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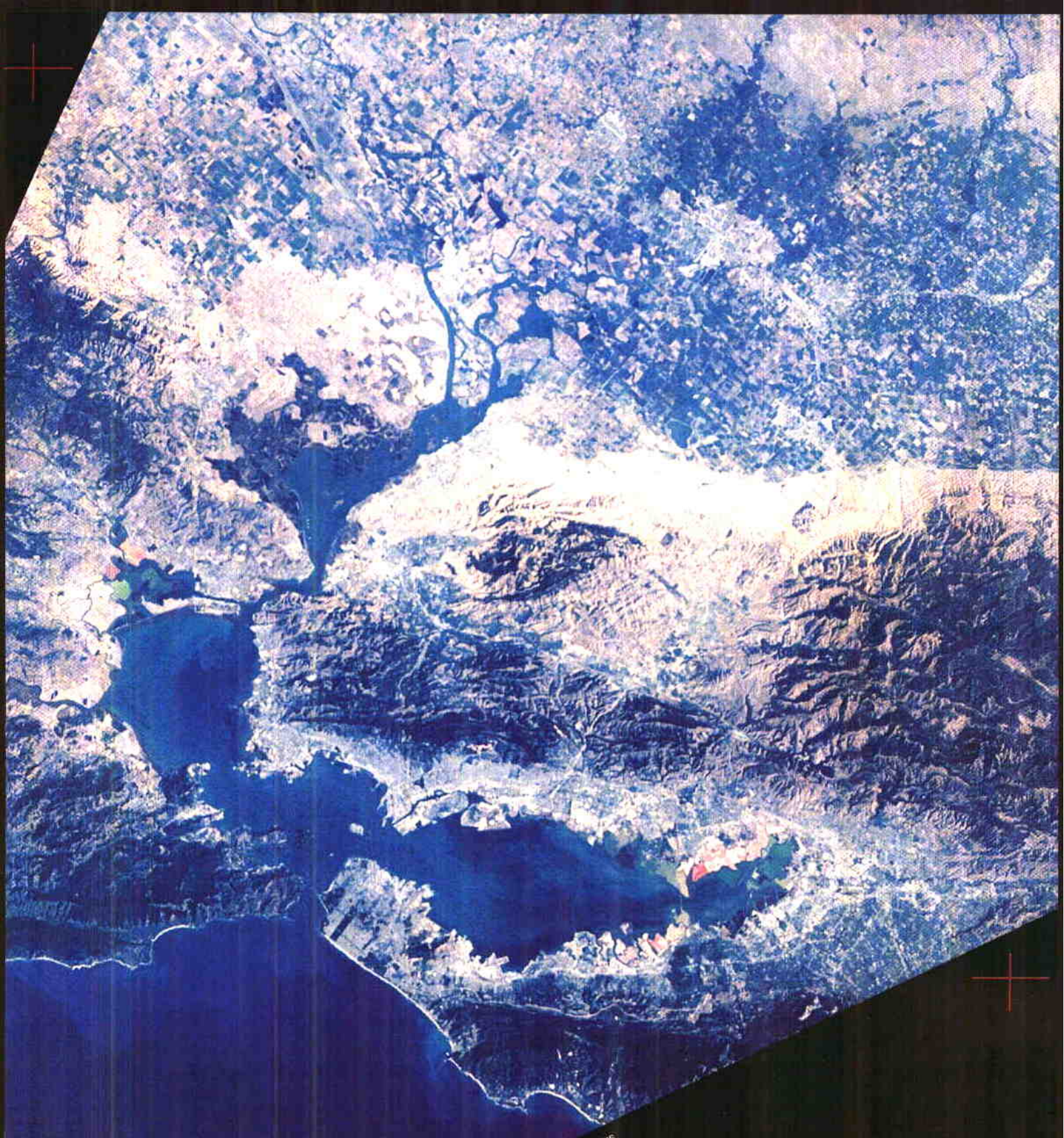
CALFED

An Experiment in Science and Decisionmaking

The California bay-delta region, where the Sacramento and San Joaquin Rivers flow into Sacramento Bay, has been the focus of great controversy for several decades. The rich ecosystems of the delta provide habitat for endangered fish species, migratory birds, and other wildlife. However, the delta has been largely re-engineered since the 1930s to divert as much as 60 percent of the natural inflow into San Francisco Bay for agricultural and urban or industrial use, especially in the San Joaquin Valley and southern California.[1] The reduced freshwater flows have significant implications for the quality of drinking water in the region and, especially, for ecological processes and the well-being of native plants and animals.[2]

The mission of the CALFED Bay-Delta Program is to develop and implement a comprehensive, long-term plan that will restore ecological health to and improve water



by Katharine L. Jacobs,

Samuel N. Luoma, and

Kim A. Taylor

management for beneficial uses of the Sacramento–San Joaquin River system. The river system serves agricultural and municipal water users throughout most of central California and is linked through major delivery systems to southern California. It covers approximately 40 percent of California's watershed and carries 60 percent of the state's water supply.[3] More than 20 million people, from Shasta Reservoir in northern California to San Diego in the south, receive at least part of their water from the delta.[4] The region's aquatic ecosystems are significant from both a regional and a national perspective. The delta supports 130 species of fish, including many that are endangered.[5] The bay-delta is comprised of a complex web of engineered waterways, dikes, dams, and diversion channels as well as important saltwater and freshwater wetlands and marshes. An estimated 700 miles of sloughs and waterways surround 57 man-made islands.[6]

The CALFED Bay-Delta Program

The CALFED Bay-Delta Program faces a challenging assignment: to develop a collaborative state-federal management plan for the complex river system and involve multiple stakeholders (primarily municipal, agricultural, and environmental entities) whose interests frequently are in direct conflict. Although many resource-management issues involve multiple stakeholders and conflict is integral to their discussion, the CALFED experience is unique because of its shared state and federal roles, the magnitude and significance of stakeholder participation, and the complexity of the scientific issues involved.

CALFED, one of the largest environmental restoration projects in the United States, is an ongoing experiment in adaptive management and stakeholder interaction. Adaptive management refers here to the application of research results and expert advice in making and modifying management decisions in real-time. Although this definition differs from the original concept, the emphasis on the use of objective, transparent scientific information for decisionmaking has enhanced flexibility and assisted in bringing key stakeholders together to work toward short- and long-term solutions.[7] Although the explicit role of science in decisionmaking for CALFED is in the early stages of development, it provides an opportunity to examine the roles of science and stakeholders in decisionmaking in general.

CALFED formally completed the first phase of its program—problem identification and development of action strategies—with the legislative passage of a Record of Decision (ROD) in August 2000. The ROD broadly established a role for "world class" science and adaptive management in the decisionmaking process. To learn from the CALFED experience, in January 2002 the U.S. National Oceanic and Atmospheric Administration's (NOAA) Office of Global Programs sponsored a forum of key participants to identify and discuss initial findings.[8] This article is derived from the findings of the forum and from related observations of the CALFED science program's initial year of activity.

History

The CALFED Bay-Delta Program was formed in 1994 under the leadership of U.S. Secretary of the Interior Bruce Babbitt and California Governor Pete Wilson. Initially a combined effort of 14 state and federal agencies with regulatory authority in the delta, CALFED was designed to develop solutions to looming water supply and environmental issues.[9]

In the early 1990s, regulatory actions to protect endangered species, in combination with serious drought and the dedication of 800,000 acre-feet of water for environmental purposes under the Central Valley Project Improvement Act of 1992, caused a near crisis for California's water management agencies. This catalyzed the CALFED process. Under pressure from the U.S. Environmental Protection Agency (EPA) to safeguard endangered fish in the Sacramento–San Joaquin Bay-Delta, the state Water Quality Control Board distributed a controversial draft decision in 1992 that limited water exports from the delta. This created panic among water users.[10] In response, Governor Wilson and Secretary Babbitt pulled California agencies (the CAL part of CALFED) and federal agencies together to work toward a coordinated solution. Federal agencies formed the Federal Ecosystem Directorate (the FED part of CALFED) in an attempt to develop a joint solution for the delta.[11]

In June 1994, the state of California signed a framework agreement to share management and regulatory responsibility for the Sacramento–San Joaquin Delta Estuary with various federal agencies. The agreement indicated that the state and federal agencies would work together on formulation of water-quality standards, endangered species protection, coordination of state water project and Central Valley project operations, and long-term solutions to problems in the estuary. The agreement covered the first 7 years of what was envisioned as a 30-year program. In December 1994, the new approach resulted in the Bay-Delta Accord—an agreement to conduct a comprehensive study of management options to address concerns about water supply and environment issues.[12]

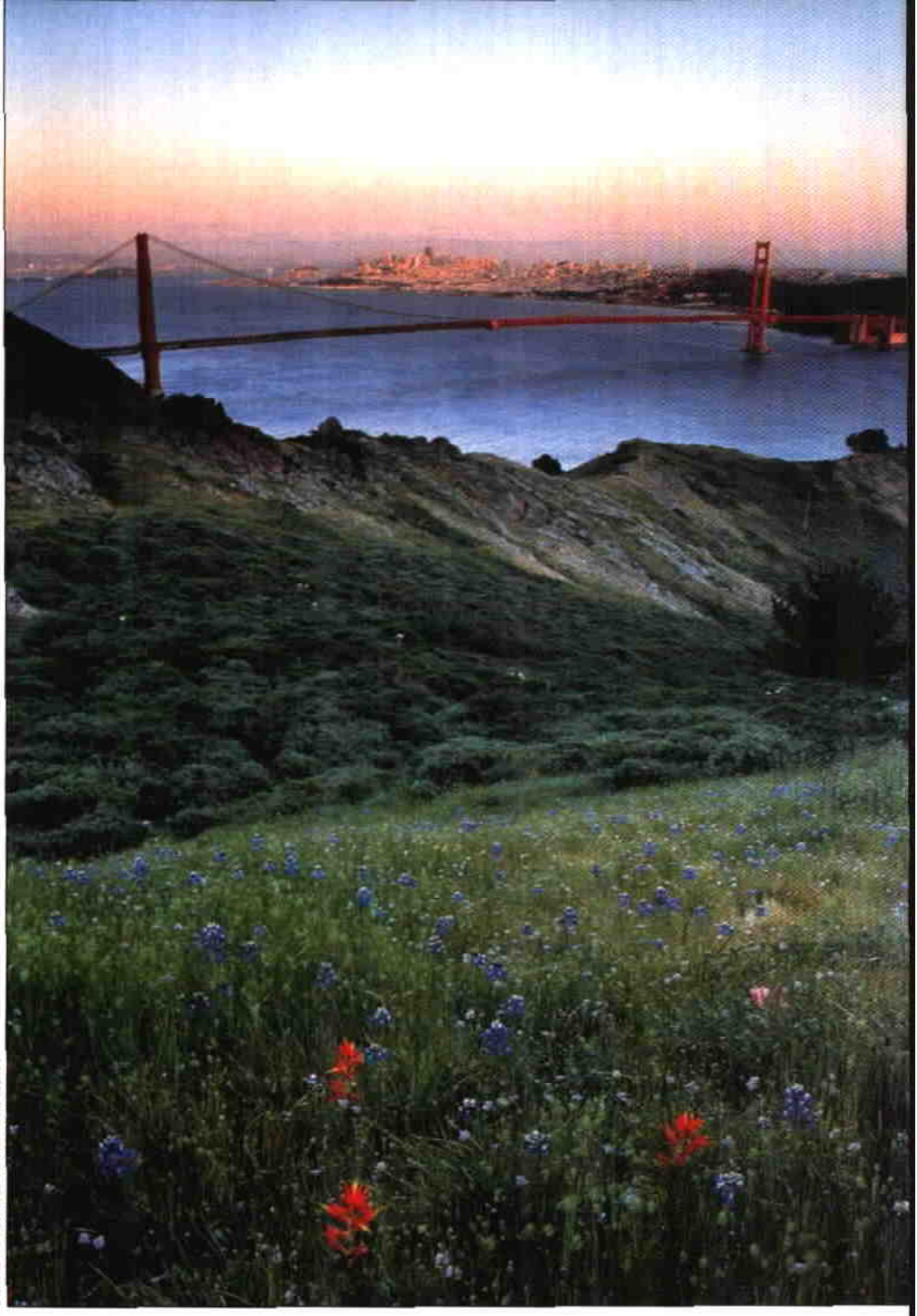
CALFED has matured to a point where significant progress has been made on a number of fronts. In March 1998, the CALFED program released a draft environmental impact statement/environmental impact report identifying alternative approaches to managing water (with the goals of improving reliability of supply, sustaining quality, and protecting levees) while simultaneously improving the protection of environmental resources. Phase two, which included environmental documentation under the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA), led to the ROD in August 2000. The ROD includes 6,500 pages of programmatic environmental documents required as part of NEPA and CEQA.

The ROD has three main elements: a state-federal agreement to control the

outflow of water through the delta; a commitment to the CALFED process; and investments in more than 600 ecosystem restoration projects. It calls for some more creative actions as well, including an environmental water account to ensure that fish are protected from project operations that increase the reliability of urban water supplies; increased storage, to be used primarily to conserve environmental resources; and significant new federal and state funding for implementation. CALFED also was successful in acquiring significant funding for specific aspects of implementation through bond initiatives and legislative appropriations, but full funding for balanced implementation of the first seven years of activities is still pending. Full implementation will continue through 2020.

Structure

The CALFED program is managed by an interdisciplinary, interagency staff and assisted by technical experts from state and federal agencies as well as consultants. In its early stages, the lack of a permanent governance structure and reliance on multi-agency support for managing money and activities created administrative problems. However, there have been numerous benefits associated with the multi-agency effort: technical collaboration among agencies, meaningful public participation, the development of real-time adaptive management techniques, and an explicit role for a science program.



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The California bay-delta region has been largely re-engineered to divert much of the natural inflow into San Francisco Bay for agricultural and urban or industrial use.

The CALFED Science Program

Since the late 1960s, scientific research related to the Sacramento–San Joaquin Bay-Delta has been ongoing within individual state and federal agencies, the university community, and the private sector. It was initially estimated that CALFED investments in science should total about $30 million per year. The CALFED ROD called for a significantly larger investment—an additional $300 million over 7 years. The ROD also emphasized the use of adaptive management in implementing CALFED, although adaptive management was not defined explicitly in the ROD.

Increasing science expenditures required carefully focusing the program. The goal was to aggressively grow the body of knowledge relevant to CALFED actions and their implications so as to have a maximum effect on the fast-paced schedule for actions in the first seven years. Important components of the program included improving the credibility of technical information, employing best scientific practices (such as peer review and expert advice), and promoting greater clarity about the state of scientific knowledge. To ensure that the science was relevant, agencies and stakeholders were asked to identify critical questions; then, experts and scientific advisors framed those questions in terms that were manageable for produc-

tive science and focused on providing answers for current management issues.

Approach

Because of the intense economic and environmental interests of the stakeholders and the technical nature of many issues, all parties were concerned about objectivity in scientific findings. In the 18 months after its initiation in September 2000, the science program sponsored, or helped sponsor, a dozen scientific workshops, conferences, and reviews to help clarify the state of scientific knowledge about the bay-delta. Issues were contentious and complex, and they included aspects of restoration, endangered species listings, new infrastructure programs, and the definition and implementation of adaptive management and water management issues.[13] CALFED commissioned more than a dozen comprehensive reviews (white papers) to support ecosystem restoration and address a range of major questions, including implications of climate change, salmonid biology, wetland restoration, and implications of chemical contamination.[14] Another major focus was developing a program to interpret and publish previously underutilized monitoring data.[15]

The workshops and reviews all involved experts in specific disciplines or panels of experts—some of whom were familiar with the system and others who were subject experts intended to provide an objective view from outside the system. In 2001, CALFED commissioned 40 different experts from a range of disciplines to participate in technical review panels or on standing boards of advisors.[16] More than 300 reviewers worldwide were asked to evaluate several hundred proposals submitted for ecosystem restoration and related science. Formal criteria were established for the selection of experts, as were protocols for the workshop and review process.

Investment in Science

From its inception, the science program has focused on both the perception and the reality of developing and using objective scientific information in the decisionmaking process. Because the specific types of information needed for evaluating the effects of alternative management options often were not available, the science program has generated new sources of information and has clarified existing data or information. (The box on this page describes five specific and interrelated goals for managing science in the CALFED science program.)

Comments from CALFED stakeholders have indicated that public support for science and credibility of technical information are enhanced when stakeholders institute a rigorous peer review process to select projects for funding. The details of this process are critical. Proposals are selected for funding only after careful technical review to establish their scientific feasibility and credibility and after consideration of relevance by a panel of technical managers from the agency and stakeholder communities. Technically deficient proposals are not considered; even invited proposals are peer reviewed and sometimes are rejected. CALFED also is establishing an on-line peer-reviewed technical publication series to help disseminate new knowledge about the watershed and

Goals of the CALFED Science Program

Five goals define how science is managed in the CALFED science program. Each of those goals contains critical elements. It is important to recognize that the five interrelated goals must move forward together for the program to succeed. The goals are:

To articulate, test, refine, and grow understanding about natural and human systems by

- investing in long-term study of critical unknowns;
- implementing regional projects with a likelihood of high impact on achieving CALFED goals;
- filling monitoring gaps;
- fostering adaptive management experiments;
- conducting specific studies that improve the basis for management actions or regulations; and
- investing in analysis of underinterpreted data sets that resulted from past monitoring.

To integrate best available scientific understanding and practices throughout CALFED by

- initiating peer review for all proposal selection processes;
- encouraging partnerships and collaboration;
- promoting publication and dissemination of CALFED science program findings; and
- enhancing public access to data.

To provide authoritative and unbiased descriptions of the state of scientific knowledge by

- holding issue-specific workshops;
- creating white papers; and
- producing books and compendiums of knowledge.

To evaluate technical performance of the CALFED science program through

- expert panels and advisors;
- standing science boards that meet regularly to advise on and review issues for the ecosystem restoration program, environmental water account, interagency ecological program, and mercury issues;
- issue-specific technical review panels that repeatedly review progress;
- overarching CALFED science program board that oversees the integrity of the science process; and
- performance measures to facilitate adaptive management.

To establish and improve communication between science, management, and public communities with

- science conferences;
- educational material;
- new technical publication series that are on line to facilitate distribution;
- issue-focused popular series for managers and the public;
- fact sheets; and
- science program activity reports.

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A key aspect of the CALFED program is the commitment that all approaches to science, including review, monitoring, and research, must move forward together. Using science issues as a forum for rational discussion may facilitate solutions.

encourage an expectation that credible science must undergo peer review.

An important part of the science program's framework is the statement—consistent with other CALFED goals—that all approaches to science (review, monitoring, short- as well as long-term research, and communication) must move forward together. This philosophy has been an expensive but worthwhile endeavor in the long term. In other words, research should not be left behind for the sake of short-term products, even when funding is tight. This unusual restriction is critical to effective investment for a long-term program. An effective investment in science must move the role of research forward, so that 5, 10, or 30 years from now stakeholders and agencies are not debating the same uncertainties that are being debated today.

Science and Decisionmaking

Another of the science program's stated goals is to try to bring out knowledge that is not only relevant but accepted as balanced and authoritative. Communication with the scientific community, stakeholders, CALFED agency managers, and the public also is essential.[17] Of course, no program can ensure that its knowledge is completely unbiased. The peer review system and public discussions with external experts are traditional scientific tools used for that purpose; their role in complementing the investment in studies is critical for CALFED.

Improving the transparency of the science behind policy decisions is key for the CALFED science program. Because multiple stakeholders are concerned about the validity of information used in evaluating management options, it has been extremely important to seek objectivity in the use of scientific information. One approach to meeting this challenge is to frame scientific discussions to avoid subjective policy judgments. Separating discussion of the status of scientific information from judgments about the decision itself is essential. Scientists can agree about assumptions, uncertainties, and needs for additional information even when they don't agree about interpretations of data.

CALFED has experimented with several management approaches that allow the use of real-time data. The environmental water account (EWA) allows water managers to acquire, store, transfer, and release water to respond to real-time ecosystem needs. The annual scientific review of the EWA provides an example of focusing on objectivity. The review panel is not asked to judge whether the EWA was successful, nor are they asked to judge whether it should continue. Instead, they are asked to specify the strengths of the existing approach, to give insights about how the EWA could be managed to better achieve its goals, and to identify key uncertainties or impediments that might reduce the effectiveness of the program.[18] Reaching consensus on less-than-absolute questions of judgment, even if it is in agreeing that something is inadequately known, lends credibility to the debate and can add to the influence of science.[19]

The framework described above inevitably leads to discussion of future information needs. This gives stakeholders and agencies alike a mechanism to establish an adequate information base before a policy choice is made. It also helps reach more carefully considered

decisions and empowers multiple groups by enabling them to guide the research agenda.[20] Using the discussion of science as a forum to maintain rational discussion may have a calming effect on potentially contentious issues and may facilitate solutions by breaking large issues into multiple—and perhaps more manageable—decisions.[21]

In evaluating the EWA, for example, the review panel concluded that both inadequate investment in staff with experience in specific areas of water management and poor scientific knowledge of the biology and ecology of protected species were impediments to effective management.[22] In the year following the review, agency decisions moved toward improving conditions in both of these areas. Even if the EWA is not continued, smaller decisions on investments will benefit water management practices.

An inevitable side effect of incorporating science into decisionmaking is the threat that actions planned on short time horizons will be slowed while data are being generated. However, it should be recognized that aggressive schedules often are delayed for other reasons; sometimes the delay is caused by controversy over technical issues. Some aspects of a science process—such as review of existing data or workshops designed to improve the clarity of existing knowledge—can occur quickly. But research rarely is successful when asked to respond within a short time frame to technically difficult questions. This can be overcome not only if a program includes a broad set of ongoing research studies that cover the major processes underlying potential policy questions (the 40-year history of research on the bay-delta watershed was a benefit in this regard) but also if policy makers recognize the necessity of review, definition of needs, and investment in new knowledge far enough in advance of decisions. For example, the EWA review process began four years before the decision on whether the experiment was a success. When review occurs far enough in advance of decisionmaking, the science process can help frame debate in its initial stages, perhaps even allowing some decisions to occur more rapidly than they otherwise would have.[23]

Finally, an important underlying hypothesis of the CALFED science program is that contributions to decisionmaking lose at least some broad-based support and credibility when science is conducted and communicated primarily within "silos" in government or stakeholder groups. The contribution of people with the same world view and information base leads to a narrow focus that may be perpetuated through the chain of command. Advocacy science (or at least the perception of advocacy) is more difficult to avoid when scientists talk mostly to their own colleagues who share the same perspective—when they are unwilling to adjust interpretations of

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Policy change can occur in response to major natural events. The prolonged drought in California was one aspect of a major environmental and regulatory crisis that catalyzed the CALFED process.

contradictory data, when groups sift through a body of knowledge for findings that support their arguments, and when groups hire their own scientists and listen to few others—in short, when values begin to play a role in interpreting scientific findings.[24]

Therefore, a major effort of the CALFED science program is to provide incentives and constant encouragement for collaboration among agencies and between agency scientists and university or private-sector scientists. The program attempts to bring different groups of scientists together for frequent discussions of specific technical issues related to important CALFED management decisions. This multidisciplinary, multiorganizational approach to science is consistent with the multistakeholder approach of CALFED overall.

Expanding collaboration and communication—and especially trust—among entrenched groups in the science setting as well as in the policy setting always is challenging. In addition to informal mechanisms to meet these challenges in the science setting, CALFED is attempting to initiate more formal consortia, so that the habits of collaboration, communication, and trust can themselves become entrenched (see the box on this page).

CALFED Partnerships and Collaboration

A major accomplishment of the CALFED science program was the 2001 initiation of the Bay-Delta Science Consortium as a mechanism to coordinate bioregional assessments, monitoring, and outreach in the bay-delta. The overall goal of the consortium is to expand collaboration and cooperation in pursuit of improved science and outreach. A central objective is to sponsor studies that break down traditional barriers among groups or demonstrate how such barriers can be overcome successfully while conducting substantial science programs.

Shared objectives include

- enhancing efficiency of facility use,
- promoting collaboration among the scientists of government, university, and private agency parties to the memorandum of understanding (MOU), and
- expanding the sophistication and productivity of bay-delta science and outreach through multidisciplinary, multi-organization cooperation.

An MOU was signed by 14 charter institutions for the consortium, including agencies, university centers, and nongovernmental organizations.

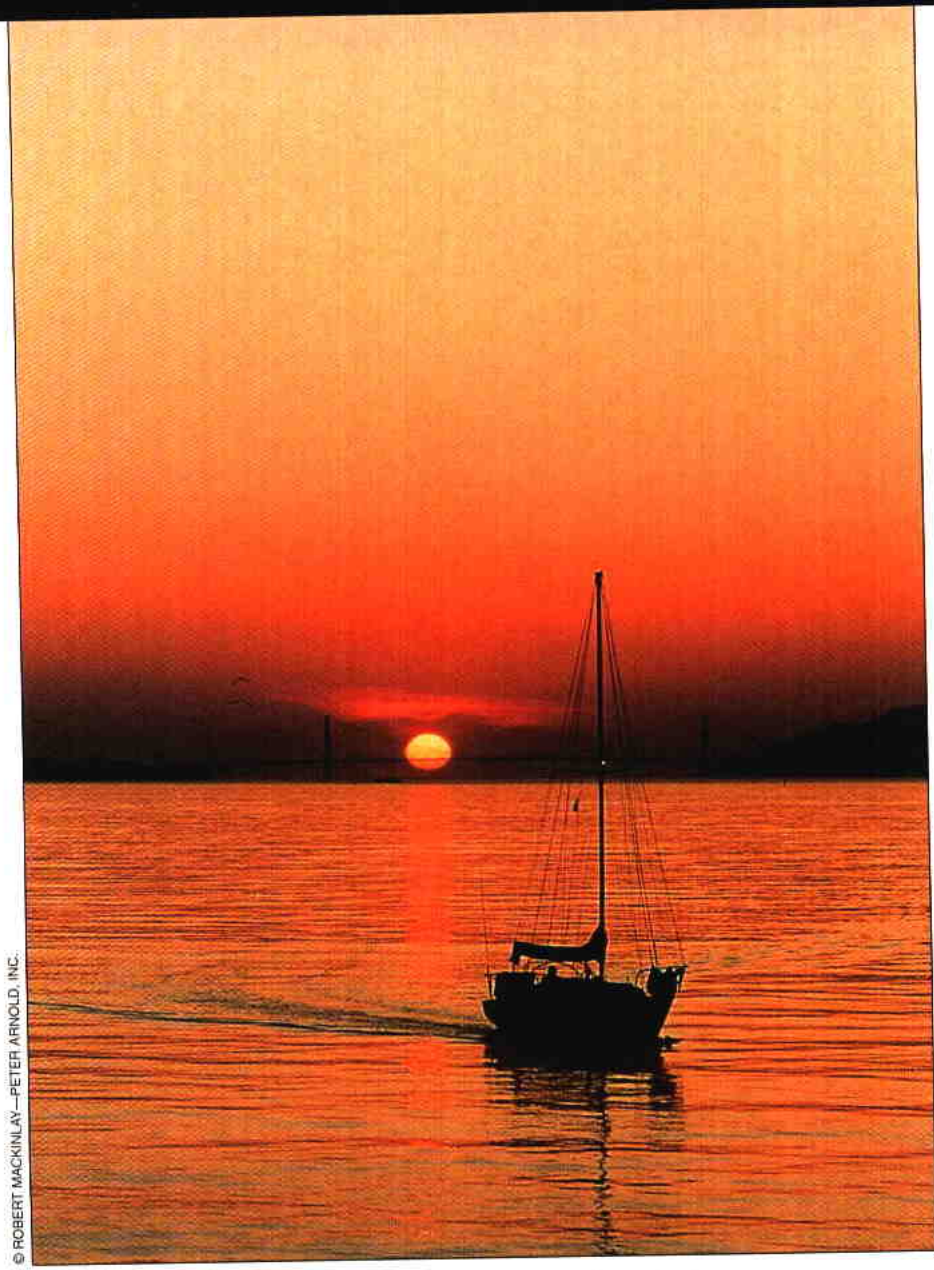
A mission statement was developed and a work statement is being produced. CALFED is funding the initial effort in hopes of developing an institution that is self-supporting. A consultant is developing the position description for the executive director, whose primary early responsibilities would be to facilitate colocation of agencies and opportunities for sharing resources and students, develop a study-support process, and fund new collaboration.

The Role of Stakeholders

Possibly more than any other environmental management project, the CALFED Bay-Delta Program has been driven by stakeholders. The program has a 32-member Bay-Delta Advisory Council, chartered under the Federal Advisory Committee Act, with stakeholder groups chosen jointly by the governor of California and the secretary of the interior.[25] The process of defining the problem, establishing goals and objectives, and selecting preferred alternatives involved more than 500 meetings. Having all of the stakeholders at the table was described during the NOAA forum as "powerful but agonizingly slow."[26] However, based on reports from many perspectives, virtually all of the participants feel that the huge investment of time and money in the stakeholder process was worth the effort. The science questions now being addressed are in large part the ones identified by the stakeholders. Public participation was successful because

- There was an absolute, up-front commitment to a stakeholder-driven process. Both the governor and the secretary of the interior were committed to this objective.
- Meetings were statewide and in multiple venues. Numerous formats were used—from large public meetings at which media were present, to private meetings with interest groups such as boards of directors from agricultural and urban water districts, to forums and workshops.
- Several key interest groups played advisory roles, such as the California Urban Water Agencies (an agriculture-urban group) and the Environmental Water Caucus. Their leadership and vision were essential to the process.
- The CALFED Bay-Delta Advisory Council played a key role in monitoring and evaluating the process and the options that had been identified.
- Participation of key players was ensured by two important conditions: the critical situation in the watershed and the significant financial resources that were available to work toward a solution. This combination of circumstances provided a unique opportunity that allowed for change.
- Progress was visible and continual: It was important to meet milestones and produce visible results. A key early success was the passage of the bond initiative.
- Decisions were made in public meetings, after an iterative review process. This helped build public trust.

Aside from the total commitment to an inclusive process, the most important component in the success of the stakeholder program likely was that sufficient resources were available to support required meetings and travel costs. For the first five years, CALFED had a $16 million yearly budget—$8 million each from the state and the federal government.[27]



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CALFED's approach to complying with the Endangered Species Act to protect Sacramento's salmon required innovation because the act's legal framework is not oriented toward managing ecosystems the size of the bay-delta system.

Understanding the Policy Process

Expedience plays a role in designing scientific agendas. Some stakeholders felt, in retrospect, that in the early stages CALFED was somewhat shortsighted in its choice of research topics.[28] This was justified by the need to have demonstrable, early successes and to avoid easily publicized failures. Like many programs, CALFED focused on trying to resolve the primary problems—even if the technical issues were intractable—because they were visible and politically expedient targets.

For example, endangered species management in the delta was centered around counting fish "taken at the pumps" (fish that had been pulled into the massive pumps that move water from sources in the northern part of the watershed to centers of demand in the southern part). For more than a decade, it was assumed that "take" at the pumps was a predominant threat to salmonids, Sacramento split-tail, and delta smelt listed as endangered.[29] One reason for this assumption might have been that the number of individual fish "taken" could be estimated with some reliability (the threat was visible and the absolute numbers seemed large). The more inclusive recent debate has emphasized the need to quantify the threat of take to populations. Research programs are being developed to find better means to meet that challenge. In retrospect, of course, many stakeholders are asking why there is not a more developed body of knowledge about cumulative threats to the populations from the many sources of stress other than take at the pumps.[30]

Although funding science only to meet immediate policy needs is typical of most modern environmental science programs, experience would suggest that such a strategy, by itself, is rarely very effective. When problems are complex and multifaceted (the "wicked" problems defined by University of California at Berkeley professors Horst Rittel and Melvin Webber), the optimal science approach should have several characteristics in addition to adequate funding—some of which might even seem contradictory.[31] The approach must adapt to new facets of problems as they appear, be sensitive to different contexts and scales, have its most immediate impact at the beginning of the development of an issue (as in the EWA), and have continuous investigation.[32]

For many applied science or adaptive management programs, a common attribute is frequent redirection of science and staff as new issues emerge. However, continuous redirection makes it difficult to produce the most credible science. Science takes time to develop. Too many changes in direction may limit adaptability; long-term, well-run programs designed around continuous investigation are, in the end, the most responsive to at least some management needs. That does not mean that all science should avoid redirection, but the CALFED premise is that continuous investigation must be in the mix in strong proportion.

In the San Francisco Bay, it is in fact long-term, multidisciplinary ecological research that has best met these science criteria and influenced policy.[33] A good long-term research program will adapt continuously to new issues on the margins—if the issues include new funding and the program has some incentive to adapt. A long-term program can develop knowledge in multiple contexts and at

multiple time scales, and therefore it is immediately "mature" as issues emerge in different contexts or as time scales change.

Traditionally, it has been difficult to obtain funding for the development of the big-picture background data required for longer-term management. The U.S. Geological Survey (USGS) has run a San Francisco Bay program since 1968.[34] One example of the value of this program (and of multi-agency collaboration) lies in the progress now being made in understanding water movement, or hydrodynamics, in the system. In the bay-delta, hydrodynamics are as complex as anywhere in the world and are overwhelmingly important to water management. More than 30 years of hydrologic and hydrodynamic study by USGS, the California Department of Water Resources, and other agencies and university scientists have led to the development of a variety of models that provide a very sophisticated base from which to develop forecasts of implications of some of the complex actions being proposed in the system.

Policy change does not only occur incrementally over the long term. It also occurs in response to major natural and political events that perturb the system. The CALFED agreements were initiated in response to a major environmental and regulatory crisis in California (the prolonged drought was one ingredient). Droughts are opportunities to build public support for consensus and provide the political support for expenditures that can encourage innovative water supply programs. Science in the Sacramento–San Joaquin Bay-Delta certainly benefited from the CALFED agreement, but the science will need some time to "catch up" to the needs of the program. A vision for consensus science agendas that address specific issues and initiate studies must occur before the next crisis begins. In this way, the political process may work to the advantage of the science-based policy in the CALFED program.

Another contradiction between science and policy is that science gains credibility through independence from the policy arena, but policy changes only when it is supported by a champion or cause. For a system as complex as this one, a high level of focus and engagement are necessary to grapple with the issues. As described above, CALFED follows a model that suggests that advocacy in policy is best supported by a science apparatus that provides as much relevant information as possible but leaves advocacy to policy makers and other arenas such as litigation. This approach is not universally agreed-upon within the global scientific community. Some scientists encourage empowering all participants and letting them advocate. In the CALFED program, debates fueled by alternative values are minimized. A science arena where advocates can find grounds for agreement is presumed to be the most conducive to successfully linking science and policy.

The Endangered Species Act

CALFED's approach to complying with the Endangered Species Act (ESA) in protecting Sacramento's split-tail, delta smelt, and winter-run salmon required innovation because ESA's regulations did not provide the latitude needed for solving multiple complex problems. ESA's legal framework focuses on individual species—and, more recently, allows for Habitat Conservation Plans—but is not oriented toward managing ecosystems the size of the bay-delta system. Even though it was readily acknowledged that science on the life cycles, behavior, and habitat requirements of key species available at the time of the development of Biological Opinions by the U.S. Fish and Wildlife Service was incomplete, the legal framework of ESA focused on using the best information available. It is not possible under the current legal system to wait for better information before moving forward with species protection.

Therefore, CALFED participants used the regulatory requirements as a baseline, then built the program—meeting the basic ESA requirements but moving beyond them to deal with multiple objectives and include adaptive management approaches. It was accepted (at least implicitly) that the CALFED agencies would manage "take" rather than populations, but the definition of "take" has evolved. In the CALFED process, unacceptable take of winter-run salmon is defined by proportion-of-the-population criterion, based upon early season estimates of the size of the listed population, real-time monitoring of salmon migration, and interpretation of take as it occurs. This is in contrast to other definitions, in which take is defined by disturbance of an individual irrespective of population size.[35] Workshops on managing salmonids and delta smelt have made the complexities of managing listed species more clear and have clarified that the agencies did recognize and were using the linkage between take and population size to manage winter-run Chinook.

ESA does not lend itself to the adaptive management model, at least overtly. But as stakeholder-based solutions, scientific transparency and collaboration, and new knowledge move forward, perhaps it will become more feasible to add elements of adaptive management to the ESA framework. Of course, that flexibility must be accompanied by strong monitoring and assessment programs to ensure that listed species remain protected.

Adaptive Management

Adaptive management allows for an iterative learning and management process and requires ongoing monitoring and evaluation of management actions that are taken. Many aspects of adaptive management are potentially beneficial for linking science and policy—this determination involves ecosystem-scale experimentation.[36] This science-based policymaking has different meanings in different settings even if it does not involve explicit experimentation.[37] In the case of CALFED, the adaptive management approach has been described as having fixed program

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The relationships built during the CALFED process have changed the public policy arena within California and expanded the role of science in decisionmaking. However, the greatest obstacle to continuing these activities remains adequate funding.

objectives but including the ability to adjust actions to ensure a durable solution as additional data are developed.[38]

Financial Considerations

The effectiveness of CALFED in coordinating the science and management of the Sacramento–San Joaquin Bay-Delta system is directly proportional to the ability to pay for needed services. Because of the complexity of the ecosystem and institutional constraints, CALFED needs a sophisticated science-based management approach—and that requires substantial resources. In general, CALFED agencies cannot adequately support long-term planning, and the implementation of plans requires even more intensive staff support. Bond money provided by the initiative process in California has provided a strong base for the development of CALFED and, to some extent, the science that supports the effort.

One of the biggest disappointments in the CALFED process to date is the limited consistency of funds appropriated from state or federal government for the agreements that were made in the Record of Decision (ROD). In fact, according to David Hayes, former deputy secretary of the interior during the Clinton administration,

> *The CALFED program is sputtering. The strong impetus to finalize a long-term plan to accommodate environmental and user needs has not translated into the legislative arena. . . . California is no longer speaking with one voice, as some stakeholders are seeking to improve on the deals that they made through the stakeholder process, thus putting strains on the delicate balance of interests that stands behind the ROD.*[39]

One problem is that legislators have attempted to modify the ROD to better satisfy their political desires through appropriations bills. The limited extent of appropriations in austere times is the primary problem. At a minimum, failure to meet the financial commitments of the ROD inevitably will require re-examination of the schedule for the program. It is interesting, however, that paying for science usually has kept pace with other commitments in the existing CALFED legislation.

The vision of the CALFED science program requires human resources to support infrastructure as well as substantial funding beyond traditional management approaches. Cooperation, collaboration, outside expertise, and advancing the debate in pace with policy decisions all need investment. If agencies do not ask for help, CALFED has no authority to force them to cooperate. However, agencies are unlikely to cede their authority to other entities and need to be provided with incentives to cooperate. As funding shrinks, who wins and who loses becomes more of an issue, and it could become difficult to set funds aside to maximize opportunities for collaboration. A greater question is whether a lack of resources will allow agencies an excuse to return to their own institutional perspectives rather than continue to collaborate.

There also are underlying incentive issues that go beyond funding. For example, scientists from some agencies get little professional credit for assisting in public policy debates, although there is great societal value to their contributions. New types of rewards and incentives are needed to encourage scientists to get involved in research that supports decisionmaking, especially if the decisions are contentious. Paying science

review boards for their work has allowed for an aggressive review process, but it excludes compensation for agency scientists. The day-to-day contributions of scientists from agencies and academia to CALFED and other policy-development processes appear to be increasing. The response of participants to the visibility and politics of such activities will be interesting to watch as CALFED matures.

The single greatest limitation to sustaining many of these proposed activities is issuing contracts. Combined state and federal sources of support provide something of a buffer. When state support was low in the earliest phases of CALFED, federal appropriations were available. In 2001 and 2002, the opposite was true. Whatever the appropriations, getting contracting officials to give priority to contracts outside their direct agency mission, moving money between state and federal entities, and spending state money outside these agencies (for experts, consultants, and small contracts for technical projects) all have proven problematic. As a result, administrative delays of more than one year are occurring before appropriated money can begin to be spent.

Final Analysis

Perhaps CALFED's major contribution has been to allow an open discussion of "what ifs" between agricultural, municipal, and environmental stakeholders who otherwise never would have met on equal footing. The program has created an environment in which it is acceptable to talk publicly about highly charged management and science issues, uncertainties, and alternatives for resolving issues. When questions are framed to aid consensus, it is possible to brainstorm collectively and develop a collective public policy agenda.

The relationships built during the CALFED process have changed the public policy arena within California and, at least temporarily, between California and the U.S. Department of the Interior. Initial indications are that a science program based upon the same philosophical approach can contribute positively to other processes. An important question is how or whether reduced funding to implement the ROD might erode consensus.

It is clear that adequate funding is a key ingredient in the success of an innovative program such as CALFED. New money for investment in experts and staff support, forums for open conversation, new science, and transparency are critical ingredients of this success. CALFED has opened new channels of communication between groups on the ground in all levels of government. Regardless of the specific outcomes, the process itself is an achievement and, at a minimum, might continue to be a laboratory for innovation in resource management.

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8. National Oceanic and Atmospheric Administration (NOAA), CALFED forum, 8 January 2002.

9. Hayes, note 1 above.

10. Ibid.

11. For a complete list of agencies involved in CALFED, see the CALFED Bay-Delta Program web site, accessible via http://calfed.ca.gov.

12. See McClurg, note 4 above, page 6.

13. Summaries of the results of these forums are published on the CALFED science program's web site, accessible via http://calfed.ca.gov/Programs/Science/Science.shtml.

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15. See http://www.csgc.ucsd.edu/EDUCATION/CALFED/CALFED_Fellows.html.

16. An example is the ecosystem restoration program's independent science board, at http://calfed.ca.gov/Programs/EcosystemRestoration/EcosystemIndependentScienceBoard.shtml.

17. Science Program Annual Report, 2001, see http://calfed.ca.gov/Programs/Science/Science.shtml.

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37. Ibid.

38. See McClurg, note 4 above, page 6.

39. Hayes, note 1 above.