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Jeffrey J. Braunscheidel
and
Gary L. Towns

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For information or assistance on this publication, contact:

MICHIGAN DEPARTMENT OF NATURAL RESOURCES,
Fisheries Division
PO BOX 30446
LANSING, MI 48909
517-373-1280

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# Effects of Redear Sunfish Introduction on Bluegill and Pumpkinseed in Joslin Lake, Washtenaw County, Michigan 1988–2003

**Jeffrey J. Braunscheidel and Gary L. Towns**

*Michigan Department of Natural Resources, Waterford Fisheries Office,*
*7806 Gale Road, Waterford, Michigan 48327*

*Abstract*.–Populations of native Bluegill *Lepomis macrochirus* and Pumpkinseed *Lepomis gibbosus* were surveyed in Joslin Lake, Washtenaw County, Michigan for seven years prior, and then for eight years after, stocking non-native Redear Sunfish *Lepomis microlophus*. Size, growth, and catch rates were monitored for all three species to evaluate any effects from Redear Sunfish introductions. Catch of all species was by trap nets and electrofishing. Sampling conducted annually from 1988 through 1994 (pre-Redear Sunfish) showed a relatively stable population of both Bluegill and Pumpkinseed in Joslin Lake. The average Bluegill length remained fairly stable after Redear Sunfish introduction while the Pumpkinseed average length increased slightly. Reductions in larger Bluegill and Pumpkinseed may have been due to increases in angling activity targeting panfish. Bluegill catch-per-unit-effort (CPUE) rates in trap nets decreased in the years following Redear Sunfish introduction while electrofishing CPUE were similar to pre-introduction levels. Trap net CPUE for Pumpkinseed remained at pre-Redear Sunfish levels initially (through 1999), then dropped sharply in the 2000–2003 samples. Pumpkinseed CPUE with electrofishing dropped sharply after the Redear Sunfish introduction and remained low for all six post-introduction surveys. Growth indices for Bluegill remained constant between pre- and post-Redear Sunfish introduction while Pumpkinseed growth indices improved after Redear Sunfish introduction. As the new Redear Sunfish population became more mature, the proportion of the panfish trap net catches composed of Bluegill and Pumpkinseed decreased while the proportion of Redear Sunfish increased. Overall combined panfish CPUE also increased. It has been observed that Redear Sunfish seem to readily hybridize with Bluegill, Pumpkinseed, and Green Sunfish *Lepomis cyanellus*. While this does not appear to have created problems even in lakes where Redear Sunfish were introduced over 50 years ago, the authors encourage more study in the possible long-term effects of hybridization as managers consider further Redear Sunfish introductions

## Introduction

The Redear Sunfish, also known as the shellcracker, is native to the southeastern United States. Since it is a popular sport fish that grows to large sizes, it has been introduced to bodies of water all over North America including southern Michigan. Redear Sunfish fingerlings stocked in several southern Michigan lakes in the 1950s produced some decent fisheries with occasional trophy-size panfish showing up in angler catches (Towns 2003). An experimental program to introduce Redear Sunfish into several additional lakes in the southern part of Michigan's Lower Peninsula began in 1984. After it appeared the initial stockings would lead to manageable fisheries, surveys were conducted to evaluate survival and related information. These surveys provided a basis for the Redear Sunfish management

plan that was developed for the Michigan Department of Natural Resources, Fisheries Division in 1990 (Towns 1991). The plan called for additional rearing and stocking of Redear Sunfish, followed by surveys to help with evaluating the results.

Since the start of the intensive Redear Sunfish management that began in Michigan in the early 1980s, some fisheries managers speculated that Redear Sunfish may compete with native panfish (Towns 2003). Previous evaluations in Michigan lakes have had only one year of pre-introduction sampling and at best 2–3 years of post-introduction sampling. Joslin Lake had several years of surveys targeting panfish evaluation already available due to its involvement in another study. Subsequent to the stocking of Redear Sunfish in Joslin Lake, intensive monitoring was conducted for several years to evaluate, in more detail, possible effects on the Bluegill and Pumpkinseed populations from introducing this species. This study was different from previous evaluations because it included multiple years of sampling prior to the introduction along with several years of comparable, post-introduction survey work.

## Lake Description

Joslin Lake is a 187-acre natural lake in northwestern Washtenaw County in southeastern Michigan (Figure 1). It is in the upper headwaters of Portage Creek, which is one of the major tributaries to the Huron River. Approximately 1,220 acres of watershed drain directly into the lake (Marsh and Borton 1974). This partial watershed area does not include the surface area of the lake or the area upstream of any major tributaries. There are four small inlets from South Lake, which join together and enter Joslin Lake on its southern end. The lake outlets via a small stream in the northeast corner that discharges to Portage Creek.

The lake is relatively shallow with most of the lake less than 10 feet deep and a maximum depth of 20 feet (Figure 1). Approximately one-third of the lake shoreline is characterized as marshy and undeveloped with emergent wetland vegetation that includes lily pads, cattails, and bulrushes. The remaining shoreline is developed with permanent homes and a few summer cottages. A Michigan Department of Natural Resources public access site and boat launch is located on the south side of the lake within the Pinckney Recreation Area.

Lake-bottom sediments are composed mainly of sand, marl, pulpy peat and fibrous peat. The nearshore area is mostly sand along the north and east sides of the lake with submerged aquatic vegetation sparse or absent. The central portion of the lake, along with the south and west shallows, have dense submerged vegetation with peat and marl bottom substrates.

The latest limnological sampling was conducted in early September 2003. Water color was a light brown with a Secchi disk reading of 8.5 feet. From the surface down, water conductivity ranged from 365 to 411 and pH from 8.3 to 7.3. Temperature was fairly constant from 71°F at the surface to 69°F at 17 feet. Dissolved oxygen ranged from 10.3 ppm at the surface to 8.5 ppm at 16 feet, and dropped to 4.7 ppm at the bottom. Water temperature was not stratified at the time of this sampling although dissolved oxygen may have been slightly stratified at the bottom of the deepest basin. Historical limnological data has shown similar conditions are also present during the summer.

### *History*

The earliest fish survey on record is from July 1973 (Fisheries Division records, unpublished data). This survey resulted in a catch of Bluegill, Pumpkinseed, and Black Crappie characterized in the analysis as a fair fishery compared to other lakes in the area. Fish growth was not determined since no scales were taken from fish for age analysis purposes. Bullhead and Largemouth Bass populations were reported as very good and angler reports of good Bluegill, bass, and bullhead fishing were noted.

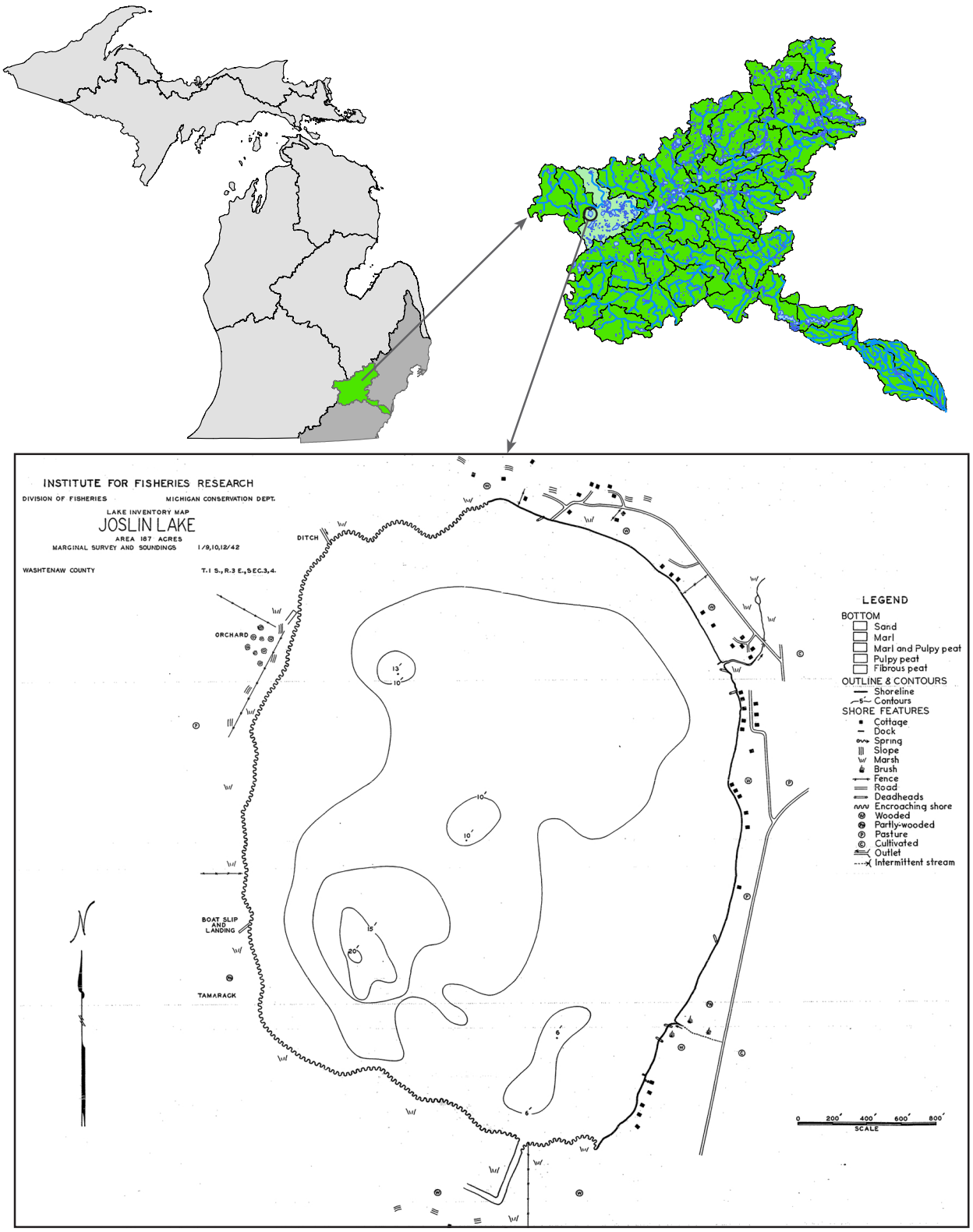


Figure 1.–Geographic location and bathymetric map of Joslin Lake, Washtenaw County.

Many small panfish were caught in a November 1985 survey (Towns 1985). More than 200 Bluegills were captured averaging just over 5 inches. This average was significantly smaller than the average size of Bluegills from surveys in other area lakes. The predominance of small panfish may have been due to reduced movement of larger fish caused by coldwater temperatures (53°F). Growth analysis indicated Bluegill and Black Crappie were about ½ inch below the state average based on length-at-age. The presence of several year classes of both species in the population provided a fair fishery for anglers.

Joslin Lake was selected as a control lake for a southern Michigan Bluegill study begun in 1988 to compare, contrast, and measure the efficacy of selected management techniques for improving the size structure of Bluegill populations of inland lakes. Joslin Lake was surveyed each year subsequent to 1988, but was dropped from the study after the 1994 survey since the lake maintained a satisfactory-to-good Bluegill population structure (despite slow growth) and was not typical of the other lakes in the study (Schneider and Lockwood 1997). The slow growth and longevity trends exhibited by Joslin Lake Bluegills continued through 1994 and the structure of the fish population during this time period remained relatively unchanged.

Historically, Joslin Lake has had a relatively large Pumpkinseed population. The average size of Pumpkinseed in standard trap nets during the period 1988–1994 was approximately 6.5 inches and growth indices were near state averages (Table 1). Because of the large Pumpkinseed and healthy snail populations that existed in Joslin Lake, an opportunity presented itself to create a trophy panfish fishery and quantitatively study the effects of Redear Sunfish introduction. Redear Sunfish had been stocked in several Jackson area lakes since 1984 with generally very good success. Not only have stocked Redear Sunfish grown to trophy panfish proportions, averaging nearly 9 inches in trap-net catches with many individuals over 11 inches, they have become self-sustaining in most of the lakes where they have been introduced (Towns 2003). Redear Sunfish were stocked into Joslin Lake in 1995, 1996, and 1997 according to the guidelines in the Redear Sunfish Management Plan (Towns 1991). This consisted of 18,700 fall fingerlings in 1995 (100/acre), 7,500 fall fingerlings and yearlings in 1996 (40/acre) (yearlings were used due to a shortage of fall fingerlings), and 16,600 fall fingerlings in 1997 (89/acre).

## Methods

Joslin Lake was surveyed from 1988 through 1994 prior to Redear Sunfish stocking, and then from 1996 through 2003 after stocking. Fish sampling was conducted in the spring (usually May) using trap nets and a boomshocker for all the years surveyed from 1988 through 2002. However, due to time constraints, only trap nets were used in the 2003 survey. Each trap net consisted of a standard, 3-foot x 5-foot pot with 1.5-inch stretched mesh and leads of various lengths to reach from shore to approximately 6 feet of water depth. Three to six trap nets were used in each survey year. Total netting effort ranged from three to ten net-nights each year. Electrofishing was conducted using a 220-volt AC boomshocker for durations ranging from 0.5 to 3.0 hours. Catch-per-unit-effort (CPUE) was standardized as catch-per-net-night for the trap nets and catch-per-hour for the electrofishing. This was calculated by taking the total catch for each gear used during the survey period and dividing it by the total effort of that gear for the same period. Total length of all fish was either measured to inch group (i.e., 1.0 to 1.9 = the 1-inch group, etc.) for length-frequency analysis, or to 0.1 inch for age and growth analysis. Scale samples or dorsal spines were collected for aging individual fish. The age-length data were then used in determining length-at-age for comparison ( growth index) to the State of Michigan averages (Schneider et al. 2000).

Table 1.–Summary of panfish data for Joslin Lake fisheries surveys prior to introduction of Redear Sunfish (1988–1994). Total lengths (TL) are in inches.

| Survey method and year | Bluegill | | | | | Pumpkinseed | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Catch rate [a] | Avg TL | % by weight | % by number | Growth index | Catch rate [a] | Avg TL | % by weight | % by number | Growth index |
| Trap nets | | | | | | | | | | |
| 1988 | 44.3 | 6.8 | 25.1 | 47.5 | -0.6 | 25.5 | 6.5 | 14.3 | 27.3 | 0.1 |
| 1989 | 35.2 | 6.6 | 15.4 | 34.3 | -0.9 | 27.5 | 6.5 | 13.8 | 26.8 | |
| 1990 | 39.3 | 6.8 | 31.1 | 48.8 | -0.6 | 10.2 | 6.8 | 10.0 | 12.6 | |
| 1991 | 107.3 | 7.0 | 39.7 | 46.4 | -0.8 | 90.0 | 6.7 | 35.2 | 38.9 | |
| 1992 | 39.5 | 6.6 | 31.6 | 45.6 | -0.9 | 27.8 | 6.5 | 25.3 | 32.1 | |
| 1993 | 262.8 | 6.4 | 79.0 | 88.0 | -1.1 | 18.2 | 6.6 | 7.0 | 6.0 | -0.3 |
| 1994 | 92.7 | 6.6 | 43.0 | 64.0 | -1.2 | 16.0 | 6.8 | 10.0 | 11.0 | |
| Average | 88.7 | 6.7 | 37.8 | 53.5 | -0.9 | 30.7 | 6.6 | 16.5 | 22.1 | -0.1 |
| Elelectrofishing | | | | | | | | | | |
| 1988 | 87.4 | 3.2 | | 44.7 | -1.3 | 37.7 | 4.5 | | 19.3 | |
| 1989 | 94.0 | 3.1 | 25.1 | 50.7 | [b] | 15.5 | 5.1 | 16.2 | 8.3 | |
| 1990 | 228.0 | 4.0 | 23.3 | 66.9 | -1.1 | 35.3 | 5.0 | 7.1 | 10.4 | |
| 1991 | 248.0 | 3.4 | 28.6 | 69.7 | [b] | 86.2 | 5.6 | 24.6 | 15.7 | |
| 1992 | 225.0 | 4.0 | 24.0 | 50.4 | [b] | 126.0 | 5.9 | 32.4 | 28.3 | |
| 1993 | 141.3 | 3.7 | 18.0 | 54.0 | [b] | 53.1 | 5.4 | 22.0 | 20.0 | |
| 1994 | 44.7 | 4.7 | 15.0 | 44.0 | [b] | 12.3 | 5.4 | 7.0 | 12.0 | |
| Average | 152.6 | 3.7 | 22.3 | 54.3 | | 52.3 | 5.3 | 18.2 | 16.3 | |

# Results

## *Prior to Redear Sunfish Introduction*

Survey information for 1988 through 1994 (Table 1) indicates that average lengths fluctuated slightly from year to year. Trap net catches had an average Bluegill length of 6.7 inches (range of 6.4-7.0 inches) and Pumpkinseed average length of 6.6 inches (range of 6.5-6.8 inches). Electrofishing samples produced an average Bluegill length of 3.7 inches (range of 3.1-4.7 inches) and Pumpkinseed average length of 5.3 inches (range of 4.5–5.9 inches). These results showed a relatively stable size structure of both Bluegill and Pumpkinseed in Joslin Lake prior to introducing the Redear Sunfish.

Catch rates for the two gear types showed slightly more variability than average lengths from year to year. Catch-per-unit-effort (CPUE) for Bluegill sampled in trap nets during this period averaged 89 fish per net-night with a range from 35 to 263. The Pumpkinseed trap-net CPUE averaged 31 fish per net-night with a range from 10 to 90. Electrofishing CPUEs for Bluegill averaged 153 fish per hour (range of 45–248) and Pumpkinseed averaged 52 fish per hour (range of 12–126). These annual CPUEs showed much more variability during the pre-Redear Sunfish period than the average lengths.

The average growth index (based on length-at-age from scale samples) for Bluegill during this period averaged -0.9 inches (range of -0.6 to -1.2) below the state average (Schneider et al 2000). Growth for Pumpkinseed was only determined for 2 years during this period (1988 and 1993). These two data points (+0.1 and -0.3 respectively) produce an average growth index of -0.1 overall for Pumpkinseed prior to Redear Sunfish introduction.

Bluegill averaged 53.5% of the trap net catch by number and 37.8% by weight during this period. They averaged 54.3% of the electrofishing catch by number and 22.3% by weight. Pumpkinseed averaged 22.1% of the trap net catch by number and 16.5% by weight. They averaged 16.3% of the electrofishing catch by number and 18.2% by weight (Table 1).

## *After Redear Sunfish Introduction*

Redear Sunfish began to appear in the electrofishing samples in 1996 and the trap-net samples in 1997. The average length caught with both gears increased gradually through the years of the study, peaking at 9.3 inches in the electrofishing in 1999 and 9.9 inches in the trap nets in 2002. Average lengths in the electrofishing samples declined to 8.3 inches in 2000 and 7.2 inches in 2002. Catch rates were low for the first few years averaging 23 fish per net night in the trap nets and 4 fish per hour electrofishing through the 2000 sampling. Redear Sunfish CPUE then jumped significantly with trap-net catches of 125 and 144 fish per net-night in 2002 and 2003 and electrofishing at 40 fish per hour in 2002. Growth was initially very good (1.7–2.2 inches above state average) through 2000 then began to diminish with growth indices of 0.4 and 0.3 inches above state average in 2002 and 2003. Similar to the catch rates, the percent of the total trap-net catch by number composed of Redear Sunfish was relatively low through 2000 (average of 20%), then increased sharply in 2002 and 2003 (59% and 55%). Electrofishing results were similar, but less drastic, with catch percentages by number averaging 1.7% through 1999 and jumping to 6.8% and 5.1% in 2000 and 2002.

The average Bluegill length remained fairly stable after Redear Sunfish introduction. After the introduction of Redear Sunfish, average Bluegill lengths in trap-net samples was 6.7 inches (range of 6.2–7.0 inches; Table 2) and equaled the overall average length of this species from the sampling period prior to the introduction of Redear Sunfish. Electrofishing samples also found the Bluegill average length remaining stable between the pre- and post-introduction periods (3.7 inches vs. 3.6 inches).

Pumpkinseed average lengths in trap-net sampling, after the Redear Sunfish introduction, increased slightly with an overall average of 7.0 inches (range of 6.3–7.2 inches) compared to the 6.6-inch

Table 2.–Summary of panfish data for Joslin Lake panfish surveys after introduction of Redear Sunfish (1996–2003). Total lengths are in inches. (RSF Stocked 1995–97.)

| Survey method and year | Bluegill | | | | | Pumpkinseed | | | | | Redear Sunfish | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Catch rate [a] | Avg TL | % by weight | % by number | Growth index | Catch rate [a] | Avg TL | % by weight | % by number | Growth index | Catch rate [a] | Avg TL | % by weight | % by number | Growth index |
| Trap nets | | | | | | | | | | | | | | | |
| 1996 | 41.3 | 6.6 | 12.9 | 27.7 | -1.1 | 48.3 | 6.9 | 20.3 | 32.4 | 0.1 | | | | | |
| 1997 | 60.0 | 7.0 | 23.9 | 38.6 | -1.0 | 14.2 | 7.2 | 7.3 | 9.1 | 0.3 | 21.0 | 6.8 | 7.5 | 13.5 | 2.2 |
| 1998 | 27.8 | 7.0 | 15.9 | 27.5 | -1.0 | 25.7 | 7.2 | 16.4 | 20.2 | 0.7 | 44.0 | 8.1 | 33.2 | 34.6 | 1.7 |
| 1999 | 65.8 | 6.6 | 29.3 | 42.2 | -0.8 | 29.3 | 6.3 | 13.4 | 18.8 | 0.6 | 11.3 | 8.3 | 10.7 | 7.2 | 1.7 |
| 2000 | 25.6 | 6.2 | 18.7 | 41.0 | -0.9 | 5.7 | 6.9 | 6.7 | 9.1 | 0.4 | 14.7 | 9.3 | 37.8 | 23.6 | 1.7 |
| 2002 | 36.3 | 6.9 | 6.4 | 17.3 | -0.9 | 9.2 | 7.2 | 2.2 | 4.4 | 0.6 | 124.7 | 9.9 | 72.1 | 59.4 | 0.4 |
| 2003 | 71.9 | 6.6 | 9.8 | 27.5 | -1.0 | 14.1 | 7.0 | 2.8 | 5.4 | 0.6 | 143.7 | 9.9 | 75.3 | 55.0 | 0.3 |
| Average | 47.0 | 6.7 | 16.7 | 31.7 | -1.0 | 20.9 | 7.0 | 9.9 | 14.2 | 0.5 | 59.9 | 8.7 | 39.4 | 32.2 | 1.3 |
| Electrofishing | | | | | | | | | | | | | | | |
| 1996 | 78.5 | 3.7 | 17.0 | 46.0 | [b] | 6.9 | 4.7 | 3.3 | 4.1 | [b] | 1.2 | 3.2 | 0.1 | 0.7 | |
| 1997 | 17.3 | 5.0 | 9.5 | 22.1 | [b] | 6.7 | 6.5 | 7.2 | 8.5 | [b] | 2.0 | 6.3 | 1.6 | 2.6 | [b] |
| 1998 | 80.0 | 3.0 | 10.1 | 44.7 | [b] | 13.0 | 6.3 | 10.6 | 7.3 | [b] | 3.0 | 4.7 | 1.5 | 1.7 | [b] |
| 1999 | 243.0 | 3.4 | 31.4 | 67.5 | [b] | 22.0 | 6.4 | 16.0 | 6.1 | [b] | 6.0 | 9.3 | 12.3 | 1.7 | [b] |
| 2000 | 53.5 | 2.8 | 5.8 | 38.4 | [b] | 14.5 | 6.2 | 11.1 | 10.4 | [b] | 9.5 | 8.3 | 18.0 | 6.8 | [b] |
| 2002 | 456.0 | 3.9 | 31.2 | 57.6 | [b] | 14.0 | 5.8 | 3.3 | 1.8 | [b] | 40.0 | 7.2 | 18.3 | 5.1 | [b] |
| Average | 154.7 | 3.6 | 17.5 | 46.1 | | 12.8 | 6.0 | 8.6 | 6.4 | | 10.3 | 6.5 | 8.6 | 3.1 | |

[a] Catch rate for trap nets is per net-night and for electrofishing is per hour.
[b] Combined growth index. Samples from trap nets and electrofishing combined for analysis.

average from the pre-introduction sampling. All years of the post-introduction trap-net sampling, with the exception of 1999, found average Pumpkinseed lengths greater than the pre-introduction averages. Pumpkinseed average length in electrofishing samples also increased from 5.3 inches pre-introduction up to 6.0 inches post-introduction.

Bluegill average CPUE in trap nets (Tables 1 and 2) decreased in the years following Redear Sunfish introduction (from 89 fish per net lift to 47), while electrofishing average CPUEs were similar to pre-introduction levels (155 vs. 153). A comparison of trap-net CPUE by inch group (Figure 2) shows most of this decrease occurred within the 6- and 7-inch Bluegill inch groups with little change in the smaller inch groups.

Average trap net CPUE for Pumpkinseed remained at pre-Redear Sunfish introduction levels (around 30 fish per net lift) through 1999, then dropped sharply in 2000–2003 samples (fewer than 10 fish per net lift). Pumpkinseed average CPUE for electrofishing samples dropped sharply after the Redear Sunfish introduction and remained low for all six post-introduction surveys with a pre-introduction average CPUE of 52 fish vs. the post-introduction CPUE average of 13. Comparing trap net CPUEs by inch group for Pumpkinseed (Figure 2) indicates that a significant decrease occurred in the 4-, 5-, and 6-inch fish after Redear Sunfish introduction.

Growth indices for Bluegill remained nearly constant between pre- and post-introduction surveys with mean growth indices of -0.9 prior to the introduction and -1.0 afterward. Pumpkinseed growth improved after the introduction with mean growth indices increasing from an average of -0.1 prior to the Redear Sunfish introduction (range of -0.3 to 0.1) to an average of 0.5 after introduction (range of 0.1 to 0.7). The Pumpkinseed growth seemed to increase gradually with a mean growth index of 0.1 in 1996 to 0.7 by 1998 and ranging from 0.4 to 0.6 in later surveys.

The composition of the total panfish trap-net catch by number changed significantly after the introduction of the Redear Sunfish (Table 2). Bluegill and Pumpkinseed comprised a significantly lower proportion of the catches with Redear Sunfish making up a progressively larger portion. The Bluegill percent by number dropped from an average of 53% pre-introduction down to less than 32%, while the Pumpkinseed percent-by-number went from an average of 22% pre-introduction down to 14% after the Redear Sunfish introduction. Redear Sunfish comprised an increasing proportion of the trap-net catch, making up more than 50% of the total catch in 2002 and 2003.

Overall trap-net catch by number for all panfish combined also changed after the Redear Sunfish became established. The combined CPUE prior to Redear Sunfish introduction averaged 93 panfish per net lift (Table 1; 1988–1994 with 1993 omitted). The last three years of sampling after Redear Sunfish introduction (2000, 2002, and 2003) averaged 149 panfish per net lift (Table 2). A comparison of the combined CPUE for all panfish from before and after Redear Sunfish introduction, separated into inch groups (Figure 3), shows some shifts in the panfish size distribution. The overall CPUE of 5-, 6-, and 7-inch panfish dropped slightly after the introduction, but large numbers of 8-, 9-, and 10-inch panfish appeared as the Redear Sunfish became established in the lake, with most of the catch of larger panfish (>8 inches) dominated by Redear Sunfish.

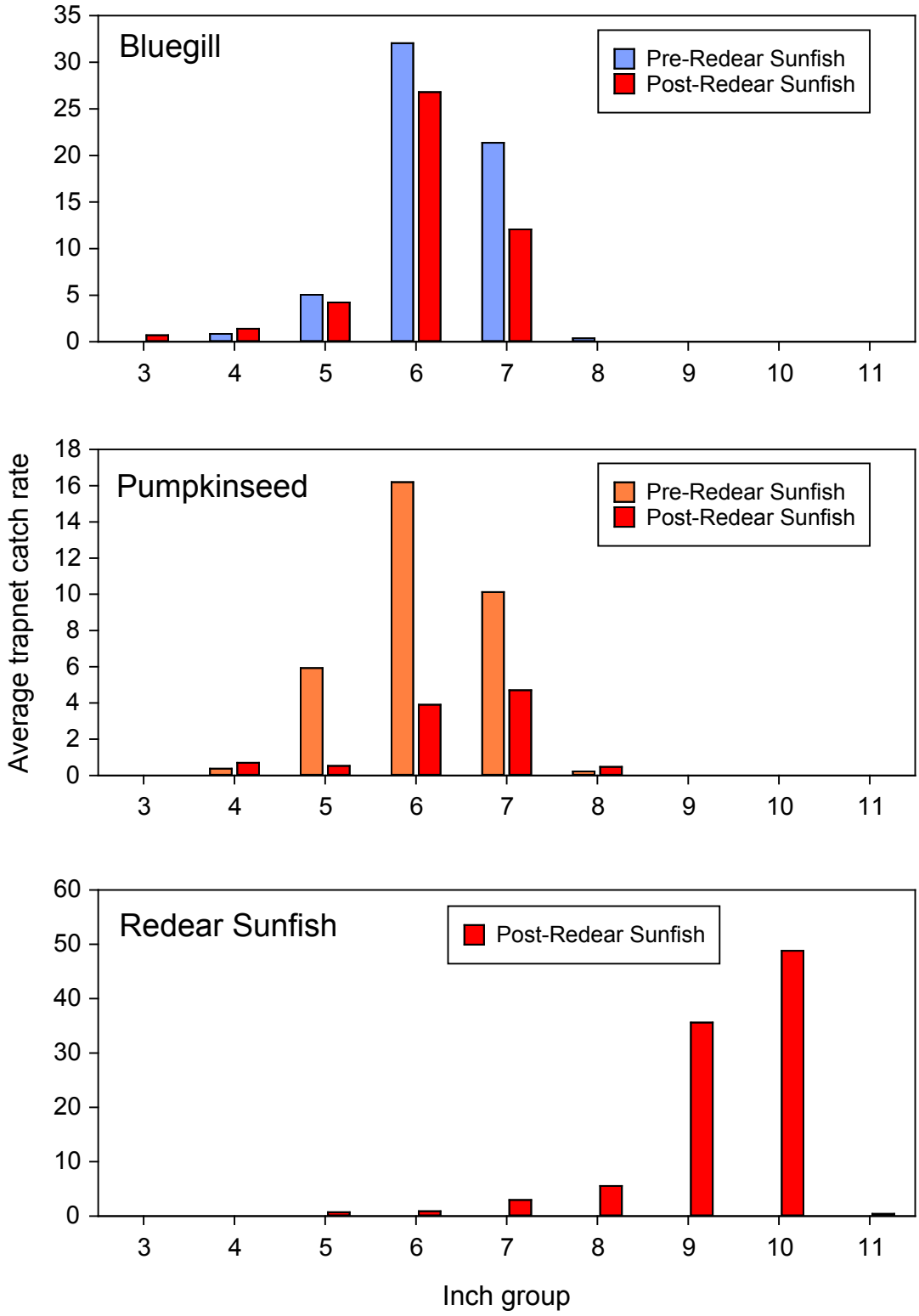


Figure 2.–Comparison of pre- and post-Redear Sunfish introduction trap-net catch rates for each species by inch group. Six years of pre-introduction data (1988-1994 with 1993 omitted) and the last three years of post-introduction data (2000, 2002, and 2003) were used for comparison.

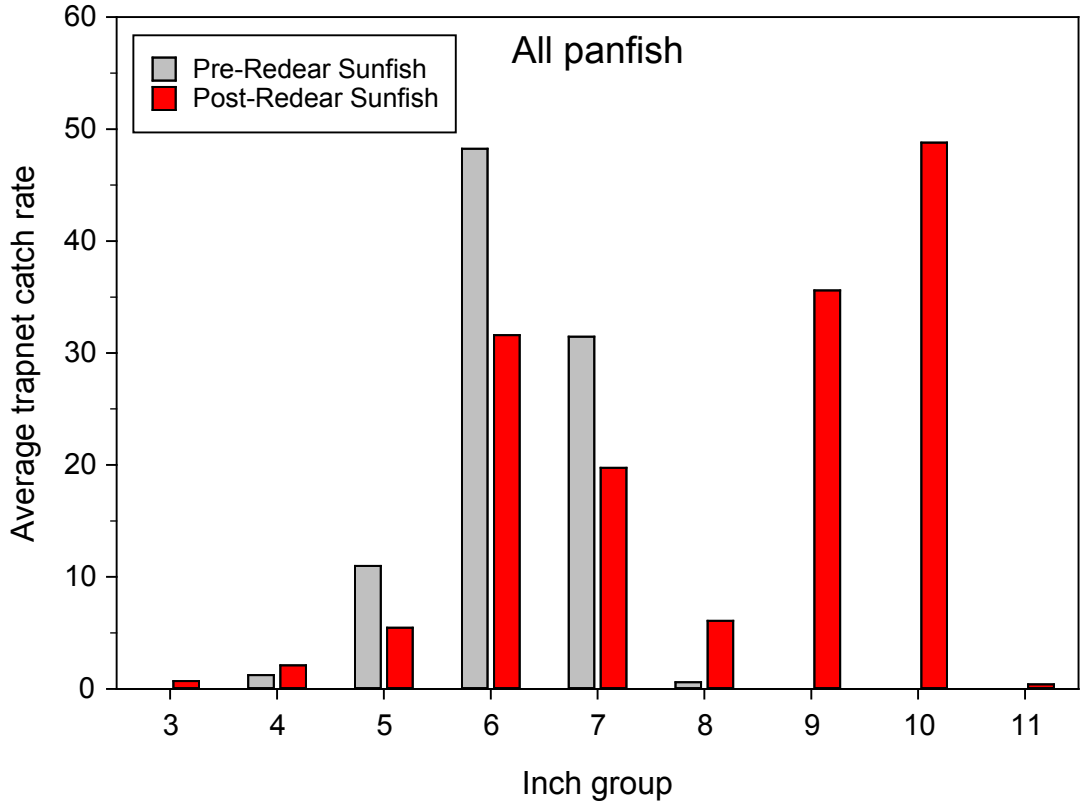


Figure 3.–Comparison of pre- and post-Redear Sunfish introduction trap-net panfish catch rates by inch group. Six years of pre data (1988-1994 with 1993 omitted) and last three years of post data (2000, 2002, and 2003) were used for comparison.

## Discussion

Fisheries managers have not been particularly concerned with the potential effects of Redear Sunfish introductions on Bluegill populations. The areas of potential competition were not thought to be significant since Redear Sunfish seem to fit into a different niche in a lake ecosystem. Redear Sunfish primarily eat snails, while Bluegill are primarily planktivores and insectivores. The Bluegill size structure and growth in Joslin Lake were very similar between the pre- and post-introduction of Redear Sunfish surveys, supporting this assumption. However, the significant decrease in Bluegill density shown by the reduction in trap-net CPUE contradicts this assumption and indicates there may be negative effects on a Bluegill population from the introduction of Redear Sunfish.

One possible explanation for the negative effects on the density of only the larger 6- and 7-inch Bluegill (Table 2) is based on angler behavior. Angling pressure on panfish has been observed to increase dramatically in many lakes where large Redear Sunfish have become established. Many of the anglers are targeting larger panfish of any species. Since the adult Bluegill occupy the same lake strata and are susceptible to the same angling methods as Redear Sunfish, an increased harvest of the larger Bluegill could occur with the higher angler effort targeting panfish. Creel census was not conducted as part of this study, so the extent of any increase in fishing effort was not measured.

Possible effects of Redear Sunfish on native Pumpkinseed populations have been a concern due to direct competition for food between these species. Competition for food, since both heavily use snails

as a primary food item, has been cited as a potential problem area (Towns 2003, Huckins 1996). A study of several southern Michigan lakes where Redear Sunfish had been introduced found the abundance of Pumpkinseed declined an average of 56%, but growth was unchanged (Huckins 2000). The sampling results of this study also show a change in the Pumpkinseed population of Joslin Lake since the introduction of Redear Sunfish. Similar to the Huckins study, Joslin Lake Pumpkinseed numbers from trap-net catch rates dropped by more than 60% (Tables 1 and 2; Figure 2). But, unlike the findings of the Huckins study, growth and average size of the remaining Pumpkinseed noticeably improved in this study. A possible complicating factor in this last conclusion arises from one of the author's observations while conducting sampling during the last few years of the study. A fair number of the larger fish identified as Pumpkinseed exhibited some characteristics that could indicate the presence of Redear Sunfish genetic material. That is, some hybrids with increased growth rates and larger size may have been incorrectly identified as Pumpkinseeds. This would not affect the conclusion that Pumpkinseed numbers decreased significantly, but it might negate the increased growth and average size observation.

In considering the overall panfish fishery (Figure 3), the increased numbers of large Redear Sunfish more than compensated for the reduced numbers of medium-sized Bluegill and Pumpkinseed. So while the populations of Bluegill and Pumpkinseed decreased, the overall quality of the panfish fishery in Joslin Lake improved with higher numbers of larger panfish available to anglers.

## *Management Implications*

While Redear Sunfish are not native to Michigan, several lakes in southern lower Michigan have developed naturally sustaining populations of this panfish (Towns 2003). Since this species exhibits growth rates 2 to 3 times greater than native Pumpkinseed (Huckins 2000), the high growth rates and the large size they typically achieve has provided an opportunity for anglers to catch larger panfish, on average, from the lakes where they have become established. Anglers seem to have accepted the improvement in the overall panfish fishery in these lakes as a reasonable trade-off for possible effects on the smaller, native Bluegill and Pumpkinseed. In fact, Redear Sunfish have appeared in some lakes that have not been stocked by Fisheries Division and seem to have no water connection to previously stocked waters. Anglers may be moving Redear Sunfish to nearby waters in attempts to build larger panfish stocks in more lakes.

The authors encourage fisheries managers to evaluate potential fish-community genetic issues when stocking Redear Sunfish. While the resulting overall panfish size structure will likely increase in stocked waters, the long-term effects of hybridization are unknown at this time. Although hybrid panfish are present in nearly every lake population, the introduction of foreign genetic material in vast amounts, which might be passed on to subsequent generations (or beyond), may be problematic. Michigan lakes that were stocked with Redear Sunfish in the 1950s still had phenotypically pure stocks of self-sustaining Pumpkinseed fifty years later. This observation helped prompt further stocking of Redear Sunfish into additional lakes in later years. However, several lakes which have been more recently stocked (late 1980s and 1990s), have produced many hybrids of what appear to be Bluegill X Redear, Pumpkinseed X Redear Sunfish and Green Sunfish X Redear Sunfish crosses. It may be that, when large numbers of fingerling Redear Sunfish stocked in some lakes reach maturity, they tend to overwhelm available spawning grounds and mix with native species resulting in a much larger number of hybrid panfish in the lake than would normally occur. These hybrids attain large sizes and are readily caught by anglers.

Some anglers have contacted the authors with observations of many large, hybrid sunfish appearing in lakes that have been stocked with Redear Sunfish. The authors have also noted this in recent surveys of some waters where Redear Sunfish have been established for longer periods (about 10 years or more). Very few hybrid sunfish were found during most of the post-Redear Sunfish sampling included in this Joslin Lake study, but there was a sharp increase in the last survey (2003) where 54 hybrid

sunfish were collected. In addition, anglers fishing Joslin Lake in subsequent years have reported that hybrid sunfish seem to be a large percentage of their catch.

While hybrids have been observed on nests, it is unknown at this time if they are sterile or if they can propagate and pass genetic material to the next generation. Childers and Bennett (1961) were successful in producing first generation hybrids from six combinations of Redear, Green Sunfish, and Bluegill in the laboratory with less success in pond experiments. After they attempted two or more replications to produce hybrids in ponds, only the Redear Sunfish (male) X Green Sunfish (female) and Green Sunfish (male) X Bluegill (female) crosses produced significantly large numbers of first generation offspring. In further experiments with Redear, only the Redear Sunfish X Green Sunfish cross produced any second-generation hybrids. Furthermore, with various Redear Sunfish crosses, from 70% to 100% of the first generation offspring were males. However, these authors did not work with Pumpkinseed—perhaps a closer relative to Redear Sunfish.

If recent advancements in the science of genetics and DNA testing were applied to this issue it would likely help answer many questions about the potential for genetic alteration of panfish communities after Redear Sunfish introductions. This issue needs further study and until it is better understood and long-term effects are known, caution should be exercised when considering the further expansion of Redear Sunfish in Michigan waters.

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