STRATEGIC SCIENCE PLAN

SALTON SEA RESTORATION PROJECT

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DEDICATION

This Strategic Science Plan is dedicated to Science Subcommittee member Dr. Richard G. Thiery, who passed away on May 4, 1999. Richard's work as a member of the Salton Sea Science Subcommittee was always timely, productive, focused on the tasks at hand, and highly valuable in helping to accomplish the many challenging assignments of the subcommittee. We all benefited from the tireless work of Richard, his thoroughness, and his dedication to the effort we all engaged in. Some of his personal contributions are cited within different sections of this science plan. He provided the subcommittee with an extraordinary combination of extensive scientific expertise of saline-lake ecology, sincere dedication to the preservation of the Salton Sea, and interpersonal skills in working with others. He stood out among us as one of the most knowledgeable and most helpful members of the subcommittee and one who was generous with his time and knowledge, both on and off the job. All of us on the subcommittee thoroughly appreciated him—not only for his expertise and dedicated work, but also for the opportunity, however short, to be his friend. We truly miss him, his work, his humor and his presence. The subcommittee lost a great contributor with his passing.

EXECUTIVE SUMMARY

SECTION I—INTRODUCTION

The Salton Sea is an ecosystem in peril. Its prehistory consists of a series of intermittent lakes dependent on infrequent flooding of the Colorado River, while the modern Salton Sea originated from the desire to harness the flow of the Colorado River for irrigation. What began as an accident of this attempt is now a permanent inland sea supported by wastewater and agricultural drainage rather than Colorado River flood flows. However, environmental degradation is challenging the ability of the Sea to sustain the biological components that society has learned to value as characteristics of this waterbody. Increasing salinity and increasing frequency and magnitude of wildlife losses indicate the Sea is under severe environmental stress. The Salton Sea Restoration Project originated to reverse this degradation, to stabilize fluctuating water levels, and to provide a permanent waterbody that sustains values of the human society that uses it. The project foundation is provided by Public Law (PL) 102-575, passed by Congress in 1992. PL 102-575 directs the Secretary of the Interior to "conduct a research project for the development of a method or combination of methods to reduce and control salinity, provide endangered species habitat, enhance fisheries, and protect human recreational values . . . in the area of the Salton Sea." That PL was followed by the Salton Sea Reclamation Act of 1998 (PL 105-372), which directs the Secretary of the Interior to "complete all studies, including, but not limited to environmental and other reviews, of the feasibility and benefit-cost of various options that permit the continued use of the Salton Sea."

Section I of this document provides background and historical information relevant to the Salton Sea Restoration Project (SSRP). Section II highlights the activities and accomplishments of the Science Subcommittee. Section III is the conceptual framework for a continuing Salton Sea Science effort that is pragmatically focused on and linked to the SSRP. Section IV contains supplemental information referred to within the other sections.

SECTION II--SCIENCE SUBCOMMITTEE

The Salton Sea Science Subcommittee (SSC) was incorporated within the Salton Sea Restoration Project in December 1997 to guide the science effort needed to support restoration. The primary purpose of the SSC is to provide a sound scientific foundation on which management judgments can be based in considering alternatives for achieving project goals. Achieving this endpoint has been accomplished by evaluating data, identifying data gaps, and awarding contracts for focused scientific investigations. Using the principles of competition and peer review, eight reconnaissance projects, four studies of fish and avian mortality, and a nutrient cycling investigation were funded in 1998 and 1999 through the Salton Sea Authority (SSA) by a research grant provided the SSA by the US Environmental Protection Agency. By September 1999, two projects had been completed and eight synthesis documents had been written to provide input to the planning documents. These investigations are providing the most comprehensive scientific evaluations of the Salton Sea ever available. An additional eight issue-specific documents were prepared by SSC members to meet urgent needs of the planning process. Findings often differ from popular perceptions and conventional wisdom about the Sea, based on earlier investigations and more fragmented scientific efforts. As a result, speculation and unknowns are being replaced by practical knowledge. The SSC also provided presentations at scientific, agency, and environmental community forums and developed a strategic science plan (SSP) to guide the long-term integration of science within the SSRP.

SECTION III—FUTURE SCIENCE ACTIVITIES

The SSP provides recommendations for the development, function, and oversight of a pragmatic science effort to support long-term management actions for restoring the Salton Sea. Development of this segment of the SSP was assisted by input resulting from an SSC request for a US Geological Survey "Tiger Team" to carry out an intense evaluation of needs. A strong scientific program specifically oriented at guiding management actions will provide a sound basis for management decisions, evaluation of progress toward achieving SSRP goals, and conceptual models for effective selection among alternatives to address specific SSRP actions.

The basic objective for the SSP is to provide a framework for a continued scientific effort in support of the restoration project that replaces the interim activities of the Science Subcommittee. This objective will be met by accomplishing the following goals:

- Establish a dedicated science office to serve as an interface with restoration efforts;
- Provide timely, objective scientific evaluation and technical assistance to management;
- Establish a long-term database program for supporting investigations and management actions; and
- Establish a steady and reliable funding base for supporting SSRP science needs.

Components of the Science Program

Environmental baselines need to be established to evaluate change from restoration efforts. Monitoring is performed to evaluate the success of restoration actions and to collect long-term data from which quantitative models can be validated. Conceptual models are used to guide the development of quantitative models by identifying processes and ecosystem functions thought to be important. Quantitative modeling then generates hypotheses about these processes and ecosystem functions that focused investigations can explore. Focused investigations fill in key information gaps, support monitoring by identifying important measures that were not initially recognized, and also help in validating quantitative models. These components interact to provide management with a solid base to assess functional system changes being achieved and the outcome of management actions relative to the SSRP goals.

Technical assistance provides the glue linking the science program to restoration management. A dedicated technical assistance component is included within this SSP to provide a focal point for management requests and to develop processes to support those requests in a timely manner.

The SSRP has need for data and information management. The projected long-term efforts of the project will be best served by formal agreement between the project and external programs for managing scientific data and information that clearly define the roles, responsibilities, and contributions of each entity. Key considerations regarding SSRP scientific data and information management are that these components are part of the integrated scientific effort rather than a separate scientific program. This is important because formatted input and availability of scientific data can be required only for investigations funded by the project. It would require a substantial investment in equipment, personnel, and facility costs to establish an internal database function within the science program.

The Science Office

Restoration of the Salton Sea is a lengthy process that will require scientific support and investigations for many years. Continuity of the science effort, effectiveness of the science undertaken in support of the SSRP, and efficiency of operations in serving management needs will be best served by a funded and staffed Science Office. This office should be established as an independent organization along with the management offices for the SSRP.

The functions of the Science Office are as follows:

- Science leadership and coordination;
- Science oversight and responsibility for SSRP science activities;
- Administration of science funding;
- Science contract awards and negotiations;
- Science outreach activities;
- Development and delivery of scientific products;
- Collaboration and coordination with the SSRP management agencies;

- Networking with external agencies and organizations for data sharing and other SSRP science needs; and
- Accountability and reporting for the science program.

The basic roles for the Science Office are that of science planning, coordination, evaluation, and contract awards and administration. The Science Office should not be involved in the internal conduct or supervision of individual scientific investigations. It is the foundation for the science program and is accountable for the quality and productivity of science efforts funded as part of the restoration project. The Science Office has two standing committees to help set priorities and to address various issues. The External Advisory Committee of stakeholders in the Salton Sea helps coordinate scientific investigations at the Sea, setting priorities and resolving science issues. The Science Advisory Committee, whose members are selected because of their technical expertise, meets as small focus groups to address specific technical issues, to assist in establishing science priorities, to serve as peer reviewers, and to provide requested scientific evaluations.

Field Station

The Salton Sea Restoration Project science activities would be greatly enhanced by a common use on-site field station. The primary purposes of this facility would be to increase cost efficiency by sharing equipment and to facilitate coordination and dialogue among scientific studies. This would be a working facility for investigators who should be isolated from external disturbances, such as tour groups and unscheduled visits by the public, media, and others. The site should provide stability for the life of the project and should not be subject to transient occupancy due to other needs for the site by the landowner. The field station could be administered by one of four entities: the private sector, as an interagency cooperative agreement for shared government facilities, as sole responsibility of a government agency, or by the Salton Sea Science Office.

Funding the Science Program

The science program has no directed purpose without the SSRP; therefore, funding for the science effort should be part of total federal appropriations for the SSRP. Base funds provided the Science Office as an annual appropriation should be augmented by contributions from the state of California, grants for specific activities, and cooperative agency science activities that are funded through agency budget processes. Base funding should be tied to Congressional authorization for the Salton Sea Restoration Project because the purpose for the science program is to provide a sound scientific foundation for management decisions and actions associated with the restoration effort. Science requires time to gather information needed by management; therefore, funding for science should not be delayed if there is a delay between SSRP authorization and appropriations for construction.

Federal funding for the Science Office will need to be provided through some federal agency as base resources to assure annual operating funds to sustain the science effort.

Funding the major components of the science effort should be approached in a manner consistent with the objectives of the following components:

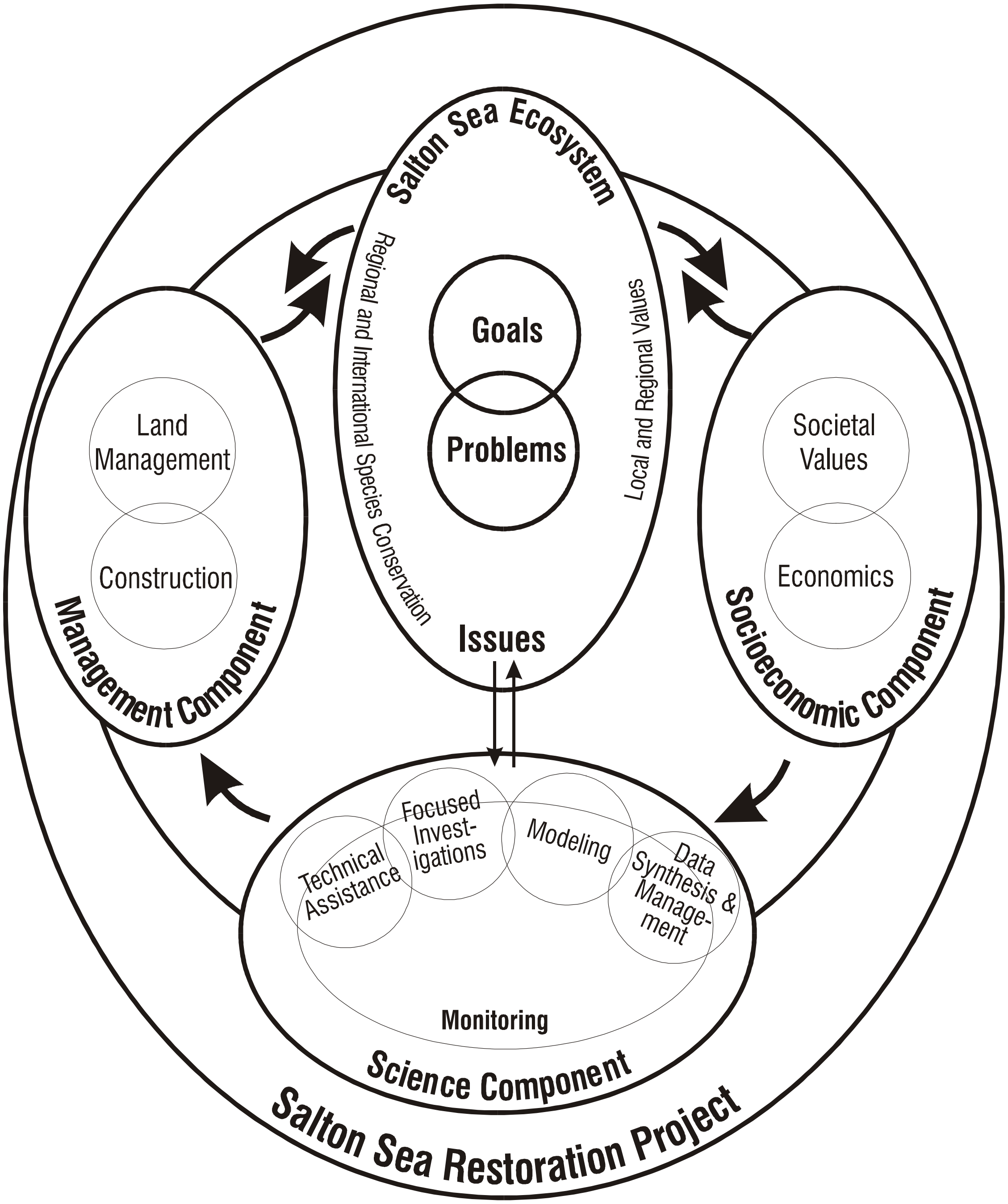
- Modeling and Focused Investigations—base funds, contributed funds from outside sources, and grants obtained for specific areas of inquiry.
- Monitoring—routine activities should be provided by cooperative state/federal agency programs, using their internal budget processes and existing program expertise. Nongovernment agencies also may contribute to a coordinated monitoring effort. Specialized monitoring associated with pilot and demonstration projects will require SSRP or base funding.
- Technical Assistance—funding to be provided by the Science Office and charged against SSRP and other management offices requesting assistance. The nature of the assistance should dictate what costs would not be borne by the Science Office.
- Data and Information Management—combined funding by the Science Office, external grants, fees for services provided, and cost-sharing arrangements with stakeholder agencies and organizations.

The Role of Review Processes in Restoration Science

External peer review is a fundamental component of quality science programs and should be an uncompromised standard for Salton Sea science. Peer review processes should be incorporated within all science activities: competitive science awards, database evaluations, data and documents released for use of the public, and collaborative science, such as monitoring.

Transition from Science Subcommittee to a Workable Science Program

Several actions are needed to assure continuity of science support for the SSRP. These include, but are not limited to, maintaining the current executive director of the SSC to oversee the transition, appointing a permanent Science Office executive director, establishing the External Advisory and Technical Advisory Committees, holding a modeling workshop to develop a conceptual model of the Sea, and producing a publication on the “State of the Salton Sea,” which summarizes current knowledge from studies directed by the SSC. Most critical to continuing the science support for restoration are obtaining temporary funding for science operations until the SSRP is authorized and obtaining commitments from stakeholder agencies for continuing oversight on current Salton Sea science investigations.



The Role of Science in the Salton Sea Restoration Project

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ABBREVIATIONS/ACRONYMS

Abbreviation/Acronym	Meaning
CEQA	California Environmental Quality Act
CHRIS	California Historic Resource Information System
CNDDB	California Natural Diversity Database
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
GIS	Geographic Information System
IPA	Interagency Personnel Act
NEPA	National Environmental Policy Act
PL	Public Law
RMC	Salton Sea Research Management Committee
SSA	Salton Sea Authority
SSC	Salton Sea Science Subcommittee
SSP	Strategic Science Plan
SSRP	Salton Sea Restoration Project
T&E	Threatened and Endangered
USBR	United States Bureau of Reclamation
USDI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

1. INTRODUCTION

SECTION 1
INTRODUCTION

1.1 PURPOSE AND BACKGROUND

This Salton Sea Strategic Science Plan (SSP) is a companion document to the Salton Sea Restoration Project (SSRP) Environmental Impact Statement/Environmental Impact Report (EIS/EIR) submitted by the Salton Sea Authority (SSA) and US Bureau of Reclamation (USBR). That document should be referred to for information about the SSRP and for additional information about the Salton Sea ecosystem (Salton Sea Authority and Bureau of Reclamation 1999). National Environmental Policy Act/California Environmental Quality Act (NEPA/CEQA) evaluations for the EIS/EIR were assisted by information provided by the Salton Sea Science Subcommittee (SSC), which was specifically established for that purpose. The SSC compiled existing information, obtained additional information needed through new investigations it identified for funding, and provided scientific evaluations through workshops and other means. SSC contributions provided important and valuable input to the SSA and the USBR. The Office of the Secretary of the Interior and the Congressional Salton Sea Task Force requested a science plan for continued science support for the Salton Sea restoration effort. This SSP is a response to that interest and is respectfully submitted for that purpose.

Section I of this document provides background and historical information relevant to the SSRP. Section II highlights the activities and accomplishments of the SSC. Section III is the conceptual framework for a continuing Salton Sea science effort that is pragmatically focused on and linked to the SSRP. Details provided within these different sections include the following:

- Section I—Purpose and background for this SSP; general perspective of the challenges involved in restoring the Salton Sea; a brief history of the waterbodies of the Salton Trough to illustrate the dynamic nature of this environment and the physical conditions that must be effectively dealt with for the SSRP goals to be achieved.

- Section II—Background on the origin of the SSC followed by highlights of activities, accomplishments, and assistance provided for the NEPA/CEQA evaluations.
- Section III—The conceptual science plan for a continuing science effort in support of the SSRP. Topics addressed are as follows:
  - Assumptions about the SSRP;
  - Goals and objectives guiding the science effort;
  - Elements of the science program;
  - A Science Office to provide oversight and direction for the science effort;
  - Funding considerations;
  - Review processes; and
  - Transitional activities to provide continuity between the current science effort and that needed for the next phase of SSRP efforts.
- Section IV—The final section provides supplemental information cited within the main body of the SSP.

1.2 GENERAL PERSPECTIVE

The Salton Sea is the latest of the waterbodies to occupy the below sea level depression in southern California referred to as the Salton Trough. A brief review of the history of this area follows to illustrate the impacts of physical factors on the dynamics of these waterbodies. The primary physical factors that the SSRP must consider are little annual precipitation, high annual evaporation rates, salinity, agricultural drainage as the primary water source, and the Sea being within a closed basin. As all other waterbodies of the Salton Trough, the Salton Sea originated from Colorado River flows; however, the Salton Sea differs in several important aspects. These factors, rather than historic perspectives, are the reasons for sustaining this waterbody and for improving its environmental quality.

The SSRP provides a long-term to permanent waterbody that sustains values of the human society that resides in this geographic area (Table 1). Irrigation has allowed this hot desert environment to become one of the world’s most productive agriculture areas. It is return flows from agricultural runoff that provide the water to sustain the Sea, despite an annual evaporation rate of approximately 5.5 feet and annual rainfall that averages less than three inches for most of the watershed (Ormat 1989). Also, since the development of the Salton Sea, dams have been constructed along the Colorado River to control flooding, and water distribution systems have been developed that control and allocate river flows to serve the needs of human society. As a result, direct flows of Colorado River water into the Salton Trough are not likely to occur again.

Table 1
Salton Sea Restoration Project Goals

	Restoration Goals
Goal 1	Maintain the Sea as a repository of agricultural drainage.
Goal 2	Provide a safe, productive environment at the Sea for resident and migratory birds and endangered species.
Goal 3	Restore recreational uses at the Sea.
Goal 4	Maintain a viable sportfishery at the Sea.
Goal 5	Enhance the Sea to provide economic development opportunities.

Source: EIS/EIR administrative draft.

Because the Salton Sea is below sea level, evaporation is the only mechanism for exporting inflows. As a result, the Sea is a sump for the silt and other materials that flow into it, such as salts deposited in agricultural fields by the irrigation waters and then leached from those fields, agricultural nutrients from fertilizers and pesticides. Increasing salinity and nutrient loading are major impacts on water quality of the Salton Sea. The current average salinity of the Sea is 44 parts per thousand (US Bureau of Reclamation statistic), or about 26 percent saltier than ocean water. The nutrient loading is a cause of eutrophication that is expressed by algal blooms that may be negatively affecting fish and bird populations of the Sea (see Reasons for Restoration, this document).

The complexity and interactions between physical and other factors that have led to declines in the environmental quality of the Salton Sea are such that a strong science effort is needed to assist management agencies to achieve SSRP goals (Table 1). These integrated efforts include assuring that the Sea continues to provide desired levels and diversity of natural resources while accommodating changes in the environment that may result from human population growth within the area.

1.3 WATERBODIES OF THE SALTON TROUGH

It is instructive to briefly review the formation and tenure of waterbodies of the Salton Trough to gain perspective about the physical forces that must be understood and addressed during the Salton Sea restoration. The Salton Trough is a rift valley about 70 miles wide that extends northwestward from the Gulf of California for approximately 130 miles. During the Tertiary period, up to approximately two million years ago, the Salton Trough was part of the Gulf of California. Reefs of oyster shells and other marine fossils were deposited during this period, some of which are now 1,000 feet above the basin floor and well above tide level, showing evidence of uplift (Blake 1914).

In the Pleistocene, or glacial, epoch 1.6 million to 10,000 years ago, heavy precipitation produced great flow volumes in the Colorado River. The sediment loads were correspondingly large, estimated at 80,000 to 110,000 acre-feet per year (Sykes 1926). Entering the gulf well upstream of its present mouth (near the current city of Yuma, Arizona), the river deposited this sediment load, forming a raised delta that spread westerly and southerly across the upper end of the gulf. This delta eventually cut off the Salton Basin from the Gulf of California (Blake 1914; Sykes 1937).

Once this separation was established, a closed basin/inland ocean that extended northward from an area near the current site of Yuma, Arizona, to an area near the San Gorgonio Pass, about 90 miles east of Los Angeles, existed in the Salton Trough (Kennan 1917). This basin later was filled by Lake Cahuilla, formed when water flowed into the Salton Trough from the meandering Colorado River (Blake 1914). It is reported that one creation of prehistoric Lake Cahuilla took 20 years to fill and grew to approximately 26 times that of the Salton Sea (United States Army Corps of Engineers 1989, cited by Cohen et al. 1999). Colorado River inflows were intermittent, depending on how the lower river channel shifted to direct water either north or south of the newly formed delta sill. Therefore, the water levels of this lake—indeed its very existence—were highly unstable due to the variability of the balance between riverine inflows and water losses from evaporation in this hot arid climate (Blake 1914). At times, when most or all of the flow of the Colorado River was diverted into the basin, the evaporation losses were more than offset by the inflow, and the lake filled. At other times, the inflow was cut off due to course changes in the river, and the lake would diminish, sometimes to total dryness. Hence, the basin has had a long history of rising and receding waters.

Physical evidence for the rising and receding of Lake Cahuilla is visible today on the rocks and slopes that form the perimeter of the basin. Lake levels of the past have left their marks, including some at an elevation of approximately sea level—some 230 feet higher than the current elevation of the Salton Sea (Setmire et al. 1990). The most recent complete evaporation of Lake Cahuilla was 300 to 500 years ago. The evaporation process left billions of tons of salts and marine fossil shells in the basin, along with sediment beds more than two miles deep (Setmire et al. 1990).

Relatively fresh water from the Colorado River displaced seawater in the old Salton Trough and converted the lake into a freshwater environment. A very different biological assemblage developed, as evidenced today by freshwater fossils in the sediments (Blake 1914). Also, because the basin has gone through periods of total submersion alternating with periods of desiccation, there are legacies of two very different kinds of deposition processes—under water and under air (MacDougal 1914).

The salient point to be gained from this historic record is that, despite the large volume of some previous waterbodies of the Salton Trough, evaporation to dryness was the eventual outcome due to the absence of sustained inflows great enough to overcome annual evaporation. An additional point of importance is that flooding by the Colorado River that resulted in water inputs to the Salton Trough was a common occurrence before dams were built along the river. During recent times, such events are reported to have occurred in 1828, 1840, 1849, 1852, 1859, 1862, 1867, 1891, 1900 and from 1905 to 1907 (Kennan 1917; Koenig 1971; Littlefield 1966). Koenig (1971) noted that the waterbodies resulting from the 1849, 1862, 1891, and 1900 Colorado River flows into the Salton Trough each evaporated in less than a decade. Also, it has been stated that "absent additional inflows, the Salton Sea created by the flooding from 1905 to 1907 would have evaporated completely by 1928" (Cohen et al. 1999). However, a critical point is that the Salton Sea is unlike any past waterbodies of the Salton Trough because it constantly receives inflows but not directly from the Colorado River.

The formation of the Salton Sea is not simply another chapter in the historical record of transient waterbodies of the Salton Trough; instead, the Sea represents the start of a new volume in the historic record of this area. Although on a different scale of magnitude of change, the expanded presence of humans, flood control dams along the Colorado River, and permanent water flows from agriculture within the basin result in ecological changes somewhat analogous to the scope of those resulting from the formation of the Salton Basin.

1.4 Reasons for Restoration

Restoration of the Salton Sea recently has become focused on the natural resources importance of the Sea and the decline in the Sea's ability to sustain the biological resources present and their attendant social and economic values for society. Overwhelming mortality of wildlife, including endangered species, has focused national attention on the Salton Sea and on the need for aggressive actions to improve the environmental quality of this important waterbody.

The biological resources and societal values of the Sea are undeniably reflected in the avian diversity at the Sea, in the productivity of the sportfishery, and in the recreational visitation of recent years. Approximately 400 species of birds have been reported at the Sea (Shuford et al. 1999); thus, the Salton Sea ecosystem is one of the richest areas in the nation for avian biodiversity. The sportfishery is one of the most productive of any California inland waterbody (Black 1988), and the large biomass of fish is the foodbase for the large number of fish-eating birds at the Sea. The interdependence between the Sea's avifauna and fish populations and the importance of the Sea to the birds of the Pacific Flyway is reflected in Table 2. Because of significant losses of interior wetlands, including more than 90 percent of those within California (Dahl 1990), the Sea serves an important role in the international, as well as regional and local, conservation of migratory birds. Significant proportions of some populations have become dependent on the Sea. For some of these species, there may be no alternatives because of bioenergetics associated with food availability (quantity and quality), travel distances between migrational stopover points and body condition relative to breeding success.

Table 2
Examples of the Importance of the Salton Sea for Migratory Birds

Species	Use of the Sea
Eared grebe (*Podiceps nigricollis*)	One of the most important migratory stopover and wintering areas for this species in the world (Jehl 1988).
Black skimmer	In some years, nearly 40 percent of California's breeding of this species

(*Rynchops niger*)	(Collins and Garrett 1996).
Gull-billed tern (*Sterna nilotica vanrossemi*)	The largest of only two nesting colonies in the western United States (Parnell et al. 1995).
Yuma clapper rail (*Rallus longirostris*)	Approximately 40 percent of the entire United States population of this federally endangered species is currently dependent on the Sea (Shuford et al. 1999).
Western snowy plover (*Charadrius alexandrinus nivosus*)	The Sea supports the greatest number of this species in the interior of California (Shuford et al. 1995).
American white pelican (*Pelecanus erythrorhynchos*)	Important migratory stopover site during fall and winter with most of the western population utilizing the Sea during some years (Anderson 1999).
Shorebirds (general)	One of the most important sites in the interior of North America for migratory and wintering shorebirds and the populations are of international importance (Page et al. 1992; Shuford et al. 1999).
General	" . . . bird populations at and immediately around the Salton Sea on almost any given day number at least in the low hundreds of thousands and at times reach the low millions of birds" (Shuford et al. 1999).

Recreational use of the Sea associated with birds includes waterfowl hunting, bird watching, and photography.

Waterfowl hunting is a long-standing tradition at the Salton Sea and even during the 1920s attracted hunters from Long Beach, Los Angeles, and other areas (Holmes 1933). The popularity of bird watching at the Sea has increased in response to the increasing diversity of its avifauna and has resulted in the international bird festival becoming an annual event. A 1993-1994 evaluation of the economic impacts associated with bird watching at the Sea disclosed an estimated $3.1 million input into the local communities and businesses (Kerlinger 1994).

The sportfishery of the Sea is primarily focused on orange-mouth corvina (*Cynoscion xanthulus*), bairdiella or Gulf croaker (*Bairdiella icistia*), sargo (*Anisotremus davidsoni*), and tilapia (*Oreochromis mossambicus* and other species and hybrids). All of these are introduced species. By the early 1980s, tilapia became the dominant fish species in the Sea (Costa-Pierce and Doyle 1997) and are a major food item for pelicans (*Pelicanus sp.*) and other fish-eating birds at the Sea. Recreation use of the Salton Sea was estimated in 1969 to average about 1.5 million days per year, with about two-thirds of this use (about 1.1 million days) being for sportfishing. A study two decades later disclosed an annual use rate of about 2.6 million days per year, but slightly less than half was for sportfishing (CIC Research 1989). Fish populations remain high (Costa-Pierce 1999).

Recreational use of the Sea is far greater than that associated with bird watching, hunting, sportfishing, and photography. On February 12, 1955, the Salton Sea State Park (now the Salton Sea Recreational Area) was dedicated and was the second largest park at that time in the state. Visitor use to the late 1970s reflected the popularity of this area (Horvitz 1999a), peaking during 1961-1962 at 660,000 visitors. There was greater visitation at that time than at Yosemite National Park (Horvitz 1998). Salton Sea Recreation Area visitation decreased to below 88,000 during 1993-1994 and 1994-1995 and has increased steadily since then to 275,000 during fiscal year 1998-1999 (Horvitz 1999b). Visitor use of a Salton Sea with improved environmental quality will significantly increase above the current levels. Factors supporting increased recreational use of the Sea include projected population growth within the Coachella and Imperial valleys, the relative proximity of this waterbody to approximately six percent of the population of the United States, and increased wildlife values of the Sea that will stimulate human visitation, in combination with the scenic beauty of the area and more than 300 days of sunny weather each year.

Despite the attributes described above for the Salton Sea, environmental degradation is challenging the ability of the Sea to sustain the biological components society values as characteristics of this waterbody. The signs of environmental degradation are manifested by periodic large-scale fish and bird die-offs and attendant chronic losses of greater frequency but with less magnitude of carcasses. The magnitude of large-scale fish die-offs is in the hundreds of thousands to millions of tilapia, and occasionally bairdiella, during individual events. The large-scale bird die-offs are killing substantial segments of some of the migratory bird populations that use the Sea. Examples include the 1992 loss of approximately 150,000 eared grebes (*Podiceps nigricollis*), approximately seven percent of the North American population of this species (Jehl 1996). The cause of that mortality and that for subsequent eared grebe mortalities at the Sea remains unknown. During 1996, an unprecedented outbreak of type C avian botulism in fish-eating birds killed more than 15,000 birds. Approximately 15 to 20 percent of the western population of white pelicans (*Pelecanus erythrorhynchos*) died during this event. More than 1,000 California brown pelicans (*P. occidentalis*) were also affected, making this the largest single loss from disease of an endangered species. These events were followed by the first occurrence of Newcastle disease in wild birds west of the Rocky Mountains. Virtually the entire production of double-crested cormorants (*Phalacrocorax auritus*) hatched on Mullet Island died from Newcastle disease during 1997. A similar event assumed to be Newcastle disease occurred the following year (Rocke and Friend 1999).

These and other diseases diagnosed as causes of bird mortality at the Sea present an unusual array of recurring die-offs for a single location. Multiple causes of mortality also have been diagnosed for fish dying at the Sea (Table 3). However, anoxia is the unquestionable cause of large-scale fish die-offs. Disease is an outcome rather than a cause, and environmental factors are often the major reason for disease occurrences (Friend 1995). A logical conclusion from the variety, frequency, and magnitude of wildlife losses at the Salton Sea is that the Sea is exhibiting severe environmental stress. Fundamental needs for reducing that stress are identification of the causes, selection of remedial actions, and evaluation of those actions before they are implemented to assess probable outcomes.

Table 3
Predominant Bacteria and Parasites Isolated from Sick and Dead Fish at the Salton Sea

Agent	Type

Aeromonas hydrophila	Bacteria
Amyloodinium ocellatum	Parasite
Pseudomonas putrefaciens	Bacteria
Vibrio alginolyticus	Bacteria
V. damsela	Bacteria
V. parahemolyticus	Bacteria

Source: United States Geological Survey, Western Fisheries Research Center.

2. SCIENCE SUBCOMMITTEE

SECTION 2
SCIENCE SUBCOMMITTEE

2.1 BACKGROUND

During December 1997, leaders from the federal government, the state of California, the Salton Sea Authority, and the Torres Martinez Desert Cahuilla Indian Tribe met and discussed the need to take coordinated measures to address the challenges presented by the Salton Sea. Among the consensus principles agreed to were to initiate an environmental review process under NEPA/CEQA to identify and evaluate specific options for addressing the Salton Sea and a process for coordinating and setting priorities for research and funding to provide enhanced scientific knowledge to assist in the evaluation of restoration options. The Research Management Committee and a Science Subcommittee were established to guide the science effort (USDI 1997, Appendix A). The charter for these groups is provided as Appendix B and their membership as Appendix C.

2.2 ACTIVITIES

The primary purpose for the Science Subcommittee in assisting the NEPA/CEQA process was to provide a sound scientific foundation for judgments associated with the various alternatives for achieving restoration project goals. Achievement of that endpoint was approached by use of the following actions:

- Gathering, synthesizing, and evaluating existing scientific information relative to the Salton Sea ecosystem;
- Identifying priority data gaps and facilitating investigations for obtaining that data;
- Making focused scientific evaluations of potential environmental impacts from proposed restoration project alternatives and management actions; and
- Developing a Strategic Science Plan to guide the long-term integration of science within the restoration project.

All NEPA/CEQA associated scientific evaluations are done at the Science Subcommittee level. The Research Management Committee acts on recommendations made by the Science Subcommittee for funding to address identified science needs. Science awards issued were funded by a US Environmental Protection Agency (USEPA) grant to the Salton Sea Authority made available for this purpose. The Science Subcommittee provides oversight for awards made. Information from those studies and other evaluations are provided to the management components of the Salton Sea Restoration Project.

2.3 ACCOMPLISHMENTS

2.3.1 Data Gathering, Synthesis, and Evaluation

There is a general perception that the Salton Sea has been "studied to death." Therefore, evaluation of past and ongoing studies was an initial undertaking to determine the extent and quality of existing information that was useful for restoration project evaluations. The University of Redlands was an important cooperator and collaborator in this effort. The university established an independent Salton Sea Database Program that interfaces with the science and management components of the restoration project. The database program provided a centralized system for storing, processing, sharing data and for distributing scientific information. Database program geographic information system (GIS) capabilities for mapping and evaluations (Appendix D, Table 1) were used to present findings to the public. Synthesis documents were prepared for existing information by various subject matter experts, Science Subcommittee subgroups, and others to address restoration project information needs (Appendix E, tables 1 and 2). In addition, a wide array of accessible documents was deposited into the University of Redlands Salton Sea Database Program (Appendix D, Table 2).

Scientific presentations at various meetings and forums associated with the restoration project were additional forms of evaluations for management consideration provided by the Science Subcommittee to the restoration project. These presentations served to enhance understanding by others of scientific considerations associated with Salton Sea restoration efforts and to inform others of the restoration project and the issues needing to be addressed. Examples of presentations are provided in Appendix E (Table 3).

2.3.2 Identification of Priority Data Gaps

An evaluation of existing scientific information about the Salton Sea disclosed that much of the information was dated and of limited use because of changes taking place within the Salton Sea ecosystem. Also, there have been no studies of the Sea as a whole, and the fragmentation of investigations that have been done does not provide a sufficient interface for findings from the various studies to meet many of the information needs. It was concluded from these evaluations that the immediate priority for science was to describe the current state of the Sea. A series of integrated reconnaissance studies were identified, funded, and conducted in a manner that provided "real time" information for use in the NEPA/CEQA evaluations. Contractual arrangements stipulated that investigators were to make their findings available during the course of their studies (Table 4). The next levels of need were determined to be an evaluation of the ecological factors resulting in major bird die-offs, followed by evaluations of important system processes within the Sea. Avian disease studies awarded are shown in Table 5. The first system process investigation to be undertaken is for nutrient cycling. The University of California, Riverside, has been tentatively selected for these studies. These investigations will be of great value in addressing nutrient loading at the Salton Sea and in guiding actions to reduce the eutrophication taking place.

Table 4
Salton Sea Reconnaissance Investigations

Area of Investigation	Awarded To
Survey of Algal Toxins in the Salton Sea	*University of California at San Diego, Scripps Institute of Oceanography*
Avifauna of the Salton Sea: Annual Phenology, Numbers, and Distribution	*Point Reyes Bird Observatory*
Fisheries Biology and Fish Ecology of the Salton Sea	*San Diego State University – Center for Inland Waters*
Salton Sea Desert Pupfish Investigations	*United States Bureau of Reclamation*
Reconnaissance of the Biological Limnology of the Salton Sea	*San Diego State University – Department of Biology*
Limnological Assessment of the Salton Sea, Riverside and Imperial Counties	*United States Bureau of Reclamation*
Survey of Selected Microbial Pathogens in the Salton Sea	*United States Geological Survey – National Wildlife Health Center*
Environmental Reconnaissance of the Salton Sea: Sediment Contaminants	*Levine-Fricke Recon*
Baseline Reconnaissance Vegetation Mapping of the Salton Sea	*University of Redlands* [1]

[1] Contributed work by the University of Redlands.

Table 5
Salton Sea Bird Mortality Investigations

Area of Investigation	Awarded To
Ecology and Management of Avian Botulism at the Salton Sea	*United States Geological Survey –National Wildlife Health Center*
Tilapia Food Habits	*The University of Southern Mississippi*
Identification and Ecology of Disease-causing Agents for Eared Grebes at the Salton Sea	*United States Geological Survey –National Wildlife Health Center*
Investigations of the Cause of Eared Grebe Mortality at the Salton Sea—Algal Blooms and Biotoxins	*Wright State University*

The prioritization of science needs is guided by serving NEPA/CEQA evaluations as the first phase of an orderly transition for scientific input to assist management actions for restoring the Sea. Science investigations are competitively awarded. Requests for proposals to address specific needs are developed by the Science Subcommittee and are broadly advertised. Proposals received initially are evaluated for relevance and general scientific merit. Proposals deemed to be of value then are submitted by the Science Subcommittee to external peer review by subject matter experts. Peer review is the dominant factor regarding which proposals are selected for funding. Successful proposals have originated from the private sector, the university community, and government agencies (Table 6).

Table 6
Salton Sea Restoration Project Scientific Investigations Funded through the Salton Sea Authority USEPA Grant (through December 1999)

Type of Organization	Number of Awards
University	6
Federal Government Laboratory	5
Private Sector	2

The high quality of scientists conducting the studies already funded has resulted in findings from these studies providing important information of direct relevance for evaluations of proposed management actions. These investigations are providing the most comprehensive scientific evaluations of the Salton Sea ever available. Findings often differ from popular perceptions and conventional wisdom about the Sea, based on earlier investigations and more fragmented scientific efforts. As a result, speculation and unknowns are being replaced by practical knowledge. For example, an internal evaluation of the impact of salinity on the fishes of the Salton Sea (Figure 1) provides an informed perspective when combined with the annual rate of increase of salinity to predict the time available for corrective actions before various species are lost from this system. Another example is shown in Figure 2. The Science Subcommittee was asked to provide an assessment of the physical and biological changes likely to occur within evaporation ponds being considered for salinity control. The time sequential changes displayed are part of that evaluation.

2.3.3 Focused Scientific Evaluations for Potential Environmental Impacts

The Science Subcommittee provided numerous evaluations of proposed management actions. Several workshops were held to evaluate various science issues and to provide evaluations of specific management being considered as restoration project alternatives. When needed, subject matter experts from outside the Science Subcommittee were invited as presenters and panelists for those workshops. Restoration project personnel directly participated in these workshops

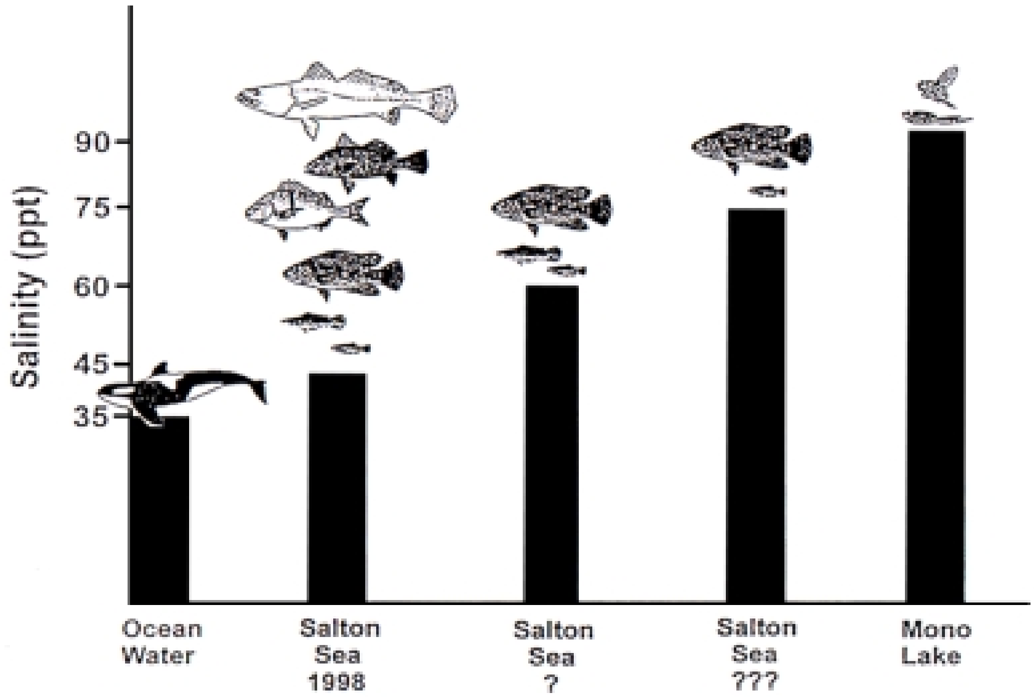


Figure 1 Probable Impacts of Rising Salinity on Fish Life of the Salton Sea (Modified from Thiery 1999)

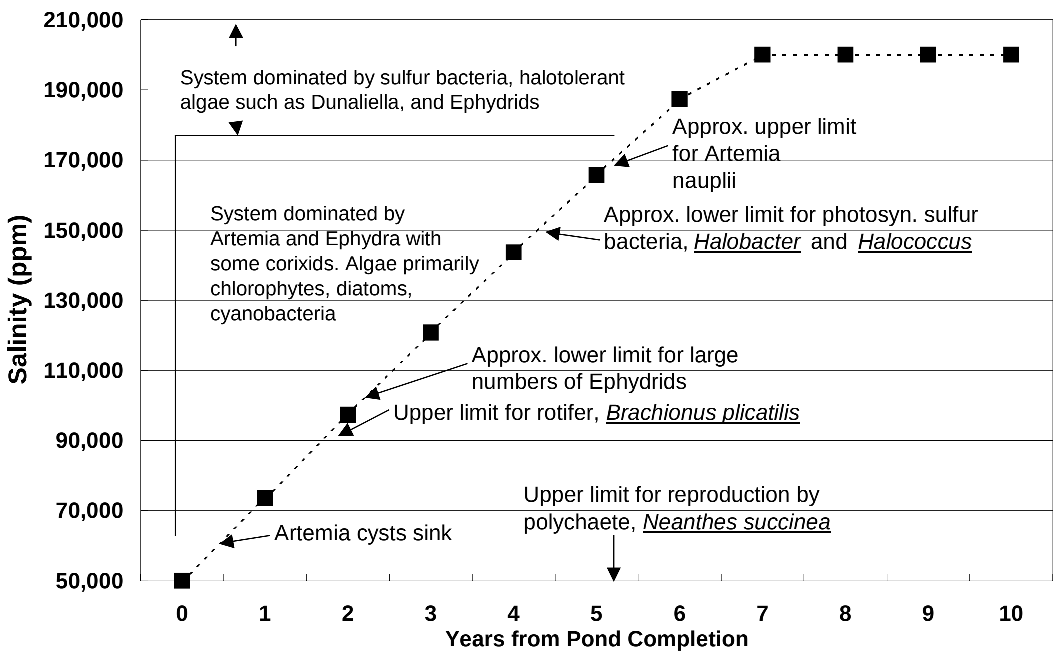


Figure 2 Projected Changes in Aquatic Ecosystems in Salton Sea Evaporation Ponds (Stephens 1999)

to facilitate input for the NEPA/CEQA evaluations. A variety of subject areas were addressed in this manner, including the No Action Alternative (Appendix E, Table 4). Evaluations are restricted to the potential biological impacts, both positive and negative, likely to occur as a result of the actions being considered and are nonjudgmental by the Science Subcommittee regarding advocacy or rejection. Evaluation results are considered by the management agencies in making decisions regarding alternatives being considered. Science Subcommittee evaluations are provided orally in some instances and as formal reports in other instances.

2.3.4 Strategic Science Plan

The restoration of the Salton Sea is recognized as requiring a long-term effort that has science needs that differ somewhat from those for the immediate NEPA/CEQA evaluations. The next section of this document provides the conceptual framework for the Strategic Science Plan to guide the long-term integration of science within the restoration project. The science plan builds on the foundation provided by the Science Subcommittee and provides a blueprint for the science process, functions, and administrative structure and funding support needed to sustain a long-term science component as an integrated component of the restoration project adaptive management approach. It also serves other science needs associated with achievement of the long-term restoration project goals.

3. FUTURE SCIENCE ACTIVITIES

SECTION 3
FUTURE SCIENCE ACTIVITIES

This Strategic Science Plan provides recommendations for the development, function, and oversight of a pragmatic science effort to support long-term management actions for restoration of the Salton Sea. A strong scientific program specifically oriented at guiding management actions will provide a sound basis for management decisions, evaluation of progress toward achievement of project goals, and conceptual models for effective selection among alternatives to address specific project needs (Figure 3).

3.1 ASSUMPTIONS

The complexity and magnitude of the restoration effort is such that no single action will result in achieving the restoration project goals. A sustained, long-term restoration effort will be required, some of which will involve significant unknowns. Therefore, a basic assumption is that the restoration effort will be an iterative process involving multiple actions and a phased approach. This type of need lends itself to a process commonly referred to as adaptive management. Among the many definitions and discussions of adaptive management is the common theme of providing a formal, systematic, and rigorous approach to learning from the outcomes of management actions, accommodating change, and improving management (Holling 1978). The basic components for such programmatic approaches include synthesizing existing information, modeling, exploring alternatives, monitoring, evaluating scientifically the results of management actions, undertaking supplemental investigations to fill important information needs, and providing feedback mechanisms to integrate these components in a manner that guides management actions and resource allocations for program activities.

Regardless of how the Salton Sea restoration is approached, the following assumptions are inherent in this Strategic Science Plan:

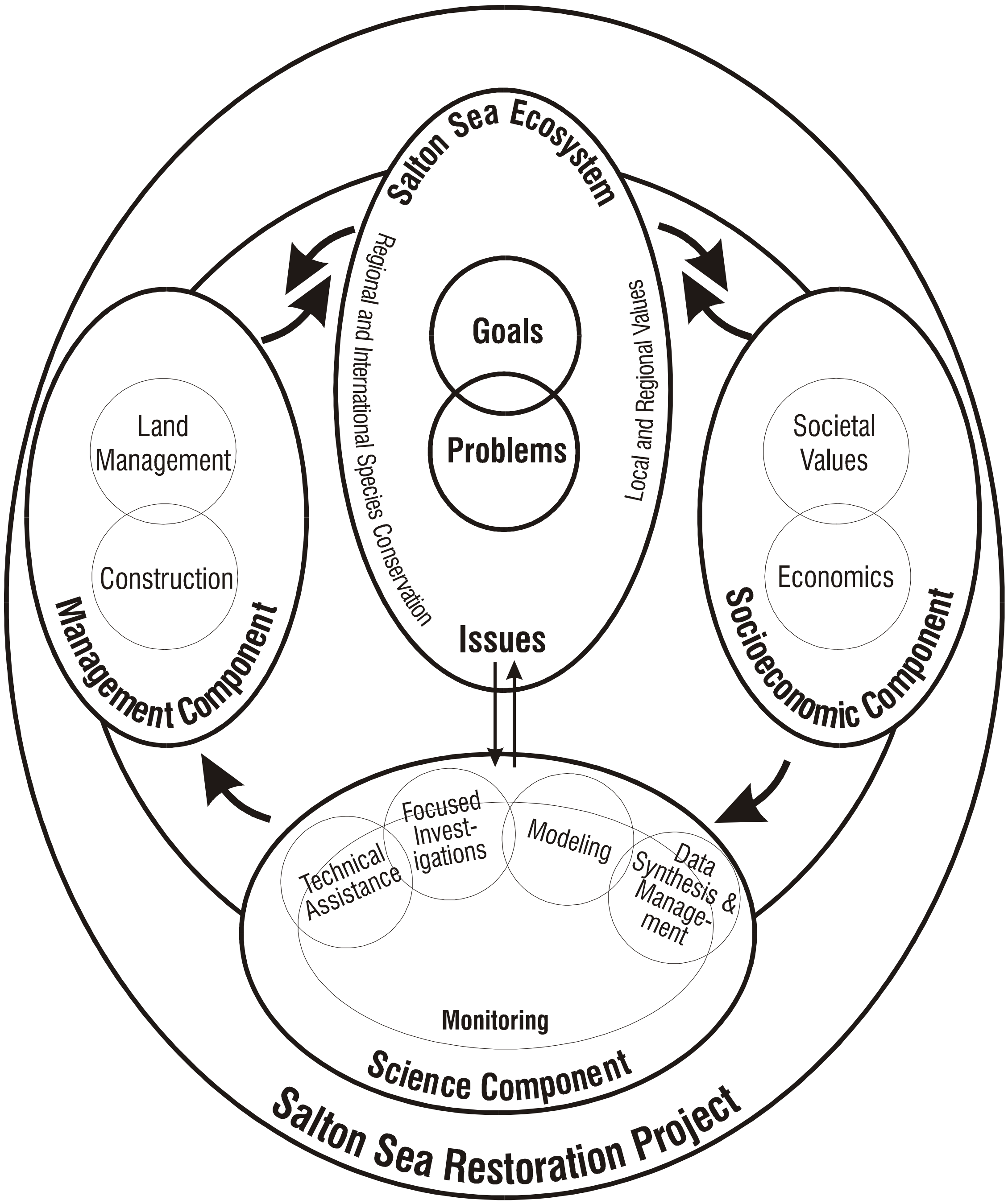


Figure 3 The Role of Science in the Salton Sea Restoration Project

- Wastewater, primarily agricultural return flows, will continue to be the source of water input to the Sea, with the exception of sparse, naturally occurring rainfall.
- Water conservation due to factors external to the Salton Sea Project will result in a Sea with less volume of water within the near future.
- The five restoration project goals are the programmatic goals to be achieved and sustained.
- There will be a long-term sustained management effort focused on goal attainment that is supported by sufficient fiscal and personnel resources to actively develop and initiate appropriate management actions.
- There will be a parallel long-term science effort that is supported by sufficient fiscal and personnel resources to effectively interface with the programmatic effort by providing a sound basis for management actions and evaluations associated with Salton Sea restoration.
- Numerous stakeholders will be involved with the activities associated with the restoration effort.

3.2 GOALS

The basic goal for this Strategic Science Plan is to provide a framework for a continued scientific effort that replaces the Salton Sea Science Subcommittee, established for the initial Restoration Project NEPA/CEQA evaluations. That subcommittee served the purpose for which it was established. Congressional authorization and funding for an SSRP will result in long-term science needs that are best served by a dedicated Science Office to administer the science activities on behalf of the management programmatic effort. The following goals address the general long-term science needs for the SSRP:

- Establish a dedicated Science Office with staff to serve as the long-term interface with Salton Sea restoration efforts;
- Provide timely, objective scientific evaluations, technical assistance, and scientific information relative to management needs and actions associated with Salton Sea restoration;
- Establish a long-term database program for supporting Salton Sea scientific investigations; and
- Establish steady reliable funding for supporting science needs associated with the Salton Sea Restoration Program.

3.3 OBJECTIVES

Inherent in the objectives identified below are two basic actions. First, build on the scientific insights and information gained to date and avoid duplication of effort in establishing the continuing scientific effort. Second, provide a smooth transition from the phase of scientific activity just completed to the long-term science effort to be initiated. These needs result in the scientific objectives that follow to address programmatic needs and the transitional actions provided in 3.7.

- Scientific Baselines: Establish environmentally sensitive baselines for measuring changes from restoration project actions.
- Monitoring Program: Establish a scientifically based environmental monitoring program for the above baselines and periodically evaluate data being obtained to assess progress in achieving restoration project goals.
- Models: Develop and refine conceptual and predictive models for scientific evaluations associated with the restoration effort.
- Coordination: Establish and maintain structured and internal mechanisms for scientific collaboration and information exchange among all parties undertaking scientific investigations within the restoration project study area.
- Focused Investigation: Identify and prioritize important information needs requiring focused investigations and fill those needs by collaborating with management to develop and evaluate demonstration and pilot projects within the larger programmatic restoration effort.
- Database Program: Establish a structured scientific database program to serve the needs of the restoration effort that is appropriately accessible to restoration project managers, the scientific community, and others.
- Data Synthesis: Develop orderly collaborative processes for seeking out scientific information about the Salton Sea and transforming findings into synthesis documents and status reports, including periodic evaluations of changes in components of the Salton Sea ecosystem.
- Technical Assistance: Develop and implement a program of scientific technical assistance and outreach to support management restoration efforts for the Salton Sea.
- Reviews: Conduct rigorous periodic scientific evaluations of the outcomes of management actions. Incorporate the findings within the adaptive management process as a means for achieving the restoration project programmatic goals.

3.4 SCIENCE COMPONENTS

The basic foundation for this portion of the Strategic Science Plan was provided by an external evaluation made at the request of the Salton Sea Science Subcommittee. The US Geological Survey (USGS) provided a “tiger team” of eight scientists from three of its four divisions, who were joined by two Science Subcommittee members (Appendix G) in an intensive two-week work session to provide recommendations for science support of Salton Sea restoration. The tiger team provided its report to the subcommittee on January 15, 1999. All but one of the basic recommendations is incorporated within this Strategic Science Plan. The recommendation not included was considered to be a matter of management policy and to be outside the scope of this plan. The content of that report is used extensively within this report.

"A successful science effort for serving the needs of the Salton Sea Restoration Program requires several components: conceptual modeling, long-term monitoring, focused investigations, quantitative modeling, technical assistance, and data management. These components are each essential, yet none can stand alone" (USGS Tiger Team 1999).

3.4.1 Concepts

Interactions among science components and activities and their relation to restoration project management are shown in Figure 4. A conceptual model guides both long-term monitoring and focused studies toward goals and objectives identified for the project. The model also promotes collaboration among managers and scientists in working toward these goals. Monitoring is essential to evaluate the success of restoration actions and to collect long-term data from which quantitative models can be validated. Conceptual models also guide the development of quantitative models by identifying processes and ecosystem functions thought to be important. Quantitative modeling generates hypotheses about these processes and ecosystem functions that focused investigations then explore. Focused investigations fill in key information gaps, support monitoring by identifying important measures that were not initially recognized, and also help in validating quantitative models. Ultimately, understanding the ecosystem can be formalized in a quantitative model that helps to anticipate the outcome of restoration actions.

Technical assistance involving time-responsive short-term needs, such as consultations, data synthesis, and evaluations, and other scientific needs for assisting management, is another important science contribution. The technical knowledge and insights of Science Office staff and others within the broader scientific community provides important input for management officials, who must respond to a wide variety of situations during the life of the restoration project. A data management program that helps integrate data among monitoring, focused investigations, modeling, and management is also an essential component of the science effort and facilitates the availability of information for some technical assistance needs. All successful studies require an awareness of each component of the science program and the ecosystem; that is, they must be integrative. Together, these components will contribute to a successful program.

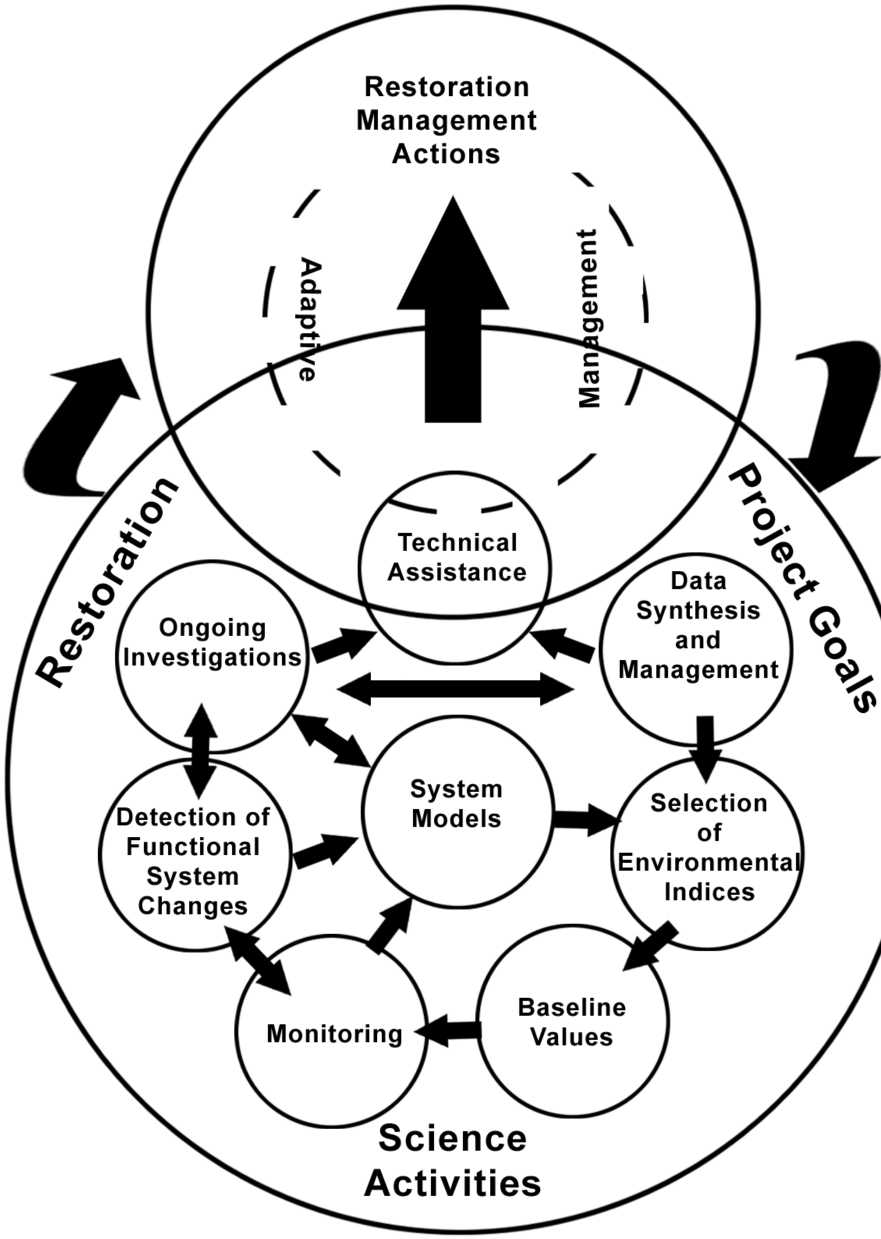


Figure 4 Salton Sea Science Activities and their Relation to Restoration Project Management Activities

ADAPTIVE MANAGEMENT

"Adaptive management is frequently cited as an effective approach to management of natural systems, however the term is widely misunderstood, and rarely is it actually undertaken. Adaptive management entails feedback between restoration practices and monitoring of responses in the ecosystem in order to measure the success of management actions and to fine tune future actions accordingly. In practice, this means that science is used to design the actions, and then monitoring results are provided to managers overseeing restoration so that adjustments can be made, if needed. This feedback works best if scientists are engaged in the design of restoration actions as experiments whose outcomes can be predicted and then measured. Modeling the ecosystem also will be most successful if approached from adaptive management principles, whereby models constructed by scientists are examined by restoration managers for applicability to the problems they face and cycled back to scientists for fine-tuning" (USGS Tiger Team 1999).

3.4.2 Models

The Salton Sea ecosystem is a complex system with many elements that defy simple explanation. Because of this complexity, it is helpful to begin by viewing the system in a simple form to which complexity may be added. The basic elements of this ecosystem include the drainage basin, which when acted upon by climate, influences the physical and chemical properties of water and, in turn, the biota. The simple conceptual representation shown in Figure 5 emphasizes the interactions between the terrestrial and quasi-marine elements, as well as interactions between the biota and their environment. The value of this type of representation is that it illustrates the interactions of major ecosystem elements. Gaining an appropriate level of knowledge for guiding management of the Salton Sea to achieve restoration project goals extends beyond the simple pictorial representation of these factors. It is necessary to gather and evaluate data for each of the elements to obtain a sound understanding of the relative importance of the various elements to the whole, to identify important data gaps, and to visualize processes that are effected by or that are the subject of management actions. These needs are served by the use of modeling.

The USGS Tiger Team recommended that a conceptual model of the Salton Sea ecosystem be developed to provide a common frame of reference for scientists and stakeholders, to guide long-term monitoring and focused investigations, to identify information gaps, and to unify and focus science activities. The team noted that the model should be considered a working tool that is flexible rather than fixed and that emphasizes processes rather than detail (USGS Tiger Team 1999).

A Science Subcommittee-sponsored workshop on ecosystem modeling recognized the need for conceptual and qualitative models to support scientific efforts associated with the Salton Sea Restoration Project. These models are not static endpoints; instead, they are dynamic tools that are continually upgraded by new

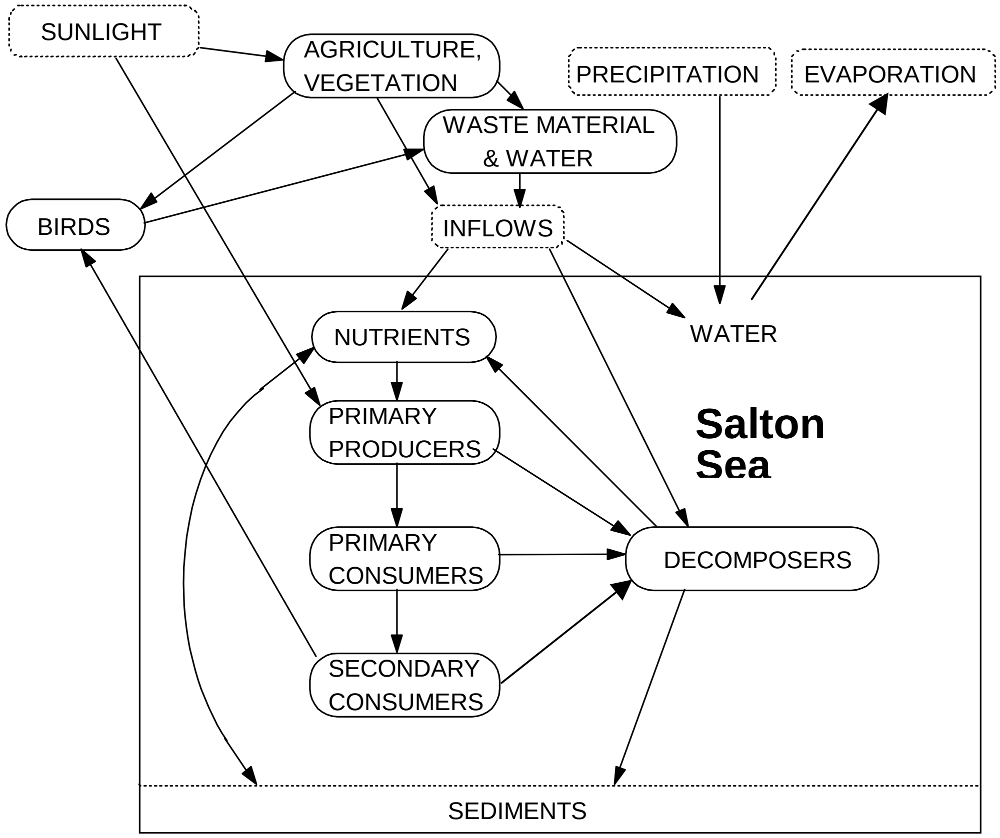


Figure 5 An Example of a Simple Conceptual Model of the Salton Sea Ecosystem

information and are used in conjunction with other information to help guide scientific inquiry and management decisions. A wealth of current scientific information about the Sea has resulted from the NEPA/CEQA focused investigations and provides a sound basis for initial modeling.

The USGS Tiger Team recommended that integrative, quantitative models, based on identified conceptual relationships, be developed for predicting ecosystem response to specific restoration actions (USGS Tiger Team 1999).

Quantitative modeling is necessary for both complete understanding of the complex interacting biotic and abiotic systems of the Salton Sea ecosystem and for predicting outcomes of restoration actions. Quantitative models test our understanding of the ecosystem, enabling scientists and managers to predict the ecosystem response to changes in various inputs, such as lowered Sea elevation and altered population levels. In addition, quantitative models help to identify gaps in data and incomplete understanding of functional relations, which in turn lead to refocused monitoring and new focused investigations (Figure 6).

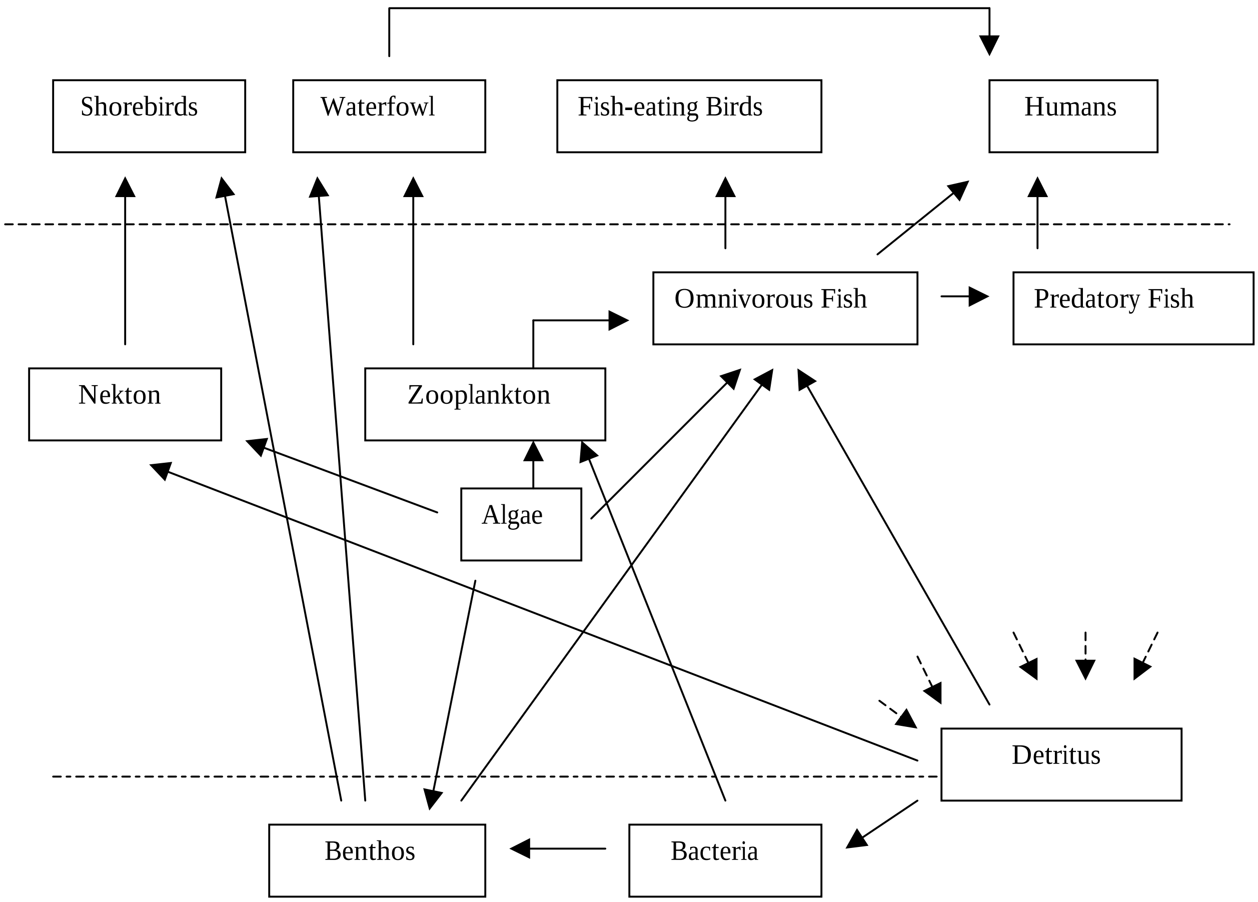


Figure 6 A Simple Example of the Salton Sea Food Web
Impact on various components of this conceptual food web will have various other impacts. Therefore, the components should be quantified to link rates of matter, nutrient, and energy flow. This added information enhances the value of the model for predicting outcomes.

Quantitative models must be flexible and dynamic. Flexibility is needed to model nested systems from detailed subsystems to complete predictive system models. The models must be able to incorporate and integrate large amounts of diverse information generated during monitoring and focused research. The models also must not be static; they must be continually refined as data accumulate and understanding of functional links improves. Refining and validating models is essential.

Quantitative modeling provides essential links among the many parts of the science program and provides checks and balances on the most important studies needed. As important, modeling helps predict specific measurable outcomes from restoration actions that can later be measured to determine effectiveness and thereby provide feedback to managers and scientists alike. This type of modeling should be a component of adaptive management processes.

3.4.3 Monitoring

"Monitoring is critical to the success of restoration. Information derived from monitoring activities is provided to managers overseeing restoration actions so that engineering and other management adjustments can be made if there is evidence that the actions, which had been taken, are not having the desired effect. Monitoring, by definition, is the repeated measurement of a variable, such as salinity or population levels for some species, at established sites and fixed intervals using standardized methods. This standardization assures the scientific validity of the measurements by accounting for natural variability inherent in the ecosystem" (USGS Tiger Team 1999).

There are two primary reasons for monitoring to be a major component of the science activities associated with the Salton Sea Restoration Project. The first of these is to provide an early detection system for undesirable outcomes, whether from an absence of management actions (no action) or from management actions taken. The second involves goal-specific evaluations to assess progress being achieved and the outcome of management actions relative to the restoration project goals. By monitoring key components of the ecosystem that are sensitive indices of functional changes, management is provided with the opportunity to respond to undesirable changes in a timely manner and to prevent more serious outcomes.

Goal-specific periodic assessments of whether management actions are resulting in the intended outcomes should be a component of all adaptive management activities, including pilot and demonstration projects within the overall restoration project. Monitoring provides feedback that is useful for assessing whether to stay the course or make course corrections. There are a large number of monitoring activities taking place within the Salton Sea ecosystem in association with various projects that are not part of the Salton Sea Restoration Project. Some of these are associated with regulatory and other agency functions (Appendix H). Coordination of effort and data sharing where appropriate should be sought in developing restoration project monitoring activities. Also, the following should be considered in developing restoration project monitoring activities:

- Sampling Design and Statistical Validity: The hallmark of a successful monitoring program is a sound sampling design that incorporates what is scientifically known about each variable, the degree of change that needs to be detected, desired sensitivity, and the available financial resources. Data from reconnaissance surveys and other existing data are taken into account to determine time of sampling, number and location of sampling stations, and number of replicate samples needed. These variables determine the statistical probability to detect change. However, sample size ultimately will be a compromise between statistical power and cost.
- Data Compilation and Evaluation: The results generated from NEPA/CEQA investigations, other ongoing efforts at the Salton Sea, and that from comparable ecosystems are invaluable in helping define sampling stations, sample sizes, and the value of various parameters in guiding the finer details of the monitoring activities. Examples include ongoing reconnaissance studies, routine data acquisition programs, focused programs, such as the San Joaquin Valley Drainage Program, the National Irrigation Water Quality Program, Binational Toxics Monitoring Program, and analogous programs in hypersaline ecosystems at other locations.
- Baseline Data: Before monitoring begins, baselines must be established to provide standards against which data gathered during monitoring can be compared. Seasonal and annual variation must be part of the baseline standards. Therefore, where existing data is inadequate, premonitoring data must be gathered to fill this void. Because of annual variation, it may be necessary to collect data for several years to provide an adequate baseline against which restoration project-induced changes (positive or negative) can be determined. Therefore, the timely selection of what is to be monitored and the establishment of baselines for those parameters must be given high priority. The rigor needed for individual baselines depends on numerous factors, including the degree of precision required in evaluating changes from the baseline values, which to a large extent depends on the consequence of incorrect evaluations.
- Quality Assurance/Quality Control: Data collected in the monitoring program must be quality assured and quality controlled at all points in the process. Sampling, sample labeling, preservation, storage, transport, analysis, and data entry and compilation must all follow established and accepted guidelines. Any automated analysis must follow guidelines of calibration and standardization.
- Keystone Species: Often a key species holds a critical place in a food web, or other critical component of the ecosystem, where knowledge of its viability indicates the viability of related groups in the community. This principle was incorporated in no action evaluations by the Science Subcommittee and is illustrated in Appendix I.

- Ecological Indicators: Ecological relations or even specific sensitivities often point to a target measure that is predictive of a large group of organisms or critical functional process within the ecosystem. These types of indices should be used as the most sensitive indicators of change and be incorporated within the monitoring activities designed for early detection of undesirable outcomes.
- Measures of Relative Abundance: Population monitoring can yield the relative abundance of a species or whether a population is increasing or decreasing, without determining the actual total population. This type of measurement is relevant for evaluating project goals involving bird use of the Sea and sportfishing.

The USGS Tiger Team recommended developing a long-term ecosystem monitoring program to establish baselines, to measure restoration outcomes, and to refine future actions by identifying key variables and analytes, by establishing appropriate spatial-temporal coverage, by assuring sufficient statistical power, by determining appropriate protocols for data comparability, by assuring adequate QA/QC, and by identifying the roles of involved agencies and organizations. The team also noted the need for investigating episodic, extreme, and unpredictable events, such as fish and wildlife die-offs, algal blooms, and unusual climatic events that can significantly affect the ecosystem or influence individual valued resources (USGS Tiger Team 1999).

It is important that the monitoring effort stay focused on evaluations that are responsive to the needs of the restoration project. This activity should not assume, replace, duplicate or derogate any agency’s statutory responsibilities for gathering data and for managing natural resources under its stewardship or take on responsibilities for other types of data gathering involving human resources and socio-economic evaluations. A wealth of monitoring programs already exists in which various types of information about physical, chemical, and biological components of the Salton Sea ecosystem are gathered (Appendix H). To the extent feasible, these programs need to be considered and collaboratively integrated as components of restoration project monitoring activities. Data sharing with others is inherent in the monitoring taking place, as is collaboration to avoid duplication of effort.

3.4.4 Focused Investigations

Fundamental information gaps exist for the Salton Sea ecosystem, some of which cannot be addressed by monitoring alone. These gaps include baseline information on the physical environment and the interaction of the biotic and abiotic components of the Sea. Determining ecosystem cause-effect relations, for example, will require testing hypotheses generated by the conceptual and quantitative models. This information is critical to determine the functional links among ecosystem components and to verify the models as reliable for managers. Other information gaps will require one-time surveys to determine monitoring needs. These surveys are in essence additional “reconnaissance” studies of the types developed for the NEPA/CEQA evaluation process. Focused investigations, whether directed research or surveys, should be aimed at priority needs to guide management during restoration and should be undertaken by consensus ranking of information needs by scientists and managers.

The USGS Tiger Team recommended that the science component for the restoration project identify and prioritize investigations relevant to restoration, based on conceptual models and recognized information gaps, in order to complete descriptions of baseline conditions with one-time surveys, to improve understanding of ecosystem functions and cause-effect relationships, and to verify and improve conceptual and quantitative models (USGS Tiger Team 1999).

Considerable effort already has been focused on identifying Salton Sea information needs. The 1997 US Fish and Wildlife Service (USFWS) research needs assessment workshop, "Saving the Salton Sea," is an example of such an undertaking. A wealth of perspective and information exists in the assessments that have been made, and those documents need to be considered in the development of focused investigations to be undertaken. However, consideration must also be given to the fact that those assessments occurred prior to the development of the Salton Sea Restoration Project and that they are not focused on goal attainment, as defined by the project. This does not negate the value of their content as resource documents from which important information and needs should be extracted. However, science activities within the restoration project should have a pragmatic focus on the stated restoration goals. Further, science activities should be fully integrated in a methodical and meaningful manner that will result in information of value for evaluating progress being made and that will provide guidance for adjustments in management actions.

Focused investigations will need to encompass a variety of approaches, including laboratory and field investigations. The use of on-site "demonstration areas" and "microcosm" experiments is an anticipated need associated with various aspects of the adaptive management approach to restoring the Sea. Integrating science, engineering design, and management in all aspects of the adaptive management process is essential. Focused investigations include short-term (one year or less) and long-term (multiple year) science efforts and require rigorous attention to coordination, data sharing, and relevancy to the needs being addressed. Priority setting for these investigations should consider time lines regarding when useable information from different investigations will be available. Priorities should relate to the needs for that information to guide management actions and other science investigations. Coordination of needs and priority setting for short-term and long-term science efforts are likely to be somewhat independent but will involve information and data sharing.

3.4.5 Technical Assistance

Management often has major needs for scientific input that is outside the scope of scientific studies. This is an important need of the Salton Sea Restoration Project and is generalized as time-sensitive consultations, syntheses and interpretation of existing information, review of proposed actions, development of graphics to illustrate concepts and issues, and other activities. This type of assistance placed a heavy demand on initial NEPA/CEQA science activities and will continue as a major need during the restoration project. The expertise and knowledge within the scientific community is invaluable in providing responses to these management needs. However, unless planned for, quality responses are often difficult to obtain within the short time frames often associated with management needs.

A dedicated technical assistance component is included within this Strategic Science Plan to provide a focal point for management requests and the development of processes to support those requests in a timely manner. It is important to minimize ad hoc disruptions and demands on investigators conducting focused investigations within the restoration project. Supplementary means should be established for addressing time-sensitive management needs, such as those identified above. This is needed to avoid conflicts between the needs of management and equally important time-sensitive requirements of investigators relative to various aspects of their scientific inquiry. Major roles for this science component include networking to access appropriate scientific expertise and technical systems that can contribute to delivering the products, coordinating and managing requests received, establishing feedback processes to evaluate the quality and utility of input provided, and transferring information to integrate relevant information and products within the Salton Sea database. That database is an additional component of long-term science activities and will often be the source of information used in responding to management needs.

3.4.6 Data and Information Management

The initial phase of the Salton Sea Restoration Project benefited greatly from the collaboration and support provided by the University of Redlands Salton Sea Database Program (e.g., Appendix D). That program is independently funded, is not a formal component of the Salton Sea Restoration Project, and has broader goals and objectives than the restoration project. None of these factors preclude continuing collaboration between the restoration project and the database program. However, the projected long-term tenure of the restoration project will be best served by formal agreements between the project and external programs that clearly define roles, responsibilities, and contributions by the project and those programs. Key considerations regarding restoration project scientific data and information management are that these components are part of the integrated scientific effort rather than a separate scientific program. This is important because formatted input and availability of scientific data can be required only for investigations funded by the project.

A major reason for collaborative efforts for data management is that it would require a substantial investment in equipment, personnel, and space costs to establish an internal science database function. It will be more cost-effective to develop collaborative arrangements with others for most of the process work and technology required for data storage, analysis, and information transfer activities associated with the science effort. Those arrangements should be supported by formal agreements. Also, because information and data needs are far greater than those resulting directly from scientific investigations funded by the restoration project, numerous collaborative arrangements and agreements will need to be made with agencies and other sources of that information to provide access to, and incorporation of, relevant scientific data into the database.

The science component of the restoration project should oversee scientific data and information management because of the multiple needs to be addressed and prioritized relative to what is to be done and when. Also, the project science component can manage this information in a manner that directly serves restoration project goals. In addition, there are numerous management needs for data and information that are outside the scope of scientific inquiry and that will require separate arrangements for access and management. Examples include cultural resources and socioeconomic information.

The above perspectives are consistent with recommendations of the USGS Tiger Team that "all technical information collected as part of restoration project funded scientific activities should be organized, stored, and made accessible through a common data management system. To the extent feasible, appropriate technical information originating from other sources should also be integrated within this system. This will assure that data meet quality control objectives, are made available to resource managers, scientists, stakeholders, and the public in a timely manner, and are in a format that enables synthesis by restoration project and other contributing scientists" (USGS Tiger Team 1999).

The data management system should have protocols for data reporting, archiving, and communicating and for assuring that data meet QA/QC guidelines, such as Federal Geospatial Data Committee requirements. This system also should have an infrastructure that includes the following:

- Classifies data into components of the conceptual models;
- Allows for remote data entry by program scientists;
- Provides offline and online serving tools for decision support and the analysis of data;
- Develops tools and methods (e.g., websites) to make information widely available in a timely manner, in synoptic form (e.g., maps, figures, summaries, indicators, visualizations) to scientists, administrators, and the public; and
- Establishes a plan for maintaining and archiving data, reports, and synopses.

The data management system also requires a process that discerns between preliminary and finalized data so that only finalized, QA/QC-approved data is released to the public or used in quantitative models.

The USGS Tiger Team recommended "establishment of a Data Management Team and methods to organize, store, approve, and disseminate data generated by the

Restoration Program science activities. The Data Management Team and procedures should be closely coordinated with science needs and with investigators and management officials to assure that resulting synoptic information is both accurate and relevant to restoration issues" (USGS Tiger Team 1999).

It is critical that data management be coordinated closely with and not independent of scientists who are monitoring, investigating, and developing the models. Scientists, working with the help of data managers, need to be ultimately responsible for interpreting correlations among ecological indicators and physical processes. These interpretations will help to evaluate status and trends in the Salton Sea ecosystem, causes and consequences of change in ecosystem components, and relations among status and trends and restoration efforts, if any. These analyses also will help in predicting future rates of change, assessing uncertainties, and guiding future investigations to reduce those uncertainties.

3.5 SCIENCE OFFICE

Restoration of the Salton Sea is a lengthy process that will require scientific support and investigations for many years. Continuity of the science effort, effectiveness of the science undertaken in support of the restoration project, and efficiency of operations in serving management needs will all be best served by a funded and staffed science office established on behalf of the project by the Secretary of the Interior.

"There is need for a permanent science body to advise Salton Sea resource and project managers (within whatever organizational structure evolves) on all aspects of monitoring and focused research during restoration. This would include three principal kinds of activities: 1) assuring a continuous information feedback process linking science and resource management; 2) managing science activities such as defining needed projects and overseeing reviews; and 3) providing oversight of data and information management activities" (USGS Tiger Team 1999).

3.5.1 Role

The Science Office should be responsible for all of the restoration project science activities and provide links among scientists and managers. Because the science activities will actually be completed by a variety of agencies and organizations, an important role of the Science Office will be to coordinate and integrate these activities. This office will define and competitively fund projects that it identifies, while other activities will involve independent efforts undertaken by various agencies or organizations that are leveraged and coordinated to help fulfill restoration project needs.

The primary functions of the Science Office should be as follows:

- Science leadership and coordination;
- Science oversight and responsibility for restoration project science activities;

- Administration of science funding;
- Science contract awards and negotiations;
- Science outreach activities;
- Development and delivery of scientific products;
- Collaboration and coordination with the restoration project management agencies;
- Networking with external agencies and organizations for data sharing and other restoration project science needs;
- Accountability and reporting for the science program.

The Science Office should not be involved in the internal conduct or supervision of scientific investigations; that is, Science Office staff should not conduct scientific investigations in support of the restoration project nor should they administratively supervise others that carry out such investigations. The basic roles for the Science Office should be that of science planning, coordination, evaluation, and contract awards and administration.

3.5.2 Organizational Components

External interagency and interdisciplinary technical work groups and advisory groups will be needed as part of the science program. These groups will assist in a variety of subject areas, such as needs assessment, priority setting, scientific evaluations, selections for contract awards, evaluations of Science Office performance and operations, preparation of syntheses documents, and other activities that enhance the productivity and quality of restoration project science activities. Some groups will be permanent bodies and others will be transient, developed for specific tasks and then disbanded when that task is completed. The organization, functions, and general attributes for various components of the Salton Sea Restoration Project science program are shown in figures 7 and 8. The Science Office is the foundation for the science program, and the Executive Director for this office is accountable for the quality and productivity of science efforts funded as part of the restoration project. Basic responsibilities and organization for that office are shown in Figure 8.

The Science Office should have two standing committees to assist in setting priorities and addressing various issues (Figure 7). An External Advisory Committee of stakeholders in the Salton Sea is an important adjunct to the Science Office. Nominations for members should be limited to one individual per organization, and for government agencies, these should be programmatic level individuals who can act on behalf of their agency in assisting the restoration project science efforts. The External Advisory Committee should meet regularly to coordinate agency scientific investigations with those being funded by the Science Office at the Sea, to discuss priorities, and to resolve such matters as coordination, data sharing, data interpretation, and other issues that may occur. The Science Office Executive Director and science coordinators also should participate in these meetings.

The other standing committee is the Science Advisory Committee. Members of this committee should be sought out by the Science Office and appointed because of their technical expertise in scientific areas of importance for the restoration project. This committee would seldom, if ever, meet as a body. Instead, small groups of members may on occasion be asked to meet on specific science topics. Mostly, the members of this committee will be called on to provide technical advice, to prepare specific evaluations, to provide input relative to priority setting, and to serve as peer reviewers and in other capacities where their scientific expertise can contribute to sound decisions and quality products.

Periodically, it may be necessary to assemble task-specific, short-term work groups of technical experts from the Science Advisory Committee or individuals who are not part of that committee. These work groups would be disbanded after the assigned tasks are completed.

3.5.3 Staffing

The Executive Director of the Salton Sea Restoration Project Science Office is the key individual and initial permanent position. Although the office function is essentially science administration, the Executive Director should be a well-credentialed scientist and an effective administrator. This is important because of the scientific leadership that the individual must bring to the Science Office and the interactions that will occur between this individual and scientists and organizations within a broad spectrum of the scientific community.

Most, if not all, other Science Office scientists should not be permanent staff. Instead, subject matter specialists to provide oversight for specific subject areas and

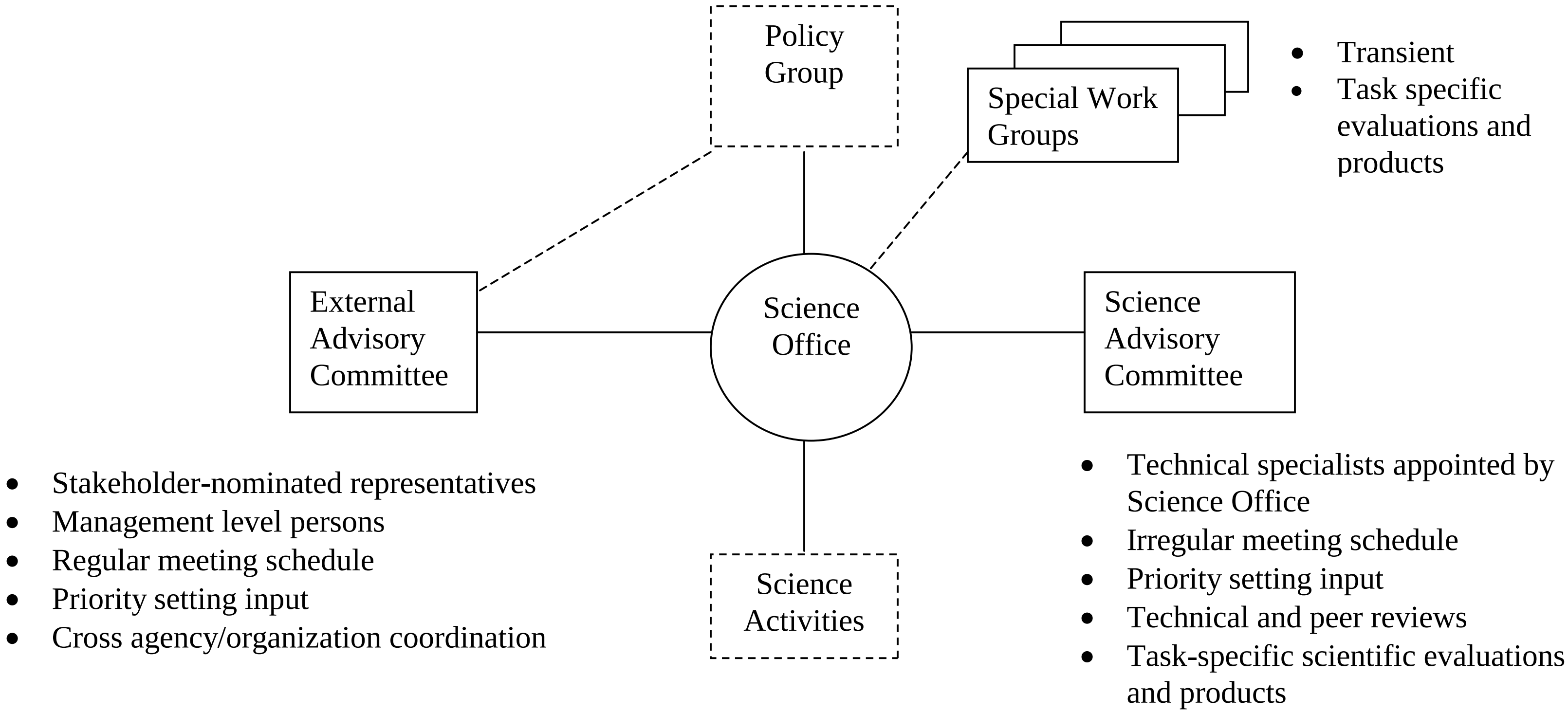


Figure 7 Salton Sea Restoration Project Science Program Components and Functions

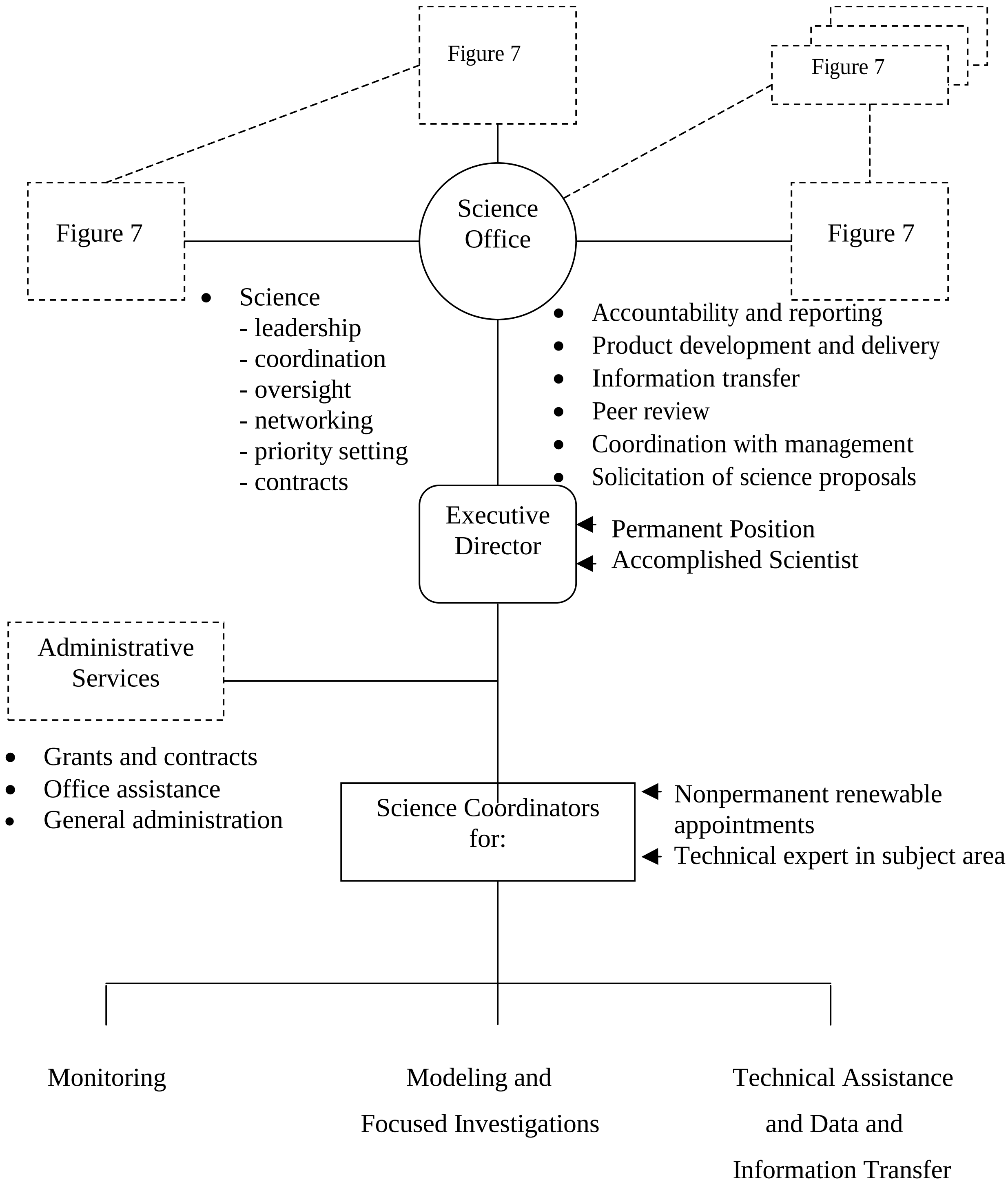


Figure 8 Salton Sea Restoration Project Science Office Components and Function

major science projects should be added to the office as necessary for two- to three-year renewable appointments provided for by personnel loaned from collaborating agencies, Interagency Personnel Act (IPA) appointments, fellows, and similar processes. An initial staffing of three science coordinators that oversee the science activities shown (Figure 8) and report to the Executive Director are needed, based on projected workloads. The eventual scope of the restoration project and associated science activities will determine if any of these positions need to be converted to permanent positions or whether additional temporary appointments are needed. These individuals should be scientists with a high level of technical knowledge in the subject areas under their responsibility and also be effective managers for science activity funding and oversight. Contracting and other formal agreements also should be used where feasible to obtain the necessary administrative and other support functions for conducting Science Office activities. Clerical support, contracting, QA/QC, and database services are examples of needs that might be provided by those means.

Administrative supervision of the Executive Director should lie within the Department of Interior if base science funds for supporting restoration project science activities are to be secured through Department of Interior budget processes. The administrative supervision of this position should be at as high a level as practical and should be organizationally removed from direct relations that could reasonably be perceived as conflict of interest in awarding funding for science contracts or establishing priorities for scientific investigations. It is anticipated that some form of restoration project policy or executive committee will guide the functional oversight of the Science Office.

3.5.4 Geographic Location

The science program needs to have close and continuous interactions with the restoration project management offices. Therefore, the geographic location for the Science Office should facilitate those interactions and minimize costs for travel between offices. Equally important is the amount of time that will be required by Science Office staff for on-site activities at the Salton Sea. These activities will primarily involve evaluations associated with overseeing scientific investigations funded through the Science Office. These and other considerations clearly point to the need for a southern California location within reasonable travel distance to the Salton Sea and restoration project management offices. Economy of operations may be enhanced by collocating the Science Office within a cooperating agency facility or a restoration project management office. However, the extent of the science effort will require dedicated space allocations, telephone lines, and administrative support staff.

3.5.5 Field Facility

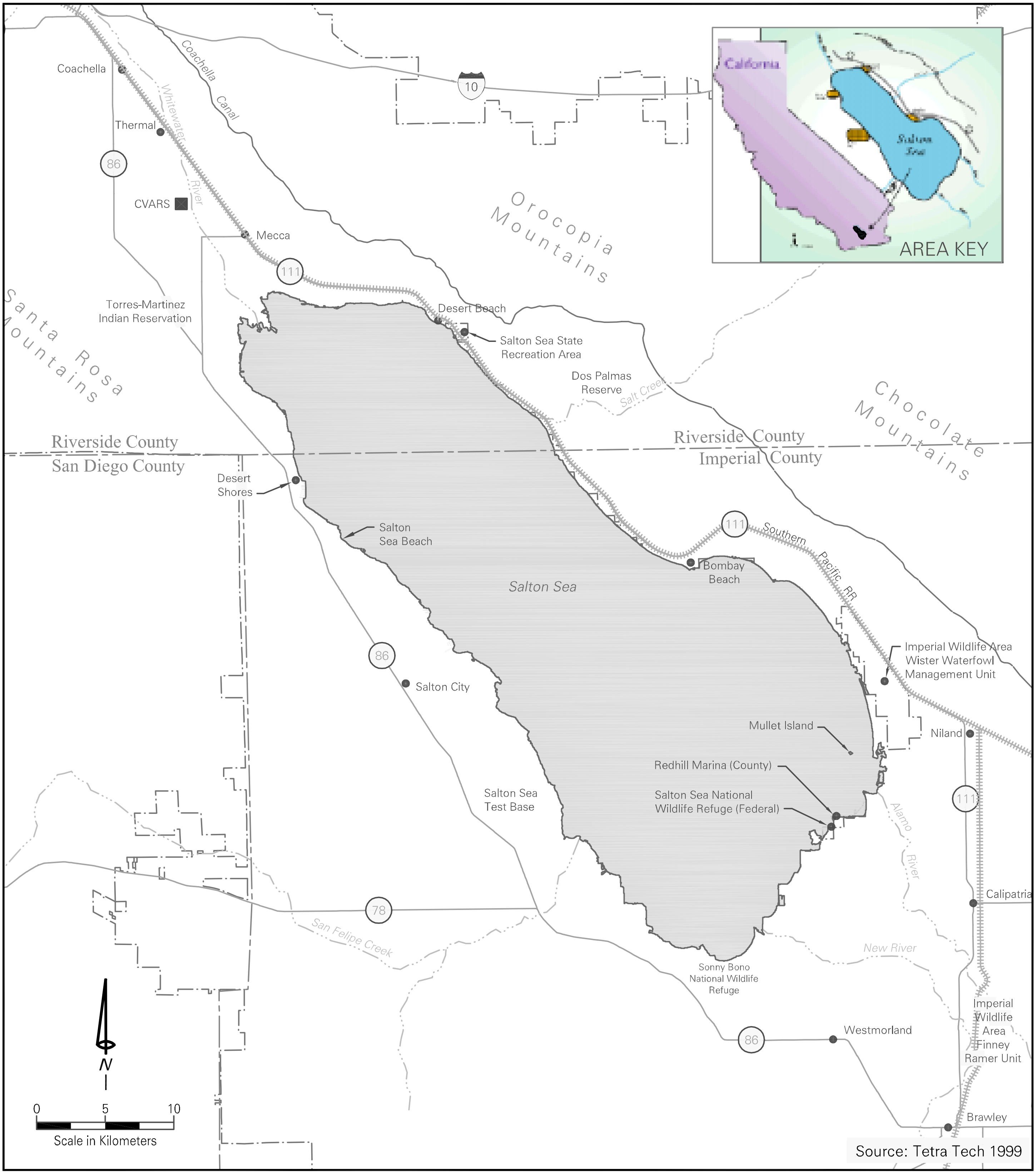
The efficiency of Salton Sea Restoration Project science activities would be greatly enhanced by a common, Science Office on-site field facility. The primary purposes for this facility are to provide cost efficiency for field operations and to facilitate collaboration and interactions among scientists conducting restoration project investigations. This facility would provide the following:

- Common Use of Equipment: On-site storage and sharing of major field equipment, such as boats, and support equipment, such as nets, freezers, and refrigerators;
- Common Base for Operations: A common contact point and interface for restoration project scientists conducting field investigations at the Sea;
- Sample Processing: A location for preliminarily processing field samples to be transported to laboratories for evaluation; and
- Access to Electronic Media: Computer access to the Salton Sea and other databases for data input, receipt, and transfer.

This facility should be limited to a field operations station and not duplicate laboratories and equipment for evaluations that are normally available within university research and other scientific laboratories, and which are components of the investigator's organization and associated collaborations. Laboratory capabilities should be limited to basic needs for preliminary storage and processing of specimens and not constitute a facility for extended work by investigators. Immediate and easy access to the Sea should be available because most work is carried out by boat.

Operational Needs. Security for supplies and equipment left at the station is an important consideration because investigators are only periodically on-site. Therefore, this facility will require on-site staffing or secure limited access to the site or be located in conjunction with other operational facilities, such as the USFWS Sonny Bono Salton Sea National Wildlife Refuge, Salton Sea State Recreation Area, Wister State Waterfowl Management Area, or other programs that can provide the security needed (Figure 9). Basic indoor essentials at the station are dependable electricity, dedicated computer hookups, running water, telephone, and sanitary facilities. It is also desirable to provide shower facilities and an air-conditioned lunch room/break area where the investigators can seek relief following their return from field activities.

Facility Location. Science activities will occur throughout the Sea. The southern portion of the Sea, including the Alamo and New River deltas, and perhaps those rivers themselves, will have the greatest amount of science activity. However, few if any investigators will confine their activities to a single area of the Sea. Exceptions will be focused investigations that address site-specific restoration project management actions, such as potential impoundments, enhanced evaporation system areas, wildlife habitat development, and other activities (Appendix J). Many factors need to be considered in selecting a site for the station. First and foremost, this is a working facility for investigators, and they should be



Location of Federal, State, County, and University Facilities in the Vicinity of the Salton Sea.

Legend

CVARS, Coachella Valley Agricultural Research Station (University of California- Riverside)

Salton Sea Area

Salton Sea, California

Figure 9

provided with isolation from external disturbances, such as tour groups and unscheduled visits by the public, media, and others. The site should provide stability for the life of the project and should not be subject to transient occupancy because the landowner/steward needs it for other purposes. Water access for boats should provide for larger open-water craft and those having shallow draft requirements.

Facility Management. Major considerations for common-use equipment are ownership, maintenance, and scheduling and formal, rather than ad hoc, oversight if the equipment is to be kept functional and available when it is needed. On-site staff should provide these functions, as well as facility maintenance and other support. If the station is co-located with another facility, it may be possible to develop shared positions with that program. However, the workload will need to be fully evaluated before pursuing such actions. The station itself also will require maintenance that will add to this workload.

Multiple options appear to be possible for station administration. These include contractual arrangements with the private sector for all or parts of station operations, interagency cooperative agreement for shared facilities, sole responsibility vested in a government agency or the Science Office, and other options that include separating facility and equipment oversight. Key considerations include stability of the arrangement for a period of one to two decades, minimizing construction needs and time for the facility to be available, avoiding all situations where station operations control the activities of the investigators rather than providing support for the investigators, and operational costs, including overhead.

Liability incurred is a major consideration in making judgments on station administration. This consideration extends to equipment, such as boats and vehicles (all-terrain and road). A wide variety of investigators, including graduate students, university scientists, and scientists from the private sector, as well as state and federal government agencies, may use this facility at various times. Some type of legal document that addresses investigator responsibilities and liabilities of both parties will need to be exercised for investigators that use the station.

Facility Costs. In addition to maintenance of facilities and equipment and scheduling their use, other costs will be incurred for Station operations. Basic operational needs, such as electricity, water, telephone, computer use, sanitation, and waste disposal, should be provided as station operational costs and, in most instances, not charged back to the investigators. The costs incurred for station operations are direct support for restoration project science and should be borne by the Science Office, provided that annual station costs are restricted to restoration project science activities and do not exceed 7.5 percent of Science Office base funds or $250,000, whichever is lower. Station closure should occur if science funds are not sufficient to maintain this level of support. This is necessary because the only purpose for the station is to serve the scientific investigations supported by the restoration project. The station cannot be allowed to become an entity that serves itself or other programs at the expense of restoration project science, thereby negatively effecting the ability of the Science Office to fund priority science needs. Station costs should be shared between base Science Office funds and as an assessment against other funds received by the Science Office.

Station startup costs should be provided as a one-time cost for basic equipment. Funding for this need should be sought as an addition within the federal budget. If the station is to be a federal facility, or built with federal funds, then construction funding will need to be placed in an agency budget for that purpose. The equipment startup funds should be included as part of that appropriation.

3.5.6 Funding Needs

The purpose of the scientific effort identified within this Strategic Science Plan is to support the proposed management activities presented in the Salton Sea Restoration Project EIS/EIR documents and subsequent actions for restoring the Salton Sea. This science effort will require dependable long-term annual funding to sustain the continuous effort that must take place alongside restoration to provide a sound scientific basis for management actions. The pragmatic purpose and orientation of this scientific effort supports primary funding for the science needed to be a direct restoration project cost.

3.5.7 Funding Strategy

Restoration project base science funds should be part of total federal appropriations for the restoration project, such as environmental evaluations, feasibility studies, construction design and construction, and other management costs. The Science Office will require base funds that are available annually. Total funding for science needs within the restoration project should be augmented to various degrees by contributions from the state of California (funds and services-in-kind), grants for specific activities, and cooperative agency science activities (state and federal) that address priority restoration project science needs and are funded through agency budget processes.

The following annual needs must be provided for on a sustainable basis through base funds for the Science Office:

- Base Operational Costs: Personnel and other costs associated with the Science Office, those for any field facility, and general costs occur annually to administer and oversee science activities and to interface with restoration project managers and others as needed.
- Long-term Science Activities: Methodical monitoring of predetermined physical and biological components of the environment is a recurring, but variable, annual cost. Similarly, multiyear scientific investigations that are time-sensitive regarding when they are initiated must be provided for. Adaptive management science activities are one example. Database management is an additional ongoing, but variable, annual cost. Matching funds being provided by others will be involved in some instances, and budget consideration for those agencies requires dependable matching federal funds.

- Flexible Funds: The Science Office must have resources available to respond to the continual array of unpredictable, time-sensitive requests from management for short-term needs, such as scientific evaluations and other forms of technical assistance and focused investigations.

Base funding provides a means for establishing annual priorities for addressing the most important needs within the above categories. Base funding also provides a framework for annually assessing total fiscal needs and developing strategies for supplemental funding to meet the larger array of restoration project science needs. Also, when funding strategies to support science needs for ecosystem restoration are considered, proactive rather than reactive scientific efforts are needed. This means that, prior to making management decisions, science may need to conduct multiyear investigations to provide the type of information needed for management to make appropriate selections among various alternatives. As a result, funding for much of the science effort must be provided well in advance of construction appropriations.

Science base funding should be tied to Congressional authorization for the Salton Sea Restoration Project because the purpose for the science program is to provide a sound scientific foundation for management decisions and actions associated with the restoration effort. The science program has no directed purpose without the restoration project; however, as noted above, science requires time to gather information needed by management. Therefore, funding for science should not be delayed if there is a delay between restoration project authorization and appropriations.

Funding needed to support the science effort is closely associated with the final scope of the restoration project. Federal funding to be made available to the Science Office will need to be provided through some federal agency as base resources to assure annual operating funds to sustain the science effort. The most desirable situation would be to have the funds authorized as no-year funds to allow any unspent funds in one year to be applied to needs in another year. At a minimum, two-year spending authority for annual appropriations is needed because of the amount of unknowns and annual variability in needs that will likely occur.

Funding in direct support of the Science Office should be flexible and be used for competitive science awards; negotiated small contracts needed to provide a variety of scientific products and activities, such as data synthesis and analysis, scientific workshops, and other input to management officials and for guiding the science effort and for administrative costs, including salaries and external technical reviews. Minimizing overhead costs to maximize the availability of funds to conduct science activities should be a major consideration in providing these funds to the Science Office. A similar consideration should be imposed on Science Office contracts and other awards for scientific investigations.

3.5.8 Use of Science Funds

The science effort involves several major components. Funding for these efforts should be approached in a manner consistent with the differences in the activities associated with those components. Recommendations are as follows:

- Modeling and Focused Investigations: Provided by a combination of flexible funding of the Science Office (base funds identified above), contributed funds from other sources, and grants obtained for specific areas of inquiry.
- Long-term Monitoring: Primarily funded by cooperative state-federal agency programs that use their internal budget processes and existing program expertise to address restoration project specific needs. In some instances, nongovernment agencies also may contribute to coordinated monitoring efforts, especially in the general area of water quality. Special monitoring associated with pilot and demonstration projects should be funded directly by the restoration project and may involve either Science Office base funds or management funds, as appropriate.
- Technical Assistance: Provided by a combination of flexible funding of the Science Office and charges against restoration project and other management offices requesting that assistance. The nature of the assistance should dictate what percentage, if any, of the costs would be borne externally and by the Science Office.
- Data and Information Management: Funding should be provided by multiple sources consistent with the various activities and needs involved. Science Office flexible funding, external grants, fees for services provided, cost-sharing (services-in-kind and fiscal) arrangements with stakeholder agencies and organizations should be used, as appropriate.

3.6 REVIEW PROCESSES

The guiding principle for restoration project science is to provide high quality, objective information to serve as a foundation for management actions. External peer review is a fundamental component of quality science programs and should be an uncompromised standard for Salton Sea science. Peer review processes should be incorporated within all aspects of the science activities, including the following:

- Competitive science awards;
- Scientific data and documents released for use of the public and general scientific community;
- Collaborative science efforts involving external programs such as monitoring programs supported by funding from other agency processes; and
- Database processes and evaluations.

Reviewers should be external parties with no vested interests in the proposals, products, and projects being reviewed. Review reports should be maintained as official records of the Science Office. The Science Office should be reviewed periodically to evaluate all aspects of its operations, including processes for funding science activities, monitoring of awards issued, timeliness and relevance of information being developed by the science effort, coordination of Science Office funded science activities with other relevant science being conducted at the Salton Sea, coordination and information transfer involving the restoration project management offices, and quality of products resulting from the science effort. The first of these reviews should take place at the end of the third year of Science Office operations. The Science Office should select the reviewers, except for the review of that office. The parent organization should select external reviewers for the Science Office, with input from that office and those of the management components of the restoration project. Restoration project management offices and stakeholder agencies served by Science Office activities should be interviewed as part of the review process of the Science Office. Costs associated with peer reviews and that of the Science Office should be borne by the Science Office.

3.7 TRANSITIONAL ACTIVITIES

It is important to provide for continuity of science support for the restoration project until a more permanent science program can be initiated. The following recommendations address transitional needs for continued oversight of current science activities and actions to provide the foundation for establishing a Science Office.

3.7.1 Transitional Science Activities

- Obtain commitments from stakeholder agencies for project officers to continue overseeing ongoing science contracts until the Science Office can assign replacements.
- Maintain the current Executive Director, Salton Sea Science Subcommittee, in a transitional oversight role for the science program until an Executive Director can be appointed for the Science Office.
- Hold a modeling workshop to develop a conceptual model of the Salton Sea ecosystem to guide further development of the science effort.
- Evaluate by modeling the effects of proposed construction of restoration project alternatives on the water circulation and sediment deposition within the Salton Sea.
- Produce a “State of the Salton Sea” publication that summarizes current knowledge gained from recent and ongoing investigations. This document will provide an important foundation for guiding scientific investigations.
- Continue to initiate and oversee science investigations to guide short-term management solutions to biological problems at the Sea and proposed management actions of the restoration project.
- Conduct a Science Subcommittee evaluation workshop to document the strengths and weaknesses of that segment of the scientific effort and to

provide recommendations for Science Office staff to consider in carrying out the next phase of scientific activities.

3.7.2 Transitional Science Office Development Activities

- Develop a position description and, as soon as Congress authorizes a Salton Sea Restoration Project, select a Science Office Executive Director.
- Decide on a location for and establish the Science Office.
- Establish guidelines for a stakeholder External Advisory Committee and a Science Advisory Committee of technical specialists to serve the Science Office.
- Develop position descriptions to staff the Science Office and seek candidates as soon after Congress authorizes a restoration project and funds to support science activities are obtained.
- Secure temporary funding for science operations until permanent support can be obtained.
- Pursue development of a common-use field facility to support restoration project science activities.
- Develop a clear mission statement, operational guidelines, and appropriate authorization for the Science Office to operate under, including processes for obtaining and disbursing funds.
- Establish oversight and external review processes for periodically evaluating the scientific effort.
- Establish peer review, QA/QC, data standards, and other processes essential for a sound scientific effort for the restoration project.
- Establish feedback processes to provide an effective management-science interface at all appropriate levels of the management and scientific processes, including developing project budgets and resource allocations.

4. References and Supporting Information

SECTION 4
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