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Sustaining the Health of the Salton Sea Ecosystem:*
A Challenge for Restoration Ecology

Milton Friend

U.S. Geological Survey

Executive Director
Salton Sea Science Subcommittee

INTRODUCTION

This presentation is about values and processes. The values are those of human society relative to the Salton Sea. The processes are the human instruments being employed to guide administrative decisions for a course of action that addresses - "Sustaining the Health of the Salton Sea Ecosystem: A Challenge for Restoration Ecology." The key words and phrases of this presentation title are the biological focus for the Salton Sea project. The processes being employed serve an important role by assisting to translate the ambiguity of the key words and phrases (i.e., Sustaining, Health, Salton Sea Ecosystem, Restoration Ecology) into pragmatic expressions of the will, or values, of human society. These processes also provide means for obtaining scientific information that has relevance for guiding administrative decisions for addressing human values associated with the Sea.

PROJECT SITE

The Salton Sea is the major component of an ecosystem with a number of unique characteristics, including being a hypersaline environment with the presence of a significant fishery. This

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fishery serves as a food base for large numbers of fish-eating birds that have become highly dependent upon the Sea due to the loss of other suitable habitat. Although the Salton Sea is the largest body of water in California and the third largest interior saline lake in North America, it is little more than 90 years of age. The Sea is located approximately 35 miles north of the border with Mexico in a closed desert basin east of Los Angeles and San Diego.

Tens of thousands of years ago, the Pacific Ocean covered the area within which the Salton Sea lies. At that time, the Pacific Ocean extended northwesterly from its present location within the Gulf of California to near the San Gorgonio Pass, about 90 miles east of the area that is now Los Angeles and across the Colorado Desert to what is now the location of Yuma, Arizona (Kennan 1917). Sediment deposits from the Colorado River eventually formed a levee in the shape of a delta-plain, thought to be 10 miles in width by 30 miles in length, extending from the present site of Yuma to the Cocopah Mountains at Black Butte. This levee separated the Gulf of California into two segments. A landlocked saltwater lake completely filled the upper basin region and the lower basin was maintained as an ocean water body. Over time, evaporation in this hot desert climate resulted in the lake becoming a dry arid basin, which eventually became known as the Salton Sink, a depression of about 100 miles in length by thirty-five miles in width. At the time of becoming dry, this depression had a maximum depth of approximately 1000 feet below sea-level and was covered with an incrustation of salt in the deeper levels of the depression floor (Kennan 1917).

Periodically over time, flows from the Colorado River, augmented by those from the Gila River, refilled the Salton Sink with fresh water. These flows are thought to have begun in Middle Tertiary times and resulted from changes in the course of the lower stretches of the River. The Salton Sink has experienced multiple periods of flooding and drying associated with the meander-

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ing of the Colorado River that appear to have occurred at four or five hundred year intervals. Kennan (1917) reported that the Sink had been dry from at least 1540 to 1902. However, the Salton Trough (Sink) received flood waters from the Colorado River on at least four occasions during this period---1849, 1862, 1891, and 1900. These waters resulted in ephemeral streams and lakes, all of which evaporated in less than a decade (Koenig 1971). The harshness of the Salton Sink during the 1800's stands in marked contrast to the current landscape. It was described by gold seekers and others crossing it as they traveled west in 1849 as a, "scorching and sterile region, a country of burning salt plains and shifting hills of sand, where the only signs of human habitation were the bones of animals and men scattered along the trails" (Taylor 1849). As recently as 1900, this area had only native Americans as permanent inhabitants and not a single acre had ever been cultivated by a Caucasian (Kennan 1917).

During 1901, water for irrigation was for the first time intentionally brought into the area from the Colorado River. In 1902, the region was renamed the Imperial Valley to enhance its image and attract settlement. By April 1902, 400 miles of irrigating ditches had been dug, and water was available for 100,000 acres of irrigable land (Chaffey, 1902). More than 10,000 settlers had come to the valley, by 1904 and at years end, 20,000 acres of reclaimed land were under cultivation and 200,000 additional acres had been covered by water stock (Kennan 1917). The following year, excessive water flows in the Colorado River breached an irrigation control structure allowing virtually the full flow of the River into the Basin. The battle to close the breach was temporarily won a year later but additional floods resulted in other breaching. At peak flow during the summer of 1906, 125 acre-feet per minute (90,000 cubic feet per second) of water flowed through the breach (Koenig 1971). Control of Colorado River flows was not accomplished until late January 1907 and left behind the Salton Sea. These flows also deepened the Alamo and New River channels, thereby enhancing their ability to serve as drainage channels into the Salton Sea (Laflin, et. al., 1995). A gorge 50 feet deep was cut by the New River. At the height of its filling in 1907. The Sea reached the level of-195 feet below sea level. The maximum water depth was about 83 feet above the pre-flood level of the Salton Sink (Koenig 1971).

The Salton Sea exists today primarily due to agricultural drainage from the Imperial, Coachella, and Mexicali Valleys. Smaller volumes of municipal effluent and storm water runoff also flow to the Sea to help offset evaporation against an average of less than 3 inches of annual precipitation. The current elevation of the Sea is-227 feet below sea level; this is 32 feet less than the level the Sea filled to in 1907 (Fig.1) but 23 feet higher than the 1925 level it had receded to (Laflin et al., 1995). The current Sea is approximately 35 miles long by 15 miles wide, has an average depth of 29.9 feet and a maximum depth of 51 feet, contains 7.3 million acre-feet of water, and evaporates 1.3 million acre-feet of water each year.

These extended comments regarding the Project Site provide a focus on one of the key phrases noted earlier, that of Restoration Ecology. The Salton Sea, by whatever name, has been a changing body of water over geologic time (Fig. 2). Before civilization, the area of the current Sea was part of the Pacific Ocean; during earlier periods of Homo sapiens, this area has periodically been dry and contained a vast freshwater lake referred to as Lake Cahuilla (named by Professor William Blake in the 1850's); and since 1907 has been a water body sustained primarily by agricultural return flows. The point here is that restoration ecology by itself has no practical meaning for the Sea as a body of water, but instead must be considered in a context of values to be addressed. Those values lie with human society and are not a scientific issue. The role of science is to provide the knowledge and technology to assist society in achieving the values it wishes the Sea to provide. What then are these values?

There was no Salton Sea when the first settlements of non-native people took place within the Salton Sink. Settlers first came to the Imperial and Coachella Valleys because of the availability of irrigation water to grow crops among the fertile sediments deposited by waters from previous times. Just as irrigation created new human values regarding this region, so has the creation of the Salton Sea. Recreation was one of the first major values humans sought from the Sea.

As early as the mid-1920's, developers had visions of the Sea becoming a resort area and began to design facilities and communities within the surrounding area. A yacht club was developed and major speedboat racing events were brought to the Sea during this time period. Shoreline and other development activities accelerated in the late 1950's and continued into the early 1970's (Laflin, et. al., 1995). Camping, boating, swimming, and water skiing became major reasons for people to visit this oasis in the desert. The Sea became acclaimed for sportfishing during the 1960's following earlier introductions of saltwater fish from the Gulf of California (Koenig 1971). Thus, a variety of recreational values became expectations for those who visited the Sea. Development of facilities provided for associated human needs and continued enhancement of economic development opportunities also became an expectation and a value.

Ecologically, the Sea has become an important wetland within the Pacific Flyway. This value has increased over time because of the severity of wetland losses within California. The current importance as bird habitat is reflected in the millions of bird-use-days during migration and the more than 380 species that have been observed at the Sea. This diversity of avafauna is unequaled in the western United States and has established the Sea as a premier bird viewing area, another recreational value.

The Salton Sea also provides a value of great importance to agriculture in the Imperial and Coachella Valleys. The Sea is, by State law and Presidental Executive Order, a repository for agricultural drainwater. This agricultural value also provides other benefits. The Sea is not a source of irrigation water but drainwater flows maintain this water body by essentially replacing the evaporation of approximately 1.3 million acre-feet of water per year. However, these flows also contribute to nutrient and other contaminant levels that impact nonagriculture values provided by the Sea. For example, the Sea is extremely eutrophic, a condition that contributes to the highly productive sportsfishery but also negatively contributes to some other aspects of the Sea that have become concerns

ISSUES

The Salton Sea has become a focus for restoration because values humans have derived from the Sea, and wish to continue enjoying, are being jeopardized. Increasing water levels have flooded buildings, roads, and agricultural areas resulting in considerable economic losses. Because of the flatness of the adjacent landscape, relatively small increases or decreases in water levels can either inundate or dry a large amount of the surrounding area. Development of marinas, other recreational facilities, and housing that is associated with proximity to the waters edge has become an unwise investment because of the instability of the Sea's water level. Wildlife have also been impacted. The majority of National Wildlife Refuge lands are now under water. This loss of habitat has affected some species such as white pelicans. This species still uses the Sea, but no longer nest there due to loss of their nesting areas by flooding.

The salinity of the Sea has reached 44 ppt, a level that is 26% greater then ocean water. Salinity is increasing at a rate of approximately 0.4 of one percent per year and will soon reach a level that will cause a collapse in fish populations, thereby eliminating the food base for the fish-eating birds that come to the Sea and have far reaching impacts on many of the other values humans expect from the Sea.

Current recreational use of the Salton Sea has decreased dramatically from the 1960's and 1970's. However, the Salton Sea State Recreation Area has experienced four consecutive years of increased visitor use. Visitation for fiscal year 1997/98 was 74 percent above the nine-year average (California State Parks 1998). Fishing remains highly productive for those that still fish the Sea but public health warnings regarding the consumption of more then small amounts of fish because of high levels of contaminants may account for the decline in number of anglers. Declines in other recreational uses of the Sea may be due to a combination of factors such as strong odors, frequent large-scale fish kills, major bird die-offs, and algal blooms that make the Sea unattractive for visitation despite the scenic beauty of the area.

Since 1992, disease outbreaks among migratory birds using the Sea have occurred with unprecedented frequency, severity, and multiplicity of cause. The notoriety associated with a large mortality from avian botulism of white pelicans and the endangered California brown pelican during 1996 did much to place the Salton Sea in the national spotlight. These and other events have awakened interest within the environmental community and have become a focus for concern by others as well.

The concerns and issues identified above have been translated into project objectives for the Salton Sea restoration effort (Table 1).

Table 1

	Project objectives for Salton Sea ecosystem restoration
1.	Maintain the Sea as a repository for agricultural drainage from the Imperial and Coachella Valleys.
2.	Provide a safe, productive environment for resident and migratory birds and endangered species.
3.	Restore recreational uses of the Sea.

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Table 1

	Project objectives for Salton Sea ecosystem restoration
4.	Maintain a viable sportfishery.
5.	Provide opportunities for economic development along the shoreline.

The project area, or ecosystem, for this effort is currently defined as the Salton Sea and the drainages which directly provide water for the Sea. However, depending on alternatives considered for addressing the project objectives, it may be necessary to broaden this geographic area. Also, additional project objectives may result from further public involvement.

PROCESS

Direction for restoration efforts at the Salton Sea is being guided by input received through National Environmental Policy Act (NEPA) / California Environmental Quality Act (CEQA) processes. The NEPA / CEQA processes are being conducted by joint lead agencies - the Bureau of Reclamation for the Federal government and the Salton Sea Authority for the State of California. These processes require full disclosure about major actions by State and Federal agencies and also require that environmental concerns and impacts be evaluated during planning and decision making. An Environmental Impact Statement (EIS) and Environmental Impact Report (EIR) will be prepared that identifies impacts associated with the various management alternatives being considered. A separate planning document provides for a feasibility evaluation of preferred management alternatives relative to their ability to meet project objectives and goals. Public involvement is an important component of these processes. Public scoping meetings were held during the week of July 13, 1998, to help define project objectives and obtain input regarding potential approaches for accomplishment of those objectives. Other scoping meetings will be held during October or November to gather additional input regarding alternative management actions being considered.

The above processes are being assisted by two multiagency groups that have been operational for several months; these are a Research Management Committee and a Science Subcommittee. The Research Management Committee currently consists of 5 members - one each from the Department of the Interior, State of California, Salton Sea Authority, Torres Martinez Desert Cahuilla Indians, and the California Water Resources Center. The members are high level officials within their respective organizations and are the decision-making body for funding science needs and making interagency management decisions regarding Science Subcommittee activities.

The Science Subcommittee consists of representatives from various stakeholder agencies in the Salton Sea and the university community. The current composition for this Subcommittee is one representative from each of the following organizations:

Federal Agencies
- U.S. Fish and Wildlife Service
- Bureau of Land Management
- Bureau of Reclamation
- U.S. Geological Survey
- U.S. Environmental Protection Agency
- U.S. Army Corps of Engineers

Independent Nation
- Torres Martinez Desert Cahuilla Indians

State Agencies
- California Department of Fish and Game
- California Environmental Protection Agency
- California Department of Water Resources

Local Government
- Riverside County
- Imperial County
- Salton Sea Authority

Water Districts
- Coachella Valley Water District
- Imperial Irrigation District

University Community
- University of California - Riverside County

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San Diego State University
University of Redlands

The Executive Director of the Science Subcommittee is accountable to the entire Research Management Committee but is not under the direct supervision or line authority of any of its members. Agencies were asked to place individuals on the Science Subcommittee that have knowledge of the scientific issues of the Sea or have discipline-oriented scientific knowledge of value for Subcommittee deliberations. These deliberations are enhanced by inviting other individuals with subject matter expertise on specific issues to participate as needed in Subcommittee meetings.

Subcommittee responsibilities are limited to considerations associated with ecological assessments. Data synthesis of existing ecological information, identification of important data gaps, and development of requests for proposals to address those data gaps are important Subcommittee functions. The Subcommittee, aided by external peer review, evaluates proposals received in response to solicitations and makes recommendations for funding to the Research Management Committee. Subcommittee members cannot receive funding awards for science needs identified nor can they be the line supervisor for investigators or organizational groups within their agency that might receive such awards.

The Subcommittee also serves as a coordinating body for science activities associated with the Salton Sea, provides evaluations of probable environmental impacts associated with proposed management actions, and monitors the progress of scientific investigations funded by the Research Management Committee. Science information needs considered by the Science Subcommittee are directly related to addressing management needs, as are all the scientific evaluations undertaken by the Subcommittee. Nonecological information needs and evaluations such as those involving socioeconomic considerations, cultural resources, hydrology, geology, and engineering assessments are obtained by the joint lead agencies from sources other than the Science Subcommittee.

The key points to note are that the Science Subcommittee is not charged with developing solutions or contributing alternatives for addressing the project objectives, nor is the Subcommittee an advocacy body regarding any preferred management alternative. This separation of responsibilities is intended to enhance both the independence of scientific evaluations and the strength of administrative decisions since those decisions will, in part, be defended on the basis of the science provided by the autonomous Science Subcommittee.

An 18 month time frame which began in June 1998 has been imposed on providing recommendations for the best management options for restoration of the Salton Sea. This constraint significantly limits the amount of new studies that can be completed to fill data gaps and places strong emphasis and evaluations of existing data to guide management decisions. Project support has been enhanced by several members of Congress from southern California forming a Congressional Salton Sea Task Force. In addition, the U.S. House of Representatives recently passed the Sonny Bono Memorial Salton Sea Reclamation Act that, among other things, provides a substantial amount of funding for project construction costs. This legislation now goes to the U.S. Senate for further consideration.

DISCUSSION/CHALLENGES

The Salton Sea project is a "work in progress". It is an ecosystem management project that is passing through an ecological risk assessment phase to determine appropriate management actions. The concept of ecological risk assessment provided by Lackey (1997) through his citations of others applies to the Salton Sea project "...a way of examining risks so that they may be better avoided, reduced, or otherwise managed" (Wilson and Crouch, 1987); "...a process to evaluate the likelihood of undesirable effects on ecological receptors from exposure to one or more stressors..." (Regens, 1995); and "...a series of questions directed to the available data to analyze the expected risk (Patton, 1995). The processes underway are oriented at evaluating the risks associated with management options for achievement of project objectives (Table 1). These objectives are responsive to different interests within society and, in some instances, compete with one another. Ultimately, choices will be made by practical constraints, such as fiscal and other considerations, and by the voices of the people and organizations affected by the consequences of administrative decisions.

Implementation of administrative decisions for the Salton Sea will clearly fall within the concept of ecosystem management as defined by Lackey (1998):

> "The application of ecological and social information, options, and constraints to achieve desired social benefits within a defined geographic area and over a specified period."

The Salton Sea project is consistent with that definition in the following ways:

1. Project objectives for restoration of the Sea (Table 1) are human values (social benefits) that have been identified through public involvement;
2. A science subcommittee has been organized to provide information relative to biological questions and potential ecological impacts from actions being considered; additional sources are being utilized for questions involving other needs;
3. The project area is geographically defined as the Sea and the drainages that provide water into this closed basin; and
4. A time period for initiation of major management actions is established by current salinity levels of the Sea and the rate of increase in those levels. Several of the project objec-

tives will become unobtainable if salinity reaches levels that cause the loss of fish populations.

It is noteworthy that the need for actions to arrest increases in salinity at the Sea is not a new focus. Feasibility and other evaluations regarding the control of increasing salinity became areas for focus in the 1960's and have been ongoing since then. However, bird mortality events at the Sea during recent years, along with other events, have resulted in expanded interests by society in the Sea and have served as a catalyst for refocusing management actions from only addressing salinity and water level stabilization to consideration of a broader array of issues. Disease has become a primary issue and results in ecosystem health being a major focus for the Salton Sea project.

Considerable debate exists regarding whether or not ecosystem health is an appropriate or meaningful concept for ecosystem management. Also, it has been noted that, "There is no intrinsic definition of health without a benchmark of desired condition" (Lackey, 1998). I contend that the Salton Sea project has health benchmarks of the desired condition, that the Sea serves as a case study for better defining the meaning of ecosystem health relative to disease in fauna as an index value, and that restoration of the Sea should be considered as an ecosystem health project in the context of Lackey's third pillar for ecosystem management. Specifically:

> "Ecosystem management should maintain ecosystems in the appropriate condition to achieve desired social benefits; the desired social benefits are defined by society, not scientists" (Lackey, 1998).

The basis for my position is that health as a concept is the antithesis of disease. Both terms are like beauty in that they involve value judgements to stimulate actions. Science can provide classifications based on measurements and evaluations regarding each of these terms but personal values will guide the response of the individual to the conditions present. Human values have been stimulated by the repeated occurrences of large-scale bird and fish mortality events at the Sea. In some instances, the personal values involved are concern for the well-being of the wildlife being affected and, in other instances, the concerns involve extrapolation to represent hazards for human health. Economic impacts and other human values are the cause for additional human concerns. These values are the primary reason for the project objective of providing a safe, productive environment for resident and migratory birds and endangered species. They are also components of all but one of the other project objectives identified above.

The 1996 outbreak of avian botulism at the Salton Sea killed more than 10 percent of the western population of white pelicans and more than 1,000 endangered California brown pelicans. During 1997, virtually the entire production of double-crested cormorants on Mullet Island died from Newcastle disease. All production in this colony was again lost during 1998 (approximately 6,000 nestlings) from what appears to be a viral infection that is currently of unknown etiology. More than 150,000 eared grebes died during a 1992 outbreak of unknown etiology. Other diseases such as avian cholera and salmonellosis have also taken their toll of bird life at the Sea.

Disease is also a concern regarding impacts on other project objectives. Die-offs of a million or more fish during a single event are recurring events. Fish kills often appear to be related to water temperature stresses and anoxic conditions that may be related to algal blooms. However, a variety of bacterial and parasitic disease agents have also been isolated from dead and dying fish. Also, in 1986 the California Department of Health Services issued a health advisory regarding the consumption of fish from the Sea because of selenium levels. Concern also exists regarding levels of other chemical contaminants reaching the Sea from agricultural activities of the surrounding area. In addition, the discharge of inadequately treated wastewater into the New River at Mexicali, Mexico, has raised human health concerns regarding the transport of human pathogens into the Sea along with water flows from the New River.

These events document the presence of disease in the bird and fish communities of the Salton Sea and concerns regarding the safety of the Sea for human use. Conceptually, the Sea has taken on the perspective for some segments of society of being a "Love Canal", that is an "environmental soup" of toxic chemicals and infectious disease agents. Response to the spector of disease has been a demand for the restoration of ecosystem health. Since disease is an outcome rather than a cause and because environmental conditions are one of the three essential factors for disease to occur (Fig. 3), we can conclude that ecosystem management should be the basic approach for addressing the disease issues at the Sea.

Society has loosely defined the benchmarks for the desired state of ecosystem health to be achieved (Table 1). These benchmarks will be further refined as the project processes underway are completed and will serve as indices for long-term monitoring. As such, they will serve as tangible values of society against which project success can be measured and adjustments made. Viewed from the perspective of a human health analogy, these benchmarks are the values against which the results for an annual physical examination are evaluated. Those evaluations serve as guidance regarding the condition of the patient and whether or not actions are needed to maintain or achieve the state of health identified by the values measurements were made against.

Maintenance of a desired level of condition is not only a challenge for human health, but is also a major focus for ecosystem management. This focus is one of sustainability of benchmark values and is a difficult concept because these values may involve ability to provide a specific function, provide desired levels of products desired by society, or serve as a foundation for development activities that benefit some segments of society. Sustainability as an issue for the Salton

Sea involves all three of these considerations. The project objectives are the stated benefits to be sustained (Table 1) but each must be further defined in the context of values to be derived since each objective is challanged by the constraints that exist.

Compromises will be required because the objectives are not mutually compatible (i.e., are constraints) if the values to be sustained are at extreme ends of the spectrum for each. For example, the availability of water of sufficient quality to maintain a future that provides for several of the stated objectives is a major constraint. The hot, arid physical environment, competition for water by an ever-expanding human population, and competition for fiscal resources to support construction costs and project maintenance are all realities that must be addressed. Also, water flows into the Sea, that are without some acceptable level of water quality, will jeopardize recreation, wildlife, and shoreline development objectives. Similarly, some shoreline development and recreation activities may jeopardize bird populations that require isolation from disturbance during the period of nesting and rearing of young.

It is essential for long-term project success that the concept of sustainability be addressed early in the processes associated with the evaluation of management strategies for the Salton Sea ecosystem. The choices made have associated fiscal and other value costs and also help to define expectations regarding project outcomes. In addition, it is also important to recognize that current values being sought by society regarding this project are likely to change over time as a result of changes in values within society. Therefore, sustainability should be viewed from a dynamic (flexible) perspective rather than as continuation into perpetuity of a currently desired situation (static).

How then is the Salton Sea project being approached? Despite my emphasis on disease outbreaks, salinity is the most critical factor to be addressed in the near-term. The salinity issue is

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analogous to the passing of sand from one end of an hourglass to the other--the time frame is finite and no amount of discussion or study will alter the end result. Loss of fish populations due to salinity exceeding their tolerance levels will result in loss of the sportfishery and the fish-eating bird populations that utilize that food base. Disease, recreational opportunities, and shoreline development opportunities will all become academic if this happens.

Salinity control is the issue most is known about. During the past 25 years, a great deal of thought has gone into how to address salinity. Basic options arising from numerous proposals that have been developed include:

1. Pump-out. These options propose to reduce salinity by removal of water that is more saline than inflows into this closed basin. Salton Sea water would be pumped deep underground, into a dry sink, or into the ocean.
2. Diked impoundment. These options transform some areas of the Sea into evaporation ponds for receiving water from the remainder of the Sea and sacrifice some portion of the Sea to reduce salinity in the remainder of the Sea.
3. Combination. These options combine various techniques including diked impoundments, pump-out, enhanced evaporation, solar power generation, and others. Of these, combinations of pump-in and pump-out have generated a great deal of attention.
4. Water import options involve reducing salinity by dilution with imported water. Sources for such water is an issue unto itself.
5. Other options have been focused on removing salts from inflow waters before they reach the Sea. However, these options do not address removal of the millions of tons of salt currently present in the Sea.

There can be no question regarding the need to control salinity. However, this task is more complex than the application of technology and processes to address a physical component of the environment. A unique and confounding aspect of this task at the Salton Sea is the need to control salinity in a manner that does not negatively impact the biological components of the Sea that are the foundation for the values society wants the Salton Sea to provide (Table 1). Modeling will be an important tool for assisting with these evaluations. A three-dimensional hydrodynamic model developed at the University of California-Davis provides a means to model hydrodynamic circulation at the Salton Sea and is especially useful for considerations involving structural modifications within the Sea such as dikes and impoundments.

All technical evaluations completed to date for the Salton Sea have been done at a preliminary or appraisal level. Efforts are now being directed to providing more in-depth evaluations leading to a plan that improves the human environment and ecological conditions of the Sea. The final EIR/EIS for support of this plan is expected to be completed by December 1999. The cooperation, support, and efforts of many will be needed to provide a sound basis for restoration efforts given the time constraints imposed on this project.

CONCLUSION

My opening comment was that this presentation is about values and processes. I have attempted to relate the social benefits, or values, sought by society from the Salton Sea and the human instruments, or processes, being employed to achieve those social benefits. In keeping with the purpose for this symposium, these concepts have been expanded to broader philosophical comments for your consideration as practitioners or researchers involved with restoration ecology. Haskell, et al (1992) noted, "...each ecosystem has its own set of indicators and end-points; therefore, each ecosystem must be assessed separately. ...our indicators and variables must be sufficiently dynamic to change accordingly. ...each scientist evaluating the ecosystem will choose different variables depending on his or her specific interest and expertise". I have displayed my interest through my comments. A challenge for ecosystem restoration is to vigorously seek out and bring together the wide variety of special interests needed to assure holistic evaluations of the complex biologic systems we hope to restore. This is necessary to provide the scientific foundation for sound decisions regarding choices to be made by society in pursuing ecosystem restoration and management.

Ecosystem health has been highlighted because I believe it is a concept deserving greater attention in restoration ecology. One aspect of this concept that I hope you will focus on is my statement that disease is an outcome rather than a cause and that environmental conditions are a critical component for this outcome. As such, disease absence and occurrence are benchmarks for evaluating environment health and should be part of long-term environmental monitoring programs. To place this in perspective, I note a recent commentary in Science titled, "Restored Wetlands Flunk Real-World Test" (Malakoff, 1998). The orientation of that commentary was failure of the restoration effort to result in anticipated functional values by the wetland. I contend that the occurrence of major disease outbreaks, especially on a recurring basis, within ecosystem restoration projects is also a "failing grade".

In keeping with this concept, I close by quoting an earlier consideration of ecosystem health by Robert Costanza (1992):

> "There is no silver bullet that will allow us to assess ecosystem health quickly, cheaply, precisely, and without ambiguity. There is no health meter with probes that can be inserted into ecosystems to yield a digital readout of health. Assessing health in a complex system--from organisms to ecosystems to economic systems--requires a good measure of judgement, precaution, and humility, but also a good measure of systems analysis and modeling in order to

put all the individual pieces together into a coherent picture."

We are attempting to fully incorporate all of the insight offered by Dr. Costanza's comments as we move forward in our efforts to restore the Salton Sea--especially the need for good judgement and humility considering how little we know relative to what we would like to know. This level of uncertainty emphasises the challenges associated with our task because of the consequences of the outcome for agriculture, wildlife, and other values associated with the Salton Sea.