STUDY PERFORMANCE REPORT

State: Michigan

Project No.: F-35-R-23

Study No.: 654

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

Period Covered: April 1, 1997 to March 31, 1998

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: We made three consecutive annual estimates of brook and brown trout populations in a section of Hunt Creek where steelhead will be stocked and in reference zones located on Hunt and Gilchrist Creeks. Adult steelhead will be stocked annually into the treatment zone (TZ) of Hunt Creek 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 so we can compare *relative* differences in our trout population statistics by comparing ratios of treated/reference between before and after periods.

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 reference zone. 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).

We characterized stream habitat conditions in each 100-m segment of the TZ during June and July 1996 and in the RZ during June 1997 using methods similar to those described in Platts et al. (1983). I used regression analysis to search for relationships between fall brown trout abundance in 100-m subsections of the TZ or RZ and habitat variables. Biomass of brown trout ≥203 mm per station in the TZ was most strongly and positively correlated with abundance of large woody debris (LWD) ($r = 0.73$). Biomass of brown trout ≥ 203 mm in the TZ was likewise significantly correlated with aggregate woody cover, e.g. the sum of LWD, small woody debris and rootwads. By contrast, no fish cover variables were significantly correlated with biomass of brown trout ≥ 203 mm in the RZ. The stream morphology variable most highly correlated with abundance of trout ≥203 mm was mean cross sectional area ($r = 0.58$) in the TZ and maximum stream depth in the RZ.

We counted and measured resident trout redds in treatment and reference zones to determine both the spatial distribution of redds and the time period when most spawning occurs. The majority of spawning occurs during the last half of October. We were unable to reliably determine when most resident trout emerge from their redds so we can not postulate what effect superimposition of steelhead redds on resident trout redds may have on their reproductive success. A subsample of resident trout redds were marked during fall 1997 so that we can determine if steelhead stocked in spring 1998 will spawn at the same locations.

Job 2. Title: <u>Monitor water temperature in treatment and reference zones.</u>

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. Water temperature affects the growth rates of juvenile and adult fish and the developmental rate of gametes in trout redds, which, in turn, determines when alevins will emerge from redds. These temperature data will be used to help separate effects on resident trout of temporal variation in temperature from possible effects of interactions with steelhead.

Job 3. Title: <u>Monitor water stage and discharge.</u>

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 salmonids. 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. Data were analyzed to determine if discharge at all 3 sites could be reliably predicted using stage height data recorded electronically at one location.

Stream discharge estimates made 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. We will continue to make occasional estimates of discharge at all three sites to assure that these relationships remain consistent over time.

Job 4. Title: <u>Characterize physical habitat in treatment and reference zones.</u>

Findings: We used modifications of methods described in Platts et al. (1983) to characterize instream and riparian habitat in the Hunt Creek TZ during June and July 1996 and in the Gilchrist Creek RZ during June 1997. Habitat parameters were measured along transects spaced 20-m apart and perpendicular to stream flow during summer baseflow conditions. Habitat data collected included stream widths and depths, frequency of occurrence of different substrate types, amount of undercut bank cover and bank stability, amount of rooted aquatic plant growth, abundance of woody debris, and primary riparian vegetation types adjacent to each 100-m segment. We measured stream discharge or read staff gauges each day before habitat was measured to confirm that discharge was similar (± 3 cfs) between days when habitat parameters were measured. On days when habitat measurements were made, mean stream discharge at the downstream boundaries of the TZ and RZ was 30.3 and 40.2 cfs, respectively.

I used regression analysis to search for relationships between fall brown trout abundance in 100-m subsections of the TZ or RZ and the habitat variables listed in Table 1. Dependent variables reflecting trout abundance in each 100-m stream segment were derived from population estimates made during fall 1996 in the TZ and during fall 1997 in the RZ. Similar analyses will be performed after steelhead are introduced to determine if their abundance is associated with similar or different habitat attributes. Pearson correlation coefficients and multiple regression model fits were judged to be statistically significant for $P = 0.05$.

Biomass of brown trout ≥203 mm per station in the TZ was most strongly and positively correlated with abundance of large woody debris (LWD) ($r = 0.73$) (Table 2). Biomass of brown trout ≥ 203 mm in the TZ was likewise significantly correlated with aggregate woody cover, e.g. the sum of LWD, small woody debris and rootwads. By contrast, no fish cover variables were significantly correlated with biomass of brown trout ≥ 203 mm in the RZ. Cover such as LWD may have been less important in the RZ because average water depth was 38% deeper than in the TZ. The stream morphology variable most highly correlated with abundance of trout ≥203 mm was mean cross sectional area ($r = 0.58$) in the TZ and maximum stream depth in the RZ. Stream morphology variables related to pool presence and quality tended to be significantly related to abundance of brown trout ≥203 mm in both the TZ and RZ. Significant positive relationships between abundance of larger trout and abundance of sand, and significant negative relationships with mean stream velocity likewise suggest that larger trout were more abundant in stations having more pool habitat. Total brown trout biomass and abundance of other size groupings of larger brown trout (trout ≥305 mm or trout ≥ 406 mm) were generally significantly correlated with the same habitat variables as trout ≥203 mm. Multiple regression analysis revealed that a model containing both the LWD and mean cross sectional area variables accounted for 65% of the variation in biomass of brown trout ≥ 203 mm among the 32 contiguous stations in the TZ. However, in the RZ these two variables accounted for only 25% of variation among 23 stations.

Abundance of young-of-the-year (YOY) brown trout per 100-m station in the TZ was significantly correlated only with gravel abundance ($r = -0.385$). This negative relationship may indicate that stations having higher water velocities were less suitable for YOY trout because gravel abundance in stations was positively related to mean stream velocity. YOY abundance in the RZ was inversely related to average depth of water near shore ($r = -0.456$) and positively related to abundance of rooted aquatic plants ($r = 0.426$) in a station.

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

Findings: We counted trout redds in both the treatment and reference zones during the 1995 and 1996 spawning periods. During 1997 redds were only counted in the upstream 2300 m of the TZ so that more frequent counts could be made. The first time a redd was identified its location was temporarily marked and its overall length and width was measured using a steel tape. We usually could not determined if redds were used by more than one female. The large size of some redds (up to 7.2 m^2) suggested that they were used by multiple spawners. On subsequent counts, previously identified redds were classified as “active” if additional cleaned gravel was evident. Most spawning in the TZ apparently occurred between mid-October and mid-November during both 1996 and 1997. The majority of brown trout probably spawned during the last half of October. Redd density near the middle of November 1996 was 34.4/km in the Hunt Creek TZ and 31.7/km in the Gilchrist Creek RZ. During fall 1997 the number of active redds in the TZ was greatest on 22-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.

During fall 1996 we used numbered steel stakes to mark 21 redd locations in the Hunt Creek TZ. Beginning on 17-March 1997 we began excavating marked redds at approximately 1-week intervals to determine the developmental stage of eggs and alevins. The purpose of these excavations was to obtain qualitative information on the developmental stage of brown trout eggs or alevins during the time period that mature steelhead are expected to spawn in the TZ.

Excavation of redds during March and April did not provide sufficient information to make projections of probable peak emergence periods. We found no eggs or alevins in half of the redds excavated and only dead eggs were found in 28% of the redds. I concluded that excavating redds was not effective because a lack of eggs or alevins in some redds could have multiple causes. For example, trout could have cleaned gravel without depositing eggs, fry could have emerged, or we may have been inefficient at capturing excavated eggs or alevins.

During fall 1997 we implanted fertilized brown trout eggs contained in 4-6 Vibert boxes at weekly intervals from 13-October to 10-November. Eggs were obtained from the Oden State Fish Hatchery. I intended to dig up eggs in one or two Vibert boxes per week beginning in early February to ascertain their stage of development. I also planned to use fry traps to capture any fry emerging from the remaining Vibert boxes during mid-March to mid-April when steelhead were expected to spawn. If this method had been successful I could have more reliably estimated if naturally spawned brown trout were likely to be present in spawning gravel when steelhead spawn during spring 1998. I also planned to use these data to relate egg development to incubation temperature so that in future years I could estimate peak emergence periods based on weekly brown trout redd counts and water temperatures. However, when we began digging up Vibert boxes in early February we found that all eggs in all boxes were dead. Some mortality could have occurred due to suffocation caused by infiltration of sand into the Vibert boxes. However, many boxes did not contain much sediment and we buried boxes in clean gravel where water velocities were similar to those where brown trout spawn in Hunt Creek. I believe that the quality of the implanted eggs was low. Eggs from the same brood fish that were reared at the hatchery suffered much higher than normal mortality (over 50% for some lots of eggs). During 1998 I will again attempt to implant eggs at weekly intervals spanning the peak brown trout spawning period but I will use different implant methods.

Job 6. Title: <u>Collect population and biological data.</u>

Findings: We have made mark-and-recapture estimates of brook and brown trout populations each fall from 1995-97 in a 3.2 kilometer treatment zone on Hunt Creek, a 0.7 kilometer reference zone on Hunt Creek, and a 2.3 kilometer 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 in all three zones.

Numbers of brook and brown trout by age are presented in Tables 3-4 for the TZ and RZ. Numbers of trout in the Hunt Creek reference zone are not presented because all scales have not yet been aged.

Job 7. Title: Test fish for BKD

Findings: Sixty brown trout were collected from Hunt Creek each summer during July 1996-97 and from Gilchrist Creek during 1990 and 1994. Trout were screened for the presence of the Salmonid kidney disease bacterium, the enteric redmouth bacterium, 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 10: Title: Analyze data and write progress report

Findings: This progress report was prepared.

Literature Cited:

Platts, W.S., W.F. Megahan, and G. W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. United States Department of Agriculture, Forest Service General Technical Report INT-138.

Table 1. Habitat variables measured or visually estimated along 160 transects (5 per 100-m station) on Hunt Creek during 1996 and in Gilchrist Creek during 1997. Habitat was measured or estimated at 0.5-m intervals along transects perpendicular to stream flow during baseflow conditions.

Variable	Description
Stream morphology	
Mean stream width (m)	Mean horizontal distance along transects from bank to bank at existing water surface, to nearest 0.1 m
Mean stream depth (cm)	Mean of all depth measurements taken along transects in each station, to nearest 0.5 cm
Maximum stream depth (cm)	Maximum depth measured along any transect in each station, to nearest 0.5 cm
Width to depth ratio	Mean stream width (m) divided by mean stream depth (m) in each station
Mean cross sectional area (m^2)	Product of mean stream width and mean depth in each station
Mean stream velocity (m/s)	Stream discharge (m^3/s) divided by mean cross sectional area in a station
Undercut bank (cm)	Sum of undercut bank measurements (Platts et al. 1983) made along 5 transects per station
Average shore depth (cm)	Mean of shore depth measurements (Platts et al. 1983) made along 5 transects per station
Variance of depth measurements	The variance of all depth measurements made in a station
Cover	Values for cover types (defined below) were determined by summing the percentages of each 0.5-m transect segment in a station composed of partially or completely submerged cover capable of providing shelter for trout
Large woody debris (LWD)	Logs > 25-cm in diameter and ≥ 2 m long
Small woody debris (SWD)	Wood 10-24 cm in diameter and ≥ 2 m long
Rootwads (RW)	Bases of trees and root structure
Brush	Accumulations of brush of sufficient density to provide overhead cover for fall fingerling or larger trout
Rooted plants	Plant beds dense enough to provide overhead cover for fall fingerling or larger trout
Aggregate woody cover	Sum of values for LWD, SWD, and RW
Substrate	Primary substrate type (defined below) was determined for each 0.5-m transect segment in a station. Values for substrate types used in regression analyses were defined as the frequency of occurrence of a substrate type in a station
Detritus/organic	Deposits of fine flocculent organic particles or coarser organic material such as leaves or needles
Clay	Particle diameter ≤ 0.004 mm
Sand	Particle diameters > 0.004 mm and < 2 mm
Gravel	Particle diameters 2-64 mm
Cobble	Particle diameters 65-250 mm
Boulder	Particle diameters > 250 mm

Table 2.–Correlation between fall biomass of trout ≥ 203 mm in 100-m stations on Hunt Creek and Gilchrist Creek and habitat variables measured during summer baseflow conditions. Asterisks indicate statistically significant correlation coefficients (P = 0.05).

Habitat variable	Hunt Creek		Gilchrist Creek	
Stream morphology	r	P	r	P
Mean stream width (m)	0.189	0.301	0.164	0.455
Mean stream depth (cm)	0.542	0.001*	0.400	0.058
Maximum stream depth (cm)	0.456	0.008*	0.647	0.001*
Width to depth ratio	-0.272	0.132	-0.248	0.254
Mean cross sectional area (m^2)	0.583	<0.001*	0.470	0.024*
Mean stream velocity (m/s)	-0.469	0.007*	-0.501	0.015*
Undercut bank (cm)	-0.105	0.568	0.134	0.542
Average shore depth (cm)	-0.011	0.953	-0.023	0.915
Variance of depth measurements	0.423	0.016*	0.478	0.021*
Cover				
Large woody debris (LWD)	0.731	<0.001*	0.236	0.279
Small woody debris (SWD)	0.254	0.160	0.063	0.776
Rootwads (RW)	0.311	0.083	-0.042	0.848
Brush	0.270	0.135	0.086	0.698
Rooted plants	-0.157	0.390	0.407	0.054
Aggregate woody cover	0.604	<0.001*	0.138	0.529
Substrate				
Detritus/organic	0.112	0.540	0.093	0.674
Clay	0.205	0.260	0.083	0.705
Sand	0.366	0.039*	0.470	0.024*
Gravel	-0.240	0.185	-0.551	0.006*
Cobble	-0.146	0.424	0.058	0.794
Boulder	-0.182	0.318	None present	

Table 3.–Fall number of brown and brook trout by age in the 3.2 km section of Hunt Creek where steelhead will be stocked each spring from 1998-2002.

	Brown trout					
	Age					
Year	0	1	2	3	4	5+
1995	3506	1104	432	282	43	21
1996	2158	966	352	156	34	13
1997	2774	934	316	134	32	4
3-year average	2813	1001	367	191	36	13
	Brook trout					
	Age					
Year	0	1	2	3	4	5+
1995	49	17	2	1	0	0
1996	26	68	4	0	0	0
1997	135	86	4	1	0	0
3-year average	70	57	3	1	0	0

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

	Brown trout					
	Age					
Year	0	1	2	3	4	5+
1995	3957	1332	506	205	23	2
1996	3399	733	314	104	29	8
1997	3437	978	235	78	28	6
3-year average	3598	1014	352	129	27	5
	Brook trout					
	Age					
Year	0	1	2	3	4	5+
1995	25	49	11	0	0	0
1996	38	54	8	1	0	0
1997	53	39	11	0	0	0
3-year average	39	47	10	0.33	0	0

Prepared by: Andrew J. Nuhfer
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