How much water does a steelhead need to thrive?

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In Pescadero Estuary, CITRIS researchers will implant 40 to 50 anadromous steelhead trout with acoustic tags to determine how much water they need to thrive.

Pescadero Estuary, located an hour south of San Francisco, is a coastal habitat under intense pressure from several interest groups, some human, others wild. The 643 citizens of the nearby town of Pescadero need fresh water to drink. Local farmers need irrigation water to grow crops. The wild denizens of the wetlands, such as the California red-legged frog and the San Francisco garter snake, need the land for their habitat. And the estuary's endangered fish species need specific seasonal water regimens and salinity levels to survive.

In recent years, competition for favored status in the management of Pescadero's water has become increasingly cutthroat, just as it has throughout the state. A growing human population requires more water

every year, leaving less for the state's other species, 279 of which are now listed by the California Department of Fish and Game as threatened or endangered.

And it is not just wildlife that is suffering, says UC Berkeley engineering professor Mark Stacey. In a 2009 Congressional Report, the EPA reported that 64 percent of US lakes and reservoirs were not clean enough to support their designated uses. "But the legal and policy environments are trying to take the non-human need for water more seriously," says Stacey, "and many policy statements now include phrases like 'co-equal goals of human water use and ecosystem function.'"

That may be progress, Stacey says, but determining "co-equality" requires building an equation that currently has many key missing variables.

"We know how much water municipalities need," Stacey says. "We know what the industrial demands are, we know the agricultural demand; we can put pretty precise numbers on each of those things. But we cannot do the same on the ecosystem side. We do not know how much water a steelhead needs to thrive."

Stacey and his collaborator Geoff Schladow, a UC Davis professor of civil and environmental engineering, are developing methods to shed light on those ecosystem needs. Specifically, they are experimenting with ways to quantify ecosystem requirements in two radically different but equally iconic aquatic California ecosystems: a mountain lake at the top end of the watershed, Lake Tahoe; and a coastal estuary at the bottom, Pescadero Estuary.

In Pescadero Estuary, Stacey and his colleagues will be implanting 40 to 50 anadromous steelhead trout with acoustic tags. The fish will be netted

and the tags—capsule-shaped, a little over half-an-inch long, and just under a quarter-inch in diameter—will be surgically implanted into the body cavity of the fish, who will then be released back into the waters.

Each tag emits a unique set of ultra-high-frequency sounds that identifies the fish carrying it. The acoustic signals will be tracked by a dozen or so receivers that will be placed on poles or floated on buoys in strategic positions around the estuary.

Using triangulation, maps, and models of known habitat characteristics like temperature, salinity, clarity, and oxygen levels, Stacey's group will develop behavioral models of how steelhead respond to various changes such as the release of water from reservoirs upstream and the influx of sea water that comes when the sandbar cutting off the estuary from the open ocean is breached each winter.

In the past, biologists have used Passive Inductive Transponder (PIT) tags to track fish in the estuary. The fish would need to be recaptured and their PIT tags read in order to get any information. "The data were much less rich," says Stacey. "What the fish were doing between catch-and-release identifications was anybody's guess."

A CITRIS seed grant is helping Stacey develop the fish-tracking and modeling part of the project, which is just one part of a larger watershed-scale effort to quantify the effects on ecosystems of flooding, water diversions, sediment loading, the timing of water releases, and the amount and distribution of oxygen in the water, Stacey says.

Another part of that broader effort is being led by Schladow, Stacey's co-PI on the $57,000 CITRIS seed grant, who is developing ways to quantify the dynamics of algal blooms in Lake Tahoe.

Over the past 40 years, UC Davis has amassed a large ecological data set

for Lake Tahoe. Schladow, who also directs the Tahoe Environmental Research Center, will put those data to use developing three-dimensional reservoir simulation models (including both hydrodynamics and water quality/ecology models) for the lake. He will deploy a real-time array of sixteen fast-response temperature sensors and an optical dissolved oxygen sensor and deploy it 120 meters below the surface of Lake Tahoe. Together, the data generated by these sensors will determine levels of plankton blooms, which are facilitated by the relationship between dissolved oxygen consumption and the cycle of plankton growth in Tahoe.

The models, which will eventually predict the clarity and water quality of the lake based on a whole range of variables, will be ground-tested by direct real-time measurements that will, Schladow says, "shorten the iterative cycle of model prediction and data comparison."

Although Schladow's and Stacey's projects look hard at these two very specific habitats, one at the top of a watershed and the other at the bottom, the lessons learned and methodologies developed will be applicable across the state and around the world, says Stacey. The ability to quantify the needs of ecosystems and the wildlife they host will be a key tool for protecting them, he says.

That tool will be imperative, says Stacey, given the trouble in which many of the state's wildlife species find themselves, and the intensification of that trouble resulting from climate change. It is not just wildlife and their habitat either. The state's functioning ecosystems provide human services, too. Water purification, productive fisheries, and protection from flooding, for example, are just some of the ecosystem services provided by wetlands such as the Pescadero Estuary and surrounding marshland.

More information: citris-uc.org/research/project …

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