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THE GOLDEYE, *AMPHIODON ALOSOIDES* (RAFINESQUE), IN THE COMMERCIAL FISHERY OF THE RED LAKES MINNESOTA

BY MARVIN D. GROSSLEIN AND LLOYD L. SMITH, JR.

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ABSTRACT

The goldeye, *Amphiodon alosoides* (Rafinesque), formerly an important species in the fishery of the Red Lakes, Minnesota, has been reduced in abundance during recent years. The decline has been significantly correlated with increased fishing effort but not with abundance of predaceous species. Growth rates of the sexes are similar in earlier years of life but the females grow faster in later years. Growth is positively correlated with summer temperatures and shows marked differences in different years. Fish attain maximum availability to commercial gill nets at a length of 13.0 to 13.4 inches and an age of 4 to 5 years. The commercial take is dependent on two or three age groups and annual abundance is strongly influenced by the strength of individual year classes. Management would be limited to control of fishing effort, but it cannot be practiced in the fishery unless entrapment gear is used instead of gill nets.

THE GOLDEYE, *AMPHIODON ALOSOIDES* (RAFINESQUE), IN THE COMMERCIAL FISHERY OF THE RED LAKES, MINNESOTA

By Marvin D. Grosslein and Lloyd L. Smith, Jr.
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The commercial fishery of the Red Lakes in north-central Minnesota is a major industry of the Red Lakes band of Chippewa Indians. This fishery has been in continuous operation since 1917 and at present is carried on exclusively by members of the tribe, who market their catch through the Red Lakes Fishery Association, a cooperative organization of the Indians. A discussion of production and associated trends in the commercial fishery of the Red Lakes has been presented by Smith and Krefting (1954).

In recent years, commercial fishing in the Red Lakes has been done exclusively by some 200 Indian fishermen who use 3½-inch-mesh (stretch measure) gill nets operated from skiffs powered by outboard motors. The Red Lakes are exploited primarily for the walleye, *Stizostedion v. vitreum* (Mitchill), and the yellow perch, *Perca flavescens* (Mitchill), which contribute an average of 63 percent and 20 percent of the total annual catch. The remaining 17 percent includes the goldeye, *Amphiodon alosoides* (Rafinesque), northern pike, *Esox lucius* L., whitefish, *Coregonus clupeaformis* (Mitchill), and other species.

The University of Minnesota and the United States Fish and Wildlife Service in cooperation with the Bureau of Indian Affairs and the Red Lakes Fishery Association initiated a fishery study covering all commercial species in 1949 to provide data on which to base management and to investigate population fluctuations and associated factors.

The marked decline in the production of goldeyes from the Red Lakes in recent years has resulted in an economic loss to the fishery. This fact and the general scarcity of published information on the species led to the present study, which deals with some phases of goldeye life history and factors influencing abundance of the species.

Samples totaling 2,821 goldeyes were taken from the commercial catches in 1949–53. In 1950, 43 goldeyes were caught by experimental gill nets. Scale samples were obtained from 1,612 fish and lengths only from the remainder. Scale impressions were made on cellulose-acetate slides by a heat-impression method (Butler and Smith, 1953) and were examined and measured on an Eberbach scale projector at 28 × magnification. Catch statistics were taken from records of the Red Lakes Fishery Association.

Robert L. Butler, Richard L. Pycha, and John Magnuson assisted in the collection of field data and in preparation of the manuscript; Dr. E. F. Cook and J. W. Barnes aided in the identification of insects; cooperation of the staff of the Red Lakes Fishery Association in the field made the study possible. Financial assistance was provided by the Great Lakes Fishery Investigations, Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service.

PRODUCTION AND ABUNDANCE

Since 1930, when detailed records of statistics of catch and fishing effort in the commercial fishery of the Red Lakes, Minnesota, were started, annual production of individual species and of all species combined has fluctuated considerably. During the period 1930–53, the average annual production of all species totaled approximately 1,079,000 pounds (table 1). In most years prior to 1946, the goldeye ranked third in total yield and for the period 1930 to 1953 it contributed an average of approximately 67,000 pounds, or 6.2 percent, to the annual average total production of the fishery.

Goldeyes were reported to have been very abundant in the early years of the commercial fishery, but there was practically no market until

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TABLE 1.—*Production of all species and of goldeyes in the Red Lakes commercial fishery, 1930–53*

[Production in thousands of pounds; data from Smith and Krefting, 1954]

Year	All species	Goldeye	Year	All species	Goldeye
1930	747	26	1943	1,312	117
1931	1,062	3	1944	1,470	57
1932	984	2	1945	1,451	108
1933	783	(1)	1946	1,478	48
1934	867	22	1947	1,534	52
1935	721	102	1948	1,363	15
1936	757	247	1949	1,061	18
1937	1,018	97	1950	652	49
1938	1,062	98	1951	758	10
1939	948	124	1952	1,117	4
1940	1,186	148	1953	1,054	4
1941	1,219	136			
1942	1,285	111	Average	1,079	67

[1] Less than 500 pounds.

smoked goldeye was introduced in 1924. Between 1930 and 1953, the lowest yield of goldeyes was in 1933, when only 362 pounds were taken. Production increased abruptly in 1934 to more than 22,000 pounds and exceeded 100,000 pounds the following year. The maximum take for the period was 247,383 pounds in 1936.

The substantial rise in total production of all species of fish in the Red Lakes after 1940 resulted from a rise in fishing intensity caused by wartime food demands. Fishing effort increased 78 percent, from an annual average of 5,965 lifts in 1930–40 to 10,639 lifts in 1941–53 (table 2). The greater effort produced a substantially larger catch of walleyes and yellow perch, but not of goldeyes.

TABLE 2.—*Total summer lifts and average catch per lift of walleye, yellow perch, and goldeye in the Red Lakes commercial fishery, 1930–53*

[Data from Smith and Krefting, 1954]

Year	Number of lifts (5-net)	Catch per lift (in pounds)		
		Walleye	Yellow perch	Goldeye
1930	6,586	61.0	11.3	4.0
1931	5,794	90.0	13.4	.3
1932	3,860	110.9	33.4	.5
1933	5,417	90.0	32.8	.1
1934	6,672	66.1	23.2	3.0
1935	7,087	40.8	21.0	13.0
1936	7,842	33.8	14.5	31.4
1937	5,172	96.3	43.5	18.6
1938	4,910	117.0	41.4	19.8
1939	5,657	95.5	33.8	21.8
1940	6,614	102.0	24.0	22.2
1941	8,086	95.6	11.2	16.7
1942	12,934	72.2	12.7	8.6
1943	14,816	52.4	13.0	7.8
1944	8,454	99.4	37.1	6.6
1945	10,596	72.9	28.2	10.1
1946	11,092	72.8	26.9	4.3
1947	12,393	69.9	25.4	4.2
1948	10,083	90.9	24.8	1.5
1949	9,905	64.0	18.7	1.8
1950	12,767	30.3	5.6	3.8
1951	12,449	44.7	9.0	.8
1952	7,856	83.3	50.7	.5
1953	6,883	78.1	65.9	.6
Average:				
1930–40	5,965	82.1	26.6	12.2
1941–53	10,639	71.3	25.3	5.2
1930–53	8,497	73.0	25.9	8.4

Fluctuations in total annual catch of all species appear to be primarily dependent on abundance of walleyes and perch and on market demand (Smith and Krefting, 1954). These two factors determine the amount of fishing and length of season, because there is a walleye quota and market conditions become unfavorable in late summer.

Since fishing effort has not been constant, estimates of abundance of all species have been based on the catch of a standard unit of gear, which consists of 1,500 linear feet of commercial gill net (5-net) set for 1 night. The average catch of goldeyes per unit of effort for the entire period 1930–53 was 8.4 pounds and the highest and lowest takes were 31.4 pounds and 0.1 pound (table 2; fig. 1). These wide fluctuations in availability correspond in general to changes in production (table 1). Since 1940, the availability of goldeye has declined steadily except for slight rises in 1945 and 1950, which were only minor interruptions in the downward trend.[1]

FACTORS ASSOCIATED WITH DECLINE OF GOLDEYE

Abundance of Associated Species

The walleye is the most important potential predator of the goldeye in the Red Lakes. The coincidence of the substantial decline in availability of the goldeye with a decrease in average availability of the walleye suggests, however, that predation by the walleye is not the major controlling influence on goldeye abundance (table 2). Since the most significant predation on goldeye would occur during the first year of life, the effects of predation would probably vary with abundance of the older walleye age groups. In recent commercial goldeye catches, age-groups III through VI were predominant.[2] Linear correlation analyses between walleye abundance and goldeye abundance, with successive offset intervals from 3 to 6 years, were applied to the data, but no significant relationships were apparent.

[1] Subsequent to completion of the present study, young-of-the-year goldeye were collected for the first time in shore-seine hauls during 1955 and 1956. In the 1958 commercial season total production increased suddenly to 60,070 pounds and the catch per 5-net lift increased to 4.7. The later data suggest a possible reversal of trend such as occurred in 1935.

[2] Age groups are given in terms of number of annuli on the scales; fish hatched in 1950 and taken in 1953 belong to age-group III throughout the calendar year.

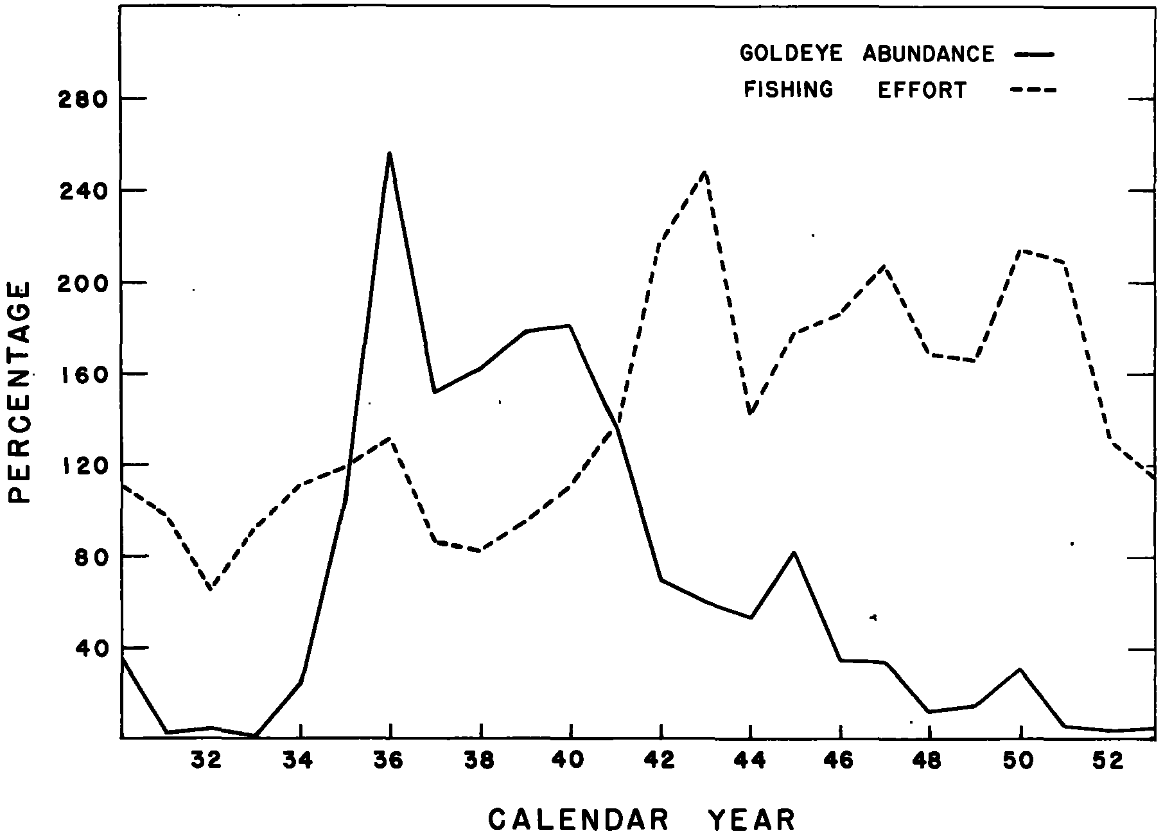

FIGURE 1.—The abundance of goldeye and the total fishing effort expressed as percentages of the 1931–40 average.

It therefore appears that the abundance of walleyes does not affect the abundance of goldeye directly. Similar appraisal of the possible influence of yellow perch on goldeye abundance failed to show a relationship. Since abundance indices of perch and walleyes fluctuate together and the estimates for the various years are based on fish of the same age groups in both species (Smith and Krefting, 1954), their combined influence on goldeye appears to be unimportant. Fluctuations in abundance of northern pike and other minor species did not appear to be related to changes in abundance of the goldeye.

Fishing Effort

During the 1930's when total fishing effort was at a low level, the wide fluctuations in goldeye abundance gave no evidence of correlation with changes in fishing effort. After 1940, however, the abundance declined steadily coincidentwith a substantial increase in fishing effort (table 2, fig. 1). Correlation of fishing effort with goldeye abundance 2 years later resulted in a significant negative coefficient ($r = -0.77, p < .001$).[3] According to Van Oosten and Deason,[4] the principal age groups in the 1937 commercial goldeye catches were the IV, V, and VI groups. In recent years, the predominant age groups have been III, IV, and V. This decrease in average age of the catch may be associated with an increase in fishing effort, but also may simply reflect the limited sampling and the characteristics of year-class strength at the time of the earlier study.

Where goldeyes have been subjected to commercial exploitation in Canadian waters, the populations have declined (Sprules 1947). Lake-of-the-Woods once supported a large goldeye population, which in recent years has nearly disappeared (Carlander 1949). The decline was accompanied by increased fishing effort although the goldeye was not particularly sought by commercial fishermen.

[3] Since annual commercial catches of goldeye have been composed chiefly of a few age groups, it would be expected that any change in abundance due to change in fishing effort would appear in about 2 years.

[4] Van Oosten, John, and Hilary Deason (MS.). A preliminary survey of the commercial fisheries resources of the Red Lakes, Beltrami and Clearwater Counties, Minnesota. The materials of this manuscript, much abbreviated, were the basis of a paper by Van Oosten and Deason (1957).

Although increased effort seems to be associated definitely with decline of the goldeye in the Red Lakes, as it has been in other waters, the mechanism of its influence is not clearly defined.

AGE AND GROWTH

Body-Scale Relation

Three to five scales, removed randomly from the region where the tip of the pectoral fin when rotated intersects the lateral line, were taken from 285 fish that ranged in length from 2.8 to 20.1 inches. The measurements of the projected images (28 ×) of all scales from each fish were averaged to obtain the estimate of scale length. Simple functions did not adequately represent the empirical data for the smaller fish, possibly because the number of measurements for fish 4.5 to 10 inches long was small; therefore, a line which appeared to fit all the data best was drawn by eye. Back-calculations of length were made from a nomograph constructed to incorporate the body-scale relation defined by this line (fig. 2).

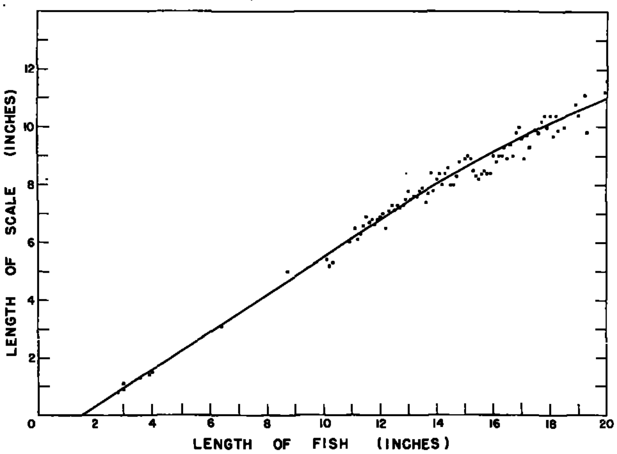

FIGURE 2.—The body-length/scale-length relation of Red Lakes goldeye, as plotted by eye from empirical points. (Scale measurements magnified 28 times.)

Calculated Growth

The growth rate of the Red Lakes goldeye is most rapid during the first 3 years of life, is reduced markedly in the fourth year, and declines steadily thereafter (fig. 3). Samples from the 1953 catch indicate that the rate of growth in both sexes decreased markedly in the fourth year, and that at the end of the fourth year and thereafter, the females exceeded the males in length (table 3).

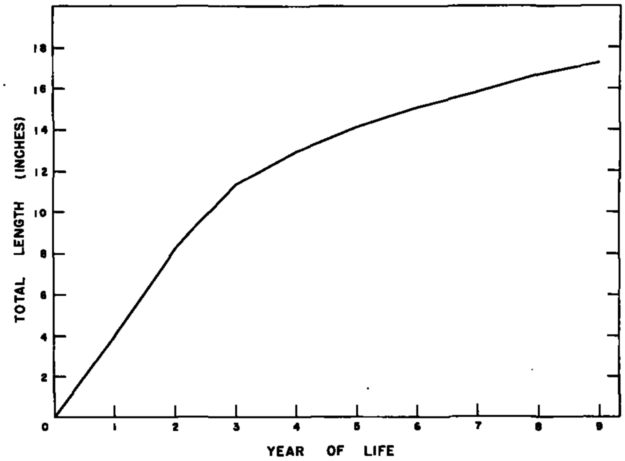

FIGURE 3.—Grand-average calculated length at the end of each year of life of goldeye from Red Lakes, sexes combined.

Slower growth of male goldeyes in the third and later years of life has been shown for Lake Texoma goldeyes (Martin 1952).

Comparison of the average calculated total lengths at the end of the first 3 years of life in the various year classes reveals only small differences, except in the 1941 and 1949 broods (table 4). Differences are greater after the fourth year of life, especially in the year-classes 1946 to 1949, which are considerably shorter at corresponding ages than are the later year classes. This difference apparently is caused by the cumulative effect of very poor growth in 1950 and 1951. The grand-average calculated total lengths of the fish captured in 1953 are shorter than the combined calculated lengths of the catches for all years except in the first year of life, because the 1953 catch was composed primarily of the year-classes 1946 to 1949. Goldeyes taken in 1937 and 1938 (Eddy and Carlander, 1942; Van Oosten and Deason; see footnote 4, p. 35) grew more slowly than those collected in the present study (table 5).

The marked differences in growth rate among year classes during the period of their greatest availability to the commercial gear would be expected to make considerable difference in the total contribution of the various year classes to the annual production. These changes would be especially apparent during periods of high population levels, but in recent years the harvest and abundance have been at such low levels that these changes were not important to the fishery.

TABLE 3.—*Average total length of 288 goldeyes of the 1953 collection at time of capture and at time of annulus formation, by sex*

[Length in inches]

Age and sex	Number of fish	Total length at capture	Calculated length at end of year of life—						
			1	2	3	4	5	6	7
IV group:									
Male	32	12.5	4.82	7.63	10.56	12.25			
Female	53	13.3	4.63	7.36	10.20	12.36			
V group:									
Male	93	13.8	4.26	8.40	11.42	12.63	13.40		
Female	42	14.7	4.17	8.19	11.60	13.03	14.10		
VI group:									
Male	46	13.9	4.16	8.20	11.21	12.34	13.12	13.60	
Female	20	15.0	4.17	8.20	11.32	12.62	13.70	14.59	
VII group: Male	2	14.6	4.17	8.40	11.03	12.26	13.12	13.90	14.30
Grand-average calculated length:									
Male			4.41	8.08	11.06	12.41	13.26	13.60	14.30
Female			4.32	7.92	11.04	12.67	13.90	14.59	
Increment of average:									
Male			4.41	3.67	2.98	1.35	0.85	0.34	0.70
Female			4.32	3.60	3.12	1.63	1.23	0.69	

TABLE 4.—*Average calculated total lengths of 1,165 Red Lakes goldeyes sampled from the commercial catches, 1949–53*

[Sexes combined; length in inches]

Year class	Date collected	Age group	Number of fish	Average calculated length at end of year of life—								
				1	2	3	4	5	6	7	8	9
1941	1949	VIII	9	3.7	8.2	10.8	12.4	13.5	14.4	15.4	16.0	
1942	1949–51	VII–IX	22	4.0	8.3	11.4	12.8	14.2	15.1	15.8	16.5	17.1
1943	1949–52	VI–IX	48	3.9	8.4	11.4	13.1	14.3	15.3	16.1	16.9	17.4
1944	1949–52	V–VIII	24	3.9	8.5	11.6	13.3	14.5	15.4	16.1	16.6	
1945	1949–53	IV–VIII	62	4.0	8.2	11.3	13.2	14.4	15.4	16.1	17.0	
1946	1949–53	III–VII	258	4.1	8.0	11.1	12.8	13.5	14.2	14.3		
1947	1949–53	II–VI	430	4.2	8.4	11.4	12.7	13.4	14.0			
1948	1951–53	III–V	190	4.2	8.5	11.7	12.8	13.7				
1949	1952–53	III–IV	122	4.9	7.6	10.6	12.3					
Grand average				4.1	8.3	11.3	12.9	14.1	15.0	15.8	16.6	17.2

TABLE 5.—*Grand-average calculated total lengths, sexes combined, of goldeyes collected from the Red Lakes fishery in 1937–38 and 1949–53, and from Lake Texoma in 1949*

[Length in inches]

Source	Date collected	Number of fish	Average calculated total length [1] at end of year of life—							
			1	2	3	4	5	6	7	8
Eddy and Carlander (1942)	1937	625	2.8	6.4	9.4	11.0	12.5	13.6		
Van Oosten and Deason (MS.) [2]	1938	10	3.1	7.9	11.0	12.4	13.5	14.4		
Martin (1952)	1949	817	7.5	8.8	11.2	12.6	13.2	14.2		
Present study	1949–53	1,165	4.1	8.3	11.3	12.9	14.1	15.0	15.8	16.6

[1] Standard lengths of the various authors were converted to total lengths through use of length conversion factor based on 361 Red Lakes goldeyes from present study. The ratio of standard length to total length was 0.815; the ratio of fork length to total length was 0.907.

[2] See footnote 4, page 35.

Comparison with Growth in Other Areas

Rawson (1947) reported that most goldeyes taken in Lake Athabaska were 6 to 11 years old and 12 to 16.5 inches long. Although the type of length measurement is not specified, it appears that these fish grow more slowly than those in Red Lakes. Bajkov (1930) presented growth data for goldeyes from several lakes in Manitoba. These data are not directly comparable with those from Red Lakes because information on the type of measurement was omitted, but comparison of annual increments represented as percentage increase suggests slower growth, especially in the earlier years of life.

Lake Texoma goldeyes (Martin 1952) apparently grew much more rapidly in their first year than did fish from the Red Lakes; in later years of life, however, the average annual increments of growth and total lengths, with one exception, were greater in Red Lakes fish (table 5). The

TABLE 6.—*Annual fluctuations in growth of Red Lakes goldeyes determined from sample years 1949 to 1953*

[Expressed as percentage deviation from the mean annual increment of the entire sample from each year's collection in different calendar years]

Year collected	Percentage deviation in calendar year—										
	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
1949	−0.4	−7.0	6.7	1.6	−7.2	−0.9	1.4				
1950		0.3	2.5	6.2	−6.4	−5.0	3.5	−0.9			
1951					16.5	0.2	3.0	7.3	−26.8		
1952					20.4	2.9	5.6	8.0	−17.1	−19.8	
1953							9.2	7.2	−10.0	−16.1	9.5

apparent unusually large first year's growth of Lake Texoma goldeyes may result from use of the 4.5-inch intercept of the body-scale regression line.

Validity of Age Determination

False annular marks on the scales of all age groups and obscure patterns in the outer zones of those from older fish hampered accurate assessment of age. The best criterion of annuli was the cutting-over of circuli in the lateral and posterolateral fields. Validity of age determinations for Red Lakes goldeyes was supported in three ways. First, the number of annuli increased systematically with increase in fish length in collections of separate years. Second, agreement was good among calculated lengths at the same age in various year classes (table 4) and was still better among calculated lengths of the different age groups of the same year classes. Third, different year classes collected in the same or different calendar years agreed with respect to the relative goodness or poorness of growth in certain calendar years. Percentage deviations of growth of Red Lakes goldeyes from the average annual increment of the period were determined separately for the samples of each year of collection, 1949 to 1953 (table 6). Although the base period is different for each year of collection, similarity among the trends gives considerable support to the validity of age determinations.

Relation Between Growth and Temperature

Water temperature may influence growth of fish directly by its effects on metabolism and behavior, indirectly through food production, or by a combination of these effects. Since temperatures in Red Lakes vary considerably in different seasons, changes in growth of goldeye could be related to this factor.

The relation between annual fluctuations in growth rate of Red Lakes goldeyes and mean air temperatures during the growing season, therefore, was evaluated by comparing the percentage annual deviations of each from the mean value for the period 1947–53 (table 7). This particular period was used because it did not include samples of less than 20 fish. Because the temperature of the shallow waters of the lake have been observed to be correlated very closely with air temperature, the mean air temperatures for June, July, and August (the major part of the growing season) were used. During the limited span of years available there was a positive correlation between fluctuations of summer temperature and rate of growth ($r=0.90$, $p=0.02$).

TABLE 7.—*Percentage deviations of mean air temperature (June, July, and August) and of mean annual growth of Red Lakes goldeyes from the average for 1947–52*

Item	Percentage deviations in calendar year—					
	1947	1948	1949	1950	1951	1952
Growth of goldeyes	6.1	12.9	10.8	−11.7	−15.4	−2.8
Mean air temperature	3.1	1.0	3.1	−3.8	−3.9	0.4

Age and Size at Maturity

Few data are available on the size and age at which goldeyes reach maturity. Dymond [5] stated that in some Manitoba lakes females spawn first when 4 years old, at a length of 12 inches and a weight of 12 ounces, but many do not mature until a year later. A few males mature at 3 years. Among the 10 goldeyes from the Red Lakes which were examined by Van Oosten and Deason (see footnote 4, p. 35) in 1938, 3 were mature males belonging to age-groups III, IV, and VI. The remaining 7 fish were females of which 4 were immature (age-groups II, III, and V) and 3 were mature (age-groups IV, V, and VI). In the present study, 34 male and female goldeyes, all of age-groups IV and V, examined in late July and early August were mature. From

[5] Dymond, J. R. The goldeye, its life history and conservation. 8 pp. (typewritten).

observations on Lakes Winnipeg and Winnipegosis, Hinks (1943) reported that only about half of the female goldeyes, 12 inches or longer, spawned in any one year.

Length-Weight Relation

A description of the length-weight relation in goldeyes of the Red Lakes was based on 156 specimens. No significant differences between the sexes were noted. The relation is expressed by the formula—

$$\log W = -2.094 + 2.844 \log L,$$

where

$$W = \text{weight in ounces},$$

and

$$L = \text{total length in inches}.$$

STRUCTURE OF THE EXPLOITED GOLDEYE POPULATION

Since nearly all samples used in the present study were taken from commercial catches, they represented the portion of the goldeye population that was available to the commercial gear. In 1953, the origin of samples (whether from Upper Red Lake or Lower Red Lake) was recorded. Because age and length-frequency distribution of samples from both lakes were similar, it was assumed that samples from mixed catches were suitable for the analysis of population structure. Length distributions and age frequencies were similar from month to month in all years.

Length Distribution of the Commercial Catch

The length-frequency distribution of the commercial goldeye catch was based on 2,787 randomly selected fish taken in 1949–53 (fig. 4). With one exception, the distribution showed an increase in the average length of the predominant size groups in successive years (table 8). This increase in average length reflects dominance of a few year classes in the catches.

The 3½-inch-mesh commercial gill nets took fish over a wide range of lengths (10.0 to 19.4 inches), but the major part of the total catch was composed of fish in the lower half of the range

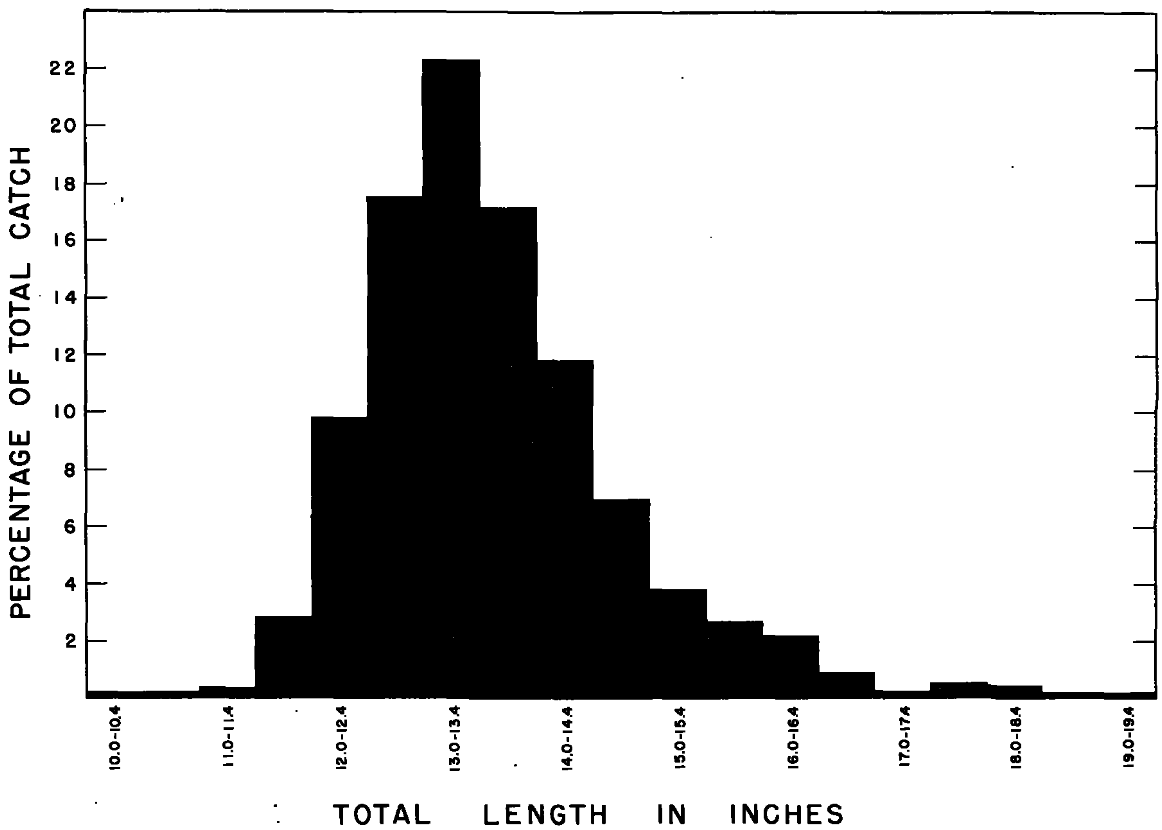

Figure 4.—Length-frequency distribution of the commercial catch of Red Lakes goldeyes, all samples combined.

TABLE 8.—*Length-frequency distributions of goldeyes taken from Red Lakes commercial catches, 1949–53*

[Modes indicated by asterisk*]

Total length (inches)	Frequency of occurrence of fish collected in—					Total
	1949	1950	1951	1952	1953	
10.0–10.4	2	1	----	----	----	3
10.5–10.9	1	----	----	----	----	1
11.0–11.4	3	3	1	----	1	8
11.5–11.9	39	15	9	9	7	79
12.0–12.4	*75	33	119	20	27	274
12.5–12.9	40	38	304	47	63	492
13.0–13.4	14	*46	*316	*155	91	*622
13.5–13.9	9	33	160	144	*134	480
14.0–14.4	5	21	74	102	128	330
14.5–14.9	4	7	40	47	98	196
15.0–15.4	6	7	29	17	48	107
15.5–15.9	*23	11	22	6	13	75
16.0–16.4	12	*23	14	6	5	60
16.5–16.9	4	9	5	2	2	22
17.0–17.4	1	2	2	1	1	7
17.5–17.9	2	3	6	4	----	15
18.0–18.4	----	2	3	3	2	10
18.5–18.9	----	1	3	----	----	4
19.0–19.4	1	----	1	----	----	2
Total	241	255	1,108	563	620	2,787

(fig. 4). The Red Lakes goldeyes first become completely available to the commercial gill nets within the size interval 13.0 to 13.4 inches total length. Although it has not been definitely determined, there is some indication that the larger fish may not be completely available to the gear.

Age Composition of the Commercial Catch

The age composition of the commercial goldeye catches was described from 1,578 fish. Age frequencies, determined from scales, were tabulated in 0.5-inch intervals to permit extension of the data to samples for which only length measurements were available. Approximately 83 percent of the commercial catch during the period 1949–53 consisted of III-, IV-, and V-group fish; age-group IV contributed 38.4 percent and age-groups III and V comprised approximately 20.7 percent and 23.8 percent of the total (table 9). The remainder of the catch was made up principally of VI-, VII-, and VIII-group fish.

TABLE 9.—*Age distribution of 1,578 goldeyes from commercial catches in the Red Lakes, 1949–53*

Year collected	Percentage [1] in age-group—									
	II	III	IV	V	VI	VII	VIII	IX	X	XI
1949	0.8	66.4	10.0	3.3	5.8	5.8	3.7	----	0.5	----
1950	----	26.7	47.8	3.5	5.1	11.4	2.3	----	0.9	----
1951	----	0.9	77.1	16.1	3.7	0.5	0.3	0.2	0.2	----
1952	----	9.6	28.6	52.4	6.7	1.4	0.3	0.5	----	0.1
1953	----	----	28.5	43.9	26.0	0.5	0.7	----	----	----
Combined samples	0.2	20.7	38.4	23.8	9.5	3.9	1.4	0.1	0.3	----

[1] Differences between summation and 100 percent represent fish which could not be aged.

The commercial catch in 1937 (Van Oosten and Deason; see footnote 4, p. 35) was dominated by age-groups IV, V, and VI, which comprised approximately 25 percent, 39 percent, and 20 percent of the total catch. Age-group III made up about 9 percent and the VII and VIII age groups contributed 5.9 percent and 0.5 percent of the total.

Strength of Year Classes

The catches from 1949 to 1952 were largely dependent on one or two age groups of the 1946, 1947, and 1948 year classes. The take in 1953 was derived chiefly from the combined catch of the 1947, 1948, and 1949 year classes. In contrast, during 1949 when abundance was three times as large as that of 1953, the catch was largely based on the 1946 year class (tables 2 and 9). The presence of unusually strong or weak year classes can affect markedly the catch in any season, since the annual harvest is dependent on the abundance of very few age groups. Although the size of year classes in recent years has been small in comparison with the hatches responsible for the greater abundance in earlier years, the number of age groups comprising the annual harvest apparently has changed little.

Sex Ratio

Males consistently outnumbered females in daily samples from the goldeye catch of 1953: in a total of 389 goldeyes, 56 percent (220) were males and 44 percent (169) females. The ratio of males was even higher (70 percent) in the age-groups V and VI which were completely available to the gear. Females outnumbered males in age-group IV as might be expected, since IV-group males in 1953 were below the size of complete availability (table 3)

FOOD HABITS

Food of the goldeye, as reported by a number of previous investigators, consists chiefly of a wide variety of insects. Examination of 34 stomachs in the present study indicated that the principal food organisms were aquatic insects (larval and adult). The common occurrence of terrestrial insects suggests that goldeyes are frequently surface feeders in shallow water. Bajkov (1930) concluded that goldeyes foraged chiefly at night since large quantities of deepwater organisms, which rise to the surface at night, were found in their stomachs. In marshes around the Saskatchewan River, movements of young fish were found to be greatest near sundown and sunrise and activity was generally greater at night than during the day (Sprules 1947). In the present study, the common occurrence of noctuid moths and fireflies in stomachs suggests that goldeyes in the Red Lakes are often nocturnal feeders.

CONCLUSIONS

The appraisal of fluctuations in abundance of the various fish populations in Red Lakes yields no evidence that the recent decline of goldeyes is attributable to an increase in the number of walleyes and yellow perch, which are the predominant species. The lower abundance of goldeyes in recent years has been accompanied by increased fishing effort, as has been observed elsewhere, but the actual influence of this factor is not clearly defined. The abundance of the goldeye population is now extremely low, but it may recover as it did in the 1930's. The recent capture of first-year fish in shore seining lends some support to this view. Available information suggests that the only change in management practice which might aid in the recovery of the population would be a reduction in fishing effort. Under present conditions, gill nets are fished primarily for the walleyes and secondarily for the perch; catch of other species is incidental. Special management of the goldeye, therefore, would not be practical unless entrapment gear of some type were employed.

Demonstration of the validity of age determination and appraisal of growth difference in various year classes have shown that prediction of available commercial stock would be possible if adequate sampling of the population prior to its entrance into the fishery could be obtained. As has been shown for various other species, the strength of individual year classes in large measure determines the size of the stock available for harvest in any particular year.

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