California Bay-Delta Authority Science Symposium on Environmental and Ecological Effects of Proposed Long-term Water Project Operations

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On June 19-20, 2003, in Sacramento, the California Bay-Delta Authority (CBDA) Science Program convened the second in its series of symposia and workshops on water project operations and environmental management in the San Francisco Estuary and watershed. The first workshop, held on April 22-23, 2002 in Sacramento California, is summarized in a Science Program report available at http://science.calwater.ca.gov/pdf/Workshop_Operations_Summary_April21-22-02.pdf.

The June 2003 symposium brought together more than 200 managers, scientists, and stakeholders to present and discuss information related to the environmental and ecological effects of proposed long-term operations of the Central Valley Project (CVP) and State Water Project (SWP). In this symposium, participants considered key science issues associated with the proposed long-term operations. The goals for this symposium were to:

1. Provide a forum for a balanced open discussion of proposed CVP and SWP operations, water management strategies, and the consequences to fish species of concern in the Delta and upstream project areas.
2. Help the public, stakeholders, and the agencies developing the biological opinions for CVP and SWP operations, pursue a common understanding of the state of knowledge and critical uncertainties associated with evaluating the implications of proposed water project operations and water management strategies in the Delta and upstream project areas.
3. Provide managers and policy makers a synopsis of the "state of knowledge and uncertainties" for some of the most important intersections between policy and science with respect to proposed changes in water project operations.

An inter-agency organizing committee developed the symposium agenda around several scientific issues related to water project operations:

- Upstream flow fluctuations and barriers to fish migration.
- Understanding Bay-Delta processes, and sources of fish mortality in the Delta.
- The effects of Delta inflow and water project operations on fish mortality: What have we learned from the Vernalis Adaptive Management Program (VAMP) and Delta Cross Channel (DCC) studies?

The symposium began with policy perspectives provided by key stakeholders and State and Federal representatives. Presentations to discuss the current state of knowledge followed from agency, stakeholder, and academic scientists. The agenda included

audience question and answer sessions, as well as panel discussions of the technical information and its implications for managers. Here we provide a brief summary of some of the major findings.

Upstream flow fluctuations and barriers to fish migration

Upstream fluctuations in flow (duration, magnitude, and frequency) resulting from reservoir operations can affect salmon spawning success, embryo development, hatching success, and juvenile rearing. These direct biological consequences have all been measured and quantified, but linking these to population-level impacts, especially across a range of hydrological conditions, requires additional investigation and analysis.

Operation of the Red Bluff Diversion Dam (RBDD) can present a substantial barrier to fish migration. Present operations (gates closed 4 months and gates open 8 months of each calendar year) have removed RBDD as a migration barrier to winter-run Chinook salmon; however, spring-run Chinook salmon adults reach RBDD at a time when the gates are closed. Thus, the affects on fish immigration depend on the basic timing of the runs relative to RBDD gate operations. Present operations of RBDD have substantially reduced the sustained accumulation of predatory fish, thereby reducing the mortality of young salmon migrating past RBDD. The most direct management options to address remaining RBDD concerns involve enlarging the fish ladders or completing substantial modifications to the water diversion structures upstream of RBDD to shorten the period of gate-in operations.

Understanding Bay-Delta processes, and sources of fish mortality in the Delta

Our understanding of Delta hydrodynamics and ecological interactions (open-water processes) has advanced tremendously in the last decade. Researchers now have a much better understanding of how tidal forces shape the physical environment of the Estuary and the affects this environment can have on the distribution of various organisms. The more we learn, however, the more we come to realize how complex the Estuary is. Continued process-based studies, coupled with monitoring of long-term trends and analyses of these data in the context of understanding the consequences of water operations, will help to further reduce the uncertainties of how water project operations affect physical processes in the Delta and the subsequent abundance and distribution of living resources.

Mortality is an important ecological process that can affect population size. Studies of fish mortality in the Delta have generally considered total mortality (mortality from all sources) or direct CVP and SWP mortality (mortality resulting from entrainment in water project diversions). Yet, conceptually at least, we also hear about other types of fish mortality, including non-project anthropogenic mortality (*e.g.*, fish mortality due to entrainment in delta agricultural diversions or fishing) and indirect mortality (*e.g.*, increases in natural and non-project anthropogenic mortality arising from water project induced changes in Delta hydraulics or water quality). Quantifying the effects of any type of fish mortality is difficult, especially in the context of population-level effects. But quantifying the population-level effects of fish mortality is an important step for comparing the potential effectiveness of different management actions. Further, the

current regulatory framework and management level responses often require quantification of the various types of mortality to assess impacts and prescribe mitigation. We may be able to enhance our approaches by thinking about how to manage and reduce total fish mortality, rather than continuing to try and manage various types of mortality independently.

Relationships emerging from recent data and analyses may provide additional restoration opportunities for species of concern. Juvenile Chinook salmon appear most vulnerable to exports when actively emigrating through the Delta. Direct CVP and SWP entrainment mortality remains a management concern, but the data suggest direct loss is often small. Splittail analysis and modeling of abundance and distribution data show that this fish is highly resilient, but that long-term success of the species depends on seasonal floodplain inundation to promote successful spawning. For delta smelt population success, three key issues emerge from the current conceptual model: (1) water exports, (2) toxic chemicals, and (3) food web effects. Evidence suggests that direct mortality from CVP and SWP entrainment may be high enough in some years to reduce the population size of adult spawners. Similarly, toxic chemicals and food limitations may result in higher mortality rates of delta smelt in some years.

The effects of Delta inflow and water project operations on fish mortality: What have we learned from the Vernalis Adaptive Management Program (VAMP) and Delta Cross Channel (DCC) studies?

VAMP and DCC investigations examine relationships between Delta inflows, water project operations, and young salmon survival in the Delta. Although the studies differ in their experimental designs, both studies contribute scientific information important to future opportunities and management actions. VAMP and DCC research both show that fish are affected on all flow variance time scales (hourly to seasonal). The VAMP studies show that San Joaquin River quantity affects water quality, but determining smolt survival relative to flow requires additional investigation of various flow regimes under this 12-year study. The DCC studies have found that local velocity profiles and time of day drive fish distribution and catch.

The VAMP and DCC studies offer new insights and tools for examining how physical processes affect fish survival in the Delta. For example, in river bends and channel junctions, fish move with the velocity vectors (current structure), not simply the bulk flow discharge. The implication for managers is that understanding water velocity structure within bends and junctions and the interactions with fish behavior may lead to novel solutions to minimize impacts of existing and proposed water operation facilities. Further, integrating contaminant research into multidisciplinary studies like VAMP and DCC can also help to reduce the uncertainty associated with through-Delta salmon survival through the application of innovative tools and research strategies.

Next steps

Science Program staff is preparing a June 2003 symposium written summary report with a target completion date of September 2003. The report will be available, along with past

workshop reports and future workshop dates, from the new Science Program website at http://science.calwater.ca.gov.

Additional Science Program workshops in July (Chinook salmon) and August (delta smelt) will consider new information on modeling and the population biology of these fish, and consider how actions under the EWA program protect these fish. A workshop in October will include a technical review of the EWA and further discussion of specific issues related to water project operations and the associated environmental impacts. For additional information on this workshop series, please visit http://science.calwater.ca.gov/workshop/workshop.shtml.