Public Comment
Bay-Delta Plan Supplemental NOP
Deadline: 04/25/12 by 12 noon

LATE COMMENT

United States Department of the Interior

Comments on the Environmental Documentation for the Update and Implementation of the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary: Comprehensive Review

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The U.S. Department of the Interior (Interior) submits these comments on behalf of the U.S. Bureau of Reclamation (Reclamation) and the U.S. Fish and Wildlife Service (FWS), pursuant to the State Water Resources Control Board (SWRCB or the Board) January 24, 2012 Supplemental Notice of Preparation and Notice of Scoping Meeting for Environmental Documentation for the Update and Implementation of the Water Quality Control Plan (WQCP) for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta): Comprehensive Review.

Interior supports the coequal goals of the State as set forth in California Water Code § 85054: 1) providing a more reliable water supply for California; and, 2) protecting, restoring, and enhancing the Delta ecosystem. Interior has two areas of expertise with which it can assist the Board in this Comprehensive Review of the Bay-Delta Plan: water resources management and fishery needs. According to the Supplemental Notice, the Board, among other reports, will be considering information in the 2010 Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem report for this Comprehensive Review. However, the Supplemental Notice specifically excludes flow and salinity objectives for the San Joaquin River and South Delta. The key issues for the Board in this Comprehensive Review, therefore, will likely be in connection with analyzing various alternative flow regimes based, in whole or in part, upon fixed percentages of unimpaired flow during various parts of the year, primarily impacting the Sacramento River and its tributaries. While these comments address the other important objectives in the Bay-Delta Plan, and highlighted in the Board's 2009 Staff Report, the focus of these comments is flow-related objectives. Interior submits these comments for informational purposes, and provides a look at flow-related issues from both water resources management and fishery needs perspectives.

Changes in Delta flows along with physical changes to land structures and alterations of the hydrodynamics have caused changes in the physical habitat components of the system, which have contributed to the decline of the Delta ecosystem. Native fish populations dependent on the

Delta have declined across the board, with some species on the brink of extinction. Food web dynamics have undergone significant changes in both abundance and composition. While other stressors on the Delta ecosystem are important, such as urban runoff, other pollutants, and invasive species, flow in the Delta is one of the primary determinants of habitat availability and one of the most important components of ecosystem function. Timing, magnitude and variability of flow are the primary drivers of physical habitat conditions including: turbidity, temperature, particle residence time, nutrient loading, etc. In addition, flow is an important component of reverse flow modification and X2 positions.

On the other hand, the natural water supply for the Sacramento River and its tributaries is limited annually by seasons and subject to extended multi-year droughts. The system is currently regulated by large water supply and power generating reservoirs which are operated most efficiently for multiple purposes including environmental flow and temperature under conditions of certainty.

Interior is recommending the Board consider and evaluate several objectives in the comprehensive review of the WQCP. Some of these objectives come from D-1641, others are new. Interior hopes that rather than simply layering new objectives onto existing objectives, that the Board will evaluate how each of the objectives interact within the WQCP and consider eliminating redundant or outdated standards. Holistic evaluation may provide an alternative that is protective of species and the ecological functions and systems on which they rely, while at the same time providing greater certainty to water project operations. Interior hopes that the information contained in these comments is useful to the Board in constructing meaningful alternatives for its Comprehensive Review of the Bay-Delta Plan.

WATER RESOURCES MANAGEMENT

I. The Delta And Its Watershed Is An Engineered Environment.

The Sacramento River system and Bay-Delta are not the same as they were prior to the construction of the Central Valley Project (CVP), State Water Project (SWP), and multiple other diversion and storage projects. Today, these systems are engineered to serve multiple public purposes. The Board has taken this fact into consideration in previous water quality control plans and water rights decisions (e.g., Decisions 1485 and 1641).

The water resources of the State of California were developed as an integrated, managed water system that regulates flow for the benefit of flood control, water supply, drought protection, power production, fish and wildlife enhancement, and recreational purposes, guided by the State and federal planning processes. This water system is designed to capture runoff, and re-regulate it over time to better distribute water resources for all beneficial uses under a wide variety of climatic conditions. An increased demand for Delta inflow and Delta outflow for fishery protection based on unregulated runoff patterns will significantly affect how this system operates, and beneficial uses of this system may be affected.

Furthermore, this system is regulated under several frameworks. The U.S. Army Corps of Engineers has established national objectives for flood control, and sets operational rules for reservoir flood space reservations and release rates. Non-federal reservoirs with hydropower systems are regulated by the Federal Energy Regulatory Commission (FERC), and are operated to meet electrical load in a reliable manner in coordination with the state's electrical grid.

The CVP is operated by Reclamation in an integrated manner for the following Congressionally authorized purposes: river regulation, navigation, flood control, water supply, fish and wildlife mitigation, protection and enhancement, and power. It is regulated for fish and wildlife and other purposes by federal legislation. Reclamation is a party to the Coordinated Operations Agreement with the California Department of Water Resources (COA) to operate the CVP and SWP to meet the Sacramento Valley in-basin demands by coordinating project reservoir and Delta export operations. Congress authorized and directed the Secretary of the Interior to execute and implement COA in Public Law 99-546. The COA, and any impacts to it, should be considered as the Board evaluates alternatives for flow-based objectives.

, Many of Reclamation's facilities are operated according to agreements with senior water right holders, the California Department of Fish and Game, and other legal settlements. Reclamation also operates to meet contractual obligations to deliver irrigation and municipal and industrial water supplies and to generate power. An increase in flow requirements, either in timing or magnitude, has the potential to significantly impact these various existing settlements agreements and contracts. Therefore, Reclamation suggests that the Board consider these aspects of the CVP as it models and evaluates alternative implementation strategies.

II. Bay-Delta Plan Objectives Should Balance And Integrate The Needs Of The Entire Ecosystem.

A. New Objectives Should Be Evaluated in Light of Existing Regulatory Requirements.

In 2008 and 2009 the FWS and National Marine Fisheries Service (NMFS) issued Biological Opinions regarding the long term operations of the CVP and SWP. FWS and NMFS concluded that the projects as proposed would jeopardize listed species and adversely modify or destroy designated critical habitats. The Biological Opinions included Reasonable and Prudent Alternatives to the proposed project to avoid jeopardy and adverse modification. Reclamation has reinitiated consultation pursuant to court order to allow for reconsideration of certain aspects of these opinions. However it is likely that actions included in the 2008/2009 Biological Opinions, or actions that provide a similar level of protection may be required to continue to operate the CVP and SWP in compliance with the federal ESA. For this reason, Reclamation encourages the Board to model and evaluate how implementing protective actions like those included in the Biological Opinions affect existing and future conditions. We would suggest that fish protective actions should be integrated to the extent possible to provide more effective solutions for multiple species and ecosystem objectives.

B. Analyze Flood Control and Cold Water Pool Needs.

The Delta Flow Criteria Report also identified the need to evaluate its proposed approach in light of flood control operation and in light of the management of the major reservoirs' cold water pools. These analyses are extremely important for identification of a preferred approach in the update of the Bay-Delta Plan. Flow objectives can potentially raise issues with these federal requirements on reservoir operations. Reclamation is also concerned with the impacts on hydropower generation, which should also be analyzed prior to identifying a preferred approach.

A significant portion of the remaining limited spawning and rearing habitats for anadromous fish populations are in the rivers and streams below the regulating dams and the attributes that make them favorable to salmonids are dependent upon winter and spring runoff captured in the reservoirs for instream flow and cold water in the late summer and fall. The storage season peaks in April to June. The Board should consider whether an unimpaired flow standard can be implemented to provide sufficient opportunity to capture and maintain storage. The ability to build the cold water storage in the CVP reservoirs may be compromised with an operation designed to mimic the unimpaired runoff pattern, which could make it more difficult to consistently achieve the river temperature targets necessary to sustain multiple life stages of salmonids including holding adults, eggs, and juveniles. This is particularly true for Shasta operations, where the entire population of winter-run Chinook salmon is currently dependent on temperature control operations.

Past juvenile Chinook salmon survival studies suggest there is a strong correlation between flow, water temperature, and survival of juvenile Chinook salmon during outmigration through the Delta. A standardized, multi-tributary study to assess the range of potential benefits and impacts on the effects of flow and temperature on juvenile salmonid management strategies within the Central Valley rivers and Delta would be useful to:

- Evaluate and analyze correlations between flow, water temperatures, and other environmental covariates with observed juvenile Chinook salmon survival from the tributaries, through the Delta, and to the ocean;
- Use a water temperature model and fish bioenergetic model to evaluate the effects of releases on water temperatures downstream of the reservoirs on both Sacramento and San Joaquin Rivers to study the potential effects of elevated seasonal water temperatures on growth and survival of juvenile Chinook salmon emigrating from both Sacramento and San Joaquin tributaries;

- Develop functional relationships for use in the fishery population/habitat model describing survival over a range of environmental conditions for juvenile Chinook salmon and/or steelhead during emigration through the Sacramento, San Joaquin River and Delta.

Similarly, water uses in the Central Valley and Delta have developed around the use of this reregulated, engineered hydrologic system. Other in-Delta water users are dependent on having low salinity water quality needed for agriculture and for municipal and industrial uses year round. Water stored in the upstream reservoirs is used to meet those water quality requirements. The ability for the reservoirs to regulate the Central Valley runoff is essential to meeting the water year type flow and water quality requirements contained in Water Rights Decision 1641. New regulations that prevent the capture of surplus flows, or reallocate them to other resources, would impact the availability of flow for other beneficial uses.

C. Objectives Should Consider All Beneficial Uses.

The Board also has the responsibility of balancing the beneficial uses of the state's water supply in development of water quality objectives. The Delta Flow Criteria report attempted to address all of the needs of the entire ecosystem (fish species, water quality, habitat values), but did not attempt to evaluate or balance these needs among each other or with other beneficial uses. The Board should consider and evaluate desired outcomes for all other beneficial uses as well as desired outcomes for fish and wildlife beneficial uses.

III. Delta Outflow Criteria Cannot Be Assessed Without Specific Implementation Proposals.

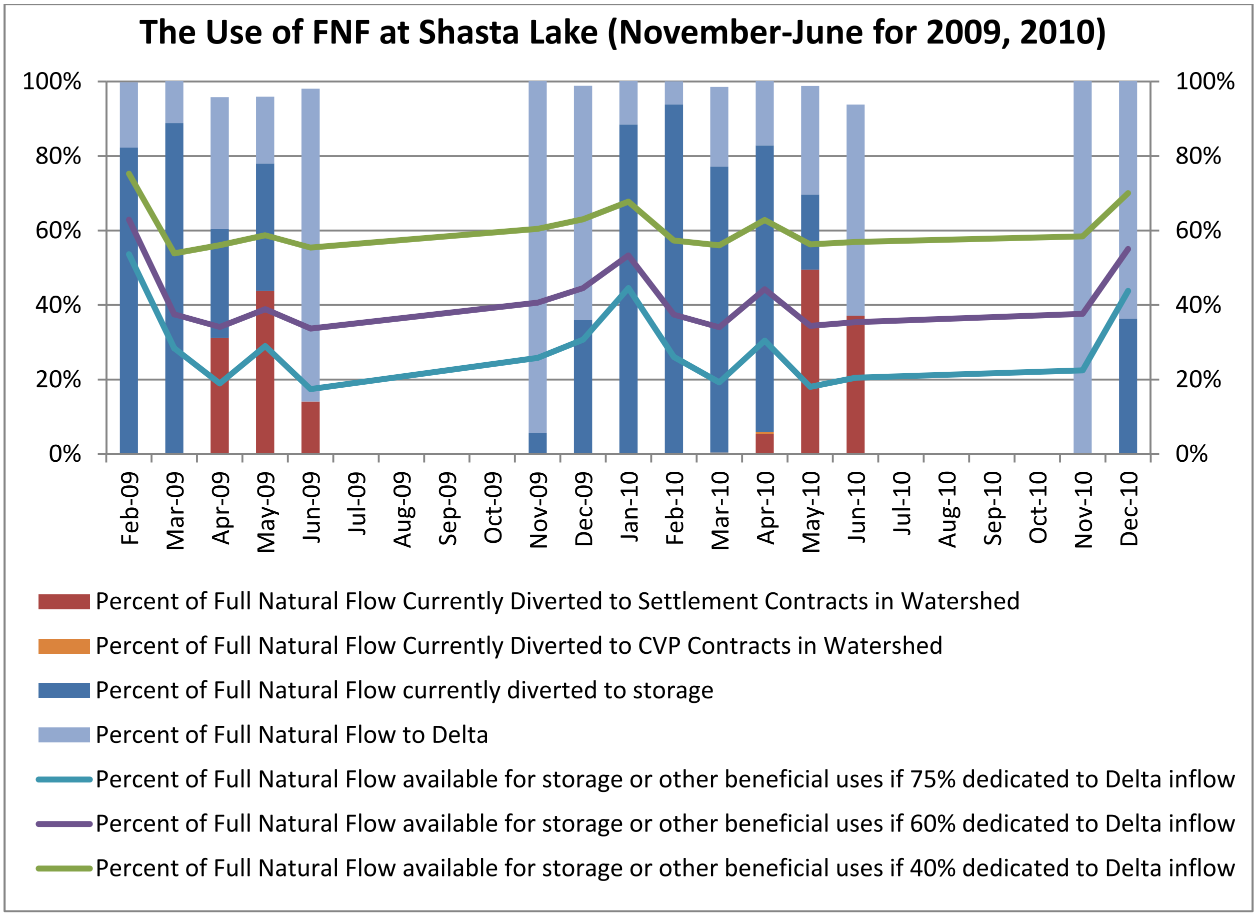
The Delta Flow Criteria Report identifies a potential need for 75 percent unimpaired flow for the Sacramento River at Rio Vista from November through June (Delta Flow Criteria Report, at p. 114.) Because the Delta Flow Criteria Report focused on Delta inflow, it is difficult to assess how such criteria might be applied to the Sacramento Basin upstream. The criteria is identified as a percentage of unimpaired flow from the entire Sacramento Basin at a specific location (Rio Vista), yet the Board has applied similar criteria in the Sacramento River to the major rim dams. Unlike the San Joaquin River, significant unimpaired flow is contributed below the major rim dams and the major rim dams provide a significant portion of the state's water supply reliability, existing fishery flows and cold water pool management, as well as flood control protection.

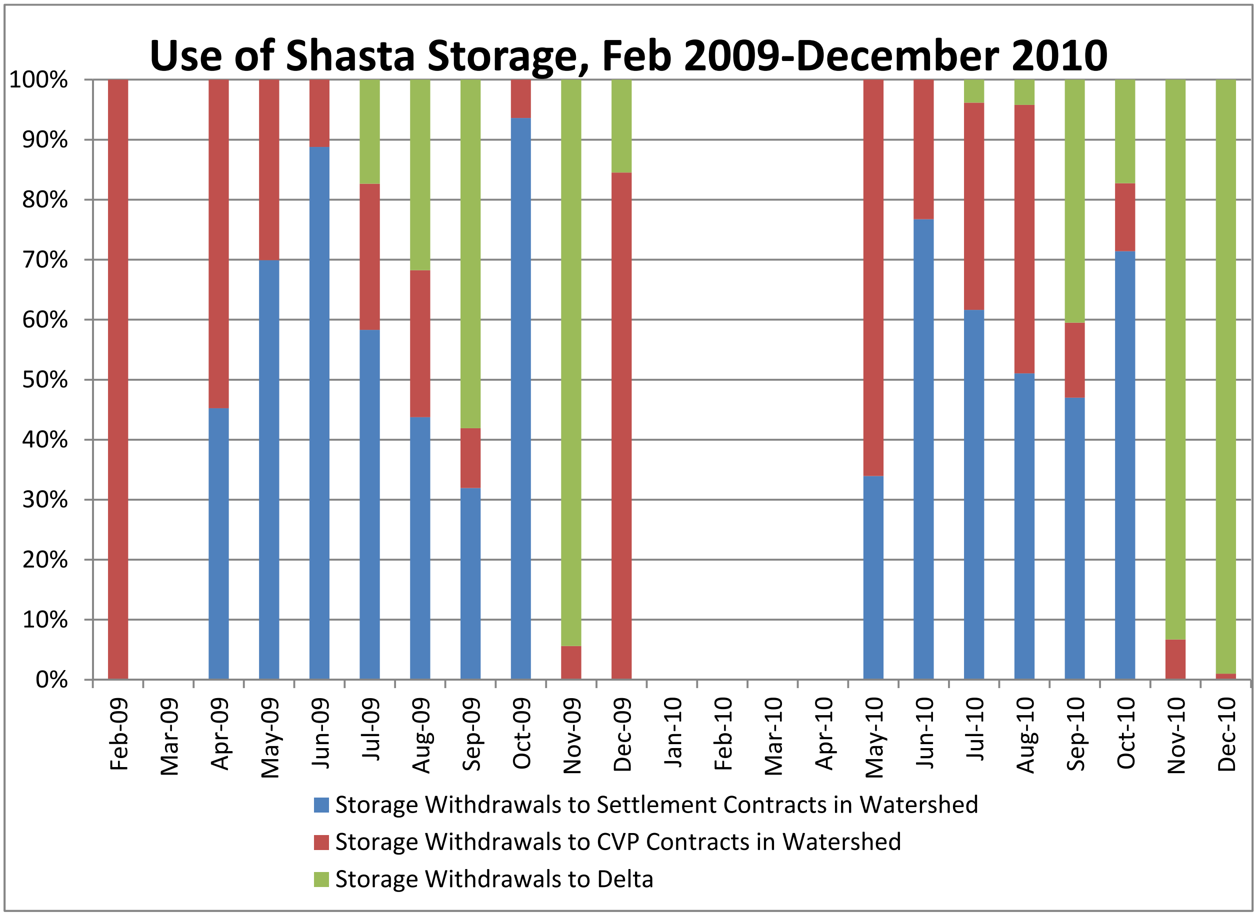
In light of the shift in water management priorities suggested by the Delta Flow criteria, the Board should consider how it plans to set and implement any new objectives in conjunction with its environmental analysis. As described above, if the goal of the Board is to produce a very specific percentage of unimpaired flow entering or exiting the Delta, flows that enter from sources below the major rim dams, riparian and appropriative diverters downstream of major rim dams, senior water rights holders in major rim dams, and existing instream flow and water quality objectives should be considered. The Board should also consider that the location of an objective has the potential to bias the implementation approach. The interplay of all of these many factors must be understood in order to propose balanced and meaningful objectives and to conduct a sufficient impact analysis.

IV. The Board Should Evaluate Other Alternatives in Addition To A Percentage Of Unimpaired Flow Methodology.

Reclamation has operational concerns about a close-to-real-time "percentage of unimpaired flow" approach. A pure unimpaired flow approach could result in extremely low flows and less storage that could result in worse conditions than experienced under today's operations.

A rough examination of Shasta Lake can illustrate the cost of this approach to the other beneficial uses in the Basin and to CVP operations. The various uses of Full Natural Flow (FNF) into Shasta Lake were examined for the years 2009 and 2010, using calculated diversions to storage, direct diversions, and contract deliveries (which generally incorporate riparian demands). The 14-day averages of daily full natural flow rates (data available online starts January 1, 2009) were then calculated to determine the flow rate requirements associated with 75%, 60% and 40% dedication of full natural flows to fishery at Rio Vista (as Delta inflow). Based on these, the portion of full natural flow that would remain available for appropriation for consumptive use is plotted against the historic use of full natural flow. This illustrates the potential for impact on both Reclamation and senior water right holders of this type of action, and also illustrates that the impact may not be to consumptive use alone. Reservoirs are used for multiple purposes (including instream flows, temperature and water quality) and will require close analysis to determine the broader impact of any significant reoperation. For example, this graphic does not illustrate that an objective based on percentage of full natural flow can also trigger withdrawals from storage (up to 158,000 acre feet in one month in this analysis.) The second graphic illustrates the historic use of stored flows, to meet senior watershed rights, CVP contract deliveries in the watershed, and to the Delta.


The Use of FNF at Shasta Lake (November-June for 2009, 2010)
100%
80%
60%
40%
20%
0%
Feb-09
Mar-09
Apr-09
May-09
Jun-09
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10
Dec-10
Percent of Full Natural Flow Currently Diverted to Settlement Contracts in Watershed
Percent of Full Natural Flow Currently Diverted to CVP Contracts in Watershed
Percent of Full Natural Flow currently diverted to storage
Percent of Full Natural Flow to Delta
Percent of Full Natural Flow available for storage or other beneficial uses if 75% dedicated to Delta inflow
Percent of Full Natural Flow available for storage or other beneficial uses if 60% dedicated to Delta inflow
Percent of Full Natural Flow available for storage or other beneficial uses if 40% dedicated to Delta inflow



Reclamation encourages the Board to consider a flow schedule objective, perhaps with a flexible volume included, as one alternative to a real-time objective based on the last 14-days estimated unimpaired flow. This could avoid many potential issues with a real-time objective based on estimated unimpaired flow:

- Francis Chung of DWR outlined many of the potential issues associated with the use of an unimpaired flow estimate in his November 21, 2010 presentation to the Board. Reclamation reiterates these concerns, and encourages the Board to work out these issues prior to proposing any objective or operational criteria based on this problematic parameter.
- Flow entering a major reservoir may be less than the estimated unimpaired flow, depending on the operations of power and consumptive use storage upstream. The operation to a 14-day estimated unimpaired flow could also require the release of high December flows in January, further reducing the ability to capture surplus flow for future consumptive use.

- Inability to reliably forecast unimpaired patterns undermines Reclamation's ability to plan reservoir operations to meet multiple criteria, and to reliably allocate water supply to its contractors in a timely manner.
- Unimpaired flow-based objectives may be contrary to federal flood control objectives.
- The interaction of new unimpaired flow-based objectives with other water quality objectives, existing water right agreements, informal agreements and legal settlements, and downstream riparian demands (from an operational perspective).
- The repercussions on the coordinated operations of the CVP and SWP under COA.
- The ability of Reclamation to manage its reservoirs over multiple years to provide drought supply reliability, including the support of public health and safety for municipal and industrial (M&I) contractors.
- Highly variable and unpredictable river flow can impact river recreation, while both highly variable elevations and higher frequency of lower elevations can impact reservoir recreation. Variable river flows may also have fish stranding and isolation effects.
- Power generation now used to meet peak summer electrical loads may be shifted to periods of lesser need, such as spring, when even under current operations power generation occasionally exceeds electrical loads.

V. The Board Should Give Consideration To Implementation Of These Objectives.

Reclamation recognizes that implementation of new objectives is a separate process from the development of the objectives themselves. However, the Board should consider a wide range of implementation strategies that do not result in any disproportional impacts to the CVP or any specific water right holder or class of water users.

Development of objectives that fail to take into account availability of resources, or cause disproportionate impacts in implementation, should be avoided. For example, the Board, in implementing objectives developed as part of the 1995 WQCP, made assumptions as part of the modeling studies that previously stored water would be released from reservoirs on San Joaquin River tributaries in order to fully comply with these objectives (*see* Chapter 12 of the Final EIR, at 16 – "For modeling purposes, both the Cumulative Impact Assessment and the Bay/Delta Plan Alternative require the release of additional water from reservoirs on tributaries to the San Joaquin River in order to fully comply with the objectives. Because these reservoirs are surrogates for parties who would be assigned responsibility for meeting the objectives if the Bay/Delta Plan is implemented, this analysis will not address impacts to those reservoirs."). The impact of this modeling assumption was that water right holders on these tributaries (including Reclamation) could be forced at times to release water previously stored (after all applicable objectives - including the one in question - had been met) to comply with this requirement.

The Board also assumed that water right holders can cure deficiencies in their diversions caused by the implementation of objectives by contracting for a substitute water supply:

> When a direct diversion is curtailed under these alternatives, the water right holder can either contract for a substitute water supply, as other prior right water users have in the past, or pump groundwater. For modeling purposes, the assumption is made that a water right holder in the Sacramento Basin will contract for a substitute water supply while a water right holder in the San Joaquin Basin will pump groundwater. Consequently, the model results show no impact on Sacramento Basin direct diverters under these alternatives, but do show an impact on the San Joaquin Basin direct diverters. (Final EIR, Chapter 5, at 16)

Unfortunately, this is not likely the case. Reclamation is prohibited by law from offering new contracts for water supply from the CVP (*see* §3404(a) of the Central Valley Project Improvement Act [Title 34 of Public Law 102-575]). Thus, the assumption "that a water right holder in the Sacramento Basin will contract for a substitute water supply" is incorrect, as are the model results that show no impact due to curtailment of direct diversions to Sacramento Basin direct diverters.

These are two examples of modeling assumptions where water was expected to be available in order to make an objective implementable – regardless of whether the water would actually be there. Objectives should be based on an accurate assessment of water actually available – if the water is not available to support the objective, then the objective needs to be revised - and if the shift of water from one beneficial use to another causes unavoidable impacts they should be clearly identified and evaluated.

VI. The Board Should Use The Appropriate Modeling Tool For The Type Of Objective Proposed (For Example, An Unimpaired Daily Flow Requires A Daily Timestep Model To Assess Its Impacts).

The recommended approach to modeling is to make use of existing or commercially available modeling packages to minimize the resources required for developing new modeling tools. This section will look at modeling tools available and their limitations. However, additional analytical tools may be needed to analyze impacts which cannot be adequately analyzed under the currently available models. The development and use of models should include emphasis on physical observations on reservoir and river operating conditions, meteorological conditions, water temperature, hydrodynamics, and other water quality variables. Eventually, various assumptions will be established through the modeling and analysis process. The methodology and hypotheses should be tested through the design and development process to ensure the accurate representation of the physical structure.

The focus of this task is the following:

- What is the objective of applying the modeling tool?
- Current available tools and their limitations.

During the 2008 Operations Criteria and Plan Biological Assessment (2008 BA) modeling process, a suite of modeling tools were applied to analyze effects of proposed CVP and SWP operations on steelhead, delta smelt and different runs of salmon. The 2008 BA modeling process used a tiered approach where models function independently and are not dynamically linked. This approach is viable because: 1) each individual model has different constraints and strength, i.e. different time steps and model resolution; 2) each individual model has unique functions and data requirements, and 3) not all the currently available modeling tools have system wide applications and they cannot be linked dynamically. A thorough discussion of the available modeling tools is listed in the 2008 BA documents (http://www.usbr.gov/mp/cvo/ocap_page.html). The model appendices (Appendices D through T) document 2008 BA modeling adequacy, credibility, data quality, model testing, sensitivity, uncertainty and results. This is a great resource to understand all the models used in the 2008 BA analysis. The climate change modeling is important and all the modeling tasks need to include the climate change impact analysis on current and future levels of project development. However, it is an enormous topic to be covered and we do not intend to cover this subject here.

A. Summary of Modeling Tools.

1) CVP/SWP System Operations Modeling.

The reservoir and river operations modeling would include consideration of historic hydrologic conditions affecting water supply, also needs to include operations of upstream rim flows and downstream water delivery operations to CVP and SWP water users. The reservoir operations model would be linked with the reservoir temperature model to develop realistic and objective estimates of the seasonal availability of cold water within the reservoirs of the Sacramento and San Joaquin Basins. An operations model needs to include analysis of opportunities for identifying potential conjunctive downstream water releases, changes in flood flow frequency and magnitude, drought sequences, and other operation parameters and water year types. The objective of the operations modeling is to develop a reliable and objective tool for evaluating CVP and SWP statewide planning and operations, water supply, water delivery, and Delta export capability based on actual hydrologic conditions and potential constraints under proposed operating conditions.

Current Available Tools - *CalSim II and CalLite*

The CalSim II model is a water resources planning model jointly developed by DWR and Reclamation. It can be used to simulate 82 years of hydrology for water year 1922-2003. (However, models are currently being developed which will include hydrology at least up to 2009). The model is designed to evaluate the CVP and SWP system for existing or future levels of land development, current or alternative operational policies and regulatory metrics, potential future facilities analysis, and water delivery.

The CalLite model is a simplified CalSim II model that can be used to simulate the hydrology of the Central Valley reservoir operations, project operations and delivery allocation decisions, salinity responses to river flow, habit and ecosystem indices, and export changes. The model focuses on simulating the Delta facilities, water quality, channel flows and ecosystem indicators, and different CVP and SWP allocation delivery procedures. The difference between CalSim and CalLite is how the model handles demands aggregation and hydrology inputs. The simulation time steps for both the CalSim II and CalLite models are monthly. Since most temperature and fishery models have shorter time steps (either daily or hourly), this monthly time step often causes problems when one attempts to integrate or link the different categories.

2) Delta Hydrodynamics Modeling.

The objectives of Delta modeling are to evaluate the interaction of hydrodynamic of flow, velocity, and salinity within the Delta and how these factors impact the aquatic species and habitats that reside in the Sacramento-San Joaquin River Delta estuary.

Current Available Tool – *DSM2*

The Department of Water Resources (DWR) DSM2 model poses the capability to simulate the flow, velocity and particle movement in the Delta. DSM2 models all of the major rivers and waterways in the Sacramento-San Joaquin and Delta. It contains three, one-dimensional modules that simulate the dynamic tidal hydraulics, water quality, and particle movement in a network of riverine channels in the Delta. Due to its shorter time steps and data requirement, DSM2 use some pre-processed monthly flows and operations input from the CalSim model and then disaggregate the data for model simulation. The time step for the DSM2 model is 15 minutes; the model simulation period covers the water year 1976-1991.

3) Water Quality/Temperature Modeling.

Reservoir dynamics affect cold water pool availability over a range of operating and hydrologic conditions. Evaluation of the availability of cold water over a range of hydrologic and seasonal conditions has been identified as an important data gap in the existing monitoring and modeling activities. Actual reservoir temperature profile data is needed to establish reliable starting temperature levels for downstream water temperature modeling. Similarly, field measurements of actual flow and water temperature within the main stem rivers downstream of the reservoirs have been identified as a significant data gap. Water temperature data from reservoirs and their downstream rivers are needed to validate and calibrate the river water temperature model.

Development of the reservoir temperature model would require compilation and analysis of reservoir profile temperature measurements, in addition to calibration of the models with respect to actual hydrologic conditions occurring within the watersheds. The objective of the temperature modeling is to develop a reliable and objective tool for evaluating performance of alternative cold water pool availability based on actual hydrologic conditions and potential constraints under proposed operating conditions.

Current Available Tools – *Sacramento River Water Quality (SRWQM) Temperature Model and San Joaquin Temperature Model*

The water quality simulation model (HEC-5Q) was developed and calibrated to include the upper Sacramento River system, including Trinity River and Dam, Shasta Dam, Clear Creek, and downstream Stony Creek. The model can be used to evaluate alternatives for coordinating reservoir release among projects to examine the effects on the flow and water temperature at specific locations in the system and examine the changes of the water use patterns on temperature. Recently, the SRWQM modeling area was extended from Knights Landing to Freeport.

The HEC-5Q temperature model also has an application in San Joaquin Basin which includes the geographic area of the upper San Joaquin River, mainstem of the San Joaquin River to Mossdale and tributaries such as Stanislaus River, Merced River, and Tuolumne River. In 2009, Reclamation expanded the San Joaquin temperature application to include the salinity (electrical conductivity) modeling capability. The time steps for both the SRWQM and San Joaquin temperature models are six hours, the simulation period covers water year 1922-2003.

4) Fish Population /Riparian Habitat Modeling.

Objectives of fish population modeling are to evaluate habitat enhancement and river management actions to benefit a broad range of aquatic species and habitats. Modeling may include evaluating the potential to re-establish a viable and valuable population of Chinook salmon and/or steelhead within the Sacramento and San Joaquin Basins given available water supplies and competing beneficial uses.

Fishery population/habitat modeling represents an important tool for integrating information on water project operations, hydrologic conditions, and the resulting instream flows and water temperatures occurring within the lower river. Modeling helps to integrate information on water temperature at various seasons and locations with conditions affecting different species and life stages of resident and migratory fish, estimates of habitat availability and quality for different species, and life stages within the various river reaches. Analysis helps to estimate and understand the causes of mortality at various life stages, seasons, and locations which can affect fishery population dynamics and biological performance.

Data requirements for fish population models generally include: 1) physical habitat conditions such as spawning gravel availability, 2) water temperatures within each stream reach as well as temperature requirements for each species and life stage, and 3) flow habitat relationships where water depths and velocities provide suitable habitat conditions for various life stages. Fish population models could be used to assess biological performance of various alternative management actions on various species and life stages of aquatic organisms in the river. Integrating and linking with the reservoir and river temperature and operations models make it possible to evaluate alternative management actions on environmental conditions for multiple species.

Current Available Tools – *Reclamation Salmon Mortality Model, SALMOD, IOS, and inSALMO*

The Reclamation salmon mortality model computes salmon spawning losses in the Trinity, Sacramento, American, and Stanislaus Rivers, based on the Reclamation Temperature Model estimates (2008 BA). The salmon mortality model is a daily time step model, and covers the simulation period of water years 1922-2003.

SALMOD is a computer model that simulates the dynamics of freshwater salmonid populations. The model had been previously used on the Sacramento River from Keswick Dam to Battle Creek. The model can simulate population dynamics for all four runs of Chinook salmon in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam. Model processes includes spawning, incubation losses, growth, mortality due to water temperature and other causes, and movement. The SALMOD model is a weekly time step model, and covers the simulation period of 1922-2003.

Interactive Objective-oriented Salmon Simulation (IOS) Winter-Run Life Cycle Model was used to evaluate the influence of different Central Valley water operations on the life cycle of Sacramento River winter-run Chinook over an 80 year period using simulated flow and water temperature inputs (2008 BA). The IOS model was designed to serve as a quantitative framework for estimating the long-term response of Sacramento River Chinook populations to changing environmental conditions (e.g. river discharge, temperature, habitat quality at a reach scale). The IOS is a daily time step model, and also covers the simulation period of water year 1923-2002.

The inSALMO model was designed to provide an individual-based Chinook salmon population model for freshwater life stages. Version 1.0 of inSALMO simulates population responses to the effects of flow, temperature, and other river management alternatives on freshwater life stages: spawning, redd incubation, and juvenile rearing and outmigration. It was developed by Lang, Railsback and Associates (LRA) and the Pacific Southwest Research Station of the U.S. Forest Service, for Reclamation and FWS. An example application of inSALMO 1.0 was developed for fall run Chinook salmon for two reaches of Clear Creek, each 500m in length, with the purpose of testing and evaluating the model. A new version of InSALMO is currently being developed that will be more fully validated with field data, increase the domain to all of Clear Creek, and add parameters to simulate steelhead populations.

The fishery models mentioned above were either directly funded or developed by Reclamation. Reclamation is aware of other fishery models developed by other agencies such as FWS, DFG, and NMFS; however, a discussion of these models is not included in these comments.

B. Modeling Limitations.

The following are general limitations of individual models. For detail or model specific limitations, see the 2008 BA.

- Model input data: the observed and measured meteorological, water temperature data may comprise some degree of errors. During the process of preparing and compiling the data, it may also encompass some human errors. Other factors that also produce the errors are the disaggregation methods of the data. All the factors mentioned above contribute to input data errors.
- Model representation and simulation period: some of the models mentioned above have long simulation period representing water years 1922-2003. Not many monitoring stations were established and functioning prior to the early 50s. In order to prepare the input data for model simulation, the model developers have to either extend or extrapolate the data. These synthetic data may not truly represent the physical and biological conditions at that time.
- Hydrology update and simulation periods: the model's hydrology is not updated to include current conditions. In order to simulate future levels of project development, some assumptions need to be made to make up the insufficient data gaps.
- The numerical solution to the governing equations included in the models can also introduce error (2008 BA).
- The models used for 2008 BA modeling are designed to compare and contrast the effect of current and assumed future operational conditions. The models are not predictive; they are not intended to forecast the future (2008 BA).

The Board has post-processed existing CALSIM model runs to estimate impacts from its proposed San Joaquin River objective. Existing CALSIM models rely on intricate assumptions and decision making based on many existing agreements and regulations, and are based on monthly time steps. It does not seem plausible that such an approach could be used to estimate how a new objective based on unimpaired flow would affect the Sacramento Basin and the Delta. Reclamation therefore encourages the Board and DWR to work with Reclamation to develop an appropriate and transparent modeling analysis for any proposal to significantly change current operations.

VII. The Board Should Consider and Evaluate The Following Issues As Part Of The Update Of The Bay-Delta Plan.

A. Need to Evaluate Reservoir Management For Drought Protection/Water Supply Reliability and Instream Flow Requirements.

Reclamation supports development of a plan which allows CVP reservoirs to be operated in a sustainable manner over the long-term. Reservoir inflow and storage yield are required for multiple purposes, including prior water rights holders, CVP contractors, fish flows, salinity control, temperature control, dissolved oxygen requirements, flood control, power, and recreation purposes. Given the competing needs for CVP water releases, Reclamation operators can find it difficult to sustain usable CVP storage yield in drought conditions.

Indexing flow objectives to water year type does not necessarily result in prudent reservoir operations. A wetter year following consecutive dry years may be the best year to conserve for future demands. Yet, a regulatory regime indexed only to water year type would generally require higher flows in such a year. Reclamation recommends that the Board model and evaluate reservoir impacts to drought planning in its alternative flow objective and program of implementation analysis, as they pertain to all project purposes, including fish and wildlife and water supply.

Allocating storage yield of a multi-purpose reservoir is not the same thing as allocating annual natural or unimpaired flow of a stream. Allocating storage yield necessarily includes multi-year drought protection, carryover storage and refill potential as critical factors in developing a sustainable plan of operation. In short, Reclamation recommends that the Board recognize the reasons for which the reservoirs were built, and evaluate the benefits and potential trade-offs to those purposes. Finally, the Board should consider the potential trade-off between establishing spring flow objectives and sufficient storage to meet fall temperature objectives and carryover for other project purposes.

B. The Board Should Evaluate Potential Impacts Caused By Higher Flow Objectives.

1) Suisun Marsh: Increased flow and increased river stage in Suisun Marsh could create challenges for on-going operation and maintenance procedures, including possible levee stability issues. Additionally, increased flow in the Marsh should be evaluated to determine potential effects on terrestrial special status species.

2) Flood control and levee maintenance: Increased river stages over longer duration could cause levee stability issues should be evaluated to determine the potential effects due to (1) the increased length of time that the levees are inundated and (2) the chance that a storm of significant magnitude would increase an already high river stage over stages typically considered protective by the Corps of Engineers.

3) Ability of the current conveyance and channel capacity of the Sacramento and San Joaquin Rivers to handle new flow requirements: Over time, channel capacity has diminished due to sedimentation of rivers and subsidence of levees. As such, channel capacity should be evaluated by the Board to ensure that if storms of significant magnitude occur during higher river stages (for higher outflow), that channel capacity can accommodate the increase and that FEMA certification is unchanged.

4) A higher flow objective may result in less water available for consumptive beneficial uses: Aside from the potential impacts to the water user community, this reduction should be evaluated to determine potential effects on the following:

- Groundwater in the Central Valley, as reduced availability of surface water supplies may cause water users to shift to groundwater to make up shortfalls, thus adding to the unavoidable impacts from the implementation of the 1995 Bay-Delta Plan;

- Supplies to wildlife refuges – Refuges are dependent upon purchases of water to meet part of their needs. A reduction in water available for consumptive use may reduce water available for sale to the refuges, if users retain this water to meet their own needs.

5) Impacts to Hydropower Generation: The Board has prepared a draft report titled "Hydropower And Electric Grid Analysis Of Lower San Joaquin River Flow Alternatives" as part of its effort to develop new objectives for the San Joaquin River. It is anticipated that a similar report (or analysis) will be prepared as part of its update to the Sacramento River/ Bay Delta plan. Any such report should take into account the greater amount of hydropower capacity in the Sacramento River Basin, the loss of generation caused by increased flow objectives, and the impacts caused by the loss of this capacity at "peak" times - thus increasing the demand for power generated from sources that generate more air pollutants and greenhouse gases.

VIII. Development And Implementation Of New Objectives Must Be Evaluated and Coordinated With The Bay Delta Conservation Plan (BDCP).

The BDCP is an ESA Section 10 Habitat Conservation Plan and Natural Communities Conservation Plan that is being developed by a group of local water agencies, environmental and conservation organizations, state and federal agencies, and other interest groups. Interior supports BDCP as the long term solution for the Delta. The BDCP planning process has gathered and analyzed existing information and studies, as well as developing new information to allow the parties to consider the BDCP plan. Interior believes this collection of information will be helpful to the Board's process. Through BDCP, years of intensive negotiation and technical work have been completed, and this work should be considered as part of the Board's consideration of objectives for the Delta.

FISHERY NEEDS

We believe it is important that the Board model and evaluate Delta flow standards that it may incorporate into the WQCP that serve broader conservation goals and objectives. The Board should analyze and consider flow approaches that facilitate and promote conservation and recovery of native aquatic species (including ESA- and CESA-listed species), ecosystem services, and ecosystems. In addition, it is also important that during this comprehensive review and update, the Board identify biological objectives for species of concern that are dependent on the Delta, and consider the best available scientific information regarding additional Delta flow objectives that could be incorporated in the WQCP that will lead to protecting and restoring a healthy Sacramento-San Joaquin Delta ecosystem on a sustainable basis.

At the end of this comprehensive review for the update and implementation of the WQCP we encourage the Board to consider incorporating Delta flow objectives that work in coordination with other objectives in the WQCP. These objectives should include three primary products: defined ecosystem goals (using specific biological/ physical indicators to track progress), Delta flow objectives that are developed to meet the defined ecosystem goals, and a process to adaptively manage flow objectives to meet the ecosystem goals. The Delta flow objectives that the Board adopts should be viewed as a starting point that will be monitored, evaluated and adaptively managed to meet the ecosystem goals. We stand ready to work with Department of Fish and Game and NMFS to assist the Board in developing Delta flow objectives and quantifiable biological objectives for aquatic and terrestrial species of concern dependent on the Delta.

Background
As the Board is aware, the challenges in restoring the Delta are contentious and complicated. Data from the Delta ecosystem suggests that current practices and flow objectives may not be adequate and/or appropriate to protect and restore the Delta on a sustainable basis. Changes in Delta flows have caused changes in the physical habitat components of the system, which has contributed to the decline of the Delta ecosystem. Fish populations dependent on the Delta have declined across the board, with some species on the brink of extinction. Food web dynamics have undergone significant changes in both abundance and composition.

Salmon populations in the Central Valley are in serious decline. Adult escapement of Chinook salmon has shown some improvement in the last two years (2010-2011); however, adult escapement for the Central Valley in 2010 was only estimated to be approximately 29% of the escapement in 2003 (CDFG GrandTab, 2012). Of the four races of Chinook salmon, two are listed under the Endangered Species Act (ESA) (winter run and spring run) and fall run Chinook salmon are at historic lows. Central Valley steelhead (threatened) are also in serious decline.

In addition, the large-scale Pelagic Organism Decline (POD) that struck the Sacramento-San Joaquin Delta has not abated, and, despite good recruitment of delta smelt and other species in 2011, abundances of pelagic fishes remain perilously low.

Flow in the Delta is one of the most important components of ecosystem function. Timing, magnitude and variability of flow are the primary drivers of physical habitat conditions, including but not limited to, turbidity, temperature, residence time, nutrient loading. These physical habitat conditions created by flow are part of what drives ecosystem function and define the key attributes comprising ultimate habitat utility and quality for resident and migratory fish species. It is technically very difficult to define the optimal timing, magnitude, and volume of flows required to provide sufficient habitat quantity and quality to protect our trust aquatic species. The further flow conditions are from what naturally occurs, the less adequate habitat conditions and behavioral triggers are for our native species. Figure 1 presents a basic conceptual model linking the various drivers of fish populations in the estuary.

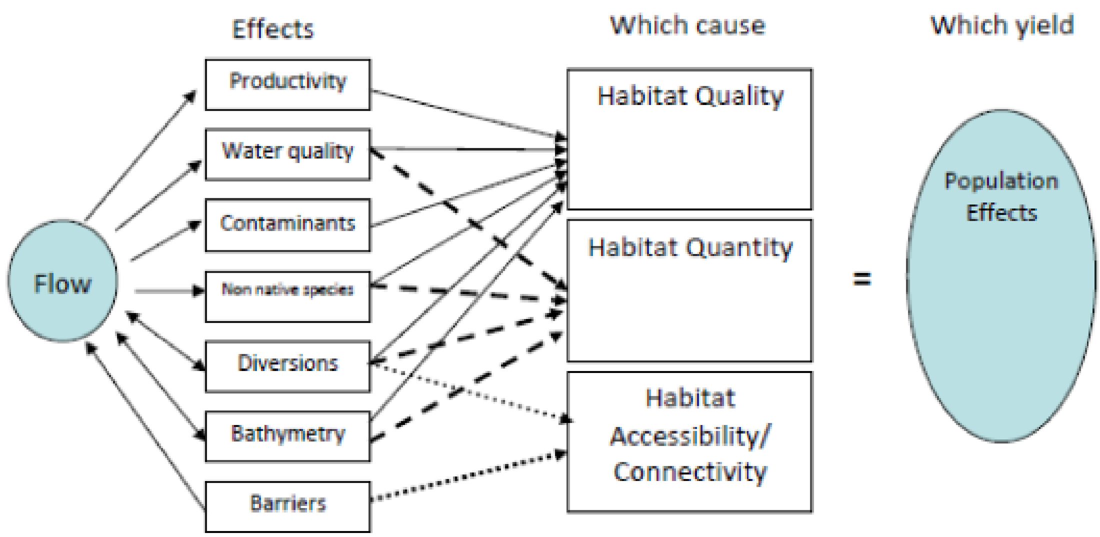


Figure 1. Conceptual model linking flow to various drivers of fish populations in the estuary.

The Board's comprehensive review for the update and implementation of the WQCP proceeding is an opportunity to review where we are, and chart a new course to achieve a healthy Delta ecosystem to protect aquatic species. These flow objectives will also contribute towards other goals that the Board and resource agencies have including: the anadromous fish doubling goals, recovery of threatened and endangered species, reducing and/or eliminating non-native species, and contributing to a healthy commercial fishery.

Clearly articulating the goals of protecting and restoring the Delta ecosystem should be the starting point in the Board's process of developing Delta flow objectives. The goals of the 1996 U.S. Fish and Wildlife Service Delta Native Fish Recovery Plan include: "to establish self-sustaining populations of the species of concern that will persist indefinitely. For Chinook salmon, green sturgeon, and splittail, the goals include having large enough populations so that a limited harvest can once again be sustained. The basic strategy for recovery is to manage the estuary in such a way that it is better habitat for aquatic life in general and for the fish species of concern in particular."

This comprehensive review should also give consideration to not only the source of the flows, but the balancing of flow needs for aquatic resources in the Delta and flow needs upstream in the rivers. When considering the needs of anadromous fish, for example, the conditions in the Delta and the conditions upstream (such as temperature objectives) are important and both affect fish populations at different life stages.

The approach taken in this comprehensive review for the update and implementation of the WQCP is focused on Delta flow objectives. It's important that this comprehensive review include ecosystem goals and specific biological and physical process objectives to model and evaluate what flows are necessary to meet those objectives. Once ecosystem goals are defined, the Board should consider broadening the scope to address all components that affect the stated goals. Management actions should be identified that are likely to attain the stated ecosystem goals that include, but are not limited to, Delta flow objectives, thus acknowledging that there are other stressors that affect the Delta ecosystem. Some of these other stressors are also under the purview of the Board's regulatory domain, which is critical to successfully integrating and adaptively managing the estuary to maintain habitat conditions required for native fish recovery. An adaptive management process and appropriate monitoring program should be created to provide the framework for meeting the ecosystem goals. We are encouraged by the Board's comprehensive review for the update and implementation of the WQCP and will work with the Board in this process of developing Delta flow objectives to achieve that end.

FWS is interested in working with the Board to approach this comprehensive review as an ecosystem recovery plan for the Delta ecosystem. It should be a carefully planned process that addresses all stressors to meet the defined ecosystem goals. The Delta recovery planning process must include the watersheds upstream to create an integrated management plan for the entire San Joaquin/Sacramento basin. Goals of the basin need to be stated upfront and a process, working with stakeholders, to achieve those goals should be developed. Goals developed in other processes (e.g. CalFed Ecosystem Restoration Program) to address Delta ecosystem needs may help guide this process.

Some key concepts the Board should consider:

- Define ecosystem goals
- Use biological and physical indicators to track progress towards ecosystem goals
- Consider all stressors
- Approach as a basin plan that includes upstream watersheds
- Design monitoring programs to inform decision making using an adaptive management approach
- Consider the Delta flow criteria as a starting point that will be adapted to meet ecosystem goals

Key Points

<u>Hydrology and hydrodynamics</u>

- Annual Delta inflow has been reduced by 22% from historic unimpaired conditions (1956-2003) with a shift of a portion of winter/ early spring inflows to summer / early fall.
- Annual Delta outflow has been reduced by 34% from historic unimpaired conditions (1956-2003) with a shift of a portion of winter/ early spring outflows to summer / early fall.
- Flow characteristics in Old and Middle Rivers have been altered from unimpaired conditions. Flows have shifted in a more upstream direction (increased magnitude and duration of negative flows) under the regulated hydrologic regime compared to unimpaired estimates that indicate positive (downstream) flows approximately 85% of the time.
- The historical position of the X2 salinity metric is highly correlated with historical Delta outflow. Under the regulated flow regime, X2 has shifted upstream in conjunction with reduced Delta outflows, and the upstream shift has increased over time. Historically, X2 exhibited a wide seasonal range tracking unimpaired inflows. Compared to pre-dam conditions, however, seasonal variation in X2 range has been reduced by nearly 40%.

<u>Delta outflow objectives</u>

- Fish populations may not be viable if inflow to the Delta and outflow to the Bay are not sufficient to support successful spawning, larval and juvenile transport, rearing, and adult migration. For this reason, FWS suggests the Board model and evaluate impacts of possible flow objectives on all these biological mechanisms.
- Delta smelt critical habitat consists of four primary constituent elements: physical habitat, water, river flow, and salinity. Delta outflow plays a role in each of these.

- Placing X2 in the relatively shallow waters of Suisun Bay during spring months greatly increases the amount of ecologically productive, higher quality habitat that is available for longfin smelt, and significantly reduces vulnerability of entrainment into the State and Federal export facilities. For this reason, FWS suggests the Board model and evaluate a range of X2 flow objectives for the January to June period. In doing so, FWS suggests a particularly thorough evaluation of a range of flows from the March to May period.
- FWS also suggests the Board model and evaluate fall X2 flow objectives for September through November of wet and above normal years to provide delta smelt with access to expanded ecologically productive habitat.

<u>Export/inflow objectives</u>

- E/I objectives contribute to fishery management objectives by allowing a certain percentage of delta inflows to contribute to outflow, which helps to create suitable hydrodynamic conditions for the transport of fish to the western Delta.
- We suggest the Board model and evaluate a range of Export/Inflow objectives to ensure that the objectives are sufficiently protective.

<u>Delta Cross Channel Gate closure objectives</u>

- FWS suggests the Board model and evaluate the WQCP's current Delta Cross Channel gate closure objectives.
- In addition to evaluating the Delta Cross Channel gates closed per the NMFS 2009 Bi Op, we suggest the Board model and evaluate providing conditions for juvenile salmon migrating from the Sacramento basin that achieve no bidirectional flow in the mainstem Sacramento River downstream of Georgiana Slough, in order to minimize the proportion of salmonids that enter the interior Delta.
- FWS also suggests the Board consider the preliminary results of the experimental DCC closures during October 2010 and October 2011 that were coordinated with Mokelumne River pulse flows. The results of these studies have shown the potential to reduce straying of Mokelumne River origin adult fall-run Chinook salmon.

<u>Suisun Marsh objectives</u>

- FWS suggests the Board model and evaluate the WQCP's current water quality standards for chlorides/EC in Suisun Bay and Suisun Marsh, in conformity with the soon-to-be final interagency Suisun Marsh Habitat Management, Preservation, and Restoration Plan and the Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California.

- It is important that the Board consider the increasingly marine nature of Suisun Marsh related to sea level rise and climate change. There is a geomorphological context within which any flow must be considered. Restoration of historical flow patterns will not produce increasing aquatic species populations unless the appropriate changes to Delta geomorphology are also concurrently made. Even returning some historical function to the Delta may require substantial return of geomorphological integrity and complexity to the Estuary.
- Looking at pre-management (historical) hydrologic dynamics in controlling ecological processes, species adaptation, and ecosystem function in streams and rivers is useful in guiding current flow criteria.
- Flow can be used as a management tool in reversing the spread of nuisance submerged aquatic vegetation, reducing populations of non-native species and managing water quality parameters (e.g., dissolved oxygen, temperature, particle residence time, etc.)
- Changes to tidal and residual flow patterns in the Delta have reduced habitat variability thought to be important to resident native species

<u>Potential new reverse flow objectives for Old and Middle Rivers</u>

- Old and Middle river (OMR) flow is a hydrodynamic metric that characterizes the effects of SWP and CVP exports on entrainment of salmonids, delta smelt and other pelagic fishes in the estuary.
- Entrainment and estimated population losses of delta smelt increase as net OMR flows become more negative (i.e., as reverse flow intensifies).
- Entrainment of delta smelt and other pelagic fishes can be minimized if OMR flows are managed to less negative levels during critical migration and rearing periods.
- FWS suggests the Board model and evaluate a range of OMR flow objectives, including objectives that would minimize entrainment of delta smelt and longfin smelt and improve habitat conditions in the context of protecting and restoring a healthy Delta ecosystem on a sustainable basis (i.e. path toward recovery)..

<u>Potential new floodplain habitat flow objectives</u>

- Seasonal floodplain inundation has a positive effect on growth rates and on the apparent survival of juvenile Chinook salmon in the Central Valley.
- Restoration of floodplains and other off channel habitat is potentially important for increasing production of juvenile salmonids in California’s Central Valley.
- The biological objectives of seasonal floodplain inundation would be to provide off channel areas conducive to juvenile salmonid rearing and growth, which should improve survival through the Delta and to the ocean.

- FWS suggests the Board model and evaluate the potential of more frequent floodplain inundation (especially Yolo Bypass flows) when determining the Delta outflows needed to restore the Delta ecosystem pursuant to the Board's public trust responsibilities.

Delta inflow objectives

- We suggest the Board model and evaluate a range of Delta inflow objectives to ensure that the objectives are sufficiently protective.
- The timing and magnitude of flow is important to the survival of juvenile salmonids. The survival of Chinook salmon smolts increases as the Sacramento River flows at Rio Vista increase.
- Flow reduces predation on juvenile salmonids via several mechanisms, such as increasing turbidity, thus reducing a predator's ability to visually locate prey.

Potential changes to the monitoring and special studies program

- Changes to the monitoring and special studies program are warranted, given changes in monitoring activities in the Delta.

- Evaluate and analyze correlations between flow, water temperatures, and other environmental covariates with observed juvenile Chinook salmon survival from the tributaries, through the Delta, and to the ocean.

- Changes to the monitoring and special studies program should be designed to inform decision making. We feel this is best achieved by using a process such as Structured Decision Making (SDM) to develop a decision support model that evaluates trade-offs and consequences among alternative management actions.
- A decision-support model developed through SDM allows for efficient and strategic monitoring by assessing where reducing uncertainty (though monitoring data) could influence management decisions.
- The SDM process provides a framework for explicitly incorporating additional information (e.g., monitoring data) into the decision-making process to effectively achieve adaptive management.

I. HYDROLOGY AND HYDRODYNAMICS

The hydrologic regime of the Delta has been altered by large scale human impacts including water impoundment behind both minor and major dams and associated water diversions out of the Delta (Kimmerer, 2002; Knowles, 2002; Kimmerer, 2004; Moyle & Bennett, 2008; Fleenor, et al., 2010). These impacts have, in turn, greatly affected the environmental conditions that native fish populations depend on. In order to better integrate the complex linkages between overall condition of Delta fish populations, specific life history strategies, and the physical environments that Delta fishes inhabit, it is necessary to first understand the underlying hydrologic and fluvial processes that govern riverine and estuarine morphology in the Delta and provide essential habitat for key aquatic species.

A. Long-term flow records and unimpaired flow estimates in the Delta have been analyzed and described in multiple reports and manuscripts, including CDWR (1999), Kimmerer (2002), CDWR (2007), Enright and Culbertson (2009), and Fleenor et al. (2010). We have utilized components of these reports and additional data analyses to provide a basic overview of the fundamental components of the natural and regulated flow regimes in the Delta. It is important to note that there is significant uncertainty associated with scientific knowledge related to the hydrology and hydrodynamics of the Delta ecosystem, and that this overview merely strives to summarize the current scientific understanding of flow related phenomena. We discuss four major flow components: Delta inflow and outflow are considered as gross hydrological components and refer to the volume and timing of freshwater flows; reverse flows and X2 position are considered as hydrodynamic components and refer to negative or upstream flows in Old and Middle Rivers and the geographical position of the commonly utilized in-Delta salinity standard, respectively. Within each component, summaries are provided that describe the alteration of flow conditions over time by comparing unimpaired and regulated flows, where appropriate. Additional sections later in this document discuss links between hydrologic and hydrodynamic changes and overall fisheries health and abundance in the Delta ecosystem.

A. Unimpaired Flow

The natural, or unimpaired, flow represents approximated inflows and outflows that would occur in the absence of storage facilities and diversions both upstream of the Delta and within the Delta. Unimpaired flows for the major Delta tributaries and Delta outflows have been estimated for the 1921 – 2003 period by the California Department of Water Resources (2007). These flow estimates are unlikely to capture the effects of longer attenuation of spring flows by upstream marshlands and floodplains or evapotranspiration and stream – aquifer interactions which were prominent features of the pre-development hydrology (Fleenor, et al., 2010). However, the estimates do provide a reasonable approximation of pre-development conditions and can serve as a valuable baseline for temporal comparisons.

B. Delta Inflow

Unimpaired Delta inflow records indicate considerable seasonal and inter-annual variability both in timing and magnitude (Knowles, 2002). Both the Sacramento and San Joaquin Rivers were characterized by high winter flows, spring snowmelt floods, and relatively low summer flows. The lesser Delta tributaries, also referred to as the Eastside streams, provided substantially less inflow to the Delta and were influenced more by winter rainfall events due to their lower elevation catchments and, often times going extremely low in the summer months. Upstream diversions and storage facilities have greatly altered the seasonal inflow patterns in the Delta (Kimmerer, 2004).

Moyle and Bennett (2008) and Fleenor et al. (2010) divide the 1949 – 2005 time period into three discrete categories reflecting the relative health and abundance of native Delta fish populations: 1949 – 1968, 1969 – 1985 and 1986 – 2005. The early 20-year period represents a time when fish were known to be doing better, and the last 20-year time frame when fish were doing worse. The middle 17 years represents a transitional water export period and contains extreme wet and dry periods. Contrasting Delta inflows from these three periods with unimpaired flows shows substantial changes in the volume and timing of freshwater inflows into the Delta from the Sacramento and San Joaquin basins (Figure 2 and Figure 3). Upstream storage and diversions in both basins have shifted a portion of peak winter/spring inflows to enhanced summer and early fall inflows. Sacramento River annual inflows into the Delta from 1949 – 1968 were reduced by 23% from unimpaired conditions, while 1986 – 2005 flows were reduced by 26% annually and by 30% and 39%, respectively, during early winter and spring flow periods. San Joaquin River annual flows into the Delta were reduced from unimpaired conditions by 57% for 1949-1968 and 55% for 1986 – 2005, with 68% and 67% reductions, respectively, during early winter and spring flow periods.

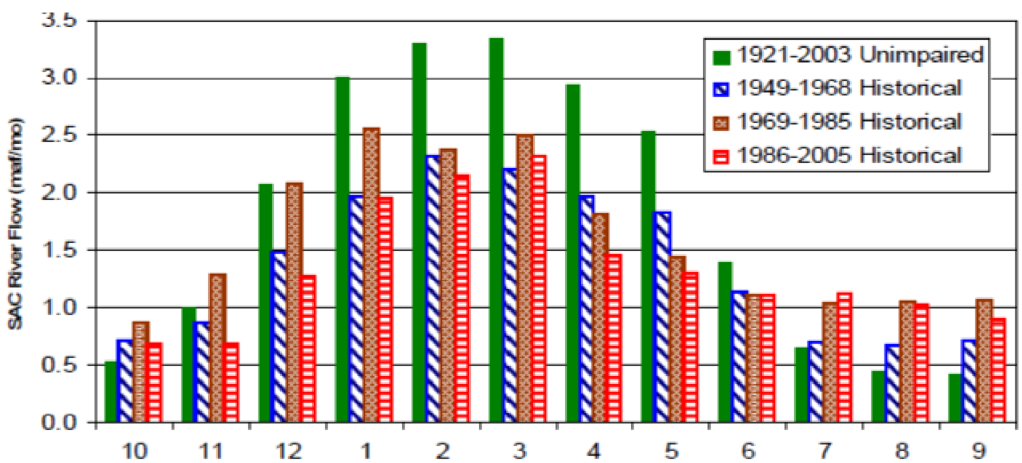


Figure 2. Changes over time to monthly average Sacramento Valley outflows (maf/mo) compared to the unimpaired record (Fleenor et al., 2010).

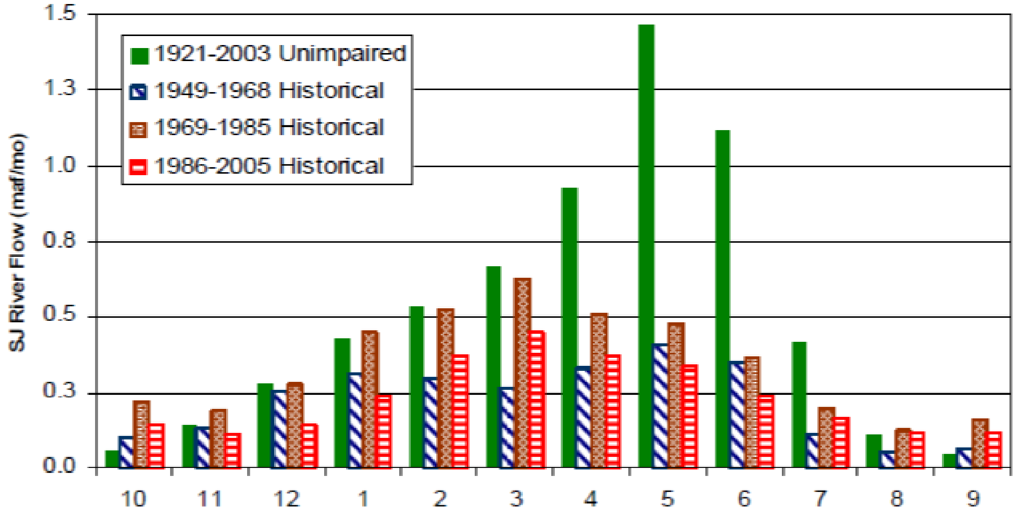


Figure 3. Changes over time to monthly average San Joaquin Valley outflows (maf/mo) compared to the unimpaired record (Fleenor et al., 2010).

C. Delta Outflow

Net Delta outflow is influenced by a variety of factors including Delta inflow, upstream storage and diversions, Delta consumptive use, and in-Delta diversions and exports (CDWR, 1999; Knowles, 2002; Kimmerer, 2004; Fleenor, et al., 2010; Moyle, et al., 2010). Figure 4 shows the long-term reduction in annual Delta outflow as a percentage of unimpaired outflow.

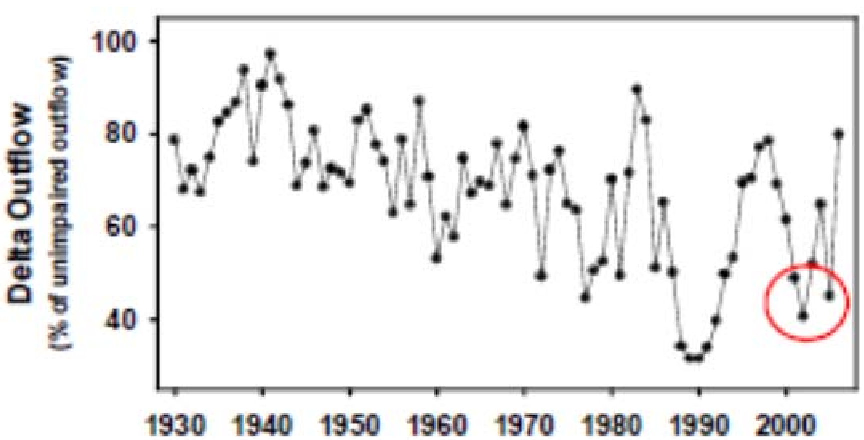


Figure 4. Delta outflow as a percentage of unimpaired outflow (1930-2005). Annual outflow reduced by more than 50% in 2001, 2002, and 2005 (Bay Institute, 2007).

The relative contributions to the reduction in Delta outflow are shown in Figure 5, comparing unimpaired outflows to the three time periods from Moyle and Bennett (2008) and Fleenor et al. (2010). It is important to note that the total volume of water potentially available as Delta inflow did not vary substantially between the three periods or the longer unimpaired period and was actually greatest during the wetter 1969-1985 period. The largest change from the 1949-1968 historical period and the 1986-2005 historical period is the increase in exports that reduce net Delta outflow. Exports increased from 0.9 maf during the earlier period (1.4 maf annual average over the 13 years of actual export) to 5.1 maf over the 1986-2005 period.

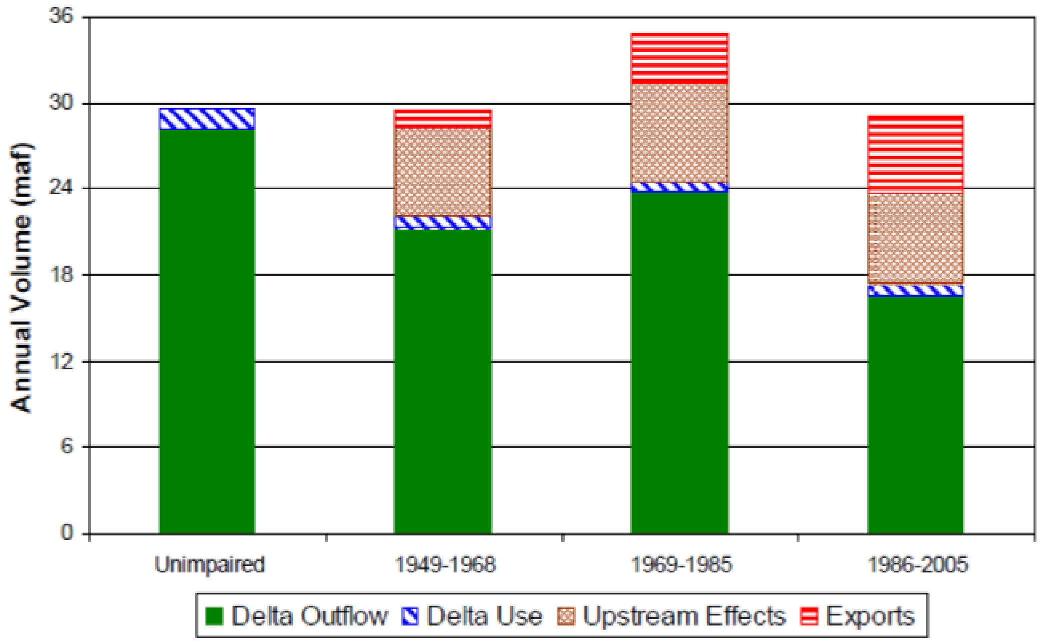


Figure 5. Comparison of annual water use during the three study periods (maf/year) compared to the Unimpaired flows from 1921-2003. Unimpaired data from DWR (2007) and other from Dayflow web site (Neglects upstream groundwater withdrawals). Fleenor et al., 2010.

D. Reverse Flows

Numerous studies have developed statistical relationships between Old and Middle River (OMR) flows and various biological parameters (e.g., Kimmerer, 2008; Grimaldo, et al., 2009).

Similarly, numerous hydrodynamic models have been utilized to simulate OMR flows and related fish entrainment indices (DRMS, 2007; Fleenor, et al., 2008; CDWR, 2009). Unimpaired OMR flow records, however, are not readily available. For the purposes of comparing unimpaired OMR flow estimates to regulated OMR flows, we rely on the simulation results developed by DRMS (2007) and Fleenor (2008) as reported in Fleenor et al. (2010). As with any model, broad assumptions and generalizations are implemented, and there is uncertainty associated with the modeling results.

Hydrodynamic simulations were made for the Delta using the RMA tidally averaged model for unimpaired, 1949-1968, 1969-1985, and 1986-2005 boundary conditions. The unimpaired flow simulations omit all gates and barrier controls while the historical data included all gates and barriers as operated. Model results indicated that continuing exports through the Delta results in reverse OMR flow conditions more than 91% of the time for the 1986 – 2005 period (Figure 6, Point B). With the deeper, wider channels of post-development, and with unimpaired conditions and no through-Delta pumping, there was a net outflow in Old and Middle rivers at least 85% of the time (Figure 6, Point A). For unimpaired flows without the increased conveyance of additional channels, and particularly the dredged Stockton Deep Water Ship Channel, more frequent positive flows would likely have occurred, although tidal energy into these channels would increase. The increased conveyance of the Stockton Deep Water Ship Channel would encourage San Joaquin River flows to take the easier path. The historical periods represent gradually increasing levels of through-Delta pumping. Early in water development, 1969 – 1985, positive outflows were reduced to 50% (Figure 6, Point C) of the time, and in recent years, 1986 – 2005 (pre-Wanger decision), positive flows occur less than 10% of the time. The model also estimates that during the intermediate period, 1969 – 1985, negative flows in Old and Middle rivers did not exceed -2,000 and -4,000 cfs for 81% and 92% of the time, respectively.

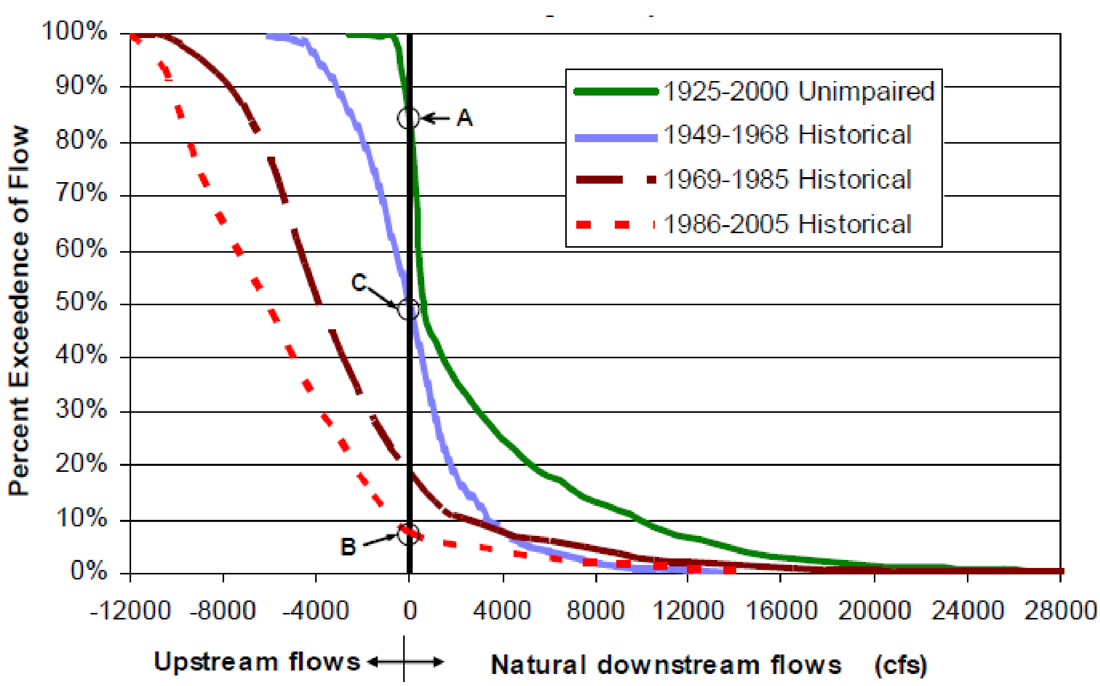


Figure 6. Cumulative probability distribution of sum of flows (cfs) in Old and Middle River resulting from pumping through the Delta showing unimpaired flows and three historical periods, 1949-1968, 1969-1985, and 1986-2005 (Fleenor et al. 2010).

E. X2 Position

X2 is defined as the distance from the mouth at the Golden Gate up the axis of the estuary to where tidally-averaged bottom salinity is 2 practical salinity units (Jassby, et al., 1995) and is included as a set of salinity requirements in the WQCP for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB, 1999; SWRCB, 2000; SWRCB, 2006). The X2 objectives are designed to restore a more natural hydrograph and salinity pattern by requiring maintenance of the low salinity zone at a specified point and duration based on unimpaired flow conditions (SWRCB, 2009).

The relationships between Delta outflow and several measures of the health of Bay-Delta estuary have been known for some time (Jassby, et al., 1995). Kimmerer et al. (2009) determined that updated abundance-X2 relationships were similar to those previously reported and are seen in a wide variety of estuarine fish species. Additionally, Moyle et al. (2010) hypothesize that a Delta with greater habitat variability, variability in tidal and riverine flows, variability in water chemistry (especially salinity), over multiple scales of time and space, would likely support greater populations of desirable fish species (SWRCB, 2009).

Delta outflows, and therefore Bay inflows, and X2 position are highly correlated (Jassby, et al., 1995; Kimmerer, 2002) (Figure 7). Since the construction and operation of major Central Valley impoundment and diversion structures and rapid population growth and land use changes in California, both Delta outflows and the X2 position have been altered (Kimmerer, 2002; Kimmerer, et al., 2009; Fleenor, et al., 2010; Moyle, et al., 2010). The Bay Institute (2003) developed the San Francisco Bay Freshwater Inflow Index which consists of six indicators to measure the amounts and degree of alteration of freshwater inflows into San Francisco Bay using unimpaired and pre-dam estimates as baselines for comparison. Three of these indicators utilize X2 position to characterize these changes over time.

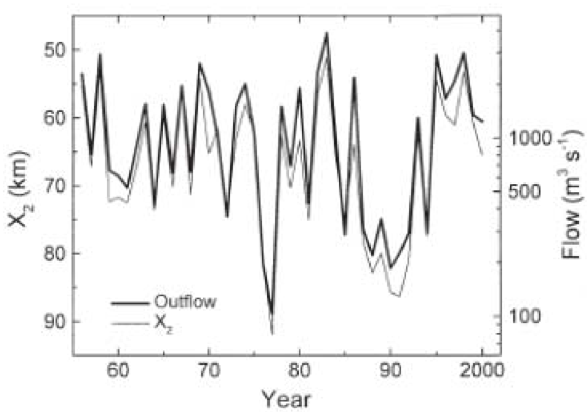


Figure 7. Time series of X2 (distance up the axis of the estuary to the 2 psu isohaline, thin line, left axis, scale reversed) and flow (heavy line, right axis, log scale), annual averages for January to June. Flow data from the California Department of Water Resources; X2 calculated as in Jassby et al., 1995. From Kimmerer (2002a).

The first indicator is the spring X2 position as a function of Delta inflows. Spring inflows have historically been highly variable as a result of the natural hydrologic regime and management operations that store and divert water upstream of the Delta. Prior to the 1970s, spring X2 values rarely exceeded 75 km from the Golden Gate (Figure 8). Since the 1970s, spring X2 has been shifted upstream as far as 90 km.

The second indicator, Change in spring inflows, compares the actual amount of Delta outflow (February 1 – June 30) to the amount that would have flowed into the Bay under unimpaired conditions. Delta outflow is characterized by X2 and the change was expressed as the movement of the X2 position upstream. The results indicate that reductions in spring flows have shifted X2 upstream, and upstream movement has increased over time (Figure 9). Between 1940 and 1989, spring X2 significantly increased, shifting as much as 20 km upstream of its predicted (from pre-dam) position. Overall, the greatest shifts have occurred in critically dry water years, but substantial upstream movement occurs in all year types. Similar results have been found through modeling studies conducted by the USFWS (2008) and Fleenor et al. (2010) (Figure 10).

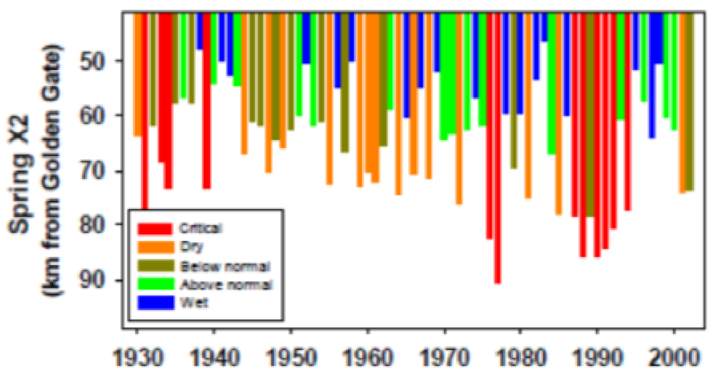


Figure 8. Spring X2 (km from Golden Gate), 1930-2002. Each bar is a single year and, for the year, unimpaired water year type is represented with the different colors. From Bay Institute (2003).

The third indicator, seasonal variation, characterizes the maximum within-year variation of freshwater inflow to the Bay and was calculated as the difference between maximum and minimum X2 location. Compared to pre-dam conditions, seasonal variation in inflows have been reduced by nearly 40%, to an average of 33 km. Reductions in seasonal flow variations resulted from increases in late summer and fall inflows to the Bay (Figure 11).

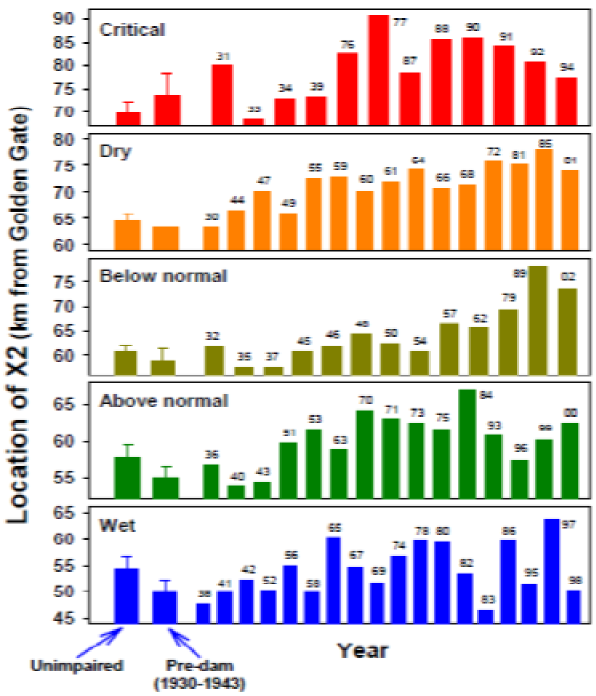


Figure 9. Location of spring X2 (km from Golden Gate) in each water year type, 1930-2002. Mean (+1SD) unimpaired X2 and mean pre-dam X2 (mean+1SD) are also shown for each year type. The number above each bar is the year (shown as last two digits). From Bay Institute (2003).

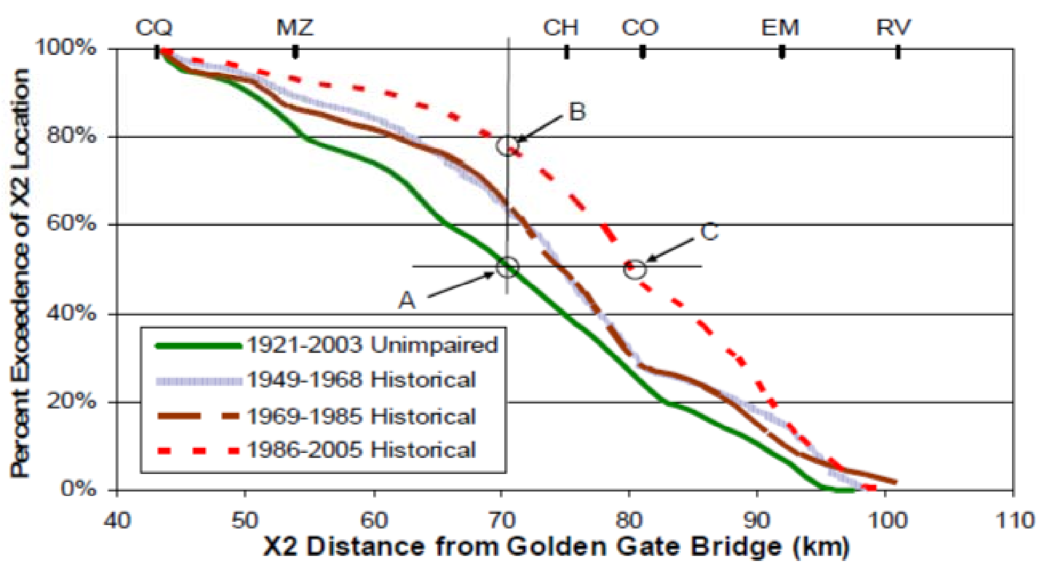


Figure 10. Cumulative probability distributions of daily X2 locations showing unimpaired flows (green solid line) and three historical periods, 1949-1968 (light solid blue line), 1969-1985 (long-dashed brown line) and 1986-2005 (short-dashed red line), illustrating progressive reduction in salinity variability from unimpaired conditions. X2 is the location of the 2 ppt salinity region of the estuary in kilometers from the Golden Gate Bridge. Paired letters indicate geographical landmarks. CQ, Carquinez Bridge; MZ, Martinez

Bridge; CH, Chipps Island; CO, Collinsville; EM, Emmaton; and RV, Rio Vista. From Fleenor et al. (2010).

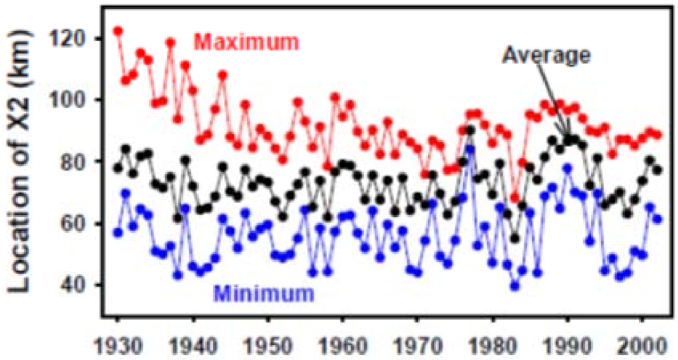


Figure 11. Maximum, minimum daily X2 locations and average annual X2 location, 1930-2002. From Bay Institute (2003).

I. DELTA OUTFLOW OBJECTIVES

A. Delta outflow and X2

Fish populations will not be viable if inflow to the Delta and outflow to the Bay are not sufficient to support successful spawning, larval and juvenile transport, rearing, and adult migration. For example, delta smelt are endemic to the Bay-Delta and the vast majority only live one year. Thus, regardless of annual hydrology, the Delta must provide suitable habitat for each life stage in every year. Different regions of the Delta provide different habitat conditions for different life stages, but those habitat conditions must be present when needed, and have sufficient connectivity to provide migratory pathways and the flow of energy, materials and organisms among the habitat components (U.S. Fish and Wildlife Service, 2008). The Service designated critical habitat for delta smelt on December 19, 1994 (59 FR 65256). The geographic area encompassed by this designation includes all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the legal Delta (as defined in section 12220 of the California Water Code) (U.S. Fish and Wildlife Service, 1994). Delta smelt critical habitat consists of four primary constituent elements (PCEs): physical habitat, water, river flow and salinity. Flow is in turn a constituent of each of these, as it may influence the distribution and quality of spawning substrate, water quality aspects of delta smelt habitat (including access to turbidity and sufficient prey density), entrainment risk, and the location, extent, and suitability of the low-salinity zone (LSZ), indexed by the two-parts-per-thousand salinity isohaline, or “X2.”

1) Location of X2 and its effects on longfin smelt

Similarly, freshwater outflow and the position of X2 in the Bay-Delta are important to longfin smelt. Freshwater flow is strongly related to the natural hydrologic cycles of drought and flood. In the Bay-Delta estuary, increased Delta outflow during the winter and spring is the largest factor positively affecting longfin smelt abundance (Stevens and Miller 1983, pp. 431–432; Jassby *et al*. 1995; Sommer *et al*. 2007, p. 274; Thomson *et al*. 2010, pp. 1439–1440). Despite numerous studies of longfin smelt abundance and flow in the Bay-Delta, the underlying causal mechanisms are still not fully understood (Baxter *et al*. 2010, p. 69; Rosenfield 2010, p. 9). Studies have shown that

Longfin smelt congregate in deep waters in the vicinity of the low salinity zone (LSZ) near X2 during the spawning period, and it is thought that they make short runs upstream, possibly at night, to spawn from these locations (CDFG 2009, p. 12; Rosenfield 2010, p. 8). Because longfin smelt spawn in freshwater, they must migrate farther upstream to spawn as flow reductions alter the position of X2 and the low-salinity zone moves upstream (CDFG 2009, p. 17). Longer migration distances into the Bay-Delta make longfin smelt more susceptible to entrainment in the State and Federal water pumps. Not only is longfin smelt abundance in the Bay-Delta strongly correlated with Delta inflow and X2, but the spatial distribution of longfin smelt larvae is also strongly associated with X2 (Dege and Brown 2004, pp. 58–60; Baxter *et al*. 2010, p. 61). As longfin hatch into larvae, they move from the areas where they are spawned and orient themselves just downstream of X2 (Dege and Brown 2004, pp. 58-60). Larval (winter-spring) habitat varies with outflow and with the location of X2 (CDFG 2009, p. 12), and has been reduced since the 1990s due to a general upstream shift in the location of X2 (Hilts 2012, unpublished data). The amount of rearing habitat (salinity between 0.1 and 18 ppt) is also presumed to vary with the location of X2 (Baxter *et al.* 2010, p. 64). However, as previously stated, the location of X2 is of particular importance to the distribution of newly-hatched larvae and spawning adults. Recent studies have shown that outflows greater than 6.3 million acre feet over the March to May period or an equivalent of 34, 525 cubic feet per second would increase the likelihood of positive productivity in the longfin smelt population (Rosenfield and Swanson 2010, pp. 17, 25).

2) Location of X2 and its effects on delta smelt

The low salinity zone (LSZ) is where fresh water transitions into brackish water, and is an indicator of habitat suitability for many organisms in the San Francisco Estuary. It is also a primary habitat for delta smelt, many of which use this region for much of their life cycle. Thus, LSZ habitat conditions are important to delta smelt during most if not all months of the year. The LSZ expands and moves downstream when river flows are high, and contracts and moves upstream when river flows are low. A metric of this salinity gradient is X2. The position of X2 depends primarily upon freshwater flow and can be managed by adjusting water project exports and Delta outflow (Jassby, et al., 1995). During the spring, X2 and net flows in Old and Middle

River (OMR) are effective predictors of the proportion of the larval and juvenile delta smelt population that is entrained in the south Delta (USFWS 2008). Turbidity is a key habitat feature for delta smelt (Baskerville-Bridges, et al., 2004; Feyer, et al., 2007) and estuarine waters are often turbid in the vicinity of X2 (Kimmerer, 2004). Flow regulation has resulted in an overall decrease in riverine sediment load, as sediment is stored behind upstream reservoirs and armored levees prevent the rivers from recruiting sediment from their floodplains (Wright & Schoellhamer, 2004). The same circulation patterns that drive the accumulation of particles in the low-salinity zone also appear to influence the distribution of organisms from plankton to larval fishes (Arthur & Ball, 1979; Cloern, et al., 1983; Bennett, et al., 2002; Kimmerer, et al., 2002). Placing X2 in the relatively shallow waters of Suisun Bay at particular times of the year, where phytoplankton growth rates are higher, is also intended to maximize productivity and support fish rearing (Arthur & Ball, 1979; Cloern, et al., 1983). However, FWS recognizes that phytoplankton blooms, and the food web they historically supported, have been suppressed by overbite clam (Kimmerer & Orsi, 1986; Jassby, et al., 2002; Winder, et al., 2011). They may be further suppressed by accumulation of ammonium due to urban wastewater inputs (Dugdale, et al., 2006).

The 2008 USFWS Biological Opinion for coordinated operations of the State and federal water projects requires that X2 be maintained at 74 km during September-October after wet water years and 81 km during September-October after above-normal water years. The action also includes a provision that passes new runoff through reservoirs in November, and is intended to provide variable benefits depending on November precipitation. The 3-dimensional UnTRIM Bay-Delta model shows the area occupied by the low salinity zone is almost 12,000 acres larger when X2 is 74km than when it is 85km. This modeled expansion of LSZ habitat is consistent with delta smelt habitat indices derived from the Fall Midwater Trawl dataset (Feyer, et al., 2007; Feyrer, et al., 2011). Fall X2 may have a population-level influence on delta smelt abundance in the fall (Feyrer, et al., 2011) and, following the overbite clam invasion of the estuary, fall X2 may also have an influence on the following generation of juveniles (Feyer, et al., 2007).

3) Adaptive Management of Fall Delta Outflow (X2)

Reclamation's Adaptive Management of Fall Outflow for Delta Smelt Protection and Water Supply Reliability (2011) outlines the following recommendations. Bullets 4-6 describe critical supporting information needs that are now being addressed through the Adaptive Management Program.

1. Use enhanced Delta outflow in wetter falls to increase the geographic area of the low-salinity zone, increasing the availability of high-quality LSZ physical habitat for delta smelt.

2. Restore LSZ connectivity to Suisun Bay in wetter falls, especially including Grizzly Bay and Honker Bay, to provide delta smelt access to the channel and shoal habitats in that area and allow access to the larger Suisun Marsh sloughs.
3. Ensure higher interannual and seasonal variability in salinity regimes in eastern Suisun Bay to reduce density of Corbula adults, thereby reducing the impacts of Corbula grazing on phytoplankton biomass and capture of selenium into the food chain year-round.
4. Improve understanding of delta smelt growth, health, and fecundity in order to evaluate the roles of delta outflow and other processes occurring through the summer and fall in determining the state of the delta smelt at the onset of the spawning migration.
5. Improve understanding of plankton and benthos dynamics in Suisun Bay and the western Delta to support modeling of the physical processes that affect the abundance and accessibility of food for delta smelt and other species during the summer and fall.
6. Improve understanding of nutrient and contaminant dynamics that may be affected by outflow variability and the location of the LSZ during the summer and fall, to support investigation of their potential influences on delta smelt growth, health, and fecundity.

In this adaptive management approach, FWS is working with IEP to develop a process that rigorously seeks to reduce uncertainty to support improved fall low salinity zone habitat management decisions over time. We believe that this effort will provide FWS, the Board and others with critical information regarding the role of fall outflow in delta smelt protection. We encourage the Board to use the information developed through the Adaptive Management Program in evaluation of fall outflow objectives.

II. EXPORT/INFLOW OBJECTIVES

The E/I objectives contribute to fishery management objectives by allowing a certain percentage of delta inflows to contribute to outflow, which helps to create suitable conditions for the transport of fish to the western Delta.

FWS suggests the Board model and evaluate the WQCP’s current Export/Inflow objectives.

III. DELTA CROSS CHANNEL GATE CLOSURE OBJECTIVES

Under the current NMFS 2009 BiOp, the Delta Cross Channel gates are to be closed no later than December 15 (unless NMFS approves a later date) and are to stay closed until June 15 (unless NMFS approves an earlier date) of each year to increase the survival of out-migrating juvenile salmon, steelhead, and green sturgeon. NMFS recommends that the DCC gates be closed as early as possible, under an adaptive management program based on monitoring outmigrant movements starting November 1. Water quality considerations in the Delta will be one cause for a request to vary from these dates, but NMFS will have final authority on closure (http://www.swr.noaa.gov/ocap.htm, accessed 2/28/12).

While closure of the Delta Cross Channel gates assures juvenile salmon will not be diverted into the interior Delta through the Delta Cross Channel, it does not assure that a similar proportion of fish will not enter the interior Delta through Georgiana Slough. Closing the DCC increases the flow and the proportion of fish entering Georgiana Slough and staying in the Sacramento River relative to when it is open (Perry, 2010). In Interior's February 2010 comments to the Board, we discussed a model being developed by Russ Perry based on an analysis of the proportion of late-fall acoustically tagged salmon entering the Delta Cross Channel and Georgiana Slough from multiple studies across years. Perry's model indicated that the probability of a juvenile salmon being diverted into the interior Delta through either the open Delta Cross Channel or Georgiana Slough was a function of flow in the Sacramento River as well as upstream flow into the Delta Cross Channel and Georgiana Slough (Perry, 2010). For example, a similar proportion of tagged fish entered the interior Delta through just Georgiana Slough (31 percent, January 2008) as when the Delta Cross Channel gates were open and diversion into the interior Delta occurred at both the Delta Cross Channel and Georgiana Slough (27 percent, December 2007) (Perry & Skaski, 2009). Perry's model is now complete and available for Board staff's review (Perry, 2010). As discussed in our February of 2010 comments, it's important to provide conditions for juvenile fishes migrating from the Sacramento basin that achieve no bidirectional flow in the mainstem Sacramento River downstream of Georgiana Slough to minimize the proportion of salmon that enter the interior Delta. This is important in addition to keeping the Delta Cross Channel closed per the NMFS 2009 Bi Op. Multiple studies have shown that survival in the interior Delta is less than other migratory routes (Brandes & McLain, 2001; Newman, 2008; Perry & Skaski, 2008; Perry & Skaski, 2009; Perry, 2010; Newman & Brandes, 2010; Perry & Skaski, 2010). More recent juvenile salmon acoustic studies continue to support these comments. Perry (2010), Perry and Skalski (2010), and Perry et al. (2012), are consistent with previous reports identified in our February 2010 comments (Perry & Skaski, 2008; Perry & Skaski, 2009; Perry, 2010).

Additionally, preliminary results from recent experimental DCC closures in October 2010 (2 day closure) and October 2011 (10 day closure) coordinated with Mokelumne River pulse flows have shown the potential to greatly reduce straying of Mokelumne River origin adult fall-run Chinook salmon to the Sacramento River basin. These results suggest that additional closures of the DCC prior to November 1 may reduce straying of returning adults to the entire San Joaquin basin and therefore, increase the potential to meet doubling goals for all San Joaquin tributaries. DCC gate closures before November 1 should be considered, modeled and evaluated whenever water quality conditions are suitable to allow closure. The results of the studies mentioned above are still being analyzed, but they will be made available by the Lower Mokelumne Joint Settlement Agreement Steering and Coordinating Committees in the near future. In light of the preliminary results of the Mokelumne pulse flow – DCC closure evaluations, an effort should be made to model and evaluate pre-November 1 DCC gate closures with any fall pulse flows from all San Joaquin River tributaries or mainstem.

IV. SUISUN MARSH OBJECTIVES

FWS suggests the Board model and evaluate maintaining the WQCP's current water quality standards for chlorides/EC in Suisun Bay and Suisun Marsh, in conformity with the soon-to-be interagency Tidal Marsh Recovery Plan. When updating and implementing the water quality standards for chlorides/EC in Suisun Bay and Suisun Marsh, it is important that the Board consider the increasingly marine nature of the Marsh related to sea level rise and climate change. Placing X2 in the relatively shallow waters of Suisun Bay at particular times of the year, where phytoplankton growth rates are higher and where a much greater amount of habitat is available, is intended to maximize productivity and support fish rearing as well as minimizing entrainment into the State and Federal export facilities. Estuarine aquatic species are adapted to estuarine aquatic environments – by definition tidal, variable in multiple dimensions and constituents, unpredictable, connected to floodplains, and punctuated by occasional catastrophic droughts and outflows (Healey, et al., 2008).

Sufficient thinking on the topic of environmental flows and the importance of naturally variable flows within rivers has led to international attention to this issue and related research (see, for example, Wolansky, 2007). A related recent article on riverine flow is germane enough to quote here extensively (Poff, 2009):

> *In the 1980s, a new way of thinking about environmental sustainability arose. Academic ecologists began to formalize their understanding of how temporal fluctuations in environmental conditions act to rejuvenate and maintain habitat quality and overall ecosystem health. Even for single species, the notion of a specific flow "preference" gave way to the realization that dynamic variation in flow is often needed to ensure the species' long-term health. For example, flushing flows below dams can certainly cause some mortality to fish; however, they also cleanse gravel beds, rejuvenate spawning and foraging habitat, and may reconnect channel to floodplain habitats, all longer-term benefits. This more holistic understanding of ecosystem health established the foundation for a paradigm shift in ecosystem management away from single species with static habitat requirements to whole ecosystems in which the assemblage of species – many having different flow "preferences" – could be sustained by a dynamic flow regime.*
>
> *This new paradigm in river systems was articulated in the principle of the "natural flow regime" (Poff et al. 1997). Basically, this perspective emphasizes the importance of recent historical (pre-management) hydrologic dynamics in controlling ecological*

processes, species adaptation, and ecosystem function in streams and rivers. The key elements of this concept are that the variation in flows is essential to sustain the ecosystem (and associated biodiversity) and that the pattern of variation typical of any river is defined by the climatic, geologic, and land cover controls on precipitation and runoff. Because these controlling factors vary geographically, natural flow regimes do so as well. An extensive literature has now accumulated to document how alteration of natural flow regimes has greatly modified ecological function and ecosystem state in streams and rivers throughout the world (Bunn & Arthington, 2002; Postel & Richter, 2003; Poff & Zimmerman, 2010).

We do not understand Delta ecosystem form and function well enough to provide assuredly successful fixes to what we believe is broken. Reintroducing proper environmental flows will only be one aspect of a Delta solution. Whether fish stocks in the Delta return to their historical abundances will depend on myriad ecosystem elements and their interactions, over most of which water resource managers have limited or no control.

A particular emphasis on the importance of landforms and geomorphology by Atwater and colleagues (Atwater et al., 1979) has led to a growing understanding that the hydrogeomorphology of the Delta and Estuary play an important role in transforming available flow into a mosaic of habitats and alternative hydraulic residences, many of which are conceptually linked to critical habitat of species of concern (Atwater et al., 1979; Bunn & Arthington, 2002; Nobriga, et al., 2005; Feyrer, et al., 2010, Enright and Burau, personal communication). It is quite likely that recent management activities in the Delta (1850-present) has led to a "short-circuiting" of tidal and residual flow patterns among and between tidal habitats and sloughs in the Estuary, with concomitant impacts on habitat variability and refuge space for native Delta organisms. The growing consensus is that management in the Delta has led to a homogenization of available aquatic habitat and the reduction in variability thought to be important to resident native species (Cloern, 2007; Healey, et al., 2008; Poff, 2009; Moyle, et al., 2010).

See Interior's February 2010 comments for more details.

V. POTENTIAL NEW REVERSE FLOW OBJECTIVES FOR OLD AND MIDDLE RIVERS

FWS also suggests the Board model and evaluate the potential for incorporating more protective OMR flow objectives into the WQCP that would reduce entrainment of delta smelt and longfin smelt and improve habitat conditions in the context of protecting and restoring a healthy Delta ecosystem on a sustainable basis (i.e. path toward recovery).

OMR flow is a hydrodynamic metric that correlates with entrainment of delta smelt and other fishes because these daily net flows reasonably index the pull or "footprint" of the CVP and SWP exports. Old and Middle River flows integrate a complex set of factors, including flows from the large and small tributaries, suppression of daily and neap–spring tidal variation, local agricultural diversions, and wind (Arthur & Ball, 1979; Monsen, et al., 2007). When combined exports are greater than San Joaquin river inflow, tidally averaged OMR flows move upstream (i.e., negative or reverse) towards the SWP and CVP.

Recent studies show that entrainment of delta smelt and other pelagic species increases as OMR flows become more negative (Grimaldo, et al., 2009; Kimmerer, 2008). Kimmerer (2008) calculated that entrainment losses can result in substantial population losses (up to 50 %) in adult and juvenile life stages and that these losses increased as OMR flows became more negative. Kimmerer's methods and estimates have recently been critiqued by Miller (2011). However, in his rebuttal, Kimmerer (2011) discounted many of Miller's criticisms and showed that entrainment could have a significant population-level consequence even if it could not be detected using traditional statistical methods. Because delta smelt are at record-low abundances, minimizing their entrainment through management of OMR flows remains a desirable goal for protection of delta smelt consistent with information provided in the Service 2008 BiOp.

X2 and Old and Middle River flows affect the entrainment dynamics of delta smelt (Kimmerer, 2008; Grimaldo, et al., 2009; U.S. Fish and Wildlife Service, 2008). However, entrainment can be reduced if OMR flow reductions are timed when delta smelt are within the footprint of the exports. Management of OMR flows for delta smelt will also provide benefits (i.e., reduced entrainment risks) for longfin smelt (Grimaldo, et al., 2009) and Chinook salmon (NMFS 200 BiOp). FWS suggests the Board model and evaluate the potential for incorporating OMR flow objectives into the WQCP.

VI. POTENTIAL NEW FLOODPLAIN HABITAT FLOW OBJECTIVES

Recent studies indicate that seasonal floodplain inundation has a positive effect on the growth and apparent survival of juvenile Chinook salmon in the Central Valley. Results of a study conducted in 1998-1999 (Sommer, et al., 2001) on juvenile salmon in the Yolo Bypass show increased growth rates and higher apparent downstream survival of fish rearing and feeding in the bypass compared to juvenile salmon that remain in the mainstem Sacramento River. The increased growth rates in the Yolo Bypass may be attributable to higher densities of preferred prey species (e.g. Diptera spp.) and higher water temperatures.

The hypothesis in Sommer, et al. is that floodplain rearing improves survival is supported by their growth data and bioenergetic modeling. "Faster growth rates reflect improved habitat conditions, which would be expected to lead to improved survival, both during migration and later in the ocean." There may be several factors involved, including; a larger and more diverse area to feed and rear, reduced competition for food and space, lower water velocities, more cover from predatory fish, and emigration at a larger size. Please refer to Interior's February 2010 comments and the appendices in our February 2011 comments to the Board for more details regarding floodplain inundation.

VII. DELTA INFLOW OBJECTIVES

The timing and magnitude of freshwater inflow into the Delta is important for upstream migration of adult salmon and directly affects the abundance and survival of juvenile salmon migrating through or rearing in the Delta. Past studies have indicated that survival of fall run smolts increase with Sacramento River flows at Rio Vista with maximum survival identified at or above 20,000 and 30,000 cfs (page 9, DOI 2010 comments). Other analyses also support the hypothesis that Sacramento River flow increases the survival of fall run juvenile salmon from the Sacramento basin as they migrate through the Delta (Newman & Rice, 1997; Newman & Rice, 2002; Newman, 2003). Increasing salmon survival rates through the Delta is needed to meet the goals of restoring and doubling natural salmon production in the Central Valley per the goals of the Anadromous Fish Restoration Program. In addition, the abundance of juveniles entering the north Delta as fry between January and March and leaving the Delta between April and June is greater at higher flows, with the greatest abundance at flows above 40,000 cfs at Freeport or Rio Vista, respectively (Brandes & McLain, 2001). While this proceeding does not cover flows on the San Joaquin River at Vernalis, survival through the San Joaquin Delta is also higher with greater flow with either a physical barrier at the head of Old River or on the San Joaquin River downstream of Old River (Figure 5-11, 5-13, and 5-14 in San Joaquin River Group Authority, 2007; Newman, 2008). It's our understanding that the Board will request additional comments on the San Joaquin River flow objectives at a future time. In the meantime, Interior's February 2011 comments to the State Board regarding San Joaquin flow objectives are still applicable, and discussed our suggestions for modeling and evaluating the San Joaquin River tributary flows (Stanislaus, Tuolumne and Merced) and the San Joaquin River flows at Vernalis. It's important that the Board integrates the San Joaquin (Vernalis) flow modeling and evaluation when it models and evaluates the WQCP Delta flow objectives in this process. Please refer to our February 2010 and February 2011 comments for more details.

Flow reduces predation on juvenile salmonids via several mechanisms. Increased flow increases suspended sediments (turbidity), reducing a predator's ability to visually locate prey (Rodriguez and Lewis1994; Gregory and Levings 1998). Increased flow can speed migration rates of juvenile salmonids (BPNWL, 1995), reducing the time spent in areas with high predation mortality. Higher flows can inundate historical floodplain habitats, providing both a refuge from predators and increased food resources for juvenile salmon. Increased food can increase growth and larger juveniles are better able to avoid predators (Jeffres and others 2008). Additionally, increased flows from tributaries could reduce water temperature, thus reducing metabolic and feeding rates for predatory fish that prefer warmer water, such as striped bass (Kruger and Brocksen 1978).

VIII. POTENTIAL CHANGES TO THE MONITORING AND SPECIAL STUDIES PROGRAM

In the 2009 Staff Report entitled: "Periodic review of the 2006 water quality control plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary", Staff recommends that the State Water Board consider changes to the Monitoring and Special Studies Program, particularly considering recommendations developed during reviews of the IEP/EMP and other recommendations available during the basin planning process. We agree that changes to the monitoring and special studies program are warranted, given changes in monitoring activities in the Delta. We recommend that any changes in the monitoring and special studies program (1) are explicitly designed to inform decision making, and (2) follow an adaptive management framework.

Design monitoring programs to inform decision making

Monitoring should not be conducted for its own sake, but as a means to improve management outcomes. In particular, monitoring should be conducted where there are uncertainties about how the system responds to management and where there is potential for monitoring information to improve future management outcomes (Lyons, et al., 2008). This is best achieved using a process such as Structured Decision Making (SDM), a decision-analytic framework that can help decision makers manage uncertainty and make use of available information to inform management actions. SDM is based in decision theory and risk analysis, and can be used to effectively develop a science-based decision making framework that is increasingly being applied to natural resource management questions (Dorazio & Johnson, 2003; U.S. Fish and Wildlife Service, 2008; Clemen, 1996; Conroy, et al., 2008). The SDM process recognizes that resource management decisions are highly complex; thus, decisions are broken down into several primary elements that help manage this complexity. Key SDM concepts include making decisions based on clearly articulated objectives, dealing explicitly with uncertainty, identifying management action alternatives, exploring consequences of alternative actions and assessing tradeoffs, and ultimately choosing a decision and action plan. Benefits to this approach include decisions that are deliberative, robust to uncertainty, transparent, and defensible, thus are more likely to achieve objectives and be accepted by others. The Board should not adopt flow criteria without going through the process of: (1) stating the objectives that flow criteria are intended to achieve, (2) identifying the set of alternative flow criteria (management action alternatives) that may achieve the stated objectives, (3) considering mathematical models and other decision-support tools that can help evaluate the consequences of alternative flow criteria, (4) clearly articulating the trade-offs associated with each set of consequences, and (5) making a decision that optimizes among the set of consequences and trade-offs, and explicitly identifies ways in which adaptive management will inform further evaluation among a set of alternative flow criteria (Figure 122).

Adaptive management is a special case of SDM and is best applied when decisions have some degree of uncertainty, are iterated, and are linked over time (i.e., an action at time t affects another action at time t+1). Management actions are important learning opportunities for iterated decisions (U.S. Fish and Wildlife Service, 2008). However, a decision process and associated monitoring program must be in place that (1) allows for collection and analysis of relevant data, and (2) provides a decision framework that allows application of new data to inform subsequent management decisions. Without an explicit link between a monitoring program and the decision making process there is the risk that monitoring data will not directly inform management decisions beyond the intrinsic value of the information in increasing ecological knowledge.

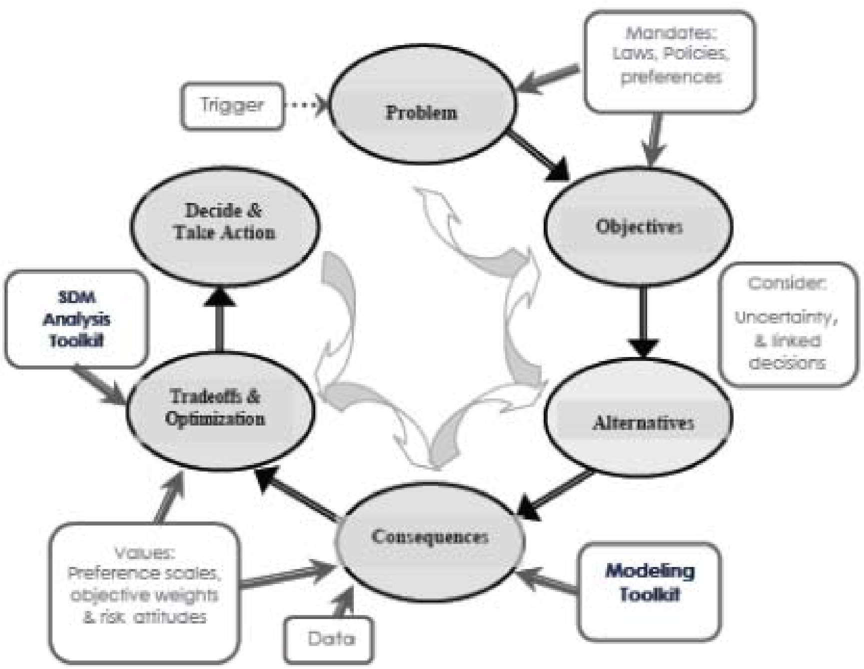


Figure 122. Structured Decision Making steps. From USFWS 2008.

Follow an adaptive management framework

The importance of an adaptive management approach and supporting monitoring cannot be overstated. Resource management decisions are almost always made with some degree of uncertainty; what makes a decision good is the process by which it was generated (which can be controlled) and the degree to which the decision framework is built to incorporate new information as it is available to reduce uncertainty and improve decision outcomes.

The Department of Interior adaptive management technical guide (Williams, et al., 2007) states: "Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders."

The National Resource Council identified 8 key components of adaptive management in their assessment of the program in the Grand Canyon (National Resource Council, 1999): "The key components of this and other working definitions include: (1) commitment to ongoing management adjustments based, in part, upon scientific experimentation, (2) shift from "trial and error" to formal experimentation with management actions and alternatives, (3) shift from fragmented scientific investigations to integrated ecosystem science, (4) explicit attention to scientific uncertainties in ecosystem processes and effects of management alternatives, (5) formal experimental design and hypothesis-testing to reduce those uncertainties and help guide management adjustments, (6) careful monitoring of ecological and social effects and of responses to management operations, (7) analysis of experimental outcomes in ways that guide future management decisions, and (8) close collaboration among stakeholders, managers, and scientists in all phases of these processes."

The first step in any adaptive management approach should be to define the fundamental objectives of any management actions. This ensures that the analysis and resulting decisions are focused on values, in contrast to our intuitive decision-making, which usually begins by discussing alternatives. Consider starting with the Calfed Ecosystem Restoration Goals (or similar) and scale down to an appropriate level (e.g., separate fundamental objectives from key means objectives that relate to management actions). The Calfed Ecosystem Restoration Program enumerated six program goals the Board should consider (Healey, et al., 2008):

- Achieve recovery of at risk native species dependent on the Delta and Suisun Bay as a first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed
- Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats that favor native members of these communities

- Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals
- Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting biotic communities, ecological processes, recreation, scientific research and aesthetics
- Prevent the establishment of additional nonnative invasive species and reduce the negative ecological and economic impacts of established nonnative species in the Bay-Delta estuary and its watershed
- Improve and/or maintain water and sediment quality conditions that fully support healthy and divers aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people

Please refer to Interior's February 2010 comments for more details regarding adaptive management.

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