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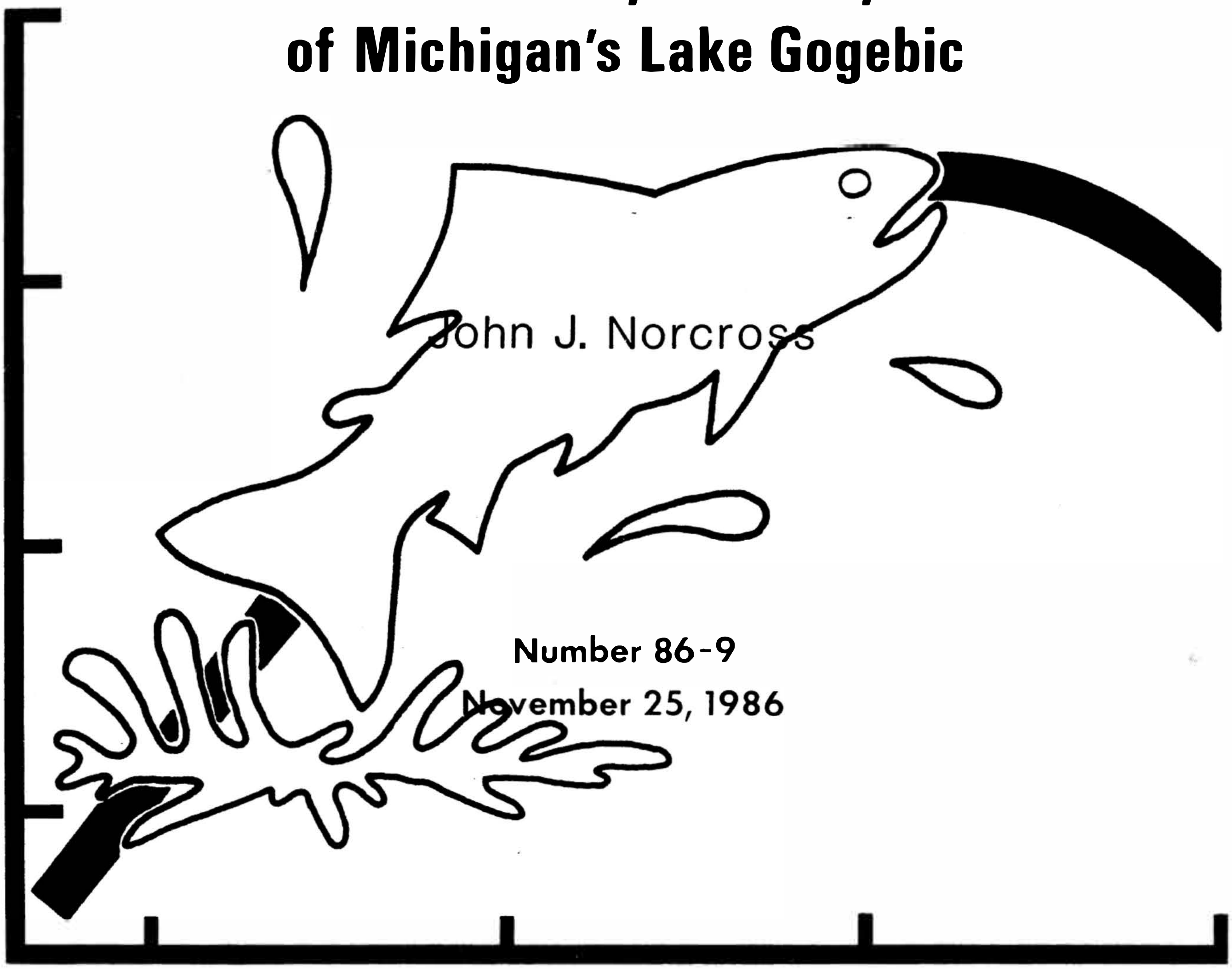
TECHNICAL REPORT

The Walleye Fishery of Michigan's Lake Gogebic



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ABSTRACT

The introduction of walleyes in Lake Gogebic in 1904 and following years resulted in the establishment of a renowned walleye sport fishery and a sharp decline in indigenous smallmouth and largemouth bass. The early walleye fishery was noted for big fish; however, since the 1920's there have been periodic reports of poor fishing due to large numbers of sublegal walleyes and the inability of most tourists to catch walleyes during the summer. Early studies, prompted by complaints, brought attention to a demise of forage species and the very slow growth of Lake Gogebic walleyes. Studies since 1971 of the spawning population indicate that recruitment of young walleyes has been stable, adult female population has been very stable, and the adult male population has peaked about every 4 years—coincident with angler complaints of excessive numbers of small walleyes. The predominant age group has varied between age III and age V for mature males and between age VII and age XII for mature females. The number of age groups contributing to the fishery has been six or more each year. The modal size of mature males increased from 13 inches in 1976 to 16 inches in 1977, then declined to less than 13 inches in 1986. A similar phenomena was not recorded for females. Tagging studies yielded population estimates of legal-sized males ranging from 38,000 (in 1977) to 63,000 (in 1984). Recent statistics from intensive tagging studies placed annual exploitation rate at 20% and natural mortality rate at 18%.

In light of continued slow growth, annual overproduction of young, and low levels of forage, it was recommended that size limits on Lake Gogebic walleyes be reduced from 13 to 12 inches. A mathematical model predicted that (1) pounds of walleye harvested by anglers would stay the same, (2) numbers of legal walleyes harvested would increase 28%, (3) number of sublegal walleyes caught and released would decrease 56%, and (4) the reproductive potential of the walleye population would decline 20%. Other recommendations call for close monitoring of the population, particularly during autumn, and educating anglers in more effective techniques for catching walleyes.

INTRODUCTION

Lake Gogebic has the distinction of being one of the prime walleye (Stizostedion vitreum) lakes in the midwest. The village of Bergland, Michigan, situated on the north shore of the lake, claims to be the "Walleye Capital of the U.S.A.". One might infer from the prestigious title that Lake Gogebic is a veritable walleye "factory" consistently producing large numbers of trophy fish. Although the lake annually produces very large numbers of walleyes, many of which attain respectable size, the fishery has not been without its share of problems, real and imagined.

Periodically, from earlier accounts to the present, have come a flood of complaints regarding poor fishing for walleyes. Angler complaints basically fall into two categories: high numbers of sublegal fish and low catch rates in July, August, and early September. Unhappily for resort owners, the summer slump in fishing success coincides with the seasonal peak in tourism.

These complaints prompted the first study of the lake and now have prompted this review of studies conducted to date. The goals of this review are to summarize the facts, provide a perspective on the problems, and guide future management and research. Particular attention is directed toward determining whether or not the quality of fishing is declining because of significant population changes and whether changes in present regulations hold promise for improved fishing.

Data on the sport fishery of Lake Gogebic have been accumulating since 1928. Metzelaar (1928) gave the first preliminary report on Lake Gogebic which included a brief description of physical features of the lake, historical development of the sport fishery, species composition, status of the fish fauna, and problems attendant with the fishery. A follow-up survey in 1938 was reported by Eschmeyer (1941a). Information gathered by creel censuses in 1940–41 was presented by Eschmeyer (1943). A weir, situated in the West Branch of the Ontonagon River below the outlet of Lake Gogebic, yielded information on movement of fish in and out of the lake (Eschmeyer 1942a). Notes on the natural reproduction of walleyes in Lake Gogebic was provided by Eschmeyer (1941b and 1942b), and a comprehensive account of the life history of the walleye in Michigan was published by Eschmeyer (1950). Schneider et al. (1976) reported on the longevity, survival, and harvest of tagged walleyes in Lake Gogebic.

Additional census and tagging studies provided estimates of angling effort and success and of walleye mortality (Sendek and Ryckman 1978). Data on length frequency distributions by sex, age composition, and relative abundance have accrued from spawn-take operations conducted each spring since 1971. A voluminous body of correspondence generated by members of the Lake Gogebic Improvement Association and the Lake Gogebic Area Chamber of Commerce, and others, attests to the socio-economic importance of this sport fishery.

History of the Sport Fishery

Metzelaar (1928) provided the earliest account of the sport fishery. According to Metzelaar, "In the 19th century Gogebic Lake was one of the outstanding, famous bass lakes of the states. Smallmouth bass (Micropterus dolomieui) predominated, next to which came largemouth bass (Micropterus salmoides), rock bass (Ambloplites rupestris), followed by bluegills (Lepomis macrochirus), and sunfish (Lepomis gibbosus). No strictly predatory fish were present, but 'minnows and shiners' were abundant and in certain seasons could be found swimming inshore in large numbers." Metzelaar (1928) then goes on to write that in 1898 or earlier, 84 good-sized northern pike (Esox lucius) and 18 muskies (Esox masquinongy) were released. He also notes that "pike perch" or "wall-eyed pike" were successfully introduced as fry around 1913.

Actually, walleye stocking began earlier. On May 3, 1985, the Baraga office of the Michigan Department of Natural Resources received word from Florence Daniels of Bergland, that her grandfather, Adolph Martin Borseth, was hired by G. A. Bergland to plant walleyes in Lake Gogebic in 1904. The fish, which came in by train, were planted from a rowboat into Bergland Bay just east of the Bergland dock. According to Bob Haas, Biologist, Mt. Clemens (personal communication), archive records indicate 300,000 fry were planted in 1904, their source unknown, but Haas suggests they came from the hatchery in Sault Ste. Marie, Michigan.

To return to Metzelaar's report, "Soon after northern pike were introduced large pike were caught in goodly numbers; the record being 27 pounds." Metzelaar goes on to state, "In later years both numbers and size dwindled and no remarkable pike have been caught since 1925 or 1924 which coincides with the rise of walleyes." He further notes that, "Ten years after their introduction, walleyes were caught in numbers with hook and line, the weight running up to 16 pounds. At present, numbers have dwindled down and the record in recent years has been around 10 pounds." Metzelaar's very pertinent statements have echoed through later reports by other investigators.

Noting the rise and decline of northern pike and the rise of walleyes, Metzelaar goes on to pose the question, "What happened in the meantime with the other fishes of the lake? If we may believe the reports of seemingly trustworthy residents, their fate under the combined assaults of the two fish predators has been anything but happy. To make a sad story brief: largemouth bass, bluegills, sunfish, minnows and shiners are no more in the lake." Metzelaar noted, "The striking absence of food fishes of the cyprinid family, commonly called minnows and shiners, has been confirmed by our own findings. Ten hauls with 120-foot seine and two settings of gill nets of two boxes each failed to produce a single minnow." Other comments by Metzelaar bear repeating, "I have analyzed the stomachs of all the pike caught by us and this reveals at a glance that the only fish eaten by the wall-eyed pike were their own young." Having noted the absence of forage fish and probable cause for their demise, Metzelaar goes on to recommend, "Certain species of shiners, notably Notropis hudsonius, ought to be reintroduced into the lake even if it be necessary to haul it over long distances."

According to Eschmeyer (1943), walleye fishing in the 1930's was somewhat cyclic with good fishing prevailing several years prior to 1936 followed by fair to poor fishing from 1936 to 1939. Persistent reports of poor fishing resulted in a Conservation Commission directive ordering initiation of a study to determine the fish yield of Lake Gogebic. There followed creel censuses, generally conducted over the fishing season from May 15 – October 30, for years 1940, 1941, 1947, 1976, and 1977 (Table 1). In those years where data collections did not continue through October 30, data were projected to include the entire open-water season. Suspect though these data might be because of inherent problems associated with coverage of a large body of water, they provide the primary estimates of angling pressure and catch rates for the sport fishery.

Walleyes were clearly the predominant species in the fishery in 1940 and 1941 (Table 1). Northern pike was next in importance to walleye, and smallmouth bass and yellow perch (Perca flavescens) were minor components of the fishery. There was a marked increase in angling effort from 1940 to 1941 and, as reported, this was thought due to improved economic conditions or to a clerical error in estimating coverage of fishing. By 1947 there was an apparent 29-fold increase in numbers of yellow perch. Estimated catch of walleyes increased by 36% over 1941 and total effort increased by 11%. Increases in both catch and effort resulted in a slight increase in walleye catch per angler hour. The estimated catch of all fish per angling hour was quite high. Whether the estimate was a true reflection of the times or not is a matter of conjecture. Unfortunately, correspondence of that period does not testify to excellent fishing in 1947.

Field reports generated in the 1940's allude to the need to plant forage species, to large numbers of young yellow perch, to the absence of bluegills, and to the relatively poor fishing for the numbers of walleyes present. A survey conducted in August 1955 captured large numbers of walleyes ranging in size from 7.0 to 27.0 inches. Yellow perch also figured prominently in the catches but these were large fish ranging in length from 9.7 to 14.4 inches. A few smallmouth bass, northern pike, rock bass, and cisco (Coregonus artedii) were taken but their sizes were not impressive. White suckers (Catostomus commersoni) were also taken in small numbers but in sizes ranging from 14 to 21 inches. A September 1957 survey also indicated that walleyes and large yellow perch predominated.

Fall surveys in 1976 and 1977 collected large numbers of walleyes ranging in length from 6 to over 22 inches. Large suckers (10 to over 22 inches) were next in abundance, followed by large yellow perch (80% were 8 inches or larger in length).

Prior to the opening of the 1976 fishing season, a number of walleyes were tagged in an effort to determine the size of the population of legal-sized fish. A creel census clerk was employed to collect information on number of fishermen, hours fished, and number of tagged and untagged walleyes appearing in the catches. The estimated number of walleyes caught in 1976 (1,814) fell far short of expectations expressed by local residents and biologists. Despite shortcomings of the survey, yellow perch appeared fairly well represented in the catches, and in all likelihood were more abundant in 1976 and 1977 than in recent years.

The last creel census, in 1977, was conducted in conjunction with another tagging study. That year the estimated catch of yellow perch exceeded that of walleye, and catches of smallmouth bass and northern pike were relegated to minor importance. Aside from the high total catch per hour in 1947 and the unusually low estimated catch rate for walleyes in 1976, catch rates for Lake Gogebic have been fairly consistent. Walleye catches are generally best after season's opener, decline markedly in summer, and increase again in the fall. This pattern is reflected in tag recovery data, and has been observed by fishermen and resort owners.

The foregoing surveys and observations document the dominant role walleyes assumed in the fish community following their introduction. Yellow perch, a close associate and major food item in a "balanced" walleye-yellow perch community, experienced a shift from many small fish to fewer larger ones. Populations of smallmouth bass and northern pike declined greatly and surviving white suckers, by virtue of their large size, were no longer available as prey items.

Walleye Spawning

The spawning of the walleye is a temperature dependent event, with the rate of vernal warming governing the chronology and tempo of reproductive activity. Spring weather in the Upper Peninsula is notably variable from day to day and between years. High winds, often associated with rapidly falling temperatures and accompanied by rain or snow, frequently disrupt the spawn-take operation. High waves generated by prevailing northwest winds may prevent nets from being fished, disrupt spawning activity, cause fish to move into deeper water, and kill eggs already deposited on spawning bars.

Eschmeyer (1941b) noted that spawning activity commences almost immediately after ice has left the lake. Males begin congregating over rubble and gravel along the eastern shore while water temperatures are still below 40 °F. Data collected since 1971 indicate that ripe females first appear on the shoals when surface temperatures are from 39 to 46 °F. In 1942, Eschmeyer (1950) found that spawning peaked when shoal water temperatures ranged from 46 to 48 °F. In years of fluctuating spring weather, as was the case in 1986, spawning may be sporadic and of low intensity and long duration. Consequently, no spawn could be collected in 1986. At times the seasonal advance is very rapid and spawning intensity peaks within days of "ice-out".

Assessment of Relative Abundance

Since the early 1970's a number of selected lakes in the western Upper Peninsula have been stocked with young walleyes hatched from fertilized eggs collected at Lake Gogebic. The spawn-take operation, conducted annually since 1971 (except 1973), represents a long-term continuing investment and major field operation for District 1 fisheries personnel of the Michigan Department of Natural Resources. Complementary to the taking of spawn has been the recording of the catch of males and females per net lift. Our standard fishing gear has been a fyke net with a 4-foot pot of 3/4-inch bar mesh and a lead up to 75 feet in length. The total catch divided by the total number of lifts yields a statistic known as the catch-per-unit effort (CPUE). A single CPUE value has little meaning in itself; however, a long-term series of average catches, each derived in uniform fashion, is of great importance in determining trends in relative abundance. In addition to obtaining yearly CPUE values, there have been periodic tagging projects for promotional and biological purposes. Net run samples, when taken, have included measurements of lengths and weights by sex, and collections of scales for age determinations.

Data collected during spawn-take operations are given in Table 2. Note that number of net nights (total fishing effort) varied from a high of 175 in 1974 to a low of 36 in 1972 and 1982. The amount of fishing effort expended depends primarily on weather and secondarily on the required quota of eggs. In most years netting terminated while spawning was still in progress but after spawning had peaked.

Total season catches show a disproportionate number of males. Two reasons are offered for the significant departure from an assumed 1:1 sex ratio at birth. First, males move on the spawning grounds earlier and remain on the spawning grounds longer than females. Consequently, males have a higher probability of capture because the nets are set right after ice out. Second, females reach sexual maturity a year or two later than males. Consequently, more females die from fishing or natural causes before they mature. Data for 1976, 1977, 1981, 1985, and 1986 show that 20 to 30% of the spawning males were less than 13 inches long, the minimum legal size for anglers. By contrast, no spawning females were less than 14 inches long. Thus, the legal-size limit provides more protection to males than females.

Because of the behavioral differences CPUE's of males and females were calculated differently to provide the best indices of relative abundance. For males, total male catch was simply divided by the total number of net nights. For females, I considered only the netting effort from the first day ripe eggs were stripped to the end of netting and counted only ripe females. Thus, females which were spent or not ready to spawn were not included in female CPUE calculations (these fish represented only a small fraction of the catch).

The CPUE data for male walleyes show very large year-to-year variation, from 18 to 197, with cycles (Table 2). These data usually reflected differences in relative population abundance, but not always. For example, the catch of both males and females was deceptively low in 1971 because spawning was drawn out by cold weather. In 11 days water temperature only rose from 37 to 44 °F. Peaks in relative abundance have occurred at 4-year intervals: 1974, 1978, and 1982. The high catch in 1986 also fits in with this trend. These peaks have corresponded with floods of public complaints about poor fishing due to small-sized fish.

Female CPUE's, on the other hand, show a less pronounced cycle and less year-to-year variation (Table 2). The different cycle reflects, in part, that females mature at a later age than males. Considering the extreme fluctuations in abundance which have characterized walleye populations at other times and locations, the 15 years of CPUE data for Lake Gogebic spawning females exhibit remarkable uniformity. This is important because it is that segment of the population which is most vital to maintenance of the stocks. The females are subjected to fishing pressure before attaining sexual maturity and, if females are faster growing and exhibit greater aggressiveness in feeding as some authors believe, they probably suffer a greater fishing mortality rate than males. In fact, Schneider (1978) determined that the total annual mortality of Lake Gogebic males 3 years and older was 20% per year, whereas females of the same ages experienced a mortality of 35% per year. Despite loss of potential spawners through fishing, it appears that the sport fishery has had little impact on population levels.

Spring CPUE data represent the best evidence there have been no extreme fluctuations in abundance of walleyes since 1971. Spring CPUE is a valuable measure of relative abundance because it is taken at that time of year when the fish are most vulnerable to passive fishing gear because they are concentrated and moving. Further, the same type of gear is employed each year and it is deployed in virtually the same locations. Another advantage is that the sex of walleyes can be easily determined by external examination in the spring. In terms of a cost-benefit ratio, CPUE by spring netting provides the best estimate of population change for the least expenditure.

The annual spring spawn-take operation has had two good effects despite local opinion to the contrary. Not only have managers been able to enhance the sport fishery resource of this district through judicious plantings of young walleyes originating from Lake Gogebic stocks, but we have been able to follow population trends of Lake Gogebic stocks as well.

One shortcoming in this method of data collection is that juvenile and immature fish are not sampled. Thus, year class failures cannot be detected from spring netting data until some years later, and even then they may go undetected because so many other year classes are present and their growth rates overlap.

Growth

Eschmeyer (1941a) summarized growth data for several species of fish in Lake Gogebic in 1929, 1938, and 1941 and concluded walleye growth was relatively slow compared to other northern Michigan lakes. The conclusion drawn by Eschmeyer is confirmed by more recent data (Table 3). Growth of Lake Gogebic walleyes is less than for walleyes in Teal and Michigamme lakes and less than the state average.

Eschmeyer (1941a) also noted the rate of growth in 1929 differed from the growth rate in 1940. Almost 5 summers were required to attain a length of 14 inches in 1929; whereas, in 1940 the same length was reached after 4 summers of growth. Data collected since 1940 document other annual variations in growth and show that Gogebic walleyes have consistently grown slower than the state average (Tables 3 and 4). These data also indicate that females grow faster than males, which is true of walleyes everywhere, and that growth of younger age groups declined in the 1980's.

Interestingly, age at maturity for females has shifted downward from age VII in 1976, to age VI in 1977, and then to age V in 1985. Whether or not this apparent shift is real, due to sampling error or to misinterpretation of scales, cannot be ascertained. Had the shift been accompanied by a significant increase in average length then the phenomenon would have been creditable, for maturity is not only a function of age but of growth as well. Since female growth did not improve, the apparent shift in age at maturity remains a matter for speculation.

Note from these tables that many age groups are present at any time and six or more of these are large enough to be included in the sport fishery. This augurs well for the fishery for such a spread of year classes provides a buffer against catastrophic collapse of the fishery. Failure of one or more successive year classes would not be severely felt, and there is no evidence on file that there has ever been a year class failure. Trends implied by CPUE values indicate a relatively stable population, albeit one that is plagued at times by excessive reproduction which results in intense intraspecific competition and, consequently, slow growth.

Slow growth might be ascribed to short growing seasons and to low basic productivity of lake waters, but these are factors shared by other Upper Peninsula lakes. Eschmeyer (1941a) observed that Lake Gogebic is adequately endowed with invertebrate foods. He noted that mayfly nymphs predominated in shallow and deep waters, followed in abundance by small clams and midge larvae, and that crustaceans were the predominant component of the zooplankton. More recent experience has shown that zooplankton needed to inoculate a walleye rearing pond can be easily obtained from Lake Gogebic—further evidence that basic productivity is not of low order. Subjectively, it does not appear that the root cause for slow growth of walleyes lies at the base of the food chain, i.e., in the production of benthos and plankton. Rather, slow walleye growth appears to be due to a low supply of forage fish. Metzelaar (1928) reported a demise of forage fishes in Lake Gogebic. Reports in succeeding years generally confirmed the near absence of forage species and strongly indicate close cropping of yellow perch and suckers. This is evidenced by the relatively low numbers of small perch and suckers present year after year.

Food habit studies by Eschmeyer (1950) show the importance of small fish to the diet of walleyes in Lake Gogebic. The young, after yolk-sac absorption, begin feeding on zooplankton then switch to insects and other invertebrates as they grow. Around fingerling size their diet changes to small fish. The diet of 134 young walleyes, 1.0 to 6.9 inches long, consisted of 88% fish and 12% insects, by volume. The diet of larger walleyes, 9.8 to 26.6 inches long, was 89.1% fish. Of this total, yellow perch contributed 46%. The remaining 54% of the fish food was made up of the following species: ninespine stickleback (Pungitius pungitius), trout-perch (Percopsis omiscomaycus), topminnow (Fundulus sp.), pike, Iowa darter (Etheostoma exile), white sucker, and walleye. Mayflies contributed 6.0% and crayfish contributed 1.7% to the total volume of food of larger walleye.

Collectively, these observations and data suggest the chronically slow growth experienced by walleyes in Lake Gogebic stems from an ecosystem that has become flawed by the overwhelming presence of the walleye. Because of the weak link in the system, namely low production at the trophic level occupied by forage fish, the walleye is forced to subsist on rations unfavorable for good growth. In a very real sense, the walleye in Lake Gogebic is its own worst enemy because of continued high population levels. Cannibalism probably has become an important self-regulating mechanism.

Age Structure

Information on the age structure of the walleye population of Lake Gogebic was obtained from the study by Eschmeyer (1950), from spawn-take operations, and from tagging studies. This information, and particularly data on yearly changes in age structure, offers insight into the population dynamics of the walleye. For clarification, the age structure of the population was stratified on the basis of sex. Although 1947 data were not obtained solely during the spawning season, as was true for the remaining years of collection, the data are included in Table 5 in order to provide comparisons with later years.

For males, the mode (the predominant age group) has shifted between age III and age V over the years (Table 5). This probably reflects relatively weak or strong year classes passing through the population. Few males under age III appear in the table because they are not sexually mature, hence they are under sampled during spawning runs. Relatively high numbers of age-I walleyes were captured in 1947 but these were taken after spawning and with different gear. Bear in mind that if a completely unbiased sample could be obtained from any fish population, on the average young fish would outnumber old fish in a progressive fashion. Males older than 8 years of age are uncommon (as best as we can judge from their scale patterns) but one fish lived an estimated 26 years based on a combination of tagging data and scale aging (Schneider et al 1976).

For females, the predominant age group in the spawning run was much older, varying between VII and XII (Table 5). In contrast to the early maturing males, very few females under age VI are mature (note that the 1947 collection included immature females).

The relative frequency of females 9 years and older deserves special attention for it is these groups that contribute the trophy specimens to the fishery. The largest walleyes taken during spawn-taking operations at Lake Gogebic (and also at Bay de Noc, Lake Michigan—Jerry Peterson, personal communication) are females. This is primarily because females grow faster than males. Table 5 indicates that old females were weakly represented in the 1985 and 1947 collections. However, this could be due to differences in interpreting growth patterns on scale samples by various investigators.

The scales of females are usually easier to interpret because of their faster growth. Growth of males may virtually cease by age X, causing age to be underestimated. For example, a male walleye tagged in 1976 at 14.5 inches and judged to be 4 years old was recaptured in 1986 when it was 16.5 inches. Thus in 10 years it had grown but 2 inches.

Size Distribution

Total lengths of spawning walleyes were measured in 1947, 1976, 1981, and 1986. These measurements were assembled into 1-inch size groups and the percentage of fish in each size category relative to the total sample was computed (Tables 6 and 7). These computations afford a means of looking back in time to determine whether there have been notable changes in the size structure of the population.

One obvious fact in Table 6 is that the proportion of males 15 inches and longer was greater in 1947 than in any succeeding year samples were collected. However, the nets (trap nets) used in 1947 may have had larger mesh and been selective for larger fish than the nets (fyke nets) used since then. The sample taken in 1976 had no clear mode and a high percentage of very small, 12-inch males. By 1977 the mode was 16 inches, reflecting a high proportion of good-sized males in the population. However, from 1977 onward there has been a notable decline in the average size of legal fish. This is a matter of concern.

On the other hand, the modal length of females has varied between 17 and 20 inches, without a downward trend (Table 7). Females have exhibited less variation in modal lengths than have males and the reason for this is not clear. The evidence at hand does not lend itself to easy interpretation. For example, the age structure of females collected in 1985 is quite different from the age structure of males collected at the same time.

While at a loss to explain some, if not most, of the changes in size composition of the male walleye population over time, it is safe to say that the size structure of the present population is measurably less than that which prevailed in 1947. The best explanation for decreased size of males is slow growth brought about by sustained high population levels.

Females did not respond similarly. The reason for this is not clear but it is well to mention once again some pertinent differences between the sexes: males enter the spawning population at an earlier age than females, males exhibit slower growth than females, and females are thought to be more aggressive feeders than males. Consequently, the rate of exploitation is greater for females than males.

Although the main body of data for this report has accrued from spring collections, there have been several fall surveys conducted primarily as follow-up projects for tagging studies. These studies are mentioned only to point up the utility of conducting fall field studies. It is during fall collections that a few young of the year and 1 1/2-year-old fish begin to appear in substantial numbers. Fall collections, therefore, provide the best estimates of the strength of oncoming year classes.

Estimates of Fishing Mortality, Natural Mortality, and Population Size

Metzelaar (1928) observed that Lake Gogebic was lightly fished. In those early times, fishery science was in its infancy and investigators were without mathematical tools to estimate fishery parameters. A body of knowledge regarding the Lake Gogebic walleye fishery has gradually emerged, beginning with an analysis of results generated from a 1947 tagging experiment (Schneider et al. 1976). To those first findings have been added results of later studies (Table 8).

The 1947 study involved over 4,000 walleyes which were tagged with metal jaw tags. Discounting specimens whose sex was not determined and fish found dead soon after handling and release, the total number of tagged fish came to 3,445 males (79.9%) and 867 females (20.1%). Tag recoveries extended for 18 years. On the basis of recoveries over time, Schneider et al. (1976) estimated that annual mortality rates were 20% for males and 41% for females. Further, most of the 20–41% annual mortality was due to natural causes because annual exploitation rates were estimated at roughly 4%. The authors noted that growth rates were very low as determined from lengths at tagging and lengths at recapture. Females grew faster than males, and that fact coupled with differential mortality rates, led the authors to suggest that females were more aggressive feeders and were more vulnerable to angling than males. Results of the tagging study also lead the authors to conclude that longevity of males was greater than that of females. That tagging project did not provide a means for estimating the size of the walleye population.

Prior to the opening of the 1976 walleye season 1,762 adult walleyes were tagged. A summer creel census and a fall test netting survey were conducted to obtain estimates of the ratio of tagged to untagged fish in the catches. The creel census data provided a population estimate of 58,500 adult walleyes in Lake Gogebic and the fall test netting provided a similar estimate of 53,600 fish. The average of the two estimates was 56,000 fish. The exploitation rate by anglers was at least 5.7%, based on voluntary tag returns by fishermen.

The following year (1977) 1,927 legal-sized walleyes were tagged. At summer's end 138 recaptures had been reported by anglers, for an estimated minimum exploitation rate of 7.2%. The total population of adult walleyes was estimated to be 38,540.

Another tagging study was undertaken in 1984. Then 998 male walleyes, obtained during the spawn-take operation, were tagged. A total of 202 tags were returned by anglers, indicating an annual exploitation rate of 20% or more (Table 8). Through the cooperative efforts of the Lake Gogebic Area Chamber of Commerce, the 1984 tagging study probably yielded the most reliable information which has been gathered to date on the exploitation of the walleye. A highly publicized fishing derby was promoted that paid substantial rewards for the return of tags and associated information. Thus, the percentage of caught tags which were actually turned in was probably much higher in 1984 than in earlier years. In 1976 and 1977 observations made in lake-side business establishments indicated that some tags were not reported.

While the 1984 tag returns provided an excellent measure of annual exploitation rates, there remained the problem of deriving a tagged-untagged ratio of the catch to obtain an estimate of population size. This was achieved by counting numbers of tagged and untagged males 14 inches and over in length which appeared in the 1985 spawn-take operation. Knowing the rate of growth, and limiting counts of untagged fish to those 14 inches and greater, provided the needed correction for recruitment. The estimated population of male walleyes 13 inches and greater was 63,000. When considering the unaccounted fraction of females in the population, the total number of legal-sized fish in Lake Gogebic in 1984 must have been around 125,000.

Estimates of annual mortality were derived by pooling age-frequency distributions for age groups III-XI males collected in 1976 and 1977. A graph of these data resulted in a catch curve of surprising uniformity, which is indicative of constant recruitment and exploitation. The annual mortality rate was computed to be 26.7%. Similar mathematical treatment of age-frequency distributions for males of age groups V-X in 1985 yielded an estimated annual mortality rate of 38.2%.

Predictions through Modeling

Modeling with computers, invaluable though it may be, by no means renders fisheries management an exact science. The unpredictable nature of weather, and the failure of assumptions (requisite in modeling) to hold true, assures that the end products of mathematical modeling will always be predictions, not certainties. However, the probability of predictions becoming reality is greatly enhanced through employment of reliable input data.

Using estimates of growth, rate of exploitation, and rate of natural mortality of populations of walleyes from a number of sources, Schneider (1976), by means of mathematical modeling, predicted changes that could be expected from a statewide increase in walleye size limit. A similar mathematical approach was used to evaluate a nascent management plan designed to correct the recurring walleye problem in Lake Gogebic.

A plethora of sublegal walleyes has plagued the sport fishery in recent years. As a consequence, consideration has been given to lowering the size limit. It was anticipated that such course of action would not only effectively reduce the numbers of small fish (thereby reducing intraspecific competition) but also increase the probability of tourist anglers being able to creel legal walleyes. The history of the fishery indicates that upsurges in numbers of young fish is a recurring event; thus if it becomes possible to predict when these events will come off, then timely and judicious changes in regulations may alleviate the problem of super-abundance of young.

Schneider (personal communication) developed a mathematical model of the Lake Gogebic walleye population. For the rate of exploitation, Schneider used a figure of 21% (estimated from the 1985 tagging study) for age-III and older walleyes and a 10% rate for age-II fish. Natural mortality was assumed to be 20%, growth estimates were based on the 1976 study, and hooking mortality for sublegal walleyes was assumed to be 10%. The model predicted that 50% of the walleyes hooked by anglers would be less than 13 inches long and 50% would be larger than 13 inches; that prediction was confirmed by data collected by local residents in 1982.

Dropping the minimum size limit (MSL) from 13 inches to 12 inches would be <u>roughly</u> equivalent to changing age of entry to age III. Yield (weight harvested) should be virtually the same, number harvested should increase 28%, number of sublegals caught and released should decrease 56%, and the reproductive potential of the population would decline 20%. Schneider further noted that by dropping the size limit and increasing the catch, the growth of survivors may improve because of thinning and that populations of prey species may build to higher levels. Because the walleye is so fecund and so abundant, natural reproduction should continue to be more than adequate.

Overview

Review of the file on the Lake Gogebic sport fishery has provided an overview from which it may be concluded that the sport fishery is strongly dominated by the walleye. Certain facts about this fishery have emerged which seem peculiar to Lake Gogebic stocks and merit documentation. The following salient characteristics of the Lake Gogebic fishery are listed below with no particular order of importance:

1. All evidence points to a relatively stable population of exploitable size groups since the early 1970's.
2. There is no evidence of a year class failure nor is there evidence of a dominant year class.
3. Six or more age groups support the fishery but the predominant size of creeled walleyes is 13 to 14 inches.
4. Growth of Lake Gogebic walleyes is consistently slow compared to state average or to growth rates found in other Upper Peninsula waters.
5. Slow growth has been attributed to a short growing season, a lack of adequate levels of forage fishes, and high population levels.
6. The sport fishery experienced a series of ups and downs shortly after establishment of the walleye.
7. High points in the fishery are usually not recognizable except by absence of complaints by anglers and resort owners.
8. Low levels of angler success have been brought to focus by a flood of complaints which center on too many undersized walleyes and the inability of most tourist anglers to catch walleyes during summer months.
9. Netting surveys have consistently demonstrated the presence of enough legal-sized walleyes to support a good-to-excellent sport fishery.
10. Exploitation rates were probably low until 1985 when the estimate arose to about 20%. In terms of walleye angling pressure elsewhere, a 20% annual rate of harvest remains modest.
11. High fecundity and very good spawning grounds cause consistently high levels of walleye reproduction in Lake Gogebic.
12. There is no evidence that the spawn-take operation has, in any way, adversely impacted the walleye population. The spawn-take operation has not only provided a stocking source but enabled collections of vital statistics which might otherwise not have been obtained. These statistics allow monitoring of trends in relative abundance, age structure, growth, and mortality. The operation also provides visual proof to skeptics of the presence of large numbers of walleyes. In retrospect, the spawn-take operation has proven providential in more ways than one.
13. The yellow perch population may be over cropped due to heavy walleye predation on small perch.

In view of the salient facts just presented, it does not appear that past management practices have adversely impacted the sport fishery. But what of the future?

It is safe to assume that angling pressure will increase in the near future. Data indicate a threefold increase in the period from 1977 to 1985. Whether this increase is really due to promotional efforts of the Lake Gogebic Area Chamber of Commerce or to low estimates in 1977 is speculative. The point is that the human population is expanding, there is increasing public interest in fishing—walleye fishing in particular, and therefore, angling pressure is bound to increase. Schneider (1978) succintly noted, "Ever increasing fishing pressure on walleye stocks necessitates an ever increasing level of sophistication in walleye management." It is with that thought in mind that we offer the following management recommendations for Lake Gogebic.

Management Recommendations

Statement:

All evidence points to yearly production of young walleye which far exceeds requirements to balance annual loss though natural and fishing mortality. Over its life span, the walleye serves a dual role, first as prey, then with advancing age and size, as predator. In the absence of an adequate forage base, the role as a cannibal on its own kind assumes greater magnitude than would ordinarily be the case. It is safe to assume that walleyes are less efficient in converting invertebrate foods to flesh than they are in converting forage fish. Manipulation of the stocks on hand offers a means of improving energy flow through the ecosystem. Unless efforts are made to thin stocks of walleyes, intense intraspecific competition and slow growth will probably continue and there will be no significant recovery by forage species.

Recommendation:

Reduce the minimum size limit on walleyes to 12 inches and follow-up with fall test netting surveys to assess the effects of regulation change. Fall surveys should continue as long as there is a question regarding the wisdom of this change.

Statement:

Early detection of any significant changes in natural and fishing mortality, relative abundance, age structure, growth, and length-frequency distributions is imperative. Singly, any of the above variables may not reveal much. Taken collectively, these quantities will provide substantial evidence as to the well being of the stocks.

Recommendation:

Continue the collection of biological data which has been an integral part of the spawn-take operation. The standard for collections has been established with use of fyke nets set in the same locations year after year. Net-run sample lengths, weights, and scale samples should be routinely collected from 200 males and 100 females each year.

Statement:

Spring collections provide no clues as to the strength of oncoming year classes. Should regulations be adopted which lower the legal-size limit there may arise a rather sensitive issue which would require field studies to resolve. Except for fall test netting in 1976 and 1977 there exists little baseline data against which results of future test netting may be made.

Recommendation:

Given sufficient funding and personnel support, fall test nettings using small-mesh fyke nets should be conducted at least biannually, if not annually. Biological data should include records of catch by species and size.

Statement:

Statements made by early investigators suggest that overall productivity may be enhanced by reestablishment of forage species. Whether or not the statement has a basis in fact must be established for there exists at present no quantitative or qualitative estimates of the forage base.

Recommendation:

Fall test netting by small-mesh fyke nets should provide both quantitative and qualitative estimates of trends in the forage base.

Statement:

Tagging studies should not rely on voluntary reporting of recaptured fish.

Recommendation:

Continue to maintain the high level of rapport with members of the Lake Gogebic Improvement Association and Lake Gogebic Area Chamber of Commerce, seek their advice to cultivate a feeling of mutual interest in the resource to insure that future tagging operations and other management practices will receive their full support.

Statement:

A considerable body of knowledge has developed, largely in the private sector, on angling techniques for walleye.

Recommendation:

Careful thought should be given to developing a means of "passing on the word" to resort owners and interested anglers so that there will be a significant increase in angling success. One approach would be to develop a brochure outlining the best techniques for walleye angling. These brochures should be disseminated to resort owners and made available to anglers statewide.

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Table 1. Observed (O) and estimated (E) fishing pressure and catch for Lake Gogebic open-water fishing, 1940–77.

	Year								
	1940[1]		1941[1]		1947[2]		1976[3]		1977[4]
Species	O	E	O	E	O	E	O	E	E
Walleye	2,360	2,878	4,318	5,265	2,244	7,182	1,347	1,814	4,744
Northern pike	367	448	334	407	1,200	6,750	362	362	84
Yellow perch	70	85	97	118	668	3,469	2,059	2,565	5,419
Smallmouth bass	73	89	53	65	33	147	1,077	1,077	72
Largemouth bass	6	7	tr	tr	8	53	—	—	112
Rock bass	6	7	tr	tr	4	11	365	430	150
Black crappie	32	39	28	35	12	73	—	—	—
White sucker	tr	tr	—	—	4	—	—	—	—
Burbot	3	3	5	6	4	—	—	—	—
Sunfish	—	—	—	—	—	—	60	60	5
Total fish	2,917	3,557	4,835	5,896	4,179	17,717	5,270	6,308	10,586
Angling hours	8,051	9,818	16,923	20,638	8,663	23,000	15,679	20,810	31,062
Walleye per angler hour	0.29	0.29	0.26	0.26	0.26	0.31	0.09	0.09	0.15

[1] Observed data for 1940 and 1941, as cited by Eschmeyer (1950), were for May 15 to mid-October. Estimates of total catch were obtained by dividing by 0.82, based on Eschmeyer (1943) judgment that the censuses were 80–85% complete.

[2] Observed data for 1947, as cited by Eschmeyer (1950), were derived from both a voluntary and random census from May 15 to September 30. The random data were used to estimate total pressure and catch for this period (letter from J. C. Schneider to files, June 11, 1977).

[3] In 1976, a random census was conducted May 15 to August 31. These data were projected through October 1976 based on the monthly proportions observed in the 1977 census.

[4] In 1977, a random census was conducted from May 15 to October 30.

Table 2. Catch statistics for spring netting (1971–86) including total catches by sex, sex ratio, effort, and CPUE for males and spawned females.

	Total				Effort		CPUE	
Year	Males	Females	Females spawned	Sex ratio (M:F)	Total[1]	Spawn[2]	Males	Spawned females
1971	1,514	148	58	10:1	83	36	18.2	1.6
1972	1,395	737	340	2:1	36	36	38.7	9.4
1973	—	—	—	—	—	—	—	—
1974	15,104	466	260	32:1	175	95	86.3	2.7
1975	2,299	340	208	7:1	64	64	35.9	3.3
1976	4,273	259	162	16:1	109	58	39.2	2.8
1977	5,727	336	117	17:1	58	51	98.7	2.3
1978	9,362	447	349	21:1	76	76	123.2	4.6
1979	5,600	504	196	11:1	67	67	83.6	2.9
1980	7,953	260	138	31:1	109	34	73.0	4.1
1981	5,115	285	169	18:1	83	69	61.6	2.5
1982	7,083	572	282	12:1	36	36	196.8	7.8
1983	6,479	514	316	13:1	77	62	84.1	5.1
1984	7,130	283	162	25:1	83	75	85.9	2.2
1985	6,117	270	93	23:1	80	30	76.5	3.1
1986	11,047	283	—	39:1	87	—	127.0	3.3

[1] Total effort is the total net nights expended to catch total males and total females; it was used to compute CPUE for males.

[2] Spawn effort is the total net nights accumulated from time females first spawned to termination of spring netting; it was used to compute CPUE for spawned females.

Table 3. Lake Gogebic walleye growth patterns expressed as deviations (in inches) from the state average, 1929–86.

Year and sex	Age group									
	I	II	III	IV	V	VI	VII	VIII	IX	X
1929										
Both	—	-1.1	-2.3	-2.4	-3.3	-4.2	-4.8	—	—	—
1940										
Both	—	—	—	-0.7	-0.1	-1.1	—	—	—	—
1947										
Male	-3.2	-0.1	-1.1	-1.5	-2.4	-2.5	-3.4	-4.2	-4.7	-5.1
Female	-2.7	-0.8	-0.6	-1.0	-1.2	-1.1	-1.4	-1.2	-1.8	-2.1
1955										
Both	—	-0.6	-2.1	-2.1	—	—	—	—	—	—
1957										
Male	—	—	-1.1	—	-2.6	—	—	—	—	—
Female	—	—	-0.7	—	-0.7	-1.4	—	—	—	—
1976										
Male	—	+0.6	-0.9	-1.5	-1.9	-2.6	-2.9	-3.2	-2.7	-3.6
Female	—	—	—	—	—	—	—	-2.4	-0.3	-1.9
1977										
Male	—	-1.5	-1.8	-2.1	-2.3	-2.7	-3.3	-3.5	—	—
Female	—	—	—	—	—	-2.4	-3.2	-3.5	-2.9	-3.1
1981										
Male	—	—	-3.3	-3.5	-3.7	-3.4	-4.5	-4.2	-3.6	—
Female	—	—	—	—	—	—	—	—	—	—
1985										
Male	—	—	-2.5	-2.3	-2.9	—	—	—	—	—
Female	—	—	—	—	-1.5	-2.3	—	—	—	—
1986										
Male	—	—	-1.9	-2.8	-3.6	-3.7	-3.7	-3.6	—	—
Female	—	—	—	—	—	—	—	—	—	—

Table 4. Average length at age of Lake Gogebic walleyes during spawning, 1947–86.

Year and sex	Age group										
	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1947[1]											
Male	10.3	12.8	14.3	15.2	16.7	17.2	17.4	17.7	18.0	—	—
Female	9.6	13.3	14.8	16.4	18.1	19.2	20.4	20.6	21.0	—	—
1967											
Both	9.5	13.3	14.4	15.8	16.7	17.2	17.8	18.2	18.6	—	—
1976											
Male	10.9	11.0	13.0	14.3	15.7	16.6	17.7	18.4	18.8	19.5	—
Female	—	—	—	—	—	19.0	20.0	19.2	20.4	21.2	22.1
1977											
Male	8.9	12.1	13.7	15.3	16.5	17.3	18.1	18.7	—	—	—
Female	—	—	—	—	15.7	16.8	17.4	18.1	19.5	20.0	21.3
1985											
Male	9.0	11.4	12.9	14.0	15.9	17.6	18.2	20.0	—	—	—
Female	—	—	—	15.0	16.9	17.9	19.3	19.9	22.1	22.8	—
1986											
Male	—	12.0	13.0	14.0	15.5	16.9	17.8	—	—	—	—
Female	—	—	—	—	—	—	—	—	—	—	—
State average both sexes	10.4	13.9	15.8	17.6	19.2	20.6	21.6	22.4	—	—	—

[1]Values from Eschmeyer (1950)

Table 5. Age frequency (%) of spawning female and male walleyes in net catches 1947–86.

Age group	Female 1947[1]	Female 1976	Female 1977	Female 1985	Male 1947[1]	Male 1976	Male 1977	Male 1981	Male 1985	Male 1986
I	21.0	—	—	—	29.0	0.8	—	—	—	—
II	1.9	—	—	—	3.9	10.4	1.8	6.3	0.3	—
III	5.2	—	—	—	3.9	24.9	28.2	11.1	11.4	20.8
IV	20.2	—	—	—	16.3	18.3	19.5	17.5	25.9	20.3
V	18.7	—	2.0	4.4	25.4	9.5	28.2	27.8	24.3	29.4
VI	14.6	0.8	14.0	15.5	7.1	8.3	14.1	20.6	24.5	20.8
VII	6.0	0.8	20.0	46.7	5.1	8.7	4.5	11.9	8.7	4.1
VIII	5.6	3.4	22.0	13.3	5.5	7.9	2.3	4.8	4.5	3.5
IX	4.5	5.1	16.0	8.9	2.4	4.1	1.4	—	0.4	1.0
X	2.2	26.3	12.0	4.4	1.2	4.1	—	—	—	—
XI	—	35.6	2.0	6.7	—	2.5	—	—	—	—
XII	—	14.4	6.0	—	—	—	—	—	—	—
XIII	—	8.4	4.0	—	—	—	—	—	—	—
XIV	—	2.5	1.0	—	—	—	—	—	—	—
XV	—	0.8	—	—	—	—	—	—	—	—
XVI	—	1.7	—	—	—	—	—	—	—	—

[1]Data not restricted to spawning season collections.

Table 6. Size frequency (%) of spawning male walleyes in net catches, 1947–86.

	Inch group[1]							
Year	<13	13	14	15	16	17	18	>18
1947[2]	0.1	1.6	8.9	19.5	17.8	24.1	20.0	8.0
1976	24.4	12.4	12.8	11.6	7.4	9.9	11.1	10.3
1977	1.25	1.4	14.6	20.4	25.7	22.6	9.6	4.6
1981	19.8	5.5	15.1	20.6	18.3	11.1	6.3	3.2
1985	25.6	17.6	21.3	11.6	9.6	9.1	4.2	1.1
1986	32.6	23.7	15.8	13.2	6.8	5.3	2.6	—

[1]For example, the 13-inch group includes fish 13.0 to 13.9 inches long.

[2]Data not restricted to spawning season collections.

Table 7. Size frequency (%) of spawning female walleyes in net catches, 1947–85..

	Inch group									
Year	<16	16	17	18	19	20	21	22	23	>23
1947[1]	1.4	11.2	20.1	26.2	17.5	11.5	7.9	2.6	0.7	0.7
1976	—	—	—	0.8	5.1	22.9	18.6	18.6	16.9	16.9
1977	1.4	13.0	20.3	17.4	13.0	5.8	4.3	11.6	7.2	5.8
1985	2.3	10.0	22.3	23.5	14.2	8.1	3.5	3.5	3.8	8.8

[1]Data not restricted to spawning season collections.

Table 8. Estimates of population size, exploitation rates, and annual mortality rates for Lake Gogebic walleyes, 1947–84.

Year	Population estimate (numbers)	Exploitation rates[1] (percent)	Natural mortality (percent)	Total mortality (percent)
1947	—	4.0	20.0	24.0
1976	56,000	5.7	22.0	26.7
1977	38,000	7.2	19.5	26.7
1984	63,000[2]	20.0	18.2	38.2

[1]Minimum estimates based on tag returns by anglers. A reward was offered in 1984.

[2]Estimated numbers of male walleyes greater than 13 inches.

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