980 Ninth Street, Suite 1500
Sacramento, CA 95814
www.deltacouncil.ca.gov

Lead Scientist's Report

Summary: This report covers seven items:

<u>Collaborative Science Activities</u>: 1) Delta Regional Monitoring Program meeting to review monitoring design; 2) Ballast Water Treatment Feasibility workshop;

<u>Science Communication</u>: 3) Summary of a journal article on 2015 snowpack in the Sierras; 4) Two synthesis articles from the San Francisco Estuary and Watershed Science (SFEWS) journal on Delta Smelt life cycle and abundance trends, and salmonids in the Delta; 5) Brown Bag Seminar on a new proposed framework for extinction; 6) One poster from the Society for Freshwater Science conference; and 7) the "By the Numbers" summary.

<u>Collaborative Science Activities</u>

Delta Regional Monitoring Program Review

The Council's Science Program is coordinating a two-phase independent science review of the Delta Regional Monitoring Program (RMP) monitoring design. The Delta RMP is a stakeholder-directed project formed to develop water quality data necessary for improving the understanding of Delta water quality issues.The monitoring design outlines the monitoring programs or special studies that are needed to answer management questions identified by the RMP. The first phase of the review will occur via teleconference on August 23, when the monitoring design will be presented by members of the Delta RMP. An initial report from the review panel will follow, providing comments regarding the scientific quality of the monitoring design to which the Delta RMP participants will then prepare a response. During the second phase, the review panel will evaluate whether the initial recommendations the review panel provided were adequately addressed. The five-member panel consists of experts in Delta hydrodynamics, statistics, large-scale monitoring efforts, and water quality.

The goal of the RMP's monitoring design is to better design current and future monitoring activities in and around the Delta, using a cost-effective approach that provides critically needed water quality information for the Central Valley Regional Water Quality Control Board and other federal, State and local agencies and organizations. The Delta RMP is currenly focused on four types of pollutants: current use pesticides and toxicity, nutrients, mercury, and pathogens. Implementation of a Delta regional monitoring program is a Delta Plan recommendation (WQ R9).

Ballast Water Treatment Feasibility Workshop

Ballast water is used as a balancing and weight distribution tool necessary for the navigation, stability, and propulsion of large seagoing ships. Vessels may take on, discharge, or redistribute ballast water during cargo loading and unloading, or as they transit through shallow waterways. In coastal and estuarine environments, the ballast water of commercial ships is recognized as one of the most important mechanisms, or "vectors," for introduced species invasions. Introduced species are identified in the Delta Plan as a major obstacle to successful restoration of the ecosystem.

The Port of Stockton in particular is one of the busiest small ports in the country, the largest of the two Delta freshwater ports, and will be one of several case studies considered in this workshop. California law requires the California State Lands Commission to implement performance standards for the discharge of ballast water into state waters. The Commission asked the Council to manage a feasibility study of shore-based treatment of ballast water including independent review of study results. The initial public workshop for the feasibility study was held on Oct. 6, 2015 and focused on a literature review, the selection process for case studies, and public comments. The second workshop will be held on Aug. 30, 2016 at the Long Beach Aquarium, and will serve as a check-in and analysis of potential technologies for shore-based ballast water treatment. In a final, future meeting, the panel will review a report of the full feasibility analysis, detailing the potential for the treatment scenarios analyzed to allow vessels to comply with California's interim performance standards.

Science Communication

Characterizing the extreme 2015 snowpack deficit in the Sierra Nevada (USA) and the implications for drought recovery

Steven A. Margulis, Gonzalo Cortés, Manuela Girotto, Laurie S. Huning, Dongyue Li, and Michael Durand. Geophysical Research Letters, June 21, 2016

California's water supply and management actions depend on snowfall in the Sierra Nevada mountains. Not all snow is equal, and simply measuring the depth of snow is not an accurate way to predict water supply, therefore, scientists measure snow water equivalents (SWE). SWE is the amount of water contained within the snowpack that would result when melted. A recent research study developed a new method to more accurately determine SWE over large areas by combining satellite images with computational models and historical data.

This study determined exactly how dry the Sierra Nevada was in 2015. The peak water volume of the snowpack was just 0.7 cubic miles, while the multiyear peak average volume is 4.46 cubic miles. The exceptionally low SWE in 2015 was rare, with approximately just a 1 in 680 chance of happening any given year. The previous four years of drought lead to the highest multiyear snowpack water deficit in the 65 years analyzed. The data suggest that California will not recover to pre-drought snowpack conditions until at least 2019, despite near average snowfall in 2016.

Satellite imagery allowed the scientists to evaluate SWE at all elevations of the Sierra. In typical years, SWE peaks at an elevation of 6,500-7,000 feet. However, in 2015 the SWE at that elevation was only 7 percent of the average. The 2015 peak SWE occurred at an elevation between 9,100-9,500 feet.

In summary, the 2015 SWE was not only significantly lower than average across all elevations, but there was also a shift to SWE peaking at higher elevations. This shift is likely driven by warmer temperatures, leading to less snowfall and more rainfall at lower elevations, combined with increased snow melt. Historically, most droughts in California have ended within one year. Warming temperatures lead to a much higher frequency of extended drought periods with much reduced snowpacks.

2016 Volume 14 Issue 2 of San Francisco Estuary and Watershed Science Journal: Including Special Section on the State of Bay-Delta Science

SFEWS is an open access journal, funded by the Council, and is a key venue for publishing the latest research addressing Delta scientific questions. The current issue of the SFEWS journal includes a special edition section that will also be the first part of the State of Bay-Delta Science (SBDS) report.

SBDS is a synthesis of the best available science about the Delta, emphasizing progress made on key research questions and remaining knowledge gaps. The first edition of SBDS, edited by CALFED Bay-Delta Program lead scientist Michael Healey, Michael Dettinger of the United States Geological Survey and Scripps Institution of Oceanography, and Richard Norgaard of the University of California at Berkeley was published in 2008. Topics for this edition of SBDS address the most relevant scientific issues for the Delta identified by senior scientists and managers. Two articles from the SBDS 2016 Special Issue, Part 1, are summarized below.

> **Delta Smelt: Life History and Decline of a Once-Abundant Species in the San Francisco Estuary**
> *Moyle, Peter B.; Brown, Larry R.; Durand, John R.; Hobbs, James A.*
>
> Delta smelt, a small fish endemic to the upper San Francisco Estuary, was once abundant in the freshwaters of the Delta and brackish waters of Suisun Bay. Much of its historic habitat is no longer available and remaining habitat is increasingly unable to sustain the population. Rapid decline of the species led to its listing as threatened under State and federal endangered species acts (ESA) in 1993, affecting water management in the Delta. Although we know more about delta smelt than any other fish in the system, this knowledge has not stopped the species' trajectory towards extinction. Currently there is a single population of delta smelt with reduced genetic diversity. Although cool, high outflow conditions of 2011 increased delta smelt populations, since then severe drought effects have pushed the species to record low levels in 2014 and 2015.
>
> Recent findings indicate that delta smelt can reside in freshwater for their entire life cycle and their upstream limits are determined by tides transporting them to favorable habitats (cool, zooplankton-rich environments). Furthermore, peripheral areas such as the Napa River, the Cache-Lindsay Slough Complex, the Sacramento Deepwater Ship Channel, and Liberty Island, provide important habitat for smelt year-round. Delta smelt are strongly associated with cool, turbid water, and thus rarely occur in the central or south Delta, especially during the summer and fall. Turbidity is thought to be an important habitat requirement for delta smelt for several reasons including: the use of turbidity from fall and winter storms (first flush) as a trigger for movement to spawning areas, the need for

turbidity to hide the translucent fish from predators, and the use of suspended particles by delta smelt to enable visual detection of their prey. The tendency for delta smelt to follow turbid waters, however, can also lead to entrainment of the fish at pumping facilities.

Although a major driver of decline of delta smelt is change to the Delta from water exports, the proximate causes are the interaction of multiple factors, including entrainment, altered hydrology, food, predation, contaminants, habitat change, drought, and invasions of alien species. While none of these factors alone caused the decline, together they have transformed the Delta into an ecosystem with limited ability to support delta smelt. Climate change and drought are expected to increase stressors on the species.

The rapid decline of the species and failure of recovery efforts demonstrate an inability to manage the Delta for the “coequal goals”, and diverse and substantial management actions are needed for positive outcomes. Such actions could include: species conservation through refuges and culture facilities; management of the species in the north Delta and Suisun Marsh; and restoring larger and more natural flows. The basic lesson from the collapse of delta smelt is that to save a species, ecosystem-based actions have to be taken quickly to halt irreversible change, and to guide inevitable change in a more favorable direction.

Anadromous Salmonids in the Delta: New Science 2006–2016
Perry, Russell W.; Buchanan, Rebecca A.; Brandes, Patricia L.; Burau, Jon R.; Israel, Joshua A.

All anadromous salmonid populations in the Central Valley must travel through the Delta twice during their life cycle: once as juveniles migrating towards the ocean, and once as adults returning to their spawning grounds. The Delta has four distinct runs of Chinook Salmon; Fall, Late-Fall, Winter, and Spring-run, named for the timing of adult upstream migration. Winter and Spring–run Chinook Salmon are listed as endangered and threatened, respectively, under the federal ESA, which affects water management of the Delta. Central Valley Steelhead are also listed as threatened.

Salmonid life history strategies evolved from the diverse array of habitats historically present within the Central Valley. Diversity in life history strategies can buffer populations against environmental stressors, and a lack of diversity may have contributed to the low abundances of Fall-run Chinook Salmon in 2008. The contemporary Delta has been modified to such an extent that salmon populations now contend with an alien environment with reduced habitat diversity. Water management actions further alter the distribution and flow of water through the Delta’s network, influencing the spatial distribution, habitat use, and survival of juvenile salmonids on their seaward migration.

Advancements in the analysis of otoliths (bones from the inner ear) have been used to provide insights about the role of the Delta in the life cycle of juvenile salmon. Otolith analyses can identify life stages when individual juvenile fish either left their natal river or entered brackish or saltwater regions of the Bay-Delta. Rearing in the Delta appears more important to salmon survival than previously appreciated.

Advances in monitoring have improved our understanding of salmonid life histories, but uncertainties in the technology remain. New methods to quantify how well trawls and beach seines capture salmonids are currently being developed, and will provide researchers with a better understanding of salmonid habitat needs. Studies using coded wire tags have provided important information on the influence of water management actions on survival of juvenile salmonids. Recent advances in tracking technology (biotelemetry) for fish have allowed for better understanding of high and low survival reaches of Delta rives and sloughs during the migration of juveniles to the ocean. Such information is critical for guiding restoration and management actions. For example, a key finding from a study spanning 2007 to 2010 was that salmon have lower survival rates when they enter the interior Delta through Georgiana Slough from the Sacramento River and through Old River from the San Joaquin River (survival is low in the interior Delta in part due to predation and entrainment at the pumps). Uncertainties, however, still remain regarding the ability to make generalizations based on the size and type of fish (hatchery-origin) studied, and the ability to distinguish when tagged salmon have been consumed by predators.

Future studies will continue to build upon these efforts, and upon a recent focus by interagency teams to understand the effects of the current drought on salmonid populations.

Brown Bag Seminar – Assessing Extinction in Fishes: Preparing for Extinction of Delta Smelt

The extinction of a species is a major consideration in balancing water supply and environmental needs. It’s usually regarded as a “yes/no” question. But, its determination can be quite complicated, as the path toward extinction is generally a many-step process. At this August 4 seminar, Drs. Peter Moyle and Jason Baumsteiger from UC Davis discussed general aspects of assessing extinction, focusing on native fishes of California including the delta smelt. They proposed six extinction categories: mitigated, regional, native range, wild, visual, and global. Mitigated extinction would apply, they suggest, when the species had become completely reliant on humans for its continued survival. Intervention activities qualifying a species for mitigated extinction included hatchery spawning/rearing and captive populations, with Winter-run Chinook Salmon provided as an example. Underlying the decision to include mitigated extinction as a separate category was the question, “Once you have manipulated a species (e.g., through domestication), is it still the same species?”

To prevent a premature determination of extinction, a waiting period is recommended, based on generation time rather than a fixed number of years, coupled with the mathematical analysis of the likelihood that the species is still extant. Given the complexity of additional extinction categories, they also proposed a new committee that would meet annually to assess extinction status. Following the formal presentations, Drs. Moyle and Baumsteiger invited the audience to ask questions and provide feedback. While the speakers received broad support for their proposed framework, some audience members questioned if the mitigated extinction category would be publicly accepted or whether such a designation arose from a mischaracterization of species' genes and genomes as static over time.

Poster summary from the 2016 Society for Freshwater Science (SFS) Meeting
The following poster, presented at the 2016 SFS meeting, is relevant to Delta water operations.

> **Natural and Anthropogenic Variability in Spring Snowmelt Recession Flows and Associations with Benthic Macroinvertebrates**
> *A.E. Steel, S.M. Yarnell, R.A. Peek, and R.A. Lusardi*
>
> Changes in the timing, extent, and duration of water flow due to climate change and reservoir operations can have downstream effects on the bottom-dwelling (benthic) invertebrates that provide food for fish and other species. In particular, dam operations can increase the rate of springtime recession, which describes the rate at which flow declines following winter snow melt. To better understand which changes in hydrologic patterns have the greatest impact on benthic invertebrates, Anna Steel and colleagues from UC Davis characterized flow for three river sites in each of two watersheds (Yuba and American). Statistical relationships between these flow characteristics (e.g., spring recession, temperature) over 24 to 80 years, and invertebrate communities during both wet and dry years were then determined. Each of the watersheds included non-regulated and regulated rivers. The most regulated sites had lower values for taxa richness (number of species) and diversity (richness and evenness among species). The exception was a regulated bypass with large tributary influxes (Rubicon River), which had similar diversity and richness to unregulated sites. The authors also found strong relationships between both water temperature and spring recession, and benthic community metrics. Increased weekly temperatures and reduced temperature variability were associated with more species-rich and diverse communities. Furthermore, as recession rates increased and recession length decreased, diversity declined, suggesting a strong signal of dam operation on benthic invertebrate communities.

By the Numbers
Delta Science Program staff will give a summary of current numbers related to Delta water and environmental management. The summary (Attachment 1) will inform the Council of recent counts, measurements, and monitoring figures driving water and environmental management issues within the Delta and the Delta catchment.

Attachment

By the Numbers Summary *(report to be provided at the Council Meeting)*

Contact

Dr. Cliff Dahm
Lead Scientist

Phone: (916) 445-0463