The ARM of the Central Valley Project Improvement Act:
Putting Science into Decision-Making

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The Central Valley Project Improvement Act (CVPIA) Fish Programs are using Adaptive Resource Management (ARM), a collaborative science-based decision-making process, to help identify actions considered most important for restoring native anadromous fish in the Sacramento-San Joaquin Bay Delta ecosystem. This relatively new, science-based approach to fish management is being used to: 1) prioritize, implement, and learn from projects; 2) develop multiple Decision Support Models (DSMs) that are based on biological objectives and can be used to examine trade-offs among management actions; and 3) revise the Program's governance structure to create an integrated CVPIA fish program, and develop science-based priorities to facilitate decision-making. By using the ARM process we are improving the CVPIA Fish Program's science-based framework, increasing our transparency and accountability, and reinvigorating our collaboration with agencies and stakeholders in the Central Valley.

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Session Title: Data for Decisions: Structured Decision Making Tools for Planning and Implementing CVPIA Actions
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Providing the Fuel for a Structured Decision Making Framework: Serving up Juvenile Salmon Data Collected with Rotary Screw Traps

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Central Valley Project Improvement Act (CVPIA) staff are developing a Structured Decision Making Framework (Framework) to guide future habitat restoration and monitoring activities in California's Central Valley. The validation of the Framework depends upon timely access to high-quality, standardized data. Historically, a substantial portion of the juvenile Fall-run Chinook Salmon (*Oncorhynchus tshawytscha*) data needed to support the Framework have commonly been stored in several, not standardized, data formats. Those formats make the recovery and analysis of data more challenging, time consuming, and less efficient.

During the past seven years, CVPIA staff worked with several partners to acquire and standardize juvenile salmon data collected with rotary screw traps in seven watersheds. Those watersheds collectively produce ~85% of the Central Valley's adult Fall-run Chinook Salmon production. The work to standardize data has led to the development of a rotary screw trap (RST) "Platform" consisting of: (1) an Access database that stores data; (2) Visual Basic programming code that supports a data entry user interface; (3) a satellite database used to look for, and correct, data quality issues; and (4) Program R programming code that conducts several analyses.

The Platform: (1) consolidates RST data from different watersheds into one standardized database structure; (2) compensates for operational conditions that affect RST data analyses, e.g. days when RSTs did not operate; (3) produces statistically robust production estimates for different combinations of juvenile life stage and temporal scale (e.g., daily, monthly, etc.); and (4) generates corresponding bootstrapped estimates of production precision. Eventually, these production estimates will form the basis of statistically powerful analyses of juvenile salmon status and trends.

The data stored in the RST Platform will serve as a fundamental source of high-quality, standardized juvenile salmon data as the Framework and its associated decision support model are validated and evolve.

Keywords: Chinook salmon, rotary screw trap, adaptive management, structured decision making
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A Structured Adaptive Approach to Prioritizing Chinook Salmon Conservation and Restoration

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Central Valley Project Improvement Act Fisheries Program used a structured decision making approach to develop a framework to allow decision-makers to identify program objectives and guide planning of broad scale fisheries activities. Using a rapid prototyping process, program stakeholders developed a coarse resolution Chinook Salmon (*Oncorhynchus tshawytscha*) model and parameterized it using a combination of expert judgment and empirical data. The coarse resolution decision support model (DSM) was built to evaluate the relative effectiveness of restoration and conservation activities across broad geographical areas. The intent is to use the DSM to identify activities and watersheds where management actions have the greatest likelihood of achieving population objectives. Evaluations of the model via sensitivity analyses indicated that it required significant refinement and improved estimates of model parameters and inputs. Here we discuss the coarse resolution fall run Chinook Salmon model and the revisions by the science integration team. We then illustrate the uses of the model for identifying fall Chinook Salmon restoration and conservation priorities using simulation and dynamic optimization.

Keywords: *Oncorhynchus tshawytscha*, restoration, decision analysis
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Connecting Concepts to Numbers: Visualization to Support Shared Understanding and Decisions

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In support of CVPIA fish doubling goals, a Science Integration Team (SIT) works with disparate data across disciplines to link conceptual models to numerical models. The SITs efforts support expenditures for physical improvement projects and scientific studies to build knowledge. It is often difficult to develop shared understandings of data, physical processes, and / or conceptual relationships across complex teams. Further complicating efforts, summary reports are often time consuming to produce and consume, making shared understanding and decisions more difficult to support.

Analysts and designers supported SIT efforts through iterative development of data visualizations to help explain data inputs, sub-models, concepts, and model outputs. We connected many different sources of data directly to the models to help explain conceptual relationships affecting salmon populations. Visualizations of data and analyses facilitate rapid transfer of information about complex concepts. Individuals were able to test relationships within the models through direct interaction with the visualizations. This agile workflow allowed the SIT to review interim work product and fostered a more iterative approach to improving the models.

Visualizations allowed the SIT to quickly compare, contrast and understand competing hypotheses. Where model review and revision was previously taking several years, current revisions occur monthly. The result is faster model development and better understanding of model inputs and outputs. Over the next few months we will further develop this iterative approach in support of management alternatives.

Our primary finding was improvements in time - we were able to make decisions and advance understanding more quickly by using iterative modern visualization techniques. We believe that connecting data more directly to decisions is becoming more practical every day. If decisions can be made more quickly, with appropriate feedback loops, improvements to the Bay-Delta ecosystem are certainly possible, both in terms of robust scientific support, and defensible public policy.

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Lessons in Model Parameterization: Quantifying Floodplain Rearing Habitat for Juvenile Salmon in a Population Model

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Recent research has shown increased growth and survival of juvenile salmon on floodplains, resulting in a significant increase in activity around floodplain habitat restoration in the Central Valley. A 2014 Department of Water Resources (DWR) study quantified historical, existing, and required (to satisfy the "Doubling Goal) floodplain habitat area in all twenty six of the Central Valley Improvement Act (CVPIA) watersheds, and subsequently the CVPIA Decision Support Model (DSM) used these areas to parameterize a portion of the juvenile salmon rearing calculation in the model. Initial evaluations of CVPIA restoration actions have produced results that both support and conflict with widely held conceptual models regarding floodplain rearing habitat needs in the Central Valley. This presentation will summarize the development of floodplain areas in the CVPIA watersheds, use of these areas to parameterize the DSM model, and selected case studies highlighting where floodplain area is and is not limiting to salmon population improvement as represented in the DSM model.

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