Design Principles for a Sustainable Ecosystem in the Bay-Delta

Ideas for Discussion

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Introduction:

According to the draft Delta Vision and as required by Executive Order S-17-06, the Blue Ribbon Task Force (TF) is responsible to: “develop a durable vision for sustainable management of the Delta” that can “restore and maintain identified functions and values that are determined to be important to the environmental quality of the Delta and the economic and social well being of the people of the state.”

The purpose of this paper is to outline design principles for a sustainable ecosystem in the Bay-Delta. It draws from the ecological principles that I submitted earlier to the TF but also from ideas outlined in the draft Vision, the excellent work of the Stakeholder Coordination Group (SCG) and various external Visions submitted to the TF. Unavoidably, it is also a reflection of my own experience and biases with regard to water and environmental management.

The draft vision ends with a set of design principles. I think this is a good way to organize the framework for a sustainable ecosystem. Designing a functioning ecosystem is in many ways analogous to designing a house. The number, size and arrangement of rooms is important in terms of how well the house will function for different purposes. In a similar way, the number, size and arrangement of habitat patches in the Bay-Delta ecosystem is important to how it will function. Local surroundings and the potential for flows of people and materials to and from the house affect its design and efficiency. The Bay-Delta is also affected by its location and its relationship with surrounding ecosystems. Finally, one can't really know how good the design of a house is until it is built. For the same reasons, we will not know how well we have understood ecosystem design until we have built it. The design principles I will propose are different from the principles in the draft vision but are intended to serve the same purpose - to stimulate and guide thinking about a sustainable ecosystem. In setting down the design principles, I will attempt to show how they might work "on the ground" by relating them to the vision produced by the SCG.

The Problem of a Sustainable Ecosystem:

Before specifying design principles, however, I need to be clear about what I mean by the terms "ecosystem" and "sustainable" and to say why I think developing a vision for a sustainable ecosystem is extremely difficult in practice.

In my view, the ecosystem of the Delta includes the human economy and society of the Delta. I think most of those participating in the Vision exercise accept this inclusive definition in the conceptual sense, but have still not fully integrated it into their thinking and planning. We tend frequently to slip into talking (and, therefore, thinking) about ecosystem as separate from economy/society. For example, when the eco-design team met recently they explicitly decided not to integrate economy and society into their thinking about ecosystem design. There are probably lots of reasons for the difficulty we have with the inclusive concept; ecology grew up as the science of the non-human world, the language we have to describe ecosystem and environment developed with the separation of humans from the natural world in mind, and so on. But the concept of sustainability is based on the integration of environment, economy and society so, if we are to have a sustainable vision it must address the integration. When I refer to ecosystem in this memo, therefore, I mean the system inclusive of the human economy and society.

Much has been written about sustainability and the integration of economy, society and environment. But what does that really mean in practice? Here are the conditions that I believe the system must satisfy if it is to be sustainable:

An economy that provides a reasonable standard of living to the majority of those who participate in it without degrading natural capital or unreasonably disenfranchising vulnerable components of society;

An environment that retains or increases its natural capital, which underlies its capacity to deliver a broad spectrum of market and non-market services to human society and economy; and,

A system of governance that supports economy and environment and is satisfactory to the majority of society.

I doubt that these conditions for sustainability will be universally acceptable to participants in the Vision process. However, neither the draft vision nor the visions produced by the SCG gave a specific definition of what was meant by sustainability, although both used the term frequently (23 times in the SCG vision document and 11 times in the draft vision if one counts "unsustainable" and "not sustainable"). Perhaps the failure to define what was meant by sustainable was strategic, but the lack of a definition points up the fact that defining a sustainable system is a wicked problem (Rittel and Webber 1973). Wicked problems are large in scale, socially and economically significant and transcend the established institutional design for problem solving. Particular aspects of wicked problems relevant to the design of a sustainable ecosystem include:

1. The problem involves an evolving set of interlocking issues and constraints. There is no definitive formulation of "the" problem;
2. Since there is no definitive definition of the problem there is also no definitive solution. Indeed, solution and problem are intimately related in that each particular solution defines the problem in a particular way;
3. Solutions are not right or wrong only better or worse;
4. Experience with other, analogous, problems may not be relevant;
5. Potential solutions are typically costly and frequently irreversible;
6. There is no immediate or ultimate test of a solution. All solutions have waves of consequences and it is impossible to know how all will play out;
7. The perception of the problem and its causes differ dramatically among interests.

Problems with these characteristics are difficult not only for policy makers but also for science because every potential solution involves multiple and often conflicting hypotheses. For wicked problems, science can offer useful insight and information but not solutions. Agreement about the problem to be tackled and potential solutions to be implemented requires debate and negotiation among powerful interests. In this sense, the SCG process has been both essential and fruitful with two "workable" visions. Furthermore, once a solution is implemented, waves of consequences begin to change the system and the problem so that new negotiations to search out new solutions are needed. This means a linear "Problem - Analysis - Solution" approach cannot be used. Rather, an iterative approach that cycles among tentative conceptualizations of the problem, provisional solutions, and relevant analyses linking the two in an adaptive and staged program of implementation is needed. Furthermore, all the key interests need to participate in this process. The SCG appears to have recognized this need and proposed a staged, adaptive implementation of various elements of their vision.

If the ecosystem can be made resilient, as suggested in the draft vision, then the time frame over which the ecosystem will deliver a desired suite of services can be extended. However, as resilience theory points out, all ecosystems go through a four stage cycle of change: growth/accumulation, conservation/asset protection, release/collapse, and reorganization. For a resilient system, the first two phases, which are the ones that appear most stable and productive in terms of human uses, can last a long time. Eventually, however, there will be a collapse and reorganization. Policy makers need to be alert to this inevitability to be able to manage and guide the release and reorganization. Attempting to hold the system for too long in a particular configuration, when all the evidence suggests it cannot remain there, can result in an unmanageable collapse. At this point in time, the Delta ecosystem appears to be in a particularly fragile state. The challenge is to manage fairly dramatic change and steer the system toward an ecosystem that is more robust and more resilient than at present. This is a particularly difficult challenge for science and management. The fact that the law requires that certain elements of the system be sustained makes the management problem that much more difficult.

The brief discussion above should suffice to demonstrate that ecosystems are changing and evolving entities that respond in complex ways to management intervention and for which sustainability is elusive. In the case of the Delta, uncontrolled drivers of change (sea level rise, changing hydrology, subsidence, earthquake, population growth, species invasion) push the ecosystem in particular directions, further emphasizing the importance of change, undermining resilience, and complicating any conceptualization of a sustainable ecosystem.

Guidance From the Draft and SCG Visions and its Implications:

The difficulty of the task notwithstanding, the TF and the SCG have offered some ideas about what they would like to see included in a sustainable ecosystem. The draft vision gives equal weight to maintenance of the water system and the ecosystem (sensu non-human system I presume) and elevates these above all other system attributes. The draft vision also highlights the Delta as a unique place valued for its beauty, regional economy and regional culture. In general, the SCG recognizes the same values although without placing any priority on a particular value or service. The inevitable conclusion from reading both documents is that the TF and the SCG envision a future Delta that looks, physically, a lot like the Delta of today but sustained by some changes in habitat and hydrology and with a more isolated system for conveying Sacramento River water to the export pumps. Although this way of visioning the future likely reflects the "realities" of the present situation, it seems unlikely that the Delta will remain much as it is today over the next century or even half century. Consider how much the Delta has changed in the past

100 years and then contemplate a 3-6 ft rise in sea level coupled with a more unpredictable flood stage to get an idea of how much change might have to occur over the next 100 years. What the PPIC report (Lund et al. 2007) and other recent analyses have highlighted is that we have entered a period of rapid and potentially catastrophic change (perhaps the collapse/release stage of the resilience cycle?). The challenge, as I noted above, is to manage the consequences of change so that the Delta continues to deliver a broad spectrum of market and non-market services - but not necessarily the same services as today. This last point is central to my thesis, the delta of the future can be productive of a broad spectrum of market and non-market services, it can be beautiful and desirable, but it may not deliver the same services as today.

Although both TF and SCG visions include many insightful and creative ideas about how to improve conditions in the Delta, both, particularly the SCG vision because it is more specific about actions to be taken, also provide a medium term vision at best. This is because the wicked nature of the problem precludes analysis far into the future. As preliminary actions are taken (the "no regrets" actions of the SCG, for example) the nature of the problem will change and new ways of conceiving and articulating solutions will be needed. Taking action to improve water conveyance will have even bigger waves of consequences for which solutions will need to be negotiated. Rising sea level, changing precipitation patterns, and rising temperatures seem likely to create cross-cutting waves of change. My point is not to discourage tackling the big problems, only to emphasize that there is no unique, long lasting solution to the ills of the Delta, no self-sustaining solution that would guarantee any particular set of valued ecosystem services. Managing the Delta ecosystem, regardless of whether one adopts an inclusive or more restricted definition of ecosystem, will be an ongoing task and the objectives of management will need to change and adapt as the Delta changes.

Ecosystem Design Principles:

Keeping in mind the wicked nature of the problem and the fact that the physical template of the Delta/estuary will be changing over time, I offer the following tentative ecological design principles. Although I embrace the inclusive definition of ecosystem, the principles address attributes of the environment much more than economy or society. This is because I am not professionally competent to fully integrate all three but also because what to do about the environment component of the sustainability triad seems to be a primary concern. For example, the SCG identified a need to:

> "Identify the desired characteristics (species, habitat, etc.) of a sustainable Delta ecosystem, and the changes in water inflows, outflows and in-Delta circulation needed to support that ecosystem (consistent with other beneficial uses)." (SCG 2007, 9)

The design principles outlined below are intended to give guidance to ensuring a productive, healthy ecosystem that provides a broad spectrum of market and non-market ecological services to enrich human economy and society. These measures will not guarantee the long-term survival of any particular species or ecological service. In my view, however, they provide the best chance of maintaining a high proportion of currently valued services into the foreseeable future.

Principle 1: The Bay-Delta is not an island

The Bay-Delta is an estuary. Ecologically, it is an ecotone that connects river to ocean, land to water, local to regional economy, and so forth. What happens or is happening outside the Bay-Delta has important implications for what is possible inside the Bay-Delta. Ecological design for the Bay-Delta cannot occur independently of structures and events upstream and in the ocean, in the regional and state economies and in the wider governance context. This would be true of any regional ecosystem. Estuaries, however, are even more strongly connected to adjacent ecosystems in the landscape, connected by their rivers to the watershed and by their tides to the coastal ocean and by both to their marginal lands.

As an ecosystem, the estuary of the Bay-Delta is a "patch" within the larger geography of the Sierras, Central Valley, Coast Range, and coastal ocean. The Bay-Delta ecosystem exchanges materials, energy and organisms with this larger landscape and these exchanges are very important for some communities and species in the estuary. The design of the ecosystem has important implications for the nature and rate of these exchanges. Levees and channelizaton, for example, change dramatically the movement of water, sediment, toxic substances, and organisms through the estuary. Patterns of both river flow and tidal flow are affected. Although listed species are not a particular focus of this paper, it is appropriate to note that a number of species of concern are known to depend on the connections between the Delta and surrounding ecosystems (e.g., green sturgeon, Chinook salmon, steelhead, Swainson's hawk, longfin smelt, and others).

The major implication of this design principle is that it is not sufficient simply to consider design issues within the Bay-Delta. The Delta has to connect effectively with ecosystems outside the Bay-Delta. In practical terms this means corridors that allow free access for river flow, tidal flow, organisms and materials across the boundaries of the Bay-Delta system. But open corridors alone may not be sufficient. The manmade geometry of Delta channels encourages strong mixing and circular flow around islands, which tends to homogenize water conditions throughout the Delta. In the historic estuary, many channels were blind ending and had a dentritic form. Tidal forcing moved water in and out of these channels, creating a heterogeneous aquatic environment and providing many points of contact between channel and marsh.

The large scale exchanges between the estuary and the larger landscape also mean that the functioning of the ecosystems upstream and downstream has important implications for what happens in the Bay-Delta. The SCG vision recognizes this connection in its emphasis on the impact of water management decisions upstream on ecosystem processes and options for management within the Bay-Delta and through its acknowledgement of the risks of a too heavy dependence on the Delta as the principal water source for most of California. However, their emphasis was on managing and influencing the flow of water and water is not the only important material exchanged along the river channels. Sediment, nutrients, toxic substances are also delivered to the Bay-Delta primarily along the river channels. Furthermore, exchange along the river channels is only a part of the exchanges affecting the Bay-Delta ecosystem. Equally important are terrestrial connections, and these are seldom highlighted in discussions of the Bay-Delta ecosystem. To ensure effective exchange of materials, energy and organisms between upland and estuary there need to be broad open corridors of connection at various places around the Delta. Urban expansion has closed off some opportunities for exchange, however, substantial corridors still exist along the Napa and Sonoma rivers, above Suisun Marsh and Cache Slough, including Cache Creek, along the Yolo bypass, up the Cosumnes and Mokolumne rivers, and along the lower San-Joaquin. To the extent possible these corridors should be protected as green space or, at least, low density residential. Existing green belts in urban areas (e.g., American River Parkway) should be examined to determine if they can be expanded or extended to create secondary habitat corridors through existing urban development. Some of these corridors will be particularly important as sea level rises, as they will allow up-slope movement of marginal wetlands.

Although urban development is the most serious land use disconnecting Bay-Delta habitats from upland habitats, roads, highways and service corridors can also impose significant barriers to movement of organisms, materials and energy between the Bay-Delta and upland areas (upstream areas too if culverts are poorly designed). Even if green space corridors are maintained to provide upland connectivity, these will inevitably be transected by highway and utility corridors. Connectivity through these barriers could be improved by raising portions of them on open causeways.

Principle 2: The habitat mosaic of the Bay-Delta is a determinant of its overall performance

Just as the Bay-Delta estuary is part of a larger landscape mosaic so is the Bay-Delta made up of a patchwork of different kinds of habitats that can be described in terms of land use (urban, agricultural, tidal wetland, park, utility corridor, etc.) or water mass characteristic (freshwater, low salinity, marine, bay, channel, shallow water, etc.). As I noted in the eco-context memo, the size and arrangement of habitat patches in the Bay-Delta has important implications for its ability to deliver ecosystem services. The current mosaic appears not to be optimal in terms of its ability to deliver certain desired services, such as healthy populations of pelagic fishes. Furthermore, trends in the mosaic (e.g., conversion of agricultural land to urban land, further subsidence of Delta islands, changing Delta hydrology) will certainly change the capacity of the system to deliver services and could make the imbalance of services worse.

The major implication of this principle is that the habitat mosaic is extremely important to the capacity of the system to deliver desired services and it needs to be designed with care. All of the external visions, including the SCG vision, propose changes in the existing habitat mosaic. In most cases, the proposed changes increase the area of habitat that can deliver non-market services (in some cases together with market services) and marginally decrease the area that actually or potentially delivers primarily market services. The SCG, for example, proposes substantial increases in freshwater and tidal marshes, establishment of new flood bypasses that can provide both agriculture and wildlife habitat, and promoting agricultural practices in heavily subsided islands that will halt or reverse subsidence. In so far as I can judge, the habitat proposals in the SCG vision are all worth pursuing. Increasing the area of seasonal or tidal wetland will have broad ecological benefits. However, I believe more needs to be done in terms of restructuring the habitat mosaic of the Bay-Delta. In particular I would like to see:

1. A stronger commitment to smart growth principles in urban planning for the communities surrounding the Delta with particular emphasis on: hardening urban boundaries so as to prevent any further encroachment into the primary zone; preventing development in the

most flood vulnerable areas of the secondary zone; limiting development in other parts of the secondary zone to low density; and directing any further expansion of urban footprint away from the Delta.

2. A more aggressive program of soil rebuilding in subsided islands of the western and central Delta. Techniques for accomplishing this are experimental and controversial so a variety of approaches needs to be tested, taking advantage of secondary benefits where possible, such as carbon sequestration, provision of water fowl and wildlife habitat, reducing risks of catastrophic levee failure (through flooding all or parts of certain islands), and so forth.

3. Deliberate experimentation with channel barriers and other techniques to reduce homogeneity of open water habitats in western and, perhaps, parts of the central delta (after appropriate hydrological modeling) to assess the potential to create greater heterogeneity of open water habitats and its consequences for valued fish species.

4. Greater emphasis on reducing the transfer of toxic substances from human dominated patches (e.g., urban, agriculture, industrial, transportation corridors) to all habitats.

In designing changes to the habitat mosaic, the aggregate plus outliers model provides a useful compromise between the advantages of large patch size and multiple patches to provide flexibility and security. The SCG vision captures this reasonably well for some kinds of aquatic and wetland habitats in its (presumably opportunistic) location of large floodplain and tidal marsh patches with smaller patches scattered in between. Similar attention needs to be given to purely terrestrial species like Lange's metalmark butterfly and Antioch dunes evening primrose, for which the available habitat is restricted to a single small remnant area of dunes.

As suggested earlier, exchanges between habitat patches are an important part of ecological function. We are very aware of this in terms of urban design and the way the human economy functions. Exchanges between habitat patches in the Bay-Delta ecosystem are no less important. Among other important exchanges, tidal and seasonal inundation of marginal wetlands contributes to the productivity and functioning of both the wetland and the adjacent water. Isolating these two kinds of habitat with a levee reduces the productive capacity of both. Other exchanges that result from human domination of the landscape are less beneficial. Sewage, storm water and industrial discharges from urban areas, agricultural run off, and highway run off deliver nutrients and toxic substances to adjacent habitat patches. Reducing these discharges and their impacts will be important to sustaining the capacity of the Bay-Delta to deliver environmental services.

<u>Principle 3: For the wet parts of the ecosystem, flow is a main driver of the physical template for the biotic community.</u>

Average flow, seasonal variation in flow and annual variation in flow are all important to the way the ecosystem functions. Flow in estuaries is of particular importance because of its effects on circulation, stratification and nutrient supply. Estuaries are characterized by two layer flow in which low salinity water moves seaward at the surface causing a compensating landward flow of high salinity water at depth. This conveyor belt circulation helps to replenish nutrients in the estuary. Rivers also deliver nutrients and other materials to their deltas where these substances are captured and contribute to the generally high biological productivity of the delta and estuary. The life cycles of estuarine species are often cued by seasonal variation in flows. Temporal variation in flows (tidal, seasonal, annual) also drive many patterns of exchange between land and water in an estuary. All of these ecological processes are disrupted by human uses of the water and land.

Conflicts in the Bay-Delta frequently center on flow as there is a direct conflict between human and environmental uses. Unfortunately, there is relatively little solid science on which to base a Delta flow regime. For some pelagic fish species there is a relationship between Delta outflow and abundance. However, in recent years this relationship appears to be breaking down or changing, so that it is a less firm basis for decisions about flow in relation to conservation of particular species. There is also a relationship between reversal of net flows in Old and Middle Rivers and entrainment of some species at the export pumps. In other estuaries, abundance of harvested species has been linked to high river discharge. Beyond these general empirical relationships, however, there is little science to guide decisions about conservation flows.

In the absence of good models of the relationship between flow and ecosystem function in estuaries, analysts have borrowed concepts from flow management in rivers. Unfortunately, concepts and models relating ecosystem function to flow in rivers is also a matter of debate. In my view, however, both theory and evidence show that there is no surplus water as far as the environment is concerned. Small amounts of flow can be diverted for out of channel purposes without measurable effect. However, as diversions increase impacts become progressively more severe. At high rates of diversion, changes in the ecosystem are likely to be quite large but further diversions may have only a small marginal effect. Thus, if one does not begin to study the effect of flow until after hydrology has been greatly altered, it can be difficult to say how important flow is. In the Bay-Delta, average flows into and through the estuary have been greatly reduced and their seasonal pattern changed dramatically. For native species whose life history is linked to flow and flow variation, productivity has likely been affected.

My point is not to argue that exports must be cut dramatically to achieve conservation in the Bay-Delta. Rather, it is to emphasize that there is no free lunch as far as flow is concerned; ecologically there is no such thing as water flowing wasted to the sea. All flow alterations have environmental consequences. Some kinds of flow alterations are more serious than others. In the Delta, furthermore, levee construction has blocked important exchanges between land and water that were mediated largely through variations in river flow. Loss of these connections may have been as important for some species as changes in flow. In addition, species invasions continually alter food webs. Although proponents of environmental conservation argue for higher flows and a more natural hydrograph, I find it difficult to say with certainty how much benefit would derive from such a change in the Bay-Delta ecosystem, which has been changed in so many ways over the past century. As a design principle, therefore, flow and flow variation are known to be important to ecosystem function but what flows and seasonal patterns are needed to support environmental services in the Bay-Delta are uncertain. This is an area where adaptive experimentation would be beneficial.

Principle 4: Macrohabitat variables (e.g., toxicity, temperature, salinity, turbidity, nutrients, aridity, etc.) establish the capacity of the ecosystem to support certain species and provide certain services.

Macrohabitat variables are variables that take similar values over large parts of the ecosystem and, to a significant degree, determine whether the ecosystem can be inhabited by particular species. For terrestrial ecosystems, soils, climate and toxic chemicals are critical macrohabitat variables. For aquatic systems, temperature, salinity, nutrients, and toxic chemicals are important macrohabitat variables. Human uses of the environment can affect macrohabitat variables, particularly the delivery of toxic chemicals. With a few exceptions (e.g., selenium and mercury), the environmental effects of toxic chemicals has received insufficient study in the Bay-Delta. Enough is known to suggest that they could be having important consequences for particular species and for the ecosystem as a whole. A better characterization of sources and fates of a broad spectrum of chemicals from ammonia to pharmaceuticals and pesticides to trace metals is needed. TMDLs are being developed but this is a slow process. Precaution argues that we should not wait for a full characterization of the problem or substance by substance regulation before taking action to reduce loads to the Delta.

Climate change is also driving trends in temperature and salinity distribution in the Delta that will have profound effects on the ecosystem. The distribution of most species is temperature dependent and most aquatic species are sensitive to salinity. Both air and water temperature in the Bay-Delta are expected to increase by 2 degrees or more over the next several decades. This change is sufficient to make the Bay-Delta uninhabitable for some local species but also to make it potentially habitable for species from warmer regions. Critical habitats for some species will shift as a result of temperature change (and sea level rise) so that long range planning for the Bay-Delta needs to incorporate mechanisms to adapt to these changes. For local species, refugia may have to be located in cooler regions if species extinction is to be prevented. Conversely, the Bay-Delta may become a potential refuge for species from elsewhere that would otherwise go extinct. Conservation planning does not currently envision species relocation to conserve biodiversity but, as the biodiversity impacts of global warming become more evident, species relocation may become necessary. Regardless, global warming is going to change the biotic community of the Bay-Delta. The ecological vision needs to recognize these changes and be able to adjust to them.

Principle 5: Temporal variability and fine scale geographic variability are important aspects of healthy functioning ecosystems.

The patch structure of the Bay-Delta that I have discussed above represents coarse scale geographic variability in ecosystem structure. For many species finer scale geographic variation in habitat characteristics (such as salinity, temperature, turbidity) and temporal variation are important to their success. Because they are an ecotone between land, fresh water and ocean, estuaries can have particularly rich fine scale variability. The ways that human uses of the Bay-Delta have altered flow patterns, channel geometry, and connectivity with the floodplain has greatly reduced the natural variability of the Delta. One option for improving the capacity of the Bay-Delta to provide environmental services is to revitalize temporal and fine scale geographic variation in certain habitat characteristics. Proposals to do this have focused primarily on pelagic species, because that is where the greatest perceived conflicts are with water exports. However, all species are adapted to particular patterns of habitat variability and many respond dramatically to occasional localized habitat disturbance. The concept that species perform best under a regime of intermediate disturbance (= temporal habitat variation) has a long history in ecology. The high productivity of Yolo bypass during occasional flooding events is an example of intermediate disturbance in action. Unfortunately, as it was with flow, it is difficult to prescribe appropriate patterns of variability for individual species. Because the Bay-Delta is such an altered system, experience in other estuaries my not be helpful in designing appropriate variability. Adaptive experimentation will be necessary to identify the most favorable patterns. The SCG vision recognized the potential benefits of habitat variation and the need for further study to assess its benefits.

Concluding Statement:

There is no single ecological design that will generate all the services desired from the Bay-Delta. Hard decisions have to be made that will impinge on all three components of sustainability; economy, society and environment. If water and ecosystem are to be co-equal objectives it is likely that both economy and society will have to adjust to favor environment in the Delta. A policy that requires a net gain in natural capital and non-market environmental services with every major project that impacts the Delta might be a place to begin. Although there is no clear and sustainable solution to the ills of the Bay-Delta, there are many partial solutions that would improve environmental capacity. Change is pending; the Delta will not stay the same. In terms of environmental management, we need to move with the changes, take advantage of our growing knowledge to build natural capital in the Bay-Delta, use science as a tool of implementation as well as evaluation, and stay the course.