**STUDY PERFORMANCE REPORT**

**State:** Michigan

**Project No.:** F-35-R-24

**Study No.:** 654

**Title:** Evaluation of brown trout and steelhead competitive interactions in Hunt Creek, Michigan.

**Period Covered:** April 1, 1998 to September 30, 1999

**Study Objective:** To determine if the introduction of steelhead into a stream where they presently do not exist will affect the abundance, survival, growth, or disease status of resident trout species.

**Summary:** Potential effects of competitive interactions between steelhead and resident brown trout in Hunt Creek are being evaluated by comparing population dynamics of resident trout in a treatment zone (TZ) before (1995-97) and after (1998-2002) adult steelhead are stocked into the TZ. In addition, resident trout populations are being estimated in reference zones (RZ) without steelhead. We have made five consecutive annual fall estimates of brook and brown trout populations in the TZ of Hunt Creek and in reference zones located on Hunt and Gilchrist Creeks. Adult steelhead will be stocked in the TZ each spring from 1998-2002. Brook and brown trout abundance, growth, and survival, will be compared between the pre- and post-steelhead-stocking periods in the TZ. We will also continue to monitor resident trout population dynamics in reference zones to help distinguish between effects of species interactions and other environmental factors influencing population dynamics

We are collecting information on stream discharge in all study zones because the magnitude and seasonal pattern of stream discharge is known to have strong effects on the reproductive success of salmonid species. We installed an electronic river stage height recorder on Hunt Creek to obtain hourly measurements of stream stage at the upstream end of the Hunt Creek RZ. We determined that discharge at the gauged site can be used to accurately predict discharge in the TZ and the Gilchrist Creek reference zone (RZ). High streamflow during spring 1998 appeared to reduce the abundance of young-of-the-year (YOY) brown trout in both the TZ and the RZ.

Hourly water temperatures were electronically recorded all year in both the TZ and RZ because water temperature differences between years can influence the outcome of certain species interactions. Warmer temperatures during the winter of 1998-99 decreased the period between brown trout egg deposition to fry emergence such that it was less likely that steelhead spawning in spring 1999 could superimpose their redds upon partially developed brown trout alevins. Warmer-than-normal water temperatures during 1998 were associated with faster growth of YOY brown trout in both the TZ and RZ.

We counted and characterized both steelhead and resident trout redds in the TZ to determine both the spatial distribution of redds and the time period when most spawning occurs. The majority of brown trout spawning occurs during the last half of October and most steelhead spawned in spring prior to 15-April. Steelhead spawned in significantly shallower and faster water than brown trout but the range of depths and velocities used by both species overlapped considerably.

During spring 1998 steelhead superimposed redds upon 2 of 31 brown trout redds marked in fall 1997. We could not assess the probability that brown trout alevins were present in redds at that time because we have been unsuccessful in determining when most brown trout emerge from their redds.

Steelhead stocked in 1998 produced approximately 2500 YOY per hectare in the TZ by September. Populations estimates for 1999 have not yet been computed. Brown trout YOY abundance was substantially lower than normal in both the TZ and RZ during fall 1998 but is more likely related to high streamflow during spring 1998 than to interactions with steelhead YOY.

**Job 2. Title: Monitor water temperature in treatment and reference zones.**

**Findings:** We recorded water temperatures hourly using electronic thermometers maintained at 5 sites. One thermometer is located near the upstream boundary of the Hunt Creek reference zone and the other four thermometers were located near the upstream and downstream boundaries of the treatment zone on Hunt Creek and the reference zone on Gilchrist Creek. Monthly mean temperatures at the upstream boundaries of the Gilchrist Creek reference zone and the Hunt Creek treatment zone are shown in table 1.

Water temperature affects the outcome of competitive interactions (De Stato and Rahel 1994), and the growth rates of juvenile and adult fish. It also controls the developmental rate of gametes in trout redds, which, in turn, determines when alevins will emerge from redds. There has been substantial temporal variability in temperature during the incubation period from 1996-99. The number of days between brown trout egg deposition and hatch predicted from incubation time models ranged from 71 d for the 1999 year class up to 118 d for the 1996 year class (Crisp 1981, 1988). Shorter incubation periods reduce the probability that steelhead would superimpose their redds upon developing brown trout alevins. We used daily surface water temperatures and the assumption that eggs were deposited on 15 October for this analysis. Water temperatures during the primary incubation period, 15 October through April, were very similar between the treatment and reference zones. Temperatures in treatment and reference zones have also been very similar during other times of year (Table 1).

**Job 3. Title: Monitor water stage and discharge.**

**Findings:** We are collecting information on stream discharge in all study zones primarily because high stream discharge around the time that fry emerge from redds is known to have strong negative effects on the reproductive success of brown trout (Nuhfer et al. 1994). Because the timing of stochastic events such as floods can differentially affect recruitment of species with different life histories (Strange et al. 1992) stream discharge in Hunt Creek is monitored throughout the year.

We installed a Sutron electronic stage height recorder in Hunt Creek on 12-August 1996 to obtain hourly measurements of water stage height near the upstream end of the Hunt Creek reference zone. We made periodic discharge measurements to establish the relationship between stage height and stream discharge at this site. We also placed staff gauges at the downstream ends of the Hunt Creek treatment zone and the Gilchrist Creek reference zone during June 1996. Staff gauges were read periodically throughout the year to establish relationships between stage height at all three locations. Stream discharge was periodically measured during 1997-98 on the same days at the downstream ends of the Hunt Creek and Gilchrist Creek study zones and at the electronic stage height recorder site.

We determined that stream discharge at the downstream ends of the Hunt Creek TZ and the Gilchrist Creek RZ were both highly correlated with discharge of Hunt Creek near the electronic stage height recorder ($R^2$'s ≈ 0.98). Thus, discharge in all stream reaches where trout populations are estimated can be reliably predicted from stream stage height data collected at one site.

Exceptionally high spring discharges occurred during spring 1998 (Figure 1) and may have reduced brown trout reproductive success. Late spring and summer 1998 discharge levels were generally lower than normal. Stage height recorder malfunctions during late 1998 and early 1999 precluded daily estimates of discharge between 16-Oct 98 and 20-March 99. Modest discharge peaks during June 1999 probably corresponded with emergence of rainbow trout. Effects of these discharges on steelhead reproductive success will be examined after fall 1999 population estimates are completed.

**Job 5. Title: <u>Locate and mark locations of trout redds and measure redd characteristics.</u>**

**Findings:** We counted brown trout redds in both the treatment and reference zones during the 1995 and 1996 spawning periods. During 1997-99 redds were only counted in the TZ so that more frequent counts could be made. All redds counted during early October were classified as active because newly excavated gravels exhibited little periphyton growth. Inactive redds were noticeably darker two weeks after being dug. Thus, during subsequent counts, previously identified redds were classified as active only if additional cleaned gravel was evident. Numbers of redds in the TZ during 1997-98 are shown in Table 2. During 1997 redds were not counted in the downstream 700 m of the TZ due to access restrictions by private landowners. However, in 1998 we obtained permission to conduct counts in this reach. Thus, 1997 and 1998 total counts were not directly comparable. The number of active redds counted in the upper 2500 m of the TZ were identical between 1997 and 1998. Redd counts conducted in 1998 indicated that 45 percent of active redds counted between 14-October and 12-November were located in the downstream 700 m of the TZ. Redds were not counted during the firearm deer season (November 15-30).

Most brown trout spawning in the TZ apparently occurs by November. The majority of brown trout spawned during the last half of October. Although some redds were classified as active during November counts, We speculate that they appear active because periphyton has not grown enough to darken the gravel of redds dug in late October (Table 2). Few brown trout were observed on redds after October. Few active redds were identified in any year during the month of December. During December most redds marked during previous counts were largely obscured by periphyton growth or sediment.

Physical characteristics of habitat used for brown trout redds (such as water velocity, depth, and substrate type) were collected and summarized. These data were compared to spawning habitat used by steelhead under Job 9.

**Job 6. Title: Collect population and biological data.**

**Findings:** We have made mark-and-recapture estimates of brook and brown trout populations each fall from 1995-99 in a 3.4 km treatment zone on Hunt Creek, a 0.7 km reference zone on Hunt Creek, and a 2.3 km reference zone on Gilchrist Creek. Total lengths of all trout collected on the marking run were recorded. Data were segregated for each 100-m section within each zone. Scale samples were collected from subsamples of trout > 9.9 cm long to determine their ages. We weighed all individual fish that were scale sampled to determine length–weight relationships for each zone. When sufficient numbers of fish were captured, we weighed and measured (but did not collect scales from) 60 trout ≤ 9.9 cm per zone for each species. Past scale reading indicated that all trout of this size were age-0.

Steelhead YOY were 2.6 times more abundant than brown trout YOY in the TZ when populations were estimated in early September 1998 (Table 3). YOY brown trout in the TZ were only 75% as abundant in 1998 as in 1997. However, the numbers of YOY brown trout in the Gilchrist Creek RZ were only 55% as abundant in 1998 compared to 1997 (Table 4). Brown trout YOY abundance in both the TZ and RZ were significantly lower in 1998 than during the pre-steelhead stocking period of 1995-97 ($P < 0.05$). Reduced reproductive success by brown trout in both streams was probably due to the flood flows that occurred during late March and early April 1998. The relatively greater impact of the flood on Gilchrist Creek brown trout YOY may be related to the greater severity of the flood peak during the same storm. Baseflow discharge of Gilchrist Creek is about 10 cubic feet per second (cfs) higher than in Hunt Creek. However, during the spring 1998 flood, discharge was about 100 cfs higher in Gilchrist Creek. Because both streams are very similar in width this disparity in discharge likely resulted in relatively higher water velocities in Gilchrist Creek during the time when YOY brown trout were probably emerging from redds.

YOY steelhead in Hunt Creek averaged 73 mm total length in early September 1998. By contrast, brown trout YOY averaged 92 mm in the TZ and 85 mm in the RZ (Table 5). Mean length of YOY brown trout was larger during 1998 in both zones compared to 1995-97. The larger size of YOY in 1998 was probably due to earlier emergence and warmer water temperatures during the growing season (Table 1). YOY were approximately 5mm longer in both zones during 1998 than in 1997. However, there were no significant differences in mean length at age of brown trout either between years within a stream or between streams ($P < 0.05$).

**Job 7. Title: Test fish for BKD**

**Findings:** Sixty brown trout were collected from Hunt Creek each summer during July 1996-99 and from Gilchrist Creek during 1990, 1994, and 1999. Trout were screened for the presence of *Renibacterium salmoninarum*, *Yersinia ruckeri*, and *Aeromonas salmonica.* Trout heads were examined for the presence of the parasite *Myxosoma cerebralis.* Virological tests were performed to detect the presence of the hemorrhagic septicemia virus, the infectious pancreatic necrosis virus, and the *Oncorhynchus masou* virus. None of these diseases or parasites has been detected in any of the brown trout collected from either Hunt or Gilchrist Creeks.

**Job 8. Title: Monitor stocking of adult steelhead**

**Findings:** On 1-April 1998, and 29-March 1999, 160 adult steelhead were stocked at the downstream end of the Hunt Creek TZ. Eighty steelhead of each sex were stocked each year.

The average length (69 cm) and weight (3.2 kg) of male and female steelhead were virtually identical both years. Males and females were of similar size. Immediately prior to stocking 34% of females were judged ripe in 1998 versus 25% in 1999. At stocking in 1998, 38% of males appeared ripe compared with 34% in 1999.

Steelhead redds in the TZ were counted twice weekly beginning 2 d after stocking and continuing until approximately 24 April during both years. Steelhead began spawning within a day after being stocked. A majority of spawning appeared to occur within a week after stocking during both years. Few steelhead were observed on redds two weeks post-stocking.

**Job 9. Title: Characterize steelhead redds**

**Findings:** We measured water depth at the front of both brown and steelhead trout redd tail spills (Grost et al. 1991), and water velocity at 0.6 of water column depth at the same point. In addition, we characterized the dominant particle size and percentage of sand imbedded in redd gravel used by both species.

Steelhead spawned in significantly shallower and faster water than brown trout (Independent samples T-test, $P < 0.05$). However, the range of water depths and velocities used by both species overlapped considerably (Table 6). The frequency distribution of brown trout redds among 100-m stations within the TZ was similar to that of steelhead. For example, on 20-October 1998 49% of active brown trout redds were located in the downstream 700 meters of the TZ while 59% of active steelhead redds counted on 2-April 1999 were located in the same stream reach.

Steelhead spawned over larger and less sand-imbedded gravel. Ninety eight percent of steelhead redds were located where the predominant substrate was gravel greater than 25 mm in diameter and less than 25% imbedded with sand. Two thirds of brown trout redds were in gravel of this size while one third were in smaller gravel ranging from 6-24 mm in diameter. Brown trout redds were more frequently more imbedded with sand than steelhead. Fifty five percent of brown trout redds were in gravel less than 25% imbedded with sand but 39% of redds were 26-50% imbedded. Six percent of brown trout redds were more than 50% imbedded.

Similarities between brown trout and steelhead redd microhabitat (depths and velocities) and mesohabitat (stream sections used most often for spawning) indicate that super-imposition of steelhead redds upon developing brown trout alevins may occur. However, the level of superimposition of steelhead redds upon brown trout redds appears low in Hunt Creek, possibly because gravel substrate is abundant. During spring 1998 steelhead superimposed redds upon only 2 of 31 brown trout redds marked in fall 1997.

The potential for superimposition of steelhead redds upon developing brown trout alevins varies between years due to differences in winter incubation temperatures. We used temperature data collected from Hunt Creek and models developed by Crisp (1981, 1988) to make projections of median hatch and emergence dates for brown trout eggs deposited during mid-October. The predicted date of brown trout alevin emergence ranged from 27-March 1999 following a warm winter, to 30-April 1996 following a severe winter. Thus, differences in winter severity or differences in incubation temperature between streams would influence the probability of brown trout alevins being present in redds during the period when most steelhead spawning takes place.

**Job 10: Title: Analyze data and write progress report**

**Findings:** This progress report was prepared.

**Literature Cited:**

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De Staso III, J. and F.J. Rahel. 1994. Influence of water temperature on interactions between juvenile Colorado River cutthroat trout and brook trout in a laboratory stream. Transactions of the American Fisheries Society 123:289-297.

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**Date:** September 30, 1999

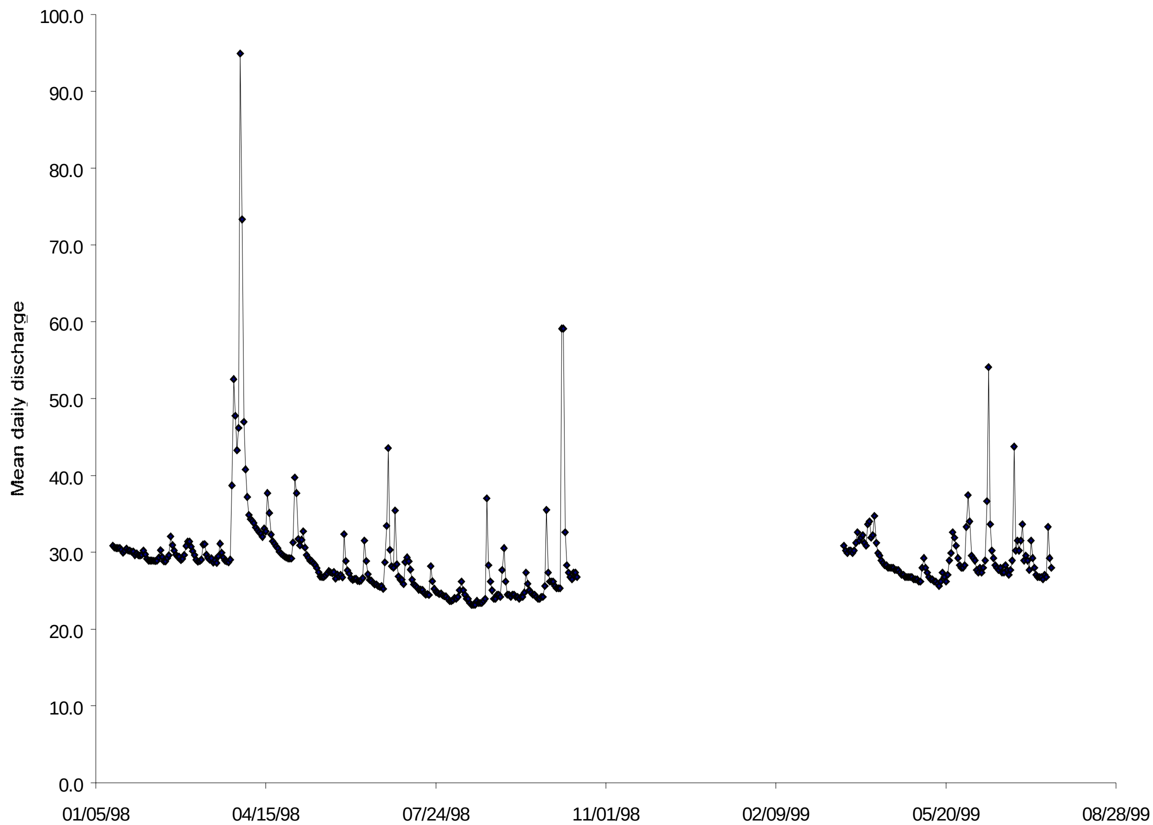


Figure 1.–Mean daily discharge (cubic feet per second) of Hunt Creek upstream of the reference zone from 15-Jan 98 to 7-July 99.

Table 1.–Monthly mean water temperatures ($^{o}$C) in Hunt and Gilchrist Creeks from 1996-98.

**Hunt Creek**

| Month | Year | | |
|---|---|---|---|
| | 1996 | 1997 | 1998 |
| January | 1.1 | 1.4 | 2.2 |
| February | 1.6 | 2.0 | 3.4 |
| March | 2.8 | 3.5 | 3.3 |
| April | 5.1 | 5.5 | 7.9 |
| May | 10.0 | 8.7 | 12.9 |
| June | 13.8 | 14.7 | 14.0 |
| July | 14.8 | 15.3 | 16.0 |
| August | 14.8 | 13.7 | 15.1 |
| September | 12.3 | 12.1 | 13.1 |
| October | 8.7 | 8.1 | 9.4 |
| November | 4.0 | 4.4 | 5.9 |
| December | 2.8 | 3.2 | 3.8 |

**Gilchrist Creek**

| Month | Year | | |
|---|---|---|---|
| | 1996 | 1997 | 1998 |
| January | 1.1 | 1.8 | 2.7 |
| February | 1.6 | 2.4 | 3.7 |
| March | 2.8 | 3.3 | 3.6 |
| April | 5.1 | 5.5 | 7.9 |
| May | 10.1 | 8.8 | 13.2 |
| June | 14.1 | 14.8 | 14.5 |
| July | 15.1 | 15.7 | 16.0 |
| August | 15.3 | 14.2 | 15.6 |
| September | 12.9 | 12.6 | 13.5 |
| October | 9.0 | 8.5 | 9.6 |
| November | 4.5 | 4.8 | 5.9 |
| December | 3.1 | 3.7 | 3.9 |

Table 2.–Numbers of brown trout redds counted in the Hunt Creek treatment zone during 1997-98. In 1997 redds were counted in a 2500-m stream reach and in 1998 redds were counted in a 3200-m reach.

| Date | Total Redds | Number of Active Redds |
|---|---|---|
| October 6, 1997 | 7 | 7 |
| October 15, 1997 | 29 | 27 |
| October 23, 1997 | 43 | 33 |
| October 29, 1997 | 44 | 17 |
| November 6, 1997 | 30 | 19 |
| November 11, 1997 | 55 | 18 |
| December 2, 1997 | 57 | 4 |
| December 11, 1997 | 28 | 2 |
| October 14, 1998 | 61 | 61 |
| October 20, 1998 | 79 | 79 |
| October 27, 1998 | 134 | 54 |
| November 3, 1998 | 66 | 37 |
| November 12, 1998 | 19 | 5 |
| December 1, 1998 | 7 | 0 |

Table 3.–Fall numbers of brown, brook, and rainbow trout (per hectare, by age) in a 3.2 km section of Hunt Creek MI where adult steelhead were stocked on 1-April 1998.

**Brown trout**

| | Age | | | | | |
|---|---|---|---|---|---|---|
| Year | 0 | 1 | 2 | 3 | 4 | 5+ |
| 1995 | 1616 | 509 | 199 | 129 | 20 | 10 |
| 1996 | 995 | 445 | 162 | 72 | 16 | 6 |
| 1997 | 1279 | 430 | 145 | 62 | 15 | 2 |
| 1998 | 959 | 510 | 127 | 94 | 17 | 3 |

**Rainbow trout**

| | Age | | | | | |
|---|---|---|---|---|---|---|
| Year | 0 | 1 | 2 | 3 | 4 | 5+ |
| 1998 | 2519 | 0 | 0 | 0 | 0 | 0 |

**Brook trout**

| | Age | | | | | |
|---|---|---|---|---|---|---|
| Year | 0 | 1 | 2 | 3 | 4 | 5+ |
| 1995 | 22 | 8 | 0.7 | 0.5 | 0 | 0 |
| 1996 | 12 | 31 | 2 | 0 | 0 | 0 |
| 1997 | 62 | 39 | 2 | 0.5 | 0 | 0 |
| 1998 | 23 | 28 | 5 | 0 | 0 | 0 |

Table 4.–Fall number of brown and brook trout per hectare by age in a 2.3 km section of Gilchrist Creek MI used as a reference zone.

**Brown trout**

| | Age | | | | | |
|---|---|---|---|---|---|---|
| Year | 0 | 1 | 2 | 3 | 4 | 5+ |
| 1995 | 2173 | 731 | 278 | 113 | 12 | 1 |
| 1996 | 1867 | 403 | 173 | 57 | 16 | 4 |
| 1997 | 1887 | 537 | 129 | 43 | 15 | 4 |
| 1998 | 1032 | 694 | 133 | 62 | 23 | 8 |

**Brook trout**

| | Age | | | | | |
|---|---|---|---|---|---|---|
| Year | 0 | 1 | 2 | 3 | 4 | 5+ |
| 1995 | 14 | 27 | 6 | 0 | 0 | 0 |
| 1996 | 21 | 30 | 5 | 0.5 | 0 | 0 |
| 1997 | 30 | 22 | 6 | 0 | 0 | 0 |
| 1998 | 23 | 12 | 8 | 0 | 0 | 0 |

Table 5.–Mean length at age (mm) of brown trout in Hunt and Gilchrist Creeks during 1995-98.

**Hunt Creek**

| | Age | | | | |
|---|---|---|---|---|---|
| Year | 0 | 1 | 2 | 3 | 4 |
| 1995 | 90 | 163 | 210 | 265 | 361 |
| 1996 | 90 | 164 | 212 | 270 | 334 |
| 1997 | 88 | 171 | 229 | 270 | 372 |
| 1998 | 92 | 173 | 224 | 271 | 323 |

**Gilchrist Creek**

| | Age | | | | |
|---|---|---|---|---|---|
| Year | 0 | 1 | 2 | 3 | 4 |
| 1995 | 81 | 153 | 198 | 263 | 338 |
| 1996 | 78 | 148 | 197 | 266 | 329 |
| 1997 | 80 | 150 | 214 | 272 | 334 |
| 1998 | 85 | 148 | 213 | 264 | 323 |

Table 6.–Total water depths (cm) at the upstream end of redd tail spills and water velocity (cm/s) at 0.6 of depth at the same point for redd sites used by brown trout and steelhead in Hunt Creek, Michigan.

| | Species | |
|---|---|---|
| Habitat Variable | Brown Trout | Steelhead |
| Mean water depth | 30.8 | 26.4 |
| 95% Confidence Interval for mean depth | 29.1-32.5 | 24.9-27.9 |
| Range of water depths used | 13.0-70.0 | 13.7-54.9 |
| Mean water velocity | 67.7 | 75.8 |
| 95% Confidence Interval for mean velocity | 62.2-73.1 | 71.8-79.8 |
| Range of water velocities used | 26.2-99.4 | 32.3-120.1 |