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Initial Assessment of Natural Hybridization Between Steelhead (*O. mykiss*) and Coastal Cutthroat Trout (*Oncorynchus clarkii clarkii)*

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Background

Coastal cutthroat trout (*Oncorhynchus clarkii clarkii*) and Rainbow Trout/steelhead (*O. mykiss*) are sister taxa. The two trout's natural geographic distribution overlaps in coastal watersheds in the Pacific Northwest (see Figure 1 for CCT distribution) and have been observed to hybridize "naturally" (see Box 1 for definition) creating viable F1 offspring (Campton and Utter, 1985).

In interior watersheds of the western United States, where Cutthroat Trout are present and *O. mykiss* are introduced hybridization is considered a risk to Cutthroat Trout populations.

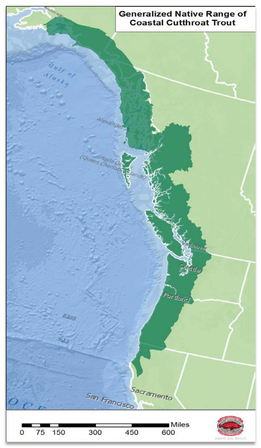

Figure 1. The generalized geographic distribution of Coastal Cutthroat Trout.

Box 1. Definition: "Natural hybridization" occurs when two taxonomically distinct organisms with overlapping distributions interbreed when their pre and post-mating isolating mechanisms break down.

Figure 2. In general, Coastal Cutthroat Trout spawn in small headwater streams that are higher in the watershed than steelhead spawning streams.

Hybridization of Coastal Cutthroat Trout and Rainbow Trout/steelhead is a more complicated in coastal watersheds because the two species naturally co-occur. Pre and post-mating isolating mechanisms have been identified (see Fig. 2 and Box 2), but hybrids are still observed throughout the distributional range of Coastal Cutthroat Trout. Within streams **estimates as high as 85% hybrids** have been reported. Despite decades of study on Coastal Cutthroat Trout and Rainbow Trout/steelhead hybrids many uncertainties remain.

In this poster we invite discussion regarding what we know and don't about hybrids and how they may or may not influence the management and conservation of either species.

State of Our Knowledge

In some cases, Coastal Cutthroat Trout and *O. mykiss* hybrids can be identified by morphology. Hybrids tend to have intermediate characteristics including body shape, morphological features, and swimming behavior.

In steelhead, the maxillary does not extend past the back margin of the eye, hyoid teeth are absent, and there is no jaw slash. In Coastal Cutthroat Trout, the maxillary extends past the margin of the eye, hyoid teeth are present, jaw slashes are visible. Hybrids have a combination of cutthroat trout and steelhead characteristics

Photo courtesy of Oregon State University

Figure 3. Coastal Cutthroat Trout (left) and steelhead (right) are closely related. Hybrids are characterized by intermediate features that include morphology and other traits such as swimming ability.

Box 2. Pre and post-mating isolating mechanisms for Coastal Cutthroat Trout and *O. mykiss:*

In general, spawning locations differ in space and time (Fig. 2).

Behavioral mechanisms such as sexual selection break down (i.e. Coastal Cutthroat Trout male sneaking behavior during spawning) resulting in higher male Coastal Cutthroat Trout and female steelhead crosses (Ostberg et al. 2004).

Post-zygotic mechanisms appear to play a role in limiting introgression (Rizza 2015).

Hybrid swarms and F1 adults are less common that previously thought suggesting reduced fitness in hybrids (see Moore et al. 2010 for reduced fitness in marine migrations of hybrids).

Morphological features tend to be highly variable and even experienced biologists can misclassify the species (Fig. 4). Kennedy et al. 2009 reported that this may impact population estimates for Coastal Cutthroat Trout and steelhead.

Kennedy et al. 2009 found that 11% of the hybrids were misclassified as steelhead and 42% of the hybrids being misclassified as cutthroat trout.

State of Our Knowledge

Campton and Utter (1985) were the first researchers to identify hybrids with genetic tools, and since then, numerous other researchers have advanced our knowledge using genetic tools to better understand the issues of hybridization.

Figure 4. Identifying Coastal Cutthroat Trout/steelhead hybrids in the field remains a challenge. Photo courtesy ODFW.

Genetic verification can help us better understand how commonly hybrids occur within populations. Costello (2006) detected hybrids in populations believed to be occupied solely by Coastal Cutthroat Trout (and used strict protocols to sample only putative pure populations). He concluded that background levels (estimated at 9%) of hybridization were higher than previously reported.

Williams et al. (2007) found high levels of hybridization present in locations in Alaska with little anthropogenic activity. Together these studies suggest that hybridization is widespread, but isn't necessarily linked to human activity or anthropogenic impacts.

Insights from the Coastal Cutthroat Trout Assessment

The Pacific States Marine Fisheries Commission and the Coastal Cutthroat Trout Interagency Committee completed workshops for a status assessment of the subspecies in late 2017. One of the assessment questions for participants was whether Coastal Cutthroat Trout/steelhead hybrids were suspected or verified within a given assessment unit (sixth, fifth, or fourth level HUC). The question was not designed to gather quantitative information but instead to better understand the perspectives and attitudes of biologists as well as document the genetic verification studies. A literature review was conducted to expand our findings and complete results will be available in late 2018.

a) SE Alaska workshop results.

b) Lower Columbia workshop with information source in pop-up box.

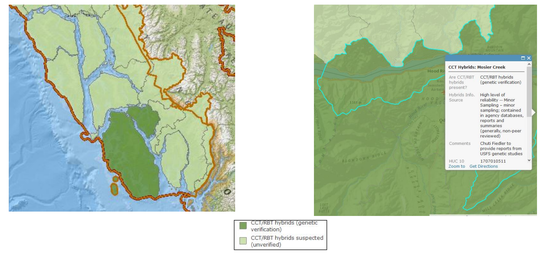

Figure 5. Left panel a) - Biologists in SE Alaska workshops responded that hybrids were suspected throughout the region (light green) but only verified on Prince of Wales Island (dark green). Right panel b)- Biologists from the Hood River reported that the incidence of hybrids was so high verification is used as part of their protocol to identify Coastal Cutthroat Trout. The information source is depicted in a pop-up and will help the assessment team document and analyze results.

Biologists and researchers reported that hybridization was suspected where Coastal Cutthroat Trout and *O. mykiss* are sympatric (Fig. 5). In general, participants responded that hybrids were suspected but that genetic verification tended to be opportunistic and was based on funding and the cooperation of partners (with the exception presented in Fig 5 b). Interestingly, in some locations participants responded that "no hybrids were suspected' (responses not shown). This response was supported by statements "that there appeared to be no morphological intermediate types".

In our final analysis we will examine a number of questions related to hybridization between Coastal Cutthroat Trout and *O. mykiss* and the practical significance for monitoring, management, and conservation.

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Acknowledgments

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For further information

Visit the Coastal Cutthroat Interagency Committee website
http://cct.psmfc.org

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