# EVACUATION RATES OF ACOUSTIC TAGS IN STRIPED BASS

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## Summary

The Sacramento-San Joaquin River Delta is the largest watershed in California, accounting for 40 percent of water run-off. The Delta drains into San Francisco Bay, the largest estuary on the West Coast. Forty percent of the river's flow is diverted to provide drinking water for 23 million Californians, and irrigation water to cultivate half the nation's fruits and vegetables. Dams, flood control structures, and agricultural development have eliminated the majority of the historical marsh habitats. American Rivers (2010) ranked the Sacramento-San Joaquin River Delta as the second most endangered river for 2010 (ranked first in 2009).

Water from the Delta is diverted and transported by two primary pumping facilities: C.W. "Bill" Jones Pumping Plant and Harvey O. Banks Pumping Plant. Both sites are equipped with fish salvage facilities upstream of the pumping plants to reduce the number of fish entrained to the pumps and into the water deliveries.

Both the federal Tracy Fish Collection Facility (TFCF) and the state Skinner Delta Fish Protective Facility use a behavioral type louver bypass system to guide fish out of the canal and into collection tanks where the salvaged fish are held and then transported and released back into the Delta.

Non-native piscivorous fishes inhabit the Delta area in and near the TFCF (Reyes *et al*. 2007). Efficiency of the louvering systems to guide fish through each water pumping facility is negatively influenced by non-native predators residing near, as well as within, the facilities. These non-native predators directly influence salvage rates by consuming native fishes, including threatened and endangered species such as juvenile Chinook salmon (*Oncorhynchus tshawytscha*), juvenile steelhead (*O. mykiss*), and adult and juvenile delta smelt (*Hypomesus transpacificus*). Highly piscivorous striped bass (*Morone saxatilis*) are often found in relatively high numbers within the TFCF, as well as upstream and downstream of the facility. While the ratio of adult and juvenile striped bass may vary seasonally, this predatory species is omnipresent, residing upstream, downstream, and within the TFCF facility (TFCF salvage data and personal observation).

Efforts to monitor, restore, and enhance the Delta's unique flora and fauna have been ongoing for years. Included in these efforts are well known cooperative monitoring and research programs such as Interagency Ecological Program and Bay-Delta Program (formerly CALFED). The Vernalis Adaptive Management Program (VAMP) is one such cooperative program and is a component of the San Joaquin River Agreement. Officially initiated in 2000, VAMP is a large-scale, long-term (12-year), experimental management program designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta. The VAMP is also a scientific experiment designed to determine how salmon survival rates change in response to alterations in San Joaquin River flows and State Water Project/Central Valley Project exports with the installation of the Head of Old River Barrier (SJRGA 2010).

Acoustic telemetry technology is a widespread and proven tool to study juvenile salmon movements (McMichael *et al*. 2010). The VAMP program's use of acoustic telemetry technology is ongoing, however, the full power of this analytical tool is only realized if it is appropriately implemented and the results are properly analyzed and understood. There is evidence of a high degree of predation on acoustic-tagged juvenile salmon (DSP-RP 2010; Vogel 2010) which confounds analyses and interpretation of acoustic telemetry data. Vogel (2010) and DSP-RP (2010) reviewed aspects of the VAMP program and made recommendations. Both reference the problems caused by differentiating between live acoustic-tagged salmon and predatory fish that had eaten acoustic-tagged salmon. This issue confounds estimation of overall salmon survival, salmon survival by reach, and fish route selection, all of which were/are key objectives of the VAMP study.

In FY 2012/13, necessary changes to Row 1 of the Tracy Aquaculture Facility were completed. We are currently awaiting repair of the system antennas and final install. This work is being accomplished by Jim Inman and associated technicians of FishBio. Technical alternatives to the PIT-tag detection system using acoustic tags are being explored at this time.

## Problem Statement

It is widely recognized that non-native piscivores consume migrating salmonids throughout the Delta including, and perhaps exacerbated within, pumping facilities. Acoustic-tagged salmon consumed by untagged predators may lead to false positive detections by acoustic receivers and confounds researchers' abilities to adequately assess acoustic data. Data are needed on the rate at which striped bass digestively pass acoustic tags that were inside predated salmon. This information will assist researchers with evaluation and interpretation of data on survival and movement of salmon and steelhead throughout the Central Valley of California, with probable application to other systems.

## Goals and Hypotheses

*Overall Goal:* Collect data that will assist with evaluation and interpretation of data on survival and movement of Chinook salmon and steelhead throughout the Central Valley of California.

*Specific Goals:*

1. Quantify the rate at which striped bass digestively pass acoustic tags that were inside predated Chinook salmon and steelhead.

2. Evaluate the role of fish size with respect to the rate at which striped bass digestively pass acoustic tags that were inside predated Chinook salmon and steelhead.

3. Evaluate the role of water temperature with respect to the rate at which striped bass digestively pass acoustic tags that were inside Chinook salmon and steelhead.

*Hypothesis:* Striped bass digestively pass acoustic tags that were inside predated salmonids at a rate primarily related to metabolic rate, gut dimensions, and feed intake.

*Null Hypotheses:*

1. Water temperature does not explain any of the variation in gastric evacuation of a non-functioning acoustic tag with internal P.I.T. Tag (NAT-PIT) beyond the variation explained by other variables.

2. Stomach fullness at introduction of NAT-PIT does not explain any of the variation in gastric evacuation of NAT-PIT beyond the variation explained by other variables.

3. Length of the striped bass used does not explain any of the variation in gastric evacuation of NAT-PIT beyond the variation explained by other variables.

## Materials and Methods

### Source and Care of Fish

The study will occur at the TAF located on the grounds of TFCF. Adult and sub-adult striped bass will be obtained from current stock, salvage operations, or predator removals at TFCF. Striped bass used in experimental trials will be maintained in circular tanks ranging from 711–2140 L in water volume. Juvenile Chinook salmon and steelhead will be obtained from a nearby hatchery and maintained in circular tanks ranging from 711–2140 L in water volume. All environmental and nutrition parameters will sufficiently meet, or exceed, species requirements. Experimental trials will be conducted at/near oxygen saturation.

### General Procedure

We will insert a non-functioning Model 795Lm Micro Acoustic Tag and with Internal Passive Integrated Transponder (PIT) Tag (*Hydroacoustic Technology Inc. [HTI], Seattle, WA) into a juvenile* Chinook salmon using the surgical process employed by prior VAMP investigators (SJRGA 2010) or placed down the gullet of an anesthetized salmon. The acoustic section of the tag will not function but the PIT Tag will function. This model of tag is 0.77 g in air, measures 7 mm maximum in diameter, and is 17.5 mm long. This tag is similar in shape, and weighs only 0.10 grams more than the HTI Model 795Lm Micro Acoustic Tag used in juvenile salmon studies in the Delta for the last couple of years. Tags inserted into steelhead will be of similar design regarding a similar shape and negligible weight difference than the HTI Model Le Acoustic Tags currently used for steelhead studies in the Delta.

An individual salmon or steelhead containing a non-functioning acoustic tag with internal PIT Tag (NAT-PIT) will be fed to a striped bass and exact time will be noted. Striped bass of sizes ranging from about 200–800 mm TL will be used. We will seek to use salmon and steelhead of sizes similar to that used during ongoing acoustic telemetry studies. Antennae placed into tanks housing

experimental striped bass and a corresponding receiver system, will be set to detect a defecated NAT-PIT and record the time of detection. Tank environmental conditions will be standardized during testing.

### Explanatory Variables

Explanatory variables of interest will include water temperature (*i.e.*, 12, 16, and 20°C), stomach fullness at introduction of NAT-PIT (*i.e.*, empty or 2, 4," and 5 salmon for striped bass 200–400, 400–600, and > 600 mm TL, respectively; or 1 and 2 steelhead for striped bass 400–600 and > 600 mm TL, respectively]), and length (range of 200–800 mm TL). Project phases will correspond to the water temperatures listed above and completed in the following order: Phase 1 Trials at 16°C, Phase 2 Trials at 12°C, and Phase 3 Trials at 20°C.

### Statistical Analyses

We will use repeated measures regression to test if a relationship exists among time elapsed at defecation of NAT-PIT and water temperature, stomach fullness at introduction of NAT-PIT, and length of the striped bass used. A Bonferroni-type correction will be employed for multiple comparisons. We will seek a precision level of +/- 10% in our estimation of time required to defecate a tag and a significance level of 0.05 will be used for all tests. Statistical analyses will be performed using JMP Statistical Software (SAS Institute Inc., Cary, NC).

## Coordination and Collaboration

This study is a direct collaborative effort between Reclamation, CDWR, and other VAMP associated groups. Study aspects will be coordinated with the Tracy Fish Facilities Improvement Program Manager, research coordinator, and the Tracy Series Editor. All experiments will be coordinated with the TFCF Fish Diversion Operators and TFCF Biology staff. Additional comments on design and implementation will be sought from staff at the Tracy Fish Collection Facility and Denver Technical Service Center, and other interested parties. Participation and inclusion of research-related modifications and updates will be provided to the Tracy Technical Advisory Team and/or the Central Valley Fish Facilities Review Team upon request.

## Endangered Species Concerns

This study will not involve the use of wild endangered or threatened species. Hatchery-produced specimens of sensitive species will be sought and used when available.

## Dissemination of Results (Deliverables and Outcomes)

The primary deliverables will be articles published in both the Tracy Volume Series and a peer-reviewed scientific journal. Technical updates will be provided to the Tracy Technical Advisory Team and the Central Valley Fish Facilities Review Team, along with posters and oral presentations given at scientific forums.

## Literature Cited

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