp.; 5. Elodea canadensis; 6. Heteranthera dubia; 7. Ranunculus sp.; 8. Potamogeton richardsonii; 9. Scirpus acutus; 10. Sirpus validus; 11. Chara vulgaris; 12. Myriophyllum sp.; 13. Pontederia cordata; 14. Eleocharis ocicularis.

Table 3. Average water temperature (C) and depth (cm) by section and date, in 1981 in the Harsens Island study area.

Section and measurement	Date									
	5/7	5/20	6/4	6/18	7/2	7/16	7/30	8/13	9/25	10/25
Section 1										
Temperature	12	14	18	20	19	24	23	24	16	12
Depth	55	58	58	65	65	70	68	65	55	--
Section 2										
Temperature	12	14	16	20	20	23	23	24	17	12
Depth	65	68	68	75	75	78	75	75	58	80
Section 3										
Temperature	12	12	20	23	23	24	23	24	--	--
Depth	95	100	125	120	120	115	118	108	--	--

Table 4. Number of individuals of 39 species of fish collected in the Harsens Island study area.

Common name	Scientific name	Number
Longnose gar	*Lepisosteus osseus*	1
Bowfin	*Amia calva*	5
Alewife	*Alosa psuedoharengus*	44
Gizzard shad	*Dorosoma cepedianum*	10
Rainbow smelt	*Osmerus mordax*	70
Central mudminnow	*Umbra lima*	6
Northern pike	*Esox lucius*	31
Carp	*Cyprinus carpio*	15
Mimic shiner	*Notropis volucellas*	1,459
Bluntnose minnow	*Pimephales notatus*	995
Sand shiner	*Notropis stramineus*	205
Spotfin shiner	*Notropis spilopterus*	199
Spottail shiner	*Notropis hudsonius*	173
Golden shiner	*Notemigonus chrysoleucas*	39
Emerald shiner	*Notropis atherinoides*	30
Common shiner	*Notropis cornutus*	1
Blackchin shiner	*Notropis heterodon*	1
Common white sucker	*Catostomus commersonii*	20
Shorthead redhorse	*Moxostoma macrolepidotum*	3
Redhorse	*Moxostoma* sp.	3
Brown bullhead	*Ictalurus nebulosus*	59
Black bullhead	*Ictalurus melas*	7
Yellow bullhead	*Ictalurus natalis*	5
Tadpole madtom	*Noturus gyrinus*	22
Brindled madtom	*Noturus miurus*	5
Trout perch	*Percopsis omiscomaycus*	42
Banded killifish	*Fundulus diaphanus*	84
Brook silverside	*Labidesthes sicculus*	970
Brook stickleback	*Culaea inconstans*	1
Rock bass	*Ambloplites rupestris*	424
Pumpkinseed	*Lepomis gibbosus*	387
Largemouth bass	*Micropterus salmoides*	231
Smallmouth bass	*Micropterus dolomieui*	119
Bluegill	*Lepomis macrochirus*	27
Black crappie	*Pomoxis nigromaculatus*	25
Johnny darter	*Etheostoma nigrum*	168
Iowa darter	*Etheostoma exile*	146
Yellow perch	*Perca flavescens*	1,326
Freshwater drum	*Aplodinotus grunniens*	9

species of fish whose adults are 10 cm or less in total length. Four species comprised the remaining 32%; with the exception of the yellow perch, these species were members of the Centrarchidae.

Five species assemblages were created: Resident, Spring, Summer, Fall, and Rare. The Resident Assemblage consisted of 14 species, all of which were represented by young-of-the-year, juvenile, and adult fish. Resident species were generally abundant throughout a wide temperature range during most of the year (Table 5). The Spring Assemblage consisted of two species, the spottail shiner and rainbow smelt. Eighty-six percent of the spottail shiners and 100% of the rainbow smelt were collected from late April through mid-June with a 12-21 C temperature range. The Summer Assemblage consisted of one species, the spotfin shiner. Ninety-three percent of these fish were collected from mid-June through mid-August (20-25 C). One species, the alewife, comprised the Fall Assemblage. Eighty-seven percent of the alewives collected were taken during one sampling period in late September at 17 C. The rare fish consisted of 21 species; they are listed in Table 6 and are discussed further in this text.

Catch and Effort

No one type of fishing gear was successful in all three sections. Night electrofishing was performed in all three sections initially; however, use of this gear was discontinued in Section 3 after 4 June because of poor visibility. The types of gear and frequency of sampling were similar in Sections 1 and 2, therefore, catch data for the inner and outer marsh were combined to represent the marsh (Table 7). Due to greater depth and open water, different types of gear were used to collect fish in Section 3 (bay).

Table 5. The Resident, Spring, Summer, and Fall Assemblages of fishes collected in the marsh and bay study sites in the Harsens Island study area.

Assemblage	Temperature Range (C)	Marsh (Sections 1 & 2)	Bay (Section 3)
Resident	12-25	Rock bass Johnny darter Sand shiner Mimic shiner Yellow perch Pumpkinseed Bluntnose minnow Golden shiner Largemouth bass Brook silverside	Rock bass Iowa darter Johnny darter Mimic shiner Yellow perch Pumpkinseed Bluntnose minnow Banded killifish Largemouth bass Smallmouth bass Brown bullhead
Spring	12-21	Spottail shiner	Spottail shiner Rainbow smelt
Summer	20-25	Spotfin shiner	
Fall	12-17	Alewife	

Table 6. Numerical catch of rare species of fish in the Harsens Island study area.

Species	Catch		
	Total	Marsh	Bay
Longnose gar	1	0	1
Bowfin	5	5	0
Gizzard shad	10	10	0
Central mudminnow	6	5	1
Northern pike	31	22	9
Carp	15	14	1
Emerald shiner	30	21	9
Common shiner	1	0	1
Blackchin shiner	1	1	0
Common white sucker	20	5	15
Shorthead redhorse	3	0	3
Redhorse	3	2	1
Black bullhead	7	0	7
Yellow bullhead	5	2	3
Tadpole madtom	22	8	14
Brindled madtom	5	0	5
Brook stickleback	1	0	1
Trout perch	42	2	40
Bluegill	27	9	18
Black crappie	25	13	12
Freshwater drum	9	6	3

Table 7. Catch and effort for fish collections from the marsh and bay in the Harsens Island study area.

Gear and measurement	Marsh	Bay
Fyke net		
Effort (net nights)	90	
Number of species	19	
Total individuals	723	
CPE (number/net night)	8.0	
BPE (g/net night)	122.6	
Electrofishing gear		
Effort (hours)	8.5	0.75
Number of species	31	10
Total individuals	2,947	127
CPE (number/hour)	347.0	169.0
BPE (g/hour)	102.8	19.3
Trap net		
Effort (net nights)		36
Number of species		21
Total individuals		737
CPE (number/net night)		21.0
BPE (g/net night)		1,544.9
Trawl net		
Effort (hours)		5.2
Number of species		27
Total individuals		2,833
CPE (number/hour)		548.0
BPE (g/hour)		8.8

Each gear type was selective for particular species, age classes, and length groups. Passive gears, such as fyke nets and trap nets, generally collected fewer fish. The fyke nets collected younger and smaller species; while the trap nets collected larger adult fish. Active gears, such as electrofishing and trawling, collected the greatest numbers of fish. Electrofishing, successful in the marsh, sampled a wide variety of age classes, species, and length groups. This gear was inefficient in collecting demersal fish such as darters and large evasive predatory fish such as bass. Trawling was used to sample only in Section 3. This gear was particularly efficient at capturing large numbers of young and small fish, as well as adults of sluggish species. The greatest numbers of fish were collected in Section 3 with the use of the trawl (Table 7).

Analyses of variance of CPE's were performed by species assemblage and gear type to detect differences among sections (1 and 2 only), dates, or day/night electrofishing. Differences in day/night electrofishing CPE's were nonsignificant ($P>0.05$). Significant differences in CPE's between Sections 1 and 2 ($P<0.05$) and among dates ($P<0.05$) were detected only for the Summer and Resident Assemblages. For the spotfin shiner (Summer Assemblage) there were significant differences in fyke net CPE's between Sections 1 and 2 and among dates. The section differences did not emerge from the analysis of electrofishing CPE's probably because sample sizes (catches) were low. The Resident Assemblage, which consisted of the rock bass, johnny darter, Iowa darter, banded killifish, brown bullhead, pumpkinseed, mimic shiner, golden shiner, yellow perch, bluntnose minnow, largemouth bass, smallmouth bass, brook silverside, and sand shiner, also exhibited significant differences among electrofishing collections by date of capture ($P<0.05$).

Species Assemblages

Resident Assemblage

Resident species comprised 90% of the total catch. Six species were game fish and eight were forage fish. Resident game species comprised 35% of the total catch, and contained two major predators. Generally, fewer top predator species, such as the largemouth bass and smallmouth bass, were collected as opposed to omnivorous species such as various centrarchids and yellow perch. The yellow perch was the most abundant of all resident game fishes collected in the study area. Resident forage species comprised 55% of the total catch. The mimic shiner, bluntnose minnow, and the brook silverside were the predominant members of the lower trophic levels in the study area.

Species in the Resident Assemblage were abundant throughout most of the year. However, 1.5-fold seasonal fluctuations in catch per unit effort (CPE) values were evident within gear categories (Table 8). These fluctuations generally corresponded to time of reproductive activity, which appeared to be related to water temperature. Seasonal CPE values were compared only within one type of gear. As gear differed between marsh and bay, data from these two areas could not be accurately compared. Fyke net data were not considered because of poor catch efficiency.

Game Species: Seasonal fluctuations in CPE values for resident game species were based on temperature regimes corresponding to spawning periods (Table 8). The brown bullhead was an exception, and had CPE values which were relatively stable throughout the spring and summer. Adult centratchids, such as the rock bass and pumpkinseed, were mainly collected with the use of trap nets during the spring and summer, and were most abundant in the bay prior to the apparent time of spawning. The young-of-the-year fish were primarily collected by electrofishing and trawling during the summer, and were most abundant in the marsh and bay after the apparent time of spawning. Few adult largemouth

Table 8. Seasonal catch per unit effort (CPE) data for resident species collected in the marsh and bay in the Harsens Island study area. (CPE for fyke nets equals number per net night; for electrofishing and trawling CPE equals number per hour.)

Resident species	Marsh					Bay			
	Spring (4/22-6/18) 12-21 C		Summer (7/2-8/13) 20-25 C		Fall (9/25-10/27) 12-17 C	Spring (4/22-6/18) 12-21 C		Summer (7/2-8/13) 20-25 C	
	Fyke nets	Electro-fish	Fyke nets	Electro-fish	Electro-fish	Trap net	Trawl net	Trap net	Trawl net
Rock bass	0.7	3.5*	1.5	6.8*	1.5*	6.9*	4.3*	3.7*	37.9*
Pumpkinseed	0.0	0.9*	2.6	23.2*	5.0*	2.3*	9.6	5.5*	7.1
Brown bullhead	--	--	--	--	--	1.3	0.4	1.9	0.4
Largemouth bass	0.0	0.0	0.8	44.4*	21.0*	--	0.4*	0.1	17.9*
Smallmouth bass	--	--	--	--	--	0.3	1.1*	0.8	30.8*
Yellow perch	0.3	70.6	0.2	48.8	53.5	11.0*	155.0*	3.1*	31.7*
Mimic shiner	0.1	10.6*	1.8	150.4*	28.0*	--	193.6	--	139.6
Johnny darter	0.1	7.4*	0.2	12.8*	4.5*	--	28.2*	--	6.3*
Iowa darter	--	--	--	--	--	--	36.8*	--	5.0*
Banded killifish	--	--	--	--	--	--	9.3*	--	20.4*
Bluntnose minnow	0.4	4.4*	1.9	32.4*	76.5*	0.3	133.9	0.1	110.4
Golden shiner	0.1	0.3*	0.1	12.0*	--	--	--	--	--
Brook silverside	--	0.3	--	187.6	247.5	--	--	--	--
Sand shiner	--	--	0.0	66.4	15.0	--	--	--	--

* An asterisk indicates a minimum difference among CPE values within a gear category of 1.5 times.

bass and smallmouth bass were collected, and the majority of the bass collected were young-of-the-year fish. Young-of-the-year largemouth bass and smallmouth bass were collected in greatest abundance during the summer, however, a substantial number of each species was also taken in the fall. A spatial segregation pattern was evident between young-of-the-year bass species. Young-of-the-year largemouth bass predominately inhabited the marsh, while young-of-the-year smallmouth bass resided in the bay. Unlike the sunfish, the yellow perch preferred cooler water temperature ranges. Adult, juvenile, and young-of-the-year yellow perch were collected in the bay by both trap netting and trawling. Perch CPE's were highest in spring, declined in summer, then increased again with the onset of cooler fall temperatures.

Seasonal changes in gonosomatic indices (GSI) indicated the apparent spawning period for each game species (Fig. 3). The maximum GSI value generally corresponded to the season in which the greatest CPE value was recorded for a species. Seasonal changes in GSI were not apparent for the brown bullhead. Although the index appeared to increase in late July, the GSI value for this species remained low. Gonad data for this species and the sunfishes were collected and recorded midway through the field collections, and, as a result, actual spawning time may not be correctly represented. All centrarchids generally spawned within the same time span, usually the summer, during warmer water temperatures. According to GSI values, adult rock bass and pumpkinseed apparently spawned from early through late July in water temperatures ranging from 20-24 C. Few adult largemouth bass and smallmouth bass were collected in the field, and those which were taken were released unharmed. GSI values were not collected for bass; however, by relating the sizes of young-of-the-year fish with sampling periods, apparent spawning periods were during late spring and early summer in a water temperature range of approximately 14-21

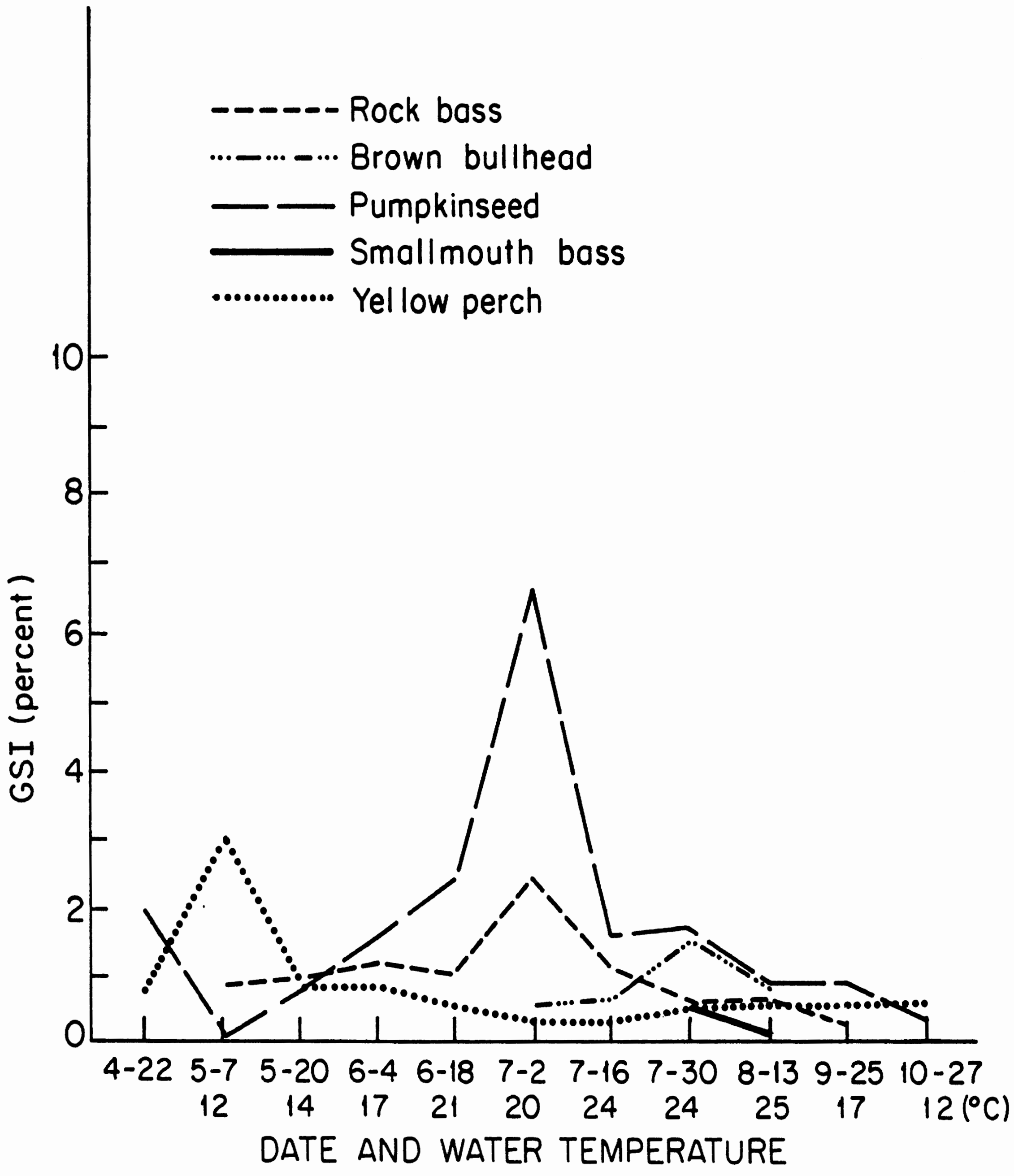

Figure 3. Seasonal changes in gonosomatic index (GSI) for resident game species taken from the marsh and bay in Harsens Island study area.

C. Adult yellow perch were apparently spawning at the onset of field work in late April, at the lowest water temperature recorded (12 C). Most of the spawning activity ceased by mid-May at a water temperature of approximately 17 C. The majority of yellow perch probably spawned prior to field collections of GSI data. Yellow perch collected during the first few sampling periods were predominately 1-year-old ripe males. Evidently, schools of small 1-year-old spawning males commonly conclude the spawning activity (Scott and Crossman 1973). Fish collected in October exhibited a fairly low GSI value; however, fully grown gonads were taken from some larger male yellow perch collected then. This observation suggested preparation for the next spawning in the spring.

Forage Species: Seasonal shifts in CPE values for resident forage species as a unit were somewhat variable (Table 8). As in the case of the game species, seasonal fluctuations observed for forage species apparently corresponded to reproductive activities.

Five forage species were endemic to a particular habitat type. The Iowa darter and banded killifish were only collected in the bay. The Iowa darter was most abundant in the spring, while the banded killifish was most numerous during the summer. The golden shiner, sand shiner, and brook silverside were only collected in the marsh. The golden shiner was most abundant during the summer. Eighty-three percent of the sand shiners collected were taken during one sampling period in mid-August. This species closely resembles the mimic shiner. Quite possibly, it was collected throughout the study but was not recognized. The brook silverside appeared in the marsh in late summer and early fall. Forty-nine percent of the collection was taken in late summer and 51% was taken during the fall. These five forage species apparently used the area as a spawning and nursery ground. Subtle spatial distribution patterns might have occurred, however, obvious patterns, as in the case of the young-of-the-year largemouth bass and smallmouth bass, were absent.

Nine forage species were collected in both marsh and bay. Two species, the mimic shiner and bluntnose minnow, displayed obvious seasonal changes in catch within the marsh. The mimic shiner was most abundant during summer, but a substantial number was also collected during fall. Conversely, bluntnose minnows were most abundant in the fall, but were also collected in the summer. The johnny darter was the only species to display seasonal fluctuations in catch within both the marsh and bay. Johnny darters, collected by electrofishing in the marsh, were most abundant during the summer with moderate numbers also taken in the spring and fall. In the bay, johnny darters were most numerous in spring trawl collections, but were also collected during summer.

Forage species collected in the marsh and bay, which did not display obvious seasonal changes in catch, were assumed to have used both locations as spawning and nursery areas. The mimic shiner and bluntnose minnow apparently used the bay as a spawning and nursery area. Increasing numbers of young-of-the-year fish in the marsh, after the apparent spawning period had ended, indicated that these two species also used the marsh as a nursery area. The bluntnose minnow may overwinter in the marsh, as they occurred in greatest abundance during the fall, a time when all other species appeared to be emigrating from the area. The johnny darter exhibited a spatial distribution pattern which appeared to favor the bay as a spawning area and the marsh as a nursery area.

GSI values were used to indicate the apparent spawning periods for each resident forage species (Fig. 4). All forage species were summer spawners with two exceptions: the golden shiner was a spring-early summer spawner, and the banded killifish was a late summer spawner. Spawning for these two species generally occurred intermittently over a

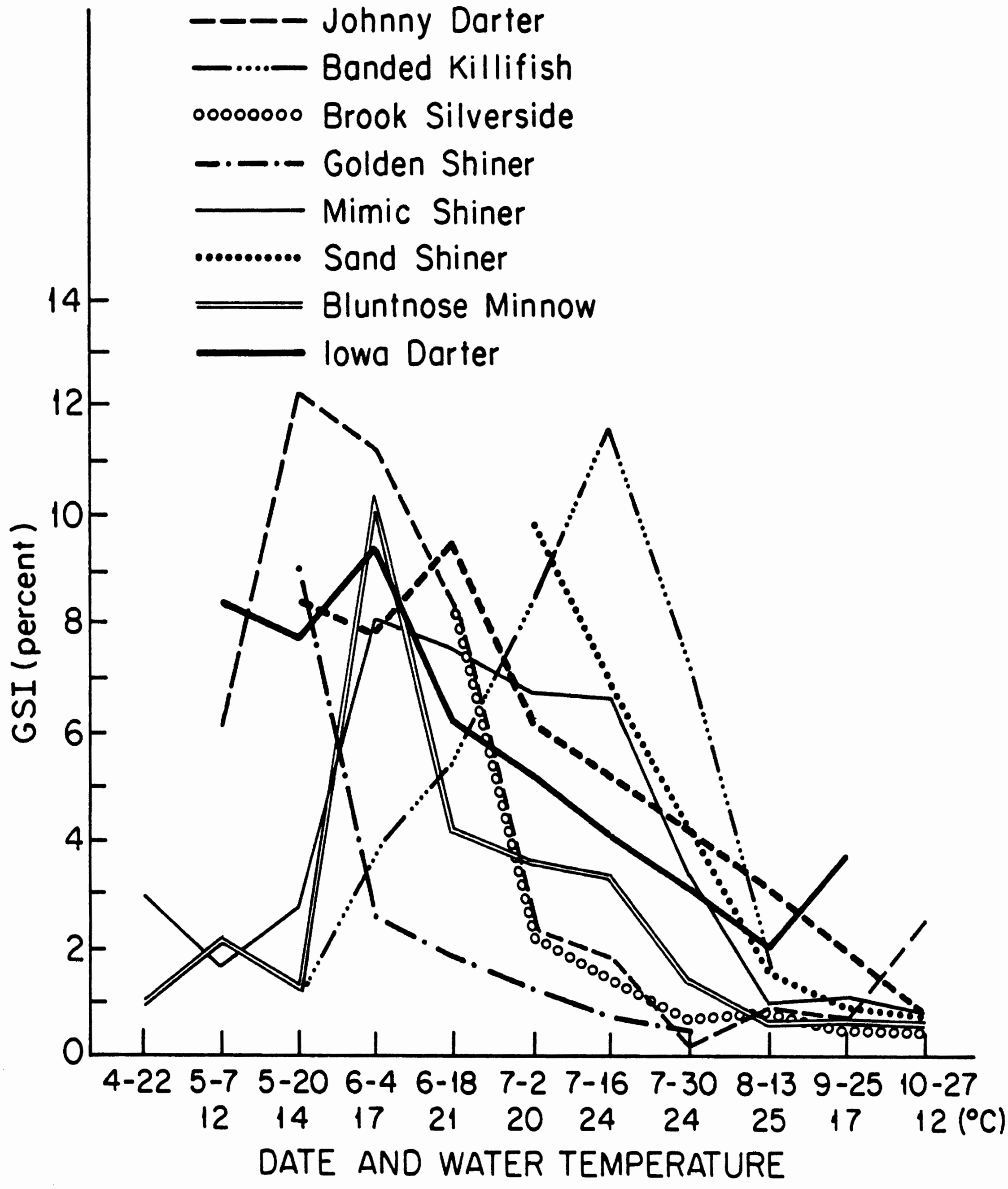

Figure 4. Seasonal changes in gonosomatic index (GSI) for resident forage species taken from the marsh and bay in the Harsens Island study area.

broad span of time and temperature range. Maximum GSI values for the golden shiner occurred in mid-May at approximately 14 C. GSI values for this species decreased steadily from this date until early July. Water temperature ranged from 14 to 21 C. Maximum CPE values discussed earlier for the golden shiner, did not correspond with the apparent spawning period, as was true of most resident game species. The values, instead, appeared related to production of young-of-the-year fish. GSI values indicated that the banded killifish apparently spawned in late summer from mid-July through mid-August in a water temperature range of 24-25 C. The species was collected in greatest abundance during its apparent spawning period.

Most species which spawned during the summer spawned over the longest period of time and the widest range of temperature. Maximum CPE values did not correspond to the apparent spawning period but rather to production of young-of-the-year fish. GSI values for most of these species were observed to decrease suddenly and then taper off gradually. The initial decrease for most of these species occurred from mid-June through early July within a temperature range of approximately 20-21 C. The earliest initial decline in GSI values was observed to occur from early through mid-June for the bluntnose minnow and Iowa darter. The temperature range corresponding to this decline was 17-21 C. The Iowa darter was the only summer spawning forage fish whose CPE was maximum during spawning rather than young-of-the-year emergence. GSI values for the sand shiner, johnny darter, and mimic shiner were observed to decline by early July at approximately 20 C. GSI values for the brook silverside indicated that spawning apparently began in early July and did not plateau until mid-August. The initial decline in GSI values for this species spanned a temperature range of 20-25 C.

Transient Assemblages

Four species, representing only 7% of the total catch, were classified as transient species. Transients were collected during three seasons of field work and were separated into Spring, Summer, and Fall Assemblages.

The Spring Assemblage was comprised of two species, the spottail shiner and rainbow smelt. The spottail shiner collection consisted predominantly of adult fish measuring greater than 40 mm in total length. Of the spottail shiners collected, only 20% were between 30 mm and 40 mm in total length. These fish were collected early in the spring season prior to the apparent spawning period, which occurred from early through mid-June, within a 17-21 C temperature range (Fig. 5). Of the total number of spottail shiners collected, only 12% were taken outside of the spring season. All of these fish were adults. The smelt collected were young-of-the-year fish, which measured less than 100 mm in total length. Adults were not present in the study area. Only 1% of the smelt collected was taken outside of the spring season.

The Summer Assemblage consisted of one species, the spotfin shiner. Ripe adult spotfin shiners, measuring greater than 40 mm in total length, were collected in significant numbers in the outer marsh. Only 1% of the total collection was comprised of fish measuring between 35 mm and 40 mm in total length. GSI values indicated that adult fish apparently spawned in the outer marsh section primarily from mid-June through late July, in a water temperature range of 21-24 C. However, young-of-the-year spotfin shiners were not collected. Only 6% of the total number of spotfin shiners were collected in the fall.

The Fall Assemblage consisted of one species, the alewife. Young-of-the-year alewives, measuring less than 95 mm, were collected on two occasions in the marsh. The majority of the collection, 87%, was taken in September at approximately 17 C.

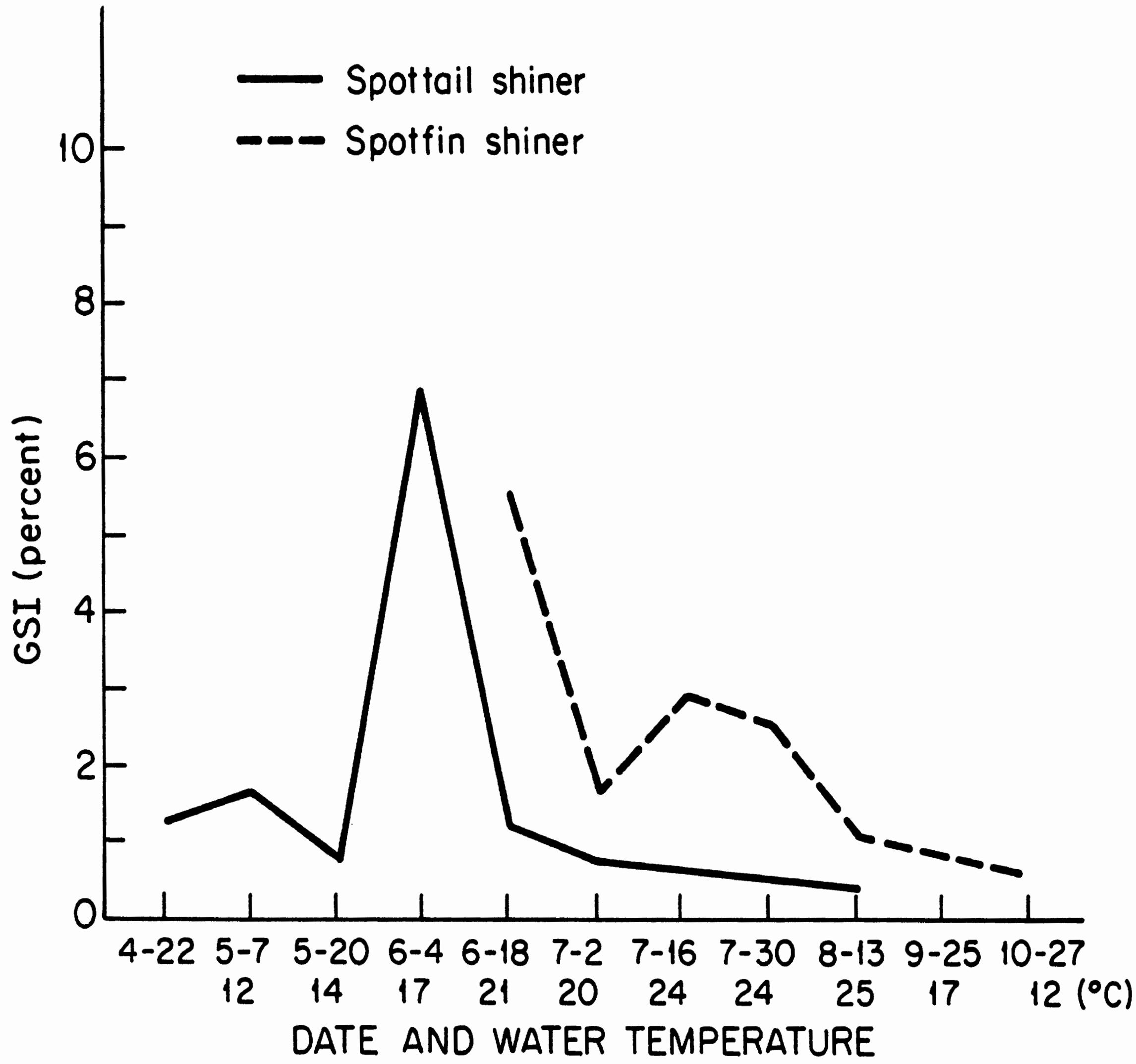

Figure 5. Seasonal changes in gonosomatic index (GSI) for spottail shiner and spotfin shiner collected in the Harsens Island study area.

The northern pike was of special interest among the rare species because of its desirability as a game species and the known requirement of a marsh habitat for spawning. The marsh apparently did not serve as a significant spawning area in 1981. A few (22) young-of-the-year pike were collected in the marsh by electrofishing during spring and early summer. Nine adults were taken in the trap nets in the bay. No spawning adults were taken in the marsh, but they would have left the marsh prior to the first sampling effort. Visually the marsh seemed ideally suited for pike spawning.

Carp were frequently observed in the marsh, but were never in great abundance. None of the gear employed was highly effective in collecting adult carp, however, electrofishing should have been effective for young-of-the-year. The lack of large numbers of young carp in the electrofishing samples suggests the marsh was not extensively used for carp spawning.

DISCUSSION

The Harsens Island study area represented two distinct shallow coastal ecosystems. The structural complexity of the vegetative community was responsible for establishing unique habitats in the marsh and bay ecosystems (Heck and Orth 1980). Dominant vegetation types characterized each ecosystem, reflecting water depth, turbidity, and organic content of the soil (R. D. Drobney, personal communication).

The fish community consisted of 39 species that were collected occasionally, seasonally, or throughout the study in the marsh or bay. Fourteen resident species dominated the community, and comprised 90% of the total fauna. Four transient species comprised 7% of the total fauna, and 21 rare species comprised the remaining 3%. This community structure was the reverse of estuarine marshes, where transient species were the predominant community component (Subramanyam and Coultas 1980; Weinstein et al. 1980; Yanez-Arancibia 1980).

Specific spatial and temporal utilization of the marsh and bay areas were evident in many fish species. Environmental parameters such as water temperature, and ecological parameters such as inter- and intraspecific interactions, were probably responsible for initiating and maintaining a schedule for each species. Spatial separation of habitat between adult and young-of-the-year fish in order to exploit various resources was probably an important consideration in the success of these species (Hall and Werner 1977).

The importance of this marsh to Lake St. Clair depended partly on its potential as a nursery area for young-of-the-year fish. Twelve of the 18 species comprising the assemblages used the marsh as a nursery area, while only five species used the marsh to spawn. Young-of-the-year centrarchids used the marsh primarily during the summer as a nursery area, generally emigrating with the onset of cooler temperature in the fall. The largemouth bass remained during cooler water temperatures, and young-of-the-year fish were collected as late as 27 October. A definite spatial distribution pattern was evident for the largemouth bass and the smallmouth bass. Individuals of both species were collected intermittently in both areas. However, young-of-the-year largemouth bass were collected more commonly in the marsh, as depicted by a 7:1 catch ratio, while young-of-the-year smallmouth bass were mainly taken in the bay. This spatial segregation pattern could not be detected for adults because few were collected. Interspecific competition may have resulted in habitat segregation by young-of-the-year bass species. Werner et al. (1977) observed spatial segregation of centrarchids throughout the summer and concluded that competition was important in determining resource utilization. Likewise, spatial segregation by young-of-the-year largemouth and smallmouth bass probably reduces competition and increases prey availability. Protective cover was provided by marsh and bay vegetation (Clady 1977; Colle et al. 1978; Davies 1972; Elliot 1976).

Six forage species used the marsh primarily during the summer as a nursery area. Three of the six species were endemic to the marsh, and also used it as a spawning area. Young-of-the-year of several forage species immigrated into the marsh after the apparent spawning period (late spring through early summer), remained there during the summer, and then emigrated from the marsh at the onset of fall.

Transients comprised only a small percentage of the species fauna. Seasonal collections were usually linked to reproductive cycles. Seasonal collections in the marsh of two species, the rainbow smelt and alewife, were related to feeding. Inshore migrations of these young-of-the-year fish are commonly related to light intensity and water temperature (McCauley 1982; Scott and Crossman 1973). Smelt and alewives were primarily collected within a mean water temperature range of 12 C - 17 C, similar to the range observed by Hart and Ferguson (1966). Young-of-the-year smelt were collected in the spring, while young-of-the-year alewives were taken in the fall. Immature fish of both species were planktivorous, and probably exploited food resources in the marsh in the presence of protective covering. Lower predation pressures, food availability, and cooler water temperatures during the spring and fall seasons, were probable advantages for these species to immigrate into the marsh.

Low predation and high prey availability were probably two reasons why young-of-the-year fish use the marsh. Heck and Orth (1980) noted that aquatic vegetation provided: (1) protection for young-of-the-year nonschooling fish from predators; and (2) prey availability through increased invertebrate abundance. Maximum utilization of the marsh in mid-August by young-of-the-year fish coincided with maximum vegetation density.

With the onset of cooler temperatures and decreases in vegetation density, larger young-of-the-year fish apparently migrated from the marsh into vegetated regions of the bay. This could not be surmised from our data, as fall catch values for the bay were absent. However, Hall and Werner (1977) observed small bluegills and shiners to migrate in the fall from shallow littoral areas into deeper areas within localized regions of vegetation. These offshore migrations were associated with increased cover and food availability in the submergent vegetation beds of probable overwintering areas.

With increasing water temperatures in spring, the shallow surface water of the marsh and bay areas warmed rapidly. Warm temperatures increased food supplies of plankton and benthos, resulting in increased prey availability (Beatty and Hooper 1958). Emerging chironomids in May and mayflies in June were particularly vulnerable prey, due to slow and patchy regrowth of perennial vegetation. Migration of adult fish into the marsh and bay was probably undertaken to exploit high prey availability.

Most species spawned in the bay, apparently during the summer according to their GSI and CPE values. Centrarchids, minnows, and darters displayed seasonal fluctuations in abundance corresponding to apparent spawning periods. These species apparently spawned throughout the summer. Yellow perch, on the other hand, preferred cooler water temperatures and spawned during the spring. A variety of ecological factors related to vegetation morphology and density contributed to the use of the bay as a primary spawning area. The fact that it was also used considerably as a nursery area suggested that the bay may have been of major importance for both purposes.

A variety of fish sampling gears were used in the marsh and in the bay to eliminate biases which might result from gear inefficiencies. However, because the types of gear employed did differ, CPE values for the marsh and bay could not be accurately compared. Fish collected in the Harsens Island marsh-bay complex were fairly representative of actual species composition, community structure, age-maturity structure, and length groups. However, a few observations, such as the rarity of adult largemouth and smallmouth bass, may have been the result of sampling error. Regular and moderately frequent sampling periods were established and the observed seasonal fluctuations in CPE and GSI values of resident species apparently represented general trends. However, in the case of transient species, biweekly sampling may have missed some important events. The apparent spawning times for centrarchids and bullheads were not accurately determined because gonad data were not collected for these species until midway through the study. The absence of early GSI values probably resulted in estimation of later than actual spawning periods.

The fish community structure characterizing the Harsens Island marsh-bay complex differed from the community structure observed in the estuarine marsh complex. The primary role of the marsh as a nursery area was analogous in both ecosystems, but community structure and spatial-temporal utilization patterns were different. The marsh, as a unit, provided a continuum of ecological interactions responsible for energy exchange with surrounding habitats. The freshwater marsh-bay complex was dependent on local energy exchange and was generally a self-contained system, while the estuarine marsh complex, also dependent on energy exchange, was a larger and more regional transient ecosystem. The importance of marshes in both complexes cannot be defined in terms of a single production value, nor can freshwater marshes, their community structure, function, and production, be accurately compared with those of estuarine marshes or saltwater marshes. Rather, each marsh should be considered a unique system, a component which enhances the ecological function of the whole lake system.

SUMMARY

Samples of fish collected in the Harsens Island marsh-bay complex were used to determine species composition and utilization of the marsh and bay habitats. Samples were generally representative of actual species composition, community structure, and age-maturity structure. This community was dominated by resident species, in contrast to estuarine marsh ecosystems which are dominated by transient species. This fact suggests that energy exchange within a freshwater marsh ecosystem is mostly self-contained.

Spatial and temporal utilization within and among the marsh and bay areas were evident in many fish species. Most species used the marsh as a nursery area and the bay as an apparent spawning area. Environmental parameters, such as temperature, and ecological parameters, such as inter- and intraspecific interactions, were probably responsible for initiating and maintaining a schedule for each species.

Young-of-the-year fish of most species used the marsh as a nursery area during the summer, with maximum CPE values generally corresponding to maximum vegetation density. Few obvious spatial and temporal segregation patterns were observed among young-of-the-year fish species. Low predation pressure and high prey availability, characteristic of vegetated habitats, probably favored marsh utilization by young-of-the-year fish. With the onset of cooler water temperatures, young-of-the-year fish apparently moved into the deeper waters of the bay.

Many types of adult fish used the bay as a spawning area during the summer. Spatial and temporal segregation patterns were not evident among adult fish species. The bay apparently provided a desirable combination of prey availability and preferred spawning habitat.

The bay was also used considerably as a nursery area, which suggests it was a self-sustaining system. The relative importance of marsh and bay habitats is irrelevant, rather, importance should be defined as the continuum of interactions between marsh and bay habitats, which are responsible for maintaining the holistic and integral equilibrium of the entire lacustrine ecosystem.

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