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Within-stream release-site fidelity of steelhead trout from Lake Erie hatchery stocks

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ABSTRACT

Straying of salmonids in Lake Erie is not well understood despite the economic importance of these recreational fisheries, which are sustained by stocking approximately 2 million steelhead trout (*Oncorhynchus mykiss*) yearlings annually. The occurrence of straying in hatchery-reared salmonid populations can be influenced by stocking strategies, such as within-stream stocking location. Conneaut Creek provides a unique opportunity to evaluate the extent of release-site fidelity of adult steelhead trout from Lake Erie, because it is equally stocked by Ohio and Pennsylvania at different distances from the stream mouth. Adult steelhead trout were collected from two Conneaut Creek sites, Conneaut Ohio (2 km from Lake Erie) and Albion Pennsylvania (61 km from Lake Erie), in spring and fall of 2009. Elemental signatures of yearling otoliths measured by laser-ablation-inductively-coupled-plasma-mass-spectrometry were used to identify hatchery stocks. The state-specific hatchery stocks were identified with high confidence using discriminant analysis (Sr and Ba concentrations in nine otolith regions; Ohio 100.0%, Michigan 86.1%, New York 92.4%, and Pennsylvania 93.2% using jackknifed mean correct assignment). Adult steelhead trout (N = 174) collected in spring and fall at Conneaut Ohio included both Ohio and Pennsylvania-stocked fish, but no Ohio-stocked steelhead trout were collected at the Pennsylvania site in either season. Of the classified adult steelhead trout, 13.8% were identified as strays from other states (New York and Michigan). These results confirm strong release-site fidelity between Ohio and Pennsylvania stocked steelhead trout and provides fishery managers with sound scientific data to refine their stocking practices.

Introduction

Steelhead trout (*Oncorhynchus mykiss*) is the migratory, potamodromous or adfluvial, life-history variant of rainbow trout in the Great Lakes (Daugherty et al., 2003) that was introduced during the late 1800s for sport fishing (MacCrimmon and Gots, 1972). While adult steelhead trout in the Great Lakes return to spawn in tributaries after 1–4 years in the lake (Seelbach, 1993), successful reproduction and recruitment are dependent on several tributary conditions, such as water velocity, minimum water depth, and temperature (Nielsen et al., 1994; Richter and Kolmes, 2005). Of these requirements, temperature is arguably the most critical factor limiting successful natural reproduction in Lake Erie tributaries. Many Lake Erie tributaries are designated "warmwater habitats" or "seasonal salmonid habitats," meaning these streams are capable of supporting use by salmonids from October to May, but not year-round (Ohio Environmental Protection Agency, 2008). Thus, little successful natural reproduction occurs in most Lake Erie tributaries (Thompson and Ferreri, 2002), and the fishery must be sustained by stocking, primarily from state hatchery systems. As such, 2 million yearling steelhead trout (Kelch et al., 2006; Ohio Division of Wildlife, 2008), are stocked in Lake Erie tributaries annually by Pennsylvania (55%), Ohio (25%), New York (15%), and Michigan (5%).

Salmonid smolts have sensitive periods for imprinting (Lema and Nevitt, 2004). If stocking of hatchery-reared fish occurs before this imprinting period (i.e., some small fish have not started smoltification), and the imprinting period is disrupted (Dittman and Quinn, 1996), then the potential for straying by spawning adults may increase. Average travel times for emigrating steelhead trout smolts are 0.3–0.8 km/h (Manning et al., 2005; Melnychuk et al., 2007, 2010), but faster average travel times (2.5 km/h) have been observed during high stream flow (Melnychuk et al., 2010) or during nocturnal migration (Brege et al., 1996; Newcomb and Coon, 1997). Thus, stocked yearling steelhead trout could leave a stream prior to imprinting (Daugherty et al., 2003), especially when stocking occurs near the river mouth (e.g., <2 km upstream) and during episodic spring freshets. With variable conditions causing short residence time for stocked hatchery yearlings to imprint on their release

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tributary, straying rates of adult steelhead trout may be greater in Lake Erie tributaries than in other systems.

Within streams, Seelbach et al. (1994) found that a majority (77%) of adult steelhead trout, stocked as yearlings in southern Lake Michigan tributaries (similar in environmental conditions to some Lake Erie tributaries), were collected at their stocking site. Release-site fidelity has been observed in other systems (Dittman et al., 2010; Quinn, 1993; Quinn et al., 1989), and it may be affected by residence time and other factors, similar to straying among tributaries. In Lake Erie tributaries, where stocking of yearlings occurs near a river mouth, the extent of upstream movement by spawning adults may be limited, thus constraining fishing opportunity throughout available habitat.

Understanding the factors affecting adult fidelity (i.e., smolt imprinting) could improve the benefit:cost relationship for state natural resources agencies, and cause assessment of hatchery practices to be based on end product (i.e., returning adults) rather than numbers of yearlings stocked. Here, we used standard stocking practices by Ohio and Pennsylvania in a single stream to address the effects of stocking location on adult (non-yearling) steelhead trout distribution of these stocks within the stream, and we identified the extent of straying by adult steelhead trout from other state-hatchery systems. First, we identified state-hatchery specific chemical signatures in fish otoliths (using discriminant analyses) and then we used these to quantify the within-stream distribution and straying by adult steelhead trout.

Otolith chemistry has proven to be an effective way to discriminate stocks originating in distinct geographical locations (Barnett-Johnson et al., 2008; Kennedy et al., 2002; Thorrold et al., 1998; Walther et al., 2008), and has also been successfully used in systems that are entirely freshwater to distinguish trout stocks (Coghlan et al., 2007; Wells et al., 2003). Techniques such as laser-ablation-inductively-coupled-plasma-mass-spectrometry (LA-ICPMS) can be used for analyzing sections of otoliths, allowing the detection of small-scale differences in otolith signatures (i.e., temporal changes in hatchery water sources; see review in Elsdon et al., 2008). Although otolith trace element chemistry is primarily affected by water chemistry, it is also influenced by other environmental factors such as water temperature (Elsdon et al., 2008). A major advantage of employing otolith chemistry is that it allows entire fish populations, or hatcheries, to be identified without artificially marking each individual. However, for otolith chemistry to be an effective tool in differentiating fish stocks, the otolith chemical signatures must be unique among stocks.

The process of raising steelhead trout is well-understood and mechanized to maximize growth and survival. Steelhead trout hatcheries need water sources that remain at relatively constant, cool temperatures to optimally raise steelhead trout. Thus, hatchery managers use various water sources throughout the year to maintain these thermal conditions. Most hatcheries rely on combinations of groundwater wells and spring-fed streams whose contribution to raceways are adjusted seasonally but are consistent from year-to-year to optimize temperature for the fish (state fish hatchery managers, personal communication). In addition, the use of different water sources within a hatchery that have varying ratios of elements can generate consistent elemental patterns in otoliths (Table 1), thus providing an ideal scenario for developing unique, discernable otolith microchemistry signatures for fish reared in Lake Erie hatcheries. Significant differences in Sr concentrations among otolith regions from rainbow trout in the Colorado and Wyoming hatchery systems have been employed to identify specific hatcheries (Gibson-Reinemer et al., 2009). We employed a similar approach to distinguish steelhead trout yearlings stocked into Lake Erie from four state hatchery systems; then, we quantified the effects of within-stream stocking location (i.e., river mouth versus upstream) on the proportions of Ohio- and Pennsylvania-stocked fish between sites across two seasons.

Table 1
Water chemistry for state hatcheries that stock steelhead trout into Lake Erie.

Hatchery	Element				
	Sr (ppb)	Ba (ppb)	Ca (ppm)	Sr:Ca	Ba:Ca
Castalia, OH	7100	90	392	18.1	0.2
Linesville, PA	140	405	39	3.6	10.4
Tionesta, PA					
Tubbs Run	44	199	11	4.0	18.1
Raceway	69	266	23	3.0	11.6
Hatchery influent	68	209	23	3.0	9.1
Hatch house	75	282	23	3.3	12.3
Fairview, PA					
Raceway	129	124	53	2.4	2.3
Trout Run	123	112	51	2.4	2.2
3-C-U, PA private					
Mission Raceway	91	118	61	1.5	1.9
Mitchell Raceway	145	154	87	1.7	1.8
Salmon River, NY					
Well source	33	145	18	1.8	8.1
River source	31	149	17	1.8	8.8
Wolf Lake, MI					
Well #4	155	172	45	3.4	3.8
Well #5	149	262	47	3.2	5.6
Well #6	116	257	44	2.6	5.8
Well #7	148	252	47	3.1	5.4
Spring source	44	470	48	0.9	9.8

Additionally, we determined the extent of straying by steelhead trout from other state hatchery systems.

Methods

Stocking in Conneaut Creek

Conneaut Creek is a Lake Erie tributary that is stocked annually by two states (Ohio and Pennsylvania). Stocking occurs at markedly different stream distances from the lake (2 km in Ohio and 69 km in

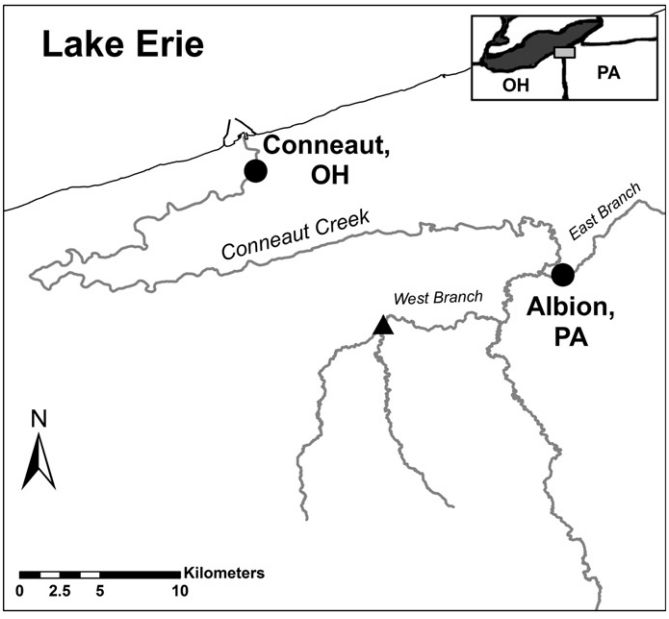

Fig. 1. Map of adult steelhead trout stocking and sample collection locations on Conneaut Creek. Circles (●) indicate where collections were taken at Conneaut Ohio (stream distance 2 km) and at Albion Pennsylvania (stream distance 61 km; 1 km upstream from the confluence of east branch and Conneaut Creek). Each location was sampled in both the spring and fall 2009. Triangle (▲) indicates Pennsylvania stocking location (stream distance 69 km), Ohio stocking location is the same site as collection location.