PREDATION DETECTION TAG EFFICACY

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Summary

Acoustic telemetry has expanded the knowledge of endangered fish behavior and movements in the Sacramento-San Joaquin Delta (Delta). The Delta is one of the most important watersheds in California as it is the primary source for both human endeavors and a majority of the state's resident biota. Because of the Delta's importance, it is a highly managed resource. Management decisions regarding the Delta's use must be flexible and adapt almost in real-time to changing demands and climatic events. Acoustic tag technology has advanced so dramatically in recent years that the technology allows for the possibility of determining at a given moment the exact location and movement patterns of federally listed endangered species such as Chinook salmon (*Oncorhynchus tshawytscha)*, and steelhead trout (*Oncorhynchus mykiss*). This allows management decisions to adapt the Delta's use for the dual benefit of endangered species and human water needs.

In order for proper management of these endangered fish, the true fate of each tagged fish must be known. Quite often, acoustically tagged fish are consumed by piscivorous predators, like largemouth bass (*Micropterus salmoides*) and striped bass (*Morone saxatilis*). The tag continues to emit a signal, even though the tagged fish is no longer alive. By inaccurately labeling a fish detection as a live salmon or steelhead rather than a consumed one, data collected on fish movement is skewed, leading to inaccurate data analysis, and ultimately, incorrect management of these endangered species. Past studies have revealed large error margins in data, causing skewed results (Vogel 2011).

A new acoustic tag has been designed to indicate when a tagged fish is consumed by a piscivorous predator. The goal of the new tag is to allow researchers to accurately distinguish between a live fish and a consumed fish. This new technology will ultimately lead to fewer false-positive detections of fish that have been consumed.

The goal of studying the reliability of this new acoustic tag technology is to determine how accurate it is at indicating when a fish is consumed. This technology is novel and has not yet been studied for its efficacy. If an effective acoustic tag is developed that can detect when a tagged salmonid is eaten, it will allow for more effective management of the Delta.

Problem Statement

Acoustic tagged salmon and steelhead are often eaten by piscivorous predators. The tag keeps pinging, even though the fish has been consumed. Developing a tag that "senses" or indicates the fish has been consumed will allow researchers to properly interpret data and manage the Delta more efficiently. It could also be used as a way to collect new data on predatory fish movements and behavior.

Goals and Hypotheses

Primary Goal: Determine the Predation Detection Tag (PDT) efficacy.

Hypothesis: Predation Detection Tag detects when a tagged salmonid is consumed by a predator.

Null Hypothesis: Data from the Predation Detection Tag inside a salmonid [does not change] when consumed by a striped bass.

Methodology

Study Location

The study will take place at the Bureau of Reclamation (Reclamation), Tracy Fish Collection Facility (TFCF), Tracy Aquaculture Facility (TAF), in Byron, CA.

Care of Study Fish

Chinook salmon (prey) and striped bass (predator) will be used as study organisms. Chinook salmon will be obtained through Coleman National Hatchery. No fish will be released in this study; therefore we won't need Department of Fish and Wildlife (CDFW) hatchery fish. All environmental and nutrition parameters will be met or exceeded for the fish.

Juvenile Chinook salmon (*Oncorhynchus tshawytscha*) will be held in tanks in the TAF at the TFCF and will be held in well water to maintain a stable temperature. Fish will be fed ad libitum daily. However, during tagging sessions, fish will be fasted for 24 hours prior to surgery to keep the visceral cavity open to receive tags. Water quality will be measured, including dissolved oxygen and temperature, and will be recorded during daily cleaning of tanks. On the day of surgeries, juvenile Chinook salmon will be netted and selected as randomly as possible for tagging. We will do this by netting many fish from a given tank and then selecting fish from the dip net without bias as to size or condition.

Adult and sub-adult striped bass will be obtained from current stock at the TAF. This stock is currently held in large circular flow-through tanks at the TAF and fed thawed anchovies every 2-4 days. Six striped bass (> 400 mm fork length (FL)) will be transferred and randomly assigned to 1 of 6 identical test tanks and allowed to acclimate. Striped bass that are feeding will be considered acclimated. Test tanks are circular, 711 L in volume, located indoors, and on a fully re-circulating system with temperature control. Striped bass used in the feeding trials will be pre-fed Chinook salmon and then fasted for 6 days prior to the feeding event. Feedings will be separated so that there will only one PDT in a predator gut at a time.

HTI™ Prototype Tags

Due to the proprietary nature of the "predation detection tag" (PDT), HTI™ can not divulge much information about the tag at this time. However, tags will be near or greater than 1.5 g with size and shape likely similar to current HTI™ tags.

Programming of the PDTs will be performed in house by a CDWR Environmental Scientist (ES) under the direction of an HTI engineer. After tags are programmed, they will be soaked and tested to make sure they are operating correctly before implantation into the study fish. Out of the 100 HTI™ tags, 20 will be implanted into fish that will not be used for feeding trials. These fish

will be held in a separate circular flow-through tank and their health, behavior, and recovery will be monitored to ensure tags will not cause harm to tagged fish. Twenty tags will be programmed but not implanted. These tags, along with the twenty above mentioned fish will be used for the tag life/control portion of the study.

Surgeries

PDTs may be prepared for surgery by rinsing with distilled water and then sterilized using ultraviolet radiation (UV). A second rinse with distilled water can be used as necessary to remove particles from the tag prior to surgery, but HTI discourages this unless absolutely necessary. Some tags may be soaked in both tricaine methanesulfonate (MS-222) and AQUI-S solutions to ensure no unwanted or unexpected reaction to either solution during surgeries. Juvenile Chinook salmon will be surgically implanted with the prototype tags during the day of the feeding trials. The surgical process that will be used will be the same as the process employed in the Vernalis Adaptive Management Program or VAMP (SJRGA 2011). However, AQUI-S may be used for anesthesia instead of MS-222 if there is no effect on the study using AQUI-S, since that will be the anesthetic used for future studies due to the shorter holding time of study fish required using AQUI-S as opposed to MS-222. All surgeries will be performed at the TAF building using the CDWR tagging equipment.

Due to the small number of PDTs being tested and low numbers of available predators we will receive a small number of replacement tags from HTI to tag additional fish in case tags or fish get dropped during surgery, if a designated predator stops eating, dies or becomes compromised, or for some other unforeseen operator error.

Feeding Trials

After surgically implanting the study fish with PDTs, tagged fish will be transported to the TAF where feeding trials will occur. An HTI™ receiver will be set up into each of the circular tanks holding striped bass to record the echoes coming from the PDTs. Consumption of tagged juvenile Chinook salmon by striped bass will be monitored and once consumed, the time will be recorded. At the end of each trial (length of time per trial has yet to be determined), we will process the data and record the time each tag changed its code to indicate consumption of a tagged fish occurred. We will then record the amount of time it took for the tag to change its signal after being consumed by the striped bass by subtracting the signal change time from the observed consumption event time. Feedings will be attempted at the same time of day, one hour after sunrise.

Chinook salmon used in the trials will be approximately 210 mm in fork length (FL) and striped bass will be > 400 mm FL. All trials will be conducted at a seasonal mean temperature of 16 Cº.

Water quality will be monitored and recorded immediately prior to feeding trials and daily in prey and predator tanks.

Predators that refuse to eat or that get sick or perish during the trials will be replaced. The new fish will be expected to consume 10 PDT tagged Chinook salmon. This will be done to keep our sample size to 60 consumed PDTs.

Controls and Tag Life

Twenty Chinook salmon will each receive a PDT and be held for 30 d in a circular 711-L tank, located indoors, on a non-recirculating system with temperature control. The tags in these fish will be the positive control tags and tag signals will be analyzed for false positives and tag failure over time. The Chinook salmon will be sacrificed after the thirty day period and examined for any internal injury from the tags.

Twenty additional PDTs will also be held in a tank concurrently to the implanted tags for a tag life assessment. Tag life data will consist of tag failure, length of time to signal failure, and burst occurrences (if any) and will be noted and recorded.

Data Processing

Raw data collected from the feeding trials as well as the tag-life portion of the study will be analyzed using HTI™ MarkTags™ software.

The study results will be mostly descriptive and will be described in the following ways: the percent failure rate of the tags will be calculated, the percentage of false-positive detections will be determined, and the elapsed time that it takes the indicator tag to activate will be noted. The predation indicator tags will be deemed efficacious if the tag failure rate is less than 5%, the false positive detection rate is less than 1%, and elapsed time from initial feeding to detection is less than 1 hour.

Within and between predator gut variability of the time to activation of tags will also be examined using either a repeated measure ANOVA or a simple multivariate analysis.

Further studies with alternate variables such as fish size, temperature, and multiple tags will be explored after results have been analyzed and evaluated.

Timeline and Budget

Planning for the tag efficacy study will be finished by March 5, 2013.

Chinook salmon will be obtained by March 18, 2013.

Surgeries to implant tags and feedings will begin in June, 2013.

The study period will go from the initiation date until all 60 experiment fish have been fed to predators.

Data processing and analyses are anticipated for completion by November 1, 2013.

Dissemination of study results is anticipated by the end of December 2013.

The expected cost of this work including surgical supplies, experimental fish, and staff time is $57,200. HTI will supply PDTs and MarkTags software for the experiments. Funding is anticipated from the Delta Fish Survival Improvements.

Literature Cited

SJRGA (San Joaquin River Group Authority), 2011. 2010 Annual Technical Report—On Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan, September 2011, 166 p.

Vogel, D.A. 2011. Evaluation of fish entrainment in seven unscreened Sacramento River diversions, 2010. Report prepared for the Anadromous Fish Screen Program, CALFED Ecosystem Restoration Program, Bureau of Reclamation, U.S. Fish and Wildlife Service, NOAA Fisheries, and the California Department of Fish and Game. Natural Resource Scientists, Inc. February 2011. 77 p. plus appendices.

PDT Efficacy Equipment List
Tag Monitoring Equipment (HTI™)
Model 290 Receiver (16-port) Hydrophones Hydrophone cables (50 ft) Panasonic Toughbook (with Windows XP and HTI Mark Tags™ installed)
Tagging Equipment
Sutures, Violet Braided Vicryl*Plus 5-0 Surgical blades, 15^{o}, 4 or 5 mm restricted depth stab Padded cradle Dosing jug Freshwater jug Air bubbler Clear vinyl tubing Aqui-S or MS-222 for anesthetization 5-gallon bucket
Miscellaneous Equipment
Gloves Nets Buckets Scissors Measuring board Scales

Predation Detection Tag Efficacy Data Sheet

Predator Tank Number _____

Striped Bass = Predator		
FL (mm)	Weight (g)	Date predator was introduced

Chinook Salmon = Prey							
Fish Number	Tag ID	FL (mm)	Weight (g)	Time and date introduced to tank	Time and date consumed by predator	Comments (reason rejected, etc.)	Crew names:
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							