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Evaluating landowner-based beaver relocation as a tool to restore salmon habitat

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ABSTRACT

Relocating American beavers (*Castor canadensis*) from unwanted sites to desirable sites (i.e., where damage exceeds stakeholder capacity) has been posited as a method to enhance in-stream habitat for salmonids in the Pacific Northwest region of the US; however, no studies have evaluated this method. From September–December 2011, we trapped and relocated 38 nuisance beavers using guidelines available to Oregon landowners. Release sites were selected from models that identified high values of beaver dam habitat suitability and where dams would increase intrinsic potential of coho salmon (*Oncorhynchus kisutch*). Mean distance moved from release sites within 16 weeks post-release was 3.3 ±0.2 (SE) stream km (max 29.2 km). Mean survival rate for relocated beavers was 0.47 ±0.12 (95% CI: 0.26–0.69) for 16 weeks post-release, while the probabilities of an individual dying to predation or disease/illness during the same period were 0.26 (95% CI: 0.09–0.43) and 0.16 (95% CI: 0.01–0.30), respectively. Dam construction was limited and ephemeral due to winter high flows, providing no in-stream habitat for coho. We conclude beaver relocation options available to landowners in Oregon may not be an effective option for stream restoration in coastal forestlands due to infrequent dam occurrence and short dam longevity.

1. Introduction

The decline of Pacific salmon populations has prompted efforts to identify factors affecting fish survival. In western Oregon, overwinter-rearing habitat was identified as the leading factor limiting recovery of coho salmon (*Oncorhynchus kisutch*; Nickelson et al., 1992a, ODFW, 2007),an anadromous fish species given federal protection under the Endangered Species Act. Overwinter stream habitat in Coastal Oregon is affected by fluctuations in stream velocities, resulting from high flow events (Nickelson et al., 1992a; Leidholt-Bruner et al., 1992). Slow moving stream micro-habitat creates shifts in macro-invertebrate abundance and community structure, providing fish foraging opportunities that are uncommon in less diverse stream sections (Pollock et al., 2004). In addition, low stream velocity allows fish to expend less energy for foraging (Pollock et al., 2003, 2004). Anthropogenic projects that place large woody debris and boulders in streams, and create

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channel alcoves, have been used to create pool habitat in coastal streams; however, projects are expensive (Leidholt-Bruner et al., 1992; MacCracken and Lebovitz, 2005; DeVries et al., 2012) and have had limited detectable effect on coho salmon recovery (Nickelson et al., 1992b; Solazzi et al., 2000).

In the Pacific Northwest, American beavers (*Castor canadensis*, hereafter beavers) co-exist with several anadromous salmonids, including coho. Ponds created by beaver dams create in-stream structure, resulting in greater aquatic productivity than reaches not dammed by beavers (Leidholt-Bruner et al., 1992; Snodgrass and Meffe, 1998; Collen and Gibson, 2001; Kemp et al., 2012). In general, beaver ponds are highly productive for fish as a result of high edge-to-surface ratios, presence of vegetation within and near the stream, and high abundance of prey (Collins, 1993; Pollock et al., 2004). High water retention from dams prolongs periods of low flow, providing areas of refuge for fish (Leidholt-Bruner et al., 1992). Reductions in winter habitat for coho smolts were observed at the Stillaguamish Basin in Washington, and attributed to loss of beaver ponds (Pollock et al., 2004). Similarly, overwinter survival and growth of coho smolts in the Copper River Delta of Alaska were positively correlated with the occurrence of beaver ponds (Lang et al., 2006). In coastal Oregon, coho fry were three times more abundant in beaver-created habitat than in pools created by other fluvial processes (Leidholt-Bruner et al., 1992). However, beaver dams in the Coast Range are primarily small and ephemeral, with few withstanding high water flows (Maser et al., 1981; Leidholt-Bruner et al., 1992).

Pollock et al. (2004) suggested an increase in beaver population size may increase availability of pool habitat for coho smolts. Others have recommended managing for beavers or mimicking their dam-building behavior to augment in-stream complexity (Finnegan and Marshall, 1997; DeVries et al., 2012). Recent changes in legislation of some western states now allow landowners to relocate beavers as a management tool (ODFW, 2012, RCW 77.32.585, UDWR, 2010). We used the Oregon Department of Fish and Wildlife's Guidelines for Relocation of Beaver in Oregon (ODFW, 2012), hereafter state guidelines, as a basis for this study. At the time of this study, no state or federal programs were relocating beavers in western Oregon. Thus, we assumed that if state guidelines were used, it would be a citizen-lead program.

Ours is the first study to evaluate beaver relocation as a tool for improving in-stream habitat for salmon. We use the term "relocation" defined by Fischer and Lindenmayer (2000) as "any intentional movement by humans of an animal or a population of animals from one location to another". Our objectives were to examine post-release rates of survival and cause-specific mortality, and movement of relocated beavers; and evaluate enhancement of coho rearing habitat through dam construction. Our measure of relocation success was construction and persistence of beaver dams at release sites, as dams are potentially important to coho rather than the presence of beavers alone. Although beavers chosen for relocation in this study were taken from areas of human-wildlife conflict (i.e., nuisance beavers), conflict resolution was not an objective or a measure of success.

2. Methods

2.1. Study area

We conducted this study in the Alsea River Basin of the central Oregon Coast Range (Fig. 1). The Alsea River drains into the Pacific Ocean, near the town of Waldport. The basin is approximately 1213 km^2 and consists of 4 sub-basins: North Fork Alsea River, Five Rivers/Lobster Creek, Drift Creek, and the South Fork Alsea River. Elevation ranges from sea level to 1249 m. Average annual precipitation is 203–254 cm near the coast and 203–356 cm in higher elevations (WRCC, 1990). Most precipitation occurs as rainfall during winter. Approximately 93% of the Alsea Basin is forested and ownership of forestlands includes US Forest Service (39%), Bureau of Land Management (24%), private industrial landowners (23%), private non-industrial landowners (13%), and state (<1%). The forest matrix is dominated by Douglas-fir (*Pseudotsuga menziesii*) and common co-dominant species include western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), red alder (*Alnus rubra*), and bigleaf maple (*Acer macrophyllum*). Understory vegetation is dominated by salmonberry (*Rubus spectabilis*), elderberry (*Sambucus racemosa*), indian plum (Oemleria cerasiformis), stinking currant (*Ribes bracteosm*), red huckleberry (*Vaccinium parvifolium*), vine maple (*Acer circinatum*), and sword fern (*Polystichum munitum*). Coho salmon in the Alsea River Basin are part of the Coastal Coho Salmon Evolutionarily Significant Unit, which is an ESA-listed threatened species (ODFW, 2007). In Oregon, the beaver population is considered abundant and healthy (Hiller, 2011), although persistent beaver dams (lasting $\geq$ 1 yr) are infrequent in the Coast Range.

2.2. Release site selection

Poor habitat conditions at release sites affect survival and reduce relocation success (Armstrong and Seddon, 2008; Moorhouse et al., 2009). We mapped and characterized potential release sites in ArcGIS (version 9.3; ESRI, Redlands, California, USA) using data associated with a 10-m digital elevation model (Clarke et al., 2008) and two other models developed from data representative of our study area. These models were used to identify sites where beavers were most likely to establish dams (Suzuki and McComb, 1998) and where dams were most likely to provide high-quality in-stream habitat for coho salmon (Burnett et al., 2007). Site selection criteria and methodology are discussed in detail in Petro (2013). We surveyed for beaver activity 1 km upstream and downstream of each potential release site, which represents the minimum distance