STUDY PERFORMANCE REPORT

State: Michigan

Project No.: F-80-R-7

Study No.: 230654

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

Period Covered: October 1, 2005 to September 30, 2006

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 *Salmo trutta* in Hunt Creek were evaluated by comparing population dynamics of resident trout in a 3.4 km treatment zone (TZ) before (1995-97) and after (1998-05) adult steelhead *Oncorhynchus mykiss* were stocked into the TZ. Adult steelhead trout were stocked each spring from 1998 through 2003. Resident brown and brook trout *Salvelinus fontinalis* populations were also estimated in reference zones (RZ's) without steelhead. Brown and brook trout abundance, growth, and survival in the TZ were compared between the pre- and post-steelhead stocking periods. Ratios of abundance and survival of resident trout populations in treatment and reference zones were compared between pre- and post-steelhead stocking periods to help distinguish between possible effects of interspecies interactions and environmental factors.

Density of yearling-and-older brown trout in the Hunt Creek TZ has declined by about half compared to pre-steelhead levels. This occurred primarily because mean annual survival of young-of-the-year (YOY) brown trout declined from 37% to 23%. Similar temporal changes in survival and density of brown trout were not observed in the Gilchrist Creek RZ. Reduced survival of brown trout YOY probably occurred because mean fall density of YOY trout (brown trout and steelhead combined) was over three times higher than the pre-steelhead abundance of brown trout YOY. Density of yearling brown trout in 2005 was similar to their density before steelhead introductions, presumably because juvenile steelhead of the same age were not present. Mean fall abundance of YOY brown trout in the TZ has not changed significantly, relative to the Gilchrist Creek RZ, indicating that steelhead did not impair brown trout reproductive success. Few significant changes in growth rates of brown trout were detected following steelhead introductions. *Myxobolus cerebralis* spores were detected in both steelhead and brown trout during most years after steelhead were stocked. However, spore densities were low and no negative effects of whirling disease on either species have been detected. *Renibacterium salmoninarum,* the causative agent of bacterial kidney disease (BKD), was first detected in trout from Hunt Creek in 2003 when 12% of brown trout and 5% of steelhead were infected. Infection rates have increased in subsequent samples of brown trout and steelhead from Hunt Creek. In Gilchrist Creek, *R. salmoninarum* was present in a substantial percentage of brown trout, mottled sculpin *Cottus bairdi,* and blacknose dace *Rhinichthys atratulus* collected in 2005. Whirling disease spores were also detected in the brown trout examined in 2005. No clinical signs of whirling disease have been detected in brown trout in either stream. The effects of infections by *R. salmoninarum* on the trout populations are not known although some fish had high levels of infection and exhibited clinical signs of BKD.

Findings: Jobs 2, 3, 6, 7, and 10 were scheduled for 2005-06, and progress is reported below.

Job 2. Title: Monitor water temperature in treatment and reference zones.–I recorded water temperatures hourly using electronic thermometers at five sites. One thermometer was located near the upstream boundary of the Hunt Creek RZ, and the other four thermometers were located near the upstream and downstream boundaries of the Hunt Creek TZ and the Gilchrist Creek RZ. Temperature data were archived and will be used in a variety of analyses such as growth rate variation among years and to predict median hatch and swim-up dates.

Job 3. Title: Monitor water stage and discharge.–Stochastic events such as floods can differentially affect recruitment of species with different life histories (Strange et al. 1992). Flow conditions during incubation and at the time of fry emergence have been negatively correlated with year class strength and density of older age classes of stream dwelling brown trout (Strange et al. 1992; Nuhfer et al. 1994; Jensen and Johnsen 1999; Spina 2001; Cattanéo et al. 2002; Labón-Cerviá 2004). Stream discharge in Hunt Creek has been monitored hourly throughout the year with a stage height recorder located 2 km upstream of the TZ from January 1998 to the present time.

Spring discharge during the primary brown trout emergence period was relatively low in 2005, similar to the previous 3 years. The relatively low variability in abundance of age-0 brown trout in Hunt Creek over the course of the study coupled with the timing and magnitude of spring runoff flows suggests that high flows had little adverse effect on their reproductive success (Table 1).

Job 6. Title: Collect population and biological data.–We made mark-and-recapture estimates of brown and brook trout populations during late summer in 2006 in a 3.4 km treatment zone on Hunt Creek and a 2.3 km reference zone on Gilchrist Creek. Similar population estimates have been made annually beginning in 1995. Populations of juvenile steelhead were also estimated during years they were present (1998-05). Estimates were computed using the Chapman variation of the Petersen formulas (Ricker 1975). I stratified population estimates by 25-mm length groups. Age data from trout scales were used to apportion population estimates by length groups into estimates by age group. Abundance data were adjusted for wetted-stream-surface area and presented as numbers per hectare.

Scales collected in 2006 have not been aged, to date. Hence, data analyses reported for this segment do not include comparisons of density, survival, or growth for years more recent than 2005. I compared abundance between groups of years using one-way ANOVA analyses. Differences between means were judged to be significant for $P \leq 0.05$.

Yearling-and-older (YAO) brown trout year classes that interacted with YOY steelhead in Hunt Creek during the year they hatched were consistently less abundant than year classes produced before steelhead introductions (Table 1). Mean density of year classes of YAO brown trout that did not compete with steelhead trout as YOY was approximately twice as high as that of the other year classes. Mean density of YOY brown trout in Hunt Creek was not different between periods. Mean brown trout abundance in the Gilchrist Creek RZ was similar for all age groups during the same years (Table 2). Yearling-and-older brook trout abundance also declined significantly in Hunt Creek after steelhead reproduced (Table 1), but a similar decline also occurred in the Gilchrist Creek where steelhead were not present (Table 2).

The presence of juvenile steelhead in Hunt Creek, particularly YOY steelhead, was clearly associated with reduced abundance of YAO brown trout. Abundance of YOY brown trout in Hunt Creek compared to Gilchrist Creek did not change significantly during this study. However, YAO brown trout in Hunt Creek were only half as abundant after steelhead introductions, as compared to those in Gilchrist Creek.

The primary cause of reduced abundance of older brown trout that interacted with steelhead trout as YOY was a reduction in mean survival of brown trout YOY from 37% to 23% (Table 3). This change represents a 38% decline in survival rates for YOY. Mean survival rates of older brown trout in Hunt Creek have not changed, but survival of yearling brown trout in the Gilchrist Creek RZ increased from 27% to 36% (Table 3).

Growth of brown trout was generally not different between periods when sympatric age groups of steelhead and brown trout were either present or absent. Mean length-at-age for both YOY and yearling brown trout in Hunt Creek were virtually identical regardless of whether or not they interacted with steelhead trout of the same age (Table 4). Age-2 brown trout were significantly larger during years when steelhead trout of the same age were present. No significant differences in growth of brown trout were detected in Gilchrist Creek during the same time periods (Table 4).

Job 7. Title: Test fish for BKD and other diseases.−Brown trout were collected from Hunt Creek and examined for diseases and parasites each summer during 1996-05 and from Gilchrist Creek in 1990, 1994, 1999, 2005, and 2006. Juvenile steelhead trout were also collected from Hunt Creek from 1998 through 2005. Trout were screened for the presence of an array of bacterial and viral pathogens as well as for the presence of *Myxobolus cerebralis* spores.

In Hunt Creek, *Renibacterium salmoninarum,* the causative agent of bacterial kidney disease (BKD), was not detected in any trout from Hunt Creek prior to 2003 when 12% of brown trout and 5% of steelhead were infected. Detection of BKD in 2003 and thereafter most likely occurred because more sensitive detection methods were used compared to previous health screenings. The percentage of fish infected with the BKD organism in 2003 was less than the average for Michigan waters and was not at a level to cause concern (M. Faisal, Michigan State University Department of Pathobiology and Diagnostic Investigation, personal communication). However, in 2004 the incidence of brown trout infected with *R. salmoninarum* increased to nearly 90% and over 25% of steelhead trout were infected. Some fish had high levels of infection and one exhibited the typical granulomatous lesions of BKD. Results from tests conducted on fish collected from Hunt Creek in 2005 are presently unavailable. In Gilchrist Creek, *R. salmoninarum* was not detected prior to 2005 when 63% of brown trout examined were infected. Mottled sculpin and blacknose dace collected from Gilchrist Creek at the same site were infected at rates of 38% and 29%, respectively.

M. cerebralis spores were first detected in brown trout collected from Hunt Creek in 1998 and were also present in samples collected each year from 2000 to 2004. The spores were first detected in steelhead collected in 1999, and in each year from 2000 through 2004. The disease-screening laboratory has not, to date, reported results from fish collected and examined in 2005. With one exception, no clinical signs of whirling disease have been observed in steelhead. Consistently high abundance of juvenile steelhead during years when adult steelhead spawned in Hunt Creek suggests that whirling disease did not cause any significant mortality (Table 1). *M. cerebralis* spores were detected for the first time in Gilchrist Creek in 2005, when 23% of brown trout examined were infected. No clinical signs of whirling disease have been observed in brown trout from either stream.

Job 10: Title: Analyze data and write progress report.−Data were analyzed and this progress report was prepared.

Literature Cited:

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Prepared by: Andrew J. Nuhfer
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Table 1.–August-September numbers of brown, steelhead, and brook trout per hectare, by age, in a 3.4-km treatment zone of Hunt Creek, MI where adult steelhead spawned each spring from 1998 through 2003. Brown and brook trout year classes that did not interact as YOY with YOY steelhead are shaded. Mean abundance of shaded year class groups was compared to un-shaded year class groups.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
Brown trout					
1995	1,618	511	199	133	21
1996	973	429	165	71	17
1997	1,286	416	147	66	16
1998	1,050	492	121	94	19
1999	950	299	164	71	28
2000	939	168	100	69	25
2001	1,023	178	65	50	20
2002	906	212	94	36	19
2003	1,011	158	76	37	11
2004	1,062	339	86	54	7
2005	1,023	451	118	42	9
Means [1]	1,192	460 [2]	159 [2]	84 [2]	21 [2]
	980	226 [2]	90 [2]	44 [2]	12 [2]
Steelhead trout					
1998	2,545	0	0	0	0
1999	2,243	343	0	0	0
2000	2,100	248	6	0	0
2001	2,343	360	3	0	0
2002	3,614	484	7	0	0
2003	4,487	381	47	0	0
2004	2	561	27	0	0
2005	0	0	99	0	0
Brook trout					
1995	24	10	1	1	0
1996	83	53	4	0	0
1997	106	53	8	0.4	0
1998	69	37	10	0	0
1999	54	11	2	2	0
2000	43	16	2	0	0
2001	22	9	2	0	0
2002	20	8	1	0	0
2003	19	9	1	0	0
2004	6	10	1	0	0
2005	29	21	1	0	0
Means [1]	50	35 [2]	5.0 [2]	0	0
	38	11 [2]	1.5 [2]	0	0

[1] Different year classes were compared for different age groups so that only year classes of brown and brook trout that interacted with steelhead as YOY were compared to other years.

[2] Differences in mean abundance between groups of years are significantly different (One-way ANOVA, $P \leq 0.05$)

Table 2.–August-September 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, 1995-05. Mean abundance of shaded year class groups was compared to un-shaded year class groups. There were no steelhead present in Gilchrist Creek.

	Age				
Year	0	1	2	3	4
Brown trout					
1995	2,179	733	280	116	14
1996	1,870	405	175	60	17
1997	1,891	540	131	45	17
1998	1,035	697	135	64	25
1999	1,694	437	201	83	8
2000	1,746	464	141	72	17
2001	2,275	615	185	86	17
2002	2,105	609	237	73	18
2003	2,497	497	218	88	9
2004	2,645	712	180	76	24
2005	3,925	823	250	116	14
Means [1]	2,502	640	184	73	17
	1,892	556	202	88	16
Brook trout					
1995	15	30	6	0	0
1996	23	32	5	0	0
1997	32	27	4	0	0
1998	26	17	6	0	0
1999	20	30	8	0	0
2000	2	11	2	0	0
2001	8	13	1	0	0
2002	11	6	2	0	0
2003	2	7	0	0	0
2004	1	10	2	0	0
2005	1	2	0	0	0
Means [1]	14	22	6 [2]	0	0
	12	13	1 [2]	0	0

[1] Different periods were used for different age groups so that abundance of the same year classes of brown and brook trout compared in Hunt Creek were also compared in Gilchrist Creek.

[2] Differences in mean abundance between groups of years are significantly different (One-way ANOVA, $P \leq 0.05$)

Table 3.–Annual percent survival of brown trout in Hunt and Gilchrist creeks, by age, from the year listed to the following year. Shading indicates that steelhead and brown trout of the same age interacted during that year in Hunt Creek. Mean survival between shaded and un-shaded groups of years was compared only for sympatric age groups. The same groups of years were compared in Hunt and Gilchrist creeks although no steelhead were present in Gilchrist Creek.

	Age			
Year	0	1	2	3
Hunt Creek Treatment Zone				
1995	27	32	35	13
1996	43	34	40	23
1997	38	29	64	29
1998	28	33	59	30
1999	18	33	42	35
2000	19	39	51	28
2001	21	53	56	38
2002	17	36	39	30
2003	34	54	71	20
2004	42	35	49	17
Means	23 [1]	42	53	
	37 [1]	32	48	
Gilchrist Creek Reference Zone				
1995	19	24	21	15
1996	29	32	26	29
1997	37	25	49	55
1998	42	29	62	13
1999	27	32	36	21
2000	35	40	61	24
2001	27	39	39	21
2002	24	36	37	13
2003	29	36	35	27
2004	31	35	64	19
Means	31	36 [1]	47	
	29	27 [1]	39	

[1] Differences in mean survival rates between groups of years were significantly different (One-way ANOVA $P \leq 0.05$).

Table 4.–Weighted mean total length at age (mm) of brown trout in Hunt and Gilchrist creeks during late summer. Fish were sampled during September from 1995 to 2001, and during August in 2002 to 2005. Shading indicates that steelhead and brown trout of the same age interacted during those years in Hunt Creek. Mean length for shaded and un-shaded groups of years were compared. The same groups of years were compared in Hunt and Gilchrist creeks although no steelhead were present in Gilchrist Creek.

	Age			
Year	0	1	2	3
Hunt Creek Treatment Zone				
1995	90	163	209	266
1996	90	164	214	270
1997	88	171	230	272
1998	91	173	224	273
1999	85	174	230	279
2000	91	168	230	274
2001	85	173	237	289
2002	83	170	234	298
2003	79	163	236	302
2004	81	162	242	303
2005	76	158	227	285
Means	86	168	234 [1]	
	85	166	221 [1]	
Gilchrist Creek Reference Zone				
1995	81	153	198	264
1996	78	148	197	267
1997	80	150	214	273
1998	85	148	213	264
1999	86	166	217	278
2000	85	159	224	269
2001	80	152	218	266
2002	78	152	223	288
2003	69	149	217	277
2004	73	153	221	272
2005	65	138	204	260
Means	81	155	218	
	76	147	208	

[1] Differences in mean length at age were significantly different between groups (One-way ANOVA $P \leq 0.05$).