EFFECTS OF STOCKING NORTHERN PIKE IN MURPHY FLOWAGE

Technical Bulletin No. 79

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

1974

ABSTRACT

Monitoring of fish populations in Murphy Flowage, a 180-acre flowage in northwestern Wisconsin, between 1955 and 1960 indicated the development of an overabundant, slow-growing population of bluegills *(Lepomis macrochirus).* In 1960 and 1961, attempts to improve bluegill growth by mechanical thinning failed apparently because only the larger bluegills were removed. Since the flowage already had a good northern pike population *(Esox lucius),* it was suggested that increasing this predator population might result in controlling of bluegill numbers and hence, improving growth. To test this hypothesis, the flowage was stocked in late December, 1963, with 8,534 northern pike fingerlings ranging in size from 10.4 to 22.8 inches in total length. On an area basis, this stocking was equal to 47 fish/acre or 40.3 lbs/acre which met the intent of approximately doubling the northern pike population in the flowage. Complete angling records were obtained by a compulsory permit system throughout the entire study from 30 April 1955 through 31 May 1970.

Population density of stocked northern pike declined drastically following stocking from 47.0 pike or 40.3 lbs/acre in 1963 to 0.2 pike or 0.6 lbs/acre by 1968. By the spring of 1966, the stocked and native northern pike population was at its lowest level since 1960. In addition, the number of fish 26.0 inches and larger declined 76 percent between the 1955-1963 and 1964-1966 periods.

Within 5 years after stocking, anglers caught only 6.6 percent of the stocked fish, comprising 9.1 percent of the pounds stocked. Ninety percent of the total number and 78 percent of the total pounds caught were taken the first year after stocking. In addition, the harvest of native pike declined drastically after stocking.

Sampling in downstream areas indicated that possibly 30 percent or more of the total number of pike stocked in Murphy Flowage had moved out of the flowage by the spring of 1965. Maximum downstream movement appeared to occur during the spawning period, involved largely stocked fish and was significantly related to population density.

In addition to harvest and emigration, pike were also lost as a result of observed natural mortality caused by a parasite, *Myxobolus,* believed to have been introduced at the time of stocking. Total observed mortality was significantly related to population density, and mortality of larger native pike was greater than that of smaller native pike.

Mortality from all causes averaged 60 percent for 9 years prior to stocking, while the first year after stocking, total mortality was 90 percent for both stocked and native pike. Total mortality remained higher than the prestocking average for 3 years.

Stocking of northern pike had no discernible impact on the bluegill population. After stocking, numbers of bluegills, particularly small ones, continued to increase, while their growth continued to decline.

Impact of stocked pike on the native pike population and angler harvest was also unfavorable. By 1965, the second year after stocking, harvest of native pike had declined to the lowest level during the 9 preceding years and by 1966, the standing crop of native pike had declined to its lowest level in the preceding 6-year period.

The decision to stock northern pike in a given body of water should be carefully considered if a lake is to be stocked to either establish, maintain, or increase a northern pike population. It is suggested that the total density after stocking of large fingerlings (10-18 inches) not exceed 8 pike/acre. If the lake to be stocked already contains a native northern pike population, the fish populations should ideally be monitored prior to stocking in order to determine whether the lake can support more pike and to avoid the problems caused when the carrying capacity is exceeded.

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Technical Bulletin No. 79

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
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1974

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INTRODUCTION

Monitoring of fish populations in Murphy Flowage between 1955 and 1960 indicated the development of an overabundant, slow-growing population of bluegills *(Lepomis macrochirus)*. In 1960 and 1961, attempts to improve bluegill growth by mechanical thinning failed, apparently because only the larger bluegills were removed. Since the flowage already had a good northern pike population *(Esox lucius)*, it was suggested that increasing this predator population might result in controlling of bluegill numbers and hence, improving growth. To test this hypothesis, the flowage was stocked with northern pike in 1963 at a rate of 47 large fingerlings per acre. This rate met the intent of approximately doubling the northern pike population in the flowage and was much greater than those stocking rates usually reported in the literature (1-5 pike/acre).

Despite rather wide utilization of northern pike for stocking purposes, there has been relatively little work evaluating the results. Furthermore, most releases which have been evaluated are mainly concerned with the stocked pike rather than the effects the stocked pike may have had on other segments of the fish population, especially on the native pike population.

Because heavy stocking failed to effectively increase the northern pike population, this paper discusses only briefly the impact of stocking on the bluegill population. Instead, emphasis is placed on a description of the interaction between the stocked fish and the native northern pike population. In regard to this interaction, angling statistics, population density, mortality, and movement are compared before and after the 1963 stocking. Data presented cover a 15-year period from 30 April 1955 through 31 May 1970.

THE STUDY AREAS

Formed in 1937 by the impoundment of Hemlock Creek, a trout stream, Murphy Flowage is located in northwestern Wisconsin (Rusk County) in the headwaters region of the Red Cedar River, a tributary of the Chippewa and Mississippi Rivers. The flowage is 1,258 feet above mean sea level and is located within a hilly, rocky region known as the Barron Hills. Although the maximum depth of Murphy Flowage is 14 feet, over 70 percent is less than 10 feet in depth. The 180-acre flowage has a volume of 874.2 acre-feet of water and has 6.4 miles of irregular shoreline. The average annual alkalinity is 37 ppm and the mean annual flow at the outlet is 18.4 cfs. Beard (1969) found 24 species of aquatic plants present in Murphy Flowage in 1967. *Potamogeton robbinsii* was the most abundant species and covered an area of approximately 104 acres. Other common species in order of decreasing abundance were *Nuphar* spp., *Myriophyllum* spp., *Ceratophyllum demersum*, and *Potamogeton amplifolius*. Clearly, a large percentage of the total area is covered by dense aquatic vegetation.

The total biomass of fish at Murphy Flowage approximates 325 lb/acre (25 lb of game fish and 300 lb of panfish). The largemouth bass, *Micropterus salmoides* (Lacepede), comprises about 30 percent of the total lb/acre of game fish and the northern pike, about 60 percent. The bluegill, *Lepomis macrochirus* Rafinesque, comprises about 80 percent of the total lb/acre of panfish. Other panfish present are the black crappie, *Pomoxis nigromaculatus* (Lesueur); pumpkinseed, *Lepomis gibbosus* (Linnaeus); rock bass, *Ambloplites rupestris* (Rafinesque); yellow perch, *Perca flavescens* (Mitchill) and brown bullhead, *Ictalurus nebulosus* (Lesueur). The white sucker, *Catostomus commersoni* (Lacepede); the tadpole madtom, *Noturus gyrinus* (Mitchell) and several species of minnows are present in limited numbers. Muskellunge, *Esox masquinongy* Mitchill, have been stocked but are not numerous.

In addition to Murphy Flowage, there are 3 other impoundments and interconnecting waters on Hemlock Creek which are included in portions of this study. These are Bucks Lake (83 acres) about 1 1/2 miles upstream from Murphy Flowage, Bolger Flowage (78 acres) 1 mile downstream, and Hemlock Lake (410 acres) 1/4 mile below Bolger Flowage. These lakes have fish populations similar to those found in Murphy Flowage with the following exceptions: Bucks Lake has an abundant minnow population but no largemouth bass or brown bullheads, Bolger Flowage contains bowfin, *Amia calva* Linnaeus, in addition to all Murphy Flowage species, and Hemlock Lake has the walleye, *Stizostedion vitreum vitreum* (Mitchill), in addition to all Bolger Flowage species.

METHODS

HARVEST DETERMINATION

Complete angling records were obtained by a compulsory permit system throughout the entire study from 30 April 1955 through 31 May 1970. Information on the hours fished and fish caught was recorded for each angler at the end of the fishing trip. All pike were measured to the nearest 0.1 inch in total length and weighed to the nearest 0.01 lb. Information on sex ratios was determined by macroscopic examination of the gonads from all pike creeled and by visual observation of milt or eggs from pike handled in the field during the spring netting period.

Throughout this report, an angling year includes the open-water season plus the ensuing ice fishing season. All annual figures presented, therefore, include data from portions of 2 consecutive calendar years, on the average from 15 April one year to 15 April of the year following. No restrictions on length of fishing season, bag limit or size limit were in effect on Murphy Flowage at any time. Angling was permitted from 4:00 a.m. to 10:00 p.m. in the summer and from 8:00 a.m. to 6:00 p.m. in the winter.

STOCKING

Northern pike were stocked in 1963, at which time the stocking totals were designed to double the number of northern pike within one year. Studies of stocked muskellunge fingerlings have indicated survival of approximately 20 percent after one year (Leon D. Johnson, Wis. Dep. Nat. Resour., pers. comm.). Since Murphy Flowage contained 10 to 14 native northern pike/acre from 1961 to 1963, a stocking goal of 50 pike fingerlings/acre was established. Assuming that survival of the northern pike fingerlings approximates that of muskellunge, there would have been a minimum of approximately 20 pike/acre one year after stocking.

In late December 1963, Murphy Flowage was stocked with 8,534 northern pike fingerlings having a total weight of 7,253 lb. On an area basis, this stocking was equal to 47 fish/acre or 40.3 lb/acre. The size range of the stocked pike was 10.4-22.8 inches in total length.

A description of the area from which the stocked pike were obtained has been summarized by Priegel (1968) as follows:

"Rush Lake is a shallow, marsh-type lake of 3,070 acres with a maximum depth of 6 feet. It is classified as a freeze-out lake and since 1956, it has been used as a natural rearing lake. Northern pike and walleye, *Stizostedion vitreum vitreum* (Mitchill), fry are stocked in the spring and during winter rescue operations, the fish are removed to restock periodical freeze-out lakes or lakes reclaimed through chemical treatment. There are no major inlets and the lake is essentially a settling basin for a small, fertile agricultural watershed. Water levels are maintained by a dam on the outlet stream, Waukau Creek, which drains into the Fox River just above Omro. Waukau Creek has an average fall of about 11 feet per mile in the 6 miles between Rush Lake and the Fox River.

"In addition to the northern pike fry that are planted in Rush Lake each spring, the lake is used by native northern pike as a spawning marsh. The fish migrate up Waukau Creek into Rush Lake and as water levels recede, the northern pike fry are stranded in the lake. Hence the winter rescue operations consist of removing planted and native northern pike."

The stocking site for all pike was located in Louler Bay approximately 500 ft. north of the upper narrows (Fig. 1). The pike were transported from Rush Lake to Murphy Flowage in tank trucks, then moved to the actual site out on the flowage using sleds and wash tubs, in air temperatures ranging from -10 to -20 F. A 6- by 10-foot heated building located on the ice was used to work in while processing the pike. Handling included finclipping all fingerlings, measuring a sample of 641 pike, weighing a sample of 170 pike, collecting scales from a sample of 82 pike, then immediately releasing the pike into the flowage.

To evaluate any initial mortality as a result of handling and finclipping, 54 pike were held in a 6- by 6-foot live box located just below the dam. One-half of these were finclipped. After 3 days, all 54 pike were found to be in good condition and were stocked in the flowage.

POPULATION AND MORTALITY ESTIMATES

Population estimates of all pike were calculated from Bailey's modification of the Petersen mark and recapture method and formula (Ricker 1958). These estimates were made each spring from 1955 through 1970 and each fall in 1964 and 1965. Confidence limits were calculated using standard statistical procedures. Since all the stocked pike consisted of one year-class and most were confined to a relatively narrow size range, all estimates were made without regard to size groups. These estimates were then used to calculate age-specific survival, mortality, and annual expectation of death from fishing and natural causes.

At all times during the entire study, the stocked pike were treated as a separate population from the native pike population. This was accomplished by excision of the dorsal lobe of the caudal fin at the time of

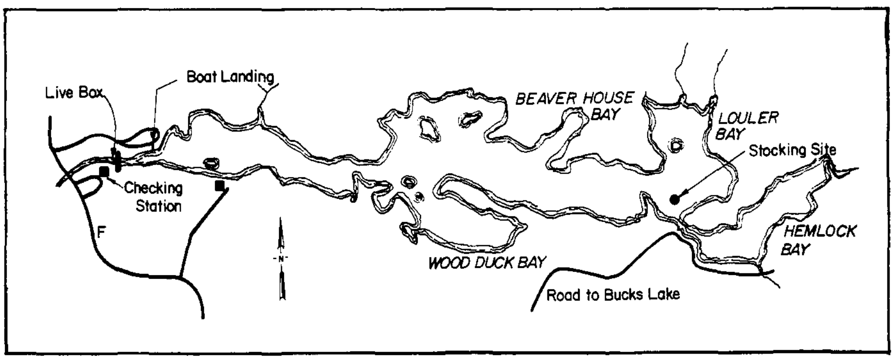


FIGURE 1. *Map of Murphy Flowage.*

stocking and the recording of this and subsequent marks for all pike handled.

GROWTH DETERMINATION

Growth of the stocked pike was compared with the same year-class (1963) of native pike each year through age group V. Since the stocked pike were of known age, the average length of stocked pike collected during each spring sampling period was used to determine growth. These average lengths were compared with the average length of native pike as determined by aging 3-4 scales from each native fish.

POPULATION SIZE

The number of stocked pike declined drastically the first year after stocking. Of the 8,534 pike stocked in December 1963, an estimated 1,296 or 15 percent were present in Murphy Flowage in October 1964 (Table 1). The decline of pike continued until an estimated 31 pike were present in April 1968. After 1968, the small numbers of stocked pike present made it impossible (by the methods used in this study) to estimate their abundance.

The abundance of stocked pike declined from 47.0 pike weighing 40.3 lb/acre at the time of stocking to 7.2 pike weighing 9.5 lb/acre in October 1964. By April 1968, there were only 0.2 pike weighing 0.6 lb/acre (Table 1). At the time of stocking, the stocked pike comprised approximately 79 percent by number and 68 percent by weight of the total (stocked plus native) pike population present in Murphy Flowage. These percentages declined so that by October 1964, the stocked pike comprised 45 percent by number and 47 percent by weight and by April 1968, 2 percent by number and 4 percent by weight.

One of the original objectives was to double the number of pike in Murphy Flowage within one year after stocking. Prior to stocking (between 1961 and 1963), the number of native pike varied from 10 to 14/acre. By October of 1965, there were an estimated 21 pike/acre. The original goal was accomplished; however, 75 percent of the total number of pike present in 1965 were native pike.

Population estimates and standing crops of native and stocked pike/acre from 1955 through 1970 are presented in Table A, Appendix.

TABLE 1. *Estimated numbers and 95 percent confidence limits of the population estimates of stocked northern pike in Murphy Flowage, 1963-68.*

Year & Month of Estimate	Population Size: Total No. Estimated Present	No./Acre	Lb./Acre	95 Percent C. L. of Population Estimate
1963 23 Dec.	8,534	47.0	40.3	Actual no. stocked
1964 15 May	7,398 (6,500)*	36.1	32.1	6,052-9,079
15 Oct.	1,296	7.2	9.5	813-1,800
1965 15 May	732	4.1	5.3	558-1,081
26 Oct.	368	2.0	4.4	171-2,400
1966 18 May	118	0.7	1.4	69-494
1967 15 May	50	0.3	0.8	36-174
1968 15 Apr.	31	0.2	0.6	23-72

*Population estimates in downstream areas indicate that at least 2,000 northern pike had migrated out of Murphy Flowage by 15 May 1964. Therefore, the population estimate for northern pike in Murphy Flowage on this date was adjusted to 6,500 pike throughout this paper.

GROWTH

Since Rush Lake from which pike were taken for stocking is a winterkill lake, all pike stocked in Murphy Flowage were assumed to be age 0. To verify this hypothesis, scale samples were taken from 82 pike and all were judged to be age group 0 except a 22.8-inch pike which was aged at I. These results were then compared with those from a sample of 641 pike which were measured to the nearest tenth of an inch. Since 92 percent of the fish in the sample of 641 pike fell within a narrow size range (13.0-18.0 inches), all other stocked fish handled were assumed to be the same age. Average length of the entire group of stocked pike during May in each succeeding year (1964-68) for age groups I-V were 15.6, 18.0, 21.9, 23.7, and 26.0 inches, respectively (Table 2 and Figure 2).

In comparison to stocked pike, native pike (sexes combined) of the same year-class as stocked pike were smaller for all ages compared, but the differences in average length between the

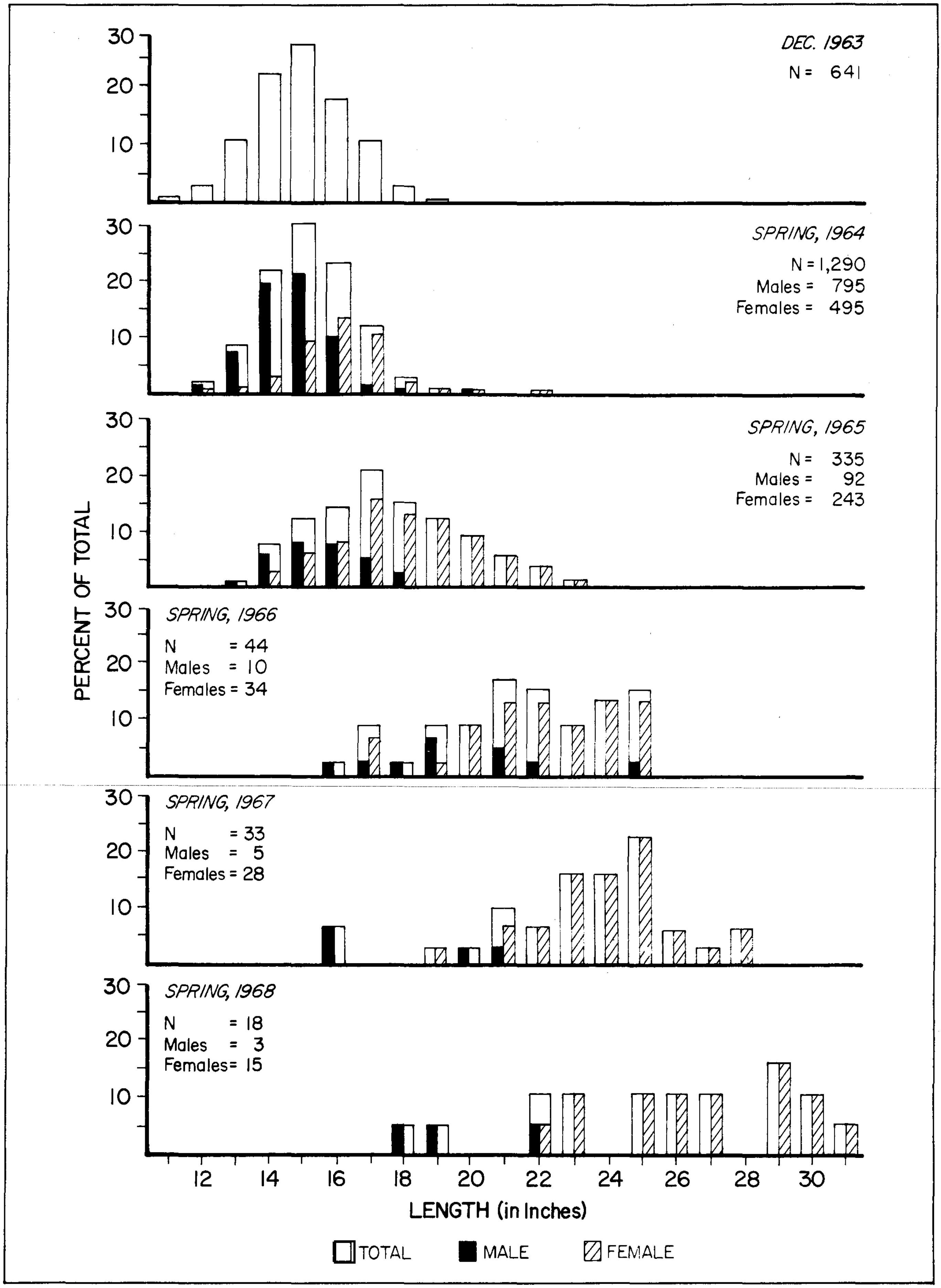


FIGURE 2. *Length distribution of northern pike stocked in Murphy Flowage at the time of stocking in December 1963 and each spring thereafter from 1964 to 1968. (The lower length in each 1-inch interval is shown.)*

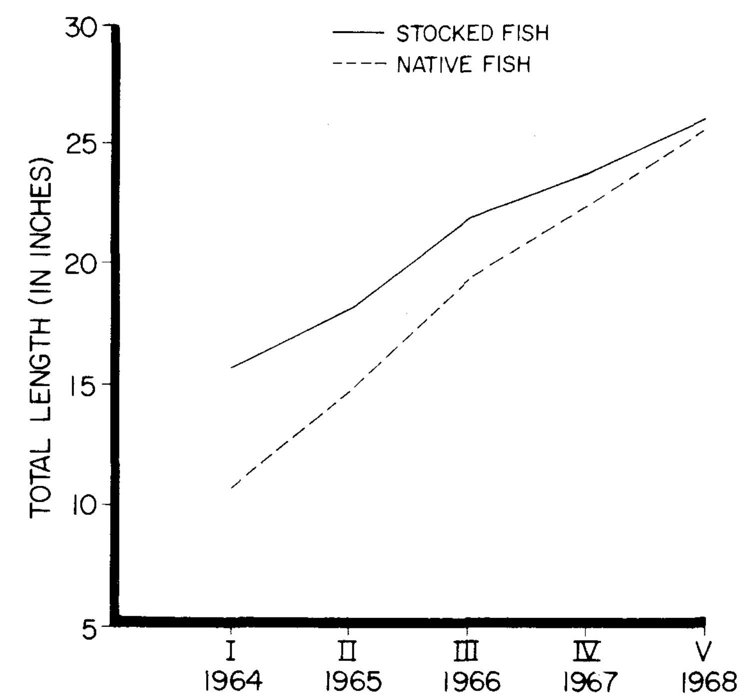


FIGURE 3. *Growth of the 1963 year-class of stocked and native northern pike (sexes combined) in Murphy Flowage, 1964-68.*

two groups decreased with increasing age. At age I, stocked pike were approximately 5 inches larger than native pike, while at age V, they were only about 1/2 inch larger. Between the ages of I and V, the native pike grew faster than the stocked pike; however, because the stocked pike were considerably larger than the native pike at the time of stocking, the native pike did not quite "catch up" to the stocked pike during the years compared (Fig. 3). The numbers of stocked pike older than V were so low that adequate comparisons of growth of older pike could not be made.

Average lengths of female pike exceeded average lengths of male pike of the same age for both stocked and native populations. Further comparisons of average length by sex indicate that some native pike were larger than stocked pike of the same age. For example, native males of age IV and V and native females of age IV were larger than stocked pike of the same age and sex (Table 2). Although the stocked pike as a whole were larger than native pike of the same age, this generalization was not valid for all age groups when compared by sex.

TABLE 2. *Growth of the 1963 year class of stocked and native pike in Murphy Flowage*

		Males		Females		Sexes Combined	
Age	Year of Sample*	No.	Avg. Length (in Inches)	No.	Avg. Length (in Inches)	No.**	Avg. Length (in Inches)
Stocked Pike							
0	1963	–	–	–	–	641	15.4
I	1964	795	15.0	495	16.4	1,290	15.6
II	1965	92	16.2	243	18.6	335	18.0
III	1966	10	20.1	34	22.5	44	21.9
IV	1967	5	18.8	28	24.5	33	23.7
V	1968	3	20.2	15	27.2	18	26.0
Native Pike							
I	1964	1	11.3	–	–	20	10.6***
II	1965	110	14.2	58	15.5	210	14.6
III	1966	52	17.9	31	20.2	109	19.4
IV	1967	47	20.4	22	24.8	84	22.4
V	1968	26	22.7	39	26.7	82	25.5

*All samples were collected in April and May except for age 0 stocked pike, data for which were taken in December at the time of stocking.
**The number of pike (sexes combined) includes some pike for which sex could not be determined. Therefore, the sum of the numbers of male and female pike do not always equal the numbers of pike with sexes combined.
***This is probably high due to size selectivity of sampling nets.

HARVEST

The maximum harvest of stocked pike occurred the first year after stocking. Of 8,534 pike weighing 7,253 lb stocked in December 1963, only 561 pike weighing 657 lb were caught by anglers through December 1968. The total number caught comprised 6.6 percent of the number stocked and the total pounds caught comprised 9.1 percent of the pounds stocked. Ninety percent of the total number and 78 percent of the total pounds caught were taken the first year after stocking (Table 3).

Total catch of northern pike including stocked and native pike declined drastically within one year after stocking. The 9-year prestocking average catch of 3.5 pike weighing 7.9 lb/acre was followed by a catch of 4.3 pike weighing 5.5 lb/acre in 1964 and 1.4 pike weighing 2.2 lb/acre in 1965. In 1964, the number of stocked pike caught exceeded the catch of native pike; however, the pounds of stocked pike caught did not exceed the pounds of native fish caught at any time (Table 4). The catch of pike from 1965 until the termination of the study in June 1970 remained lower in both number and pounds than at any time during prestocking years.

Average length of all angler-caught pike declined after stocking. The 9-year (1955-1963) mean length of native pike caught before stocking was 21.2 inches while the first year after stocking (1964), mean length of native pike caught was 19.4 inches and mean length of stocked pike caught was 17.1 inches. Annual average length of the stocked pike caught from 1965 through 1967 was 19.8, 23.6 and 26.4 inches, respectively. Because most stocked pike were caught before much growth could occur, the average length of all angler-caught stocked pike was only 17.6 inches. Of the total catch of 561 stocked pike, 71 percent were less than 18.0 inches. The 29 percent caught over 18.0 inches represented only 2 percent of the original number stocked. Thus if there had been an 18.0-inch size limit in effect at Murphy Flowage, it is likely that only about 2 percent of the stocked pike would have been legally caught.

TABLE 3. *Catch of stocked northern pike during open-water seasons in Murphy Flowage, 1964-68.**

Year	No. Pike Caught		Lb. Pike Caught	
	No.	Percent of Total No. Caught	Lb.	Percent of Total Lb. Caught
1964	502***	90	514**	78
1965	35	6	58	9
1966	16	3	47	7
1967	7	1	31	5
1968***	1	–	7	1
Total	561	100	657	100

*Based on returns from 8,534 pike weighing 7,253 lb. stocked in December, 1963.
**Includes 33 pike weighing 39 lb. caught through the ice from 1 January through 15 April 1964.
***No stocked pike were caught from 15 December 1968 to the termination of the project on 1 June 1970.

TABLE 4. *Annual catch of native and stocked northern pike in Murphy Flowage, 1955-1968.*

Year	No. Caught		Lb. Caught	
	Total	No./Acre*	Total	Lb./Acre*
1955-1963 avg.	630	3.5	1,422	7.9
1963	684	3.8 (4.9)**	1,386	7.7 (2.8)**
1964	774	4.3 (60.5)	990	5.5 (48.5)
1965	252	1.4 (14.0)	396	2.2 (14.2)
1966	162	0.9 (9.8)	324	1.8 (14.6)
1967	252	1.4 (2.8)	702	3.9 (4.4)
1968	198	1.1 (0.4)	450	2.5 (1.6)

*Shown in parentheses are the percentages of the total catch which were stocked fish.
**Includes 0.2 stocked pike/acre weighing 0.2 lb./acre caught between 1 January and 15 April 1964.

MOVEMENT

NATIVE PIKE

During the early years of this study, there were occasional verified reports of anglers catching finclipped or tagged native northern pike in areas downstream from Murphy Flowage. In order to obtain more information on movement, 496 native northern pike were caught and tagged in Bucks Lake, about 1 1/2 miles upstream from Murphy Flowage between 1961 and 1967. Among approximately 10,000 native northern pike handled in Murphy Flowage from 1961 through 1970, there were no tagged pike from Bucks Lake (Snow and Beard 1972). Between 1964 and 1966, 1,300 native northern pike in Murphy Flowage were given distinctive marks. Spring and fall surveys made during 1964-66 in 3 downstream areas–Hemlock Creek, Bolger Flowage, and Hemlock

Lake (Fig. 4)–resulted in the capture of 310 native northern pike of which only 4 had been marked in Murphy Flowage, 2 in 1964 and 2 in 1965.

STOCKED PIKE

In contrast to the very limited movement of native northern pike, the stocked pike moved quite extensively. Reports of stocked pike being caught by anglers in Bolger Flowage in early May 1964, prompted efforts to estimate the minimum number of pike that moved out of Murphy Flowage. Nets were, therefore, set in Hemlock Creek, Bolger Flowage, and Hemlock Lake in 1964, 1965 and 1966 so that movement into and out of Bolger Flowage was blocked (Fig. 4). Population estimates made in Bolger Flowage indicated the presence of approximately 1,633 stocked and 1,020 native pike in 1964 and 829 stocked and 954 native pike in 1965. Of these fish, all stocked pike were from Murphy Flowage. In 1966, only 26 stocked pike were caught and marked in Bolger Flowage; for this reason, attempts to estimate numbers of pike in Bolger Flowage were abandoned.

Of 8,534 northern pike stocked in Murphy Flowage in December 1963, an estimated 1,633 were in Bolger Flowage by 21 May 1964. Since stocked pike were also captured upstream and downstream from Bolger Flowage, it is possible that as high as 25 percent of the total number stocked went over the Murphy Flowage dam by the time of the estimate in 1964 and possibly 30 percent or more by the time of the 1965 estimate. Most of the initial movement within Murphy Flowage and to downstream areas probably occurred within a 4-month period during the winter of 1963 or early spring of 1964. These results are somewhat similar to those reported by Carlander and Ridenhour (1955). They found that newly stocked pike dispersed to all parts of 3,600-acre Clear Lake, Iowa, within 6 months after stocking.

Due to low water levels in the winter, it is unlikely that large numbers of northern pike moved over the dam during this season. Since in spring, water levels are higher and spawning activity occurs, it is likely that this was the period of maximum downstream movement. This hypothesis is supported in part by the capture of northern pike in a fyke net placed on 27 April 1965 200 feet below the Murphy Flowage dam to block downstream movement in Hemlock Creek. From 27 April to 4 May, the daily catch of stocked pike declined from 24 to 0 (Fig. 5). Between 4 and 8 May, no northern pike were captured and the net was removed. Of the total catch of 61 mature northern pike, 59 were stocked pike. In Murphy Flowage, spawning usually occurs from the first or second week of April

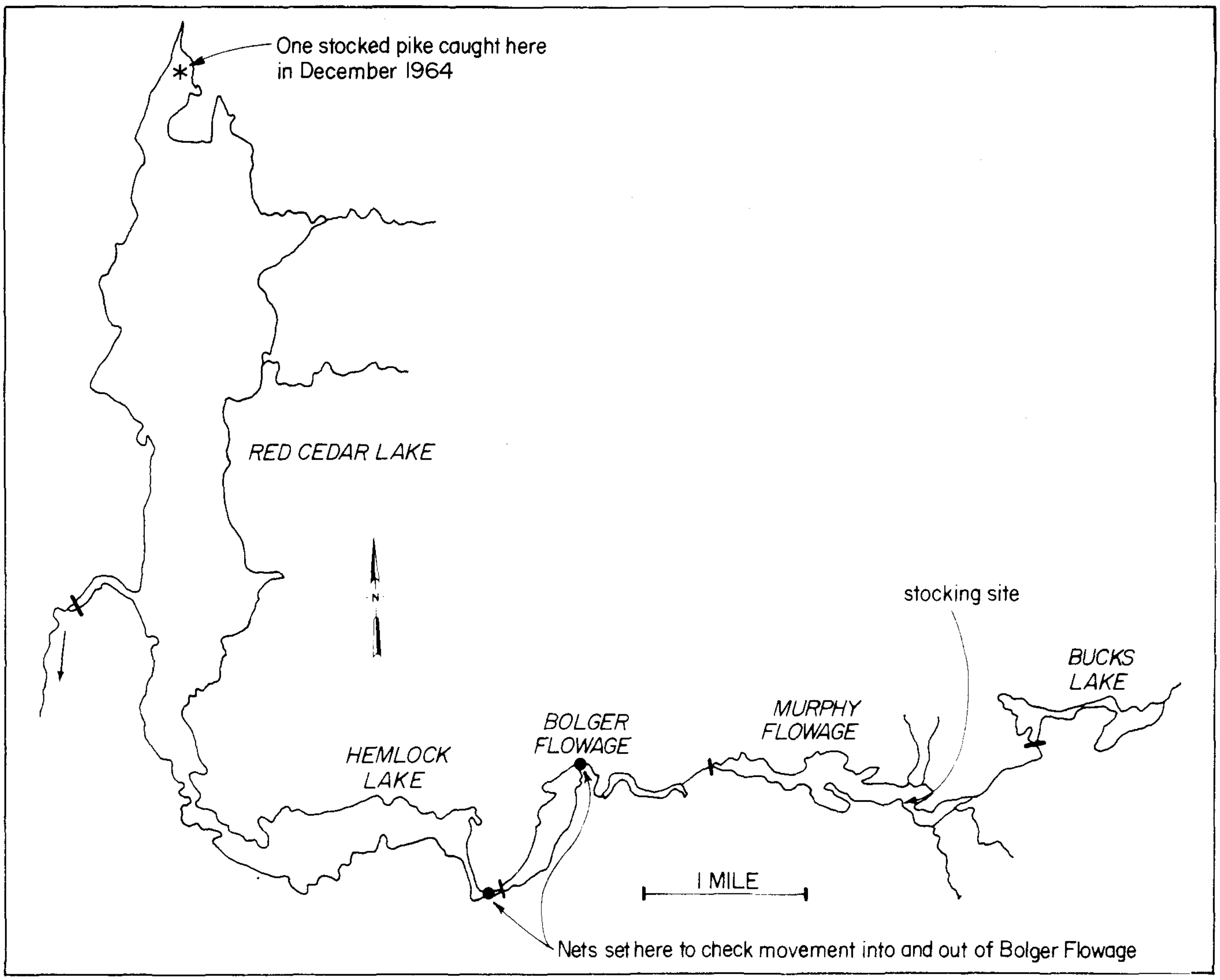


FIGURE 4. *The Hemlock Creek System and Red Cedar Lake.*

View of Bolger Flowage (center) where an estimated 20 percent of the pike stocked in Murphy Flowage in December 1963 were found in May 1964. Stocked pike were also found in Hemlock Lake (upper left) and Red Cedar Lake (across the top).

View of the Murphy Flowage dam. By 1966, approximately 30 percent of the pike stocked in December 1963 left the flowage over this dam.

until about the first of May. Since the catch of pike in the Hemlock Creek net steadily declined over the 8-day period which encompassed the end of the spawning period and since the catch was zero from 4 May through 8 May, it seems reasonable to assume that maximum movement of northern pike out of Murphy Flowage occurred during the spawning period.

To make further observations on the movements of stocked pike, 18 pike captured below Murphy Flowage were given an additional finclip and released about 400 feet upstream from the Murphy Flowage dam on 27 April 1965. Within 24 hours, 1 of these was recaptured about 1 1/4 miles upstream from the point of release. On 28 April, an additional 23 were released just below the Hemlock Creek net. Within 48 hours, 2 of these pike were captured in Bolger Flowage, about 2 miles downstream from the point of release.

During additional electrofishing surveys made in Hemlock Lake in the spring of 1965 and each fall from 1964 through 1966, from 7 to 19 percent of the total northern pike captured were stocked pike from Murphy Flowage. The total number of stocked and native pike caught varied from 7 to 72 pike. Evidence of the farthest downstream movement of a stocked pike was provided by a fish caught by an ice fisherman in the northern part of Red Cedar Lake in the winter of 1964-65, a distance of approximately 7 miles from Murphy Flowage (Fig. 4).

Further analysis indicates that pike movement to downstream areas was density dependent. The percentage of pike marked in Murphy Flowage in fall (Oct.-Dec.) and recovered in Bolger Flowage the following springs was significantly related to fall population density (Fig. 6). The percentage of pike recovered was 23, 5 and 0 percent for 1964, 1965, and 1966, respectively. Although there were only 3 points, the level of significance (.05) gives some indication that movement was density dependent.

The fact that stocked pike moved to downstream areas while the native pike did not, may be due to intraspecific competition. Prior to stocking, from 1955 to 1964, there was sufficient spawning habitat, good reproduction, and a steady increase in the abundance of forage, mainly small bluegills. With this combination of favorable environmental factors, the native pike population increased to a maximum of 13.1 pike weighing 22.4 lb/acre by May 1964 (Table A, Appendix). In December 1963 when pike were stocked, the native pike population may have been at or near the carrying capacity of the flowage for pike. Therefore, when pike were stocked, they had to compete for food and space with a high density of native pike at a time when the stresses of such competition were at a maximum. Because the stocked pike were also exposed to the additional stresses of handling and stocking and were in effect "misplaced individuals," they were at a disadvantage and could not effectively compete for food and space with the native pike. However, since the availability of small bluegills was at a maximum, I believe the stresses of searching for space were dominant and thus continuous searching, particularly during the spawning period, lead the stocked pike to and over the Murphy Flowage dam to downstream areas.

This explanation for the facts that stocked pike moved, while native pike did not and movement was significantly related to density may also account for the very limited movement of native pike to downstream areas before stocking (1963) when population density was considerably lower than the first 2 years after stocking.

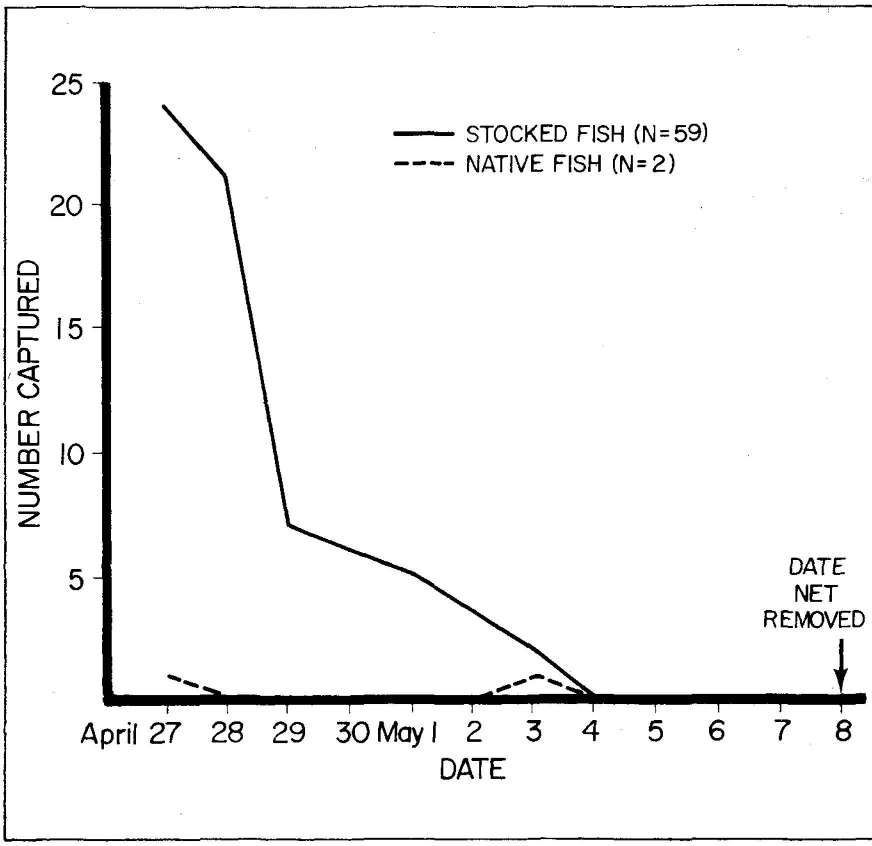


FIGURE 5. *Northern pike captured in Hemlock Creek below the Murphy Flowage dam between 27 April and 4 May 1965.*

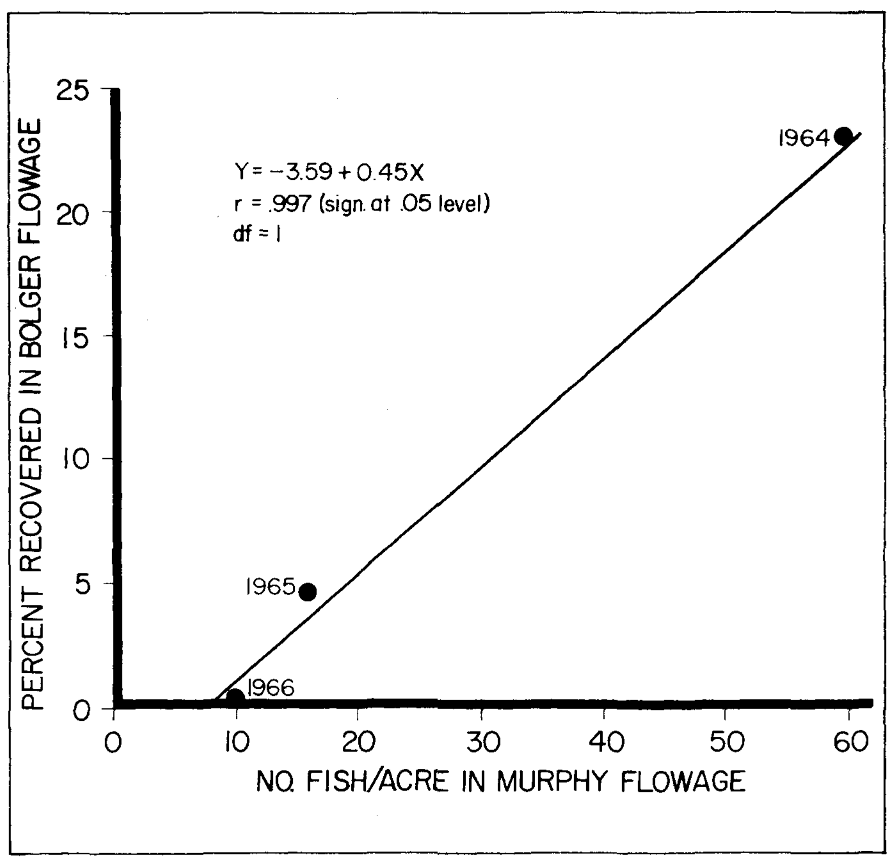


FIGURE 6. *Relationship between population density and percent recoveries of stocked and native northern pike marked in Murphy Flowage in fall and recovered in Bolger Flowage the following spring, 1964-66.*

OBSERVED MORTALITY

Natural mortality of fish occurs throughout the year; however, only a very small portion of natural mortality is observed by man in the form of visible dead fish. Before 1964, dead pike were rarely seen in Murphy Flowage. However, beginning in 1964, dead pike were found. For this reason, the term "observed mortality" has been used to distinguish these pike from those pike not observed that died from other natural causes.

During 5 years after pike were stocked, only 268 dead pike were found, a number too small to be considered a massive die-off. Although the actual extent of mortality was not known, as soon as dead pike were noticed, systematic observations were initiated throughout the flowage each spring. Based on these data, several important comparisons relating the numbers of dead stocked and native pike to other parameters were made.

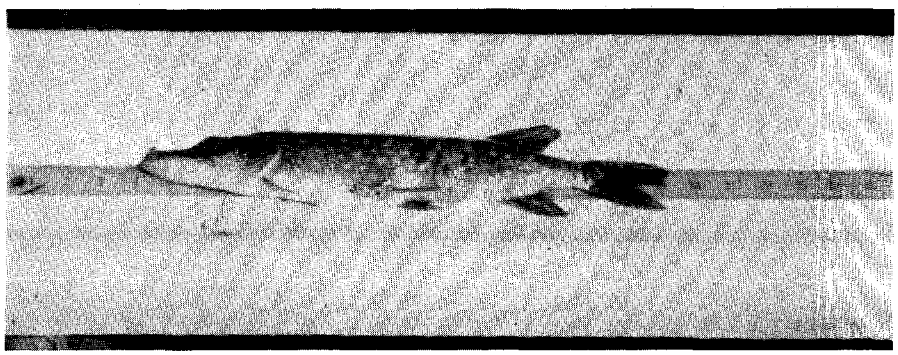
CAUSES

Fresh dead pike taken to the DNR laboratory in Madison were reported to be infected by the protozoan parasite, *Myxobolus* sp.* The parasitized areas on the body surface of sick fish appeared as round open sores about an inch in diameter.

Between 1955 and 1964, there was no observed mortality of northern pike and on no fish caught and released for population estimates during these years were any signs of *Myxobolus* infection ever observed. Beginning in 1964, the year after stocking, and continuing through 1968, mortality was observed. Because no mortality was observed until 1964, and because *Myxobolus* had been known to occur in Rush Lake, the lake from which northern pike were removed for stocking in Murphy Flowage, the parasite was believed to have been introduced to the flowage at the time of stocking.

Of the observed mortality which occurred, nearly half (44 percent) took place in June 1964, at which time densities of stocked and native pike amounted to 49.2 pike/acre. After 1965, pike densities declined to less than 11.0 pike/acre and fewer dead pike were picked up, although observed mortality did persist (Table 6). This suggests that the outbreak of *Myxobolus* was dependent upon the density of the host species. A test of the relationship between population density and the number of dead fish recovered through June was significant beyond the .01 level (Fig. 7). Thus high pike densities, especially in 1964, undoubtedly increased transmission of the parasite from one fish to another, resulting in higher mortality than would have occurred at lower pike densities.

Another factor which alone would not have caused the mortality that was



One of the infected pike picked up at Murphy Flowage.

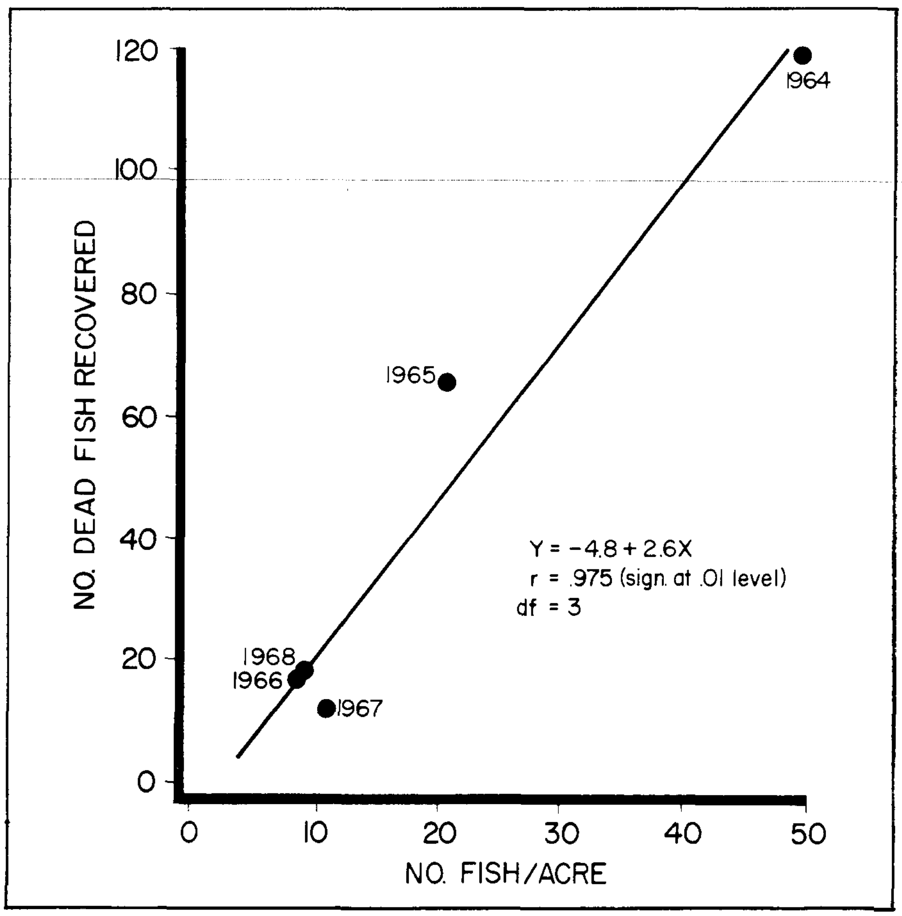


FIGURE 7. *Relationship between standing crop and dead fish recovered during June 1964-68.*

*Although positive identification was not made, the organism causing the infection was tentatively identified as *Myxobolus* sp.

observed, but may have affected the time of mortality was increasing water temperatures. In 1964, the water temperature reached 65 F on 18 May, but did not stay above this level until 8 June. Water temperatures during the time of peak mortality (13-23 June) ranged from 66 to 78 F. Although these temperatures cannot be considered high, the increases which did occur may have contributed to the time of the mortality observed.

TABLE 5. *Comparison of the size distribution of dead native northern pike collected between 14 April and 20 July 1964 with the 15 May 1964 population estimate in Murphy Flowage.*

Size Range (in Inches)	1964 Population Estimate	Dead Fish No.	Dead Fish Percent of Estimate
14.0-17.9	864	12	1.4
18.0-21.9	1,023	11	1.1
22.0-25.9	330	18	5.5
26.0+	139	20	14.4

TABLE 6. *Number of dead northern pike picked up during June in Murphy Flowage, 1964-68.*

Dead Pike	1964	1965	1966	1967	1968
Stocked Pike	53 (32)*	13 (69)*	2 (50)*	–	2 (100)*
Native Pike	53 (45)*	52 (56)*	15 (47)*	12 (57)*	15 (40)*
Unknown	13	–	–	–	1
Total	119	65	17	12	18

*Shown in parenthesis is the percentage of dead fish recovered that were finclipped during April or May of the same year.

EXTENT

Size, Age, and Origin of Fish

In 1964, a total of 145 dead northern pike were picked up: 70 were stocked pike, 62 were native pike, and 13 were pike of unknown origin. Pike from 12.0 to 35.0 inches in length were found. Larger native pike were picked up in greater numbers than smaller native pike. For example, 61 percent of the dead native pike were over 22.0 inches long and 32 percent, over 26.0 inches in length. The number of larger native pike picked up also comprised a higher percentage of the estimated population than smaller pike. The number of dead native pike picked up expressed as a percentage of the population was 1.4 percent for the 14.0- to 17.9-inch group, compared to 14.4 percent for dead pike over 26.0 inches in length (Table 5).

Possible explanations for the fact that the observed mortality apparently affected larger native pike more than smaller pike were: (a) that larger fish may have floated up more readily and were, therefore, more easily seen, or (b) that larger pike were more susceptible to infection by the parasite. Regarding these hypotheses, even if the larger fish did, in fact, float up more readily, it is unlikely that this alone could account for the large differences in the percentages of the various size groups picked up. If all sizes of pike had been affected equally, a greater proportion of smaller fish should have been recovered, even if recoveries were biased by the larger fish being easier to see.

These data suggest that larger native pike were actually more susceptible to the parasite than were smaller pike. This assumption is supported by the fact that numbers of pike over 26.0 inches in the spring estimates and in the harvest declined steadily for the first 3 years after stocking. Since this decline was due neither to exploitation nor to movement out of the flowage, it was most likely the result of the observed mortality.

These results are similar to those reported for Potters Lake, Wisconsin, (Krohn 1969) in that the mortality affected the native pike more severely than the stocked pike, but differed in that the mortality occurred in August and was apparently from a different cause than that reported here. Although the cause of death was not determined in Potters Lake, it was associated with high water temperatures and high pike density.

Marking of Fish

Fin-clipped pike which were handled for population estimates between 1 April and 15 May each year comprised a high percentage of the dead pike (Table 6). Results of a Chi Square test comparing recently clipped dead pike (dorsal fin in 1964) with live fish caught by anglers in June 1964 indicate that the percentage of dorsal clips among dead fish was significantly higher than among live fish at the .05 level. A further Chi Square test indicates a significant difference at the .05 level between the percentage of dorsal-fin-clipped fish among live fish caught before observed mortality occurred and the same percentage among pike caught after mortality occurred (i.e., before June and after July). All results were similar for both stocked and native populations. This gives strong reason to believe that a differential mortality occurred between marked and unmarked fish, and of course, invalidates some of the assumptions which were made concerning population estimates. All population estimates therefore include all dead fish picked up from the end of marking through June to help compensate for the lower-than-expected ratio of fin-clipped pike in the live samples. These results differ from those found by Groebner (1964) in 456-acre Lake George, Minnesota. Here, there was no differential mortality noted between marked and unmarked northern pike in live and dead samples picked up in 2 years.

In addition to the dorsal fin clip in 1964, all pelvic and pectoral fins were utilized for marking between 1965 and 1968. Although significance tests were not made, it appears that the percentage of recently clipped pike would be significantly higher in dead samples than in live fish samples regardless of which fin was clipped.

EFFECTS

Stocking Infected Fish

This study would be incomplete without considering how the stocking of infected pike may have influenced the results. It has been shown that *Myxobolus* affected larger native pike more than other groups of pike. The data analyzed also suggest that the number of dead pike picked up and the number of pike emigrating each were density dependent. However, there is one major difference between losses of pike due to parasitic infection and losses due to emigration. *Myxogolus* affected both stocked and native pike, while downstream emigration was only characteristic of the stocked pike. Furthermore, the estimated number of pike that emigrated was 10 to 15 times the known number of pike killed as a result of parasitic infection. If only stocked pike are considered, the number lost by emigration is 20 to 25 times the number lost to known observed mortality.

The stocked pike reacted to high densities by emigrating to areas downstream. The native pike did not emigrate. Therefore, the proportion of native pike affected by *Myxobolus* in Murphy Flowage was greater than the proportion of stocked pike affected. Since the largest total loss of pike was from emigration and not parasitic infection, I concluded that if pike not carrying *Myxobolus* had been stocked, the results would have been much the same as those experienced by stocking infected pike except for the effects the parasite had on the native pike, particularly the larger native pike.

Stocking in Drainage Lakes

Another consideration is the possible effects of stocking pike in a seepage lake where emigration could not occur in contrast to a drainage lake such as Murphy Flowage. In Murphy Flowage, initial observed mortality (within one year) was high and the data suggest that losses from emigration and parasitic infection each were density dependent. Therefore, I believe that the results of stocking pike would be similar in both drainage and seepage lakes, except that losses in seepage lakes would be from higher natural mortality rather than emigration. The absence of losses by emigration would be compensated for by increased natural mortality from parasitic infection, disease and/or other natural causes, so that total mortality would be about the same in either lake type. These conclusions are supported in part by the high mortality of stocked pike which occurred within one year of stocking in Nebish Lake, a seepage lake in northcentral Wisconsin where pike from the same source as those stocked in Murphy Flowage were stocked in 2 occasions (Krohn 1969).

EXPLOITATION AND MORTALITY

In addition to the observed mortality described in the previous section, northern pike in the flowage were lost to other natural causes: unobserved natural mortality and emigration from the flowage. In order to evaluate these other losses, this section has been kept separate from the earlier discussion of observed mortality. In this section, the term, "natural mortality," refers to loss of northern pike by any natural means (i.e., loss due to observed mortality, unobserved mortality, and movement out of the flowage).

Maximum annual mortality of pike in Murphy Flowage occurred after pike were stocked in December 1963. Prior to stocking (1955-1963) natural mortality (v) for native pike averaged 21 percent, exploitation (u) averaged 39 percent, and total mortality (a), which is equal to (v)+(u), averaged 60 percent. The first year after stocking, natural mortality of the native pike increased to 86 percent, exploitation decreased to 4 percent and total mortality reached 90 percent (Table 7). Mortality for native pike remained high for 3 years (1964-66) after stocking, then declined to prestocking levels

TABLE 7. *Annual mortality estimates (Percent) for northern pike in Murphy Flowage, 1955-1967.*

Year of Estimate	Natural Mortality (v)	Exploitation (Angling Mortality) (u)	Total Mortality (a)
Native Pike			
1955-1963 avg.	21	39	60
1964	86	4	90
1965	76	4	80
1966	74	3	77
1967	51	8	59
1964-67 avg.	72	5	77
Stocked Pike			
1964	84	6	90
1965	79	5	84
1966	44	14	58
1967	24	14	38
1964-67 avg.	58	10	68

in 1967. Exploitation rates remained considerably less than prestocking levels for the duration of the study.

Mortality of the stocked pike was similar to that of the native pike the first 2 years after stocking. However, during the third and fourth years (1966 and 1967), natural mortality of stocked pike decreased to a greater extent than in the native population. This difference is to be expected because the stocked pike represent one year-class and mortality is, therefore, size- and age-specific, while mortality for the population of native pike represents several year-classes and is not age-specific. In other words, mortality for stocked pike was low in 1966 and 1967 because, on the average, the stocked pike were older and larger than the native pike.

High mortality is a common occurrence among native pike populations (Snow and Beard 1972) and also among stocked pike soon after stocking. In an evaluation of stocking efforts in Wisconsin, Krohn (1969) reported high mortality within one year after stocking pike in several Wisconsin lakes.

EVALUATION OF STOCKING

IMPACT ON BLUEGILLS

One of the original purposes of stocking northern pike was to determine the effect of stocking on the most abundant panfish, the bluegill. Studies prior to stocking had shown that from 1955 to 1963, growth rate of bluegills declined and density increased. The northern pike were stocked at a time when the numbers of preferred-size bluegills (2.0-3.0 inches) were at a record high; yet after stocking, bluegill numbers continued to increase while pike numbers declined drastically (Fig. 8). During the early years of this study, northern pike and bluegill populations were considered low and fishing was considered very good for both species. This situation was not duplicated at high population densities of both species, and soon after stocking, mortality factors other than angling soon reduced the pike population below that of prestocking levels. Furthermore, the growth of bluegills was slower after pike were stocked than before (Fig. 9). This decline was probably correlated with the continued increase in the abundance of small bluegills rather than with any interaction between the pike and bluegill populations.

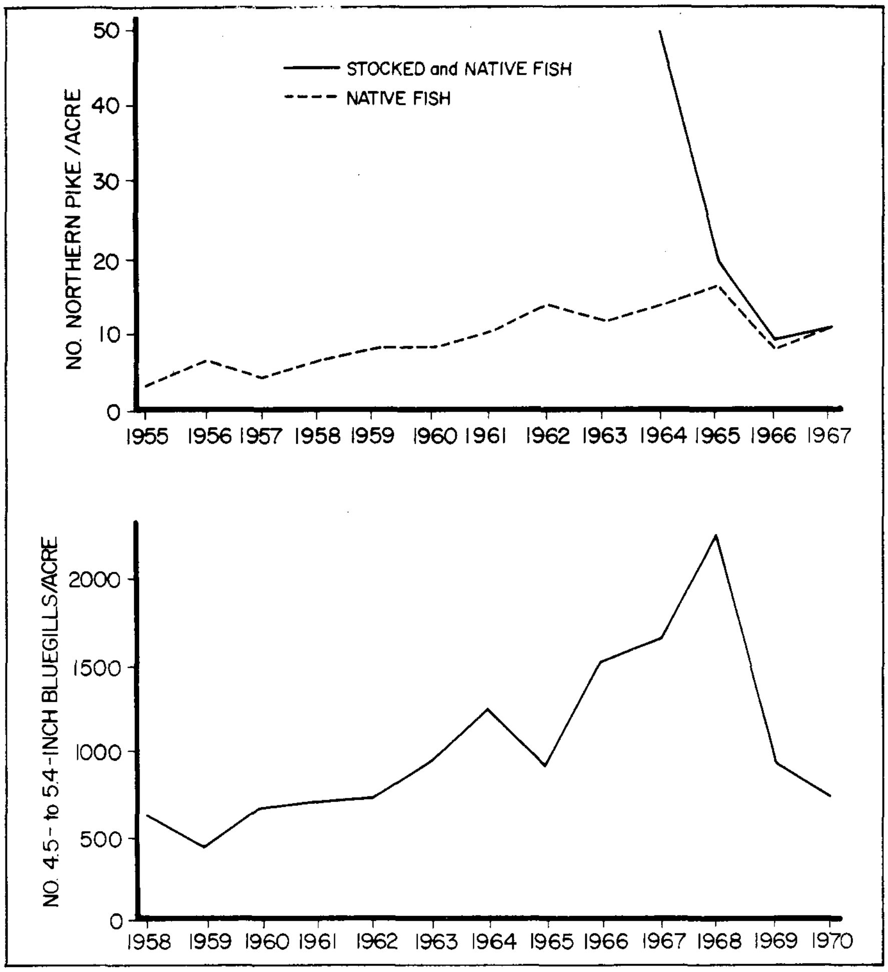


FIGURE 8. *Standing crop of northern pike and bluegills. (Points are plotted at a difference of 3 years for this reason: the size of bluegills consumed by northern pike was 2.0-3.0 inches. However, the minimum size of bluegills which could be caught for population estimates was 4.5-5.4 inches. On the average, it took bluegills approximately 3 years to grow from a size of 2.0-3.0 inches to 4.5-5.4 inches.)*

IMPACT ON NATIVE PIKE

In an evaluation of various fishing and fish population parameters before and after stocking of northern pike in Murphy Flowage, special emphasis has been placed on the impact stocking had on the native northern pike population. Such impact has been given little attention in most other papers dealing with northern pike stocking. For the purpose of evaluation, comparisons involve a 9-year period prior to stocking (April 1955–April 1964) and a 2-year period after stocking (April 1964–April 1966). The abundance of stocked pike declined 92 percent within 16 months after stocking and 99 percent within 28 months. Thus, for all practical purposes, it can be considered that the population of stocked fish disappeared in slightly over 2 years. Figure 10 summarizes some of the "before" and "after" comparisons made.

The standing crop increased from 8.2 pike weighing 12.5 lb/acre prior to stocking to 30.8 pike weighing 35.2 lb/acre during the "after" period. The annual spring population estimates from 1960 through 1966 for stocked and native pike were 7.1, 10.3, 13.7, 11.9, 49.2, 20.5, and 8.5 pike/acre, respectively. By the spring of 1966, the total population was at its lowest decrease. Aside from a large increase in numbers the first year after stocking, there was a general decline by 1966, especially among larger pike.

The annual fishing pressure declined from a prestocking average of 90 hours/acre to 54 hours/acre after stocking. Although there had been considerable variation in pressure before stocking, it had leveled off the 4 years preceding stocking. However, pressure dipped to new lows the first 2 years after stocking. There had been no special publicity given the stocking program, but past experience had indicated that with improved fishing success, anglers respond with increased pressure. Increases in pressure did not percent were caught by anglers and 90 percent of these were taken the first year. The total catch of 739 pike during the first open-water season after stocking was a record high and stocked pike comprised 61.8 percent of this total. However, by weight, the 1964 open-water catch was equaled or exceeded in 5 of the previous 9 seasons when only native pike were present. The total harvest during 1964 (open water and ice seasons) was equaled or exceeded in numbers during 3 of the previous 9 years and in weight 8 of the previous 9 years. The average catch of native pike declined 59 percent in number and 70 percent by weight during the 1964-66 "after

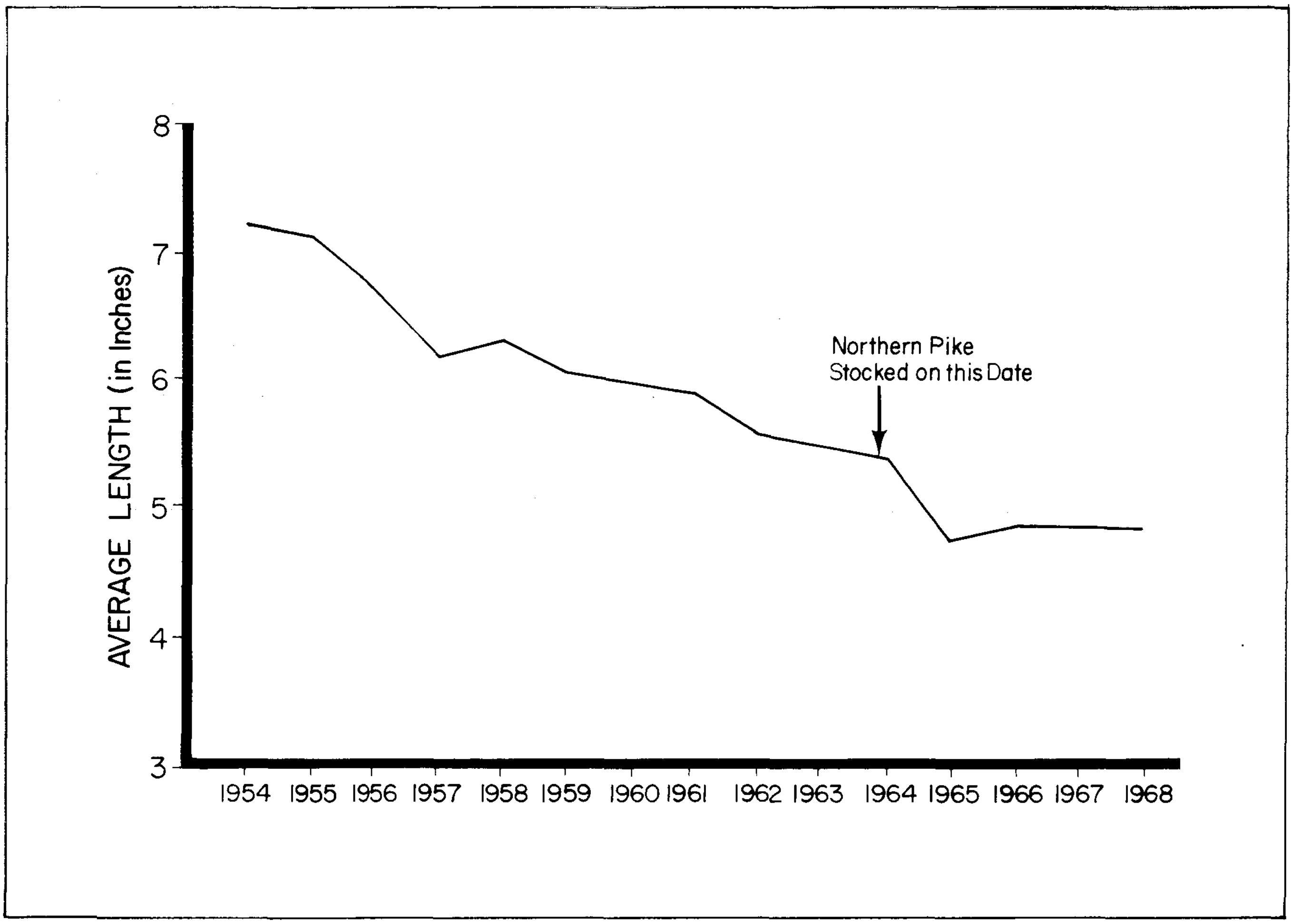


FIGURE 9. *Average length of age IV bluegills at the end of the growing season, 1954-1968.*

level since 1960. Probably more important than the variation in total numbers was the decline in abundance of large pike. For example, the number of northern pike over 26.0 inches in length declined from an average of 75 (0.4/acre) before stocking to 18 (0.1/acre) after stocking, a 76 percent occur after stocking.

The average annual harvest of northern pike was 3.5 pike/acre and 7.9 lb/acre before stocking and 2.9 pike/acre and 3.8 lb/acre after stocking. There was thus a much greater decline in poundage than in numbers. Of the 8,534 pike stocked, only 6.5 period" as compared to the 1955-1964 "before period". The average annual catch of native pike over 26 inches dropped from 64 to 4 during the same two periods.

The high harvest immediately after stocking resulted in a catch rate of 7.2 pike/100 hours of fishing the first

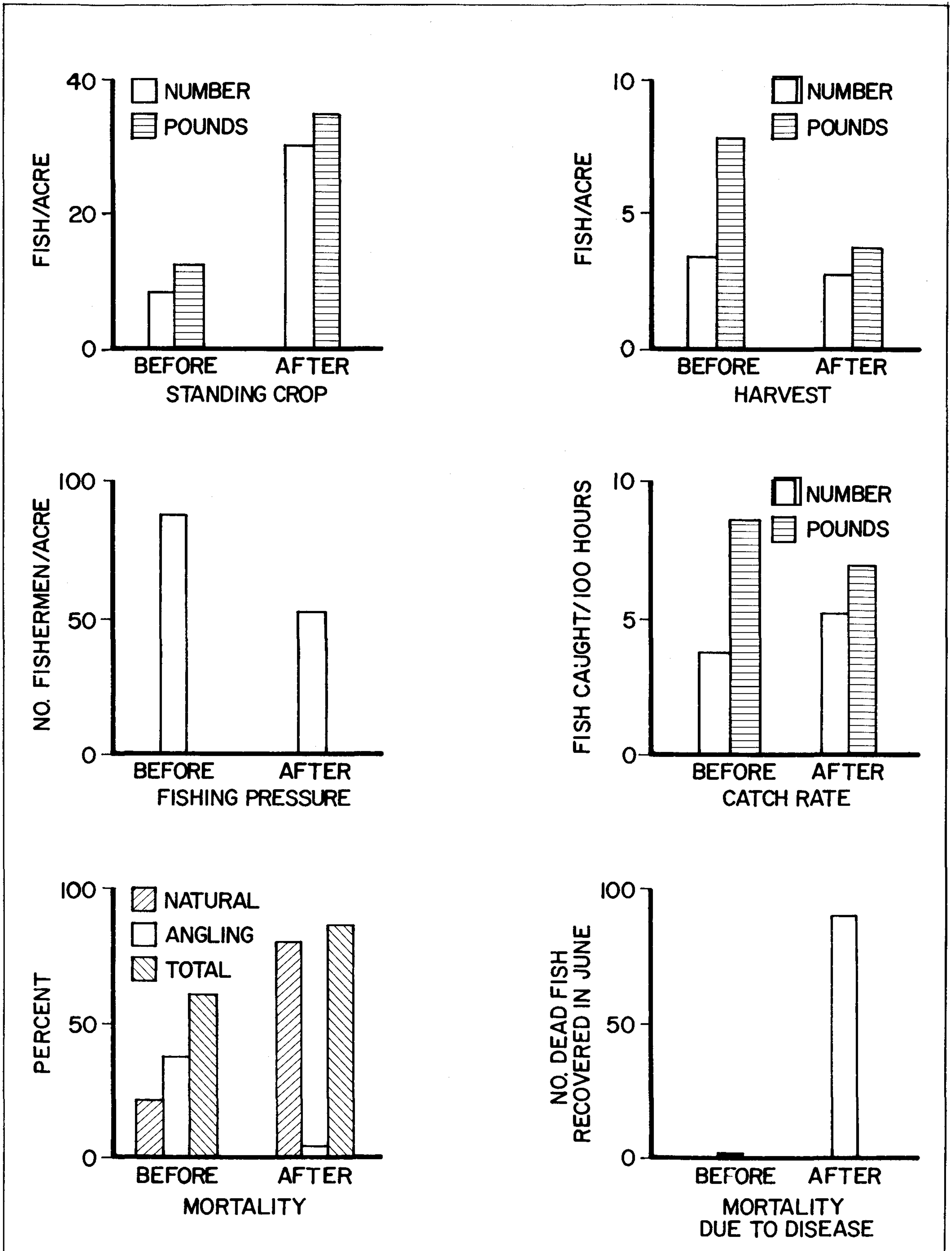


FIGURE 10. *Comparison of annual mean fishing and population statistics of northern pike before and after stocking. (The "before" period represents mean data from April 1955 through April 1964 and the "after" period represents mean data from April 1964 through April 1966.)*

season after stocking. This high figure is reflected in the increased overall catch rate from 3.9 pike/100 hours before stocking to 5.4 pike/100 hours after stocking. By contrast, the catch rate in pounds/100 hours declined from 8.8 to 7.0 for the same two intervals.

The only harvest statistics which increased after stocking were the total catch and the catch rate for the first open-water season after stocking. Thereafter, these and all other catch statistics declined. The total harvest of both stocked and native northern pike after stocking was not exceptionally high and because of gradually increasing numbers before stocking, was probably not much higher than what could have been expected from the native population alone in the absence of stocked pike. It seems that the stocked pike had a suppressive or detrimental effect on the total harvest of native pike and especially on the catch of large pike.

Total annual mortality increased from 61 percent before stocking to 86 percent after stocking. Natural mortality increased from 22 percent to 81 percent, whereas mortality by angling declined from 39 percent to 5 percent from 1955-1964 to 1964-1966. Mortality and exploitation rates were similar for native and stocked pike after stocking, while for all previous comparisons, there were drastic differences. A portion of the increases in mortality were attributed to losses from parasitic infection, which affected large native pike most severely, and to losses of stocked pike by emigration.

In conclusion, the northern pike stocked in Murphy Flowage were more of a detriment than an asset. There was a very temporary increase in the total catch and the rate of catch in numbers of pike but not in pounds. Results from all other aspects were unfavorable, particularly with regard to the impact on the native population of pike. The standing crop of native pike declined in 1966 to the lowest level in 6 years and the harvest in 1965 declined to its lowest level in 9 years.

SUMMARY AND MANAGEMENT IMPLICATIONS

Following stocking of 8,534 large northern pike fingerlings in December 1963, population density of stocked northern pike in Murphy Flowage declined drastically—from 47.0 pike or 40 lb/acre in 1963 to 0.2 pike or 0.6 lb/acre by 1968. By the spring of 1966, the total northern pike population (i.e., stocked and native fish) was at its lowest level since 1960. In addition to the change in total numbers, abundance of large native pike also declined. The average number of pike 26.0 inches and larger during the 1964-66 period was 76 percent less than that during the 1955-1963 period.

Within 5 years after stocking, anglers caught only 6.6 percent of the number of pike originally stocked, comprising 9.1 percent of the pounds stocked. Ninety percent of the total number and 78 percent of the total pounds caught were taken the first year after stocking. As with population estimates, total catch of stocked and native northern pike caught declined drastically after stocking. Of the total catch of stocked pike between 1964 and 1968, 29 percent of the catch, representing only 2 percent of the original number stocked, were over 18.0 inches.

Sampling in downstream areas indicated that possibly 30 percent or more of the total number of pike stocked in Murphy Flowage had moved out of the flowage by the spring of 1965. Maximum downstream movement appeared to occur during the spawning period, involved largely stocked pike, and was significantly related to population density of northern pike in Murphy Flowage. Movement of stocked pike as a result of population density suggests that at the time of stocking, the flowage was at or close to its carrying capacity for nothern pike. This assumption is supported by the presence, during the 1955-1963 period, of an increasing native northern pike population which reached a maximum density at the time of stocking. The additional stocked pike were apparently unable to successfully compete for food and space with the native pike and hence, a major segment moved downstream.

In addition to harvest and emigration, northern pike were also lost as a result of observed natural mortality caused by a parasite, *Myxobolus,* believed to have been introduced at the time of stocking. Larger native pike were picked up in greater numbers than smaller native pike. Although in 1964, northern pike over 26.0 inches comprised only 6 percent of the population, 32 percent of the dead fish recovered were over 26.0 inches.

Although parasitic infection was the factor which actually caused the mortality observed, high pike population densities, especially during the first year after stocking, were believed to have increased susceptibility of the pike to infection, resulting in higher mortality than would have occurred at lower pike densities. The relationship between population density and the number of dead pike recovered was significant beyond the .01 level.

Due in part to this observed mortality as well as to emigration, stocking of northern pike had no discernible impact on the bluegill population in the flowage. After stocking, numbers of bluegills, particularly small ones, continued to increase, while their growth continued to decline. Murphy Flowage simply could not support a population of northern pike large enough to significantly control the high population of bluegills present at the time of stocking.

Impact of stocked pike on the native pike population and angler harvest was also unfavorable. By 1965, the second year after stocking, harvest of native pike had declined to the lowest level during the 9 preceding years and by 1966, the standing crop of native fish had declined to its lowest level in the preceding 6-year period. Except for a temporary increase in total catch and catch rate in numbers (but not in pounds), other fishing statistics–average annual harvest and fishing pressure–declined after stocking.

The problems resulting from stocking–emigration, observed mortality, the unfavorable impact of stocked pike on the native pike population, and the failure of stocking to control bluegill numbers–require that the decision to stock northern pike in a given body of water be carefully considered.

If a lake is to be stocked to either establish, maintain, or increase a northern pike population, it is suggested that the total density after stocking of large fingerlings (10-18 inches) not exceed 8 pike/acre. This stocking rate is based on the fact that at Murphy Flowage, the best northern pike fishing during the 15-year study was provided when the denisty of adult pike (14 inches and larger) was from 5 to 8 pike/acre.

If stocking is anticipated, and if the lake to be stocked already contains native northern pike, no pike known or suspected to be infected by *Myxobolus* should be used for stocking purposes. In addition, the fish populations should ideally be monitored for several years prior to stocking in order to determine whether the lake can support more pike and to avoid the problems caused when the carrying capacity of the lake for northern pike is exceeded. Those problems which may occur are as follows:

1. Competition between stocked and native pike may force stocked pike to move out of an impoundment or drainage lake. Unintentional movement into downstream areas where pike are not needed or wanted may do more harm than good.

2. Overstocking or high densities of pike may increase the susceptibility of these fish to parasitic infection or exceptionally high mortality from other causes.

3. Heavy stocking of pike into waters where native pike are already present may have an unfavorable effect on angling success.

Because of these problems caused when the northern pike carrying capacity of a lake or flowage is exceeded, northern pike should not be stocked in such situations with the intent of controlling stunted bluegills. Such control is unlikely to occur because once bluegills are so abundant that their growth is stunted, numbers of predator fish needed to control them are apt to be higher than the carrying capacity of the waters involved.

APPENDIX

TABLE A. *Standing crop of native and stocked northern pike in Murphy Flowage expressed as fish and pounds per acre, 1955-1970. (All are spring estimates except as indicated.)*

Time of Estimate	Native No./Acre	Native Lb./Acre	Stocked No./Acre	Stocked Lb./Acre	Total No./Acre	Total Lb./Acre
1955	2.4	4.5			2.4	4.5
1956	5.6	10.5			5.6	10.5
1957	3.6	7.5			3.6	7.5
1958	5.7	11.0			5.7	11.0
1959	7.5	11.0			7.5	11.0
1960	7.1	11.7			7.1	11.7
1961	10.3	15.0			10.3	15.0
1962	13.7	17.7			13.7	17.7
1963	11.9	15.6			11.9	15.6
1963 Dec.			47.0	40.3	59.5*	59.3*
1964	13.1	22.4	36.1	32.1	49.2	54.5
1964 Oct.	8.7	10.4	7.2	9.5	15.9	20.0
1965	16.4	17.8	4.1	5.3	20.5	23.2
1965 Oct.	7.7	11.0	2.0	4.4	9.7	15.4
1966	7.9	11.3	.7	1.4	8.5	12.8
1967	10.7	17.1	.3	.8	11.0	17.8
1968	8.7	14.8	.2	.6	8.9	15.5
1969	6.2	14.0	**	–	6.2	14.0
1970	2.8	7.3	**	–	2.8	7.3
Grand Average***	8.4	13.1	8.3	8.0	10.9	15.6

*Total standing crop for December 1963 was estimated by addition of the number stocked and the mean number of native fish estimated present in May 1963 and 1964.

**After 1968 all stocked pike were included with the native fish. Only 5 were handled in 1969, and one in 1970.

***Grand averages include spring estimates only from 1955 through 1970 for native fish and all estimates from 1964 through 1968 for stocked fish.

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ACKNOWLEDGMENTS

Special thanks are due to Leon D. Johnson for many helpful suggestions throughout the study period and to the following individuals who so capably assisted with field work and tabulation of the data: Thomas D. Beard, research biologist since 1967, Lyle Groth and Donald Stafford, technicians who were with the project since it started, and Alvin Johnson, Ingvald Tronstad, Ronnie Masterjohn, and Jon Peterson, technicians who were each with the project from 2-7 years. Thanks are also due to many other individuals in the Bureaus of Research, Fish Management, and Law Enforcement who provided equipment and assisted at various times. Special thanks is also due to Lyle M. Christenson, Thomas L. Wirth, and Gordon R. Priegel under whose supervision the major part of this study was conducted.

The manuscript was critically reviewed by Gordon R. Priegel, Lyle M. Christenson, and Robert Hunt.

This research was supported in part from funds supplied by the Federal Aid to Fish Restoration Act under Dingell-Johnson Project F-83-R.

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Edited By Susan Nehls