HOOK-AND-LINE YIELD OF LARGEMOUTH BASS AND REDEAR X GREEN SUNFISH HYBRIDS IN A ONE-ACRE POND

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A PRIMARY OBJECTIVE OF MANAGING FRESH-WATER FISH IN PONDS has been to increase the number of desirable-size fish taken by anglers. The search for means of attaining this objective has included tests of stocking various combinations of fishes and various numbers of these selected combinations; reducing the number of fish in a particular body of water to increase the growth rate and consequently the average size of the fish that remain; using fertilizer materials to increase the food supply and, in turn, the number and weight of fish supported by the water; feeding artificial and/or natural fish foods to increase the fish that may be supported by the water; and concentrating large numbers of desirable-size fish without sufficient food, with the intention of causing hunger to make the fish more vulnerable to baits offered by anglers. All these measures probably increase the catch. However, when most species of animals are subjected to some form of predation, they develop a resistance to this predation that eventually will reduce losses. Where the fisherman is the predator and the fish his prey, the hook-and-line catch usually declines sharply as the number of man-hours of fishing increases (Bennett, 1962, p. 192). This resistance to predation is undoubtedly important in the perpetuation of the species.

In a man-made and man-controlled fresh-water pond, the question of whether or not these fish resist being caught becomes rather unimportant in relation to the ultimate survival of the species of fish stocked. Where fee-fishing is an objective, a fish that shows little resistance to capture is highly desirable. A pond-owner may have additional work and expense in keeping a catchable crop of fish in his pond, but the extra effort is related to extra remuneration.

Very early in the investigations of hybrid sunfishes, we discovered that the hybrids were more vulnerable to fishermen's baits than the parent species. The reason for this increased vulnerability was not clear. Observations of behavior of hybrids toward baited hooks led us to believe that some kinds of sunfish hybrids were more aggressive than their parent species, less wary, and less able to learn by observation how to avoid being caught. Perhaps all these characteristics are involved; certainly there is no doubt that the hybrids are more vulnerable.[1]

Since it is possible to develop a fish that is highly vulnerable to angling, what other methods now in use to increase the catch of fish may be applied, along with the increased vulnerability, to increase the catch still more? One immediately

[1] Childers, William F.: Hybridization of four species of sunfishes (Centrarchidae). Unpublished doctoral thesis, 1965, University of Illinois, Urbana, 74 p.

thinks of using inorganic fertilizers to increase the standing crop of fish that the pond will support.

This paper is a report of an experiment in which we attempted to produce a high hook-and-line yield of fish through the use of sunfish hybrids and pond fertilization. Largemouth bass, Micropterus salmoides (L.), and grass pickerel, Esox americanus vermiculatus Le Sueur, were added to prevent an overpopulation of F_1 hybrids and to reduce the number of F_2 hybrids which we knew the F_1 hybrids were capable of producing (Childers and Bennett, 1961, p. 7).

The hybrids used in this experiment were produced by isolating adult male redear sunfish, Lepomis microlophus (G.), and adult female green sunfish, L. cyanellus Raf., in a pond that had no other fish. The experiment was run in North Pond.

Description of North Pond

North Pond is a small gravelpit pond on the William Utterback farm southeast of Gibson City, Illinois. The pond has a very irregular outline and is composed of three sections (figure 1) which are connected in the spring when water levels are high but which become separated by low ridges of land when the water level drops 24 to 30 inches, usually late in summer. The north and south sections of North Pond are separated by an irregular piece of land which becomes an island when the water is high. On this island is a small oval-shaped pond known as Island Pond, about 35 feet long, 20 feet wide, and 4 feet deep. When the water level is very high, Island Pond becomes connected with the north section of North Pond by a shallow channel.

Stocking

Early in May 1959, we decided to use Island Pond for the natural production of F_1 hybrids from redear sunfish males and green sunfish females. On May 6 Island Pond was treated with rotenone, and on May 20-22 eight redear males and three green sunfish females were released in this pond. Nests guarded by redear sunfish males were observed in Island Pond on May 28, but at that time the nests contained no eggs.

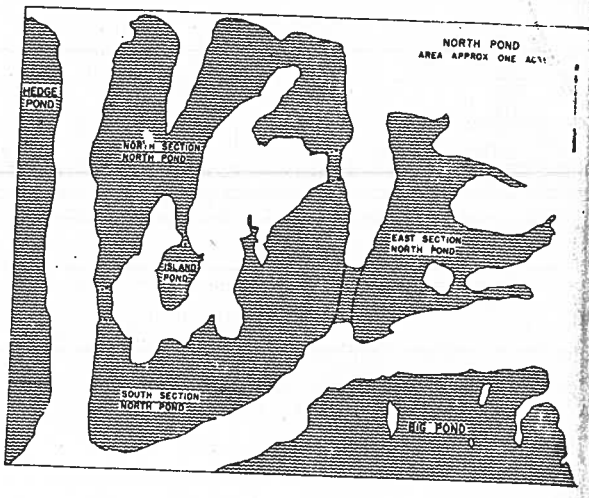

FIGURE 1.--Map of North Pond showing Island Pond and north, east, and south sections which become separated during low water.

North Pond was treated with rotenone on June 22, 1959. The fish population in North Pond was eliminated so that it could be stocked with known numbers of F_1 hybrids from Island Pond. Excessive rains in the Gibson City region, however, caused a gradual rise of the water levels in the gravelpits. By July 1, there was a water connection between North Pond and Island Pond, and this allowed the eight redear sunfish males, the three green sunfish females, and their hybrid young to escape into North Pond.

Minnow seine hauls in the north section of North Pond on August 3 produced large numbers of hybrid sunfish about one-half inch long.

By September 14, the level of North Pond had dropped enough to cause separation of the three parts. All of the young hybrids that could be taken with a minnow seine appeared to be in the north section (connected directly with Island Pond). On this day, 27 largemouth bass, 3.0 to 4.6 inches in length, were seined from Hedge Pond (just across the levee west) and released in the south section of North Pond.

TABLE 1.--Fish stocked in North Pond for the largemouth bass and redear x green sunfish experiment

Kind of fish	Number	Range of size (inches)	Mode size (inches)	Date	Source
Redear sunfish, male[1]	8	5.2- 6.7	6.0	May 20, 1959	Zigler's Pond.
Green sunfish, female[1]	3	5.5- 6.0	5.5	May 22, 1959	Do.
Largemouth bass-------	27	3.0- 4.6	4.0	Sept. 14, 1959	Hedge Pond.
Do------------------	250	1.0- 2.0	1.5	June 20, 1960	Parkhill's Pond.
Do------------------	140	3.2-11.0	6.5	Aug. 23, 1960	Allerton Lake.
Grass pickerel--------	13	6.0- 9.0	7.0	Mar. 24, 1961	Fairmount Quarry.

[1]Originally stocked in Island Pond, from which they escaped into the north section of North Pond.

Five hundred F_1 hybrid sunfish were seined from the north section and released in the east section on October 5. During the following year (1960), 250 bass fry and 140 fingerling and larger bass were scattered among the sections of North Pond. Table 1 shows all the fish stocked in North Pond.

The escape of the sunfish parents and their offspring from Island Pond on July 1 forced a change in our plan. Once the fish had escaped from the confines of Island Pond, we decided to proceed with the experiment even though the number of F_1 hybrids in North Pond was not known and the parent species were present. Bass were stocked for the purpose of reducing what appeared to be excessive numbers of the F_1 hybrids.

Fertilization Program

North Pond was treated with inorganic fertilizer during the spring and summer months of 1961-64, inclusive. The fertilizer was provided by the International Minerals and Chemical Corporation of Skokie, Illinois. An approximate analysis of this fertilizer, developed for use in ponds by Dr. R. P. Thomas, agronomist for the company's Plant Food Division, appears in table 2. We were unable to evaluate this fertilizer for use in pond fertilization, though we can make the general statement that the material created an abundance of algae and was applied in an experiment in which a very high fish yield was obtained. In making this statement, we recognize the fact that we ran no control experiments (where no fertilizer was used) and made no similar tests using other fertilizer materials.

The fertilizer was applied by spreading it in shallow water in each of the three

TABLE 2.--Approximate analysis of the inorganic fertilizer supplied by the International Minerals and Chemical Corporation

Element	Elemental (pounds)	Oxide	Pounds
Nitrogen-----	120	-----	------
Phosphorus---	100	P_2O_5	240
Potassium----	50	K_2O	60
Calcium------	349	CaO	493
Magnesium----	30	MgO	51
Sodium-------	256	NaO	346
Sulfur-------	227	SO_3	568
Chlorine-----	24	-----	------
Iron---------	27	Fe_2O_3	60
Manganese----	1	MnO_4	40
Zinc---------	.6	ZnO	18
Copper-------	.3	CuO	7
Boron--------	.1	B_2O_3	40
Barium-------	.3	BaO	10
Strontium----	.1	SrO	7

sections of North Pond. Each application required three 50-pound sacks. Applications were made at intervals of 7 to 10 days until the algae became abundant and there appeared to be danger of excessive fertilization. Thereafter, fertilizer was added when algae became less abundant.

The total amount of fertilizer applied to this 1-acre pond varied from year to year: in 1961 and 1962, the total was a little more than 1,200 pounds per year; in 1963, it was about 1,500 pounds; and in 1964, approximately 2,000 pounds.

Creel Census

North Pond was used by a group of 15 to 20 fishermen who paid for the privilege of fishing the Utterback gravelpit ponds. These fishermen were required to record their fishing periods and catches at a central station. Mr. Utterback checked the creel records frequently to make certain that all fishermen were filling out individual creel cards for each of the ponds they fished. The records were believed to be substantially complete.

In 1960, the year that followed the first production of the redear x green sunfish hybrids, fishing was not permitted in North Pond until September and most of the fish were still very small. Fishing pressure for that season amounted to only 33.5 man-hours per acre, and only 4 bass and 47 hybrids were kept. In other years, the fishing pressures were much greate however, except during one year, th were always less than 300 man-hours p acre. The yields of fish in numbers a weights of bass and hybrid sunfish p acre, along with the fishing pressure a total yield in pounds per acre, are sho in table 3.

The catch of bass was considered to b very high for all years after 1960, rangi from 46.5 pounds per acre in 1961 t 105.3 pounds per acre in 1963. The aver age size of the bass caught, however, wa relatively small (from 0.42 to 0.79 pound Evidence to be presented later suggest that few bass escaped being caught lon enough to become large.

The numbers of hybrid sunfish in th catch rose precipitously after the firs season until peak numbers were caught i 1962 and 1963. In 1964 and 1965 the num bers dropped as steeply as they had risen and the average size of the hybrids in creased rapidly, indicating that few were left.

The Quality of Fishing

Fishery biologists have more or less agreed that an average seasonal catch rate of one fish per man-hour represents reasonably good fishing. This calculation must include all the hours spent by fishermen when nothing is caught; and these hours, when recorded, usually equal or

TABLE 3.--Hook-and-line yield of largemouth bass and hybrid sunfish from North Pond, 1960-65, inclusive, with fishing pressure and the total yield

Year	Largemouth bass			Hybrid sunfish			Fishing pressure (man-hours per acre)	Total yield (pounds per acre)
	Number	Weight (pounds)	Average weight (pounds)	Number	Weight (pounds	Average weight (pounds)		
1960	4	3.8	0.94	47	12.4	0.26	33.5	16.2
1961	71	46.5	.66	642	119.8	.19	243.0	166.3
1962	133	93.4	.70	1,819	323.0	.18	312.5	417.3
1963	134	105.3	.79	1,077	249.7	.23	297.8	355.0
1964	[1]121	[1]71.2	.59	150	54.2	.36	177.5	125.4
1965	200	83.1	.42	71	54.6	.77	193.5	137.8

[1] Includes 3 grass pickerel weighing 1.75 pounds; the average weight figure is for largemouth bass only.

exceed those when catches are made. The "good fishing" definition of one fish per man-hour fails to designate the weight of the fish or the average weight per man-hour. As the one-fish-per-man-hour criterion is based largely on catches made while fishing for panfish, an appropriate weight figure might be one-quarter or one-half pound per man-hour or 1 to 2 pounds per man-day (about 4 or 5 hours).

Table 4 shows the average rate of catch for the years 1960-65, inclusive, in number and weight of fish per hour of fishing. On the basis of the definition of good fishing, North Pond produced exceptional fishing in all years and really phenomenal fishing in 1962 (when the average rate of catch was 6.2 fish and 1.33 pounds per hour of effort). It was evident from the fishing records that the fishermen considered the fishing exceptional, as fishing in North Pond for that year amounted to 312.5 man-hours per acre.

Of some interest were the individual records of 1962 catches made by three fishermen in North Pond. These fishermen were experienced and proficient, and each spent more than 25 hours fishing North Pond during the 1962 season. There were no restrictions on fishermen using North Pond except that fish must be taken by angling. Fisherman A, during 49.5 hours of fishing effort, caught 3 largemouth bass weighing 1.8 pounds and 352 hybrids weighing 65.1 pounds. Fisherman B, during 90.5 hours of fishing effort, caught 57 bass weighing 50 pounds and 789 hybrids weighing 141.4 pounds. Fisherman C, during 39.8 hours of fishing effort, caught 6 bass weighing 1.8 pounds and 304 hybrids weighing 46.6 pounds. These three catches represented 16, 46, and 12 percent, respectively, of the catch made by all fishermen.

Although unusually large catches of largemouth bass were taken during most years, it was evident that the hybrids were responsible for the phenomenal catches of 1961, 1962, and 1963.

To obtain information about the dynamics of the hybrid sunfish population in North Pond, fishermen's catches of the hybrids during September and October of 1960 and May and June for the years 1961 through 1965 were arranged in a table to show length-frequency (table 5).

TABLE 4.--Average rate of catch and fishing pressure in North Pond during the years 1960-65, inclusive

Year	Average rate of catch: Number of fish per hour	Average rate of catch: Pounds of fish per hour	Fishing pressure (man-hours per acre)
1960	1.5	0.48	33.5
1961	2.9	.68	243.0
1962	6.2	1.33	312.5
1963	4.1	1.19	297.8
1964	1.5	.71	177.5
1965	1.4	.71	193.5

The mean lengths of fish caught during September and October 1960, May and June 1961, and May and June 1962 were 6.6, 6.3, and 6.0 inches, respectively. This steady decrease in average lengths of fish caught may be explained by the production of two or possibly three F_1 hybrid broods. A 1959 brood of F_1 hybrids was probably produced by the parent species before the fish escaped from Island Pond into North Pond, a second 1959 brood of F_1 hybrids was produced in North Pond shortly after the parents escaped from Island Pond, and a third F_1 hybrid brood may have been produced during the spring of 1960.

The first 1959 brood of hybrids grew rapidly, and in less than 2 years individuals caught by fishermen had attained lengths of 5.5 to 7.0 inches. The second 1959 brood grew more slowly; these hybrids were not large enough to be caught by fishermen during 1960. The bimodal length-frequency distribution of fish captured by fishermen during May and June 1961 (table 5) indicated that some individuals of the second 1959 brood were being caught by fishermen at that time. Apparently the bulk of the fish caught during 1962 through 1965 were members of the second 1959 brood.

Redear male x green female F_1 hybrids are approximately 70 percent males and

TABLE 5.--The length-frequency distribution of redear x green sunfish hybrids taken by fishermen from North Pond during selected months of the years 1960-65, inclusive

Total length (inches)	September and October 1960	May and June 1961	May and June 1962	May and June 1963	May and June 1964	May and June 1965
4.0	---	---	5	2	---	---
4.5	---	2	14	1	---	---
5.0	---	6	136	35	1	---
5.5	4	7	225	29	4	---
6.0	6	1	208	117	8	---
6.5	21	6	124	69	4	---
7.0	11	10	85	72	23	---
7.5	---	3	28	32	14	1
8.0	[1]3	---	20	41	15	1
8.5	[1]2	[1]2	3	12	7	3
9.0	---	---	3	6	2	14
9.5	---	---	---	2	---	8
10.0	---	---	---	1	1	2
Total number	47	37	851	419	79	29
Mean length	[2]6.6	[3]6.3	6.0	6.6	7.3	9.1

[1]Possibly parent fish which were originally stocked in Island Pond.
[2]Excluding the 5 possible parent fish, the mean length of the remaining 42 hybrids was 6.5 inches.
[3]Excluding the 2 possible parent fish, the mean length of the remaining 35 hybrids was 6.1 inches.

30 percent females. They are fertile and, when stocked in ponds containing no other fish, invariably produce a large F_2 hybrid generation (Childers and Bennett, 1961, p. 7). During the 1961-65 spawning seasons, male hybrids were observed guarding nests and many of the nests examined contained eggs or larvae. The fact that almost no individuals from these year classes appeared in the catch strongly suggests that the survival of F_2 and backcrossed hybrids, in the face of predation from a numerically large bass population, was insignificant.

The Final Census

During the first 6 days in September 1965, the three sections of North Pond were treated with rotenone and a census of the fish was made. At this time the three sections of the pond were entirely separate. The south and the north sections of North Pond were treated with rotenone by the drip method of Tate, Moen, and Severson (1965, p. 158), and the methylene blue technique of Bouck and Ball (1965, p. 161) was used in an attempt to keep alive as many of the fish as possible. About 80 percent of the fish in the south section were saved; this included 18 large hybrids, a few of which are shown in figure 2. The operation in the north section was somewhat less successful, although some fish were kept alive. The east section was treated with rotenone in an application strong enough to kill the fish, and no attempt was made to keep any alive. Live fish were released in other gravelpit lakes on the property.

A census of the fish in North Pond after the summer fishing period appears in table 6. Of the 61 bass measuring 10 inches or more in total length, most were less than 12 inches long, only 5 were more than 12 inches long, and the largest

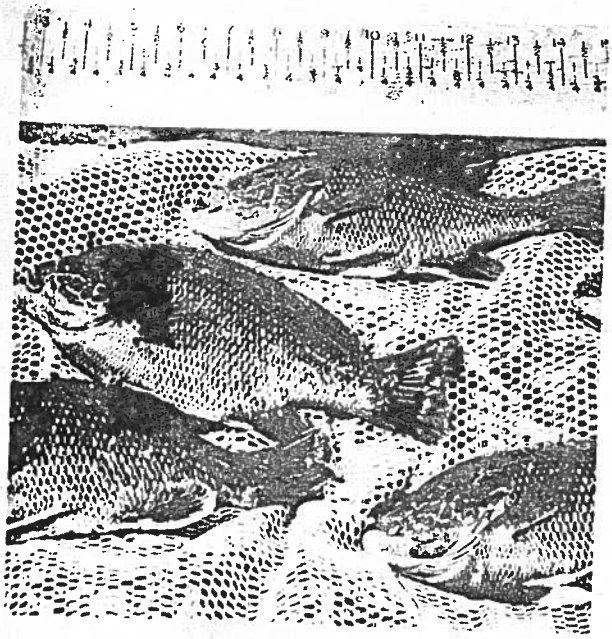

FIGURE 2.--Redear x green sunfish hybrids taken from North Pond during the final census in 1965. These fish ranged from 8.5 to 10.5 inches in length and from 0.6 pound to 1.2 pounds in weight.

was 16.5 inches long and weighed 2.5 pounds. The scarcity of bass exceeding 2 pounds in weight after 6 years suggests that these fish were being cropped efficiently, and this is substantiated by the high annual hook-and-line yields of bass (table 3). In addition to the bass of useful sizes, the census showed 311 bass of intermediate sizes (probably yearlings and 2-year-olds). The fingerlings in the south and north sections were from 2 to 4 inches long and had a modal length of 2.5 inches. In the east section the young-of-the-year were larger and very fat; 45 had an average length of 4.9 inches. The 404 young-of-the-year did not represent the total number that must have been present at the beginning of the poisoning operation. Past experiences indicate that many of this size group probably were eaten by the larger bass before the latter felt the effects of the poison.

The 104 pounds of bass in the final census must not have represented the total poundage the pond will support, because during the summer fishermen had taken from it an additional 83.1 pounds which could not have been completely replaced by September.

Scales for age determinations were taken from 26 of the 29 redear x green sunfish hybrids collected in the final census. Age determinations of these 26 fish are shown in table 7. Two fish in the 1962 year class and one in the 1963 year class showed considerable variation in appearance from the typical F_1 hybrid type, but it was impossible to determine whether they were F_2 or backcrossed individuals.

Discussion

The experiment with hybrid sunfish in North Pond was, in our opinion, unusually

TABLE 6.--Census of all fish in North Pond, September 1-6, 1965

Kind of fish	Number	Total weight (pounds)	Average weight (pounds)	Percent of total weight	Pounds per acre
Largemouth bass:					
Large, 10.1 to 16.5 inches-------	61	47.7	0.782	--------	------
Small, 6.0 to 10.0 inches--------	311	51.4	.165	--------	------
Fingerlings, less than 6 inches--	404	5.5	.014	--------	------
Total, bass-------------------	(776)	(104.6)	--------	83.1	104.6
Redear x green sunfish hybrids-----	29	20.4	.703	16.2	20.4
Grass pickerel---------------------	10	.8	.082	.7	.8
Totals-----------------------	815	125.8	--------	100.0	125.8

successful in that it appeared to accomplish more than we had anticipated. In the first place, the hook-and-line yield of fish per acre in 1962 was the largest for any single year that we have recorded for any Illinois lake or pond. Second, the rate of catch, in terms of fish per man-hour and pounds per man-hour, exceeded any of our previous records. We believe that these new records were related to the use of the redear x green F_1 hybrids.

A replication of this experiment to determine whether it can be duplicated to give equally satisfactory yields is a future objective. We suggest that other pond-owners and fish-management biologists set up ponds for their own tests.

It is, of course, essential that the sunfish stock consist of only redear males and green sunfish females. The correct identification of the sexes should create no problem if one waits until the sunfish spawning season is about to begin, or has begun, before selecting males and females. Males in spawning condition will show a discharge of a white, milky fluid (milt) from the urogenital opening when the posterior abdominal region is gently squeezed. Females nearly ready to spawn will have the abdomen greatly enlarged. If the females are ripe, the eggs will be discharged when light pressure is exerted on the abdomen.

It is essential that no errors be made in stocking, as males of either redear or green sunfish will usually select their own females in preference to those of another species. Thus, any fish of doubtful sex should be discarded. Once a hybrid pond is contaminated through incorrect stocking with redear or green sunfish of the wrong sex, few or no hybrids will be produced.

Because Island Pond was small, it received only 8 male redear sunfish and 3 female green sunfish. These escaped with their young into North Pond to form the first and only sunfish stocking. In the years 1960 through 1965, fishermen caught more than 3,800 hybrids. Further, as 417 bass were stocked in North Pond in 1959 and 1960, the pond must have produced many more small hybrids that were consumed by bass.

TABLE 7.--Average lengths of 26 hybrid sunfish of the year classes 1959-63, inclusive, taken in the final census of North Pond, September 1-6, 1965

Year class	Number	Average total length (inches)
1959---------	2	10.4
1960---------	7	9.4
1961---------	9	9.3
1962---------	[1]7	8.8
1963---------	[2]1	8.3

[1]Two in this year class appeared to be F_2 hybrids or other crosses.

[2]This fish appeared to be an F_2 hybrid or other cross.

There are several indications that the bulk of the F_1 hybrids were produced in 1959, and that much smaller year classes were produced in 1960 through 1962. In 1959 the parent species were the only sunfish that were sexually mature. In 1960 the F_1 hybrids spawned in 1959 were sexually mature, but the size differential between the parent species and F_1 hybrids was so great that they probably would not come together to produce backcrosses. Only 3 of the 29 hybrids collected in the final census could be identified as F_2 or backcrossed individuals.

The unusually high yield of largemouth bass might be explained on the basis of the stimulus to bite created by the voracious biting activity of the more numerous hybrids. Fish are in competition for food in most aquatic habitats, and the fact that one species apparently feeds voraciously and without hesitation might decrease the normal wariness of another species. As mentioned previously, the fact that large bass were relatively few in the final census indicated that the bass population was being cropped efficiently.

Acknowledgments

We wish to thank Mr. William Utterback not only for the use of his pond for this experiment, but also for his assistance in

obtaining a complete creel record from his fisherman cooperators who fished the pond. We also wish to acknowledge the assistance of Messrs. Charles Birkeland, David L. Thomas, Paul A. Fishman, John A. Holbrook, II, and other students who helped with the fertilization program and in making the final fish census.

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A NOTE ABOUT SQUAWFISH

In 1956 the U.S. Fish and Wildlife Service studied the spawning, distribution, extent of predation, migration, and age of the northern squawfish (Ptychocheilus oregonensis) of the Columbia River. As a part of the studies on distribution and migration, several hundred fish were captured by electric shocking in the Middle Fork and main John Day Rivers of Oregon. A numbered metal tag was clamped around the upper right maxillary of each fish. The tags used were conventional bird-leg bands, and sizes varied with the length of the fish. All tagged fish were released at points of capture.

In October and November 1956, about 4 months after the original tagging, reshocking some of the same areas revealed that some tagged fish were still in the same pools into which they had been released originally. In 1958, two tagged squawfish were caught in the main John Day River, each within one-half mile of the original release site. In July 1960, a squawfish tagged in August 1956 and released in the main John Day River at Prairie City was recovered at the same location.

In July 1966, a male squawfish that had been tagged in November 1956 was recovered about one-half mile from its original release site in the Middle Fork John Day River. When tagged, this fish measured 12.7 inches in total length; when recovered, it measured 14.5 inches in total length.

Studies of the squawfish in other areas have provided the following data on growth in other waters: The average length of 5-year-old fish in a sample of 261 Columbia River squawfish measured was 12.42 inches (range, 7.6 to 15.6); the average calculated length of 5-year-old fish in 72 squawfish taken in Seeley Lake, Idaho, was 7.9 inches; and the fork length of 5-year-old Sacramento River squawfish was about 13.0 inches. Obviously, if the scale-reading techniques are comparable, the growth rates vary considerably with the locality.

Did the jaw tag inhibit growth and discourage traveling, or are squawfish just normally slow growers and homebodies?

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