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POPULATION CHARACTERISTICS OF NORTHERN PIKE IN A LAKE SUPERIOR ESTUARY

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ABSTRACT

Northern pike (Esox lucius) were studied in the St. Louis River estuary to document spawning areas, determine movement patterns, and obtain data on age, growth and mortality. Allouez Bay and Grassy Point were the major spawning areas in the lower estuary. The sex ratio during the spawning season was one to one. Females had a slight growth advantage during the first year of life but growth was similar to males during the second year. After age III, females grew faster than males. Most northern pike were harvested within 5 km of their spawning areas. Total annual mortality was 45% and is low compared to inland studies. The low annual mortality rate was probably a result of reduced angling mortality due to the dispersal of fish throughout the estuary and Lake Superior. Habitat preservation is the most important management goal.

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INTRODUCTION

Northern pike (Esox lucius) provide a major recreational fishery in the St. Louis River estuary. During the past century, development of the ports of Duluth, Minnesota and Superior, Wisconsin has eliminated much of the spawning habitat needed to perpetuate this fishery. The shallow water habitat that remains is threatened by industrial waterfront development. In addition, water quality problems, caused primarily by paper mill effluents over the past 50 years, give the fish a poor flavor and discourage harvest by anglers. However, recent water quality improvements have triggered an increase in fishing pressure.

Due to the lack of fisheries data needed to adequately manage the estuary, the present study was conducted with the objectives of documenting spawning areas, determining movement patterns, and obtaining data on age, growth and mortality of the St. Louis River northern pike.

STUDY AREA

The St. Louis River is the largest United States tributary entering Lake Superior. The river originates in northern Minnesota; however, the lower 40 km (4,452 ha) forms an estuary and is the state boundary between Wisconsin and Minnesota (Fig. 1).

The majority of the estuary is less than 3 m deep, except for a 7- to 9-m dredged navigational channel. A power dam near the Village of Fond du Lac prevents further upstream migration of fish. From the dam downstream to Fond du Lac (3 km) a series of rapids limits small boat navigation. From Fond du Lac to the Arrowhead Bridge the river takes on the character of an estuary with numerous bays, small islands, emergent vegetation and shallow water. Downstream from the Arrowhead Bridge the river is characterized by shipping channels and waterfront development in the form of docks, piers and bridges. The only areas left undisturbed in the lower estuary are Wisconsin's Grassy Point, a portion of Minnesota Point, and Allouez Bay.

The estuary supports a large and diversified fish population including walleye (Stizostedion vitreum vitreum), yellow perch (Perca flavescens), rainbow trout (Salmo gairdneri), brown trout (Salmo trutta), chinook salmon (Oncorhynchus tshawytscha), burbot (Lota lota), emerald shiner (Notropis atherinoides), spottail shiner (Notropis hudsonius), white sucker (Catostomus commersoni), longnose sucker (Catostomus catostomus), shorthead redhorse (Moxostoma macrolepidotum) and silver redhorse (Moxostoma anisurum). Many of these species are seasonally abundant, using the estuary to spawn but spending the majority of the year in Lake Superior.

METHODS

During 1978 and 1979, 2,088 northern pike were captured in the St. Louis River estuary using 1.2-m fyke nets made of 25.4- and 10-mm stretch mesh and 22.8-m leads. Nets were set immediately after ice-out and were lifted daily from 19-29 April 1978 and 24 April to 3 May 1979.

All northern pike captured were measured to the nearest 2.54 mm (total length). Weights were recorded to the nearest 45.4 grams. The majority of female weights were from ripe or green fish. Sex was determined by external examination. In 1978, fish more than 500 mm in length were tagged with a yellow Floy FD 688 anchor tag printed with a number for each individual fish and inscribed with "Mail to DNR, Brule, Wis.". In 1979, fish more than 380 mm in length were marked with the same type of anchor tag. Tags were inserted into the muscle at the midpoint of the dorsal fin base and locked between the interneural spines. Fish that were not tagged were measured and released. Tags were voluntarily returned by anglers.

Age and growth data were obtained only from northern pike sampled in 1979. Several scales from each fish were impressed on acetate slides and magnified 42.6 times with a microprojector. Anterior scale radius and radius to each annulus were measured. The outside margin was considered an annulus since scale samples were collected in early spring prior to the summer growth period.

An estimate of total annual mortality was made using a catch curve (Ricker 1975). The estimate of angling mortality was based solely on tag returns.

RESULTS AND DISCUSSION

Reproduction

Allouez Bay and Grassy Point were identified as the two primary spawning areas (Fig. 1). Spawning areas were identified by netting in habitats known to be used by northern pike for spawning (Scott and Crossman 1973, Priegel and Krohn 1975) and by the number of spawning-condition fish captured in those areas (Table 1).

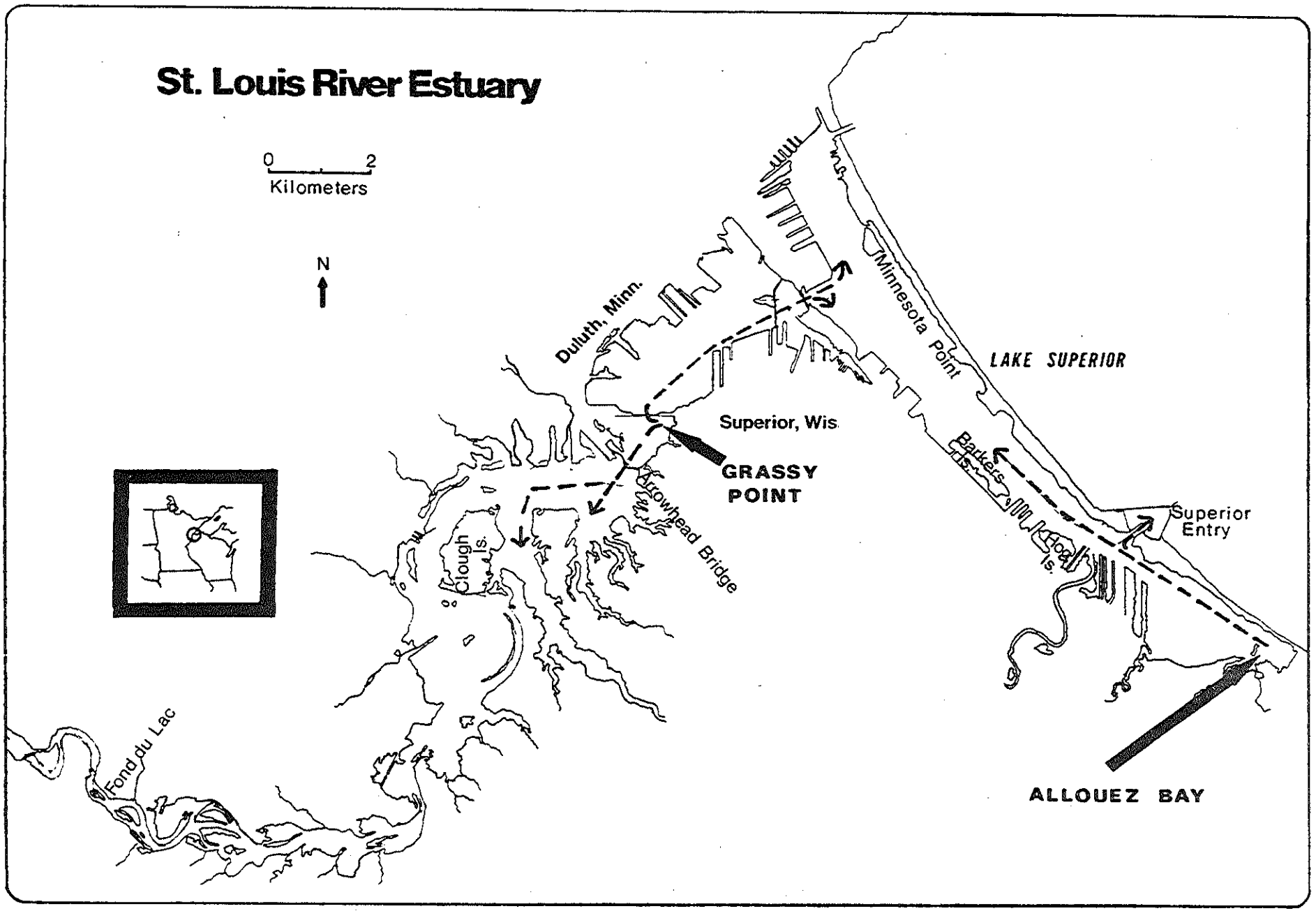

FIGURE 1. St. Louis River Estuary showing northern pike spawning areas and dispersal patterns of tagged fish away from major spawning areas (broken lines).

TABLE 1. Number of northern pike captured and tagged at spawning areas in the St. Louis River estuary, 1978-1979.

Location	Year	Number Captured	Number Tagged	Effort (net/days)
Allouez Bay	1978	808	554	15
	1979	577	568	14
Grassy Point	1978	76	50	4
	1979	451	420	10
Hog Island	1978	73	50	6
	1979	39	39	6
Barkers Island	1978	58	17	2
Clough Island	1979	6	6	1
Total		2,088	1,704	58

Allouez Bay is a large bay (538 ha) located at the eastern end of the estuary, but the actual spawning area is limited to the extreme eastern end of the bay (25 ha). Grassy Point is a smaller bay (14 ha) near the Arrowhead Bridge. Both areas are undeveloped, contain shallow water and emergent vegetation, and represent less than 1% of the estuary's total area.

Other minor spawning areas include Hog Island, Barkers Island and Clough Island. Northern pike spawning habitat is abundant in the estuary upstream from Clough Island; however, this area was not sampled during the study.

Water temperatures during the sampling period ranged from 4-10 C. Peak spawning activity was observed between 5.5-7.0 C.

Sex Ratio

The overall sex ratio during spring sampling in 1978 and 1979 was one to one (male to female). Male northern pike generally moved into spawning areas earlier than females. For example, on the first sampling day in 1979, 89% of the catch consisted of males. By the middle of the run 49% were males, and at the end of the spawning season 36% were males.

Weight-Length Relationship

Weight-length equations were obtained using fish captured during 1979. The weight-length relationship of male northern pike was expressed by the regression equation ($r = 0.97$):

$$\log_e w = -12.1595 + 3.0295 \ (\log_e l)$$

and for female northern pike ($r = 0.98$):

$$\log_e w = -12.5979 + 3.1125 \ (\log_e l)$$

where w = weight in grams and l = total length in millimeters. There was a significant difference between sexes at the p 0.05 level.

A third equation expressed by the regression ($r = 0.98$):

$$\log_e w = -13.0065 + 3.1704 \ (\log_e l)$$

was obtained by combining sexes and may be more practical in fisheries management if sex cannot be determined.

Age and Growth

Females were slightly longer than males after the first year but were similar in length to males at the end of the second year (Table 2). After age III, females grew faster than males. Males had a slight length advantage after age VII, but the calculations were based on a single 14-year-old fish.

Other researchers have reported that females generally grow faster than males after age II (Clark and Steinbach 1959, Snow and Beard 1972, Scott and Crossman 1973, Priegel and Krohn 1975). On the other hand, Wolfert and Miller (1978) found similar growth increments for males and females beyond age III in Lake Ontario.

A comparison of growth rates with other Great Lakes studies was made by averaging the calculated lengths of males and females for each age group (Table 3). St. Louis River northern pike grew slower than those reported from Lake Ontario and Georgian Bay but generally grew faster than those from Lake Erie after age V. Despite slower growth, St. Louis River northern pike have a longer life span (14 years) than other reported Great Lakes populations. Miller and Kennedy (1948) reported a 24-year-old pike in Lake Athabaska, Canada and surmised that the long life span was a result of slow growth.

TABLE 2. Calculated total lengths (mm) at the end of each year of life for male and female northern pike from the St. Louis River, 1979.

Age Group	Sex	Number of Fish	Year of Life													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
I	Male	3	259													
II	Male	20	276	412												
	Female	3	263	407												
III	Male	73	279	424	494											
	Female	23	284	431	513											
IV	Male	25	291	422	509	563										
	Female	18	312	424	528	584										
V	Male	6	235	396	550	625	664									
	Female	6	249	416	557	628	675									
VI	Male	3	261	447	539	619	665	694								
	Female	7	280	448	570	645	706	755								
VII	Male	2	276	401	533	601	677	734	766							
	Female	2	247	430	613	698	788	825	851							
VIII	Female	5	280	376	526	645	725	775	833	861						
X	Female	2	249	370	463	546	656	743	775	857	909	947				
XI	Female	1	231	378	500	602	676	762	805	856	909	937	965			
XII	Female	1	208	330	411	508	630	686	744	800	861	919	947	970		
XIV	Male	1	224	386	508	630	691	734	815	876	930	958	988	1,006	1,026	1,049
Weighted Mean	Male		278	420	503	581	669	714	782	876	930	958	988	1,006	1,026	1,049
	Female		283	420	542	610	700	764	815	853	897	938	956	970		
Increment of Mean	Male		278	142	83	78	88	45	68	94	54	28	30	18	20	23
	Female		283	137	122	68	90	64	51	38	44	41	18	14		

TABLE 3. Mean total length (mm) of northern pike from Great Lakes studies.

Study	Year of Life													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Lake Ontario (Wolfert and Miller 1978)	243	506	652	718	754	777	788	807						
Lake Erie (Clark and Steinbach 1959)	290	447	539	600	648	671	727	765	792	833				
Georgian Bay, Ontario (Wainio 1966)	245-546	305-749	457-787	483-890	521-941	648-1,041	698-1,041	749-1,041		990-1,080				
St. Louis River, Lake Superior (present study)	281	420	523	596	685	739	799	865	914	948	972	988	1,026	1,049

Movement

Movement of northern pike within the estuary was determined from angler tag returns. After 4 years, 75% of the angler tags returned came from within a 5-km radius of the spawning locations. The other 25% of tagged northern pike were caught throughout the estuary, with the exception of four northern pike which migrated to the mouth of the Amnicon River (10 km east of the Superior entry).

Other northern pike tagging studies have also shown that the distance between tagging and recapture locations is generally less than 10 km (Carbine and Applegate 1948, Finke 1966, Diana et al. 1977, Gengerke 1977). But Carbine and Applegate (1948) also reported a maximum northern pike movement of 79 km from the tagging location in the Muskegon River, Michigan. And Moen and Henegar (1971) found one northern pike that moved 322 km from the tagging location in Lake Oahe on the Missouri River. In the present study, the maximum distance between the tagging and recovery sites was 28 km.

Twenty-two northern pike (12 females, 10 males) tagged at Allouez Bay in 1978 returned to the same area to spawn in 1979. One female spawning in Allouez Bay in 1978 spawned at Grassy Point in 1979.

Mortality

Total annual mortality was estimated to be 45% for both sexes of northern pike age III and older. This is similar to findings by Wolfert and Miller (1978) that eastern Lake Ontario northern pike had a 44% total annual mortality rate when caught in gill nets and 38% when caught in trap nets (Table 4). Using data reported by Clark and Steinbach (1959), I calculated a 40% total annual mortality rate for Lake Erie northern pike.

Total annual mortality rates for northern pike from the St. Louis River and other Great Lakes studies were lower than annual mortality rates reported for Wisconsin inland waters (Snow and Beard 1972, Snow 1978, Kempinger and Carbine 1978); however, northern pike inhabiting estuaries and bays of the Great Lakes are dispersed over a much larger area and are probably less vulnerable to angling mortality.

Angling mortality was determined by angler returns of tags during the first year after tagging. The average angling mortality for the two-year study was approximately 8% (Table 4). Of 761 fish tagged in 1978, 101 (15.1%) have been returned to date and 92 (8.9%) of 1,033 fish tagged in 1979 have been returned (11.3% return for the first two years combined, Table 5). These figures must be considered a minimum estimate of angling mortality since some fish may have lost their tags and some anglers do not return tags.

Northern pike exploitation was greatest from May through August with the peak occurring in July during 1978-79 and occurring in May during 1980-81. Similar results were also reported for other Wisconsin waters -- the Black River (Finke 1966), Lake Poygan and Big Lake Butte des Morts (Priegel 1968), and Big Cedar and Gilbert lakes (Priegel and Krohn 1975).

Anglers caught twice as many females as males during the 1979 spawning season despite a one-to-one sex ratio. This phenomenon was also observed in Big Cedar and Gilbert lakes, Wisconsin (Priegel and Krohn 1975).

Natural mortality was calculated as the difference between total and angling mortality estimates; in this case, it was 37%. Although this estimate is similar to other inland studies, it must be considered a maximum rate since the angling mortality rate is a minimum estimate.

TABLE 4. Northern pike mortality rates from various waters (no size limits).

Study	Percent Angling Mortality	Percent Natural Mortality	Percent Total Mortality	Length Of Study (years)
Bucks Lake, Wisconsin (Snow and Beard 1972)	21*	36	57	1
Murphy Flowage, Wisconsin (Snow 1978)	26*	40	66	15
Escanaba Lake, Wisconsin (Kempinger and Carline 1978)	46*	14	60**	6
Lake Ontario (Wolfert and Miller 1978)			44 (gill nets) 38 (trap nets)	1
Lake Erie (calculated from Clark and Steinbach 1959)			40	3
St. Louis River, Lake Superior (present study)	8[1]	37	45	2

*Angling mortality based on creel data and population estimate.
**Calculated as the slope of age versus $\log_e$ of number of fish in each age.
[1]Based on voluntary tag returns, 1978-79.

TABLE 5. Number of northern pike tags returned by anglers.

Year Tagged	Number Tagged	Number of Tags Returned					
		1978	1979	1980	1981	1982	Total
1978	671	76 (11.3)*	12 (1.8)	9 (1.3)	4 (0.6)		101 (15.1)
1979	1,033		58 (5.6)	24 (2.3)	9 (0.9)	1 (0.1)	92 (8.9)
Total	1,704						193 (11.3)

*Percentage of tags returned in parentheses.

MANAGEMENT RECOMMENDATIONS

Despite elimination of valuable spawning habitat in the St. Louis River estuary and an increase in fishing pressure since water quality problems were improved, the northern pike population remains a viable recreational fishery and does not require fishing regulation changes at this time. If fishing pressure continues to increase, mortality rates should be periodically monitored to determine if the population is being adversely affected. Presently, natural mortality accounts for most of the total annual mortality, but the relatively short study period may not reflect trends in exploitation rates.

Habitat preservation is the most important goal for northern pike in the St. Louis River estuary. Loss of habitat for waterfront development will continue to threaten the lower estuary. Movement of northern pike away from the two major spawning areas has documented the importance of these areas to the recreational fishery. Loss of either spawning area will reduce the fishing opportunities in the lower estuary. The impact of northern pike spawning in the estuary upstream from Clough Island was not studied, but I suspect this area contributes to the overall fishery. Preservation of this area and other suspected spawning areas should also be encouraged.

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