# Walleye growth in relation to water temperature, food availability and population density in Escanaba Lake, 1956-82. Report 130 [1984]

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Madison, Wisconsin: Dept. of Natural Resources, [1984]

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DEPARTMENT OF NATURAL RESOURCES
RESEARCH
REPORT 130
December 1984

# WALLEYE GROWTH IN RELATION TO WATER TEMPERATURE, FOOD AVAILABILITY, AND POPULATION DENSITY IN ESCANABA LAKE, 1956-82

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ABSTRACT

From 1956-82, nearly 19,000 walleyes captured in fyke nets during the spring spawning period were aged by the scale method. Annual growth increments were compared with various biological and abiological parameters to determine the impact of these factors on the growth of adult walleyes in Escanaba Lake. Walleye growth appeared to be positively correlated to both food supply and water temperature during the open water period and negatively correlated with adult walleye density. There was a positive relationship between annual growth increment and rate of angler exploitation of adult walleyes in the previous year, indicating that intraspecific competition was a factor influencing growth.

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Department of Natural Resources • Madison, Wisconsin

## INTRODUCTION

Mean length-at-age data for walleyes have been collected from at least 141 Wisconsin lakes since 1966 (Klingbiel and Anathanarayanan 1984). While these data are important in defining ranges in length of walleyes at various ages and in indicating possible growth differences between regions of the state, they do not explain the factors affecting walleye growth.

In this study, mean length-at-age data was summarized for 18,897 walleyes captured during the spring spawning period in Escanaba Lake, Vilas County from 1956-82. Mean annual growth increments for adult walleyes over this period were compared with water temperatures, adult walleye densities, and angler exploitation rates in order to assess the impact of these factors on walleye growth. This information should be of interest to fish managers and may aid them in explaining disparities in walleye growth among the water bodies within their jurisdiction.

## STUDY AREA AND METHODS

Escanaba Lake, located in the Northern Highland State Forest, is in Vilas County (Fig. 1). The shoreline is forested and uninhabited, and the lake has a surface area of 293 acres and a maximum depth of 26 ft. The water is soft, with a total alkalinity of 16 ppm. Since 1946, the walleye sport fishery of Escanaba Lake has been unregulated by size, bag, or season restrictions.

Walleyes were captured in 1- or 3/4-inch-square mesh fyke nets during the spring spawning periods of 1956-69, 1972, 1974, 1977, and 1979-82. Each fish was measured (total length to the nearest 0.1 inch), and a sample of scales was collected from the left side below the lateral line and at the tip of the pectoral fin when depressed against the side of the fish.

The walleyes were later aged by examining their scales with either an Eberbach Scale Reader, Bausch and Lomb Tri-Simplex Microprojector, or a Realist Microfiche Reader. Prior to 1980, all scale samples were pressed on an acetate slide and the scale image was projected to determine age. From 1980-82, only the scales from fish 15.0 inches and longer were pressed, because light penetration through scales from smaller fish was adequate for accurate age determination from the scales directly.

From fall 1958 through fall 1982, population estimates of fingerling walleyes were determined by mark-recapture techniques. Usually several hundred fingerlings were marked each fall with permanent fin clips. The type of clip changed from year to year, so that when marked adult fish were captured in fyke nets or by angling, their known age from a distinctive fin clip could be compared with the age determined from scale analysis. This continuous supply of known-aged fish improved the accuracy of our age determinations from scale reading.

Mean lengths at the various ages were determined for all fish captured and for males and females separately (fish were externally sexed by extrusion of gametes). Mean annual growth increments in these three categories were determined by subtracting the mean length of fish age x in a given year from

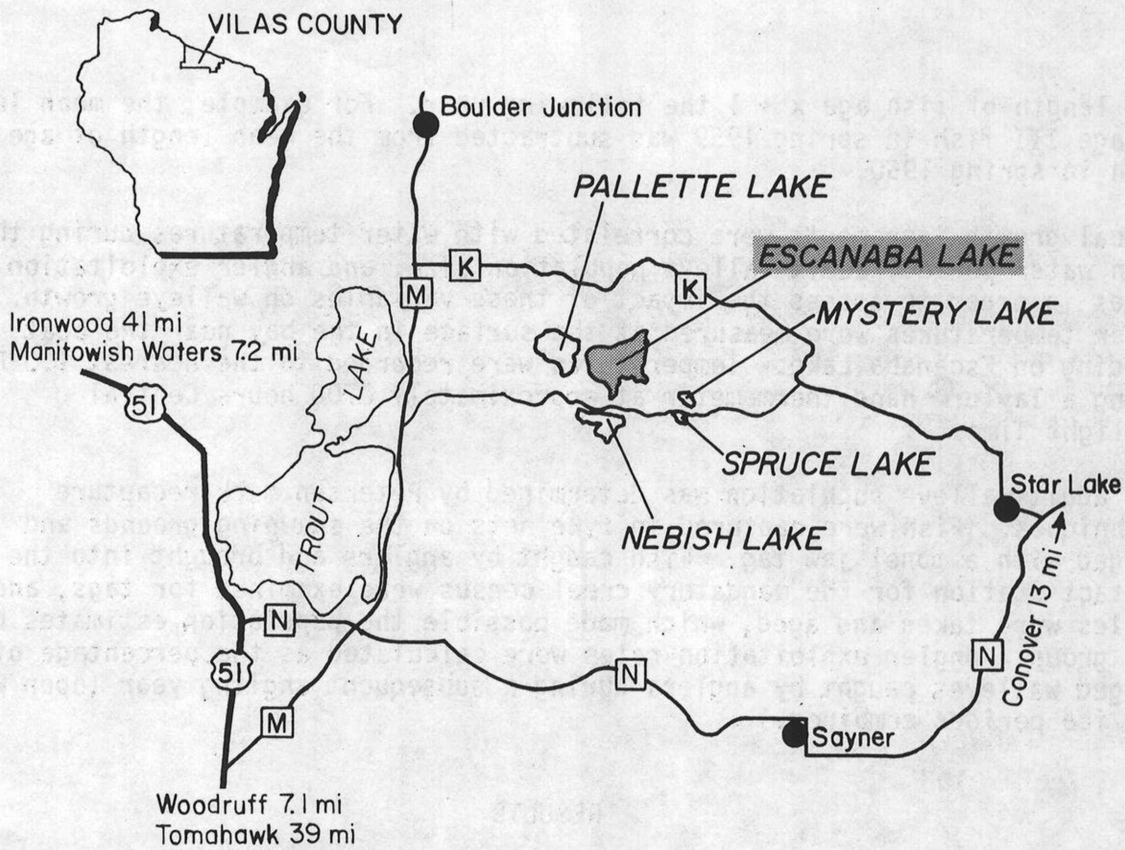
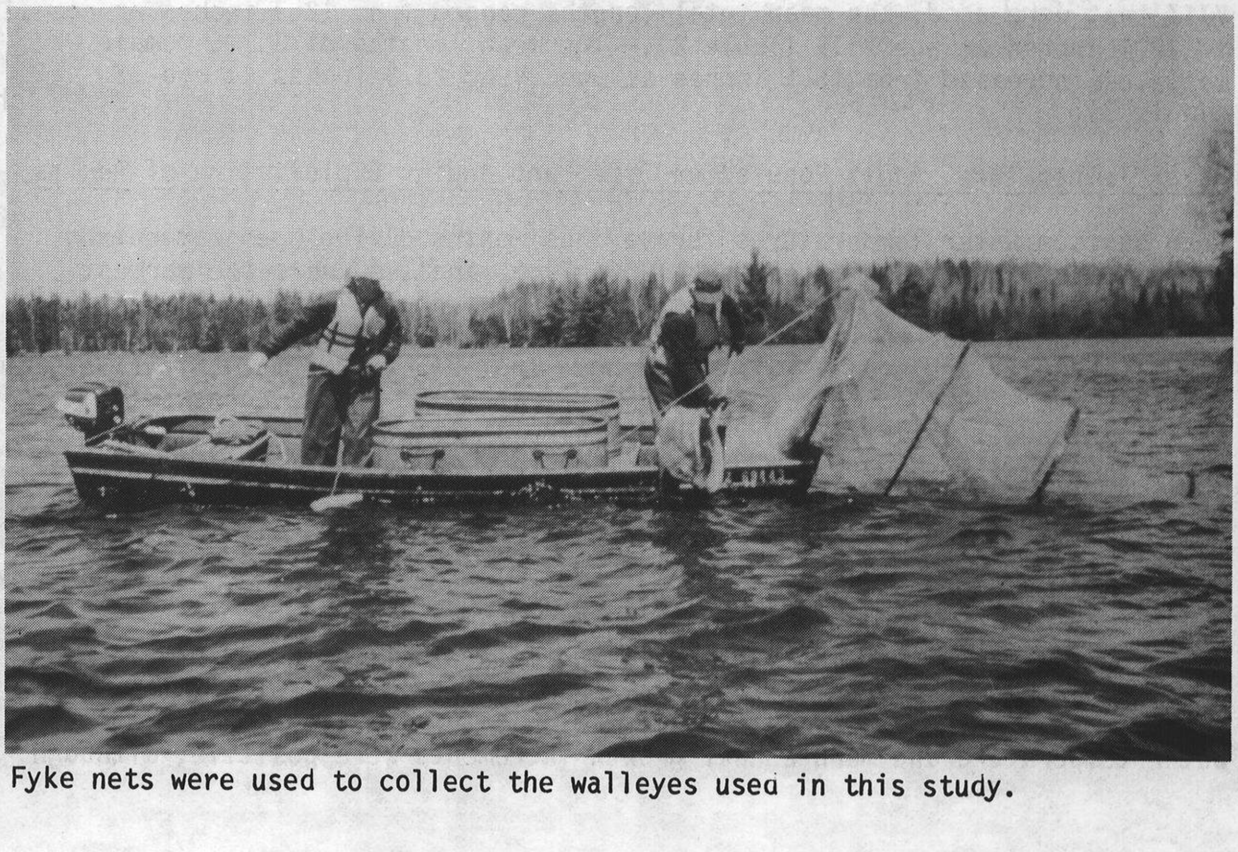



FIGURE 1. Escanaba Lake and the four other lakes in the Northern Highland Fishery Research Area.



Fyke nets were used to collect the walleyes used in this study.

the length of fish age x + 1 the following year. For example, the mean length of age III fish in spring 1959 was subtracted from the mean length of age IV fish in spring 1960.

Annual growth increments were correlated with water temperatures during the open water period, adult walleye population size, and angler exploitation rates in order to assess the impact of these variables on walleye growth. Water temperatures were measured at the surface in the bay near the boat landing on Escanaba Lake. Temperatures were recorded to the nearest 1.0°F using a Taylor® hand thermometer at approximately 0700 hours Central Daylight Time.

The adult walleye population was determined by Petersen mark-recapture techniques. Fish were captured in fyke nets on the spawning grounds and tagged with a monel jaw tag. Fish caught by anglers and brought into the contact station for the mandatory creel census were examined for tags, and scales were taken and aged, which made possible the population estimates by age group. Angler exploitation rates were calculated as the percentage of tagged walleyes caught by anglers during a subsequent angling year (open water and ice periods combined.)

## RESULTS

### Mean Length-at-Age Data

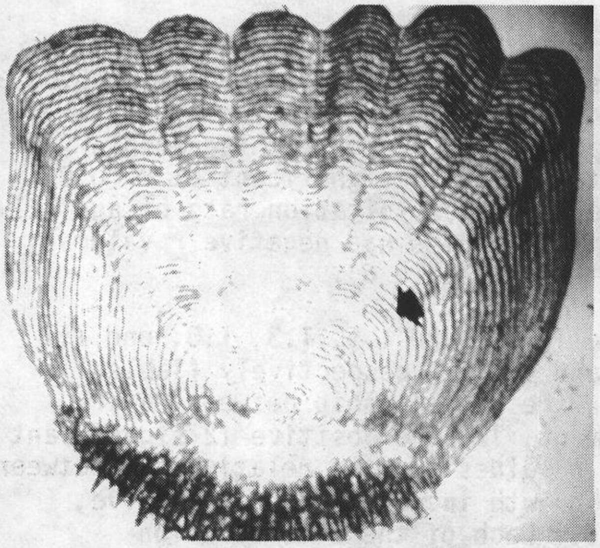
During spring fyke netting operations from 1956-82, 18,897 captured walleyes were aged. Mean total lengths increased from 10.3 inches at age II to 24.7 inches at age XI (Table 1). For the 11,234 male walleyes between ages III and VIII that were aged, the mean total lengths ranged from 12.3 inches at age III to 18.1 inches at age VIII (Table 2). The mean lengths of 3,305 female walleyes increased from 15.1 inches at age IV to 23.3 inches at age IX (Table 3).

### Water Temperature, Adult Population Size, and Angler Exploitation of Adults

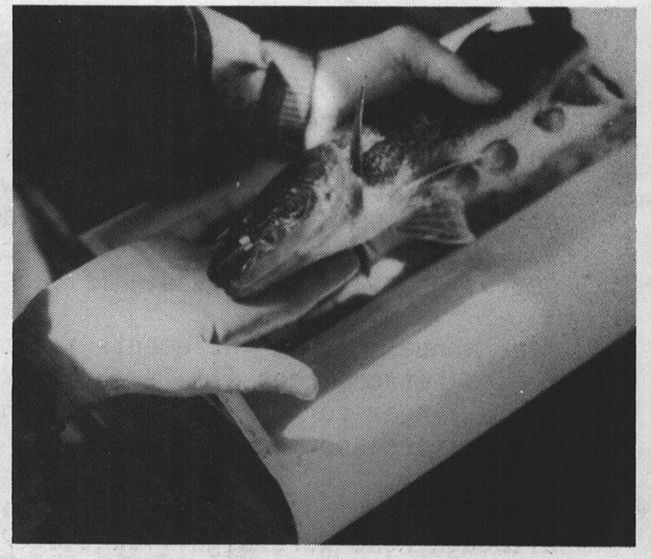
Mean surface water temperatures for various months during open water from 1958-68 and 1979-81 indicated that 1959, 1963, and 1980 were the warmest years, while the coolest years were 1960, 1965, and 1967 (Table 4). The estimated number of walleyes age III+ ranged from 1,495 (1964) to 7,667 (1980). Age IV and age V+ walleyes ranged from 945 (1965) to 4,870 (1959) and 725 (1966) to 2,990 (1960), respectively (Table 4). Figure 2 shows the density of adult walleyes from 1953-83. The angler exploitation rates of walleyes age III+ ranged from 0.13 in 1959 to 0.42 in 1967 (Kempinger et al. 1975; Serns, Northern Highland Fishery Research Area files, unpubl. data). (See Table 4.)

### Mean Annual Growth Increments

Mean annual growth increments for male and female walleyes combined ranged from 1.6 inches for ages III-IV to 2.0 inches for ages VI-VII (Table 5). Thirteen of 18 linear correlation coefficients for the relationship between water temperature and mean annual growth increments were positive, although



Shown here is a scale from a 2-year old walleye. The arrow indicates the first annulus (year mark) and the second annulus is just forming on the outside edge of the scale.



Monel metal jaw tag is shown on this Escanaba Lake walleye.

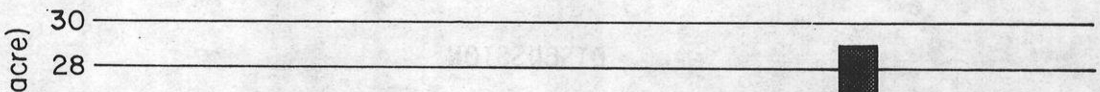



FIGURE 2. Adult walleye density in Escanaba Lake, 1953-83.

none (either positive or negative) were significant relationships at $P<0.05$ (Table 6). Seven of 9 correlation coefficients for the relationship between the estimated size of the adult walleye population and growth increments for adults were negative; again, none were statistically significant at $P<0.05$. All of 3 linear relationships between the angler exploitation rate of age III+ walleyes and mean annual growth increments of adults had negative $r$ values, one being statistically significant at $P<0.05$ (Table 6).

Mean annual growth increments for male walleyes were 1.5, 1.3, 1.0, and 1.1 inches between ages III-IV, IV-V, V-VI, and VI-VII, respectively (Table 7). Of 18 linear correlation coefficients for the relationship between water temperature and mean annual growth increment, 17 were positive (2 significant at $P<0.05$; 1 at $P<0.01$). All (9 of 9) $r$ values for the relationship between adult walleye population size and annual growth increments were negative, although none were significant at $P<0.05$. Each of the 3 correlation coefficients for the relationship between rates of angler exploitation and annual growth increments were negative, but none were significant at $P<0.05$ (Table 8).

Mean annual growth increments for female walleyes for ages IV-V, V-VI, VI-VII, and VII-VIII were 1.6, 1.5, 2.1, and 1.8 inches, respectively (Table 9). Six of the 18 correlation coefficients for the relationship between annual female growth increments and water temperature were negative (none significant at $P<0.05$), while only 1 of 9 $r$ values for the comparison of growth increments to numbers of adult walleyes was negative (1 positive $r$ value was significant at the 0.05 level). All (3 of 3) of the correlation coefficients for the relationship of angler exploitation rates to annual growth increments were negative (Table 10).

## DISCUSSION

According to Colby et al. (1979), the growth rate of adult walleyes seems to be affected by two factors--temperature and amount of food consumed. They indicated the amount of food consumed was a function of both forage abundance and walleye population density. In the present study, data were available on water temperatures during the open water period and population estimates of adult walleye in spring; however, accurate estimates of forage abundance were lacking.

When data on the relationship between water temperature and mean growth increments for the three walleye groups--sexes combined, males, and females--were compared, positive correlation coefficients ($r$) were found in 42 of 54 (78%) of the comparisons (2 were significant at $P<0.05$, 1 at $P<0.01$). This indicates that temperature may be positively influencing adult walleye growth in Escanaba Lake. Other authors have reported that adult walleye growth is usually positively related to water temperature (Stroud 1949; Colby et al. 1979); however, others found that if temperatures are too high during the summer, growth may be inhibited (Eschmeyer and Jones 1941). In Escanaba Lake, 7 of 9 comparisons of mean annual growth increment and mean water temperatures during June-August were negative, indicating high temperatures in mid-summer may deter growth.

There appeared to be an inverse relationship between adult walleye population density and adult walleye growth in Escanaba Lake. Seventeen of 27 (63%) of the coefficients of correlation (r) between mean annual growth increments and estimates of adult population size were negative (however, none were significant at $P < 0.05$). If the comparisons of female walleye growth increments were excluded (many comparisons had small sample sizes), 89% (17 of 19) of the correlation coefficients were negative. An inverse relationship between walleye population density and growth has been documented by other authors (Carlander 1948; Carlander and Whitney 1961).

Although accurate forage abundance data were lacking in the present study, data from Escanaba Lake (Kempinger et al. 1975) and Oneida Lake, New York (Forney 1967), indicated an inverse relationship between forage abundance and the angler exploitation rate of walleyes. Because data were available on the angler exploitation rate of age III+ walleyes, this parameter was considered an index of food availability and used to compare with mean growth increments.

All 9 of the linear correlation coefficients between mean growth increments and annual exploitation rates were negative (1 comparison was significant at $P < 0.05$), indicating that walleye growth was positively influenced by available food supply. (This assumes that food supply and exploitation rate are inversely related as indicated by the other studies cited above). Stroud (1949) reported that a reduction in the growth of walleyes in Norris Reservoir, Tennessee, after 9 years of impoundment was probably due to a decreased food supply accompanied by an increased population density.

In his work on walleyes in Oneida Lake, New York, Forney (1979) also found that a high angler exploitation rate in one year would be expected to increase the food supply of the remaining walleyes, resulting in good growth the following year. To test this theory on the Escanaba Lake data set, walleye growth increments (sexes combined) between ages III and IV in one year were correlated with the adult walleye exploitation rate in the previous year. The simple linear correlation coefficient (r) for this relationship was 0.641, which was significant at $P < 0.05$ (10 df), indicating that walleye growth was positively influenced by the angler exploitation rate of adults in the previous year.

## SUMMARY

From 1956-82, 18,897 walleyes captured in fyke nets during the spring spawning period were aged by the scale method. Annual growth increments were determined and correlated with food supply, water temperature, and population density.

There appeared to be a positive relationship between walleye growth and mean water temperatures during the periods of May, May-June, May-August, May-September, and May-October; however, temperatures during June-August seemed to be negatively related to walleye growth.

Growth of adult walleyes appeared to be negatively related to adult population density and positively related to food supply. Growth was positively influenced by the rate of angler exploitation in the previous year.

TABLE Ia. Mean length-at-age data for all* walleyes captured during spring fyke netting operations, 1956-82.**

| Year | II | III | IV | V | VI | VII | VIII | IX | X | XI |
|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | 10.4 (75) | 12.8 (269) | 13.6 (229) | 15.1 (518) | 16.4 (97) | 17.9 (128) | 19.6 (31) | 22.1 (17) | -- -- | 28.0 (2) |
| 1957 | 9.8 (81) | 11.7 (392) | 13.8 (149) | 14.3 (100) | 15.9 (227) | 21.0 (109) | 18.6 (43) | 17.9 (4) | 21.6 (4) | -- -- |
| 1958 | -- -- | 11.4 (531) | 12.9 (493) | 14.5 (49) | 14.5 (42) | 18.0 (67) | 18.5 (16) | 23.1 (23) | -- -- | -- -- |
| 1959 | 10.7 (3) | 12.4 (17) | 13.3 (629) | 14.7 (337) | 15.6 (35) | 18.4 (36) | 19.7 (45) | 19.0 (3) | 21.2 (3) | -- -- |
| 1960 | 11.5 (15) | 13.2 (5) | 14.0 (6) | 15.4 (522) | 16.7 (440) | 19.9 (38) | 22.9 (30) | 18.7 (11) | 25.4 (10) | -- -- |
| 1961 | 9.5 (8) | 12.9 (74) | 13.3 (17) | 16.3 (16) | 16.8 (339) | 18.2 (390) | 21.0 (25) | 23.2 (12) | 22.3 (10) | -- -- |
| 1962 | -- -- | 11.4 (275) | 14.6 (54) | 14.2 (5) | 15.8 (17) | 19.0 (213) | 20.3 (336) | -- -- | -- -- | -- -- |
| 1963 | -- -- | 10.8 (1) | 13.3 (299) | 15.6 (16) | 16.0 (11) | 17.9 (14) | 20.9 (81) | 21.8 (179) | 18.5 (6) | -- -- |
| 1964 | 10.4 (36) | 12.3 (36) | 13.3 (2) | 16.1 (132) | 17.3 (17) | 18.5 (9) | 21.8 (23) | 23.5 (107) | 22.2 (99) | -- -- |
| 1965 | 10.7 (40) | 13.3 (274) | 12.9 (93) | -- -- | 18.6 (180) | 19.3 (5) | 23.8 (65) | 26.7 (17) | 22.6 (94) | 25.8 (14) |
| 1966 | 10.0 (17) | 12.7 (147) | 15.1 (178) | 16.4 (17) | -- -- | 20.3 (76) | 22.5 (68) | 23.3 (30) | -- -- | -- -- |
| 1967 | -- -- | 12.5 (557) | 14.0 (138) | 16.9 (96) | 18.3 (45) | 21.2 (19) | 23.0 (40) | 22.8 (55) | 26.3 (10) | -- -- |
| 1968 | 10.5 (3) | 11.7 (59) | 14.1 (195) | 15.6 (53) | 18.0 (49) | 20.3 (18) | 21.4 (22) | 23.7 (7) | 22.4 (24) | 24.9 (5) |
| 1969 | -- -- | 11.4 (179) | 14.0 (158) | 15.6 (353) | 16.9 (85) | 18.5 (54) | 19.4 (20) | 21.1 (11) | 23.2 (12) | 22.4 (15) |
| 1972 | -- -- | 11.9 (27) | 13.4 (216) | 15.6 (201) | 18.2 (60) | 18.4 (18) | 19.3 (31) | 20.5 (13) | 21.1 (13) | 21.9 (13) |
| 1974 | 11.1 (13) | 13.4 (127) | 15.2 (235) | 16.2 (314) | 17.7 (134) | 18.9 (84) | 20.0 (71) | 21.2 (24) | 22.3 (21) | 24.1 (26) |
| 1977 | 10.5 (2) | 11.8 (296) | 14.3 (311) | 16.9 (66) | 18.5 (138) | 19.9 (85) | 21.3 (31) | 25.4 (11) | 26.2 (5) | -- -- |
| 1979 | 9.9 (5) | 11.9 (165) | 13.9 (248) | 15.3 (292) | 16.9 (210) | 18.9 (83) | 20.1 (67) | 21.5 (46) | 22.4 (36) | 23.3 (27) |
| 1980 | 9.8 (22) | 11.8 (372) | 13.5 (168) | 14.9 (159) | 16.3 (201) | 18.1 (126) | 20.1 (53) | 22.3 (53) | 23.8 (31) | 25.1 (13) |
| 1981 | 9.4 (14) | 12.3 (122) | 13.7 (434) | 15.3 (143) | 16.3 (86) | 17.2 (75) | 19.3 (45) | 21.3 (23) | 22.9 (12) | 26.0 (8) |
| 1982 | 10.6 (17) | 12.2 (153) | 14.5 (69) | 16.4 (259) | 16.9 (43) | 17.3 (33) | 18.5 (36) | 21.2 (10) | 22.0 (11) | 25.8 (4) |

*Males, females, and those whose sex could not be determined by extrusion of gametes.
**Units in inches, no. in each age group in parentheses.



SOURCE: SERNS, S.L., "WALLEYE GROWTH IN RELATION TO WATER TEMPERATURE, FOOD AVAILABILITY, AND POPULATION DENSITY IN ESCANABA LAKE, 1956-1982", WDNR RES.RPT.130 (1984)

TABLE Ib. Summary statistics for mean length-at-age data (sexes combined) presented in Table Ia.*

| Age | Number Aged | Unweighted Mean Length | Standard Deviation | Range of Annual Means |
|---|---|---|---|---|
| II | 351 | 10.3 | 0.6 | 9.4 - 11.5 |
| III | 4,078 | 12.2 | 0.7 | 10.8 - 13.4 |
| IV | 4,321 | 13.8 | 0.6 | 12.9 - 15.2 |
| V | 3,648 | 15.6 | 0.8 | 14.2 - 16.9 |
| VI | 2,456 | 16.9 | 1.1 | 14.5 - 18.6 |
| VII | 1,680 | 18.9 | 1.1 | 17.2 - 21.2 |
| VIII | 1,179 | 20.6 | 1.6 | 18.5 - 23.8 |
| IX | 656 | 22.0 | 2.1 | 17.9 - 26.7 |
| X | 401 | 22.7 | 1.9 | 18.5 - 26.2 |
| XI | 127 | 24.7 | 1.8 | 21.9 - 28.0 |
| Total | 18,897 | | | |

*Length in inches.

SOURCE: SERNS, S.L., "WALLEYE GROWTH IN RELATION TO WATER TEMPERATURE, FOOD AVAILABILITY, AND POPULATION DENSITY IN ESCANABA LAKE, 1956-1982", WDNR RES.RPT.130 (1984)

TABLE 2a. Mean length-at-age data for male walleyes captured during spring fyke netting operations, 1956-82.*

| Year | III | | IV | | V | | VI | | VII | | VIII | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | 12.8 | (241) | 13.6 | (214) | 14.8 | (449) | 15.9 | (75) | 16.9 | (90) | 17.5 | (18) |
| 1957 | 11.6 | (223) | 13.2 | (107) | 13.6 | (86) | 15.0 | (185) | 17.3 | (39) | 17.0 | (22) |
| 1958 | 11.3 | (552) | 12.9 | (482) | 14.2 | (44) | 14.5 | (35) | 15.9 | (45) | 16.6 | (10) |
| 1959 | 12.4 | (13) | 13.1 | (526) | 14.4 | (258) | 15.3 | (29) | 16.6 | (25) | 16.6 | (24) |
| 1960 | 13.7 | (5) | 13.8 | (4) | 14.5 | (274) | 15.7 | (190) | 17.5 | (15) | 16.2 | (6) |
| 1961 | 12.8 | (45) | 13.1 | (13) | 14.9 | (8) | 15.4 | (169) | 16.5 | (159) | 19.9 | (13) |
| 1962 | 11.4 | (207) | 14.1 | (24) | 14.2 | (5) | 15.3 | (10) | 16.7 | (77) | 17.2 | (91) |
| 1963 | -- | -- | 13.2 | (273) | 15.1 | (10) | 15.5 | (5) | 16.4 | (9) | 18.4 | (25) |
| 1964 | 12.4 | (3) | 13.3 | (2) | 15.0 | (62) | 15.8 | (8) | 17.0 | (2) | 17.8 | (2) |
| 1965 | 13.3 | (167) | 14.8 | (80) | -- | -- | 17.0 | (55) | -- | -- | 20.2 | (6) |
| 1966 | 12.7 | (117) | 14.8 | (113) | 15.9 | (10) | -- | -- | 17.7 | (16) | 19.2 | (18) |
| 1967 | 12.5 | (392) | 13.6 | (69) | 16.4 | (30) | 17.1 | (14) | 18.1 | (4) | 19.5 | (7) |
| 1968 | 12.6 | (49) | 13.7 | (151) | 15.1 | (32) | 16.5 | (15) | 17.3 | (4) | 18.8 | (3) |
| 1969 | 12.1 | (168) | 14.0 | (145) | 14.9 | (195) | 16.0 | (29) | 17.7 | (21) | 18.2 | (7) |
| 1972 | 11.9 | (25) | 13.1 | (181) | 15.2 | (115) | 17.1 | (20) | -- | -- | 18.8 | (4) |
| 1974 | 13.4 | (118) | 14.7 | (148) | 15.9 | (232) | 17.2 | (59) | 18.3 | (21) | 19.5 | (6) |
| 1977 | 11.8 | (285) | 14.0 | (226) | 15.7 | (26) | 17.1 | (72) | 17.9 | (36) | 17.8 | (9) |
| 1979 | 11.9 | (148) | 13.6 | (175) | 14.7 | (145) | 15.9 | (82) | 16.9 | (23) | 18.0 | (23) |
| 1980 | 11.8 | (287) | 13.2 | (128) | 14.4 | (102) | 15.6 | (119) | 16.7 | (59) | 18.1 | (26) |
| 1981 | 12.4 | (93) | 13.5 | (330) | 14.6 | (67) | 15.6 | (44) | 16.3 | (46) | 17.7 | (22) |
| 1982 | 12.1 | (124) | 13.7 | (37) | 14.9 | (78) | 15.9 | (21) | 16.6 | (21) | 17.8 | (26) |

*Units in inches, no. in each age group in parentheses.

TABLE 2b. Summary statistics for mean length-at-age data (males) presented in Table 2a.*

| Age | Number Aged | Unweighted Mean Length | Standard Deviation | Range of Annual Means |
|---|---|---|---|---|
| III | 3,262 | 12.3 | 0.7 | 11.3 - 13.7 |
| IV | 3,428 | 13.7 | 0.6 | 12.9 - 14.8 |
| V | 2,228 | 14.9 | 0.7 | 13.6 - 16.4 |
| VI | 1,236 | 16.0 | 0.8 | 14.5 - 17.2 |
| VII | 712 | 17.1 | 0.7 | 15.9 - 18.3 |
| VIII | 368 | 18.1 | 1.1 | 16.2 - 20.2 |
| Total | 11,234 | | | |

*Length in inches.

SOURCE: SERNS, S.L., "WALLEYE GROWTH IN RELATION TO WATER TEMPERATURE, FOOD AVAILABILITY, AND POPULATION DENSITY IN ESCANABA LAKE, 1956-1982", WDNR RES.RPT.130 (1984)

TABLE 3a. Mean length-at-age data for female walleyes captured during spring fyke netting operations, 1956-82.*

| Year | IV | | V | | VI | | VII | | VIII | | IX | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | -- | -- | 17.2 | (39) | 17.9 | (17) | 19.7 | (23) | 22.1 | (10) | -- | -- |
| 1957 | 13.3 | (1) | 16.8 | (5) | 19.5 | (26) | 23.2 | (65) | 20.8 | (7) | -- | -- |
| 1958 | -- | -- | -- | -- | -- | -- | 22.8 | (16) | 21.4 | (5) | 22.7 | (22) |
| 1959 | 14.3 | (55) | 15.5 | (40) | 16.7 | (4) | 21.9 | (3) | 23.3 | (21) | 23.1 | (1) |
| 1960 | 14.5 | (2) | 16.4 | (181) | 17.4 | (6) | 22.1 | (7) | 24.8 | (8) | 23.8 | (9) |
| 1961 | 13.9 | (2) | 18.2 | (5) | -- | -- | 19.2 | (185) | 21.2 | (12) | 23.9 | (2) |
| 1962 | -- | -- | -- | -- | 20.1 | (1) | 20.7 | (64) | 21.5 | (161) | 24.2 | (3) |
| 1963 | 15.5 | (2) | -- | -- | -- | -- | 21.4 | (4) | 21.9 | (8) | -- | -- |
| 1964 | -- | -- | 17.1 | (22) | -- | -- | 18.7 | (5) | 20.2 | (12) | 24.8 | (77) |
| 1965 | 16.2 | (4) | -- | -- | 19.2 | (25) | -- | -- | -- | -- | -- | -- |
| 1966 | 16.4 | (20) | 17.9 | (4) | -- | -- | 21.0 | (30) | 24.1 | (48) | -- | -- |
| 1967 | 16.0 | (18) | 17.5 | (38) | 19.6 | (17) | 22.1 | (6) | 23.2 | (18) | 24.8 | (18) |
| 1968 | 15.5 | (16) | 16.6 | (16) | 19.1 | (20) | 21.7 | (9) | 23.6 | (8) | 25.0 | (1) |
| 1969 | 15.1 | (4) | 16.7 | (104) | 17.3 | (35) | 19.1 | (23) | 19.8 | (10) | 21.9 | (7) |
| 1972 | 14.9 | (25) | 16.3 | (53) | 17.7 | (27) | 18.5 | (13) | 19.5 | (21) | 20.6 | (10) |
| 1974 | 16.0 | (57) | 16.9 | (52) | 18.0 | (56) | 19.0 | (56) | 20.2 | (54) | 21.4 | (14) |
| 1977 | 15.1 | (34) | 17.5 | (23) | 20.3 | (44) | 21.2 | (34) | 22.7 | (17) | 25.2 | (9) |
| 1979 | 14.4 | (53) | 16.0 | (134) | 17.5 | (107) | 19.7 | (49) | 21.3 | (39) | 22.4 | (30) |
| 1980 | 15.1 | (24) | 15.8 | (53) | 17.3 | (76) | 19.2 | (60) | 22.1 | (23) | 23.2 | (39) |
| 1981 | 15.0 | (26) | 16.0 | (62) | 17.2 | (38) | 18.7 | (28) | 20.9 | (23) | 23.8 | (12) |
| 1982 | 15.5 | (3) | 17.2 | (147) | 18.1 | (17) | 18.7 | (10) | 20.4 | (10) | 22.3 | (6) |

*Units in inches, no. in each age group in parentheses.

TABLE 3b. Summary statistics for mean length-at-age data (females) presented in Table 3a.*

| Age | Number Aged | Unweighted Mean Length | Standard Deviation | Range of Annual Means |
|---|---|---|---|---|
| IV | 346 | 15.1 | 0.8 | 13.3 - 16.4 |
| V | 978 | 16.8 | 0.8 | 15.5 - 18.2 |
| VI | 516 | 18.3 | 1.1 | 16.7 - 20.3 |
| VII | 690 | 20.4 | 1.5 | 18.5 - 23.2 |
| VIII | 515 | 21.8 | 1.5 | 19.5 - 24.8 |
| IX | 260 | 23.3 | 1.4 | 20.6 - 25.2 |
| Total | 3,305 | | | |

*Length in inches.

SOURCE: SERNS, S.L., "WALLEYE GROWTH IN RELATION TO WATER TEMPERATURE, FOOD AVAILABILITY, AND POPULATION DENSITY IN ESCANABA LAKE, 1956-1982", WDNR RES.RPT.130 (1984)

TABLE 4. Mean surface water temperatures during the open water period, estimated number of adult walleyes, and angler exploitation rate of walleyes, 1958-81.

| Year | Mean Water Temperatures (°F) May | May-Jun | Jun-Aug | May-Aug | May-Sep | May-Oct | Estimated No. of Adult Walleyes in Population ≥Age III | ≥Age IV | ≥Age V | Angler Exploitation Rate of Walleyes ≥Age III |
|---|---|---|---|---|---|---|---|---|---|---|
| 1958 | 55.0 | 59.0 | 67.7 | 64.5 | 63.6 | 61.0 | 5,695 | 2,995 | 775 | 0.22 |
| 1959 | 57.9 | 64.2 | 70.5 | 67.3 | 66.1 | 62.6 | 4,930 | 4,870 | 2,310 | 0.13 |
| 1960 | 51.4 | 57.7 | 68.1 | 63.9 | 63.4 | 60.8 | 3,235 | 3,035 | 2,990 | 0.31 |
| 1961 | 51.4 | 59.2 | 69.5 | 65.0 | 64.3 | 61.5 | 3,410 | 2,800 | 2,700 | 0.22 |
| 1962 | 57.9 | 62.4 | 68.5 | 65.9 | 64.3 | 61.8 | 4,700 | 1,510 | 1,130 | 0.37 |
| 1963 | 52.5 | 60.3 | 70.0 | 65.6 | 64.2 | 62.6 | 1,660 | 1,660 | 790 | 0.31 |
| 1964 | 58.1 | 62.3 | 68.4 | 65.8 | 64.2 | 60.7 | 1,495 | 1,195 | 1,195 | 0.18 |
| 1965 | 54.5 | 59.7 | 67.7 | 64.4 | 62.5 | 59.7 | 2,705 | 945 | 795 | 0.19 |
| 1966 | 50.0 | 58.2 | 69.2 | 64.4 | 63.9 | 60.8 | 3,035 | 1,715 | 725 | 0.27 |
| 1967 | 48.9 | 55.5 | 68.6 | 63.7 | 63.2 | 60.5 | 6,155 | 1,795 | 1,010 | 0.42 |
| 1968 | 53.8 | 59.6 | 68.3 | 64.7 | 64.1 | 62.0 | 4,080 | 2,580 | 820 | 0.17 |
| 1979 | 50.0 | 57.5 | 69.2 | 64.4 | 63.7 | 60.9 | 4,858 | 3,012 | 1,847 | 0.34 |
| 1980 | 59.9 | 63.3 | 69.9 | 67.4 | 65.8 | 62.5 | 7,667 | 2,602 | 1,600 | 0.36 |
| 1981 | 56.5 | 61.4 | 64.6 | 66.5 | 65.2 | 61.8 | 4,067 | 3,424 | 1,330 | 0.18 |

TABLE 5. Mean annual growth increments for male and female walleyes, 1958-81.

| Growing Season | Mean Annual Growth Increment (inches) Age III-IV | Age IV-V | Age V-VI | Age VI-VII |
|---|---|---|---|---|
| 1958 | 1.9 | 1.8 | 1.1 | 3.9 |
| 1959 | 1.6 | 2.1 | 2.0 | 4.3 |
| 1960 | 0.1 | 2.3 | 1.4 | 1.5 |
| 1961 | 1.7 | 0.9 | -0.5* | 2.2 |
| 1962 | 1.9 | 1.0 | 1.8 | 2.1 |
| 1963 | 2.5 | 2.8 | 1.7 | 2.5 |
| 1964 | 0.6 | -- | 2.5 | 2.0 |
| 1965 | 1.8 | 3.5 | 1.9 | 1.7 |
| 1966 | 1.3 | 1.8 | 1.1 | -- |
| 1967 | 1.6 | 1.6 | 1.3 | 2.0 |
| 1968 | 2.3 | 1.5 | 2.6 | 0.5 |
| 1979 | 1.6 | 1.0 | 1.0 | 1.2 |
| 1980 | 1.9 | 1.8 | 1.4 | 0.9 |
| 1981 | 2.2 | 2.2 | 2.1 | 1.5 |
| Grand means (±std. deviation) | 1.6 (0.6) | 1.9 (0.7) | 1.7 (0.5) | 2.0 (1.1) |

*Negative values not included in grand means or regression analyses in Table 6.

SOURCE: SERNS, S.L., "WALLEYE GROWTH IN RELATION TO WATER TEMPERATURE, FOOD AVAILABILITY, AND POPULATION DENSITY IN ESCANABA LAKE, 1956-1982", WDNR RES.RPT.130 (1984)

TABLE 6. Linear correlation coefficients (r) for relationship between adult walleye mean annual growth increments and various abiotic and biotic variables in Escanaba Lake, 1958-81.

| Variables | Correlation Coefficient<br>Mean Annual Growth Increment<br>Age III-IV | <br><br>Age IV-V | <br><br>Age V-VI |
|---|---|---|---|
| Water temperature (F) | | | |
| May | 0.137 | 0.125 | 0.508 |
| May-June | 0.185 | 0.111 | 0.526 |
| June-August | -0.048 | -0.191 | -0.232 |
| May-August | 0.286 | 0.022 | 0.371 |
| May-September | 0.226 | -0.204 | 0.249 |
| May-October | 0.484 | -0.189 | 0.235 |
| No. adult walleyes in population | | | |
| ≥Age III | 0.236 | -0.429 | -0.408 |
| ≥Age IV | 0.027 | -0.213 | -0.061 |
| ≥Age V | -0.508 | -0.244 | -0.119 |
| Angler exploitation rate | | | |
| ≥Age III | -0.043 | -0.304 | -0.626* |
| Degrees of freedom (df) | 12 | 11 | 11 |

*Significant at $P < 0.05$.

TABLE 7. Mean annual growth increments for male walleyes, 1958-81.

| Growing Season | Mean Annual Growth Increment (inches)<br>Age III-IV | <br>Age IV-V | <br>Age V-VI | <br>Age VI-VII |
|---|---|---|---|---|
| 1958 | 1.8 | 1.5 | 1.1 | 2.1 |
| 1959 | 1.4 | 1.4 | 1.3 | 2.2 |
| 1960 | -0.6* | 1.1 | 0.9 | 0.8 |
| 1961 | 1.3 | 1.1 | 0.4 | 1.3 |
| 1962 | 1.8 | 1.0 | 1.3 | 1.1 |
| 1963 | -- | 1.8 | 0.7 | 1.5 |
| 1964 | 2.4 | -- | 2.0 | -- |
| 1965 | 1.5 | 1.1 | -- | 0.7 |
| 1966 | 0.9 | 1.6 | 1.2 | -- |
| 1967 | 1.2 | 1.5 | 0.1 | 0.2 |
| 1968 | 1.4 | 1.2 | 0.9 | 1.2 |
| 1979 | 1.3 | 0.8 | 0.9 | 0.8 |
| 1980 | 1.7 | 1.4 | 1.2 | 0.7 |
| 1981 | 1.3 | 1.4 | 1.3 | 1.0 |
| Grand means (±std. deviation) | 1.5<br>(0.4) | 1.3<br>(0.3) | 1.0<br>(0.5) | 1.1<br>(0.6) |

*Negative values not included in grand means or regression analyses in Table 8.

SOURCE: SERNS, S.L., "WALLEYE GROWTH IN RELATION TO WATER TEMPERATURE, FOOD AVAILABILITY, AND POPULATION DENSITY IN ESCANABA LAKE, 1956-1982", WDNR RES.RPT.130 (1984)

TABLE 8. Linear correlation coefficients (r) for relationship between male adult walleye mean annual growth increments and various abiotic and biotic variables, 1958-81.

| | Correlation Coefficient | | |
|---|---|---|---|
| | Mean Annual Growth Increment | | |
| Variables | Age III-IV | Age IV-V | Age V-VI |
| Water temperature (°F) | | | |
| May | 0.684* | 0.022 | 0.719** |
| May-June | 0.514 | 0.079 | 0.684* |
| June-August | -0.038 | 0.097 | 0.184 |
| May-August | 0.327 | 0.190 | 0.527 |
| May-September | 0.081 | 0.222 | 0.411 |
| May-October | 0.011 | 0.316 | 0.086 |
| No. adult walleyes in population | | | |
| ≥Age III | -0.418 | -0.064 | -0.231 |
| ≥Age IV | -0.261 | -0.104 | -0.022 |
| ≥Age V | -0.096 | -0.440 | -0.141 |
| Angler exploitation rate | | | |
| ≥Age III | -0.137 | -0.367 | -0.455 |
| Degrees of freedom (df) | 10 | 11 | 11 |

*Significant at $P<0.05$.
**Significant at $P<0.01$.

TABLE 9. Mean annual growth increments for female walleyes, 1958-81.

| Growing Season | Mean Annual Growth Increment (inches) | | | |
|---|---|---|---|---|
| | Age III-IV | Age IV-V | Age V-VI | Age VI-VII |
| 1958 | -- | -- | -- | 0.5 |
| 1959 | 2.1 | 1.9 | 5.4 | 2.9 |
| 1960 | 3.7 | -- | 1.8 | -0.9* |
| 1961 | -- | 1.9 | -- | 2.3 |
| 1962 | 1.3 | -- | 1.3 | 1.2 |
| 1963 | 1.6 | 0.6 | -- | -0.8 |
| 1964 | -- | 2.1 | -- | -- |
| 1965 | 1.7 | -- | 1.8 | -- |
| 1966 | 1.1 | 1.7 | -- | 2.2 |
| 1967 | 0.6 | 1.6 | 2.1 | 1.5 |
| 1968 | 1.2 | 0.7 | -- | -- |
| 1979 | 1.4 | 1.3 | 1.7 | 2.4 |
| 1980 | 0.9 | 1.4 | 1.4 | 1.7 |
| 1981 | 2.2 | 2.1 | 1.5 | 1.7 |
| Grand means | 1.6 | 1.5 | 2.1 | 1.8 |
| (±std. deviation) | (0.8) | (0.5) | (1.3) | (0.7) |

*Negative values not included in grand means or regression analyses in Table 10.

SOURCE: SERNS, S.L., "WALLEYE GROWTH IN RELATION TO WATER TEMPERATURE, FOOD AVAILABILITY, AND POPULATION DENSITY IN ESCANABA LAKE, 1956-1982", WDNR RES.RPT.130 (1984)

TABLE 10. Linear correlation coefficients (r) for relationship between female adult walleye annual growth increments and various abiotic and biotic variables, 1958-81.

| Variables | Correlation Coefficient<br>Mean Annual Growth Increment<br>Age IV-V | Age V-VI | Age VI-VII |
|---|---|---|---|
| Water temperature (°F) | | | |
| May | 0.023 | 0.259 | 0.161 |
| May-June | 0.050 | 0.225 | 0.359 |
| June-August | -0.283 | -0.329 | 0.478 |
| May-August | -0.044 | 0.243 | 0.345 |
| May-September | -0.018 | 0.263 | 0.439 |
| May-October | -0.053 | -0.375 | 0.369 |
| No. adult walleyes in population | | | |
| ≥Age III | -0.423 | 0.017 | 0.406 |
| ≥Age IV | 0.420 | 0.227 | 0.689 |
| ≥Age V | 0.733* | 0.497 | 0.375 |
| Angler exploitation rate | | | |
| ≥Age III | -0.330 | -0.310 | -0.570 |
| Degrees of freedom (df) | 9 | 8 | 6 |

*Significant at $P < 0.05$.

SOURCE: SERNS, S.L., "WALLEYE GROWTH IN RELATION TO WATER TEMPERATURE, FOOD AVAILABILITY, AND POPULATION DENSITY IN ESCANABA LAKE, 1956-1982", WDNR RES.RPT.130 (1984)

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## ACKNOWLEDGMENTS

The data presented in the report represents the collective effort of many permanent and seasonal employes who worked at the Escanaba Lake checking station during the period of 1956-1982. I would especially like to thank the late W. S. Churchill, who was research project leader at Escanaba lake from 1956 to 1962, J. J. Kempinger, project leader from 1962 to 1979, O. C. Baccus, fishery research technician from 1954 through 1982, and M.H. Hoff, assistant project leader since 1979.

I would also like to thank L. M. Christenson, R. L. Hine, G. Lange, and H. E. Snow for their critical reviews of the manuscript.

This research was supported by funds provided by the Federal Aid in Fish Restoration Act under Dingell-Johnson project F-83-R. (This does not represent a final report for any one study--the data was collected over several years under various studies.)

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