Potential Effects of Whitewater Parks on In-Stream Trout Habitat

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1. Introduction

A Fish Observatory at one of Recreation Engineering and Planning's drop structures in Boulder Creek

A whitewater park consists of one or more manmade structures in a stream, which create hydraulic features used by whitewater enthusiasts. During the past twenty years, boating at whitewater parks has become a popular recreational activity. Nationwide, at least thirty whitewater parks have been built, with twelve in Colorado. Whitewater parks can contribute notably to local economies when recreational users and associated tourists patronize local businesses. In addition, whitewater parks often are incorporated into larger river restoration projects aimed at enhancing the aesthetic, recreational, and ecological value of river corridors.

Whitewater park structures are built using boulders and cement, affixed precisely onto the streambed and designed to mimic natural river features. "U" drop structures create waves and holes with associated plunge pools. Current deflectors redirect fast flowing water to mid-channel areas and create lateral eddies along the banks. Single and clustered boulders create lateral and mid-channel eddies. Individual instream structures may be intended to create specific hydraulic features during low, medium, or high flow conditions. In addition to instream structures, stream bank stabilization, riparian revegetation, and footpath construction is commonly included in whitewater park design. Some banks may be re-graded and terraced using anchored boulders, which prevent erosion while providing river access and streamside seating.

Whitewater parks alter habitat for aquatic biota, including macroinvertebrates and fish. Instream structures can alter streambed substrate composition, water depth and velocity, and cover. Bank stabilization can influence channel morphology, decrease sediment influx to the stream, and reduce cover that might otherwise be provided by undercut banks. Riparian revegetation, especially with woody species, can increase shading, cover, and inputs of detritus to the stream. Despite these apparent relationships, after a thorough literature review I found no studies to date that evaluate the effects of whitewater parks on stream biota.

In this report I : 1) assess potential effects of whitewater parks on salmonid fishes, in a general context and 2) recommend strategies for fisheries conservation to whitewater park engineers. To determine potential effects of whitewater parks on trout fisheries, I reviewed literature from the fields of fish population biology and stream restoration ecology.

2. Whitewater park impacts on physical habitat and salmonid fish

No scientific studies to date address the effects of whitewater parks on stream fishes. However, instream structures are commonly used to improve fish habitat in streams, and researchers have evaluated their effect on salmonid fishes. Below is a literature review evaluation effects of instream structures on salmonids, most specifically addressing the question: how do whitewater parks affect stream salmonids?

Salmonid fishes, which include salmon, trout and char, have a variety of physical habitat requirements throughout their life cycle. Stream-dwelling populations occupy clean, cold, well-aerated waters that provide abundant oxygen. Spawning occurs in coarse gravel substrate with swiftly-flowing water that delivers oxygen to and removes waste products from incubating eggs. After hatching and emergence from the gravel, fry inhabit side channels, backwaters, and slow-moving lateral areas with abundant cover. As they grow, juvenile and adult fish move to deeper habitat, and become fiercely territorial. A dominance hierarchy develops, with the largest, most aggressive individuals occupying the most energetically-favorable habitats: low-velocity areas near faster currents that provide abundant drifting insects, the major food source for most salmonids (Armstrong et al. 2003, Hendry et al. 2003, Hunter

1991, Mitchell et al. 1998). Preferred positions also tend to be near cover, which can be provided by woody debris, boulders, whitewater, undercut banks, or instream or overhanging vegetation (Allouche 2002, Fausch and White 1981). Deep pools with cover provide excellent habitat for salmonids (Greenberg et al. 2001). Pool habitat is particularly important during the winter, when anchor ice can form in shallow riffles, and during periods of particularly high or low flow. Though individual species requirements vary, in general, deep pools and instream cover frequently are cited as the most important habitat attributes determining salmonid abundance (Allouche 2002, Armstrong et al. 2003, Hunter 1991).

Often, streams become channelized as a result of human activities. In addition to being aesthetically displeasing, channelized streams often are morphologically unstable, biologically unproductive, and lack habitat diversity (Zika and Peter 2002). To improve salmonid habitat, resource managers sometimes add instream structures that increase habitat heterogeneity. Structures used for stream restoration include overpour structures (dams, weirs, and rock-filled gabions), current deflectors, boulders, and cover structures such as large woody debris. Instream structures may aerate water via surface turbulence, increase deposition of fine particles, provide improved habitat for invertebrates, offer cover for fishes, and, in the case of overpour structures, create self-scouring pools (Gowan and Fausch 1995, Hendry et al. 2003, House and Boehne 1985, Hunter 1991, Mitchell et al. 1998, Muhar 1996, Negishi and Richardson 2003, Roni et al. 2002, van Zyll de Jong et al. 1997, Zika and Peter 2002).

Research demonstrates that, in response to placement of instream structures, salmonids may increase in abundance (Gowan and Fausch 1996, Hendry et al. 2003, Hunter 1991, van Zyll de Jong et al. 1997) and/or move to occupy newly-created habitats (House and Boehne 1985, Shuler 1994). Habitat requirements can vary with life stages and season. Deep pools are particularly important during low-flow conditions, while during high-flows, instream structures dampen high-velocities and provide flow refugia for fish (Binns 1994, Gore and Hamilton 1996, Mitchell et al. 1988, Scruton 1996, van Zyll de Jong et al. 1997). Cover is most critical for juvenile salmonids during winter, when interstitial spaces between cobbles and boulders provide thermal refugia (Allouche 2002, Mitchell et al. 1998). Even simple boulder placement can provide efficient feeding sites for salmonids, producing fish with better body condition, and, as a result, increased overwinter survival rates (Shuler 1994).

Though not primarily intended to provide salmonid habitat, whitewater park instream structures produce hydraulic effects similar to structures built for stream restoration. Whitewater park U-drops are overpour structures that create self-scouring plunge pools, providing two important features for salmonids, deep pool habitat and whitewater cover. Current deflectors reduce bank erosion and undercutting, however, the decrease in cover for fish due to less undercutting is offset by the cover provided by the deflector itself. Current deflectors also create lateral eddies or slack water in their wake. Placement of boulders in the channel increases habitat heterogeneity for fish and invertebrates, offers protective cover for juvenile salmonids, provides resting areas during high flows, and creates energetic ally efficient feeding areas for drift feeding fish (Armstrong et al. 2003). The similar design of whitewater park structures and restoration structures strongly suggests that whitewater park instream structures provide beneficial habitat for both juvenile and adult salmonids.

A typical set of drop structures in Breckenridge, Colorado.

Although whitewater park structures provide excellent salmonid habitat, an increase in salmonid abundance or a shift in habitat use to newly created habitats is not assured. Salmonid populations do not always increase after placement of instream structures for restoration purposes (Binns 1994, Pretty 2003, Roni et al. 2002). This result may occur at sites where habitat attributes such as depth and cover are not the factors limiting salmonid populations. For example, cold temperatures in high elevation streams can limit reproduction and survival of juveniles, while in other areas, competition from introduced species or predation might limit populations (Allouche 2002, Hunter 1991, Milner et al. 2003). Use of created habitats may occur only during certain seasons (Roni 2002); Binns (1994) found that brook trout used pools created by instream structures during periods of low flow, but with moderate flows, trout occurred throughout available habitats. If only a few instream structures are built, the small change in amount of high quality habitat may not result in higher density of fish populations. Finally, in the case of whitewater parks, disturbance from whitewater boaters could cause salmonid emigration from the whitewater park area during periods of high use.

3 Potential effects of the whitewater park on trout

During construction of instream structures, increased sedimentation and streambed disturbance will likely reduce invertebrate and fish density in the locality of the whitewater park. However, trout are highly mobile, and will readily recolonize accessible areas of high-quality habitat (Gowan and Fausch 1995, 1996). Deep pools and bankside eddies created by U-drop overpour structures will improve trout habitat at Site 1, by providing cover (boulder and whitewater), resting and feeding areas. Placement of large boulders in the active channel would improve habitat heterogeneity, and supply resting spots and cover for trout. Riparian revegetation would improve streambank stability, and shrubby, overhanging vegetation could provide cover for fish at the channel margins.

Use of the whitewater park by boaters may scare trout away from pools created by overpour structures, or from bankside areas with human high usage. High recreational use periods will likely be during summer high flows, when the instream structures are intended to create hydraulic features that whitewater boaters use. Trout will be more likely to use the pool habitat created by instream structures during the winter, due to habitat limitations resulting from low flow conditions, and cold temperatures that can cause anchor ice formation in shallow riffles. During winter, when pool habitat is most critical and often limiting for trout populations, very little use by whitewater boaters would be expected.

Instream drop and boulder structures, and riparian revegetation efforts will improve fish habitat; however, a related increase in trout population density is not necessarily predicted. Likely, trout will move to constructed pool and deep eddy habitat during winter low flow periods, and may move away from these areas during high flow, higher usage periods. At any scale larger than that of the whitewater park, a significant increase or decrease in trout population density, caused by whitewater park construction or usage, is not expected.

4. Summary and recommendations

Whitewater parks alter river habitat in many ways. Effects on physical habitat for trout include 1) increased number and volume of scour pools created by U-drop structures, 2) increased availability of eddies and increased variability in flow velocity created by large-boulder placement and U-drop structures, and 3) increased cover available to fish in the form of large boulders and whitewater. In addition, riparian revegetation is often included in whitewater park design, and can provide cover to fish if vegetation overhangs the wetted channel. Riparian revegetation also stabilizes the streambank, which can reduce cover otherwise provided by undercut banks, but may also decrease sedimentation by controlling erosion. Overall, whitewater parks tend to increase habitat complexity, thereby improving trout habitat.

The effects a whitewater park on trout fisheries will depend on the characteristics of the site and ecological factors limiting trout populations. When factors other than physical habitat characteristics are limiting, such as predation or disease, increasing habitat quality or pool volume is unlikely to affect trout populations. If trout are limited by habitat, trout will likely use new, high-quality habitats created by instream structures. In particular, increased use of pools by trout in whitewater parks is most likely to occur during winter low-flow periods, when pool habitat is most critical. Trout may leave these areas during the summer, when recreational usage peaks.

Whitewater parks should be constructed with aquatic and fisheries conservation concerns as a primary concern. The following recommendations are proposed to enhance fisheries conservation efforts on the river:

1) River access should be limited to a few clearly-marked access locations, to limit bank erosion and/or trampling of spawning or nursery areas. Planting thick brushy species such as willow can discourage usage of undesirable access areas.

2) Scruton (1996) described a salmonid stream restoration project, and documented that pools constructed with artificial undercut bank structures had a greater biomass of large brook trout than pools constructed without the artificial cover. Whitewater park designers might consider incorporating cover for fish into the design of overpour structures. For example, open-ended, 4 – 6 inch diameter PVC piping could be placed into the cement structure, creating artificial caves. This

would encourage fish to use cover within the pool area, instead of leaving the pool, when whitewater boaters are present. To determine if trout use this type of artificial cover, snorkel surveys could be conducted after whitewater park construction is complete.

3) Consider placing attractive signs in parking areas or along the river, to educate whitewater boaters, fishermen, and other users about ecology of the site and minimum impact skills.

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Research and Professional Experience:

Ms. Claire C. McGrath has seven years experience conducting aquatic habitat inventories and salmonid distribution studies as a graduate research assistant and a consulting biologist in the Rocky Mountain and Pacific Northwest regions. She is experienced in various standard techniques for stream reach inventory, channel stability evaluation, Rosgen stream channel classification, Hankin-Reeves inventory, and snorkel and electrofishing surveys for describing salmonid distribution.

Presently, Ms. McGrath is a doctoral candidate at the University of Colorado, where she investigates ecological interactions between native and non-native trouts in streams in the Rocky Mountains. In her current research, Ms. McGrath works cooperatively with the U.S. Fish and Wildlife Service, the National Park Service, and the Colorado Division of Wildlife. Her primary research interest is the quantification and mitigation of anthropogenic disturbances to river ecosystems. Specific interests include geomorphologic and ecological effects of hydrologic alteration, invasive species ecology, and fisheries management.