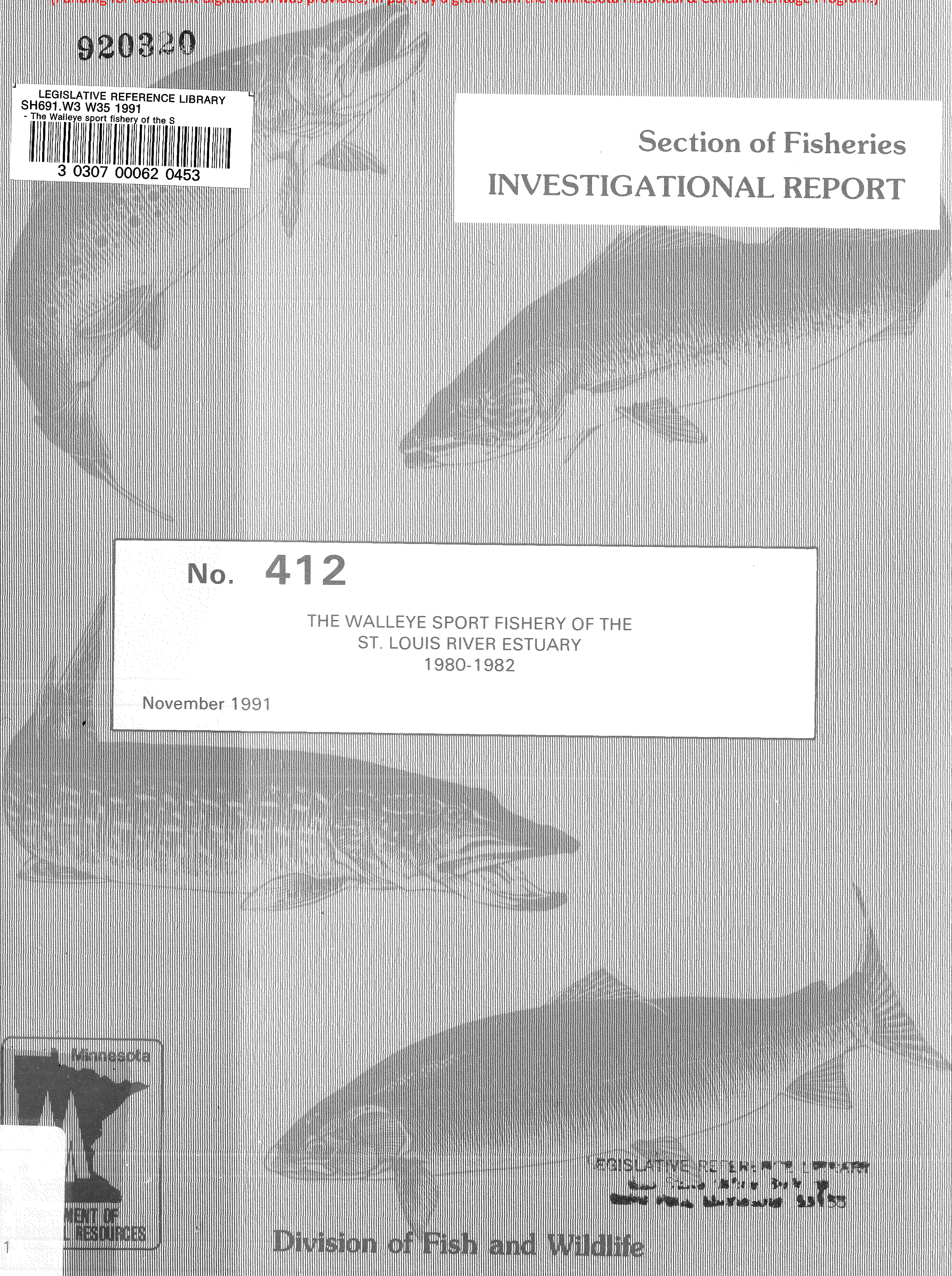

Section of Fisheries

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THE WALLEYE SPORT FISHERY OF THE ST. LOUIS RIVER ESTUARY 1980-1982

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THE WALLEYE SPORT FISHERY OF THE ST. LOUIS RIVER ESTUARY 1980 - 1982

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Abstract.--A substantial sport fishery, dependent on spawning aggregations of walleye in the St. Louis River estuary, developed quickly in 1979 after improvements in water quality. Annual estimates of walleye harvested (from May through July) in 1980 to 1982 were 45,718; 24,141; and 23,816. Fishing effort, catch rate, harvest, and voluntary tag returns declined annually after 1980. Population estimates of spawning walleye were based on tag returns observed in a creel census, and ranged from 77,670 in 1981 to 78,569 in 1982. Estimates of the number of walleye larger than 508 mm were 15,916 in 1980; 35,997 in 1981; and 28,086 in 1982. Angler caught walleye grew slower than walleye from other exploited walleye populations in Minnesota. Further information on use of the estuary, recruitment, growth, maturity, and changes in age and size structure is needed to accurately assess the effect of exploitation on this population.

Introduction

The St. Louis River estuary walleye fishery was essentially unexploited from 1900 to 1979. Before 1900, Ojibway Indians used the fishery for sustenance, and a substantial commercial fishery existed (Kaups 1978). After 1900, industrialization and development occurred on the river above the town of Fon du Lac. By the time oxygen levels were first measured in 1946, water pollution had resulted in lethal summer oxygen levels for fish (DeVore, 1978). The Western Lake Superior Sanitary District (WLSSD) waste water treatment facility began treating upstream effluents in 1978. Angler interest and fishing pressure increased in 1979 when anglers noticed that the disagreeable taste and odor of the fish flesh had disappeared. Limit catches of large walleye were made with relative ease during that summer.

The Minnesota and Wisconsin Departments of Natural Resources were concerned that little was known about the walleye population and commenced coordinated studies in 1980. These studies included walleye tagging, quantitative creel surveys, index netting, and reproductive success assessment. This document details a three year study by the Minnesota Department of Natural Resources to: 1) quantify fishing effort and catch of walleye by anglers landing in Minnesota, 2) estimate the walleye spawning population size, 3) collect vital statistics on the adult population, and 4) determine walleye movements.

Study Area

The St. Louis River estuary contains the border between Wisconsin and Minnesota for most of its length and extends from Lake Superior to the base of the hydroelectric dam located at the lower end of the dalles of Jay Cooke State Park (Figure 1). The estuary is 30 km long, has a maximum width of 13 km, and a surface area of 4,654 ha. The estuary is narrow and river-like at the upper end, and widens downstream to become more lentic. Below the Blatnik Bridge (Highway 53) the estuary is comprised of shipping channels, slips, and extensive littoral areas. DeVore (1978) provided a detailed map and description of the estuary.

Materials and Methods

Walleye Tagging

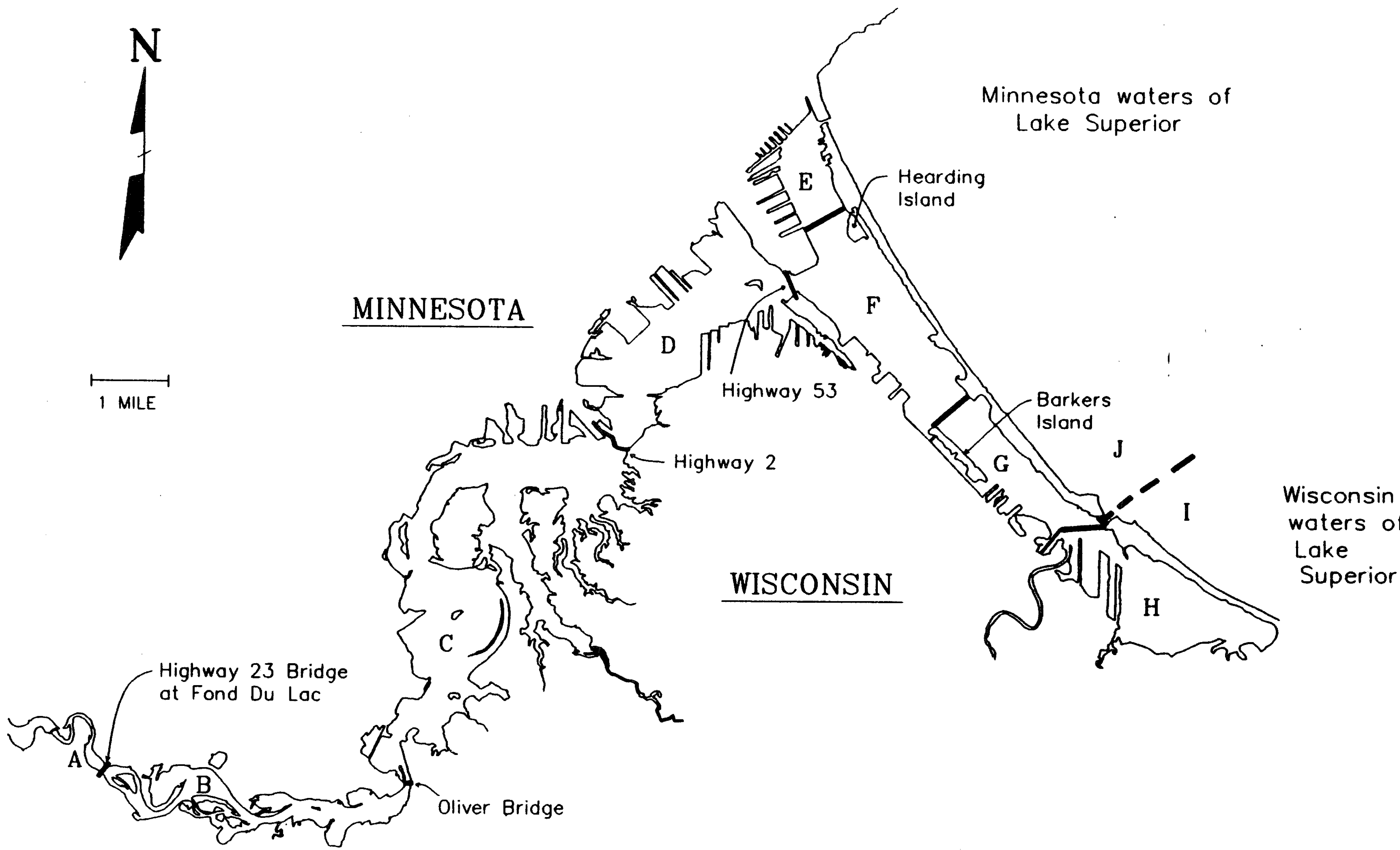
Walleye were captured for tagging on their spawning migration by either entrapment (1980) or electrofishing (1980-1982). In 1980, fish were trapped in a diversion channel near the hydroelectric dam at Fon du Lac (Figure 2). This method proved unsatisfactory as only 672 were tagged in 14 trap days. The remaining 2,078 fish tagged in 1980 were captured in a joint operation with the Wisconsin Department of Natural Resources using their a.c. electrofishing boat. In 1981 and 1982, walleye were captured between the hydrodiversion outflow and the highway 23 bridge using a pulsed-d.c. boom electrofishing boat. Optimum parameters were 300 volts, 70-80% duty cycle, and 60 hertz drawing about 4-5 amperes. Fish were attracted and stunned within 0.5 m of the anode, reviving almost instantly after removal from the water. Fish were held in a tub until completion of the 5-10 minute electrofishing run and transferred to a stock tank in a work boat for tagging. Fish were measured to the nearest 4 mm, sexed by physical examination, tagged with a numbered Floy FD67B tag, and examined for diseases and deformities. The distal half of either the right pelvic (1980) or right pectoral fin was removed by clipping to determine Floy tag loss. Tags were inserted near the posterior end of the first dorsal fin with the T-bar anchored between the interneural bones.

Creel Survey

In 1980, a stratified random creel survey was conducted during the months of May, June, and July to estimate fishing effort by anglers and their catch of walleye. The survey clerk recorded information from completed trips of boat anglers landing at six sites and from shore anglers that were reasonably accessible from the boat landings. Two clerks changed sites at two hour intervals. Before we began the survey, we assigned the sampling sites to two clusters. The cluster to be sampled and the sites to be sampled within each cluster were selected at random. Clustering was discontinued after 1980 because of a possible overestimate of fishing pressure. In 1981 and 1982 only one clerk was used, and sampling sites were selected at random in proportion to their use during the previous year (Fleener 1971). All weekends and six randomly selected weekdays in a two week period were sampled. Clerks worked 8 h days starting at 0700 hrs. or at 1250 hrs. Clerks recorded the number in each party, start time of the trip, angler residence, and the number and total weight ($\pm$ .1 kg) of each species harvested by each party. In 1981 and 1982, walleye were measured to the nearest 2 mm total length (TL) as time permitted. Each fish was inspected for tags and fin clips and the second dorsal spine was excised from a sample of the catch for aging.

Population Estimates

The number of spawning walleye using the St. Louis River estuary was estimated weekly using the Chapman modification of the single census Peterson method (Ricker 1975). The percentage of tagged fish was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1 MILE
MINNESOTA
WISCONSIN
Minnesota waters of
Lake Superior
Wisconsin
waters of
Lake
Superior
Hearding
Island
Barkers
Island
Highway 53
Highway 2
Highway 23 Bridge
at Fond Du Lac
Oliver Bridge
A
B
C
D
E
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G
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J

FIGURE 1

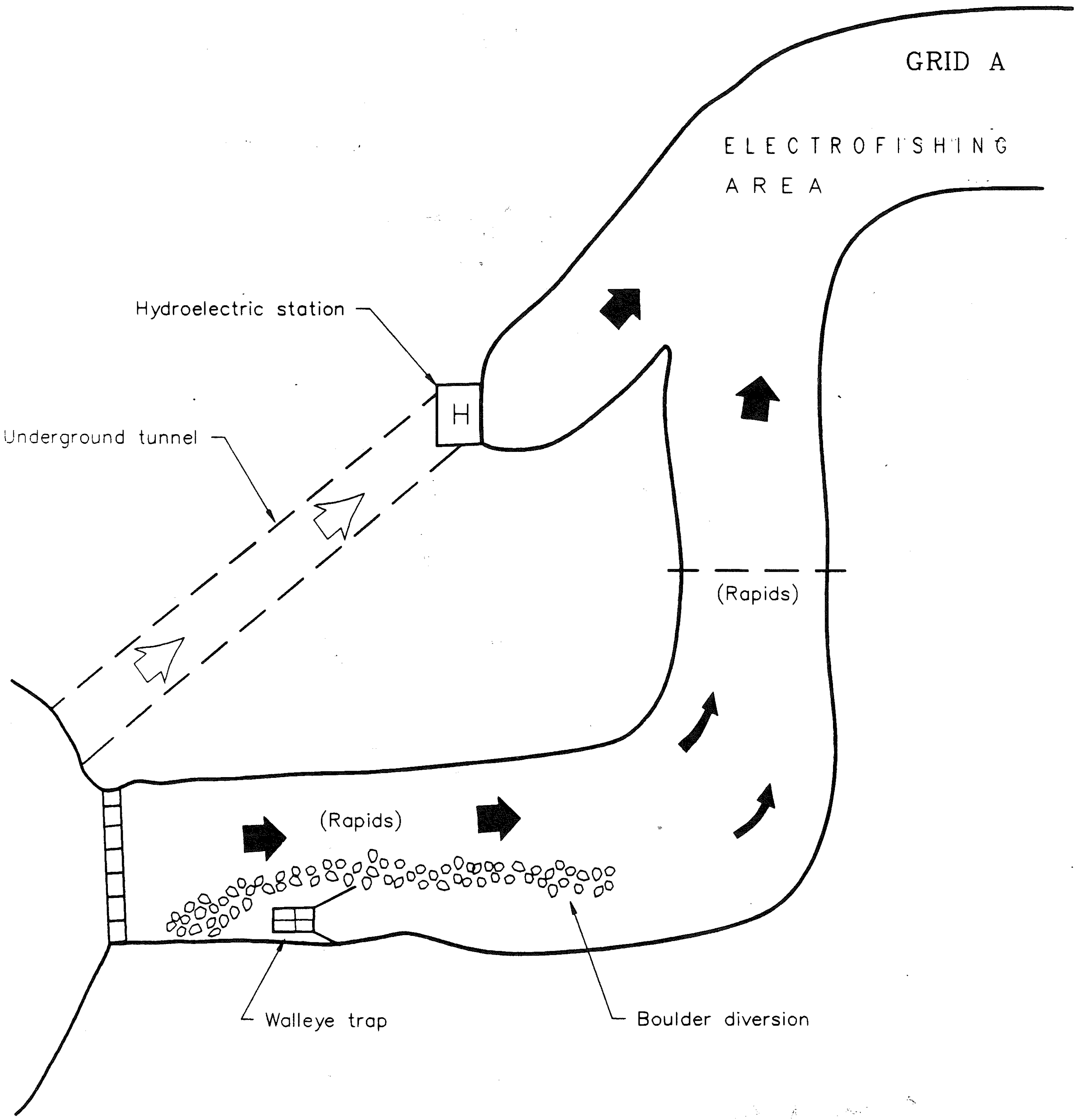

FIGURE 2

Sketch of St. Louis River showing approximate location of dam, hydro, walleye trap, and electrofishing area (drawn to approximate scale).

determined from creel census data and was adjusted for tag shedding. Tag dilution, caused by immigration of untagged fish or emigration of tagged fish, was evaluated in each year by regression of the arcsin of the square root of the percent of tagged fish in the creel against time (Parker 1955). Potential biases in the total population estimates resulting from differences in angling or electrofishing vulnerability were detected during all three years of the creel survey (Figure 3). As a result, the number of marked walleye at large each year was reduced to reflect the number "effectively tagged" (Ketchen 1953, Ricker 1975).

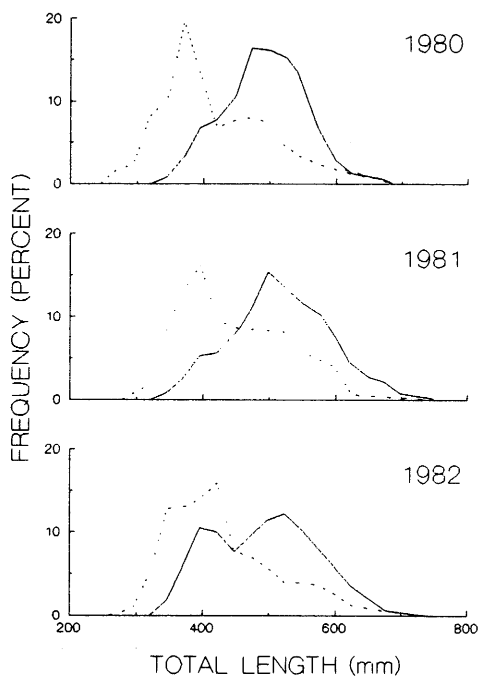

Figure 3.--Frequency polygons of angler caught (dashed line) and tagged (solid line) walleye in the St. Louis River estuary.

Population estimates were also calculated for walleye larger than 508 mm TL. This was the approximate size of peak recruitment to the commercial fishery of the Red Cliff Band of Chippewa (Busiahn 1981, Busiahn 1982, Bronte and Gurnoe 1983). Also, not all females were sexually mature until 533 mm TL (T. Margenau, Wisconsin Department of Natural Resources, personal

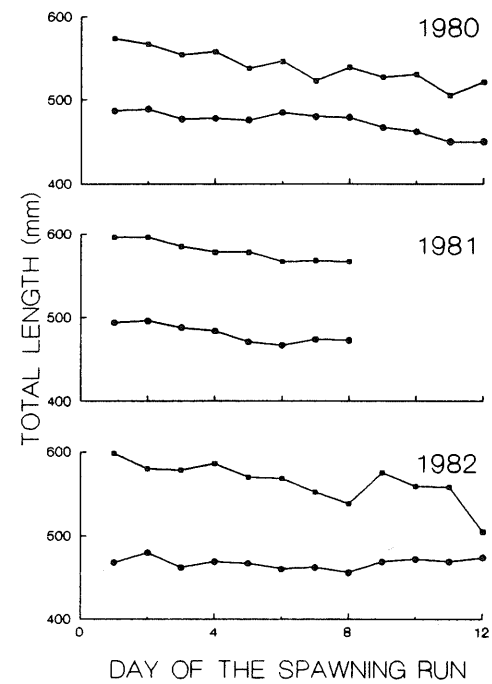

Figure 4.--Daily mean length of walleye tagged in the St. Louis River estuary. Squares represent females and dots represent males.

communication), and we wanted to evaluate exploitation of the broodstock.

Unless otherwise noted, we used 0.05 as our probability of a type I error.

Movements

Walleye movements were tracked through recording of tag returns from 10 grid areas (Figure 1). These grids began at the base of the dam and continued downstream to include Lake Superior. Grid boundaries were selected by natural landmarks and habitat changes. Analysis of variance (ANOVA) was conducted to determine if recoveries from the grids were related to size or sex of the fish.

Results

Walleye Tagging

A total of 7,978 walleye were tagged over the three years: 2,750 in 1980; 2,249 in 1981; and 2,978 in 1982. Male to female

Table 1. Summary of walleye tagging operations in the St. Louis River estuary, 1980-1982.

Year	1980	1981	1982	Total
Number tagged	2,750	2,249	2,978	7,977
Males (%)	1,855 (67.5)	1,479 (65.8)	2,354 (79.0)	5,688 (71.3)
Females (%)	895 (32.5	770 (34.2)	613 (20.6)	2,278 (28.6)
Unknown (%)	--	--	11 (0.4)	11 (0.1)

ratio averaged 2.5:1 (Table 1). Spawning runs peaked on 25 April in 1980, 16 April in 1981, and 29 April in 1982. Peak spawning coincided with river water temperatures of 6.1°-11.1° C. Males averaged 479 mm total length (TL) and females 599 mm TL. Mean length of the sexes for individual years varied only 2% from the cumulative mean for males and 6% for females. Mean size decreased as the run progressed (Figure 4).

Creel Survey

Estimates of fishing effort, harvest, and catch rates declined annually from 1980 to 1982 (Table 2). Fishing effort ranged from 179,745 angler-hours in 1980 to 134,829 angler hours in 1982. Virtually all fishing effort was from boats. Harvest ranged from 45,718 walleye in 1980 to 23,816 in 1982. As mentioned earlier, we are concerned that our estimate of harvest in 1980 was too high because of a potential bias caused by sample site clustering. Sport harvests, however, were consistent with the Red Cliff commercial harvests and with voluntary tag return rates (Figure 5) suggesting our 1980 estimate of sport harvest was accurate. Catch rate ranged from 0.221 walleye/h in 1980 to 0.170 walleye/h in 1982. Average weight of creeled walleye ranged from 0.966 kg in 1981 to 0.839 kg in 1982. Yield ranged from 12.3 kg/ha in 1980 to 4.3 kg/ha in 1982. Most anglers caught no walleye (Table 3). Limit catches were kept by 3.3% of anglers in 1980, declining to 0.5% in 1981 and up again to 1.4% in 1982.

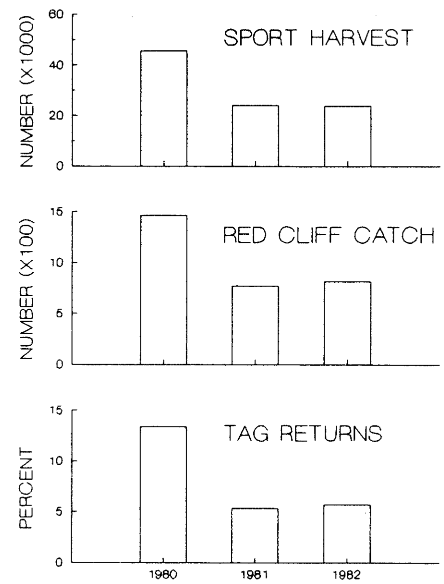

Figure 5.--Number of walleye harvested, commercial catch of the Red Cliff Band of Chippewa, and percent of tags voluntarily returned, 1980-1982.

A total of 783 (9.8%) tagged walleye were reported caught during the three years of study, 367 in 1980, 183 in 1981, and 233 in 1982 (Table 4). A larger percentage of tagged males (10.5%) was reported caught than females (8.3%). Our double tagging experiment in 1980 suggested a tag loss rate of 7.5% from tag insertion through July 1980. Tag loss during the first year for fish tagged in 1980 was estimated at 17.9% based on 1981 electrofishing recaptures. Tag loss after the first year was apparently minimal because only 16.7% of the fish that were fin clipped in 1980 and captured again during 1982 electrofishing were missing tags.

Table 2. Angler hours, walleye harvest (95% confidence interval), catch rates (walleye/angler-hour), average weight (kg), and yield (kg/ha) from St. Louis River estuary, 1980-1982.

Year	Month	Angler-hours	Walleye harvest	Catch rate	Average weight	Yield
1980	May	71,475	18,605 (13,791 to 23,419)	0.235	0.930	3.7
	June	76,243	20,798 (13,691 to 27,905)	0.245	0.925	4.1
	July	32,027	6,315 (3,013 to 9,617)	0.178	0.676	4.5
1980	**Total**	179,745	45,718 (36,521 to 54,915)	0.221	0.907	12.3
1981	May	89,835	11,909 (9,897 to 13,921)	0.133	1.030	2.6
	June	41,037	8,949 (6,961 to 10,937)	0.218	0.930	1.8
	July	19,028	3,283 (2,535 to 4,031)	0.173	0.871	0.6
1981	**Total**	149,900	24,141 (21,215 to 27,067)	0.171	0.966	5.0
1982	May	41,884	4,917 (3,873 to 5,961)	0.117	1.057	1.1
	June	60,645	12,072 (10,038 to 14,106)	0.199	0.848	2.2
	July	32,300	6,827 (5,318 to 8,336)	0.212	0.689	1.0
1982	**Total**	134,829	23,816 (21,077 to 26,555)	0.170	0.839	4.3

Table 3. Distribution of the walleye catch among anglers, 1980-1982, St. Louis River estuary.

No. of fish kept	Percentage of anglers that kept that number 1980	1981	1982
0	52.9	57.9	57.3
1	20.3	24.2	23.2
2	11.0	9.2	10.2
3	6.6	4.9	4.5
4	4.0	2.1	2.7
5	1.9	1.0	0.6
6	3.3	0.5	1.4

Table 4. St. Louis River tag returns by year and sex.

	1980	1981	1982	Total
		Number tagged		
Males (%)	1,855 (67.5)	1,479 (65.8)	2,354 (79.4)	5,688 (71.4)
Females (%)	895 (32.5)	770 (34.2)	613 (20.6)	2,278 (28.6)
Total	2,750	2,249	2,967	7,966
		Number recaptured		
1980				
Males (%)	265 (14.3)			265 (14.3)
Females (%)	102 (11.4)			102 (11.4)
Total	367 (13.4)			367 (13.4)
1981				
Males (%)	42 (2.3)	95 (6.4)		137 (4.1)
Females (%)	22 (2.5)	24 (3.1)		46 (2.8)
Total	64 (2.3)	119 (5.3)		183 (3.7)
1982				
Males (%)	12 (0.7)	34 (2.3)	147 (6.2)	193 (3.4)
Females (%)	5 (0.6)	12 (1.6)	23 (3.8)	40 (1.8)
Total	17 (0.6)	46 (2.0)	170 (5.7)	233 (2.9)
Total				
Males (%)	319 (17.2)	129 (8.7)	147 (6.2)	595 (10.5)
Females (%)	129 (14.4)	36 (4.7)	23 (3.8)	188 (8.3)
Total	448 (16.3)	165 (7.3)	170 (5.7)	783 (9.8)

Fish tagged in 1981 lost only 7% of their tags based upon examination of fish captured by electrofishing a year later. Most tagged fish were reported caught early in the summer of tagging. May and June returns accounted for 89.2% of all returns, and May through July for 97% of all tag returns.

Angler caught walleye were smaller than walleye captured by electrofishing for both sexes. Mean length of angler caught males was 457 mm TL (N=595) while the mean length of the males we tagged was 470 mm TL (N=5,688). Mean length of 185 angler caught females was 537 mm TL compared with a mean length of 559 mm for 2,282 tagged females. Fish less than 483 mm TL had a mean voluntary tag return rate of 18.7% while those larger than 483 mm TL had a mean voluntary return rate of 15.2%.

Mean size of angler caught fish did not vary by grid nor with time, except in 1980. There was no significant difference between grids in total length of harvested walleye of either sex during any year of the survey. Average size of females, however, declined as the season progressed in 1980.

Most tags were reported by residents of the Duluth metropolitan area. Duluth residents (living within 32 km of Duluth) annually reported 60%, 52%, and 50% of all returned tags (Table 5). Superior, Wisconsin residents reported an average of 15.7% of all tags. Thus, residents of the area immediately surrounding the estuary reported 70.7% of all tags. Minnesota residents from other locations accounted for 22.7% of all returns while other Wisconsin residents accounted for only 3.6% of all tags reported. Non-residents of either state reported 3% of all tags.

Population Estimates

Estimates of the number of spawners changed little between years: 77,878 ± 26,176 in 1980, 77,670 ± 23,274 in 1981, and 78,569 ± 22,599 in 1982. Tag dilution apparently did not occur in 1980 (P = 0.15), nor in 1981 (P = 0.16), but did occur in 1982 ($P < 0.0005$). Thus, the 1982 population estimate of spawners is probably too high. Estimates of the number of walleye greater than or equal to 508 mm TL were 18,601 ± 9,146 ($\alpha = 0.05$) in 1980; 41,565 ± 19,398 in 1981; and 29,062 ± 14,393.

Growth and Mortality

Growth data (mean length at age) are reported in Table 6. Growth did not conform to a von Bertalanffy growth model using the iterative fitting procedure of Rafail (1973). This may be because of the exaggerated decrease in growth rate between ages three and four (Figure 6). Three years of growth data were inadequate to discern trends.

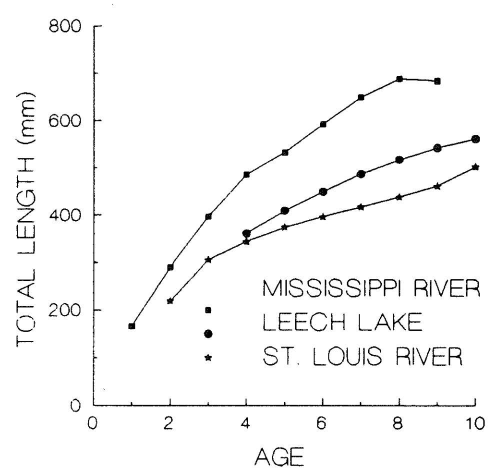

Figure 6.--Length at age of walleye stocks from three Minnesota walleye fisheries. Mississippi River data from Thorn (1984) and Leech Lake data from Schupp (1972).

Estimates of mortality rates from the catch curve were equivocal because recruitment was variable. The age distribution for 1980 to 1982 combined was bimodal with modes at age six and eleven (Figure 7). The mode at age eleven was primarily because of the abundant 1970 year-class. The estimated annual mortality rate (A) for the three study years combined was 0.48 for age ten and older. The estimated annual mortality rate for the 1970 year-class was 0.38 for ages ten through twelve. The maximum age observed for all assessment gear was twenty

Table 5. Residency of anglers reporting tagged walleye from the St. Louis River estuary by year.

Angler residency	1980 Totals (%)	1981 Totals (%)	1982 Totals (%)	Totals (%)
Duluth & vicinity	185 (60.1)	90 (52.0)	110 (50.2)	385 (55.0)
Superior	42 (13.6)	33 (19.1)	35 (16.0)	110 (15.7)
Other Minnesota	66 (21.4)	39 (22.5)	54 (24.7)	159 (22.7)
Other Wisconsin	11 (3.6)	8 (4.6)	6 (2.7)	25 (3.6)
Other	4 (1.3)	3 (1.7)	14 (6.4)	21 (3.0)
Total	308	173	219	700

Table 6. Mean size at age (n) and mean age for creeled walleye, 1980-1982. A "+" indicates an increase from one year to the next and a "-" indicates a decrease from one year to the next.

Age	Mean length (mm) 1980		1981		1982
2	203 (4)	+	282 (1)		
3	259 (4)	+	340 (6)	+	299 (3)
4	323 (19)	+	368 (23)	-	337 (24)
5	379 (12)	+	383 (80)	-	352 (31)
6	421 (18)	-	395 (82)	-	381 (25)
7	462 (15)	-	417 (71)	-	397 (31)
8	445 (7)	-	444 (33)	-	427 (23)
9	462 (5)	+	474 (19)	-	444 (16)
10	505 (44)	+	511 (34)	-	462 (12)
11	516 (16)	-	513 (94)	-	486 (7)
12	521 (7)	+	543 (18)	-	539 (22)
13	521 (2)	+	544 (6)	+	562 (9)
14	610 (8)	-	561 (7)	+	604 (6)
15	699 (1)	-	569 (1)		
16	630 (1)	-	559 (4)		
17			516 (1)	+	622 (1)
18			693 (1)		
19					686 (1)
Mean age	8.2		8.1		7.8

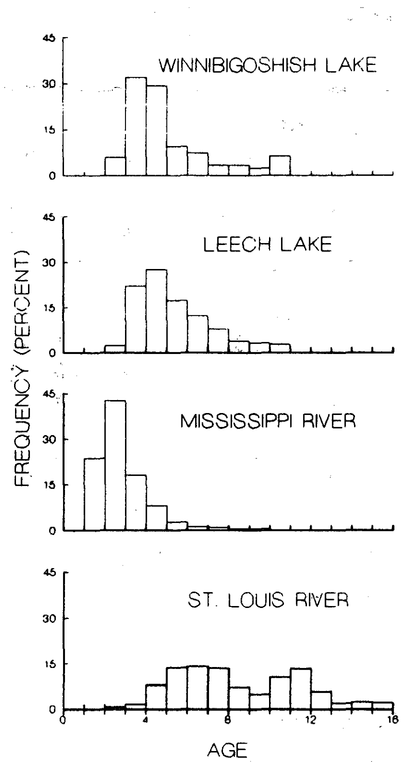

Figure 7.--Age frequency distributions of walleye harvested from four Minnesota walleye fisheries. Winnibigoshish data from Osborn and Schupp (1985), Leech Lake data from Schupp (1972), and Mississippi River data from Thorn (1984).

years (S. Schram, Wisconsin Department of Natural Resources, personal communication). Based on this twenty year life span, we estimated the instantaneous rate of total mortality (Z) to be 0.223 which corresponds to an annual mortality rate of 0.20 (Hoenig 1983). It is important to note that this is an estimate for all ages of the population whereas estimates stated above are for distinct intervals. A comprehensive list of survival estimates for various components of the stock is found in Schram et al. (1991).

Movements

Tag returns indicated that the transition zone from lotic to lentic habitat was the preferred habitat (Table 7). The upper part of the estuary (Grids A and B) is a lotic habitat which accounted for 31.7% of all tag returns (Figure 1). Grid C (Spirit Lake), which is between 9.2 and 22.0 km below the dam, accounted for 54.9% of all tag returns; 64.0%, 49.5%, and 46.2% annually. This area is largely littoral and closely resembles habitat found in many walleye lakes. Grid D, an extensively developed part of the harbor, yielded 2.2% of tag returns. Grids E, F, G, and H, which comprised most of the lower harbor, and had most of the shipping traffic, yielded 6.6% of tag returns. Six walleye were reported caught from unknown locations in the river. Lake Superior recoveries accounted for 3.8% of all tag returns with most of those (69.0%) coming from Grid I. While only one tagged fish was reported from Lake Superior north of the Duluth city limits, several were reported from between the city of Superior and the Apostle Islands. The mean distance traveled before recapture was 19.4 km for females and 11.8 km for males. The greatest distance traveled was about 175 km for a fish recaptured near the Bad River, which lies near the Wisconsin-Michigan border.

Discussion

The spawning aggregation of walleye in the St. Louis River estuary provided a new, high quality fishery. Catch rates were comparable to large, natural walleye lakes in Minnesota, but older and larger fish were surveyed (Figure 7, Table 8). Responses to increased exploitation can be expected to include increased growth rate, earlier age at first maturity, and increased variability of year-class strength (Spangler et al. 1977).

Lake Superior's cold temperature is the primary abiotic factor which may limit increased growth rate in response to exploitation. It is not clear whether the slow growth rate of walleye is due to the cold, infertile water of Lake Superior, or to historically light exploitation. If temperature is limiting growth, the population may face a greater danger of over harvest than other populations. Future emphasis should be placed on monitoring growth because information in this study covered such a short duration. Changes in growth rate may indicate the need for further study to determine the effects of exploitation. We recommend SPOF (1983) as a guideline.

Table 7. Location (by grid and year) of angler catches of tagged walleye in the St. Louis River.

Grid	Habitat	1980 Total	(%)	1981 Total	(%)	1982 Total	(%)	Total	(%)
A	River	11	(3.2)	13	(6.8)	43	(18.4)	67	(8.8)
B	River	71	(20.9)	50	(26.3)	54	(23.1)	175	(22.9)
C	Estuary	217	(64.0)	94	(49.5)	108	(46.2)	419	(54.9)
D	Harbor	7	(2.1)	10	(5.3)	0		17	(2.2)
E	Harbor	0		0		1	(0.4)	1	(0.1)
F	Harbor	3	(0.9)	4	(2.1)	3	(1.3)	10	(1.3)
G	Harbor	0		0		2	(0.9)	2	(0.3)
H	Harbor	15	(4.4)	8	(4.2)	14	(6.0)	37	(4.8)
I	L. Superior	3	(0.9)	9	(4.7)	8	(3.4)	20	(2.6)
J	L. Superior	6	(1.8)	2	(1.1)	1	(0.4)	9	(1.2)
K	River, unknown	6	(1.8)	0		0		6	(0.8)
No information		28		2		0		30	
Total known location		339		190		234		763	
Year total		367		192		234		793	

Table 8.--Harvest statistics from four walleye fisheries in Minnesota.

Fishery	CPUE (walleye/h)	Mean weight (kg)
Winnibigoshish Lake (1975-1978)[a]	0.220	0.53
Leech Lake (1965-1967)[b]	0.183	0.64
Pool 4, Mississippi River (1977-1981)[c]	0.042	0.73
St. Louis River (1981-1982)	0.192	0.91

[a] Osborn and Schupp (1985)
[b] Schupp (1972)
[c] Thorn (1984)

Walleye may stay in the estuary year-round in the future making them more vulnerable to overexploitation. Spawners remained in the estuary for a longer period each year of the study, and a post-spawning migration of immature fish apparently moved into the estuary in 1982. Age and growth data will be very useful for detecting changes in the population.

The conclusions and statistics presented in this report are based on the assumption that one of two scenarios is true. Either we observed all the spawners of the walleye stock, or we observed the same percentage of all age groups in the larger stock each year of the study. It is possible that some of the stock may be spawning in the Namadji River or in Lake Superior. Effective management of the spawning aggregation is only possible if the whole stock is managed. Coordinated interagency efforts are needed to determine if a significant portion of the stock is spawning elsewhere.

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