2. The Science PSP

A. Goal of This Proposal Solicitation Package

A core set of issues for the entire CALFED Program is how water use and management activities interact with and affect aquatic species, at scales ranging from specific sites, such as salmon-spawning grounds below reservoirs, to systemwide operations that cover the net timing and movement of water from upstream areas into statewide diversion systems. The interactions between water management activities and the recovery of at-risk species provide much of the impetus for many planned Science Program actions. Over the next few years, a variety of water management actions are being considered for full-scale projects in the Delta region (termed the Delta Improvements Package), all of which have been implicitly designed to address historical problems with water quality, at-risk fish species, and water supply reliability. In addition to the water management projects, hundreds of other actions that also affect Bay-Delta system species and ecosystem processes are being undertaken (lists of these actions are described in CALFED Program Plans and the CALFED Programmatic Record of Decision.

This solicitation is designed to develop knowledge that will help us understand the core issues described above and develop the context needed to compare benefits and costs of a host of different projects. This knowledge will be obtained by studying such geomorphologic and ecosystem processes as hydrodynamics, water chemistry, sediment transport, contaminant fate and effects, and animal and plant community function and response, particularly in the Delta and Suisun Marsh. Development of this knowledge will require understanding the responses of key species, which in turn will depend on understanding how their population biology is coupled to changes in habitats and ecosystem processes. It will also require understanding the potential implications of changes likely in the future, such as shifts in regional hydrologies under climate change or large-scale population increases and movement, for water budgets and ecosystem processes. This solicitation includes priorities of the Science Program itself and priorities resulting from collaborative work with the Ecosystem Restoration, Conveyance, Environmental Water Account, Levee, Drinking Water, and Water Management programs.

B. Priority Topic Areas

The focus of this solicitation is on information needs that have been defined by the Science Program as the highest immediate priorities through consultation with stakeholders, the CALFED management community, and the scientific community. Proposals that bring out compelling ideas outside these topics will also be considered, but they must be exceptional to receive funding.

The three priority topic areas for the 2004 call for proposals are:

- water operations and biological resources;
- ecological processes and their relationship to water management and key species; and
- performance assessment to improve tools and evaluate implications of future changes.

These priority topic areas are described below. Proposals that can show their relevance to multiple questions will be given strong consideration.

i. Water Operations and Biological Resources

The first priority topic area for this solicitation is the understanding of the linkages between water operations and biological resources, particularly at-risk aquatic species[4]. These linkages must be better understood if we are to meet the objectives presented in the CALFED Programmatic Record of Decision. CALFED agencies have launched many projects aimed at improving water supply reliability through the use of storage and "conveyance" improvements, promoting water conservation, and restoring ecosystem processes and key species[5] populations. The credibility of ecosystem management and measures taken to modify water management in support of biological resources ultimately depends on showing whether management actions are actually helping to restore populations of key species, and, if so, how.

During recent Science Program workshops and reviews, several questions relevant to water operations and environmental issues were raised repeatedly, including:

- What are the population-level effects of large and small water diversions in the Delta and small diversions throughout the Bay-Delta system on salmonids and delta smelt at different life stages?
- What are the ecological benefits of the different uses of environmental water assets in streams, rivers, Suisun Marsh, and the Delta?
- What is the relative importance of different sources of stress, such as predation and incidental take by export facilities on key species?
- How do environmental processes and water operations combine to affect the distribution, fate, and population success of at-risk or other native species?

These management concerns are described in more detail in Attachment 1.

The Science Program is seeking creative approaches to provide answers to these questions. A number of specific study ideas have been discussed extensively in many CALFED meetings as examples of steps that could be taken to improve our understanding relevant to these questions. These include:

- What is the importance of natural predation in the Delta compared to incidental take at Delta export facilities?
- What is the impact of ocean harvest of Chinook salmon compared to other stressors?
- What is the role of upstream stresses on salmonids compared to stressors in the Delta and Suisun Marsh?
- What is the magnitude of indirect mortality in the Delta and Suisun Marsh?
- How do the South Delta temporary barriers affect flows and fish?
- Do contaminants or other water quality attributes have measurable effects on key species of concern in the Delta and Suisun Marsh?

A more detailed discussion of examples of management questions and potential study topics can be found in Attachment 1.

ii. Ecological Processes and Their Relationship to Water Management and Key Species Conservation

Learning about how natural ecological processes work, and links between these processes, resource management actions and populations of key species, especially in focal areas like the Delta, is a

[4] At-risk species are salmonids (especially threatened or endangered runs and species), delta smelt, longfin smelt, Sacramento splittail, and green sturgeon.

[5] *Key species* refers to both at-risk and other native fish species.

fundamental part of providing science in support of CALFED management decisions and is the second topic area for this solicitation. Examples of CALFED issues that would benefit from a better understanding of these linkages include operations of the Delta Cross Channel, decisions on a Through-Delta Facility, long-term commitments of contracted water, improvements proposed for the South Delta, decisions about configurations and facilities near the large diversion points, the use of the Environmental Water Account, and shallow water habitat restoration in support of key species.

We are beginning to understand how to operate diversions more effectively for both fish and water quality at the Delta Cross Channel as we learn the detailed linkages between flows and fish movement at such junctions. Detailed knowledge of processes in the San Joaquin River and the Stockton Deep Water Ship Channel is pointing toward solutions to alleviate the reduced dissolved oxygen problem in that region. New knowledge of mercury distribution and methylation processes has set the foundation for a comprehensive mercury strategy for the Bay-Delta system. These issues are all well defined or locally constrained.

New knowledge has also pointed out important challenges that affect multiple CALFED objectives. For example, management actions such as closing the Delta Cross Channel gates are designed to keep salmonids out of the central Delta in response to mark-recapture studies that show a reduction in survival rates for salmon that enter the central Delta. Environments such as the Delta, however, may play an important nursery function, and some restoration actions are designed to create habitat that might be useful as nursery habitat. These conflicting effects raise the question of whether there is greater net benefit in keeping salmonids out of the central Delta or in letting them in at certain times. Similarly, maintaining low salinity water in the central Delta is critical to sustaining drinking and environmental water quality, but research in Suisun Marsh suggests some variability in salinity could benefit native fish. Likewise, shallow water habitat and wetlands were thought to favor native fish, but shallow water habitat can take many forms in the Delta with different outcomes for native fish species. The Delta issues respond to water and environmental management upstream and downstream of the Delta, and processes in the Delta are linked to processes in the rivers, the estuary, and ocean. Analyses of the relative importance of stressors or the life stages of key species that require considering ecological processes in the rivers, the Delta, the estuary, or the sea, are of particular relevance to this solicitation.

Examples of study topics that focus on Delta ecological processes and links to environmental management include:

- What role does water residence time in the Delta play in the success of salmon and delta smelt populations?
- How do the massive invasions of exotic flora affect native fish in the Delta, and how will changes in water management or Delta configurations affect the flora?
- Why are Delta habitats and ecological processes beneficial for many species but not for others?
- What processes control food availability, and how do these processes in turn influence populations of key species?
- How do State and federal water diversion operations affect ecological processes in channels within the "zone of influence" of the pumps?
- What processes govern patterns in the salvage of native species at diversion facilities?
- What processes control the flux and concentrations of organic carbon in Delta waters, and how do activities such as wetland restoration, diversions, and levee maintenance interact with these processes?

More detailed descriptions of cross-program management issues and potential study topics are contained in Attachment 1.

iii. Performance Assessment—Improving Tools and Implications of Future Changes

The Science Program has the overall responsibility for developing a performance assessment program for CALFED, supporting studies that will help CALFED agencies effectively measure direct responses to actions, and conducting independent technical reviews of performance assessment. The Science Program's overall approach is to develop portfolios of performance measures that include simple administrative metrics (e.g., dollars spent), quantifiable but simple results of expenditures (e.g., acre-feet of water conserved), and quantified direct effects (e.g., number of salmon spawning on restored habitat). The ideal portfolio would also address geographic scale by including, for example, information about causal effects of individual projects, information about effects of multiple projects in a watershed, and sound scientific analyses that help distinguish effects of multiple actions from each other and natural processes. This approach is described in more detail on the Science Program website.

This solicitation is for studies that will:

- help improve existing approaches or develop new ones for substantiating cause-and-effect relationships between multiple CALFED actions and specific program goals (e.g., regional recovery of a fish population);
- assist in providing better information about the implications of likely shifts in climate, population increases, and broad land use changes on CALFED actions or expected outcomes; or
- improve predictions of the performance of combinations of CALFED actions.

CALFED is in the unique position of having several environmental and biological monitoring programs in place, some of which have been in operation since the 1950s. Although large data needs remain, the historical data provide some baseline information about the status of the system before CALFED began. This large data set is an excellent resource for developing proposals on performance assessment across multiple programs or issues. Proposals that expand on the approach to developing performance measures listed on the Science Program website by further developing the examples shown on the website with metrics that might increase the comprehensive or explanatory power of those measures are also encouraged. Proposals for new monitoring approaches, analyses of trends in potential indicators, or designs for adaptive management frameworks using analysis of existing data focusing on any link between flows and ecological responses would support critical information needs related to performance assessment. Proponents particularly interested in adaptive management approaches are encouraged to conduct detailed reviews of previous CALFED-funded projects (e.g., Ecosystem Restoration Program projects, Drinking Water Quality Program projects, Water Use Efficiency Program projects), workshops where adaptive management approaches for CALFED have been the central focus, and develop partnerships with CALFED agencies prior to submitting proposals to conduct adaptive studies requiring environmental manipulations.

CALFED agencies have launched many projects supporting water conservation, surface water and groundwater storage and management, ecosystem restoration, and refinements in water operations in support of the core program goals. Many of these projects and improvements are designed for the current climate regime and human population distributions, but important climate and population changes are predicted that could have significant implications for the long-term success of CALFED. Specific management questions that would help unravel likely scenarios and interactions between climate, operations, and restoration changes include:

- What are the most likely scenarios for future changes in climate, and what implications do they have for CALFED actions?
- What are the implications of forecasted changes in precipitation, the hydrologic cycle, and water temperature for Delta habitats, ecological processes, and important management factors (such as salt concentrations and flux and key species abundance and distribution)?

- Do those implications change under different operational regimes?

Two basic science needs are associated with evaluating the reliability of CALFED's solutions under future scenarios: improving current water operations modeling, including developing and building links to ecological models, and developing methods for quantitatively evaluating combinations of CALFED actions under likely future scenarios of change, including climate shifts. Current modeling approaches would be improved by studies ranging from a focus on the modeling tools themselves (e.g., examinations of actual and modeled operations to quantitatively define weights and priorities under ranges of hydrologic and demand conditions, nonlinear operational decision models, and internal mass balance checks) to studies that develop quantitative links between hydrologic conditions, habitat ecosystem characteristics such as geomorphic processes or water temperature, and water operations. In addition, a better understanding of the interdependencies between water supply, demand, and regional hydrologies would support a more detailed scenario evaluation. More detail on science needs and examples of potential study topics related to modeling are presented in Attachment 1.

The present state of knowledge is such that scenario building and forecasting with state-of-the-art science models offer great possibilities for evaluating the implications of future changes on CALFED projects. Needs exist for studies that consider the effects of different combinations of changes (e.g., in water management, in configuration of the Delta, and in changing climate) on Delta habitats and ecological processes. Proposals that include forecasts of potential responses of physical, chemical, and biological aspects of the Delta and associated influences on key water operation factors, such as management of exports, management of Delta inflows, water demand, needs for storage, and reservoir operations, would be of interest. Similarly, water conservation, patterns of storage and release of surface water and groundwater, and patterns of water use interact to affect streamflows that are critical for native fish. Questions that need to be addressed in this area include:

- Are there ways to optimize or combine different aspects of water management to help meet ecosystem and supply reliability goals?
- Can experiments be conducted to evaluate the performance of such approaches?

More detail on science needs and examples of potential study topics related to evaluating the implications of future changes on CALFED success are presented in Attachment 1.

C. General Description of Scientific Studies Needed

Attachment 1 describes, in detail, examples of potential study topics that would address the broad information needs of the three topic areas described above. These study topics are summarized below.

- Studies are needed that further our knowledge of the abundance, distribution, and trends of key species and the processes that affect them. The implications of these issues for ecological processes that affect key species—such as how carbon fluxes could be influenced and why they are changing—need to be known; the factors controlling the abundance and distribution of macrophytes, especially those species that affect the suitability of habitat for native species, and the role of zooplankton in affecting native species trends also need to be further investigated. Benthic communities also need to be better understood, especially in floodplains (e.g., Yolo Bypass) and the Delta and Suisun Marsh area.
- Studies are needed that further our knowledge of the at-risk species most emphasized in managing environmental water assets—salmonids and delta smelt. Quantitative syntheses of life cycles of salmonids, delta smelt, and other native fish of interest, such as longfin smelt and Sacramento splittail, are needed. For salmonids, more knowledge is needed of the abundance and effects of hatchery fish on wild populations of all salmon runs, the genetic composition of all runs, and what factors influence existing escapement trends and their estimation. All aspects of spring-run salmon

need to be better understood, as do the factors that underlie trends in the Sacramento and San Joaquin Rivers for all runs and what underlies the differences between these two systems.

- Studies are needed that further our knowledge of how invasive species influence the outcomes of the issues described above. Hypothesis-driven studies of the life cycles of those species that most threaten restoration success (e.g., predators such as centrarchid fish, aquatic macroflora such as *Egeria densa*, and invasive zooplankton and benthos) are needed.
- Studies are needed that further our knowledge of the relative importance of different stressors for different species, which applies to nearly every Bay-Delta issue. For instance:
  - What physical, chemical, and biological attributes of the Bay-Delta system are important for the species discussed above?
  - How does water movement in the Delta and adjacent bays affect fish and ecosystem functions, and how might present and future exports change water movement on all scales?
- The implications of direct mortality at the export facilities remains a question that is not fully resolved with regard to long-term influences on populations of native and endangered species. Improving knowledge of the implications of stressors other than exports is necessary so that export-related effects can be evaluated in a broader ecosystem context. A mechanistic understanding of the environmental controls on the population dynamics of key species is part of the knowledge necessary to understand these processes.
- Studies are needed that further our knowledge of the effects of predation on native species. These effects are important because predation confounds interpretation of effects attributed to changes in Bay-Delta system configurations, fish screens, and water management.
- Studies are needed that further our knowledge of the fate, transport, and influences of trace elements, nutrients, and organic chemicals (including pesticides) so that water management issues can be compared to inputs of chemicals as stressors. Mercury, selenium, emerging pesticides and other chemicals, and legacy pollutants such as polychlorinated biphenyls (PCBs) and metals from mining are of special interest.

D. Types of Scientific Studies That Will Be Considered

Proposals will be considered for a wide range of types of scientific study. Approaches of particular interest under this solicitation are described below.

i. Hypothesis-Driven Field Research

Hypothesis-driven field research or experimental research is encouraged. A clear conceptual model, centered on the question that will be addressed (at the appropriate scale or level of analysis), is a required part of every research proposal. Proposals to observe, assess, or monitor key aspects of a system are acceptable, but the design of the study must be hypothesis driven and centered on conceptual models that clearly explain expected outcomes.

ii. Quantitative Analysis of Existing Data Sets

Hypothesis-driven quantitative analysis of existing data relevant to Bay-Delta system issues is a high priority for funding because of the immediate opportunities and cost benefits such analysis offers. Proposals that include quantitative analysis of existing data to address questions heretofore not analyzed are strongly encouraged.

iii. Models

The Science Program is soliciting proposals for the development of innovative or expanded models that include biological/chemical components. Models include conceptual as well as mechanistic representations of what we think we know about processes or some component of a system. The purpose of conceptual and mechanistic modeling should be to help determine where to focus research or explain choices, identify questions, uncover counterintuitive outcomes, or consolidate knowledge and professional judgment to forecast outcomes. Some types of models that are relevant to CALFED are further developed than others. Mathematical models of Bay-Delta system hydrodynamics and circulation are becoming more sophisticated and more accurate descriptions of reality because of a long history of support. Although the Science Program aims to continue such support, it is especially interested in further development and application of biological models, population models for key species, and relevant ecological models as they apply to key issues. New or expanded models that tie advances in physical modeling to biological/chemical processes are also of special interest. Development of ecological, biological, and physical models that are more complementary to alternative analyses or compatible with simultaneous use of alternative models is an especially critical need, given the complexity of the Bay-Delta system and the limits to all modeling.

Skepticism about model use often comes from dubious assumptions or improper applications. Thus, research that would improve the inputs, test assumptions, or refine applications of models to further our knowledge of the science topics identified above, are of major importance. This work is especially critical for biological models, where sound adequate field or laboratory data do not support many of the key assumptions. Because the internal workings of models are complex, an unhealthy competition can develop between modelers. The Science Program is not interested in fostering such competition. All modeling proposals should explain their choice of models among alternatives (if alternatives exist) and succinctly summarize the strengths and weaknesses of each potential choice. Comparisons among models, including outcomes, and an evaluation of the pros and cons of each model would strengthen modeling proposals.

iv. Science Communication: Monographs, Synthesis of Existing Literature, and Innovative Tools

Key science issues can be addressed in a monograph or review article describing what is known about a subject. These monographs provide CALFED with a solid foundation for public discussions of what is and is not known about specific issues. Ideas for monographs or literature syntheses that include creative ways to address or summarize the state of knowledge about critical subjects that have been inadequately covered to date (within the areas of relevance defined above) are strongly encouraged. Proposals must contain balanced analysis, direct consideration of uncertainties and assumptions, and a clear conceptual model of what will be covered. Examples of syntheses previously funded by CALFED agencies can be found at http://science.calwater.ca.gov/white_papers.shtml.

Communicating scientific information to the stakeholders, CALFED management community, and policy community in a manner that retains the core vision developed by scientists but also uses terms and decision frameworks common to the management community is a constant challenge for the Science Program. Proposals for summarizing and synthesizing information targeted for stakeholder, management, and policy audiences using innovative approaches, such as interactive websites or streaming video, are also encouraged, especially if they are part of a proposed research effort

v. Monitoring

Monitoring is critical to evaluating CALFED performance. The Science Program is interested in funding proposals for new and innovative approaches to monitoring, particularly proposals that specifically address the combined measurement and evaluation of system status and trends, examine how best to monitor changes caused by groups of CALFED projects, test and compare new monitoring methods and technologies, or offer interpretation of existing monitoring data. Although the Science Program is

focusing on learning how and what to monitor more effectively, it is not supporting existing monitoring programs or efforts, nor does it intend to provide future funding to support long-term efforts through PSPs. The Ecosystem Restoration Program is currently soliciting for proposals to monitor specific restoration projects and support ongoing monitoring efforts; other individual CALFED programs are expected to do the same.

E. Criteria for Evaluating Proposals

Proposals will be reviewed using a multistep evaluation process. The Authority will be relying on many scientific experts to assist in the review of proposals. Individual scientific experts assisting with reviews of proposals will represent diverse scientific and technical fields, including academic, government, and private interests. Details about the review process and the criteria against which proposals will be evaluated are described in Attachment 2. These criteria are summarized below.

i. Relevance to Priority Topic Areas and Support of CALFED Management Needs

The selection of proposals will focus on the relevance of proposals to the issues and science needs described above and in Attachment 1. Exceptionally compelling ideas outside these priorities, accompanied by exceptionally creative implementation ideas, will also be considered. *Relevance* is defined broadly because the Science Program recognizes that understanding processes can often lead to more useful insights than overly simplistic analyses focused on a single issue.

ii. Likelihood to Generate Knowledge

A proposal must demonstrate that the authors are knowledgeable in the area in which they propose to work, have a feasible plan for attacking the problem they address, and are likely to succeed in implementing that plan and delivering a useful product. Explicit conceptual models are also essential to a good proposal. The evaluation process will explicitly look for clear conceptual models as one means of showing that the authors are knowledgeable about the context of their proposal and likely to succeed in addressing their problem.

iii. Equal Consideration of Long-Term and Short-Term Benefits to CALFED Management

Equal consideration will be given to both long-term studies (i.e., studies that take the long view on difficult problems) and short-term studies (i.e., studies that address critical and immediate needs within shorter time frames but develop less new data). Learning about some aspects of the role the Bay-Delta system plays in the life cycle of Chinook salmon, for example, could require decades of study because many aspects of the ecosystem are poorly understood. In contrast, data may already exist to address issues such as the environmental conditions that contribute to incidental take of delta smelt, splittail, or threatened runs of Chinook salmon at the diversion facilities, so advances related to these issues might occur quickly.

iv. Equal Consideration of Ecosystem-Based and Species-Specific Studies

Equal consideration will be given to both ecosystem-based and species-specific studies. It is recognized that several species are of great regulatory concern in the Bay-Delta system: delta smelt, splittail, green sturgeon, winter- and spring-run Chinook salmon, and steelhead. We must know more about these species as soon as possible to facilitate the decisions that lie ahead for CALFED agencies. However, native fish in general are also a serious concern, and it is fully recognized that all species depend on a larger ecosystem for success. History shows that neither ecosystem-based nor species-specific approaches alone are adequate for successful restoration or understanding of impacts. This solicitation will consider proposals relevant to either, as long as the question is relevant to the issues critical to understanding the Bay-Delta system.

v. Feedback to the CALFED Management Community

The iterative feedback loop between scientists and the CALFED management community is critical to reducing uncertainty in our understanding of key populations and ecosystem processes and our ability to manage them. Proposals must include descriptions of how scientific knowledge will be communicated.

vi. Publication and Sharing of Knowledge

Recipients of Science Program funding are expected to publish their findings in media that are widely available and peer reviewed. Plans for doing so must be concisely described in the proposals. Publication will influence future success in this process. In addition, recipients are expected to regularly share information about the status of their research, working hypotheses, and findings with the greater CALFED community by participating in the biennial CALFED Science Conference.

vii. Monitoring Proposals

Monitoring must be carefully designed, conducted, and updated to serve the intended purposes. Monitoring requires interpretation to be effective, so any monitoring proposal must include explicit descriptions of questions that the data will address, interpretation approaches, data quality measures, and electronic archives that make the data readily available to interested parties.

viii. Modeling Proposals

Modeling proposals will be rigorously evaluated both for the support of sound field or laboratory data for key assumptions and for proper applications of the modeling approach. Proposals that offer further support for population models, for example, are of special interest, so modeling proposals should carefully define applications appropriate to the assumptions. The Science Program will also look favorably on proposals that use models in new ways or advance the status of important models.

ix. Collaborative Proposals

The Science Program places a high priority on multi-institutional, multidisciplinary, collaborative proposals for two reasons: because integrated, interdisciplinary scientific approaches are needed for the complex management questions facing CALFED agencies and because collaborative approaches have been identified as a means of strengthening communication between the research and CALFED management communities. Organizing such approaches, however, requires additional effort in the proposal, and special criteria will be used to review and evaluate the collaborative elements of proposals for signature projects. These additional criteria require:

- an overarching management structure for coordinating scientific work, managing finances, supporting collaborative field efforts, integrating data analyses and interpretive products, and including clear and distinct responsibilities of a project manager;
- overall strength of the assembled team, including an appropriate mix of expertise for the core scientific questions being addressed, track record, and/or aptitude for collaborative work; and
- integration of scientific approaches, including the articulation and use of compatible conceptual models, potential for interpretive products that use data from multiple teams, and a clear indication that the collaborative effort is greater than the sum of its parts.