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CALFED BAY-DELTA PROGRAM

Office Memorandum

Date: December 21, 1995

To: CALFED Staff

From: Michael Norris

Subject: Summary memo for Bay Delta Modeling Forum on Biological Models at the office of Contra Costa Water District in Concord on 12-12-95

I attended a Bay Delta Modeling Forum (BDMF) conference dealing with Biological Models on 12-12-95 at the office of Contra Costa Water District (CCWD) in Concord. This was the ninth of possibly a dozen workshops that will be conducted by BDMF. The conference was well attended and included Randy Brown from DWR as a guest speaker. Inclement weather prevented Lisa Lucas from Stanford University from attending and presenting her talk. An agenda and signup list are attached. There were no other handouts which was unlike the other BDMF forums. A roundtable discussion was conducted at the end although I did not stay for that part of the agenda. A summarization of the material presented by each speaker follows below.

1. **Wim Kimmerer, San Francisco State University (SFSU) / Romberg Tiburon Centers**

Kimmerer discussed the objectives of the workshop which are to describe the current status of biological modeling, clarify capabilities and limitations of biological models, and assess future possibilities. Kimmerer says the talk will focus on open-water systems and not on marshes and riparian zones which are another topic. Kimmerer prefers models with some predictive capability which is why theoretical models are not of much use to biologists. Models are useful because they can predict the consequence of a series of assumptions and allow one to reevaluate and revise assumptions. Alternative models are rarely tested which isn't so good according to Kimmerer who says it's actually best if ones model doesn't work at first so that the model developer can find out why. Models that work up front may not work under a different scenario. Kimmerer discussed management models which predict the consequence of management actions and give a best estimate of how a system will respond. Also, the use of models in management decisions is good because assumptions are made explicit as opposed to relying on expert opinion alone concerning the result of an action. Kimmerer discussed the difference between engineers and biologists who tend to work with mechanistic and empirical models, respectively. Hydrodynamic modeling was briefly discussed. Biological modeling as it applies to birth rate and death rate was discussed and an example was presented for the decline of Eurytemora Affinis (a copepod). Empirical biological models include the fish X-2 model and a model for the salmon smolt survival through the Delta and a striped bass young-of-the-year model. There are also population models (survival models for threatened species and stock-recruit models) and physical models with biological capabilities such as particle tracking capabilities.

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2. **Randy Brown, DWR**

Brown says we need models because its hard to make decisions about the Bay-Delta. Its easier for a manager to make a decision if a model supports that decision. An example is the closing of the Delta cross channel gates to help fish at certain times of the year which is decided by modeling. Conceptual models are important according to Brown. One should put down on paper what they think they know about a system and not just show someone equations from a model. Empirical models, such as the X-2 model, are important. According to Brown, the Delta Accord that was signed on December 15, 1994 has an X-2 component in it and it probably would not have been signed without it. Brown says "what-if" games are good for modelers and are important in helping managers make decisions. The development of a "life-cycle salmon model" is important. According to Brown, Jim Lecky from the National Marine Fisheries Service (NMFS) gets asked questions like "how important is 2% take at the pumps to ocean harvest of salmon" for example. If a life-cycle salmon model can be developed, the question can be easier to answer. Brown finished by saying we need to bring to the table what the limitations and assumptions of the models are. Often the biologists don't agree on a model so it is important to get buy-off on a model that someone develops.

3. **Sam Williamson, National Biological Survey, Fort Collins, Colorado**

Williamson discussed an "instream flow incremental methodology" modeling routine used for quantifying salmon pre-smolt production in the Trinity River. Williamson stresses knowing "premises", "purposes", and "products" before one models. The success or failure of smolt survival will be judged by the number of fry and pre-smolts "exiting the system" which is 28-miles from Claire Engle Reservoir and Lewiston Dam. The model uses a weekly time step and proceeds in progression from the "start" to "spawning" to "maturation/growth/graduation" to "mortality/continuous movement/super imposition" to "migration". Movement and mortality are still not well understood according to Williamson. Williamson notes the original purpose of the modeling was to do a "flow study" but this was changed as work proceeded to "writing an EIS". He objects to this and feels that the data is not good enough top support writing an environmental document. Williamson showed a graph of average weekly flow output of the Trinity during a year (historic and current) and notes that what is wanted from the model is a "desired output" that enhances the survival of the smolt. However, in spite of the work that has been done, Williamson says one can't reliably get that from the model yet.

4. **Loo Botsford, Dept Wildlife, Fish, and Conservation Biology, U.C. Davis**

Botsford discussed population modeling in the Central Valley and Columbia Watershed. Botsford discussed limitations of empirical models such as intra-series correlation which is the idea that one does not have as many degrees of freedom as one thinks. Botsford says that when computing correlations between two time series, if adjacent points are not independent, then the effective number of degrees of freedom in the series is less than the number of samples. If this goes uncorrected, a significant relationship will be identified more frequently than specified. Botsford says it is essential for one to compute the number of degrees of freedom (N*). Botsford then discussed mechanistic models and introduced the concept of combining empirical and mechanistic models since neither are perfect. Botsford discussed the modeling done for the Columbia River system where the Redfish Lake Sockeye, Snake River Fall Chinook, and the

Snake River Summer Chinook are endangered species. There are "population" and "fish passage" models developed for the system and these are refereed to as "paired models". Running the models can lead to different answers and Botsford was assigned to a committee where one had to look at the models and see why they ended up with different answers. As an example, one model will say that the declining chinook is due to the construction of dams over time and it's "paired" model will say it due to changing temperature trends. For the Central Valley Watershed, Botsford discussed Biosystem models, Hydrodynamic models, and Extinction models. Botsford worked mainly with the extinction model and is concerned with predicting when an endangered species can be "delisted" through modeling.

5. **Jim Cowan, University of Southern Alabama**

Cowan discussed striped bass, which were introduced into the Delta 120-years ago, and how his modeling looks at the numbers of "young-of-the-year" (YOY) and adult striped bass. Cowan discussed the "recruitment variability" of the striped bass and says it is due to "density independent environmental factors" (such as fishing, toxic materials and pollutants, exotics) that affect the mortality rates of YOY and adult striped bass and not to density dependent factors. Cowan investigated a correlation between declining YOY and the number of diversions on the system for baseline high and low flow scenarios of 20,000 and 5,000 cfs, respectively. An Individual Based Model (IBM) is used that tracks the life history of individuals, is sensitive to individual variability, and uses bioenergetic relationships. The model begins by one specifying the number of spawning females and then simulates the process in growth of mortality of individual YOY through the first year of life. After age 0, a leslie projection model based on adult population data are used to link years in multiple year runs. A 2-dimensional hypothesis particle tracking model transports individual particles on a basis of average channel velocity 3-dimensionally within the water column by deterministic and stochastic motions. The Particle Tracking Model (PTM) was used to determine the daily probability that a given "smart" particle in a given region would remain in that region, move to another region, or be entrained in an agricultural diversion. Model runs showed that, under high flow, a much higher fraction of larvae end up in the Bay (80% versus 30%) as opposed to low flow. Further, a seven fold increase in recruitment occurs for high flow with no diversions and exports compared to high flow with diversions and exports. Results indicated that a 50% decrease in diversions had little effect over baseline conditions but an 80% decrease in diversions did have a significant effect on increased female spawners. This bothered Cowan a little and it suggested some density-dependance whereas the model was run as density-independent. Also, an increase in zooplankton appears to correlate with the 80% reduction in diversions. Cowen summarized by saying that flow has a significant effect on recruitment variability and diversions negatively effect recruitment although neither factor alone is responsible for striped bass decline.

6. **Jim Quinn, U.C. Davis**

Quinn discussed how he and some graduate students ran a finite element model of the Sacramento River and Delta system. The model enables up to 10,000 fish particles to be run at ½ hour time steps. The model is an individually based model of striped bass eggs and larvae and the effects of temperature and salinity have been studied to date. Empirical equations are used to simulate particle movement of the "egg", "pre-larval", and "post-larval" stages of striped bass. Quinn showed charts of eggs being released along the Sacramento River and San Joaquin Rivers

and then tracking the movement of the eggs with time. The graphs even show some of the eggs being sucked into the project pumps. The model has been run for the years 1983 and 1984 and the results are being studied. One admitted deficiency in the model is that it treats the particles as "neutrally buoyant" which is true at the egg stage but not entirely true as the life cycle progresses. Some stages for example can hang around the bottoms of streams for awhile which the model does not simulate.

7. **Tom Powell, U.C. Berkeley**

Powell discussed his participation in the U.S. Global Ocean Ecosystem Dynamics (U.S. GLOBEC). The program has a $6.5 million annual budget and 15% of that goes into modeling. Most work in U.S. GLOBEC has occurred on the east coast. Areas studied include the Northwest Atlantic and Georges Bank, the latter of which has suffered significant economic damage from the fisheries being closed down. Studies are being done to see when the Georges Bank area can be reopened. Other studies include monsoonal studies in the Arabian Sea, the Southern Ocean, and a study of the California Current System which Powell hopes can begin soon. Powell briefly discussed declining fish stocks and presented an example of the Atlantic Cod which has gone up and down over the years. With respect to the California Current System, Powell says that future changes in global atmosphere and ocean will impact large and meso-scale physical processes and sardines can be expected to be impacted too.

8. **Wim Kimmerer, San Francisco State University (SFSU) / Romberg Tiburon Centers**

Kimmerer discussed the "fish X2 model" which is an example of an empirical model. X2 is defined as the distance from the Golden Gate inland to where the salinity is equal to 2 parts per thousand. The steps in empirical modeling were outlined such as an exploratory analysis that describes what it is one is modeling and what it is one is using as predictor variables. There are limits with empirical models. Data from water year 1972 may not be appropriate to use in an empirical model in 1995 but it may be alright to use in a mechanistic model where coding could be written to incorporate physical changes over time. X2 data can be scattered by "data outliers" and difficult to plot out on a straight line. Kimmerer noted a log transformation of a data set often results in the smoothing out of a graph including the outliers. Lengthy discussion was held about how to treat data outliers as it applied to the inclusion of X2 criteria in the Delta Accord. Kimmerer noted there are many variables related to X2 such as POC supply rate, Eurytemora and total copepod abundance, Neomysis abundance, crangon abundance index, starry flounder abundance index, longfin smelt abundance index, splittail abundance index, striped bass survival index and herring production.

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