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THE UNIVERSITY OF MANITOBA

VARIATIONS IN ABUNDANCE OF WALLEYES, STIZOSTEDION VITREUM VITREUM (MITCHILL), IN CEDAR AND MOOSE LAKES, MANITOBA

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A Thesis

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ABSTRACT

During the summers of 1962 to 1964, experimental gill netting was conducted in Cedar and Moose Lakes, Manitoba. The age structure of walleyes caught in 9.5 and 10.8 cm experimental nets was examined to determine relative strengths of year classes in both populations. Age compositions of additional samples from the commercial fisheries on both lakes were also examined. Year classes were ranked in order of relative frequency of occurrence in the experimental catches.

Estimates of year class strength for each population were correlated with annual fluctuations in walleye catches of the commercial fisheries six years after hatching.

Strengths of year classes in Cedar and Moose Lakes were positively correlated with spring discharges from the Saskatchewan River during the first year of life of the year classes. This relationship was best for Cedar Lake walleyes in June and for Moose Lake walleyes in April. The manner in which high discharges may have promoted the success of walleye year classes is discussed.

The future abundance of Cedar and Moose Lakes walleyes might be predicted on the basis of observations of spring discharges from the Saskatchewan River. Such information would permit effective management of the commercial walleye fisheries on these lakes.

INTRODUCTION

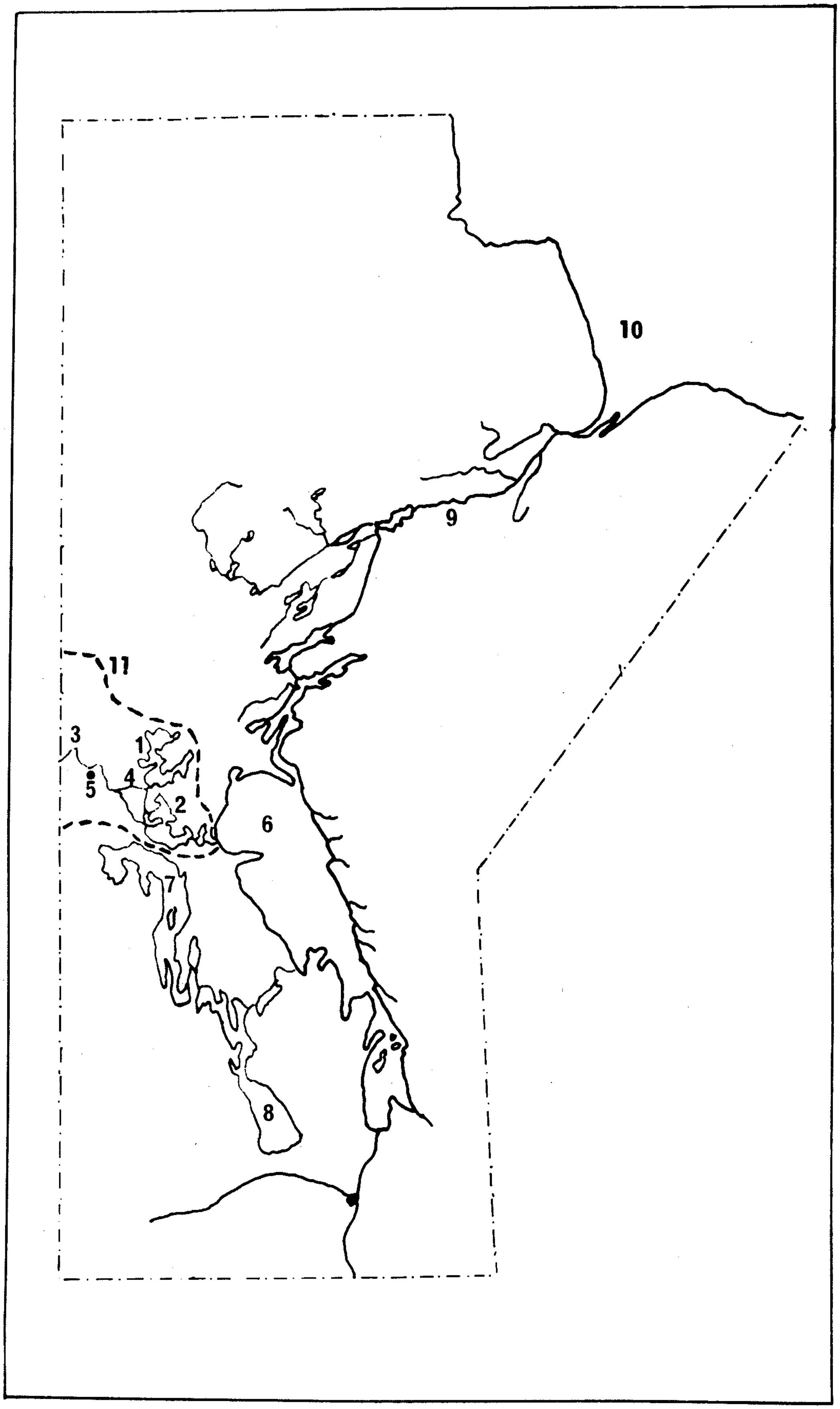
Cedar Lake and Moose Lake are located in west-central Manitoba (see Fig. 1). Each support a major commercial gill net fishery during the summer and winter seasons. The walleye (Stizostedion vitreum vitreum (Mitchill)) constitutes approximately 50 percent of the cash value of commercial catches and is the most important commercial species in each fishery (Anon., 1961). Some other species contributing to the fishery and of secondary importance are sauger (S. canadense), lake whitefish (Coregonus clupeaformis), pike (Esox lucius), goldeye (Hiodon alosoides), ciscoes (Coregonus spp), and some suckers (Catostomus and Moxostoma spp).

A biological survey was made in the summer months of 1962 to 1964 inclusive with the intent of assessing the productive capacity of the two lakes prior to their inundation caused by the construction of a hydro-electric power dam at Grand Rapids, Manitoba. As part of the general survey, experimental gill net catches of the above species and others were made. Data regarding walleyes in these experimental catches were employed in the present study.

Pronounced variations in catches of various fish species are common for freshwater commercial fisheries (Hile, 1937; Hile et al, 1953; Smith and Krefting, 1954; and Pycha, 1961). Frequently such variations are caused by fluctuations in the strength of individual year classes of fish recruited into the fishery during a given year. Consequently, annual fluctuations in the magnitude of commercial

FIGURE 1. Map of the province of Manitoba showing Cedar and Moose Lakes, the Saskatchewan River Drainage Basin and other associated drainage systems.

1. Moose Lake
2. Cedar Lake
3. Saskatchewan River
4. Summerberry River
5. The Pas
6. Lake Winnipeg
7. Lake Winnipegosis
8. Lake Manitoba
9. Nelson River
10. Hudson Bay
11. Eastern end of Saskatchewan River Drainage Basin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catches may depend upon factors other than exploitation. In some cases, however, intense exploitation may sufficiently deplete spawning stocks and thereby reduce the abundance of subsequent progeny entering a fishery. Most previous investigations into conditions affecting the strength of year classes in fish populations have emphasized environmental factors prevalent during the spawning, incubation and fry stages (Hile, 1941; Miller, 1952; Smith and Pycha, 1960; Johnson, 1961; Franklin and Smith, 1963; Lawler, 1965; Forney, 1966; and others).

In this study, fluctuations in year class strengths of walleyes in Cedar and Moose Lakes will be described. Although data on year class strengths and environmental conditions were insufficient to consider all factors which may have been related to fluctuations in walleye abundance, the relationship of discharge from the Saskatchewan River (which is connected to both lakes) to year class strengths will be considered. Finally, results will be related to the success of commercial fishing on each lake.

Growth data on the walleyes in both lakes were also examined. Information obtained from this examination, however, was not directly pertinent to the principal objective of the study which was the description of fluctuations in walleye abundance in Cedar and Moose Lakes and the relationship of these fluctuations to discharge. Since growth data were examined to contrast growth rates of walleyes in both populations, analyses of growth rates have been presented in Appendix B.

LITERATURE REVIEW

The effective management of any commercial or game fish species depends upon a thorough knowledge of its life history. Because of its abundance and importance both as a commercial and game species, most aspects of the walleye's life history have been studied and documented in the literature. A survey of some of this literature is presented below.

The walleye, a spring spawner, usually spawns in April and early May or when water temperatures have risen above 4.5 C. There is considerable evidence suggesting that walleyes exhibit a homing tendency during the spawning season and that there is little intermingling of these spawning populations. That walleyes will seek out previously used spawning areas in preference to other suitable areas has been noted by such North American investigators as Stoudt and Eddy (1939), Eschmeyer (1950), Smith _et al_ (1952), Rawson 1957a) and Forney (1963). This homing behaviour and the lack of intermingling of spawning stocks has also been observed for a similar European species of percid (_Lucioperca_ sp) in Lake Vänern, Sweden, by Puke (1951). Crowe (1962) examined and found a similar behaviour in spawning walleyes of northern Green Bay, Lake Michigan. Olson and Scidmore (1962), conducting a more intensive investigation on Many Point Lake, Minnesota, concluded "... that the return of some walleyes to the same spawning site is of a non-random nature" and "... that this return is most likely a homing behavior". Extensive intermingling of walleyes on spawning areas has been observed by Whitney, cited by Olson and

Scidmore (1962), in Clear Lake, Iowa. Here, however, it is important to point out that spawning areas were separated by less than 2 miles, whereas in other studies they were separated by greater distances.

Male walleyes are first to arrive on the spawning grounds, and even after the females arrive, predominate in the spawning run. Spawning occurs in streams, along wave - washed shores of lakes, or over shoals, and generally in water less than one meter deep. The variety of substrates over which a number of investigators have observed walleye spawning is listed by Eschmeyer (1950). It would appear from this review that the preferred substrate is a gravel-rubble bottom with a good flow or circulation of water. Eschmeyer also made observations on the nocturnal spawning behaviour of walleyes. A more detailed study of the walleye's spawning behaviour has been made by Ellis and Giles (1965). Eschmeyer (1950) further determined egg production in walleyes and discussed the mortality of spawned eggs. Other studies regarding mortality in walleye eggs are those by Johnson (1961), who examined the survival of naturally spawned eggs on five different substrates, and Smith and Kramer (1963), who determined the effects of pulp mill effluents on walleye eggs.

According to Eschmeyer (1950) and Rawson (1957a), males are last to leave the spawning sites. Rawson (1957a) observed that in the post-spawning movement, walleyes moved back into Lac la Ronge, but they concentrated inshore near the stream in which they had spawned. In July, he found they were moving into deeper waters and scattering, thus intermingling with fish from other spawning runs. By August a 1:1 sex ratio was restored in the lake. The wide dispersion and intermingling of runs following spawning has also been observed in walleye populations studied by Stoudt and Eddy (1939), Eschmeyer (1950), Smith et al (1952), Crowe (1962), Olson and Scidmore (1962), and Crowe et al (1963). Forney (1963) closely examined the dispersion of three spawning runs of Oneida Lake walleyes and from his study concluded that no random mixing of these spawning populations occurred in late summer.

The above tagging studies among others have shown that walleyes will move extensively and are capable of migrating great distances. Doan (1942) found that one tagged walleye in Lake Erie had travelled about 200 miles before being recaptured. Wolfert (1963), studying the movement of walleyes tagged as yearlings in the same lake, noted that 10 fish (2 percent of the total recaptures in 3 years) had travelled over 110 miles. One of these fish was recaptured in Saginaw Bay, Lake Huron, 236 miles from its point of release. Tagged walleyes released above dams will frequently be recaptured below them (Eschmeyer, 1950 and Desrochers, 1953). Migrations over great distances are exceptions, however, since only a few such "wandering" walleyes are captured. Average distances travelled by walleyes appears to be less than 50 miles.

With regard to the bathymetric distribution of walleyes, Deason (1933) stated that they were infrequently taken in appreciable numbers from water deeper than 8 fathoms (15 m). Hile and Juday (1941), in an investigation of the depth distribution for fishes in northeastern Wisconsin lakes, found walleyes to be abundant at 7 m in one thermally stratified lake. In another lake, they captured walleyes at all depths at which ciscoes occurred. The ciscoes were gill netted in water as shallow as 8 m, but were most prevalent below the thermocline at depths between 15 and 25 m. Rawson (1957a) observed that the average depth at which most Lac la Ronge walleyes were captured during the whole summer was less than 15 m. In August, however, the fish had moved into water 15 to 20 m deep. He attributed this movement to the walleye's pursuit of its "favorite" food item, ciscoes, which, during August, were abundant at similar depths. During the winter, Rawson further noted that walleyes inhabited the shallow bay areas of the lake. As to the daily activity patterns of walleyes, they are known to be most active during dusk and dawn when they are feeding inshore (Carlander and Cleary, 1949).

Upon hatching, walleye fry leave the spawning grounds for open water where they lead a pelagic existence until about mid-summer (Eschmeyer, 1950; Forney, 1966; and Houde, 1967). By mid-summer, when they have reached a length of approximately 30 mm (about 1 to 2 inches), the fry begin moving inshore and may be found in areas less than one meter deep. Both Raney and Lachner (1942) and Eschmeyer (1950) have observed that young walleyes school in shallow weedy areas in July and as summer progresses move gradually into deeper water. By September, young walleyes are no longer inshore.

The food habits of walleyes have received attention from numerous researchers. Most authors concerned with first-year growth made quantitative studies on the feeding habits of walleye fry. Another investigation pertaining to food of first-year walleyes is that by

Wolfert (1964). A recent study by Houde (1967) examines feeding and food selection of larval walleyes during their first six weeks of life. Results obtained by these studies illustrate the diversity of animal species which constitute the diet of young walleyes. In general, however, walleyes in the early stages of life tend to feed mostly on crustacean plankton and convert later to a diet of insects and finally fish, although variability occurs in the time at which fish become predominant in the diet.

Quantitative observations on feeding habits of sub-adult and adult walleyes have been made by Eschmeyer (1950), Rawson (1957b), Priegal (1963), Fedoruk (1966), and others. Other workers have given descriptive accounts of the walleye's feeding habits (Clemens et al, 1923 and 1924; Doan, 1942; Mendis, 1956; Rawson and Atton, 1953; Rawson, 1957a, 1959, 1960; Niemuth et al, 1962; and Reed, 1962). Seaburg and Moyle (1964) briefly mention digestive rates in walleyes. A review of the variety of organisms which were found to be utilized as food by walleyes is given by Eschmeyer (1950).

Of the many studies which have been conducted on the biology of the walleye, a large number have considered the growth of the fish. Although earlier biologists had made brief observations on walleye growth, it appears that the more intensive growth studies, i.e. those employing the scales to determine age, were first done on Great Lakes' walleyes (Adamstone, 1922; Hart, 1928; and Deason, 1933). Most investigations concerning growth in walleye populations have been in the USA (Schloemer and Lorch, 1942; Carlander, 1945 and 1948; Cleary, 1949;

Stroud, 1949; Eschmeyer, 1950; Patterson, 1953; Hile, 1954; Carlander and Whitney, 1961; Smith and Pycha, 1961; and Forney, 1965). In central Canada, very few detailed works have been done on the walleye's growth. One of the more noteworthy studies on growth of walleyes in central Canada was that made by Rawson (1957a) on walleyes of Lac la Ronge, Saskatchewan. Some surveys of commercially exploited lakes in northern Saskatchewan have included observations on walleye growth (Rawson and Atton, 1953; Mendis, 1956; and Rawson, 1957b, 1959, and 1960). Reed (1962) recorded some growth data for walleyes in the Saskatchewan River in Saskatchewan. Bajkov (1930) listed data which he states were representative of the average growth of walleyes in the prairie provinces. Kennedy (1948 and 1949) examined the growth of walleyes in Lake Manitoba. Two other studies, by Newton (1935) and Fedøruk (1961), have been conducted on walleyes occurring in Manitoba. Findings of the above authors, among other, point to the tremendous variability in growth rates for walleyes of different populations. This population variability is extensively documented by Carlander (1948) and Eschmeyer (1950). In general, growth rates of walleyes decreased as populations occurred farther northward. Deviations from this trend were noted and were probably caused by variations in habitat, food, and inter-relationships of the walleye with other fish species. It has also been observed that commercial exploitation can influence walleye growth (Kennedy, 1948).

Growth of young-of-the-year walleyes has been specifically examined by some authors. The first extensive study of this nature was done by Raney and Lachner (1942) on Oneida Lake. Eschmeyer (1950) also considered first-year growth in walleyes of Lake Gogebic, Michigan. Time of spawning and hatching, size of brood, water temperature, abundance of predators, and food organisms, particularly young yellow perch, all affect the first-year growth of walleyes (Dobie, 1956; Forney, 1966; Maloney and Johnson, 1957; Smith and Moyle, 1945; and Smith and Pycha, 1960).

Relatively little research on the biology of walleyes or other fish species occurring in Cedar Lake and Moose Lake has been done previous to the present study. In 1961, personnel from the Fisheries Branch, Department of Mines and Natural Resources, Province of Manitoba, conducted a tagging program on the more important commercial fish species in Cedar Lake and Moose Lake to determine rates of exploitation, and the degree of fish movement within and between the two lakes and adjacent waters. It was observed that walleyes in both lakes, in comparison to the other fish species, were subjected to the highest rate of commercial exploitation. Results of the study further indicated that Moose Lake walleyes remained in the lake, whereas recoveries of walleyes tagged in Cedar Lake shortly after the spawning season were made in both Lake Winnipeg and the Saskatchewan River (L.A. Sunde, personal communication). Walleyes in Cedar Lake therefore may not be a discrete population. Fisheries Branch personnel have also taken periodic samples of the commercial catches from both lakes.

Other biological investigations not specifically dealing with fish have been made on Cedar Lake and Moose Lake. In 1960, biologists from the U.S. Fish and Wildlife Service with assistance from provincial biologists briefly surveyed the fish resources, as well as wildlife resources, of the area (Anon., 1961). Webb (1965) studied limnology and benthic production of the southern basin of Cedar Lake in 1962.

DESCRIPTION OF THE AREA

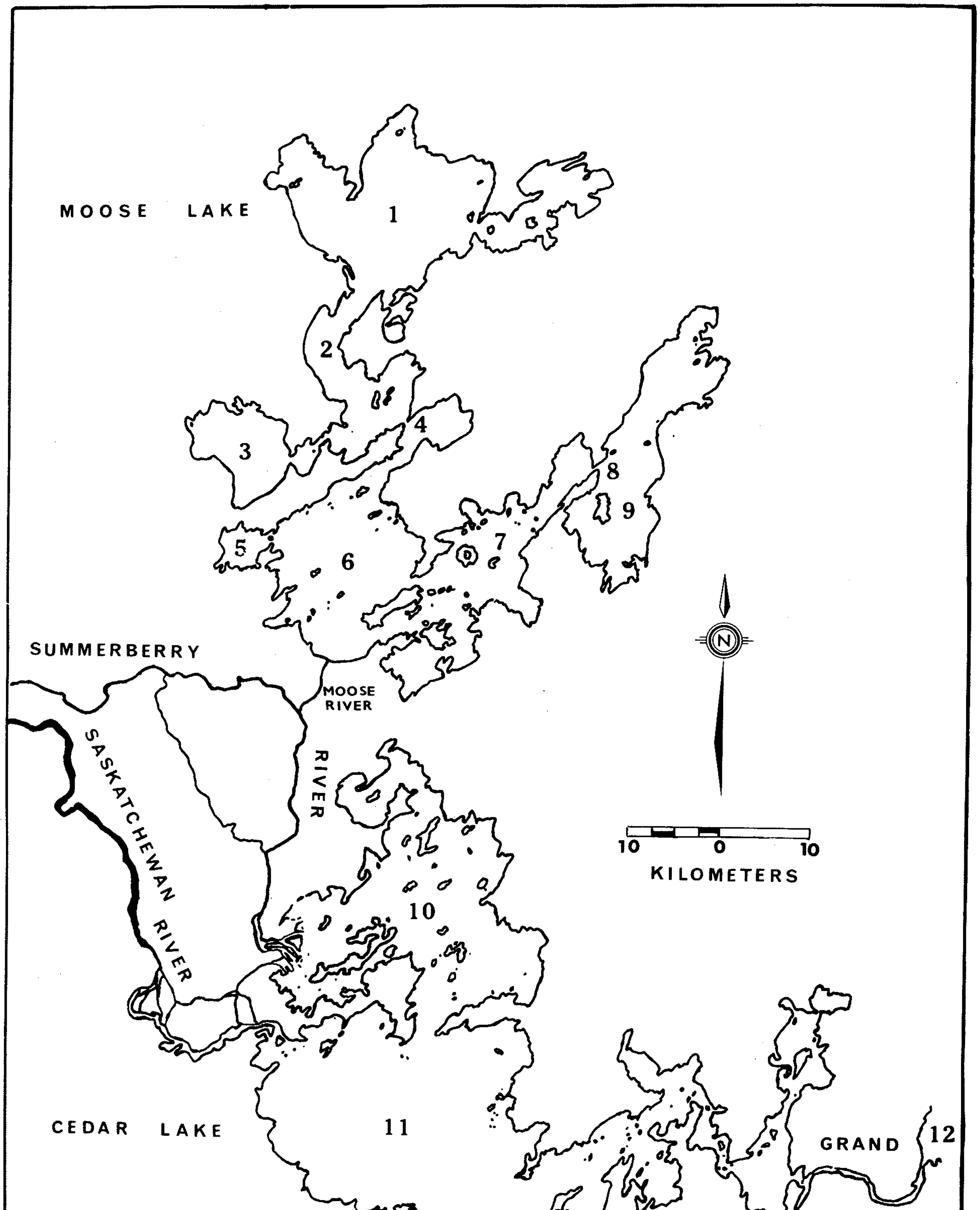
Cedar Lake and Moose Lake lie in the west-central part of Manitoba near the extreme eastern end of the Saskatchewan River Drainage Basin (Fig. 1). At The Pas, the Saskatchewan River breaks through a glacial end moraine, The Pas Moraine, and in the Summerberry Marsh gives off a major channel, the Summerberry River. These two rivers drain into Lake Winnipeg via Cedar Lake, Cross Lake, and the Grand Rapids. Both lakes border the eastern edge of the Summerberry Marsh.

Cedar Lake (53° 15'N, 100° 15'W) is located in the Interlake - Westlake Plain. This region consists of Silurian dolomite most of which is overlaid by calcareous glacial till. Most of Moose Lake (54° 00'N, 100° 10'W), north of Cedar Lake, lies within the Saskatchewan Delta. This is the largest lake in the area. The southwestern edge of the lake encroaches upon the Interlake-Westlake Plain. The Saskatchewan Delta contains alluvial clay deposits which cover Ordovician limestone. Relief of the terrain in both these regions is slight (Weir, 1960).

Cedar Lake has an area of 129,499 hectares (Anon., 1961) and is divided into two sections; a shallow north arm, and a deeper main basin (Fig. 2). Average depth of the north arm is about 3 m while its maximum depth is 5.5 m (Webb, 1965). It is shallowest at the outlet of the Summerberry River. The main basin has a mean depth of 5.8 m. At the shallow west end, the main basin of Cedar Lake receives the Saskatchewan River. From here the bottom slopes gradually to a maximum depth of 10 m near the west end of the basin (Webb, 1965). The main basin

FIGURE 2. Map of Cedar and Moose Lakes showing their general features.

1. North Arm of Moose Lake
2. Burntwood Channel
3. Opuskow Bay
4. North Arm Narrows
5. Crossing Bay
6. Big Wave Bay
7. Pickerel Channel
8. East Arm Narrows
9. East Arm of Moose Lake
10. North Cedar Lake
11. South Cedar Lake
12. Lake Winnipeg


MOOSE LAKE
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SUMMERBERRY
MOOSE RIVER
RIVER
SASKATCHEWAN RIVER
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KILOMETERS
N
CEDAR LAKE
11
GRAND
12
RAPIDS
CROSS LAKE

drains into a long arm which in turn discharges into Cross Lake.

Moose Lake, which has an area of 155,804 hectares (Anon., 1961), is broken up into a number of basins. It can be divided into three major units; the North Arm, Big Wave Bay, and the East Arm. These are each separated from one another by a channel and a narrows (Fig. 2). Two larger bays are Opuskow Bay off the south-west end of Burntwood Channel and Crossing Bay off the western edge of Big Wave Bay. Moose River links the Summerberry River to the southwest corner of Big Wave Bay. Direction of flow in Moose River varies in accordance with water levels in the lake and the Summerberry River. A number of smaller streams, which drain surrounding marshes, flow into Moose Lake, The East Arm, which is the deepest part of the lake, has a maximum depth of 19.8 m. Big Wave Bay has a fairly uniform depth of 6.1 m, but is shallow near the mouth of Moose River. Pickerel Channel, joining Big Wave Bay to the East Arm, has a maximum depth of 12 m midway between the two basins. The North Arm, Burntwood Channel, and Opuskow Bay are very shallow. Maximum depth of the North Arm is 4.3 m. Average depth of the Opuskow Bay - Burntwood Channel area is approximately 2 m.

The ice-free period for both lakes generally extends from mid-May to November. From the time of break-up on Cedar Lake in 1962, surface water temperatures rose to a high of about 21 C by July 31 (Webb, 1965). Surface water temperatures of Moose Lake in 1960 were very similar to those of Cedar Lake (Anon., 1961). Dissolved oxygen concentrations in both lakes are high during the summer. Webb (1965) found that the mid-summer oxygen concentration of Cedar Lake in 1962 was about 90 percent of the air saturation value. No summer stratification of temperature or oxygen content occurs in either lake because of thorough mixing brought about by the wind. Rooted aquatic vegetation is abundant in sheltered areas, particularly in the shallow northern portions of each lake. Exposed shorelines of both lakes are subject to severe wave action and consequently each lake has beaches of coarse gravel, limestone slabs, and boulders.

Webb (1965) classified Cedar Lake as a eutrophic lake. Since the topography surrounding Cedar Lake and Moose Lake is similar, it is expected that both lakes would have a similar trophic nature; however, parts of Moose Lake, i.e. the northern end of Pickerel Channel and the East Arm, have been classed as oligotrophic (Anon., 1961).

COLLECTION OF DATA AND METHODS

The biological survey conducted during the summers of 1962 to 1964 consisted of two phases; a systematic study of the limnology of each lake, and a program of experimental gill net fishing. In 1962, the survey was concentrated on Cedar Lake, while in 1963, it was moved to Moose Lake. During the summer of 1964, each lake was surveyed for alternating bi-weekly periods. The data utilized for the age and growth study of walleyes were extracted from these annual surveys.

Experimental Gill Netting

Gill nets employed in the survey were constructed of white woven-nylon webbing. Mesh sizes ranging from 3.8 to 13.3 cm (stretched measure) were used in the experimental gangs. Composition of the gangs varied with respect to the number, length and mesh size of the nets. Most nets were 45.7 m in length. Nets were joined, in order of increasing mesh size, by a sideline in a bridle or halter-like arrangement. This method of joining left a space of about 5 m between nets. Often additional sections of net (91.4 m) were set nearby the experimental gang. Catches from these additional nets were added to the catch from the same mesh size nets included in the experimental gang. In 1964, some of the sets were made up of only one mesh size. All sets were made on the bottom. Inshore sets were made at right angles to the shoreline with the smallest mesh on the inshore end. The duration of most sets was somewhat less than a day (18 to 20 hr). On occasions nets remained in the water longer. In two instances in

Cedar Lake they were lifted after two days. In one of these two day sets, the additional nets were removed after one day while the experimental gang was left for two days. The nets could not be lifted after a specific length of time because bad weather often hampered lifting the nets. No record was kept of the exact time each set lasted. Details of each net set are given in Tables A-I and A-II of Appendix A.

Twenty-five net sets were made in Cedar Lake of which four were made in 1963. Thirty-six sets were made in Moose Lake and three of these sets were made in 1962. Most sets in both lakes were made in areas open to commercial fishing. In 1963 and 1964, a total of fifteen sets were made in the East Arm of Moose Lake, which was then closed to summer fishing. No experimental netting was done in the area north of the North Arm Narrows of Moose Lake, and only four sets were made in the northern section of Cedar Lake.

A total of 1279 walleyes was captured in experimental gill nets; 764 were taken from Cedar Lake and 515 from Moose Lake (see Tables A-III and A-IV). The length-frequency distribution of walleyes captured in each mesh are presented for each lake in Tables A-V and A-VI. Gill nets which most effectively captured walleyes were of mesh sizes 5.1 to 10.8 cm (stretched measure).

Commercial Catch Samples

During the study period, commercial catches of walleyes from both lakes were poorly sampled. In June, 1962, 198 walleyes were sampled from the catches of two commercial fishermen on Cedar Lake.