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GROWTH POTENTIAL OF THE NORTHERN PIKE (ESOX LUCIUS)[1]

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It has long been known that most fishes have an indeterminate type of growth, but it has only recently been appreciated that their potential rate of increase is vastly greater than the average growth in nature. Since fishes are also notably subject to dwarfing under conditions of overpopulation, extreme competition and restricted space, it follows that the variation of size at a given age may be enormous. It is also known that a reduced growth in early life does not destroy the growth potential, for when placed under favorable conditions the dwarfed fish may grow at an unusually rapid rate. These phenomena have been determined chiefly through studies using the scale method of estimating age, but may be more directly and conclusively investigated by experiments. The present paper reports data bearing on the growth of the northern pike, obtained during the course of experiments conducted from 1937 to 1939. The results bear on each of the growth tendencies mentioned above.

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[1]Contribution from the Institute for Fisheries Research of the Michigan Department of Conservation.

These experiments were undertaken by the Institute for Fisheries Research of the Michigan Department of Conservation, to obtain information on the possibility of artificially propagating northern pike. The data bearing on the fish cultural problem will be reported elsewhere. The work was done at the Drayton Plains Hatchery, with the effective cooperation of A. T. Stewart, then District Fisheries Supervisor, and his staff. Thanks are also due Dr. Albert S. Hazzard, Director of the Institute for Fisheries Research, for assistance in planning the work. I should like to express my appreciation to Dr. Carl L. Hubbs for assistance in the analysis of the data, and for suggestions and help in the preparation of this report.

The northern pike used in this experiment were hatched from eggs taken on April 7 and 8, 1937 at Walled Lake, Oakland County. On May 3, about 150,000 fry were stocked in the Ortonville Rearing Pond, which has an area of nearly 3 acres, an average depth of 2.5 feet and a maximum depth of 8 feet. Food for the growing pike was furnished by the introduction of 6,200 small minnows on June 2. On June 16 the pond was stocked with 30,000 largemouth bass fry and some of these were probably eaten by the northern pike. Sometime during the spring, probably during a period of heavy rainfall in early June, large numbers of fish, of 19 species, gained access to the pond, and doubtless contributed to the nourishment of the pike. All of the fish thus accidentally introduced, with the exception of 850 yearling bluegills, were young of the year. The yearling bluegills spawned successfully in the pond and produced a large

number of young, which further augmented the already abundant food supply. The known source of these extraneous fish and other circumstances make it virtually certain that no pike were included.

Samples of the pike, seined on June 25, July 14 and August 17, were preserved to determine the length and weight. Of about 100 netted on the first date, a random series of 40 was preserved. All of the fish that could be seined on the other dates, 21 on July 14 and 12 on August 17, were kept (the soft bottom and the dense growth of plants made collecting difficult). When the pond was drained on October 14, 362 pike were recovered, along with many small minnows and bluegills. All of these fish were individually weighed and measured.

A tremendous spread in length developed early in the growing season (Table 1, Figs. 1-2, and Pl. I). The pike in the June 25 sample ranged from 50 to 135 mm.; those in the July 14 series, from 62 to 222 mm.; those in the August 17 sample, from 79 to 263 mm. It is possible that the largest and smallest individuals in the pond on these dates escaped capture. The 362 fish remaining on October 14 had the unprecedented size range of 83 to 446 mm. (Plate II), with the average at 207.2 mm. The great divergence in size obviously increased as the summer advanced. Many of the pike grew very rapidly and quite variably; others grew little and formed a very compact size group (Fig. 1).

The survival and growth of these pike in the Ortonville Pond followed the pattern of other highly predacious fishes in pond culture.

A few of the fish get a head start and grow to a large and variable size. Others, with a poorer start, find the competition so severe that they remain small and uniform in length. Cooper's study (1937) of pond cultured largemouth bass illustrates these relations.

The largest fish taken on October 14 had grown at an average rate of 2.6 mm. (0.1 inches) per day. The largest fish at each collection date during the summer were all growing at a rate of more than 2.0 mm. per day, and the largest fish taken on July 14 was growing at a slightly faster rate (2.7 mm. per day) than the largest specimen taken on October 14 (Table 1). Other workers (Embody, 1915; Webster, 1929; Rawson, 1932; Van Engel, 1940; Elsen, 1941) have found that the northern pike and the muskellunge, a very close relative of the northern pike is capable of exceedingly rapid growth. During part of the first season pike in nature grow as much as 3.3 mm. per day (Carbine, 1942). The only comparable rate of early growth per day which has been published is for the longnose gar, Lepisosteus osseus (Hubbs, 1921).

The diversity of growth in weight of the northern pike in the Ortonville Pond was even more striking (Table 1 and Fig. 3). On October 14 the smallest specimen weighed only 2 grams; the largest one, 460 grams (just over a pound). The 362 northern pike remaining on October 14 had grown an average of 0.42 grams in weight per day during the 171 days since hatching. The largest fish (460 grams) grew at the rate of 2.69 grams per day during this same period.

The extremely rapid growth of some of the pike in the Ortonville Pond is an example of the great growth potential possessed by fishes. The large food supply, warm temperature and other conditions were obviously conducive to exceptionally rapid growth. Why, then, did some of the fish become stunted in the same pond, to produce the striking divergence in size? Several possibilities come to mind.

It is possible that the small fish were diseased, though the evidence available does not favor this explanation. They were obviously emaciated and all but 6 of the 140 died within 5 days after the removal of the fish from the Ortonville Pond to the Drayton Plains Hatchery, whereas none of the larger fish, treated in the same way, died during this period. Examination by Lowell A. Woodbury of those that died disclosed no external or internal parasites that could be regarded as responsible for the mortality. It is also possible, though inherently improbable, that the dwarfed fish had never learned to eat. Another theoretical possibility, that the dwarfs failed to grow because of genetic factors, is negated by the rapid growth made during the next season (p.). Overcrowding and the space factor may have contributed to the dwarfing of some of the pike in the pond but such an explanation would be inconsistent with the very rapid growth of other pike in the same pond.

The most plausible explanation for the great diversity in size of the pike in the Ortonville Pond is that some of the fish obtained an advantage in feeding that was maintained through the season, whereas others lived under conditions that were unfavorable. An early start,

due to hatching a day earlier or to earlier assumption of predation may have given certain fish an initial advantage. Some may have taken up a habitat where food conditions were excellent, whereas others may have become established, either by random choice or because other places were pre-empted, in sites where there was little food. In support of this view, evidence may be cited that the young of the northern pike and the muskellunge do occupy definite home ranges of limited extent. While conducting another northern pike experiment at Drayton Plains Hatchery in 1939, I found that young pike could be found throughout the summer in definite spots about the pond. Similarly Elson (1941) found that young muskellunge were nearly always to be found in certain well-defined areas. According to him, the young muskellunge do not range widely in search of food, but wait for the food organism to come to them. He also found that in trapping fingerlings, one setting of a net would take two or more individuals, but several days intervened between the catches. He also stated that a lead of 40 or 80 feet in length was no more effective on traps than a lead half that length. These observations suggest that the foraging range of the muskellunge is limited, and this evidence presumably applies also to the closely related northern pike. An early fixation of the feeding ranges, some favorable and others unfavorable, might well lead to differential growth.

The presence of the other 19 species of fish in the pond brought about a severe competition for food. Although an abundance of small fish was present, perhaps the largemouth bass and the perch were more

adept at catching small fish than were the small northern pike. In an experiment to test the relationship between muskellunge fry and the fry of other species, Elson (1941) placed muskellunge fry and largemouth bass fry in the same container. Until the end of July neither the muskellunge nor the largemouth bass showed any inclination to molest each other, but competition for food was keen. The largemouth bass fry were much more adept at capturing small minnows than were the muskellunge.

In discussing the feeding habits of the muskellunge, MacKay and Werner (1934:315) stated: "Due to this habit of poising over its prey, the maskinonge often loses its victim, since the minnow fry are usually quite active and either swim away in the meantime or have started to swim away when the lunge strike, causing the latter to miss or obtain an insecure hold. Furthermore, the lateral body movements of the swimming minnow make it difficult for the maskinonge to strike accurately." The habits of the northern pike are very similar to those of the muskellunge and it is believed that these observations made on the muskellunge apply to the northern pike. It is therefore probable that the small northern pike in the Ortonville Pond were so weak and emaciated that they were not strong enough to catch minnows and were forced to subsist on inadequate food. They were greatly emaciated.

Further data on the growth of the northern pike were obtained at the Drayton Plains Hatchery, where the 6 survivors of the 140 small fish and 103 of the large fish, that were taken in the draining of the

Ortonville Rearing Pond on October 14, 1937, were kept in a pond until October 17, 1939. On December 15, 1937, 51 northern pike that were received from the Belle Isle Aquarium in Detroit were placed in the same pond with the other northern pike. The three series of pike were marked for future identification by clipping different fins for each lot. During the course of the experiment 65,295 minnows and perch were placed in the pond as food for the pike. Adult bluegills which were also introduced spawned successfully in the pond and produced an additional source of food. The pond was partly drained on May 26 and November 9, 1938, on which dates all of the pike were counted and each lot was weighed as a unit but individual weights and measurements of length were taken on only a random sample. All of the pike were individually weighed and measured when the pond was completely drained, on October 17, 1939.

The tremendous growth made by some of the northern pike in the Ortonville Pond was not maintained throughout their retention at the Drayton Plains Hatchery (Table 2; Figs. 2-5). The average growth increments in the rearing pond at the Drayton Plains Hatchery were as follows: 63.1 mm. from October 14, 1937 to May 26, 1938; 58.2 mm. from May 26 to November 9, 1938; 121.25 mm. for the first year; and only 26.3 mm. for the second year in the pond, from November 9, 1938 to October 17, 1939. These fish therefore made excellent growth during their first winter and first summer in the Drayton Plains pond but the increase in growth during the second full year was only 21.7 per cent of that of the first year. The marked decrease in the growth rate of

the pike during their third year of life, in a rearing pond, caused them to be smaller than average at that age and caused an unusually abrupt depression of the growth curve for the third year. By the end of their third summer, on October 17, 1939, the three groups in the Drayton Plains pond varied in average length from 14.3 to 16.4 inches, whereas in natural waters in Michigan, northern pike usually reach the legal length of 14 inches early in their second summer according to Dr. W. C. Beckman (unpublished report, Institute for Fisheries Research). As shown in Figure 4, the small fish remained smaller than average and the large fish larger than the mean until the end of the second summer, when the growth of both groups leveled off to fall far below the average for the species during the third year. The basis of comparison, the curve of growth in natural waters, is taken from Van Engel's extensive data (1940) for the pike of Wisconsin, which grow at about the same rate as do the pike in Michigan, as determined by Beckman. Because the time at which the annulus forms on the scales of Wisconsin fishes has not been determined, it has been assumed (Fig. 4) that the time of the formation of the annulus in Michigan is the same as that for Wisconsin. In Michigan Beckman (1943) determined that the formation of the annulus may be expected to be completed by the first of June (average for the entire state), except in unusually cold years.

The depressed growth of the adult pike in the rearing pond, during the third year of life, may be attributed to the space factor (the Drayton Plains pond was stocked at the rate of 320 northern pike per acre). It is thought that despite the presence of large quantities of food, northern pike will grow very little in rearing ponds, after

having attained a certain size. This species appears to require large bodies of water in order to reach large size.

The growth of the small and large pike at the Drayton Plains Hatchery furnished an experimental demonstration of the principle of growth compensation. This term was proposed by Gilbert (1914), who found that salmon (Oncorhynchus nerka) which were large at the end of the second year of life, grew in succeeding years more slowly on the average than did the fish that were small at the end of the second year. Eventually all individuals reached a nearly uniform length at maturity. Van Oosten (1929) determined that the law of growth compensation holds for the lake herring (Leucichthys artedi), but although the lengths of the small fish and the large fish became more uniform in each succeeding year of life (the smallest yearlings became the fastest growing fish and the largest yearlings the slowest growing fish) the length of the smallest fish did not quite come to equal that of the large fish in later years. Hubbs (1921; 1921a) and Hile (1936) also found that fish which grew more slowly than usual in early life compensated for the deficiency by growing faster in later life. There is a large body of other data to indicate that the growth potential of animals is not readily destroyed by a stunting of the early growth.

It is obvious that the small fish grew faster in the Drayton Plains pond than did the medium- and large-sized fish (Figs. 2-5), but, when the pond was drained on October 17, 1939, the small fish had almost caught up with the medium-sized ones while the growth in length of the medium-sized ones paralleled that of the large fish. The rapid growth that was made by the small pike, particularly during their second summer is a striking example of the great growth potential possessed

by the northern pike. Although the differences between the lengths of the three groups diminished during each of the two years, the small fish never quite attained the size of the large fish (Figs. 4-5). The increments in length of each of the three groups of northern pike during each growth period between sampling dates shows that the small fish were the fastest growing fish and the large fish were the slowest growing (Table 3). This table also shows that these small northern pike were not "genetic runts." Although the small fish got off to a bad start in their first summer, when they were given the proper conditions they were able during the next two years to overcome very largely the effects of the unfavorable conditions to which they were subjected in their first summer of life.

SUMMARY

A tremendous spread in length developed early in the season in northern pike reared in hatchery ponds and this great divergence increased as the summer advanced. Many of the pike grew rapidly and quite variably while others grew very little and formed a compact size group. The growth of the northern pike in rearing ponds follows the pattern of other highly predaceous fishes in pond culture.

The extremely rapid growth of some of the northern pike in rearing ponds is an example of the great growth potential possessed by fishes. The largest fish at the end of the first summer had grown at an average rate of 2.6 mm. and 2.69 grams per day.

The tremendous growth made by some of the northern pike during their first summer was not maintained throughout their retention in

rearing ponds for two additional years. It is believed that northern pike will grow very little in rearing ponds after having attained a certain size.

The growth of the northern pike in rearing ponds furnished an experimental demonstration of the principle of growth compensation. The smallest fish at the end of the first year became the fastest growing fish in succeeding years and the largest fishes became the slowest growing fish. The rapid growth that is made by these small fish is another striking example of the growth potential of the northern pike.

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TABLE 1

GROWTH OF THE NORTHERN PIKE IN THE ORTONVILLE POND FROM THE TIME OF HATCHING ON APRIL 27 UNTIL OCTOBER 14, 1937

Sampling date	Number of fish in sample	Age (days)	Total length (mm.) Range	(av.)	Growth per day (mm.)[1] Range	(av.)	Weight (grams) Range	(av.)	Growth per day (grams) Range	(av.)
June 25	40	60	50-135	(72.6)	0.7-2.1	(1.1)	...-13	...	...-0.22	...
July 14	21	79	62-222	(107.0)	0.7-2.7	(1.2)	1-78	(13.4)	0.01-0.99	(0.17)
Aug. 17	12	113	79-263	(171.0)	0.6-2.2	(1.4)	2-102	(46.7)	0.02-0.90	(0.41)
Oct. 14	362	171	83-446	(207.2)	0.4-2.6	(1.2)	2-460	(72.1)	0.01-2.69	(0.42)

[1] Northern pike are approximately 9 mm. long when hatched.

TABLE 2

GROWTH OF THE NORTHERN PIKE IN POND NO. 3 AT THE DRAYTON PLAINS HATCHERY BETWEEN OCTOBER 14, 1937 AND OCTOBER 17, 1939

Sampling dates[1]	Total length (mm.) Range	Total length (mm.) (av.)	Increment[2] of average length (mm.)	Percentage increment of average length	Average weight (grams)	Increment of average weight (grams)	Percentage increment of average weight	Average growth per day: millimeters	Average growth per day: grams
Small fish (Ortonville stock)									
Oct. 14, 1937	87-109	(95.6)	96.6	91	4.1	4.1	100	0.51	0.02
May 26, 1938	160-197	(179.7)	84.1	47	31.6	27.5	87	0.38	0.12
Nov. 9, 1938	264-336	(307.2)	127.5	42	145.2	113.6	78	0.76	0.68
Oct. 17, 1939	356-373	(363.8)	56.6	16	230.0	84.8	37	0.17	0.25
Large fish (Ortonville stock)									
Oct. 14, 1937	195-371	(274.1)	265.1	97	101.3	101.3	100	1.55	0.59
May 26, 1938	297-385	(339.1)	65.0	19	227.5	126.2	55	0.29	0.56
Nov. 9, 1938	347-535	(394.0)	54.9	14	319.2	91.7	29	0.33	0.49
Oct. 17, 1939	260-652[3]	(417.1)	23.1	6	361.7	42.5	12	0.07	0.12
Belle Isle fish									
Dec. 15, 1937	209-305	(245.2)	236.2	96	61.9	61.9	100	...	...
May 26, 1938	272-326	(301.6)	56.4	19	168.4	106.5	63	0.35	0.66
Nov. 9, 1938	324-396	(386.6)	84.9	15	234.0	65.6	28	0.33	0.39
Oct. 17, 1939	357-420	(384.3)	27.8	7	267.3	33.3	12	0.08	0.10

[1] A random sample of fish taken on May 26 and Nov. 9, 1938 was measured; all fish were weighed and counted.
[2] The eggs hatched on April 27, 1937 at which time the fry were approximately 9 mm. long.
[3] This fish was probably missed on May 26 and Nov. 9 when only a random sample of fish was measured.

TABLE 8

THE AVERAGE INCREMENT OF LENGTH AND WEIGHT AT EACH COLLECTION DATE FOR THE THREE SIZE GROUPS OF NORTHERN PIKE REARED AT THE DRAYTON PLAINS HATCHERY

Size group	Length of fish at hatching (mm.)	Average increment in length (mm.)				Average total length Oct. 17, 1939	
		Oct. 14, 1937	May 26, 1938	Nov. 9, 1938	Oct. 17, 1939	mm.	inches
Small fish	9.0	86.6	84.1	127.6	56.6	353.8	14.3
Belle Isle fish	9.0	236.2[1]	66.4	54.9	27.8	384.3	15.1
Large fish	9.0	265.1	65.0	54.9	23.1	417.1	16.4

Size group	Average increment in weight (grams)				Average weight Oct. 17, 1939	
	Oct. 14, 1937	May 26, 1938	Nov. 9, 1938	Oct. 17, 1939	grams	ounces
Small fish	4.1	27.5	113.6	84.8	230.0	8.1
Belle Isle fish	61.9[1]	106.5	65.6	33.3	267.3	9.4
Large fish	101.3	126.2	91.7	42.5	361.7	12.8

[1] The average weight and average length of the Belle Isle fish are for December 15, 1937, the date that these fish were placed in the rearing pond.

Plate I. Group photograph of northern pike collected at the Ortonville Rearing Pond on June 25, 1937. These fish range in size from 50 to 135 mm.

Plate II. Group photograph of northern pike collected at the Ortonville Rearing Pond on October 14, 1937. These fish range in size from 83 to 446 mm.

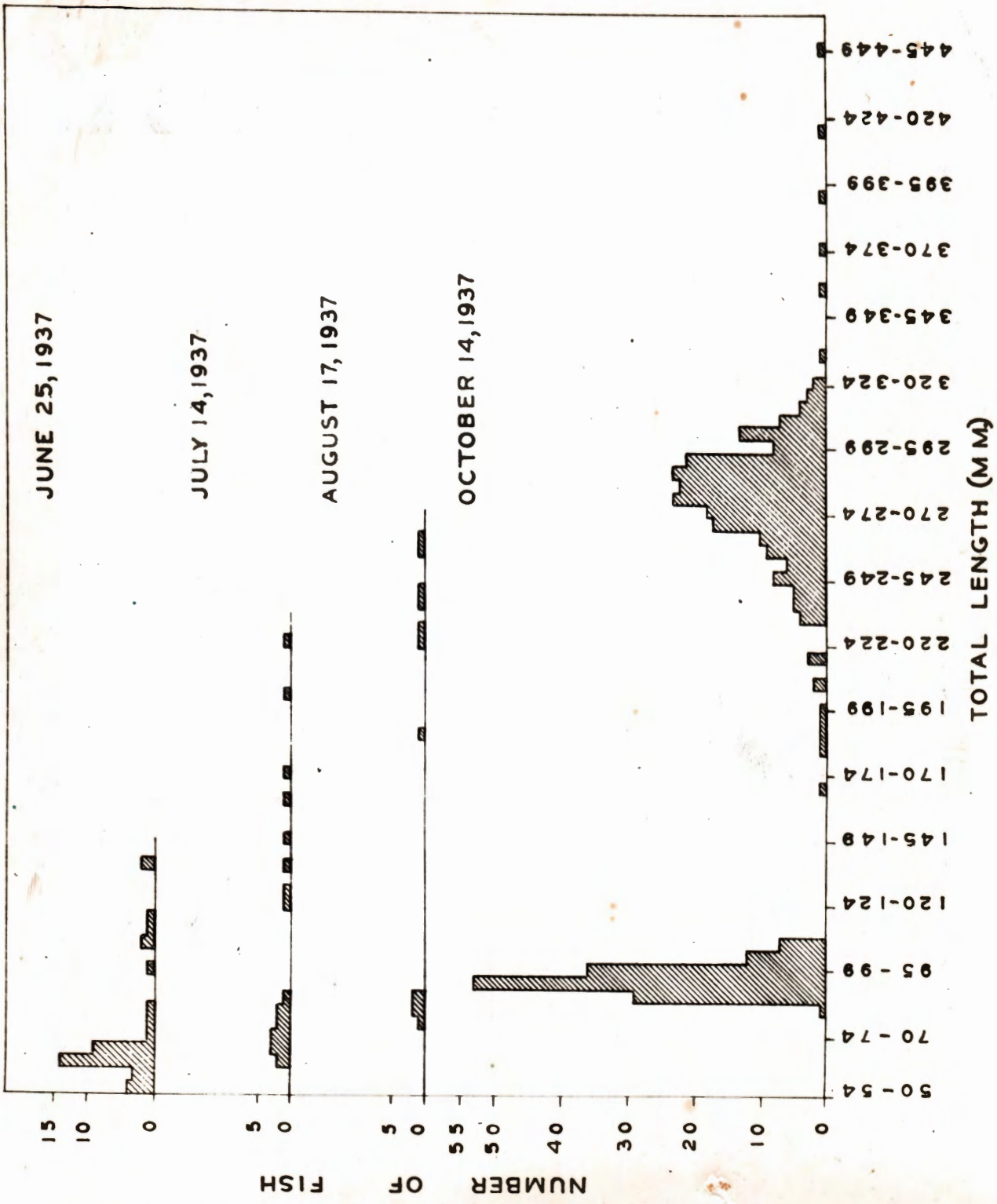


Fig. 1. Histogram showing the growth of the northern pike in the Ortonville Rearing Pond.

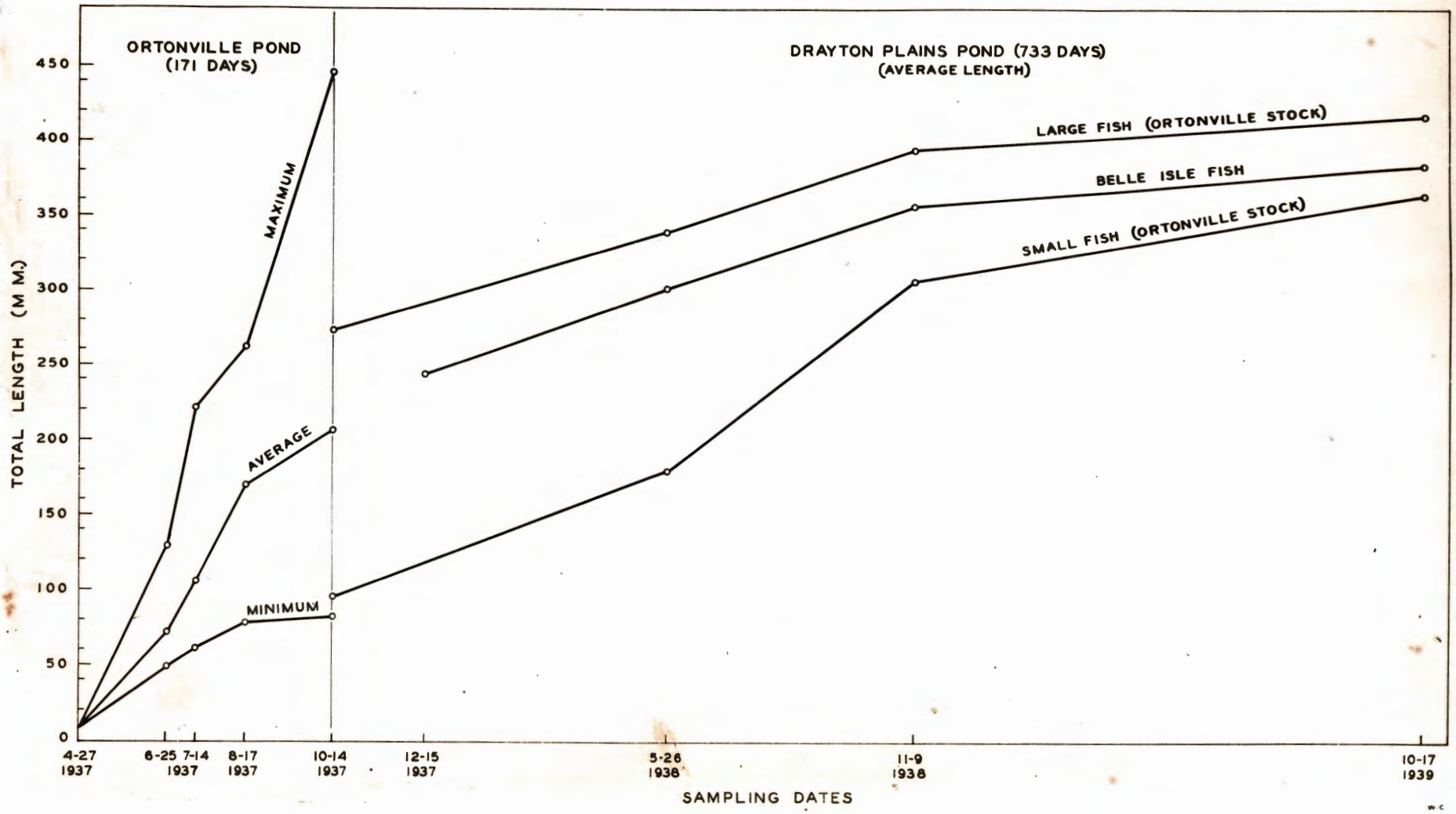


Fig. 2. Growth in length of the northern pike in rearing ponds at Ortonville and Drayton Plains.

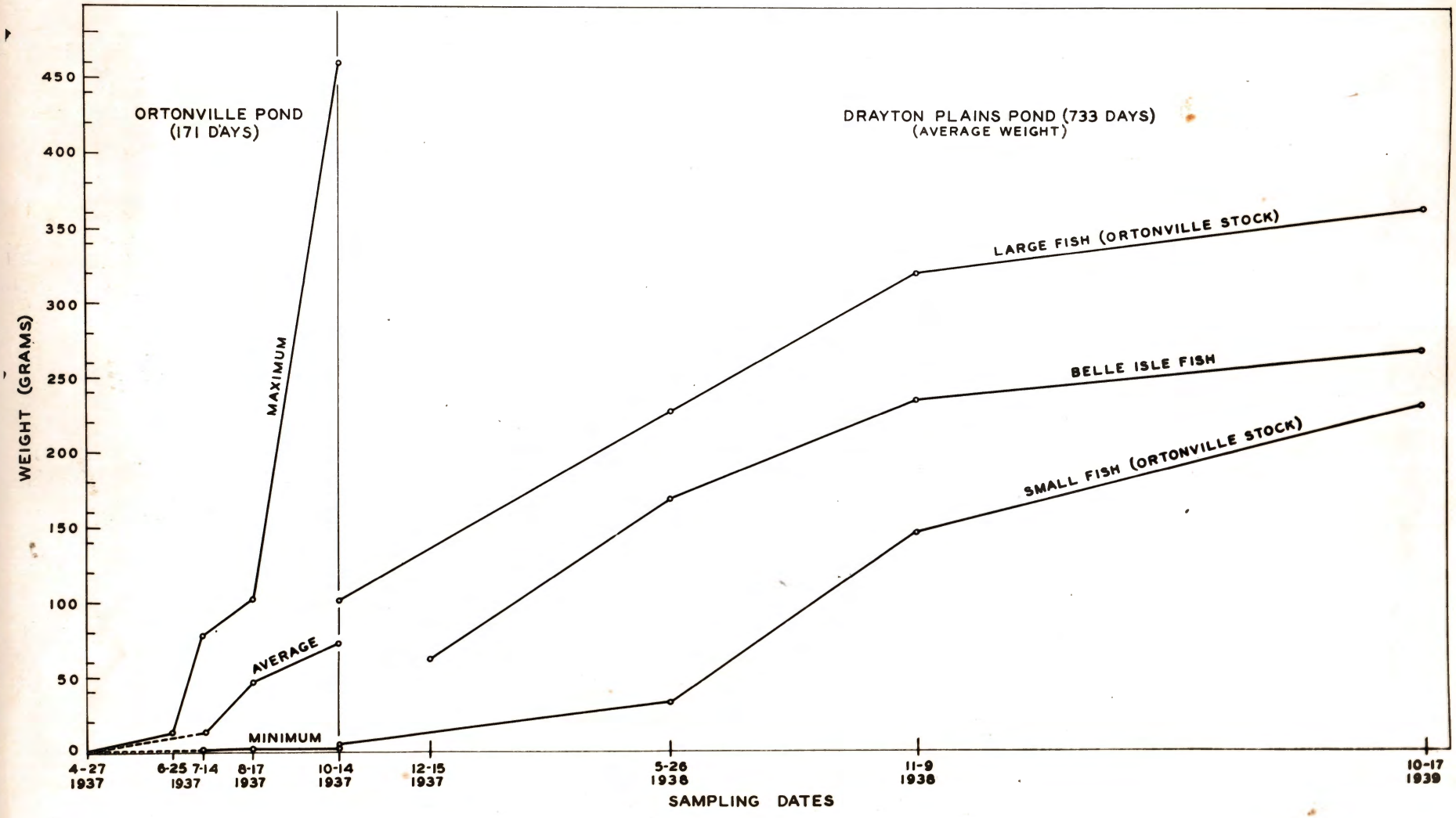


Fig. 3. Growth in weight of the northern pike in rearing ponds at Ortonville and Drayton Plains.

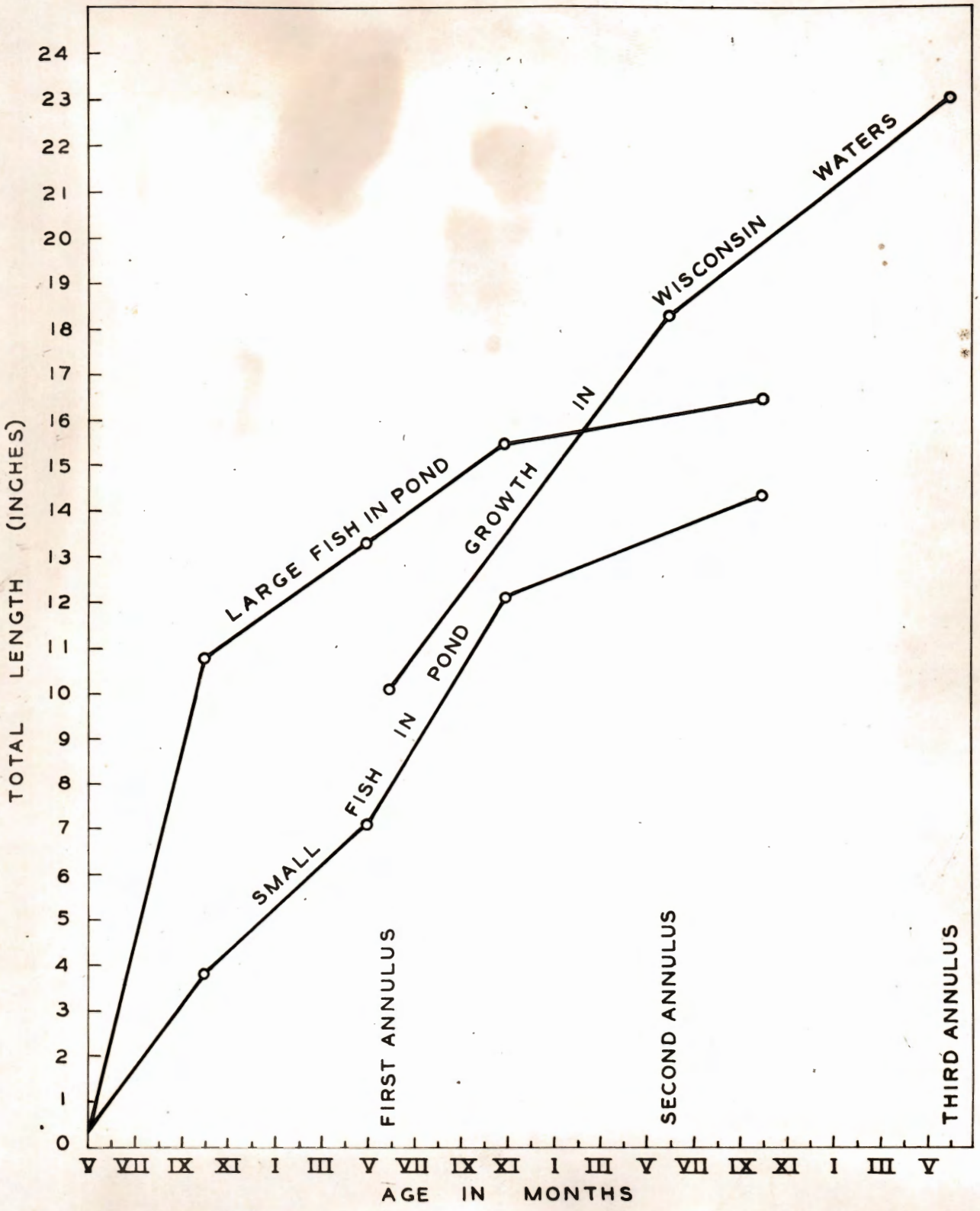
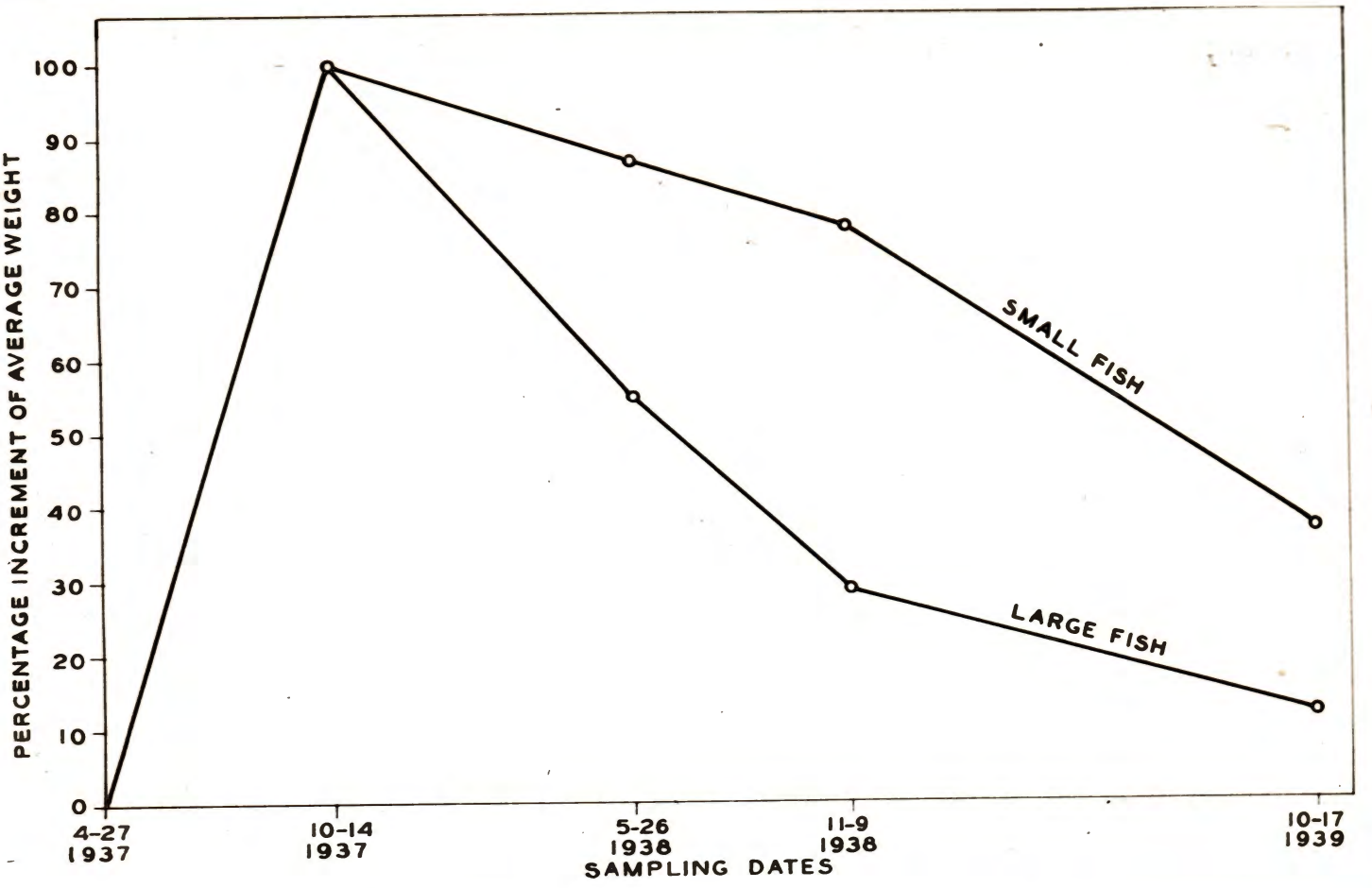


Fig. 4. Growth of small and large northern pike in rearing ponds and the average calculated growth of the species in natural waters.



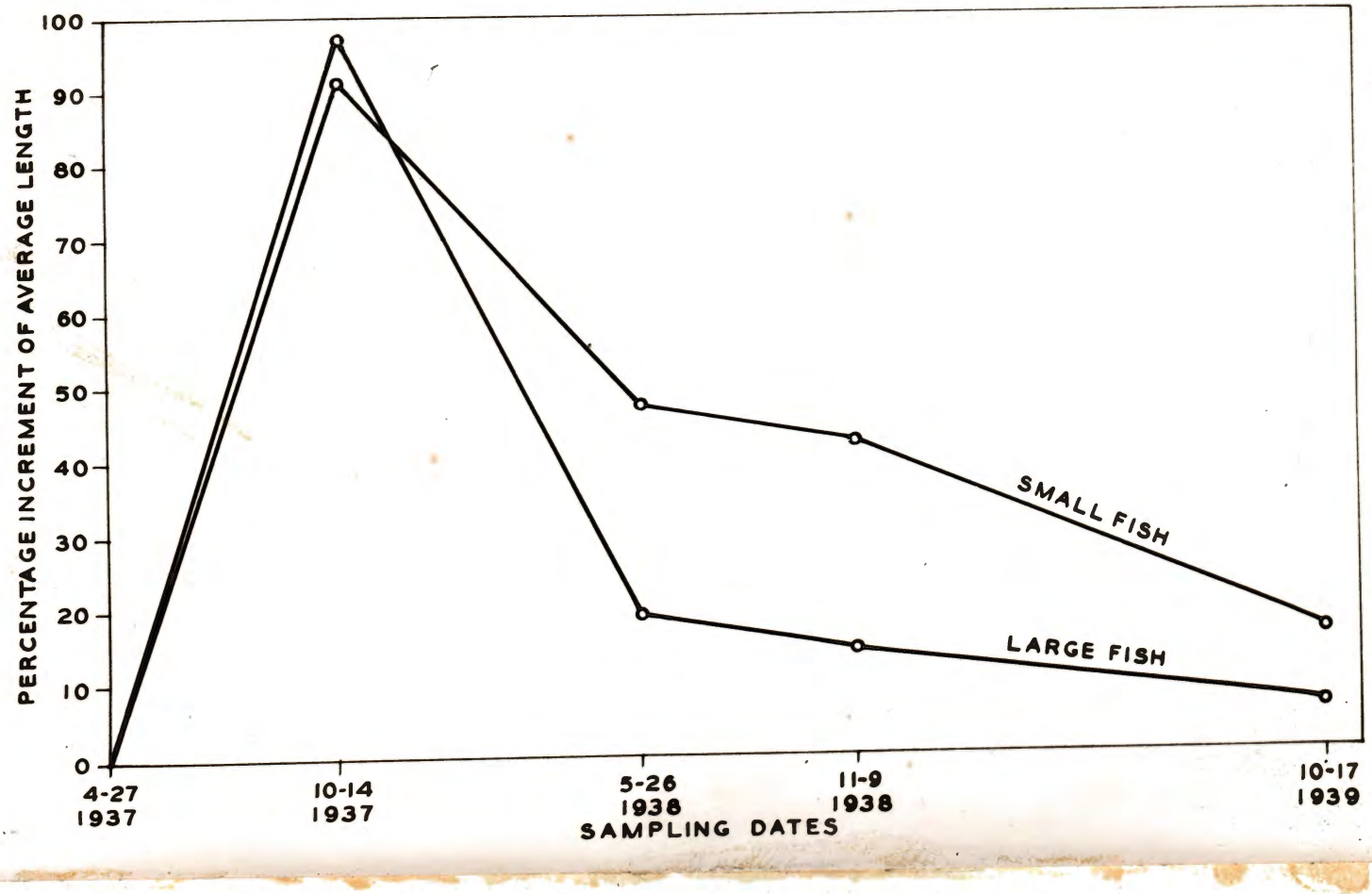


Fig. 5. Percentage increments of the average weight and average length of small and large northern pike in rearing ponds at Ortonville and Drayton Plains.