North American Journal of Fisheries Management 21:943–946, 2001

Upstream Movement of Residual Hatchery Steelhead into Areas Containing Bull Trout and Cutthroat Trout

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Abstract.—Hatchery-reared steelhead *Oncorhynchus mykiss* that do not emigrate as smolts shortly after release may harm wild fish communities through ecological interactions. We used systematic, stratified snorkeling surveys to document the relative abundance of wild rainbow trout (nonanadromous *O. mykiss*), bull trout *Salvelinus confluentus,* and westslope cutthroat trout *O. clarki lewisi* as well as the upstream limit of residual hatchery steelhead (hatchery-reared steelhead that had failed to emigrate by June 1). Our objective was to determine whether residual hatchery steelhead had migrated upstream from their release point into an area containing westslope cutthroat trout and a threatened population of bull trout. Hatchery steelhead made up a larger proportion of the salmonid community in the sites near their release location and constituted a lower proportion as distance upstream from the release location increased. However, residual hatchery steelhead had migrated over 12 km upstream into an area containing westslope cutthroat trout and a threatened stock of bull trout.

The stocking of hatchery steelhead *Oncorhynchus mykiss* smolts poses ecological risks to wild salmonids in areas where both occur (Pearsons and Hopley 1999). Hatchery steelhead have been observed to reduce the growth of wild rainbow trout (nonanadromous *O. mykiss*) in stream enclosures (McMichael et al. 1997), to prey on wild fish (Martin et al. 1993; Jonasson et al. 1995; Hawkins and Tipping 1999), and to spawn with wild rainbow trout (Pearsons et al., in press) . The magnitude of ecological risk is strongly dependent on the degree of spatial and temporal overlap between hatchery and wild salmonids. Temporal overlap increases when hatchery steelhead do not migrate to the ocean by a specified time (e.g., June 1). These fish are referred to as residuals. Spatial overlap can increase when hatchery steelhead move from their release sites and then residualize. Although hatchery fish may migrate upstream from their release sites, it is generally assumed that the ecological risks are low upstream of the sites where anadromous salmonid smolts are released. However, if wild populations upstream of the release sites are listed as threatened or endangered under the Endangered Species Act, then the risks may be unacceptable.

We investigated whether hatchery steelhead smolts stocked downstream of populations of bull trout *Salvelinus confluentus* and westslope cutthroat trout *O. clarki lewisi* posed ecological risks to these species. Our objectives were to determine whether hatchery steelhead residuals would move upstream into areas with bull and westslope cutthroat trout and to evaluate what portion of the stream salmonid community was composed of residual hatchery steelhead as distance upstream of the release location increased.

Methods

Study area.—Our research was conducted within the Teanaway River watershed in central Washington State (Figure 1). This watershed drains the eastern slope of the Cascade Mountains and flows into the Yakima River, which subsequently enters the Columbia River at river kilometer 531 (measuring from the mouth). The study area contains 13 native fish species—rainbow trout (steelhead), westslope cutthroat trout, bull trout, mountain whitefish *Prosopium williamsoni*, chinook salmon *O. tshawytscha*, redside shiner *Richardsonius balteatus*, speckled dace *Rhinichthys osculus*, longnose dace *Rhinichthys cataractae*, bridgelip sucker *Catostomus columbianus*, largescale sucker *Catostomus macrocheilus*, shorthead sculpin *Cottus confusus*, Paiute sculpin *Cottus beldingi*, and torrent sculpin *Cottus rhotheus*—and one nonnative species—brook trout *S. fontinalis*. McMichael et al. (1997, 1999, 2000) provide more details on the biota and physical features of the study area. We released hatchery-reared steelhead into Jungle Creek 0.5 km above its junction with the North Fork Teanaway River (NFT; Figure 1). The bull trout population in the NFT is largely limited to the upper portion of the drainage, although individuals are occasionally observed in the lower por-

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Received July 24, 2000; accepted March 13, 2001

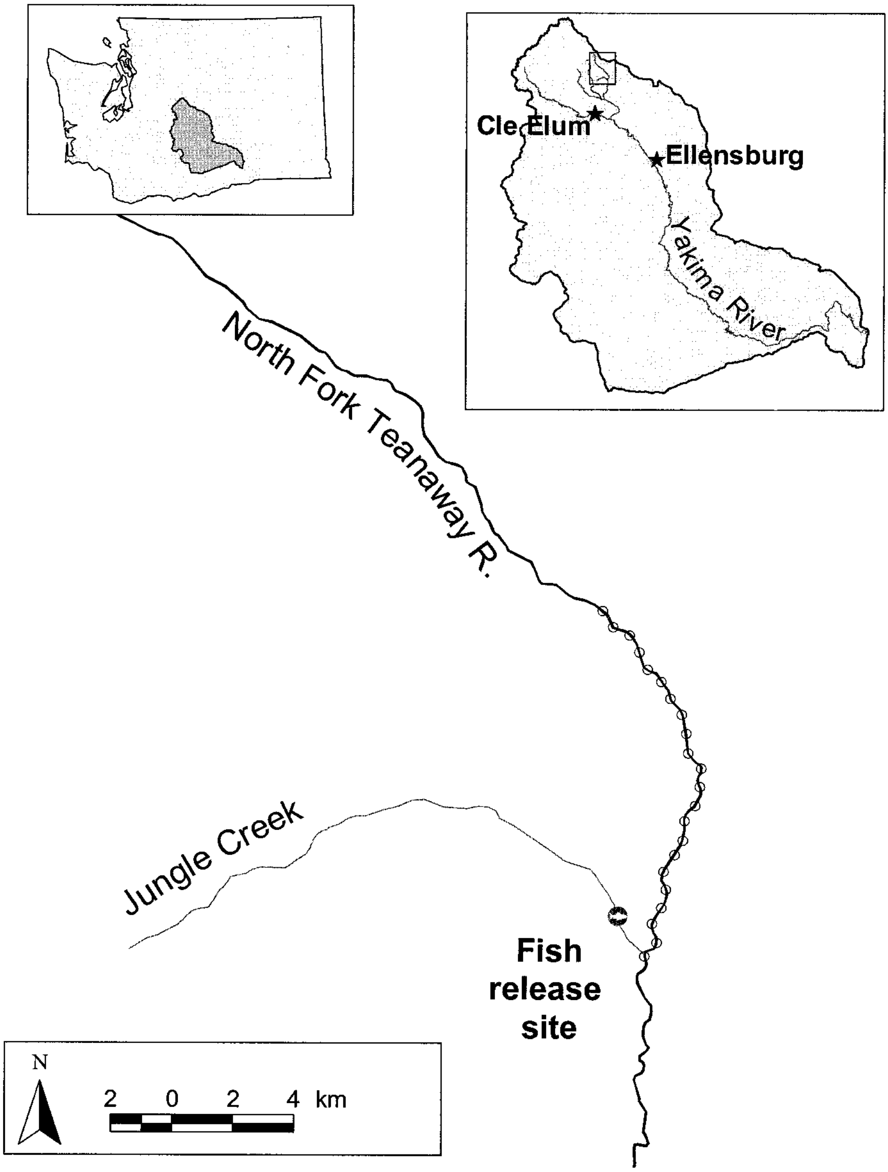

FIGURE 1.—Map of the study area showing the hatchery steelhead release location on Jungle Creek. Snorkeled reaches are denoted by open circles on the North Fork Teanaway River.

tion as well (Pearsons et al. 1994). Westslope cutthroat trout are also more abundant in the upper portion of the NFT drainage, although their range extends farther downstream and they are more abundant than bull trout (Pearsons et al. 1994).

Experimental design.—We released 32,579 hatchery steelhead smolts marked with adipose fin clips into Jungle Creek during early May 1994 (see McMichael et al. 1999 for more details on release timing and the parentage and rearing history of the hatchery fish). The mean fork length of the fish was 180 mm (95% confidence interval, 177–184 mm).

To determine the extent of spatial overlap between residual hatchery steelhead and wild rainbow, bull, and westslope cutthroat trout in the NFT, we snorkeled pools and runs at 0.65-km intervals from the mouth of Jungle Creek upstream 13.4 km on June 24, June 30, and July 12, 1994; a total of 22 sites were sampled. Each site was sampled by two snorkelers moving through separate 100-m sections of pool or run habitat (the short riffles that were present were also sampled). The second snorkeler at that strata would start approximately 100 m upstream of the first snorkeler's site. Therefore, two continuous 100-m sites were surveyed every 0.65 km. Data for both sections at each interval were combined.

Snorkeling was conducted during the night of July 12 to better estimate bull trout abundance. No bull trout were observed during daytime surveys on June 24 and 30. The differences (one-way analysis of variance [ANOVA]) between day and night percent composition for the same sites were not significant for wild rainbow trout ($P = 0.30$), residual hatchery steelhead ($P = 0.23$), or westslope cutthroat trout ($P = 0.61$). Therefore, data collected at night were used for the upper 9 sites (where bull trout were thought to be), and data collected during the day were used for the remaining 13 (lower) sites.

The number, species, origin (hatchery or wild), and visually estimated lengths of fish were recorded by the snorkelers. Because a range of lengths (e.g., 100–175 mm) was recorded for fish within a species at each reach, we used the maximum estimated lengths for size comparisons. We used ANOVA and Tukey's honestly significant difference test to determine significant ($\alpha < 0.05$) differences in length among species. The relative abundances of wild rainbow, bull, and westslope cutthroat trout were expressed as percentages of all salmonids observed at each site.

Results

Residual hatchery steelhead were detected in 14 of 22 reaches in the NFT in 1994 and extended as far as 12.8 km upstream of the mouth of Jungle Creek (Figure 2). These fish were sympatric with wild salmonids in each reach. They descended Jungle Creek after they were released in early May and ascended the NFT instead of continuing downstream towards the sea. Residual hatchery steelhead were roughly equal in abundance to wild rainbow trout at sites up to 3.8 km upstream of the point where they entered the NFT. Between about 4.5 and 9.0 km upstream, wild rainbow trout were the most abundant salmonids observed (with the exception of the sites sampled around 8.3 km, where the only salmonids observed were westslope cutthroat trout). Between 9.6 and 13.4 km upstream, westslope cutthroat trout became more abundant. Bull trout were observed only in the upper 5 reaches. Hatchery steelhead were observed in the same sites as bull trout 12.8 km upstream of the confluence of Jungle Creek and the NFT.

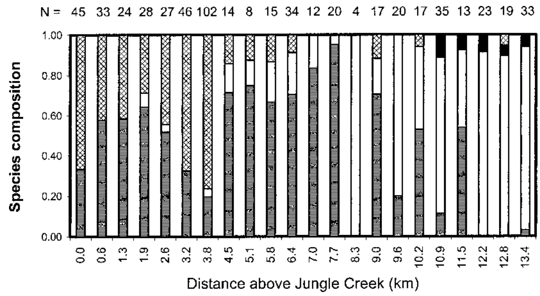

FIGURE 2.—Species composition (proportion) of salmonids observed in the North Fork Teanaway River by systematically snorkeling sites upstream from the mouth of Jungle Creek (where hatchery steelhead entered the river) in summer 1994. Sample sizes (the total number of salmonids observed) are shown for each sample reach. Crosshatched bars denote hatchery steelhead, black bars bull trout, clear bars westslope cutthroat trout, and bars with horizontal lines rainbow trout.

The largest residual hatchery steelhead that we observed (226.1 mm) were significantly larger on average than the largest individual wild bull trout (147.9 mm; $P = 0.01$), westslope cutthroat trout (185.8 mm; $P = 0.02$), and rainbow trout (174.1 mm; $P < 0.01$) observed in the study area. The largest residual hatchery steelhead had a size advantage of about 65% over the largest bull trout observed.

Discussion

Species that are located upstream of hatchery steelhead releases should not be considered immune from interactions. We found that residual hatchery steelhead moved at least 12.8 km upstream from their release site. This upstream movement resulted in the spatial overlap of hatchery steelhead with westslope cutthroat and bull trout. Bull trout are listed as a threatened species in the mid-Columbia River basin, and the population in the North Fork Teanaway River has recently been estimated as 10–44 fish (1994–1999; Washington Department of Fish and Wildlife, unpublished data). Jonasson et al. (1995) also found residualized hatchery steelhead up to 21 km upstream of their release sites in the Imnaha River watershed in Oregon. Hume and Parkinson (1987) reported that 11.7–17.5% of the hatchery-reared steelhead fry they released moved up to 750 m upstream. Underwood et al. (1995) reported spatial overlap between hatchery steelhead and wild bull trout in the Tucannon River, Washington, with only slight differences in microhabitat use.

Hatchery steelhead were observed threatening, chasing, crowding, nipping, and butting wild rainbow trout in this and other studies we have conducted (McMichael et al. 1997, 1999, 2000). These agonistic interactions were frequently initiated by the hatchery steelhead and often resulted in the displacement of wild rainbow trout from preferred locations (McMichael et al. 1999). In addition, we observed the displacement of wild rainbow trout during the spring when hatchery steelhead were released (McMichael et al. 1999). Although we did not attempt to document the behavioral interactions among hatchery steelhead, bull trout, and westslope cutthroat trout, we recommend a risk-averse approach that reduces the likelihood of spatial overlap between residual hatchery steelhead and bull trout in areas where bull trout populations are depressed.

Based on the size differences that we observed (the largest residual hatchery steelhead were significantly larger than the largest wild salmonids), the hatchery steelhead that migrated upstream might behaviorally dominate the wild salmonids. Abbott et al. (1985) reported that a 5% weight advantage assured dominance in the steelhead they examined.

Increased recognition of the risks of hatchery programs has led to reforms intended to reduce the adverse impacts of hatchery steelhead releases. It is unclear how rapidly these reforms will be implemented or how effective they will be. Evaluation of strategies intended to increase harvest or conservation benefits while minimizing ecological risks to wild stocks will be essential.

Acknowledgments

We thank those that spent many hours stumbling around in the darkness with us. Those individuals include Andrew Murdoch, Eric Bartrand, John Long, and Ernie McKenzie. Corey Duberstein, Pacific Northwest National Laboratory, created the study area map. This study was funded by the Bonneville Power Administration through a contract with the Washington Department of Fish and Wildlife's Yakima Species Interactions Study.

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