STUDY PERFORMANCE REPORT

State: Michigan

Project No.: F-80-R-1

Study No.: 654

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

Period Covered: October 1, 1999 to September 30, 2000

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 (1998-02) adult steelhead were stocked into the TZ. In addition, annual resident trout populations are being estimated in reference zones (RZ) without steelhead. We have made six 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 were stocked in the TZ each spring from 1998-00. Brook and brown trout abundance, growth, and survival in the TZ are being compared between the pre- and post-steelhead-stocking periods. Resident trout population dynamics in reference zones are being monitored to help distinguish between possible effects of interspecies interactions and environmental factors.

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 winters of 1998-99 and 1999-00 decreased the period between brown trout egg deposition to fry emergence such that it was less likely that steelhead spawning in 1999 or 2000 would have superimposed their redds upon partially developed brown trout alevins.

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 occurred. The majority of brown trout spawning occurred during the last half of October and most steelhead spawned 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.

Steelhead have superimposed their redds upon 7% of redd sites used by brown trout the previous fall.

Steelhead stocked in 1998 and 1999 produced 2,541 and 2,241 YOY per hectare, respectively, in the TZ by September. Population estimates for 2000 have not yet been computed. Brown trout YOY abundance in both the TZ and RZ was significantly lower in 1998-99 than during the pre-steelhead stocking period of 1995-97.

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 downstream boundaries of the Gilchrist Creek reference zone and the Hunt Creek treatment zone are shown in Table 1.

Water temperature can affect 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 each year. The relationship between discharge at the stage-height-recorder site and other sites on Hunt and Gilchrist creeks was determined. Thus, discharge in all stream reaches where trout populations are estimated can be reliably predicted from stream stage height data collected at one site.

An exceptionally high spring discharge of 95 cfs occurred on 31-March 1998 and may have reduced brown trout reproductive success. Spring discharge peaks during 1999-00 have not exceeded 40 cfs. 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.

Job 5. Title: Locate and mark locations of trout redds and measure redd characteristics.

Findings: We counted brown trout redds in both the treatment and reference zones during the 1995 and 1996 spawning periods. During 1997-99 only redds in the TZ were counted 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. Redd numbers in the TZ during 1997-99 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 and 1999 we obtained permission to conduct counts in this reach. Thus, 1997 total redd counts can not be directly compared with counts in subsequent years. Redds were not counted during the firearm deer season (November 15-30).

Most brown trout spawning in the TZ apparently occurs by November. We have consistently observed the largest number of active redds during counts made during the last 10 days of 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.

Habitat characteristics near brown trout redds such as water velocity, depth, and substrate type were collected and summarized for about 30 redds each year. 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 1995-2000 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. Populations of juvenile steelhead have been estimated during 1998-2000. 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.

September abundance of steelhead YOY was approximately 2.4 times higher than brown trout abundance in the TZ in both 1998 and 1999 (Table 3). Brown trout YOY abundance in both the TZ and RZ was significantly lower in 1998-99 than during the pre-steelhead stocking period of 1995-97 (ANOVA $P < 0.05$). Abundance of YOY brown trout in Hunt Creek averaged 997/ha in 1998-99, after steelhead were stocked, compared to 1289/ha during 1995-97. YOY brown trout in the Gilchrist Creek RZ averaged 1361/ha during 1998-99 compared to 1976/ha in 1995-97 (Table 4). Reduced reproductive success by brown trout in both streams during 1998 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.

Age-1 brown trout were significantly less abundant in 1999 than in 1995-97. Their lower abundance was partially attributable to the lower abundance of the 1998-year class but survival of the 1998-year class was also significantly lower than average survival of YOY from 1995-97. By contrast, survival of the 1998-year class of brown trout in the Gilchrist Creek RZ was significantly higher than average survival of YOY from 1995-97. Survival of yearling-and-older brown trout did not change significantly in either the TZ or the RZ.

Brown trout YOY and yearlings were larger than juvenile steelhead of the same age. YOY steelhead in Hunt Creek averaged 73-mm total length in both 1998 and 1999. Yearling steelhead averaged 149 mm in 1999. By contrast, brown trout YOY averaged 85 mm in the TZ and 86 mm in the RZ in September 1999 (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: <u>Test fish for BKD and other diseases</u>

Findings: Sixty brown trout were collected from Hunt Creek each summer during 1996-00 and from Gilchrist Creek during 1990, 1994, and 1999. In 1999, we also collected juvenile steelhead from the Hunt Creek TZ for whirling disease testing. Brown trout were screened for the presence of *Renibacterium salmoninarum*, *Yersinia ruckeri*, and *Aeromonas salmonica.* Five-fish pools of trout heads were examined for the presence of spores 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 have been detected in any of the brown trout collected from Gilchrist Creek. No viral diseases or pathogenic bacterial diseases have been detected in brown trout from Hunt Creek. However, in 1998, one potential *M. cerebralis* spore was seen in one five-fish pool of brown trout from Hunt Creek. Histological confirmation was not possible so the spore could not be positively identified. In 2000, a M. *cerebralis* spore was observed in one five-fish pool of brown trout and three spores were observed in a second pool. The State of Michigan fish pathologist gave the Hunt Creek population a whirling disease positive classification based on this second observation.

Job 8. Title: <u>Monitor stocking of adult steelhead</u>

Findings: On 1-April 1998, 29-March 1999, and 21-March 2000, 160 adult steelhead were stocked at the downstream end of the Hunt Creek TZ. Eighty steelhead of each sex were stocked each year. Steelhead stocked in 2000 were larger than in prior years and a higher percentage of both sexes were ripe at planting. Size at planting and percent ripeness is summarized in table 6.

Steelhead redds in the TZ were counted twice weekly beginning 2 d after stocking in 1998-99 and once a week in 2000. Steelhead began spawning within a day after being stocked in all years. A majority of spawning appeared to occur within a week after stocking during all years. Few steelhead were observed on redds two weeks after 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-embeddednes of redd gravel used by both species.

Steelhead spawned in significantly shallower and faster water than brown trout (ANOVA $P < 0.05$). However, the range of water depths and velocities used by both species overlapped considerably (Table 7). The frequency distribution of brown trout redds among 100-m stations within the TZ was similar to that of steelhead.

On average, steelhead spawned over larger gravel than brown trout. Nearly 84 percent of steelhead redds were sites where the predominant substrate was gravel larger than 25 mm in diameter. Brown trout redds were in gravel of this size 60 percent of the time. Steelhead and brown trout spawned over smaller gravel, ranging from 6-24 mm in diameter, 16 percent and 39 percent of the time, respectively.

Brown trout redds were more frequently embedded with sand than steelhead redds. All steelhead redds were less than 25 percent embedded with sand compared to 53 percent of brown trout redds. Thirty nine percent of brown trout redds were 26-50 percent embedded. Six percent of brown trout redds were more than 50 percent embedded.

Steelhead superimposed their redds upon brown trout redds dug the previous fall approximately 7 percent of the time. In spring 2000, steelhead superimposed redds upon 3 of 40 brown trout redds marked during fall 1999. 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. I 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.

Job 11: Title: Estimate populations of resident trout and steelhead in additional streams

Findings: During July and August 2000 we made mark-and-recapture estimates of resident trout species, steelhead, and other potamodromous species in four additional streams. Streams sampled were the Baldwin River, Houghton Creek, Little South Branch of the Pere Marquette River, and the Platte River. These data are not yet analyzed.

Literature Cited:

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Table 1.–Monthly mean water temperatures (°C) in Hunt and Gilchrist Creeks near County Road 612 from 1996-99.

Month	Year			
	1996	1997	1998	1999
Hunt Creek				
January	0.9	1.0	1.9	1.6
February	1.4	1.7	3.2	2.6
March	2.6	3.0	3.1	3.8
April	4.9	5.5	7.9	8.1
May	9.9	8.6	13.2	12.5
June	13.9	14.9	14.2	15.5
July	14.9	15.5	16.2	16.7
August	15.0	13.8	15.3	14.7
September	12.3	12.2	13.2	12.3
October	8.7	7.8	9.4	8.3
November	3.8	4.3	5.9	6.1
December	2.5	3.0	3.7	3.1
Gilchrist Creek				
January	1.2	1.5	2.5	1.5
February	1.7	2.1	3.5	2.5
March	2.8	3.1	3.4	3.6
April	5.2	5.5	8.2	8.0
May	10.4	9.1	13.9	12.7
June	14.7	15.6	14.8	16.1
July	15.7	16.4	16.4	17.5
August	15.9	14.7	15.9	15.4
September	13.2	13.0	13.7	12.9
October	9.1	8.9	9.6	8.5
November	4.3	4.7	5.8	6.0
December	2.9	3.6	3.7	2.9

Table 2.–Numbers of brown trout redds counted in the Hunt Creek treatment zone during 1997-99. In 1997 redds were counted in a 2500-m stream reach and in 1998-99 redds were counted in a 3400-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
October 4, 1999	4	4
October 12, 1999	17	17
October 26, 1999	110	95
November 4, 1999	177	89
November 11, 1999	185	22
December 2, 1999	120	5

Table 3.–Fall numbers of brown, brook, and rainbow trout per hectare, by age, in 3.4 km of Hunt Creek MI where adult steelhead were stocked in 1998-99.

	Age					
Year	0	1	2	3	4	5+
			Brown trout			
1995	1616	509	199	130	20	10
1996	970	428	161	74	15	6
1997	1283	414	145	64	15	2
1998	1048	490	120	92	18	3
1999	947	297	163	70	26	1
			Rainbow trout			
1998	2541	0	0	0	0	0
1999	2241	340	0	0	0	0
			Brook trout			
1995	22	8	0.7	0.5	0	0
1996	80	49	5	0	0	0
1997	102	51	6	0.4	0	0
1998	67	35	8	0	0	0
1999	41	10	2	1	0	0

Table 4.–Fall numbers of brown and brook trout per hectare, by age, in a 2.3 km section of Gilchrist Creek MI used as a reference zone, 1995-99.

	Age					
Year	0	1	2	3	4	5+
			Brown trout			
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
1999	1689	435	199	80	7	3
			Brook trout			
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
1999	17	33	0	0	0	0

Table 5.–Mean length at age (mm) of brown trout in Hunt and Gilchrist Creeks during September 1995-99.

	Age				
Year	0	1	2	3	4
Hunt Creek					
1995	90	163	210	265	361
1996	90	164	212	270	334
1997	88	171	229	270	372
1998	92	173	224	271	323
1999	85	174	230	279	336
Gilchrist Creek					
1995	81	153	198	263	338
1996	78	148	197	266	329
1997	80	150	214	272	334
1998	85	148	213	264	323
1999	86	166	217	276	355

Table 6.–Mean total length (mm), weight (kg), and ripeness of adult steelhead stocked in Hunt Creek during 1998-2000.

	Year		
Parameter	1998	1999	2000
Mean total length of males	701	686	788
Mean total length of females	694	688	732
Mean weight of males	3.2	3.2	4.7
Mean weight of females	3.2	3.3	3.9
Percent ripe males	38	34	60
Percent ripe females	34	25	36

Table 7.–Mean water depths (cm) at the upstream end of redd tail spills and mean 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	28.4	25.0
Range of water depths used	12.5-70.0	8.8-54.9
Mean water velocity	67.3	72.7
Range of water velocities used	24.4-99.4	30.5-120.1