STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-80-R-8

Study No.: 230654 **Title:** Evaluation of brown trout and steelhead competitive interactions in Hunt Creek, Michigan.

Period Covered: October 1, 2006 to September 30, 2007

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 (1998–2006) 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 trout and brook trout abundance, growth, and survival in the TZ were compared between cohorts that interacted with juvenile steelhead and those that did not.

Density of cohorts of yearling-and-older brown trout in Hunt Creek that interacted with steelhead as young-of-the-year (YOY) was about half that of allopatric cohorts. This occurred primarily because mean annual survival of (YOY) brown trout declined from 37% to 23% when YOY steelhead were present. 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. 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. Density of yearling brook trout cohorts that interacted with steelhead was lower than for allopatric cohorts. Few significant changes in growth rates of Hunt Creek brown trout or brook trout were detected following steelhead introductions.

Findings: Jobs 2, 3, 6, and 10 were scheduled for 2006-07, 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, Zorn and Nuhfer 2007). 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 and stable during 2007. With the exception of 1998, significant spring floods during the primary emergence period have not occurred. 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 trout, rainbow trout, and brook trout populations during late summer in 2007 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. 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 2007 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 2006. 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 all 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 (Table 1). Mean brown trout abundance in the Gilchrist Creek RZ was similar for all age groups during the same years (Table 2). Yearling brook trout abundance declined significantly in Hunt Creek after steelhead reproduced (Table 1). Yearling abundance in the Gilchrist Creek RZ also declined over the same period but the change was not statistically significant.

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 is a 38% decline in survival rates for YOY. Mean survival rates of older brown trout in Hunt Creek and Gilchrist Creek have not changed (Table 3).

Growth of YOY and yearling brown trout was not different between periods when sympatric age groups of steelhead and brown trout were either present or absent (Table 4). Cohorts of age-2 brown trout that were sympatric with steelhead trout were 12 mm larger than allopatric brown trout.

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

Literature Cited:

Cattanéo, F., N. Lamouroux, P. Breil, and H. Capra. 2002. The influence of hydrological and biotic processes on brown trout (Salmo trutta) population dynamics. Canadian Journal of Fisheries and Aquatic Sciences 59:12–22.

Jensen, A. J., and B. O. Johnsen. 1999. The functional relationship between peak spring floods and survival and growth of juvenile Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*). Functional Ecology 13:778–785.

Lobón-Cerviá, J. 2004. Discharge-dependent covariation patterns in the population dynamics of brown trout (*Salmo trutta*) within a Cantabrian river drainage. Canadian Journal of Fisheries and Aquatic Sciences 61:1929–1939.

Nuhfer, A.J., R. D. Clark, Jr., and G. R. Alexander. 1994. Recruitment of brown trout in the South Branch of the Au Sable River, Michigan in relation to stream flow and winter severity. Michigan Department of Natural Resources, Fisheries Research Report 2006, Ann Arbor.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada, Bulletin 191.

Spina, A. P. 2001. Incubation discharge and aspects of brown trout population dynamics. Transactions of the American Fisheries Society 130:322–327.

Strange, E. M., P. B. Moyle, and T. C. Foin. 1992. Interactions between stochastic and deterministic processes in stream fish community assembly. Environmental Biology of Fishes 36:1–15.

Zorn, T. G., and A. J. Nuhfer. 2007. Influences on brown trout and brook trout population dynamics in a Michigan River. Transactions of the American Fisheries Society 136:691–705.

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Table 1.–August–September numbers of brown trout, steelhead trout, 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 trout and brook trout year classes that did not interact as YOY with YOY steelhead trout are shaded. Mean abundance of shaded year class groups was compared to un-shaded year class groups.

	Age				
Year	0	1	2	3	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
2006	937	382	200	63	16
Means	1,150	447[a]	166[a]	84[a]	21[a]
	980	226[a]	90[a]	47[a]	12[a]
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
2006	3	0	2	20	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
2006	3	21	1	0	0
Means	42	32[a]	4	0.5	0
	38	11[a]	1.5	0	0

[a] 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 trout and brook trout per hectare, by age, in a 2.3 km section of Gilchrist Creek, MI used as a reference zone, 1995–2006. 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
2006	2,771	796	334	128	43
Means	2,547	666	209	73	17
	1,892	556	202	94	22
			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
2006	4	2	0	0	0
Means	11	18	4[a]	0	0
	12	13	1[a]	0	0

[a] 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
2005	37	44	53	37
Means	23[a]	42	53	28
	37[a]	35	48	27
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
2005	20	41	51	37
Means	31	36	48	23
	27	30	39	26

[a] 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 2006. 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.

Year	Age 0	Age 1	Age 2	Age 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
2006	82	163	225	287
Means	86	168	234[a]	
	84	165	222[a]	
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
2006	72	139	196	252
Means	81	155[a]	218[a]	
	75	146[a]	206[a]	

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