Studying reintroduction of bull trout with simulations

March 28 2019, by Rasha Aridi

The Boundary Dam, downstream from the study site, generates a third of Seattle's energy on average. The dam is pictured here in June 2014 discharging approximately 90,000 cubic feet of water per second. Photo courtesy of Meryl Mims. Credit: Meryl Mims, Virginia Tech

A multi-institutional team of researchers, led by Meryl Mims, has assessed how environmental, demographic, and genetic factors play a role in the reintroduction of bull trout in Washington State.

Their project is one of the first to use an advanced computer model to simulate the genetic and demographic outcomes of the reintroduction by projecting 200 years into the future.

"This is a study that was really driven by a policy need to understand how management actions might influence a species in the future and what the range of outcomes would look like," said Mims, an assistant professor in the Department of Biological Sciencesin the College of Science. "This was a unique opportunity to use computer simulations to understand how a species—in this case, bull trout—may respond to changes in its habitat."

Their collaborative work was published in *Ecosphere* in February and has been five years in the making.

The reintroduction of species can be expensive and resource-intensive, and is not always successful, either. Due to declining or extirpated populations, in part because of habitat fragmentation, the bull trout, Salvelinus confluentus, was listed as threatened under the Endangered Species Act in 1999. The species' natural range extends from the Pacific Northwest to western Canada.

Mims and her team developed a framework to evaluate the reintroduction of aquatic species, focusing their efforts on the spatial, demographic, and genetic factors of reintroducing the bull trout to three watersheds of the Pend Oreille River system in northeastern Washington State.

"It was extremely encouraging for me to be part of this collaboration where stakeholders, scientists, and managers were willing to share data and really support this effort, which was driven by everyone wanting the best available science," said Mims, an affiliated faculty member of the Global Change Center, housed within the Fralin Life Science Institute.

There are five hydroelectric dams on the Pend Oreille River between the U.S. and Canada. Downstream of the study system, the 340-foot Boundary Dam generates approximately 46 percent of the power produced by Seattle City Light. However, the dams can create major disturbances as aquatic species are unable to make their way upstream and past dams. For many species, movement is critical to their life history.

Bull trout persist in metapopulations—groups of the same species separated by space. Movement of individuals between populations is critical to the persistence of metapopulations. Local extinction can occur in an area due to a multitude of reasons, but the recolonization of unoccupied patches is important for the persistence of the species. Dams and culverts threaten the ecosystem's connectivity by isolating populations and reducing the likelihood of recolonizations.

Erin Landguth, a computer scientist at the University Montana studying how wildlife populations interact with the landscape, created CDMetaPOP to understand the complexities of how species such as bull trout interact with their landscapes. The team used a wide variety of parameters, including demographic information, vital rates, a map of the landscape, empirical genetic data, and movement data to project bull trout populations 200 years into the future.

"One of the powerful things with a simulation like this is that, for many reasons, we often cannot do empirical studies where we are able to validate the studies on the ground," Mims said. "We're interested not only in how things are responding in the next decade or two, but also in the probability of long-term persistence."

The simulation gave insight as to what needs to be done for a successful reintroduction of bull trout. The researchers asked: If a reintroduction were to take place, is there a difference in repopulating with a genetically diverse or a similar group of trout? By tracking neutral genetic variation, the team found that the original genetic stock is not significant when studying 200 years into the future. The key to persistence, they found, is connectivity and the availability of habitat. The metapopulation structure allows for bull trout to access unoccupied patches. As a result, sufficient movement of genes between populations, called gene flow, is likely to maintain genetic variation.

"With what we know about the species, given its biology and the inputs that we provided for the model, there are scenarios in which the species will persist so long as connectivity is sufficiently high in the system. The river system looks like a good place to potentially reintroduce the species," Mims said. "That was really encouraging."

The study system is already seeing major changes. Improvements include removal of barriers, such as Mill Pond Dam in 2018, and adding fish passages to dams and culverts to allow for upstream movement and to control non-native species that compete with or prey on native wildlife. Many of these improvements and changes are in response to requirements by the Federal Energy Regulatory Commission to relicense big hydroelectric dams, like the Boundary Dam, owned and operated by Seattle City Light utility company.

"CDMetaPOP is already being used for other species and applied wildlife management questions—not just in freshwater ecosystems, but for terrestrial species, as well. I expect that these types of approaches, and CDMetaPOP in general, will continue to be extremely valuable tools," Mims said.

However, simulations need reliable data as inputs. For many species, not enough is known about their natural history to be able to develop a complex simulation.

Mims is still in collaboration with her team, and they plan to continue their research to further understand the specifics of connectivity, its long-term implications, and the effects of fish being able to move freely through dams and culverts.

Researchers are also interested in the challenges brought on by climate change. As temperatures increase due to climate change, aquatic species tend to move upstream to cooler waters. With dams and culverts preventing them from doing so, aquatic species are unable to access these cool water locations which would support their populations. This can pose further problems for the decline of species and their possible reintroduction.

This research is an example of a successful, multiyear collaboration. Mims met her co-authors through the Landscape Genetics Distributed Graduate Seminar as a graduate student, and they have since developed this collaboration to engage stakeholders, Seattle City Light, federal agencies, and graduate students. Seattle City Light and West Fork Environmental provided field data, while the Kalispel Tribe, indigenous to the area, collected genetic samples.

More information: *Ecosphere* (2019). esajournals.onlinelibrary.wile … ll/10.1002/ecs2.2589

Provided by Virginia Tech

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