STUDY PERFORMANCE REPORT

State: Michigan

Project No.: F-80-R-3

Study No.: 654

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

Period Covered: October 1, 2001 to September 30, 2002

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. Resident trout populations are being estimated annually in reference zones (RZ's) without steelhead. We have made eight consecutive annual fall estimates of brook and brown trout populations in the TZ of Hunt Creek, and in RZ's located on Hunt and Gilchrist Creeks. Adult steelhead were stocked in the TZ each spring from 1998-02. Brook and brown trout abundance, growth, and survival in the TZ were compared between the pre- and post-steelhead-stocking periods. Ratios of abundance, survival, and growth 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.

Introductions of steelhead were associated with significantly lower mean annual survival of age-0 brown trout in the TZ, as compared to the Gilchrist Creek RZ. Reduced survival of year classes of YOY brown trout that interacted with steelhead has resulted in significantly lower abundance of age-1 and age-2 brown trout in the TZ, as compared to the same year classes in the Gilchrist Creek RZ. Both YOY and yearling brook trout in the TZ were less abundant after steelhead introductions than during the pretreatment period. Mean abundance of YOY brown trout in the TZ has not changed significantly, relative to the Gilchrist Creek RZ, since steelhead have been stocked. No significant changes in growth rates of brown trout were detected following steelhead introductions.

Findings: Jobs 2, 3, 5, 6, 7, 8, 9, 10, and 11 were active this year, 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.

I used water temperature data collected during the primary incubation period, 15-October through April, to estimate whether brown trout fry were likely to emerge before steelhead spawned the following spring. The number of days between brown trout egg deposition and hatch predicted from incubation time models (Crisp 1981, 1988) ranged from 69 d for the 2001- year-class up to 118 d for the 1996 year class (Figure 1). Predicted dates for median swim-up were as early as 25-March for the 2001-year class and as late as 30-April for the 1996-year class. This analysis suggests that some brown trout alevins were still in their redds when steelhead spawning took place during each spring from 1998-02. Thus, steelhead redds that are superimposed upon brown trout redds dug the previous fall could cause mortality of brown trout fry.

Job 3. Title: Monitor water stage and discharge.–Stream discharge is monitored 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 at a site located 2 km upstream of the TZ.

An exceptionally high spring discharge of 95 cfs occurred on 31-March 1998 (Figure 2). This flood did not appear to impair brown trout reproductive success in Hunt Creek but fall YOY abundance in the Gilchrist Creek RZ was substantially lower than normal in 1998. Spring discharge peaks during 1999-00 did not exceed 40 cfs. The 2001 year class of brown trout was relatively strong in all zones in spite of a brief flood peak of 87 cfs on 12-April 2001. Mean daily discharge on that date was 70 cfs. Mean daily discharge during the steelhead incubation period (approximately 1-April to 15-June) has been generally quite low and stable (Figure 2).

Job 5. Title: Locate and mark locations of trout redds and measure redd characteristics.– Brown trout redds were again counted in the 3,400-m Hunt Creek TZ during the primary spawning period in fall 2001. Spawning activity has been consistently highest during the last half of October and actively spawning fish were frequently observed during late October redd counts. Figure 3 shows that highest numbers of active brown trout redds present near the end of October in 3 of 4 years from 1998 to 2001. Few brown trout were observed on redds after October in any year. Redds were not counted during Michigan's firearm deer season (November 15-30) to reduce conflicts with landowners along the creek. The number of active redds observed in all years during the first week of December ranged from 0 to 5 during 1998-01

Job 6. Title: Collect population and biological data.–We again made mark-and-recapture estimates of brook and brown trout populations during late summer (August or September) in 2002 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. Similar population estimates have been conducted each year since 1995. Populations of juvenile steelhead were also estimated during years they were present (i.e. 1998-02). Scales collected in 2002 have not yet been aged. Hence, data analyses reported for this segment do not include comparisons of abundance, survival, or growth for years more recent than 2001.

Abundance of steelhead YOY has averaged 2.3 times higher than that of brown trout in the TZ in years when steelhead were stocked (1998-01) (Table 1). Brown trout YOY abundance in the TZ during 1998-01 was not significantly different than during the pre-steelhead-stocking period of 1995-97 ($P < 0.05$). Relative abundance of YOY brown trout in the TZ, compared to the Gilchrist RZ, likewise has not changed significantly. However, abundance of YOY brook trout and yearling brown trout and brook trout in the TZ declined significantly after steelhead were stocked (Table 1). Moreover, abundance of yearling brown trout in the TZ has declined significantly relative to their abundance in the Gilchrist Creek RZ. Abundance of age-2 brown trout year classes (1998-99 year classes) that interacted with steelhead as YOY in the TZ were significantly less abundant, compared to the same year classes in the Gilchrist Creek RZ.

In the Gilchrist Creek RZ, mean abundance of YOY brown trout was significantly lower during 1998-01 than from 1995-97, but this average was strongly influenced by a weak 1998 year class (Table 2). By contrast, abundance of both YOY and yearling brown trout in the Hunt Creek RZ was significantly higher during 1998-01 than during 1995-97 (Table 3). Effects of an intermittently active beaver dam located downstream, which sometimes impounds water within the sampling area, confounds interpretation of data from the Hunt Creek RZ.

Introductions of steelhead were associated with significantly lower mean annual survival of age-0 brown trout in the Hunt Creek TZ (Table 4). Mean survival of age-0 brown trout declined from 36% to 22% in the TZ, but increased from 28% to 35% in the Gilchrist Creek RZ. Mean annual survival of age-0 brown trout was over twice as high in the TZ, relative to the Gilchrist Creek RZ, before steelhead were stocked (Figure 4). Mean annual survival of age-1 and age-2 brown trout in the TZ did not change significantly relative to the Gilchrist Creek RZ (Figure 4). However, survival of three-year-old brown trout in the TZ was significantly higher, relative to the Gilchrist Creek RZ, after steelhead were stocked.

There were no statistically significant differences in mean length at age for any age group of brown trout in either the TZ or Gilchrist Creek RZ between test periods (Table 5). In fact, mean length at age was remarkably similar between years in spite of substantial variation in year class abundance.

Job 7. Title: <u>Test fish for BKD and other diseases.</u>–Brown trout were collected for disease screening from Hunt Creek each summer during 1996-02 and from Gilchrist Creek during 1990, 1994, and 1999. In 1999 and 2001-02, we also collected juvenile steelhead from the Hunt Creek TZ. 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. *M. cerebralis* spores were detected in brown trout collected in 1998 and in each year from 2000 to 2002. Relative spore density is determined by making five passes over a 22 by 22 mm cover slip at 200X magnification. Spore densities determined for brown trout by this method have been low. In most years, 60 fish heads were combined into approximately twelve pools before they are examined for spores. In 2002, spores were found in half of the pooled brown trout samples and spore density in positive pools ranged from one to four.

M. cerebralis spores were not found in steelhead screened in 1999 but they were found in eight of twelve pools of steelhead examined in 2001, and in five of thirteen pools examined in 2002. Spore density in steelhead was low, 11 or fewer per screening slide in 2001. In 2002, four of five screening slide had three or fewer spores, but 30 spores were found in one pool of three steelhead heads. With one exception, no clinical signs of whirling disease have been observed in either brown trout or steelhead. One rainbow trout examined in 2002 exhibited a depression in the skull. The consistently high abundance of juvenile steelhead, over 2000 YOY per ha, suggested that whirling disease has not caused any significant mortality.

Job 8. Title: <u>Monitor stocking of adult steelhead.</u>–Adult steelhead were stocked at the downstream end of the Hunt Creek TZ each spring from 1998-02. Eighty steelhead of each sex were stocked each year. Size at planting, percent ripeness, and estimated egg production is summarized in Table 6. Estimates of egg deposition have been higher during the latter three years of the study because female steelhead have been larger.

Steelhead redds in the TZ were counted twice weekly beginning 2 d after stocking in 1998-99 and once a week in 2000-02. 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.–Microhabitat characteristics of steelhead redds have been reported in previous segments.

Job 10: Title: Analyze data and write progress report.–This progress report was prepared.

Job 11: Title: Estimate populations of resident trout and steelhead in additional streams.– During July and August 2000-02 we made mark-and-recapture estimates of resident trout species, steelhead, and other potamodromous species in five additional streams. Streams sampled were the Baldwin River, Houghton Creek, the Little South Branch of the Pere Marquette River, the mainstem Pere Marquette River, and the Platte River. Resident trout species populations were likewise estimated in rivers inaccessible to Great Lakes fish. These streams were the North and South Branch Boardman Rivers, Hersey River, mainstem Manistee River, and the North, South, and mainstem Au Sable Rivers. I will test hypotheses relating vital statistics of resident trout populations to the presence and abundance of potamodromous salmonids after scale samples are read in 2003.

Literature Cited:

Crisp, D. T. 1981. A desk study of the relationship between temperature and hatching time for the eggs of five species of salmonid fishes. Freshwater biology 11:361-368.

Crisp, D. T. 1988. Prediction, from temperature, of eyeing, hatching, and 'swim-up' times for salmonid embryos. Freshwater Biology 19:41-48.

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.

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.

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Table 1.–Fall numbers of brown, brook, and rainbow trout per hectare, by age, in 3.4-km treatment zone of Hunt Creek MI where adult steelhead were stocked in 1998-02.

	Age					
Year	0	1	2	3	4	5+
Brown trout						
1995	1,616	509	199	130	20	10
1996	970	428	161	74	15	6
1997	1,283	414	145	64	15	2
1998	1,048	490	120	92	18	3
1999	947	297	163	70	26	1
2000	933	165	98	68	24	3
2001	1,019	176	64	49	18	5
Before Steelhead 1995-97	1,289	450 [1]	169	89	17	6
After Steelhead 1998-01	987	282 [1]	111	70	21	3
Rainbow trout						
1998	2541	0	0	0	0	0
1999	2241	340	0	0	0	0
2000	2097	245	0	0	0	0
2001	2341	357	2	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
2000	41	14	1	0	0	0
2001	20	7	2	0	0	0
Before Steelhead 1995-97	68 [1]	36 [1]	4	0.3		
After Steelhead 1998-01	43 [1]	16 [1]	3	0.3		

[1]Differences between abundance during before and after period are significantly different ($P < 0.05$)

Table 2.–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, 1995-01.

	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
2000	1741	461	140	70	15	0
2001	2272	612	184	84	15	2
Before 1995-97	1976 [1]	557	193	71	15	3
After 1998-01	1684 [1]	551	164	74	15	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
2000	2	9	1	0.5	0	0
2001	7	10	1	0	0	0
Before 1995-97	21	26 [1]	5 [1]	0.2 [1]	0	0
After 1998-01	13	16 [1]	3 [1]	0.1 [1]	0	0

[1] Differences between abundance during before and after period are significantly different ($P < 0.05$).

Table 3.–Fall numbers of brown and brook trout per hectare, by age, in a 0.7 km section of Hunt Creek, MI used as a reference zone, 1995-01.

	Age					
Year	0	1	2	3	4	5+
Brown trout						
1995	374	300	172	91	16	14
1996	236	66	102	129	28	23
1997	1,038	116	84	64	30	6
1998	1,442	419	90	86	39	13
1999	541	252	166	67	16	10
2000	524	144	87	53	10	0
2001	869	66	24	32	16	0
Before 1995-97	549 [1]	161 [1]	119	94 [1]	25	14 [1]
After 1998-01	844 [1]	220 [1]	92	59 [1]	20	6 [1]
Brook trout						
1995	2,843	395	40	0	0	0
1996	2,303	200	12	0	0	0
1997	3,453	360	7	0	0	0
1998	3,752	1306	32	0	0	0
1999	1,896	177	21	0	0	0
2000	2,137	108	6	0	0	0
2001	1,525	225	0	0	0	0
Before 1995-97	2,866 [1]	318 [1]	19	0	0	0
After 1998-01	2,327 [1]	454[1]	15	0	0	0

[1] Differences between abundance during before and after period are significantly different ($P < 0.05$).

Table 4.–Annual percent survival of brown trout in Hunt and Gilchrist Creeks, by age, from the year listed to the following year.

Year	Age 0	1	2	3
Hunt Creek Treatment Zone				
1995	27	32	37	12
1996	43	34	40	20
1997	38	29	63	28
1998	28	33	59	28
1999	17	33	42	34
2000	19	39	50	27
Before 1995-97	36 [1]	32	47	20
After 1998-00	22 [1]	35	50	29
Hunt Creek Reference Zone				
1995	18	34	75	31
1996	49	127	62	23
1997	40	77	104	60
1998	17	40	74	18
1999	27	34	32	15
2000	13	16	37	29
Before 1995-97	36	80	50	38
After 1998-00	19	30	48	21
Gilchrist Creek Reference Zone				
1995	19	24	21	14
1996	29	32	25	27
1997	37	25	48	53
1998	42	29	60	11
1999	27	32	35	19
2000	35	40	60	22
Before 1995-97	28 [1]	27	31 [1]	31 [1]
After 1998-00	35 [1]	34	52 [1]	17 [1]

[1] Differences between survival during before and after period are significantly different ($P < 0.05$).

Table 5.–Mean total length at age (mm) of brown trout in Hunt and Gilchrist Creeks during September 1995-01.

	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
2000	91	168	230	274	338
2001	85	173	237	289	338
Before 1995-97	89	166	217	269	355
After 1998-01	88	172	231	279	334
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
2000	85	159	224	269	337
2001	80	152	218	266	336
Before 1995-97	80	150	203	267	334
After 1998-01	84	156	218	269	338

Table 6.–Mean total length (mm), weight (kg), and ripeness of adult steelhead stocked in Hunt Creek during 1998-2002. Egg production was estimated from female size-and-fecundity data collected from steelhead at the Little Manistee River Weir in 1998.

	Year				
Parameter	1998	1999	2000	2001	2002
Mean total length of males	701	686	788	745	781
Mean total length of females	694	688	732	727	740
Mean weight of males	3.2	3.2	4.7	4.0	4.5
Mean weight of females	3.2	3.3	3.9	3.9	4.0
Percent ripe males	38	34	60	61	64
Percent ripe females	34	25	36	44	14
Estimated egg production	288,267	294,594	346,951	351,850	359,708

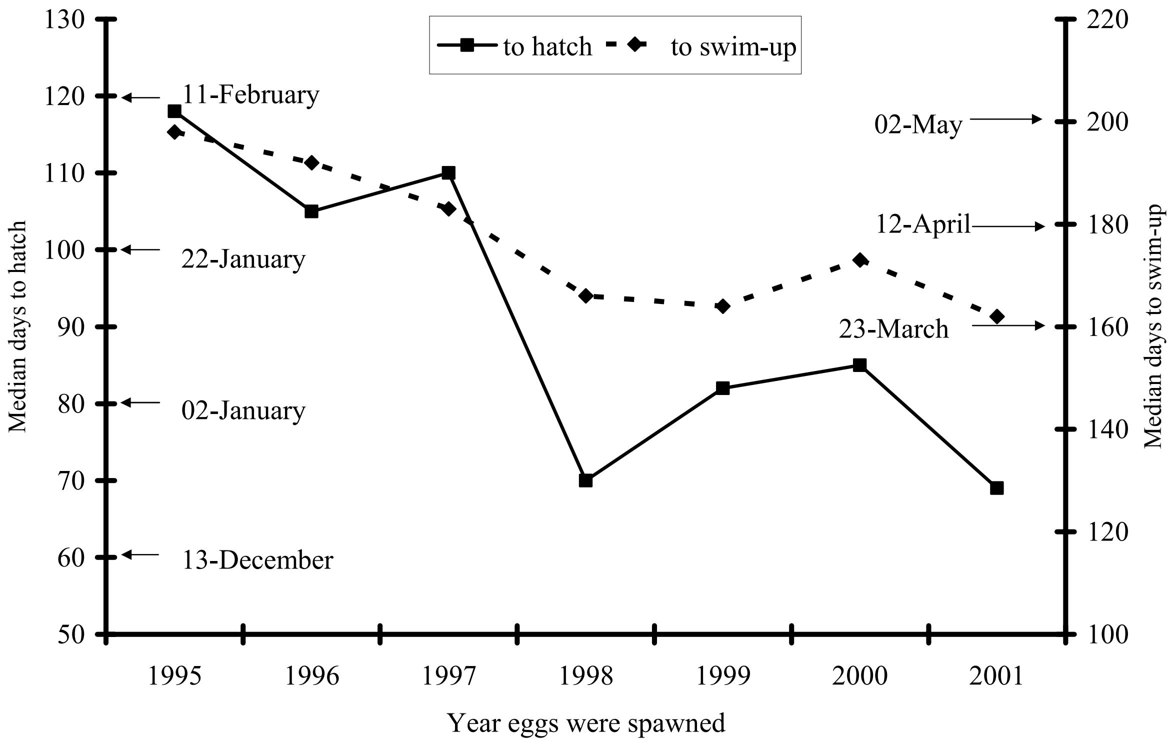

Figure 1.–Median numbers of days to brown trout hatch and swim up for brown trout spawning in the Hunt Creek TZ on 15-October. Projections are based on mean daily water temperatures during the incubation period and predictive models developed by Crisp (1988).

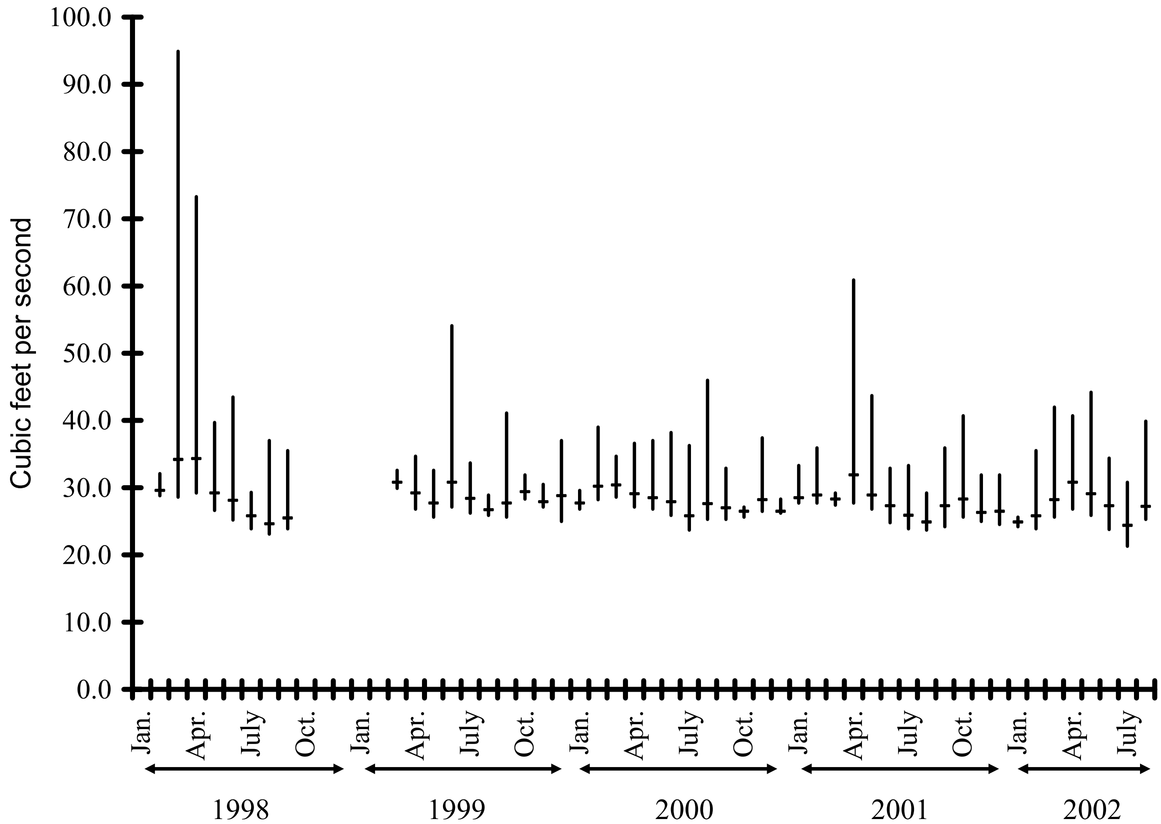

Figure 2.–Monthly mean, maximum, and minimum daily discharge (cfs) of Hunt Creek upstream of the treatment zone from February 1998 through August 2002. Horizontal bars represent mean daily discharge and the ends of the vertical bars depict maximum and minimum daily discharge levels. No data were presented for months with any missing daily-discharge data.

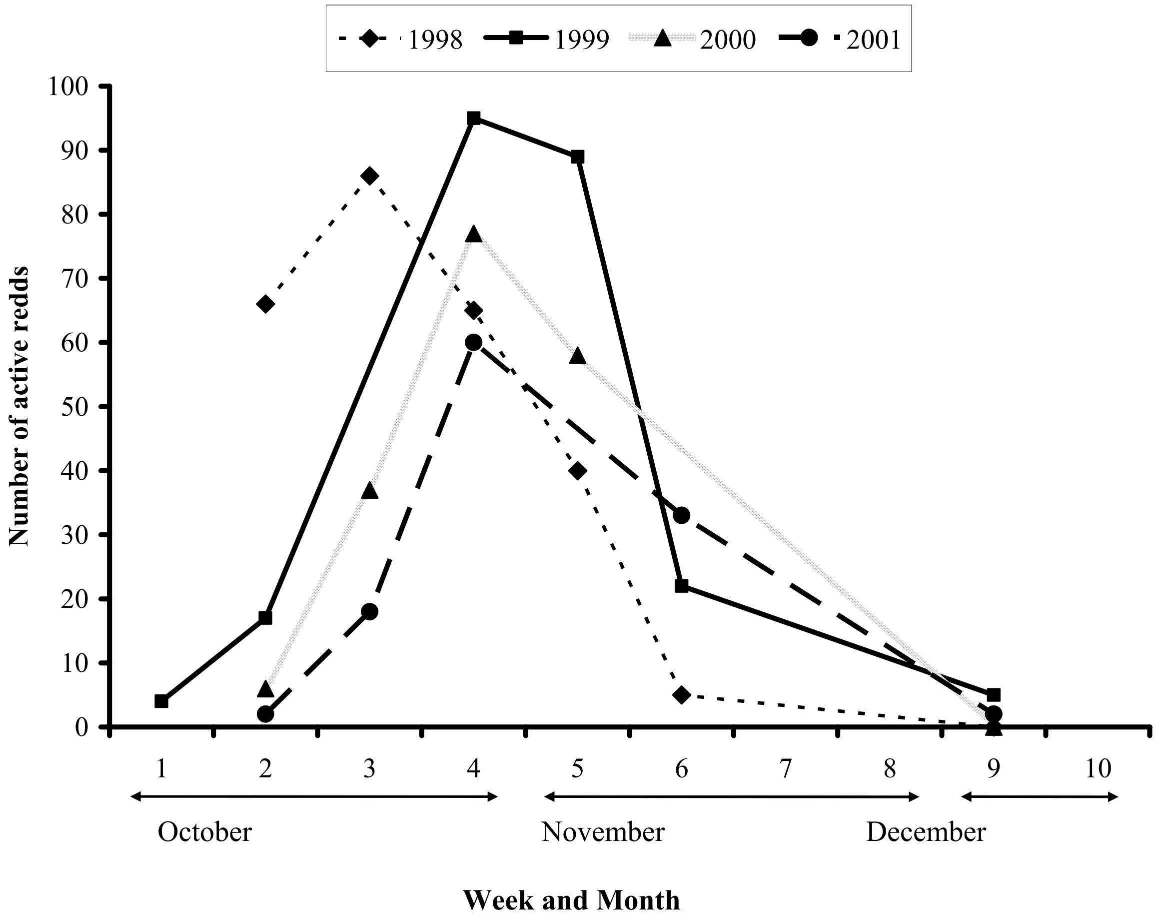

Figure 3.–Number of active brown trout redds by week in the 3400-m treatment zone of Hunt Creek during 1998-01. Week 1 is the first full week of October and week 9 is the first week of December. No counts were conducted during the last half of November to reduce conflicts with deer hunters on private properties along the creek.

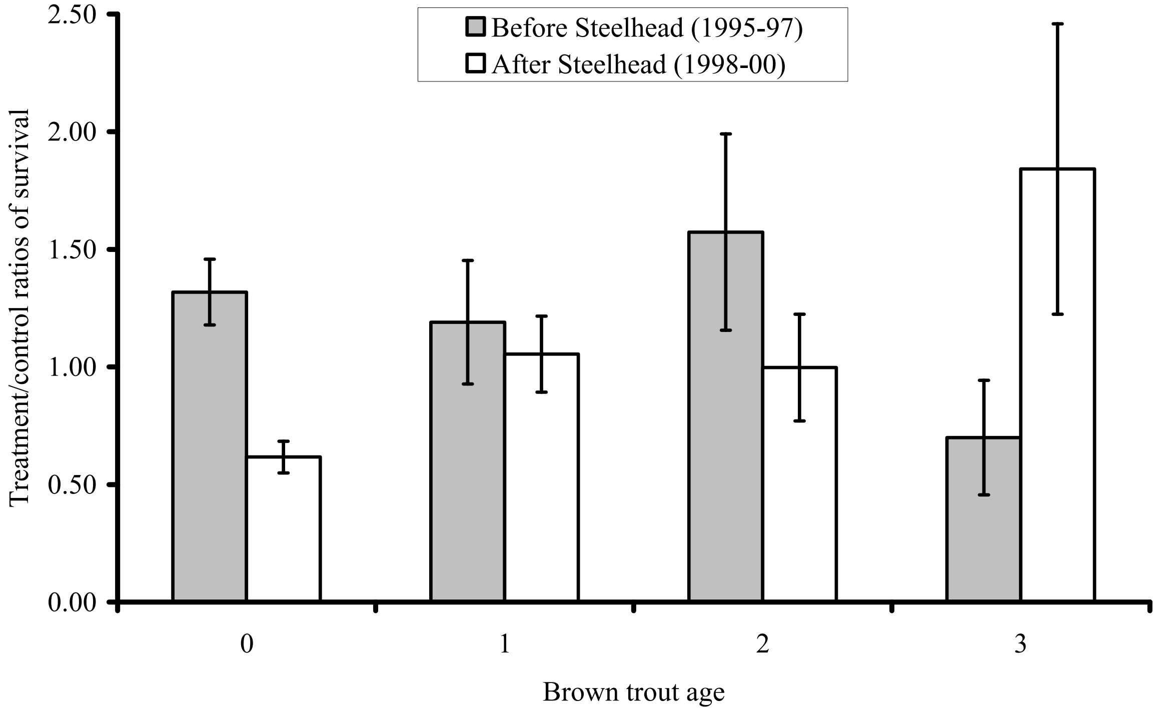

Figure 4.–Ratios of annual brown trout survival in the treatment zone of Hunt Creek to survival in the Gilchrist Creek reference zone. No steelhead were present the reference zone during either the before or after period. Error bars are ±2 SE.