Integrated Water Operations and Multi-Species, Multi-Performance Indicator Ecosystem Effects Analysis: The San Francisco Delta Ecological Flows Tool (DeltaEFT)

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As demonstrated in recent EIR/S applications for the North-of-the-Delta Offstream Storage Investigation and the Bay Delta Conservation Plan, the Ecological Flows Tool (EFT) clearly communicates the trade-offs for representative performance indicators of multiple focal species. EFT currently supports two eco-regions: (1) SacEFT (www.dfg.ca.gov/ERP/signature_sacriverecoflows.asp) for characterizing the ecological consequences of management-related changes in flow and temperature regime and channel restoration activities on the middle and upper Sacramento River and (2) DeltaEFT for the San Francisco Delta. TNC and ESSA Technologies have recently completed version 1 of the Delta Ecological Flows Tool (DeltaEFT). TNC's effort to extend EFT to the Delta has emphasized detailed reviews of pre-existing biophysical relationships (e.g., DRERIP, BDCP, SWRCB, POD research) as well as support from expert-led workshops to prioritize, vet and customize indicators. Delta flow management scenarios (inflow regimes, conveyance alternatives, gate operations, export pumping rates, sea-level rise) are evaluated in DeltaEFT by linking physical variables to important Delta habitat conditions and focal species targets such as: Brazilian waterweed suppression, invasive overbite clam suppression, invasive Asiatic clam suppression, Chinook/steelhead (multiple run types) smolt development & growth, smolt predation mortality, smolt temperature stress, an index of delta smelt habitat suitability, delta smelt entrainment risk, and tidal wetland inundated area and salinity/inundation regimes. In addition to enabling rapid comparative scenario evaluation (climate change, alternative conveyance and operations), DeltaEFT provides guidance on both target flows (to maximize the related ecological benefits) and avoidance flows (to reduce negative consequences), bracketing the range of discharges to be evaluated experimentally. The presentation provides results from recent applications of DeltaEFT to BDCP alternatives, including summarizing trade-offs among Delta species, and highlighting the significance of future climate change adaptation strategies.

Keywords: Ecological flows, environmental flow assessment, functional flow assessment, integrated modeling

Poster Topic: Modeling

Using Conceptual Models to Evaluate Delta Restoration Actions

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State and federal agencies, in collaboration with other partners, are working to improve ecosystem health in the Bay-Delta watershed, increase abundance of native species, and rehabilitate natural processes through protection and/or restoration of habitats. Due to uncertainties inherent in our understanding of dynamic ecosystems, restoration activities should be implemented within a science-based, transparent, and formal adaptive management process. Conceptual models represent a critical component of this process, in that they formalize and apply current scientific understanding, and provide a venue through which to identify areas of uncertainty, identify possible restoration actions, develop expectations, assess likelihood of success, define monitoring needs, and evaluate tradeoffs associated with different management actions. The Adaptive Management Planning Team and Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) developed an initial suite of life history and ecosystem conceptual models and a scientific evaluation process to assess outcomes of proposed restoration actions in the Delta. The models were developed using a common approach and a robust set of tools so that this process would support consistent application of adaptive management. An early use of the models and evaluation process was to evaluate draft conservation measures for the Bay Delta Conservation Plan. Current application of these models and scientific evaluation process is focused on evaluating restoration options at Prospect Island. This process provides for critical review of restoration options so that managers may weigh the potential outcomes, geographic and temporal scale, reversibility, and overall opportunity for learning associated with different restoration actions. Additionally, it allows for evaluation on whether a pilot scale effort is warranted or if a more aggressive restoration effort should be undertaken.

Keywords: Conceptual Models, Adaptive Management, Delta, Restoration, DRERIP

Poster Topic: Modeling

Delta and Longfin Smelt Bioenergetics: Determining Maximum Consumption

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Delta and longfin smelt abundance in the San Francisco Estuary has declined dramatically since the 1980s. Individual-based population life-cycle models (IBMs) were developed for both species to explore the population response to various environmental and management scenarios. However, key data gaps exist for the bioenergetics (growth) components of both IBMs, necessitating laboratory studies to determine the quantity of food consumed by delta and longfin smelt. The objectives of the first part of this study were to create rearing conditions required to study the temperature-dependent food consumption by various life stages of smelt, and to develop a methodology to estimate the daily food consumption. An aquaculture facility, consisting of three independent recirculating systems with four tanks each, was constructed and tested. Cultured juvenile and adult delta smelt were used to develop methods to assess diel feeding patterns and gastric evacuation times and rates. Adult and juvenile delta smelt were successfully maintained in the new aquaculture facility. Three experimental groups of adult fish were held simultaneously at water temperatures of 9, 13 and 17°C. Stomach contents from juvenile and adult delta smelt were successfully retrieved by dissection. Both smelt life stages fed actively during multiple feeding events throughout the day, but no consumption occurred during nighttime hours. Gastric evacuation of juvenile and adult delta smelt after satiation feeding was completed after approximately 21 and 28 hours, respectively, and an exponential model was the best fit to describe gastric evacuation over time. Application of a feeding model indicated that daily consumption by adult delta smelt at a water temperature of 10°C averages approximately 1% of the fish wet weight. Methods presented here will facilitate the establishment of temperature and size dependent consumption components of bioenergetics models for both species.

Keywords: Delta smelt, longfin smelt, bioenergetics, IBM, consumption, gastric evacuation,

Poster Topic: Modeling

Delta Simulation Model (DSM2) Grid Extension

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The Delta Simulation Model (DSM2) grid was extended to the Golden Gate Bridge to allow for its use in simulating sea level rise, island flooding and other scenarios in which significant seawater intrusion is anticipated.

The Delta Simulation Model 2 (DSM2) is a one-dimensional hydrodynamic and water quality model of the Sacramento-San Joaquin Delta. In its standard form, DSM2's geographic extent encompasses I-Street (Sacramento) to the north, Vernalis to the south, east side streams (around I-5) to the east, and Martinez to the west. Although suitable to simulate many Delta modeling scenarios, the western boundary at Martinez is inadequate when significant ocean water intrusion is expected, such as in sea level rise and flooding of Delta islands, particularly those located close to the western boundary.

To use DSM2 to study scenarios in which seawater incursion is predicted, the DSM2 grid was extended to the Golden Gate Bridge through a series of arcs and "reservoirs". These arcs and reservoirs were designed to simulate the volume and salt transport through the bays west of Martinez. This extended grid was calibrated and tested against historical records and RMA simulations of extensive Delta islands flooding.

Modeling tests and extensive sensitivity analyses indicate that DSM2 with the extended grid perform reasonably well, and was found to be reliable for comparative analyses.

Keywords: salt transport, salinity intrusion, hydrodynamic modeling, water quality

Poster Topic: Modeling

Stanislaus River Floodplain Area versus Flow Relationships

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The problem we are trying to solve is to quantify the relationship between flow and floodplain area on the Stanislaus River. The approach we are using is to develop a two-dimensional hydraulic model of most of the Stanislaus River, using previously collected LIDAR and SONAR data, to simulate total wetted area for flows ranging from 250 to 5,000 cfs. The resulting total wetted area versus flow graph is then examined to determine the flow at which floodplain inundation begins, as shown by an inflection point in the graph. The total wetted area at this flow is subtracted from the total wetted area at higher flows to determine the inundated floodplain area at each flow. The main findings are that, for two of the four segments we have completed modeling for, floodplain inundation starts at 1,250 cfs, and increases fairly linearly with increasing flow. The scientific and management implications of our findings are providing a method to quantify the benefits of high spring flows for floodplain inundation. Our findings provide insight as to flows that are needed to sustain the floodplain inundation aspect of the Stanislaus River ecosystem.

Keywords: Floodplain Flow modeling

Poster Topic: Modeling

A Framework for Developing Stream Flow and Thermal Regimes for Multiple Salmonid Species in the Central Valley

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Stream flow and temperature are critical factors in the conservation, protection, and recovery of endangered or threatened anadromous fish species in the Central Valley. These factors are interrelated as temperature is often controlled by stream flow, particularly in rivers regulated by reservoirs. Flow is a major determinant of physical habitat and transport. We use the flow regime concept for developing instream flows for anadromous fish. The concept recognizes that biologically important flows include not only flow magnitude, but also frequency, timing, duration, and rate of change of flows. Seasonal, inter annual, and spatial variability, to which anadromous fish are adapted, are as important as quantity. The flow regime approach also considers flows required for maintaining or improving important ecosystem functions, for example, migration cues, habitat connectivity and diversity, stream channel morphology and geometry, and stream temperature.

Water temperature influences growth and feeding rates, metabolism, development of embryos and alevins, timing of life history events, and the availability of food. For protecting and recovering vulnerable populations (e.g., endangered or threatened), we use optimal water temperatures for each of their life stages. These optimal temperatures serve as the base of setting water temperature criteria for the listed species. Water temperature data from monitoring stations are analyzed and compared with temperature criteria. Using statistical or process-based models, we estimate how much water would be required to meet the established temperature requirements. Using developed models and weather forecast, we are able to provide advice for real-time water operations to maintain adequate stream temperatures for anadromous fish. Flows for sustaining optimal water temperatures are particularly important in warm seasons when flow is low and air temperature is high.

The final environmental flows are the integration of instream flows derived from the flow regime approach with temperature sustaining flows.

Keywords: Environmental flow, instream flow, water temperature, salmonids, water operations

Poster Topic: Modeling

Advancement of Bathymetry in the Sacramento-San Joaquin Delta

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Historical information concerning the water depths and river geometry of the Delta is inconsistent and of variable quality. Moreover, this information, known as bathymetry, changes over time, causing old data to be less and less representative. As bathymetry is a key input to a wide array of models from many disciplines, using old data can result in errors in the scientific community's basic understanding of the scientific processes in the Delta.

However, the application of new data collection technology by DWR scientists has allowed for the rapid detailed mapping of sloughs throughout the Delta. With the use of an R2 Sonic multibeam echosounder for depth collection and a Trimble R8 for RTK positioning corrections, higher quality data is gathered which allows for both better model inputs and, when mapped, the appearance of subtle bathymetric features.

Datasets showcasing this modern bathymetry include areas of Middle River, Lower Mokelumne River, Columbia Cut, Turner Cut, Miner Slough, and the Sacramento Deep Water Ship Channel, among other locations of interest in the Delta.

Bathymetric information is a basic building block for many different environmental, fisheries, hydrodynamic, engineering, geological, and sediment studies that aids project implementation. Hydrodynamic modelers, biologists, engineers, geologists, construction inspectors, reclamation districts, and ecological scientists depend on detailed, up to date bathymetric information. Thus, the collection of accurate, current data by DWR aids the scientific community's fundamental understanding of the processes in the Delta.

Keywords: bathymetry, modeling, DWR, mapping, GIS, subsurface, riverbed, GPS, RTK, multibeam

Poster Topic: Modeling

Application of an Ecosystem-Scale Selenium Model to the San Francisco Bay-Delta Estuary

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Ecosystem-scale selenium modeling frames a site-specific occurrence of selenium; quantifies selenium exposure of fish and birds through foodweb biodynamics; and narrows uncertainties about how to protect it by integrating a system's ecology, biochemistry, and hydrology and a species' physiology and ecotoxicology. The most important regulated estuarine sources of selenium are 1) internal inputs of oil refinery wastewaters from processing of crude oils at North Bay refineries; and 2) external inputs of irrigation drainage from agricultural lands of the western San Joaquin Valley conveyed mainly through the San Joaquin River. We present here a quantitative example of the application of ecosystem-scale selenium modeling for the Bay-Delta. The questions addressed in the example are: What are the implications for ecosystem concentrations of selenium if a fish tissue and/or wildlife selenium guideline is implemented (a guideline based upon selenium concentrations in a predator)? More specifically, what changes in dissolved or particulate selenium concentration in the Bay-Delta would be necessary to achieve the selected tissue concentrations in predators? Agencies have traditionally regulated contaminants on the basis of dissolved concentrations, and managed inputs from different sources based upon their implications for dissolved concentrations (e.g. total mass daily loadings). This example ties the new concept of tissue guidelines to the traditional concept of dissolved-concentration-based management. Inherent in every regulatory guideline are assumptions about the environment being regulated. The model allows an explicit evaluation of the implications of different assumptions. The specificity of illustrated scenarios demonstrates that enough is known about the biotransfer of selenium and the interconnectedness of habitats and species to set a range of limits and establish an understanding of the conditions, biological responses, and ecological risks critical to management of selenium in the Bay-Delta.

Keywords: selenium, foodweb biodynamics, ecosystem-scale modeling, North Bay

Poster Topic: Modeling

Nutrient Loads in Rivers and from Point Sources Used to Develop a SPARROW Model for California and Adjacent States, U.S.A.

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Sources of, and factors affecting, the transport of total nitrogen (TN) and total phosphorus (TP) are being evaluated for a study area that covers most of California and some areas in Oregon and Nevada by using the SPARROW model (SPAtially Referenced Regression On Watershed attributes) developed by the U.S. Geological Survey. Mass loads of TN and TP calculated for monitoring sites at stream gauging stations are regressed against factors affecting land to water transport, including fertilizer use, recharge, atmospheric deposition, stream characteristics, and other factors, to understand how TN and TP are transported under average conditions. SPARROW models have been used successfully in other parts of the country to understand how nutrients are transported and how management strategies can be formulated, such as with Total Maximum Daily Load (TMDL) assessments.

Fertilizer use, atmospheric deposition, and climatic data were obtained for 2002, and loads for that year were calculated for monitored streams and point sources (mostly from wastewater treatment plants). The stream loads were calculated by using the adjusted maximum likelihood estimation method (AMLE). River discharge and nutrient concentrations were de-trended in these calculations in order eliminate the effect of temporal changes on stream load. Effluent discharge information, and TN and TP concentrations from point sources, were obtained from USEPA databases and from facility records. TN and TP point-source loads were estimated at some sites by using effluent discharge information.

Annual loads to the Delta for both TN and TP are highest from the Sacramento River because of the greater discharge of that river, although daily concentrations tend to be higher in other regions, such as the San Joaquin Valley. Wastewater facilities, located mostly around large cities near the Delta, San Francisco Bay, and southern California account for 75% of the point source TN and TP loads throughout the study area.

Keywords: SPARROW, model, Nutrients, point sources, water quality, loads,

Poster Topic: Modeling

Assessment of Watershed Analysis Risk Management Framework (WARMF) Model Data from Sacramento and San Joaquin Watershed

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The Department's Bay-Delta Office (BDO) uses the WARMF model to generate inflow boundary conditions for Delta Simulation Model 2 (DSM2) simulations of water quality in the Sacramento-San Joaquin Delta. The Municipal Water Quality Investigation (MWQI) branch was asked by the BDO to find flow, DOC or TOC data for stations where the WARMF model lacks these data, or there is a concern that the WARMF data are incorrect. Data were gathered the period from January 1990 to December 2010. In total, there were 183 supplemental flow stations identified at 114 WARMF model locations, and 304 supplemental DOC and TOC stations identified at 225 WARMF model locations. Data and reports including maps and graphs were provided to BDO.

Keywords: Watershed, Analysis

Poster Topic: Modeling

Improvements in CVP/SWP System Operational Planning: High Acuity Simulation Platforms to Better Capture Hydrological Sensitivity

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Problem Statement:

Current system operations planning models across the CVP/SWP use monthly timesteps and incorporate simplifying assumptions for hydrologic processes. Although models like CALSIM II have been improved over time, existing models are limited in their ability to address complex regulatory requirements, a shifting hydrologic regime, and the need to balance environmental indicators. Advances in computational capabilities now mean that new models can be developed to overcome these limitations, to address future hydrologic uncertainty, and to greatly improve modeling accuracy.

Approach:

Several model development steps are proposed. First, we propose a physics-based hydrologic representation of the upper basin source areas using kinematic wave propagation, and incorporating the snowmelt energy balance, representative elementary area (REA) principles, variable source area (VSA) contributions, in-basin storage, vadose/phreatic interrelationships, isotopic information on source fluxes, and other factors. Second, to represent future hydrologic conditions and move toward "real-time" simulations, we would develop alternatives to the traditional use of historic hydrologic records. The model would rigorously express physical runoff functions and retain operational, regulatory, demand, and facility information. We propose to also refine initial boundary conditions, including reservoir carryover, basin antecedent moisture, groundwater storage, potentiometric surfaces, etc. Third, we propose a deliberate shift to a daily timestep for all model functions. Fourth, reservoir temperature, stratification, and basic water quality simulations would be incorporated into the model framework.

Relevance:

A new integrated model would: (1) re-assess upper basin hydrology given accelerated hydroclimatic signals; (2) move to real-time CVP/SWP simulation and Bay-Delta response; (3) provide alternatives to the use of historic hydrologic records; (4) develop contemporary *worst-case* and *extreme event* sequences; (5) use daily timesteps for operations, reservoir water quality, and flow routing; and (6) re-evaluate existing model frameworks to affirm proper representations of land use, accretions, depletions, new facilities, and groundwater relationships.

Keywords: operations modeling, hydrology, climate change, flow routing, reservoir water quality

Poster Topic: Modeling