

## Assessing the Survival and Behavior of Radio Tagged Chinook Smolts on the Lower Stanislaus River

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Dramatic declines in abundance have been observed in Central Valley salmonid populations over the past few decades. Despite significant study of factors influencing the survival of salmonids in the lower Stanislaus River, there is still a great deal of uncertainty regarding the specific sources of mortality for juvenile salmonids along this stretch of river, at a fine spatial scale. For example, it is unknown whether survival is constant throughout this migration corridor or whether in-channel mine pits (e.g., Oakdale Recreation Ponds) are contributing to losses. In order to assist the Anadromous Fish Restoration Program (AFRP) in planning restoration activities, it is important to understand the spatial distribution of mortality, and identify geographic areas along the migratory corridor where losses occur. During the spring of 2012, we conducted a tagging study using radio telemetry technology to determine whether there is spatial variation in survival of Chinook smolts on the lower Stanislaus River (between river miles 10-40). In addition, we tracked experimental fish using mobile radio telemetry surveys and monitored their movement and behavior during their outmigration. These data will allow us to explore whether reach specific differences in biotic and abiotic characteristics contribute to differences in survival along the Stanislaus River. Moreover, the results from this study will serve to fill a knowledge gap regarding juvenile salmonid behavior during rearing and outmigration (e.g., travel times, habitat use, diel patterns of movement), which will enhance our understanding of Stanislaus River salmonid life histories, while also further supporting the AFRP's objectives for salmon recovery in California's Central Valley.

**Keywords:** Chinook, Stanislaus River, survival, outmigration, radio telemetry.

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## **Estimating Relative Survival of Feather River Fish Hatchery Steelhead, *Oncorhynchus mykiss*, Smolts under Different Release Strategies**

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The Department of Water Resources and the Department of Fish and Game are preparing Hatchery and Genetic Management Plans (HGMP) for the three salmonid programs at the Feather River Fish Hatchery (FRFH). A primary goal of the HGMPs is to devise biologically-based artificial propagation management strategies that reduce ecological and genetic impacts to state and federal Endangered Species Act listed salmonids. Review of the existing data has revealed many gaps in information needed to evaluate potential impacts and develop management strategies that ameliorate those impacts. For example, the FRFH annually releases up to 450,000 steelhead, *Oncorhynchus mykiss*, smolts into the lower Feather River, yet little or no data has been collected on migration behavior and survival of these fish after release.

Using acoustic telemetry we are studying migration behavior FRFH steelhead smolts and the effect of release location and time of day of release on survival through the Feather River. In cooperation with the California Fish Tracking Consortium we will also be able to track fish into the Sacramento-San Joaquin Delta (SSJD) and out to the Pacific Ocean. Preliminary results comparing two release sites (river kilometer 66.8 and 35.4) and morning or evening release indicate that relative survival through the Feather River is greater for fish released at the downstream release site and in the evening. Data regarding migration behavior and survival through the SSJD to the Pacific Ocean will also be discussed. Results from this study will improve the performance of the FRFH steelhead program and provide insight about through SSJD survival for migrating *O. mykiss*.

**Keywords:** *Oncorhynchus mykiss*; acoustic telemetry; survival; migration behavior; hatchery management

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## Tracking Juvenile Salmon with Micro-Transmitter Technology: Lessons Learned from a Pilot Sacramento River Study

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River flow, fish size and migration timing can have significant effects on juvenile Chinook salmon *Oncorhynchus tshawytscha* survival during emigration from the highly-modified Sacramento River System to the Pacific Ocean. To date, the use of telemetry technology has been constrained to relatively large, surgically implanted tags which have required the use of larger (110-160 mm FL+), hatchery-raised salmon (often post-yearling late-fall Chinook salmon) which migrate in December to February. Extensive study has revealed survival from the upper Sacramento to the Golden Gate Bridge is quite low (~7-15%). These results are frequently used as a proxy for survival of fall-, winter- and spring-run's of Chinook salmon. However because of size and migration timing differences, late fall-run smolts may be poor surrogates for smaller sub-yearling fish that migrate at different times of year, with different migration strategies.

To remedy concerns related to surrogate performance, a consortium of federal, state, university, and private scientists implemented a pilot study using the Juvenile Salmon Acoustic Telemetry System (JSATS) to evaluate on Sacramento River Chinook salmon emigrants during the spring of 2012. An array of 54 receivers was deployed from Battle Creek on the upper Sacramento and on the Feather River to the Golden Gate in April. Coleman National Fish Hatchery (CNFH) fall-run (410) and Feather River Fish Hatchery (FRFH) spring-run (139) Chinook salmon were raised to representative sizes (76-130 mm) and implanted with JSATS tags to measure relative survival from the Upper Sacramento and Feather River hatcheries to Benicia Bridge for early versus late releases (CNFH fall-run), in-river versus trucked survival (FRFH spring-run), and a delta-specific release (CNFH fall-run). Acoustic receivers will be down loaded in July 2012. We also tested detection range, post-surgery tag retention/survival, and tag failure rates. Key lessons learned as well as pilot study results will be presented.

**Keywords:** JSATS, juvenile Chinook salmon, movement, survival, acoustic telemetry

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## **Applying Predator-Prey Models to Reach-Specific Survival Estimates of Juvenile Late-Fall Chinook Salmon in the Sacramento-San Joaquin River Delta**

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Understanding factors affecting the mortality rates of juvenile salmon emigrating from the Sacramento River is critical for devising water management strategies that maximize survival. Predation by non-native piscivorous fishes is widely thought to be a primary mechanism causing mortality of juvenile salmon in the Delta. Casting juvenile salmon survival in the context of predator-prey theory can therefore provide insights about how migration dynamics of juvenile salmon contribute to their mortality. Migration rates of juvenile salmon change considerably as they transition from a riverine environment to the tidally-driven environment of the Delta. In the upper reaches of the Delta, fish migrate downstream quickly whereas in tidal regions, migration rates slow considerably due to tidal forcing. When prey move quickly through a gauntlet of predators, predator-prey theory predicts that survival will depend only on distance traveled. In contrast, when prey move slowly relative to predators, theory indicates that survival will depend only on travel time. In the Delta, we hypothesize that survival transitions from distance- to time-dependence as fish migrate from the upper to lower reaches of the Delta. To understand how both travel time and travel distance affect mortality rates, we 1) quantified the effect of river flows on migration rates, and 2) fit predator-prey models to reach-specific survival estimates of juvenile salmon collected between 2007 and 2010. We then used model selection to compare alternative predator-prey models where survival depends on travel time, on travel distance, or a mixture of both time and distance. Our analysis will provide a mechanistic basis for understanding how water management actions that alter the quantity and routing of river flow influence migration of juvenile salmon, and in turn, how changes in migration dynamics influence survival.

**Keywords:** telemetry, juvenile chinook salmon, survival, predator-prey models, migration

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## **Survival and Route Selection of Juvenile Chinook Salmon in the Southern Sacramento-San Joaquin River Delta, 2011**

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Juvenile salmonids typically have low survival migrating through the Sacramento-San Joaquin River Delta. Improving survival requires knowledge about the migration routes salmon take through the Delta and on reaches with high mortality. 2011 was the final year of the Vernalis Adaptive Management Program acoustic-tagging study, with 1,899 juvenile fall Chinook salmon tagged and released in the San Joaquin River approximately 12 miles upstream of the confluence with Old River. Tagged smolts were monitored at 25 fixed-site acoustic receiver locations throughout the south Delta to Chipps Island. Acoustic-tag detections were analyzed with a release-recapture model to estimate route selection probabilities at the head of Old River and survival probabilities in key reaches of the San Joaquin and Old rivers. Results on survival, route selection, and travel time will be presented and compared to similar studies from previous years. This information is crucial for appropriate management of salmon populations through the Delta.

**Keywords:** Chinook, salmon, acoustic-telemetry, release-recapture, San Joaquin, route selection, survival

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## **Napa River Steelhead Smolt Utilization of Napa Plant Site Tidal Marsh Using Acoustic Tags**

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Funded by NMFS (ARRA) and Ducks Unlimited, the intent of this project was to tag and track wild juvenile Napa River steelhead (Central California Coast ESU) through the lower Napa River, particularly in the vicinity of the newly-restored and breached 1,600 acre Napa Plant Site (old Cargill salt ponds). The purpose of this Project is three-fold: to quantitatively assess the utilization of restored tidal marsh habitats by wild Napa River steelhead smolts that were collected via Napa County Resource Conservation District's rotary screw trap in the upper Napa River; to assess utilization of the restored marsh by other special-status Chinook salmon, steelhead and green sturgeon that were tagged by other investigators (with permission) associated with the California Fish Tagging Consortium; and to determine the regional effectiveness of tidal restoration efforts on these species.

Fourteen acoustic (VEMCO) receivers were installed in the Napa River, upstream and downstream from the Napa Plant site, and strategically within the three units (North, Central, and South units) of the site to document steelhead entrance into the units, residency time in the vicinity of each receiver/unit, and where possible, to describe habitat preference by steelhead within each of the units. VEMCO receivers were also installed in the lower Napa River and Mare Island Strait to determine distribution and timing of outmigration.

**Keywords:** steelhead, tidal marsh, habitat distribution, VEMCO, acoustic tag, Napa River.

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## Seasonal Distribution and Habitat Usage of Juvenile Striped Bass in the San Francisco Estuary Watershed

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Several long term studies document the behavior of adult striped bass (*Morone saxatilis*) inhabiting the San Francisco Estuary Watershed, however, comparatively little is known about the distribution or pelagic habitat use of juveniles (<2 year olds). Understanding juvenile striped bass behavior can help to illuminate predator-prey interactions and guide restoration planning. To investigate seasonal distribution and pelagic habitat usage, juvenile striped bass (n=99; mean fork length= 285 mm) were surgically implanted with acoustic transmitters in June and July 2010 and tracked via stationary receivers (n=300) through October 31, 2011. Juveniles were tagged on the American (n=11), Sacramento (n=22), and San Joaquin rivers (n=33), the Sacramento Ship Channel (n=15), and Three Mile Slough (n=18). We have detections for 82% of the tagged fish totaling over one million records. Both distribution and pelagic habitat usage differed significantly between season and tagging locations. Juveniles tagged at sites within the Estuary had similar seasonal distribution patterns, while those tagged in the American River exhibited extended freshwater residency. Juveniles were distributed more closely to their tag site location or made more visits to the area than to other locations except San Pablo Bay. As day length increased, the distribution of juveniles tagged at estuarine sites shifted toward warmer (20°C) and higher salinity (>5 ppt) waters in the west Delta and San Pablo Bay, respectively. As day length decreased, distribution shifted away from the San Pablo and Central bays and into Carquinez Strait, Central Delta, and North Delta. During the second summer, several fish migrated over 200 Km upstream into the Sacramento and Feather rivers. Habitat usage was dominated in warm (>20°C), fresh and temperate (10-20 °C) polyhaline waters in summer, temperate, fresh and euhaline in fall, temperate mesohaline and fresh over winter, and temperate fresh and oligohaline habitat during spring.

**Keywords:** juvenile striped bass, biotelemetry, seasonal distribution, pelagic habitat,

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## Environment and Movement Patterns of Largemouth Bass in the Sacramento - San Joaquin Delta

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To successfully manage the novel ecosystem of today's Delta we must have an understanding of key interactions between organisms and their environment. Much of our knowledge about the largemouth bass, a non-native but numerically dominant species in the Delta, originates from lake studies conducted in other regions of the country. Due to the unique complexity of the Delta, it is important to examine the life history and behavior of this species in a local context. To help achieve this goal, a telemetry positioning system was deployed over 15 months in a flooded island in the south-central Delta. The array was designed to examine the daily and seasonal movement patterns of tagged largemouth bass, particularly the species' interaction with beds of submerged aquatic vegetation and open-water habitats. The positioning system was located within an existing Delta-wide array of presence/absence monitors, allowing for observations of both coarse- and fine-scale movements. Results suggest three general classes of behavior in adult largemouth bass: a) non-resident, b) wide-ranging resident, and c) localized resident. Non-resident fish showed long range movements (~4 to ~20 river km from the tagging location) which generally occurred during the summer months. Resident fish remained in the study area over several months, and displayed seasonal movement patterns which appeared to be related to breeding behavior. Additional analyses will focus on impacts of local environmental factors, such as water temperature, vegetation density, and tidal cycles, on these movement patterns. This work sheds light on the population connectivity and habitat use of largemouth bass in the Delta and provides insight into how bass may colonize or use future shallow-water restorations. The information gained will be important as management decisions attempt to balance needs of both native fish and desirable sport fish, such as the largemouth bass.

**Keywords:** largemouth bass, telemetry positioning system, submerged aquatic vegetation

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## Using Acoustic Telemetry to Determine Movements, Behavior and Critical Spawning Habitat for Green Sturgeon in the Sacramento River

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The green sturgeon, *Acipenser medirostris*, is one of two acipenserid fishes native to the Central Valley. On April 7, 2006 the Southern DPS, which constitutes the spawning population of the Sacramento River, was listed as “threatened” under the Endangered Species Act (ESA). Recent interest in green sturgeon behavior, habitat preferences, and migratory path ways has led us to develop a series of telemetric and hydrologic studies to identify and describe potential aggregate and spawning locations. Over the past five field seasons we have tracked green sturgeon both actively and passively within the putative spawning grounds. Using this movement data as a basis for identifying fidelity to specific habitat units, we have now begun mapping and describing the physical and hydrologic characteristics of known spawning locations. These studies will provide new information about habitat preference, and the availability of preferred habitat within the Sacramento drainage.

**Keywords:** green sturgeon, biotelemetry, Sacramento River

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## Advancements in Delta Smelt Acoustic Tagging

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Delta smelt, previously one of the most common resident pelagic fish in the San Francisco Estuary, have dramatically declined in abundance since the 1980s. In order to develop sound management and restoration strategies, critical data gaps concerning delta smelt life history, habitat requirements, and exposure to key environmental stressors need to be addressed. Detailed resolution of fish movement and activity over spatial and temporal scales can be achieved by acoustic telemetry. The aim of this study was to assess the feasibility of tagging adult delta smelt to advance the long-term goal of establishing an estuary-wide smelt acoustic telemetry system. Cultured adult delta smelt (age-1 and age-2) were injected with a low viscosity polyurethane resin in order to determine the volume and shape of the peritoneal cavity. Dimensions of adult delta smelt peritoneal cavities permitted the use of the smallest currently available acoustic transmitter as a prototype for production of dummy tags along a gradient of sizes and weights. Three differently sized transmitters and PIT (Passive Integrated Transponder) tags were surgically implanted into age-1 and age-2 delta smelt to evaluate survival, tag retention, and wound closure over 28 days. Handling and anesthesia did not affect the survival of delta smelt during the study period. Cumulative mortality of all fish implanted with tags was significantly higher than that of the untreated control group, and survival was a function of tag size/weight. However, survival in the PIT-tagged group approached 75% over the 28-day period, emphasizing the potential use of a small, injectable acoustic transmitter – currently under development by the US Army Corps of Engineers - for delta smelt field studies as early as 2014.

**Keywords:** Delta smelt, acoustic telemetry,

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