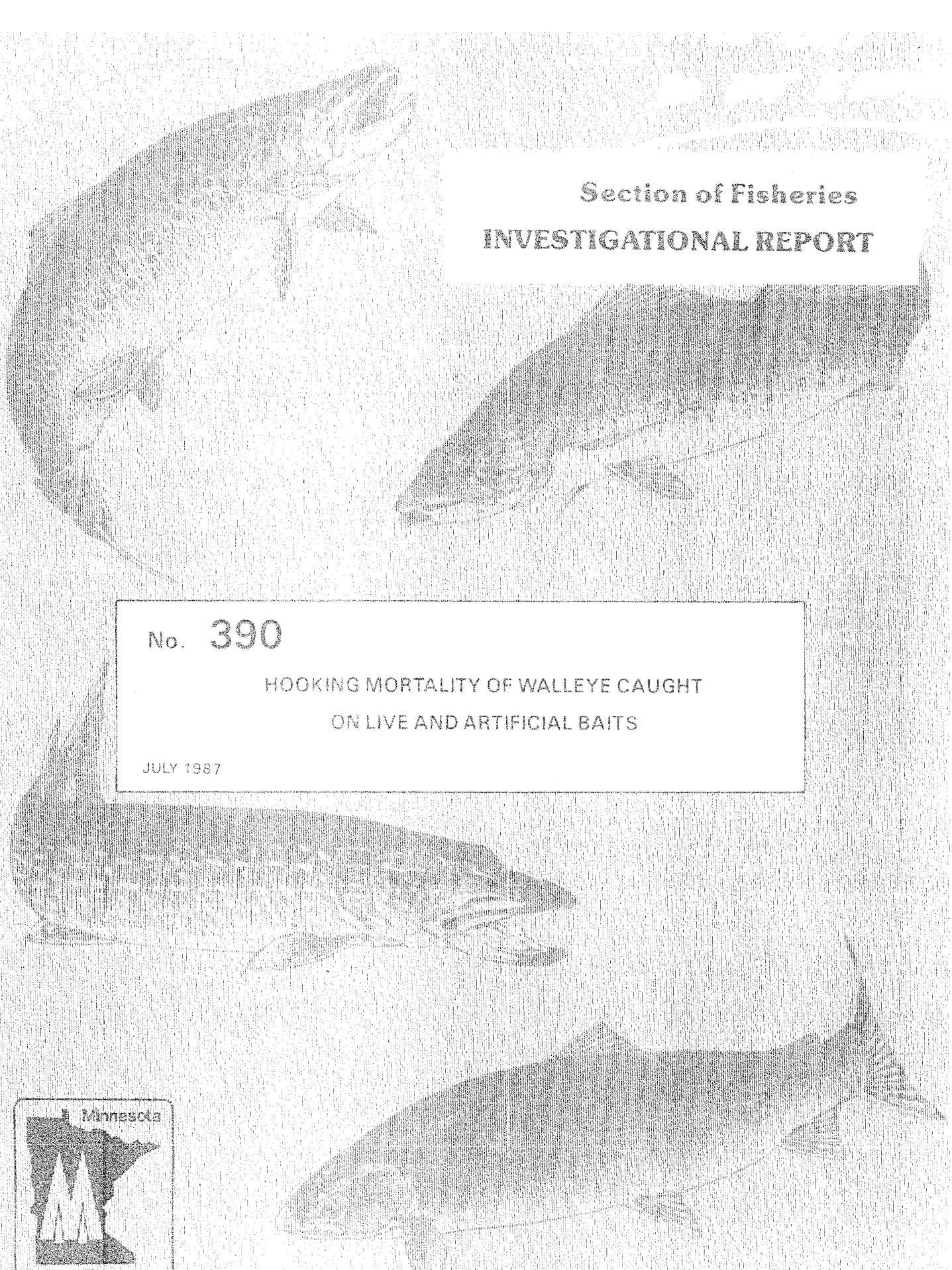

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HOOKING MORTALITY OF WALLEYE CAUGHT ON LIVE AND ARTIFICIAL BAITS

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Hooking Mortality of Walleye Caught on Live and Artificial Baits[1]

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ABSTRACT

Hooking mortality rates were determined for adult walleye (Stizostedion vitreum vitreum) caught on leeches and artificial lures. Adjusted for natural mortality, the mortality of walleye caught and released by anglers was 5% though some evidence suggested hooking mortality could have been as high as 23%. Natural mortality (mortality of unhooked walleye) was estimated to be 1% over a three month summer period. Mortality of walleye caught on leeches (10%) was higher than mortality for walleye caught on artificial lures (0%). Walleye caught on artificial lures were hooked primarily in the lips whereas fish caught with leeches tended to be hooked more deeply in the throat and gut. Walleye caught on leeches were smaller than those caught with artificial lures and were more likely to be males. Catch rates were similar for live and artificial baits but varied between the two ponds and two years studied. Low hooking mortality rates for both live and artificial baits suggest that release of angler caught walleye may have the potential to reduce fishing mortality and to expand recreational fishing opportunities.

INTRODUCTION

Walleye (Stizostedion vitreum vitreum) stocks are facing increasing recreational fishing pressure. Protective size limits and catch-and-release programs have the potential to reduce fishing mortality and manipulate the size structure of highly exploited walleye populations (Brousseau and Armstrong 1987). These techniques have been used successfully with other species to increase numbers or sizes of fish caught and released (Anderson and Weithman 1978; Hunt 1981; Hall et al. 1986). The potential benefits of catch-and-release or protective size limits for walleye can only be realized if released fish survive the effects of hooking, landing and handling. Most current information on the effects of hooking and handling fish is for salmonids, esocids and bass. This information indicates that hooking mortality may vary with size or origin of caught fish (Mongillo 1984; Loftus 1986), anatomical location of hooking (Warner and Johnson 1978; Hulbert and Engstrom-Heg 1980; Loftus 1986), water temperature (Dotson 1982), depth of capture (Feathers and Knable 1983), angler handling (Mason and Hunt 1967; Wydoski 1977; Hulbert and Engstrom-Heg 1980), and tackle type (Shetter and Allison 1955; Klein 1965; Clapp and Clark 1986). In particular, use of live baits has generally resulted in higher mortality for released fish than artificial lures (Wydoski 1977). This is a major concern for a walleye fishery since leeches, minnows and nightcrawlers are popular baits used by anglers.

The purpose of this study was to estimate mortalities resulting from the catch, handling and release of walleye hooked with artificial lures and leeches. Additionally, we contrasted angler catches for each bait type.

DESCRIPTION OF STUDY PONDS

Two privately-owned study ponds, Klawitter's and Clubhouse, were selected in Washington County, Minnesota. Klawitter's Pond had a surface area of 1.4 ha, a mean depth of 2 m and a maximum depth of 5 m. The pond was adjacent to the owner's residence and the only access was through his property. Clubhouse Pond had a surface area of 2.8 ha, a mean depth of 2 m and a maximum depth of 3 m. This pond was located on a game farm and access was also controlled through the owner's property. In addition to controlled access, the two ponds were selected because they were near a source of adult walleye, were capable of sustaining 100 adult walleye per surface ha, were easily fished from their banks or from small boats and were readily accessible to a large number of volunteer anglers.

METHODS

Adult walleye were captured in April 1985 and 1986 from a spawning run in Pleasant Lake, Minnesota. The fish were marked with individually numbered disc dangler tags (Wydoski and Emery 1983) in 1985 and double marked with disc dangler and numbered anchor tags in 1986. The sex of each fish was determined and its length (mm) and weight (g) were measured. Marked walleye were stocked at a rate of 100 fish per surface ha (Table 1) and allowed one to two weeks for acclimation to the ponds and recovery from the stocking process before fishing was initiated.

Two types of terminal tackle were selected for evaluating hooking mortality. Rapala Shad Raps (TM Normark,Inc.)[2] with two barbed treble hooks were used as artificial lures. Leeches (Nephelopsis obscura) fished on a single No. 6 straight-shanked hook were used as live bait. Both types of

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[2] Use of trade names does not imply endorsement of product.

Table 1. Number of walleye stocked in each pond and number of each sex (M=male, F=female, U=fish of undetermined sex) hooked once on leeches or Shad Raps.

Pond and year	Number stocked			Number hooked once: Shad rap			Number hooked once: Leeches		
	M	F	U	M	F	U	M	F	U
Klawitter's									
1985	66	68	2	14	10	1	15	13	0
1986	89	49	0	6	2	0	12	4	0
Clubhouse									
1985	161	111	12	24	20	3	14	7	0
1986	185	92	4	31	23	2	47	15	0
TOTAL	501	320	18	75	55	6	88	39	0

terminal tackle are popular with Minnesota walleye anglers. Anglers fished with their own rods and reels but were provided 6-lb test line, Shad Raps and hooks. Boats and leeches were available to anglers at each pond.

Anglers were supplied with report cards to record fishing effort by gear type and information on walleye which were caught and released. Gear used was recorded for each 30 min period. Anglers were asked to fish an equal amount of time with each gear. Upon catching a fish, anglers recorded the fish's tag number, time of capture, anatomical location of hooking, fishing technique, playing time, noticeable injuries, bleeding and tag loss. Fishing effort was measured in angler-hours with an angler-hour defined as one line fished for 60 minutes. Anglers were allowed to fish multiple lines.

A workshop with a local sportsmen's group was used to enlist volunteer anglers. Anglers were informed on the scope of the study, fishing procedures and how to record data on angler report cards. Anglers were not coached on hook removal techniques but were instructed to behave as they

normally would while removing the hook.

An attempt was made to catch approximately 25% of the walleye in each pond with each of the two terminal gears and to leave 50% unhooked as a control group. Walleye catch by gear type was monitored on a daily basis and effort stopped when the desired number of fish were caught and released. In 1985, fishing in Klawitter's Pond was conducted 27-30 April and fishing in Clubhouse Pond from 27 April - 31 August. In 1986, Klawitter's Pond was fished 3-26 June and Clubhouse Pond 5 May - 10 June. Water temperatures during fishing ranged from 13-28 C.

Fish were recovered from the ponds after angling periods by netting, electrofishing and chemical treatment with rotenone. Copper sulfate was used to stimulate movement of walleye into trap nets and gill nets. Two to four weeks were allowed between the termination of angling and the start of the recovery periods to allow for any delayed mortality. Recovery operations in 1985 on Clubhouse Pond were from 1-15 October and for Klawitter's Pond 13-15 May. In 1986, recovery of fish was from 9 July - 30 October in Klawitter's Pond and 25 June - 9 July in Clubhouse Pond. Loss of disc dangler tags from marked walleye was monitored in both ponds in 1985.

Catch and mortality rates were compared with a variety of statistical techniques. Differences between proportions were evaluated using a z-test modified to incorporate a continuity correction (Zar 1974). Confidence intervals (CI) were reported for proportions rather than standard errors since confidence intervals near zero were not symmetric. Confidence intervals for proportions were calculated using the quadratic method of Fleiss (1981). Catch rates were compared using two-way and one-way analyses of variance for unbalanced designs. Square root transformations were made to stabilize variances.

RESULTS

Angler Catches

A total of 839 marked walleye were available to anglers in the two ponds during the two year study (Table 1). The walleye ranged in total length (TL) from 289 mm to 600 mm with a mean of 469 mm. Males averaged 451 mm and females 524 mm TL. Sex ratio of the stocked fish was 1.5:1, males to female.

Anglers caught a total of 298 fish that had retained their numbered tags. Fish were landed 345 times but were identifiable by numbered tags only 337 times due to tag loss in 1985. The effort expended to catch these fish was 1,092 angler-hours (Table 2). Effort was not evenly distributed between ponds and years because catch rates were variable and volunteer angler assistance was less reliable in 1986. Most of the volunteer effort was expended in 1985. Average catch rates for each pond and year varied from 0.046 to 1.015 fish/hour. Males and females were caught in proportion to their relative abundances when live and artificial bait catches were considered together. Walleye available to the anglers were 59% males and the anglers catch was 60% males.

Recovery of Tagged Fish After Angling Periods

Nearly complete recovery of fish was attained in Klawitter's Pond. All walleye stocked in 1985 were recovered, and all but five stocked walleye were recovered in 1986. Three of the unrecovered fish had been caught on leeches and two had not been hooked. Two fish recovered in 1986 were found dead during the study. They also had been caught on leeches. All seven walleye that were hooked twice in Klawitter's Pond were recovered alive. Loss of disc dangler tags in 1985 was 0.8% for fish that had been in the pond approximately four weeks.

Table 2. Fishing effort and catch per unit effort (CPUE) by bait type for walleye in each pond and year. Square root transformations of CPUE were used to calculate means and 95% confidence intervals. CPUE values were converted to their original units for the table.

Pond and year	Bait type	Total effort (angler-hours)	CPUE (fish/angler-hour) Mean	Confidence interval	N
Klawitter's					
1985	Leeches	69.4	0.247	0.125-0.379	123
	Shad Raps	96.3	0.249	0.154-0.351	160
1986	Leeches	45.6	0.312	0.124-0.524	31
	Shad Raps	33.9	0.171	0.000-0.404	32
Clubhouse					
1985	Leeches	396.2	0.022	0.008-0.036	547
	Shad Raps	323.6	0.075	0.048-0.102	482
1986	Leeches	66.6	0.836	0.492-1.230	33
	Shad Raps	60.5	1.190	0.754-1.690	36

Recovery of tagged fish in Clubhouse Pond was poor. In 1985, 88% of the walleye stocked in the pond were recovered by netting and poisoning. Sixty-one (24.5%) of the recovered walleye had lost their disc dangler tags. Mortality in 1985 was roughly estimated by making several assumptions. In 1986, only 56% of the walleye were recovered. Eleven of 24 walleye that were hooked twice and all four walleye that had been hooked three times were recovered alive. Application of rotenone to Clubhouse Pond in 1986 was also ineffective in recovering the remaining fish. Because of ineffective recovery of fish, tag losses, and suspected poaching of large numbers of fish, mortality in Clubhouse Pond was not estimated in 1986.

Natural and Hooking Mortalities

Natural mortality (mortality of unhooked fish) was low in Klawitter's Pond. Only 1% (2/190 fish; CI=0-.04; p=.90) of the unhooked walleye were

not recovered from Klawitter's Pond for the combined collections of 1985 and 1986. It was assumed that two fish had died. All unhooked individuals were recovered in 1985.

Mortality of walleye caught by anglers was also low in Klawitter's Pond. No mortality (0/33 fish; CI=0-.07; p=.90) was observed in Klawitter's Pond in 1985. The number of fish hooked in Klawitter's Pond in 1986 was too low to establish reliable mortality estimates so data from both years were combined to increase sample sizes. Assuming that the three released walleye which were not recovered had died, mortality of released walleye in Klawitter's Pond in 1985 and 1986 was 6% (5/77 fish; CI=.03-.14; p=.90). Hooking mortality was estimated at 5% after adjusting for natural mortality.

A rough estimate of hooking mortality for Clubhouse Pond in 1985 was 16%. The rough estimate was calculated by assuming that no natural mortality occurred, tag loss was independent of whether or not the fish had been hooked, and the proportion of hooked fish in the recoveries represented the proportion of hooked fish that were still alive but not recovered from the pond.

Mortality by Bait Type

The type of terminal tackle used to catch walleye and the anatomical location where they were hooked influenced mortality. Mortality of fish caught on leeches was higher than mortality of fish caught on Shad Raps. The 1985-1986 combined estimate of mortality for walleye hooked on leeches in Klawitter's Pond was 11% (5/44 fish; CI=.05-.23; p=.90). No fish hooked on Shad Raps died (0/33 fish; CI=0-.10; p=.90). Two fish caught with leeches were known to have died and three unrecovered fish were assumed to have died. Fish caught with Shad Raps were hooked primarily in the lips (Table 3). Fish caught on leeches tended to be hooked more deeply in the

Table 3. Numbers of times walleye were hooked at various anatomical locations using leeches and Shad Raps as terminal tackle. Walleye were hooked in a combination of locations 24 times. Combinations were not included in the table.

Bait type	Anatomical location of hook				
	Lips	Mouth	Throat	Other internal	Other external
Leech	58	20	64	10	0
Shad Rap	128	17	1	0	6
TOTAL	186	37	65	10	6

throat and gut than fish caught on Shad Raps (Chi-square=103.6; df=4; $p<.01$). Adjusted for natural mortality, mortality of fish caught with leeches was 10% in Klawitter's Pond. Rough estimates of hooking mortality for Clubhouse Pond in 1985 were 13% for fish caught on Shad Raps and 23% for fish caught on leeches.

Catches by Bait Type

Sex and size of the walleye caught by angling were influenced by the type of bait fished. When compared with their proportion in the population of fish available to anglers, males were more readily caught with leeches than females but were less vulnerable to Shad Raps. Males comprised 69% of walleye caught on leeches ($Z=2.145$; $p=.03$) but only 52% of walleye caught on Shad Raps ($Z=-1.595$; $p=.11$). Females exhibited an opposite tendency, comprising 31% of walleye caught on leeches ($Z=-1.999$; $p=.05$) and 44% (not significant) of walleye caught on Shad Raps. The mean length of fish caught on leeches (458 mm TL) was smaller than the mean size of fish caught on Shad Raps (488 mm TL; $T=-5.10$; $df=1,291$; $p<.01$). Size selection by bait type was

also apparent for each sex. Significantly smaller males ($T=-2.61$; $df=191$; $p<.01$) and females ($T=-3.19$; $df=88$; $p<.01$) were caught on leeches than Shad Raps.

Fish caught more than once tended to select different bait types on successive hookings. All fish hooked three times were caught on both live and artificial baits. Fish hooked twice also tended to select different baits ($Z=1.287$; $p=.198$). Fifty-eight percent of the fish caught twice during the study were hooked on both live and artificial baits as opposed to 42% that were hooked twice on the same type of bait.

Though interactions with the pond and year confounded the analysis of catch rates by bait type, catch rates for leeches and the artificial lure were similar (Table 2). When catches by the two types of bait were compared for each pond in each year, only Clubhouse Pond in 1985 showed a significant difference. Here, the catch rate for Shad Raps was higher than for leeches ($F=12.898$; $df=1,1027$; $p<.01$) but the difference was only 0.05 fish/angler-hour.

DISCUSSION

Mortality rates were not determined for Clubhouse Pond because fish recovery efforts following angling periods were suspect. This possibility is supported by removal activities in Klawitter's Pond in which intensive netting in July 1986 failed to collect 18% of the stocked fish but subsequent netting in October captured all but five of the remaining fish. Low water clarity (secchi disc reading of 18 cm) limited recovery of rotenoned fish in Clubhouse Pond.

Walleye hooking mortality using leeches for bait was greater than hooking mortalities of walleye reported in other studies (Table 4). Schaefer (1986) reported only 2% of 240 walleyes were hooked deep in the

Table 4. Mortality rates for selected species reported in the literature.

Species	Mortality rate	Bait types used
Walleye		
Fletcher 1985	1.1%	No distinctions made
Schaefer 1986	0.8%	Minnows and Shad Raps
This study	10.3%	Leeches
	0.0%	Shad Raps
	5.4%	Leeches and Shad Raps
Rainbow trout		
Mongillo 1984	1.3-11.2%	Artificial flies
	1.3-11.2%	Artificial lures
	23.0-35.9%	Natural baits
Brook trout		
Mongillo 1984	0.0-4.3%	Artificial flies
	3.9%	Artificial lures
	5.6-48.8%	Natural baits
Atlantic salmon (landlocked)		
Mongillo 1984	3.9-26.0%	Artificial flies
	0.3-15.0	Artificial lures
	5.7-35.0	Natural baits
Largemouth bass		
Schramm et al. 1985	14%	No distinctions made
Smallmouth bass		
Clapp and Clark 1986	8.8%	Minnows
	0.6%	Artificial spinners

mouth or stomach using minnows and Shad Raps and only 0.8% died from hooking. A larger proportion of our fish (25%) were hooked in the throat or gut. Fletcher (1985) reported 1.1% hooking mortality for 180 walleye but did not specify the types of bait used. Walleye survival after catch and release was monitored for only 2, 4 or 12 days by other investigators but survival of some walleye was documented for up to 14 weeks in our study. Greater losses in this study may have resulted from long-term hooking mortalities which were

not measured in the other investigations. Nonetheless, hooking mortalities for this study were within the range of rates reported for other species.

Size, rather than sex, appeared to be the more important factor influencing catches for each bait type. Smaller fish were caught on leeches than Shad Raps. Although females available to anglers were larger than males, a size difference in catches for each bait type was still apparent when the sexes were considered separately. The difference between mean lengths of fish caught on each bait may have been even greater if a wider range of sizes of walleye had been used.

Variations in walleye vulnerability to angling in separate ponds and years may have resulted, in part, from differences in the availability of forage. Variations in walleye vulnerability to angling in Oneida Lake were probably related to food abundance (Forney 1980). Rotenone applied to Clubhouse Pond following the 1985 angling period and the stocking of a maintenance diet of fathead minnows may have increased angling success in 1986.

MANAGEMENT IMPLICATIONS

Low hooking mortality rates suggest that catch-and-release fishing, slot or maximum size limits may be feasible as a management tool for walleye. Minimum survival of released fish, as projected from confidence intervals of hooking mortality, should be 77% for walleye of sizes used in this investigation. Caution should be used in applying our figures to smaller walleye as they may be susceptible to higher hooking mortality. Nonetheless, this study demonstrated that walleye can be recycled to be caught again, thereby providing multiple recreational opportunities from a single fish. Additional benefits of releasing walleye might include larger fish available to anglers and better balance of predator/prey relationships

(Anderson and Weithman 1978; Brousseau and Armstrong 1987).

Restricting the use of live bait such as leeches could reduce mortality of released walleye but may not be useful with slot length limits which are designed to harvest small fish. Although fish caught on leeches were more susceptible to being hooked in critical anatomical areas, leeches may be more appropriate than an artificial lure for harvesting small walleye since leeches caught smaller fish than Shad Raps.

Survival of hooked walleye might be enhanced by educating anglers on techniques for releasing fish. For instance, lethal injuries which occur when hooks are removed from vital areas can be reduced by cutting the leader and leaving the embedded hook (Hulbert and Engstrom-Heg 1980). Although they were not coached on appropriate fish handling or hook removal techniques, the anglers who volunteered to participate in our study may have been more aware of good release techniques than the average angler.

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