**Introgressive hybridization between coastal rainbow trout and stream-type steelhead >1,000 miles from the sea**

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**ABSTRACT**

**INTRODUCTION**

Harvest restrictions, habitat restoration, and stocking of hatchery-reared fishes are three primary tools used in conventional fisheries management. Currently there are at least 809 hatchery facilities in operation in the United States (Trushenski et al. 2018), and different hatchery programs are initiated to address a variety of potential management objectives. For example, conservation hatcheries are typically focused on preserving gene pools and recovering wild populations whereas production hatcheries are geared towards efficiently producing large numbers of fish to increase recreational harvest opportunities (Trushenski et al. 2010). Among other things, hatchery stocked fish can help to offset losses due to harvest, overcome habitat limitations (e.g., lack of suitable spawning habitat), and create recreational fishing opportunities (Noble 1986). Despite the many documented benefits of hatchery programs, hatchery-reared fish may negatively interact with native fishes, through processes such as hybridization (Naish et al. 2007).

Rainbow trout (*Oncorhynchus mykiss*) is the most widely introduced fish species globally and has been introduced into 99 countries (Crawford and Muir 2007) and outside of their native range within North America (Fausch 2008). Declines in native fishes and aquatic taxa have been documented in many waters into which introduced populations of rainbow trout have become established (Fausch 2007 and references therein; Ellender and Weyl 2014). Negative ecological interactions between introduced rainbow trout and native species could include predation, competition, disease transfer and hybridization (Gozlan et al. 2010). Hybridization between rainbow trout and native salmonids (hereafter genetic introgression) can be particularly problematic as genetic dissimilarities between stocks can decrease fitness and potential long-term survival of native salmonids (Muhlfield et al. 2009). Specifically, the disruption of co-adapted gene complexes (Hallerman, 2003; Naish et al., 2007), introduction of maladaptive phenotypes (Bolstad et al. 2017), and increased susceptibility to disease (Currens et al. 1997) may arise due to genetic introgression potentially reducing fitness, resiliency, and adaptive potential in native populations.

The Salmon River in Idaho as well as other tributaries of the Snake River basin support native populations of a migratory rainbow trout known as steelhead. Historically, the Snake River basin produced large runs of steelhead; however, returns dropped precipitously in the early 1980s (Copeland et al. 2017), and the Snake River basin steelhead distinct population segment (DPS) was listed as threatened under the Endangered Species Act in 1997 (NMFS 1997). Extensive habitat restoration efforts have been initiated in the tributaries of the Upper Salmon River to increase the abundance of steelhead populations (REFS). In the Lemhi River in particular, co-managers have identified insufficient stream flow, loss of access to historically important tributary habitat, and mainstem habitat simplifications as primary factors leading to decreased abundance and productivity of steelhead (REFS). A series of restoration projects have been initiated to address these varied objectives, and associated with these efforts, extensive monitoring has been conducted in the Lemhi River to track steelhead abundance and productivity. In the late 1960s and early 1970s, non-resident rainbow trout (presumably fertile) were stocked into the Pahsimeroi River and nearby Lemhi River (IDFG stocking records database), but to date, no work has examined whether populations of rainbow trout have persisted in the area or whether there has been genetic introgression between rainbow trout and native steelhead.

The objectives of this study were to analyze the genetic ancestry of juvenile and adult *O. mykiss* captured from the Lemhi River and its tributaries and assess whether signatures of introduced rainbow trout are present in the system. To address these questions, we genotyped a combination of adults sampled at weirs and juveniles collected via electrofishing and rotary screw traps and compared these fish to known reference populations (e.g., coastal rainbow trout as well as steelhead hatchery broodstock from the Snake River basin).

**METHODS**

Within the Lemhi River, genotype data was generated from 860 O. mykiss captured between 2009 and 2013. Samples were from 1) adults collected at tributary weirs (Table 1), 2) juveniles at rotary screw traps (Table 2), and 3) mixed life-stages collected during roving electrofishing surveys throughout the Lemhi River drainage (Table 3).

*Collections*

Table 1: Adult (putative) steelhead collections from tributary weirs in the Lemhi River drainage. The stream, collection year, collection code, number sampled, and number successfully genotyped for each collection are shown.

**RESULTS**

**DISCUSSION**

**ACKNOLWEDGEMENTS**

**LITERATURE**

The term ‘wicked problems’ was coined to describe conflicts associated with the management of introduced species, wherein no single, straight-forward management solution is feasible (Haubold 2012). Put another way, introduced species may provide a clear social or political benefit (e.g., creating an economically important fishery) while simultaneously posing a biological or conservation risk. The wicked nature of the problem is then a need to balance the conflicting needs or desires of different stakeholders. Rainbow trout (*Oncorhynchus mykiss*) have been classified as a conflict species (Woodford et al. 2016); the species has been introduced into 99 countries worldwide (Crawford and Muir 2007) as well as outside of their native range within North America (Fausch 2008) and have elicited declines in native fishes and aquatic taxa in every continent into which they have become established (Fausch 2007 and references therein; Ellender and Weyl 2014).

The management of introduced rainbow trout is complicated in regions where they form the basis for recreational opportunities (Ellender et al. 2014).