MacFarlane[1], B.R., A.P. Klimley[2], S.L. Lindley[1], A.J. Ammann[1], P.T. Sandstrom[1], C.J. Michel[2], E.D. Chapman[2]
[1]NOAA Fisheries, Southwest Fisheries Science Center, Santa Cruz, CA 95060
[2]University of California, Davis, Dept. of Wildlife, Fish, & Conservation Biology
bruce.macfarlane@noaa.gov

Survival and Migratory Patterns of Central Valley Juvenile Salmonids: Progress Report

We are in the second year of a three-year project describing reach-specific rates of survival and movement of juvenile late-fall Chinook salmon and steelhead. Variation in rates will be related to natural and anthropogenic covariates, such as water flow, water temperature, and riparian habitat use. This CALFED funded project rapidly grew to include other agencies (U.S. Army Corps of Engineers, U.S. Fish & Wildlife Service, East Bay Municipal Utility District, Bay Planning Coalition, and California Department of Water Resources) to address their salmon-related issues. In 2006, the consortium placed 220 acoustic receivers throughout the Sacramento River, Delta, and San Francisco Estuary that will detect the presence of tagged fish. In 2007, 200 late-fall Chinook smolts and 200 juvenile steelhead from Coleman National Fish Hatchery were tagged and released into the system near the hatchery. An additional 194 late-fall Chinook and 49 steelhead were tagged and released near Sacramento for Delta and Estuary related projects. High mortality (> 80%) was recorded between release near the hatchery and Ord Bend, 150 km downstream, for both species. Survival was about 10% at the west end of the Delta. Only 2% of the Chinook and 7% of the steelhead were detected at the Golden Gate. This very low survival may have been related to water conditions; 2007 was a dry year with low river flows, which may have resulted in high predation. Data analysis resulted in changes in release strategies and the number of tagged fish in 2008 to improve survival estimate confidence intervals downstream of the upper river high mortality section. In 2008, 304 Chinook and 300 steelhead were released in the Sacramento at three spatially separated locations, and an additional 471 Chinook and 50 steelhead were released downstream for Delta and Estuary studies. Data from the 2008 releases are currently be checked and added to the database.

CALFED Statement of Relevance
This project is providing for the first time high spatial resolution data on survival and movement of juvenile salmonids, which can be used to assess influences of natural and anthropogenic factors, such as flow, water temperature, diversions, and riparian habitat alteration, on salmonid populations.

SESSION: Migratory Movements and Success of Salmonids (I), 10/22/2008, 1:20 PM, Room 306

Ammann[1], A.J., E. Chapman[2], C. Michel[1], M. Thomas[2]
[1]National Marine Fisheries Service, 110 Shaffer Road, Santa Cruz, CA 95060
[2]UC Davis, One Shields Ave., Davis, CA
arnold.ammann@noaa.gov

Tag Effects in Yearling Salmonids with Implanted Acoustic Transmitters

The use of surgically implanted acoustic transmitters, coupled with an extensive array of receivers, is allowing researchers to track the movement and survival of juvenile salmonids. When implanting a tag it is essential to know that the tag and the tagging procedure do not negatively affect the fish. Additionally, tag expulsion rates should be determined for each tag type, fish species and size class. We performed laboratory trials to test how implanted tags affect the growth and survival of hatchery-raised yearling late-fall Chinook salmon and yearling steelhead. The Chinook were implanted with dummy tags similar to Vemco V7-4Ls, about 3.7% tag to body weight. Steelhead were implanted with tags similar to Vemco V9-1Ls, about 2.8% tag to body weight. Growth and survival rates of tagged fish were compared to untagged controls and surgery controls (25 fish per treatment). For each species, all treatments were held in the same tank, fed daily rations of 2% biomass, and examined, weighed and measured every 30-45 days. Chinook growth rates were similar among treatments. Steelhead growth rates were lower for the tag treatment. Survival was similar among treatments for both species. Tag expulsion did not occur in Chinook after 90 days, while 5 out of 25 steelhead expelled their tags within 30 days. These results suggest that late-fall Chinook yearlings are not greatly affected by tag implantation. In contrast, steelhead growth rates are affected and tag loss is significant. The results of this laboratory study will help interpret results of movement and survival data obtained from tagged fish released into Central Valley and San Francisco Bay systems.

CALFED Statement of Relevance
This study is providing data to support and interpret results of a large-scale salmonid tracking study funded by CALFED.

SESSION: Migratory Movements and Success of Salmonids (I), 10/22/2008, 1:40 PM, Room 306

Lindley[1], S.L., C. Michel[1], P.T. Sandstrom[2]
[1]NOAA Fisheries, Southwest Fisheries Science Center, Santa Cruz, CA 95060
[2]University of California Davis, One Shields Ave. Davis, CA 95616
steve.lindley@noaa.gov

Estimating Reach-specific Smolt Survival Rates and the Factors Influencing them from Acoustic Tagging Data

Our extensive array of acoustic receivers arranged along the Sacramento River between Battle Creek and the Golden Gate, combined with releases of acoustically-tagged chinook and steelhead smolts, allows estimation of reach-specific survival rates. The analysis is complicated by the fact that not all live animals passing a receiver are detected. The Cormack-Jolly-Seber model in Program MARK can be used to obtain maximum likelihood estimates of reach-specific survival rates along linear portions of the river, and some amount of branching can be handled with multi-strata models. The effects of individual covariates (e.g., fork length) can be included to explain variation in survival or detection probabilities among individuals, and the effects of reach-related factors (e.g., bank cover, water velocity) can be included to explain variation in these parameters among reaches, potentially giving insight into the causes of variation in survival. We will present the results of such analyses for smolt release experiments conducted in 2007 and 2008.

CALFED Statement of Relevance
This project is providing for the first time high spatial resolution data on survival and movement of juvenile salmonids, which can be used to assess influences of natural and anthropogenic factors, such as flow, water temperature, diversions, and riparian habitat alteration, on salmonid populations.

SESSION: Migratory Movements and Success of Salmonids (I), 10/22/2008, 2:00 PM, Room 306

Workman[1], M.L., J.E. Merz[2], W.N. Heady[3]
[1]East Bay Municipal Utility District, 1 Winemaster Way Ste K, Lodi, CA 95240
[2]Cramer Fish Sciences, Hedberg Way, Oakdale, CA
[3]UC Santa Cruz, 100 Shaffer Rd., Santa Cruz, CA 95060
mworkman@ebmud.com

Lower Mokelumne River Steelhead Acoustic Study

Development of the Central Valley Fish Tracking Consortium has provided collaborative project opportunities throughout the Sacramento San Joaquin Bay and Delta System. Over the past two years Mokelumne River studies have made use of the extensive acoustic receiver array system deployed as part of this Consortium to track the movement, survival, and habitat use of hatchery origin smolt steelhead *Oncorhynchu mykiss*, hatchery steelhead kelts and multiple life stages (>160mm) of the wild river population of *O. mykiss* . In February and March 2007, East Bay Municipal Utility District (EBMUD) tagged 57 hatchery smolts and released them at New Hope Landing on the lower Mokelumne River. We also tagged 7 re-conditioned hatchery kelts and released them adjacent to the Mokelumne River Fish Hatchery. Concurrently, we collected 64 river-produced and post-yearling residual hatchery steelhead by boat electrofishing, and released them at original capture locations throughout the non-tidal Mokelumne River (within 20 km of Camanche Dam). In 2008 EBMUD tagged 100 yearling hatchery steelhead to be planted in the Bay, Delta, and River, and 10 hatchery kelts released in the river. Concurrently in 2008, 12 actively-migrating steelhead captured by rotary screwtrap near tidewater of the lower Mokelumne River were tagged, and 50 *wild O. mykiss* were tagged for assessment of small scale movements within the LMR. Here, we report information recovered on ten receiver stations deployed from the base of Camanche Dam through the Mokelumne River delta and the station grid located throughout the Sacramento San Joaquin Delta and Estuary. Data from the existing network of approximately 220 hydroacoustic receivers located within the Sacramento-San Joaquin River system, Delta and San Francisco Bay estuary will be used to determine movement patterns, survival, and gross habitat use of hatchery and wild *O. mykiss* from the Mokelumne River.

CALFED Statement of Relevance
Steelhead are important biological components of the Central Valley ecosystem and their abundance is often used to judge the ecological health of the system. Our ability to accurately track steelhead behavior, migration paths, and survival and to accurately assess production origin on these parameters has biological as well as potential regulatory and operational implications throughout the Bay-Delta system.

SESSION: Migratory Movements and Success of Salmonids (I), 10/22/2008, 2:20 PM, Room 306

Bremner[1], A.M., W.N. Brostoff[1], P.E. LaCivita[1], T. Keegan[2], D. Woodbury[3]
[1]U.S. Army Corps of Engineers, 1455 Market Street, 15th Floor, San Francisco, CA 94103
[2]ECORP Consulting, Inc., 2525 Warren Dr., Rocklin, CA 95677
[3]National Marine Fisheries Service, 777 Sonoma Ave. RM 325, Santa Rosa, CA 95404
allison.m.bremner@usace.army.mil

Juvenile Salmonid Outmigration Trends in Relation to Dredging Activity Sites in the San Francisco Estuary

Information on the temporal and spatial distribution of Federally-listed juvenile Chinook salmon and steelhead in San Francisco Bay is needed for assessing potential impacts to these species from dredging activities. Currently, work windows are used that limit dredging activities to periods of time when listed salmonids are thought to be absent in the bay. Through the use of hydroacoustic telemetry we hope to increase our knowledge of juvenile salmonid migratory behavior to better manage dredging operations. Through a collaborative multi-agency effort, Chinook salmon and steelhead smolts implanted with ultrasonic tags are being released each year during the winter months of 2007-2009. As the smolts move from the Sacramento River, through the Estuary, and under the Golden Gate Bridge during their outmigration, they are detected by strategically-located hydrophones placed to better define juvenile salmonid migratory routes, transit times, and distribution relative to dredging and dredged material placement sites, thus providing the information needed to make management decisions. Data from the 2007 field season revealed that the tagged smolts: utilized deeper channels more often than shallow areas during outmigration; traversed the San Francisco Estuary from the release point in Rio Vista, CA to the Golden Gate in an average of 20 days and 41 days for Chinook salmon and steelhead, respectively; and were detected at dredging and dredged material placement sites. This project is coordinated with complementary research conducted by ECORP Consulting, Inc. for the Bay Planning Coalition. This study was designed and funded in collaboration with the San Francisco Bay Region Long Term Management Strategy for the Placement of Dredged Material and the CALFED grant recipients at the NOAA Fisheries Salmon Ecology Laboratory in Santa Cruz and the University of California Davis Department of Fish, Wildlife, and Conservation Biology.

CALFED Statement of Relevance
This project is one part of a multi-agency/research institute project which has the common goal to gain knowledge about the migratory behavior of native species so the new information can be used to protect habitat for the native species in the future.

SESSION: Migratory Movements and Success of Salmonids (I), 10/22/2008, 2:40 PM, Room 306

Perry[1], R.W.*, P. Brandes[2], J.R. Skalski[1]
[1]University of Washington, Box 355020, Seattle, WA, 98195-5020
[2]U.S. Fish and Wildlife Service, 4001 N. Wilson Way, Stockton, CA 95295
rwperry@u.washington.edu

Migration Routes and Survival of Juvenile Late-fall Chinook Salmon Migrating through the Sacramento – San Joaquin River Delta

Understanding effects of water management actions on survival of juvenile salmon is critical to management of water and fisheries resources, but the complexity of the Sacramento – San Joaquin River Delta poses challenges in studying such problems. During 2007 and 2008, we acoustically tagged late-fall juvenile Chinook salmon and monitored their migration through the Delta. To better understand how survival among different migration routes contributes to overall survival through the Delta, we developed a mark-recapture model that explicitly estimates both the fraction of tagged fish using specific migration routes and survival within each route. In 2007, an estimated 30%-40% of juvenile salmon migrated through Steamboat and Sutter Slough, a migration route which precludes fish from being entrained into the interior Delta via the Delta Cross Channel or Georgiana Slough. Of fish that remained in the Sacramento River, an estimated 33% of fish entered the Delta Cross Channel when it was open, and approximately 15% entered Georgiana Slough regardless of whether the Delta Cross Channel was open or closed. Accounting for fish distribution among all routes, tagged fish had a 35% probability of being entrained into the interior Delta when the Delta Cross Channel was open and a 9% probability when it was closed. Although standard errors were large, estimated survival for fish migrating through the interior Delta was lower than survival in the Sacramento River, a finding consistent with previous research. However, survival through the interior Delta contributed less than other routes to overall survival through the Delta due to the lower fraction of fish migrating through the interior Delta. Although small sample size limits broad inferences from the 2007 data, this study, ongoing analysis of the 2008 data, and research in 2009 is beginning to shed light on processes affecting survival and movement of juvenile salmon through the Delta.

CALFED Statement of Relevance
Management actions taken under the Water Supply Reliability objective affect distribution of water through the Delta. The Ecosystem Restoration Program is aimed at supporting sustainable animal populations. Our study addresses both objectives by examining how water distribution in the Delta affects routing and survival of migrating juvenile salmon.

SESSION: Migratory Movements and Success of Salmonids (II), 10/22/2008, 3:20 PM, Room 306

Chapman[1], E.D., P.T. Sandstrom[1], A.J. Ammann[2], C. Michel[2], A.P. Klimley[1], R.B. MacFarlane[2], S.L. Lindley[2]
[1]University of California Davis, One Shields Ave., Davis, CA 95616
[2]NOAA, Southwest Fisheries Science Center, 110 Shaffer Rd., Santa Cruz, CA 95060
edchapman@ucdavis.edu

Diel Migrations of Salmon Smolts in the Sacramento River, Delta, and San Francisco Bay Estuary

We have been able to track fine scale movements of chinook salmon, *Onchorhynchus tshawytscha*, and steelhead trout, *Oncorhychus mykiss*, in the Central Valley of California through the use of ultrasonic telemetry. Miniature, ultrasonic coded beacons were implanted within the peritoneum of 500 fish during January of 2007 and released at four locations throughout the Sacramento River and Delta. These fish have been detected by an array of monitors established throughout the watershed extending from Redding to the Golden Gate Bridge in the San Francisco Bay. The detections of chinook over the following months (January, February, and March) exhibited a diel pattern of migration, that is there are few detections during daytime and many during nighttime. This is likely because individuals remain within a confined area during the day moving little, and then become active at night swimming extensively downstream. Furthermore, the difference between the ratio of more frequent nighttime detections to less frequent daytime detections of chinook smolts decreases in the Delta and San Francisco Bay Estuary. Steelhead, which reside upriver longer, do not exhibit the same diel pattern to detections at any point during their out migration. There may be other environmental cues that stimulate migrations of steelhead such as rainfall events (see Sandstrom et al. poster), but it does not appear to be related to day length.

CALFED Statement of Relevance
Late Fall Chinook smolts are exhibiting diel patterns of migration which may help managers determine the use of water in the Sacramento River. These fish are traveling at night in the upper river and by limiting the use of pumps during the day we may be able to reduce mortality.

SESSION: Migratory Movements and Success of Salmonids (II), 10/22/2008, 3:40 PM, Room 306

Michel[1], C.J.*, A. Ammann[2], P. Sandstrom[3], E. Chapman[3], S. Lindley[2], A. Klimley[3], R. MacFarlane[2]
[1]University of California-Santa Cruz/National Marine Fisheries Service, 110 Shaffer Rd, Santa Cruz, CA 95060
[2]National Marine Fisheries Service, 110 Shaffer Rd, Santa Cruz, CA 95060
[3]University of California - Davis, Department of Wildlife, Fish, & Conservation Biology, One Shields Avenue, Davis, CA 95616
michel@biology.ucsc.edu

A High-resolution Account of the Survival and Movement Rates of Acoustically Tagged Juvenile Chinook Salmon (Oncorhyncus tshawytscha) during the 2007 and 2008 Season

Acoustic tagging and tracking has become a very simple, high-resolution way of understanding fish movements. This method is essential in understanding the movements of highly migratory fish such as the late-fall run Chinook salmon (*Oncorhyncus tshawytscha*) smolts as the make their way through the Sacramento River watershed. We are specifically interested in learning more about their survival and timing of their downstream migration using an array of monitors throughout the watershed. This information, coupled with different morphological and environmental variables, will allow us to evaluate and understand their migration patterns. Initial results from 2007 data showed very low survival in the upper Sacramento river, with very few smolts making the 530 kilometer journey from release at the Coleman National Fish Hatchery to the Golden Gate Bridge. The few that did make it to the ocean took an average of 25 days to make the trek. Data from the 2008 season is being analyzed and will also be presented.

CALFED Statement of Relevance
By providing invaluable high-resolution movement and survival information for these economic and ecologically important fish, we will be able to assess the impacts of anthropogenic and natural factors on the population. This could lead to improved management and conservation efforts to help curtail their decline.

SESSION: Migratory Movements and Success of Salmonids (II), 10/22/2008, 4:00 PM, Room 306

Heady[1], W.N.*, M.L. Workman[2], J.E. Merz[3]
[1]Ecology and Evolutionary Biology Department, UC Santa Cruz, Long Marine Laboratory, Santa Cruz, CA 95060
[2]East Bay Municipal Utility District, 1 Winemasters Way Suite K2, Lodi, CA 95240
[3]Cramer Fish Sciences, 636 Hedburg Way # 22, Oakdale, CA 95361
heady@biology.ucsc.edu

Fine Scale Habitat Associations, Movement and Survival of Steelhead Trout of the Mokelumne River, CA using Acoustic Telemetry in Standardized Transects

Steelhead (*Oncorhynchus mykiss*) are highly adaptive with myriad life history trajectories including lifetime freshwater residence and anadromy, and yet populations are in severe decline. In California, all but one steelhead Distinct Population Segment are listed as threatened or endangered. In the Central Valley, declines are clearly linked to water management (McEwan 2001), with dams eliminating approximately 82% of historical spawning and rearing habitat (Yoshiyama et al. 1996 in McEwan 2001). Of particular ecological and management interest are answers to questions related to behavior, movement and survival of wild O. mykiss within the freshwater system prior to, during or instead of seaward migration. In a collaborative effort, the East Bay Municipal Utilities District, University of California and Cramer Fish Sciences have conducted two years of acoustic telemetry of over 300 wild and hatchery *O. mykiss* of the Mokelumne River. In efforts to answer the above questions the locations of acoustically tagged *O. mykiss* were monitored using standardized transects along 39km of the Mokelumne River between the upstream limit to anadromy, Camanche Dam, and tidal influence. Transects were traveled weekly to monthly from February 2007 through March 2009 in a 12ft aluminum skiff using a hand held hydrophone and receiver. For each transect, the time, surface water temperature, habitat parameters, streamflow and weather are associated with specific GPS locations of acoustically tagged fish. In 2008, acoustically tagged wild *O. mykiss* were also tagged with a visual tag to enable snorkel surveys to document behavioral interactions with habitat features and other fish. An angler survey is being conducted to investigate angling effects on *O. mykiss* movement and survival. Results of habitat associations, site fidelity, degree of movement, intraspecific interactions, percent anadromy and survival of approximately 126 acoustically tagged wild *O. mykiss* over a two year period are presented.

CALFED Statement of Relevance
Central Valley *Oncorhynchus mykiss* are listed as threatened under the Endangered Species Act. Knowledge of wild *O. mykiss* habitat associations, movement and survival in relation to managed and altered systems, will enable managers to focus efforts towards more effective restoration, water management, fisheries and wildlife management and recovery.

SESSION: Migratory Movements and Success of Salmonids (II), 10/22/2008, 4:20 PM, Room 306

Sandstrom[1], P.T.*, A.J. Ammann[2], E.D. Chapman[1], A.P. Klimley[1], R.B. MacFarlane[2], S.L. Lindley[2], C. Michel[2]
[1]University of California Davis, One Shields Ave., Davis, CA 95616
[2]NOAA Fisheries, Southwest Fisheries Science Center 110 Shaffer Rd., Santa Cruz, CA 95060
ptsandtrom@ucdavis.edu

Fine-Scale Movement and Depth Distribution of Juvenile Steelhead Trout in the Sacramento River and San Francisco Bay Estuary

Little is known about the movement patterns of juvenile steelhead trout. Four juvenile steelhead trout were tagged and tracked with miniature ultrasonic transmitters that recorded depth. Tagged steelhead made small initial movements for the first 24 hours after release. The two individuals tracked for multiple days exhibited a significant response to tidal flows. Fish moving the greatest distances upstream or downstream were observed in the top 3 m of the water column and closely followed changes in water flow direction. Steelhead trout were observed near the bottom of the water column, where influence of flow is reduced, when making fine-scale movements or ignoring the prevailing water flow. The fish we tracked continuously for five days during the summer showed a diel pattern, moving during the daytime and typically holding in an area of less than 1 km at night. This fish was found at depths ¡Ü3 m 86% of the total daytime detections. The second steelhead tracked during the spring, when juveniles are outmigrating, moved further at night than during the day for the first four days. This fish also exhibited behaviors of holding and localized movements during the daytime rather than at night. 81% of daytime detections were ¡Ý3 m in depth, while 79% of nighttime detections occurred in the top 3 m of the water column. By characterizing movement patterns of smolts we will increase our understanding of the behaviors other juvenile steelhead may exhibit between automated receiver sites along the outmigration corridor at various times of the year.

CALFED Statement of Relevance
The fine-scale movements of juvenile steelhead trout are of importance in the Delta because of predation and responses to water flow.

SESSION: Migratory Movements and Success of Salmonids (II), 10/22/2008, 4:40 PM, Room 306