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Science FINDINGS

INSIDE

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"Science affects the way we think together."
Lewis Thomas

Location, Location, Location: For Coho Salmon, It's All About the Neighborhood


Kristin Kirkby

Juvenile coho salmon (Oncorhynchus kisutch) and rainbow trout (O. mykiss) in a pool with cobble substrate in a stream in the Oregon Coast Range. Pacific salmon need different types of freshwater habitat depending on the season and their life stage.

IN SUMMARY

For decades, federal, state, and nonprofit organizations have been working to restore freshwater habitat for Oregon coastal coho salmon (Oncorhynchus kisutch), a species listed as threatened under the federal Endangered Species Act. Much of the restoration, however, has been done without directly considering the availability and connectivity of seasonally important freshwater habitats.

Research by Rebecca Flitcroft, a research fish biologist with the U.S. Forest Service Pacific Northwest Research Station, and colleagues reveals that connectivity among different types of freshwater habitat is important for coastal coho salmon. In fact, salmon occupancy in rivers or streams over time is best explained by the level of connectivity among habitat used for spawning, summer rearing, and winter refuge. Juvenile fish benefit when they can move easily among these habitat types.

Restoration projects that focus on only individual habitat segments may not result in watershed-scale improvements. Targeted restoration that fills habitat gaps may be more effective when diversity, location, and proximity of seasonally important habitats already present in a watershed are considered.

Resource managers are using these findings to reevaluate how they think about coho salmon habitat, as well as habitat for other species such as trout and beaver.

"If it weren't for the rocks in its bed, the stream would have no song."
—Carl Perkins

Oregon coastal coho salmon (*Oncorhynchus kisutch*) have been listed as threatened under the federal Endangered Species Act (ESA) since 1998. The listing came after scientists noticed a precipitous decline not only of coho, but of steelhead and Chinook salmon as well. Their decline was triggered by factors ranging from commercial fishing and habitat degradation to a decline in oceanic food sources—possibly linked to changes in long-term climate patterns.

Freshwater habitat is critically important for all sea-run salmon. Depending on the species, adult salmon may travel hundreds of miles inland via rivers and streams to lay their eggs. Once hatched, juvenile salmon spend up to 1 year or more rearing in freshwater before migrating to the ocean. Their life cycle is complete when they return to freshwater to spawn.

The 1994 Northwest Forest Plan requires federal agencies to find ecologically sound ways to protect the long-term health of forests and wildlife in more than 24 million acres of federal land in western Washington, Oregon, and northern California. That includes protection for coho salmon. Efforts to protect and enhance salmon habitat in streams on federal land intensified when the species received federal protection under the ESA.

However, in addition to federal land, the vast network for coho salmon habitat also cuts through state, tribal, and private land. The different ownerships have different management requirements, which means that stream enhancement efforts tend to be inconsistent and fragmented. Consequently, **connectivity** among the different types of freshwater habitat used by coho salmon during various stages of life, and at different times of the year, is often overlooked.

“There’s a disconnect in the way we own and divide our land and the way fish use those landscapes,” says Rebecca Flitcroft, a research fish biologist with the U.S. Forest Service Pacific Northwest Research Station. “Fish are moving through a whole suite of land ownership areas. Their needs aren’t based on the checkerboard of land ownership that we impose upon them”.

KEY FINDINGS

- Proximity and connectivity of seasonally important coho salmon habitats—for example, habitats for adult spawning, juvenile summer rearing, and juvenile winter refuge—better explain the patterns of juvenile fish occupancy in waterways in the Oregon Coast Range than habitat quality alone.
- It is possible to predict core areas where juvenile coho salmon will be. However, juvenile coho salmon will move beyond these core areas when their populations are high or when winter stream conditions are mild enough to allow for survival in areas with otherwise limited winter rearing habitat.
- Deep-seated landslides produce a variety of stream habitats, all within a relatively short stretch of stream, that are used by juvenile coho salmon at different times of year.
- Riparian protections designed to preserve and protect coho salmon habitat are linked to the type of land ownership (federal, tribal, state, private) rather than the distribution of the species.

Different Life Stage, Different Needs

Flitcroft and her colleagues point out that salmon habitat is complex. Salmon require several types of freshwater habitat: shallow riffles with gravelly substrate for spawning, pools at least 1.5 feet (or 0.5 m) deep for juvenile summer rearing, and off-channel alcoves or similar areas that offer refuge from strong currents and turbid water brought on by runoff from winter storms. To survive, coho salmon need a connected habitat network that meets the needs of each life stage, and these core areas of habitat occupancy by juvenile coho salmon are predictable over time. Flitcroft has found that the connection among the different instream habitats may be a greater determinant of long-term population health than the quality of individual habitats alone.

Becky Flitcroft

A researcher measures the amount of water and rate at which it moves. Stream discharge measurements allow scientists to model streamflow to better understand seasonal habitats. Streamflow is a driver of habitat connectivity and of the shifts in habitat functionality throughout the year.

“We don’t usually do restoration from the perspective of seasonal habitats, but we need to,” she says.

The mix of ownerships and land uses across the Oregon Coast Range adds challenges to habitat restoration efforts. Young coho salmon must be able to move easily from the spawning habitats, to cool summer pools, and then to winter refuge areas that are outside the swift-running waters of a stream’s main channel, Flitcroft explains.

“Often in planning restoration work, we don’t look to see if spawning habitat is close to summer habitat and then close to winter habitat. But those places where habitats are available in close proximity are the places we are likely to consistently find juvenile coho salmon. It makes sense: juvenile fish don’t have the jumping and movement capability that adult fish have,” Flitcroft says.

Any kind of barrier can break up a river system. That includes culverts, dams—even small ones that are used for water intakes—or things that create a step that the fish would have to move across. A change in the velocity of the water can be a barrier for juveniles, she explains.

On the other hand, naturally occurring disturbances often have more minimal effects than do human alterations to salmon-bearing streams. Fallen logs, for example, usually don’t completely block streams, and, in fact, they can help create slow-moving pools that are prime habitat for summer rearing.

On a larger scale, deep-seated landslides have served to create some of the best collection of habitats for young fish. These large, slow-moving landslides are distinguished from smaller debris flows by their size and their long-lasting effects. They are massive enough to expose layers of earth that were deposited up to 56 million years ago. They change the slope of the land; alter the shape and velocity of rivers; form wide valleys; and, in some cases, create waterfalls and lakes. The large landslides functionally change rivers, and in so doing, create many of the elements that enhance fish-rearing habitats. And these habitats aren’t

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isolated. They form connected neighborhoods that include the variety of habitats that salmon need for spawning, summer rearing, and winter refuge.

An earlier study led by Joshua Roering, with the University of Oregon, found evidence of deep-seated landslides in as much as 25 percent of the Oregon Coast Range. Some of them occurred within the past 150 years, but most are ancient and occurred as long ago as 2 million years.

Building on this work, Flitcroft and Helen Beeson, with the University of Oregon, mapped the connectivity of coho seasonal habitat in a section of the Umpqua River basin in the central Oregon Coast Range. They compared habitat connectivity in streams that ran through terrain affected by extensive deep-seated landslides with those that flowed through terrain with uniform valley-ridge topography and no evidence of landslides. Using extensive field-study data on stream conditions, they identified distinctive habitat types and calculated the distances between them. Sections of stream in which more than one seasonal habitat type was found within specific distances of each other were deemed high connectivity reaches, and therefore likely to provide good habitat for coho salmon.

They found that the quantity of habitat types and their connectivity were greater in the areas that were highly affected by deep-seated landslides. Those areas tended to have wide valleys upstream from narrow valleys. Wide valleys provide more potential for the river to interact with the floodplain to develop side channels or other slow-water environments that are critical, and uncommon, habitats in the Oregon Coast Range.

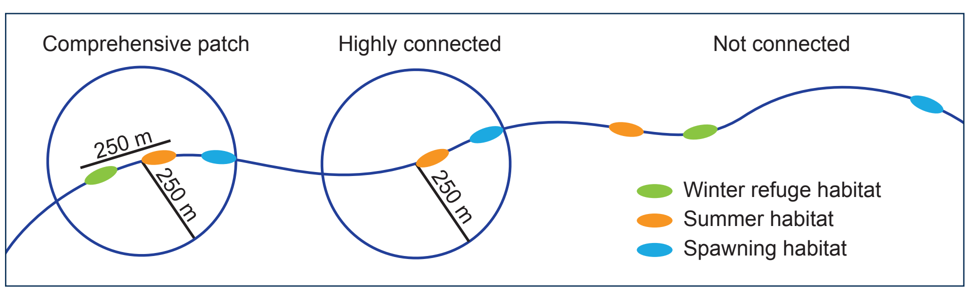
Land and fishery managers can incorporate this kind of information in their decision-making process when planning restoration projects. "Because we can map the location of deep-seated landslides and the distribution of coho salmon, this provides an opportunity for managers to possibly prioritize these areas for restoration because these locations are more likely to be able to inherently support coho habitat," Flitcroft says.

In other words, geological processes have already provided a foundation for habitat that can be used strategically. For example, working from maps of deep-seated landslides, we can assess affected waterways to determine if the three ideal habitat types are present. Waterways without all three, or where the different habitat types are not within 550 yards of one another, could highlight which types of restoration project likely would yield the most benefit for juvenile coho salmon.

Becky Flitcroft

While rearing habitat for juvenile coho salmon may be present along stream margins during low winter flows (upper image), habitat in alcoves off the main stream channel is needed for winter refuge when storm runoff floods such alcoves on the main channel (lower image).

Becky Flitcroft



The comprehensive patch of habitat in the illustration includes areas where adult coho salmon spawning habitat is close to summer and winter refuge habitats used by juveniles. Highly connected habitat includes two of the three habitat types. Comprehensive and highly connected habits were more common in stream reaches affected by deep-seated landslides compared to reaches without these landslides in the Oregon Coast Range. Adapted from Beeson et al. 2018.

Re-creating Neighborhoods

The conditions created by deep-seated landslides fit with a new broader concept of connected neighborhoods, which Flitcroft and her colleagues now use when talking about their findings with partners who plan restoration projects.

"People didn't know how fish were using these habitats in the '90s, but in the last 20 years we've learned more about the importance of headwater areas and disturbance events, such as landslides," she says.

As more people learn about these findings, she and her colleagues have gotten requests by federal land managers and the Oregon Department of Fish and Wildlife (ODFW) to learn more about habitat neighborhoods. She said this knowledge is already informing the way specific habitat restoration actions are being designed.

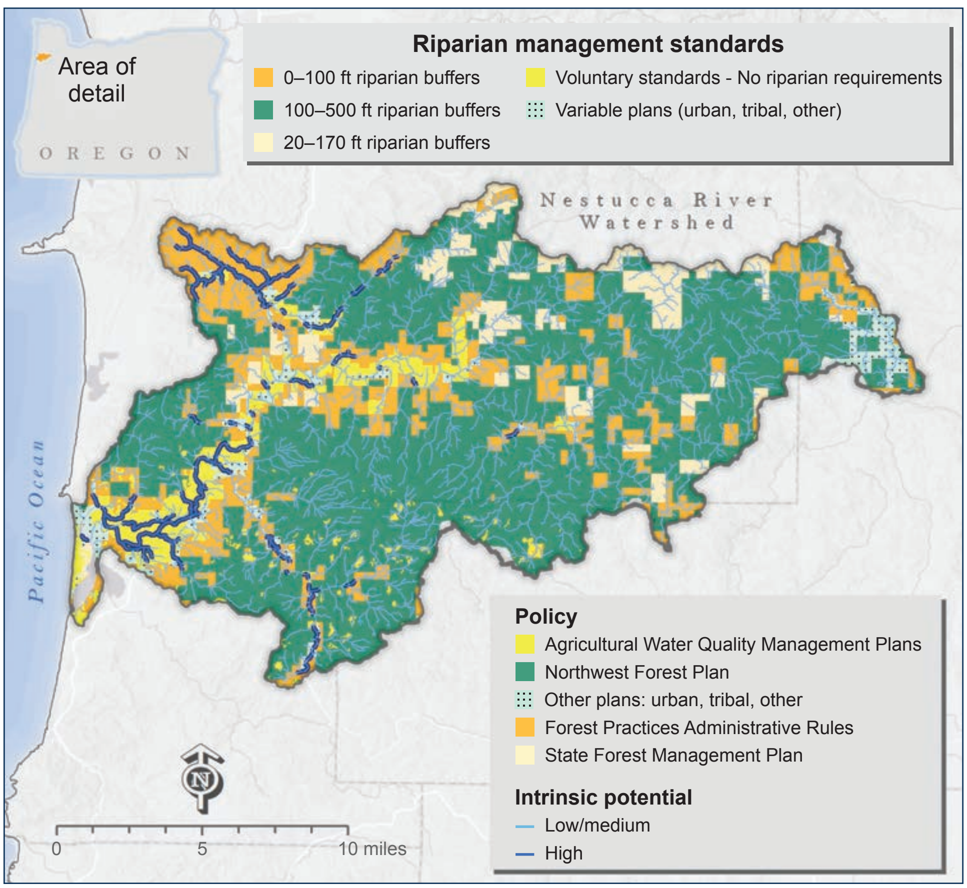
"Quite a few folks are interested. This concept of connectivity is also being picked up by our colleagues in Alaska," she says.

At the ODFW, research aquatic ecologist Kara Anlauf-Dunn is part of the Research, Evaluation, Data, Decision support (REDD) group. The group looks for innovative tools and methods for managing native fish resources and that managers can use to think about aquatic conservation.

Anlauf-Dunn says Flitcroft's research on the value of complementary habitats in proximity to one another inspired her monitoring group to conduct an analysis of their own datasets. They found similar results showing that the more connected and higher quality the habitat for juvenile salmon, the more likely adults will occupy spawning habitats nearby. "This particular work has us starting to think differently about how we monitor habitats and fish across space and through time," she says.

In Utah, Brett Roper, an aquatic ecologist at the National Stream and Aquatic Ecology Center, says the work by Flitcroft and her colleague Brett Boisjolie at Oregon State University point to the need for comprehensive, connected habitat neighborhoods, in contrast with previous approaches of, say, concentrating on summer habitat alone. The result, he said, could improve fish populations across whole basins.

"Although she has applied this concept to coho salmon on the Coast Range, it is starting to influence my ideas relative to inland cutthroat trout and beaver," he says.



A variety of ownerships and management standards are present within watersheds of the Oregon Coast Range. This results in different levels of riparian protections throughout a river network. Adapted from Boisjolie et al. 2019.

The Checkerboard Challenge

If stream habitat connectivity is important to salmon survival, the challenge lies in the checkerboard pattern of different land ownerships overlaying a watershed. When streams and their associated habitat systems run through federal, state, and private lands—each with its own set of rules and standards—it is difficult to form a coordinated effort to help the salmon.

Flitcroft and Boisjolie mapped nearly 70,000 miles of streams in the Oregon Coast Range and showed how policies for riparian standards—the standards for streamside vegetation management—changed with every river mile.

Flitcroft says their mapping of policies across the landscape is the most detailed that has ever been completed for the Oregon Coast Range and clearly shows a lack of connection between riparian protections and the intrinsic potential of streams to support populations of coho salmon. This is another example of research that ODFW's Anlauf-Dunn says is likely to help her own efforts.

"Our work is typically across ownership boundaries, and Becky and Brett's work mapping the spatial arrangement of protective policies along river networks really highlights one of the primary challenges we have had in evaluating restoration effectiveness across the landscape. I hope to use their data that maps these disparate protections in the next coho salmon review," says Anlauf-Dunn.

In the Nestucca River watershed in northern Oregon, for example, Flitcroft and Boisjolie found that federal land covered by the Northwest Forest Plan was adjacent to land governed by agricultural water quality plans, a handful of urban and tribal areas, Oregon State Forest Management Plan areas, and others. Each ownership has its own set of rules on how much streamside vegetation buffer should be preserved. The Northwest Forest Plan areas require the most: up to 498 feet. The rules for private forests ranged from 0 to 100 feet. And the rules for agricultural lands—through which 45 percent of streams with high salmon potential flowed—require no buffers at all.

Within the Oregon Coast Range, total stream length covered by any one set of riparian management policies ranged from 12 to 40 percent, setting entire watersheds up for an inconsistent pattern of riparian protection. Further, they found that watersheds containing streams with high potential to support coho salmon habitat often had gaps in their protective standards.

The problem is what to do about it. Flitcroft and Boisjolie researched all the different riparian regulations—and the lack thereof—throughout the Oregon Coast Range.

The regulatory mix illustrated the tension between the government's responsibility to safeguard public resources and the interests of private property owners who may view government regulation as a threat.

This mix of ownerships and differing regulation requirements is not unique to Oregon, or even the United States. Flitcroft and Boisjolie researched how this challenge is being addressed elsewhere.

The European Union, for example, created the Habitats Directive nearly 30 years ago to protect 220 habitats and about 1,000 species throughout the continent, at the same time attempting to address societal demands on the affected areas.

In the United States, Hawaii and California are taking special legal measures to ensure the protection of their ecosystems in similar ways. Hawaii is doing it because its ecosystem—an island chain isolated in the middle of the Pacific Ocean—relies heavily on a range of natural resources that must be preserved. California's focus is on the scarcity of its water.

In Oregon, much of the stream habitat with the highest potential to produce fish is in private hands and subject to the fewest restrictions.

Becky Flitcroft

Stream habitats for juvenile coho salmon change throughout the river network. Small headwater streams may provide critical winter habitat (above), while larger streams provide habitat throughout the year.

LAND MANAGEMENT IMPLICATIONS

- Habitat "neighborhoods" that account for the availability and connectivity of seasonal habitats may be a useful concept when developing restoration plans for coho salmon populations.
- Deep-seated landslides can affect several miles of stream and have long-lasting effects. The locations of deep-seated landslides have been mapped in the Oregon Coast Range, and such maps identify areas with high potential to support connected habitats that may then be targeted for instream restoration actions.
- Riparian protections often are placed in areas of the river network that do not contain ideal habitat for coho salmon. This reduces the potential of these protections to effectively shield or enhance habitats for these fish.

The Oregon Watershed Enhancement Board has spearheaded an effort to involve private landowners in overhauling riparian protection standards, but it is an involved process. The researchers say the most efficient way to improve and expand coho habitat—at least in the short term—is to concentrate restoration efforts in the most effective locations.

Flitcroft says that in the early years, restoration projects were often pragmatic, their location driven by funding or the presence of willing landowners. Now, with her research on the importance of connected habitats, managers have tools to make those decisions more targeted.

"Yesterday is not ours to recover, but tomorrow is ours to win or lose."

—Lyndon B. Johnson

For Further Reading

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Scientist Profile

REBECCA FLITCROFT is a research fish biologist with the Pacific Northwest Research Station. She earned her Ph.D. in fisheries science from Oregon State University. Her four primary lines of research include multiscale salmonid ecology, stream network analysis, climate change and salmonid life history, and integrated watershed management. She is particularly interested in statistical and physical representations of stream networks in analysis and monitoring to more realistically represent stream complexity and connectivity for aquatic species.

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