Updating the State of Bay-Delta Science to Reflect New Findings Learned about the System Since 2008

Darcy Austin, Delta Science Program, Darcy.Austin@deltacouncil.ca.gov

The State of Bay-Delta Science, 2008 (SBDS, 2008), a synthesis of the scientific knowledge of the Bay-Delta system, is currently being updated by the Delta Science Program (DSP). The update to *SBDS, 2008* will be written for a broad audience with different sections of the report addressing diverse needs. The executive summary will target high-level decision-makers, including the Governor, agency secretaries, the legislature, and Congress, while the main document will target decision-makers and agency managers who are familiar with the system, as well as technical specialists and scientists. The key questions to be addressed revolve around the state of scientific knowledge, including changes throughout the system, insights from an integrated synthesis of data and analyses, and prevailing certainties and uncertainties. This living document, which will be revised by scientific experts every four years, will include future web-based updates as new information arises.

Topics may include: a brief summary of *SBDS, 2008*; defining a new baseline for the big issues of water quality, aquatic ecosystems, levee system fragility, water supply and climate change; a systems-scale view; alternative futures; the role of science and other social science perspectives; and the way forward.

Future updates to the document will complement the DSP Science Action Agenda by identifying actions necessary to fill knowledge gaps and address uncertainties of the system. In turn, this document will be shaped by information gleaned from actions performed under the Science Action Agenda. The next update to *SBDS* is scheduled for completion in 2015.

Keywords: State of scientific knowledge, water quality, aquatic ecosystems

Poster Topic: The Key to Effective Decision-making through Science and Communication: A Preview of the State of Bay-Delta Science, 2015

Recent Advances in Understanding Flow Dynamics and Transport of Water-quality Constituents in the Sacramento – San Joaquin River Delta

David Schoellhamer, US Geological Survey, dschoell@usgs.gov
Brian Bergamaschi, US Geological Survey, bbergama@usgs.gov
Stephen Monismith, Stanford University, monismith@stanford.edu
Scott Wright, US Geological Survey, sawright@usgs.gov

This abstract summarizes a draft chapter of the State of Bay-Delta Science report that describes advances during the past decade in understanding flow dynamics and how water-quality constituents move within California's Sacramento-San Joaquin River Delta (Delta). Water-quality constituents include salinity, heat, oxygen, nutrients, contaminants, organic particles, and inorganic particles. These constituents greatly affect the quantity and quality of benthic, pelagic, and intertidal habitat in the Delta and how water diversions and other human manipulations of flow alter habitat. The Pacific Ocean, the Central Valley watershed, human intervention, the atmosphere, and internal biogeochemical processes are all drivers of flow and transport in the Delta.

Improved understanding of flow and transport has led to identification of significant new policy-relevant issues such as transport pathways created by the Delta Cross Channel, residence time, and the continued clearing of Delta waters. When the Delta Cross Channel is open, flow of water and transport of water-quality constituents from the Sacramento River into the central Delta is enhanced. Residence time is a key ecological variable that varies tremendously within the Delta. Some channels efficiently transport water and its constituents to the Bay or pumps and some dead-end sloughs have much smaller tidal excursions and longer residence times. Submerged aquatic vegetation (SAV) has increased dramatically in the Delta, particularly in the south Delta, and appears to trap sediment and increase water clarity. SAV and decreased sediment supply from the watershed may explain observed decreases in turbidity. To address these issues and to manage the ongoing drought, continuous monitoring of flow and constituent fluxes and research on residence time, effects of SAV, effects of placement and removal of salinity barriers, and deposition and erosion of particulates are needed.

Keywords: flow, water quality, transport, Delta, State of Bay-Delta Science report

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Water Quality, Contaminants, and Their Effects on Delta Species, Ecosystem Services, and Drinking Water Supply

Stephanie Fong, State and Federal Contractors Water Agency, sfong@sfcwa.org
Valerie Connor, State Water Resources Control Board, valerieconnor@att.net
Inge Werner, Swiss Centre for Applied Ecotoxicology, Inge.Werner@oekotoxzentrum.ch
Jay Davis, San Francisco Estuary Institute, jay@sfei.org
Lynda Smith, Metropolitan Water District of Southern California, lsmith@mwdh2o.com
Richard Connon, University of California, Davis, reconnon@ucdavis.edu

Contaminants in the Delta affect water quality, impact associated species, and potentially impact drinking water supply. They originate from agricultural and urban runoff, wastewater treatment effluent discharge, industrial waste, and atmospheric deposition, as well as being applied directly to surface waters. There is also a legacy of contaminants such as persistent organic compounds, mercury, and selenium, which can accumulate through the food chain leading to health risks for humans and wildlife.

Although the Bay-Delta is one of the most studied surface water systems in the world, the ecological impacts of contaminants remain unquantified, and their effects poorly understood. Fish kills that were a common occurrence in past decades are now confined to spills or first flush events, however, sublethal effects of significant concern have been reported. In fish, for example, contaminants can negatively affect the immune system, impact growth and development, directly alter behavior, and have detrimental impacts on sensory systems that affect the ability to avoid predators, recognize kin, find spawning grounds, and reproduce successfully. These sublethal impairments are often difficult to measure and to attribute to specific contaminant classes, because contaminants co-occur in space and time and can interact additively, synergistically, and antagonistically.

Standard bioassay methods that are based on acute toxicity of select species are not sufficient to adequately address the impact of contaminants on aquatic life. Bioassay endpoints that are currently used to evaluate contaminant impacts for regulatory purposes thus need to be enhanced.

Contaminants are also a concern in regard to the Delta as a source for drinking water. Drinking water agencies that rely on the Delta have invested in upgrades to water treatment processes over the last decade, and have also implemented an integrated system of monitoring and forecasting tools to inform water treatment operations.

Keywords: Contaminants, Fish Health, Population Effects, Toxicity, Bioassays, Bioaccumulation, Sublethal Effects,

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Delta Smelt: Biology of a Once Abundant Species in the San Francisco Estuary

Peter Moyle, University of California Davis, pbmoyle@ucdavis.edu
Larry Brown, US Geological Survey, lrbrown@usgs.gov,
John Durand, UC Davis, jrdurand@ucdavis.edu
James Hobbs, UC Davis, jahobbs@ucdavis.edu

The delta smelt (*Hypomesus transpacificus*) is a small, semi-transparent pelagic fish, endemic to the upper San Francisco Estuary (SFE). Although once very abundant, it may soon be extinct in the wild. They are now mainly found in the lower Sacramento River, north Delta, and associated areas. Delta smelt use tides and river flows to maintain themselves in cool (<24°C), low salinity (<7 ssu), turbid (>12 ntu) water. Most adults move up to spawn in fresh water and juveniles move down to rear in brackish water, where they feed on zooplankton. Some smelt have also been found year-around in fresh water. Delta smelt have well-developed predator avoidance mechanisms except as eggs and larvae. Their populations fluctuate widely from year to year but the trend since the 1980s has been downward, most conspicuously since 2002, with record low numbers in 2014-15. The ultimate cause of decline is growth of water demand by a rising human population and the growing California economy. Proximate causes are multiple and interactive, but reduced food supply, predation on larvae, and changes in water quality seem to be especially important. In general, the SFE has become an increasingly unfavorable environment for smelt, especially during the current drought. The Delta smelt is facing new insults to its survival, including effects of physical changes, climate change, and new alien invaders. The captive population can only be used for recovery if suitable conditions exist for smelt in the wild for its entire life cycle. The decline of smelt and other species suggests a general failure to manage the SFE for the "co-equal" goals of biotic sustainability and water supply reliability. The delta smelt is a conservation reliant species; recovery to self-sustaining populations would take massive changes to the SFE.

Keywords: native fishes, reconciliation, POD

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Anadromous Salmonids in the Delta: New Science 2006-2016

Russell Perry, US Geological Survey, rperry@usgs.gov
Patricia Brandes, US Fish and Wildlife Service, pat_brandes@fws.gov
Rebecca Buchanan, University of Washington, rabuchan@uw.edu
Jon Burau, US Geological Survey, jrburau@usgs.gov
Josh Israel, US Bureau of Reclamation, jaisrael@usbr.gov

The functional role of the Sacramento-San Joaquin River Delta in the salmon's life cycle depends on the extent to which each life stage uses the Delta. However, the Delta's complex channel network poses significant challenges for quantifying the role of the Delta and the effect of water management actions on population dynamics of anadromous salmonids. As part of the upcoming report on the State of Bay-Delta Delta Science, we review recent and emerging science over the past decade that is shedding new light on anadromous salmonids in the Delta. Over the past decade we have observed the wide-spread adoption of biotelemetry techniques, which provides detailed spatiotemporal information on tagged individuals as they migrate unimpeded through a network of stationary telemetry stations situated throughout the Delta. These studies have provided new insights about the residence time, behavior, movements, migration routing, and survival of juvenile salmon in the Delta. For example, new statistical methodologies now allow researchers to estimate 1) the proportion of fish using key migration routes, 2) survival within each migration, and 3) the contribution of each migration route to overall survival of juvenile salmon migrating through the Delta. However, telemetry studies have been restricted to large, taggable-sized fish (> 90 mm), primarily of hatchery origin. Consequently, there remains a significant knowledge gap about wild juveniles and fry- and parr-sized fish — life-stages that are expected to rear for considerable time in the Delta. To address the diversity of life stages and life-history strategies of salmon that rely on the Delta, life-cycle models and individual-based models are currently being developed to evaluate the effect of proposed water management actions in the Delta. This new research is shaping water and fisheries management in the Delta, helping managers to understand how specific management actions will affect particular life stages at specific locations.

Keywords: salmon, Delta, water management, telemetry, life cycle models, survival

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Predation on Fishes in the Sacramento – San Joaquin Delta: Current Knowledge and Future Directions

Gary Grossman, University of Georgia, Grossman@uga.edu

The Delta is a heterogeneous, highly modified aquatic system and it is a challenge to quantify the precise impact of predation on fish populations because of the plethora of covarying factors capable of negatively affecting fish populations (e.g., habitat loss, water export and altered flows, invasive species, contaminants, and disease). In addition, because of anthropogenic alterations in physical habitat, predation intensity varies spatially and includes localized high predation "hotspots". I reviewed the general background of predator-prey theory, and then described predator-prey relationships of Delta fishes. I first evaluated the quality of the data on predator-fish prey interactions in the Delta and then, based on frequency of occurrence data, I ranked predator consumption rates of prey as occasional, moderate, and common. I recorded 32 different predator categories, although some categories contained multiple species (e.g. gulls). I recorded 36 different prey species and five multi-species categories (e.g. unidentified fishes). The data indicated that most predators were occasional consumers of individual prey species. Most predators consumed a variety of both native and invasive fishes, indicating a lack of specialization. Both striped and largemouth bass exhibited wide dietary breath preying upon 32 and 28 categories of piscine prey respectively. Sacramento pikeminnow, also displayed wide dietary breadth of piscine prey with 14 different prey categories eaten. Data for reptilian, avian and mammalian predators were sparse, however these predators may have significant effects in altered habitats or when salmonids are stocked. In conclusion, extant data suggest that invasive and native fish piscivores, are generalists that likely consume whatever is locally available (i.e., mainly invasive prey species). However, the data base of predators and their fish prey is not strong and I would urge future efforts to undertake long-term dietary studies with attempts to establish predator preferences, rather than just consumption.

Keywords: Predation, Predators, Invasives, Interior Delta, Population Regulation

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