COMPREHENSIVE (PHASE 2) REVIEW AND UPDATE TO THE BAY-DELTA PLAN

FINAL BAY-DELTA PLAN WORKSHOPS SUMMARY REPORT

PREPARED FOR:

State Water Resources Control Board
1001 I Street
Sacramento, CA 95814
916.341.5300

PREPARED BY:

ICF International
630 K Street, Suite 400
Sacramento, CA 95814
916.737.3000

June 2013

ICF International. 2013. Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan. Final Bay-Delta Plan Workshops Summary Report. Final. June. (ICF 00427.11.) Sacramento, CA. Prepared for State Water Resources Control Board, Sacramento, CA.

Contents

Acronyms and Abbreviations

Action Plan	San Francisco Bay Delta Action Plan
ADF	Area Duration Frequency
AF	acre-feet
Bay-Delta Plan	2006 Water Quality Control Plan for the Bay-Delta Estuary
BDCP	Bay Delta Conservation Plan
BO	Biological Opinion
Board	California State Water Resources Control Board
BOs	Biological Opinions
CCWD	Contra Costa Water District
cfs	cubic feet per second
CVFPP	Central Valley Flood Protection Plan
CVO	Central Valley Operations
CVP	Central Valley Project
CV-SALTS	Central Valley Salinity Alternatives for Long-term Sustainability
CWA	Clean Water Act
CWEMF	California Water and Environmental Modeling Forum
DCC	Delta Cross-Channel
DFG	Department of Fish and Game
DWR	California Department of Water Resources
DWSC	Deep Water Ship Channel
E/I	export/inflow
EFT	Ecological Flows Tool
ESA	Endangered Species Act
FLaSH	Fall Low Salinity Habitat
FMWT	fall midwater trawl
FRPA	Fish Restoration Program Agreement
FWS	U.S. Fish and Wildlife Service
GGSA	Golden Gate Salmon Association
HORB	head of Old River barrier
I/E	inflow/export
km	kilometers
LCPSIM	Least-Cost Planning Simulation Model
LSZ	Low Salinity Zone
NMFS	National Marine Fisheries Service's
NRDC	Natural Resources Defense Council
OCAP	Operations Criteria and Plan
OMR	Old and Middle River
PCFFA	Pacific Coast Federation of Fishermen's Associations
POD	pelagic organism decline
ppb	parts per billion
RAFT	River Assessment for Forecasting Temperature

RM	River Mile
RMP	Regional Monitoring Program
RWTP	Regional Wastewater Treatment Plant
S.M.A.R.T	specific, measureable, achievable, relevant, and time bound
SalSim	San Joaquin River Fall- run Salmon population model
SDBSIM	Supply-Demand Balance Simulation Model
SDM	structured decision making
SJTA	San Joaquin Tributaries Association
SWAP	Statewide Agricultural Production
SWP	State Water Project
TMDLs	total maximum daily loads
TMML	total maximum monthly load
UMARP	Unified Monitoring Assessment and Reporting Program
USBR	U.S. Bureau of Reclamation
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
VAMP	Vernalis Adaptive Management Plan
WEAP	Water Evaluation and Planning System
WQCP	Water Quality Control Plan

Bay-Delta Plan Workshops Summary Report

The "Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan: Final Bay-Delta Plan Workshops Summary Report" is comprised of the January 2013 Draft Bay-Delta Plan Workshops Summary Report and comments submitted on the Draft Report by April 23, 2013. The report and comments are available on the State Water Resources Control Board's website at: www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/comp_review.shtml

Background

The California State Water Resources Control Board (Board) is tasked with updating the 2006 Water Quality Control Plan for the Bay-Delta Estuary (Bay-Delta Plan). The Board planning activities for this process have four phases. Phase 1 focused on San Joaquin River flow requirements and southern Delta water quality objectives. The current phase (Phase 2) focuses on fish and wildlife beneficial uses. Phase 3 will focus on modifications to water rights and Phase 4 will focus on the development and implementation of flow requirements for priority Delta tributaries.

Phase 2 workshops were held to conduct discussions and generate information regarding the scientific and technical basis for considering potential changes to the Bay-Delta Plan. The workshops were informal; the Board did not take any official action and there was no sworn testimony. Information provided during the workshops will augment information developed through earlier reviews and will inform the Board members and staff on what, if any, changes should be made to the Bay-Delta Plan.

Three workshops were held. Full workshop agendas are provided in Appendix A.

1. Ecosystem Changes and the Low Salinity Zone, September 5–6, 2012 – including the effects of the low salinity zone on various estuarine species, the interaction of salinity with non-flow related factors, and the identification of modeling or other tools that can be used to measure and reasonably protect estuarine habitat.
2. Bay-Delta Fishery Resources, October 1–2, 2012 – including flow, cold water pool, habitat, and water project operational constraints needed to reasonably protect Central Valley steelhead, Sacramento River winter-run, Central Valley late fall–run Chinook salmon, and pelagic species (including Delta smelt and longfin smelt); and the interaction of these issues with non-flow related factors.
3. Analytical Tools for Evaluating the Water Supply, Hydrodynamic, and Hydropower Effects of the Bay-Delta Plan, November 13–14, 2012 – including the CalSim II water supply model, DSM2 and RMA2 hydrodynamic models, Plexus hydropower model, and others as applicable, together with results from applying these models to various scenarios.

Workshop Overview

The workshops were facilitated by Dr. Brock Bernstein, a sub-contractor for ICF International. Each workshop included a presentation by an independent expert panel organized by Dr. Peter Goodwin, Lead Scientist for the Delta Stewardship Council's Science Program; interest panels organized by Dr.

Bernstein; opportunities for public comment.; and questions directed to panelists and stakeholders by the State Water Board and staff.

The State Water Board notice announcing the workshop series identified broad areas of interest and somewhat more targeted questions as overall guidelines to assist stakeholders and the Invited Panel in planning their participation. Through subsequent discussion with the workshop facilitator, who also acted as a go-between with State Water Board staff, participants identified specific topics to focus on and developed technical material they believed would be useful to the State Water Board in its decision-making process. In some cases, participants reviewed draft written materials and presentations with the facilitator to help ensure their appropriateness and utility. The facilitator also assisted participants in adjusting the level of technical detail and the relative balance between scientific and management issues in order to achieve consistency across presentations and to more directly address State Water Board members' requests for certain kinds of information.

The Invited Panel and stakeholders submitted written materials prior to each workshop and then summarized this material in verbal presentations during each workshop. The information presented focused on a relatively small number of key issue that are central to understanding the Delta ecosystem and the effects on the ecosystem created by water withdrawals and the amount of flow at different times and places. For each of these key issues, the following sections briefly summarize key points of agreement and disagreement, along with uncertainties and questions. The questions listed are based on those expressed by State Water Board members and others that are implicit in the arguments advanced by stakeholders.

Overall, there was general agreement on broad principles and conclusions related to each issue and much less agreement on the specifics of patterns and processes, and the causes of these, as well as the predicted outcomes of alternative policies. The remainder of this workshop summary is necessarily at a high level, primarily because identifying specific sources of disagreement and uncertainty requires a careful and thorough diagnosis that was beyond the scope of this report. However, such diagnostic efforts in other situations have identified a range of possible sources of scientific disagreement, including different motivating questions and the use of different datasets, data subsetting or processing (e.g., outlier analysis, transformation) procedures, data analysis methods, model assumptions, and/or interpretation criteria. For example, Dr. Hilborn's presentation during Workshop 3 recounted an example from global fisheries management in which a divisive and long-standing dispute about fisheries' stock status was traced to the use of different core indicators and datasets. Where such conflicts impede policy development and management decisions, this sort of forensic analysis is an important prerequisite for the sort of collaborative monitoring, data analysis, and modeling efforts the Invited Panel and other stakeholders called for. While there was broad agreement on the value of such collaboration, neither the Invited Panel nor individual stakeholders identified a specific mechanism or mechanisms for achieving this.

Summary of Key Points of Agreement, Disagreement, Uncertainties, and Questions

Research and Conflict Resolution Approach

Beginning with their presentation in Workshop 1, the Invited Panel and several stakeholders emphasized the complexity of scientific questions facing both scientists and managers, and the value of collaboration among interested parties in addressing these questions.

Key points of agreement

Scientific questions related to ecosystem management and restoration, and to managing human activities such as landscape alteration and water diversions, are "wicked" in the sense that they:

- Include an array of multiple factors that are often poorly characterized.
- Involve factors whose relationships change over space and time and will be further modified by climate change.
- Involve entities and people with competing interests and perspectives.
- Are affected by the weak coupling between science and management.

Such questions would benefit from a more collaborative approach that brings together competing perspectives and interests in a structured framework that combines modeling, monitoring, and analysis to focus directly on policy priorities. This would be an antidote to the current state of affairs with its emphasis on conflicting scientific perspectives and conclusions-advanced "science combat," i.e., competing journal articles, workshop and conference presentations, and submissions to management agencies.

There was broad agreement on this basic diagnosis and prescription and several participants referred to specific instances where such collaboration had paid large dividends (e.g., some restoration projects, large-scale hydrological models). In addition, some stakeholders put forward a proposal for a broadly-based joint fact finding process to diagnose the sources of disagreement and propose new analyses, monitoring, modeling, or adaptive experiments to help resolve them. This proposal received unanimous support from a broad cross section of stakeholders from all stakeholder categories.

Key points of disagreement

There were no disagreements voiced.

Uncertainties

While the issue of dealing with "wicked" problems is endemic and not limited to the Bay-Delta, there are no widely accepted methods or formulas for dealing with them and it is not clear which aspects of other successful efforts would be appropriate for the situation in the Bay-Delta. In addition, any larger-scale collaborative effort of the type recommended would necessarily cut across the geographic jurisdictions and/or legal authorities of numerous entities, both public and private. It is therefore not clear who has the needed convening authority or whether such a process would fit within the existing roles of the Delta Stewardship Council and its two subsidiaries, the Independent Science Board and the Delta Science Program. For example, the inclusive joint fact finding process that was proposed, and that would have included all interested stakeholders, would be fundamentally different from existing science evaluation processes currently managed by the Delta Stewardship Council.

Questions

- What can the State Water Board do to promote broader collaboration and strengthen the link between science and policy making?

- How can the level of trust between stakeholders be improved in order to support more collaborative data gathering, data access, analysis, and modeling efforts?
- What types of processes should be created and institutionalized to organize and integrate the available scientific expertise?
- How could collaborative processes be designed and managed so that they do not overburden entities who are already engaged in other processes such as BDCP?

Salinity and the Low Salinity Zone (LSZ)

The measurement and management of salinity was a core issue in the description of ecosystem processes related to pelagic fish and subsequent discussion of how to manage flows to maintain or restore fish populations.

Key points of agreement

Stakeholders agreed that climate change effects, particularly sea level rise, will increase salinity in the Delta. Stakeholders also agreed that salinity is correlated with the abundance and distribution of some pelagic fish species, although Delta smelt have recently been found upstream of the LSZ.

Key points of disagreement

At a finer level of detail, however, there were substantial disagreements about the extent to which the LSZ is a reliable marker of valued habitat and a predictor of pelagic fish abundance, as well as about the extent to which the design of historical sampling programs has biased the picture of the relationships between fish distribution and abundance and the LSZ. In addition, some participants believed that salinity and the position of the LSZ is a primary factor affecting pelagic fish distribution and abundance while others believed that the role of the LSZ is strongly contingent on other factors that also affect habitat value. From an operational perspective, there were disagreements about the degree to which the LSZ can be accurately positioned using the data and tools currently available.

For example, some participants argued that the LSZ is only characterized in terms of its average position and that its higher frequency excursions, which can be large, are as important as, or more important than, its average position.

Uncertainties

Major uncertainties revolved around the reliability of ecological relationships to the LSZ as a central basis for planning and the degree to which the combination of pumping and Delta inflows moves the LSZ around in the Delta.

Questions

- Are there ways to position X2 using less water, e.g., by pulsing flow at different parts of the tidal cycle?
- Can X2 flows in different seasons be better balanced in order to achieve multiple benefits?

Flow

Flow—how and where it is measured, its impacts on different aspects of the ecosystem, its relationship to other stressors and requirements, and how it should be managed—was central to most of the presentations across all three workshops.

Key points of agreement

History and setting

All presenters agreed that flow is a key factor in the system because of its role in creating and modifying physical and geochemical habitat structure, influencing productivity, transporting contaminants and other constituents, and affecting fish movement, especially at key times and places. However, present day flow patterns are quite different from natural patterns. These natural patterns (e.g., large-scale sheet flow) cannot be restored because of the pervasive modifications to the structure and function of the hydrologic system to meet a wide range of human needs (e.g., hydroelectric power, flood control, irrigation and municipal supplies). Ongoing alterations to the water system, along with climate change, will continue to modify flow patterns in the future and the effects of climate change, in particular, will be difficult to predict. Thus, past history is not necessarily a reliable guide to how much flow will be available in future years and conditions, nor to the variability in flow over a range of space and time scales.

Measurement

Flow measurements are essential to defining policy options, predicting and documenting their results, and to ongoing management of the system. However, because flow cannot be measured continuously at all times and places, a variety of summary indicators (e.g., inflow/export ratio) are used to track flow at key times and places, as management targets, and as input to data analyses intended to assess the ecological impacts of changes to flow. While useful and necessary, such summary indicators should be used with caution because they gloss over important details and their relationship to the underlying data is not always fully described or understood. For example, despite the implications of the mathematical structure of the inflow/export ratio, a decrease in exports is not necessarily equivalent to an increase in river inflows. In addition, even the complex models used to describe current and forecast future flow conditions are simplifications with constraints on their spatial and temporal resolution that leave out factors such as evapotranspiration, return flows, and groundwater/surface water interactions. Expanding existing models to include such factors would be valuable in some instances. Finally, residence time and its effects on turbidity, phytoplankton populations, productivity, and predation (among other factors) should be considered along with direct measures of flow.

Context for measurement and management

While there was significant disagreement among participants about the content of specific policies, there was broad agreement about several principles that should inform flow management. First, flow should be managed in the context of the entire upstream/downstream system and not simply at one or a few strategic points. This is because the system is hydrologically connected such that decisions at one point will affect flow at other points, both upstream and downstream. In that context, pulse flows are a potentially valuable tool that should be more fully investigated. Second, flow is also functionally related to a number of stressors (e.g., temperature, contaminants), conditions (e.g.,

water depth, salinity), and processes (e.g., productivity) whose interactions with flow should be considered collectively. Third, there are, however, several factors that are somewhat independent of flow (e.g., improved habitat, availability of floodplains, presence of fish escape corridors) and that could be addressed separately from (but related to) direct flow management. Fourth, flow should be managed to simultaneously achieve multiple biological objectives (e.g., preserve cold water pools, avoid dewatering redds). This will, however, be made more difficult because there are many more constraints in the water system than in the past, due to increased demand, multiple requirements for different beneficial uses, and climate change impacts. Finally, flow management will involve making challenging tradeoffs because of significant constraints stemming from other state policies (e.g., renewable energy goals, competition in the energy market, cap and trade system) and the fact that not all types of power production (e.g., solar, hydroelectric, gas fired) are equivalent and equally flexible.

Impacts/effects on resources

There was no broad agreement on the specific effects of flow or changes in flow on the status of key resources.

Key points of disagreement

History and setting

There was substantial disagreement about whether historical correlations between flow and other factors (e.g., fish distribution and abundance) are both reliable and necessarily predictive of future conditions (see *Fish*, below, for more detail). While there was agreement that the physical and biological systems have changed over time, there was considerable disagreement about the degree to which such changes have fundamentally undermined these historical correlations.

Measurement

There were significant disagreements about whether unimpaired flow is a satisfactory representation of the natural flows at key points in the system. There were also important differences in the way the term "unimpaired flow" was defined and used. In addition, participants presented different assessments of the impact of water withdrawals on outflow, both overall and at different times of the year.

Context for measurement and management

Despite agreement about basic principles (see above), stakeholders' presentations highlighted important differences in their view of the specifics of how flow should be measured and managed. First, the priority attached to flow compared to other factors (e.g., habitat degradation, foodweb changes) differed markedly, as did assumptions about whether increases in flow alone, with accompanying attention to other habitat requirements, would achieve goals to increase fish populations and their resilience. In terms of measures of flow, there was substantial disagreement about whether unimpaired flow is an adequate or realistic basis for setting flow standards based on different perspectives on how it should be measured and different assumptions about both how well it reflects natural flows and whether it captures factors important to fish and other resources. Participants also had a wide range of perspectives on the extent to which the 2010 Flow Criteria are valid guidelines for management action given the current knowledge of the system. Finally, there

were disagreements about the relative importance of sub-daily, as opposed to net, flows in affecting populations of juvenile salmon.

Impacts/effects on resources

Stakeholders expressed a wide range of opinion on the impacts on fish and other resources of changes to flow and the degree to which flow should be adjusted to meet the needs of individual species as well as the ecosystem as a whole. These included the specific amounts of in-Delta flows necessary for maintaining fish resources, the extent to which X2 has a reliable relationship to the abundance of Delta smelt and other pelagic fish species, the need for high outflow in the fall for Delta smelt, and longfin smelt requirements for spring flow. Another set of disagreements surrounds the degree of correlation between specific flow regimes (e.g., negative Old and Middle River [OMR] flows, the location of X2) and the magnitude of entrainment/salvage and whether net negative flows in the south Delta are acceptable, particularly in dry years, both for salmon and other fish species. There is also controversy about the value of increased spring flows to salmon survival and the degree to which higher or pulse flows reduce predation on young salmon. Finally, participants disagreed about the extent to which simple increases in flow will increase turbidity and the value of turbidity to different species at different times and places.

Uncertainties

Disagreements among stakeholders about the role flow plays in the ecosystem and about how to manage flow are reflected in a core set of uncertainties.

History, setting, and measurement

It is not clear how much weight to place on recent studies (e.g., 2011 Fall Low Salinity Habitat [FLaSH] study) compared to older studies from periods when key aspects of the system (e.g., invasive species, productivity) were different. This is compounded by uncertainty about the accuracy and value of summary indicators (e.g., net negative flow) in understanding the role of flow in both and short- and long-term flow effects. The ability to use such indicators is in turn complicated by an incomplete understanding of the types of variability in flow and how they affect the system. All of these uncertainties, along with the complexity of the system and uncertainty about climate change impacts, combine to create fundamental uncertainties about the value of flow as a predictive variable. On a more specific level, the term “unimpaired flow” appears to be defined differently and used in distinct ways in different contexts, creating uncertainty in discussions about flow management.

Context for measurement and management

In terms of management, the two core uncertainties are whether changes to flow will produce the expected benefits and how this uncertainty can be evaluated and addressed in the process of making decisions about whether the timing and amount of outflows should be adjusted, and how.

Impacts/effects on resources

There is substantial uncertainty, stemming from different sources, about the relationship between specific flow levels and key outputs such as amounts of different habitat types or abundances of different species of fish, the ecological role of fall flows particularly for longfin smelt, and the relative

importance of San Joaquin flows to the Delta ecosystem, specifically salmon populations. Finally, there is uncertainty surrounding the sources of turbidity in the system.

Questions

- What is the conceptual context for thinking about flow (e.g., annual, seasonal, finer timeframes)?
- How important is a detailed understanding of flow's relationship to other factors?
- What new analyses would improve understanding of the relationship between flow and fish abundance?
- How do specific percent unimpaired flows implemented in different water years compare to the flows recommended by different parties?
- What are the levels of flow at different times/seasons and in different parts of the system compatible with recovering fishery resources?
- How should residence time related to key factors be included in setting flow criteria?
- How can the value of flow for improving habitat (e.g., increasing floodplain inundation) be maximized/optimized?
- How can the State Water Board include habitat restoration and other ecosystem objectives in the Bay-Delta Plan?
- Is the proposed new flow index for Old and Middle River objectives an improvement over current practice?
- Should existing total maximum daily loads (TMDLs) for turbidity and organic matter be revised to account for new information and/or changes in the system?
- How can flow be managed to increase turbidity and perhaps reduce entrainment?

Fish and Habitat/Ecosystem

Effects on individual fish species and on the functioning of the aquatic ecosystem as a whole were a major focus of discussion.

Key points of agreement

Concerns about fish species (i.e., pelagic species and salmonids) have been spurred by significant declines in the abundance of several key species, some of which are listed under the state and federal Endangered Species Acts. Not all major fish species have declined, however, and some species have increased during the same time period during which declines occurred. In attempting to explain these changes in abundance, stakeholders agreed that fish respond to a suite of habitat factors, including flow, food, physical habitat structure, and predation, among others, and that conditions across the entire life cycle are important. The role of physical habitat received particular attention, with participants agreeing that fish require spawning and rearing habitat in addition to simple survival, that pelagic fish are more flexible in their habitat use than previously assumed, and that increased flow, by itself, will not result in improved habitat where river channels are essentially armored drainage canals (e.g., higher flows will just make more rip rap wet).

Participants agreed that life cycle models of key fish species would help organize existing knowledge and may reduce key uncertainties but warned that managing for individual species risks ignoring the important role of diversity and community structure in the functioning of the ecosystem.

Participants also agreed that fishes' smaller-scale and shorter-term behavior and responses to habitat condition are important features of the ecosystem and that improved information on such behavior and responses should be included in decision making, restoration planning, and perhaps life cycle models. Because ocean processes and variability influence the Bay-Delta in important ways, these should be included in life cycle models.

In terms of entrainment and salvage, stakeholders agreed that both are estimates and the relationship between them changes depending on conditions. They also agreed that physical barriers at key points and times in the system can increase survival by reducing entrainment and salvage.

Stakeholders all agreed that the goal of doubling the natural production of Chinook salmon has not been achieved and that changes to the Central Valley and State Water Projects alone will not be sufficient to ensure salmon recovery. In addition, any flow management decisions must account for the potential of dewatering redds in the Sacramento River, and reservoir releases must be carefully controlled to preserve the needed cold-water pool for salmon. Participants also agreed that salmon life history diversity is a key factor in improving the resilience of these populations and that preserving and increasing such diversity may involve changes to hatchery management practices. The survival of juvenile salmon is an important factor in population status and improved shoreline, riparian, and floodplain habitat has the potential to increase juvenile salmon survival, as does the control of predation, which is a limiting factor on salmon populations.

Key points of disagreement

There was substantial disagreement about the extent to which the LSZ and X2 are reliable markers of valued habitat and predictors of fish abundance, as well as the degree to which historical trends in abundance are affected by flow and LSZ location. These disagreements are related to a more basic conflict about the robustness of historical statistical relationships between flow and the abundance/survival of salmon and other fish species and the extent to which these relationships are guides to future action and can predict the effects of changes in flow.

In terms of the overall aquatic ecosystem, stakeholders disagreed about the extent to which ecosystem changes (e.g., invasive weeds, foodweb changes) are reversible or can be mitigated, as well as about the relative importance of such factors compared to flow. There was also disagreement about the extent to which nutrient and foodweb impacts are affecting fish communities and, more specifically, about the validity of proposed linkages between the forms of nutrients present and the abundance of predatory fish that target pelagic fishes. There was also a range of opinions about whether the area available for floodplain and other habitat restoration is enough to make a meaningful contribution to species abundances.

The degree of consensus among different groups with regard to flow effects on salmon survival differs between the Sacramento River and San Joaquin River corridors. The issue is more controversial for the San Joaquin River. There was no agreement about the relationship between juvenile salmon migration and survival and flow and, more specifically, the extent to which increased San Joaquin River outflows would benefit salmon, or whether higher/lower exports are associated with changes in salmon survival. Stakeholders also presented differing opinions about the degree to which tidal influences affect salmon migration routes through the Delta and the

potential consequences of such effects for salmon survival. While there was broad agreement that predation on juvenile salmon is an important concern, there was no agreement about the importance of predation on pelagic species compared to other factors (e.g., availability of food, habitat). Nor was there agreement on whether reducing the abundance of striped bass would release other predators' populations from top-down control, thereby undermining the positive effects of reductions in striped bass abundance.

Uncertainties

New information on distribution of pelagic species and the flexibility of their habitat use caused some uncertainty about whether the characteristics of sampling gear and the design of historical sampling programs bias estimates of fish population and distribution.

Other key uncertainties generally reflect the core set of disagreements among stakeholders, chief among them questions of pelagic species' specific habitat requirements and about the proper balance between addressing flows and needs for improved/expanded habitat. For example, the relative contributions of food, temperature, and predation to Delta smelt populations compared to the position of the LSZ is uncertain. Such uncertainties lead in turn to additional uncertainties about the relative benefit of habitat restoration projects and, in the design of such projects, how much weight to give historical relationships between fish and habitat features. More specifically, the influence of the proposed "vise" mechanism on the pelagic organism decline and current fish mortality is highly uncertain, as is the relative importance of the San Joaquin River in Delta productivity and as habitat for key life stages of some fish species. While stakeholders agreed that the ocean influences the Bay-Delta, the nature of such influences on habitats and processes is also uncertain. Similarly, life cycle models are being developed for key species, but the extent to which these will benefit management is not yet clear.

Entrainment and salvage are important processes, but the actual levels of entrainment and salvage by species, the specific conditions that increase the risk of entrainment and/or salvage, and the population level effects of entrainment/salvage are all uncertain.

In terms of salmon, the mechanisms (e.g., increased turbidity, reduced transit time) by which flows affect predation rates on juvenile salmon are uncertain, as is the relative importance of downstream flows vs. tidal flows in affecting salmon migration, especially in the western Delta. Similar uncertainties relate to the extent to which the Delta Cross Channel Gates are a useful tool for reducing salmon mortality; and the extent to which striped bass abundance can be reduced without releasing other predator populations from top-down control.

Questions

- What specific measurable ecological outcomes represent adequate protection of fishery resources?
- Should existing monitoring programs be adjusted to provide a more complete picture of fish distribution and abundance?
- How can information about the historical ecology of the Delta best be used to inform current decision making?
- What are the flows required to make different restoration projects viable?

- Are there habitat indices, other than X2, that provide a better fit to abundance patterns and should be used as management tools?
- How do various stressors contribute to overall ecosystem status?
- Can connections between parts of the Delta (e.g., Sacramento River and Yolo Bypass) be tightened in order to improve specific habitat conditions (e.g., turbidity)?
- Can real-time experiments be conducted with the Delta Cross Channel Gates?
- How can flow best be managed to reduce predation risk, particularly for juvenile salmon?
- Can pulse flows be used to improve conditions for salmon at specific times and places?
- Can existing management policies (e.g., predictable flows, hatchery practices) be modified to increase salmon life history diversity?
- Can salmon ocean catch management be coordinated with inland management to improve overall salmon survival?

Nutrients and Plankton

Changes in productivity and the foodweb, and the possibility that these are due to shifts in the amount and type of nutrients available, were important elements in the discussion of factors influencing pelagic fish distribution and abundance.

Key points of agreement

There was broad agreement that the amounts and types of nutrients strongly affect the level of primary productivity and that nutrients can also affect the composition of the plankton community. Participants also agreed that the composition of the plankton community has changed significantly over time and that the Bay-Delta has become less productive over time. The timing of flows is also important for optimizing productivity.

Key points of disagreement

Participants disagreed about several specifics within the overall picture of productivity trends in the Delta, mostly focused on the relative importance of the various factors that play a role in influencing productivity. These included the relative importance of foodweb changes vs. flow, foodweb changes vs. habitat degradations, and the relative importance in explaining declining productivity of changes in nutrients vs. habitat, flow, and invasive species. There were also disagreements about the productivity of the LSZ relative the other parts of the system and to other, similar systems elsewhere. Finally, participants disagreed about how much weight to place on a consideration of the effects of changes to the Delta's productivity on downstream resources.

Uncertainties

Uncertainties are associated with several aspects of both the causes and effects of changes to nutrient characteristics and foodweb productivity. There are unresolved questions about whether excess ammonium lowers phytoplankton production and the degree to which changes in nutrient ratios propagate through the foodweb. In addition, it is not clear whether changes to nutrient loading and ratios will contribute to improvements in fish populations and, more generally, what the long-term effects of the nutrient management strategy might be. In terms of inputs to the Delta, there is

uncertainty about the relative importance of productivity transported into the system via rivers (Sacramento and San Joaquin) vs. local productivity from wetlands and floodplains, and the degree to which the LSZ is energetically subsidized from both upstream and downstream. Finally, the potential impacts on productivity of grazing by the invasive clam in restored habitat is unknown.

Questions

- How should the expected control of anthropogenic nutrient inputs be factored into the Bay-Delta Water Quality Control Plan?
- If the LSZ is being energetically subsidized, what protections for these upstream/downstream areas are needed?
- How should flow be managed to increase the residence time and productivity of plankton?

Invasive Species

Invasive species have significantly altered the Bay-Delta ecosystem and the potential for further changes is a concern.

Key points of agreement

Stakeholders agreed that invasions will continue to occur and that some of these will cause significant effects.

Key points of disagreement

Stakeholders disagreed about the relative importance of potential invasions vs. current and known sources of disturbance and impact.

Uncertainties

Uncertainties are associated with when invasions will occur, which invasive species will enter the system, and what the effects of invasions will be.

Questions

- How can the management system be adjusted to prepare for likely but essentially unpredictable impacts?
- What is the timeframe of potential future invasions?

Contaminants

The role of contaminants in the system was a concern for a subset of stakeholders involved with waste discharge.

Key points of agreement

Stakeholders agreed that contamination is likely to be causing impacts both on certain individual species and on overall habitat condition.

Key points of disagreement

Stakeholders disagreed about the relative importance of contaminant impacts vs. other factors.

Uncertainties

It is not clear which contaminants are causing impacts and what the specific mechanisms are by which contaminant impacts may be occurring.

Questions

- Are existing contaminant control strategies adequate?
- Should flow be considered as part of a strategy to control contaminant effects?

Management, Adaptive and Otherwise

The management and regulatory context will be a critical element in determining whether scientific information, and associated uncertainty, are used and addressed to create effective decisions and policies.

Key points of agreement

All stakeholders acknowledged that management must move forward with existing information and tools, while making provision for incorporating new information when available. However, the nature of intertwined human and natural systems is such that tradeoffs are now more constrained and there is no longer the luxury of setting a policy and waiting many years to see how it has worked out; there is a need for more immediate feedback and adaptation. Thus, adaptive management is required but difficult and will require changes to current policy and decision-making processes.

An adaptive management process will benefit from improved communication and collaboration among managers and scientists (as discussed in other sections of this report). In order for such collaboration to be effective, the State Water Board should set specific and quantifiable goals that that will focus scientific investigations and will also provide a structure for improving the coordination of monitoring, modeling, and assessment activities. Structured planning and decision-making processes are helpful in ensuring that decisions and goals are logically linked to specific outcomes and in provided a framework for applying modeling and other analysis tools. This in turn will make it more likely that monitoring focuses on desired endpoints related to objectives and will generate data needed to model and evaluate future changes to the system (e.g., infrastructure, climate).

Stakeholders also agreed that climate change will affect the system and must be explicitly planned for. Uncertainties stemming from climate change and the inherent complexity and dynamism of the Bay-Delta system require a systematic adaptive management approach. However, the need for adaptive management should not become a reason to delay decision and action. While the existing management system is not always well suited to an adaptive management approach, the triennial review process is one mechanism that could support such an approach, and ongoing and planned management actions (e.g., adjustments to flow, habitat restoration) should be used as intentional experiments that will improve understanding. Another useful approach would be to identify a range of possible flow alternatives (as opposed to a single alternative) so that specific choices are available when adaptation is required.

Both managers and scientists must remain aware of and account for interactions among species and the respective objectives related to each species, as well as of the often nonlinear behavior of ecosystems. That is, the ecosystem must be managed as a system, not as a collection of independent pieces. As a result, developing flow objectives is an optimization problem that requires balancing competing needs in a dynamic system with multiple interacting components.

Key points of disagreement

Participants disagreed about which specific aspects of the system should be included in an adaptive management framework and how the necessary tradeoffs should be identified and evaluated. They also discussed, but did not agree on, whether new management models (e.g., leaky pipe vs. bet hedging) are needed to account for improved information about how the system functions. There was also a wide range of opinions about what "achievable" means in practice when defining management objectives.

Uncertainties

Key uncertainties included which potential future events should be included in adaptive management plans, what thresholds should be identified for adaptive management triggers, and how to deal with factors that are outside the scope of the State Water Board's authority. It was also unclear how different stressors should be weighted in an adaptive management approach and how climate change will affect the foodweb and other aspects of the ecosystem.

Questions

- How can the current management/regulatory/science system be modified to promote effective adaptive management?
- How can the State Water Board improve its ability to deal with the inherent uncertainty of many physical and biological processes?
- How should the State Water Board balance actions in areas with more and less certainty?
- How can key capacity (e.g., modeling) be improved and supported?
- How can a coordinated monitoring and assessment framework for the Delta be developed?
- How can the management system learn to operate on multiple timeframes?
- How will climate change affect the ecosystem?
- How can the State Water Board reconcile competing policies or goals (e.g., turbidity) that can pull stakeholders in different directions?
- How can flow standards and other regulatory criteria be made more flexible and adaptive?
- Can existing planning requirements for operation of the Central Valley and State Water Projects be modified in order to improve management flexibility and responsiveness?

Modeling Approaches

Models are an essential part of scientific and management processes in the Bay-Delta.

Key points of agreement

There was general agreement, both explicit and implicit, with the Invited Panel's key concepts and recommendations. It is important to recognize that modeling capability includes not just the models themselves but the experts who design and run them, as well as the mechanisms and pathways for incorporating their results into management decision processes. Combined with their complexity, this makes it difficult to conduct effective external reviews of the major models used for research, planning, and management.

Stakeholders agreed on several basic principles that should inform the development and use of models. First, modeling capabilities have advanced to the point that they can be used in real time and near-real time to explore alternative hypotheses and related management decisions/actions. In this context, they can help define boundaries (e.g., of processes as well as connections between parts of the system). This structure can then help focus management attention and action and be used to evaluate alternative policies and hypotheses and deal with uncertainty. Understanding the implications of alternative flow standards will require using a suite of models to look at different aspects of the system (e.g., reservoir storage, hydro power, habitat, temperature related to anadromous fish, etc.). Second, many of the existing modeling tools (e.g., CalSim II) are not predictive tools but are best suited for comparative analysis and are constrained to operate under existing water rights rules and policies. Third, models should be developed and validated through collaborative efforts that include a broad range of stakeholders and perspectives. Collaboration should be extended to model application, where cooperative modeling efforts that involve multiple agencies and stakeholders can accomplish much more than any entity could on its own, thereby leading to better decisions. For example, the use of models and modelers in planning for specific restoration projects has started to build the broader collaborative networks envisioned in the Invited Panel's recommendations. Fourth, using a range of models (rather than a single "best" model) to capture the range of hypotheses and uncertainties will provide a more powerful analysis of the implications of alternative policies and decision rules. Finally, making the best use of modeling capabilities will require improving the regional cyber infrastructure and access to validated data.

Stakeholders also agreed that all models have inherent strengths and weaknesses or constraints that must be taken into account, a major reason that complete and transparent documentation is needed. One important constraint is that models have time steps that are tuned to the availability of data and/or the nature of the planning and decision process. Integrating models of different types of processes must therefore consider differences in fundamental time steps and whether monitoring/data gathering programs should be modified to support additional integrative studies in the future.

Another key constraint is that there are some data types and processes (e.g., return flows) that are simply too difficult to monitor on short time steps and/or small spatial scales and must be dealt with at a more aggregated level.

Participants agreed that modeling tools are much more embedded and widely used in decision making for hydrology than for biology and that, as a result, there is a greater degree of collaboration and cross fertilization within the hydrodynamic modeling community than within the biological modeling community. Nevertheless, there is an obvious need for more collaboration between biologists and modelers of the physical system. One potential avenue for fostering such collaboration is the development of life cycle models for important fish species. For example, integrating fish behavior (e.g., acoustic tracking of salmon) and fish life cycle models with hydrodynamic modeling

can pay large dividends in understanding the effects of flow regimes, turbidity, and other physical factors. However, scaling models up from small particles (e.g., phytoplankton) to fish is challenging and the required collaborative networks are just beginning to develop. Despite such challenges, stakeholders agreed that life cycle models are a critically important tool for integrating information across life stages and habitats; however, they are not yet available for all species of interest.

In terms of one specific aspect of climate change, models exist (e.g., DSM2, SELFE) that can estimate the amount of flow needed to keep salinity at bay under different sea level rise scenarios.

Key points of disagreement

No serious disagreements were expressed related to the value of models and how they can be used. However, there were disagreements about the level of uncertainty associated with some key modeling inputs (e.g., number of salmon returning to specific rivers, level of predation) and about which specific decisions should be assessed with which modeling frameworks.

Uncertainties

One major uncertainty was related to the degree to which past hydrological conditions can or should be used as a baseline for current modeling analyses, given that models' current embedded assumptions reflect conditions that are shifting due to factors such as climate change (although the nature and magnitude of future changes are also highly uncertain). Another major uncertainty is the extent to which current models ignore external factors (e.g., broader range of water supply options) that could increase both the flexibility and the number of management options. Finally, participants pointed out that some aspects of the system's behavior cannot be fully and quantitatively defined at all spatial and temporal scales, i.e., there is some unresolvable uncertainty in all models.

Questions

- What institutional arrangements and incentives are needed to promote implementation of the Invited Panel's key recommendations, particularly related to the more strategic use of modeling?
- What role could the State Water Board play in promoting the type of collaborative modeling recommended?
- How can the State Water Board improve its independent capacity to evaluate modeling results and use modeling tools in its decision making?
- Is there a need for some sort of standard setting or evaluation to ensure that models used in planning and decision making are validated and comparable?
- How could external reviews of key models be implemented, given their complexity and the necessity that reviewers have an intimate understanding of models' structure and function?
- How much weight should the State Water Board place on model results; how should model results be better integrated into the State Water Board's decision processes?
- How can management objectives be more clearly defined in order to provide better starting points for modeling evaluations?
- How can the existing policy process be adjusted to take better advantage of modeling tools and to foster collaborative, multi-party modeling efforts?

- Are there significant incompatibilities between the nature of modeling approaches and aspects of the policy-making process that limit the applicability of modeling tools?

Workshop 1: Ecosystem Changes and the Low Salinity Zone

The topic of Workshop 1 was, "Ecosystem Changes and the Low Salinity Zone." The Board identified key interest groups in the initial noticing for Phase 2 and designated a consultant, Brock Bernstein from ICF International, to work with stakeholders to develop a workshop format and a series of panels to represent each interest group. A copy of the final agenda for Workshop 1 is in Appendix A. Two specific questions were posed for discussion during this workshop:

1. What additional scientific and technical information should the Board consider to inform potential changes to the Bay-Delta Plan relating to ecosystem changes and the low salinity zone (LSZ) that was not addressed in the 2009 staff report and the 2010 March *Development of Flow Criteria for the Sacramento–San Joaquin Delta Ecosystem* report (2010 Flow Report)? For large reports or documents, what pages or chapters should be considered? What is the level of scientific certainty or uncertainty regarding the foregoing information? What changes to the Bay-Delta Plan should the Board consider based on the above information to address existing circumstances and changing circumstances, such as climate change and BDCP?
2. How should the Board address scientific uncertainty and changing circumstances, including climate change, invasive species, and other issues? Specifically, what kind of adaptive management and collaboration (short-, medium-, and long-term), monitoring, and special-studies programs should the Board consider related to ecosystem changes and the low salinity zone as part of this update to the Bay-Delta Plan?

Panel 1: Invited Expert Panel

Dr. Peter Goodwin, Delta Stewardship Council— What's New Since 2010?

Dr. Peter Goodwin, lead scientist for the Delta Stewardship Council, provided some background information on the expert panel. He explained that the present (September 2012) panel was being convened to provide a summary of new information since 2010, and he asked that panel members speak on behalf of science as much as possible.

Dr. Goodwin and the Delta Stewardship Program's Science Program designed the panel and developed the following five goals and guidelines for the panel:

1. It should be interdisciplinary.
2. It should also be representative of the different groups doing work in the Delta.
3. It should highlight uncertainty and where disagreements lie (where future research needs to be done).
4. It is acceptable for the panelists to disagree. There is no requirement for a uniform message.
5. The panelists should focus on what the Board members most need to know.

Dr. Goodwin explained that this panel's (September 2012) presentations build on the 2010 Flow Report. The invited panel provided a presentation during the development of the Flow Report in 2010, and the five key points of that presentation were:

1. Environmental flows are more than just volumes of inflows and outflows.
2. Recent flow regimes both harm native species and encourage nonnative species.
3. Flow is a major determinant of habitat and transport.
4. Recent Delta environmental flows are insufficient to support native Delta fishes for today's habitats.
5. A strong science program and a flexible management regime are essential to improving flow criteria.

Dr. Goodwin introduced the other members of the expert panel and provided an overview of their presentations.

Dr. Bill Fleenor, University of California, Davis—Hydrologic Changes to the Delta

Presentation summary: *The Delta is an "ecosystem in stress" due to habitat loss, increased consumptive use, decreased inflow, decreased fall outflow, and declining water quality.*

Dr. Fleenor began his discussion with a description of the historic ecology of the Delta and recommended an upcoming "must-read" report by the Bay Institute, *Sacramento–San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process*, which provides a tremendous pre-European ecology view of the Delta focusing primarily on mapping from the early 1800s. The authors of this report did not limit themselves to studying the legal Delta; they considered everything below 25 feet elevation. They identified over 384,000 acres of open water and wetlands in the historic Delta and an additional 124,000+ acres that were inundated every year. Another 144,000 acres were seasonally flooded, but for less time and for fewer years. Historically, there were extensive habitats of all types, particularly in the LSZ, and gradients hydraulically connected the various habitats. Ninety percent of this historic habitat has been lost or impaired.

Dr. Fleenor showed a graph illustrating that long-term water availability has not changed much since the droughts of the 1920s and 1930s. However, he explained the timing of the precipitation is changing, and more rainfall as opposed to snowfall is occurring now than in the past. Since the 1930s, in-Delta consumptive use has remained fairly constant, but upstream consumptive use and export pumping have increased significantly. Outflow has also decreased, with significant decreases in the fall and early winter, which are time periods of particular concern for the LSZ.

Dr. Fleenor also expressed concern about water quality, reporting that based on monthly averages, up to 15% of inflows in a dry year come from wastewater and agricultural drainage, and the daily averages may be much higher.

All of these factors combined have caused the Delta to become an ecosystem in stress.

Dr. Wim Kimmerer, San Francisco State University—Ecosystem and Low Salinity

Zone Changes

Presentation summary:

- *The shape and size of the salinity field varies with flow.*
- *Pelagic species live in a dynamic habitat.*
- *The LSZ is a key region for some species.*
- *The LSZ is unproductive and subsidized by upstream and downstream sources.*
- *Relationships between abundance and X2[1] are not only about the LSZ.*
- *Simple correlative relationships can be misleading.*

Dr. Kimmerer's presentation focused on describing the current understanding of how the LSZ is affected by flow and how it functions as an ecosystem. He showed how the LSZ moves based on flow changes and how the location of X2 can affect the shape and size of the LSZ and the quality of habitat within it. He noted that there is "geographic habitat," which is tied to a specific location, and "dynamic habitat," which is tied to conditions. The LSZ, a preferred habitat for pelagic organisms, is a dynamic habitat. The LSZ may be more productive when it overlies specific types of geographic habitat, like the Suisun Marsh, as opposed to the channelized, sterile channels of the Delta further upstream.

High flows occurred in the Delta during 2011, and monitoring results show that there was an increase in abundance of Delta smelt. Though this is just a correlation, Dr. Kimmerer encouraged the Board to pay attention to events like this and look into what factors influenced the results.

Scientists know that the LSZ is a key region for some species, but this is not just because of salinity itself. One of the key attributes of the LSZ is that it is a maximum turbidity zone, which may help pelagic species avoid predators. A variety of other species are also associated with the LSZ and surrounding salinity regions.

However, Dr. Kimmerer stressed that correlations do not necessarily carry with them an understanding of cause. For example, longfin smelt have an affinity for the LSZ and are often associated with it, but they are not always found there. Another example is there is a strong correlation between the rise of the *Potamocorbula* clam and the decline of phytoplankton biomass in the Delta. It is tempting to link these two trends mathematically, but a number of other conditions in the Delta were changing at the same time, including flow fluctuations and ammonia loading. Clam grazing by itself may explain most of the phytoplankton decline, but not necessarily all of it.

Interagency Ecological Program monitoring data show that chlorophyll production values are higher in the lower and higher salinity zones neighboring the LSZ. Mixing between the zones reseeds the LSZ biomass and keeps it "propped up." Microzooplankton and copepods are also subsidized by neighboring zones.

[1] X2 is defined as the distance from the Golden Gate Bridge (in kilometers) to a specific isohaline indicating a boundary in the low salinity zone.

Many of the recent changes in the way the Delta ecosystem functions can be attributed to static flow conditions in the summer and fall, including the rise of the *Potamocorbula* clam, the profusion of *Egeria densa* and largemouth bass, and the current rise of Microcystis; however, this does not necessarily imply that flow modification will reverse those changes.

Dr. Jim Cloern, U.S. Geological Survey—Managing the Estuary for an Uncertain

Future

Presentation summary: *The Bay-Delta ecosystem has been transformed by the cumulative effects of human actions and changes in the climate system, and the system continues to change. This will require durable policies that anticipate and adapt to these changes. The Board can look to science for help in anticipating change (through modeling) and in detecting changes (through monitoring) that will require policy adaptation. However, these three elements (policy making, forecasting models, and monitoring) are weakly coupled. Durable policies will require stronger relationships between policy makers and scientists and between the two types of scientists (those developing the models and those collecting the data through monitoring).*

Dr. Cloern provided some examples of how human actions and changes in the climate system can change estuarine ecosystems and showed how what appear to be small changes in salinity can cause bigger reactions. The cumulative effects of human actions and climate variability have already profoundly changed the Bay-Delta ecosystem, and it continues to change. Some of the anticipated future changes include the invasion of the quagga mussel, changed flows, catastrophes that could breach levees and flood Delta islands, and a rise in cyanobacteria adapted to high temperatures and produce toxins. As sea level rises, the relationships of X2 and the LSZ to other variables will change. For example, Dr. Cloern cited a study that found with one foot of sea level rise, an annual average of at least 465,000 acre-feet of additional Delta outflow would be required to maintain 1981–2000 salinity conditions at the western edge of the Delta. With continued sea level rise, the volume of required outflows would continue to increase. if one of the Board's policy goals is to maintain salinity at a particular location, that policy will need to anticipate changes and build in contingencies because the same flows will not maintain X2 at the same location with higher sea levels.

Dr. Cloern believes that these changing and uncertain future conditions will require durable, relevant, and effective policies able to anticipate changes and that build in contingencies for when these changes occur. He recommends that the Board keep a pulse on the estuary to detect changes, which will require stronger relationships with the scientists making observations and running forecasting models. He suggested scientists should allow policy-making bodies to develop a list of questions for modelers. He cited a need for a new process to shape the kind of science that is done so that the information produced by forecasting models is exactly what policy makers need.

He also cited a need for stronger couplings between the two types of scientists. Forecasting models produce hypotheses, and those hypotheses need to be tested. He said that while there are some great monitoring efforts in the Delta right now, they are not testing exactly the right things to confirm the models.

Dr. Cloern recommended the members of the Board consider using their power and influence to marshal the resources to establish a stronger working relationship between the scientific community and policy makers to inform durable policy making.

Dr. Anke Mueller-Solger, Interagency Ecological Program—Changing Science for a Changing Estuary

Presentation summary: *Changing conditions in the Delta, the array of multiple factors driving these changes, and the weak couplings between science and policy add up to a truly "wicked" problem. A new approach is necessary for making policy decisions in the Delta. The solution is adaptive management, which is intended to deal with uncertainty.*

Dr. Mueller-Solger discussed the adaptive management process in general and then provided an example of what adaptive management of fall outflow might look like. She pointed out that fluctuations in the system are necessary in order to learn how the system works, and the stable X2 location after the mid-1980s offered little opportunity to observe varying conditions. She also noted that changing conditions in the Delta, the array of multiple factors driving these changes, and the weak couplings between science and policy add up to a truly "wicked" problem.

The high flows in 2011 were a great learning opportunity because scientists participating in the FLaSH Study were able to observe different conditions and how those conditions affected various species. Dr. Mueller-Solger said studies like this must continue into the future to produce usable data and inform policy decisions. The FLaSH studies represented an impressive mobilization of resources, but this level of effort is likely not sustainable over time. There is room for improvement, and Dr. Mueller-Solger recommended dedicating a chief scientist and staff to the effort for at least 10 years and adding integrative modeling and monitoring of other seasons, species, and processes to the effort.

The FLaSH studies provided lessons for science and adaptive management. Adaptive management of the Delta will require strong couplings between policy makers, observational scientists, and forecast modelers, and will require appropriate timelines for observing changes and management effects. Dr. Mueller-Solger asserted it will require a year-round integrative approach and must be appropriately funded and headed by knowledgeable leaders and staff.

Dr. Cliff Dahm, University of New Mexico—Conclusions and Recommendations

Dr. Dahm summarized the "take-home" messages from the preceding presentations:

- The combination of habitat loss, increased consumptive use, decreased flow and inflow, and water quality degradation has created a stressed ecosystem in the Delta.
- The habitat represented by the LSZ is dynamic in space, has physical constraints (such as the engineered channels of the Delta), and is home to many different biological processes.
- Beware of simple correlative relationships.
- Both human actions and climate variability can impart major changes to the estuary.
- Science needs to inform Delta policy.

- Adaptive management must be applied to the Delta.

Dr. Dahm's professional experience has been mostly outside of California; his work has focused on estuaries in Florida, Australia, and South Africa. In addition to summarizing the expert panel's input, his presentation discussed ways that efforts underway in Florida and South Africa can help California to establish flow standards for the Delta. He worked in Florida for 20 years, where a statute was passed in 1972 stating that minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area. Defining "significantly harmful" has been a big challenge for Florida, but they have been setting flows for rivers and for estuaries based on this statute. Florida recognized that the hydrograph has various portions that need to be considered differentially, so they use a "building block method."

This method takes periods of time, such as critically low flow periods, periods of base flows, periods of changing flows, and periods of high flows and blocks them into different segments. Then flow requirements are determined for each of those different blocks. Florida uses a daily time step for flows, whereas California usually uses a monthly time step.

Setting flow criteria has been a big issue in South Africa for the past 15 years. The post-apartheid constitution requires that basic water needs are the first priority in flow allocation, the second priority is the environment, and the third priority is agriculture and industry. They have established eight guiding principles for setting flow criteria, four of which are germane to the Delta:

1. A modified flow regime should mimic the natural one so that the timing of different kinds of flows is preserved.
2. The first flood of the wet season should be preserved.
3. Floods should be present during the natural wet season (not necessarily all floods, and some may be truncated in duration so that usable water can be extracted).
4. Most water should be harvested during wet periods (little should be harvested during dry periods).

Research shows the importance of flows for streams, rivers, and estuaries. While flow is not the only variable, it is not unimportant. Flows interact with a number of other variables, including contaminants, nutrients, predators, nonnative species, native species, habitats, turbidity, algal blooms, and many other stressors. He emphasized flows and flow criteria do deserve the Board's consideration.

Questions from the Board and Staff

Diane Riddle (Staff, Senior Environmental Program Manager) wondered, despite the uncertainty related to the science, what could the Board be doing in the next couple of years to move forward in its planning process. Are there any certain actions that the Board should be taking in the short term?

Cliff Dahm said the Board should link policy with modeling and monitoring research as it gathers information for its decision making.

Jim Cloern responded that the Board needs to institute processes that don't yet exist.

Bruce Herbold (Invited Expert Panel, U.S. Environmental Protection Agency) said the Board should utilize adaptive management processes. Conditions in 2011 offered a way to check

assumptions and hypotheses. Adaptive management requires doing something. He suggested using the FLaSH effort as an example. Where there are uncertainties, ask specific questions. Push to change current conditions. He pointed to Dr. Mueller-Solger's presentation, saying there is a very stable system out there and that it is necessary to make sure variability occurs in association with studies. Dictating percent unimpaired flow will not do the job. However, choosing to provide a certain percentage of unimpaired flow to reproduce a certain condition in a given year and deploying studies to monitor the effects of the action could work. The 2011 FLaSH studies show that getting rapid results is possible.

Fran Spivey-Weber (Board) agreed that there should be a tighter nexus between modeling, monitoring, and decision making. She asked the expert panel what makes the connection so weak and asked for input on the corollary: What changes need to happen to strengthen these relationships?

Dr. Jim Cloern responded that the weakness of this connection is not limited to California but there are the same issues at the national and regional level. California has an opportunity to lead the way in strengthening these couplings. With sufficient and appropriate support California can take on this task. It is necessary to shape requests for proposals and get the communities of scientists who do observation and modeling together. It is also necessary to make sure monitoring programs are measuring: (1) the right things, (2) at the right places, and (3) at the right times to check the things being anticipated through modeling. He suggested there is not a good template to follow and encouraged that California be the template.

Steven Moore (Board) thanked the expert panel for reminding the Board of all the moving parts in the Delta. He said Dr. Jim Cloern's submittals highlight the dynamism of the underlying system. The Bay-Delta Plan has a lot of variables, but flow standards are based on past patterns. He asked: How do we modify our approach to developing flow standards to take into account this moving foundation?

Bruce Herbold said a lot has changed since 2010. Certain changes can be anticipated, like the quagga mussel. The system is changing rapidly, and knowledge of the system is growing rapidly. The basin plan process is probably not going to keep up with the changes and the advances in knowledge. Once sea level goes up a meter, trying to get an X2 at 65 kilometers (km) from the Golden Gate Bridge will probably not be possible. He suggested contingencies need to get built into the plan for anticipated events.

At this point in the workshop, members of the Board decided to ask their questions up front and then let the expert panel respond.

Felicia Marcus (Board) posed three questions to the expert panel for future consideration and input:

1. Climate change will have an undeniable impact on the Delta. What is our time frame? How do we take climate change into account in the Bay-Delta Plan? How should we adjust how we think about what we should be coming up with?
2. How should we deal with flow in the context of multiple stressors, some of which are influenced by flow and some of which are not?
3. Any input on how we could integrate the idea of mimicking natural flows into our thinking will be helpful.

Steven Moore said the FLaSH studies were an enlightening experience. Setting up an institutional infrastructure for such long-term monitoring will be a collaborative exercise between the Board, DWR (Department of Water Resource), the Bureau of Reclamation (USBR), and water rights interests, but the Board is committed to this as a process. Mr. Moore then expressed a belief that through the Board's planning process, it can encourage collaboration, and through the Board's funding mechanisms, it can encourage those collaborative processes. He encouraged Board staff to build on the existing Bay-Delta Plan language. He then asked the expert panel what the Board could do. What related regulatory programs could the Board use to look at stressors other than flow? How can the Board structure the Bay-Delta Plan to encourage relationships between water and land management? Mr. Moore requested input on how the Board can better structure the regulatory program not to get in the way of habitat restoration.

Tam Doduc (Board) asked Dr. Cliff Dahm to share some of the studies that have been done on the flow issue in Australia and other places so the Board can replicate their successes and avoid their failures. She asked: The Board heard today that flows matter, but flows come with associated costs. The Board's challenge is to balance decisions among different stakeholders. Ms. Doduc is curious if the panel has any suggestions from a scientific perspective in terms of this balancing decision, whether it be on flows, invasives, etc. Are there options that would result in improvements?

Fran Spivey-Weber shared the following questions and thoughts:

1. (Directed to Board staff): Are you providing questions to the science programs that you need answered in order to advise the Board? If not, is there something the Board can do to help make that happen?
2. (Directed to the expert panel): The Board will need to establish some triggers for adaptively changing policy goals. What should those triggers be?
3. Dr. Bill Fleenor said during his presentation that the volume of agricultural runoff should stay the same in the future, but that the amount of wastewater entering the system can be expected to increase. Fran Spivey-Weber expressed her belief that the assumption that there will be an ever-increasing amount of wastewater from population growth is probably not true. For example, concentrations may be changing and waste may be used for energy production. We cannot assume that the way we've used water in the past is the way we'll use it in the future or that the kinds of water we've used in the past will be the kinds of water we're going to use in the future.

Dr. Peter Goodwin said the reason the Delta Stewardship Council is so excited to participate in this process is that it is committed to not having the process done in a vacuum. The council has completed a survey of science plans that are used to address these issues in the U.S. and the world. The Board is welcome to access this research. Dr. Goodwin suggested the real question is, "How can you corral this incredible depth of expertise in the scientific community?" He said eventually the panel will come back with responses to all of the questions later in the Phase 2 process.

Dr. Bruce Herbold Dr. Herbold shared some thoughts on potential triggers that would require changes in Board policies and brought up ammonia as an example. Ammonia must be regulated now, but experts believe it will be 13 years before the ammonia problem is solved. So a certain set of policies must be set for the current conditions, but the ammonia issue will be redefined in 13 years or so, and that will require a new set of policies.

Dr. Herbold referenced Steven Moore's question regarding how the Board could make sure it wasn't getting in the way of habitat restoration: Salinity in the Delta is going to be a result of climate change and Board policy. Once the restoration community knows what the salinity levels will be in different types of water years, they can make much better plans regarding habitat restoration.

Dr. Herbold also encouraged the Board to plan for known changes: Catastrophes will occur, and the Board should set up those anticipated conditions. We know that once so many hectares of Delta islands are flooded, protecting beneficial uses of the Delta will be much different, so that is a usable trigger. The Board should also anticipate the impending huge impact of the quagga mussel. "Anticipatable" issues are the triggers. This approach will require more active involvement by policy makers.

Steve Culberson (Invited Expert Panel, U.S. Fish and Wildlife Service) had five main points in response to Board questions:

1. The Board should take into account that the coastal ocean is coming to the estuary. There are occurrences of marine species for the first time in Yolo County.
2. Synthetic science should be a priority, but it is not clear how to do this. The Board can have more control over this by training, hiring, paying for modeling, and directing its activities.
3. Regional ecological management will need to be considered as we look at water quality standards. For example, will marshes be allowed to become more saline as climate changes?
4. Subject matter for the science community needs to come from the Board. What questions do you need help answering? We can help you formulate questions and answers.
5. How do we get scientists into the meetings and discussions where decisions are made every day? The Board needs to have its questions answered as it goes along. That is learning.

Larry Brown (Invited Expert Panel, U.S. Geological Survey) said he agreed with Steve Culberson's comments. He said for science to better inform policy development, it will take people, funding, and time. It is not necessarily the only agency responsible for this because there are other agencies and groups concerned with the Delta. However, the Board needs new people who are equipped to answer Board questions on a full-time basis. The experts on the Expert Panel are all very busy with the other things they are doing. To implement Dr. Jim Cloern's vision of better coupling science and policy making, it is going to take something new. It is going to require dealing with people and deciding how it is going to be done. Dealing with people is a really "wicked problem."

Panel 2: Regulatory and Fishery Agencies

Patrick Coulston, California Department of Fish and Game—Low Salinity Zone and Inflow/Outflow Effects on Bay-Delta Species

Presentation summary: *Delta smelt and longfin smelt are at risk. Increased impairment of Delta outflow threatens longfin smelt viability, and decreased size and quality of fall LSZ habitat threatens delta smelt viability. Studies show that the LSZ and key species respond positively to Delta outflow, and the high flows in 2011 show that increased flows can have a positive effect on smelt abundance.*

Department of Fish and Game believes that the 2006 Bay-Delta Plan is insufficiently protective of smelt species and that the Bay-Delta Plan update must call for more robust flows and a lower X2.

Patrick Coulston observed that the timing of the Board's update of the Bay-Delta Plan coincides with a period of tremendous scientific information generation regarding the Delta. He explained that the Department of Fish and Game (DFG) is interested in a Bay-Delta Plan update because it is relevant to the smelt species dependent on the LSZ. DFG believes that smelt species are truly at risk, and without more protection, delta smelt could be lost and longfin smelt extirpated from the system. Most importantly, DFG believes the current Bay-Delta Plan is insufficient to protect smelt because it allows for very high levels of outflow impairment and does not guard against high fall X2, regardless of water year type.

Four smelt listing actions have occurred since the 2006 Bay-Delta Plan was published, and the documents associated with these listing actions are rich in data. Mr. Coulston recommended that the Board review that data and incorporate them into its decision-making process and documents.

DFG believes that improved Bay-Delta Plan objectives could have a positive influence on the viability of smelt species. The high flows and resultant increase in smelt species abundance suggests that more robust flows and a lower X2 should be a goal for the Bay-Delta Plan update.

John Shelton, California Department of Fish and Game—System Ecology, Watershed Functions and Services

Presentation summary: *The Delta is a complex adaptive system that requires adaptive management. The adaptive management model is accepted and has been well-vetted around the world. The planning and policy-making process for the Bay-Delta Water Quality Control Plan must be reframed so that it can be done well and so that adaptive management can inform the process. Good adaptive management requires clear goals and objectives.*

Mr. Shelton discussed the nature of complex systems and why they require adaptive management. He provided an explanation of how adaptive management works, noting that the Delta Stewardship Council's Delta Plan provides an excellent description of adaptive management and the Board should use it as a resource by the Board. For adaptive management to work, the policy process has to be framed in such a way that monitoring results can inform policy adjustments in a continuous process (the "policy cycle"). The planning and policy-making process for the Bay-Delta Plan must be reframed to involve adaptive management. The Board will need to establish clear goals and objectives to ensure an effective policy cycle.

Matt Nobriga, U.S. Fish and Wildlife Service—Low Salinity Zone Effects on Delta

Smelt

Presentation summary: *The U.S. Fish and Wildlife Service (FWS) believes flow is important for delta smelt survival and recovery. Research shows that Old and Middle River (OMR) flows contribute to entrainment of adult delta smelt in the State Water Project (SWP) and Central Valley Project (CVP) pumps and that OMR flows are the primary driver of larval delta smelt entrainment. Multiple factors have contributed to the long-term degradation of the LSZ. However, Delta outflow is still an extremely*

important aspect of habitat suitability for delta smelt. For these reasons, FWS suggests that the Board model a range of flow objectives that could be incorporated into the Bay-Delta Plan.

Mr. Nobriga noted FWS's interest in the Bay-Delta Plan update is related to its role in enforcing the Endangered Species Act and delta smelt's status as a listed species. Though delta smelt are not thriving as a species, they can still reproduce successfully in the system, which means there is a possibility for the species to recover if the conditions are favorable.

Mr. Nobriga focused his presentation on providing new science related to delta smelt entrainment at the SWP and CVP pumps. Recent studies have shown that high adult delta smelt salvage usually happens when OMR flows are negative and turbidity is high. OMR flows contribute to adult delta smelt entrainment, but they are not the only factor. However, there is a linkage between the timescale of flows on OMR and adult delta smelt salvage, which suggests that adaptive management of flows on OMR could make a difference in entrainment rates. FWS believes that combining turbidity and OMR flow in the Bay-Delta Plan process could make for an improvement in delta smelt entrainment.

Modeling and data agree that the driver of larval delta smelt entrainment at the pumping facilities is OMR flow. Simple simulation modeling shows that entrainment can cause delta smelt to decline, especially in a post-pelagic organism decline (POD) environment in which delta smelt populations do not reach carrying capacity in the summer.

There is also new science regarding delta smelt rearing habitat. By and large, there is no striking trend in delta inflow. However, there is an increasing trend in exports since the mid-1980s. The data show that fall habitat suitability for delta smelt is closely, but nonlinearly, related to X2, and fall habitat suitability is correlated with abundance. It is uncertain if higher flows are better for delta smelt; however, it is certain that low flows are not better for fish. The data suggest that habitat suitability is something that can be managed with the location of X2. Mr. Nobriega noted that for these reasons, FWS suggests the Board model a range of flow objectives that could be incorporated into the Bay-Delta Plan.

Erin Foresman, U.S. Environmental Protection Agency—Flow Interactions with

Species Abundance and Water Quality Standards

Presentation summary: *The U.S. Environmental Protection Agency (USEPA) has determined that aquatic life beneficial uses in the Delta are not adequately protected by current water quality control standards. New science shows that X2/abundance relationships have overwhelming support and that flows are important year-round for species living in LSZ habitat. To halt the decline of native fish species in the Delta, USEPA recommends that the Board connect percent unimpaired flows to habitat elements and regulate X2 through percent unimpaired flows on a year-round basis.*

Erin Foresman reviewed some basic Clean Water Act (CWA) concepts. USEPA has fully delegated the water quality standards program to the Board. The Board submits its standards to USEPA, who decides whether or not to approve them. In the recent *San Francisco Bay Delta Action Plan* (Action Plan), USEPA found that aquatic life beneficial uses are not adequately protected by the current water quality control standards. The Action Plan proposes measures for improving water quality, restoring aquatic habitat, and improving the management of the Bay-Delta estuary and identifies an

update of flow standards as the first priority. Other priorities include a Delta regional monitoring program, the total maximum daily load (TMDL) program, selenium objectives, pesticide pollution prevention, methyl mercury, and the Bay Delta Conservation Plan (BDCP).

Ms. Foresman then discussed new information. Recent studies support X2/abundance relationships and confirm that the statistical correlation is valid even though all of the causes are not understood. Considerable advancements have been made in modeling capabilities, most notably the LSZ can now be modeled in three dimensions. New modeling efforts have assessed what the LSZ looks like when X2 is in different locations and have shown that access to food, turbidity, and surface area of the LSZ are all maximized when X2 is between 65 and 74.

New research also supports the idea that LSZ is important year-round. The Board's 2010 Flow Report identifies the need to expand the fall X2 requirements into the winter. USEPA believes it is clear that X2 can be managed and that fish population declines can be halted by utilizing percentages of unimpaired flows. USEPA recommends that the Board connect flow to essential habitat elements to determine what percentages of unimpaired flows will achieve target habitat conditions.

Questions from the Board

Steven Moore expressed the Board is interested in recommendations on how to approach this update. He asked how the Board should approach the modeling of different objectives and whether the Board should take climate change into account.

Matt Nobriga said the BDCP is trying to incorporate climate change into its modeling and that yes, the Board should look at what might be coming. For the here and now, climate change might or might not be all that relevant.

Fran Spivey-Weber referred back to Mr. Nobriga's statement that low flows will not work for fish species and asked how important it is to understand the relationship of flow to other factors (e.g., turbidity).

Matt Nobriga said it is important for the Board to understand the relationship of flow to other factors. He agreed with Dr. Cliff Dahm's assertion that flow matters. Other factors matter too, but how much is not entirely certain. He suggested we have to be careful with correlations, but correlations that hold up over a long period of time might be helpful. Mechanisms offer the opportunity to do something more efficient over time. Mr. Nobriga expressed it would be great to know if it were possible to manage with less flow in the fall if another factor were modified, and yes, there should always be a pursuit of more knowledge.

Panel 3: Resource Management Agencies

Russ Stein, Department of Water Resources—DWR Recommendations

Russ Stein of DWR said although there has been substantial progress in our understanding of the estuary, information about the influence of LSZ position on fish and ecosystem processes in the fall is still inconclusive. Habitat is influenced by a complex suite of interacting factors, including temperature, salinity, turbidity, food supply, predation, channel configuration, and connectivity

among habitats. Additional study is needed for a deeper level of understanding. Many of the studies discussed during the workshop are still in progress, and the results are not conclusive. Stein then summarized DWR's suggestions. He said DWR encourages the Board to evaluate the relative importance of the information presented during the workshop. DWR also recommends an adaptive management approach for the Bay-Delta Plan. Such an approach provides the tools necessary to respond to new information as it emerges. DWR also encourages the Board to look to BDCP for guidance, as it represents a multi-agency, interdisciplinary effort to create a credible adaptive management plan for restoration of the estuary. It also contains excellent information on projected future Delta conditions. Mr. Stein then introduced the three panel speakers.

Dr. Ted Sommer, Department of Water Resources— X2 and Non-Flow Criteria

Presentation summary: *Based on recent data, including evidence that pelagic species populations may be shifting (geographically and within the water column), and new understandings of delta smelt habitat requirements, DWR recommends that the Board undertake continued research to examine the mechanisms by which flow and other drivers affect aquatic species. DWR also recommends that the Board develop regulations to decrease loading of selected contaminants and develop response plans for specific anticipated changes, such as invasive species. DWR believes that there is enough information to justify some fairly large-scale restoration projects in the Delta.*

Ted Sommer noted that DWR submitted a 50-page document to the Board as a part of this workshop that summarizes the available information since 2009. He summarized this new research in his presentation.

Fish Abundance and Distribution

The decline of pelagic fish species in the Delta has been well-documented. However, recent abundance studies show that delta smelt still have some resilience (the ability to respond positively to favorable conditions). Recent research also shows that part of the reductions in reported smelt abundance can be explained by shifts in fish distribution—the fish are moving out of the traditional sampling areas. Historically (pre-mid-1980s), longfin smelt lived in the fresher areas of the LSZ, but recently they have moved to saltier areas of the LSZ. They are also moving in the water column away from where the trawling occurs. Striped bass abundance reporting is likely affected by distribution shifts as well. Historically, most of the striped bass catch was out in the channel area. In recent years, there has been an apparent shift towards inshore areas. There may be a similar response in delta smelt. Monitoring efforts normally focus on the occurrence of delta smelt in the LSZ, but some evidence shows that in recent years there has been a modest shift of delta smelt into the north Delta and the Cache Slough complex. Once Liberty Island was flooded, FWS sampling showed that delta smelt moved relatively quickly into the area. FWS surveys also show consistent delta smelt use of the Sacramento Deep Water Ship Channel (DWSC). DWR believes this data shows that pelagic fish are more flexible than previously thought, and their habitat extends beyond the LSZ. These outside areas should be recognized for management and restoration.

Physical, Chemical, and Biological Fish Habitat

As expected in an estuary, the distributions of many organisms are affected by the position of the LSZ. Studies since 2009 continue to show that salinity is an important driver of fish distribution.

However, it continues to be difficult to separate the relative importance of the LSZ position from the effects of multiple interacting factors.

Dr. Sommer discussed the 2011 FLaSH studies. There was a big increase in the fall abundance of delta smelt in 2011, but the resulting report will be clear that the results are inconclusive. It is a challenge to identify the relative importance of fall conditions from the rest of the year, as well as determine to what degree fall flows were responsible for the delta smelt abundance increases. Some of the FLaSH results were contradictory. He cautioned against drawing too many conclusions from one year of observations.

Since 2009, more information has become available about the habitat needs of delta smelt. For example, we now know that key factors for delta smelt habitat include high turbidities and moderate temperatures, and that they do not appear to have strong substrate preferences, but sandy shoals may be important for spawning. Additional new data suggest that delta smelt generally require moderately tidal habitats, occur in a wide range of channel sizes (though they seem to be rarer in small channels), and prefer open water habitat adjacent to long-residence time areas.

Dr. Sommer also pointed out that the effects of contaminants on fish are still poorly understood, especially regarding chronic effects. Emerging research suggests that urban pesticide use may be more important than previously thought.

Predation ("Top-Down" Effects)

In the Sacramento DWSC, a hotspot for delta smelt, studies show that silversides are indeed feeding on smelt. Increases in the abundance of nonnative predators, such as striped bass and largemouth bass, may have important effects on native species' populations, but the magnitude of these effects is unknown.

Food Web Changes ("Bottom-Up" Effects)

Recent studies show that the Delta food web continues to change, with shifts in the phytoplankton and zooplankton communities, and increasing populations of invasive jellyfish, shrimp, and clams. New data is also helping us understand food web subsidies to the LSZ. The LSZ itself is not that productive, and we now have some indications that more productive areas upstream of the LSZ are subsidizing the food web in the LSZ.

Recommendations

Dr. Sommer made the following recommendations to the Board:

- Undertake continued research to examine the mechanisms by which flow and other drivers affect aquatic species.
- Develop regulations to decrease loading of contaminants.
- Develop response plans for specific changes such as invasive species.

He also told the Board there is enough information available to justify large scale restoration projects.

Andrew Schwarz, California Department of Water Resources—Climate Change and Non-Flow Criteria

Presentation summary: *Ongoing changes in climate mean that past climate and hydrology alone are unlikely to be good predictors of future conditions. Recent conditions and climate modeling may provide a better indication of what to expect in the near-term. Regulatory thresholds should be established with consideration given to changes in climate and hydrology that have already occurred and that are projected to occur in the future. Some major changes to consider are flooding of Delta islands, salinity increases in the Delta, earlier snowmelt runoff and changes in hydrology, and increased temperature. Programs to improve and protect ecosystem conditions will be most likely to meet their objectives if they are designed to function within altered climatic conditions rather than today's climate and hydrology.*

Andrew Schwarz said that DWR believes historical observations are no longer enough to project future conditions. California gets most of its water supply in less than 15 storms per year. That storm track is likely to change in the years to come due to climate change, but climate models are uncertain about how it will change. If just one or two storms per year are diverted away from California, it could have a huge impact on water supply. Though there is a huge variability in climate change modeling—some models show California getting wetter while others show California getting drier—all models predict that California will get warmer. This will have effects on snowpack, which is a critical factor for water supply in California.

Monthly average runoff measurements show that more runoff is already occurring during winter and early spring, while less is occurring in the summer. Since flow patterns have been changing over time and will continue to change, Mr. Schwarz cautioned that using historical unimpaired flows as a basis for flow criteria runs the risk of over-regulating flows during part of the year and under-regulating them during another part of the year.

Because of impending shifts to precipitation and sea level rise, there will be less water available for management, and the flows needed for fish native to the Delta will change. Mr. Schwarz told the Board DWR has been developing techniques to incorporate the effects of climate change into water management planning and has set up an independent Technical Advisory Group, which the Board is welcome to join.

John Leahigh, California Department of Water Resources—Dealing with Uncertainty

Presentation summary: *DWR believes that there is a common misunderstanding of how much control the SWP has in managing the system. Because of the many ecological uncertainties in the Delta, DWR believes that the relative value of enhanced environmental flows is uncertain relative other beneficial uses. Using stored water in an already storage-poor environment to regain a marginal degree of flow variability in the Delta will likely result in certain and significant impacts on other beneficial uses. DWR recommends adaptive management as the most effective approach to balance uncertainty.*

John Leahigh's office at DWR is responsible for the real-time management of the SWP. As the previous speaker, Andrew Schwarz, pointed out, California's precipitation regime is uniquely variable, and the managed water systems in California (i.e., SWP, CVP) protect against flooding, manage water temperatures, and help make water supplies more reliable. The California's water

storage capabilities are limited (California's water storage capacity is five times less than the Colorado Basin's, even though the average unimpaired flow is similar), which means DWR's ability to mitigate for droughts is constantly at risk.

Most of the Delta's outflow is unregulated because of the storage-poor environment of the system, because some of the rivers basins are not regulated, and because a good portion of runoff in the Sacramento Valley is from precipitation that falls below the dams. Even in average rainfall years, DWR is unable to regulate a good portion of the flows that could be used for inter-seasonal management. DWR expects that any reduction of impairments will result in adverse impacts on benefits derived from those impairments.

Ecological uncertainty is strongly influencing the regulatory environment. As a direct result of the rapidly changing understandings with regard to the Delta ecology, regulations on SWP operations have been rapidly changing as well. This rapidly-evolving scientific understanding of the Delta does not fit well with long-term prescriptive standards found in the previous Bay-Delta Plan. DWR recommends an adaptive management approach to balance uncertainty. Annual reviews that gather new insights and lessons learned as part of an adaptive management approach can help the Board tailor protective actions to limit impacts to other beneficial users.

Questions from the Board

Steven Moore acknowledged the importance of adaptive management yet sees a struggle with the timescale in modifying the Bay-Delta Plan, which has a 17-year cycle. He suggested further discussion be had on the useful timescales of adaptive management. He gave the example that scientists and regulators should not react too swiftly to the 2011 data since it is only one data point, yet expressed concern that actions could be too rigid. He wondered if there should be a collective commitment to planning on a more frequent basis and said there is a conflict between the need for long-term planning and the need to be able to respond quickly.

> **Ted Sommer** responded that there are no easy answers. A remarkable amount of information was learned from last year's FLaSH studies. Though there is a lot that is uncertain, enough was learned to substantially change the direction of the science that is being done. He suggested there needs to be a willingness to take some actions that may have adverse responses in order to get the conclusive data needed to help inform decision making.

Steven Moore asked, regarding an earlier suggestion that a first flush be allowed to pass through the system to mimic natural hydrology, what the management implications to the SWP would be. He questioned if this action would be a fine-tuning of operations or a game-changer.

> **John Leahigh** indicated the SWP and CVP only have so much control over the hydrograph. Using the SWP to meet what is maybe marginal/arbitrary flow criteria would be a "great expense" in regards to the supply that would be expended towards that criteria. He pointed to the need to be aware of the trade-offs because of the great expense of water. Every year is unique as far as the hydrology goes. Even wet years can look different from each other. A criterion that is easy to meet in one wet year may be difficult to meet in another wet year or be quite costly. An adaptive approach makes more sense if it is tailored more towards what's doable and not costly to other beneficiaries. For a first flush, there is great risk. It is unknown if that is going to be the first of many storms or the only one.

Fran Spivey-Weber said it is not simply the environment that is going to have to be adaptively managed, but also other things being done now that are affected by water, like agricultural and urban water use. There will be a tremendous learning curve for everyone over the next 30 or 40 years and longer because of climate change. It is not just about fish and streams; it is about how we operate. She said though DWR raised the issue of uncertainty between flow and other stressors, it is clear they are not unrelated.

> **Ted Sommer** said at some level, everything is affected by flow. We are dealing with an estuary that is driven by flow. But there are external stressors like contaminants.

Fran Spivey-Weber pointed out there are many different timeframes at work. The Board has a time frame of "now" for decision making; a time frame of building a tunnel; a timeframe of sea-level rise; and a timeframe of major snowpack change. She suggested that it might be necessary to come up with a nested set of ideas, approaches, and regulatory recommendations which recognize these different timeframes and have a way of being triggered to move into the next timeframe. The current situation is about a species which is not very resilient. Building up that resiliency is important because it is only going to get more difficult. She said the Board is going to need some help in deciding how to make those trade-offs and that many trade-offs will need to happen among all of those who are using the water.

Felicia Marcus noted that Dr. Sommer's presentation differed from previous presentations because he addressed stressors outside of salinity. She asked Dr. Sommer to define whether or not he perceives disagreement between his presentation and the previous ones.

> **Ted Sommer** said the reason he did not discuss flows is because he was asked to summarize new information since 2010, and a lot of information regarding flow was provided in 2010. DWR does believe that flow is a major contributor to fish distribution, and is fairly certain that the winter and spring flows affect abundance of fish. DWR is uncertain about the importance of flows in fall.

Felicia Marcus asked for more information about the potential effect on abundance data of delta smelt moving upstream.

> **Ted Sommer** said the long-term surveys that have been going on in the Delta for years are very valuable but were originally designed for species other than the ones being focused on now. DWR is now trying to expand sampling on the margins of the Delta to provide better insight into fish distribution in these areas.

Felicia Marcus brought up Fran Spivey-Weber's observation that timeframes come into play in myriad ways. Ms. Marcus asked how the Board should apply adaptive management in different time frames, how adaptive management should be done in the short run, and how can it can be structured into a regulatory format. She wondered how adaptive management and practical sensibility can be integrated into a workable framework in the short run and in the long run, and likes Fran Spivey-Weber's idea to clearly lay out the different timeframes.

Panel 4: Environmental/NGO Groups

Dr. G. Fred Lee, CA Sportfishing Alliance/CA Water Impact Network—Enhanced Delta Flows Needed to Help Control Water Quality Impacts of Delta Pollutants

Presentation summary: *The CWA is ineffective in controlling unregulated and nonpoint-source pollutants. In establishing public trust flows into and through Delta channels, the Board should incorporate dilution flow levels necessary for mitigating water quality impacts of Delta pollutants.*

Dr. Lee noted the CWA is based on exceedance of water quality objectives and TMDLs, which works to control pollutants from discrete sources, but does not work to control presently unrecognized pollutants or pollutants from nonpoint sources. He showed that there is a relationship between flow and water quality and believes that dilution flows are the only real solution for pollutant-loading problems in the Delta. Increased flows would also be beneficial to fish.

Dr. Lee also believes that the Board and IEP Delta monitoring under D-1641[2] is grossly inadequate to evaluate impacts of Delta water export on Delta water quality. D-1641 makes it clear that the Board must understand and monitor the impacts of altering Delta flows on Delta water quality in implementing water rights permits. Dr. Lee believes that this is not adequately being done under the current monitoring program. More study is necessary to understand the impact of water exports and upstream diversions on Delta water quality. Dr. Lee also recommends that construction of the BDCP tunnel diversion should not proceed until the potential impacts of alterations in Delta flows on water quality are fully known.

Dr. Jonathan Rosenfield, Bay Institute/Natural Resources Defense Council—Effects of Flow, Other Stressors, and Climate Change on Estuarine Habitat and the Low-Salinity Zone and Use of Biocriteria and other Decision Tools to Guide Adaptive Management of Efforts to Attain Water Quality Objectives and Protect Beneficial Uses

Presentation summary: *The best available science strongly supports flow standards that are based on a percentage of unimpaired flows and that take into account species' sensitivities to the timing, duration, and frequency of flows. The Board should adopt a clear, transparent, and fully-defined adaptive management strategy for the Bay-Delta Plan update.*

Jonathan Rosenfield's presentation was prepared on behalf of American Rivers, the Natural Resources Defense Council (NRDC), and the Pacific Coast Federation of Fishermen's Associations. The key points of his presentation were:

- Numerous Delta-dependent species are in long-term decline.

[2] D-1641 implemented flow objectives for the Bay-Delta estuary in 1999 and was revised in 2000.

- Delta outflows are the "master variable" driving abundance for numerous Delta species and ecosystem processes.
- "Non-flow" stressors must be addressed, but they cannot substitute for flow.
- Increasing water diversions reduce Delta outflows.
- The Board's focus on tracking unimpaired flows is scientifically sound and ecologically appropriate.
- The Board should employ adaptive management to adjust flow requirements as needed. This will require:
    - Identification of biological and physical outcome targets that are specific, measureable, achievable, relevant (to the goal), and time bound) (S.M.A.R.T).
    - Development of decision pathways to implement adaptive management.
    - Adaptive ranges that include flows currently believed necessary to support public trust resources.

There is a high and increasing degree of certainty that increased Delta freshwater outflows (relative to available annual runoff) are absolutely necessary (even if not sufficient alone) to protect and restore estuarine habitat, fish and wildlife beneficial uses, and public trust resources of the Bay-Delta estuary's LSZ. The Delta is in the middle of a persistent, human-caused, severe drought. At any given flow, less water makes it out of the Delta than in past time periods. Since 1967, the state has seen 11 unimpaired wet years, but the Delta has seen only 4 wet years (based on outflow), and the state has had one unimpaired super-critical year, but the estuary has seen 17 super-critical years.

Many Delta species' abundances are correlated with Delta inflow/outflow. He acknowledged that correlation is not the same as causation, but pointed out that a statistically significant correlation is not an accident and suggests a strong driving force. Dr. Rosenfield has found that new studies and publications support the Board's findings in the 2010 Flow Report, including:

1. Existing flows are inadequate to protect public trust resources.
2. Winter/spring outflows should be substantially increased and should be implemented as a percentage of unimpaired flows occurring in a narrow averaging period.
3. Fall (and possibly summer) outflows should be increased to provide sufficient habitat following wetter year types.
4. Nonflow measures (such as physical habitat) interact with flow but are not interchangeable and cannot substitute for flow.

Dr. Rosenfield also recommended that the updated Bay-Delta Plan include a clear, transparent, and fully-defined adaptive management strategy, also known as a "logic chain" approach. Good adaptive management requires knowing your goals so that clear decision pathways can be worked out in advance. He cautioned that adaptive ranges will have to be set that do not fall short of minimum flow criteria needed to attain ecological goals. He cited a 2011 study by Richter et al., the results of which indicated that for standards of river protection around the world on highly modified river systems, 75% unimpaired flow is considered low. The 2010 flow criteria may or may not be sufficient to attain desired outcomes in the Delta, but flow standards are well-suited to adaptive management. Flow standards can be implemented and revised rapidly and equitably among providers.

Dr. John Cain, American Rivers—Interconnections between Floodplain Inundation, Water Turbidity, and Fish Habitat

John Cain emphasized the importance of the "logic chain" approach to adaptive management and reinforced the importance of flows as a "master variable." He noted that high flows have a huge footprint change and trigger many responses and that there is clear evidence that inundation of floodplain habitat is good for salmon and other species. The Central Valley Flood Plan calls for more floodplains, but Dr. Cain observed that floodplains only work for fish if they are inundated frequently. Without the "master variable" (flow), there will be no benefit. Flows don't just change the LSZ; they change how everything works in the watershed.

Dr. Tim Stroshane, California Sportfishing Alliance/California Water Impact Network (C-WIN)—Recent Salinity and Selenium Science and Modeling for the Bay-Delta Estuary

Presentation summary: *Salinity reduction is needed to prevent harm to southern Delta agricultural beneficial uses and water rights holders. Selenium reduction and sequestration is required to prevent contamination and ecological damage to southern Delta fish and wildlife beneficial uses and for public health. Greater freshwater flows to and through the southern Delta are necessary to achieve both of these purposes. C-WIN recommends that the Board lower the water column selenium objective, keep water moving through the Delta estuary, and adopt a land retirement strategy to sequester selenium in the San Joaquin Valley.*

Dr. Stroshane pointed out that the CVP is largely responsible for the doubling of dissolved solids in the Delta over the past 40 years. Regarding salinity, C-WIN recommends that the updated Bay-Delta Plan incorporate:

- Salt recirculation, reduced assimilative capacity, and exports of high quality water.
- Recent modeling results (if not agency conclusions) from the DWR Low-Head Pumping Study and USBR Dilution Flow Study.
- Analysis of effects of Board's interior southern Delta proposal under CWA Anti-Degradation
- Policy and interior Delta water rights.
- Research on Old River salinity problems.

Dr. Stroshane observed that since the 1960s, several management approaches have been developed to deal with the selenium reservoir, but none have solved the problem. The current approach to selenium management also does not address how selenium builds up in predator tissues. To address the selenium problem, C-WIN recommends that the Board:

- Lower the water column selenium objective. Recent research indicates that the water-column selenium criterion should be reduced from 2 parts per billion (ppb) to 0.2 ppb in estuaries.
- Keep water moving through the Delta estuary. Actions that lengthen residence time and reduce flows (San Luis Drain and peripheral tunnels) appear likely to increase selenium bioaccumulation in highly receptive species at the base of Bay-Delta estuary food webs.
- Adopt a land retirement strategy to go with new flow objectives.

Dr. Tom Cannon, California Sportfishing Alliance/California Water Impact Network—Effects of Past Standards on Flow and Pelagic and Salmonid Species and Measures Necessary to Protect those Species

Presentation summary: *The 1995 flow standards have almost no export restrictions and have imposed new export/inflow (E/I) criteria that allow water to be pumped straight out of the LSZ at critical times of the year. Adding water from reservoirs to make up for the water lost out of the LSZ causes the LSZ to be pushed further towards the export pumps, and the remaining water is a mixture of seawater and reservoir water that is poor in nutrients, a condition Dr. Cannon refers to as the "vise." He believes this condition caused the pelagic organism decline (POD) of 2001 and 2002. C-WIN recommends revised flow standards that reduce exports and increase outflow.*

Dr. Cannon said that the 1978 flow standards had numerous flaws, the major one being the monthly average criteria. While this flaw was addressed with the 1995 flow standards, unfortunately these standards had two major flaws: (1) almost no export restrictions, and (2) new export/inflow ratio criteria. Revised standards that incorporate some of the recommendations of the *Draft 1982 Two Agency Agreement* and the draft 1993 (D-1630) standards would significantly eliminate many of the Delta's ongoing problems. These recommendations involve reducing exports and increasing outflow, and are well within the findings and recommendations of the Board's own 2010 Flow Report. Dr. Cannon suggested the following key solutions:

1. Not exporting the LSZ at any time of the year.
2. Keeping the LSZ as far down in the Bay as long as possible.
3. Minimizing movement of the LSZ into the central and southern Delta.
4. Focusing on natural flow regimes and salt movements by not causing dramatic one-day shifts because of standards.
5. Limiting high inflows of reservoir water just to maximize exports and meet E/I standards. C-WIN recommends setting delta outflow or X2 flow standards and applying them in May, June, and July, and potentially applying them in August, September, and October as well. Specifically, these standards should be:

- Set Delta outflow standards at 8,000–10,000 cubic feet per second (cfs) to maintain an X2 location of River Mile (RM) 74–75.
- Set export limits at 6,000–8,000 cfs.
- Maintain a 12,000–14,000 cfs Delta inflow.

Questions from the Board

Steven Moore recounted that during the workshop thus far, there had been much discussion about LSZ and effects therein and some nuances about how it gets subsidized by other areas. In addition to talking about the Delta, he expressed an interest in the secondary effects of the LSZ as it relates to the bay and its species. There was some mention in the submitted materials about how the northern anchovy may be impacted by reduced productivity in the LSZ. He asked is the speakers could touch on the issue of diversity and its importance.

Jonathan Rosenfield said the LSZ and the estuary as a whole subsidize things downstream. Estuaries are nursery areas for bay shrimp, flounder, salmon and other fishes, and even beyond fishes to whales. The ocean influences the estuary, but there is also a flow from the estuary to the ocean. There is an area of impact and public trust value that is beyond the LSZ but is affected by inflow and outflow.

Steven Moore asked if the lack of productivity in the LSZ is putting investments of public funds and effort at risk and if there has been an observed response of native species in tidal restoration.

Jonathan Rosenfield responded that there have been reports of fish leaving the LSZ due to lack of food. He suggested thinking of the fish as part of the food web. Some of those fish go to the ocean where they are food for another species. Though the Board will have to divide things up into manageable units, in reality the Delta, bay, and ocean are a hydrological and biological continuum.

Steven Moore asked if there is a connection with diversity in the bay.

Jonathan Rosenfield responded that yes, he considers the Bay-Delta to be an area of extreme diversity. It supports four runs of Chinook salmon, more than any other river system in the world. There are distinct population segments of sturgeon. The San Francisco Bay is a division point between two different types of biotic regimes and represents the southern extremity of the ranges for many species. It is an area of historical diversity and diversity formation.

Tam Doduc asked Dr. Rosenfield to explain the implication in his presentation that flow standards are easily implemented and revised in a short period of time.

Jonathan Rosenfield replied by acknowledging the perspective that flows are not easy and do can take time. He clarified that he had been contrasting flows with permitting and construction/earth-moving efforts, which are long-term processes. He emphasized his intention was not to minimize the care and time it takes to create water quality standards or the impacts those standards have. His suggestion was in case of drought, flood, or other extreme circumstances, flow criteria could be waived. If immediate action was warranted, increased instream flow could be implemented. In terms of the timeframe for management, of the available options that have a big and certain response, freshwater flow is something that could be adjusted.

John Cain: observed there may be two competing hypotheses being considered, which are (1) we need to restore habitat, and (2) we need to restore flow. He posed the question of if restoring habitat is the goal, how much do you need to restore to actually make a difference? Probably tens of thousands of acres, and that is going to take a long time. A flow management action could be done relatively quickly. There is a cost on someone, but if it does not work, it is reversible. A wetland is not reversible and must be in place for 5–10 years to see if the results are what are expected.

Panel 5: In-Delta Water Interests

Linda Dorn, Sacramento Regional County Sanitation District—Introductions

Ms. Dorn introduced the panel members representing wastewater interests. She relayed the Sacramento Regional County Sanitation District's support of the Board's 2009 staff report regarding nutrients.

Dr. Michael Connor, Bay Area Clean Water Agencies—Suisun Bay Eutrophication Issues; Impacts of Nutrient Loadings on Phyto- and Zooplankton

Presentation summary: *Bay Area Clean Water Agencies believe that Board actions should focus on improving geographic and agency collaboration on environmental management of the Bay-Delta through monitoring coordination and integrated modeling strategies. They also believe the Board should balance scientific uncertainty with management consequences through expanding joint fact-finding efforts, collaborating with wastewater dischargers on the funding consequences of new policies, and focusing on "no-regrets" actions.*

Michael Connor opened with the acknowledgement that there will always be scientific uncertainty related to Delta processes, no matter how much research is done. Ecosystem processes are not fully understood by science, nor are they matched by governance. The broad spectrum of Delta and upper bay drivers (e.g., flows, nutrient inputs, turbidity, food chain, etc.) are rarely combined and often have different managers and scientists. He pointed out, however, that policy decisions need to be made now.

He believes that joint fact-finding processes (like IEP, the Bay-Delta Science Program, Regional Monitoring Program (RMP), and the San Francisco Bay Numeric Nutrients Endpoints), which combine agency scientists, outside scientists, and some interest groups, are working well. However, these efforts could be expanded, and there are some important gaps that need to be filled, including understanding upstream nutrients. He believes it was a mistake for the Board to divide Regions 2 and 5 regarding agricultural runoff and nutrient input. The scientific community has still not pulled all of the historic nutrient data into good models or explanations of how the bay as a whole is working. He recommends using these data sets more intelligently.

Dr. Connor said that the Bay-Delta Science Program works, but he thinks it should be expanded. One agency is needed to synthesize all of the available Delta science and information because it doesn't work to have multiple agencies trying to summarize research for their own purposes. He also called for an integrated modeling and observational framework to explain good long-term monitoring data. One example of the need for this kind of strengthened coupling is that wastewater loadings are flat year-round, but ammonia loading to the Suisun Bay increases during the winter months. This means that the increased ammonia loading must be attributed to processes other than wastewater discharge, and this should be taken into account when setting policy.

Wastewater dischargers see themselves as partners with the Board in implementing the Board's policies. However, the Board must be sensitive to the fact that policies can amount to capital

planning for dischargers, and funding for large modifications is in short supply. He believes the CWA was successful because it initially provided a federal match of 85%. As the Board sets further policies, it must consider how they will pay for resultant modifications to infrastructure.

The wastewater management industry is changing how it thinks about wastewater. In the past, the focus was on the treatment of wastewater. Now it is considered a "recycled resource." The Bay Area Clean Water Agencies would like to strategize with the Board on these issues. Dr. Connor would be happy to share ideas from Colorado and Montana, which have produced some interesting examples of how states can meet USEPA requirements for nutrient removal. He would like the Board to emphasize "no regrets" actions.

Dr. Connor recommends that Board actions should:

1. Improve geographic and agency collaboration on environmental management of the bay and Delta through monitoring coordination and integrated modeling strategies.
2. Balance scientific uncertainty with management consequences through nurturing joint fact-finding.

Dr. Mike Bryan, Sacramento County Regional Sanitation District—Need for a Comprehensive Delta Monitoring Framework as Part of the Bay-Delta Plan Implementation Program

Presentation summary: *There is a need for a comprehensive Delta monitoring framework that would provide the data needed to determine the efficacy of the Board's objectives and policies. The Bay-Delta Plan update process should be used to develop this framework in partnership with the Delta Science Program and others. Adaptive management should be used to refine framework questions and monitoring program elements over time.*

Dr. Bryan acknowledged there are many great monitoring programs in the Delta that provide a tremendous amount of information, but they all have an individual focus. A comprehensive monitoring framework is necessary to coordinate their efforts, and the Bay-Delta Plan process offers an opportunity for the Board to play a vital role in developing such a framework. A comprehensive monitoring framework can provide the data needed to determine the efficacy of the Board's water quality and flow objectives and policies.

Dr. Bryan believes such a framework should include:

- Conceptual models of ecosystem function and the effects of CVP/SWP system operations, stressors, and climate change.
- Definition of desired ecological and water supply target conditions.
- Definition of performance metrics and measurements used to evaluate successful acquisition of desired target conditions.
- An adaptive management component that directs future actions and monitoring consistent with the framework and technical findings.

His specific recommendations to the Board are:

- The Bay-Delta Plan update process is an opportunity to develop a comprehensive scientific monitoring framework for the Delta that includes the key questions the Board needs to have answered. The Board should partner with the Delta Science Program and others to develop this framework.
- Adaptive management should be used to refine framework questions and monitoring program elements over time.
- The Board should seek refinements in how and when specific objectives are applied in an effort to "break adverse hydrologic trends without breaking the hydrologic bank."

Questions from the Board

Fran Spivey-Weber said she would be interested in hearing thoughts from yesterday's expert panel on the idea of the Board developing a monitoring framework. She asked if these recommendations are something that the experts can work with. The members of the expert panel agreed to provide their thoughts later in the workshop.

Tam Doduc asked Dr. Bryan how quickly a monitoring framework could be designed.

Mike Bryan replied it will take time to develop such a framework, but the Board doesn't have to do it alone. The Board can be a leader and pose the right questions. Many of the monitoring programs have the right questions posed already, but if not, the Board may not get the answers it needs. Most of the effort is in getting out there to collect the data. He suggested if the research questions are not clear, it is difficult to collect the right data. If the questions are clear and data collection is underway, it is easy to add one more element to monitor.

Cameron Irvine, Sacramento County Regional Sanitation District—Data Quality Objectives, Invasive Clams, Contaminants

Presentation summary: *Decision makers should have sound environmental data. This requires development of clear data quality objectives, and ensuring the data undergo appropriate quality assurance/quality control, peer review, data validation, and stakeholder review processes. A thorough and critical review of all information to develop a weight-of-evidence conclusion is further recommended to assess the overall confidence in the data.*

Cameron Irvine stated his intent to present material that will assist in improving the quality of data used to inform adaptive management plans and management decisions in the Delta, thus reducing uncertainty. Adaptive management was designed for situations with known uncertainties and where management decisions do not work as expected. Studies can be designed to address the uncertainty, but the studies and their data must conform to certain standards. His key points were:

- Data used by resource managers as a basis for decisions must minimize uncertainties through:
  - Data quality objectives.
  - Quality assurance/quality control.
  - Data validation.
  - Peer and stakeholder review.

- When generating data to be used in decision-making processes and utilizing Delta models, there should be a thorough and critical review of all information to develop a weight-of-evidence conclusion. Such review should assess the relative importance of data, the spatial and temporal variability of data, and overall confidence in the data.

Dr. Susan Paulsen, City of Antioch— Salinity Impacts of Water Withdrawals

Presentation summary: *The city of Antioch has historically used the Delta for its freshwater supply, but the time during which the city can take fresh water has declined over time as the estuary has become saltier. The City is concerned that implementation of the BDCP conveyance around the Delta will cause salinity increases far above those that would be caused by sea level rise alone. The City requests that salinity not be allowed to rise (nor outflows decline) beyond current D-1641 and X2 operations criteria, compliance points should not be moved landward, the gauging station at Antioch be considered as a point of interest for salinity and flow, and that mitigation be provided for impacts on beneficial uses caused by implementation of the BDCP.*

Susan Paulsen provided some information about the City of Antioch. The city has used the Delta for its freshwater supply since the 1860s, but the time during which they can take fresh water has declined over time. She provided evidence from early reports that before the drought of 1917–1919, the Delta was far fresher than the ensuing years, including the 1920s and 1930s, which are commonly selected to represent historical Delta conditions. The City of Antioch believes the Board should use pre-1917 data when considering historical conditions in the Delta.

The City is also concerned that implementation of the BDCP conveyance around the Delta will cause salinity increases far above those that would be caused by sea level rise alone. Modeling of the BDCP's "preliminary proposal" shows that it would cause significant increases in salinity at Antioch and in the western Delta, which would have serious ramifications on ecosystems and on the drinking water supply.

She provided the City's recommendations to the Board in establishing flow and salinity criteria:

- Water quality criteria set by the Board will govern project operations.
- Long-term average measures (e.g., salinity and flow) are less informative than time series model results or data.
- Salinity and flow should be analyzed using a pre-1918 condition as the 1920s, 1930s, and 1960s do not represent the baseline.
- Historical data show that the Delta ecosystem and native species are adapted to historical freshwater conditions.

The City of Antioch recommends that the Board not allow salinity to increase above existing levels and believes that the Board has a role to play in looking at mitigation for BDCP effects. The City also requests that compliance points (e.g., Emmanton) not be moved landward and asks the Board to consider using the gauging station at Antioch as a point of interest for salinity and flow in the western Delta.

John Herrick, South Delta Water Agency— SWP/CVP Operations and Problems with Delta/Project Modeling

Presentation summary: *Recent history has shown that less water is available in the system after a moderate drought than previously assumed. The South Delta Water Agency urges the Board to revisit its assumptions about the availability of water for meeting basic beneficial use objectives during drought years.*

John Herrick has observed that recent history has shown some of the assumptions the Board has made in the past about (1) when water is available, and (2) what makes water unavailable are invalid. At the beginning of the 2009 water year, after only two years of drought, it was clear that there would be insufficient water to meet X2 and fishery flows if 2009 were to be another drought year. It eventually rained, so the problem was solved, but it is important to note that if it had not rained in 2009, a string of additional water quality objectives outside of X2 also would not have been met. Mr. Herrick cautioned the Board not to make the same assumptions as in the past about how much water will be available in drought conditions, especially if the Board intends to determine that flows in the third and fourth years of droughts are necessary to protect environmental beneficial uses.

Mr. Herrick noted the models that were run during the D-1641 hearing process assumed that environmental flows would be available without specifying from where they would come. He cautioned that such assumptions will not be appropriate for the Bay-Delta Plan water rights proceeding.

Questions from the Board

Fran Spivey-Weber requested that the expert panel address the preceding recommendations.

Steven Moore added that he would also like the expert panel to think about how the Bay-Delta Plan currently discusses monitoring and how it could be modified. The expert panel agreed to provide their thoughts at the end of the workshop.

> **Michael Connor** said better use needs to be made of existing monitoring programs and of existing funding. Fifty million is spent annually on monitoring efforts in the Delta. Can the agencies work more efficiently? He asked the Board to consider the monitoring requirements related to issuance of permits and to ask themselves: "How can we be more efficient in what we require people to do?" He suggested agencies need to combine funds and efforts because it is not affordable to have staffs at each agency doing their scientific studies separately.

Steven Moore inquired how the Board can modify the existing Bay-Delta Plan Monitoring and Special Studies program. The agencies who spend the money on the monitoring efforts need to be brought into the discussion regarding how to make those efforts more efficient. He found it interesting that many presenters suggested a monitoring framework would help answer the question, "What is the efficacy of the Board's rules?" when the idea is also to look at the efficacy of other efforts, like DWR's operations and the Biological Opinions. He emphasized that coordination would provide the best results in reaching Delta goals.

Felicia Marcus thanked the panel and said she agrees with Steven Moore. However, she reminded those assembled that the most helpful things they can provide to the Board are concrete suggestions that acknowledge the beneficial uses of others. She urged people to take into account what the Board

has to do. Regarding uncertainty and science, she noted that the Board will always have to move without certainty. Anything suggesting that in the face of uncertainty more funds and more studies are needed is not helpful to the process. She thanked the presenters for their suggestion about efficiently using the incredible array of resources already dedicated to the Delta instead of simply suggesting that more money needs to be spent.

Michael Connor believes that an easy first step to more closely link the monitoring and regulatory communities would be for the Board to come up with a list of questions each year on crucial scientific issues that inform the Board's decisions. He also believes the Bay-Delta Science Program should become the lead agency for modeling efforts.

John Herrick pointed out that discussions about monitoring efforts don't address the main issue. The issue is the Board has to determine how much flows are allocated where and when. The triggers have already been tripped: delta smelt are almost gone. Numeric objectives must be set, and those decisions will have to be made based on uncertainty. He believes that fishery biologists need to take a firm position, say the 1995 Bay-Delta Plan does not work, and tell the Board what needs to be done differently. Then the Board can decide whether or not to follow their advice.

Steven Moore agreed that monitoring is not a substitute for the job of the Board.

Fran Spivey-Weber observed that there are other things the Board can do separately from the Bay-Delta Plan in the near-term. It would be helpful to receive input on what can be done to help the Delta outside of the plan, but she would like to focus mainly on the plan update.

Panel 6: State and Central Valley Project Contractors

Dave Fullerton, Metropolitan Water District— Ecosystem Changes to the Bay- Delta Estuary: A Technical Assessment of Available Scientific Information

Presentation summary: *The assumption that more flows will restore the Delta ecosystem is based on correlation and does not respect the complexity of the system, nor does it take into account the immense level of change experienced in the Delta. The SWP and CVP contractors want to impress upon the Board the difficulty of moving back towards something that is "natural" as opposed to moving forward based on current understanding of Delta relationships.*

Dave Fullerton announced the intent if the State and Central Valley Project Contractors' panel is to discuss changes in the Bay-Delta ecosystem and evaluate different options for improving that ecosystem through investments or regulations. He noted that the SWP and CVP contractors disagree with much of the materials submitted for this workshop, but will reserve most of their comments on specific fish species until the next workshop.

He observed that the model for managing the Bay-Delta in the mid-1980s was to make correlations between species and flow and then to incorporate those flows into regulations. To some extent, that model is carried over into the present. There is more recognition of other factors, but the linear chain between more flow and more fish is still a powerful driver of policy. However, that view is based on

correlation and does not respect the complexity of the system. Scientists, regulators, and managers need to focus on understanding mechanisms.

An immense level of change has been experienced in the Bay-Delta and upstream; it is one of the most transformed landscapes in the world. Tidal marsh acreages have been reduced, reservoir capacity upstream has increased, irrigated acreage in the Central Valley has increased, Delta outflow and diversions have increased, the sedimentation rate in Suisun Bay has slowed, and deepening and widening of Delta channels has occurred.

Mr. Fullerton and the other panelists performed an assessment of the available scientific information and identified changes to five key ecosystem attributes as having contributed to the decline in the Delta estuary:

- Changes to the food web.
- Changes to the physical landscape.
- Warming of water temperature.
- Reduced turbidity.
- Changes to flows and the location of the LSZ.

He explained that the following panelists would discuss the two paradigms that are currently before the Board: the flow-centric and food web paradigms.

Paul Hutton, Metropolitan Water District—Flow and Salinity Time Trends in Perspective

Presentation summary: *Unimpaired flow is a calculation; it is not a good approximation of natural flows. "Natural flows" cannot be recreated in the Delta of today because the physical conditions of the historic Delta are no longer intact. The Board should consider climate when evaluating time trends. Consideration of climate changes shows that SWP and CVP operations were not the primary driver of outflow change in the Delta between the two most recent decades.*

Paul Hutton explained, in terms of annual volume, that actual historical natural flow was likely lower than today's calculated "unimpaired flow." Observed flows at the end of the nineteenth and beginning of the twentieth centuries were artificially high because the levees had been constructed but water diversions were still in their infancy. He also observed that there has been no statistically significant trend towards reduced Delta outflows over the past 100 years. He then showed some graphs illustrating the Delta outflow difference between the 1990s and 2000s. By factoring in unimpaired outflow, Mr. Hutton was able to show that SWP and CVP operations were not the primary driver of outflow change in the Delta between the two most recent decades.

Sheila Greene, Westlands Water District—Flow Functions

Presentation summary: *Due to the highly altered state of the Bay-Delta estuary, it is highly uncertain that mimicking "natural flows" would restore biological functions. Large changes in flow made under scientific uncertainty could lead to large adverse impacts on beneficial uses.*

Sheila Greene made four points about the "natural flow" paradigm:

1. The natural flow approach was developed for riverine systems, primarily as a conservation measure to protect systems that were largely unaltered.
2. The natural flow approach has been used to a lesser extent as a restoration tool in more altered ecosystems, but the level of success diminished with the level of alteration that had occurred in the system.
3. When the natural flow approach has been applied in altered systems, it has been done in a piecemeal fashion and oriented toward very specific goals.
4. Estuaries are much more complex than riverine systems.

In reviewing the available literature, Ms. Greene found the natural flow approach is uncertain in highly altered and estuarine systems and changes in reservoir releases cannot restore habitat complexity, supply depositional materials, restore widespread seasonal floodplain inundation, restore the natural nutrient balance, or decrease Delta water temperature.

Ms. Greene observed that several submittals for this workshop recommend using flow to maintain the LSZ at certain points. Based on her review of the recent literature, an X2 of 60–74 km is not supported by the literature. There is no positive correlation between phytoplankton and flow since the invasion of the *Potamocorbula* clam. There is no correlation between X2 or salinity ranges and delta smelt abundance or distribution. Longfin smelt are correlated to flow, but not to salinity. She pointed out that USEPA conceded in 2012 that the role of the LSZ in the decline in abundance of pelagic species is uncertain.

After reviewing recent scientific papers, Ms. Greene concluded, due to the highly altered state of the Bay-Delta estuary, it is very uncertain that mimicking "natural flows" would restore biological functions. Ms. Greene cautioned the Board that large changes in flow made under scientific uncertainty could lead to large adverse impacts on beneficial uses.

Dr. Chuck Hanson, Hanson Environmental, Inc.— Changes in Bay-Delta Physical Landscape over Time

Presentation summary: *So many changes in the Bay-Delta physical landscape have occurred over time that increased environmental flows may not result in the desired outcomes for fish. The SWP and CVP contractors believe that the Board should look to habitat restoration and nutrient regulation, which, according to the scientific literature, could produce meaningful, positive changes to the Bay-Delta estuary.*

Historically, flow supported a wide variety of ecosystem functions in the Bay-Delta; however, many of those functions have been lost. For example, there has been a significant loss of wetland habitat, floodplain access, and shallow-water channel margin habitat, and a reduction in organic matter and food production. Dr. Hanson claimed that a change in flows will not produce much change in habitat availability because of the channelized nature of the system. Increased winter-spring flows could have an adverse impact on salmonids by reducing coldwater pool storage in the summer. A big element of reestablishing flow/habitat functions must be restoration of tidal wetlands, seasonal floodplains, and shallow water, low-velocity, channel-margin habitat.

There is broad consensus that invasive species have changed the ecological community, but Dr. Hanson's review of the literature found that the potential effect of water project operation on colonization by invasive species has not been analyzed and is an untested hypothesis.

Dr. Hanson concluded with the following key points:

- The Board should seek to understand the physical, chemical, and biological changes that have occurred in the Bay-Delta estuary.
- The Board should endeavor to understand the underlying mechanisms stressing the estuary and the functions served by flow in the estuary before considering whether to dedicate more water for environmental purposes.
- Scientific literature shows habitat restoration and nutrient regulation could produce meaningful, positive changes to the Bay-Delta estuary.

Dr. Patricia Glibert, University of Maryland—Nutrients and the Food Web

Presentation summary: *The availability of nutrients affects the quantity of food web species (e.g., phytoplankton), and too much or too little of an individual nutrient can be a stress. Recent science shows that nutrient ratios can alter the quality of food at all levels of the food web, and changes in the ratio of phosphorus to ammonium can explain many food web and ecosystem changes in the Delta. Invasive species may be as much a response to nutrient and ecosystem changes as they are a cause of ecosystem change. Correction of the phosphorus to ammonium ratio could result in a reduction of invasive species and an increase in native species. Flow affects nutrients in the water in several ways, and ecological stoichiometry may help to provide a mechanism for relationships between fish and flow.*

Dr. Glibert focused on ecological stoichiometry and how it could provide a mechanism for relationships between fish abundance and flow. She said it is widely acknowledged that growth of phytoplankton is limited to the abundance of the nutrient that is in shortest supply, but recent research in the field of ecological stoichiometry shows that the relative proportion of those nutrients sets the quality of phytoplankton. Ammonium is a paradoxical nutrient. It is a preferred form of nitrogen for phytoplankton under some conditions, but it can be inhibitory or even toxic under other conditions and to some species.

Over the past few decades, the ratio of ammonium (or nitrogen) to phosphorus has changed dramatically in the Delta. Nitrogen in the Delta has increased steadily over time, while phosphate levels have declined since the mid-1990s (when phosphorus was eliminated from detergents). This means that the nitrogen to phosphorus ratios in the Delta have increased.

Dr. Glibert described the common belief related to nutrient availability and phytoplankton growth, which assumed that if nutrients were in sufficient supply, they should not regulate the species composition of algae. However, recent research shows that while the total nutrient load sets the total amount of productivity and biomass of an ecosystem, the relative proportions of nutrients set the quality of the biomass through the match or mismatch between organismal requirements for nutrients and their availability. This is illustrated by the rise in limnoithona and the decline in eurytemora as the nitrogen to phosphorus ratios began to climb in the mid-1990s. This change in algal composition can be predicted using ecological stoichiometry based on the elemental needs of the two species—eurytemora are not as ammonia-tolerant as limnoithona. Changes at the bottom of the food web alter the community at the top, which can help explain the concurrent decline in longfin smelt and rise of centrarchid species.

Dr. Glibert showed that the Bay-Delta is not unique in the trajectory of many food web changes due to changes in nutrient loads and ratios. The Rhine River, the Potomac River, the Lower Ebro River in Spain, and the Lower Hawkesbury-Nepean River in Australia have all experienced similar increases in the nitrogen to phosphorus ratio along with concurrent invasions of exotic species. Correction of the phosphorus to ammonium ratio on the Potomac River has resulted in a reduction of invasive species and an increase in native species.

Flow has an effect on nutrients in the ecosystem—it affects the residence time, or the exposure time, of beneficial and inhibitory/toxic nutrients. Flow also imports new nutrients, dilutes point-source nutrients, alters reactions at the sediment surface, and exports nutrients downstream where they can form blooms displaced in time and space from the source. Ecological stoichiometry may help to provide a mechanism for relationships between fish and flow.

Dave Fullerton, Metropolitan Water District—Summary

Mr. Fullerton summarized the SWP and CVP contractors' presentations and noted that the key theme of all the presentations is the need to determine mechanisms. He recommends that the goal of science to serve the Board's needs should be to determine cause and effect and find mechanisms to invest in or regulate the problem to make a measurable difference in regard to target species. The SWP and CVP contractors believe that habitat restoration and nutrient regulation offer the best opportunities.

Questions from the Board and Staff

Steven Moore found the idea compelling that nutrients encourage the growth of invasive species, including egeria. He asked Dr. Glibert about the nutrient ratio studies around the world. In the areas where nitrogen could be controlled, was there a response in terms of egeria densities and commensurate centrarchid response?

> **Patricia Glibert** said one of the most significant studies occurred on the Potomac River, which had problems with egeria's equivalent, hydrilla. Hydrilla abundance has declined with the removal of nitrogen from Potomac wastewater treatment plants, and the emergence of more native species has been observed. It does take time, and hydrilla is an aggressive invader, but it thrives when the environment is right. The plant is ammonia-tolerant and is able to use water column and sediment resources for its nutrition. It grows very productively, and when it grows rapidly, it can raise the local pH in the water significantly, which has the following consequences: (1) it grows tenfold faster at higher pH than at lower pH, so it can grow under its own self-induced toxic conditions, and (2) by raising the pH, additional phosphate begins to efflux from the sediment. This sets in motion other biochemical processes from which other species can benefit.

Felicia Marcus asked Dave Fullerton if the SWP and CVP contractors would offer their opinion on the mix of stressors in the Delta at future workshops.

> **Dave Fullerton** answered in the affirmative.

Felicia Marcus acknowledged that it is clear correlation alone is not enough, but the Board still needs help in determining the mix of Delta stressors. It is not helpful to say simply that the problem is not flow. She brought up the example of smoking; for a long time, scientists knew there was a

correlation between smoking and unhealthful side effects, but they were not certain what the mechanisms were. Now they know what the mechanisms are, and the correlations still stand up.

> **Dave Fullerton** said there are other correlations just as compelling. He likened correlations to a hall of mirrors in which all of the images are approximately as good as each other but the key is trying to figure out which is real. He acknowledged that many correlations exist, but insisted the true cause must be uncovered.

Diane Riddle clarified that during the D-1461 hearing process, environmental flows under drought conditions were assumed to come from coldwater pools, not, as implied in John Herrick's presentation, from an unknown source.

Steven Moore felt that John Herrick's presentation told an incomplete story regarding reservoir releases. He thought the takeaway message from that presentation seemed to be not to change reservoir release requirements.

Diane Riddle said the message she heard from that presentation was for the Board to consider carryover capacity criteria.

Fran Spivey-Weber asked Dr. Glibert if she believes denitrification of the Delta is an option that could create balance in the Delta.

> **Patricia Glibert** said the Potomac is an excellent model for the Delta system because the Blue Plains Wastewater Treatment Plant undertook phosphate removal in the 1970s and a series of steps to remove nitrogen in the 1980s. We have seen ecosystem changes with each of the nitrogen reduction efforts.

Fran Spivey-Weber noted that Felicia Marcus's smoking analogy was an excellent one. The Board will be making decisions soon, and it may not have all the answers. The Board needs input on the things over which it can have some influence. Input during these workshops should focus on how flow relates to other factors and how the Board should take that into account.

> **Dave Fullerton** said that the SWP and CVP contractors intend to discuss those topics at the next workshop.

Panel 7: Sacramento Valley Water Suppliers

David Guy, President of the Northern California Water Association, introduced Walter Bourez. He will answer the questions posed by the Board, but will also set the stage for presentations at future workshops. He will first give you a glimpse into the effect of tides, will look into correlation work, and then will respond to "how do we look at this moving forward? What are the best approaches?"

Walter Bourez, MBK Engineers, Representing the Northern California Water Association and Sacramento Valley Water Users

Presentation summary: *It is highly uncertain whether it is possible to position the LSZ to generate specific benefits for the Delta's fish, but it is highly certain that attempting to do so with Sacramento River Basin streamflows would adversely and significantly impact many beneficial uses.*

Uncertainty in LSZ Positioning

Walter Bourez showed that daily tidal flows dwarf net Delta outflows and cause the position of the LSZ to move considerable distances twice daily. There is uncertainty as to whether Sacramento River flows are really controlling X2 in any way, and the Board should be asking what it will really get in return for trading Sacramento River flow for Delta outflow when there is such a huge tidal influence.

He pointed out that the actual positions of the LSZ and X2 are not known—they are only estimated—and there are significant discrepancies between flow-based X2 estimates and water quality-based X2 estimates. He noted that the flow to X2 ratios currently used to estimate X2 may be outdated because the bathymetry of the Delta has changed since the ratios were established. This uncertainty in how X2 is measured should be taken into consideration when correlations are made between X2 and fish abundance.

For these reasons, Mr. Bourez believes there is considerable uncertainty that attempting to control the LSZ or X2 using Sacramento River flow will produce fishery benefits.

Use of Hydrologic Data

Mr. Bourez cautioned the Board that attempting to recreate past hydrology through regulatory requirements may not produce past environmental conditions. Wet year environmental conditions cannot be replicated by increased reservoir releases because during wet years, many elements aside from flow are more favorable, including reduced water temperatures and increased sediment and nutrients.

Concurrent Trends in Sacramento Basin Hydrology and Pelagic Populations

Mr. Bourez observed that Sacramento Valley consumptive use of water has been essentially stable since the 1970s, while Delta pelagic fish have declined during that time. He could not find any correlations between Sacramento Valley land use and pelagic organism abundance but did note that the greatest fluctuations in Delta outflow can be attributed to changes in hydrologic conditions. He urged the Board to consider differences in hydrology when comparing environmental conditions in different time periods.

Risks of Unimpaired Flow-Based Standards

Mr. Bourez modeled the effect of Delta flow requirements based on 50% or 40% of unimpaired flow (as proposed in the 2010 Flow Report) on reservoir storage capabilities. He found that these flow requirements would have significant adverse impacts on Sacramento Valley water resources, including significant reductions in reservoir storage, impacts on flows for salmon and steelhead, and impacts on hydropower generation during peak-demand periods. He pointed out even without unimpaired flow requirements, the water storage system often cannot meet public health and safety

needs during critical years. That is a very important trade-off when considering releasing water for Delta needs.

Water Management to Support Multiple Beneficial Uses

California water systems are managed for multiple beneficial uses, including salmon and steelhead rearing and spawning, agricultural water supplies, Pacific Flyway migratory bird habitat, peak hydropower generation, recreation, and drought-year protection for urban water use. Mr. Bourez asserted these beneficial uses would suffer under new Delta flow requirements based on unimpaired flows.

Questions from the Board

Steven Moore asked if Mr. Bourez could model the effects of a first flush allowance, which would provide more of the wet year benefits like turbidity, over a multi-year drought scenario.

> **Walter Bourez** said that would be interesting because it could provide a lot more benefit without as many of the costs.

Tam Doduc expressed her frustration that the Board has not heard more exciting new proposals during the workshop for moving the Bay-Delta Plan update process forward. If setting unimpaired flow criteria is not the right approach, what is? "No action" is not a feasible alternative.

> **Walter Bourez** recommended coordination and more efficient management of the system. Some things could be coordinated that are not currently coordinated that could make a big change without a lot of extra cost. An easy place to start would be to coordinate pulse flows with hatchery releases, which is not currently done.
>
> The water cost is enormous to move the location of X2 very far, so it does not seem to be a wise use of the resource. However, a pulse flow when X2 is moving out tidally could help move it further, as opposed to trying to move X2 when the tide is moving in. X2 might be easier to move when it is already going in the desired direction.
>
> D-1641 requires flow releases in the spring, which means there are lower reservoirs in the fall and less water available for flows during the fall. Mr. Bourez suggested revisiting that decision and balancing spring X2 flows with other needs. He believes the Board should first decide exactly what its goals are, and then see how the system can be managed to meet those goals.

Fran Spivey-Weber noted that there was a lot of discussion about climate change during the first day of the workshop. It is clear that climate change will happen whether the Board has a plan for it or not, and that it will affect everyone, including the CVP and SWP, agriculture, utilities, and fish. It will require change and adaptation. She asked for the participants in future workshops to share with the Board how they plan to factor climate change into their operations. She encouraged the various agencies and interest groups to work with the Board to plan creatively for the changes that are coming.

Return of the Invited Expert Panel

The members of the invited expert panel each spoke in response to the presentations that were made during the workshop.

Steve Culberson, U.S. Fish and Wildlife Service

Mr. Culberson revisited the question of how the Board could bring policy-makers and scientists into greater communication and streamline the policy-making/monitoring feedback loop. Steve suggested that the Board could support existing collaborative, community-based learning and information exchange efforts. For example, CALFED made a number of attempts at integrated policy forums. One involved trying to bring a common modeling framework to some 3D modeling efforts. The group was making some good progress, but that was halted because of CALFED's demise. That effort laid a good foundation, and the Board could resurrect it without too much expense. The science community needs decide how to call out those efforts and bring them to the Board's attention. Two examples are the CALFED Science Program and the California Water Modeling Program.

Dr. Bruce Herbold, U.S. Environmental Protection Agency

Dr. Herbold provided another suggestion for an existing/past effort that the Board could support. The Unified Monitoring Assessment and Reporting Program (UMARP) completed a draft report, but then the participants got involved in the FLaSH studies. It is comprehensive, in a landscape format, and is relevant to something that the Board and the law says is important. Through the UMARP, the Board could take an active role in helping to decide what questions need to be answered through monitoring efforts. He suggested that the Board should also focus on efficiencies. The UMARP framework can answer outstanding questions.

Dr. Herbold also spoke on behalf of Jim Cloern, who could not attend the second day of the workshop. Dr. Cloern suggested that the Delta Science Program, IEP, and the Board develop a list of questions related to anticipated Delta changes including flooded islands, new conveyances, 5-year droughts, quagga mussels, and climate change. These questions could be used to create a combined effort of monitoring programs and models that would enlighten timeframes and triggers for changing Board policy. Dr. Cloern also suggested including social scientists in this study to do cost-benefit analyses on a policy level. He volunteered his time for this effort.

Dr. Herbold said that he agrees with Dr. Cloern. There are several issues for which the future is clear. Quagga mussels are a good example: they will invade and be dominant. There is a clear trigger. Baseline conditions need to be determined. A durable plan needs to be developed, near-term changes need to be anticipated, and action needs to begin now.

Dr. Anke Mueller-Solger, Interagency Ecological Program

Dr. Mueller-Solger had another suggestion for an existing effort that could be helpful and could use some additional support to make it more useful to the Board. The California Water Quality Monitoring Council was created by a Memorandum of Understanding signed by USEPA and the California Resources Agency in November 2007. The Board spearheaded the effort, and IEP is a partner. The purpose of the council is to improve the coordination and cost-efficiency of the current monitoring in California and to increase public access to monitoring data and information. The council went through a formative period during which a series of groups and portals were set up, and an estuaries workgroup was established.

IEP plans to do some of its required reporting under D-1641 through the estuaries workgroup portal. This will make the information more accessible and will integrate it with other efforts. IEP is taking an effort that is already required (monitoring under D-1641) and replacing it with something

better (reporting through a publicly accessible, integrated portal). This does not require much in the way of new resources.

Dr. Mueller-Solger pointed out that under D-1641, some of the monitoring is done by DWR as a part of IEP, some is done by other DWR departments, and some is done by USBR. Not all of this data will go into the Monitoring Council's website, but all of it should. She suggested that the Board could easily effect more integration just by requiring D-1641 monitoring results to be posted on the Monitoring Council's website.

IEP does a significant amount of monitoring, much of which is required. Much of what IEP is monitoring is detailed in the requirements, but how that data is assessed, used, and shared is not clearly defined. It could be made clearer. Cooperation is more than coordination; it cannot be mandated, but it can be supported.

Dr. Peter Goodwin, Delta Stewardship Council Science Program

Dr. Goodwin had three pieces of advice for the Board:

1. *Use the Delta Plan*. He suggested that the Board use the Delta Stewardship Council's Delta Plan as a resource. It is built on the fundamental premise of the best available science. The Delta Stewardship Council is purely a facilitator, networking and building the science community. Everyone agrees we need to look at the Delta differently. What's going to transform the world to make it better? What innovations can we bring to the table? He encouraged the Board to involve itself with the development of a science plan for the Delta.

   The Board is faced with making decisions that will have many ramifications for a complex system. Scientists are reductionists by nature—they look at various elements of the problem, but it is hard to look right across the complexity of the system as a whole. What are the questions the Board needs to ask, how do we mobilize scientists to address these complex problems?

2. *Think about governance*. How do we build on the successes of IEP?

3. *Data management issues*. The Board and scientists should ask the following types of questions: How can models be designed to use existing data? How do we project different futures and different alternatives? How do we communicate about such a complex system? How do we transmit information to other branches of science? How can we make the science understandable so the connections between the answers and the questions are clear?

Dr. Goodwin expressed that nobody is benefiting from uncertainty, and because there seems to be far more that brings the various Delta interests together, there is an opportunity to do something special over the next few years.

Questions from the Board

Fran Spivey-Weber directed her first question to Peter Goodwin. She observed that Michael Connor, Mike Bryan, and Cameron Irvine all said they were eager to incorporate the volumes of information they have produced into the Delta Science Program. She asked if the Delta Science Program has that information already and, if not, if there is a mechanism for it to get that data.

Peter Goodwin made clear that the Delta Science Program absolutely wants that information and the best ideas possible. He suggested maybe the program put out a challenge to get good ideas on the table that the program scientists could evaluate with models. He invited everyone in

attendance to come to the Bay-Delta Science Conference (October 16–18 in Sacramento). The Delta Science Program will be using that forum to look for ideas and input.

Fran Spivey-Weber asked if the Delta Science Program's Science Plan is building scenarios around different LSZs and if it is focused on where the LSZ should be.

Peter Goodwin said the Delta Science Program is trying to build the program into a centralized place where everyone will come to make a contribution to the understanding of the system. The program is undertaking synthesis activities that pull together information from disparate sources. The Science Plan is a roadmap for the issues; it will point out current knowledge, who the experts are, and who is working on particular issues. The hope is that the program will provide a forum for interactions between groups and scientists.

Fran Spivey-Weber noted that the Water Quality Monitoring Council's estuaries workgroup is tasked with laying out a vision for the estuary. She asked what recommendations it is making for the estuary and what its vision looks like. She suggested checking in with that group to find out.

Steven Moore also suggested asking the estuaries workgroup for recommendations on what indicators are meaningful in terms of outcome targets.

Public Comments

Joe McGahan, Grassland Bypass Project

The Grassland Bypass Project discharges the majority of the selenium that goes into the San Joaquin River. Mr. McGahan believes that the selenium discharges by the Grassland Bypass Project are less than those characterized by Dr. Stroshane in his presentation. He also noted that there is a difference in the form of selenium that is discharged by agriculture as opposed to industrial selenium, which is more toxic. The dischargers in the Grassland Bypass Project are active participants in the TMDL, total maximum monthly load (TMML), Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), and Irrigated Lands Programs, and have significantly reduced salinity and selenium in its discharge. He encouraged the Board to use realistic selenium discharge numbers in its modeling.

John Herrick, South Delta Water Agency

Mr. Herrick noted that the Board's job through this process is to develop a public trust balance. To develop this balance, the Board must put a value on the estuary and compare it to the value of other beneficial uses. He observed that agencies and interest groups are eager to tell the Board what not to do but are hesitant to tell them what to do. He believes that the Board is going to have to force people to take positions, under oath if necessary, and answer the question: "Are the State Board's 1995 criteria sufficient?"

Michael Jackson, California Water Impact Network/ California Sportfishing Protection Alliance

Mr. Jackson focused his comments on what he would do if he were in the Board's position:

1. Take a look at Jonathan Rosenfield's presentation regarding estuaries around the world, whose caretakers have determined that only up to 20% of the flows can be removed to preserve a healthy estuary. Ask Board scientists whether or not they believe this to be true. This issue is about how much water can be lost from the estuary, rather than where the water comes from or how it comes out. The problem is that too much water has been promised for too many uses.
2. Set a time period (10–15 years) by which the goal (limiting the removal of water from the estuary to a specific amount) must be reached. This is the only way to ensure the dual goals of preserving the estuary and making the water rights reliable.
3. Determine whether or not certain uses are more important than others. He acknowledged this would be a difficult process that may take a year to determine. The economy of California is part of that balance and that economy is mostly of the urban areas; therefore, in droughts, the Board should provide an urban preference. Water delivery commitments must be reduced. As of the last estimate of how much water has been promised through water rights, four times the amount of water had been committed than falls in the typical water year. The Board will be addressing that problem in the water rights phase regardless of what else it decides to do with the Bay-Delta Plan.

   Ask the scientists how much water can be taken out of a watershed like this before it collapses. If they can find a watershed that is thriving with 50% or 60% of its water diverted, there must be another reason why the fish in the Delta are dying.
4. As an interim measure, screen the diversions that already instead of spending money on fish screens for new BDCP diversions. Evaluate, based on current science, whether the planned BDCP screens will actually be effective. The salmon cannot be saved by taking all of the Sacramento River water out of the system.
5. Be efficient with money. The Board will be responsible for paying scientists and staff, paying for the decisions that are made in terms of monitoring, and paying for monitoring systems. Hire independent economists to assess the value of a healthy Delta estuary. This has not been done to date, and until that value is known, a balance cannot be determined. A similar effort was undertaken at Mono Lake, and the economists came to the conclusion that the lake was of greater value than the proposed diversions by the Department of Water and Power. The Delta is in its current predicament because the externalized costs were never analyzed. The Board needs to take control of this process. An economic analysis must be done, as well as a water availability analysis.

In summary, Mr. Jackson urged the Board to balance beneficial uses, perform an economic analysis to determine the value of the Delta ecosystem in relation to other beneficial uses, and to perform a water availability analysis.

Brett Baker

Brett Baker was born and raised in the Delta, studied fish biology at the University of California, Davis, and worked as a biologist for DFG. He had three comments and posed a question for the Board to consider while moving forward with the Bay-Delta Plan update.

1. Flow standards will have to be set for numerous conditions and will have to take into account what is occurring in the Delta during a number of timeframes, including the tidal cycle, lunar cycle, and time of year.

2. Regarding timeframes, by the 1920s, most of the Delta was reclaimed, but POD did not occur until the last 10 years. The Board should be careful with the type of habitat that is created and the effects water flows might have on inviting invasive species into the estuary. Mr. Baker recommended some books for a historical perspective on water in California: *Cadillac Desert*, *Kings of California*, and the film *Chinatown*.
3. It may not be within the Board's power to restore or create habitat, but the Board's power lies in its ability to affect how and when certain types of habitat are affected, like floodplain habitat and channel margin habitat.

Mr. Baker summarized his key point as being that flow has a correlation to habitat. The Delta needs more water at the right times of the year. Identification of mechanisms can help determine when the water needs to be let down the river. He also asked the Board to consider how a Bay-Delta Plan which incorporates adaptive management differ from the current regulatory framework and how adaptive management would work in this process. He did not believe this was clearly articulated during either of the two days of the workshop.

Fran Spivey-Weber thanked Mr. Baker for his comments and assured him that the Board will be answering the question of what adaptive management means before it is put into the plan or made a requirement.

Tim O'Laughlin, San Joaquin Tributaries Authority

Mr. O'Laughlin had one request and one question for the Board and Board staff.

The San Joaquin Tributaries Authority sent a set of CDs to Board staff in June or July and would like that data incorporated into the administrative record for Phase 1.

In regards to Phase 2, Mr. O'Laughlin inquired if a geographic boundary has been set. It was clear that Phase 1 was limited to the San Joaquin River and its tributaries, but he feels the announcements for Phase 2 have been unclear as to whether the San Joaquin River is under consideration. The Phase 2 topics (fall X2, fall attraction flows, water surface elevation, dissolved oxygen, and flows on Old and Middle Rivers) were not discussed during Phase 1. He asked if those topics would be incorporated in Phase 1 for the San Joaquin River, or if San Joaquin River interests should participate in Phase 2 as well.

Board staff committed to following up with Mr. O'Laughlin on both points after the workshop.

Closing Thoughts

Felicia Marcus remarked that the most effective advocates during the workshop put themselves in the other person's shoes (or "chairs" in this case). She thanked everyone for their participation.

Workshop 2: Bay-Delta Fishery Resources

The topic of Workshop 2 was, "Bay-Delta Fishery Resources." The Board identified key interest groups in the initial noticing for Phase 2 and designated a consultant, Brock Bernstein from ICF International, to work with stakeholders to develop a workshop format and a series of panels to represent each interest group. A copy of the final agenda for Workshop 2 is in Appendix A. Two specific questions were posed for discussion during this workshop:

4. What additional scientific and technical information should the Board consider to inform potential changes to the Bay-Delta Plan relating to Bay-Delta fishery resources, specifically pelagic fishes and salmonids, that was not addressed in the 2009 staff report and the 2010?

   March *Development of Flow Criteria for the Sacramento–San Joaquin Delta Ecosystem* report (Board's 2010 Flow Criteria Report). For large reports or documents, what pages or chapters should be considered? What is the level of scientific certainty or uncertainty regarding the foregoing information? What changes to the Bay-Delta Plan should the Board consider based on the above information to address existing circumstances and changing circumstances, such as climate change and the BDCP?

5. How should the Board address scientific uncertainty and changing circumstances, including climate change, invasive species, and other issues? Specifically, what kind of adaptive management and collaboration (short-, medium-, and long-term), monitoring, and special-studies programs should the Board consider related to Bay-Delta fisheries as part of this update to the Bay-Delta Plan?

Welcome and Agenda Review

Board Chair Charles Hoppin reviewed the agenda and introduced the Board members and Board staff. He assured those assembled that it is the Board's intention to listen closely to everyone's presentations and encouraged presenters to suggest functional solutions to help the Board move forward. **Board Staff, Rich Satkowski (Senior Water Resources Control Engineer, Division of Water Rights)** provided a quick overview of the goals for the workshop.

Panel 1: Invited Expert Panel

Dr. Peter Goodwin, Delta Stewardship Council

Dr. Peter Goodwin, lead scientist for the Delta Stewardship Council, provided an overview on how the expert panel was convened. The panel represents a range of disciplines and is tailored to answer the specific questions posed for this workshop. All of the panels the council has convened have gone above and beyond what the council expected. But according to Dr. Goodwin, this panel in particular went far beyond expectations, conferring every day and having very high-level discussions trying to define levels of scientific certainty.

Sam Harader, Delta Stewardship Council

Sam Harader introduced the panel members.

Expert Panel Group Report

Dr. Kenneth Rose, Louisiana State University

Introduction to Expert Panel Format

Before giving his presentation, Dr. Kenneth Rose introduced the format of the expert panel. He explained that the expert panel drafted a report for the Board responding to the questions posed for Workshop 2. The report is organized around three themes:

6. Theme 1: Implications of science for management.
7. Theme 2: Need for improved science to reduce uncertainty.
8. Theme 3: Key emerging science.

Dr. Rose described the format of the expert panel's presentation: panel members would first summarize, theme by theme, what is contained in the report; each panel member would then have an additional amount of time to present individual thoughts not affiliated with the report or the panel as a whole.

Implications of Science for Management

Presentation summary: *The expert panel undertook a review of new science and determined that the Board should make the following improvements to fishery management:*

- *Develop new water quality objectives that account for multiple species, correlations, and nonlinear responses.*
- *Monitor effectiveness of management actions.*
- *Develop a strategy for assessing water quality under future scenarios.*
- *Reassess the use of summary indicators.*
- *Proceed with management decisions based on existing science.*
- *Clearly state the effects of biological objectives on beneficial uses.*
- *Consider the short-term variability of water quality parameters.*
- *Consider contaminants and other stressors together with flow.*

Dr. Rose summarized Theme 1 of the expert panel's report. The expert panel believes that management of the Bay-Delta system can be improved in the context of fishery resources. Current scientific understanding led the panel to the following specific suggestions for improved management:

Develop new water quality objectives that account for simultaneous effects on multiple species, correlations between criteria, and nonlinear responses of fishery resources to criteria. The expert panel cautioned the Board to avoid simply overlaying objectives for multiple species. Since

different objectives can affect each other (e.g., management for X2[3] affects the coldwater pool, which affects temperature management for downstream salmonids), the expert panel proposed that the Board take a synergistic approach and acknowledge that biological responses to objectives will often be nonlinear in nature.

Monitor effectiveness of management actions with respect to ecosystem and fish goals. The expert panel believes that compliance monitoring needs to move more towards "effectiveness monitoring" such that the actual intended benefits of the objectives are measured. This would require the Board to define "habitat" in specific terms.

Develop a strategy for assessing water quality under future system configurations. The expert panel encouraged the Board to anticipate some of the large-scale impending changes, like infrastructure changes (e.g., dual conveyance), planning actions (e.g., reservoirs), and climate change. Panel members believe now is the time to start collecting the data the Board will need in 5–10 years to assess the next round of water quality objective revisions.

Board Chair Charles Hoppin asked Dr. Rose if he, as a scientist, presumes that it is the Board's task to save all fish species that would be negatively affected by climate change. Mr. Hoppin asked where the Board should draw the line, from a scientific standpoint.

> **Dr. Rose** suggested discussing the topic later, as he felt that the question, though valid, was not appropriate for discussion at this particular point in the presentation.

Assess the use of summary indicators for specific purposes. The expert panel agrees that the use of hydrology summary indicators are useful for some purposes, but the usefulness of summary measures needs to be demonstrated before such measures are used as an index for specific fish benefits. Summary indicators do not describe how water is routed through the system. For example, the use of an inflow/export ratio implies that a decrease in exports is equivalent to an increase in river inflows, but studies to date have not supported this conclusion. Summary indicators do not index in any detail how, where, and to what extent river inflows and exports are influencing the fish species of concern.

Proceed with management based on existing data and models. New data analyses and models are continuously under development, and there is no promise that the next development will be a "breakthrough." Progress on this front is usually incremental. The expert panel recommends that the Board move forward using models that are established, well-documented, readily available, and transparent, and make sure that the process has a mechanism for inserting new information. "Do not wait for the next analysis."

State the beneficial uses of water flow in terms of water quality objectives. The expert panel believes the Board should clearly show how any biological objectives it establishes will affect other beneficial uses. Clarity and transparency of the process is very important given the contentious atmosphere surrounding the Bay-Delta Plan update.

Consider the short-term variability of water quality parameters. The expert panel included this suggestion as a reminder that fish operate on a different time scale than the one water managers use in their summaries. Averages or sums can mask short-term (e.g., daily) variability.

[3] X2 is defined as the distance from the Golden Gate Bridge (in kilometers) to a specific isohaline indicating a boundary in the low salinity zone.

Consider contaminants and other stressors together with flow. While separating flow from other stressors is prudent and practical, care should be used with this approach because flow is related to many of these stressors. Any approach that tries to make these elements modular will eventually need to address the issues collectively.

Comment from the Board

Board Vice Chair Fran Spivey-Weber stated that the Board is very aware there are other stressors. The Board is not totally flow-focused, but for many of the stressors, there seems to be a flow component. Ms. Spivey-Weber noted that the Board is looking for input on the relationships between flow and other stressors.

Dr. John Largier, University of California, Davis—Improving Science to Improve Policy and Management

Presentation summary: *The expert panel believes the Board could improve management of the Delta by making a focused effort to improve certainty on a few specific issues. The expert panel recommended that the Board improve knowledge on entrainment, focus attention on population diversity, and also invest in the following resources:*

- *Models to assess benefits of management.*
- *Field evaluations of flow changes.*
- *Assessments of ocean forcing.*
- *Assessments of changes in nutrients and plankton production.*

Dr. John Largier summarized Theme 2 of the expert panel's report. The panel believes that because improved understanding can reduce uncertainty, uncertainty in the expected outcome of policy choices and management options can be reduced through strategic investment in improved scientific knowledge. The expert panel focused on determining which of the scientific unknowns, if resolved, could help the Board with its task. The expert panel's specific suggestions for Board investment are as follows.

Models to assess benefits of the Bay-Delta Plan for specific species on sufficiently fine time and space scales. The expert panel believes the Board should invest in models that can quantify the expected benefits to fish under different management options and that can evaluate trade-offs. More finely-scaled models are necessary to resolve the scale of fish–environment interactions. Such modeling should take into account seasonal and annual flows; tributary, main-stem, and delta flow; multiple life stages; population processes; and factors other than flow rates. These kinds of details are increasingly being used in models and should increase certainty.

Experimental evaluation of current flow-related management actions. The expert panel believes that flow-related management actions occurring now should be used as experiments. Flows are altered constantly, and the Board should be looking at the effects of those flow changes on fish and other beneficial uses. Such field evaluations could help the Board to improve its mechanistic understanding of the system, to confirm that expected benefits are realized, to reduce uncertainty in assessment of benefits, and ultimately to refine water quality objectives.

Link ocean variability to variability in Bay-Delta habitats and in fish species abundances. The expert panel acknowledges that the influence of the ocean on the Bay-Delta tends to be overlooked because the rivers are so heavily managed. However, the expert panel believes the Board should invest in understanding the ocean–Bay-Delta relationship because the ocean heavily influences conditions in the Bay-Delta through dispersal of benthic species, trophic subsidies, and its role as habitat for anadromous fish.

Resolve the effect of nutrient types and ratios on Bay-Delta ecosystem processes. Current research shows that changes in nutrient loading appear to be causing changes in the phytoplankton community. The expert panel believes that investment in an increased understanding of how nutrient conditions affect the lower food web (phytoplankton and zooplankton) would enable better determination of whether remediation is possible and ultimately whether such remediation is likely to change the food web sufficiently to contribute to improvements in fish species abundances.

Refine assessment of the impacts of entrainment on fish populations. The expert panel feels that the system of determining entrainment effects on fish populations could be improved significantly, and this is an effort on which the Board should focus. In current calculations to quantify proportional entrainment, there is high uncertainty in the numbers for entrainment and abundance and in the salvage-to-entrainment ratios. Further, explanatory variables need to be monitored in parallel with entrainment.

Consider population diversity in the assessment of how species respond to water quality objectives. The expert panel believes that water should be managed to account for and encourage the drivers of fish population diversity, which allows for populations to better absorb stress and respond to changing conditions. Monitoring and laboratory experiments are needed to determine how water quality variables affect diversity in the species of interest, and studies are needed to examine how current and future climate changes may affect baseline and variability in flows.

Randy Baxter, California Department of Fish and Game—Key Emerging Science

Presentation summary: *Many important new ideas have emerged in Delta science since publication of the 2006 Bay-Delta Plan. The Board should consider the following key new ideas as it updates the Bay-Delta Plan:*

- *Pelagic fishes are more flexible than previously understood.*
- *Regime change may mute beneficial flow effects.*
- *Improved juvenile salmon survival in the Delta requires broad-scale improvement in shoreline and riparian habitat.*
- *Sub-daily hydrodynamics may be more important to juvenile salmonids than previously understood.*
- *Management actions should focus on encouraging salmonid life history diversity.*
- *San Joaquin River inflow is more important than previously understood.*
- *Biological (lifecycle) models are available to enhance understanding and guide management.*

Randy Baxter summarized Theme 3 of the expert panel's report, which focuses on key emerging science. He observed that scientific knowledge has continued to increase since the 2006 Bay-Delta Plan was published, and this knowledge can better inform management. He highlighted the key new ideas since 2006, which the expert panel believes should be considered in a forward-looking plan.

Pelagic fishes are more flexible than previously understood. New science is showing that pelagic fish distributions are shifting. This implies flexibility within these populations to respond to changing conditions over time.

Board Chair Hoppin asked if the newly discovered flexibility of the pelagic fishes should put into question the validity of the current X2 standards, which were developed before the Liberty Island levees were breached and before delta smelt were discovered in the Sacramento Deep Water Ship Channel (DWSC).

> **Mr. Baxter** responded that use of the northern estuary by delta smelt is generally limited to reproduction and rearing, and delta smelt use the low salinity zone (LSZ) for other life stages. Delta smelt use of the northern estuary in the summer seems to be low. Therefore, he believes the potential for shifting delta smelt completely into the northern estuary and out of the LSZ is low.

Regime change may mute beneficial flow effects. Over the past 45 years, there have been distinct declines in flow/abundance relationships for several species. This means that increased flows are still correlated with increased fish abundance, but not at the levels seen in the past. Such coincidental downward shifts in abundances reflect regime change, as do other large-scale changes in the estuary like invasive weeds, harmful algal blooms, and the presence of jellyfish. Such regime changes elsewhere in the world have stabilized, so it is unlikely that the current regime in the Bay- Delta could be changed without large-scale modifications or massive restoration. It is also possible that the current regime may not be reversible.

Improved juvenile salmon survival in the Delta requires broad-scale improvement in shoreline and riparian habitat. Through-Delta survival for juvenile salmonids is poor. Flow alone is not enough to achieve good survival in the Delta because predation and poor habitat are contributing factors. Smaller fry entering the Delta must be able to survive and rear for several weeks, and that is not possible among the riprap. Shoals need to be available at a variety of water levels, and the fry need to have easy access to faster water. Floodplains can provide this type of habitat in the upstream areas, but even in upstream areas, opportunities to create this type of habitat are limited. In the Delta, significant modification of the channels would be required to successfully provide this type of shallow habitat.

Sub-daily hydrodynamics may be more important to juvenile salmonids than previously understood. Delta exports are managed to reduce "net" negative flows, which are assumed to be broadly harmful to juvenile salmonids. However, recent studies suggest that sub-daily flow variability appears to be important to juvenile salmonids, and that net flows are largely unrelated to sub-daily hydrodynamics. The expert panel believes that Delta management and juvenile salmon studies may have become overly reliant on an assumed major adverse effect of net negative flows on juvenile salmon behavior and movement. The new data suggests that sub-daily hydrodynamics should also be considered when evaluating water quality objectives intended to benefit juvenile salmonids.

Management actions should focus on encouraging salmonid life-history diversity. Water management for salmon has been focused on larger smolts and rapid through-Delta passage. However, this approach ignores the importance of life history diversity in regards to population stability and resilience. Recent research has shown that dependence on the single life history strategy of moving quickly through the Delta may be a major contributing factor to the salmon stock collapse. Management actions that contribute to poor life history diversity include predictable flows, poor,

homogenous rearing habitat, hatchery practices, and rates of ocean harvest. True recovery will require addressing all these management hindrances.

Board Chair Hoppin asked why there is variability in what age the salmon are when they come back to the rivers to spawn, and what triggers the fish to come back.

> **Mr. Baxter** explained that age maturity is in part an inheritable trait, and fish who return to spawn when they are older than other fish do have an advantage.

Board Vice Chair Spivey-Weber asked if hatchery management practices are being reevaluated since they don't fall under the responsibility of the Board.

> **Mr. Baxter** said that question would be better addressed by the fishery agencies during the next panel.

San Joaquin River inflow is more important than previously understood. New science shows that the San Joaquin River plays a disproportionately strong role in Delta productivity—the river is an important source of high-value phytoplankton and copepods, which serve as summer and fall fish food. Additionally, as fish sampling is extended into the San Joaquin River, the results indicate that it could be an important location for splittail, and it may be an important spawning and rearing area for Sacramento blackfish and Sacramento pikeminnow.

Biological models are available to enhance understanding and guide management. Lifecycle modeling has increased over recent years and should be used to explore trade-offs between different management options.

Individual Comments

Randy Baxter, California Department of Fish and Game— Individual Presentation: DFG's Efforts to Reduce Uncertainty in Fish Sampling and Distribution

Presentation summary: *The California Department of Fish and Game (DFG) has several efforts planned or underway to improve certainty relating to fish sampling efforts and understanding of fish distribution. DFG has begun to assess, in greater detail and with more precision than before, net depth, true volume of water filtered, and net size selectivity of trawling efforts, and it plans to incorporate video tracking into the sampling effort. DFG has also designed studies to improve understanding of delta smelt distribution and behavior.*

Mr. Baxter's individual presentation focused on the actions DFG has taken and plans to take to improve fish sampling. Sampling does not provide actual population size, but it is valuable because it provides important trend information assumed to relate to population size. He acknowledged that there are uncertainties related to the fish sampling efforts in the Delta; however, the core process cannot be changed too substantially because relative abundance indices rely on consistency across time in sampling gear and methods.

DFG is working to increase certainty in these sampling efforts. So far it has acoustically measured the net mouth area for the midwater trawls to estimate the true volume filtered and has begun electronically tracking net depth in the water. In September 2012, DFG began using simultaneous

multi-trawl sampling to determine relative size selectivity of the gears, and starting in November 2012, it will begin using a "SmeltCam" to identify vertical and lateral distributions of pelagic fishes.

Board member Felicia Marcus asked if cameras are being used in other ways—for example, in a stationary way.

> **Mr. Baxter** responded that the "SmeltCam" is a light-based camera, so turbidity is an issue for that particular technology. However, DFG is looking into utilizing sonar technology.

Mr. Baxter noted that there are also uncertainties related to the scientific community's knowledge of fish distribution. As new studies have shown that delta smelt have potentially shifted in distribution, DFG has recently extended summer and fall surveys into the Cache Slough and Sacramento DWSC areas to identify specifically how the delta smelt are using these areas. Data gathered through this effort will be used to inform future restoration efforts. DFG will also undertake further investigation into delta smelt benefits relative to habitat choices, and it plans to conduct fall low-salinity habitat studies to contrast delta smelt fall habitat use in the LSZ versus in the Cache Slough complex and Sacramento DWSC.

Brad Cavallo, Cramer Fish Sciences—Individual Presentation: Reassessing the Effects of Inflow and Exports on Salmon Survival

Presentation summary: *Brad Cavallo proposed that the Board reevaluate use of summary indicators like the inflow/export (I/E) ratio, which implies that inflows and exports have equivalent effects on salmonid success. Mr. Cavallo said that he knows of no study that has shown exports to be an important driver of salmonid success in the Delta, and he observed that there is limited ability to influence a tidal system with inflows.*

Mr. Cavallo noted that the Board had expressed a keen interest in actual science—information that could be used to inform better management of the Delta. He stated that his goal for his individual presentation was to provide some useful ideas to the Board.

Mr. Cavallo observed that there is a tendency to conflate the influence of inflows on salmonid survival with the influence of southern Delta exports. The use of the I/E ratio implies that inflows and exports have equivalent effects—that one unit of inflow is equivalent to one unit of decreased outflow. Mr. Cavallo believes this issue is deserving of greater scrutiny. Vernalis Adaptive Management Plan (VAMP) studies show that increased flows on the San Joaquin River correlated with juvenile salmon survival, but exports did not have a similar effect. Survival declines have occurred despite exports being held at very low levels. No study has shown that exports are an important driver of salmonid success in the Delta, and there is limited ability to influence a tidal system with inflows. Mr. Cavallo suggested that the Board consider asking why the export signal is weak relative to survival. He believes that an alternative hypothesis needs to be developed to explain what is driving salmonid success in the Delta.

Questions from the Board

Board Vice Chair Spivey-Weber asked Mr. Cavallo to clarify whether he was asserting that exports are not the primary factor in juvenile salmonid survival. She asked if any studies have looked at exports in relation to their contribution to regime change.

Mr. Cavallo responded that he is not asserting that exports are unimportant or that they should be ignored, but he does believe other factors should be studied.

Board member Steven Moore asked if Mr. Cavallo could suggest any alternative metrics that could be used to measure export-related impacts on salmonids.

Mr. Cavallo said that the ideal alternative metric would be survival through the Delta and growth of fish; things that relate to the success of the population at large. Those are things that can be difficult to measure.

Eric Danner, National Marine Fisheries Service—Individual Presentation: River Assessment for Forecasting Temperature

Presentation summary: *The National Marine Fisheries Service's (NMFS) new river temperature forecasting tool, the River Assessment for Forecasting Temperature (RAFT) model, could assist the Board in figuring out how to manage for X2 without adversely affecting the coldwater pool.*

Eric Danner observed that objectives can affect one another—for example, management for X2 affects the coldwater pool, which in turn affects temperature management for downstream salmonids. He announced that NMFS has developed a new tool, RAFT, for forecasting temperatures at a very high resolution. It was designed to assist in water management for winter-run Chinook salmon on the Sacramento River. The model has proven to be very precise and accurate in determining temperature and has the capacity to look at different discharge flows and temperatures. Mr. Danner suggested that RAFT could assist the Board in managing for X2 while avoiding adverse effects on the coldwater pool.

Mr. Danner then referred back to the question asked by Board Chair Hoppin earlier in the workshop regarding when salmon return to the freshwater system to spawn. He said that NMFS is working on a couple of lifecycle models now. One of these models looks at how salmon use resources from egg to adult and could provide some insight on how availability and use of resources affect the timing of salmon spawning returns.

Dr. John Largier, University of California, Davis—Individual Presentation

Presentation summary: *Dr. Largier feels that some of the most important concepts for the Board to consider going into the Bay-Delta Plan update process are ocean forcing, nutrient loading, and how flow affects fish on a small, local scale.*

Dr. Largier believes ocean forcing and estuarine circulation have a greater influence on plankton levels in the Delta than is currently assumed and that these issues deserve further study. He also believes that the Board needs to identify unequivocal links between factors. He observed that nutrient concentration is an important influence on many conditions in the Delta, and nutrient concentrations can be controlled by flow as well as loading. He suggested the Board identify these relationships and the parties involved.

Dr. Largier pointed out that fish as individuals experience a small-scale environment. He acknowledged that in order to manage the system, the Board must aggregate indicators, but he cautioned the Board to be true to the actual mechanisms as well. He encouraged the Board to seek a better understanding of how flow affects fish, especially at a sub-daily scale.

Questions from the Board

Board Chair Hoppin asked whether it is possible that with climate change, pelagic species will adapt to a more upstream area with a comparable saline environment.

Mr. Baxter acknowledged that pelagic species probably have some range for adaptability, but a big concern is that in the interim, as climate change is occurring, two types of habitats will be butting into each other. This leads to concern that the pelagic species will have more interaction with predators. Studies of fish behavior in years like this one, in which the LSZ might be further east than the Suisun Bay, will be helpful in understanding how pelagic fish are able to survive those types of conditions.

Board member Moore requested clarification on the state of knowledge about biological responses to ocean influences during high-flow events.

Ted Sommer said that in 2011, a high-flow year, evidence of increased transport of marine phytoplankton was not observed. A phytoplankton bloom did occur at Rio Vista, but that was too far upstream to have been influenced by the ocean.

Dr. Ted Sommer, California Department of Water Resources—Individual Presentation: Managing for Salmon Life History Diversity

Presentation summary: *Ted Sommer believes the Board should encourage multiple life history strategies for salmon. Relevant Board actions could include identifying and supporting future projects such as increasing connectivity between the Yolo Bypass and Sacramento River.*

Dr. Sommer believes some of the most pressing challenges for salmonids are the lack of rearing habitat and lack of habitat diversity in the Delta and on the Sacramento River. He observed that there has been a man-made regime change for out-migrating salmon as the Sacramento River has been turned into more of a drainage canal than a riverine system. The river now flows deep and fast, which works well for flood management and flushing out contaminants and mining debris but is a disaster for out-migrating salmon. The water now moves too fast to generate plankton, and there is very little riparian vegetation to generate insects, so the salmon have no food as they migrate down the system. The steep, riprapped slopes provide no shallow-water habitat in which the fish can hide or rest, so they are sitting ducks for predators.

Although there is a positive benefit of flow on salmon survival as they migrate through the system, this is likely because it creates an "express bus" that rushes them through the miles of poor habitat. There is a lot of evidence that life history diversity is important for salmon health; rushing them through the Delta may improve survival, but it may harm the species by homogenizing it. Humans are in essence performing "unnatural selection" on the species and selecting for only the juvenile salmon that can get on the "express bus."

Dr. Sommer urged the Board to encourage other life history strategies for salmon that involve entering the Delta at a small size without necessarily getting eaten by a predator. In addition to a fair chance of migrating through the system without being eaten by predators, salmon need rearing habitat or there will be a continued erosion of salmon health in the Central Valley. He recommends that the Board try to anticipate some of the future projects that my benefit young salmon. Increased connectivity of the Yolo Bypass to the Sacramento River with greater flood frequency is probably the

best opportunity to provide rearing habitat. The Board has the power to "grease the skids" for such a project and help it get completed faster.

Questions from the Board

Board Chair Hoppin observed that conditions on Butte Creek appear to typify Dr. Sommer's comments about the value of slower moving water. Butte Creek is almost stagnant at times, but the rearing habitat for smolts there is successful at a level that is unequaled in California. He asked Dr. Sommer if that is the type of habitat he believes should be expanded.

Dr. Sommer agreed that there has been success on Butte Creek, but he cautioned that the Sacramento River and Delta still represent a long "biological desert" that the fish must traverse in order to survive.

Mr. Baxter agreed that, based on his experiences in the Sutter Bypass, if the Sacramento River system can be more closely linked to the Yolo Bypass, conditions should improve for salmon. Letting the water flow through the floodplains also allows it to pick up the turbidity that is so important downstream.

Dr. Kenneth Rose, Louisiana State University

Presentation summary: *Dr. Rose recommended revisiting the recommendations in the Board's 2010 Flow Criteria Report and assessing what the results would have been of percent unimpaired flow implementation by water year. He also believes the Board should face the issue of Delta optimization by looking at the problem in its entirety rather than in steps.*

Dr. Rose provided his thought on the Board's 2010 Flow Criteria Report. He hoped that his impressions as an outsider might be helpful to the Board. He felt that the report was very clear up to a point but then became somewhat vague in its reasoning. To strengthen the analysis, he recommended going back to compare implementation of percent unimpaired flows by water year versus the flows recommended by the various groups. He was also surprised that the analysis was not done by water year type.

Dr. Rose believes the effort facing the Board is an optimization problem, and that it's been made more difficult because it has become "step-wise". He cautioned that when parts of an optimization process are frozen, the ability to optimize the solution in a dynamic way is lost (i.e., looking at fish issues first, then going back and looking at another issue later, after decisions about fish have been made). He feels the problem would be more tractable if it is dealt with all at once.

Finally, Dr. Rose was surprised by the degradation of trust among the various parties involved in the Delta. He is afraid that people will override most of the science issues in the Delta. He put out a plea for people to respect each other, and pointed out that "we're all learners and students."

Questions from the Board

Board Vice Chair Spivey-Weber asked Dr. Sommer about any potential opportunities for encouraging salmon life history diversity on other tributaries to the Delta.

Dr. Sommer said that his colleagues presenting later in the day on the Resource Management Agencies panel would provide more ideas, but that the Yolo Bypass, Putah Creek, Cache Creek, and other smaller areas have tremendous potential for restoration.

Board member Marcus expressed surprise that the expert panel did not talk more about necessary studies on predation.

Mr. Cavallo suggested that the necessary predation studies at this point need to evaluate management options because it is clear that predation in the Delta is a problem.

Mr. Harader mentioned that predation studies will be one of the topics discussed at the upcoming Bay-Delta Science Conference.

Dr. Sommer agreed that predation is a major cause of mortality, and the goal of future research should be on determining where predation is unusually high and why. Genetic studies and modeling are looking at this issue, but studies at a finer scale and at specific locations are needed.

Panel 2: Regulatory and Fishery Agencies

Erin Foresman, **(U.S. Environmental Protection Agency [USEPA])**, introduced the panel members. She noted that the panel worked together to produce the presentation, but each agency would present its own perspective.

Kevin Shaffer, California Department of Fish and Game—Salmonid Recovery and Conservation

Presentation summary: *Mr. Shaffer shared DFG's recommendations to the Board regarding to salmonid fish species. DFG believes the Board should develop objectives that will allow the Board to meet its narrative goal of doubling natural Chinook salmon production. DFG also requested that the Board support operation of the Delta Cross-Channel (DCC) gates and address three key upstream flow management issues that affect salmonids: red dewatering, restoration of floodplain habitat, and riparian processes and regeneration.*

Mr. Shaffer acknowledged that the Board asked for input on pelagic and salmonid fish species at the workshop, but he and DFG feel that it's important for the Board to look at all at-risk fish, as individuals and as a community, as the Board moves forward with its responsibilities. In particular, DFG is carefully studying sturgeon in addition to salmon and steelhead because of sturgeon's high ecological and angling values in the Central Valley. He also encouraged the Board to consider aquatic and riparian communities. He noted that DFG is still supportive of the information and recommendations presented in the Board's 2010 Flow Criteria Report. He then made recommendations for the Board to consider regarding salmonid fish species.

Mr. Shaffer observed that the narrative objective stated in the 1995 and 2006 Bay-Delta Plans (to maintain water quality and other watershed conditions sufficient to double the natural production of Chinook salmon from the average production of 1967–1991) has still not been achieved. DFG recommends that the Board develop objectives that improve inflow- and nonflow-related habitat conditions for Central Valley Chinook salmon to prevent further decline of the salmon population and to meet the narrative objective for salmon protection in the Bay-Delta Plan. Mr. Shaffer believes that information produced by recent (post-2006) studies and programs could be helpful to the Board in this effort. Mr. Shaffer identified the following plans and programs as potentially helpful to the Board:

- Constant Fractional Marking Program.
- Chinook Salmon Escapement and Steelhead Monitoring plans.
- California Hatchery Scientific Review Report.
- NOAA Fisheries Central Valley Recovery Plan.

Recent studies have also shown a positive salmonid survival response to closing the DCC gates and combining that closure with pulse flow. DFG believes that the DCC gates are an important management tool. Mr. Shaffer recommended the Board amend the Bay-Delta Plan with the operating criteria laid out in NMFS's Operations Criteria and Plan (OCAP) Biological Opinion (BO), add criteria for optional gate closures in October to allow a pulse flow experiment in the lower Mokelumne River, and extend the experiment to 14 days.

In addition, DFG requests that the Board address three key upstream flow management issues that affect salmonids: redd dewatering, restoration of floodplain habitat, and riparian processes and regeneration. Mr. Shaffer shared some recent study results that showed 23% of redds were dewatered on the Sacramento River downstream of Keswick Dam during the winter of 2012 as a result of water management operations. DFG recommends further study and modeling to identify the flows needed in the Sacramento River system to prevent dewatering of redds and, as an interim measure, recommends a more stable flow management regime September–March.

Mr. Shaffer believes that an investment by the Board in healthy aquatic environments, floodplains, and riparian buffers will allow anadromous fish species and humans to transition through climate change in the short- and long-term. He also repeated the importance of DFG's recent studies in informing the Board's upcoming decisions regarding salmonids.

Questions from the Board

Board Vice Chair Spivey-Weber asked Mr. Shaffer if DFG is evaluating the effects of ocean catch on salmonid populations.

> **Mr. Shaffer** responded in the affirmative and noted that the constant fractional marking program shows each hatchery's contribution to ocean fishing. Based on the *California Hatchery Scientific Review Report*, some changes are already being initiated at Central Valley hatchery facilities. There are things that can be done to improve the scientific integrity of management actions and to minimize effects of hatchery stock on wild salmonid stocks. He observed that ocean management for recreational fishing and commercial fishing is a multi-agency, multi-state, multi-tribal effort. DFG's data will be taken to the Pacific Fishery Management Council to help it make decisions.

Patrick Coulston, California Department of Fish and Game—Entrainment Effects on Smelt Species

Presentation summary: *Regardless of whether entrainment of smelt species at the State Water Project (SWP) and Central Valley Project (CVP) pumps has an overall population effect, DFG believes the Board should limit Old and Middle River (OMR) reverse flows and manage X2 to minimize entrainment of smelt species and ensure adequate quantity and quality of juvenile rearing habitat.*

Mr. Coulston recalled that he spoke about longfin smelt in relation to the LSZ and outflow at Workshop 1 and explained he would be discussing smelt entrainment during Workshop 2. He recommended two documents he believes the Board should consult regarding smelt:

- DFG's 2009 SWP incidental take permit effects analysis.
- USFWS's 2008 delta smelt BO.

Mr. Coulston observed that because entrainment is generally not measured right where it happens, it is largely under observed. Some of the contributions to this under observation are that there are losses before the fish make it to the screens, there are issues with screen efficiency, and larvae are not counted during salvage. He also pointed out that entrainment and salvage often get confused in conversation. However, they are not the same, and the relationship between them changes. Both entrainment and salvage numbers are estimated, which is a good concept to keep in mind when salvage and entrainment reports are reviewed.

Mr. Coulston showed some data indicating that longfin smelt have a particular vulnerability to entrainment in dry years, likely due to their reliance on the LSZ.

He noted that delta smelt are vulnerable to entrainment at all life stages. Salvage studies have shown that drier winter and spring conditions increase delta smelt vulnerability, and higher X2 values and negative OMR flows are predictive of delta smelt entrainment. Higher smelt entrainment is observed in years with higher X2 values—if the LSZ is further upstream in the Delta, the smelt are living in closer proximity to the pumps. Turbidity also plays a role in adult delta smelt entrainment.

An important point of scientific discussion is the effect of entrainment on smelt populations. Whether or not entrainment at the SWP and CVP has a population effect, DFG believes that individual losses of protected species should not be ignored, and the system should be managed to avoid entrainment losses of smelt. DFG recommends limiting OMR reverse flows and maintaining X2 at specific ranges during certain times of year to minimize entrainment and ensure adequate quantity and quality of juvenile rearing habitat. DFG also recommends that the Board add some mechanisms into the Bay-Delta Plan to allow for additional decision-making inputs and decision- making processes.

Patricia Brandes, U.S. Fish and Wildlife Service—Salmonids

Presentation summary: *Patricia Brandes presented a summary of key recent salmonid research topics that USFWS recommends the Board consider in its update of the Bay-Delta Plan. New data is available to help the Board determine the timing of protective actions for salmonids. Specifically, USFWS recommends increased flows, a physical barrier at the head of Old River, and more frequent, longer DCC gate closures. USFWS also requests that the Board provide support for upstream survival monitoring*

and believes an adaptive management approach should be included in the Bay-Delta Plan update, with stronger protective measures for fish in the interim.

Patricia Brandes presented USFWS's recommendations that during the Bay-Delta Plan update process, the Board should consider updated, recent, and past information on the following topics:

- Status (escapement and adult and juvenile production indices) of the salmon stocks.
- Juvenile abundance indices at Chipps Island relative to flow.
- Genetic information at Sacramento, Chipps Island, and at fish facilities.
- Survival information from the San Joaquin Delta, including the head of Old River barrier (HORB) and the importance of continued survival monitoring.
- Increasing frequency and duration of DCC gate closures and establishing flow conditions that achieve no bidirectional flow to minimize the proportion of juvenile salmon entering Georgiana Slough.

According to Ms. Brandes, indicators demonstrate that more protections are needed to meet the 1995 and 2006 goal of doubling the natural production of Chinook salmon. Abundance indices show that juvenile salmon abundance leaving the Delta (at Chipps Island) is still higher at higher flows. She said that information on temporal distribution of winter- and spring-run Chinook salmon in the Delta is now available and should be used to help the Board determine the timing of protective actions for these particular races. She added that the 2010 VAMP studies also provide information that could be helpful to the Board in revising the Bay-Delta Plan objectives.

Ms. Brandes observed that modeling efforts have shown greater survival benefits with a physical HORB compared to a nonphysical HORB. USFWS believes that there is a potential to use a physical HORB while still being protective of delta smelt.

Ms. Brandes reemphasized DFG's earlier stated support of increasing the frequency and duration of DCC gate closure to be consistent with the 2009 BO. It is clear from studies that the proportion of fish entering Georgiana Slough is a function of flow, and fish even enter the slough at high tide when the DCC gates are closed. If the tidal influence can be moved farther downstream with flows, it will result in less fish being forced into Georgiana Slough.

FWS also recommends that the Board consider the importance of continued survival monitoring upstream. This is critical because there is no consistent survival monitoring occurring in the Sacramento River through the Delta and because the VAMP monitoring is no longer occurring.

Board Chair Hoppin noted that it seems all data regarding salmonid survival is based on hatchery fish. He asked if there is an assumption that no difference in viability exists between hatchery fish and wild fish.

> **Ms. Brandes** responded that no such assumption has been made, but hatchery stocks are the only salmonids available for experimentation. She believes, from a relative standpoint, that continued study of hatchery fish should provide a framework in assessing favorable conditions versus unfavorable conditions. She noted that Phil Sandstrom has tagged wild steelhead and compared their behavior to hatchery steelhead, and his report is available.

Board Vice Chair Spivey-Weber asked about recent experiments at the Mokelumne River hatchery in which the fish were not hand fed.

Mr. Shaffer said that particular experiment was designed to add behavioral diversity to the hatchery fish population by forcing the fish to find food on their own. He explained that fish behavior studies require large numbers of fish to be observed, and it's not possible to experiment with wild stocks of an at-risk species. There are no assumptions that the hatchery fish would be the same as wild fish, but hatchery fish are all that are available to assess behavior at all.

According to Ms. Brandes, USFWS recommends that the Board utilize an adaptive management plan to address scientific uncertainty and changing circumstances. A functional adaptive management plan requires the identification of specific biological and physical indicators that can be used to track progress and success. A range of flow alternatives should also be identified up front so when adaptation is required the Board will know how to change its management practices. USFWS urges the Board to consider a more protective approach while adaptive management plan development proceeds. There is evidence that increased flows will benefit native species, and exports affect salmonid survival.

Ms. Brandes then provided a review of the key points presented to the Board during Workshop 1.

Garwin Yip, National Marine Fisheries Service—Salmonids

Presentation summary: *NMFS believes that adequate flows are an essential component of habitat for all life stages of listed and nonlisted anadromous fish and supports the goals and biological objectives identified in the DFG report, "Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta" (DFG's 2010 Flow Criteria Report) and the Board's 2010 Flow Criteria Report. Garwin Yip presented NMFS' specific suggestions for the Board, which include managing reservoir releases to preserve the coldwater pool, looking for alternative methods to protect salmonids, requiring increased outflow in the San Joaquin River, supporting modifications to the DCC gate closure objectives, and using a precautionary approach to adaptive management.*

Mr. Yip reviewed the low numbers for winter-run Chinook salmon that have characterized returns since the late 1960s. He noted that although this species is protected under the Endangered Species Act (ESA), Section 7 of ESA does not require federal action to ensure recovery of any species; it only bars federal agencies from taking actions that would harm the species. So although there are some good requirements in the NMFS 2009 BO for the long-term operations of the CVP and SWP, it is limited to the streams controlled by the CVP and SWP; in and of itself it is not enough to lead to recovery of the species. NMFS looks to the Board to further this effort, as the Board has jurisdiction over several factors and species that NMFS does not, including San Joaquin River tributaries operations, Sacramento River tributaries, and fall-run and late fall-run Chinook salmon.

NMFS believes that adequate flows are an essential component of habitat for all life stages of listed (and nonlisted) anadromous fish. The 2010 National Academy of Science's study found that "the strategy of limiting net tidal flows toward the pump facilities is sound, but…this action alone will [not] benefit the San Joaquin salmon, unless it is combined with an increase in San Joaquin River flows." However, regarding reservoir releases, NMFS cautions against attempting to mirror the natural flow regime. NMFS believes this would create problems for winter-run spawning, incubation, and rearing, and that releases need to be carefully controlled to preserve the coldwater pool for listed species. Mr. Yip suggested that new outflow objectives should be established in concert with

CALSIM modeling and evaluation, and 2010 springtime outflow criteria may need to be modified to protect reservoir releases. Mr. Yip encouraged the Board to manage the "whole ecosystem."

To deal with uncertainty, NMFS suggests that the Board take a precautionary approach, utilize monitoring and adaptive management processes, and make a substantial commitment of resources. Specific suggestions include managing reservoir releases to preserve the coldwater pool, looking for alternative methods to protect salmonids (like screening currently unscreened diversions), requiring increased outflow in the San Joaquin River, and supporting modifications to the DCC gate closure objectives. He added that there continues to be strong support, even with new information, for the goals and biological objectives identified in the DFG and Board 2010 flow criteria reports.

Dr. Bruce Herbold and Erin Foresman, U.S. Environmental Protection Agency—New Flow Analyses and Concepts for Water Quality Objectives

Presentation summary: *Dr. Bruce Herbold and Erin Foresman presented USEPA's recommendations to the Board regarding update of the aquatic life beneficial use objectives. USEPA believes that fish benefit from flows that mimic the natural hydrograph pattern. They acknowledged that the 1995 Bay-Delta Plan objectives restored some of the springtime hydrograph pattern, but would like the Board to build on that success to improve habitat in all seasons. USEPA also encouraged the board to utilize controlled experiments and the triennial review process to increase precision management of the estuary.*

Dr. Herbold presented to the Board the USEPA's recommendations, which focus on springtime Delta outflow, fall Delta outflow, and the San Joaquin migratory corridor.

USEPA believes the spring outflow starts too late; it should begin in January or be activated based on a flow or turbidity measure from the first storm. Dr. Herbold then called the Board's attention to the Roe Island trigger, which was part of the 2006 Bay-Delta Plan. USEPA believes this particular requirement has manipulated the system such that the Roe Island trigger is not activated. The trigger's intent was to ensure that duration of flows were historically comparable, but USEPA believes it resulted in water being held back in the reservoirs to avoid activating the trigger. This led to the type of flows that cause redd dewatering, as was described in DFG's presentation. USEPA believes the Roe Island standard should remain in the Bay-Delta Plan, but that the trigger should be removed. Dr. Herbold believes the reservoirs should be operated to preserve the coldwater pool, but he took pains to point out that the coldwater pools also have to be released at the right times in a way that meets objectives and does not dewater redds. He noted that there is agreement among agencies that the Board's process does not require prioritization of one species over another.

Regarding fall outflow, Dr. Herbold observed that the NMFS BO links fall flow requirements to year type. USEPA believes that there is a potential to key flow requirements to more sensitive measures of when and to what degree flows are appropriate.

Dr. Herbold remarked that a major change in the I/E ratio has occurred in the San Joaquin River along with the salmon decline. During the time of year when adult salmonids are returning to the river to spawn, the I/E ratio has increased from 3:1 to 10:1. He urged the Board to consider both spring and fall downstream flow connections and to ensure there is water flowing from the San Joaquin River to the bay at some point in both seasons,.

Dr. Herbold turned his attention to answering the Board's request for new information and recommended the Whipple and Grossinger report entitled *Sacramento–San Joaquin Delta Historical Ecology Investigation*, which concludes that historically, the Delta was mostly a freshwater estuary partly because the landscape of the historical Delta was a lot more resistant to salinity intrusion. He then reviewed some basic concepts regarding X2 and the LSZ from the USEPA's presentation at the first workshop and noted that flow variation has been restored to some extent in the springtime but has been lost in the fall.

Erin Foresman identified how the concepts Dr. Herbold introduced could be used to inform the update of the Bay-Delta Plan outflow objectives. She recommends identifying and considering a range of water quality objectives. The "no action alternative" is the existing regulatory framework (the 2006 Bay-Delta Plan plus the FWS and NMFS BOs and DFG's incidental take permit), and it is inadequate for protecting aquatic life beneficial uses. Criteria from the Board's 2010 Flow Criteria Report should be considered, as well as the recommendations Dr. Herbold offered. USEPA believes it would be informative for the Board to look at a broader range of alternatives than have been previously identified.

Ms. Foresman pointed out that the triennial review process, which is already built into the water quality control plan framework, provides for built-in adaptive management. USEPA believes this process should be utilized along with controlled experiments and monitoring to increase precision management of the estuary.

Questions from the Board

Board member Marcus noted that most of the presentations as a part of the regulatory and fishery agencies panel focused mostly on flows. She asked why other tools that the Board could use were not discussed.

> **Dr. Herbold** said he focused on flows because the workshops were billed as Delta outflow workshops. He observed that there is certainly a lot of other information out there, and the conversation could expand greatly.
>
> **Ms. Foresman** noted that the USEPA's Action Plan, which was discussed in Workshop 1, focused on contaminants.
>
> **Roger Guinee (U.S. Fish and Wildlife Service)**, a member of Panel 2, observed that flow is the "master variable"—improving flows also lowers water temperature, improves the I/E ratio, provides floodplain habitat, helps juvenile fish grow and avoid predation, and contributes to positive flows in OMR.
>
> **Mr. Shaffer** stressed that flows are required to allow floodplains to function but also noted that several factors are independent of flow, such as improved habitat, floodplain availability, whether or not fish have escape corridors, and how the water is managed once it is in a floodplain or in the Delta.

Board member Marcus agreed with Mr. Guinee that flow is related to many factors, but pointed out that flow alone doesn't accomplish all of those objectives. For example, floodplain habitat has to be made available before increased flows can inundate floodplains. She explained that she was asking the question because she was curious why the regulatory and fishery agencies' presentations were so flow-centric.

Board member Moore recalled Ms. Brandes' presentation, which suggested that higher flow would lead to less predation in the Delta. He asked the panelists to expand on that idea and cite mechanisms and/or studies.

Ms. Brandes said there are a variety of mechanisms depending on location in the Delta, including flow year type, structures, and higher turbidity, but that in general, higher flows decrease predation. Studies that bear this out include the 2011 VAMP studies (in comparison to the 2010 and 2009 VAMP studies) and some technical memorandums penned by Mark Bowen regarding a physical versus nonphysical HORB.

Panel 3: Resource Management Agencies

Dean Messer, **DWR Chief of the Environmental Resources Division**, reviewed the major points from DWR's presentation at Workshop 1. He encouraged the Board to take advantage of the consensus approach being developed in the Bay-Delta Conservation Plan (BDCP) process, as he believes the BDCP addresses the ecosystem as a whole, taking a broader approach to provide a balance. He noted that DWR respectfully requests that any changes to flows in the Delta be considered in a collaborative framework such as the BDCP. He then introduced the other panelists.

Brett Harvey, California Department of Water Resources—Salmonid Habitat, Diversity, and Management

Presentation summary: *Brett Harvey mentioned recent studies that have indicated exports do not affect salmonid migration as much as previously assumed. DWR, through the BDCP process, is embarking upon an effort to restore a variety of salmonid rearing habitats, including floodplains, wetlands, and riparian corridors to foster life history diversity in salmonid populations. DWR requests that when setting flow requirements, the Board consider how those flows will interact with restored habitats, and how benefits could be maximized beyond pushing out-migrating salmon out of the system as quickly as possible.*

Brett Harvey contrasted the traditional model of salmon management, which he calls the "leaky pipe" model, with DWR's alternative guiding model, which he refers to as the "bet hedging" model. The leaky pipe model aims to get juvenile salmon out of the river system and into the ocean as quickly as possible. Along the way, the fish may encounter a number of risks, including stranding, diversions, and predation. This model still underlies many management actions in the Central Valley, like hatchery supplementation, gate closures, fish trucking, and export restrictions. He pointed out that salmon have not thrived under this model.

DWR's bet hedging model utilizes an approach focused on improving hatchery management practices and developing a suite of habitat types that provide opportunities for growth along the migration corridor and along tributary streams. DWR believes it is important to allow the salmon to "hedge their bets" and develop various life history objectives because the most important factors for fish will vary from year to year. A bet-hedging approach will provide resilience for the salmon populations in this climate of changing conditions.

Mr. Harvey said recent studies have shown that exports do not have as big of an effect on salmon migration as previously thought, and exports have a minimal effect on the flow split at Georgiana Slough. He stated that he does not intend to suggest that exports have no effect on salmon

populations or that export restrictions have had no benefit; he acknowledged that there has been a drop in salvage since the Bay-Delta Accord. However, he believes that the impacts of exports under the current management restrictions are likely less than assumed.

He observed that restricting exports in the past has not worked to restore the salmon population, and suggested a new approach is necessary. DWR proposes fostering life history diversity by providing a variety of rearing habitats that will restore natural buffering mechanisms to the populations. The narrow window of available ocean reentry time is thought to be a major driving force behind the 2008 collapse of the salmon population. He also said recent studies have shown that Delta rearing of juvenile salmonids is more important that previously understood and have shown how the riprapped channels of the Delta offer very little in the way of shallow water habitat or habitat diversity. He stressed the importance of floodplain habitat, tidal wetlands, and shallow-water riparian habitat for juvenile salmonid growth and survival.

Mr. Harvey concluded that the interior Delta is a bad place for migrating fish, so actions that minimize migration of juveniles into the interior Delta would be beneficial. He acknowledged that higher flows help survival numbers, but pointed out that moving that they also reduce life history variability. For this reason, DWR believes that flows need to be coordinated with habitat restoration, an approach he said is being taken in the BDCP.

Questions from the Board

Board Chair Hoppin asked if DWR has considered using a screening device at Georgiana Slough.

Dennis McEwan (DWR) said DWR is testing an acoustic barrier across Georgiana Slough.

Board Chair Hoppin asked if the barrier has to be passive.

Mr. McEwan noted that a hard barrier could cause a hydrodynamic problem.

Board Vice Chair Spivey-Weber asked where the flows would come from for the increased habitat proposed by DWR.

Mr. Harvey said that flow is not his specialty, but requested that when making flow regulations, the Board consider how those flows will interact with floodplains and how benefits could be maximized beyond pushing fish past the "leaks" in the leaky pipe model.

Mr. McEwan noted that it often does not require more flow to activate floodplains—it just requires the banks to be adjusted to allow the water into the floodplain at a lower elevation.

Gardner Jones, California Department of Water Resources—Recommended Use of the BDCP and Related Restoration Activities in the Delta

Presentation summary: *Gardner Jones presented a summary of the conservation measures proposed in the BDCP, which follows the "bet-hedging" model presented by Mr. Harvey. DWR believes large-scale restoration provides one of the most promising opportunities to improve conditions in the Delta and has plans to restore 113,000 acres of habitat over the next 50 years. Mr. Jones feels the BDCP conservation strategy, along with its APM, will eventually create a number of new knobs that can be controlled to improve conditions in the Delta.*

Gardner Jones referred to Mr. Harvey's presentation and noted that the conceptual model for managing fish like salmon and steelhead is evolving. The leaky pipe approach has been used for years and has resulted in conditions that reinforce the viability of hatchery fish and suppress life history diversity. He described how the BDCP is taking a new approach, moving away from the leaky pipe model and towards the bet hedging model. The bet hedging approach is rooted in the hypothesis that large-scale restoration efforts are needed to restore fish populations and more natural flow patterns in the Delta. The BDCP built on ideas that were developed through CALFED, the CALFED Ecosystem Restoration Program, the Delta Blue-Ribbon Task Force, the Public Policy Institute of California, and independent science advisors.

Mr. Jones explained that his presentation would focus on key conservation measures that characterize the BDCP approach. The BDCP conservation strategy includes 200 biological goals and objectives for 57 species, 11 of which are aquatic species. It also includes 22 conservation measures, 10 of which involve habitat restoration. The BDCP calls for restoring 113,000 acres of habitat over 50 years, including 65,000 acres of tidal habitat, 10,000 acres of floodplain habitat, and at least 20 miles of channel margin habitat. It also identifies measures to enhance floodplain habitat in the Yolo Bypass.

Board Chair Hoppin repeated Vice Chair Spivey-Weber's question from the previous presentation in which she asked where the flows are assumed to come from for new habitats.

> **Mr. Jones** responded that all restoration is not created equal—some simply requires ingenuity, and some will require additional flows. For example, Liberty Island provides great habitat and does not require any additional flows.

Mr. Jones noted that the Delta is a highly variable system, and there is a high degree of uncertainty of what actions will translate into more fish, so the BDCP incorporates an adaptive management plan based on identifying S.M.A.R.T. (specific, measurable, attainable, realistic, and timely) goals and utilizing a "decision tree" process that provides flexibility to test management actions and learn from them. The BDCP also proposes a suite of other conservation measures that address "other stressors" like methylmercury, Stockton DWSC dissolved oxygen levels, urban stormwater treatment, predator control, and nonphysical fish barriers. It also proposes a system of dual conveyance that would export water from the Sacramento River north of the Delta.

Mr. Jones concluded with the thought that DWR believes large-scale restoration provides one of the most promising opportunities to improve conditions in the Delta, and that the "bet-hedging" approach will create a number of new knobs that can be controlled to improve conditions in the Delta.

Dennis McEwan, California Department of Water Resources—Near-Term Habitat Restoration Actions in the Delta, Suisun Marsh, and Yolo Bypass

Presentation summary: *Dennis McEwan provided an overview of DWR's intertidal and subtidal restoration projects called for in the Fish Restoration Program Agreement (FRPA) Implementation Plan. Its restoration efforts are focused on recovery of Delta native fish, and its objectives include habitat creation and food web production. DWR has made monitoring and adaptive management key elements of these projects.*

Mr. McEwan ran through DWR's plans for near-term habitat restoration actions in and around the Delta. Much of the restoration actions underway will help to meet the requirements of the FRPA, which was executed between DWR and DFG in 2010 to lay out an implementation strategy for meeting the habitat restoration requirements of the delta smelt and salmonid BOs and the longfin smelt incidental take permit. The FRPA Implementation Plan calls for restoration of 8,000 acres of intertidal and associated subtidal habitat over 10 years, and is funded through SWP funds. The main goal of FRPA restoration is not just to restore habitat, but to restore the processes that lead to creation and maintenance of those habitats—to recapture functions of tidal marshes, which include food web production. He observed that tidal marshes were the "bread basket" of the historical Delta's food web. Additional goals and objectives of the FRPA Implementation Plan are to:

- Restore functions and processes that promote primary and secondary productivity and export to pelagic habitat.
- Enhance migratory pathways for salmonids by increasing the amount and quality of rearing habitat.
- Monitor and adaptively manage restoration areas to ensure desired ecological outcomes.
- Be consistent with other Delta plans and programs.

Mr. McEwan added that to accommodate sea-level rise, DWR is trying to build into these restoration projects the ability for the intertidal areas to migrate upslope along with sea-level rise. He then provided an overview of some of the near-term restoration projects already underway at Prospect Island, in the Suisun Marsh, and in Yolo Bypass.

Questions from the Board

Board member Moore asked if DWR is working with the Port of Sacramento, which owns part of Prospect Island, on its restoration plans.

> **Mr. McEwan** responded in the affirmative. He explained that the property owned by the Port of Sacramento on Prospect Island was purchased for mitigation of the Sacramento DWSC deepening project. The owners are amenable to undertaking one large restoration project with DWR as opposed to implementing two separate projects on the same island.

Board Vice Chair Spivey-Weber asked if DWR is planning these projects with tidal influence and salinity levels in mind.

Mr. McEwan explained that salinity is only an issue for the Suisun Marsh restoration efforts, as the upstream projects are all freshwater ecosystems. He assured Board Vice Chair Spivey-Weber that DWR is trying to restore historical processes wherever possible.

Board Chair Hoppin asked panel member **Paul Fujitani (U.S. Bureau of Reclamation [USBR])** to summarize USBR's enormous responsibilities regarding the planning requirements for pumping efforts. He said he found this information very sobering when it was presented during the hearings that informed development of the Board's 2010 Flow Criteria Report.

Mr. Fujitani's office at USBR is in charge of planning and operations of the CVP. He explained that CVP operations must be scheduled 3–5 days in advance to coordinate with the hydropower market, and additional travel time from reservoirs to the Delta must also be taken into account. Releases from Shasta Dam take 5 days to reach the Delta, releases from Oroville Dam take 3 days to reach the Delta, and releases from Folsom dam take 1 day to reach the Delta. USBR must also plan its operations to meet Delta water quality standards; right now, they are operating to maintain Contra Costa chloride standards. USBR relies heavily on weather and tidal forecasts for the Delta, but because of the lead time required for hydropower coordination and reservoir release travel time, it must make management decisions 1–2 weeks in advance. This means that managing at a subdaily flow level would be incredibly challenging.

Board Chair Hoppin asked panel member **Ron Milligan (USBR)** if he had anything he wanted to say, since he was a member of the panel but did not provide a presentation.

Mr. Milligan said he did not have any specific thoughts related to the current workshop topic but noted that in the third workshop, which will focus on water supply, hydrodynamic, and hydropower effects, USBR will discuss outflow requirements and their effects on coldwater holding upstream.

Panel 4: Environmental/NGO Groups

Dr. Jonathan Rosenfield, Bay Institute/Natural Resources Defense Council—Role of Delta Inflows, Outflows, Hydrodynamics, Old and Middle River Flows, and Entrainment on Pelagic and Salmonid Species

Presentation summary: *Jonathan Rosenfield outlined the freshwater flow criteria that are necessary to protect public trust fisheries in the Delta and provided some suggestions for how the Board could make decisions in the face of uncertainty. He explained how long-standing and recent studies show that improvements in Delta outflow and hydrodynamic conditions are absolutely necessary, if not alone sufficient, to protect and restore native fishes and invertebrates. He does not believe that the Board's 2010 Flow Criteria Report's recommendations are too aggressive. He urged the Board to make the necessary changes to restore native fish species in the Delta now. He supports the use of adaptive management to address specific uncertainties, but cautioned that it must not be used as a rationale for inadequate protections of imperiled resources.*

Dr. Rosenfield reviewed some basic concepts from Workshop 1 and concluded that the Board has a very strong scientific basis for significantly increasing winter/spring Delta outflows because the Bay-

Delta estuary is experiencing a man-made, permanent drought. He noted that Delta freshwater flow criteria are closely linked to attributes of viability, including abundance, spatial extent, diversity, productivity, and stability, for many species.

Dr. Rosenfield provided results from recent studies showing that given current flow patterns, by the time longfin smelt populations would be able to stabilize, they would be extinct. Recent studies also indicate that the flows necessary to support restoration of pelagic fish species, which would require approximately 20,000–35,000 cubic feet per second on average for the spring months (a 75% improvement in median flows as compared to the 1998–2009 period), far exceed contemporary flows, but they are attainable and consistent with flows of the 1956–1987 period. Data for other species show that flows necessary for longfin smelt population growth are consistent with improved abundance of other pelagic species and food web productivity.

Dr. Rosenfield then spoke about Delta hydrodynamics and the population effects of entrainment. He asserted that data collected over the years provide a strong scientific basis for limiting net negative flows in the southern Delta. Annual salvage data from 1993 to 2011 show that tens of millions to hundreds of millions of fish are entrained each year by southern Delta exports. Several studies show that for some species, entrainment mortality is an episodic and substantial impact on the

population. Dr. Rosenfield provided a quote from a 2011 report by Wim Kimmerer stating that "a loss [of delta smelt] to export pumping…can be simultaneously nearly undetectable in regression analysis, and devastating to the population. This also illustrates how inappropriate statistical significance is in deciding whether an effect is biologically relevant."

Dr. Rosenfield pointed out that entrainment has effects on fish populations beyond direct mortality. Southern Delta reverse flows and the constant risk of entrainment impose an "unnatural selection" pressure on native fish species, which reduces adaptive fit and the species' potential to rebound. This is a life history effect, and it is difficult for species to capitalize on favorable conditions when there is constant mortality. Additionally, the consistent mortality and poor conditions in the southern Delta restrict the range of native fishes, which increases those species' susceptibility to catastrophic events. Dr. Rosenfield does not find it surprising, given the constant entrainment risk and southern Delta conditions, that delta smelt and longfin smelt are rarely found in the area anymore or that San Joaquin salmon have difficulty entering or leaving the area.

Dr. Rosenfield acknowledged that specific levels of in-Delta flows that are necessary to maintain public trust resource remain undetermined, but he emphasized that there is zero scientific evidence supporting maintenance of the current quasi-permanent net negative flow conditions in the southern Delta, particularly in drier years. He believes that the Board's public trust objectives for Delta hydrodynamics must do more than "avoid extinction." These objectives may be managed adaptively (in real time and across water quality control plan triennial review periods) to learn what works, but Mr. Rosenfield cautioned that the requirements of the BOs must be used as the lower limit of the adaptive range. He also believes that net positive flows in OMR will be necessary during ecologically sensitive seasons, during drier years, and/or when abundance falls below critical thresholds. He recommended that the upper end of the adaptive range include net positive flows with duration increasing as hydrology permits.

Dr. Rosenfield then provided some guidance on how to address uncertainty in a planning framework. He recommended a set of questions that should be asked and answered to help the Board identify what it is trying to achieve. These questions include:

- What specific, measureable ecological outcomes represent adequate protection of the public trust? By when will these be attained?
- What stressors currently prevent the attainment of those goals and targets?
- How much change (specifically) in those stressors is necessary to contribute to the biological targets? By when will this stressor reduction occur?
- What actions will the Board implement in order to affect stressor reduction targets within the specified time frame?
- How much is each of these actions expected to contribute to stressor reduction?

Dr. Rosenfield reminded the Board of its goal to double salmonid populations from the 1967–1991 average and encouraged the Board to identify a goal for when this would be accomplished.

He then encouraged the Board to think critically about some of the "red herrings," or myths, of Delta management. The first is the argument that "we cannot go back to the ecosystem of the past." Dr. Rosenfield feels that this idea leads people to think that scarcity must be a fact of the future or that near-extinction for important species is the best that can be hoped for. Dr. Rosenfield does not agree with this view and asserted that with flow and habitat improvement necessary for some species (e.g., smelt), other species (e.g., splittail and salmon) could do substantially better than they have since sampling began.

The second "red herring" dispelled by Dr. Rosenfield is the argument that the Board's 2010 Flow Criteria Report is too aggressive and the Board should tweak flow criteria and use adaptive management to better understand the problem and evaluate potential solutions. Dr. Rosenfield cautioned that adaptive management is no panacea. The precarious nature of public trust resources in the Delta does not allow a lot of room for incremental changes. Adaptive management is appropriate to address uncertainty regarding specific parameters, but it cannot be a rationale for inadequate protections of imperiled resources. If the Board wants to see a difference in the state of protected resources, it must make some big changes.

Questions from the Board

Vice Chair Spivey-Weber asked Dr. Rosenfield if he is involved in the BDCP process, and if so, whether the issues he brought up during his presentation are part of the BDCP discussions.

> **Dr. Rosenfield** responded that he has been involved in the BDCP process and his issues of concern are part of the discussion when he's in the room. He believes there is some receptivity to his ideas. He has heard conflicting messages in the BDCP discussions. At the same time BDCP proponents are arguing that a peripheral canal is necessary to allow operational flexibility and avoid entrainment, they are also arguing that entrainment does not have a population effect on fish species. Dr. Rosenfield remarked that a peripheral canal on its own will not restore native fish populations, and the other BDCP conservation measures will not solve those problems without increased flows.

Board member Moore observed that there appears to have been some success with spring flow management, but that fall flows need to be altered as well. He said he will be interested to hear suggestions about seasonal flow management as the Board moves forward.

> **Dr. Rosenfield** noted that most of his presentation information was related to winter and spring flows—these flows are a natural part of the hydrograph. Winter and spring are the seasons

during which many species take advantage of the natural flow pulse to increase productivity and to migrate. The science behind fall outflows is newer; however that science is showing that fall outflows will be a necessary action because of the degraded state of the Delta.

Dr. Rene Henery, Bay Institute/Natural Resources Defense Council/Trout Unlimited—Salmonid Migration Pathways in the Delta and Upstream Flow and Temperature Requirements

Presentation summary: *Dr. Rene Henery reviewed recent studies, noting that they show strong scientific evidence for the benefits of increased flows and floodplain habitat restoration for salmonid species. He encouraged the Board to set objectives for Sacramento River inflows, Delta outflows, floodplain habitat connectivity, salmonid migratory corridors, and upstream temperature conditions. He believes that increasing Delta outflows need not come at the expense of upstream reservoir storage and counseled the Board to develop and implement a robust adaptive management program tied to clearly defined biological outcome metrics.*

Dr. Henery began by highlighting some of the themes he has seen emerging from recent science. These themes are:

- Adequate Sacramento inflows are critical to the health of the Delta and anadromous fish populations.
- Benefits of inflows for anadromous fish include increased survival, improved outmigration, floodplain inundation, and life history strategy diversification.
- Inflows must be developed with consideration for upstream habitat conditions.

He noted that native salmonids are "on the precipice." A recent study shows that if present trends continue, 78% of the 32 native California salmonid taxa will likely be extinct or extirpated within the next century. The main causes of this decline are flow alteration, loss of access to upstream rearing habitat, and loss of floodplain habitat. He observed that there are other factors involved in the salmon population decline; however, he believes the Board's actions can have the most significant effects on the three he listed.

Dr. Henery said that scientific literature since 2010 supports the idea that more flows will be good for fish. These studies show that restoring floodplain connectivity and restoring flow regimes in both the Delta and its watershed are the restoration actions below major dams most likely to result in direct benefits to salmon and other species. These actions would help to ameliorate flow and temperature problems, buffer effects of climate change, increase habitat diversity and population resilience, and support improved survival. He counseled that flow increases need to be managed in a way that is sensitive to upstream resources and the entire watershed, as a disproportionate allocation can lead to adverse flow and temperature conditions below the dams. Dr. Henery believes salmon are a great indicator species for the Board to use as it makes management changes because salmon are a symbol of continuity in the system. They span a lot of spatial and temporal scales.

Dr. Henery encouraged the Board to take steps to revision and refocus how it approaches management of the system. In the past, it has focused on a single life history strategy, but that can be expanded to multiple strategies with ecosystem restoration and increased flows.

Dr. Henery provided the following specific recommendations to the Board:

- ***Sacramento River Inflow and Delta Outflow Objectives.*** Increase winter/spring inflow and outflow objectives to improve migratory survival of juvenile salmonids; releases from upstream sources should be made proportionally.
- ***Floodplain Habitat Flow Objectives.*** Establish Sacramento River inflow and structural modifications objectives such that flows from the Sacramento River inundate floodplains for 15–120 days between December and May every year or twice in every 3 years.
- ***Migratory Corridors.*** Establish objectives that provide adequate migratory corridors through the Delta for both juvenile and adult salmon.
- ***Maintain Adequate Upstream Temperature Conditions.*** Build on the CALSIM modeling done for BDCP Alternative 8 to ensure that both temperature compliance and Delta flow objectives are met.
- ***Adaptive management.*** Develop and implement a robust adaptive management program tied to biological outcome metrics that clearly define success.

John Cain, American Rivers—Importance of Floodplain Inundation for Salmonids and Splittail

Presentation summary: *John Cain believes that flow regime change in addition to restoration of floodplain and channel margin habitat will be required for the protection and recovery of native fish species. He urged the Board to add floodplain inundation flow standards and salmon restoration objectives to the Bay-Delta Plan and advised the Board to change the water right responsibilities of other water right holders to achieve these objectives.*

Mr. Cain began the presentation by showing a photo comparing salmon smolts found in a floodplain and smolts found in a river channel. The floodplain smolts were significantly larger than river channel smolts. Mr. Cain said he would proceed with his presentation under the assumption that everyone agrees floodplains are good for fish and that the intent of his presentation is to focus on what the Board needs to do to activate floodplains.

Mr. Cain noted that some new studies and reports have been published on floodplains and fish habitat in recent years, and he recommended that the Board review the following information:

- The Central Valley Flood Protection Plan (CVFPP) and associated appendices and projects.
- BDCP studies regarding floodplain habitat.
- San Joaquin River restoration planning studies.

Mr. Cain said he was glad to see DWR representatives advocating for ecosystem restoration, but American Rivers feels the Board must compel DWR to construct such projects through a binding of its water rights.

He recommended that in the face of scientific uncertainty, the Board should focus its actions on areas where there is certainty. There is certainty that increasing the area of frequently available habitat would be beneficial, and doing so would increase phytoplankton availability in the system. Increasing the area of available habitat would also increase turbidity, which has been shown to give native species a competitive advantage over predators that use sight to hunt. He also believes that the weight of the evidence supports increased flow, and the Board should increase flow standards as

a precautionary principle. Mr. Cain then offered a list of criteria the Board could use in its decision-making processes.

Mr. Cain noted restoration of floodplains and upstream rearing habitat (including side channels and levee setbacks to increase channel margin habitat) is critical for the protection and recovery of native fish species and emphasized the necessity of both physical restoration efforts and increased reservoir releases to achieve increased floodplain inundation. Mr. Cain pointed out there is currently a disconnect between restoration planners and those controlling the flow regime. This fragmented environment forces restoration planners to design their projects within the narrow confines of the current flow regime. Increased flows would allow for more frequent floodplain inundation and would open up many new restoration opportunities.

Board Chair Hoppin observed that neither the Nag's Ranch Project nor the Knights Landing Ridge Cut required additional flows.

> **Mr. Cain** acknowledged that not all projects require increased flows, but noted that increased flows would open up many additional floodplain restoration opportunities. He also mentioned that though the projects mentioned by Board Chair Hoppin provide increased habitat in the western tributaries of the Yolo Bypass, neither are migration pathways for salmon. He believes the increased habitat should be augmented by increased inundation of the Yolo Bypass itself.

Board member Marcus asked Mr. Cain to identify the best places on the San Joaquin River for floodplain restoration.

> **Mr. Cain** responded that the best place for floodplain restoration on the San Joaquin River is between Vernalis and the Delta—the area considered for a Lower San Joaquin River bypass.
>
> Mr. Cain continued his presentation by sharing the original as-built drawings for the Fremont Weir, which demonstrate how the Fremont Weir was originally notched to allow water into the Yolo Bypass at lower flows. He recommended that the floodplain restoration efforts under the CVFPP and the water management decisions facing the Board should be integrated into a joint floodplain restoration effort.
>
> Mr. Cain recommended the Board include floodplain inundation flow and salmon restoration objectives in the updated Bay-Delta Plan, and that the Board should use its authority to change the water right responsibilities of DWR, USBR, and other water right holders to achieve these objectives. Water rights should be modified to allow for the diversion of water onto floodplains and to provide for increased frequency of floodplain inundation.

Questions from the Board

Board Chair Hoppin noted that increasing flows could also increase the risk of flooding homes along the river. Balancing those risks is part of the problem.

> **Mr. Cain** acknowledged that floodplain restoration is more complicated than tidal marsh restoration because of the necessary flows. However, he believes that the risks identified by Board Chair Hoppin reinforce his overall point. Designated floodplains and levee setbacks won't just make more fish; they will also increase public safety. The best way to improve public safety is to give the river more room for flood flows.

Board Chair Hoppin cautioned that part of the intent behind the CVFPP's proposed expansion of floodplain habitat is to reduce the cost of maintenance. This means the levees may be set back, but there is no guarantee the agencies will maintain the vegetation that grows up in the floodplain areas.

Board Vice Chair Spivey-Weber asked which months are being referred to when "winter/spring releases" are discussed.

> **Mr. Cain** responded that generally, winter/spring releases for floodplain inundation would occur in January–April.

Dr. Tom Cannon, California Sportfishing Alliance/California Water Impact Network—Specific Needs of Pelagic Organisms and Salmon and Recommendations for Their Protection

Presentation summary: *Dr. Tom Cannon argued that outflow criteria are too low in non-wet years and in wet-year summers to protect Delta fishes, their food supplies, and their LSZ habitat. He noted that export criteria expressed as E/I ratios do not protect Delta fishes, their food supplies, or their LSZ habitat from being exported from the Delta, and showed how direct effects of low outflow and high exports translate downstream in the form of lower bay inflow, fewer nutrients, fewer organisms, and reduced LSZ productivity. He suggested to the Board a set of specific minimum export and outflow criteria to protect beneficial uses in the bay and Delta.*

Dr. Cannon began his presentation with a recommendation that the Board read the 1972 article "Distribution and Abundance of Young-of-the-Year Striped Bass, *Morone saxatilis*, in Relation to River Flow in the Sacramento–San Joaquin Estuary" by Turner and Chadwick. He then provided a summary of key points from his Workshop 1 presentation, including a description of the phenomenon he refers to as "the vise."

He believes the solution to the problem of the vise in the Delta is higher outflows and lower exports. He presented specific minimum criteria for each season, which include inflow and outflow requirements, export limits, and DCC closure recommendations, which he believes will protect native species. He stressed that his recommended standards are "minimum," not "optimum," and are a must for non-wet years and spring and summer seasons if the goal is recovery of pelagic species.

Dr. Cannon then talked a bit more about the vise's effect on native species and on the food web, and he showed the Board what the results would have been if his minimum criteria were implemented during different historical timeframes.

He then demonstrated how vulnerable delta smelt are to exports and increased water temperatures. He pointed out that salvage efforts during early summer are not accurate estimates of how many delta smelt are entrained at the pumps because average delta smelt size in the month of June is 25 millimeters—too small to salvage. Warm summer inflows are also dangerous to smelt. Few smelt are salvaged after June because the smelt simply cannot survive the warm water and do not make it to the Clifton Court Forebay.

Dr. Cannon acknowledged his suggested criteria would significantly reduce exports, but he pointed out that they would also reduce reservoir releases, which would benefit storage and the coldwater pool. He listed a few other benefits to reduced exports, including fewer zooplankton getting sucked out of the Delta. Dr. Cannon shared the results of studies demonstrating how much zooplankton is

removed from the Delta system after pumping volumes are increased in June of each year. Reduced exports would also help San Joaquin salmon emigrants actually make it to the bay.

Panel 5: Sacramento Valley Water Suppliers

David Guy, President of the Northern California Water Association, introduced **Robert Latour**, who works with the Virginal Institute of Marine Sciences and would present a fresh perspective on Delta data analyses related to flows. Mr. Guy noted that one of the scheduled panelists, Dave Vogel, was unable to attend the workshop due to medical reasons and requested that the Board allow Mr. Vogel to share his recommendations during Workshop 3 or at another time. Board Chair Hoppin said the Board would do whatever it could to accommodate Mr. Vogel's presentation. He also informed the Board that **Walter Bourez**, panelist from Workshop 1, was also present and would be available to answer any questions.

Dr. Robert Latour, Northern California Water Association/ Sacramento Valley Water Users—Data Analyses in Relation to Water Flow for Fishes in the Sacramento–San Joaquin Delta Ecosystem

Presentation *summary: Robert Latour performed an independent review of the fall midwater trawl (FMWT) process and data. He discovered some uncertainties related to the FMWT Abundance Index and noted that the catch rate of target species is extremely low. A statistical analysis of the raw FMWT data indicates widely variable flow/abundance relationships and shows that turbidity has a better relationship with abundance than flow. He recommended some improvements to the FMWT methods and suggested some additional data analyses that could be performed with existing data.*

In his review of the FMWT methods and data, Dr. Latour identified a lot of room for improvement and the following uncertainties related to the FMWT abundance index:

- The FMWT does not capture changes in habitat use even though the independent science panel shows that there have been changes in habitat use by several species.
- The FMWT abundance index [(average fish caught) x (water volume sampled)] is difficult to understand and interpret. Dr. Latour said he was shocked that there haven't been any attempts to introduce environmental covariates into an understanding of fish caught per individual trawl.
- There is no estimate of error range in the FMWT Abundance Index.
- The FMWT catches very few of the target species per tow. This suggests a problem with the trawl, and calls into question whether it provides a robust enough measure to infer population changes. Dr. Latour strongly encourages the addition of hydroacoustic and camera equipment to the FMWT efforts.

In Dr. Latour's own analysis of the FMWT data, he found that year, month, area, and Secchi depth (a measure of turbidity) were all statistically significant covariates in relation to catch; however, he found no statistically significant relationships between flow and catch. In extended statistical analysis of the data, Dr. Latour found that no flow variable explains much of the variation in pelagic fish catch data, and turbidity consistency has a stronger relationship with abundance than flow. He

suggested further study of turbidity/abundance relationships, which could prove a fruitful line of research in the future.

Dr. Latour provided the Board with recommendations for further analysis of existing FMWT data. These recommendations are to investigate turbidity abundance relationships with more robust turbidity data and to analyze trends in habitat use. He then provided some suggestions on how the FMWT process could be improved utilizing the existing resources. He suggested performing some pilot studies in which trawl net performance is tested and in which the FMWT is extended to additional locations, depths, and habitats to assess changes in habitat use. He also recommended expanding trawl hours to assess diel movements and differential tow success, incorporating hydroacoustic and camera equipment into the process, and testing the prey field (plankton) along with the target species.

Questions from the Board

Board Chair Hoppin acknowledged the catch rate of the FMWT is low compared to similar trawling efforts on the east coast, but asked whether the results of the FMWT aren't still relevant. He expressed concern that exploring more efficient methodologies would require all the old data to be thrown out. He asked if it is possible to move forward without starting from square one.

> **Dr. Latour** said that there must be enough confidence in the data to be sure the methods are testing above the level of the noise. However, he believes the basic core function of the FMWT trawls can be maintained while adding on new and evolved ideas in response to data needs. For example, addition of a plankton net does not jeopardize the trawl; it just represents an additional data source that allows inferences to be made about food interactions.

Board member Moore asked if Dr. Latour had the opportunity to look at the tidal cycle in relation to turbidity. For example, turbidity at Point San Pablo is driven by the spring neap tidal cycle, in which waters move further and scour out areas that have not been touched in a while.

> **Dr. Latour** responded that his turbidity studies were related to the food web, not to contaminants.

Panel 6: In-Delta Water Interests

Dr. Diana Engle, Larry Walker Associates, on behalf of the Sacramento County Regional Sanitation District—Addressing Uncertainty Regarding the Pelagic Food Web: Perspectives and Suggestions

Presentation summary: *Dr. Diana Engle suggested that the Board support additional studies to assess the Sacramento River's contributions to the pelagic food web, consider direct effects of residence time on plankton when making flow management decisions, and support improvements to the experimental approaches being used to study nutrient effects in the Delta (i.e., move away from the "cubitainer" approach). She also believes that the BDCP has made a grave omission in not accounting for the possibility that new habitat can become a net sink for phytoplankton if colonized by the Potamocorbula clam.*

Dr. Engle announced that her intent was to discuss uncertainties regarding the Sacramento River as a source of pelagic food and to offer suggestions to help the Board tackle key uncertainties relating to the pelagic food web in general. She observed that plankton transported by the Sacramento River is presumably an important food subsidy for downstream areas, but phytoplankton biomass in the Sacramento River declines starting above the city of Sacramento, and there is little research or data that explains why this occurs. She was careful to show that when there is a marked decline in phytoplankton levels in the lower Sacramento River, a majority of phytoplankton loss begins at the Interstate 80 bridge and occurs upstream of the Sacramento Regional Wastewater Treatment Plant (RWTP).

Board Chair Hoppin noted that phytoplankton levels are affected by seasonal and monthly variability. He asked how Dr. Engle would establish a baseline for phytoplankton levels.

> **Dr. Engle** responded that there aren't many Sacramento River phytoplankton studies, so not much data is available. There is a focus on spring sampling, but it is unknown what the phytoplankton pattern looks like through the rest of the year.

Dr. Engle recommended that the Board undertake additional monitoring to understand what is going on upstream of the Delta in the Sacramento River—whether there is an upstream bloom, where the phytoplankton is growing, and what environmental conditions cause the phytoplankton to grow. Those questions cannot be answered based on the existing sampling transects. She believes the Board should conduct frequent, finely spaced phytoplankton monitoring that starts well above the legal Delta.

Board member Moore recalled that a presentation earlier in the workshop discussed the importance of the San Joaquin River's contribution to phytoplankton in the Delta. He asked Dr. Engle how the Sacramento River's contribution compares to the San Joaquin River's.

> **Dr. Engle** said that the San Joaquin River produces more and different kinds of phytoplankton than the Sacramento River. However, she does not feel that constitutes a reason to completely write off the Sacramento River's contribution. Delta smelt do move up to the Sacramento River for spawning and rearing, and they need a functional food web.

Dr. Engle suggested that the Board consider direct effects of residence time on plankton when managing flows—specifically, whether residence times associated with flow criteria are conducive to growing the desired types of plankton in the right places and transporting the plankton to the right locations. Phytoplankton blooms occur in water that is constantly moving, which means that residence time is an important driver of the pelagic food web. In addition to affecting the intrinsic growth rates and biogeochemical processes of different phytoplankton species, residence time also affects the contact time between plankton and "filters," such as beds of clams and aquatic weeds. Habitat restoration will affect residence time in many ways, and residence time discussions need to be a part of restoration planning. She asked the Board to consider residence time as an variable that can be changed to affect phytoplankton availability.

Board Chair Hoppin asked if it was fair to say that the lengthening of residence time would produce more plankton.

> **Dr. Engle** said that very slow residence time favors growth of phytoplankton species that are considered to be negative. However, a balance must be struck because fish cannot keep up with the phytoplankton when the water is moving too quickly. It would be helpful to know where the clam "hot spots" are.

Board member Moore noted that one of the main goals of tidal and floodplain restoration is to increase food web productivity. He asked if a point might be reached in the future when wetland productivity becomes so abundant it eclipses the importance of upstream phytoplankton food web subsidies.

> **Dr. Engle** pointed out that phytoplankton growth in Delta wetlands would only be available locally in the Delta. She assumes part of the reason dual conveyance is being considered is because a decision has been made that the phytoplankton growing in the San Joaquin River are important for downstream uses.

Dr. Engle then spoke a bit about the BDCP and what she believes is an alarming omission in its habitat restoration plans. The habitat restoration component of the BDCP assumes that restored habitat will be a net producer of phytoplankton and zooplankton, but it did not account for the effects of clam grazing, which can be huge. She stressed that the effects of clam grazing need to be incorporated into the BDCP effects analysis, and that the document needs to account for the possibility that new habitat can become a net sink for phytoplankton when colonized by *Potamocorbula*. She believes an adaptive management opportunity exists in observing clam behavior in new habitats.

Dr. Engle also feels the experimental approaches being used to study nutrient effects in the Delta need to be improved. She described several drawbacks to the currently utilized "cubitainer" approach. She suggested future studies should utilize larger-scale, long-term (ideally flow-through) mesocosm research strategies.

Board Chair Hoppin noted that several speakers during the workshop described the importance of increasing flows. He said it sounds like Dr. Engle may be saying that, in regards to the food web and in certain circumstances, lower flows might be beneficial.

> **Dr. Engle** responded that she's not saying lower flows are better per se, but timing is very important. She said the condition of the Delta is already much more lake-like than river-like in many ways. This could explain the profusion of aquatic weeds and predator fish species. She does not believe the Delta needs lower flows than it already has because it already shows signs

that water is moving too slowly in certain places. However, once adequate flows are established, Dr. Engle believes it would be appropriate to examine how to maximize residence times.

Dr. Michael Connor, East Bay Dischargers Authority—Nutrients in General and the Direct and Indirect Effects of Ammonia

Dr. Michael Connor did not have a PowerPoint presentation but shared his thoughts on some of the previous presentations. He believes that Dr. Engle's ideas in relation to residence times are crucial to the Board and that residence times must be considered not only in relation to phytoplankton, but also as they relate to turbidity, light penetration, and grazers. A robust model will be necessary to address all of these issues. Dr. Connor also reiterated his suggestion from the first workshop that the Board integrate Delta studies and standards with the San Francisco Bay Numeric Nutrients Endpoints effort.

Dr. Connor encouraged the Board to establish specific criteria that will allow it to judge whether management actions are successful. He suggested utilizing the Independent Science Board to help the Board develop alternatives and identify success criteria.

Dr. Deanna Sereno, Contra Costa Water District—Use of an Index for Old and Middle River Flow Objectives

Presentation summary: If the Board chooses to implement flow objectives for OMR, the Contra Costa Water District (CCWD) recommends that the Board use a flow index instead of the United States Geological Survey (USGS) OMR values.

Dr. Deanna Sereno said the purpose of her presentation was to offer the Board a concrete recommendation on a single, focused point: if the Board chooses to implement flow objectives for OMR, the CCWD recommends that the Board use a flow index rather than the OMR values derived from USGS velocity measurements.

There are several implementation issues associated with using USGS OMR values. The three main problems with USGS OMR values are that daily values are not provided in real-time, measurements are missing over 30% of the time, and the values are affected by many factors that further complicate forecasting of project operations.

CCWD believes that use of a flow index would solve the implementation issues associated with the USGS OMR values. Dr. Sereno demonstrated the benefits of using a flow index, among them that it is based on readily available information, provides real-time information, and would improve operations forecasting. She also showed that use of a flow index would remain representative of regional hydrodynamics and would be just as protective of fish as the USGS OMR values.

Dr. Sereno said CCWD is not suggesting specific OMR flow standards but is recommending that the Board use a flow index should it decide to develop standards.

Questions from the Board

Board Vice Chair Spivey-Weber asked why a flow index has not already been developed.

Dr. Sereno responded that a flow index has been developed, but there has been resistance to utilizing an index. Many people are inclined to think that if a standard is to be set that will affect

fish, the standard should be based on something fish feel (velocity, represented by the USGS OMR values). However, there is gaining recognition that the USGS values themselves are an index—a summary variable that represents hydrodynamics in the system.

Board member Moore asked Board staff members if they had any questions or comments on the idea of using a flow index.

Board staff Diana Riddle (Senior Environmental Program Manager) responded that CCWD had presented the flow index information to Board staff. She noted that Dr. Sereno had indicated CCWD was in the process of consulting with the fisheries agencies, so Board staff is waiting to hear the fisheries agencies' opinions on the flow index.

Board member Doduc asked Dr. Sereno what she thinks the timeframe is going to be on identifying and addressing issues from the fisheries agencies and Board staff.

Dr. Sereno believes questions and issues from fisheries agencies and Board staff can be addressed by the end of the current water year.

Board member Marcus asked why the question of using the USGS OMR values versus a flow index is important to CCWD.

Dr. Sereno said CCWD is a Delta diverter with its own water rights, curtailments, and biological opinions, in addition to being a CVP contractor. CCWD diversions can affect flows in OMR but don't likely affect salvage at the CVP and SWP pumps. CCWD could be affected by OMR flow criteria, so it wants the Board to use an optimal measure of whether or not those criteria are being met.

Panel 7: State and Central Valley Project Contractors

Dave Fullerton, Metropolitan Water District—Introduction

Dave Fullerton provided a short review of the concepts presented by the SWP and CVP contractors at the previous workshop. During the first workshop, the water contractors attempted to identify the scale of ecological changes that have occurred in the Delta relative to the food web, physical landscape, water temperature, turbidity, and flows. They also discussed how deteriorated conditions might be modified by management and regulation, and identified management targeted at food web improvements as the most promising of the options.

Board Chair Hoppin acknowledged that the Board has flip-flopped in its approach to the food web; it has gone from encouraging clarity to encouraging turbidity.

Mr. Fullerton introduced the panel members and explained that the panel would first address salmon, then pelagic fish species. The water contractors plan to provide the Board with specific recommendations at the end of the workshops after all the science has been presented. He said their goal for this workshop is to provide the Board with scientific information that will help it make decisions with confidence and effectiveness.

Board Vice Chair Spivey-Weber asked Mr. Fullerton how important he believes increased flows are to the Delta.

Mr. Fullerton responded that he believes flows are important, but compared to a number of other factors, there is a lot of unregulated water moving around in the system.

Dr. Chuck Hanson, Hanson Environmental, Inc.—Relationships between Flow and Salmon Survival

Presentation summary: *Dr. Chuck Hanson argued that increased reservoir releases would not benefit juvenile salmonid survival and could adversely impact reservoir coldwater reserves and carryover storage. He believes there is no relationship between salmon smolt survival and SWP/CVP export rates and that increasing Delta inflow or outflow would not significantly affect salmonid migration rates. Dr. Hanson also noted the juvenile salmon mortality rate of 75% or more upstream of the Delta is high compared to other large-river systems, and data show ocean conditions likely were the driving force behind the salmon population crash of 2008.*

Dr. Hanson first defined his objective: to provide the Board with a scientific basis for identifying potential recommendations based on opportunities and constraints of alternative management strategies. He acknowledged flows support various natural functions but said reservoir releases do not support as many natural functions as natural flow, such as turbidity. He also noted that increased flows will be unable to activate shallow-water habitat without physical modification of the currently channelized system.

Board Chair Hoppin said he had heard a suggestion that it would be possible to increase turbidity by increasing the velocity of flow.

Dr. Hanson said that approach would likely be unsuccessful since the primary source of turbidity comes from runoff in the watershed and areas that have not been stabilized as much as the lower Sacramento River and the Delta.

Dr. Hanson remarked that multiple interacting variables, not just flows, affect salmonid populations, including predation, water temperature, quality of spawning and rearing habitat, water diversions, channelization, reduced access to floodplains and wetlands, ocean rearing conditions, and ocean harvest. He showed that the survival of juvenile San Joaquin River fall-run salmon has declined substantially in recent years despite high flows in the San Joaquin River. An increase in predator species could be part of the reason for declining juvenile survival.

Board Vice Chair Spivey-Weber observed that if predators are major contributor to juvenile salmonid mortality, it seems lower flows would lead to a concentration of predators.

Dr. Hanson acknowledged that Ms. Spivey-Weber's impression was correct but noted that when flows are increased in much of the channelized Delta system, there is no corresponding increase in lateral area. He said that the real relationship between salmonid survival and increased flow lies in increased turbidity—higher turbidity reduces the vulnerability of young fish to sight predators—and in getting the fish through the system and past the predators more quickly. Dr. Hanson showed data indicating that mortality rates of juvenile Chinook salmon are very high in the upper watersheds before the fish reach the Delta.

Board Chair Hoppin commented that Dr. Hanson's graph shows high juvenile salmon mortality in the upper Sacramento River watershed. He asked if Dr. Hanson had similar mortality data for the years before all of the Sacramento River diversions were screened and whether those screens had made a positive contribution to juvenile salmon survival.

Dr. Hanson said he does have data that span that period but there is such high variability in the results of those studies that it would be difficult to determine the effect of the screens. However, he does think the screens have been beneficial.

Dr. Hanson acknowledged that there is a relationship between flow and juvenile survival. However, it takes a large change in flow to effect a small change in survival. Flow alone is just part of the package; data from 2006 and 2009 suggest that ocean rearing conditions might have had the biggest influence on salmon populations in those years. Dr. Hanson observed that fish size and migration routes also have an effect on juvenile salmon survival—survival rates are higher for salmon migrating through the Sacramento River and lower for migration via the interior Delta. He said nonphysical barriers appear to reduce juvenile salmonid migration into the interior Delta but warned that a physical barrier at Georgiana Slough wouldn't be practicable because it is an important recreational boating corridor.

Dr. Hanson made additional arguments, including:

- There is no real relationship between the duration of juvenile salmonid migration and flow (i.e., increased flow alone will not reduce the duration of juvenile migration or reduce vulnerability to predation).
- Water temperature management within reservoirs is critical to maintaining suitable spawning and rearing habitat, and reservoir releases have no effect on instream water temperatures for most of the lower reaches of the Sacramento and San Joaquin Rivers and the Delta.
- Juvenile salmon survival through the Delta is independent of SWP/CVP export rates.
- Salmon salvage at the SWP/CVP facilities represents an extremely small percentage of juvenile salmonid outmigrants, and there is no relationship between smolt survival and SWP/CVP export rates.
- Tides dominate hydrodynamics in the Delta; sub-daily tidal flows are a major factor affecting salmonid migration route selection, and tidal flows overwhelm inflows in the western Delta. This means that increasing Delta inflow or outflows would not significantly affect salmonid migration rates.

Board Chair Hoppin asked if Dr. Hanson believes pulse flows could have a positive effect on juvenile salmonid migration.

Dr. Hanson said short-term events are important migration cues for salmon moving out of the system and adults moving upstream. Those small-scale flow changes would not be detected in the type of analysis he performs, but he is conducting the types of fine-grained monitoring needed to analyze the effects of pulse flows.

Board Chair Hoppin asked if man-made pulse flows or man-made events designed to mimic natural events could have the same effect on fish as natural flows.

Dr. Hanson said that some work has started on the Mokelumne and Cosumnes Rivers testing short pulse flow reservoir releases and how they stimulate downstream migrations. The responses in fish so far have been mixed, but Dr. Hanson believes that these studies will help separate out the role of flow change versus turbidity change.

Board member Moore asked about the efficacy of pulse releases made during storm events.

Dr. Hanson said that studies are presently underway assessing the effects of pulse flows released during storm events (to ensure flow synchronicity in the watershed) as well as after storm events (to increase the duration of flows).

Dr. Steve Cramer, Cramer Fish Sciences— Integration of Scientific Information and Decision-Making

Presentation summary: *Dr. Steve Cramer recommended that the Board support the development and use of salmonid lifecycle models to help determine if resources have been used in the most effective way. He also advised the Board to focus on protecting the coldwater pool to maintain suitable temperatures for spawning and rearing salmon, support creation, restoration, and conservation of floodplain and other habitats, and support the use of nonphysical barriers and other mechanisms to decrease salmonid migration into the interior Delta.*

Dr. Cramer noted there are a myriad of variables to consider when looking at Chinook salmon abundance. He showed some additional data reinforcing Dr. Hanson's assertion that ocean conditions are likely the driving force behind the 2008 salmon population crash.

Board Chair Hoppin asked what triggers salmon to return to the system to spawn and why there is age variation among individuals when that occurs.

Dr. Cramer said genetics are an important contributing factor to this variability—different stocks reach maturity at different ages, and separate socks in identical environments would have different maturity rates. While a portion of maturity is inherited, there are also environmental influences. Fish will respond to environmental factors with differences in growth between seasons.

Board Chair Hoppin asked if it is possible for salmon to be triggered to return home when conditions are less than optimal.

Dr. Cramer responded that timing of migration is an inherited trait, but different genetics cause different fish to return at different times during the migration season. Maintaining this genetic diversity is important for long-term survival of the species, and it is one of the challenges facing the Board in terms of finding a balance.

Dr. Cramer spoke about the importance of understanding what each life stage contributes to the robustness of the overall salmon run. He noted that lifecycle models that are spatially and temporally accurate can help the Board understand if it has used resources in the most effective way for the health of the salmon run.

Dave Fullerton, Metropolitan Water District— Introduction to Smelt Issues

Mr. Fullerton introduced the key points of the State Water Contractors' presentations on delta smelt:

- Lifecycle modeling indicates key drivers are food, temperature, and predation.
- Nutrients are important drivers of food web productivity.
- No statistical foundation supporting a relationship between X2 and delta smelt abundance in any season.

- Neither LSZ nor X2 define habitat.
- Entrainment does not drive abundance. Operations sensitive to OMR and turbidity have successfully ended large entrainment events.

Dr. Richard Deriso, Inter-American Tropical Tuna Commission (IATTC)—Lifecycle Model and Delta Smelt Entrainment

Presentation summary: *Dr. Richard Deriso's delta smelt lifecycle modeling results show that the most important influences on the delta smelt population are food abundance, temperature, predator abundance, and density dependence. Neither entrainment nor fall X2 appears to affect delta smelt abundance patterns. Entrainment levels are related to turbidity levels and OMR flows, suggesting turbidity can be used to manage adult entrainment.*

Dr. Deriso has developed a delta smelt lifecycle model with data spanning 1972–2010. Modeling results indicate the following:

- Food abundance, temperature, predator abundance, and density dependence are the most critical factors impacting the delta smelt population.
- Entrainment from water export operations is NOT an important factor affecting smelt population growth rate.
- Fall X2 is NOT an important factor affecting smelt population growth rate.
- Efforts should be focused on addressing environmental conditions affecting the species, such as food supply.

The data show a historic relationship between turbidity, OMR flow, and adult smelt entrainment. Dr. Deriso believes that turbidity can be used to manage adult entrainment.

Dr. Noble Hendrix, QEDA Consulting, LLC— Delta Smelt Habitat and Abundance

Presentation summary: *Through independent analysis, Dr. Noble Hendrix discovered that the relationship between X2 and delta smelt abundance, as determined by Feyrer et al. (2011), is in fact a series of induced correlations and is therefore meaningless. Factors other than X2 (like longitude and date) serve as better predictors of smelt abundance than the "habitat index" developed by Feyrer et al. Dr. Hendrix suggests the current "habitat index" model be expanded.*

Dr. Hendrix's presentation focused on his analysis of the Feyrer et al. (2011) study, which proposed a statistically significant relationship between X2, a fall "habitat index" measure, and delta smelt species abundance. Dr. Hendrix' analysis shows that Feyrer's argument for a correlation between X2 and the habitat index is basically a circular argument. X2 is measured by salinity, and habitat index is also based in part on salinity. Because X2 and the habitat index are both based on measures of salinity, it is guaranteed that there will be a correlation between the two.

Following the same methods of Feyrer et al., Dr. Hendrix fit a series of different habitat indices based on temporal and spatial factors to the presence/absence results of the FMWT catches. He found that other habitat indices, including longitude and date, fit the FMWT data better than Feyrer et al.'s habitat index. Dr. Hendix was careful to note he is not suggesting longitude and date should be used

as a model to predict delta smelt abundance but that the current habitat index model needs to be expanded.

Additionally, the FMWT catch data is used to establish Feyrer et al.'s habitat index as well as the FMWT abundance index. Correlations between Feyrer et al.'s habitat index and the FMWT abundance index are induced because the same data is used to produce both sets of data. This means a high correlation between the two indices is to be expected and is meaningless. Dr. Hendrix concludes that Feyrer et al.'s argued relationship between X2 and the FMWT index is simply a series of induced correlations.

Dr. Hendrix suggested the habitat index model should be expanded to incorporate more factors and should reflect the spatial patterns observed in smelt distribution.

Dave Fullerton, Metropolitan Water District—Outflow and Longfin Smelt Abundance

Presentation summary: *Mr. Fullerton showed that there is no demonstrated mechanism to explain the correlation between longfin smelt abundance and X2 and demonstrated that even if outflow per se increased abundance, the increases would be very small. He also illustrated that many factors other than flows are correlated with longfin smelt abundance, and suggested that the Board must take into account all of the other factors when determining what management actions would benefit longfin smelt.*

Mr. Fullerton showed that longfin smelt abundance has more of a discernible relationship to X2 than does delta smelt abundance. However, abundance levels related to each individual measure of X2 have dropped over the years, likely due to the invasion of the *Potamocorbula* clam and the pelagic organism decline (POD). This means that increasing flows to move X2 further west under current conditions would not result in a large population gain or restore populations to anything close to the levels of 20 or even 10 years ago.

Mr. Fullerton noted that although there is a correlation between X2 and longfin smelt abundance, no mechanism has been identified to explain the correlation. Many factors other than X2 correlate to longfin smelt abundance as well, including unimpaired flow, Napa River flow, Secchi depth, water depth, Mysid density, ammonium levels, and phosphorus/nitrogen ratios. Mr. Fullerton believes that the most plausible causal mechanism for longfin abundance is food supply and, ultimately, nutrient patterns. Mr. Fullerton recommends that the Board be more diligent about integrating data from different surveys into the assessment of what might be affecting longfin smelt abundance.

Dr. Richard Dugdale, San Francisco State University—Ammonium Inhibition and the Food Web

Presentation summary: *Dr. Richard Dugdale presented recent research showing that excess ammonium in the Bay-Delta estuary results in low phytoplankton production because it inhibits the uptake of nitrogen. He believes that the Board should seek to reduce ammonium discharge to improve phytoplankton production (and improve native species success) in the Delta.*

Dr. Dugdale presented a summary of his recently published paper, "River Flow and Ammonium Discharge Determine Spring Phytoplankton Blooms in an Urbanized Estuary." In it, he assesses the

empirical evidence supporting the "ammonium paradox"—that excess ammonium in the Bay-Delta estuary results in low phytoplankton production despite the traditional paradigm that excess nutrient loads cause phytoplankton blooms.

He observed that the Bay-Delta estuary has become less and less productive over time. He showed plots illustrating the link between phytoplankton and fish yield. The invasion of the *Potamocorbula* clam can explain some of the phytoplankton collapse, but the clams are not very active in the springtime, and the phytoplankton levels remain suppressed at that time of year. Additionally, the phytoplankton levels began to decline before the *Potamocorbula* clam populated the estuary. There was another variable changing in the system at the same time phytoplankton levels were waning: an increase in ammonia loading.

Recent science shows the pool of nitrogen phytoplankton needs to grow becomes unavailable for phytoplankton use when ammonium is present in the system above a certain level (4 micromoles). When that concentration is reached or exceeded, the available nitrogen does not get taken up for primary productivity and simply exits the bay into the ocean.

Dr. Dugdale recalled that there was a phytoplankton bloom in 2010 and observed flows in that year were over 50% greater than in 2009, and ammonium levels in 2010 were less than in 2009 by almost 1 ton per day. Under these conditions, phytoplankton levels increased by a factor of 10, zooplankton levels increased by a factor of 10, delta smelt populations increased by 70%, and longfin smelt populations increased by 194%.

Dr. Dugdale cautioned that although increased flow would affect nutrient concentration, it would not solve the loading problem. Too much flow could dilute the available nitrogen as well as the ammonium. Ammonium loading must be decreased in order to restore the proper ratio of ammonium to nitrogen. According to this research, Dr. Dugdale believes the most effective management action to improve primary productivity in the Bay-Delta estuary is to reduce ammonium discharge.

Questions from the Board

Mr. Fullerton offered to address some questions raised by the Board earlier in the workshop. The Board had asked about turbidity in the Delta, and Mr. Fullerton said turbidity in the winter and spring in the Bay-Delta estuary (particularly in Suisun Bay) is dominated by suspended sediment coming in from upstream. However, as measured by USGS, there is less and less suspended sediment coming into the system for the same amount of flow, and this has downstream repercussions. Less turbidity has the secondary effect of causing the depths to increase. The system goes out of balance if there is not enough sediment coming down the river, and the tides eat away at the bottom of the water column. Mr. Fullerton believes this is one reason why the channels have gotten so much deeper in the last 20 years. A paper by Schoellhammer suggested that around 2000, the reserve of sediment in the bottom of the estuary that is drawn on and suspended when turbidity is not high in inflows was depleted. That could be a big reason why turbidity dropped so much in the system in 2000. Mr. Fullerton observed that summer and fall turbidity levels are tightly correlated with phytoplankton and chlorophyll production.

Panel 8: San Joaquin Valley Water Suppliers Panel

Tim O'Laughlin and Doug Demko, San Joaquin Tributaries Association (SJTA)

Presentation summary: *The SJTA believes that increased flow alone is not enough to protect public trust resources in the Delta; SJTA feels a suite of flow and nonflow actions are necessary, including increased flows, installation of the HORB, predator suppression efforts, habitat restoration, the marking, harvesting, and exclusion of hatchery fish, and a reduction in Chinook salmon ocean harvest levels. They also noted that if the Board desires greater turbidity and phytoplankton in the system, the total daily maximum loads for turbidity and organic matter need to be revised to acknowledge that these elements are not pollutants. They discussed predator suppression at length and recommended that the Board require DFG to launch a predator control effort before DFG asks for increased flows.*

Mr. O'Laughlin believes the Board should set more specific and quantifiable goals than are contained in the 2006 Bay-Delta Plan. He noted that quantifiable goals are necessary in order to make informed decisions about what can be achieved with flows alone. Mr. O'Laughlin does not believe that the Board has had frank discussions about what can and can't be done to protect public trust resources in the Delta and what can be achieved based on the water costs of what has been proposed in the Board 2010 Flow Criteria Report. Mr. O'Laughlin proposed that the Board consider the following types of specific goals:

- Increase juvenile survival in tributaries.
- Increase juvenile survival in Delta.
- Increase ocean abundance.
- Increase freshwater returns.
- Increase natural/wild fish abundance.

He then listed some management actions the Board could take to meet the above specific goals:

- Increase spring flows.
- Install the HORB.
- Suppress predators.
- Improve habitat.
- Mark/harvest/exclude hatchery fish.
- Reduce ocean harvest.

Doug Demko reviewed what he considers to be the three key studies relating to flow and salmon smolt survival. The first study, published in 2001 by Baker and Morhardt, was a summary of relationships between river flow exports and Chinook salmon survival through the Delta. It drew on the results of the pre-VAMP coded wire tag releases. Baker and Morhardt found there is no scientific evidence that increases within the managed flow range would increase salmon smolt survival in the Delta or Delta tributaries. They also found there is no relationship between salmonid survival and the export rate. Their data show that migration route has a much greater influence on salmon survival than does flow.

In 2008, Newman published a paper that undertook a reanalysis of VAMP data. The paper showed that there is little evidence for an association between exports and survival. Newman also concluded the installation of the HORB could increase salmon survival.

In Dauble et al. 2008, an independent panel reviewed the VAMP studies to determine whether results provide evidence for a relationship between flows, exports and HORB operation, and salmon survival. The study found that Delta hydraulics and the impacts of predation appear to affect survival rates more than river flow. The study also recommended the installation of the HORB.

Mr. Demko wants the Board to use the best available science and believes the Board has been over reliant on flawed science, like the 2005 DFG San Joaquin River Fall-run Chinook Salmon Population Model, and should pay closer attention to the three reports he summarized. If the Board decides to disregard the reports, Mr. O'Laughlin requests that the Board inform the SJTA why it does not feel that the reports represent good science. He noted that the BDCP and the OCAP BO do not use the 2005 DFG population model.

Mr. O'Laughlin noted the attention being paid during the workshop to the importance of turbidity and phytoplankton to pelagic organisms and in salmon smolt survival. He pointed out that the Regional Board determined, through the TMDL process, that algae, nutrients, and phytoplankton are pollutants and established a TMDL for turbidity. If the Board would like to see more phytoplankton and turbidity in the Delta, it will need to change the TMDLs. He also observed that recent phytoplankton studies show almost none of the phytoplankton produced in the San Joaquin River makes it to the Delta because it is taken up by diversions.

Mr. O'Laughlin and Mr. Demko then discussed the benefits and drawbacks of various management actions proposed earlier in the presentation, summarizing them as follows:

Increasing spring flows. As a management action to increase salmon smolt survival, this alternative has the lowest scientific certainty of all the alternatives proposed by SJTA as there is no evidence that more flows in the managed range would increase salmon smolt survival in the Delta or Delta tributaries. He noted that in a 2012 letter, the USEPA recommended if the Board uses an unimpaired flow approach, the Board must specify quantifiable, measurable functionalities and goals. They observed that reservoir releases do not change flow functionality in a managed system because reservoir releases under managed flow conditions do not change Delta water temperature, dissolved oxygen, nutrients, or predation.

Installation of the HORB. As a management action to increase salmon smolt survival through the Delta, this alternative has high scientific certainty and would result in a quantifiable benefit. Studies have shown that salmonid survival doubles if the fish stay in the San Joaquin River instead of entering Old River.

Predator suppression. As a management action to increase salmon smolt survival, predator suppression has high scientific certainty and could be achieved immediately with little or no cost if anglers are used to remove predators from the system. Mr. O'Laughlin mentioned that the anecdotal evidence of the effect of predation goes back decades, and striped bass population estimates for the Clifton Court Forebay alone are around 1 million. He has observed total buyoff amidst the various Delta interest groups that predation is a problem for salmon survival in the Delta, and the predator suppression program on the Columbia River has been a great success. Mr. O'Laughlin recommended that the Board should require DFG to get predators under control before it asks for increased flows.

Board Chair Hoppin asked if focusing predator suppression efforts on predation hotspots would provide significant relief.

Mr. Demko said focusing on predation hotspots would be a start but would not provide the necessary level of eradication to make a real difference in salmon survival levels. Striped bass migrate to areas where the salmon smolt populations are highest, and, during the spring salmon smolt outmigration, striped bass are common as high in the Stanislaus River as Knights Ferry.

Delta habitat restoration. Mr. Demko observed that shallow-water habitat is a critical nursery area for the young of almost all native fish, but shallow-water habitat has been virtually eliminated from the Delta. He noted that flows have little to no impact on Delta habitat anymore since most of the channels are lined in riprap. He explained that this means more flows just get more rocks wet. Additionally, increased flows make less of a difference further down in the Delta because of the huge tidal influence. For these reasons, Mr. Demko cautioned that restoration of Delta shallow-water habitat cannot be accomplished through flow management. As an alternative for increasing salmon smolt survival in the Delta, Delta habitat restoration has medium scientific certainty and would be a long and costly effort.

San Joaquin River and tributary habitat restoration. Mr. Demko observed that as a management action to increase salmon smolt survival, floodplain restoration on the San Joaquin River and in tributaries has medium scientific certainty and would be long-term and costly. He cautioned that the opportunities for floodplain restoration on the San Joaquin River and tributaries are limited and floodplains with characteristics like the Yolo Bypass cannot be created through managed flows. Restoration of large areas of floodplain habitat would require major physical changes to the system.

Board Member Hoppin acknowledged creation of a big floodplain like the Yolo Bypass is unlikely on the San Joaquin River but said smaller projects could still be beneficial. He believes that as the Board is trying to mitigate for all the things (mainly dams) that have allowed society to move forward, it is not unreasonable for the Board to ask for improved conditions on the San Joaquin River system. He believes the Board needs to start upstream and work its way downstream, optimizing the ability of fish to upmigrate, spawn, and return to the ocean. He acknowledged the Board cannot ask the SJTA to improve conditions or mitigate for losses downstream of a certain point. He feels there is a reasonable expectation that the species under consideration can proliferate in the SJTA's zone of responsibility, and the SJTA should not have to be responsible for other zones. He said he can only reasonably expect the SJTA to provide the flows, temperatures, and habitat that will allow fish to return to the river system.

Reduce nonnative predator and Chinook hatchery fish influences. Mr. Demko and Mr. O'Laughlin believe that hatchery fish need to be marked, harvested, and excluded. They cited studies showing that fishing of both natural and hatchery fish has not only masked the decline of wild fall-run Chinooks, but also has led to the exploitation of wild stocks at unsustainably high rates with probable negative consequences for their life history and genetic diversity. Mr. Demko and Mr. O'Laughlin recommended a suite of actions that could reduce the influence of hatchery fish:

- Eliminate all offsite releases of hatchery Chinook salmon.
- Tag 100% of hatchery Chinook salmon with coded wire tags.
- Develop management plans with population-specific targets.
- Operate exclusion weirs at tributary mouths.

Decrease ocean harvest. As a management action to increase freshwater salmon returns, the scientific certainty is high that decreasing the ocean harvest would make an immediate contribution, but it would also have an immediate cost to fishermen. However, Mr. O'Laughlin observed that the Board's goal for 24 years has been to increase the number of adults returning to freshwater, and stressed the only way to achieve that is to change how NMFS manages the ocean harvest.

Mr. O'Laughlin believes a suite of flow and nonflow actions are necessary to protect public trust resources in the Delta, incorporating all of the management action alternatives discussed during the presentation. He recommended the Board pick a flow alternative that will provide reasonable protection to public trust resources and to clearly state what public trust resources will be protected and at what level. He cautioned against being vague.

Public Comments

Dierdre Des Jardines, California Water Research

Dierdre Des Jardines discussed the issue of "unstored water" in the Delta, which is a large component of supply for Delta exports. She explained that unstored water is the amount of water that would naturally be in the Delta over and above releases from upstream storage. She believes the quantification of unstored water has been divorced from the discussion of water quality and fish protection even though the two were very intertwined in early Board decisions. She stated her intent to review the information presented at the 1960 and 1967 Board hearings on USBR and DWR applications for diversions in the Delta. At those hearings, the quantity of water available in the Delta was a major issue. Joint studies by USBR and DWR showed that USBR's applications for diversions on the Sacramento River below Shasta Dam and in the channels of the Delta assumed the unimpaired flow of the Feather River, which was also the water supply for the SWP. The Board recessed, and USBR agreed on a protocol for sharing shortages, which was the first Coordinated Operating Agreement. The Board then approved USBR's applications.

Ms. Des Jardines then described the 1967 hearings on DWR's applications to divert water. At the time, the Board was considering only approving the application for diversion of stored water from the Feather River because it was concerned that USBR's diversions might be taking up all of the stored water in the Delta. DWR produced a study showing that, with augmentation of water supplies in the Sacramento River of 900,000 acre-feet from the planned Dos Rios Dam on the Eel River, there would be sufficient water. Ms. Des Jardines pointed out that the Dos Rios Dam was never built, but the Board has not revisited the issue of water supply for diversions of unstored water.

She noted that the Board had originally barred diversion of unstored water in the Delta in the months of July, August, and September because studies by USBR indicated no water would be available during August and only infrequently during July. A study by DWR indicated that September was also a month of questionable supply. However, DWR filed a petition for reconsideration of Water Right Decision 1275 and of the season of diversion, arguing that not all Delta diversions were being used at the same time and some of the upstream water rights were still in development. DWR's study showed that in 1 out of 5 years, water would be available for diversion. Ms. Des Jardines observed that the assumptions of this study were never checked, and the Board assumed that the study was sufficient to show water would be available in some years and approved the diversion. However, diversions of unstored water now occur in every year during these months, whether the water year

is wet or dry, yet the Board has not revisited the issue of the surplus water available in the Delta during July, August, and September.

She also pointed out that DWR's definition of "surplus water" in the Delta is circular. It defines surplus water as "existing when export limits allow diversion of more water than is being released upstream." As a result, Ms. Des Jardines said, there are many times when diversions of water are so high that normal outflows from the channels of the Delta to the lower Sacramento River are reversed. These negative outflows are not captured by the DWR definition of Delta outflow, which includes the entire flow in the mainstem of the Sacramento River. She looked at data showing Delta outflow as measured at Jersey Point, and they show prolonged high negative values starting in the mid-1980s. She noted that this was a time of many of the negative step-changes that have been discussed during the workshop, including declines in the pelagic fish, reduced Secchi depth, and population explosion of the *Corbula* clam in the Suisun Bay.

Ms. Des Jardines remarked that studies continue to show high entrainment of adult fish in the summer months and a recruitment break between spring and fall populations of threadfin shad, which were formerly the most abundant fish in the estuary.

She observed that climate change studies indicate the shortages of water supply in the summer will only be getting worse and that the percentage of dry and critically dry years will increase, starting now and becoming very marked at mid-century.

Ms. Des Jardines believes these diversion problems have been long standing and that they will be getting worse. She urged the Board to review export water supply along with its own review of water quality standards and recommended requiring both the CVP and SWP to provide quantity reports of unstored water diversions.

Leah Orloff, Contra Costa Water District

Leah Orloff noted that CCWD's key input for the workshop was provided by Deanna Sereno. However, Ms. Orloff wanted to provide a brief response to a few things she heard throughout the workshop.

First, in response to Board Chair Hoppin's question regarding whether the increased salinity in the Delta is due to climate change, Ms. Orloff responded that the answer is, "not primarily." The increased Delta salinity observed in the last 150 years of the historical record is primarily due to channelization, land use changes, and water operations.

Second, in response to the Board's question about tidal marsh restoration and whether the salinity effects are being considered, Ms. Orloff's said CCWD certainly hopes so. Ms. Orloff said CCWD takes every opportunity to remind proponents that they need to consider these things. In particular, with respect to Suisun Marsh, CCWD is following this issue very closely. Some projects in Suisun Marsh will increase salinity intrusion, and some will act to repel salinity. It depends on the location and the connectivity to channels and bays. Of course, CCWD's direct interest is in drinking water quality at its intakes, but this issue also has ecosystem effects.

Finally, Ms. Orloff responded to several comments heard during the workshop about increased DCC closures. She believes the closure of the DCC has the potential to increase salinity in the interior Delta and may contribute to adverse fish effects by contributing to reverse flows on the San Joaquin

River. She recommended that if the Board considers additional DCC closures that it should perform a careful balancing of beneficial uses.

Kaila Hirschbein, Golden Gate Salmon Association (GGSA)

Kaila Hirschbein explained that the GGSA represents commercial fishermen, recreational fisherman, businesses, and Native American tribes, all of whom rely on salmon for their livelihoods. The GGSA believes that salmon are an important public trust resource, and should be at the front of everyone's minds. She was pleased to see a lot of consensus during the workshop on what work needs to be done to protect and restore salmon. She noted that the GGSA has been working with the Salmon Task Force and with the fish agencies to put together a comprehensive plan to achieve the salmon doubling goal. The report is not complete yet, but it addresses predation hotspots, flow, habitat restoration, and other on-the-ground efforts that can be done in the next few years to ensure sustainability and that salmon fishing remains a viable livelihood for the GGSA's members.

Ms. Hirschbein noted that, even if all of the Salmon Task Forces' projects are implemented, habitat restoration and on-the-ground changes will have no benefit without improved flows. The GGSA believes the best option for the salmon is to take a comprehensive approach with habitat restoration and restoration of the natural hydrograph.

She urged the Board to understand that this issue is not about "people versus fish"—there are tens of thousands of people who rely on salmon for their livelihoods. Salmon is an important part of California's history and culture.

Board Chair Hoppin expressed gratitude to the GGSA and the Salmon Task Force for developing a recovery plan. He remarked that a plan that lines out steps to recovery is very helpful to the Board, and he applauds the GGSA for taking the time to develop such a plan.

> **Ms. Hirschbein** thanked the fish agencies for their participation in plan development as well and said that the plan should be complete in the next few months.

Zeke Grader, Pacific Coast Federation of Fishermen's Associations (PCFFA)

Zeke Grader introduced himself as the Executive Director for the PCFFA, which is a member of the GGSA. He stated his goal was to remark on the relationship of flows to salmon that have been observed by members of his organization over the past 50 years. He noted that his interest is only in what is necessary for abundant salmon runs.

He observed that in years with higher flows, which also usually indicate less pumping, his fishermen see good salmon production. This was very evident during the El Niño years of the mid-1980s. However, during the drought years of the early 1990s, which were also marked by increased pumping to make up for shortages to the water system, PCFFA fishermen saw salmon production drop off.

Mr. Grader believes that many of the presentations of the workshop were full of clutter and did not provide much clarity. He was careful to note that the PCFFA is not interested only in flows; his organization is working on many other issues that affect salmon run population, like ocean conditions, predation, water quality, and hatchery reform. He noted that if people are concerned

about predation, it might be time to consider re-introducing the commercial striped bass fishery, which existed in California for about 50 years between the 1880s and 1930s.

Mr. Grader expressed his appreciation of the Board's willingness to take on the issue of flows. He said it was disappointing to see both the CALFED and Delta Vision processes run for the weeds when it came to addressing flow. He encouraged the Board to keep a perspective on what is going on overall. He said that it is fairly clear by reviewing the records that flow will be a critical component of restoring salmon.

Patrick Porgans, Planetary Solutionaries

Patrick Porgans reminded the Board that it has a mandate to protect fish and recommended numeric flow requirements for fish during the D-1641 hearings. He does not believe the Board has done an adequate job in protecting fish. He observed that the current process appears to be focused on minimizing the amount of flows needed to meet the salmon doubling goal, and the water contractors are characterizing predation as a "big problem" in order to avoid increasing flows for fish. He said the Board needs to ignore such stall tactics and establish numeric flow requirements for fish.

He also remarked that the Board has stood by and done nothing every time USBR and DWR have violated the terms and conditions of their permits, despite requests from the State Senate Pro Tem to enforce the law. He said the bottom line is that high flows mean high fish populations. He also said it is necessary to tie river, Delta, and ocean studies together. He closed by praising Dierdre Des Jardines's research and presentation.

Chris Shutes, California Sportfishing Protection Alliance

Chris Shutes stated that his organization would be submitting reports to the Board that present a different vision of striped bass' predation functions on salmonids than were presented by the SJTA. He also paraphrased Matt Nobriga, who during the "Striper Trial" said, in his opinion, reducing the number of striped bass in the system would likely not increase the number of successful salmon up-migrants.

Mr. Shutes noted that the California Sportfishing Protection Alliance takes issue with many of the things heard during the workshop, but that one issue in particular stuck out for him. The SJTA said it is willing to deal with salmonids and predation downstream up to a certain point, but that it doesn't seem to be willing to contribute San Joaquin River flow for Delta hydrodynamics and pelagic fisheries. He said he can understand why the SJTA doesn't wish to increase flows, but he thinks it is up to the Board to make sure flow is firmly included in its consideration of San Joaquin management actions.

Board member Marcus asked Mr. Shutes to provide a short explanation of why he doesn't think striped bass and predation make a difference for salmon.

> **Mr. Shutes** said research shows that there is more predation by striped bass on other predators than there is on salmon. However, he stated that he is not a striped bass expert, so he will leave it to the fisheries experts to answer the Board's question.

Return of the Invited Expert Panel

As requested by the Board, the Invited Expert Panel members reconvened to share their thoughts on the concepts presented by the other panels throughout the workshop.

Board Vice Chair Spivey-Weber asked the Expert Panel members if, based on what they heard during the workshop, they would change any of their recommendations. *[The panel provided three lists to the Board: (1) the implications of current fisheries science for improved management, (2) recommendations for strategic investment in improved scientific knowledge, and (3) key new ideas that should be considered in a forward-looking Bay-Delta Plan.]*

Dr. Rose replied that the panel members reached a consensus on the matter and decided they would not remove anything from the lists of recommendations but might emphasize certain issues differently. First, it became clear that predation is a much more prevalent issue than the panel had originally assumed. Second, the panel would emphasize several other things, like the real need for field experiments. Third, the panel would emphasize the huge numbers of correlations that are being used to determine what is going on in the Delta and what the management actions should be.

Dr. Largier echoed Dr. Rose's thoughts, remarking that he as an individual would not take anything out of its lists or add anything, but he would amplify the following concepts:

9. Bottom-up effects of the food web.
10. The importance of smaller scales for some indices.
11. The importance of turbidity in the food web.
12. Environmental influences on data.
13. Predation.
14. Entrainment.
15. The importance of specific measurable goals for management actions.

Mr. Cavallo said the workshop presentations caused him to think mainly about data. He thinks the Expert Panel's recommendations could be improved by emphasizing telemetry data from fish-tagging efforts. He recommended that the Board look carefully at existing and upcoming fish-tagging reports that will help explain what's going on with salmon in the Delta and what does and does not influence them.

Board Chair Hoppin observed that invasive species are often discussed almost in passing. He noted that some invasive species come and go, like the mitten crab, but some become a permanent part of the ecosystem with an economic value, like striped bass. Currently, there is concern about jellyfish and the *Potamocorbula* clam. Mr. Hoppin asked the expert panel to discuss how the Board should deal with invasives and at what point invasive species evolve into a permanent part of the ecosystem.

Dr. Rose remarked that prevention is the best approach—there are ways to reduce the risk of invasive species. These methods may not eliminate the risk, but they do reduce the risk. Once preventative measures are in place, it becomes a question of optimization. He observed that invasive species are a part of life in the Delta, so the Board needs to develop a flexible way to deal with them focused on cautionary principles.

Mr. Baxter said that most of the important invasive species are in the system to stay, but just like any other organism out there, circumstances (either man-made or natural) will shift for or against them. The more that is understood about those species, the more management agencies will be able to adjust the conditions that are under their control to be inhospitable to invasives. Mr. Baxter also noted huge environmental changes are likely to occur in the future that will push freshwater fish into smaller habitats, and there is likely not much the Board will be able to do about it.

Dr. Sommer observed that regulators and scientists often do not look at species in the same way. Scientists look at invasive species and native species as indicators. The decline in both pelagic fish populations and in nonnative bass and threadfin shad populations indicated to the scientific community that something huge is changing within the system.

Dr. Rose noted that modeling can help the Board prepare for big changes and invasive species invasions and help to determine the system's vulnerabilities.

Board member Marcus said she likes the idea of giving the native species more of a fighting chance and doesn't believe that native species should be given up on at this point.

Board member Moore pointed out an item in the Expert Panel's original submission and asked if the panel would want to update it. He recalled a slide identifying four "management hindrances," which included lack of variable flow in the Delta, a homogenous Delta, hatchery practices, and harvest in the ocean. Mr. Moore wondered what the Board could do to address any of those hindrances. The Board has some control over flow, and Mr. Moore pointed out that there is already a variable flow regime in the current Bay-Delta Plan. He also mentioned timescales and observed that timescales of scientific effects and timescales of water supply operators are very different. He asked the Expert Panel to discuss optimization of time scales in terms of management. In regards to the hindrance of a homogenous Delta, Mr. Moore observed that the Board could affect change in that area by facilitating restoration projects through permitting. He said the Board needs to be informed about how much detail it should get into in terms of specific projects that should be required to protect beneficial uses. He does not believe the Board has much control over hatchery practices or ocean harvest practices. Finally, he asked if it would be fair to say that the Expert Panel would add a fifth "management hindrance" for predation?

Dr. Rose responded he would not personally add predation to the list of management hindrances. He would include predator control as a potential management action that the Board could encourage or demand. He is not convinced that predation rises to the level of importance of the previously identified management hindrances.

Mr. Cavallo pointed out that those "management hindrances" related specifically to salmon life history diversity.

Mr. Baxter noted that DFG will be convening a panel to investigate predation, how DFG might perform experiments to see what predation impacts actually are, and if it is possible to do anything about it. He personally does not feel he has enough information on predation to make any solid statements about the necessity of predator control efforts.

Board Vice Chair Spivey-Weber recalled that the CCWD recommended using a flow index if OMR flow standards are established. She asked if any members of the Expert Panel have assessed the suggested flow index.

Mr. Harader indicated the flow index has not yet been studied.

Mr. Cavallo noted that it requires a lot of scientific knowledge to address the question of a new flow index, as there is a lot of evidence that the effects are different for salmonids than for other fish.

Dr. Largier believes that several indices should be studied, and the one that works best and has the best mechanistic results is the one that should be selected. He observed that the best way to select an index is not to simply accept the first option suggested. He believes that someone must "get dirty" with the data in a situation where everyone can discuss it.

Dr. Rose observed that the Board is faced with a difficult challenge in filtering through all of the contradictory information that is being presented in the workshops. The Expert Panel's impression is that some of the information provided during the workshop was very good, some of it was simply chatter, and some of it was misguided. The Expert Panel suggests the best way to approach this process is not through review and summary but through approaching the issues raised during the workshops like scientific questions. It will be a formidable science challenge to figure out what is the good information. He remarked that there will always be issues of trust involved in proceedings like the present one, but some of the uncertainties caused by different people getting different results from the same data can be resolved if the right people are put in a room together.

Board member Marcus noted that the SJTA presentation cast some doubt on the 2005 DFG San Joaquin River Fall-run Chinook Salmon Population Model. She asked the Expert Panel members if they agree that there are other, better studies on which to rely.

Mr. Cavallo believes there are different purposes to the DFG model and the other studies recommended by SJTA. He said that he has read the DFG report and thinks there is something real there regarding flows. He'd like someone to do the analysis the right way and not just discard the data.

Dr. Harader remarked that one criticism of the DFG model is that it only looks at one part of the salmonid lifecycle.

At this point, a DFG representative, not a member of the Expert Panel, spoke on behalf of DFG. He noted that DFG has continually rebutted Mr. O'Laughlin's criticisms of the model. The model has been revised, and DFG would be happy to provide that information to the Board. He said DFG would be happy to discuss the model with the Board but did not discuss it during the workshop because DFG was not aware that the San Joaquin River would be discussed. He said that DFG would work with Board staff to ensure the Board has the latest information.

Closing Thoughts

Board Chair Hoppin thanked everyone for their participation and for remaining civil.

Workshop 3: Analytical Tools for Evaluating Water Supply, Hydrodynamic, and Hydropower Effects

The topic of Workshop 3 was, "Analytical Tools for Evaluating the Water Supply, Hydrodynamic and Hydropower Effects of the Bay-Delta Plan." The Board identified key interest groups in the initial noticing for Phase 2, and designated a consultant, Brock Bernstein from ICF International, to work with stakeholders to develop a workshop format and a series of panels to represent each interest group. A copy of the final agenda for Workshop 3 is in Appendix A. Two specific questions were posed for discussion during this workshop:

16. What types of analyses should be completed to estimate the water supply, hydrodynamic, and hydropower effects of potential changes to the Bay-Delta Plan?
17. What analytical tools should be used to evaluate these effects? What are the advantages, disadvantages, and limitations of these tools?

Welcome and Agenda Review

Board Vice-Chair Fran Spivey-Weber opened the workshop and introduced members of the Board and Board Staff. Board Staff, Rich Satkowski (Senior Water Resources Control Engineer, Division of Water Rights) provided an overview of the topics to be covered in the workshop.

Panel 1: Invited Expert Panel

Dr. Peter Goodwin, lead scientist for the Delta Stewardship Council, described how the expert panel was convened. The panel represents a range of disciplines (water resources, hydrodynamic modeling, hydropower modeling, and ecological modeling) and was tailored to answer the specific questions posed for the workshop.

Dr. Jay Lund, from UC Davis, noted that the theme of the panel's presentation was "Modeling is for developing insights." He provided an overview of the panel's presentation.

John DeGeorge, Resource Management Associates

Dr. John DeGeorge provided some background on Delta modeling concepts, and used some animations to demonstrate basic Delta mechanics. The Delta is made up of rivers flowing into an estuary, he said, and showed that the mixing and movement of water where it meets the estuary drives much of the water quality and ecosystem function in the Delta; these factors are therefore the focus of Delta modeling. The primary mechanisms affecting water quality and salinity in the Delta are net flow, tidal mixing, and gravitational circulation. He also reviewed key criteria for good modeling in the Delta.

Key Questions from the Board

Board Chair Charles Hoppin questioned the use of particle models to predict the movement of fish.

> **Dr. DeGeorge** said that there have been some encouraging results in the area of utilizing particle models, along with turbidity and salinity, to predict Delta smelt behavior. However, he acknowledged that these models need to be tested with more observational data. He also believes that there should be more collaboration between biologists and modelers. **Dr. Lund** noted that one of the Expert Panel members, Jon Burau, was unable to attend the workshop because he was in the field preparing an experiment in this vein. He believes models can help scientists figure out how much of fish movement is influenced by hydrodynamics and how much is behavior.

Board Vice-Chair Spivey-Weber asked Dr. Goodwin how better collaboration between biologists and modelers could be achieved.

> **Dr. Goodwin** said that fish behavior modeling is one of the most active research areas in the Delta right now, and that networks are being created. **John Durand** agreed that, in general, biologists have done a poor job of interfacing with engineers, but he believes that a good community is developing now.

Jay Lund, UC Davis

Dr. Lund provided a summary of the Expert Panel's written report to the Board. It contains 12 key concepts organized into three areas. He noted that the general philosophy of modern engineering is that if one uses mathematical models to make mistakes, fewer mistakes will be made in the field.

Framing Comments: "How do we explore a large, complex, controversial problem?"

18. Models do not stand alone. The model, the input data, and the modeler are all important, and the modeler is often the most important element.
19. "Different models for different problems." There is no one best model, and having a variety of models available helps explore and test insights and estimates.
20. Models summarize understanding, and provide a forum for technical people to have discussions.

Models can summarize a large amount of information; the designs of the most complex systems in the world rely on computer models (buildings, bridges, aircraft). The expert panel believes models are needed for adaptive management and planning.

Near-Term Recommendations: "Getting more useful insights from modeling efforts."

21. Use models to show how the Delta works and ensure that all parties have a full understanding of Delta physical processes.
22. Models must be documented and interpreted more critically. Many available models can provide critical insights, but models should be more thoroughly documented, more explicitly tested, and more thoughtfully and critically interpreted in both development and application.
23. Each model application should include strengths, weaknesses, and limitations. All model results are imperfect. Modelers should best know model weaknesses and limitations and state them with their results. Inadequate presentation of weaknesses and limitations reflects poorly on

model and modeler reliability. Boards and agencies should insist on more complete interpretations of results, including weaknesses. The Expert Panel suggests tests for Delta hydrodynamic models.

24. There is a need for clear statements of desired states: "What are we looking for?" Modeling is a search for insights; as such, modeling would be more useful at the policy level if the modelers knew what the Board's desired states for the Delta were. The Expert Panel believes that if the modelers do not have a clearer vision of what the Board is looking for, modeling results will present what the different stakeholders are looking for.
25. The Board can make better use of modeling. The Expert panel recommends using a group of independent experts to advise on modeling issues. It also recommends employing independent experts to assess and summarize the body of presented modeling results and encouraging stakeholder groups to present consolidated, organized, and documented sets of modeling results, with syntheses for policy. Independent technical assessments can raise the overall quality of testimony and insights from results.
26. The State needs a plan for Delta-related modeling. The Expert Panel believes that the State agencies should come together in a community approach to develop one plan because the modeling needs for the Delta exceed the capacity of any one agency, consulting firm, or university. A community-based approach could dampen some of the "combat science" that is so common.

Preparing for the Future: "The Delta is a changing problem, and useful models and data take time to develop."

27. Integrate our understanding by integrating our models. Dr. Lund said that integrated understanding requires an integration of modeling, and will give the Board a better ability to find insights and solutions. The Expert Panel believes this will require stronger state leadership to achieve.
28. Model and data development are too important for one agency. Each agency has limited financial resources and expertise for modeling and data development, and the interests of individual agencies are often too narrow to develop broader insights and solutions. Community-based modeling efforts seem promising for overcoming these limitations, and the Expert Panel believes that the State Board is in a good position to encourage cooperative data and model development efforts.
29. Major changes will occur in parts of the Delta and Bay, and adapting to those changes will be easier with forward-looking and adaptive analytical capabilities.

Key Questions from the Board

Vice-Chair Spivey-Weber asked the panel where they envision the leadership for a statewide modeling effort will come from.

Dr. Lund said he believes the Board itself is in a position to motivate the State to develop that leadership. **Dr. DeGeorge** noted that multi-disciplinary efforts do happen, but the collaboration occurring now is on a project-by-project basis. Once the collaboration begins on each project, each party gains tremendous insight from crossing over. **Dr. Lund** agreed, observing that interdisciplinary efforts have been sporadic, not systematic or sustained.

Board Member Tam Doduc asked the panel for recommendations on how to motivate and fund a statewide multidisciplinary modeling effort.

Dr. Lund does not believe the Board is in the position to fund a statewide modeling effort, but he does think the Board is in a position to motivate the development of a plan. He remarked that much of the IEP's data collection is motivated by State Board requirements. He suggested that the Board might expand its requirements to include sustained modeling. **Greg Gartrell** supported Dr. Lund's suggestion, observing that encouraging established programs to change into more comprehensive programs will be slightly easier than trying to create new programs with no extra funds. **Dr. Lund** mentioned that a Delta Science Plan will be developed over the coming year, and proposed that a comprehensive monitoring program should be part of the discussion.

Board member Felicia Marcus asked how the Delta Stewardship Council currently plans to address this issue in the Delta Science Plan.

Dr. Goodwin said that in developing the Delta Science Plan, the Delta Stewardship Council is tasked with examining how collaborative approaches and accessibility of data can be enhanced, including how to improve the cyber infrastructure for easy communication. **Mark Stacy** noted that when a group "releases" its data, it doesn't necessarily mean the data is accessible. He believes that building accessibility into even short-term projects is a way to help build collaboration.

Board Chair Hoppin expressed concern that the State does not have an official salmon policy, other than the narrative salmon doubling goal.

Dr. Goodwin noted that the science community can provide the scientific basis for how policy decisions can be made, but the actual decisions have to be made by the Board.

Board Vice-Chair Spivey-Weber said that the policy folks often need the scientists to help sort out the science from the policy and help identify policies that are not flexible or responsive enough. **Board Chair Hoppin** said it is easy to identify an end goal, but it will take a long time to achieve that end goal, and many species could go extinct during that timeframe. He thinks an interim plan is needed.

Dr. Goodwin advised the Board to have faith in the adaptive management process.

Board Vice-Chair Spivey-Weber observed that it is difficult to practice adaptive management in a system that is utilized to the maximum (for water export, for fishing, etc.). She believes that for adaptive management to work in the Delta, the Board will have to be more conservative with resources, and that will be difficult from a political perspective.

John DeGeorge, Resource Management Associates

Dr. DeGeorge showed some more model animations that illustrate how salinity accumulates in the Delta during the dry season, how water exports affect salinity and source water distribution, and what affects residence time in the Delta.

Key Questions from the Board

Board Chair Hoppin requested that similar model runs be performed for the peripheral pipeline.

Dr. DeGeorge observed that source water distribution in the Delta will change radically if the export location is moved.

Jay Lund, UC Davis

Dr. Lund recommended that Board procedures should:

- Increase the demonstrable quality and discussion of modeling results and conclusions.
- Improve the organization and coherence of modeling work and insights.
- Improve the long-term development of analytical tools and data among many groups.
- Organize policy-making to better employ modeling results. Dr. Lund commented that policy-makers and scientists often try to organize science to be better for policy-making, but he believes that sometimes, policy-making needs to be reorganized to better take advantage of modeling results.

Elaine Archibald, California Water and Environmental Modeling Forum

Elaine Archibald made a brief statement describing the California Water and Environmental Modeling Forum's (CWEMF's) capacity and willingness to assist the Board. She noted that CWEMF is a non-profit, non-partisan organization that is highly respected, and could help via technical workshops, peer review, and bringing biologists and modelers together. She also noted that in 2005, similar to the current call for a community-based modeling process, CWEMF called for the development of a strategic analysis framework and hoped to start developing databases that could be used with models to answer questions and solve some of California's water-related problems. She believes that document could be the basis for a Delta modeling plan.

Panel 2: Alternative Modeling Approaches

Russ Brown, ICF International–Daily Hydrology and Fish Tracking Methods in the Central Valley and Bay-Delta

Dr. Russ Brown encouraged the Board to compile, organize, and evaluate daily historical data. He believes that a collection of "daily data atlas" files would greatly increase shared understanding of aquatic habitats and fish distribution, movement, and abundance patterns throughout the Central Valley and Bay-Delta. Such a compilation of daily data would:

- Provide an official organized inventory of flows, habitat conditions, and fish data to identify flow-fish relationships and patterns.
- Allow the comparison of daily flow, temperature, and salinity data with daily reservoir and Delta objectives to identify effective changes in operations (rules).
- Estimate adjustments in daily historical flow, habitat, and fish data to identify and evaluate likely benefits.

- Provide a basis for water accounting and fish tracking to achieve a reasonable balance of multiple beneficial uses and public trust values (documentation).

David Purkey, Stockholm Environment Institute – The Central Valley WEAP Model

David Purkey presented his organization's Water Evaluation and Planning System (WEAP) model to the Board. He described it as a "generic, object-oriented, programmable, integrated water resources management platform" that has been used by the California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) for major system-level planning exercises. He said he had not spoken to Board staff in detail about their interest in WEAP, but thinks they are considering using it to look at larger-scale opportunities for the Delta and to help identify arrangements that could achieve multiple benefits.

Key Questions from the Board

Board Member Steven Moore observed that the Board has heard a lot about the weaknesses of analyzing data on a monthly time-step, and asked if WEAP offers the opportunity to drill down to a finer (for example, daily) time scale.

Dr. Purkey said that the user can define the time scale used in the model, and WEAP has been used at a fine time scale for specific locations. However, he believes that a monthly time-step is appropriate for system-wide analysis, and to program the model to assess the entire system on a daily time-step would require the model to be rebuilt.

Panel 3: Regulatory and Fishery Agencies

Dean Marston, CA Department of Fish and Game – San Joaquin River Fall-run Chinook Salmon Population Model: "SalSim"

Dean Marston provided an overview of the different versions of DFG's San Joaquin River Fall-run Salmon population model, including version 2.0, which is referred to as "SalSim," and addresses flow and multi-ecosystem questions. SalSim is a system-wide, full life cycle model that contains three submodels: a water operation model, a water temperature model, and a salmon model. It assesses three interrelated geographical areas (inland, delta, and ocean), and has the ability to link with other basin-wide models, like HEC-5Q. DFG expects to release the SalSim model in January of 2013, once model documentation is complete.

Key Questions from the Board

Board Chair Hoppin asked if salmon straying to rivers other than their home streams for spawning has an advantage for genetic diversity, or if DFG considers straying in all cases to be detrimental.

Mr. Marston acknowledged that not all straying is bad, depending on the goal.

Board Chair Hoppin asked how carrying capacity is balanced in the model. He asked if food supply is an issue for smolt carrying capacity, and whether hatchery-released smolts monopolize the food supply.

Mr. Marston responded that carrying capacity can be an issue at any part of the life cycle. For example, redd availability is the limiting factor for spawning, and channel constriction is the limiting factor for fry rearing. He said there are a variety of ways carrying capacity enters into the equation, but he has not seen any indication that food supply is a limiting factor for smolts.

Patrick Coulston, CA Department of Fish and Game–Observations Regarding the Use of Biological Models

Patrick Coulston focused his comments on smelt-related models and methods. He provided specific biological model recommendations as follows:

- Salvage-density method of entrainment assessment. This method is crude but simple and transparent. It has historically been used on a monthly time-step, but could be used on a finer time-step.
- Kimmerer proportional entrainment method. This method estimates the proportion of the population entrained, and comes close to approximating the population effect of entrainment.
- Abundance-X2 (outflow) models. Several credible potential mechanisms underlie this model, and it has pretty good predictive capability. There is a pretty consistent relationship between outflow and age-0 longfin smelt.
- Delta smelt abiotic habitat index. This model is based on evidence that salinity and turbidity best predict juvenile delta smelt occurrence. However, it does not address biological components of habitat.

He noted that applicable full life cycle models for smelt are not presently available, and likely will not be available within the necessary timeframe for the Bay-Delta Plan update.

DFG believes that collaboration on the selection and use of both physical and biological models is critical, and recommends establishing workgroup(s) to support efforts, seek consensus, and ensure that models are appropriate for the questions being asked. DFG also recommends that the Board strive for a priori mutual understanding of model assumptions and limitations, and consult with input data-set experts as appropriate.

Key Questions from the Board

Board Chair Hoppin asked if all turbidity is created equal—for example, when biologists talk about the smelt benefits of turbidity, are they talking about sediment or phytoplankton?

Mr. Coulston responded that not all turbidity is created equal. Any type of turbidity can assist smelt in avoiding predation, but turbidity caused by sediment does not play a role in food provision, whereas turbidity caused by phytoplankton does.

Candan Sokyan, US National Marine Fisheries Service – A Flexible, Multi-Input Life Cycle Model for Chinook Salmon in the Central Valley of California

Dr. Candan Sokyan explained that salmon have a complex life cycle that takes them through the river and ocean and exposes them to a diversity of threats. He believes the best way to determine which

efforts will be most effective to help salmon is through life cycle modeling, and he showed the Board how NMFS' salmon life cycle model works. The model is intended to identify the direct and indirect effects of Delta management actions on Chinook salmon. NMFS believes the current model, which will be complete by the end of 2012, is robust, but can be improved. NMFS expects to release the second version of the model by the late fall of 2013.

Key Questions from the Board

Board Vice-Chair Spivey-Weber asked if the NMFS developers of the salmon life cycle model have been working with DFG and SalSim.

Dr. Sokyan responded that NMFS has not worked directly with DFG or the SalSim model, since NFMS' model focuses specifically on the Sacramento River. However, NMFS is planning some workshops and Dr. Sokyan hopes to talk to Mr. Marston and DFG.

Julie Zimmerman, US Fish and Wildlife Service – Using "Structured Decision Making" to Manage Uncertainty and Improve Management Outcomes

Julie Zimmerman relayed FWS' recommendation that the Board utilize the structured decision making (SDM) process for the Bay-Delta Plan update. SDM could help the Board establish a sound decision-making process, synthesize modeling and other technical information, and develop a plan to evaluate and manage uncertainty. She noted that FWS used SDM for their American River habitat restoration effort, participating in a week-long process with a professional SDM coach. FWS believes SDM is a good way to create a defensible, transparent process.

Bruce Herbold, US Environmental Protection Agency

Dr. Bruce Herbold did not have an official presentation; instead, he responded to some of the comments and questions he heard during previous presentations.

- **Smelt and types of turbidity**. The function of turbidity changes with season. During the wintertime, sediment is the main thing that causes turbidity. In the larval smelt facility, they use clay to substitute for turbidity and it works just fine for the smelt; so as far as smelt are concerned, turbidity caused by sediment and food blooms are interchangeable, if not surrogates for each other.
- **How to balance the "conflicting needs" of salmon and smelt**. Dr. Herbold noted that in the Prospect Island planning process, there were conflicts between the needs of smelt and salmon, but they utilized a process similar to SDM and were able to find compromises. It was a very productive, fun day, and they were able to use various models on the spot to identify trade-offs of different ideas in real time. He urged the Board to set up a similar process that will allow it to utilize models in a similar way. He also noted that salmon and smelt are not always in conflict with each other; for example, they both rely on the first flush of the winter and the accompanying rise in turbidity. They are not in competition with each other; rather their conflicts are with how we manage the system.
- **Salmon goals**. In response to **Board Chair Hoppin's** concern that the State and Board have no real goals for salmon outside of the narrative doubling goal, Dr. Herbold noted that the Board

does have other salmon goals expressed as beneficial uses. These include the "Rare" beneficial use category, the cold-water fish objective, and migratory corridors objective in the Bay-Delta Plan. He encouraged the Board to use modeling tools to help figure out how to meet these objectives.

- **Adaptive management "on the cusp."** Management needs to be very involved with modeling and monitoring. The Delta is no longer in a position where an experiment can be set up and left alone to gather data for 20 years. The Board needs to monitor the Delta constantly to see what models are correct, and to distinguish the signal from noise. He believes that the Board will be able to do its job if it puts together the great physical models that exist with the upcoming fish models.

Panel 4: Resource Management Agencies

Eric Reyes, CA Department of Water Resources— General Model Descriptions and CALSIM II Case Study Description

Eric Reyes Provided a brief discussion of the capabilities and limitations of four selected water models utilized by DWR:

- CALSIM II, a statewide long-term planning model that simulates operations of the State Water Project (SWP) and Central Valley Project (CVP). It represents the Sacramento and San Joaquin River systems as well as the Delta and accounts for system operational objectives, physical constraints, and legal and institutional agreements and statuses. It can evaluate potential water supply impacts throughout the state using comparative analysis and has the ability to incorporate climate change and sea level rise effects. It links to and informs other models and processes. Its drawbacks include a monthly time-step, coarse resolution, assumption of existing water rights rules, and imprecise groundwater representation.
- CalLite is a screening-level model derived from CALSIM II that runs quickly and allows DWR to come up with potential management ideas and screen out bad ideas.
- DSM2 is a Delta hydrodynamic model that outputs flow, velocity, depth, and water surface elevations. These results feed into two additional modules that can simulate (1) the fate and transport of conservative and non-conservative constituents and (2) the transport of neutrally-buoyant particles. It also has the capability to perform nutrient modeling, but more data needs to be collected before this function is reliable.
- SELFE is a 3D model of the Delta, bay, and ocean and has a very fine resolution grid. Because it is so detailed, it takes a long time to run the model. DWR uses this model to study the impacts of sea level rise and is part of the joint NMFS, DWR, and NASA effort called SESAME, which is a full life cycle, energy-based model of salmon migration through the upper Sacramento River, Delta, and ocean. It can also help determine how much flow it will take to keep salinity out of the Delta as sea levels rise. It is fully functional but presently only available for DWR internal use. DWR is working on model documentation and hopes to release it for public use by summer of 2013.

Mr. Reyes then took the Board through a CALSIM II case study of fall X2 requirement impacts. He showed that different metrics can produce different impacts and that model results need to be evaluated both qualitatively and quantitatively. Based on this model simulation, Eric concluded that

storage is generally lower when implementing fall X2 requirements and that storage impacts can be more pronounced in periods following the implementation of fall X2 requirements. In general, reduced storage is accompanied by reduced exports and a reduced ability to meet temperature requirements for listed species. He also made some points about the limitations of "unimpaired flow" requirements.

Mr. Reyes' take-home points were as follows:

- Models are simplifications of the real physical world and should be used with caution.
- There are multiple modeling tools that should be used together to examine the California water system holistically.
- The effects of climate change and sea level rise should be considered in all modeling.
- System objectives and impacts will likely need to be balanced.

Key Questions from the Board

Board Chair Hoppin asked if DWR has the ability to analyze the results of CALSIM II model predictions against physical data to see if the model is accurate.

> **Mr. Reyes** responded that such an analysis is possible, but **Mary Johannis** noted that the strength of CALSIM II is as a planning tool, for comparative analysis, and is not used in an absolute sense to predict specific outcomes.

Board Chair Hoppin referred back to Mr. Reyes' observation that the groundwater representation in CALSIM II is imprecise, and asked Mr. Reyes to elaborate.

> **Mr. Reyes** explained that the model assumes a static water demand for each of the geographic regions based on land use, and assumes that if the water contractors in a region are shorted water supplies, they will pump groundwater to make up for the deficit. It also assumes that there is enough groundwater available to meet these demands. That may not be a realistic outcome.

Board member **Moore, Tara Smith,** and **Mr. Reyes** then discussed how SELFE and DSM2 relate to each other, and how reservoir carryover requirements are programmed into the CALSIM II model.

Mary Johannis and Tom Fitzhugh, US Bureau of Reclamation—Suggested Approaches to the Use of Analytical Tools for Evaluating Water Supply, Hydrodynamic, and Hydropower Effects

Ms. Johannis described the status of Central Valley temperature models and USBR's use of PLEXOS to evaluate power benefits. She explained that the Central Valley Operations (CVO) temperature models are used each spring to develop a temperature management plan for the year. They are not used to manage temperature in real time. She noted that USBR is working with other agencies to optimize water operation models (like CALSIM II) for temperature variables and to develop new water temperature modeling tools.

USBR has a San Joaquin water quality model that analyzes the relationships among reservoir operations, water temperature regimes, and fish survival. Ms. Johannis acknowledged that CALSIM II is a powerful planning tool, but pointed out that it is restricted to current operations and does not have integrated temperature or hydropower generation analyses.

Ms. Johannis remarked that USBR also has the PLEXOS model under contract, which is a powerful tool used to estimate the value of hydropower generation.

Tom Fitzhugh took the Board through a CALSIM II modeling case study showing the implications of implementing an unimpaired flow standard on the San Joaquin River. The model results show that implementation of a 60% unimpaired flow standard would result in a reduction in total water deliveries of approximately 25%, a reduction in October 1 reservoir storage levels of more than 50%, and operational uncertainty. Ms. Johannis noted that the CALSIM II results are useful, but do not tell the whole story, as a 50% reduction in storage will likely result in power generation, recreation, and temperature effects as well.

Ms. Johannis concluded with USBR's recommendation that the Board use the entire suite of available tools (not just CALSIM II) to assess effects of potential new water quality standards. She also urged the Board to take into account reservoir operational considerations as well as the CVP objectives of flood control, water supply, drought protection, fish and wildlife protection, power generation, and recreation. She believes the Bay-Delta Plan objectives should attempt to create situations where an acre-foot of water can meet as many purposes and goals as possible, and observed that the timing of when water moves through the system dictates how many needs can be met by a unit of water. She also urged the Board to involve water project operators in the decision-making process because of their invaluable experience of the system.

Key Questions from the Board

Board member Doduc asked what operational challenges will be posed by an unimpaired flow requirement, and how DWR and USBR might overcome those difficulties. **Board Chair Hoppin** asked for recommendations on a better method to accomplish the environmental goals of the Board if the resource management agencies do not like the unimpaired flow approach.

> **Ron Milligan** (USBR) said that the Board will have to answer a lot of questions about unimpaired flow, such as what time-step will be used to manage it, and at what physical location unimpaired flow will be measured. He noted that there are a lot of diverters between the main reservoirs and Freeport who help deplete the basin.

Board Chair Hoppin observed that there is a certain amount of through-flow, or return flow, back into the system from diverted water. He asked how return flows are calculated by USBR.

> **Mr. Milligan** responded that return flows are too difficult to calculate on a real-time basis. USBR prefers to look at aggregate responses to determine if the basin is depleting or if the creeks are starting to run. He thinks that Delta outflow is a reasonable metric to use as a goal.

Board Vice-Chair Spivey-Weber asked how much engagement the resource management agencies have with other groups to help explore other options.

> **Ms. Johannis** mentioned that under Phase 1 of the Bay-Delta Plan update, the resource management agencies have come together with the fishery agencies and NGOs for the San Joaquin settlement process. They are utilizing models to inform the process and Ms. Johannis hopes the effort will be successful. **Mr. Milligan** believes that the more multidisciplinary discussion that takes place, the better the ideas and proposals will be. **Tara Smith** noted that DWR, USBR and NMFS are planning a 2014 monitoring effort together. She believes CWEMF and IEP continue to be good places for information exchange.

Panel 5: Environmental / Non-Governmental Organizations

John Cain, American Rivers–Analytical Tools and Approaches for Adaptive Management, Flood Plain Restoration Planning, and Reservoir Re-Operation

John Cain reviewed the "logic chain" approach to decision-making that was developed for the BDCP process, and which he and Jonathan Rosenfield introduced during Workshop 1. He encouraged the Board to use this process for the Bay-Delta Plan update and subsequent adaptive management, noting that the logic chain approach has been reviewed by two science panels convened by the Delta Science Council, and that it is tailored for the Delta ecosystem. He also believes the Delta Regional Ecosystem Restoration Implementation Plan would be a useful tool for the Board to use in decision-making and adaptive management.

In analyzing floodplain restoration opportunities, Dr. Cain recommended utilizing Area Duration Frequency (ADF) analysis, which is a novel way to measure how much floodplain habitat will be created that is useful to the target species. He then recommended an approach for evaluating and determining new reservoir re-operation standards and proposed appropriate time-steps for various types of modeling.

Key Questions from the Board

Board Chair Hoppin provided a "reality check," noting that the Board will likely not be able to recommend specific restoration actions in the Bay-Delta Plan, and that the most the Board can likely do through this process is to set flows that they hope will support restoration and hope they get it right.

Dr. Cain warned against vague objectives and said he believes that the objectives set by the Board should be specific, measureable, achievable, relevant, and time-bound (SMART). Even if the objective turns out not to be achievable due to circumstances beyond the Board's control, if the objective is measureable, it can at least be revisited in the future and changed if it proves to be unachievable. However, if the objective is vague, the Board might end up in the same place it is right now 20 years in the future.

Leo Winternitz and Clint Alexander, The Nature Conservancy – Multi-Species Ecosystem Effects Analysis and Flow Criteria Evaluation

Leo Winternitz described TNC's Delta Ecological Flows Tool (EFT), which takes outputs from established physical and hydrologic models and uses established biological models to provide information on how different flows will affect a suite of habitats and species in the Delta. Clint Alexander provided a description of how the model works and noted that the model utilizes a representative suite of indicators to look at habitat effects, as opposed to selecting favorite species and looking at species effects separately. He observed that one of the early messages from their initial Delta EFT analyses was that climate change will be a very important factor in all future Delta

management decisions. Mr. Winternitz and Mr. Alexander believe the Delta EFT will be a helpful tool to the Board in assessing the potential ecological effects of new Bay-Delta Plan objectives.

Chris Shutes, CA Sportfishing Protection Alliance / CA Water Impact Network–Water Balance Modeling for the Comprehensive Review and Update to the Bay-Delta Plan

Chris Shutes introduced himself as the FERC Projects Director for the California Sportfishing Protection Alliance. He focused his presentation on water balance modeling, and made five specific recommendations to the Board as they move forward with water balance modeling in the Bay-Delta Plan update process.

30. The Board needs independent modelers for credibility, and will need to work closely and iteratively with them. Model outputs need to be unbiased and un-gamed.
31. No single existing water balance model will work for the Board's purposes. Mr. Shutes pointed out that CALSIM II does not model anything upstream of the rim dams and was designed to manage CVP and SWP operations, not to balance uses.
32. The Board needs a model that is its "servant." He recommended that the Board take the lead and develop a model that meets the Board's needs, and consider upstream models as well as CALSIM II.
33. Mr. Shutes believes the Board needs to change the rules in CALSIM II or else create a new model. If the Board utilizes CALSIM II but does not change the assumptions and policies embedded within the model, the model will make all the policy and legal decisions for the Board.
34. Finally, Mr. Shutes recommended that the Board ensure that modeling rules, assumptions, inputs, and outputs be systematically developed and transparently disclosed. This is necessary to evaluate alternative operations substantively, to comply with CEQA , and to manage the message.

Tim Stroshane, CA Sportfishing Protection Alliance / AquAlliance / CA Water Impact Network–Water Availability Analysis for River Basins Tributary to the Bay-Delta Estuary

Tim Stroshane recommended that the Board implement its 2010 flow determinations, which call for proportional flows from all Delta tributaries, and apply the California Doctrine to determine the tributary contributions to proportional Delta inflows. Under the California Doctrine, public trust protection is provided first to all beneficial uses. Riparian water right holders may divert next, constrained by the state constitutional requirement of reasonable use. Pre-1914 appropriators may divert next, to the extent there remains a surplus of water available in the river. Finally, to the extent that there is still water available in the system, post-1914 permittees and licensees may then divert. Dr. Stroshane recommended that the Board perform a planning-level water availability analysis to determine the amount of water available for diversion in the system. This process would enable the Board to confront and address the least reliable water rights claims.

Peter Vorster, Bay Institute / NRDC

Peter Vorster made the following recommendations to the Board regarding their impact analysis of potential Bay-Delta Plan updates.

- Utilize models that can incorporate a broad range of water management strategies (including demand management and alternative supply sources), differing assumptions regarding water users' contributing flows, climate change assumptions, and economic analysis of alternative strategies. These alternative strategies should include agricultural water use efficiency, urban water use efficiency, urban stormwater recapture, and recycled water. Mr. Vorster does not believe that CALSIM II is the optimal tool for assessing potential water supply impacts. It is not able to model alternative water management options and has highly constrained assumptions about demand. He recommends that the Board also consider WEAP and CALVIN.
- Include daily and weekly, as well as monthly, time-steps, where possible.
- Compare different percentages of unimpaired flows against changes in specific flow needs of fish, habitat, and the ecosystem. He does not advocate a slavish adherence to a daily unimpaired flow, but believes it is a good template to use for adaptive management. He also noted that he was concerned by some of the assertions made in the SWP contractors' written submittal for Workshop 3. Despite what the contractors are trying to argue, it is indisputable that the SWP and CVP have had an extremely significant impact on outflows compared to pre-project conditions, and that the projects have caused a reduction in spring outflows above and beyond the effects of reduced precipitation.

Key Questions from the Board

Board Vice-Chair Spivey-Weber asked Mr. Vorster if he had had the opportunity to use the logic chain approach.

Mr. Vorster said he had not personally used the logic chain approach, but said that he sees potential in the process. He observed that both the Bay Institute and NRDC endorse the logic chain approach.

Panel 6: State and Central Valley Project Contractors

Wayne Lifton, Cardno-Entrix, Inc.–Adaptive Management

Wayne Lifton summarized the adaptive management process and noted that successful adaptive management requires the commitment of a substantial amount of resources over a long period of time, and it also requires stakeholder involvement from all sides. He mentioned some drawbacks and sources of adaptive management failure. He cautioned that the Board should consider whether it has the appropriate resources and time to successfully implement adaptive management. If the Board cannot carry it out properly, adaptive management is not the answer.

Paul Hutton, Metropolitan Water District–A Model to Estimate Natural Delta Outflow

Paul Hutton acknowledged that a return to natural conditions is not possible for the Delta, but pointed out that understanding natural conditions can help with restoration efforts. The key point of his presentation was that "unimpaired flow" does not provide a reasonable approximation of natural flow, even though it is often used as a proxy for natural flows throughout the system. He is currently developing a monthly model to estimate natural flows in the Central Valley that will incorporate upper watershed water use, evapotranspiration, and groundwater-surface water interactions and will estimate inter- and intra-annual variability.

David Sunding, UC Berkeley–Modeling the Economic Impact of Changes in Delta Water Supplies

David Sunding observed that changes in Delta water supplies can have significant economic consequences and reviewed the state of available economic impact models. He compared two urban economic impact models: the Least-Cost Planning Simulation Model (LCPSIM), which is an optimization model, and the Supply-Demand Balance Simulation Model (SDBSIM), which is a simulation model. He believes that the SDBSIM model has numerous advantages over LCPSIM.

Model runs performed by Dr. Sunding show that there are $1.4 billion in losses for every 100,000 acre-feet (AF) of reduced exports. The mainstay model for estimating effects on agricultural production is the Statewide Agricultural Production (SWAP) model, which Dr. Sunding believes is a big academic achievement, but which could be improved. SWAP shows that there are $300 million in agricultural losses for every 100,000 AF of reduced exports. He pointed to the process used to review and develop models for estimating the economic impact of AB 32 as a peer review process that worked well and could serve as a template for a SWAP peer review process.

Key Questions from the Board

Board Chair Hoppin noted that from Dr. Sunding's remarks, it sounds like the peripheral pipeline could be a profitable venture.

> **Dr. Sunding** said that it is too early to tell at this point. BDCP regulatory certainty needs to be more fully fleshed out, as do the range of possible outcomes under the no-action alternative and the preferred alternative. Once those factors are determined, the models can be run.

Board Member Marcus asked where the Board should look to determine the economic effects on fishermen.

> **Dr. Sunding** noted that the models he discussed look only at impacts on ratepayers of water agencies and acknowledged that those models are not the only places to look in society for economic impacts. He said that commercial fishing impacts are relatively simple once a relationship to change in stock can be established. There are other types of economic impacts as well, including the public value of restored ecosystems.

Ray Hilborn, University of Washington–Life Cycle Models, Decision-Making, and Resolving Scientific Uncertainty

Ray Hilborn noted that any management decision, whether it is adaptive or not, must be based on models. He believes the core of any fish policy evaluation must be life cycle models, and took the Board through an idealized "management procedure evaluation." He cautioned that the model output will not provide a policy decision; policy decisions are a political process.

Dr. Hilborn shared his recent experience in finding common ground among scientists on a controversial issue. He believes that scientific consensus is possible if the structure of the process is properly defined, and recommended that the Board utilize a similar process for the Bay-Delta Plan update. He made the following recommendations for finding common ground:

- Define a scientific, specific objective.
- Invite participants who are representative of different perspectives, do not have dominant personalities, and include young post-doctoral researchers who are not closely identified with past publications.
- Ensure that the data is the focus of the work, and assemble a public database that is available for all members of the team to explore.

Key Questions from the Board

Board Vice-Chair Spivey-Weber mentioned that the Board had heard about several life cycle models that are under development, and also heard about the importance of time-steps in modeling. She asked Dr. Hilborn how much weight should be given to the life cycle models with shorter time-steps.

> **Dr. Hilborn** said that most life cycle models run on an annual time-step, but that some of the control rules may run on a weekly or daily basis, so the underlying model is both daily and annual. At this point he was not prepared to offer a critique of any life cycle model versus another.

Board Chair Hoppin noted that anadromous fish spend a significant portion of their life cycle in the ocean, which is beyond the control of the Board. He asked if the Board should overcompensate for factors not under its control with the factors that are under its control.

> **Dr. Hilborn** observed that any salmon life cycle model incorporates many factors that are not under the control of various management agencies. However, he noted that it is important to consider ocean processes in life cycle models because uncertainties like ocean upwelling need to be faced. He also advised the Board to take ocean harvesting into account.

Panel 7: San Joaquin Valley Water Suppliers

Tim O'Laughlin and Doug Demko, San Joaquin Tributaries Association–Comments Pertaining to Use of SJR Salmon Population Models to Modify Flow Standards for the Purpose of Doubling Natural Production of Chinook Salmon

Tim O'Laughlin and Doug Demko provided a critique of DFG's San Joaquin River Fall-run Salmon population model. Mr. O'Laughlin does not believe that linear regression analysis, which was used in versions 1.0 and 1.6 of the model, has any predictive power for salmon populations. He cautioned the Board to take a close look at the data before assuming that more flows will lead to more fish. He provided some graphs showing that juvenile escapement can vary dramatically at the same flows.

Mr. O'Laughlin said that DFG has admitted it moved on to version 2.0 of the San Joaquin River Fall-run Salmon population model (SalSim) because of the weaknesses of the previous model. This indicates to him that the previous model versions, which formed the basis for the Board's "Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives," no longer represent the best available science. He also mentioned that the San Joaquin Tributaries Association (SJTA) has concerns about SalSim, and chided DFG for not involving the SJTA or the public in development of SalSim or utilizing data collected by the SJTA. He does not believe SalSim could be accurate during the smolt outmigration phase of the life cycle, since they do not have good data on predation rates or predation hot spots, or during the spawning phase of the life cycle, since DFG has not included SJTA's data on redd superimposition in the model. Mr. Demko noted that recent studies have shown that predator species like striped bass are present in San Joaquin River tributaries during salmon outmigration periods.

Mr. O'Laughlin noted that the SJTA supports the development of life cycle models. Doug Demko discussed some of the data requirements of life cycle modeling, and explored the reliability of some of the data sets that are regularly used, specifically the numbers produced through the salmon carcass surveys. Based on studies conducted by the SJTA, Mr. Demko believes the Board should use some skepticism when dealing with input data. He pointed out that fish are inherently difficult to count.

Mr. O'Laughlin relayed the SJTA's support of SMART objectives, as well as of utilizing the CALSIM II model. Mr. O'Laughlin agreed with Dr. Lifton's remarks on adaptive management, echoing his sentiments that adaptive management will require a great many resources and time, and that to be achieved successfully, a lot of barriers will need to be broken down. He also questioned the Board's phased approach to the Bay-Delta Plan update, noting his concern that breaking up the process by geographical region may obscure the full impact of certain management decisions.

Key Comments from the Board

Board Vice-Chair Spivey-Weber observed that there is not much trust between DFG and the SJTA, which makes scientific collaboration, which is supposed to involve unbiased discussion of data, difficult. She believes that the SJTA should be a part of the Bay-Delta Plan update process, but she urged the SJTA to come to the table without rancor.

Panel 8: In-Delta Water Interests

Susan Paulsen, City of Antioch–City of Antioch Testimony

Susan Paulsen relayed three recommendations to the Board from the City of Antioch.

35. Model recent years. Dr. Paulsen observed that most hydrologic models re-operate historical hydrology (for example, CALSIM II simulates hydrology from the years 1922–2003), but pointed out that significant hydrologic changes have occurred since that time. She urged the Board to ensure that the period of 2007–present is simulated in CALSIM II and DSM2 to establish that the models accurately simulate conditions under current operational rules.
36. Evaluate water sources. Dr. Paulsen asked the Board to model the effects of their objectives on water source and residence time. She remarked that source water is important to water quality and salinity, and noted that the City of Antioch is located on the San Joaquin River but the City's intake captures mostly Sacramento River water. The City fears the majority of its source water will change if BDCP is built, resulting in increased salinity and reduced water quality in the south, central, and western Delta. The City has confidence in the available source fingerprinting models.
37. Evaluate the effects of new habitat. Dr. Paulsen pointed out that, depending on location and design, restored habitat can increase salinity in the central and western Delta and will likely result in changes to erosion and deposition patterns. The City believes models should be adjusted as necessary to reflect changes to geometry caused by BDCP restoration activities.

Dr. Paulsen also reviewed the City of Antioch's requests from the previous two workshops.

Panel 9: Sacramento Valley Water Suppliers

Dave Vogel, Natural Resource Scientists, Inc.–Insights into the Problems, Progress, and Potential Solutions for Sacramento River Basin Native Anadromous Fish Restoration for Consideration in the Bay-Delta Water Quality Control Plan Update.

Note: Dave Vogel intended to give this presentation during Workshop 2, which focused on Bay-Delta fishery resources, but was unable to attend.

Mr. Vogel provided an overview of salmon restoration progress on the upstream reaches of the Sacramento River. Highlights include Red Bluff Diversion Dam gate removal, large-scale spawning gravel injections downstream of Keswick Dam, Iron Mountain Mine pollution control, water temperature control, and the screening of water diversions. He noted that remarkable progress has been made on tributaries to the Sacramento River as well. His studies show that predation is a problem for juvenile salmonids in the Delta, and he believes that the predation problems in the Delta need to be fixed before the benefits of upstream restoration actions can be fully realized. His key point is that predation in the Delta is not uniform; it occurs in highly localized sites possessing abnormal conditions favoring predatory fish.

Mr. Vogel cautioned the Board to carefully analyze the potential salmon impacts of high unimpaired flow criteria. His concern is that high unimpaired flows could deplete the cold-water storage in upstream reservoirs. Mr. Vogel recommended pulse flows to help stimulate salmon outmigration, which were proven to be a successful boon to outmigration in 2003.

He recommended that the Board undertake some specific actions and studies that could benefit salmon, and encouraged the Board to use adaptive management to try out actions to see if they work. His recommended actions and studies were:

- Modeling studies of changes to thermal regime and water supply from high unimpaired flows.
- Evaluate efficacy of pulse flows with and without natural events.
- Fine-tune temperature compliance and management of cold-water pool.
- Add expertise to flow/temperature management.
- Greatly expand spawning gravel injections.
- Re-create shallow-water Delta rearing habitats.
- Fix problems with breached levees.
- Eliminate predator "hot spots."
- Implement new study approaches for shorter reaches in the Delta to determine mortality sites using adaptive management instead of "global" studies.

Key Questions and Comments from the Board

Board Chair Hoppin asked if hatchery fish would be given an unfair advantage if pulse flows were coordinated with hatchery releases in the spring.

> **Mr. Vogel** acknowledged that in general, hatchery fish compete for resources with wild fish. However, he pointed out that when hatchery fish are released at the same time that wild fish are migrating out of the system, they can provide protection from predation for the wild fish because of their sheer numbers.

Board Chair Hoppin believes that it is encouraging to see that the Golden Gate Salmon Association and NCWA have hired the same consultant. He feels it's an indication that groups are willing to get together and solve problems.

Mark Petrie, Ducks Unlimited–on serving Bird Habitat in California

Mark Petrie observed that to date, Bay-Delta Plan update discussions have focused almost solely on fish. He noted the importance of waterfowl, and described the Central Valley's critical role in the Pacific flyway. He urged the Board to ensure a reliable water supply for wetlands that support migrating and over-wintering waterfowl. Ducks Unlimited has developed a model that shows the food supply-and-demand effects of various water supply scenarios, and encouraged the Board to utilize this model when determining the effects of potential Bay-Delta Plan objectives.

Walter Bourez, MBK Engineers, NCWA, Sacramento Valley Water Users–Changes in Condition and Advances in Analytical Tools

Walter Bourez observed that there have been significant changes in water system operations within the Bay-Delta watershed since adoption of the 2006 Water Quality Control Plan (WQCP), which the Board will have to take into account during the Bay-Delta Plan update process. These include changes to Yuba River operations pursuant to the Yuba Accord and changes to Feather River operations pursuant to the Oroville FERC relicensing proceeding. The most significant changes have been caused by implementation of the salmon and smelt Biological Opinions (BOs), which have resulted in approximately one million AF of additional Delta outflow over levels required under the 2006 WQCP. Mr. Bourez's studies show that the BOs have limited the SWP and CVP's ability to divert surplus water, decreased water supply reliability for many beneficial uses, and reduced agencies' abilities to utilize water transfers. He urged the Board to utilize an updated baseline that includes this increased outflow during their studies for the Bay-Delta Plan update. He also recommended that they recognize the trade-offs between competing priorities and uses that have been created by the BOs.

Mr. Bourez then provided an overview of the analytical tools available to the Board to evaluate the effects of changes in the WQCP. The tools presented by Mr. Bourez are commonly used for impact analysis under CEQA and NEPA. He provided a list of tools that model water operations, economics, Delta flow and salinity, water budget, water quality, groundwater, temperature and salmon effects, power generation and use, and historical data analysis and statistical models. He noted that use of these tools by qualified personnel now constitutes the industry standard for evaluating the impacts of water-related projects and must be used in developing changes to the WQCP. He then took the Board through an example of analytical tool use, focusing on the short-duration spring pulse flows proposed by **Dave Vogel**.

Mr. Bourez cautioned the Board against relying too heavily on unimpaired flow estimation methods and pointed out that the way unimpaired flow is estimated must be understood for the data to be used properly. He warned that quantitative comparisons between unimpaired flow and observed flow are an inappropriate use of unimpaired flow estimates. He noted that unimpaired flow is a conceptual quantity that relies on flow-gage correlations and makes extrapolations from other watersheds and basins. Often the flow from a very small subwatershed is extrapolated out to provide the entire unimpaired flow estimate for a very large watershed. He also showed that unimpaired flow estimation methods are not consistent over time.

Key Questions from the Board

Board Chair Hoppin remarked that several presenters over the course of the workshop had recommended that there be independent analysis of the models utilized by the Board, yet there seem to be few people who are qualified to perform these sorts of QA/QC who are not invested in a model of their own design. He asked Mr. Bourez for recommendations on obtaining an unbiased analysis.

> **Mr. Bourez** believes that the members of the modeling community are very good about giving honest answers. He recommended that the Board utilize available expertise, including DWR's USBR's suites of modelers, which are outstanding resources. He also recommended running model results by the water system operators to get a litmus test for whether or not the model results accurately represent reality.

Vice-Chair Spivey-Weber asked if Mr. Bourez had looked outside the established system for changes to improve flexibility and water supply reliability, like wet meadows, new reservoirs, or more aggressive groundwater storage activities.

> **Mr. Bourez** responded that he has spent a large part of his career studying conjunctive use in the Sacramento Valley, and said that reliable tools for better understanding complex groundwater relationships are close to being developed. Regarding new reservoirs, Mr. Bourez observed that the issue boils down to what people can afford to pay to build a reservoir.

Vice-Chair Spivey-Weber asked about the level of successful communication that occurs between state/federal agencies and water agencies, as well as among biologists, modelers, and those who are undertaking monitoring efforts.

> **Mr. Bourez** said that communication in the water modeling community is excellent. He believes that CWEMF and the Bay Institute are the best organizations for facilitating modeling discussions. He believes that communication among biologists, modelers, and monitoring folks is good on individual projects, but when it comes to larger efforts and processes, Mr. Bourez believes there is room for improvement.

Panel 10: Hydropower Producers

Dave Modisette, CA Municipal Utilities Association– Hydropower Resources

Dave Modisette provided background information on hydropower generation in California. He observed that the SWP and CVP make up 30% of all hydropower resources in the state, and that changed water quality objectives in the Bay-Delta Plan will have some impact on nearly all power generation and pumping facilities within both systems.

Mr. Modisette explained that for all practical purposes, electricity must be produced and used immediately because it cannot be stored in an economical way. He noted that hydropower is a unique commodity because it allows power to be stored behind dams in the form of water. It is also the most economical source of power available and has become essential for grid operations support because of its ability to be ramped up and down quickly. He noted that hydropower's flexibility is crucial for the development and integration of future renewable energy sources, as it will need to "fill in the gaps" when other renewable sources are not available (e.g., when the wind is not blowing and the sun is not shining).

Timothy Haines, State Water Contractors–Power Capabilities, State Energy Laws, and Implications for SWRCB

Timothy Haines discussed the SWP flexible power generation capabilities and asked the Board to ensure that the Bay-Delta Plan water quality objectives are aligned with state energy policy. He said that changes in state energy policy are increasing the complexity of power generation operations and showed how AB32 and SB 2X1 place additional demand on flexible power generation. He observed that changes to the Bay-Delta Plan could potentially reduce the availability of flexible power generation. He noted that the Bay-Delta Plan water quality objectives may be at cross- purposes with

state energy policy if they impact flexible hydropower, limit CAISO's ability to manage the grid, increase the statewide cost of power, or increase the amount of carbon in the power generation fleet. He urged the Board to include a proper assessment of hydropower impacts in Phase 2 of the Bay-Delta Plan update.

Key Questions from the Board

Board Chair Hoppin asked if the SWP is able to generate power when there are mandated water releases.

> **Mr. Haines** answered that the SWP generally tries to utilize mandated flows to produce power, but **Jerry Toenyes** pointed out that some mandates call for more water than can be used to generate power. In those cases, water gets sent through the reservoir spillways and its power generation potential is lost.

Board Chair Hoppin asked if the members of the Hydropower Producers panel could provide additional information to the Board after the workshop on how much energy is lost due to large mandated water releases. He also requested information on what happens during normal power generation operations and what happens during spill conditions.

Board member Marcus asked for some examples of how water policy has impinged on the flexibility of the hydropower generation system.

> **Mr. Toenyes** said that the BOs have affected when water releases must occur, and caused a significant amount of water to be released through the spillway on the Trinity River. He referred the Board members to Ron Milligan with USBR for more information.

Board member Moore acknowledged that the issue of concern for the hydropower producers is whether or not the Board's management decisions will incrementally create less flexibility for power generation. He asked the panel members to describe a scenario in which flexible power is needed but they are not able to produce it, which would be the Board's threshold of not being able to meet beneficial use needs.

> **Mr. Haines** said that threshold could be reached if a reservoir was depleted earlier in the year, leaving less water for summertime peak production.

Jerry Toenyes, Northern California Power Agency– Delta Flow Objectives May Impact Central Valley Project and Central Valley Project Improvement Act

Jerry Toenyes warned the Board that changes to Delta outflows could have unintended consequences for the CVP such as undermining ongoing environmental restoration programs, reducing generation value, and increasing cost per megawatt-hour. He described how the CVP Improvement Act requires $50 million per year to be spent on the Restoration Fund, which pays for fish and wildlife improvement activities. Reduced water deliveries shift the burden of paying for this restoration fund from water users to power generation revenue. Releasing more water in the spring reduces the value of the power generated from those releases, so there may be less money available for restoration activities, while the cost to power customers would increase. Mr. Toenyes believes this would undermine two decades of CVPIA progress and negatively impact fish and wildlife. Increased Delta outflow objectives would also impact cold-water storage and gravel replacement,

decrease the water available for wildlife refuges, and create negative carbon impacts if hydropower generation is reduced in California.

Key Comments from the Board

Vice-Chair Spivey-Weber acknowledged that it would not be good for the Board to place the full burden of its actions on the shoulders of the CVP and SWP. She remarked that water agencies are working closely with energy agencies and the Air Resources Board to figure out what can be done to reduce energy demand at peak times overall. She believes the Board will have to work closely with other agencies to ensure that the burden does not fall on a few, and to develop a mixed portfolio.

Dave Modisette, CA Municipal Utilities Association–Conclusion

Mr. Modisette concluded the Hydropower Producers panel by urging the Board to fully analyze the hydropower impacts for any Delta outflow changes that are considered. He recommended the PLEXOS model and noted that he and other members of the public power community have expertise on the SWP and CVP as well as energy modeling and would like to work with the Board to assist in conducting these analyses.

Panel 11: California Energy Agencies

Dennis Peters, CA Independent System Operator – Electric System Modeling to Assess Bay-Delta Flow Criteria Proposals

Dennis Peters said that it is his and his colleagues' hope that the Board will strive to achieve its policy goals while ensuring electric system reliability at reasonable cost to ratepayers. He noted that California energy agencies are concerned that the Board's new Delta water quality objectives could cause the loss of capacity and flexibility of power generation resources and that they might shift energy production capability to periods of lower value. He requested that the Board develop a clearly defined set of water flow criteria proposals so that the effects on the energy grid can be properly modeled.

Mr. Peters then provided an overview of the five types of modeling performed to assist with electric system planning. These modeling approaches are supply/demand balances, transmission system assessments, local capacity assessments, system simulation, and flexibility assessment.

Mike Jaske, CA Energy Commission

Mike Jaske explained how the modeling approaches summarized by Mr. Peters would intersect with flow criteria proposals. Like Mr. Peters, Dr. Jaske noted that the energy community needs to understand the Board's proposals in order to model their potential effects, so clearly defined alternatives are necessary. He mentioned that he is still not entirely certain what the definition of unimpaired flow is. Dr. Jaske went on to describe in more detail the modeling approaches introduced by Mr. Peters.

Dr. Jaske summarized the potential consequences of changed flow objectives, which would change the annual pattern of power generation. Specifically, he voiced the following concerns.

- Studies suggest climate change will modify rainfall/snowfall, and additional changes from unimpaired flow criteria will shift water usage for dispatchable hydro toward spring months, but the extent and implications are uncertain.
- Seasonal shifts mean energy generated will have less value because spring energy loads are lower and spring is already a high production period for wind and Pacific Northwest hydropower.
- If spring usage constrains hydropower operation, it would decrease the flexibility of the power generation system, and replacement options for flexible energy (like natural gas, energy storage, and demand response programs) are extremely expensive.
- Any increased chance of spill means some energy value is lost.

Dr. Jaske then showed a table illustrating the importance of hydropower capacity to meet local deficits. He explained that the current electric system is a partly-competitive industry, and there are no incentives or mechanisms to direct power generators to build capacity into areas where power capacity is short. The California Energy Commission is pushing energy suppliers to incorporate resource adequacy assessments into their planning process, but hydropower is extremely important in filling in power deficits.

Nathaniel Skinner, CA Public Utilities Commission

Nathaniel Skinner discussed ratepayer cost concerns. He noted that reducing the flexibility of the hydroelectric fleet is likely to have impacts on ratepayers since hydropower costs are very low and any form of replacement energy will be more expensive. It is estimated that each megawatt of lost hydroelectric flexibility will cost approximately $2 million to replace with a combined cycle or combustion turbine power plant. He showed that even without any changes to the Delta flow criteria, the requirements of AB32 and SB 2X1 will radically change the way the power system is operated.

Mr. Skinner believes that it is critical to understand the full implications of Bay-Delta Plan alternative proposals on the use and capabilities of hydroelectric facilities. He reiterated his earlier point that energy policies mandating renewable generation are increasing the need for flexible hydroelectric power, and expressed his concern that Bay-Delta flow criteria proposals may reduce this flexibility. He asked that the Board provide energy agencies with time to identify, procure, and construct replacement power generation options if the flexibility of the hydropower system will be reduced because of Bay-Delta flow objectives.

Key Questions from the Board

Board Vice-Chair Spivey-Weber asked if there were any other options for replacing flexibility in the power supply network other than natural gas facilities, storage facilities, or demand-response programs.

> **Mr. Skinner** responded that the California Public Utilities Commission is starting to look at how programs can be more tightly focused to help reduce overall rates. Additionally, the peak times of system demand might change in the future. For example, as electric vehicles become more widespread, their time of charging could occur during non-peak hours.

Board Member Marcus asked Mr. Peters to provide some detail regarding how much of the power used in California is imported.

Mr. Peters said that in the CAISO area, about 25% of the energy used is imported from out of state. Imports from Oregon and Washington tend to be produced by hydropower, and energy from eastern states tends to be a mix. However, California no longer imports energy produced from coal.

Board Vice-Chair Spivey-Weber asked if anyone is looking at small instream hydropower generation as a way to fill in the local capacity deficits.

Dr. Jaske responded that many groups are looking into small hydro, but that these facilities are not dispatchable because they have a minimal reservoir behind them. They produce energy, but they do not contribute to system flexibility.

Public Comments

John Shelton, Staff Environmental Scientist, CA Department of Fish and Game

John Shelton remarked that DFG is a public trust agency, as is the Board, and said that as such, DFG is tasked to come up with the best available science. He said that DFG takes this charge very seriously and has developed good science, noting where more information is needed. He argued for the need for an increased, varied flow regime to increase genetic diversity of the salmon population.

Dean Marston, Fisheries Program Manager, CA Department of Fish and Game

Dean Marston provided a rebuttal to SJTA's criticisms of DFG's San Joaquin River Fall-run Salmon population models. He explained that SalSim has been a collaborative process between DFG, academia, consultants, and Federal fish agencies. SJTA was invited to participate in model development in 2008 but declined. He also said that DFG does make its data publicly available and noted that SJTA's studies did not find any statistically reliable differences between DFG's salmon carcass survey method of estimating salmon run size and SJTA's weir/camera method. This means that both could be used.

Regarding SJTA's assertions about limiting factors, Mr. Marston referred to a report by Hubbard showing that flows did a far better job of predicting the number of outmigrating juveniles than did the number of spawners. He also noted that DFG welcomes all new data and does not refuse to use good data. He noted that in SalSim and previous versions of the salmon population model, DFG used proven and statistically reliable non-linear relationships. He said that DFG will provide a thorough, written rebuttal to SJTA's assertions.

He concluded with the opinion that a "great society" experiment was conducted in the San Joaquin River basin, in which salmon production was traded in favor of water supply. He believes that natural salmon production needs to be increased so that hatchery production can be decreased, but "we won't know what kind of natural production we're going to get until we start increasing flows to see what natural production we can achieve."

John Shelton, Staff Environmental Scientist, CA Department of Fish and Game

Mr. Shelton returned to note that DFG has several goals and objectives provided by legislation, by the Fish and Game Commission, and by laws. DFG also collaborates with multiple stakeholders, the Board of Forestry, the ERP Conservation Strategy, the San Joaquin River Chinook Salmon Restoration Program, Klamath-Trinity Salmon Fisheries Program, and co-manages with NMFS on salmonid recovery plans.

Dierdre DesJardines, California Water Research

Dierdre DesJardines urged the Board to undertake a water availability analysis as a part of the Bay-Delta Plan update. She observed that the only water supply availability analyses performed for the Delta were done in 1956 and 1966, and that DWR's SWP water supply permits were issued based on the assumption that additional water storage facilities would be built. These facilities were never constructed. She pointed out that BCDP's modeling efforts are showing huge problems with dead pool storage, not just because of climate change, but because of the aggressive delivery targets. She noted that the public trust charge of the Board is to ensure that its decisions are made on sound hydrology. The only way to accomplish this, said Ms. DesJardines, is to require a new water availability analysis and to utilize conservative assumptions about climate change. She observed that the only water supply model that doesn't rely on historic hydrology is WEAP, and that the WEAP model predicts huge increases in dry and critically dry years by mid-century. She also requested that the Board digitize the 1956 and 1966 water availability analyses and make them available to the public on the internet.

Additional Water Board Comments

Board Vice-Chair Spivey Weber said that the Board would think long and hard about follow-up to this workshop. She believes that some form of structured decision making will likely be necessary to provide constituents in each region a way in which they can try to solve some problems. The key points she is taking away from the workshop are that the Board needs to be clear about what it's going to do, needs to develop measureable objectives, and needs to utilize a suite of models to assess the effects of potential new objectives. She said the Board would work with Board Staff to decide how the modeling tools will be incorporated into the process. She encouraged stakeholders to approach the Board with ideas on how to solve problems.

Board member Marcus thanked those of the presenters who tried to help the Board understand the complexity of the issues, and said she looks forward to using what's relevant from the workshop as the process moves forward. She reminded those assembled that the Board is not creating a "plan for the ages," but is updating an existing plan to the best of its ability, and thinks it can be done in a reasonable way in the timeframe allotted.

Board member Moore thanked everyone for their genuine contributions. He knows everyone takes these issues very seriously and he believes in the stakeholders' stewardship.

Board Chair Hoppin joked that the thought of the Board making a horrible decision on the Bay-Delta Plan update has made a lot of people come together, and that it is amazing how much the

Board has energized stakeholders just by horrifying them. He observed that the key theme of the workshop seemed to be that everyone wants to ensure that the Board makes an informed decision.

Appendix A

Workshop Agendas

COMPREHENSIVE (PHASE 2) REVIEW AND UPDATE TO THE BAY-DELTA PLAN

Workshop 1: Ecosystem Changes and the Low Salinity Zone

Wednesday, September 5, 2012
Continuing on Thursday, September 6, 2012
9:00 a.m. to 5:00 p.m.

Joe Serna, Jr.-Cal/EPA Building
Coastal Hearing Room
1001 I Street, Second Floor
Sacramento, CA 95814

Agenda

Note: Times are approximate and may shift based on the length of presentations and/or the discretion of the Water Board. Written comments can be found at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/cmnt081712.shtml

Day 1: 9/5/12

9:00 – 9:15	Welcome, agenda review
9:15 – 10:45	Invited Panel
10:45 – 10:55	Break
10:55 – 12:00	Regulatory / fishery agencies
12:00 – 12:55	Lunch
12:55 – 1:30	Regulatory / fishery agencies (cont.)
1:30 – 3:10	Resource management agencies
3:10 – 3:20	Break
3:20 – 5:00	Environmental / NGO groups

Day 2: 9/6/12

9:00 – 10:40	In-Delta water interests
10:40 – 10:50	Break
10:50 – 12:30	State / Central Valley Project contractors
12:30 – 1:30	Lunch
1:30 – 2:30	Sacramento Valley water suppliers
2:30 – 2:45	Break
2:45 – 3:45	Public comments
3:45 – 5:00	Additional Water Board questions

Invited Expert Panel

The Invited Expert Panel assembled by Dr. Peter Goodwin, the Delta Science Program's Lead Scientist, will focus on:

- Effects of the low salinity zone on various estuarine species
- Interaction of salinity with non-flow related factors
- Identification of modeling or other tools that can be used to measure and reasonably protect estuarine habitat

One or more of the following will make presentations:

Larry Brown	US Geological Survey
Jim Cloern	US Geological Survey
Steve Culberson	US Fish & Wildlife Service
Cliff Dahm	University of New Mexico
Bill Fleenor	UC Davis
Bruce Herbold	USEPA
Wim Kimmerer	San Francisco State University
Anke Mueller-Solger	Interagency Ecological Program

Regulatory / Fishery Agencies Panel

Agency	Presenter	Topic
USEPA	Erin Foresman	• Flow interactions with species abundance and water quality standards
CA Dept. Fish & Game	Patrick Coulston	• Low Salinity Zone and inflow / outflow effects on Bay species
	John Shelton Randy Baxter (alternate)	• System ecology, watershed functions and services, and Central and South Delta interactions
US Fish & Wildlife Service	Matt Nobriga	• Low Salinity Zone effects on Delta Smelt

Resource Management Agencies Panel

Agency	Presenter	Topic
CA Dept. Water Resources	Ted Sommer	• X2 and non-flow criteria
	Andrew Schwarz	• Climate change and non-flow criteria
	John Leahigh	• Dealing with uncertainty

Environmental / NGO Panel

Agency	Presenter	Topic
Bay Institute / NRDC	Jonathan Rosenfield	• Effects of flow, other stressors, and climate change on estuarine habitat and the LSZ • Use of biocriteria and other decision tools to guide adaptive management of efforts to attain water quality objectives and protect beneficial uses
American Rivers	John Cain	• Interconnections between floodplain inundation, water turbidity, and fish habitat • Associated modeling • Modification of export facilities and operations under existing conditions and with approved BDCP
CA Sportfishing Alliance / CA Water Impact Network	Tim Stroshane	• Recent selenium science and modeling in relation to ecosystem changes and listed and non-listed species
	G. Fred Lee	• Importance of high tributary flow to minimize water quality impacts
	Tom Cannon	• Effects of past standards on flow and pelagic and salmonid species and measures necessary to protect those species

In-Delta Water Interests Panel

Agency	Presenter	Topic
Bay Area Clean Water Agencies	Michael Connor	• Suisun Bay eutrophication issues; impacts of nutrient loadings on phyto and zooplankton
Sacramento County Regional Sanitation District	Mike Bryan	• Water quality, data quality objectives, regional monitoring
	Cameron Irvine	• Data quality objectives, invasive clams, contaminants
City of Antioch	Susan Paulsen	• Salinity impacts of water withdrawals
South Delta Water Agency	John Herrick	• SWP / CVP operations and problems with Delta/Project modeling

State and Central Valley Project Contractors

Agency	Presenter	Topic
State Water Contractors, San Luis & Delta-Mendota Water Authority	Dave Fullerton Sheila Greene Patricia Glibert Chuck Hanson Paul Hutton	• Exploring the mechanisms driving changes to the Bay-Delta Estuary

Sacramento Valley Water Suppliers Panel

Agency	Presenter	Topic
N CA Water Assoc., Sacramento Valley Water Users	Walter Bourez	• Uncertainty in LSZ positioning • Concurrent trends in Sacramento Basin hydrology and pelagic populations • Risks of unimpaired flow-based standards • Water management to support multiple beneficial uses

COMPREHENSIVE (PHASE 2) REVIEW AND UPDATE TO THE BAY-DELTA PLAN

Workshop 2: Bay-Delta Fishery Resources

Monday, October 1, 2012 (9:00 a.m. to 5:25 p.m.)
Continuing on Tuesday, October 2, 2012 (9:00 a.m. to 5:00 p.m.). and
Wednesday, October 3 (if needed)

Joe Serna, Jr.-Cal/EPA Building
Coastal Hearing Room
1001 I Street, Second Floor
Sacramento, CA 95814

Agenda

Note: Times are approximate and may shift based on the length of presentations and/or the discretion of the Water Board.

Day 1: 10/1/12

9:00 – 9:10	Welcome, agenda review
9:10 – 10:40	Invited Panel
10:40 – 10:50	Break
10:50 – 12:15	Regulatory / fishery agencies
12:15 – 1:00	Lunch
1:00 – 2:25	Resource management agencies
2:25 – 2:35	Break
2:35 – 4:00	Environmental / NGO groups
4:00 – 5:25	Sacramento Valley water suppliers

Day 2: 10/2/12

9:00 – 10:25	In-Delta water interests
10:25 – 10:35	Break
10:35 – 12:00	State / Central Valley Project contractors
12:00 – 1:00	Lunch
1:00 – 2:25	San Joaquin Valley water suppliers
2:25 – 2:40	Break
2:40 – 3:40	Public comments
3:40 – 5:00	Additional Water Board questions

Invited Expert Panel

The Invited Expert Panel assembled by Dr. Peter Goodwin, the Delta Science Program's Lead Scientist, will focus on:

- Focus on Delta smelt and salmonids
- Flow, cold water pool, habitat, and water project operational constraints needed to reasonably protect pelagic species, Central Valley steelhead, Sacramento River winter run, Central Valley spring run, and Central Valley late fall run Chinook salmon
- Interaction of these issues with non-flow related factors

One or more of the following will make presentations:

Ted Sommer	CA Dept. of Water Resources
John Largier	UC Davis
Randy Baxter	CA Dept. of Fish & Game
Kenny Rose	Louisiana State University
Eric Danner	National Marine Fisheries Service
Brad Cavallo	Cramer Fish Sciences

Regulatory / Fishery Agencies Panel

Agency	Presenter	Topic
USEPA	Bruce Herbold Erin Foresman	• New flow analyses and concepts for water quality objectives
CA Dept. Fish & Game	Kevin Shaffer	• Salmonid recovery and conservation
	Patrick Coulston	• Entrainment effects on smelt species
US Fish & Wildlife Service	Matt Nobriga	• Salmonids
	Pat Brandes	
	Roger Guinee	
US Nat'l Marine Fisheries	Garwin Yip	• Salmonids

Resource Management Agencies Panel

Agency	Presenter	Topic
US Bureau of Reclamation	Ron Milligan	
	Paul Fujitani	
CA Dept. Water Resources	Brett Harvey	• Salmonid habitat, diversity, and management
	Gardner Jones / Dennis McEwan	• Recommended use of BDCP and related restoration activities in the Delta

Environmental / NGO Panel

Agency	Presenter	Topic
Bay Institute / NRDC / Trout Unlimited	Jonathan Rosenfield	• Role of Delta inflows, outflows, hydrodynamics, Old and Middle River flows, and entrainment on pelagic and salmonid species
	Rene Henery	• Salmonid migration pathways in the Delta • Upstream flow and temperature requirements
American Rivers	John Cain	• Importance of floodplain inundation for salmonids and splittail
CA Sportfishing Alliance / CA Water Impact Network	Tom Cannon	• Specific needs of pelagic organisms and salmon and recommendations for their Protection

In-Delta Water Interests Panel

Agency	Presenter	Topic
Contra Costa Water District	Deanna Sereno / Greg Gartrell	• Effects of Old and Middle River flows
Sacramento County Regional Sanitation District	Diana Engle / Michael Connor	• Nutrients in general and the direct and indirect effects of ammonia

Sacramento Valley Water Suppliers Panel

Agency	Presenter	Topic
N CA Water Assoc., Sacramento Valley Water Users	Robert Latour	• Data analyses in relation to water flow for fishes in the Sacramento – San Joaquin Delta ecosystem
	Dave Vogel	• Insights into the problems, progress, and potential solutions for Sacramento River Basin native anadromous fish restoration for consideration in the Bay-Delta Water Quality Control Plan update

State and Central Valley Project Contractors

Agency	Presenter	Topic
State Water Contractors, San Luis & Delta-Mendota Water Authority	Chuck Hanson Steve Crammer Sheila Greene	• Factors affecting salmon abundance
	David Fullerton Frances Brewster Nobel Hendrix Richard Deriso Scott Hamilton	• Factors affecting smelt abundance

San Joaquin Valley Water Suppliers Panel

Agency	Presenter	Topic
San Joaquin Tributaries Assoc.	Doug Demko Andrea Fuller Michelle Palmer	

COMPREHENSIVE (PHASE 2) REVIEW AND UPDATE TO THE BAY-DELTA PLAN

Workshop 3 Analytical Tools for Evaluating Water Supply, Hydrodynamic and Hydropower Effects

Tuesday, November 13, 2012
Continuing on Wednesday, November 14, 2012
9:00 a.m. to 5:00 p.m.

Joe Serna, Jr.-Cal/EPA Building
Coastal Hearing Room
1001 I Street, Second Floor
Sacramento, CA 95814

Agenda

Note: Times are approximate and may shift based on the length of presentations and/or the discretion of the Water Board

Day 1: 11/13/12

9:00 – 9:10	Welcome, agenda review
9:10 – 10:40	Invited Panel
10:40 – 10:50	Break
10:50 – 11:10	Alternative modeling approaches
11:10 – 12:10	Regulatory / fishery agencies
12:10 – 1:00	Lunch
1:00 – 2:00	Resource management agencies
2:00 – 3:00	Environmental / NGO groups
3:00 – 3:15	Break
3:15 – 4:15	San Joaquin Valley water suppliers
4:15 – 5:00	State / Central Valley Project contractors

Day 2: 11/14/12

9:00 – 9:15	Welcome, agenda review
9:15 – 9:30	Conclude State / Central Valley Project contractors
9:30 – 10:30	In-Delta water interests
10:30 – 10:40	Break
10:40 – 11:30	Dave Vogel Workshop 2 presentation
11:30 – 12:30	Sacramento Valley water suppliers
12:30 – 1:20	Lunch
1:20 – 2:20	Hydropower producers panel
2:20 – 3:20	CA energy agencies
3:20 – 3:35	Break
3:35 – 4:05	Public comments

4:05 – 5:05 Additional Water Board questions

Invited Panel

The Invited Panel assembled by Dr. Peter Goodwin, the Delta Science Program's Lead Scientist, will focus on:

- The CalSim II water supply model and the DSM2 and RMA2 hydrodynamic models
- Plexus hydropower model
- Other models as applicable
- Results from applying these models to various scenarios

One or more of the following will make presentations:

Jon Burau	US Geological Survey
John DeGeorge	Resource Management Associates
John Durand	UC Davis
Greg Gartrell	Contra Costa Water District
Marianne Guerin	California Water and Environmental Modeling Forum
Jay Lund	UC Davis
Bill Smith	Montgomery Watson Harza
Peter Smith	US Geological Survey, retired
Mark Stacy	UC Berkeley

In addition, Elaine Archibald of the California Water and Environmental Modeling Forum will briefly describe the CWEMF's capacity to assist the State Water Board.

Alternative Modeling Approaches Panel

Agency	Presenter	Topic
ICF International	Russ Brown	• Historical Data and Delta OPS Model
SEI	David Purkey	• CV-WEAP Model

Regulatory / Fishery Agencies Panel

Agency	Presenter	Topic
CA Dept. Fish & Game	Bob Hughes	• Available for Q&A period
	Dean Marston	• EC-5Q and SalSIM
	Patrick Coulston	• Perspective on biological models
US Dept. of Interior: Fish & Wildlife Service	Julie Zimmerman	• Structured decision making
US EPA	Bruce Herbold	• Available for Q&A period
US Nat'l Marine Fisheries	Candan Sokyan	• Chinook salmon life-cycle modeling

Resource Management Agencies Panel

Agency	Presenter	Topic
CA Dept. Water Resources	Parviz Nader / Tara Smith	• General model descriptions
	Eric Reyes	• CALSIM II case study description
US Dept. of Interior: Bureau of Reclamation	Mary Johannis	• Temperature models, CALSIM II case study, operational considerations
	Tom Fitzhugh	
	Derek Hilts (FWS)	
	Ron Milligan or Paul Fujitani	

Environmental / NGO Panel

Agency	Presenter	Topic
Bay Institute / NRDC	Peter Vorster	• Uses and limitations of models in addressing alternative water management strategies
American Rivers	John Cain	• Tools for adaptive management and floodplain restoration
CA Sportfishing Alliance / CA Water Impact Network	Tim Stroshane	• Water availability analysis
The Nature Conservancy	Chris Shutes	• Water balance modeling
	Leo Winternitz	• Multispecies ecosystem effects
	Clint Alexander	• Analysis using the Delta Ecological Flow Tool

San Joaquin Valley Water Suppliers Panel

Agency	Presenter	Topic
San Joaquin Tributaries Assoc.	Gary Lorden	• CDFG Escapement model
	Jay Bartroff	
	Dan Steiner	
	Avry Dotan	

State and Central Valley Project Contractors Panel

Agency	Presenter	Topic
State Water Contractors, San Luis & Delta-Mendota Water Authority	Wayne Lifton	• Adaptive management
	Paul Hutton	• Model to estimate natural flow
	David Sunding	• Models for measuring the economic impact of changes in Delta water supplies
	Ray Hilborn	• Resolving scientific uncertainty

In-Delta Water Interests Panel

Agency	Presenter	Topic
Bay Area Clean Water Agencies	Michael Connor	• Available for Q&A period
City of Antioch	Susan Paulsen	• Modeling current and future water quality in the Delta

Sacramento Valley Water Suppliers Panel

Agency	Presenter	Topic
N CA Water Assoc., Sacramento Valley Water Users	Walter Bourez Mark Petrie	• Changes in condition and advances in analytical tools

Hydropower Producers Panel

Agency	Presenter	Topic
CA Municipal Utilities Assoc.	Dave Modisette	• Overview
State Water Contractors	Timothy Haines	• Power capabilities, state energy laws, implications for SWRCB
Northern California Power Agency	Jerry Toenyes	• CVP, possible power capabilities, and possible CVPIA impacts
CA Municipal Utilities Assoc.	Dave Modisette	• Bay-Delta hydro resources, factors for SWRCB to consider in modeling

California Energy Agencies

Agency	Presenter	Topic
CA Energy Commission	Mike Jaske	• A joint presentation on various hydro- electric modeling approaches, the issues they are intended to illuminate, and applicability to flow criteria proposals
CA Public Utilities Commission	Nathaniel Skinner	
CA Independent System Operator	Dennis Peters	

Appendix B

Comments Received

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Ecosystem Conservation Division/Water Branch
830 S Street
Sacramento, CA 95811
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

April 22, 2013

Felicia Marcus, Chair
State Water Resources Control Board
1001 I Street
Sacramento, CA 95814

SUBJECT: State Water Resources Control Board meeting April 9th, 2013: Comments on informational item 4 pertaining to the update of 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary

Dear Ms. Marcus:

The purpose of this letter is to provide you with comments on an informational item that was discussed at the April 9th, 2013 Board meeting of the State Water Resources Control Board (State Water Board). Informational item 4 pertained to the next steps for the *Draft Summary Report on Technical Workshops in Support of the Comprehensive (Phase 2) Review of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (Bay-Delta Plan). Dr. Brock Bernstein presented an overview of the summary report on the Bay-Delta Plan workshops that were conducted on September 5 and 6, October 1 and 2, and November 13 and 14, 2012. Dr. Peter Goodwin, Lead Scientist for the Delta Science Program (DSP), gave recommendations for next steps to update the Bay-Delta Plan. Several interested stakeholders also had comments and made recommendations on next steps at the Board meeting.

The California Department of Fish and Wildlife (CDFW) supports the State Water Board in its strategic approach to update the Bay-Delta Plan and its commitment to base its decisions on best available scientific information. In this letter, we reflect on the process that has been used to-date and make suggestions for next steps to update the Bay-Delta Plan. Our three main points are as follows:

A. The State Water Board is using a robust, open and transparent process to gather scientific information and stakeholder input on the Bay-Delta Plan update.
B. Objective criteria exist for evaluating best available science and scientific credibility.
C. Sufficient scientific information currently exists for the State Water Board to update the Bay-Delta Plan for Phase 1 concurrently with the Phase 2 process.

Each of these points is discussed in greater detail in the remainder of this letter.

A. State Water Board Process to update the Bay-Delta Plan is very robust and is producing solid scientific information

The State Water Board anticipated the Bay-Delta Plan update in its 2008 Strategic Work plan. On August 29, 2008, it initiated a periodic review of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary by issuing a notice of public workshop to solicit input on potential modifications to the Bay-Delta Plan.

In August 2009, the State Water Board produced a staff report on the *Periodic Review of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (State Water Board 2009). The staff report was based on a review of scientific literature and relevant information and includes a discussion of scientific issues that were recommended by staff to be addressed in the water quality planning process.

In August 2010, the State Water Board produced the *Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem*, which was the culmination of several days of expert panel deliberations on flow criteria (particularly Delta outflow) necessary to protect public trust resources. Flow criteria in the 2010 report were based on best available scientific information submitted during the multi-day proceeding which included a discussion of unimpaired flow conditions, ecological functions and the statistical relationships between flow and native species abundance.

In October 2010, the State Water Board released its first draft of a report titled *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives* (Technical Report). The Technical Report was prepared to provide the State Water Board with the scientific information and tools necessary to inform potential changes to the San Joaquin River (SJR) flow and southern Delta water quality objectives, which is Phase I of the Bay-Delta Plan update.

The Technical Report underwent an independent scientific peer review in the fall of 2011, including review by scientists from the Oakridge National Laboratory and University of Washington (UW). A key point made by Dr. Julian D. Olden (Olden, J.D. 2011, p. 3.) of UW is that *"[t]he assumption is made [in the Technical Report] that present-day hydrographs that aim to mimic unimpaired hydrographs represent more 'natural' conditions that favor the life-histories of Chinook salmon and steelhead trout in the San Joaquin River basin. This assumption is both well defended in the Technical Report and by decades of scientific research conducted in California and elsewhere."* The Technical Report was subsequently revised in February 2012, and again in December 2012.

In May 2012, the Delta Independent Science Board provided a memorandum to the State Water Board stating that the Technical Report *"makes a persuasive case that fish and wildlife need more flow and more natural spatial and temporal patterns of flow. The report's external scientific reviewers, who endorsed these conclusions, are respected and experienced scientists with extensive expertise in salmonid biology, and they provided a thorough review of the report."*[1]

The reports described above contain scientifically well-substantiated and documented information that is foundational to the Bay-Delta Plan update. It is our opinion that these reports provide a sound scientific basis for the State Water Board to establish flow objectives to protect beneficial uses identified in the Bay-Delta Plan. In addition, the use of focused scientific and technical workshops and independent scientific peer review to generate these reports demonstrates that the State Water Board has used an open and transparent process to gather public input on the Bay-Delta Plan update. These workshops and peer review are discussed in the next section.

Bay-Delta Plan Workshops and Summary Report

Three scientific/technical workshops for the comprehensive review and update of the Bay-Delta Plan were held during the September to November 2012 time period. The proceedings of these workshops are summarized in a January 2013 report titled *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan: Draft Bay-Delta Plan Workshops Summary Report* (Workshops Summary Report).[2]

The workshops were attended by a diverse group of public agencies, NGOs, stakeholders and the general public. The Workshops Summary Report describes key points of agreement, disagreement, uncertainties and questions which should be very useful to the State Water Board. We suggest, however, that disagreement does not necessarily constitute a credible scientific debate and recommend the State Water Board should carefully evaluate the information it received and ensure that only the best available, scientific information is used to inform your decision-making processes.

Each of the workshops included an invited panel and a fish agencies panel (CDFW, USFWS, NMFS and USEPA). Participants on these panels are some of the most highly regarded scientific experts on the San Francisco Bay-Delta estuary and have a strong record of peer-reviewed publications. We recommend that you consider the input of these panelists carefully as you sort through and evaluate input by various stakeholders.

---

[1] Delta Independent Science Board 2012, p. 2.

[2] ICF International. 2013. Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan: Draft Bay-Delta Plan Workshops Summary Report. Prepared for State Water Resources Control Board. Sacramento, CA.

At this time we do not see a benefit to the State Water Board finalizing the Workshops Summary Report. It is more-or-less an accurate representation of the discussions that occurred during the workshops. We therefore do not include in this letter any suggested changes to that summary report.

B. Objective criteria exist for evaluating best available science and scientific credibility.

The State Water Board has the enormous task of evaluating thousands of pages of scientific and technical information that it has received from state, federal and local agencies and non-governmental organizations (NGOs). This information has been submitted as part of the public scoping process for preparation of environmental documents to support the Bay-Delta Plan update, including three informational workshops on various technical issues in late 2012 and during informational proceedings that occurred in 2010.

We believe there are objective criteria for evaluating the use of *best available science* and *scientific credibility* which will be helpful to the State Water Board. The Sacramento-San Joaquin Delta Reform Act of 2009 requires the Delta Stewardship Council to use best available science in implementing its Delta Plan.[3] We believe the Delta Plan criteria for best available science is a useful framework to evaluate the weight of scientific information.[4] The Delta Plan also includes a generalized ranking of scientific credibility which could also be useful to the State Water Board. Beginning with the most rigorous category, these criteria include:

1. Independently peer-reviewed publications including scientific journal publications and books;
2. Other scientific reports and publications;
3. Science expert opinion; and
4. Traditional knowledge.

We recommend the State Water Board give special deference to the invited panel and fish agencies panelists' expert opinions and written submittals, with particular weight given to panel members having a solid record of peer-reviewed published journal articles on the San Francisco Bay-Delta estuary. Similarly, we recommend the State Water Board give weight to peer-reviewed publications that were submitted or referenced in exhibits.

---

[3] California Water Code § 85308(a).

[4] These criteria include relevance, inclusiveness, objectivity, transparency and openness, timeliness and peer review. See Appendix A of the Final Draft Delta Plan (Delta Stewardship Council 2012).

C. Sufficient scientific information currently exists for the State Water Board to update the Bay-Delta Plan for Phase 1 concurrently with the Phase 2 process.

We support your staged-approach to the environmental review of the 2006 Bay-Delta Plan and the environmental review for potential changes to water rights and other measures to implement any revisions to the Bay-Delta Plan. We believe it prudent for the State Water Board to proceed with the Phase 1 update of the 2006 Bay-Delta Plan in parallel with Phase 2. Our perspective is that the State Water Board is using a very robust process for the Bay-Delta Plan update based upon solid scientific information. We do not agree with the suggestion by some stakeholders that the State Water Board needs to conduct more scientific and technical workshops before making a decision on Phase 1.

Some water user entities, such as San Joaquin Tributaries Authority, have claimed that the State Water Board did not provide meaningful opportunities to participate or provide input in the development of the Technical Report and Substitute Environmental Document (SED) for Phase 1. This is, of course, not true. In fact, the Technical Report for Phase 1 states as follows:

> "The State Water Board released the first draft of the Technical Report on October 29, 2010. In order to receive comments and other technical information related to that draft, the State Water Board solicited public comments and held a public workshop on January 6 and 7, 2011. The purpose of the public workshop was to determine whether: 1) the information and analytical tools described in the Draft Technical Report are sufficient to inform the State Water Board's decision-making to establish SJR flow and southern Delta salinity objectives and a program of implementation to achieve these objectives; and 2) the State Water Board should consider additional information or tools to evaluate and establish SJR flow and southern Delta salinity objectives, and a program of implementation to achieve these objectives. The State Water Board received 21 comment letters on the Draft Technical Report which are available at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/comments120610.shtml".

The Phase 1 SED is based on the Technical Report. Moreover, the State Water Board, in compliance with CEQA and the Porter Cologne Act, has provided opportunity to comment on the SED and held subsequent public participation workshops on the Phase 1 SED. Therefore, it cannot be said that the State Water Board has not provided an open, transparent, and meaningful opportunity to participate and gather input on Phase 1.

We believe the weight of scientific evidence shows that a higher percentage of unimpaired flows from each of the tributaries (Stanislaus, Tuolumne, and Merced rivers)

is necessary to protect public trust resources. A flow regime that more closely resembles a natural hydrograph along with other actions (for example, improving riparian and floodplain habitat) is necessary to protect fish and wildlife resources. We agree with one of the fundamental conclusions in the 2010 Flow Criteria report that flow and physical habitat interact in many ways, but are not interchangeable, and that the best available science indicates that current flows are insufficient to protect public trust resources.

In summary, we believe there is sufficient scientific information to move forward on the Bay-Delta Plan update. If however, you deem it necessary to convene additional workshops for Phase 2, we suggest you do so after the State Water Board issues a draft Technical Scientific Report for Phase 2.

Conclusion

CDFW believes this update of the 2006 Bay-Delta Plan will be a watershed moment that sets California on a path to a functioning Bay-Delta ecosystem while ensuring a reliable water supply. Ensuring sufficient freshwater flows that mimic the features of a natural hydrograph is essential to maintain ecosystem integrity. As such, flow objectives should be the focus of the Bay-Delta Plan update as there are no other processes that can effectively address the issue of proper allocation of the state's water resources for use within the Delta. Many species depend on these flows, especially those whose populations that are threatened or endangered. As natural flows and the patterns of those flows have been reduced or altered, ecosystem productivity and species and habitat diversity in the Delta have diminished. CDFW looks forward to being an active partner in the effort to update and implement the revised Bay-Delta Plan.

If you have any questions, please feel free to contact me at scott.cantrell@wildlife.ca.gov or call me at (916) 445-1272.

Sincerely,

Scott Cantrell

Scott Cantrell
Chief, Water Branch

ec: Diane Riddle
State Water Resources Control Board
driddle@waterboards.ca.gov

Stephani Spaar
Department of Water Resources
sspaar@water.ca.gov

Ryan Wulff
NOAA National Marine Fisheries Service
ryan.wulff@noaa.gov

Roger Guinee
U.S. Fish and Wildlife Service
roger.guinee@fws.gov

Erin Foresman
U.S. Environmental Protection Agency Region 9
foresman.erin@epamail.epa.gov

Sandra Morey
Ecosystem Conservation Division
sandra.morey@wildlife.ca.gov

Carl Wilcox
Bay Delta Conservation Plan
carl.wilcox@wildlife.ca.gov

Scott Wilson
Bay Delta Region
scott.wilson@wildlife.ca.gov

Jeff Single
Central Region
jeff.single@wildlife.ca.gov

Neil Manji
Northern Region
neil.manji@wildlife.ca.gov

Tina Bartlett
North Central Region
tina.bartlett@wildlife.ca.gov

Stafford Lehr
Fisheries Branch
stafford.lehr@wildlife.ca.gov

Glenda Marsh
Water Branch
glenda.marsh@wildlife.ca.gov

Central Valley Clean Water Association
Representing Over Fifty Wastewater Agencies

MICHAEL RIDDELL– CHAIR, CITY OF RIVERBANK
JEFF WILLETT – SECRETARY, CITY OF STOCKTON
TERRIE MITCHELL – SACRAMENTO REGIONAL CSD
ED CROUSE – TREASURER, RANCHO MURIETA CSD

April 23, 2013

Ms. Felicia Marcus, Chair and Board Members
Ms. Dianne Riddell, Environmental Program Manager
State Water Resources Control Board
PO Box 100
Sacramento, CA 95814

Subject: **Comments on report titled *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, Draft Bay-Delta Plan Workshops, Summary Report* prepared by ICF International dated January 2013.**

Chair Marcus and Board Members:

At a meeting held on April 9, 2013 regarding the Phase 2 Bay-Delta Plan update, comments were invited by the State Board on the discussion that occurred that day and on the report titled *Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan, Draft Bay-Delta Plan Workshops, Summary Report* (Summary Report) that was used to initiate the discussion. The Central Valley Clean Water Association (CVCWA) is providing comments to identify concerns with the report and to seek modification of the report. Additionally CVCWA is reiterating some of the comments we made at the Board meeting concerning the proposal to evaluate nutrients.

CVCWA is a nonprofit association of Publicly Owned Treatment Works (POTWs) located throughout the Central Valley. CVCWA's primary mission is to represent wastewater agencies in regulatory matters while balancing environmental and economic interests. CVCWA members have a deep commitment to the protection of beneficial uses in the waters of the Central Valley, and have a special interest in the protection of uses in the Delta. With the exception of one, CVCWA members include all POTWs in the legal Delta.

Comments on the Report:

The Summary Report consists of four main sections: (1) a 17-page opening section that attempts to summarize key points of agreement, key points of disagreement, uncertainties, and questions for each of several topical areas, and (2) three sections that include summaries of panel presentations, questions by Board members, and answers to those questions for each of three Phase 2 workshops held in the fall of 2012.

CVCWA has specific comments regarding the "key points of agreement" that were listed for the topics "Nutrient and Plankton" and "Contaminants" and a general comment regarding the report.

Nutrients and Plankton

The report states, on Page 11, that "There was broad agreement that the amounts and types of nutrients strongly affect the level of primary productivity and that nutrients can also affect the composition of the plankton community."

CVCWA believes that this statement misrepresents the discussion that occurred during the panel proceedings. A more accurate and acceptable statement would be that:

> There was broad agreement that the role of nutrients in the Delta ecosystem should be addressed, that linkages between flows, residence times and nutrient effects must be examined, and that nutrient management strategies should be developed and evaluated.

CVCWA requests that the subject "key points of agreement" statement in the report be eliminated in favor of the suggested statement. At a minimum, it is requested that the words "strongly" and "can" be replaced with the word "may" if the current sentence is retained.

Contaminants

The report states, on page 12, that "Stakeholders agreed that contamination is likely to be causing impacts both on certain individual species and on overall habitat conditions."

CVCWA disagrees that this agreement was reached during the panel proceedings. CVCWA requests that the following substitute statement be made in the summary section of the report:

> "It was largely agreed that the role of contaminants, in combination with flow, should be considered in these proceedings."

CVCWA requests that the current "key points of agreement" statement in the report be eliminated in favor of the suggested statement. At a minimum, the current statement should be modified by replacing the words "is likely to" with the word "may".

Finally, CVCWA requests that language be added to the beginning of the report to clarify that this document is essentially a compilation of meeting notes by the contractor, ICF International, and that conclusions regarding points of agreement and disagreement are merely the opinions of the author(s), and are not the product of a rigorous attempt to validate the results of the panel discussions with participants. It should also be noted that the statements made in the report do not reflect approval by the panel members or by other participants in the process and shall have no regulatory or binding effect on any party.

Nutrient Proposal:

With members both inside and outside the Delta, CVCWA has been closely tracking and looking for opportunities to participate in the development of nutrient objectives. We have met with both State Water Board staff and Central Valley Regional Water Board management to discuss the development of objectives for nutrients. The nutrient effort in the Central Valley is just beginning. Based on other efforts in the San Francisco Bay and Southern California that both funding and time are needed to develop the necessary science for appropriate objectives. We urge the State Water Board to work closely with the Central Valley Region and its stakeholder, including CVCWA, in developing nutrient objectives and its implementation plan both inside and outside of the Delta.

One step contemplated by the Delta Science Program at the State Water Board was to assemble stakeholder to hold a workshop on Delta nutrients. CVCWA would like to be involved in this effort.

We appreciate the opportunity to provide these comments and are available to answer any questions you have.

Sincerely,

Debbie Webster

Debbie Webster
Executive Officer

c: Pamela Creedon – Central Valley RWQCB

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 942360001
(916) 653-5791

April 22, 2013

Felicia Marcus, Chair
State Water Resources Control Board
P.O. Box 100
Sacramento, California 95812

Via email: bay-delta@waterboards.ca.gov

Dear Chairwoman Marcus and Members of the Board:

The Department of Water Resources (DWR) appreciates the opportunity to respond to information presented to you at the April 9th State Water Resources Control Board (State Water Board) meeting as part of the "next steps" item on the San Francisco Bay/ Sacramento-San Joaquin Delta Estuary Water Quality Control Plan phase 2 update (Bay-Delta WQCP phase 2 update). DWR commends Brock Bernstein and ICF on the effort put into accurately summarizing the information presented to the State Water Board during the science workshops in the fall of 2012. As stated in that report, scientific uncertainties, as opposed to disagreements, exist and warrant further discussion.

In particular, the ICF report states, in part: (1) "major uncertainties revolved around the reliability of ecological relationships to the LSZ as a central basis for planning and the degree to which the combination of pumping and Delta inflows moves the LSZ around the Delta;"[1] (2) "the role flow plays in the ecosystem and about how to manage flow are reflected in a core set of uncertainties"[2] including the weight of recent studies, expected benefits from flow, and "the relationship between specific flow levels and key outputs such as amounts of different habitat types or abundances of different species of fish, the ecological role of fall flows particularly for longfin smelt, and the relative importance of San Joaquin flows to the Delta ecosystem, specifically salmon populations,"[3] and "sources of turbidity in the system;"[4] (3) there exist "questions of pelagic species' specific habitat requirements and about the proper balance between addressing flows and needs for improved/expanded habitat;"[5] (4) "entrainment and salvage are important processes, but the actual levels of entrainment and salvage by species, the specific conditions that increase the risk of entrainment and/or salvage, and the population level effects of entrainment/salvage are all uncertain;"[6] (5) "in terms of salmon, the mechanisms (e.g., affecting salmon migration, especially in the western Delta;"[7] and, (6) "uncertainties are characteristics and foodweb productivity."[8] DWR agrees with ICF that some aspects of

1 ICF International, Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan Draft Bay-Delta Plan Workshops Summary Report (January 2013) page 4.
2 *Id* at p. 7.
3 *Id.*
4 *Id* at p. 8.
5 *Id* at p. 10.
6 *Id.*
7 *Id.*
8 *Id* at p. 11.

the science on fish species are inconclusive, unknown or questionable. Thus, contrary to what was presented by the Bay Institute on April 9th, the State Water Board should seek out further information in an attempt to find better answers. The science is not conclusive, nor does the scientific community have consensus.

Specifically, DWR reiterates the main messages it presented at the science workshops. There is a significant amount of new understanding regarding the physics, chemistry and biology of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Much of the information included in the 2009 Staff Report for the Bay-Delta WQCP phase 2 update is supplanted by new information. Principally, new information is eroding the historic notion that river flows and the location of the low salinity zone are the master variables to restoration of the Bay-Delta. Rather, it is clear that the whole range of ecosystem stressors must be considered. The relative importance of flow is unknown and warrants further investigation.

Furthermore, the science shows that exports appear to have no significant effect or only a modest contribution on salmonid survival. In other words, the influence of the State Water Project on downstream migrating salmonids is less substantial than has been previously hypothesized. At the same time, there is an underemphasis on life history diversity, habitat for rearing and migrating salmonids, and the marine portion of the salmonid lifecycle.

Further workshops that explore the areas of uncertainty and disagreement reported by ICF are valuable. Following the conceptual process presented to you by Dr. Goodwin would help to increase the amount of information available in this update. Based upon the recommendations provided by both of these parties, DWR recommends that the State Water Board continue to seek information and not rush to end the workshop process.

DWR looks forward to the next steps that the State Water Board will take in this process and will continue to fully participate and provide the best available science. If you or your staff have any questions on submissions by DWR, please contact Katherine Kelly, Chief of Bay-Delta Office at (916) 653-1099 or Kathy.Kelly@DWR.

Sincerely,

Katherine Kelly for

Paul Helliker
Deputy Director

To advance the economic, social and environmental sustainability of Northern California by enhancing and preserving the water rights, supplies and water quality.

April 8, 2013

Felicia Marcus, Chair
Members of the Board
State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Re: Informational Item: Current Status of Phase 2 of the Comprehensive Update of the Bay-Delta Water Quality Control Plan

Dear Chair Marcus and Members of the Board:

The Northern California Water Association (NCWA) and the Sacramento Valley Water Users have actively participated in the Comprehensive Update of the Bay-Delta Water Quality Control Plan (WQCP) Phase 2 process over the past year and we have provided testimony and technical information to help the State Water Resources Control Board (the ñSWRCBò) update the WQCP. We have the following comments for your consideration:

1. The SWRCB's 2012 technical workshops significantly advanced the development of viable Bay-Delta solutions by enabling many parties to present complicated scientific information in detail and by encouraging questions of the witnesses from the SWRCB and discussion between the witnesses and the SWRCB. In these ways, the 2012 workshops provided the SWRCB with important information upon which the Phase 2 process must be based. Even though the parties do not all agree on the significance and relative importance of the information presented to the SWRCB, the parties generally agree that it is important for the SWRCB to base any decision on the best available scientific information.

2. The information provided to the SWRCB during the 2012 workshops, as reflected in the ICF report, demonstrates that there are major scientific disagreements among the various parties. For instance, in discussing flows, the ICF report states (at page 6) that the stakeholders disagree about: ñthe priority attached to flow compared to other factors (e.g., habitat degradation, foodweb changes)ò and about ñwhether increases in flow alone, with accompanying attention to other habitat requirements, would achieve goals to

increase fish populations and their resilience.ò We believe that it is crucial for all of California that these questions be addressed through a systematic and thorough scientific investigation in order to guide future ecosystem management and restoration. To accomplish this goal, we recommend that the SWRCB, working with the Delta Science Program, convene the type of expert panels recommended by the Invited Expert Panel, the California Water and Environmental Modeling Forum and Mr. Walter Bourez during the November 2012 workshop. Those collaborative expert panels should then be charged with refining the ICF report and designing scientific analyses to test the competing hypotheses. Only by this type of systematic effort can we move beyond ñcombat scienceò and determine how best to reasonably protect all beneficial uses that are included in the WQCP and to achieve the Delta Reform Act's coequal goals of water supply reliability and ecosystem restoration.

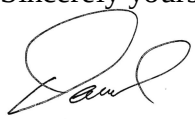
3. We also believe that, to make progress on the Bay-Delta's issues as rapidly as possible, the SWRCB also must do more than authorize the above-referenced scientific investigation. We believe that the SWRCB should ask stakeholders to propose, not later than June 1, 2013, ñon the groundò projects that a variety of interests probably could support and that stakeholders are willing to begin to implement as soon as possible. The SWRCB should require that proposed projects be ready to implement by June 2014. We believe that the SWRCB should assemble these fast-track projects into an update to the 2006 Bay-Delta WQCP's program of implementation. The SWRCB then should use its authority under Water Code section 13247 to facilitate the permitting and approval of these projects by other state agencies. The SWRCB also should engage with relevant federal agencies to develop memoranda of understanding to expedite those agenciesô consideration and permitting of the fast-track projects. In this way, the SWRCB and participating stakeholders can begin to take real actions that will have real benefits for public trust resources while scientific experts are developing longer-term actions.

4. We believe that the SWRCB should describe, in the update of the Bay Delta WQCP, the responsibilities of the SWRCBôs sister state agencies in helping to implement that plan. We believe that Water Code section 13247 gives the SWRCB authority, through the WQCP process, to direct other state agencies to take certain actions needed to implement the Bay-Delta WQCP, absent contrary statutory direction. We believe that the updated WQCP should make clear that the SWRCB will require other state agencies to act in a manner consistent with the WQCP, again absent contrary statutory direction, by means of agreements, memoranda of understanding or other devices.

5. Lastly, we believe that it is important that the SWRCB and other state and federal agencies coordinate and integrate the Phase 2 process with the Bay-Delta Conservation Plan (BDCP) process. At present, there are a multitude of opportunities for confusion and conflict between these processes. We suggest that, given the huge investment of time and public resources, the SWRCB incorporate the analyses that have been prepared as part of the BDCP in the Phase 2 effort, and provide clear direction to the public regarding exactly how the SWRCB intends to sequence its Phase 2 effort in relation to the BDCP process.

We look forward to working with you and your staff should the SWRCB choose to pursue this path. We plan to attend the April 9 meeting and will be prepared to discuss this proposal.

Sincerely yours,



David J. Guy
President

These three pictures were presented by Patrick Porgans at the
State Water Resources Control Board's April 9, 2013 informational agenda item.

WB-DWR-Bay-Delta

From: Michael Warburton <warburto@sonic.net>
Sent: Tuesday, April 23, 2013 11:55 AM
To: WB-DWR-Bay-Delta
Subject: Science, Flows and Management Under Uncertainty

Dear Water Boards,

Thank you for extending the comment period on your next steps in managing the update of the Bay-Delta Water Quality Control Plan. Our organization, The Public Trust Alliance, has been concentrating recent efforts on rivers not connected to the Delta (the Carmel and Salinas, mostly in Monterey County), but we hope that our experience and comments will be useful to your current work. We continue to believe that the State Water Boards' unique position as legal Trustees managing key public resources for common benefit (including, most importantly, future generations of Californians, who will be managing and using those resources long into the future), provides key guideposts for making appropriate public decisions. We urge you not to disregard either your legal duties or your commensurate authorities in this area because they point to realistic opportunities for responsible public action.

The words "co-equal goals" included in 2009 legislation did not revoke, or even drastically amend, the California Public Trust Doctrine; the law still requires trustees to "protect trust resources when feasible." We are deeply grateful that the official report of public workshops included so much attention to the terms of public debate about the appropriate role and authority of "science" in determining appropriate public action. We join with other stakeholders in recognizing such independent analysis as vital to informed public decision making. We think we can find even more common ground with other parties if additional effort is put on exploratory rather than adversary approaches to understanding the "natural" constraints we are confronting, as well as the complex social, economic, cultural and institutional forces which play such prominent roles in shaping and defining our "environment."

We have come to see the public trust doctrine as key "adaptive tissue" in our institutional infrastructure (this mixing of biological and physical metaphors is deliberate). Clearly, decision makers and community members have a lot of learning to do on any realistic path to consensus. We all have heard that our Constitution is "not a suicide pact" but we don't seem to have taken it to heart. Policy gridlock is neither an inevitable nor a legally acceptable strategy for Public Trustees dealing with California Water problems. The law requires reasonable and timely action based on the best information available. Human beings, in fact, have been making decisions and taking action on the basis of "incomplete" information for thousands of years. CEQA and Water Boards are comparatively recent institutional innovations while the legal contours of the Public Trust have been shaped over millennia. The Byzantine Emperor Justinian's legal advisors recognized Centuries of prior authority that limited potential acts of even the most powerful political actors because some things are just so valuable for public use that they cannot be treated as private property.

Perhaps the most salient feature of the public trust is that public rights and duties move with the water, and not with socially determined boundaries. As climate change shifts relationships between land, water and place, the changing public trust provides key opportunities for adaptation, both physically and institutionally.
The flow criteria that the public is entrusting you to enact and enforce for the San Francisco Bay Delta should be both ecologically and socially "sustainable." The conventions and practices suggested by the California Public Trust Doctrine are important components of your "tool kit."

The people and methodologies described in the excellent workshop report make this topic a very personal

one for me. Thirty two years ago, I arrived as a new member of the scientific staff of the International Institute for Applied Systems Analysis to work on a "Discussion Paper" for an Interagency Meeting of United Nations Agencies engaged in "Environment and Development" work in the Himalayan Foothills. The Canadian Ecologist, C.S. Holling, was the Institute's Director, and fisheries biologist Carl Walters was just putting his theory of "Adaptive Management" together. I even think I met Ray Hilborn on a brief trip through U.B.C in Vancouver a couple of years later. In any case, there was a very deep discussion transpiring regarding what "science" should and should not claim authority for in managing complex ecosystems. And what are appropriate roles for various disciplines in collaborating on credible and useful policy recommendations?

We looked especially at policy issues characterized by "Uncertainty" and long periods of gridlock. Our Himalayan work was originally published as several academic papers and then, in 1986, as Uncertainty On A Himalayan Scale: An Institutional Theeory of Environmental Perception and a Strategic Framework for the Sustainable Development of the Himalayas (Ethnographica, London). It was republished in 2007 with collaboration of the Peter Martin Center at Oxford Business School and Himal Press of Kathmandu, with a new Introduction by British Anthropologist, Michael Thompson and the Former Minister of Water Resources for Nepal. The title of that introduction was "The Triumph of Hype Over Experience," and I think it offers many useful suggestions for breaking out of "War of Experts" situations. There is actually a fairly longstanding scientific literature and associated methodological recommendations for dealing with "wicked problems" and your Board might find this useful in formulating next steps.

Thanks again for this extended period to comment.

Sincerely,
Michael Warburton
Executive Director
Public Trust Alliance
A Project of Resource Renewal Institute
187 East Blythedale Ave.
Mill Valley, CA 94941
tel. (510) 610-0868
michael@rri.org

SOUTH DELTA WATER AGENCY

4255 PACIFIC AVENUE, SUITE 2
STOCKTON, CALIFORNIA 95207
TELEPHONE (209) 956-0150
FAX (209) 956-0154
E-MAIL Jherrlaw@aol.com

Directors:
Jerry Robinson, Chairman
Robert K. Ferguson, Vice-Chairman
Natalino Bacchetti
Jack Alvarez
Mary Hildebrand

Counsel & Manager:
John Herrick

April 23, 2013

Via E-mail
bay-delta@waterboards.ca.gov

Ms. Diane Riddle
Environmental Program Manager
Hearings and Special Programs Section
Division of Water Rights
State Water Resources Control Board

Re: Comments to Draft Bay-Delta Plan Workshops Summary Report

Dear Ms. Riddle:

The following comments are submitted on behalf of the South Delta Water Agency.

The Draft Report referenced above contains a good summary of the issues and positions submitted by the stakeholders during the workshop process. SDWA has no criticisms or suggested changes to the summary, but believes certain issues need to be addressed further in the Report.

There are a number of fundamental issues that are pre-conditions to the SWRCB Bay-Delta Process. These issues need to be addressed before any of the other issues outlined in the Report can be examined. The first of these is the water supply. Although the Report for the most part accurately summarizes my testimony, I do not believe it adequately recognizes the importance of the issue. The recent history of 2007, 2008 and 2009 not only indicated that the SWP and CVP were incapable meeting minimum fishery flows after just two years of drought, but that those projects were also incapable of delivering export supplies if the two year drought had become a three year drought.

This is not simply an issue of calibrating models, but indicates that the assumption that millions of acre feet can be exported from the estuary on a regular basis is factually wrong. If the

current storage and release rules for the projects cannot meet fishery water quality requirements in the third year of a drought (and thereafter) discussions about multi-year protections for fish are possibly moot. The previous and current Bay-Delta processes were/are based on the assumption that 3-7 MAF of water can be exported from the Delta while still maintaining a healthy estuary and related fisheries. The data from 2007-2009 reveals that not to be the case. Export pump limitations due to fishery concerns did not result in a lack of storage for meeting fishery objectives, and not did limit the amount available for export; ***the lack of water did***. Unless the SWRCB believes that fisheries can survive with only a two year protection of minimum fishery flows, the entire process should be suspended until the actual yield of the system, and how that yield can provide for fishery flows is determined. As the SWRCB's D-1485 noted, full mitigation of the projects would require the virtual shutting down of the export pumps. Can the SWP and CVP be operated to protect fish and have enough water thereafter to provide some level of exports?

Of course any investigation about such yield will be vehemently opposed by export interests. However, such opposition does not change the fact that the SWP and CVP ***ran out of water after only two years of drought***. It would be a dereliction of duty by the SWRCB to proceed under the assumption that the protection of fisheries will not occur during any years after a two year drought.

Second, there is a fundamental legal and factual issue dealing with climate change and sea level rise. Initially of course, the basis on which predicted sea level rise and precipitation changes will manifest themselves requires extensive analysis and discussion. Clearly the use of models to predict such things is suspect at best and unreliable at worst. However, even if the assumptions being considered are supportable, it raises the question of how to deal with those predicted changes. It is incumbent on the SWRCB (and the fishery agencies) to address the question of "what legal obligations it is under if it believes that 'natural' climate and estuary changes are likely to result in the extinction of certain species regardless of what protective actions it undertakes/requires?"

Put another way, if the SWRCB concludes that sea level rise will cause the extermination of say, Delta smelt, does that mean it can legally ***not*** protect smelt from the adverse impacts of the projects? It is clear the export interests are trying to lessen their obligations by not only blaming other factors for fish population declines, but also trying to limit future requirements by complaining "the fish are doomed anyway." We know of no legal principle that would allow the take of endangered species based on the "defense" that the species will go extinct anyway. However, that is just what is being asserted in this process. The SWRCB should publically indicate if it believes it has any leeway in protecting fishery beneficial uses based on the speculative conditions resulting from climate change.

Third, the process does not seem to be taking into consideration legal mandates associated with CVPIA's fish doubling requirement and similar California statutes. If federal law requires that the Bureau of Reclamation in conjunction with FWS and NMFS doubles certain listed anadromous fish species, then there appears to be no basis on which to "balance" proposed fishery actions against impacts to parties assigned to meet the obligations. Has not federal law already decided the extent to which actions are required to double said species? If the SWRCB believes it can implement/require/adopt measures that will not meet federal obligations on the federal parties under its jurisdiction, it needs to so state and explain why. We already have an AFRP with complete and detailed specifics on what needs to be done to double the listed fish species; how can the SWRCB contemplate otherwise?

Fourth, much of the report covers the proposals and suggestions for getting better inputs for adaptive management. However, the question of adaptive management itself is not dealt with. It is clear to all outside observers that the practice of adaptively managing the Delta for the past 30 years has been an unambiguous failure. Unless someone believes that failure is the result of faulty data or incomplete data, the very assumption of adaptive management should be re-examined. Apparently there is something inherent in the process which leads to failure at every turn. The likely culprit is the CalFed notion that the "regulated and regulators should work together." Clearly, when regulatory agencies are obligated to take export needs into consideration the fisheries suffer the consequences. The SWRCB should state why it believes the adaptive management process should be continued.

Lastly, SDWA again raises the issue of responsibility and mitigation The Bay-Delta process seeks to protect fisheries (and other beneficial uses) which requires some level of balancing. That balancing looks at the benefit of the protection compared to the cost of providing the protection. This notion makes sense and is required when the Board is looking at just what is needed from a global perspective. It does not make sense and is not required when the cause of the fishery decline is due to the adverse impacts of one or more parties. It is clear that the export projects are a major cause of the fishery decline and the destruction of the estuary. No balancing is necessary to require such parties to fully mitigate their impacts; they can be required to mitigate those impacts under the Board's authority over the water right permits granted to the CVP and SWP. Thus, before contemplating what other actions are necessary, or who might be required to undertake those actions, the Board should/must first require the "guilty" parties to mitigate their impacts. By not doing this first, the Board ends up "balancing" the cost of making a party mitigate its impacts; clearly not the intent of Water Code Section 13241. In practice, the Board ends up giving those who caused the fishery crash "credit" because its too expensive to fully mitigate those impacts.

Thus, before deciding on any changes to the water quality objectives, the SWRCB should hold hearings on draft Cease and Desist Orders against the projects for their impacts to the fisheries. Of course those hearings will be long, expensive and contentious, but so is every Bay-

Delta proceeding. Such CDO hearings would resolve the issue of what the projects do to the fish, and rightfully place the costs of mitigating the same.

Please feel free to contact me if you have any questions.

Very truly yours,

JOHN HERRICK

April 23, 2013

Via email: Bay_Delta@waterState Water Boards.ca.gov

Members of the State Water Resources Control State Water Board
Attn: Ms. Jeanine Townsend, Clerk to the State Water Board
P.O. Box 100
Sacramento, CA 96812-0100

Re: Comments on April 9, 2013 Bay-Delta Informational Item

Dear State Water Board Members:

The San Luis & Delta-Mendota Water Authority[1] ("Water Authority") appreciates this opportunity to provide additional comments on the April 9, 2013 Bay-Delta Informational Item. The Water Authority has participated in all of the Phase 2 technical workshops and State Water Resources Control State Water Board ("State Water Board") proceedings pertaining to the Comprehensive Review of the Bay-Delta Water Quality Control Plan, including the meeting on April 9th.

We appreciate the deliberate manner in which the State Water Board is proceeding with the Comprehensive Review. There is much at stake and therefore much call for action. But there is also great debate about what is the best path forward. Many of the questions the State Water Board is wrestling with are also being considered in other forums, both from science, policy, and management perspectives. It is the State Water Board's responsibility when making such significant decisions to not only carefully consider the available information but also how those decisions will affect the other, numerous efforts currently underway intended to address the same or related issues.

The Water Authority was pleased that Dr. Peter Goodwin, Lead Scientist for the Delta Science Program, participated in the April 9th meeting and discussed the Program's effort to develop a collaborative science process intended to close the gaps of uncertainty and disagreement that adversely affect the reliability of the scientific information upon which policy and management decisions are currently being made. The approach to solving today's science challenges through collaboration is so broadly supported that such processes are also being developed for use in implementing the proposed Bay Delta Conservation Plan and correcting the remanded biological opinions on operations of the State and federal water projects. In fact, with regard to the remand, submittals to the federal court by State and federal agencies involved in the litigation regarding new science collaboration efforts on issues that have been embroiled in litigation for years were so compelling that, in large part, they served as reason for the federal court to allow both the United States Fish and Wildlife Service

[1] See attachment 1 for a description of the Authority.

842 SIXTH STREET
SUITE 7
P.O. BOX 2157
LOS BANOS
CALIFORNIA
93635
(209) 826-9696
OFFICE
(209) 826-9698
FAX

and National Marine Fisheries Service more time to respond to its previous remand orders. Whether in the end there is a single collaborative process or multiple, the approach of establishing such an effort is essential to successful and enduring outcomes.

Fostering collaborative processes is consistent with previous State Water Board approaches, when in the past the State Water Board has encouraged parties to get together to resolve scientific and management issues to better inform State Water Board decision making. Examples include the 4 Agency Fish Agreement that served as a basis for many of the objectives in the 1978 Bay-Delta Plan and Water Right Decision 1485. Another is the 1994 Bay-Delta Accord that served as the basis for many of the changes contained in 1995 Bay-Delta Plan and Water Right D1641. The success and durability of these previous decisions are in large part due to the time dedicated to resolving the issues beforehand.

In order for a collaboration to be effective it should start with the development of the process. The Water Authority believes that the attributes for such a collaborative process should include:

- Identify and address the major underlying science questions related to the policy and management issue;
- Deal exclusively with science, not with policy or management decisions;
- Avoid duplicating other ongoing, collaborative science efforts focused on the same subjects; rather, associate with them so the results are complimentary and cohesive;
- Address science information provided by all interested parties so that the full breadth of hypotheses are considered;
- Make use of outside science experts on focused topics, as appropriate; and
- Conduct the process in such a way that participants are treated with respect and equality.

With a process established, a properly functioning and meaningful collaboration will should be provided the policy and management issues important to the State Water Board. In order to determine which policy and management issues require further scientific investigation, the State Water Board should consider asking a key set of questions:

- What does the State Water Board want to accomplish within its legal Water Authority;
- What objectives can achieve or contribute to the desired biological or ecological function(s);
- To what extent does the identified biological or ecological function(s) benefit targeted species;
- What is the full range of actions available to achieve the desired function(s);
- How certain is the predicted outcome of each action alternative; and
- What is the adaptive management approach to address the uncertainty?

Once the State Water Board has established a clear picture of its objective(s), the relevant areas of collaborative scientific investigation are more easily determined. The State Water

Board cannot study the entire universe of issues; rather, it must focus on those issues relevant to the objective(s) the State Water Board is trying to achieve within its legal authorities.

Because of the importance of meaningful collaborative science, the Water Authority is less enthusiastic to hear a proposal to conduct yet another independent scientific review of the issues. Since 2005, there have been no less than 10 separate independent scientific reviews of factors affecting the Delta ecosystem[2]. While each review has had value in terms of providing a snapshot of the current understanding of the science issues, they have done little to close the gaps of uncertainty and disagreement. In fact, because of the way various factions have used selected quotes from many of these independent reviews, it could be argued that they have resulted in hampering progress by creating positions about the science as opposed to promoting collaborative exploration. The Water Authority would not attempt to dissuade the Delta Science Program from conducting another review but would encourage the State Water Board not to let it become a distraction from a concerted and coordinated effort that begins to drill in on the known science questions critical to beneficial policy and management decisions. The Water Authority believes the essential question for the State Water Board to consider at this time is how it can best cooperate with and facilitate the collaborative efforts currently being developed or underway.

One other area of concern that arose on April 9 was the suggestion that, in light of the current scientific uncertainty and disagreement, State Water Board staff proceed with developing revised water quality objectives by incorporating adaptive management. Adaptive management is an essential tool; however, it is one that can and has been exercised, at least in part, in many forms, some beneficial, some not. Adaptive management provides a means for carrying out and assessing alternative management actions in the face of uncertainty. The adaptive management process, when appropriately implemented, should facilitate testing of management alternatives, evaluation of outcomes, iterative modifications of management actions, and learning. However, it cannot compensate for a lack of knowledge, the complexity of ecological systems, or underestimating sources of uncertainty including socio-political uncertainty. In our October 26, 2012 submittal for the Analytical Tools Workshop (#3), the Water Authority and State Water Contractors provided a background and requisites for a successful adaptive management program. In the end, structuring and implementing an adaptive management program is a major undertaking that requires institutional support and sufficient time. Decision-makers must recognize the complexity, limitations, and experimental nature of adaptive management prior to making policy and management decisions about such a program.

It is necessary to reiterate that the Comprehensive Review is of critical importance. The decisions made will affect California's people and environment for years and so a thoughtful and purposeful process is warranted. Despite claims to the contrary, science does not have all of the answers; there remains much uncertainty and disagreement about hypotheses of factors potentially affecting the ecosystem. The State Water Board has taken a significant and

[2] See attachment 2 for a listing of independent science reviews.

valuable step by conducting the science information workshops in 2012. As Dr. Goodwin stated on April 9, the workshops have established the scientific foundation for moving forward. The question now is "how?" In the Bay Delta Conservation Plan development process, the State and federal fish agencies have been wrestling with issues also being considered by the State Water Board, such as spring and fall outflow, and have concluded that there currently is not enough information to make a determination about what standard are appropriate. Instead, they have agreed to pursue better information through a structured, time bound, science, policy, and management decision making process called Decision Tree.

Lastly, some interested parties are clamoring for the State Water Board to make a quick decision. But the State Water Board should consider a significant amount of complex information in order to establish water quality objectives which will "attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved." (Water Code § 130000). Historically, to accomplish this task, the State Water Board has dedicated a substantial amount of time to allow the State Water Board, its staff, and interested parties to present, synthesize, and consider the scientific information prior to making a policy or management decision. For example, before adopting the 1978 Bay-Delta Plan, the State Water Board conducted **32 days** of hearings over approximately one year (from November 15, 1976 to October 7, 1977). For the 1991 Bay-Delta Plan, the State Water Board dedicated **60 days** of hearings over almost three years before adopting revised standards (from July 7, 1987 to August 23, 1990). More recently the trend seems to be toward fewer workshop days (the 2006 Bay-Delta Plan was informed by at least **16 days** of workshops between October 27, 2004 and March 22, 2005) despite the decisions and consequences becoming increasingly more complex. With so much at stake, we want to take this opportunity to praise the State Water Board for the science based path that it has been embarked upon and encourage continued progress toward better information. Only through examination of the full breadth of scientific information can the policy and management choices made result in amenable and beneficial outcomes for California.

The Water Authority appreciates this opportunity to provide additional comments and look forward to further participation in the development of new Water Quality Control Plan objectives. Please feel free to contact me for further information or with any questions you or your staff might have.

Sincerely Yours,

Daniel G. Nelson
Executive Director
San Luis & Delta-Mendota Water Authority

cc: Members of the State Water Resources Control State Water Board

Attachment 1

The Water Authority is a joint powers authority, established under California's Joint Exercise of Powers Act. (Gov. Code, § 6500 *et seq*.) The Water Authority is comprised of 29 member agencies, 27 of which hold contractual rights to water from the federal Central Valley Project ("CVP"). The Water Authority member agencies have historically received up to 3,100,000 acre-feet annually of CVP water for the irrigation of highly productive farm land primarily along the San Joaquin Valley's Westside, for municipal and industrial uses, including within California's Silicon Valley, and for publicly and privately managed wetlands situated in the Pacific Flyway. The areas served by the Water Authority's member agencies span portions of seven counties encompassing about 3,300 square miles, an area roughly the size of Rhode Island and Delaware combined. The Water Authority's members are: Banta-Carbona Irrigation District; Broadview Water District; Byron Bethany Irrigation District (CVPSA); Central California Irrigation District; City of Tracy; Columbia Canal Company (a Friend); Del Puerto Water District; Eagle Field Water District; Firebaugh Canal Water District; Fresno Slough Water District; Grassland Water District; Henry Miller Reclamation District #2131; James Irrigation District; Laguna Water District; Mercy Springs Water District; Oro Loma Water District; Pacheco Water District; Pajaro Valley Water Management Agency; Panoche Water District; Patterson Irrigation District; Pleasant Valley Water District; Reclamation District 1606; San Benito County Water District; San Luis Water District; Santa Clara Valley Water District; Tranquillity Irrigation District; Turner Island Water District; West Side Irrigation District; West Stanislaus Irrigation District; and Westlands Water District.

Attachment 2

Anderson JJ, Gore JA, Kneib RT, Lorang M, Van Sickle J. 2011. Report of the 2011 Independent Review Panel (IRP) on the Reasonable and Prudent Alternative (RPA) actions affecting the operations Criteria And Plan (OCAP) for State/Federal water project operations. Report prepared for Delta Stewardship Council, Delta Science Program dated 12/9/2011.

California Hatchery Scientific Review Group (California HSRG). 2012. California Hatchery Review Report. Prepared for the US Fish and Wildlife Service and
Pacific States Marine Fisheries Commission. June 2012. 100 pgs.

Dauble D, Hankin D, Pizzimenti JJ, Smith P. 2010. The Vernalis Adaptive Management Program (VAMP): Report of the 2010 Review Panel. Prepared for the Delta Science Program. Dated 5/13/2010.

Gaines S, Luoma S, Monismith S, Simenstad S, Sogard S. 2006. Interagency Ecological Program Science Advisory Group report on the 2005-2006 programmatic review of IEP's delta smelt program.

Huggett RJ, Anderson JJ, Campana ME, Dunne T, Giorgi AE, Glibert PM, Klein CA, Luoma SN, McGuire MJ, Miller T, Obeysekera J, Pfeffer MJ, Reed DJ, Rose KA, Tullos DD. 2010. A Scientific Assessment of Alternatives for Reducing Water Management Effects on Threatened and Endangered Fishes in California's Bay Delta. National Academies Press. Washington, D.C. 94 pp.

Huggett RJ, Anderson JJ, Campana ME, Dunne T, Gilbert J, Giorgi AE, Klein CA, Luoma SN, Miller T, Monismith SG, Obeysekera J, Paerl HW, Pfeffer MJ, Reed DJ, Rose KA, Tullos DD, Vaux Jr HJ. 2012. Sustainable water and environmental management in California Bay-Delta. National Academies Press.

Kimmerer WJ, Brown R. 2006. A summary of the June 22-23, 2005 predation workshop, including the expert panel final report. CALFED Bay-Delta Program and Department of Water Resources.

Reed D, Goodwin P, Paerl HW, Peebles EB, Sobczak WV, Taylor EB. 2011. Review panel summary report: Draft plan for adaptive management of fall outflow for delta smelt protection and water supply reliability. Delta Science Program, July 1, 2011.

Rose KA, Kimmerer WJ, Leidy GR, Durand J. 2008. Independent peer review of USFWS's draft effects analysis for the operations criteria and plan's biological opinion. Report prepared for U.S. Fish and Wildlife Service dated 10/23/2008.

US Department of Commerce. 2005. The NMFS review process for the California Central Valley and State Water Projects' biological opinion deviated from the Region's normal practice. Final audit report no. STL-17242-5-0001 dated July 2005.

Vaux Jr HJ, Campana ME, Gilbert JB, Giorgi AE, Huggett RJ, Klein CA, Luoma SN, Miller T, Monismith SG, Obeysekera J, Paerl HW, Pfeffer MJ, Tullos DD. 2011. A review of the use of science and adaptive management in California's Bay Delta Conservation Plan. National Academies Press, Washington, D.C.

Main Office
10060 Goethe Road
Sacramento, CA 95827-3553
Tele: [916] 876-6000
Fax: [916] 876-6160

Sacramento Regional Wastewater
Treatment Plant
8521 Laguna Station Road
Elk Grove, CA 95758-9550
Tele: [916] 875-9000
Fax: [916] 875-9068

April 23, 2013

Chair Felicia Marcus and Board Members
State Water Resources Control Board
P.O. Box 100
Sacramento, CA 95812-0100

Submitted electronically to Bay-Delta@waterboards.ca.gov

Subject: Comments on April 9, 2013 Information Item-Next Steps for Comprehensive (Phase 2) Review of 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.

Dear Chair Marcus and Board Members:

The Sacramento Regional County Sanitation District (SRCSD) provides wastewater conveyance and treatment services to over 1.3 million customers in the greater Sacramento area. Our mission is to protect human health and the environment. We take our mission seriously and work on a daily basis to meet our obligations to protect water quality and beneficial uses in the Delta.

At the April 9, 2013, State Water Resources Control Board (State Board) meeting, the State Board stated its desire to provide stakeholders an opportunity to comment on the next steps to be taken in addressing important scientific issues as part of the Comprehensive (Phase 2) Review of 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay Delta Plan Update). SRCSD appreciates this opportunity to provide input on the next steps for the Bay Delta Plan Update. We request to be included in the planning and coordination efforts for future workshops managed by the Delta Science Program, in particular the workshops pertaining to nutrients, invasive species, and adaptive management.

SRCSD participated in the planning, coordination, and funding of the March 2009 CalFed Ammonia Workshop, which yielded a report by experts emphasizing a number of valuable scientific recommendations, including the need for integration/holistic evaluation of flow and nutrients through the use of comprehensive models. Drawing from that experience, one important product of the upcoming workshops should be a synthesis report with recommendations on issues to identify data gaps. This report should guide prioritization for future research, with a focus on addressing the validity of clearly articulated hypotheses. This synthesis of available science can inform the Bay Delta Plan Update, help to connect scientific hypotheses to policy and management determinations, and aid in the prioritization of future research work. An excellent example of this is the recent 2012 draft Suisun Bay Ammonium Synthesis Report. This report, prepared by the San Francisco Estuary Institute for the San Francisco Bay Regional Water Quality Control

Board, will assist in the process of making nutrient management decisions in San Francisco Bay and will be considered in the development of nutrient numeric endpoints (NNEs) in San Francisco Bay. The draft report is attached for your convenience.

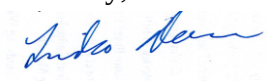
The expert panels' process proposed by the Delta Science Program as a next step in the Bay Delta Plan Update can provide valuable scientific information that can assist the State Board in making policy decisions. However, the conduct and outcome of the workshops cannot replace the process of combining science, policy and management considerations to properly and effectively set water quality objectives and a program of implementation under the Clean Water Act and the California Water Code. SRCSD appreciates State Board member Moore's perspective on nutrients that the NNE process must be science based, with an adaptive management component, and is not just a stream-lined process to establish numeric ambient objectives. Key elements of a Delta NNE process should include:

- Adequate funding.
- Recognition of the time required to develop a sound approach.
- Stakeholder involvement and independent science review.
- Focus on management plan development to determine achievable outcomes as drivers for regulatory requirements.

We need to have outcome-based regulatory policy that will clearly, and measurably, improve the ecosystem. The outcome based regulatory policy should consider controls on an array of stressors.

In conclusion, SRCSD looks forward to assisting the Delta Science Program and the State Board in developing workshops for the update to the Bay-Delta Plan that allows for a balanced and integrated scientific dialogue and process to occur, which will inform and prepare the State Board members to make the hard balancing decisions when updating the Bay-Delta Plan. If you need further information please contact me at 916-876-6030, or dornl@sacsewer.com.

Sincerely,



Linda Dorn
Environmental Program Manager

cc: Stan Dean, District Engineer
Prabhakar Somavarapu, Director of Policy and Planning
Terrie Mitchell, Legislative and Regulatory Affairs Manager
Kurt Ohlinger, Chief Scientist

Attachment: San Francisco Bay Nutrient Management Strategy, November 2012 Draft

November 2012

San Francisco Bay Nutrient Management Strategy

San Francisco Bay Regional Water Quality Control Board

This document was prepared collaboratively by the San Francisco Bay Regional Water Quality Control Board, the San Francisco Estuary Institute and the Southern California Coastal Water Research Project with input from stakeholders, and funding support from the State Water Board and the Bay Area Clean Water Agencies (BACWA)

Contact information is as follows:

San Francisco Bay Regional Water Quality Control Board (Water Board) Naomi Feger *nfeger@waterboards.ca.gov*

San Francisco Estuary Institute (SFEI) David Senn *davids@sfei.org*

Southern California Coastal Water Research Project (SCCWRP) Martha Sutula *marthas@sccwrp.org*

1. Purpose of the Nutrient Strategy

This document presents a draft strategy for developing the science needed to make informed decisions about assessing nutrient impacts on water quality, protecting beneficial uses, and managing nutrient loads to San Francisco Bay. The document first provides relevant background, after which management decisions related to nutrients are highlighted. The document then lays out a plan, developed collaboratively by the San Francisco Regional Water Quality Control Board (Water Board) and Bay stakeholders, for the technical studies required to support decisions regarding nutrient management.

2. Background

San Francisco Bay has long been recognized as a nutrient-enriched estuary. Nonetheless, dissolved oxygen concentrations found in the Bay's subtidal habitats are much higher and phytoplankton biomass and productivity are substantially lower than would be expected in an estuary with such high nutrient enrichment, implying that eutrophication is controlled by processes other than straightforward nutrient-limitation of primary production. The published literature suggests that phytoplankton growth and accumulation are largely controlled by a combination of factors, including strong tidal mixing, light limitation due to high turbidity, and grazing pressure by clams (Cloern et al. 2012)

There is a growing body of evidence that suggests the historic resilience of San Francisco Bay to the harmful effects of nutrient enrichment is weakening. Since the late 1990's, regions of the Bay have experienced significant increases in phytoplankton biomass (30-105% from Suisun to South Bay) and significant declines in DO concentrations (2% and 4% in Suisun Bay and South Bay, respectively; J. Cloern, unpublished data). In addition, an unprecedented autumn phytoplankton bloom in October of 1999, and increased frequency of cyanobacteria and dinoflagellate (2004 red tide event) blooms occurring in the North Bay, further signal changes in the Estuary.

The indications of decreased Bay resilience have come to the fore at a time when the availability of resources to continue assessing the Bay's condition is uncertain. Since 1969, a USGS research program has supported water-quality sampling in the San Francisco Bay. This USGS program collects monthly samples between the South Bay and the lower Sacramento River to measure salinity, temperature, turbidity, suspended sediments, nutrients, dissolved oxygen and chlorophyll a. The USGS data, along with sampling conducted by the Interagency Ecological Program, provide coverage for the entire San Francisco Bay –Delta system. The San Francisco Bay Regional Monitoring Program (RMP) has no independent nutrient-related monitoring program, but instead contributes approximately 20% of the USGS data collection cost. Thus, there is currently an urgent need to lay the groundwork for a locally-supported, long-term monitoring program to provide information that is most needed to support nutrient-related management decisions in the Bay.

The timing also coincides with a major state-wide initiative, led by the California State Water Resources Control Board (State Board), for developing nutrient water quality objectives for the State's surface waters, using an approach known as the Nutrient Numeric Endpoint (NNE)

framework. The NNE establishes a suite of numeric endpoints based on the ecological response of a waterbody to nutrient over-enrichment and eutrophication (e.g. excessive algal blooms, decreased dissolved oxygen). In addition to numeric endpoints for response indicators, the NNE framework must include models that link the response indicators to nutrient loads and other management controls. The NNE framework is intended to serve as numeric guidance to translate narrative water quality objectives.

Since San Francisco Bay is the State's largest estuary, and one for which there is currently a relative wealth of data, it became a primary focus of a state-wide effort to develop NNEs for estuaries. This San Francisco Bay effort was initiated by a literature review and data gaps analysis to recommend indicators to assess eutrophication and other adverse effects of anthropogenic nutrient loading in San Francisco Bay and summarize existing literature in the Bay using these indicators and identify data gaps (McKee et al., 2011). The review made five major recommendations: 1) develop an NNE assessment framework for the Bay, 2) quantify external nutrients loads, 3) develop a suite of models that link NNE response indicators to nutrient loads and other co-factors, 4) implement a monitoring program, and 5) coordinate development of the Bay NNE workplan with nutrient management activities in Sacramento and San Joaquin Delta. The San Francisco Bay Water Board is the State lead for the current effort to develop San Francisco Bay nutrient water quality objectives.

At an RMP-sponsored workshop on nutrient management in the Bay (June 29-30, 2011), participants engaged in monitoring activities in the Bay-Delta were convened on day two to discuss elements of a monitoring strategy. They agreed that developing a NNE assessment framework and funding of a monitoring program were priorities, but that these efforts must begin with spatially–explicit conceptual models of the linkages between nutrient loads, ecological response indicators and Bay beneficial uses.

Another issue that has come to the attention of the Water Board and local stakeholders is that of the potential impact of ammonia/ammonium on Bay beneficial uses. While the USGS has documented a loss of resiliency throughout San Francisco Bay, productivity in Suisun Bay continues to be lower than the South Bay. Recent studies argue that elevated levels of ammonium limit primary productivity in Suisun Bay (Dugdale et al., 2007, 2012; Parker et al., 2012a), and perhaps elsewhere in the Estuary (Parker et al., 2012b). There is currently disagreement within the scientific community about the potential role ammonium plays in limiting primary productivity. To help resolve the issue, the Water Board supported studies in Suisun Bay in 2010 that explored the relationship between ammonium concentrations, nitrogen uptake, and phytoplankton biomass; in the spring of 2011 the Water Board initiated a two-year follow-up study. Additional follow-up studies that are currently underway or planned include toxicity tests and TIE method development to identify the cause of inhibition of diatom growth in Suisun, studies to evaluate copepod toxicity due to ammonium, spiking studies,

investigations into the potential influence of nutrient ratios on system response, and the importance of nutrient fluxes from sediments. These data and information from additional studies being conducted in the Delta should be reviewed, synthesized and a process should be developed to resolve these outstanding questions and concerns about ammonium.

In addition, given that several factors (light-limitation/turbidity; grazing pressure by clams; tidal mixing) contribute to maintaining phytoplankton biomass at relatively low levels in this otherwise nutrient-rich estuary, improved understanding is needed with regards to the relative importance of these factors, including temporal and spatial considerations, and regarding susceptibility to future changes in the level of control they exert (e.g., decreases in suspended sediment loads).

Considering the compelling evidence of changing conditions in San Francisco Bay, uncertainty about future monitoring programs, and new nutrient policies on the horizon, there is a strong need for a coherent nutrient science and management strategy for the Bay. Section 3 identifies upcoming management decisions related to nutrient overenrichment and eutrophication. Section 4 lays out the goals of the nutrient strategy and a plan, developed collaboratively by the Water Board and Bay stakeholders, for the technical studies required to support decisions regarding nutrient management. The current version of the strategy focuses on priority work elements within a five-year planning horizon, with the recognition that this work will extend beyond that time period and will build upon these foundational early efforts. Some commitments have already been made by various groups to fund or undertake priority tasks. These efforts will be tracked as part of the program management work element of this strategy.

There is considerable ongoing research on the role of nutrients in a changing San Francisco Bay ecosystem. Given that this is the case, this nutrient science and management strategy will likely require modification as new information becomes available. While the strategy has a five-year planning horizon, it will remain flexible and adapt to new information.

3. Key Nutrient Management Decisions and Questions

Several key management decisions and questions provide the context for the San Francisco Bay nutrient management strategy. The primary anticipated management decisions include:

1) Establishing Bay nutrient objectives
2) Evaluating the need for revised objectives for dissolved oxygen (in sub-habitats) and ammonium/ammonia
3) Developing and implementing a nutrient monitoring program
4) 303(d) listing decisions for the adverse effects of nutrients – whether impairment exists currently or is forecast in the future
5) Specifying nutrient limits in NPDES permits (e.g. municipal and industrial wastewater and municipal stormwater permits) as well as determining additional data collection needs

6) Determining whether management actions are necessary to prevent or address nutrient enrichment impacts and if so, the schedule, and nature for municipal wastewater treatment plant upgrades and stormwater treatment

Nutrient management issues may be influenced by, or can influence to some degree, decisions on other issues, such as the regulation of freshwater flow from the Delta, a regional sediment management strategy, recycling of wastewater, management of nutrient loading to the Delta, wetland restoration, and the development of nutrient TMDLs, e.g., Suisun Marsh, Sonoma Creek and Napa River.

These upcoming decisions are the foundation for five key management questions that, in turn, drive the elements of the nutrient strategy, and correspond to the recommendations laid out in a recent literature review and data gap analysis that was conducted as an early step in the NNE process (Table 1 below; McKee et al., 2011).

Table 1. Summary of management questions developed with input from the Nutrient Workgroup, and corresponding recommendations from the San Francisco Bay NNE literature review (McKee et al. 2011)

Type	Management Question	Recommendation From McKee et al. 2011 Review
Status and trends	Is there a problem or are there signs of a problem? Are trends spatially the same or different in San Francisco Bay? a. Is eutrophication currently, or trending towards, adversely affecting beneficial uses of the Bay? b. Are beneficial uses in segments of San Francisco Bay impaired by any form of nutrients (e.g. ammonium)? c. Are trends spatially the same or different in San Francisco Bay?	Implement a monitoring program to support regular assessments of nutrient support for the Bay beneficial uses. Coordinate with Delta nutrient monitoring and management.
Objectives	What are appropriate guidelines for identifying a nutrient-related problem?	Establish a nutrient assessment framework for the Bay
Sources and Pathways	Which nutrient sources, pathways, and cycling processes are most important to understand and quantify? (Get the loads right!) a. What is the relative contribution of each loading pathway (municipal wastewater, Delta inputs, NPS, etc.)? b. What are contributions of internal sources (e.g. benthic fluxes) from sediments and sinks (e.g. denitrification) to the Bay nutrient budgets?	Quantify external sources of nutrients to the Bay and develop a spatially-explicit budget of the Bay.
Fore-casting	What nutrient loads can the Bay assimilate without impairment of beneficial uses?	Develop load-response models
	What is the likelihood that the Bay will be impaired by nutrient overenrichment/eutrophication in the future?	

4. Nutrient Strategy Goals and Work Elements

Generating the scientific understanding needed to fully support all of the management decisions and questions will likely take a decade or more, and will require a significant

investment of resources. Therefore, it is imperative that a well-reasoned and cost-effective nutrient strategy be adopted that identifies logical first steps, leverages existing resources, requires development of a funding plan and incorporates elements of adaptive management.

With this philosophy in mind, the five-year strategy has six principal goals:

1. Define the problem (develop conceptual models, synthesize and interpret the available data)
2. Establish guidelines (water quality objectives; i.e., assessment framework) for eutrophication and other adverse effects of nutrient overenrichment, including ammonium;
3. Implement a monitoring program that supports regular assessments of the Bay;
4. Develop and utilize nutrient-load response models to support nutrient management decisions;
5. Evaluate control strategies to reduce nutrient inputs from wastewater treatment plants and other sources; and
6. Consider alternative regulatory scenarios for how to move forward with nutrient management in SF Bay.

Work elements and a list of major tasks associated with each goal are detailed in the sections below. Workplans and/or scopes of work will be developed to accomplish many of the tasks in this strategy and stakeholder review is necessary step in the process. The phasing and timeframe of these work elements and major tasks is provided in Table 2.

WORK ELEMENT 1. NUTRIENT PROGRAM ADMINISTRATION

The SFB Nutrient Management Strategy is being developed and implemented through a collaborative process between the Water Board and multiple partners and stakeholders.Generating the scientific understanding needed to fully support all of the management decisions and questions will likely take time and significant resources, and will involve complex decisions. This work element lays out the basic components of the program for implementing the Nutrient Strategy.

Task 1.1 Develop Governance Structure

A straightforward and transparent governance and decision-making structure for funding and implementing the Nutrient Strategy is needed to

- maximize the effectiveness of stakeholder input;
- identify and allocate limited resources toward research, monitoring, and modeling that will most effectively inform management decisions;
- determine when it is appropriate to carry out external scientific review of approaches that are developed within key work elements (e.g., assessment framework, monitoring, modeling), and major work products, including scientific studies, and what the process for these reviews will be.

Task 1.2 Develop Funding Plan

While this document focuses in detail on activities that should be completed during the next 5 years, implementation of the Nutrient Strategy work elements will likely be a carried out over a substantially longer period. The cumulative costs of sustaining the nutrient-related research, monitoring, and modeling are anticipated to be high. SFB is an ecosystem of regional, state-wide, and national significance, and a valued resource for both the public and private sectors.

As such, a funding plan will be developed that casts a wide net, targeting resources from the discharger community, federal science agencies (e.g., NSF, NOAA), state funding, and foundations, as well as developing partnerships with other SFB science and monitoring programs, and partnerships with regional university and research institutes. This task involves developing initial costs estimates of the work, developing a funding plan, and on-going fundraising.

Task 1.3 Nutrient Program Management

This task involves managing the Nutrient Strategy implementation. Activities will include scientific oversight, stakeholder engagement, coordinating SAG meetings, coordinating external scientific review, information dissemination, fundraising, and overall program management (e.g., overseeing projects, project and contract management).

WORK ELEMENT 2. DEFINE THE PROBLEM

Task 2.1 Develop Conceptual Models of Ecosystem Response to Nutrient Loads

The goal of this task is to develop conceptual models for SFB that characterize important processes linking nutrient and organic matter loading, biological responses, and indicators of adverse effects of nutrient over-enrichment.

The approach to nutrient objectives proposed for San Francisco Bay involves: 1) the use of response indicators to diagnose adverse effects from nutrient overenrichment in an assessment framework 2) the use of models to link response indicators to nutrient loads that will sustain and protect beneficial uses. The conceptual models developed in this task are needed to confirm appropriate indicators and their linkages to SF Bay beneficial uses; identify the spatial and temporal scales of importance in monitoring; and frame the questions that may eventually be explored through quantitative modeling efforts. The conceptual models will identify the key drivers/factors that need to be incorporated into models (e.g., internal processes of biogeochemical cycling of nutrients and carbon, including important internal sources and sinks, important physical drivers, and interactions between nutrients and other stressors). Because of the large differences in hydrography and nutrient dynamics between regions of the Bay, the Bay will be divided into a manageable number of segments and habitat-types, and conceptual models will be evaluated across these sub-embayments and habitat types.

Task 2.2 Develop Problem statement and future scenarios

A problem statement will be developed for SFB that addresses the question "If SFB had a nutrient problem, how would it manifest itself?" A nutrient problem can take multiple forms, and the form(s) may vary by subembayment, habitat, and seasonally. The problem statement will address this spatial and seasonal variability, and be linked to beneficial use impairment.

With the problem statement identifying states of the SFB ecosystem that would result in beneficial use impairment, and the conceptual models from Task 2.1 serving as a framework for evaluating change, a list of plausible future scenarios for the Bay will be developed that identify changes that could lead to a problem, and changes under which a problem would be less likely to occur. Two broad categories of scenarios are envisioned: i) changes in management actions (e.g., increases or decreases in nutrient loads via various sources, changes in the timing or quantity of freshwater flows); and ii) changes in environmental factors outside of human control (e.g., changes in suspended sediment load and water clarity, changes in temperature, interannual variability in freshwater flow, large-scale climate forcings and climate change).

The combination of the conceptual models and evaluation of future scenarios will assist in visualizing the spectrum of current, suspected, or potential future sources of impairment.

Task 2.3 Synthesize and Interpret Existing Ambient Water Quality Data and Identify Major Data or Conceptual Gaps in Bay Response to Nutrients

Through nearly 40 years of Bay-wide research by the USGS[1], and nearly 40 years of California-sponsored research and monitoring in northern San Francisco Bay and the Delta[2], there is an enormous archive of nutrient and phytoplankton related data. Some of this data has been analyzed in scientific publications. Other data has received limited attention to date.

This task will synthesize and interpret nutrient and phytoplankton-related data in SFB's subembayments. The data will be interpreted within the context of the conceptual models developed in Task 2.1, and where necessary conceptual models will be modified to reflect new insights. Goals will include: i) identifying spatial, seasonal, and temporal trends in ecosystem condition or response; ii) developing improved understanding of ecosystem response to nutrients; and iii) compiling and preparing data for eventual use in numerical modeling.

Based on analysis in Tasks 2.1-2.2, this task will also identify major data and knowledge gaps, and identify monitoring priorities and additional scientific investigation (e.g., Special Studies) that will be required in order to adapt conceptual models into quantitative models (Work Element 6).

Task 2.4 Develop Nutrient Loading Conceptual Model

[1] http://sfbay.wr.usgs.gov/access/wqdata/index.html
[2] http://www.water.ca.gov/iep/products/data.cfm

A conceptual model for external loads to SFB will be developed that considers major sources and pathways through the watershed, airshed, and oceanic sources. This conceptual model will identify differences in important loads between subembayments.

Task 2.5 Synthesize Existing Loading Data, Identify Data Gaps, and Refine load estimates

The purpose of this task is to synthesize existing information to develop, to the extent possible, spatially and temporally explicit estimates of nutrient and organic carbon external loads via major pathways. This task will also identify major data gaps that contribute to current uncertainty in total loads, speciation of those loads, and the relative importance of various sources. In addition, the Water Board is requiring a two year effluent characterization data collection effort (July 2012 through 2014) by Bay area municipal wastewater dischargers and industrial dischargers which can be used to refine the wastewater load estimates

WORK ELEMENT 3. NUTRIENTS AND POTENTIAL IMPAIRMENT IN SUISUN BAY

The Interagency Ecological Program's (IEP) conceptual model for the Pelagic Organism Decline (POD) recognizes that multiple factors may be acting in concert to degrade habitat and contribute to the sudden decline in native and non-native pelagic fish species (Baxter et al., 2010) in Suisun Bay and in the Delta. Factors considered include physical alterations to habitat; water withdrawals and changes in flow regime; land use changes; invasive species (including the Asian overbite clam, *Potamocorbula amurensis*, and multiple invasive copepods and other zooplankton); and changes in nutrient concentrations. Recent studies have argued that anthropogenic nutrient loads, in particular ammonium (NH4), play a role in ecosystem change and degradation. Dugdale et al (2007, 2012) and Parker et al. (2012a,b) present the case that elevated NH4 concentrations in Suisun and the Delta inhibit primary productivity (Dugdale et al., 2007; Parker et al., 2012a,b), and potentially contribute to low phytoplankton biomass in Suisun, with cascading effects up the food web. Elevated NH4 levels have been suggested to contribute to the increased frequency of *Microcystis* blooms in the Delta (Lehman et al., 2008). Changes in nutrient ratios (N:P) and forms of N have been hypothesized to be exerting additional bottom-up pressures on Delta and Suisun food webs, through influencing phytoplankton community composition and other pathways (e.g., Glibert et al., 2011).

Given the scientific and regulatory attention that issues such as elevated NH4 and shifts in N:P are receiving in Suisun Bay, and in order to resolve the differing scientific perspectives on the issues, a separate work element was created. Nutrient related issues can be divided into four broad categories: 1. NH4 inhibition of primary production; 2. NH4 toxicity to copepods (e.g., Teh et al., 2011); 3. NH4 concentration increases and N:P shifts, and effects on phytoplankton community composition and the Suisun/Delta food web; and 4. other potential causes of low primary productivity in Suisun. A detailed accounting of all relevant projects and their timelines is beyond the scope of this document, but is under development in Task 3.2.

Task 3.1 Field studies and experiments to assess potential impairment due to elevated ammonium or changes in N:P

A number of field and laboratory studies are underway, some affiliated with the Nutrient Strategy (e.g., SWAMP Suisun Bay studies) or funded by the Delta Science Program or the State and Federal Contractors Water Agency (SFCWA). Other studies are currently under review, planned or are funded and slated to start in late 2012 or 2013. These studies will be tracked, results synthesized (Task 3.2), and where applicable conceptual models will be refined to incorporate new understanding.

Task 3.2 Synthesis of Research to Date and Suisun Ambient Water Quality Data

A series of synthesis reports will be prepared on the following topics: 1.) NH4 inhibition of primary production; 2.) NH4 toxicity to copepods; and, 3.) NH4 concentration increases and N:P shifts, and effects on phytoplankton community composition and the Suisun/Delta food web.

These reports will summarize results of peer-reviewed studies or reports from Suisun and the Delta to date, as well as relevant studies from other systems. In addition to reviewing published work, new analyses and data interpretation will be carried out, utilizing the abundant monitoring data collected by IEP/DWR and USGS, with the goal of characterizing temporal and seasonal trends, quantifying loads and internal transformations of nutrients, and using statistical tools to identify potential causal mechanisms underlying ecosystem change.

Task 3.3 Assess Science Related to Ecosystem Impacts in Suisun Bay and Relationship to Nutrients

An approach is necessary to resolve issues that have been raised relative to nutrient impacts in Suisun Bay and develop a coordinated science plan. The strategy recommended here is to convene one or more expert panels and sponsor technical workshop(s) to address the three broad categories of proposed nutrient-related impairment in Suisun Bay. The goals of these expert panels will include: 1. evaluating existing scientific evidence for nutrient-related impairment in Suisun Bay; 2. identifying areas of agreement and disagreement within the scientific literature and among the regional research community; 3. recommending studies that can address critical conceptual gaps and data gaps. The results of these panels and the reports from Task 3.2 will be used to refine conceptual models and inform monitoring and special studies (Work Element 5) and modeling (Work element 6). Consideration will be given to involving an external third party, e.g., the Delta Science Program or the USEPA or some other entity in convening or sponsoring the technical workshops.

WORK ELEMENT 4. ESTABLISH GUIDELINES

The purpose of this work element is to develop the technical foundation for policy decisions to establish nutrient-related water quality objectives. This strategy assumes that the development of nutrient related water quality objectives would be

accomplished using an approach consistent with the “nutrient numeric endpoint framework”—the numeric guidance that would serve as a means to translate narrative nutrient water quality objectives. This numeric guidance will be centered on an "assessment framework," a structured set of indicators and associated thresholds that can be used to categorize potential ecological states of the Bay from supporting to impairment of beneficial uses. These assessment frameworks also specify the spatial and temporal density and types of data needed to make an assessment of beneficial uses support.

The Bay NNE literature review and data gaps analysis proposed a suite of indicators appropriate to assess the effects of eutrophication and other adverse effects of nutrients on Bay beneficial uses (McKee et al. 2011). Indicators were proposed for three principal habitat types: 1) subtidal unvegetated habitat, 2) vegetated subtidal (seagrass and other SAV), and 3) intertidal flats. The review proposes specific tasks to develop the NNE assessment framework for each habitat types. These tasks are given in Table 3. An initial rank of high, medium, and low priority was assigned to each by the Water Board. Prioritization of work elements reflects: 1) percentage of habitat type represented in the Bay and 2) best professional judgment as to whether an indicator represents the most sensitive assessment of potential impacts to beneficial uses. Based on these two criteria, phytoplankton (biomass and community composition), dissolved oxygen, HABs and HAB toxins were the primary NNE indicators of interest in unvegetated subtidal habitat. Ammonium, N:P ratio and other nutrient forms are also indicators of interest, pending the outcome of studies being conducted in Suisun Bay (see Work Element 3) and assessment by a working group of scientists.

Indicators representative of other habitat types such as intertidal flats and seagrass are of high interest in the Bay as well as other estuaries around the state. Several studies are ongoing to support decisions on NNE thresholds in California estuaries outside of the Bay. Thus, these work elements are designated as moderate priority, with the intention of evaluating the applicability of these studies to assessment of these habitats in San Francisco Bay sometime in the future.,

Five tasks were designated as high priority and as such they are components of planned activities during the first four years.

Task 4.1 Nutrient Assessment Framework

The purpose of this task is to develop an assessment framework that considers the use of phytoplankton, algal toxins and nutrient forms (e.g. ammonium and other nutrient species or ratios) to assess the condition of the Bay. This will be done by choosing the precise indicators and metrics; specifying how and when they will be measured; and creating decision rules for how the indicators will be combined in order to classify Bay segments into categories of degree of beneficial use support (from supporting to impairing beneficial uses). Existing data on phytoplankton, nutrients and other co-factors will be used to graphically illustrate options with respect to how to use data to make an assessment.

Task 4.2 Review of Dissolved Oxygen Objectives

McKee et al. (2011) found that dissolved oxygen monitoring data taken along the longitudinal "spine" of the SF Bay typically meets established DO objectives. However, SF Bay dissolved oxygen objectives were established in the first Basin Plan in 1975 and the science of supporting derivation of dissolved oxygen objectives has evolved considerably since that time. The main focus of this review is on the application of the DO objectives to shallow water habitats, tidal marshes, managed ponds and tidal sloughs, although it can be argued that a comprehensive review should be conducted. Near-term tasks consist of: 1) synthesizing existing dissolved oxygen data; and 2) evaluating the adequacy of existing dissolved oxygen objectives.

4.2a Synthesize existing dissolved oxygen data

This task will synthesize existing dissolved oxygen data Bay-wide and for specific habitats, such as tidal sloughs, and shallow subtidal areas. This topic was not covered in the Bay NNE literature review and data gaps analysis (McKee et al. 2011). The synthesis effort will include analysis of data currently being collected (since 2011) at 6 USGS moored stations (DO, chlorophyll, and fluorescence), as well as other data sources, including historical studies conducted in the Lower South Bay. This synthesis will assess status and trends of dissolved oxygen relative to Basin plan standards, and will assess whether objectives are being met and whether there is evidence of impairment.

4.2b Evaluate existing dissolved oxygen objectives

The purpose of this task is to synthesize data on dissolved oxygen requirements of species representing the variety of beneficial uses in SF Bay and to inform whether there is a need to revise dissolved oxygen objectives for SF Bay. The product would be a report that synthesizes methodology, summarizes availability of DO tolerance data for key indicator species, and, assuming data are available, calculates DO criteria protective under acute and chronic conditions for the range of beneficial uses represented in SF Bay. To the extent feasible, this analysis will also qualitatively consider naturally occurring low oxygen (e.g., in tidal wetlands or in waters exiting naturally low-oxygen habitats) versus low oxygen due to anthropogenic perturbations. Depending on available resources, this work may be phased so that shallow subtidal areas and tidal sloughs are initially the focus of the review. Based on the synthesis in subtask 4.3b, data

gaps will be identified and, if necessary, recommendations for additional data collection to support the derivation of DO criteria will be made.

Task 4.3 Macroalgal Assessment Framework

The objectives of this task are: 1) to document baseline abundance of macroalgae in a variety of habitat types and regions of the Bay and 2) participate in statewide effort to develop an assessment framework for eutrophication in intertidal flats and shallow subtidal habitat, based on macroalgae. The intent is that progress on this work element would be monitored for applicability to the Bay and that SF Bay stakeholders have the opportunity to comment on studies supporting these work elements, while progress is made on other tasks.

WORK ELEMENT 5. MONITORING PROGRAM DEVELOPMENT AND IMPLEMENTATION

The purpose of this work element is to develop the San Francisco Bay monitoring program. Targeted habitats include unvegetated and vegetated subtidal and mudflat habitat in the Bay. Managed pond habitats will be excluded, as this habitat type will be addressed in a separate work element in the strategy. Two major tasks are associated with this work element.

Task 5.1 Develop a Monitoring Program

5.1a Identify elements of a core SF Bay monitoring program to assess status and trends of loads and Bay response.

The purpose of this task is to recommend specific indicators and methods, spatial and temporal density of sampling that should be included in a "core" monitoring program to make regular assessments of the status of the Bay with response indicators and to assess trends in external nutrient loads and response. An evaluation of existing monitoring data (predominantly USGS data) collected in the Bay will be considered, along with the potential for maximizing synergies and leveraging resources. The product of Task 5.1a will be used to develop a detailed nutrient monitoring program for the Bay (5.1c). This task will involve bringing together local or national level scientists and managers to determine the core elements of a SF Bay monitoring program, including spatial and temporal considerations, including the consideration of how to optimize the use of moored stations and boat cruise sampling collection efforts. In addition, decisions will need to be made on the spatial extent of the monitoring program, and how to coordinate monitoring efforts in the estuary and share data across programs.

Load monitoring may be included as an element of the monitoring program for point and non-point sources, including stormwater, wastewater, agriculture and Delta inputs to the northern estuary.

5.1b Develop a program of special studies to improve fundamental understanding and quantification of processes in the system

In addition to status and trend monitoring, special studies will be carried out to address fundamental data or conceptual gaps that need to be filled to support the assessment framework and model calibration and validation. Data or conceptual gaps identified in any of work completed under this strategy will be compiled and prioritized as part of this task.

5.1c Develop San Francisco Bay nutrient monitoring program Work Plan and QAPP

The purpose of this work element is to develop the work plan and quality assurance project plan (QAPP) for the Bay nutrient monitoring program. The work plan and QAPP covers monitoring to assess status and trends in external nutrient loads and ecosystem response of the Bay to those loads. This task includes development of field, sampling handling, laboratory analyses, data management and reporting procedures for data collection.

Task 5.2 Implement the San Francisco Bay nutrient monitoring program

The expectation is that the existing monitoring program currently conducted by the USGS will transition over a number of years to this locally sponsored program. The program is anticipated to be adaptively managed.

WORK ELEMENT 6. MODELING PROGRAM DEVELOPMENT AND IMPLEMENTATION

The purpose of this work element is to develop models to forecast the nutrient and carbon sources, pathways, and loads to SF Bay, and simulate the ecological response to those loads and other environmental factors in the Bay. These models will be used to engage stakeholders in discussion of options for nutrient management under a variety of different scenarios. Previous work elements will define conceptual models and scenarios of interest (Work Element 1), and management endpoints of concern (Work Element 2).

Task 6.1 Modeling of External Sources

Task 6.1a Basic Loading Estimates or Modeling

Building on the loading conceptual model and loading data compiled in Tasks 2.3 and 2.4, respectively, initial nutrient load estimates will be calculated. To the extent feasible, spatially explicit (e.g., subembayments) and temporally-explicit nutrient loads will be quantified. The nutrient sources considered will include: municipal and industrial wastewater discharges; stormwater discharges; flows from the San Joaquin and Sacramento Rivers entering through the Delta, along with other smaller downstream tributaries; exchange across the Golden Gate; and direct atmospheric deposition. Nutrient fluxes from Bay sediments to the water column will also be considered. Initial estimates of municipal and industrial wastewater loads will be based on treatment technologies employed (expected effluent nutrient speciation and concentrations) and flow. When historical data is available, these data will be used to refine municipal and industrial wastewater loads. In addition, the Water Board is requiring a two year effluent characterization data collection effort (July 2012 through 2014) by Bay area

municipal wastewater dischargers and industrial dischargers. These data will be used to further refine load estimates.

Task 6.1b Review models for Estimating Nutrient/ Organic Carbon Loads

This task will review existing models or types of models that can be used to estimate the sources and pathways of nutrient load to the Bay and summarize the data requirements. The task will begin by identifying the types of questions that the model(s) or empirical data must answer. The intent is to review models and tools that can assist in decision-making on nutrient management strategies and test the cost-effectiveness of implementation scenarios. This work element will feed into the development of a modeling strategy.

Task 6.2 Modeling of Load-response

Task 6.2a Basic Numeric Modeling and Scenario Analysis

The purpose of this task is to develop and apply basic numeric biogeochemical models, as an early step in modeling efforts, to inform future model development and data collection. The models will be used to quantitatively synthesize existing data; develop nutrient budgets; support evaluation of proposed indicators as part of the NNE; test appropriate management endpoints; determine how key processes should be modeled and assess the relative importance of and uncertainty related to those processes; and identify major data gaps at an early stage to inform the monitoring program and the need for special studies. In addition, these models may be used to evaluate biological responses under future scenarios (e.g., changes in nutrient loads, changes in major physical drivers affecting productivity, decreases in suspended sediment concentrations).

Initial model development will focus on Suisun Bay and South Bay or Lower South Bay. A technical advisory group consisting of regional and national experts would be convened to develop a modeling study plan. A key task of this group will be to identify the main questions to be addressed through the modeling work, approaches for incorporating key processes into the model, and the appropriate model platform(s). It should be emphasized that the model(s) developed and used in this task are not intended to be the final models that may ultimately be required for the Bay (which may be more complex and computationally intensive), but rather as scoping tools.

Task 6.2b Review of existing models and available model approaches to model the ecological response of the Bay to nutrient loads and other co-factors

This task will produce a review of available models and/or modeling platforms that will be the basis for developing a modeling strategy for the Bay. A work group will identify the management questions and endpoints (indicators) of concern and relevant spatial and temporal scales, focusing on hydrodynamic, water quality (dissolved oxygen, nutrients, carbon) and a phytoplankton-zooplankton production and phytoplankton speciation models. A review will be conducted of existing Bay and Delta hydrodynamic and water quality models or other applicable types of models, from simple spreadsheet

to complex dynamic simulation models, their data needs, and advantages and disadvantages.

Task 6.3 Develop and Implement Modeling Strategy

The purpose of this task is to synthesize information generated from Tasks 6.1 and 6.2 tasks to develop a modeling strategy for the Bay. The strategy will identify questions to be answered by the models and what policies will be informed; types of models needed (e.g. external loads, bay hydrodynamic and water quality); potential modeling platforms; amount of data required and estimates of cost; and schedule. Information will be presented as cost/benefits of model options with trade-offs in terms of what indicators can be modeled at varying levels of accuracy/precision or timescales. The strategy will also address what partnerships need to be created to build and maintain a model.

WORK ELEMENT 7. CONTROL STRATEGIES

This work element will identify control strategies that are feasible in the near-term and long-term for reducing nutrient loads to the Bay, and evaluate their potential effectiveness for addressing nutrient-related impairment in the Bay, and their cost-efficiency. This could be accomplished via a work group that would identify key decisions and environmental, technical, and economic considerations or individual groups of stakeholders may work on this task and present the results of their efforts to the wider stakeholder group. All major nutrient sources should be considered, including municipal and industrial wastewater loads, stormwater runoff, and agricultural and other loads from the Delta. Effort directed toward exploring control strategies for various sources will be prioritized based on their relative importance and potential for load reductions, and based on spatial/temporal considerations. The evaluation of control strategy options will also consider multiple benefits. Work Element 7 will be carried out in parallel with the other activities above so that implementation plan scenarios can be considered as part of development of nutrient objectives. Where applicable, implementation scenarios will be evaluated and refined through modeling work in Task 6.4. Where necessary and feasible, the potential effectiveness of control strategies will be evaluated through scenario modeling (Task 6.3).

WORK ELEMENT 8. REGULATORY APPROACHES

This work element will identify and evaluate potential regulatory approaches for achieving nutrient load reductions in SFB should reductions be necessary. A variety of approaches will be considered and evaluated for their applicability to the San Francisco Bay setting and for their potential effectiveness for achieving nutrient objectives. As with Work Element 7, this work will be carried out in parallel with other tasks so that, should nutrient regulations be necessary, a range of options will already have been evaluated to a certain degree. Where it is feasible, the potential effectiveness of different regulatory approaches (and related control strategies) may be evaluated through scenario modeling (Task 6.3).

Table 2. GANTT chart of approximate timing of work elements and tasks associated with 5-yr nutrient plan

Task No.	Brief Task Description	Yr1	Yr2	Yr3	Yr4	Yr5
Element 1 Nutrient Program Administration						
1.1	Develop Governance Structure					
1.2	Develop Funding Plan					
1.3	Nutrient Program Management					
Element 2: Define the Problem						
2.1	Create Conceptual Model(s) of Ecosystem Response to Nutrient Loads					
2.2	Develop Problem Statement and future scenarios					
2.3	Synthesize and Interpret Existing Ambient Water Quality Data; Identify Data Gaps					
2.4	Develop Nutrient Loading Conceptual Model					
2.5	Synthesize Existing Loading Data and Data Gaps Analysis					
Element 3: Nutrients and Potential Impairment of Suisun Bay						
3.1	Field studies and experiments to assess potential impairment due to elevated ammonium or changes in N:P					
3.2	Synthesis of Research to Date and Ambient Water Quality Data in Suisun Bay					
3.3	Assess science related to Ecosystem Impacts in Suisun Bay and Relationship to Nutrients					
Element 4: Establish Guidelines						
4.1	Nutrient Assessment Framework					
4.2	Review of Dissolved Oxygen Objectives					
4.2a	Synthesize existing dissolved oxygen data					
4.2b	Evaluate existing dissolved oxygen objectives					

Task No.	Brief Task Description	Yr1	Yr2	Yr3	Yr4	Yr5
4.3	Macroalgal Assessment Framework.					
Element 5: Monitoring Program Development and Implementation						
5.1	Develop a Monitoring Program					
5.1a	Identify elements of a core SF Bay monitoring program					
5.1b	Develop a program of special studies to improve fundamental understanding and quantification of processes in the system					
5.1c	Develop the Bay nutrient monitoring program Work Plan and QAPP					
5.2	Implement the Bay nutrient monitoring program and special studies program (some special studies will begin in Yr2)					
Element 6: Modeling Program Development and Implementation						
6.1	Modeling of External Sources					
6.1a	Basic Loading Estimates or Modeling					
6.1b	Review Models for Estimating Nutrient/Organic Carbon Loads					
6.2	Modeling of Load-Response					
6.2a	Basic Numeric Modeling and Scenario Analysis					
6.2b	Review of existing models/platforms to model Bay hydrodynamics & water quality					
6.3	Develop and Implement Modeling Strategy					
7	Control Strategies					
8	Regulatory Approaches					

Table 3. Specific recommendations for science to support development of habitat-type specific nutrient assessment frameworks

Habitat Type	Recommended Action	Priority
All subtidal	Sponsor a series of expert workshops or develop an expert panel to develop a draft assessment framework based on indicators of phytoplankton (biomass, productivity, assemblage, cyanobacteria cell counts and toxin concentrations) and dissolved oxygen	High
	Form a working group of Bay scientists to synthesize available data on factors known to control primary productivity in different regions in the Bay, developing consensus on relative importance of ammonium inhibition of phytoplankton blooms to Baywide primary productivity, and determining next steps with respect to incorporating ammonium into the NNE assessment framework for the Bay.	High
	Consider a review of the Bay dissolved oxygen objectives, either Bay-wide or for specific habitat types such as tidally muted areas (tidal sloughs, managed ponds)	High
Un-vegetated Subtidal	Utilize IEP-EMP data to explore use of macrobenthos to assess beneficial use impairment in oligohaline habitats. Consider including biomass in the protocol to improve diagnosis of eutrophication or other nutrient-related beneficial-use impairment. Determine whether combination of indicators can be used reliably to diagnose eutrophication and other nutrient-related beneficial-use impairment distinctly from other stressors.	Low
Submerged Aquatic Vegetation	Conduct studies to establish light requirements for the Bay seagrass species;	Low
	Collect baseline data to characterize prevalence of macroalgal blooms and other stressors on seagrass beds	Moderate
	Evaluate the findings of statewide NNE studies characterizing effects of macroalgae on seagrass for applicability to the Bay	Moderate
	Participate in statewide group to develop an assessment framework for eutrophication in seagrass, based on phytoplankton biomass, macroalgae, and epiphyte load.	High
Intertidal Flats	Evaluate the findings of studies characterizing effects of macroalgae on intertidal flats for applicability to the Bay	Moderate
	Participate in statewide group to develop an assessment framework for eutrophication in intertidal flats, based on macroalgae and other supporting indicators.	High
Tidally muted habitats - managed ponds	Synthesize existing DO oxygen data for tidally muted areas and collect baseline data primary and supporting indicators (macroalgal biomass and cover and phytoplankton biomass, taxonomic composition, and HAB toxin concentrations) in these habitats needed to make a full assessment of status of eutrophication.	High

References

Baxter, R., Breuer, R., Brown, L., Conrad, L., Feyrer, F., Fong, S., Gehrts, K., Grimaldo, L., Herbold, B., Hrodey, P., Mueller-Solger, A., Sommer, T., Souza, K. (2010). Interagency Ecological Program 2010 Pelagic Organism Decline Work Plan and synthesis of results. University of California, Davis, California: http://www.water.ca.gov/iep/docs/FinaPOD- 2010Workplan12610.pdf

Cloern, J.E., Jassby, A.D. (2012). Drivers of change in estuarine-coastal ecosystems: Discoveries from four decades of study in San Francisco Bay. Rev. Geophys., 50, RG4001, doi:10.1029/2012RG000397.

Dugdale, R.C., F.P. Wilkerson, V.E. Hogue and A. Marchi, (2007). The role of ammonium and nitrate in spring bloom development in San Francisco Bay. 2007. Estuarine, Coastal and Shelf Science 73: 17-29

Dugdale, R.C., F.P. Wilkerson, A.E. Parker, A. Marchi, and K. Taberski (2012). "River flow and ammonium discharge determine spring phytoplankton blooms in an urbanized estuary". Estuarine, Coastal and Shelf Science, in press.

Glibert, P. M., D. Fullerton, J. M. Burkholder, J. C. Cornwell, and T. M. Kana. (2011). Ecological stoichiometry, biogeochemical cycling, invasive species, and aquatic food webs: San Francisco Estuary and Comparative Systems. Reviews in Fisheries Science 19:358-417.

Lehman, P.W., G. Boyer, M. Satchwell, and S. Waller. (2008). The influence of environmental conditions on the seasonal variation of Microsystis cell density and microcystins concentration in San Francisco Estuary. Hydrobiologia. 600: 187-204.

McKee, L.J., Sutula, M., Gilbreath, A.N., Beagle, J., Gluchowski, D., Hunt, J. 2011 Numeric nutrient endpoint development for San Francisco Bay – Literature review and data gaps analysis. Southern California Coastal Water Research Project Technical Report No. 644. www.scwwrp.org

Parker AE, Hogue, VE, Wilkerson FP, Dugdale RC. 2012a. The effect of inorganic nitrogen speciation on primary production in the San Francisco Estuary. Estuarine, Coastal and Shelf Science xxx (in press): 1–11.

Parker, A.E., Dugdale, R.C., F.P. Wilkerson (2012b) Elevated ammonium concentrations from wastewater discharge depress primary productivity in the Sacramento River and the Northern San Francisco Estuary. Mar. Pollut. Bull. 64(3):574-86.

Teh, S., I. Flores, M. Kawaguchi, S. Lesmeister, and C. Teh. 2011. Full Life-Cycle Bioassay Approach to Assess Chronic Exposure of *Pseudodiaptomus forbesi* to Ammonia/Ammonium. Unpublished report submitted to State Water Resources Control Board.

April 23, 2013

Ms. Felicia Marcus, Chair
Members of the Board
State Water Resources Control Board
1001 I Street
Sacramento, California 95814

Re: Informational Item, State Board Meeting April 9, 2013: Current Status of Phase 2 of the Comprehensive Update of the Bay Delta Water Quality Control Plan

Dear Chair Marcus and Members of the Board:

The State Water Contractors ("SWC") appreciates this opportunity to provide input on next steps in the Bay Delta Water Quality Control Plan (Bay Delta Plan) Phase II process. The SWC participated in all of the Phase 2 technical workshops and State Water Resources Control Board ("State Board") meetings, including the informational meeting on April 9th.

The SWC are pleased that Dr. Peter Goodwin, Lead Scientist for the Delta Science Program, attended the April 9th State Board meeting, putting forth a proposal for the Independent Science Board ("ISB") to review areas of scientific uncertainty. The SWC understand the difficulty in putting forth a proposal, and appreciate the Delta Science Program doing so.

If the State Board were to accept the Delta Science Program's offer to assist, the SWC would recommend a process that is slightly different than those previously undertaken by the ISB. The SWC think it is important for the State Board members to maintain their existing active oversight role in reviewing the science, but the DSP procedures for independent reviews may make this difficult due to the physical and institutional separation between the ISB and the State Board members.

1121 L Street, Suite 1050 • Sacramento, California 95814-3944 • 916.447.7357 • FAX 916.447-2734 • www.swc.org

The DSP's Procedures for Independent Scientific Review, October 26, 2011, (http://deltacouncil.ca.gov/sites/default/files/documents/files/DSP_Review_Procedures_110712.pdf) suggest a process where the requesting agency (*i.e.*, the State Board) has a limited role in the development of the panel's charge, selection of panel members, and the submission of information. There are also few opportunities for stakeholder input into the ISB process. Stakeholders and the general public are provided information about the issues the ISB panel is reviewing but have little opportunity to interact with the panelists, to ask questions, and to provide information. If the State Board were to engage the Delta Science Program and ISB, the SWC would recommend that the State Board members maintain active involvement in the ISB process, and ensure more transparency and public participation than is provided for in the usual ISB panel review procedure. Specifically, the State Board should ensure an opportunity for stakeholders to provide input in the development of the panel's charge, the selection of panel members, and should be provided an opportunity to interact with the panel and be permitted to submit information to the panel for review.

If the State Board were to engage the ISB, it is also important that the State Board set aside sufficient time for the ISB to rigorously review the scientific questions put before them. The ISB should be provided the time needed to review the data, methods, and assumptions applied, for example, in the underlying literature, and by stakeholders in their workshop submissions. There are a number of science summaries that have been completed in recent years on a variety of issues, so another science summary report would not be expected to further scientific understanding. To be meaningful, the ISB review would need to rigorously review the underlying scientific bases for the different hypotheses that attempt to explain aspects of the system, not simply report or summarize them.

In addition to an ISB review or similar science review process, the State Board should continue to gather information required for sound decision-making. For example, the SWC would encourage the State Board to request information about the Bay Delta Conservation Plan, the Delta Stewardship Council's Delta Plan, the OCAP Remand Science Program, and the Suisun Marsh Plan. The State Board would likely benefit from a comprehensive understanding of what is being undertaken in these various processes, and how they relate to the Bay Delta Plan. For example, in the BDCP there are numerous near-term actions that are being proposed. The implementation of these actions would begin immediately after the BDCP permits are issued. These actions are not hypothetical, as the environmental documentation and permits are already being drafted, and the financial investment in these projects by the state and federal water contactors has already been quite significant. At the April 9th State Board meeting, some of the State Board members were interested and encouraged by actions that could be implemented in the near-term. For this reason, the SWC wanted to highlight the fact that the BDCP is where the largest investment has been, and will continue to be, made in the Delta, and the SWC think the State Board would have great interest in its progress to date.

The State Board also requested public comment about the areas of scientific uncertainty that warrant further investigation. The SWC believe the Dr. Brock Bernstein report accurately captured the range of scientific uncertainty that extends through a large number of important scientific questions. However in order to determine which areas of uncertainty should be the focus of further scientific review, the State Board needs to, as an initial matter, ask and answer a key set of questions. As an initial matter, the State Board needs to determine what it wants to accomplish, as well as what it can accomplish from a technical perspective. To answer these questions, the State Board needs to consider: 1) what biological or ecological change(s) it wants to achieve (*i.e.*, what ecosystem processes or functions should be restored); 2.) how would restoring the identified biological or ecological function benefit targeted species, including an assessment of whether a change in species abundance is expected; and 3.) what is the full range of actions available that can restore, or contribute to restoration of those functions; 4.) how certain are we in the predicted outcome of each action alternative. Once the State Board has established a clear picture of its intended outcome and how the Bay Delta Plan review relates to other activities in development, the relevant areas of scientific uncertainty are more easily determined. Instead of trying to study the entire universe of issues, the State Board would be focused on those issues relevant to what is possible and most beneficial for species. Furthermore, the stakeholders could provide meaningful input regarding the methods for achieving the targeted outcomes. And, the ISB could provide meaningful input regarding the scientific strength of those findings.

At the April 9th State Board meeting, the Dr. Goodwin's staff proposed its four possible areas of scientific uncertainty for the ISB review. If the SWC recall correctly, those issues were: 1.) Delta outflow; 2.) through Delta flows; 3.) invasive species (*i.e.*, how invasive species have modified the system and what can be done to reverse or limit future invasions); and 4.) nutrients.[1] Given the current lack of clarity on desired outcomes described above, the SWC question whether these are the most important areas of uncertainty for this review of the Bay Delta Plan. The SWC understand why flows are on the list; having been the primary focus of the Bay Delta Plan proceedings thus far, but the State Board needs to answer the questions posed above before it can determine whether these four areas are the most relevant areas of uncertainty to resolve. Moreover, the issues of "outflow" or "through Delta flows" are very broad, so it is difficult to assess which specific issues within these broad categories of scientific uncertainty would be the focus of the proposed ISB review.

Invasive species are certainly an important issue, but so are predation and many other issues that did not make the list. The SWC included a discussion of those in our joint

[1] Dr. Goodwin's staff may also have proposed adaptive management as one of the topics for review. If adaptive management is one of the proposed topics, the SWC refer the State Board to comments provided by San Luis Delta Mendota Water Authority (April 23, 2013) regarding adaptive management.

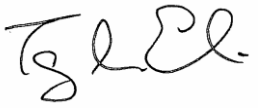
SWC-CVP submittal in the Ecosystem Change workshop (Workshop 1). The SWC are not aware of the invasive species studies being particularly controversial.

And finally, nutrients were included on the list of important issues for ISB review. While the SWC certainly agree that nutrients are important, we aren't sure that nutrients are one of the top four areas of uncertainty that the ISB should consider in the context of this review of the Bay-Delta Plan. Unless, the State Board will be considering a new nutrient standard as part of this Bay-Delta Plan review. However, there are a number of ongoing State Board and Regional Board processes that are already addressing the development of nutrient strategies and water quality objectives. The State Board is working on its statewide nutrient policy for inland surface waters, and the San Francisco and Central Valley Regional Water Boards are both working on nutrient strategies and objectives. As part of those processes, there will be independent science reviews. As those processes are on different schedules from State Board's consideration of new standards in the Bay Delta Plan, it seems premature to elevate nutrients for review by the ISB as part of this Bay Delta Plan update. However, the SWC would support the State Board accelerating those other processes.

The SWC have been, and will continue to be, actively involved in the nutrient issue in a number of forums. The SWC did include an extensive discussion of nutrients in its joint SWP-CVP submittal in the Ecosystem Change Workshop (Workshop 1). The SWC felt that was important to include because the State Board seemed to be asking a question in Workshop 1 that is larger than just the Bay Delta Plan update, being what is driving changes in the ecosystem. The SWC do believe that nutrient forms and ratios are driving some big changes in the ecosystem; and until nutrients are addressed at the Sacramento Regional Wastewater Treatment Plant, and elsewhere, the effect of nutrients will hinder the potential benefits of restoration actions. With the possible exception of understanding how nutrients might influence the perceived benefits of flow (*e.g.,* understanding whether nutrients or food availability are mechanisms underlying the longfin smelt abundance correlation with winter-spring outflow), it seems appropriate for the State Board to begin narrowing its review to issues that are directly relevant to this Bay Delta Plan review.

The SWC look forward to working with you, and your staff. If you have any questions, please feel free to contact me at (916) 447-7357 ext. 203.

Sincerely,



Terry Erlewine
General Manager

THE BAY INSTITUTE

NEXT STEPS RE: SWRCB COMPREHENSIVE REVIEW (PHASE 2) OF THE 2006 BAY-DELTA WATER QUALITY CONTROL PLAN

Table 1: Overview and rebuttal of some major rationales offered by parties during the Phase 2 workshops arguing that the primacy of freshwater flow as a driver of ecosystem processes and species viability in the San Francisco Bay-Delta estuary is uncertain.

RECURRING ASSERTIONS WITHOUT SCIENTIFIC SUPPORT	DOCUMENT, PAGE NO.	SCIENTIFICALLY SUPPORTED ARGUMENT	SAMPLE OF SUPPORTING EVIDENCE (Literature cited below)	COMMENTS ON LITERATURE
Flow-abundance correlations are based on misuse of datasets; ergo, the basis for flow manipulations is weak.	SJTA Submittal, 2012a, p. 2 SVWU Latour Report, 2012, p. 11-14 SJTA Submittal, 2012b, p. 62 (p. 2 of technical memorandum from Fishbio, D. Demko and others Jan. 30, 2012) SWC Submittal, 2012, p. 7-8 • LFS moving, FMWT SWC Submittal, 2012, p. 13 -18 • Flow-abundance SWC Submittal 2012, p. 58-60 • Am Shad not related to flow	***Flow-abundance correlations are statistically significant and biologically important.***	1. Nislow and Armstrong 2011 2. Zeug 2010 3. Mount et al. 2012 4. Moyle et al. 2012 5. Miller et al. 2010 6. Mac Nally et al. 2010 7. CDFG 2010a 8. Stevens and Miller 1983 9. Jassby et al. 1995 10. Kimmerer 2002a 11. Kimmerer 2002b 12. Rosenfield and Baxter 2007 13. Sommer et al. 2007 14. Kimmerer et al. 2009 15. Rosenfield 2010 16. Thomson et al. 2010	1. Some flow regimes critical to multiple life history stages for juvenile salmon 2. Flow regime one of three significant predictors or extirpation for Spring run Chinook salmon 3. Synthesizes major stressors in the Delta affecting ecosystem, 3 of 5 are flow related. 4. Describes how major stressors have degraded the estuary and harmed native species. The major stressors include flow alteration. 5. Importance of seasonal flows in maintaining life history diversity 6. Analysis of POD decline finds flow the major stressor 9.10. 11-14. Species abundance-Delta outflow correlations 11. Multiple potential mechanisms that could explain strong correlations between freshwater flow and species response 15. Delta outflow drives most of the potential stressors affecting LFS populations
The relationship between spring flow and survival is weak.	SJTA Submittal 2012a., p. 1, 2 SJTA Submittal 2012b., p. 2-5 SVWU Latour report, 2012, p. 3-4	***The relationship between spring flow and survival is strong.***	1. Jassby et al. 1995 2. Sommer et al. 2002 3. Sommer et al. 2001 4. Kimmerer 2002a 5. Miller et al 2010 6. CDFG 2010 7. Thomson et al. 2010 8. TBI et al. 2010; Exh. 2	1. Abundance of organisms increases with flows 2. Splittail benefit from magnitude, timing, & duration of spring flows & floodplain inundation 3. Salmon growth and survival related to flow in the Yolo bypass 4. Winter-spring outflows associated with increased survival of striped bass 5. Salmon juvenile life history diversity supported by freshwater flow 6. San Joaquin salmon survival strongly correlated

				with freshwater flow rates at Vernalis 8. Demonstrates that flow-abundance relationships reflect strong relationship between Delta outflow and inter-generation population growth among longfin smelt and *Crangon* shrimp

RECURRING ASSERTIONS WITHOUT SCIENTIFIC SUPPORT	DOCUMENT, PAGE NO.	SCIENTIFICALLY SUPPORTED ARGUMENT	SAMPLE OF SUPPORTING EVIDENCE (Literature cited below)	COMMENTS ON LITERATURE
Abundance estimates are based on faulty datasets; ergo, there are more organisms, or they are distributed more widely, etc.	SWC Submittal 2012, p. 7-9, 15-16 • FMWT biased, on sampling population SWC Submittal 2012, p. 58 • Striped bass and FMWT	***Abundance estimates and flow correlations are based on multiple ecological sampling programs with consistent trends of multi-species decline.***	1. Rosenfield and Baxter 2007 2. Rose 2000 3. IEP Report 1999 4. Baxter et al. 2010 5. Matern et al. 2002 6. Feyrer et al. 2007	The SF Bay-Delta Estuary is among the most studied estuaries in the world. 1. Assesses longfin smelt abundance and distribution using three long-term sampling programs that sample different areas of the estuary (two of which sample year-round). Finds similar relationships between longfin abundance and winter freshwater outflow from the Delta in each data set. 2. Discusses importance of long term data sets. 3-6. Each demonstrate declining trends in various fish populations in the estuary using data from different long term sampling programs
Restoring physical habitat diversity not only improves food production but also is a better basis for restoring resilience, providing refugia, etc., than improving flows	SJTA Submittal, 2012a, p. 11-12 SJTA Submittal, 2012b , P. 30-33 SWC Submittal 2012, p. 29-30 • DS SWC Submittal 2012, p. 45 • Green Sturgeon SVWU Vogel 2012, p. 2-3 • Habitat in Delta needs to be fixed	***There is no scientific basis for implementing actions to restore physical habitat as a substitute for improving flow conditions***	1. State Board Flow Criteria Report 2010 2. CDFG 2010 3. SFEP 2011 4. BDCP Effects Analysis 2012 5. Winder et al. 2011 6. BDCP Red Flag Reviews 2012 7. NRC 2010	Relationships between physical habitat and food availability for some species, especially pelagics, poorly understand. Also, functionality of restored habitat dependent to great extent on improved flow conditions, e.g., . floodplains cannot be restored without providing flows to inundate floodplain habitat at sufficient duration and frequency in the necessary seasons.

RECURRING ASSERTIONS WITHOUT SCIENTIFIC SUPPORT	DOCUMENT, PAGE NO.	SCIENTIFICALLY SUPPORTED ARGUMENT	SAMPLE OF SUPPORTING EVIDENCE (Literature cited below)	COMMENTS ON LITERATURE
Other factors (i.e. Ocean conditions, ***or*** *Thermal experience,* ***or*** *Predation,* ***or*** *Habitat alteration,* ***or*** *Invasives,* ***or*** *Floodplains,* ***or*** *Upper watershed,* ***or*** *Contaminants,* ***or*** *Dissolved Oxygen,* ***or*** *Food availability) influence abundance more than flow*	**Predation** SJTA Submittal, 2012b, p. 37-44 • Salmon SWC submittal 2012, p. 23-24 • Delta smelt SVWU Vogel 2012, p. 17-18 **Invasives** SJTA Submittal, 2012b, p. 33 • E. densa SWC Submittal 2012, p. 1, 5, 9-14, 22-23, 55-56 • Decline in northern anchovy, longfin and delta smelt linked to food decline and Amur clam	***Flow is a "master" variable driving numerous other potential stressors; there is no evidence that other stressors are more important than freshwater flow, and many are exacerbated by flow alteration.***	1. Baxter et al. 2010 2. NRC 2010 3. Mac Nally et al. 2010 4. Thomson et al. 2010 5. Lindley et al. 2011 6. Winder et al. 2011	1. Identifies flow as the most important stressor to the ecosystem due to strong effects on fish populations and factors controlling those populations. 2. NRC committee concluded that there was (1) strong support for increasing SJR flows to support SJR salmon survival through the Delta and (2) that the conceptual support for tidal wetland restoration to benefit Delta smelt is "weak." 3. Analyzed numerous factors potentially related to post-2000 decline in multiple pelagic fishes and found that X2 had a profound effect on declining fish species and on their prey. 4. Covariates strongly associated with pelagic fish abundance were X2, water clarity, and export flows, 5. Implicates ocean conditions as proximate cause of recent fall Chinook collapse, but clearly states: "*...anthropogenic effects are likely to have played a significant role in making this stock susceptible to collapse during periods of unfavorable ocean conditions*". See also Figure 18. 6. Reductions in Delta freshwater flow implicated as driver of non-native species invasions.

RECURRING ASSERTIONS WITHOUT SCIENTIFIC SUPPORT	DOCUMENT PAGE NO.	SCIENTIFICALLY SUPPORTED ARGUMENT	SAMPLE OF SUPPORTING EVIDENCE (Literature cited below)	COMMENTS ON LITERATURE
There is no evidence for population level effects of entrainment; ergo, basis for OMR criteria or other measures pertaining to reverse flows is weak. *Tidal flows overwhelm system, so delta outflow is not important*	SWC Submittal 2012, p. 12-13 • LFS - Entrainment not a problem, by-catch from shrimp fishery is bigger problem SWC Submittal 2012, p. 25-27 • Delta Smelt	***There is convincing evidence that entrainment has population level effects and that Old and Middle River criteria or other measures to limit entrainment and reverse flows is justified and appropriate.*** ***Estuaries are by definition tidally influenced, BUT, net (average) flows are, by definition, not negative for long periods***	1. Castillo et al. *in press* 2. FWS 2012b 3. NMFS 2011a and b 4. TBI 2012 5. FWS 2011 6. Kimmerer 2011 7. Kimmerer 2008 8. Mac Nally et al. 2010 9. Rosenfield 2010 10. Thomson et al. 2010 11. Cloern and Jassby 2012 12. Jassby et al. 2002 13. National Research Council 2010	1. Documents much higher levels of pre-salvage mortality at South Delta exports than had been assumed previously. 6. Re-analyzes Kimmerer 2008 (7) & confirms finding that entrainment mortality can and probably has had population-level impacts in the recent past. Also finds that meaningful population-level impacts can occur that cannot be detected by standard statistical analyses. 8. Increases in water exports in both winter and spring associated with decreased abundance of delta smelt. Increases in spring exports negatively associated with abundance of threadfin shad. Delta smelt mortality at pumping facilities may be important to population dynamics under some circumstances, particularly during dry years 12. Significant fraction of estuarine primary productivity exported and/or negatively impacted by changed hydrodynamics 13. "*The committee concludes that the strategy of limiting net tidal flows toward the pump facilities is sound, but the support for the specific flows targets is less certain.*" [p. 58]

RECURRING ASSERTIONS WITHOUT SCIENTIFIC SUPPORT	DOCUMENT, PAGE NO.	SCIENTIFICALLY SUPPORTED ARGUMENT	SAMPLE OF SUPPORTING EVIDENCE (Literature cited below)	COMMENTS ON LITERATURE
"Regime shift": changes have occurred in the system to such an extent there is now a new "regime"; implying previous flow correlations are no longer valid.	SJTA Submittal 2012a., p. 5 and SJTA Submittal 2012b., p. 16 • Flows don't explain survival since 2003 SWC Submittal 2012, p. 46 • Green Sturgeon	***The concept of an irreversible shift in an ecosystem stable state ("regime shift", as it is used here) is neither consistent with scientific understanding of ecosystem dynamics nor an appropriate basis for determining that a healthy native ecosystem cannot be restored.***	1. E.g. Clements 1936 v. Gleason 1926 2. Meffe and Carroll 1994, p. 216-217 3. Suding and Gross 2006, pp. 190-209	1. The "Gleasonian vs. Clementsian" debate. Clements was a proponent of ecological "climax" (stable states) and treating communities as complex organisms. Gleason was the first to argue that communities are largely formed by chance, that they are not predictable and are subject to continual change (i.e. ecosystems are not fixed on a deterministic course). 2. Describes more recent ecological theory; populations and species interactions are influenced by various elements (e.g. disturbance, patch dynamics, stochastic processes) and suggests "nature in disequilibrium" is a more accurate model. 3. Reviews different theories of how ecosystems change. Relates theories to improving restoration efforts of degraded systems.

LITERATURE CITED IN TABLE 1

Baxter, R. R. Breuer, L. Brown, L. Conrad, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, P. Hrodey, A. Mueller-Solger,T. Sommer, K. Souza. 2010. Pelagic Organism Decline Work Plan and Synthesis of Results. Interagency Ecological Program, Sacramento, CA.

BDCP "Red Flag" Documents [California Department of Fish and Game; US Fish and Wildlife Service; and National Marine Fisheries Service. April 2012 BDCP EA (Ch. 5) Staff "Red Flag" Review Comprehensive List. Available at: http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Effects_Analysis__Fish_Agency_Red_Flag_Comments_and_Responses_4-25-12.sflb.ashx (BDCP Red Flag Reviews 2012).

California Department of Fish and Game. 2005. San Joaquin River salmon population model. SWRCB SJR Flow Workshop Sept. 17, 2008. Marston, D. and A. Hubbard. http://www.waterrights.ca.gov/baydelta/docs/sanjoaquinriverflow/dfgpresentation_salmon.pdf (CDFG 2005).

California Department of Fish and Game. 2010a. Quantifiable biological objectives and flow criteria for aquatic and terrestrial species of concern dependent on the Delta. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?Do (CDFG 2010a.).

California Department of Fish and Game. 2010b. Flows needed in the Delta to restore anadromous salmonid passage from the San Joaquin River at Vernalis to Chipps Island. Exhibit #3, Prepared for the Informational Proceeding to Develop Flow Criteria for the Delta Ecosystem Necessary to Protect Public Trust Resources Before the State Water Resources Control Board (CDFG 2010b.).

Castillo, G. J. Morinaka, J. Lindberg, Robert Fujimura, B. Baskerville-Bridges, J. Hobbs, G. Tigan, L. Ellison. (*in press).* Pre-Screen Loss and Fish Facility Efficiency for Delta Smelt at the South Delta's State Water Project, California. Accepted by: San Francisco Estuary and Watershed Science. Available at: http://www.fws.gov/stockton/jfmp/docs/DRAFT-Delta-Smelt-Pre-Screen-Losses- SWP.pdf.

Cloern J.E. and A.D. Jassby. 2012. Drivers of Change in Estuarine-Coastal Ecosystems: Discoveries from Four Decades of Study in San Francisco Bay. Review of Geophysics, 50, RG40001. doi:10.1029/2012RG000397.

Enright, C. and S.D. Culberson. 2010. Salinity trends, variability, and control in the northern reach of the San Francisco Estuary. San Francisco Estuary and Watershed Science, 7(2).

Feyrer, F. M.L. Nobriga, T.R. Sommer. 2007. Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. Canadian Journal Fisheries and Aquatic Sciences 64:723-734.

Feyrer, F., K. Newman, M. Nobriga, and T. Sommer. 2010. Modeling the Effects of Future Outflow on the Abiotic Habitat of an Imperiled Estuarine Fish. Estuaries and Coasts. DOI 10.1007/s12237-010-9343-9.

Feyrer, F. 2012. Declaration of Frederick V. Feyrer In Support of Defendants' Opposition to Plaintiffs' Motion for Injunctive Relief, July 1, 2011. (Doc. 944). (Feyrer Declaration 2012).

Gleason, Henry A. 1926. The Individualistic Concept of the Plant Association. Bulletin of the Torrey Botanical Club 53: 7-26.

Interagency Ecological Program (IEP). 1999. J. Orsi, editor. Report on the 1980-1995 fish, shrimp, and crab sampling in the San Francisco Estuary, California. Technical Report #63. California Department of Fish and Game, Stockton, CA. http://www.estuaryarchive.org/archive/orsi_1999 (IEP Report 1999).

Jassby, A. D., J. E. Cloern, and B. E. Cole. 2002. Annual primary production: Patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnology and Oceanography 47 (3), 698-712.

Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel, and T. J. Vendlinski. 1995. Isohaline Position as a Habitat Indicator for Estuarine Populations. Ecological Applications 5:272-289.

Kimmerer, W. J. 2002a. Effects of freshwater flow on abundance of estuarine organisms: Physical effects or trophic linkages? Marine Ecology Progress Series 243:39-55.

Kimmerer, W. J. 2002b. Physical, Biological, and Management Responses to Variable Freshwater Flow into the San Francisco Estuary. Estuaries 25:1275-1290.

Kimmerer, W.J. 2008. Losses of Sacramento River Chinook salmon and delta smelt to entrainment in water diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary Watershed Science 6(2). Available at: http://escholarship.org/uc/item/7v92h6fs.

Kimmerer, W. J., E. S. Gross, and M. L. MacWilliams. 2009. Is the Response of Estuarine Nekton to Freshwater Flow in the San Francisco Estuary Explained by Variation in Habitat Volume? Estuaries and Coasts 32:375-389.

Kimmerer, W.J. 2011. Modeling Delta Smelt Losses at the South Delta Export Facilities. San Francisco Estuary and Watershed Science, 9(1). Available at: http://escholarship.org/uc/item/0rd2n5vb.

Lindley, S.T. C.B. Grimes, M.S. Mohr, W. Peterson, J. Stein, J.T. Anderson, L.W. Botsford, D.L. Bottom, C.A. Busack, T.K. Collier, J. Ferguson, J.C. Garza, A.M. Grover, D.G. Hankin, R.G. Kope P.W. Lawson, A. Low, R.B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F.B. Schwing, J. Smith, C. Tracy, R. Webb, B.K. Wells, and T.H. Williams. 2009. What Caused the Sacramento River Fall Chinook stock collapse? NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-447

MBK Memorandum 2011. Written by Walter Bourez to, December 15, 2011. Submitted to State Water Resources Control Board Phase II Comprehensive Review Workshops Workshop 2, "Bay-Delta Fisheries" to be held October 1-2, 2012. Prepared by W. Bourez. Written on behalf of the Northern California Water Association. Submitted September 14, 2012.

MBK Report. 2012. Evaluation Of Potential State Water Resources Control Board Unimpaired Flow Objectives, April 25, 2012. Submitted to State Water Resources Control Board Phase II Comprehensive Review Workshops Workshop 2, "Bay-Delta Fisheries" to be held October 1-2, 2012. Prepared by MBK Engineers. Written on behalf of the Sacramento Valley Water Users Group. Submitted September 14, 2012.

Mac Nally, R., J. R. Thomson, W. J. Kimmerer, F. Feyrer, K. B. Newman, A. Sih, W. A. Bennett, L. Brown, E. Fleishman, S. D. Culberson, and G. Castillo. 2010. Analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR). Ecological Applications 20:1417-1430. Available at: http://online.sfsu.edu/~modelds/Files/References/MacNallyetal2010EcoApps.pdf.

Mattern, S. A., P. B. Moyle, and L. C. Pierce. 2002. Native and alien fishes in a California estuarine marsh: twenty-one years of changing assemblages. Transactions of the American Fisheries Society, 131:797-816.

McElhany, P., M. H. Rucklelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. NOAA Technical Memorandum NMFS-NWFSC-42. Available at: http://www.nwfsc.noaa.gov/publications/techmemos/tm42/tm42.pdf.

Meffe, G.K. and C.R. Carroll. 1994. Principles of Conservation Biology. Sinauer Associates.

Michel, C. River and Estuarine Survival and Migration of Yearling Sacramento River Chinook Salmon (*Oncorhynchus tshawytscha)* Smolts and the Influence of Environment. A thesis

submitted in partial satisfaction of the requirements for the degree of Master of Arts in Ecology and Evolutionary Biology. December 2010.

Mount, J., W. Bennett, J. Durand, W. Fleenor, E. Hanak, J. Lund, and P. Moyle. 2012. Aquatic Ecosystem Stressors in the Sacramento–San Joaquin Delta. Public Policy Institute of California, San Francisco, CA. 24p. Available at: http://www.ppic.org/content/pubs/report/R_612JMR.pdf.

Moyle, P., W. Bennett, J. Durand, W. Fleenor, B. Gray, E. Hanak, J. Lund, and J. Mount. 2012. Where the Wild Things Aren't: Making the Delta a Better Place for Native Species. Public Policy Institute of California, San Francisco, CA. 55p. Available at: http://www.ppic.org/content/pubs/report/R_612PMR.pdf.

National Marine Fisheries Service. *Delta Operations for Salmonids and Sturgeon (DOSS) Working Group. Presentation for the Independent Review Panel, 11-8-11, by Bruce Oppenheim (NMFS) and Thuy Washburn, USBR.* Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/OCAP_2011_presentations_09_DOSS_ann_rev_11_7_11.pdf (NMFS 2011a.).

National Research Council. 2010. A Scientific Assessment of Alternatives for Reducing Water Management Effects on Threatened and Endangered Fishes in California's Bay Delta Committee on Sustainable Water and Environmental Management in the California Bay-Delta; ISBN: 0-309-12803-X, 104 pages (NRC 2010).

National Marine Fisheries Service. *Annual Report of Activities October 1, 2010, to September 30, 2011, Delta Operations for Salmonids and Sturgeon (DOSS) Technical Working Group.* October 2011. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/DOSS_Annual_Report_10_18-11_final.pdf (NMFS 2011b.).

Nislow, K. H. and J. D. Armstrong. 2011. Towards a life-history-based management framework for the effects of flow on juvenile salmonids in streams and rivers. Fisheries Management and Ecology. DOI: 10.1111/j.1365-2400.2011.00810.

Parker, A., Simenstad, S., George, T., Monsen, N., Parker, T., Ruggerone, G., and Skalski, J. 2012. Bay Delta Conservation Plan Effects Analysis Phase 2 Partial Review, Review Panel Summary Report. Delta Science Program. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/BDCP_Effects_Analysis_Review_Panel_Final_Report_061112.pdf (BDCP Effects Analysis 2012).

Rose, K. A. 2000. Why are quantitative relationships between environmental quality and fish populations so elusive? Ecological Applications 10: 367-385.

Rosenfield, J. A. and R. D. Baxter. 2007. Population dynamics and distribution patterns of longfin smelt in the San Francisco estuary. Transactions of the American Fisheries Society 136:1577-1592.

Rosenfield, J.A. 2010. Conceptual life-history model for longfin smelt (Spirinchus *thaleichthys)* in the San Francisco Estuary. California Department of Fish and Game. Sacramento, CA. http://www.dfg.ca.gov/ERP/conceptual_models.asp.

SVWU Latour Report. 2012. Data Analyses in Relation to Water Flow for Fishes in the Sacramento San Joaquin Delta Ecosystem. Prepared for State Water Resources Control Board Phase II Comprehensive Review Workshops Workshop 2, "Bay-Delta Fisheries" to be held October 1-2, 2012. Prepared by R. J. Latour. Written on behalf of the Sacramento Valley Water Users Group and Northern California Water Association. Submitted September 14, 2012.

SJTA Submittal. 2012a. Summary of Scientific Certainty Regarding San Joaquin Basin Chinook Salmon. Prepared for State Water Resources Control Board Phase II Comprehensive Review Workshops Workshop 2, "Bay-Delta Fisheries" to be held October 1-2, 2012. Prepared by D. Demko, D. M. Hellmair, M. Peterson, S. Ainsley, M. Palmer, and A. Fuller. Written on behalf of the San Joaquin Tributaries Authority. Submitted September

14, 2012.

SJTA Submittal. 2012b. Review of Scientific Information Pertaining to SWRCB's February 2012 Technical Report on the Scientific Basis for Alternative San Joaquin River Flow Objectives. Prepared for State Water Resources Control Board Phase II Comprehensive Review Workshops Workshop 2, "Bay-Delta Fisheries" to be held October 1-2, 2012. Prepared by D. Demko, M. Hellmair, M. Peterson, S. Ainsley, M. Palmer, and A. Fuller. Written on behalf of the San Joaquin Tributaries Authority, September 14, 2012.

San Francisco Estuary Partnership. 2011. The State of San Francisco Bay 2011. Available at: http://sfestuary.org/StatcofSFBay2011/ (SFEP 2011).

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32:270-277.

Sommer, T., F. Mejia, M. Nobriga, F. Feyrer, L. Grimaldo. 2011. The Spawning Migration of Delta Smelt in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science , 9(2).

Sommer, T.R., M.L. Nobriga, W.C. Harrell, W. Batham, and W.J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Science 58:325-333.

State Water Resources Control Board. 2010. Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem. August 3, 2010. California EPA. Sacramento, CA. Available at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/final_rpt080310.pdf (SWRCB 2010).

SWC submittal 2012. Bay-Delta Fisheries Resources: Pelagic Organisms. Prepared for State Water Resources Control Board Phase II Comprehensive Review Workshops Workshop 2, "Bay-Delta Fisheries" to be held October 1-2, 2012. Submitted by State Water Contractors, Inc. and San Luis Delta-Mendota Water Authority, September 14, 2012.

Stevens, D. E. and L. W. Miller. 1893. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin River system. North American Journal of Fisheries Management 3:425-437.

The Bay Institute. 2012. Collateral Damage: A citizen's guide to fish kills and habitat degradation at the state and federal water project pumps in the Delta. Novato, CA. Available at: http://www.bay.org/publications/collateral-damage. ("TBI 2012").

Thomson, J. R., W. J. Kimmerer, L. R. Brown, K. B. Newman, R. Mac Nally, W. A. Bennett, F. Feyrer, and E. Fleishman. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecological Applications 20:1431-1448. Available at: http://online.sfsu.edu/~modelds/Files/References/ThomsonEtal2010EcoApps.pdf.

U.S. Fish and Wildlife Service 2012a. First Draft 2011 Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project and State Water Project. Available online at: http://www.usbr.gov/mp/BayDeltaOffice/docs/Signed_FINAL%202011-F-0043_%20SWP-CVP%20BO%20Dec%2014%20FIRST%20DRAFT.pdf. (FWS 2012a).

U.S. Fish and Wildlife Service. 2012b. Endangered and Threatened Wildlife and Plants;12-month Finding on a Petition to List the San Francisco Bay-Delta Population of the Longfin Smelt as Endangered or Threatened. 50 CFR Part 17. [Docket No. FWS-R8-ES-2008-0045]. Available at: http://www.fws.gov/cno/es/speciesinformation/Longfin%20Smelt%2012%20month%20finding.pdf (FWS 2012b.).

Winder, M., A.D. Jassby, and R. Mac Nally. 2011. Synergies between climate anomalies and hydrological modifications facilitate estuarine biotic invasions. Ecology Letters 14: 749–757. Available at: http://online.sfsu.edu/~modelds/Files/References/Winder2011EcolLetters.pdf.

Zeug, S.C. 2010. Predictors of Chinook Salmon Extirpation in California's Central Valley. Fisheries Management and Ecology 18: 61-71.

THE BAY INSTITUTE

NEXT STEPS RE:
SWRCB COMPREHENSIVE REVIEW (PHASE 2) OF THE 2006 BAY-DELTA WATER QUALITY CONTROL PLAN
April 2013

Table 2: Selected areas of uncertainty germane to management of flows and estuarine habitat that may be relevant to Phase 2

AREA OF UNCERTAINTY	POTENTIAL NEXT STEPS
Can levels of flow, salinity, and/or other water quality parameters be directly manipulated to help control the abundance and distribution of certain invasive species (e.g. Egeria, Corbula, etc.) in the SF Bay-Delta estuary? What specific levels (magnitude, duration, timing, frequency/variability) of flow, salinity, etc., are necessary to control/contain each target invasive species?	Laboratory studies to address tolerance of target species to specific levels of flow, salinity, etc., may provide initial results during Phase 2. Results from actual field tests of the hypotheses generated from those studies could be incorporated during implementation using the AM process.
Can substantial fish prey items (e.g., zooplankton) from restored wetlands and floodplains be exported to the Low Salinity Zone and/or other habitats in the estuary? If so, what factors (e.g. location and design features of restored sites, salinity at those sites, transport flows, etc.) most strongly affect this capacity?	Modeling during Phase 2; incorporation of results from restored sites during implementation using the AM process. Analyses using particle tracking models would need to address whether food prey items are consumed by target organisms rather than predators on those organisms or invasives.
How will the potential for restored shallow water rearing habitats in the Delta be affected by climate change in terms of (a) sea level rise, (b) increased temperatures, and (c) changes in the seasonal timing of freshwater flow events? What do these changes suggest about the selection of and/or importance	Modeling during Phase 2 and continuing through implementation. Because increased productivity as a result of large-scale physical habitat restoration is proposed by many as a major potential factor in the AM of flows in the SF Bay-Delta Estuary, better understanding and predicting the efficacy and functionality

of these restoration sites to different species and the manipulation of flow, salinity and other water quality parameters to maintain the functionality of these sites?	of restoration sites (in toto) is a prerequisite for making future decisions.
How do the interactions between flow (from different sources), exports from the South Delta , and turbidity affect rates of salmon, DS, and LFS entrainment? Most importantly, what is the relevant resolution (time step) for each of these variables?	Use existing data to better understand resolution (the relevant time step = averaging period, lag between variable manipulation and response) and model interactions between parameters.

Holcomb, Valerie

From: Brock Bernstein <brockbernstein@sbcglobal.net>
Sent: Saturday, June 15, 2013 10:17 AM
To: Holcomb, Valerie
Subject: FW: Technical Edits for State Water Resource Control Board WQCP Phase 2 Workshop Summary Report

Brock B. Bernstein, Ph.D.
308 Raymond St., Ojai, CA 93023
(805) 646-8369
(805) 646-3849 fax

From: Mizell, James@DWR [mailto:James.Mizell@water.ca.gov]
Sent: Thursday, April 04, 2013 4:52 PM
To: brockbernstein@sbcglobal.net
Cc: Nader-Tehrani, Parviz@DWR; Kelly, Kathy@DWR
Subject: Technical Edits for State Water Resource Control Board WQCP Phase 2 Workshop Summary Report

Hi Brock,

Thanks for giving us the opportunity to provide you with some suggested revisions in the Bay-Delta Plan Workshop Summary Report. As I mentioned on the phone this afternoon, the Department of Water Resources has a handful of minor technical clarifications it would like to see incorporated into the final report that gets presented to the State Water Board next week. Overall, DWR staff were very impressed with how accurately ICF was able to encapsulate such a barrage of information.

The six suggestions below will increase the specificity, and thereby the accuracy and utility, of the report. If you could forward these to the team that compiled the report and ask that they review and incorporate where possible, I would certainly appreciate the effort.

The comments are:

1) p. 32, 2nd paragraph, 3rd sentence:

"California's water storage capabilities are limited (California's water storage capacity is five times less than Colorado's, even though the average unimpaired flow is similar), which means DWR's ability to mitigate for droughts is constantly at risk."

Should be replaced with:

"The Sacramento River Basin's water storage capabilities are limited (Sacramento Basin's water storage capacity is five times less than the Colorado Basin's, even thought the average unimpaired flow is similar), which means DWR's ability to mitigate for droughts is constantly at risk."

2) Page 9, Last Para. The degree of consensus among different groups with regard to flow effects on salmon survival differs between the Sacramento River and San Joaquin River corridors. The issue is more controversial for the San Joaquin River.

3) Page 34, Para. 1. The sentence should read: "IEP is now trying to expand sampling on the margins of the Delta to provide better insight into fish distribution of these areas."

4) Page 70, Para. 3 (Ted Sommer response to Moore). Ted Sommer's response did not focus on the potential contribution of plankton from the ocean. Rather, his response was comparing a hypothesized mechanism by which flow affects the food web and observations made in a high flow year that were inconsistent with that mechanism. The hypothesized effect of flow is that blooms will occur when the low salinity zone is located in Suisun Bay (i.e. high flow conditions), where there are broad shoals that give plankton more light. Observations in 2011 (a wet year) did indeed show a fall bloom, but that the bloom came from upstream.

5) Page 75, Para. 4. Recommend changing this sentence to read: "Based on the bet hedging model, DWR recommends an approach that includes on improved hatchery management practices and development of a suite of habitat types that provide opportunities for growth along the migration corridor and along tributary streams."

6) Page 75, Last Para. This sentence about Brett's comments would be better worded as follows: "He acknowledged that higher flows help survival numbers, but pointed out that trying to moving all fish too quickly through the system could also reduce life history variability."

In addition, John Leahigh's first name is misspelled in a number of places in the report (written as Jon). I know he would appreciate it if ICF could please make a correction.

The intent of offering these clarifications is not to change the meaning of the report. If your staff have any questions whatsoever on these comments or feel that they may inadvertently change the substance of the text, they are free to call me at 916-653-7533 and I can get them in touch with our staff that recommended the clarification in question.

All the best,

Tripp Mizell, Attorney
California Department of Water Resources
Office of the Chief Counsel
1416 9th Street, Room 1118-D
Sacramento, CA 95814
(916) 653-7533
james.mizell@water.ca.gov