Life history of the grass pickerel (Esox americanus vermiculatus) in southeastern Wisconsin. Number 37 1966

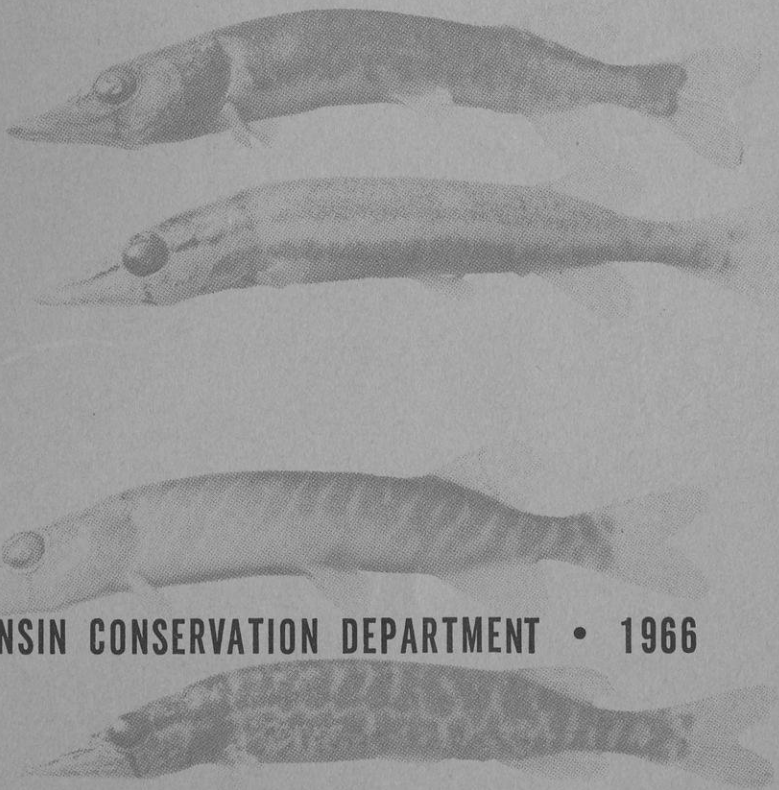
Kleinert, Stanton J.; Mraz, Donald

Madison, Wisconsin: Wisconsin Conservation Department, 1966

LIFE HISTORY OF THE GRASS PICKEREL

(Esox americanus vermiculatus)

IN SOUTHEASTERN WISCONSIN



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LIFE HISTORY OF THE GRASS PICKEREL (Esox americanus vermiculatus) IN SOUTHEASTERN WISCONSIN

by

Stanton J. Kleinert and Donald Mraz

Technical Bulletin Number 37

WISCONSIN CONSERVATION DEPARTMENT
MADISON, WISCONSIN 53701

1966

2500-28

ACKNOWLEDGMENTS

Thanks are due Conservation Department personnel Spencer Chapman and Lee Jones who helped gather field data; Leon Johnson who photographed the northern pike and grass pickerel for comparison studies; Thomas Wirth and Lyle Christenson who reviewed the manuscript; and Wilbur Byam, Francis Paulin, Stanley Kmiotek, and other field personnel who provided fishery survey information. Thanks are also due Dr. George Becker of Wisconsin State University at Stevens Point who furnished ichthyological survey information from the Lower Wisconsin River.

This research was supported in part from funds supplied by the Federal Aid to Wildlife Restoration Act, under Dingell-Johnson project F60R.

Edited by Ruth L. Hine

CONTENTS

INTRODUCTION

Three species of the genus *Esox* occur in Wisconsin: the muskellunge, *Esox masquinongy,* the northern pike, *Esox lucius,* and the grass pickerel, *Esox americanus vermiculatus.* Muskellunge are chiefly confined to northern Wisconsin, while northern pike occur statewide. Grass pickerel have a southern distribution in the state, although in recent years the species has become established in some waters in northeastern Wisconsin. The first two species, because of their large size and desirability to the angler, have been the object of research studies and substantial fish management effort in the form of stocking and angling restrictions. Until the present paper, study of pickerel in Wisconsin has been confined to observations of distribution and habitat.

Cahn (1927) observed grass pickerel in the headwaters of the Fox River in Waukesha County, but made no mention of their occurrence in other southeastern Wisconsin counties. Greene (1935) extended the distribution to include Kenosha, Milwaukee, Racine, and Walworth Counties, and the Mississippi River in Southwestern Wisconsin. He described pickerel as being fish of sluggish, weedy areas, in small to moderate-sized streams.

Today, grass pickerel are known to occur along the lower Wisconsin River, in ten southern counties, and in Vilas and Oneida Counties in northern Wisconsin. Although grass pickerel are not widely distributed in the state, the species does reach high population levels in certain areas.

Due to its small girth, the little pickerel is not easily taken in fyke nets or large-mesh seines commonly used in fish survey work. For this reason their presence and abundance may go undetected. Pleasant Lake fisheries surveys in 1952 employing a 1,000-by-15-foot seine with a mesh stretch of 1½ inches, and in 1958 employing 1½-inch stretched-mesh fyke nets caught only 3 pickerel. An abundant pickerel population was not noted until Pleasant Lake was first electrofished in the fall of 1961. Subsequent electrofishing surveys of lakes — Lakes Beulah, Eagle Spring, Upper Phantom and Pickerel located within a 26-mile radius of Pleasant Lake — similarly revealed high pickerel population levels.

Generally, the species has received little attention until Crossman (1962) documented the biology of grass pickerel in Jones Creek, Leeds County, Ontario, summarizing his work and the contributions of other workers in one monograph. The present study, conducted mainly at Pleasant Lake in Walworth County, also treats the biology of the pickerel, departing from past studies by investigating the early life history and population levels.

The general objective of the study was to determine the ecological role of grass pickerel in southeastern Wisconsin because of concern over reportedly declining northern pike populations in this area of the state. To meet this objective, a pickerel life history study was required to provide information on the relative abundance, age and growth, spawning and nursery requirements, and food at all stages of life. In addition, grass pickerel and northern pike life histories were compared to determine interspecies competition.

Pleasant Lake was chosen as the principal study area due to its relatively small size (138 acres) and landlocked position in southeastern Wisconsin's pickerel range. The study extended from September, 1962 to October, 1965. During this period pickerel population estimates were made at Pleasant Lake during fall electrofishing surveys. The lake was netted each spring to detect the time and location of spawning. Later, the nursery areas were sampled for eggs, fry and fingerlings to detect the development and food of the young. Age and growth data were secured by scale analysis and recapture of marked, known-age fish.

Limited electrofishing surveys were conducted at Lakes Beulah, Denoon, Eagle Spring, Upper Phantom, Pickerel and Ripley to provide catch-rate measures of pickerel abundance and to provide pickerel for age, growth and food studies. The number of mature eggs contained in spawning females from Pleasant and Rock Lakes was determined. Spawn taken from Eagle Spring Lake and Lake Ripley pickerel was hatched at the Delafield Station. The young were reared in muslin enclosures in the Delafield Ponds providing fry and fingerlings for identification comparisons with northern pike reared at the same time. Pickerel and northern pike brood fish were reared together in three ponds at Delafield to see if hybridization would occur and to determine the growth and production of fingerlings of both species in the same environment. Pickerel and northern pike fry were reared together in two ponds at Delafield to determine the production of fingerlings resulting from known numbers of fry.

Life history information was also obtained on northern pike, present in all study areas but Rock Lake, which furnished interesting comparisons with the parallel life history of grass pickerel.

DESCRIPTION OF THE STUDY AREAS

Pleasant Lake is a landlocked kettle lake situated in Walworth County at the terminus of the Kettle Moraine area of southeastern Wisconsin. The lake covers 138 acres with a maximum depth of 32 feet and an average depth of 15 feet (Fig. 1). The lake basin is roughly circular, the littoral zone being predominantly sand and gravel with

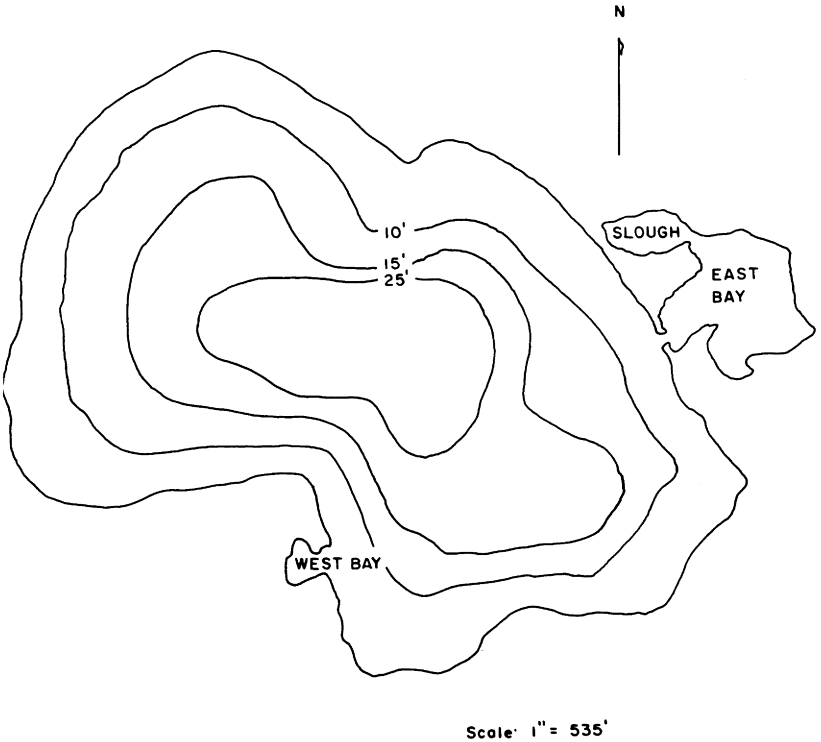


Figure 1. Contour map of Pleasant Lake.

mud occurring along the west and south shores. Joining the east shore by a narrow channel, the east bay and slough form an area of 15 acres, less than 5 feet deep. Pickerel are more abundant in the east bay than in any other location in the lake and the slough is the primary pickerel spawning and nursery area.

During the term of the study, fall 1962 to fall 1965, local precipitation was well below normal; over this period the lake level fluctuated 24 inches. The lowest water levels claimed 10 acres of shallow, vegetated habitat, the habitat preferred by grass pickerel, leaving a third of the east bay, the slough, the west bay, and portions of the lake's shoreline dry during the summer, fall, and winter of 1964 and 1965.

In periods of low precipitation, the east bay retains most of its water, while the slough becomes dry. The east bay has a silt bottom while much of the slough has a peat bottom. Both areas receive leaves and twigs from the wooded shoreline, forming the surface substrate in early spring during the pickerel spawning run. The first vegetation to become noticeably abundant is the moss, *Dreplanoclaudus* spp., which appeared in dense growths in the slough in the early springs of 1963

and 1964, but rarely occurred in the bay and was never noticed in other parts of the lake. As spring progresses, both bay and slough support water lilies, *Nymphæa tuberosa* and *Nuphar advena,* pondweeds, *Potamogeton* sp., filamentous algæ, and cattails, *Typha latifolia.* In the spring of 1965, following the dry conditions of the previous year, the sedge *Eleocharis intermedia* became established along the shallow margins of both the bay and the slough.

Water samples were collected from the lake proper, the east bay, and the slough, on April 19, 1965, five days after the ice had left the lake. Analysis showed Pleasant Lake to be a clear water lake of average fertility for southeastern Wisconsin lakes, having a pH of 8.0, total alkalinity of 170 p.p.m., total phosphorus 0.25 p.p.m., and specific conductance 348 micromhos (Table 1). The east bay and slough were quite dilute, having received considerable snow-melt runoff, yet the products of leaching (iron, ammonia nitrogen, Kjeldahl nitrogen, and color) from the marsh vegetation and the drainage area were higher in the slough. The slough showed a pH value of 7.3, compared to 8.0 for the bay and the lake.

Panfish, predominantly bluegill, *Lepomis macrochirus,* provide most of Pleasant Lake's sport fishery. Largemouth bass, *Micropterus salmoides,* and northern pike, *Esox lucius,* are caught in limited numbers. Walleye, *Stizostedion vitreum vitreum,* have been stocked on several occasions, but have failed to reproduce; only a few individuals remain.

Lakes Pickerel (27 acres), Beulah (570 acres), Denoon (162 acres),

TABLE 1

Water Analysis Data for Pleasant Lake, April 19, 1965

Measurement	Lake Proper	East Bay	Slough
pH	8.0	8.0	7.3
Total alkalinity	170	98	52
Specific conductance	348	197	118
Fe (total)	0.02	0.02	0.08
Cl^-	5.4	3.4	2.6
SO_4^{--}	47.5	38.0	44.3
NH_3-N	0.03	0.03	0.06
K-N	0.26	0.21	0.42
NO_3-N	0.08	0.06	0.07
PO_4(D)	0.02	0.02	0.02
PO_4(T)	0.25	0.02	0.05
Ca^{++}	24.4	15.8	10.0
Mg^{++}	24.4	16.0	8.8
Na^+	2.44	1.84	1.00
K^+	1.52	1.56	1.64
Color	10	15	45

Units are p.p.m. with the exception of specific conductance (micromhos) and pH. Color is based on the platinum-cobalt scale with 1 unit equal to 1 mg. platinum per liter.

Aerial view of Delafield ponds.

Ripley (428 acres), and Upper Phantom (111 acres), are natural drainage lakes; the latter four have been raised above former levels by dams. Eagle Spring Lake (227 acres) is a shallow impoundment of the Mukwonago River. All of these lakes are fertile, hard-water lakes typical of the region. Each lake has a large littoral zone characterized by soft bottom sediments and abundant vegetation. Rock Lake (46 acres) is a spring-fed lake managed for rainbow trout, *Salmo gairdneri;* 60 percent of the lake is over 20 feet deep.

The Delafield Ponds resemble natural ponds having a firm bottom overlain with mud. The ponds range in size from 0.5 to 6 acres, are drained yearly, and are supplied with water from Lake Nagawicka, a fertile hard-water lake.

MATERIALS AND METHODS

Grass Pickerel Distribution

The present grass pickerel distribution in southeastern Wisconsin and in Vilas and Oneida Counties of northeastern Wisconsin was determined incidental to fisheries surveys conducted by Wisconsin Conservation Department personnel. This information was assembled through written communication with district fish managers and fish-

eries research biologists in 1963. Recent records of grass pickerel in Dane and Rock Counties in southern Wisconsin were obtained from the University of Wisconsin Museum of Zoology. The occurrence of grass pickerel along the lower Wisconsin River was determined in 1962 by Dr. George Becker of Wisconsin State University at Stevens Point during ichthyological survey investigations. The known distribution of grass pickerel in Wisconsin may be extended as additional survey work is carried out.

Fall Field Work

Pleasant Lake was electrofished seven times each fall from 1962 to 1964, and six times in the fall of 1965. The electrofishing gear consisted of a three-phase 230-volt A.C. generator with three electrodes suspended in the water in triangular fashion. The shocking unit was mounted on a square-end work boat powered by a five-horsepower outboard motor. The boat was driven at slow speed by the operator seated in the stern, while one or two men dipped fish with longhandled dip nets from the front deck.

Shocker surveys were usually conducted at night due to the stillness of the water and the greater visibility beneath the water surface illuminated by four 150-watt floodlights. However, shocker surveys under ideal daylight conditions (bright sun and dead calm) yield as many pickerel. The surveys circuited the perimeter of the lake, covering the shallows to a depth of 8 feet and the East Bay where there was sufficient depth to operate. Exceptions to this course occurred when winds reduced visibility into the water, limiting shocking to the lee side of the lake.

Captured pickerel were measured to the nearest 0.1 inch total length, marked by clipping the tip of the tail, and released. The ratio of marked to unmarked fish in succeeding catches permitted population estimates by the Schnabel (1938) method. In 1962 and 1963, all marked pickerel were released in the center of the lake, yielding a single population estimate. In 1964 and 1965, two population estimates were made: one for the East Bay and one for the lake proper. Fish caught in the East Bay were marked and released there, while fish caught in the main lake were given a different mark and released in the center of the lake.

All fish used to determine the length-weight relationship were collected in the fall of 1963. Weights were read to the nearest gram.

Scales were taken from the area midway between the lateral line and the anterior base of the dorsal fin. Scale impressions were made in cellulose acetate and examined at a magnification of x43. Although scales from northern pike and muskellunge are difficult to age, the pickerel scales presented little problem. The samples of pickerel in

this study were all collected from late September to mid-October and growth for the year is assumed to be complete. The number of growing seasons completed by each fish is actually one greater than the number of annuli. To validate scale-read age data, pickerel fingerlings marked with a left pelvic fin-clip were stocked in September 1963 in Pleasant Lake and later recaptured during spring and fall surveys to provide known-age growth data.

Pickerel studies at Pleasant Lake were augmented by studies at other lakes. A combined sample of 137 pickerel from Lakes Beulah, Eagle Spring, Upper Phantom, Pickerel, and Ripley was caught during September-October shocker surveys 1962-64, preserved in 10 percent formalin, and later used for age, growth and food studies. In October of 1962 a sample of 143 pickerel from Eagle Spring Lake was weighed and measured for length-weight relationships. In three collections, made at eight-hour intervals September 20-21, 1963 from Pickerel Lake, 72 pickerel were taken. Stomach analyses of these fish provided information on the feeding periodicity over a 24-hour period.

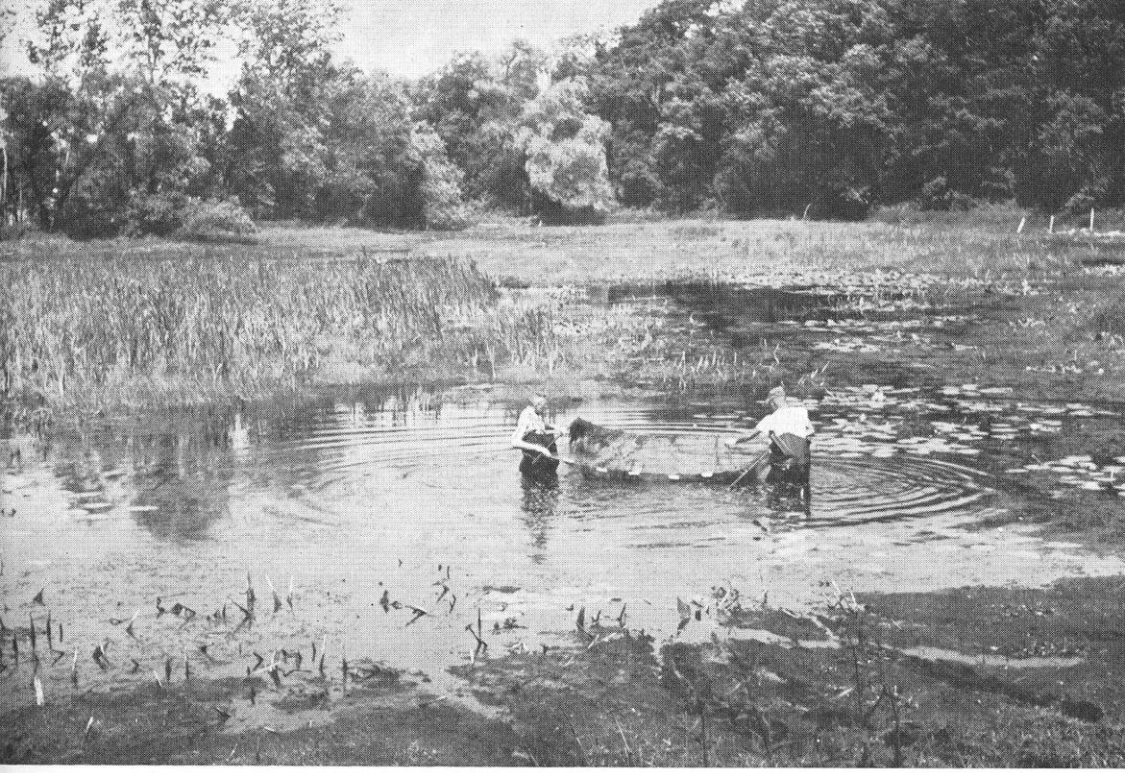
Spring and Summer Field Work

Fyke nets were set at Pleasant Lake as soon as the ice disappeared in April 1963, March 1964 and April 1965, and fished for a period of about two to three weeks. Each year three 1½-inch stretched mesh nets were set in the main lake and one 1-inch stretched mesh net was set in the East Bay. The larger webbing worked well for northern pike, but failed to hold pickerel less than about 10 inches, while the smaller webbing retained most pickerel greater than 7 inches.

Pickerel caught in the nets were sexed, measured, tail notched, and released. The time when females were gravid was noted and compared with water temperatures recorded by Taylor maximum-minimum thermometers at the netting sites. The ratio of marked to unmarked pickerel in the net catches in the East Bay permitted Schnabel population estimates of the spawning population in 1963, but low water levels in the East Bay in the spring of 1964 and 1965 made netting difficult and a similar population estimate could not be made.

Calculations of the number of mature eggs contained in a combined sample of nine ripe females from Pleasant and Rock Lakes were made in 1963 by counting the number of mature eggs in single cubic centimeter sections from anterior, medial, and posterior regions of the ovary. These three counts were averaged and then projected to include the total volume of the ovary.

As the ice left the slough, observations were initiated to detect pickerel spawning activity. Areas where pickerel congregated were determined, then searched for eggs and fry and later seined for fingerlings.



Seining for pickerel fingerlings in the slough at Pleasant Lake.

Fingerlings were preserved in 10 percent formalin for later stomach analysis.

During the period of May and June, when pickerel fingerlings were being collected in the slough, zooplankton samples were taken. In 1963 and 1965, zooplankters were taken by pulling a number 2 silk-cone net a measured distance through the water. In 1964, low water levels and dense vegetation necessitated changing this procedure to dipping and pouring a known volume of water through a number 2 silk-cone net. Single cubic centimeter measures from the samples were placed in a Sedgwick-Rafter cell and viewed under the binocular microscope, permitting the zooplankters to be identified and counted. Densities of zooplankters were estimated by averaging the counts of three 1 cc. measures from each water sample. The averaged count derived for 1 cc. of sample was then projected to enumerate the number of zooplankters in one liter of pond water. Zooplankton found in the slough, as determined by the net samples, were then compared with zooplankton found in fingerling stomachs.

DISTRIBUTION IN WISCONSIN

The occurrence of grass pickerel in southern Wisconsin has been generally determined, but has not been worked out in detail. This

species is known to occur in Milwaukee, Racine, Kenosha, Waukesha, Walworth, Jefferson, Dane and Rock Counties. Although most waters have been surveyed with fyke nets or large-mesh seines, less than 25 of 138 lakes found in these six counties have been electrofished.

Within the Rock River drainage, grass pickerel have been found in the Yahara, Koshkonong and Bark River systems, but not found in the Oconomowoc River system. Within the Fox River drainage, grass pickerel have been found in the Pewaukee and Mukwonago River systems, and in the Honey Creek system, but have not been found in Lakes Como and Geneva, which flow into the Fox River via the White River. The occurrence of grass pickerel within each local drainage system can be sporadic, as evidenced by the presence of pickerel in the Nehmahbin Lakes and their apparent absence from Lake Nagawicka located just above the Nehmahbin Lakes on the Bark River chain. The southern Wisconsin range is directly linked to connections with the Mississippi via the Fox, Des Plaines, Rock, and Wisconsin Rivers.

Northern pike are more widely distributed in southeastern Wisconsin, occurring in all waters mentioned above.

Wisconsin Conservation Department fisheries surveys in Vilas and Oneida Counties of northeastern Wisconsin have shown grass pickerel are present in Partridge, High, and Fishtrap Lakes and in the Grassy Creek flowage and Minocqua thoroughfare. Since these waters are connected with various other bodies of water, it is reasonable to assume a wider distribution. The northern occurrence is isolated and is believed due to an accidental introduction during fish transfer operations in the early 1940's.

During the summer of 1962, Dr. George Becker sampled the waters of the lower Wisconsin River and its tributaries. Grass pickerel were found at six stations along the lower Wisconsin River and at six stations located in tributaries of the lower Wisconsin River, and from Glass Lake, a slough of the Mississippi River (George Becker, in litt., June 18, 1963). The stations cover the Wisconsin River system from below Sauk City to the Mississippi River. Becker noted that where grass pickerel were taken, northern pike were also taken. Fifteen collecting stations located along the lower Wisconsin River yielded neither species.

FALL POPULATION ESTIMATES

During the fall shocker surveys in Pleasant Lake, most pickerel were caught along the east, southeast and northeast shorelines of the lake, and were abundant in the shallow East Bay. These areas have a soft bottom and abundant vegetation. Few pickerel were found along the remaining shoreline, which had a sparsely vegetated gravel or sand

bottom. In 1962 and 1963 over half of the pickerel caught came from the East Bay. By September 1964, declining water levels had reduced the East Bay to 60 percent of its former size and only a third of the pickerel caught came from the bay. In 1965, low water levels also prevailed in the East Bay and only a fourth of the pickerel taken in the fall shocker survey came from the bay. The slough joining the East Bay also held pickerel, but was inaccessible to the shocker, completely drying up in the summer of 1964.

The 1962 survey indicated almost all pickerel 4 to 7 inches long (young-of-the-year length range) came from the East Bay. Counts of pickerel under 7 inches caught by the shocker showed 95.8, 66.7, and 51.3 percent came from the East Bay in 1963, 1964 and 1965, respectively. This evidence corroborated spring observations indicating the East Bay and slough are the main spawning and nursery areas; young-of-the-year pickerel born here tend to remain the first summer of life, showing little dispersal about the lake.

Lengths of 1,609 pickerel caught during the three falls of electrofishing ranged from 3.7 to 14.0 inches. All four years the length-frequency distributions were bimodal, peaking at about 5.0 and 8.2 inches in 1962, 5.7 and 8.2 inches in 1963, 5.5 and 9.2 inches in 1964, and 5.3 and 9.5 inches in 1965 (Table 2 and Fig. 2). These peaks correspond with the young-of-the-year and yearling length ranges in 1962 and 1963, and to young-of-the-year and yearling to 2-year-old length ranges in 1964 and 1965. The major mode occurred in the yearling length range in 1962 and 1963 and in the yearling to 2-year-old length range in 1964 and 1965. Average lengths were 7.4 inches in 1962, 7.2 inches in 1963, 8.4 inches in 1964, and 8.7 inches in 1965. The greater average lengths in 1964 and 1965 reflect the greater proportion of older fish in the populations those years.

Previous pickerel population densities were given by Eschmeyer and Clark (1939), who found 101 and 111 fish per acre in two Michigan ponds, and Carbine and Applegate (1948) who recovered 369 grass pickerel following rotenone poisoning in a 14.8-acre Michigan lake (24.9 per acre) — 81.2 percent of these were young-of-the-year.

Catches of 577, 494, 245, and 297 pickerel with recaptures of 5.2, 5.9, 10.2, and 9.8 percent were used to make population estimates at Pleasant Lake in 1962, 1963, 1964, and 1965. Schnabel estimates for the pickerel population of Pleasant Lake are shown in Table 3, along with the pounds per acre projection for the Schnabel estimates. In the falls of 1962 and 1963 when water levels were high, the number of pickerel per acre in the East Bay was probably at least four times greater than in the falls of 1964 and 1965.

The Schnabel population estimate procedure assumes a random sample is obtained and that marked fish return to the unmarked popu-

TABLE 2

Total Lengths of Grass Pickerel Caught and Recaptured at Pleasant Lake During Fall Electrofishing Surveys, 1962-65

Length Interval in Inches	1962		1963		1964		1965	
	No. Caught	No. Recaps	No. Caught	No. Recaps	No. Caught	No. Recaps	No. Caught	No. Recaps
3.5- 3.9	0	0	1	0	3	0	1	0
4.0- 4.4	18	0	4	0	8	1	5	1
4.5- 4.9	34	1	16	0	7	2	20	0
5.0- 5.4	34	1	72	0	9	0	24	2
5.5- 5.9	16	0	75	0	9	0	14	1
6.0- 6.4	29	0	22	0	5	1	8	1
6.5- 6.9	47	2	15	1	1	0	7	0
7.0- 7.4	80	2	25	1	1	0	0	0
7.5- 7.9	82	9	53	6	12	2	2	0
8.0- 8.4	92	6	78	8	27	3	29	0
8.5- 8.9	86	7	64	3	43	9	26	1
9.0- 9.4	30	0	41	8	49	2	27	6
9.5- 9.9	17	1	17	1	30	2	40	5
10.0-10.4	6	1	2	1	24	2	31	7
10.5-10.9	3	0	5	0	9	1	29	1
11.0-11.4	0	0	1	0	2	0	27	4
11.5-11.9	1	0	1	0	1	0	12	0
12.0-12.4	1	0	0	0	0	0	4	0
12.5-12.9	1	0	0	0	0	0	1	0
13.0-13.4	0	0	1	0	0	0	0	0
13.5-13.9	0	0	1	0	0	0	0	0
14.0-14.4	1	0	0	0	0	0	0	0
Total	578	30	494	29	240	25	297	29

lation following release. Neither of these conditions were satisfactorily evident in the present study. Despite these shortcomings, we believe the data give a true indication of the fluctuations and trends of pickerel abundance over the 4-year period, presenting population information not heretofore available by any other means or method.

The shocker could not operate in water less than 2 feet deep or in dense vegetation, areas where fingerling pickerel are abundant, so the number of fingerling pickerel caught was not proportionate to their true representation in the population. This fact was illustrated by the major mode of the pickerel length-frequency curve, peaking in the yearling length range in 1962 and 1963, and peaking in the yearling to 2-year-old length range in 1964 and 1965, rather than showing the major peak in the young-of-the-year length range at least one of these years, as would be expected.

Recaptures of marked pickerel under 7 inches were rare, as were recaptures of marked pickerel in the East Bay, when released in the main lake. These two phenomena were related as most of the marked East Bay pickerel released in the lake were under 7 inches. Although 66.6 percent of the pickerel marked in 1963 came from the East Bay, only 13.8 percent of the recaptures were taken in the bay. The lake, however, provided 33.4 percent of the marked fish and yielded 86.2

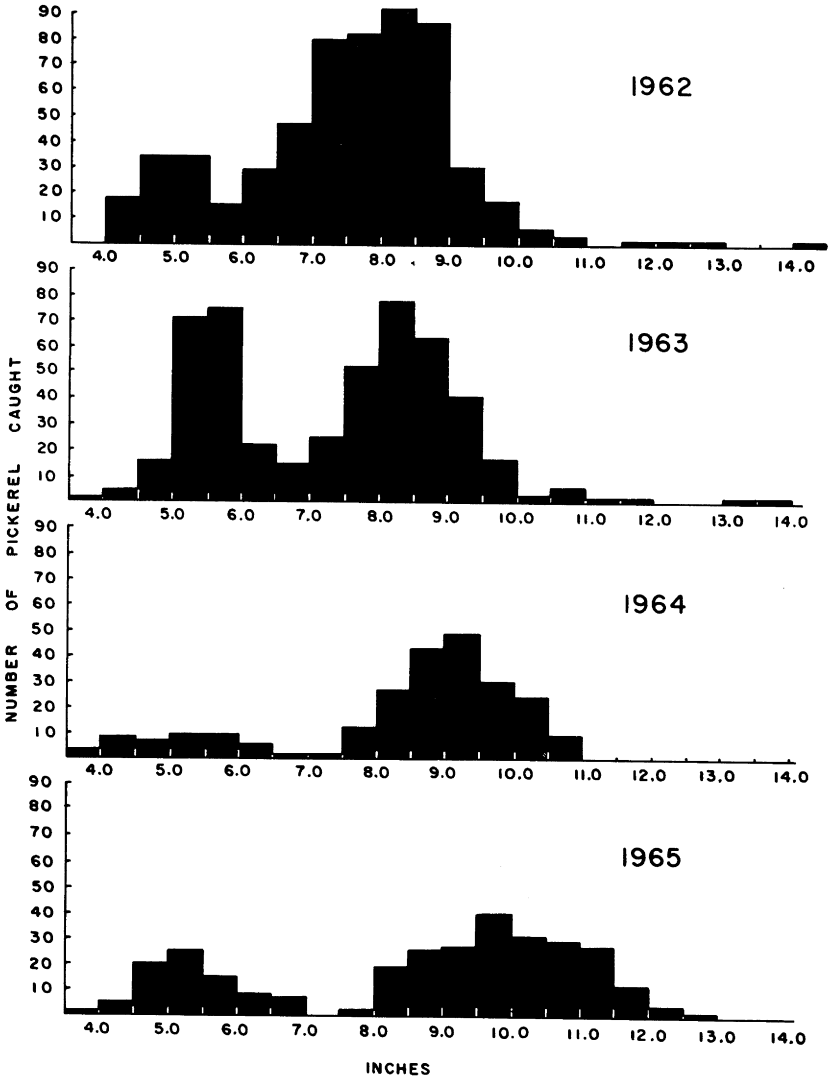


Figure 2. Total length-frequency histograms of grass pickerel caught at Pleasant Lake during fall electrofishing surveys, 1962-65.

percent of the recaptures. In 1963, pickerel under 7 inches represented 41.5 percent of the catch, yet yielded only 3.5 percent of the recaptures. The problem of mixing was overcome when separate population estimates were made for the lake and East Bay in 1964 and 1965, as no mixing between lake and bay fish occurred and pickerel under 7 inches were more equally represented in the length distributions of marked and recaptured fish.

Population bias created by undersampling fingerling pickerel is be-

TABLE 3
Schnabel Population Estimates of Grass Pickerel Present in the Fall in Pleasant Lake, 1962-65

Measurement	Year			
	1962	1963	1964	1965
Number of pickerel and (number per acre)				
Pleasant Lake	5,419 (39.3)	3,121 (22.6)	1,300 (9.4)	1,240 (9.0)
East Bay only	—	—	226	190
Main Lake only	—	—	1,074	1,050
Pounds of pickerel and (pounds per acre)				
Pleasant Lake	483.0 (3.5)	276.0 (2.0)	151.8 (1.1)	193.2 (1.4)
East Bay only	—	—	22.2	17.6
Main Lake only	—	—	129.6	175.6

lieved to have compressed the estimate below the true value each year. Bias caused by the failure of marked fish to return to the East Bay during the 1962-63 population estimate procedure could either compress or inflate the estimate, depending upon the percentage of marked to unmarked fish caught. However, the associated tendency, the poor recapture of pickerel under 7 inches, would tend to inflate the population estimate in 1962 and 1963. Since both factors for compressing and inflating the estimate may have operated in 1962 and 1963, the nature of the estimate error cannot be known. In 1964 and 1965, when undersampling fingerling pickerel was suspected to be the major source of bias, the population error is believed in the direction of underestimation.

Schnabel estimates progressively declined from 1962 to 1965, taking the sharpest drop between 1963 and 1964, indicating the population was declining over this period. Catches of pickerel per hour of electrofishing in Pleasant Lake also reflected a sharp drop between 1963 and 1964 (Table 4). The catch rate declined in spite of the fact that our ability to catch pickerel increased each year as the locations of abundance and technique of netting pickerel were learned. Had our fishing effectiveness remained constant the three years of the study, the catch rate would have shown a more spectacular decline. The reason for the increased catch rate in 1965 over 1964, in spite of similar population estimates the two years, reflects the unusually favorable electrofishing conditions in the fall survey of 1965. In the fall of 1965, the weather was favorable each survey night and no mechanical breakdowns occurred. Our ability to find and catch pickerel had also reached its highest state of efficiency, and larger pickerel most vulnerable to the shocker predominated in the population.

The chief reason for the sharp population decline between 1963 and

TABLE 4

Electrofishing Catch Rates of Grass Pickerel From Southeastern Wisconsin Lakes, 1962-65

Lake	Year	Hours Fished	Avg. No. Caught/Hour	Avg. Length (Inches)
Pleasant	1962	38.0	17.3	7.4
Pleasant	1963	24.0	21.8	7.2
Pleasant	1964	22.5	11.7	8.4
Pleasant	1965	20.0	16.1	8.7
Denoon	1962	3.0	3.3	8.9
Eagle Spring	1962	2.0	73.5	9.4
Upper Phantom	1962	2.0	24.0	7.4
Pickerel	1963	3.0	23.7	6.5
Beulah	1963	5.0	20.4	8.1
Ripley	1964	2.0	7.5	7.4
Total or Average for All Lakes Combined		121.5	17.8	7.8

1964 was the poor 1964 year class. Young-of-the-year pickerel numbered 178 in 1962, 205 in 1963, 42 in 1964, and 78 in 1965. The partial failure of the 1964 and 1965 year classes is believed principally due to declining water levels in 1964 and 1965, stranding many fingerlings and adults in the slough nursery area. Fingerling pickerel could still be seined in the slough in August of both years, even though the slough had become landlocked from the lake and was rapidly drying up. In winter the remaining water in the slough experienced oxygen depletion, eliminating any surviving pickerel.

The estimates of the total poundage of pickerel in Pleasant Lake from 1962 to 1965 showed less change than did the estimates of pickerel numbers. The difference between the highest population estimate of 5,419 in 1962 and the lowest population estimate of 1,240 in 1965 was fourfold, while the poundage estimates of 483.0, 276.0, 151.8, and 193.2 in the successive years of the study showed a threefold variation between the highest and lowest values.

Fall electrofishing catch rates of pickerel from seven southeastern Wisconsin lakes varied from 3.3 fish per hour at Denoon Lake to 73.5 fish per hour at Eagle Spring Lake, averaging 17.8 fish per hour (Table 4). The catch of pickerel per hour in Lakes Eagle Spring, Upper Phantom, Pickerel, and Beulah equalled or exceeded catch rates of pickerel in Pleasant Lake, suggesting these lakes may support pickerel population levels equal to or greater than the estimated populations of Pleasant Lake.

During the four-year study at Pleasant Lake, the northern pike population was believed to be at a very low level in spite of stockings of 500 northern fingerlings each summer from 1962 to 1964. The number of northern pike in Pleasant Lake could not be determined, although

spring netting and fall shocking surveys indicated few adult northern pike present and extremely small year classes. Shocker catches of northern pike exceeding 14 inches amounted to only 15, 18, 18, and 18 fish in the four years of the study; fyke netting during the spawning run yielded only 7, 13, and 26 adult northern pike in 30, 55, and 53 net days in three springs. At Lakes Pleasant, Eagle Spring, Upper Phantom, and Pickerel, pickerel were seen while electrofishing from 5 to 20 times more frequently than were northern pike. At Lakes Beulah and Ripley, pickerel were seen twice as frequently as northern pike. It is not known whether the pickerel - northern pike ratio observed in the shocker surveys reflects a true ratio or whether it is biased by dissimilar vulnerabilities of the two species to electrofishing.

REPRODUCTION

Spawning

Water in the East Bay slough warms before the lake in early spring, and pickerel aggregate as soon as the ice begins to recede. Spawning takes place almost immediately and continues for approximately two weeks, as evidenced by the presence of ripe pickerel in the area and the presence of eggs on the bottom. Although pickerel are most numerous in the slough at spawning time, a few can be seen scattered about the other shorelines and bays, suggesting that spawning occurs in many locations. However, eggs and fry are abundant only in the slough and are difficult to find elsewhere in the lake.

During the spawning period pickerel were most often seen in groups of two to six or more fish in the few inches of water bordering the margin of the slough. Females could often be identified at sight by their bulging abdomens. Pickerel were wary at this time, darting into deeper water when approached by an observer. Numerous attempts were made to observe the spawning behavior during the three springs of the study; however, cloudy weather, wind and the wariness of the fish prevented observation of the spawning act.

A fyke net was set as soon as open water developed in the East Bay in 1963, 1964 and 1965. In 1963 the bay opened the first week in April; a warming trend continued uninterrupted by freezing weather. Ripe females were taken the first day the net was tended on April 5 (water temperature: low 48°F., high 53°F.), and were caught until the net was removed on April 12. In 1964 the bay opened during a warming trend in mid-March; however, freezing weather returned, persisting intermittently for three weeks. Ripe females were taken the first day the net was tended on March 16 (water temperature: low 40°F., high 53°F.), and were caught until the net was removed on April 7. In 1965

the bay did not open until the third week in April. Ripe females were taken the first day the net was tended on April 15 (water temperature: low 40°F., high 42°F.) and were taken until the net was removed on April 22. Ripe male and female northern pike were taken with ripe pickerel in the bay fyke net over the 1963, 1964, and 1965 netting periods, indicating the two species share similar spawning dates and locations.

The Schnabel estimate for pickerel in the East Bay spawning run in 1963 was 1,274 fish (23.5% of the previous fall's estimate). This estimate did not include smaller fish as the netting gear failed to hold pickerel under 7 inches. Low water levels in the springs of 1964 and 1965 made recapturing marked pickerel in the spawning area difficult and similar population estimates could not be made.

Sex ratios for spawning populations at Pleasant Lake could not be determined since the netting gear selected larger pickerel, which were predominantly females. Seinings (¼-inch mesh) of pickerel spawning runs in the Lake Ripley inlet caught 12 males and 10 females on March 25, 1964 and 13 males and 10 females on April 1, 1964, suggesting the sexes may be equally represented in the spawning runs.

Both yearling males and females could be sexed in the spring; the males showed milt and the females flowed eggs at spawning time, indicating both sexes mature in the first year of life. McCarraher (1960) noted mature pickerel entering the spawning grounds at 4.0 inches in length.

A combined sample of nine females was caught in Pleasant and Rock Lakes on March 30, 1963, just prior to spawning. Counts of the mature eggs in the ovaries ranged from 843 for a 6.3-inch fish to 4,584 for a 12.8-inch fish (Table 5). Mature eggs were clear, yellow amber in color, and from 1.5 to 2.4 mm. in diameter in contrast to the smaller white opaque immature eggs, also contained in the ovary. The regression of

TABLE 5

Relationship Between Total Length and Number of Mature Eggs for Grass Pickerel Caught Prior to Spawning in Pleasant and Rock Lakes, April, 1963

Total Length in Inches	Projected Count of Mature Eggs	Regression Equation Estimate of Mature Eggs
6.3	843	615
6.6	625	692
8.6	808	1,356
9.5	2,133	1,748
10.3	2,050	2,147
11.2	3,176	2,656
11.5	2,854	2,841
11.7	2,361	2,969
12.8	4,584	3,732

mature egg number on total length was calculated for this group of nine females and is given by Log $N = 0.75474 + 2.54433$ Log L, where (L) represents total length in inches and (N) equals the number of mature eggs.

In addition to mature eggs, the ovaries held immature eggs, constituting about 20 percent of the volume of the ovary. Carbine (1944) divided the eggs of a 6.2-inch female grass pickerel into three size groups, reporting 803 mature eggs, 4,004 eggs of intermediate size, and 10,925 immature eggs contained in the ovaries. Carbine suggested the presence of three sizes of eggs indicated the likelihood of more than one spawning during the year.

Evidence of a second spawning period, occurring in summer or fall, was reported by Lagler and Hubbs (1943) who collected young in Michigan in November of 1941 comparable in size to young collected in June. Crossman (1962) made similar observations, noting two distinct sizes of fingerling pickerel collected on October 16, 1960 in Jones Creek, Leeds County, Ontario, the smaller fingerlings resembling those collected on June 1, 1960. Scales of these smallest October specimens showed 6 and 12 circuli compared to 26-39 for four larger individuals. Crossman also reported finding a female in late August with ovaries distended with mature ova, when most females contained only immature ova.

Clear, yellow amber eggs similar to mature eggs observed in pickerel caught in spring were seen in 27, 17 and 11 percent of the females occurring in samples from Delafield Pond IV (September 4, 1963), Pickerel Lake (September 23-24, 1963), and Beulah Lake (October 1 and 9, 1963). Females containing these eggs averaged 2.3 inches longer than females containing only white immature eggs (10 inches compared to 7.7 inches). The ovaries of pickerel caught in the fall were less than half the size of those examined in the spring; the amber eggs occupying less than 20 percent of the ovary had to be separated from surrounding tissue with a probe while mature ova of females caught in the spring were loosely contained and easily freed from the ovary.

The first suspected fall-hatched fingerling, 31.5 mm. long, was caught in the nursery slough at Pleasant Lake on May 9, 1963; six other fingerlings caught on this same date ranged from 10.0 to 17.0 mm. (Fig. 3). A second large fingerling, 37.0 mm., containing 13 smaller pickerel, was caught on April 24, 1964; the 13 pickerel held in the stomach together with 22 pickerel sampled in the slough ranged from 6.5 to 11.5 mm. In each case the larger pickerel were a month advanced in length and development. Since the ice covering the slough had disappeared only six weeks previous to finding the larger fingerlings in both 1963 and 1964 it was thought likely they had been hatched in fall. Two sizes of fingerlings were also observed in collections made on May 25, 1964

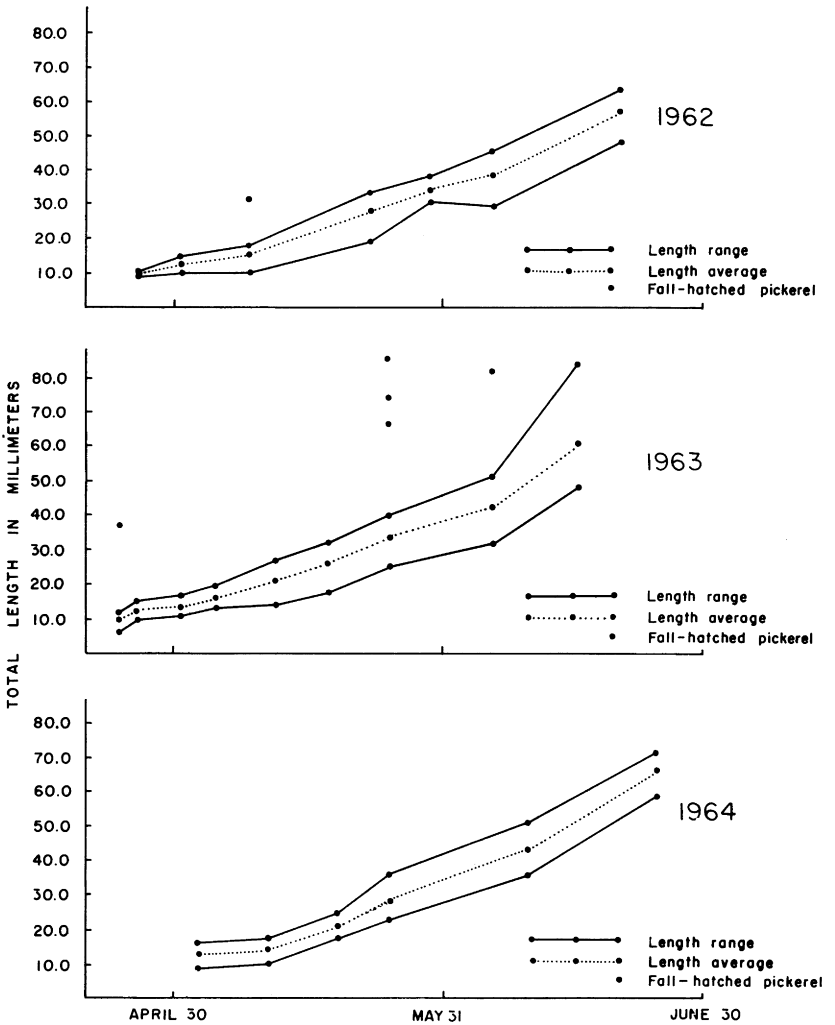


Figure 3. Total lengths of grass pickerel fingerlings caught in the East Bay and nursery slough of Pleasant Lake during the spring and summer of 1963-65.

when one large fingerling (74.0 mm.) and 24 smaller fingerlings (25.0-39.0 mm.) were taken and on June 3, 1964, when 3 large fingerlings (66.0-85.0 mm.) and 19 smaller fingerlings (31.0-49.0 mm.) were taken. In 1965 no large fingerlings believed to be fall-hatched were observed.

Pickerel caught in the 1964 spring spawning runs at Lake Ripley and Eagle Spring Lake were held and spawned at the Delafield station. Difficulty was encountered in stripping sperm from the males (average length 8 inches). To obtain sperm, the gonads were removed, macerated, and mixed with eggs. Three lots of fertilized eggs were placed

in Downing jars; the fry first appeared in the jars 15 days (average water temperature 46°F.), 14 days (average water temperature 47°F.), and 11 days (average water temperature 48°F.) following fertilization. The three lots of eggs yielded hatches of 9.7, 21.9, and 21.9 percent, producing 10,188 fry.

Fry first appeared in three lots of northern pike eggs, also taken in the spring of 1964, 21 days (average water temperature 40°F.), 14 days (average water temperature 45°F.), and 13 days (average water temperature 46°F.). The three lots of northern pike eggs required an average of 177.6 degree days (one degree F. above 32°F. over a 24-hour period) to reach hatching, while the three lots of pickerel eggs required an average of 195.1 degree days to reach hatching.

Development in the Nursery Area

In the springs of 1963 and 1964, eggs were collected in the slough by hand sorting the aquatic moss *Dreplanoclaudus* spp. covering the bottom. In the spring of 1965, *Dreplanoclaudus* spp. did not appear abundantly in the slough, and eggs were collected by sorting through leaves and twigs lifted from the bottom with dip nets.

Pickerel eggs were first found in the slough on April 5, fry on April 12, and fingerlings on April 26, in 1963. Eggs, fry, and fingerlings were first found on March 16, April 5, and April 24 in 1964 and on April 17, April 28, and May 3 of 1965. These observations indicate the developmental period from fertilization to feeding required from 2 to 5 weeks during the three springs. Slough water temperatures over this period varied from 34 to 65°F.

The best area to catch fingerlings continued to be the east edge of the slough, where eggs and fry had been most abundant earlier. Before fingerlings had reached 2 inches, they could be caught, "blind stabbing," with a long-handled cheesecloth dip net. As fingerlings grew larger, a 4-by-6-foot seine (¼-inch stretched mesh) was successfully used. A longer seine would have worked better in weed-free conditions, but vegetation so choked the slough by early summer, that a 6-foot seine was all two men could handle. Fingerlings were caught with the shocker in the East Bay in the fall.

Pickerel fingerlings were collected in the slough into June, 1963, into August, 1964, and into July, 1965. In 1963, the slough remained open to the bay into fall, but water levels receded which separated the slough from the lake by early July of 1964 and 1965, trapping many fingerling pickerel. These trapped pickerel perished as the slough dried to a mud flat by fall of both years.

Growth of pickerel fingerlings in different years appeared to be similar. Length averages for fingerlings caught the last week of May were 33.0 mm. in 1963, 33.5 mm. in 1964, and 28.0 mm. in 1965 (Fig.

3). Length averages of fingerlings caught in mid-September shocking surveys were 132.5 mm. in 1963, 122.5 mm. in 1964, and 126.0 mm. in late September, 1965. Pickerel fingerlings removed from Delafield Pond IV the first week of September averaged 152.5 mm. in 1963 and 145.0 mm. in 1964.

Northern pike were observed spawning and their eggs were collected in the slough in 1963. In 1964, northern pike were not observed in the slough nor were their eggs found when the area was searched. In 1965, northern pike were not observed in the slough, but their eggs were found in all of the collections made there. Northern pike fingerlings did not appear in any collections of fingerlings made in the slough in either 1963 or 1964, but were found among pickerel fingerlings taken from the slough to mid-June, 1965. After mid-June, 1965, pickerel fingerlings continued to be sampled in the slough, but no more northern pike were taken. Fall shocker surveys and spring nettings from the fall of 1962 to the spring of 1965 indicated northern pike year classes were almost negligible, being represented by only a few fish.

Identifying Eggs, Fry, and Fingerlings

Because both northern pike and grass pickerel occur in Pleasant Lake, spawning at similar times in similar locations, it was feared the eggs and young of the two species might be difficult to separate. However, subsequent comparison studies of the eggs, fry, and fingerlings of both northern pike and grass pickerel indicated the two species can be distinguished at these developmental stages.

Diameters of mature eggs from ripe pickerel 6.3 to 12.8 inches long ranged from 1.5 to 2.4 mm., while the diameter of mature eggs from ripe northern pike 18.0 to 23.2 inches long were 2.3 to 3.2 mm. Water-hardened pickerel eggs are yellow, while water-hardened northern pike eggs appear amber. The color difference may be a function of egg diameter, as the two colors seem to grade into one another; the larger pickerel eggs and the smaller northern pike eggs appearing similar. Although the diameters of the eggs of the two species overlap, mixed samples of northern pike and pickerel eggs yield a bimodal frequency curve of egg diameters permitting separation of most eggs.

Grass pickerel and northern pike were hatched in jars and held separately in muslin enclosures in the Delafield ponds. As the fry progressed into the fingerling stage, they were fed live cladocerans and copepods. Samples of both species of fish were taken at 5.0 mm. length intervals from the fry stage until a length of 75.0 mm. was reached.

Study of these samples revealed that the two species can be distinguished at lengths less than 12.0 mm. and again at lengths greater than 20.0 mm. (Figs. 4-8). Between 12.0 mm. and 20.0 mm., identification is more difficult. Until lengths of 12.0 mm., the two species can be

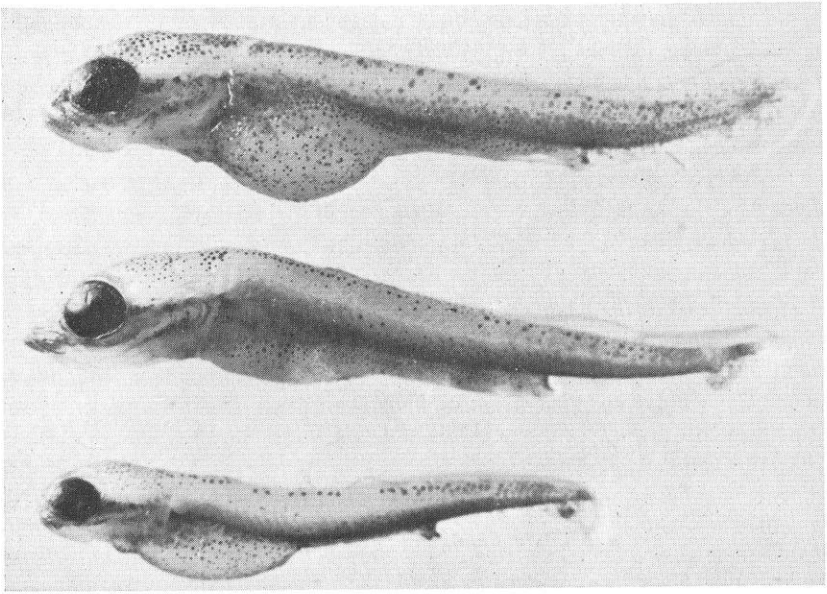


Figure 4. Northern pike fry 12.0 mm. (top), grass pickerel fingerling 12.0 mm. (middle) and grass pickerel fry 8.5 mm. (bottom). Northern pike fry are larger than pickerel fry and become feeding fingerlings between 12.0 and 13.0 mm., in contrast to pickerel which begin feeding between 9.0 and 10.0 mm.

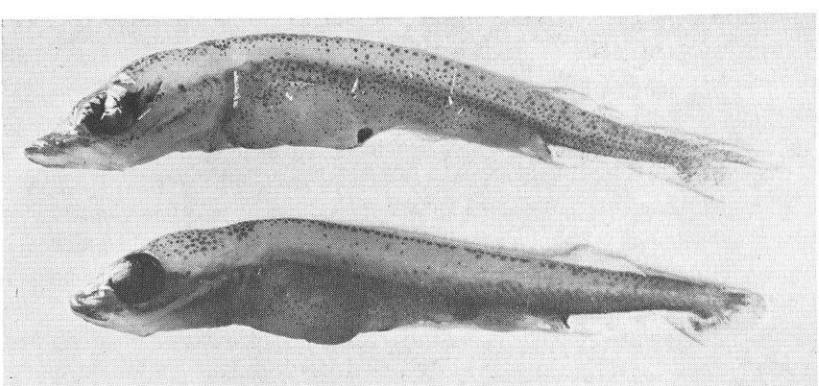


Figure 5. Northern pike fingerling 14.0 mm. (top) and grass pickerel fingerling 13.0 mm. (bottom). Northern pike is uniformly spotted along the sides of the body in contrast to the pickerel which has large pigment-free areas.

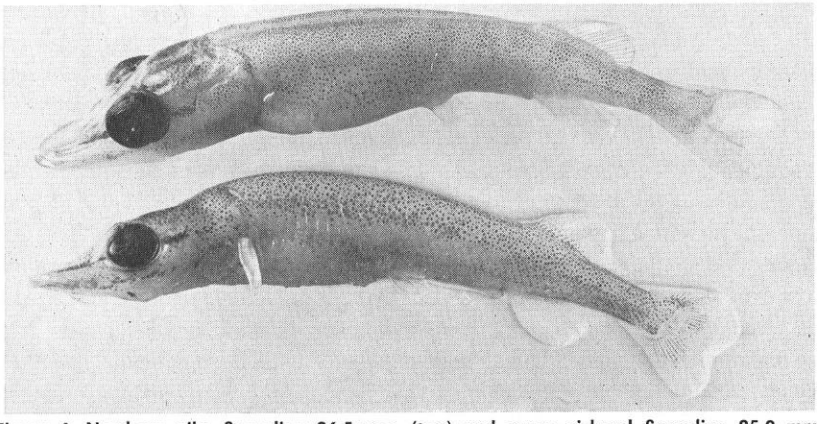


Figure 6. Northern pike fingerling 26.5 mm. (top) and grass pickerel fingerling 25.0 mm. (bottom). Northern pike is uniformly spotted while the pickerel shows a pigment-free area below the lateral line.

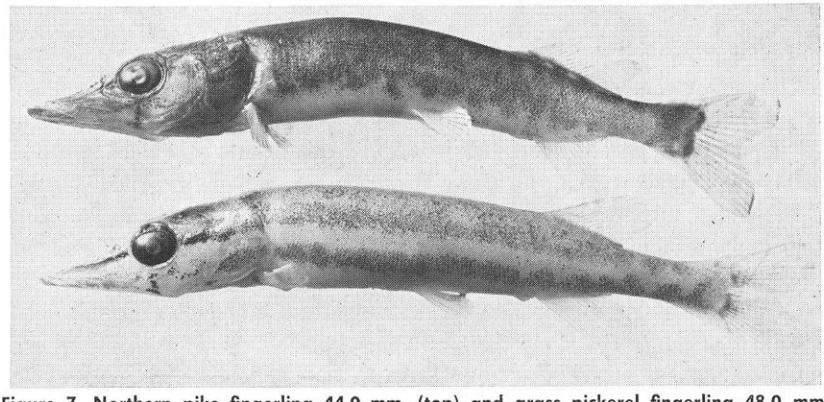


Figure 7. Northern pike fingerling 44.0 mm. (top) and grass pickerel fingerling 48.0 mm. (bottom). Pigment-free area extending from snout to tail identifies the pickerel.

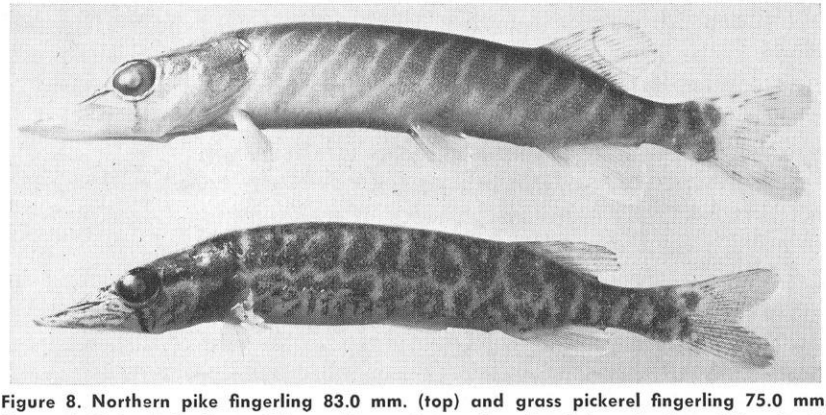


Figure 8. Northern pike fingerling 83.0 mm. (top) and grass pickerel fingerling 75.0 mm. (bottom). Pickerel displays adult markings; pigment-free line below the lateral line is still apparent.

separated by observing development with respect to length. At hatching, pickerel are between 5.0 and 6.0 mm., while northern pike fry seldom are encountered under 6.5 mm. From 7.0 to 8.0 mm., pickerel fry already have black eye pigment, while northern pike have light tan eyes. Pickerel have fully developed mouths by 9.0 mm. and begin feeding by 10.0 mm., while northern pike have fully developed mouths by 11.0 mm. and most begin to feed by 12.0 mm. Between 12.0 and 20.0 mm., a period of growth lasting about 7 days, pigmentation has not developed sufficiently to permit the accurate detection of the pigment-free line extending from the snout to the tail. This line is characteristic of pickerel up to 125 mm. long. Northern pike do not have this pigment-free area; instead the side of the body is more uniformly spotted. As grass pickerel exceed 20.0 mm., identification becomes progressively easier, using the criterion of the pigment-free line. By the time a length of 45.0 mm. is reached, pickerel have the coloration and markings of the adult, permitting instant identification.

Observations on Grass Pickerel-Northern Pike Relationships

Pickerel and northern pike brood fish were stocked prior to spawning in three Delafield ponds at the ratio of approximately 3 to 1 (Table 6). Spawning was not observed in any of the ponds and was believed to have occurred well under the water with no conspicuous disturbance of the water surface to alert the observer's attention. Eggs and fry were extremely difficult to collect in the ponds and were rarely found, although fingerlings could be obtained in limited numbers.

Draining the ponds in September revealed a greater number and poundage of pickerel fingerlings in one pond, a greater number and poundage of northern pike fingerlings in one pond, and northern pike fingerlings and adults in the third pond with no surviving pickerel. No hybrid fingerlings were seen among the fingerlings produced. Northern pike brood fish showed a higher April to September survival in two ponds; both species showing similar survival percentages in one pond.

In two ponds, equal numbers of northern pike and pickerel fry were stocked. A total mortality occurred in one, and a greater number and poundage of northern pike was produced in the other.

The presence of northern pike fingerlings in the ponds could be detected much earlier than the presence of pickerel fingerlings. In Pond IV in 1963 fingerling pickerel outnumbered fingerling northern pike 2 to 1 in early September when the pond was drained; however, pickerel were rarely seen through the summer while northern pike were usually visible along the pond margins. Northern pike also trapped more easily in the pond inflow box, yielding 6 fingerlings for every fingerling pickerel trapped during the summer. The poor trap catches of pickerel and the failure to see pickerel along the pond margins

TABLE 6

Vital Statistics from Delafield Spawning and Rearing Ponds Stocked with Grass Pickerel and Northern Pike, from April to September, 1963-64

Measurement	Adults Stocked						Fry Stocked			
	Pond III (1964)		Pond IV (1963)		Pond IV (1964)		Pond II (1964)		Pond V (1964)	
	N. Pike	Pickerel	N. Pike	Pickerel	N. Pike	Pickerel	N. Pike	Pickerel	N. Pike	Pickerel
Pond size (acres)	1.7		1.5		1.5		0.5		0.7	
Number stocked (males, females)	8, 6	30, 22	16, 8	54, 25	8, 6	30, 22	—	—	—	—
Average length (inches)	20.7	9.1	19.3	7.9	19.9	9.2	—	—	—	—
Estimated number mature eggs	172,072	45,805	179,108	38,452	153,585	46,809	—	—	—	—
Number of fry stocked	—	—	—	—	—	—	2,000	2,000	1,500	1,500
Fingerling yield in September	165	0	205	421	57	4	—	—	341	78
Average length of fingerlings (inches)	6.3	—	7.4	6.1	5.8	5.8	—	—	6.5	4.8
Pounds of fingerlings	8.3	0	16.2	20.5	1.8	.2	0	0	26.9	2.4
Percent survival of adults	36	0	34	39	86	27	—	—	—	—

Looking for young pickerel and northern pike in the Delafield ponds.

tended to support Crossman's (1962) observations indicating pickerel apparently move very little and only short distances to hunt for food or shelter.

Growth of pond-reared pickerel to early September was similar to growth of pickerel in southeastern Wisconsin lakes, averaging 6.1, 5.8, and 4.8 inches in three ponds producing fingerlings. Growth of pond-reared northern pike fingerlings over the same period averaged 7.4, 5.8, and 6.5 inches, being below the 8- to 12-inch length range of northern pike of the same age in southeastern Wisconsin lakes.

PICKEREL FOOD

Among 351 fingerling stomachs examined during the study, all contained food except 11 from fish in the 30.0 to 80.0 mm. length range. Food of pickerel from 9.5 to 15.0 mm. consisted principally of cladocerans, copepods, and occasionally ostracods. Pickerel from 15.0 to 40.0 mm. long continued to eat cladocerans and copepods, with tendipedid larvæ, Odonata nymphs and fish forming part of the diet. At lengths between 40.0 and 80.0 mm., zooplankters were rarely found in the stomachs, the diet being almost entirely tendipedid larvæ, Odonata and ephemerid nymphs, small fish, and *Hyalella* spp. Crossman (1962) noted the stomach contents of grass pickerel 20.0 to 50.0 mm. long from Jones Creek consisted of Cladocera, Amphipoda, Ostracoda, Odonata, and less frequently Diptera, Plecoptera, Hemiptera, and Iso-

poda. In the size range 50.0 to 100.0 mm., fish made their appearance but the diet was predominantly Trichoptera, Odonata, and crayfish.

The principal cladocerans found in the nursery area were *Simocephalus* spp., and *Bosmina* spp. The principal copepod was *Cyclops* sp. These were also the chief zooplankters found in fingerling stomachs. Three species of fish were found in fingerling pickerel stomachs: blackchin shiners, *Notropis heterodon*, lake chubsuckers, *Erimyzon sucetta kennerlii*, and smaller pickerel.

Counts of zooplankters found in the slough were compared with zooplankters found in fingerling stomachs (Table 7). These counts did not exceed 37.3 copepods and 0.5 cladocerans per liter in 1963, 13.6 copepods and 18.2 cladocerans in 1964, and 13.8 copepods and 73.9 cladoc-

TABLE 7

Mean Number of Food Organisms Per Stomach in Grass Pickerel Collected in the Nursery Slough of Pleasant Lake during the Spring and Summer of 1963-65

No. Stomachs Examined	Avg. Length Fish (mm.)	Cladocera	Copepoda	Ostracoda	*Hyalella*	Tendipedid Larvae	Odonata & Ephemerid Nymphs	Fish
				1963				
4	10.0	3.8	.5	0	0	0	0	0
4	12.0	3.3	1.5	0	0	0	0	0
5	14.0	2.8	2.2	0	0	.2	0	0
5	22.5	3.3	4.5	0	0	0	0	0
6	27.5	5.4	.2	0	0	1.4	0	0
2	33.5	5.5	0	0	0	.5	0	0
3	38.5	0	0	.7	0	.3	.7	.7
4	56.5	0	0	1.3	.3	0	1.3	1.5
				1964				
9	11.0	1.6	4.6	.2	0	0	0	0
18	12.0	2.7	10.9	.8	0	0	0	0
26	13.0	3.2	7.6	.1	0	.1	0	0
22	15.0	3.1	9.4	.3	0	.8	0	0
28	21.0	3.2	4.8	.2	0	.7	.1	.3
16	26.0	8.9	2.6	0	0	2.6	.1	0
24	32.5	6.8	1.4	0	.1	1.2	.1	.1
19	42.0	4.2	.1	0	0	.3	1.7	.3
16	57.0	.4	0	0	1.3	.4	1.9	.3
6	73.0	0	0	0	2.2	.1	2.3	.2
8	80.5	0	0	0	.4	.9	3.9	.4
13	83.0	0	0	0	0	0	1.0	0
7	95.5	0	0	0	0	.7	.3	0
				1965				
23	13.0	.7	4.4	1.3	0	0	0	0
21	14.0	2.4	18.5	.2	0	.5	0	0
13	20.0	5.7	1.2	.1	0	1.7	.9	.3
10	28.0	5.8	.2	0	0	2.6	.1	0
11	42.5	.9	0	0	0	0	2.0	.4
11	65.5	0	0	0	0	.1	1.3	.3
15	73.0	0	0	0	0	.1	1.5	.1
2	80.5	0	0	0	0	0	0	.5

erans in 1965. No drastic change in the availability of copepods was noted between the springs of 1963 and 1965; however, cladocerans, principally *Simocephalus* spp., became more abundant each spring. The May average for cladocerans sampled in the slough in 1963, 1964 and 1965 was 0.2, 10.2, and 38.4 per liter over the three-year period. In spite of the fluctuations in abundance of zooplankters observed in slough water samples, the average number of zooplankters in fingerling stomachs remained fairly consistent each year (Table 8). Franklin and Smith (1963) also noted little relationship between the apparent availability of *Cyclops* sp. and cladocerans per liter of slough water and their abundance in northern pike fingerling stomachs.

Stomach analysis of 12 northern pike fingerlings between 12.5 and 20.8 mm. present in the slough in 1965 showed the food to be identical to grass pickerel fingerlings of the same length taken at the same time.

Crossman (1962) noted the diet of grass pickerel over 4 inches was almost completely fish and crayfish, but dragonfly nymphs appeared occasionally. Stomach analysis of a combined sample of 267 pickerel (6.0 to 13.5 inches long) from Pleasant Lake, Lower Phantom Lake, Pickerel Lake, and Beulah Lake revealed 104 stomachs contained food,

TABLE 8

Zooplankters in Grass Pickerel Stomachs and Abundance of Zooplankters Determined from Dip Net Samples in the Nursery Slough of Pleasant Lake During the Springs of 1963-65

Date	Avg. Length Fish (mm.)	No. Stomachs Examined	Copepoda		Cladocera	
			Mean No. Per Stomach	Mean No. Per Liter of Water	Mean No. Per Stomach	Mean No. Per Liter of Water
			1963			
April 26	10.0	4	.5	3.7	4.8	0
May 1	12.0	4	1.5	3.2	3.3	.1
May 9	14.0	5	2.8	4.6	2.8	.4
May 17	22.5	5	6.5	8.4	3.3	0
May 23	27.5	6	.2	20.4	6.3	.5
May 31	33.5	2	0	37.3	4.0	0
			1964			
April 24	11.0	9	4.6	.4	1.6	1.4
April 28	12.0	18	10.9	.6	2.7	.9
May 1	13.0	26	7.6	2.5	3.2	18.2
May 5	15.0	22	9.4	2.1	3.1	5.3
May 11	21.0	28	4.8	13.6	3.2	.7
May 18	26.0	16	2.6	1.3	8.9	.2
May 25	32.5	24	1.4	.2	6.8	.8
June 3	42.0	19	.1	.3	4.2	.5
			1965			
May 3	12.0	23	4.4	.4	.7	2.2
May 11	14.0	21	18.5	4.5	2.4	34.3
May 18	20.0	13	1.2	13.8	5.7	73.9
May 25	28.0	10	.2	1.6	5.8	43.0
June 9	42.5	11	0	.3	.9	4.0

while 163 were either empty or the food was so digested as to be unrecognizable. Among the 104 stomachs containing food, 93 held fish, 7 held dragonfly nymphs, and 2 held crayfish. Small bluegill and pumkinseed, *Lepomis gibbosus*, were the predominant fish eaten, with bluntnose minnows, *Pimephales notatus* and blackchin shiners second in importance. Certain pickerel showed a capacity to ingest very large food fish. A 4-inch bluegill was found in the stomach of a 9.6-inch pickerel and a 3-inch perch was found in a 7.8-inch pickerel.

Crossman (1962) noted only 9 cases of cannibalism in the 387 stomachs examined. These instances of cannibalism occurred between June 18 and August 20, 1960, and were not concentrated in the spring when the young first hatched. In Pleasant Lake samples, cannibalism was also rare, only 7 of 351 grass pickerel less than 112.0 mm. having eaten other pickerel. The most dramatic case of cannibalism, however, was the 37.0 mm. fingerling caught in the slough on April 24 with 13 pickerel 6.5 to 11.5 mm. contained in its stomach. None of the stomachs of adult pickerel examined in the present study contained other pickerel.

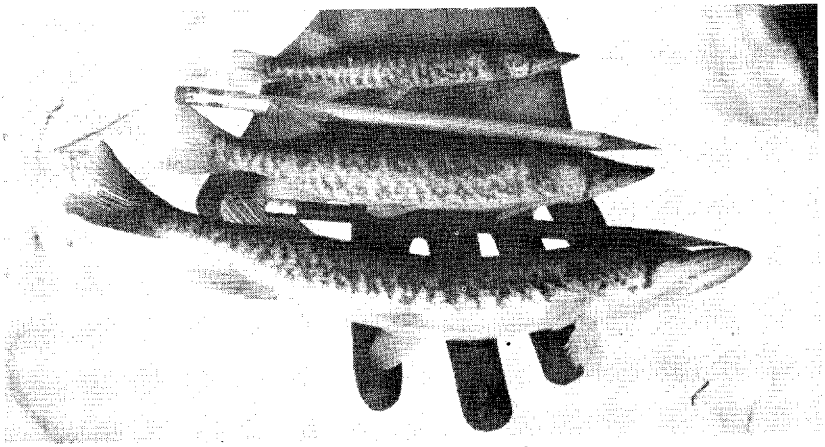
A 24-hour feeding study was undertaken at Pickerel Lake in 1963 to investigate the feeding periodicity of grass pickerel. Pickerel were collected with the shocker at 8-hour intervals for a 24-hour period on September 23-24. The sampling periods corresponded with mid-afternoon (2:00-3:00 p.m.), evening (10:00-11:00 p.m.) and dawn (6:00-7:00 a.m.). Approximately 25 pickerel were caught each period. All pickerel containing food had eaten small bluegills, with the exception of one fish containing a dragonfly nymph. Thirty-two percent, 61 percent, and 10 percent of the pickerel contained undigested or partially digested food in the mid-afternoon, evening, and dawn samples respectively. These data suggest feeding varied considerably over the 24-hour period. The high percentage of stomachs containing food in the evening sample suggests feeding reached a maximum in the late afternoon or early evening. The low percentage of stomachs containing food in the dawn sample indicated little feeding occurred at night.

GROWTH

Age and Growth

Scale analysis of a sample of 45 Pleasant Lake pickerel taken in early October, 1962 indicated average lengths of 5.3, 7.8, 9.8, and 14.0 inches at Ages 0, I, II, and IV, respectively (Table 9). Females were larger than males at Ages 0 and I. No males Age II or older were encountered, indicating that females grow faster and live longer than males (Fig. 9).

A stocking of 411 fin-clipped grass pickerel fingerlings, ranging from 4.6 to 7.6 inches and averaging 6.1 inches, was made in Pleasant Lake in September 1963. Lengths of five stocked fish ranged from 8.5 to 10.0



Pickerel Age Groups I, II and III.

TABLE 9

Average Total Lengths of Age Groups of Grass Pickerel Caught at Pleasant Lake in October, 1962

Length Range (Inches)	Age Group 0		I		II		III		IV	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
3.0-3.4	1	—	—	—	—	—	—	—	—	—
3.5-3.9	—	—	—	—	—	—	—	—	—	—
4.0-4.4	1	—	—	—	—	—	—	—	—	—
4.5-4.9	3	—	—	—	—	—	—	—	—	—
5.0-5.4	3	2	—	—	—	—	—	—	—	—
5.5-5.9	2	1	—	—	—	—	—	—	—	—
6.0-6.4	—	—	—	—	—	—	—	—	—	—
6.5-6.9	1	2	2	—	—	—	—	—	—	—
7.0-7.4	—	—	2	3	—	—	—	—	—	—
7.5-7.9	—	—	1	2	—	—	—	—	—	—
8.0-8.4	—	—	5	4	—	—	—	—	—	—
8.5-8.9	—	—	1	1	—	1	—	—	—	—
9.0-9.4	—	—	—	—	—	1	—	—	—	—
9.5-9.9	—	—	—	—	—	3	—	—	—	—
10.0-10.4	—	—	—	—	—	—	—	—	—	—
10.5-10.9	—	—	—	—	—	2	—	—	—	—
11.0-11.4	—	—	—	—	—	—	—	—	—	—
11.5-11.9	—	—	—	—	—	—	—	—	—	—
12.0-12.4	—	—	—	—	—	—	—	—	—	—
12.5-12.9	—	—	—	—	—	—	—	—	—	—
13.0-13.4	—	—	—	—	—	—	—	—	—	—
13.5-13.9	—	—	—	—	—	—	—	—	—	—
14.0-14.4	—	—	—	—	—	—	—	—	—	1
Total number	11	5	11	10	0	7	0	0	0	1
Average length	5.0	5.9	7.7	7.9	—	9.8	—	—	—	14.0
Total number (Sexes combined)	16		21		7		0		1	
Average length (Sexes combined)	5.3		7.8		9.8		—		14.0	

inches, averaging 9.2 inches, when recaptured in the fall of 1964. Three females averaged 10.2 inches and one male was 8.6 inches when taken in April 1965. Lengths of 15 stocked fish ranged from 9.1 to 12.3 inches, averaging 10.5 inches in the fall of 1965. Stocked fish were somewhat larger than native fish aged by scales, possibly due to the fact they averaged 1 inch larger than native fingerlings when stocked; however, both native and stocked pickerel showed similar growth rates.

Scale analysis of a combined sample of 280 pickerel from Pleasant, Upper Phantom, Beulah, Pickerel, Ripley, and Eagle Spring Lakes indicated average lengths in inches at different ages: Age 0 (5.7); I (8.2); II (9.9); III (11.3); and IV (14.0), (Table 10 and Fig. 10). Females were longer than males at Ages 0, I and II; no males of Age III or older were encountered, giving further evidence that females exceed males in growth and longevity.

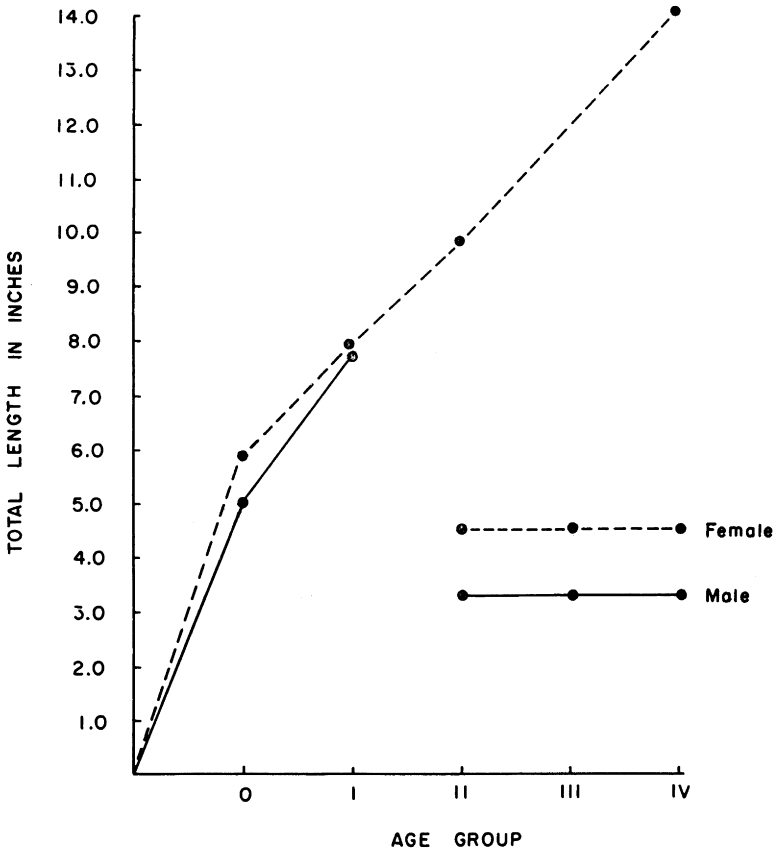


Figure 9. Average total lengths of age groups of grass pickerel caught at Pleasant Lake in October 1962.

TABLE 10

Average Total Lengths of Age Groups of Grass Pickerel Caught at Six Southeastern Wisconsin Lakes in September and October, 1962-64

Length Range (Inches)	Age Group									
	0		I		II		III		IV	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
3.0-3.4	1	—	—	—	—	—	—	—	—	—
3.5-3.9	1	—	—	—	—	—	—	—	—	—
4.0-4.4	6	—	—	—	—	—	—	—	—	—
4.5-4.9	14	8	—	—	—	—	—	—	—	—
5.0-5.4	18	8	—	—	—	—	—	—	—	—
5.5-5.9	9	13	—	—	—	—	—	—	—	—
6.0-6.4	3	9	—	—	—	—	—	—	—	—
6.5-6.9	4	11	4	1	—	—	—	—	—	—
7.0-7.4	5	5	6	5	—	—	—	—	—	—
7.5-7.9	1	2	10	10	2	—	—	—	—	—
8.0-8.4	—	—	11	13	—	3	—	—	—	—
8.5-8.9	—	—	5	7	6	1	—	—	—	—
9.0-9.4	—	—	5	2	5	1	—	—	—	—
9.5-9.9	—	—	—	2	7	10	—	—	—	—
10.0-10.4	—	—	1	3	2	9	—	2	—	—
10.5-10.9	—	—	1	—	—	6	—	3	—	—
11.0-11.4	—	—	—	1	1	3	—	4	—	—
11.5-11.9	—	—	—	—	—	1	—	1	—	—
12.0-12.4	—	—	—	—	—	2	—	3	—	—
12.5-12.9	—	—	—	—	—	1	—	1	—	—
13.0-13.4	—	—	—	—	—	—	—	—	—	—
13.5-13.9	—	—	—	—	—	—	—	—	—	—
14.0-14.4	—	—	—	—	—	—	—	—	—	1
Total number	62	56	43	44	23	37	0	14	0	1
Average length	5.4	6.0	8.1	8.3	9.3	10.2	—	11.3	—	14.0
Total number (Sexes combined)	118		87		60		14		1	
Average length (Sexes combined)	5.7		8.2		9.9		11.3		14.0	

Crossman (1962) aged 253 grass pickerel from Jones Creek, Ontario. Conversion of Crossman's length-age data from fork lengths measured in millimeters to total lengths measured in inches indicated the following average lengths in inches at different ages: Age I (4.4); II (5.6); III (7.1); IV (7.6); V (8.6); VI (9.8); and VII (11.0). Females exceeded males in growth and longevity as in the samples from southeastern Wisconsin lakes. The slower growth of the Ontario pickerel may be due to their occurrence at the northern limit of the pickerel range.

Length-Weight Relationship

The length-weight relationships determined for October 1962 samples of 123 Pleasant Lake pickerel and 143 Eagle Spring Lake pickerel were Log W = —.829145 + 2.751936 Log L, and Log W = —1.261038 +

3.205516 Log L, where (L) represents total length in inches and (W) weight in grams (Figs. 11 and 12). The Pleasant Lake fish were lighter than the Eagle Spring Lake pickerel in the larger length ranges due to the fact that very few large pickerel entered into the Pleasant Lake weight calculations, while large fish predominated in the Eagle Spring Lake group. Combining the two samples would yield weights for 8-,

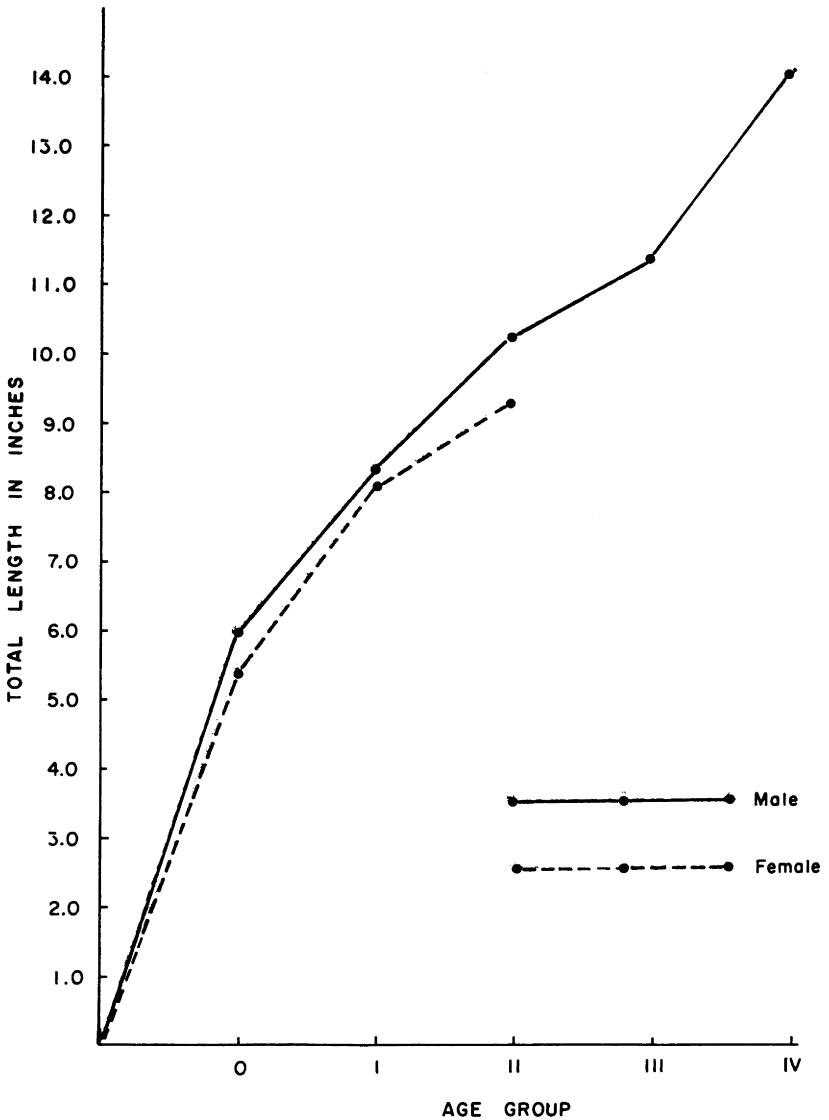


Figure 10. Average total lengths of age groups of grass pickerel caught at six southeastern Wisconsin lakes in September and October, 1962-64.

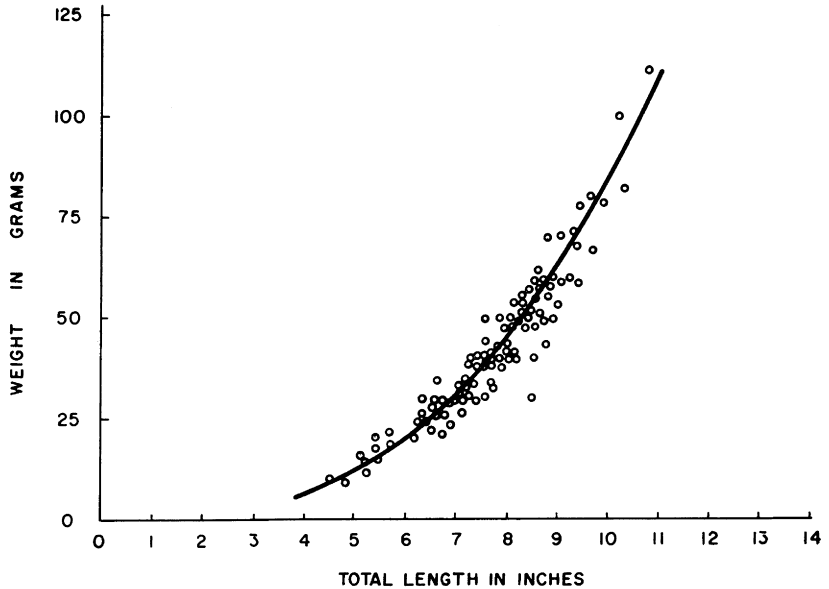


Figure 11. Length-weight relationship for grass pickerel caught at Pleasant Lake in October 1962.

10- and 12-inch pickerel of approximately 19, 86 and 141 grams. The heaviest pickerel weighed was a 13.4-inch female from Eagle Spring Lake weighing 225 grams.

IMPLICATIONS FOR MANAGEMENT

Studies at Pleasant Lake indicated grass pickerel can become abundant in a lake environment, reaching an estimated maximum fall population level of 39.3 fish and 3.5 pounds of fish per acre. Pickerel were found to prefer shallow, weedy locations and reached their highest population densities in such situations. Grass pickerel were found to be of small size. Fish exceeding 12 inches were rare; the largest pickerel observed was 14 inches long. Among pickerel measured at Pleasant Lake, only 10 percent exceeded 10 inches long and less than 1 percent exceeded 12 inches.

Neither four years of study at Pleasant Lake nor the experience of southeastern Wisconsin Conservation personnel revealed any evidence that pickerel are sought by anglers. However, pickerel are caught by anglers seeking game and panfish. Few fishermen recognize the species, believing pickerel to be young northern pike. Among those fishermen recognizing the species, the prevalent notion was that grass pickerel are a nuisance fish to be discarded.

Studies of the grass pickerel-northern pike association were not as fruitful as hoped because both species were never abundant in the

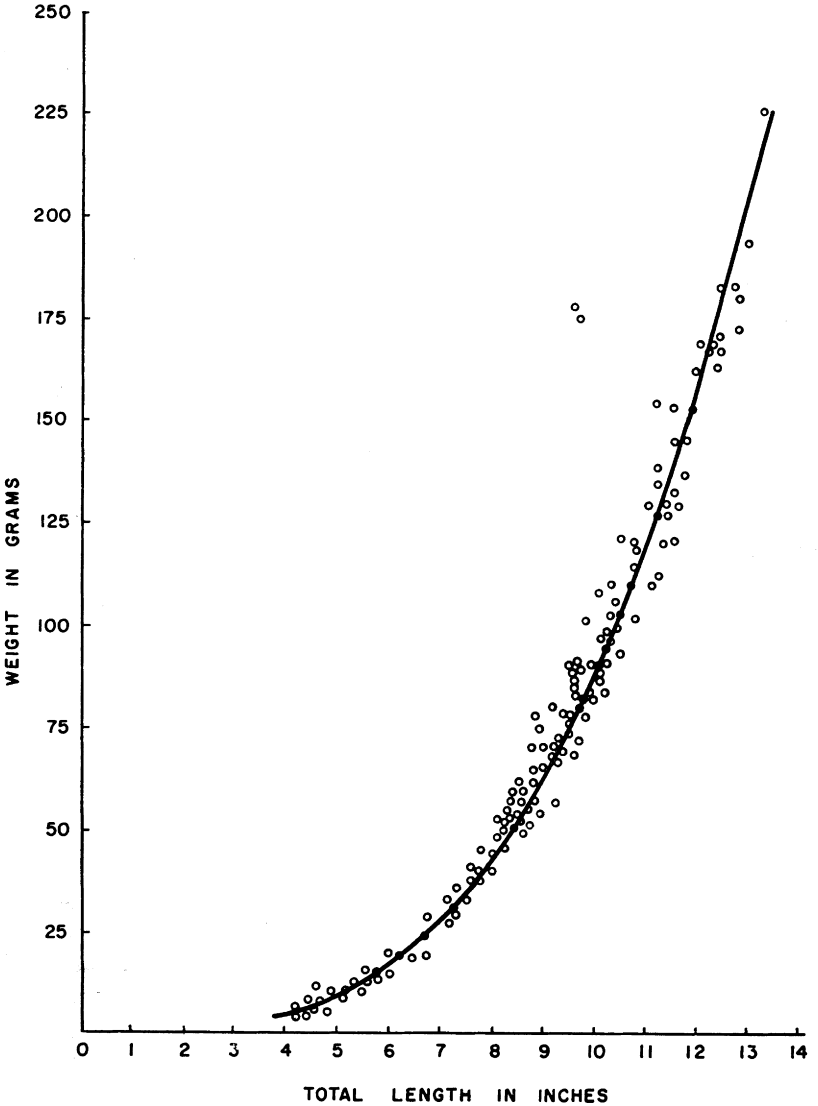


Figure 12. Length-weight relationship for grass pickerel caught at Eagle Spring Lake in October 1962.

study areas simultaneously. In the Pleasant Lake slough nursery area, pickerel young were always abundant, but northern pike young were found only in 1965, and then only a few could be collected. In the Delafield ponds, young of both species were never abundant and few fingerlings were collected. Observations of the grass pickerel-northern pike association at Pleasant Lake did show that both species shared similar spawning times and locations. The time required for hatching

and development to the feeding stage were similar for both species when hatched and held at the Delafield station. The diet of young northern pike determined by Hunt and Carbine (1951) and Franklin and Smith (1963) is similar to the diet of pickerel in Pleasant Lake. With increase in fish size, a progression in feeding occurs from microcrustacea, to insects, to vertebrates. The parallel life histories of grass pickerel and northern pike with respect to time and location of spawning, onset of feeding in the nursery area, and similar food habits set up the conditions whereby interspecies competition for food or predation of one species upon the other in the nursery area could occur.

At the time of this writing, northern pike populations are reportedly declining in southeastern Wisconsin. The nature and extent of this reported decline cannot be confirmed, as past fishery survey data provide little information of what northern pike population levels might have been. Curiously, grass pickerel are sometimes abundant in lakes where northern pike populations are low. Hence the theory has originated that competition between northern pike and grass pickerel may be depleting northern pike numbers. The present study could not document competition between grass pickerel and northern pike as is believed to occur between northern pike and muskellunge (Threinen, 1950). However, a competitive relationship may exist.

The diet of adult grass pickerel consists almost entirely of fish; hence, the species may be valuable as a predator. Thompson and Hunt (1930) noted a significant difference in the number of fish per acre when grass pickerel were present. Where grass pickerel occurred in numbers, 2.49 fish per square yard of stream were counted in 26 collections. The remaining 86 collections taken where pickerel were absent averaged 5.71 fish per square yard of stream.

Grass pickerel and northern pike have been crossed artificially (Schwartz, 1962) and have been known to hybridize in the wild. Muskellunge and grass pickerel have also been artificially hybridized, the resulting hybrids being heavier-bodied than the parents, with distinct vertical bars on the sides of the body and bright orange fins (Tennant and Billy, 1963). The desirability of pickerel-northern pike and pickerel-muskellunge hybrids as potential sport fishes has yet to be determined.

Today grass pickerel are known to be more widely distributed in Wisconsin than was known during Greene's ichthyological survey of 1935. The recent broadening of the known pickerel range to include Jefferson, Dane, and Rock Counties in southern Wisconsin and the lower Wisconsin River may not reflect a true extension of the species as these waters are connected to waters previously known to contain pickerel. However, the isolated occurrence of grass pickerel in northeastern Wisconsin has been noted within the last 25 years and can only

be explained by an accidental introduction of the species by man.

Under present Wisconsin fishing regulations there is no open season on grass pickerel except on special waters. Changing the present regulations to include grass pickerel may not be warranted, however, due to the lack of fisherman interest in the species.

In light of the fact that the small grass pickerel is not utilized by anglers and since the impact of pickerel on populations of other fishes, particularly northern pike, may be detrimental, present management efforts should be directed at preventing the spread of the species.

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