

Science News

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Tracking Fish is More Than Just a Game of Tag

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As the old saying goes, there's more than one fish in the sea. But if you want to know how many fish there are, or where they're going, there's more than one way to tag a fish to track its movement and life history. A number of different tagging options have been used in the Delta. The following is a look at different kinds of tags that have been used in the Delta and elsewhere.

- **Coded Wire Tag (CWT)**

Fish raised in a hatchery have their adipose fin (a small second fin on the back of a fish directly in front of the tail fin) clipped to differentiate them from fish raised in the wild. In addition to the fin being clipped, a CWT—a microscopic piece of magnetic wire with a tiny code engraved on it—is injected into the nose of the fish when they're young. These tags, which have been used in the Delta for about 20 years, can track the history of the fish. When they're caught as adults, the tags reveal where and when the fish were born. Although these 'mark and recapture' studies can provide a start and end point to a fish's movement over a defined period, they can't provide information on the path taken by the fish between the two points.

Another drawback with CWTs is that "you have to kill the fish to remove the tag," said Chris Holbrook, a biologist with U.S. Geological Survey (USGS). "You have to physically capture them, which requires an incredible amount of effort and is usually extremely costly. You have to drag nets and actually encounter the fish, which is sort of why CWT has fallen by the wayside in recent years. Due to the low recapture rate in the Delta, most fish tagged with CWTs are never caught after release," he said. Holbrook added that the CWT does last forever. "You could catch [the fish] any time—even as a carcass"—and extract birth information from the CWT.

- **Passive Integrated Transponder (PIT) Tag**

This tag has no battery, but provides a unique code, like a CWT, yet can be read without killing the fish. A PIT tag is nearly identical to the microchips used to identify pets and works the same way. A PIT tag is a tiny microchip assembly sealed in glass, which is injected into the body cavity of a fish. If a tagged fish passes within a meter or so of a scanning device, the scanner reads the unique identification number from the chip in the PIT tag. As with microchips for pets, a hand held scanner can also be used in the field to identify fish. Thus PIT tags have many of the advantages of CWTs (small, relatively cheap and lasts the life of the fish). "It is more expensive than a CWT, but less expensive and longer lasting than battery powered tags," said Dr. John Pizzimenti, a member of the Vernalis Adaptive Management Plan (VAMP) independent review panel and a scientist from GEI Consultants in Oregon. "In order to read the tag, the fish must be recaptured (like CWT) but does not need to be sacrificed as it can be read using equipment that supplies the electromagnetic power to make the tag



Different types of tags (radio, acoustic, PIT)
 (Image courtesy of Michael Melnychuk,
 University of Washington)

Vernalis Adaptive Management Plan Final Report Released

The independent review panel of the Vernalis Adaptive Management Plan (VAMP) recently submitted its final report. VAMP is a large-scale, decade-long experimental management program that was designed to protect juvenile Chinook salmon emigrating from the San Joaquin River through the Sacramento-San Joaquin Delta while providing scientific information for the State Water Resources Control Board's review and potential modification of the San Joaquin River flow objectives included in the Water Quality Control Plan (Bay-Delta Plan).

During a two-day meeting in March, the panel was charged to provide an independent review of the science generated by the VAMP and make recommendations for how this science should be used to inform changes to the Bay-Delta Plan. Key panel conclusions are:

1. There is evidence that higher flows increase survival of juvenile Chinook salmon passing through the Delta from the San Joaquin

send its unique signal to a special receiver. Fish passing dams and fish facilities can be read automatically.”

“PIT tags have become the primary source of salmon recovery data on the Columbia River where fish return to known locations or must pass confined spaces in fish passage facilities at dams,” Pizzimenti added. “Incidentally, PIT tags are being recaptured on Caspian Tern islands where they are regurgitated by birds after consumption of tagged smolts. This is leading to estimates of smolt predation by birds there.”

- **Acoustic Tag**

Acoustic tags are surgically implanted, battery-operated tags that send a coded pinging sound signal. Researchers can identify individual fish by the signal code when they pass near underwater microphone receivers at various locations. “Acoustic tags provide a better location accuracy and can even provide 3-D positioning by using triangulating signals from multiple microphones. This can be useful when designing fish passage systems and studying fish approach and passage behavior to a small entrance in a large river,” said Pizzimenti.

Acoustic tags have a battery and emit a signal that can generally be heard at great distances—hundreds of meters away. “The reason we’ve seen a lot of acoustic tagging recently is when you tag a fish and release it, you can be a large distance away from the fish and record its presence,” said Holbrook from USGS. “We put out sensors throughout the river—like listening posts—where you can generally hear across the entire river. Most of the time if a migratory fish with an acoustic tag swims past your listening post/receiver, then it will get recorded. None of those other technologies can do that,” he said. “You can put a post at one place in the river and essentially know all the fish that pass that site.” Acoustic tags clearly tell scientists how many fish get through the Delta and the paths they take.

Acoustic tag microphones are usually submerged at fixed locations. The California Fish Tracking Consortium (<http://californiafishtracking.ucdavis.edu/>) has set up arrays of acoustic receivers extending all the way to Point Reyes to detect Sacramento River salmon on their way to the ocean. They can also be carried in a boat, but the boat must stop, set up the microphone, then record. Potential drawbacks of acoustic tags are that they require many microphones, are more expensive, and acoustic tag life is limited to the size of battery, which is limited by the size of fish. “The smallest fish that can generally be tagged is about three inches and can carry a battery life of less than a month,” Pizzimenti said. Acoustic tags can’t be used in smelt; the small size of smelt requires CWT or PIT. Additionally, noise from boat motors, turbulence and hydroelectric dams can disrupt or mask acoustic sound signals.

- **Radio Tag**

This tag consisting of a tiny transmitter and battery pack is surgically implanted in juvenile fish (or in the gut of an adult fish). It sends radio waves of a unique signal through the water column to the air, where they are picked up by a radio antenna. Radio tags can be tracked using antennae mounted on aircraft, boats, cars and points along shorelines, at dams and fish passage facilities, and on foot (hand held). Unfortunately, that signal doesn’t travel very well in water. “The deeper a fish swims, the weaker the signal in the air,” Pizzimenti said. This decreases the accuracy for determining the exact location of the fish due to ‘depth – distance’ signal confusion as both depth and distance weaken the signal to varying degrees.

Radio tags also have a trailing fine wire antenna, which may affect a

River, but the situation is complicated by other factors and survival is generally very poor.

2. Evidence for improved survival with reduced exports is weak because of the very narrow range of export flows that occurred during the study.
3. Placing a rock weir or operable gate at the Head of Old River to keep salmon out of the Old River channel and in the San Joaquin River channel improves survival.
4. The VAMP participants should continue to use acoustic tagging technology, but should also use coded wire tags or other tagging technology to track fish throughout their life cycle.

Given the rapid changes in tagging technologies and recent evidence of extremely low salmon survival rates, the panel recommended that the VAMP program continue to collect acoustic tagging data supplemented by other tagging methods and that the findings be reviewed on a more regular basis—every three years. The panel was also struck by the high rates of predation observed in recent years and urged researchers to improve understanding of predation effects by more broadly characterizing predator distribution, abundance and feeding habits.

Telemetry Studies Results Given at UCD Symposium at Bodega Bay

During a Delta Science Program-funded University of California, Davis symposium May 20-21, participants from the Central Valley and beyond presented the results of electronic tagging studies of salmon migration. Highlights included:

- Results from the California Fish Tracking Consortium receiver network that can track the movement of tagged salmon and steelhead from Keswick Dam to Point Reyes
- Advances in fish tagging

fish's swimming ability. Like acoustic tags, radio tag life is limited to the size of battery which is limited to the size of fish. Radio signals are further weakened by dissolved salts and therefore are less effective in briny or salt water.



Surgical implant of an acoustic tag
(Image courtesy of California Department of Fish and Game)

Other Options

Other sophisticated ways to tag or identify fish include the use of genetic markers (known DNA type); physical markers including freeze branding, ocular tags (tiny numbered tag that fits into the eye socket); and otoliths (the ear bone in juvenile fish that can be read like tree rings after a

fish is killed). Finally, fish are still tagged using externally placed physical tags in the fish that can be seen. "These carry limited information and can be lost (as most tags can be lost or altered) to make them unreadable," Pizzimenti said. Each tag type has a cost, benefit and type of application that differs from the others.

"There is no one type of tag that fits all needs for the type of data being collected," Pizzimenti said. "In the Bay Delta, CWT have value, but acoustic and radio tags have been put to greater use in recent years and tell biologists much more about the behavior and survival of salmon smolts as they move from the Delta to the ocean."

It's impossible to pick one form of tagging over another as "the best," Holbrook said. "It depends on the study—the question you're trying to address. You'll see studies using multiple telemetry systems sometimes; one may answer one question very well; but to answer a suite of questions in the same study, you sometimes need to use a couple different methods," he said. One thing is certain though, advances in fish tagging and tracking technology have greatly expanded our knowledge of the life cycles of fish.

technology including smaller tags and improved receivers

- Effects of tides, river flow, gate operations, and route choice on salmon survival in the Delta
- New discoveries about the movement of salmon, steelhead, sturgeon, and other fish in rivers and coastal waters
- Detailed information about fish use of restored and natural habitats

Continued advances in fish tagging technology, including smaller and longer lasting tags, are providing new opportunities for understanding the behavior and fate of fish. The new smaller acoustic tag sizes are allowing researchers to tag smaller fish such as juvenile salmon and track their movements over long distances. Tagging technology also allows researchers to identify individual fish throughout their life span. More than one scientist described the travels of their favorite individual fish over long distances and several years. It is now common for researchers to track tagged fish from other studies and share data about their movements.

Tag Type	Pros	Cons	Image
Coded Wire Tag	<ul style="list-style-type: none"> • Small • Inexpensive • High survival from tagging • Proven technology; long history 	<ul style="list-style-type: none"> • Fish must be caught and killed to read tag • Only two data points possible: point of release and point of recapture • Recapture rate small in Bay Delta • Requires large sample sizes 	
Passive Integrated Transponder	<ul style="list-style-type: none"> • Small • Inexpensive • No battery; lasts forever • Don't have to kill fish to read tag 	<ul style="list-style-type: none"> • Detection rate low - Very small detection range of about a meter 	

<p>Acoustic Tags</p>	<ul style="list-style-type: none"> • Can use far fewer fish (less than 1,000) • Provide better location accuracy • Can be recorded from large distances away 	<ul style="list-style-type: none"> • Cost • Limited battery lifespan • Equipment issues: tags can fail, microphones can fail • Noise interference (boats, pumps) • Issues with identifying when a smolt's been eaten by a predator 	
<p>Radio Tags</p>	<ul style="list-style-type: none"> • Send out radio signal • Useful for tracking movement • Tracking from a distance 	<ul style="list-style-type: none"> • Limited battery lifespan • Wire antenna trailing out from fish • Signal doesn't travel well in water • Need to follow fish around with boat • If predator swallows fish, antenna gets swallowed 	

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