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CALFED & S.F. ESTUARY PROJECT

MANAGEMENT Cues

STATE OF THE ESTUARY

2001 CONFERENCE & 2002 REPORT

News from the scientific arena that has direct relevance to critical questions and assumptions in the water management community.

YESTERDAY'S & TOMORROW'S MANAGEMENT QUESTIONS?

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Excerpted from his 2001 conference speech

Comparing today's with yesterday's Bay-Delta management issues and approaches, it is obvious that we have moved away from legislation and toward collaboration.

Looking back ten years ago, the major management issues presented in the S.F. Estuary Project's 1993 *Comprehensive Conservation and Management Plan* (CCMP) for the Bay and Delta included the decline of biological resources, pollutants, freshwater diversions and altered flow regimes, dredging and waterway modification, and intensified land use. The Estuary Project's 2000 *Report Card* on CCMP progress talks about wetlands, exotic species, watershed management, economic incentives for local government, runoff, estuary education, regional monitoring, and inflow standards. Comparing the two, one issue for which interest had receded by 2000 was dredging.

How were these issues addressed, in terms of management response? It is interesting to compare "pre-CCMP" and "post-CCMP" approaches to Estuary management over the past 36 years. Pre-CCMP events included the passing of the McAteer-Petris Act of 1965, the Porter-Cologne Act of 1969, the Federal Water Pollution Control Act of 1972, and the Basin Plan Revision of 1986, when we established pollution standards for the Bay. The Clean Water Act was reauthorized in 1987, which was when stormwater programs really came into play. The Central Valley Project Improvement Act was enacted in November 1992, and there were several new listings under the Endangered Species Act . The pre-CCMP period was dominated by legislation.

Post-CCMP, major events included the 1994 Bay Delta Accord; Prop 204, a billion dollar investment in the environment; the Baylands Ecosystem Habitat Goals Report (September 1999); and Prop 13, a $2 billion investment in water infrastructure and the environment approved in March 2000. In June 2000, CALFED set forth its framework for action, and the Record of Decision was established in August of 2000.

Managing the system is more than just slicing somebody's water allocation.

The CCMP was a turning point in how we do business. We have moved toward collaborative efforts and economic incentives and away from legislative mandates.

The most critical post-CCMP event was CALFED. CALFED's Science Program seems to be headed in the right direction. We're getting more and better science than ever. The Ecosystem Restoration Program has people thinking about how to develop projects, questions, and answers to those questions. The Environmental Water Account is an innovative tool to help manage water and conflict is another big step forward for the Bay-Delta system.

Taking CALFED to the next level will require implementation at the regional level, which means offering incentives for local governments. Projects do not get implemented by state and federal agencies, which are really just people who provide funding. We need to make sure there is a regional focus people can buy into. Some promising local developments offer good examples.

One is Santa Clara County's Measure B, which was on the ballot in November 2000. The Santa Clara Valley Water District had run out of money to do flood control, so it structured Measure B so as to also improve the functions and values of Santa Clara County streams. The measure passed by a two-thirds vote, the district working with stakeholders to come up with a package lots of people could support. Another promising effort is a recent Memorandum of Understanding on water quality attainment strategies signed by regional stormwater and wastewater agencies and the S.F Regional Water Quality Control Board. This MOU will help us make better decisions about pollution limits in the Bay.

No matter what strides we make in legislation and collaboration, geography and politics will always play a critical role in Estuary management. In my experiences with the Estuary Project and CALFED, there is a gap between Sacramento and the Bay Area. Sacramento people in government respond to Sacramento people in government. The Bay Area is "that thing down there." The Bay Area has to build stronger links with Sacramento and Southern California. Managing the system is more than just slicing somebody's allocation (Ritchie, SOE, 2001).

MORE INFO?
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INTRODUCTION

This document is a draft list of cues for resource and water managers suggested by the new science and research presented at the October 2001 State of the Estuary Conference in San Francisco. CALFED and the S.F. Estuary Project started this experiment by asking a handful of advisors to identify messages in conference presentations of relevance to water policymakers. These cues do not represent the direct recommendations of presenting scientists, but rather a first step toward making the essential leap from science to action and policy.

Readers are invited to submit comments and feedback on the cues, or new cues suggested by reading the State of the Estuary 2002 Report. Any revisions and additions to the cues will be made available to all interested parties upon request.

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ESTUARINE PHYSICS TERMS

Estuarine scientists use many terms to describe the complicated physical processes in estuaries, where freshwater from the rivers mixes with saltwater from the sea. The salinity of freshwater is 0 practical salinity units (psu) and the salinity of seawater is 35 psu.

The gravitational pull of the sun and moon generates tides with flood (landward) and ebb (seaward) currents. Tidal currents are strongest during full and new moons, called spring tides, and weakest during half moons, called neap tides. This sloshing back and forth is usually much greater than the tidally-averaged (residual) movement of water caused by river inflow or wind. Tidal and residual currents carry and mix (transport) salt, sediment, plankton, and other constituents. Saltwater is heavier than freshwater; therefore, saltier water tends to be near the bottom of estuaries. The difference in the amount of salinity between the top and bottom of the water column (stratification) can be great enough to prevent the top and bottom waters from mixing.

Salinity is greatest near the ocean and smallest near the rivers. This difference in longitudinal salinity (gradient) from the river to the ocean can cause the tidally-averaged currents to flow landward along the bottom and seaward along the surface (gravitational circulation). The null zone is the region in an estuary where the residual, near-bottom, landward current reverses and flows in the seaward direction as a result of river inflow. In many estuaries, the null zone contains an estuarine turbidity maximum (ETM) where suspended sediment concentrations (SSC) and turbidity are greatest (Schoellhamer, USGS).

X2

X2 is the distance, in kilometers, from the Golden Gate Bridge to the tidally averaged near-bed, 2-psu isohaline (a kind of "contour line" in the Estuary's waters where the salinity is 2 psu). A salinity standard established under the 1994 Bay-Delta Accord requires that between February and June fresh water flows be released from upstream in a way that maintains X2 within a range of positions in Suisun Bay associated with the abundance of aquatic organisms and some threatened and endangered fish.

CLIMATE CHANGE

Global and coastal climate change over the next 20-30 years will impact the timing of Sierra snowmelt and runoff, and associated water management. Related ocean warming and cooling phases may also affect species abundance.

- Major hydroclimatic changes will likely occur in the Estuary within the next 20-30 years. These near-term changes may combine climate variations witnessed both in the prehistoric past and in the last 100 years with projected greenhouse effects and other human influences on the global climate. These long-term variations have potentially significant implications for water management and endangered species restoration efforts.
- Global warming may affect ocean climate on several time scales, lasting from one to many decades. Thus the period considered by managers and scientists analyzing abundance trends in many estuarine living resources, or changes in community composition, is important. For coastal species that rear in the Estuary, abundance cycles may not repeat for 40-60 years, in concert with changes between cool and warm ocean phases that can last for 20-30 years. These broad-scale, and long-term oscillations can confound our ability to see the precise effects of management decisions, which are often made on the basis of much shorter timeframes. In addition, our understanding of past conditions may not allow us to predict future conditions or the full consequences of ecosystem restoration given large scale changes resulting from shifts in climate. Thus gathering feedback on if, and how, management actions affect abundance may take many decades, and require monitoring across several ocean cycles.
- Finding ways to sift out natural variability from the changes caused by humans is important. Upstream changes in the food web, shallow water habitat restoration, the establishment of numerous introduced species, and modifications of water storage and conveyance systems all cloud our ability to predict future changes in the ecosystem.
- Understanding the sources and magnitude of variability associated with climate change and proactively incorporating this understanding into future actions will be a major challenge for scientists and managers. New knowledge enabling us to see weather patterns like El Nino a year in advance, for example, offers us real opportunities to make more sophisticated day-to-day management decisions. Clearly, we can begin to define envelopes of time within which long-term changes are likely endure. It is the process of integrating system complexity and likely future scenarios into these "envelopes" that may prove tricky.

A long-term trend toward higher May average salinities, and the shift from spring to winter flows due to climate change, will affect freshwater management.

- Learning more precisely how X2 (see Estuarine Physics Terms p.3) is related to fish abundance and survival may allow us to use the trend of increasing May salinity to identify which estuarine processes are most likely to be stressed by climate change.
- The loss of the spring outflow peak may shift hydrodynamics at the Bay-Delta interface in a way that changes seasonal fish abundance and distribution patterns.
- Outflows from the Sacramento River into the Delta are currently managed to maintain fresh water near municipal drinking water intakes in the western Delta. A number of management actions designed to increase our capacity to maintain desired salinity levels are now being evaluated by the CALFED Bay-Delta Program. Including the long-term rise in May Delta salinity levels in probabilistic forecasts for water operations may provide a more robust context for evaluating changes in water management infrastructure over a longer time horizon.
- Resource managers are currently using interventions such as augmentations to spring-time river flow to support salmon emigration. These flow regimes are designed to more closely mimic historical patterns. However, the availability of reservoir water to support these activities may significantly change as warmer temperatures associated with global climate change result in a greater proportion of reservoir inflows arriving during winter as rain runoff rather than spring as snowmelt runoff.
- A shift from spring to winter flows has several implications for the way we currently manage outflows to meet the X2 standard. There are two sets of outflow requirements; the first is a minimum outflow standard (Collinsville); the second are X2 requirements at Chipps Island that are pegged to reservoir inflow rates between the months of February and June. A shift in flow timing will make the latter outflow requirements easier to meet, but will leave less water available in the storage system to meet the minimum outflow requirements later in the season. The combination of sea level rise AND the shift from spring to winter flows may make it even more difficult to meet current X2 requirements if the tidal prism pushes salt water further inland (for more info on X2 implications, see next page).
- From a broader perspective, high winter outflows and lower spring outflows will result in a lower yield to overall water operations in California which may require changes in the current flood control and water supply paradigm.

For more info on the science behind these cues, see the State of the Estuary 2002 *report: Dettinger, p. 19, Hieb p. 9, and Knowles, p. 38.*

X2 & ESTUARINE PROCESSES

Gaining a finer scale understanding of how water, sediment, salt and organisms move around and interact in the Suisun Bay region, and how local physical and biological processes work, can both broaden and focus the range of resource management options, including X2.

- Deeper understanding of water and particle movements in the Suisun Bay region imply that our previous assumptions about the mechanisms behind the X2 relationship with the abundance of specific fish species and estuarine food production relationship were too simple (see Estuarine Physics Terms p.3).
- New science suggests that though many (but not all) of the positive relationships between fish and X2 have continued since the 1994 Bay-Delta Accord, the mechanisms are probably more complex and species-specific than previously thought. These mechanisms may include the location of the low salinity zone, transport of eggs and larvae, food supply and turbidity.
- Untangling the web of complex physical processes to clarify which ones dominate sediment resuspension in different parts of Suisun Bay and other embayments may ultimately help predict both patterns of erosion and deposition and explain the transport of particles from one area to another. These processes are important for tidal marsh preservation and restoration and for tracking pollutant transport from contaminated areas to areas of less contamination. Such understanding also might help us manage those fish that stay with specific water masses.
- The foundation of our understanding of how many of the Estuary's biological and physical processes work, and how aquatic biota benefit from the low salinity environment, was once the "Entrapment Zone" conceptual model. Under this model a predominant entrapment zone (a localized area of substantial accumulation in suspended sediment and plankton) occurred at a bottom salinity of about 2 psu (see Terms). Managing outflows to position the low salinity zone adjacent to the broad, shallow waters of Suisun Bay was thought to maximize the ecological benefits of the entrapment zone. This conceptual model was a major underpinning of the X2 outflow standard.
- New science has led to a substantial revision of the entrapment zone conceptual model. Instead of a single, dominant entrapment zone associated with the low salinity field, this conceptual model suggests there are several potential locations for "maximum turbidity zones" (ETMs) mainly focused at locations where abrupt changes in bottom topography (sills) occur. These bottom features interact with the forces resulting from tidal water movement and freshwater outflow to create transient turbidity maxima. Thus, unlike other large estuaries such as Chesapeake Bay which are thought to have a single ETM associated with X2, the northern S.F. Bay Estuary has a sequence of ETMs associated with sills and X2.
- The ecological significance of the new entrapment zone and circulation model, for freshwater management and X2, is still being explored. But from management perspective, the mechanistic meaning of X2 is more complicated than previously thought.
- New science and recent flows management experiences suggest several things for managers to consider. First, the relationships between X2 and certain aquatic species is largely unchanged by recent data, and thus the empirical basis for an X2/outflow standard is still intact. However, as we learn in more detail about "mechanisms" it may be possible to manage individual species with specific targeted actions, rather than through coarse, large scale X2 manipulations. Second, new measurements of Delta outflows in recent years have identified a big uncertainty relevant to the current X2 accounting mechanism. Real-time USGS measurements of Delta outflow suggest the calculated daily index is off by 10s of 1,000s of cubic feet per second over the neap-spring tidal scale. X2 is currently pegged to 3-day, calculated outflows. One potential way to reconnect X2 accounting with actual flows is to use a 14-day running average to span the variability associated with the neap-spring tidal cycle. In addition, any estuarine eco-performance evaluation should be based on measured, rather than calculated, outflows.
- Recent gaming and operational experience examining X2 and requirements for import-export ratios and Delta cross channel closures suggest that all have similar effects on water allocations, thus slight refinements in X2 alone are not likely to lead to significant changes in water accounting. This is not to say that refinements will not be important as they accumulate over time; but biological effects might be hard to detect, and small changes in water allocation might increasingly lead to points of conflict as we push the system closer to its limits.
- Further research and integration of results should soon provide much more detailed information for water and resource managers about which outflow processes support which fish and why, and which estuarine processes are more vulnerable than others to different flow scenarios, and to inter-annual variability.

For more info on the science behind these cues, see the State of the Estuary 2002 *report: Knowles p. 38, Burau p. 39, Schoellhamer p. 41, Jaffe p. 42, and Kimmerer p. 46.*

RESTORATION OF HABITATS & PROCESSES

Watershed protection programs work.

- Watersheds have responded positively to collective actions on the East Coast, which instead of focusing on a single stream section or problem offer a combination of people-oriented programs, science elements to describe and analyze systems, and government regulatory and land use planning efforts. Such coordinated efforts may be a useful action template for improving the health of San Francisco Estuary watersheds.

River functions and fish life histories are more complex than previously thought, and require adaptive, ecosystem-scale restoration approaches and management.

- Recent science suggests that the connection between river and floodplain is critical to restoration success. One potential implication is that small scale, isolated lowland river projects may not make much difference in the health of salmon and other target species. Opportunities for targeting actions that re-establish channel and floodplain connections include reoperation of the Central Valley's flood control and water supply system and large scale, soft engineering approaches to river management in upper watersheds.
- New science suggests that salmon have much more complex lifecycles and are more opportunistic in using a diverse array of habitats than previously thought. Such insights can enhance our ability to manage salmonid populations and implement effective restoration actions by expanding our focus beyond bottlenecks to salmon movement, and production-driven monitoring of populations.
- Chaotic events, such as floods and ongoing system alterations such as dredging and mitigation projects, offer opportunities for restoration. Institutional flexibility would allow us to take advantage of such opportunities.
- Adaptive management, namely analyzing whether actions and investments are actually reaching restoration goals, remains critical but challenging to implement. Such management may include monitoring at all stages of a project, analysis of the monitoring data, changing or discontinuing practices that do not fulfill objectives, and recreating the institutional structure so it can respond to such feedback. One benefit of CALFED's adaptive management framework is to acknowledge uncertainty. Adaptive management is a tool that could also allow us to conduct experiments, and develop techniques and expertise as we implement restoration. The challenge for managers is to apply this framework to a large-scale program, and to develop studies, tasks and decision milestones that enable managers to change previously agreed-upon restoration strategies. CALFED's Ecosystem Restoration Program may require a landscape level scale strategy to account for the performance of the projects funded to date and to guide future efforts.

Successful Bay wetland restoration may require long-term commitments to infrastructure management and maintenance, and to invasive species control.

- Prior experiences in acquiring and attempting to manage and restore North Bay salt ponds suggest that managing the infrastructure (levees, tide gates and other flood control and water facilities), and having the staff and financial resources to undertake this management in the long term, is a key part of restoration. Lessons learned here can help inform planned restoration of 16,000 acres of South Bay salt ponds recently acquired by the federal and state governments from Cargill.
- Recent Bay wetland surveys suggest that it is doubtful whether tidal marsh restoration objectives can be achieved for a wide range of endangered and other native species if wetland habitat trends continue to progress towards Atlantic-type marsh structure and vegetation patterns (due to the invasion by Atlantic smooth cordgrass). Analysis shows that tidal marsh restoration without adequate control of invasives may threaten rather than promote recovery of endangered species. Management may require a sustained commitment to long-term regional eradication planning and programs for smooth cordgrass and for other infrequent non-native cordgrasses in the Estuary, and possibly for broadleaf pepperweed.

The sediment supply for Bay-Delta restoration is limited.

- There are currently a large number of tidal marsh restoration and preservation activities planned and underway. These marshes depend on a balance between sediment deposition and erosion. A simple estimate of that balance suggests that the system is not in equilibrium, that the supply of sediments to marsh environments may not be stable, and that the accumulation of sediment in one wetland may reduce the sediment available to, or even rob sediment from, another wetland.
- Studies of tidal and shallow water habitat restoration confirm that large-scale restoration in both the Bay and Delta may be constrained by the small sediment supply. From a management perspective, this means that managing mud may become as important as managing toxics and exotics, and that sediment can no longer be considered a nuisance, but a valuable resource. Actions impacting sediment dynamics like dredging, hardening levees, tidal restoration, or airport fills can have significant long-term impacts on estuarine habitat
- Recent sediment erosion and deposition science, and projected sea level changes, confirm that the Estuary is a dynamic, evolving physical system whose habitats will be changing with or without human intervention. Restoration goals and priorities may need to be revisited to match the habitats we want to restore with those that physical processes will actually sustain in the Estuary of the future. This may mean we refocus on restoring our diminishing intertidal mudflats, or give higher priority to allowing marshes to expand inland. Goals and expectations for CALFED's and the S.F. Joint Venture's regional ecosystem restoration plans may need to be revised to take into account the sediment deficit in the entire watershed, and consider new priorities based on where restoration is most likely to succeed, and over what time period. The recent priority on restoring shallow water habitat in the Delta to benefit fish, for example, may need to be revised based on new science indicating long time lines for restoration, and promotion of invasive species as a result of such projects.
- The gap between the long-time frame necessary for many subsided sites in the Bay and Delta to return to vegetated wetlands and the short-time frame of most public policy and investment in restoration efforts may need to be addressed through education, and longer-term financial planning. Prioritization of restoration investments might benefit from considering the feasibility of accumulating enough sediment to achieve stated goals.

For more info on the science behind these cues, see the State of the Estuary 2002 *report: Schueler p. 54, Mount p. 27, Brown p. 31, Cavallo p. 29, Reed p. 32, Siegel p. 59, Baye p. 62, Williams p. 22, and Jaffe p. 42.*

CONTAMINANTS

Understanding contaminant accumulation patterns and processes can help refine management strategies.

- Pollutants in the Estuary are currently managed on the basis of concentrations in water, organisms, and sediment. Combining long-term physical and biological monitoring information can help unravel the connections between source of trace metals, the biological and physical processes that control their uptake, and highlight where load management strategies could be focused.
- New science suggests that bioaccumulation patterns and physiological effects of contaminants vary from one contaminant to another. These differences can be used to refine management strategies, support development of site-specific water quality objectives, and refine water quality assessments. Such work, in combination with physical process monitoring and research, demonstrates that researchers can separate out natural from human influences on estuarine contamination.
- Studies show that introduced species such as the Asian clam *Potamocorbula amurensis* may not only impact the ecology of a system, but may also change contaminant dynamics. Selenium concentrations in clam-based predators suggest that Dungeness crab, white sturgeon and splittail are potentially at risk for reproductive toxicity. Selenium remains an important Bay-Delta management challenge.
- Food webs play an important role in the degree and extent of bioaccumulation and can help explain the difference in body burden observed in different species. Investigating the food web-contaminant pathways in detail for pollutants of concern in the Estuary can help distinguish between different causal factors.

Mercury methylation could be a useful tool for managing ongoing ecological threats from the region's mercury legacy.

- Mercury remains a red-letter contaminant with major impacts on the health of the Bay-Delta ecosystem, it's fish, the people who eat locally-caught seafood, and wetland and shallow water habitat restoration efforts.
- New science indicates that significant amounts of mercury-contaminated hydraulic mining debris still remain both in the main bodies of San Pablo and Suisun Bays, and along their margins. There is a higher likelihood of buried mercury being reintroduced into the estuarine food web via tidal marshes constructed from or situated on this debris. Those choosing between restoration locations should consider mercury in any risk management strategy.
- Studies of the pattern of deposition and erosion of hydraulic mining debris suggest that contaminated sediment will remain in the system for several hundred years and that the erosion of deposits can remobilize and redistribute these debris from embayment to embayment. The system response to such historical inputs may mask the response to smaller, more recent inputs, from other sources.
- The discharge of mercury into San Francisco Bay is currently managed on the basis of mercury concentrations in water and fish. Though levels of mercury in fish tissue is the current trigger for regulatory action, methyl mercury could be a useful tool for predicting bioaccumulation potential. The focus should be not just regulating a pollutant, but managing a form of a pollutant — methyl mercury — which is much more bioavailable than other forms in the ecosystem. Efficient management may mean making clearer links between mercury methylation and different sources and compartments in the environment. The management answer still lies in best attainable technologies; pollution prevention; watershed restoration at mine sites; and baylands management, but priorities might shift in relation to the methylation outlook.

Piling materials can impact herring reproduction.

- Among the human activities that influence successful herring reproduction, contaminant impacts are more obvious than the impact of freshwater diversions and associated salinity fluctuations. New science suggests that tar creosote pilings often used as spawning substrates by herring result in extremely low survival rates in herring embryos. Replacing old pilings, or requiring new pilings of PVC or other materials, could have a significant positive effect on the future success of herring in the Bay system, and thus on commercial fishing prospects.

Earthquakes may cause levee failures and impact drinking water quality.

- Monitoring suggests a 60-70% chance of a magnitude 6.7 magnitude or greater earthquake in the Estuary region by the year 2030 and, as we emerge from the 1906 stress shadow, a return to the days when a magnitude 6 or greater quake occurred every four years. Such quakes could cause multiple levee breaks that will be extremely difficult to repair, or may be irreparable if an entire island is flooded by water. Any massive levee failure could increase the size of the tidal prism and pull seawater further inland, impacting drinking water intakes. Risk assessments that include these changing probabilities of earthquakes can provide a more detailed way of comparing the costs and benefits of different levee management options.
- The Bay Area Economic Forum, an umbrella group of local government, business, labor and education representatives, recently reported potential economic losses of more than $28 billion in the region if the Hetch Hetchy water system breaks during a major earthquake. Such a failure could have a major impact on water management in the Bay and Delta.

For more info on the science behind these cues, see the State of the Estuary 2002 *report: see Brown p. 43, Stewart p. 45, Jaffe p. 42, Abu-Saba p. 68, Cherr p. 68, Anderson p. 30, and Zoback p. 20.*